MITSUBISHI ELECTRIC

Changes for the Better

Numerical Control (CNC)

PLC Programming Manual

M800/M80/E80 Series

IB-1501271(ENG)-P

Introduction

These specifications are the programming manual used when creating the sequence program with the PLC development software, or Mitsubishi Electric FA engineering software MELSOFT Series (GX Developer/GX Works2).
The PLC (Programmable Logic Controller) instructions are largely categorized into the basic instructions, function instructions and exclusive instructions. There are many types of instructions. The instructions can be used according to the purpose and application such as the PLC support function used when supporting the user PLCs.
Supported models are as follows:

Supported models	Abbreviations in this manual
M800W Series	M850W, M830W
M800S Series	M850S, M830S
M80W Series	M80W
M80 Series	M80 TypeA, M80 TypeB
E80 Series	E80 TypeA, E80 TypeB

Abbreviations in this manual are as follows:

Abbreviations	Supported models
M800, M800 Series	M800W Series/M800S Series
M80, M80 Series	M80W Series/M80 Series
M800/M80, M800/M80 Series	M800W Series/M800S Series/M80W Series/M80 Series
M8, M8 Series	M800W Series/M800S Series/M80W Series/M80 Series/E80 Series

Be sure to keep this manual always at hand.

⚠ CAUTION

⚠ **An effort has been made to describe special handling of this machine, but items that are not described must be interpreted as "not possible".**

⚠ **This manual is written on the assumption that all the applicable functions are included.**
Some of them, however, may not be available for your NC system.
Refer to the specifications issued by the machine tool builder before use.

⚠ **Some screens and functions may differ depending on each NC system (or version), and some functions may not be possible. Please confirm the specifications before starting to use.**

⚠ **To protect the availability, integrity and confidentiality of the NC system against cyber-attacks including unauthorized access, denial-of-service (DoS) (*1) attack, and computer virus from external sources via a network, take security measures such as firewall, VPN, and anti-virus software.**
(*1) Denial-of-service (DoS) refers to a type of cyber-attack that disrupts services by overloading the system or by exploiting a vulnerability of the system.

⚠ **Mitsubishi Electric assumes no responsibility for any problems caused to the NC system by any type of cyber-attacks including DoS attack, unauthorized access and computer virus.**

In this manual, the following abbreviations might be used.
MTB: Machine tool builder

Also refer to the manuals on "Manual List" as necessary.

Manual List

Manuals related to M800/M80/E80/C80 Series are listed as follows.
These manuals are written on the assumption that all optional functions are added to the targeted model.
Some functions or screens may not be available depending on the machine or specifications set by MTB. (Confirm the specifications before use.)
The manuals issued by MTB take precedence over these manuals.

Manual	IB No.	Purpose and Contents
M800/M80/E80 Series Instruction Manual	IB-1501274	• Operation guide for NC • Explanation for screen operation, etc.
C80 Series Instruction Manual	IB-1501453	• Operation guide for NC • Explanation for screen operation, etc.
M800/M80/E80/C80 Series Programming Manual (Lathe System) (1/2)	IB-1501275	• G code programming for lathe system • Basic functions, etc.
M800/M80/E80/C80 Series Programming Manual (Lathe System) (2/2)	IB-1501276	• G code programming for lathe system • Functions for multi-part system, high-accuracy function, etc.
M800/M80/E80/C80 Series Programming Manual (Machining Center System) (1/2)	IB-1501277	• G code programming for machining center system • Basic functions, etc.
M800/M80/E80/C80 Series Programming Manual (Machining Center System) (2/2)	IB-1501278	• G code programming for machining center system • Functions for multi-part system, high-accuracy function, etc.
M800/M80/E80 Series Alarm/Parameter Manual	IB-1501279	• Alarms • Parameters
C80 Series Alarm/Parameter Manual	IB-1501560	• Alarms • Parameters

Manuals for MTBs (NC)

Manual	IB No.	Purpose and Contents
M800/M80/E80/C80 Series Specifications Manual (Function)	IB-1501505	• Model selection • Outline of various functions
M800/M80/E80/C80 Series Specifications Manual (Hardware)	IB-1501506	• Model selection • Specifications of hardware unit
M800W/M80W Series Connection and Setup Manual	IB-1501268	• Detailed specifications of hardware unit • Installation, connection, wiring, setup (startup/adjustment)
M800S/M80/E80 Series Connection and Setup Manual	IB-1501269	• Detailed specifications of hardware unit • Installation, connection, wiring, setup (startup/adjustment)
C80 Series Connection and Setup Manual	IB-1501452	• Detailed specifications of hardware unit • Installation, connection, wiring, setup (startup/adjustment)
M800/M80/E80 Series PLC Development Manual	IB-1501270	• Electrical design • I/O relation (assignment, setting, connection), field network • Development environment (PLC on-board, peripheral development environment), etc.
M800/M80/E80 Series PLC Programming Manual	IB-1501271	• Electrical design • Sequence programming • PLC support functions, etc.
M800/M80/E80/C80 Series PLC Interface Manual	IB-1501272	• Electrical design • Interface signals between NC and PLC
M800/M80/E80 Series Maintenance Manual	IB-1501273	• Cleaning and replacement for each unit • Other items related to maintenance
C80 Series Maintenance Manual	IB-1501454	• Cleaning and replacement for each unit • Other items related to maintenance

Manuals for MTBs (drive section)

Manual	IB No.	Contents
MDS-E/EH Series Specifications Manual	IB-1501226	• Specifications for power supply regeneration type
MDS-E/EH Series Instruction Manual	IB-1501229	• Instruction for power supply regeneration type
MDS-EJ/EJH Series Specifications Manual	IB-1501232	• Specifications for regenerative resistor type
MDS-EJ/EJH Series Instruction Manual	IB-1501235	• Instruction for regenerative resistor type
MDS-EM/EMH Series Specifications Manual	IB-1501238	• Specifications for multi-hybrid, power supply regeneration type
MDS-EM/EMH Series Instruction Manual	IB-1501241	• Instruction for multi-hybrid, power supply regeneration type
DATA BOOK	IB-1501252	• Specifications of servo drive unit, spindle drive unit, motor, etc.

Manuals for MTBs (Others)

Manual	No.	Purpose and Contents
GOT2000 Series User's Manual (Hardware)	SH-081194ENG	• Outline of hardware such as part names, external dimensions, installation, wiring, maintenance, etc. of GOTs
GOT2000 Series User's Manual (Utility)	SH-081195ENG	• Outline of utilities such as screen display setting, operation method, etc. of GOTs
GOT2000 Series User's Manual (Monitor)	SH-081196ENG	• Outline of each monitor function of GOTs
GOT2000 Series Connection Manual (Mitsubishi Electric Products)	SH-081197ENG	• Outline of connection types and connection method between GOT and Mitsubishi Electric connection devices
GT Designer3 (GOT2000) Screen Design Manual	SH-081220ENG	• Outline of screen design method using screen creation software GT Designer3

■ For M800/M80/E80 Series

Manual	No.	Purpose and Contents
GOT2000 Series Connection Manual (Non-Mitsubishi Electric Products 1)	SH-081198ENG	• Explanation for connection types and connection method between GOT and other company's devices
GOT2000 Series Connection Manual (Non-Mitsubishi Electric Products 2)	SH-081199ENG	
GOT2000 Series Connection Manual (Microcomputers, MODBUS/ Fieldbus Products, Peripherals)	SH-081200ENG	• Explanation for connection types and connection method between GOT and microcomputers, MODBUS/fieldbus products, peripherals
GT SoftGOT2000 Version1 Operating Manual	SH-081201ENG	• Explanation for system configuration, screen configuration and operation method of monitoring software GT SoftGOT2000
GOT2000/GOT1000 Series CC-Link Communication Unit User's Manual	IB-0800351	• Explanation for handling CC-Link communication unit (for GOT2000 series/GOT1000 series)
GX Developer Version 8 Operating Manual (Startup)	SH-080372E	• Explanation for system configuration, installation, etc. of PLC development tool GX Developer
GX Developer Version 8 Operating Manual	SH-080373E	• Explanation for operations using PLC development tool GX Developer
GX Converter Version 1 Operating Manual	IB-0800004	• Explanation for operations using data conversion tool GX Converter
GX Works2 Installation Instructions	BCN-P5999-0944	• Explanation for the operating environment and installation method of GX Works2
GX Works2 Version 1 Operating Manual (Common)	SH-080779ENG	• Explanation for the system configuration of GX Works2 and the functions common to Simple project and Structured project such as parameter setting, operation method for the online function
GX Works2 Version 1 Operating Manual (Simple Project)	SH-080780ENG	• Explanation for methods for such as creating and monitoring programs in Simple project of GX Works2
GX Works2 Version 1 Operating Manual (Simple Project, Function Block)	SH-080984ENG	• Explanation for methods for such as creating function blocks, pasting function blocks to sequence programs, and operating FB library in Simple project of GX Works2
GX Works2 Version 1 Operating Manual (Structured Project)	SH-080781ENG	• Explanation for methods for such as creating and monitoring programs in Structured project of GX Works2
GX Works3 Installation Instructions	BCN-P5999-0391	• Explanation for the operating environment and installation method of GX Works3
MELSEC-Q CC-Link System Master/ Local Module User's Manual	SH-080394E	• Explanation for system configuration, installation, wiring, etc. of master/local modules for CC-Link system

■ For C80 Series

Manual	No.	Purpose and Contents
MELSEC iQ-R Module Configuration Manual	SH-081262	• Outline of system configuration, specifications, installation, wiring, maintenance, etc.
MELSEC iQ-R CPU Module User's Manual (Startup)	SH-081263	• Outline of specifications, procedures before operation, troubleshooting, etc. for CPU module
MELSEC iQ-R CPU Module User's Manual (Application)	SH-081264	• Outline of memory, functions, devices, parameters, etc. for CPU module
MELSEC iQ-R CC-Link IE Field Network User's Manual (Application)	SH-081259	• Explanation for functions, parameter settings, programming, troubleshooting, etc. of the CC-Link IE Field Network function
QCPU User's Manual (Hardware Design, Maintenance and Inspection)	SH-080483	• Outline of specifications, necessary knowledge to configure the system and maintenance-related descriptions for Q series CPU module, etc.
GX Works3 Operating Manual	SH-081215	• Outline of functions, programming, etc.

Reference Manual for MTBs

Manual	No.	Purpose and Contents
M800/M80 Series Smart safety observation Specification manual	BNP-C3072-022	• Explanation for smart safety observation function
C80 Series Smart safety observation Specification manual	BNP-C3077-022	
M800/M80 Series Interactive cycle insertion (Customization) Specification manual	BNP-C3072-121-0003	• Explanation for interactive cycle insertion
M800/M80 Series Synchronous Control Specifications manual	BNP-C3072-074	• Explanation for synchronous control
M800/M80 Series Multiple-Axis Synchronization Control Specifications manual	BNP-C3072-339	• Explanation for multiple-axis synchronization control
M800/M80 Series GOT Connection Specifications manual	BNP-C3072-314	• Explanation for GOT connection
M800/M80 Series PROFIBUS-DP Specification manual	BNP-C3072-118	• Explanation for PROFIBUS-DP communication function
M800/M80 Series EtherNet/IP Specifications manual	BNP-C3072-263	• Explanation for EtherNet/IP
M800/M80 Series FL-net Specifications manual	BNP-C3072-368	• Explanation for FL-net
M800/M80 Series CC-Link (Master/Local) Specification manual	BNP-C3072-089	• Explanation for CC-Link
M800/M80 Series CC-Link IE Field (Master/local) Specifications manual	BNP-C3072-283	• Explanation for CC-Link IE Field
M800/M80 Series CC-Link IE Field Basic Specifications manual	BNP-C3072-337	• Explanation for CC-Link IE Field Basic

Precautions for Safety

Always read the specifications issued by the machine tool builder, this manual, related manuals and attached documents before installation, operation, programming, maintenance or inspection to ensure correct use.
Understand this numerical controller, safety items and cautions before using the unit.
This manual ranks the safety precautions into "DANGER", "WARNING" and "CAUTION".

⚠ **DANGER** **When there is a great risk that the user could be subject to fatalities or serious injuries if handling is mistaken.**
⚠ **WARNING** **When the user could be subject to fatalities or serious injuries if handling is mistaken.**
⚠ **CAUTION** **When the user could be subject to injuries or when physical damage could occur if handling is mistaken.**

Note that even items ranked as " ⚠ CAUTION", may lead to major results depending on the situation. In any case, important information that must always be observed is described.

The following signs indicate prohibition and compulsory.

⃠	**This sign indicates prohibited behavior (must not do).** **For example, ⃠ indicates "Keep fire away".**

●	**This sign indicates a thing that is compulsory (must do).** **For example, ⏚ indicates "it must be grounded".**

The meaning of each pictorial sign is as follows.

⚠ CAUTION	 CAUTION rotated object	 CAUTION HOT	 Danger Electric shock risk	 Danger explosive
⃠ Prohibited	 Disassembly is prohibited	 KEEP FIRE AWAY	● General instruction	⏚ Earth ground

For Safe Use

Mitsubishi Electric CNC is designed and manufactured solely for applications to machine tools to be used for industrial purposes.

Do not use this product in any applications other than those specified above, especially those which are substantially influential on the public interest or which are expected to have significant influence on human lives or properties.

⚠ DANGER

Not applicable in this manual.

⚠ WARNING

Not applicable in this manual.

⚠ CAUTION

1. Items related to product and manual

⚠ **For items described as "Restrictions" or "Usable State" in this manual, the instruction manual issued by the machine tool builder takes precedence over this manual.**

⚠ **An effort has been made to describe special handling of this machine, but items that are not described must be interpreted as "not possible".**

⚠ **This manual is written on the assumption that all the applicable functions are included.**
Some of them, however, may not be available for your NC system.
Refer to the specifications issued by the machine tool builder before use.

⚠ **Refer to the Instruction Manual issued by each machine tool builder for details on each machine tool.**

⚠ **Some screens and functions may differ depending on each NC system (or version), and some functions may not be possible. Please confirm the specifications before starting to use.**

⚠ **To protect the availability, integrity and confidentiality of the NC system against cyber-attacks including unauthorized access, denial-of-service (DoS) (*1) attack, and computer virus from external sources via a network, take security measures such as firewall, VPN, and anti-virus software.**
(*1) Denial-of-service (DoS) refers to a type of cyber-attack that disrupts services by overloading the system or by exploiting a vulnerability of the system.

⚠ **Mitsubishi Electric assumes no responsibility for any problems caused to the NC system by any type of cyber-attacks including DoS attack, unauthorized access and computer virus.**

2. Items related to start up and maintenance

⚠ **Read this manual carefully and confirm the safety enough before executing the operation of the program change, forced output, RUN, STOP, etc. during operation. Operation mistakes may cause damage of the machine and accidents.**

3. Items related to program development

⚠ **Always observe the cautions before development to develop a program.**

⚠ **If the data transferred does not follow the file name rule, unexpected operations will occur.**
E.g. PLC program erasure

⚠ **Do not read a sequence program on which a conversion error occurred into the GX Developer/GX Works2. The file may include unexpected contents to result an illegal operation.**

⚠ **When an error occurred at GX Developer/GX Works2 On-line function, the error message may not explain exactly the state in the CNC side. Always refer to the error list.**

Disposal



(Note) This symbol mark is for EU countries only.
This symbol mark is according to the directive 2006/66/EC Article 20 Information for end-users and Annex II.

Your MITSUBISHI ELECTRIC product is designed and manufactured with high quality materials and components which can be recycled and/or reused.
This symbol means that batteries and accumulators, at their end-of-life, should be disposed of separately from your household waste.
If a chemical symbol is printed beneath the symbol shown above, this chemical symbol means that the battery or accumulator contains a heavy metal at a certain concentration. This will be indicated as follows:
Hg: mercury (0.0005%), Cd: cadmium (0.002%), Pb: lead (0.004%)
In the European Union there are separate collection systems for used batteries and accumulators.
Please, dispose of batteries and accumulators correctly at your local community waste collection/recycling centre.

Please, help us to conserve the environment we live in!

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Handling of our product

(English)
This is a class A product. In a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.

본 제품의 취급에 대해서

(한국어 /Korean)
이 기기는 업무용 (A 급) 전자파적합기기로서 판매자 또는 사용자는 이 점을 주의하시기 바라며 가정외의 지역에 서 사용하는 것을 목적으로 합니다 .

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1

Outline

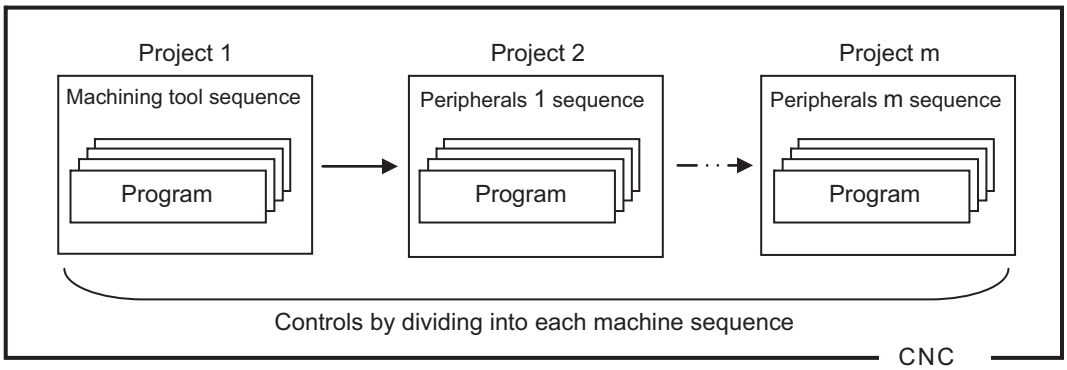
This programming manual is used when creating a sequence program for this CNC using the MELSEC PLC development software package (GX Developer/GX Works2).
The PLC (Programmable Logic Controller) instructions are largely categorized into the basic instructions, function instructions and exclusive instructions. There are many types of instructions. The instructions can be used according to the purpose and application such as the PLC support function used when supporting the user PLCs.

2

PLC Processing Program

2.1 Outline of PLC Processing Project

In M800/M80 series, the project is divided into each machine sequence, the multiple divided projects can be independently controlled/started by one CNC.
When the projects are divided into multiple parts, the execution order by each project can be specified on the setting screen. This is called "Multi-project function". PLC follows the execution order setting and executes the process by each project.
It is possible to divide the program which is stored in the project into the program by the control unit. (Refer to "Outline of PLC Processing Program (2 Program Methods)")

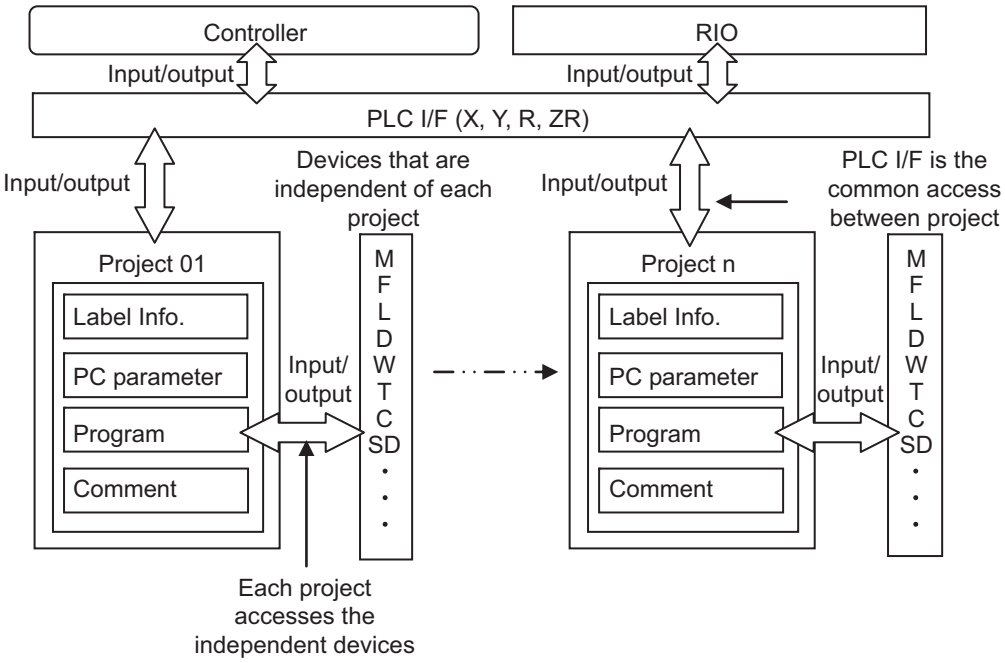


For example, when creating the sequence of machine tool and the peripherals separately, this function allows the each sequence to be created/managed in separate project. This will enable the machine to start smoothly without having the program setting error or device redundant error, because the program setting/ device can be controlled by each sequence.

2.2 Multi-project Function

2.2.1 Outline

Multi CPU configuration of MELSEC sequencer is mounted as the CNC specification. The multiple projects can be independently managed/ started up by one CNC with this function.
It is enabled when the number of the project to be used is changed on the multi project parameter setting screen.
Also on the same setting screen, the execution project and the execution order can be changed.
Each project can use the each independent device (PLC I/F (except for X, Y, R, ZR)).
When the maximum project No. increases, the step No. and the device No. that can be used for 1 project will decrease. (Refer to "Multi-project Setting Parameter (Project Setting)" or "Multi-project Setting Parameter (Device Setting)" in "Parameters: Bit Selection Parameters")
The total configuration of the multi-project is shown in the following figure.



2.2.2 Range of Usable Project

The range of usable project differs depending on the models as follows.

- M800 Series : 1 to 6 project (3 projects and more will be additional specifications.)
- M80 Type A, M80W : 1 to 3 project
- M80 Type B : 1 to 2 project
- E80 Series : 1 to 2 project

2.2.3 Multi-project Function Usage Steps

To enable the multi-project function, follow the steps below and set the multi-project parameter and the device No. parameter.

(1)Multi-project function change steps

When the sequence program is already stored in CNC, follow the steps below and carry out the setting.

	Development procedure	Reference
1	Back up the sequence program	PLC Development Manual "PERIPHERAL DEVELOPMENT ENVIRONMENT: Reading the Sequence Program from the CNC Controller"
2	Format the temporary storage area (RAM in CNC)	PLC Development Manual "PERIPHERAL DEVELOPMENT ENVIRONMENT: Initialization for PLC Data Storage Area"
3	Clear the data in built-in ROM (ROM in CNC) (Clear the data by writing the empty temporary storage area into the built-in ROM.)	PLC Development Manual "PERIPHERAL DEVELOPMENT ENVIRONMENT"
4	Set the multi-project parameter and the device No. parameter	(2) New setting steps of Multi-project function
5	Change the PC parameter of the backup sequence program	PLC Development Manual "PERIPHERAL DEVELOPMENT ENVIRONMENT"
6	Write back the backup sequence program	PLC Development Manual "PERIPHERAL DEVELOPMENT ENVIRONMENT"

(2)New setting steps of Multi-project function

When the sequence program has not yet stored in CNC, follow the steps below and carry out the new setting.

	Development procedure	Reference
1	Curry out the setting of the multi-project parameter	Parameters: Multi-project Setting Parameter (Project Setting)
2	Curry out the setting of the device No. parameter	Parameters: Multi-project Setting Parameter (Device Setting)
3	Restart the CNC	

2.3 PLC Processing Program Level and Operation

The details of the user PLC processing level and the time chart are shown below.

PLC processing level

Program name	Description (frequency, level, etc.)
Initial processing program	This program starts only once at power ON. When this program operates, machine input and operation board input are not read.
High-speed processing program	This program starts periodically at each standard interrupt signal. This program has the highest level as a program that starts periodically. It is used in signal processing where high-speed processing is required. The steps for high-speed processing program should be up to 1000 steps with basic instructions. (Application example) Position count control of turret and ATC magazine (Note) The standard interrupt signal cycle differs according to each model, and must be confirmed separately.
Main processing program	This program runs constantly except during the high-speed process program. When the user PLC one-scan process is completed, the next scan process starts at the next reference interrupt signal cycle.

Additionally, the execution order in each processing unit is executed by the project unit order. The execution order of project is executed in the order that is set by the user. They are not executed simultaneously. The order is determined on the multi-project parameter setting screen on the built-in PLC (built-in edit function). It is not possible to set the order with GX Developer.
When the execution order of the project is not specified, the project will be executed sequentially from 1.

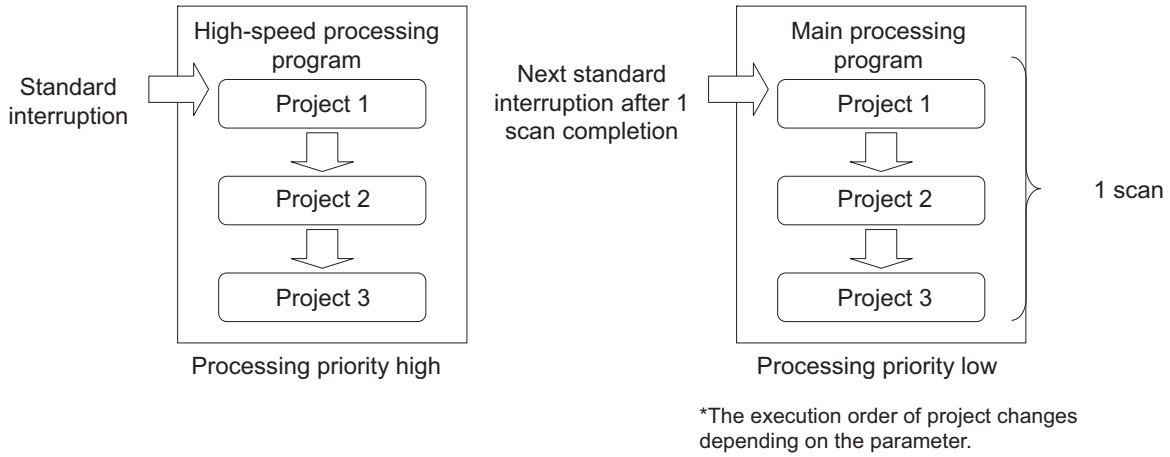
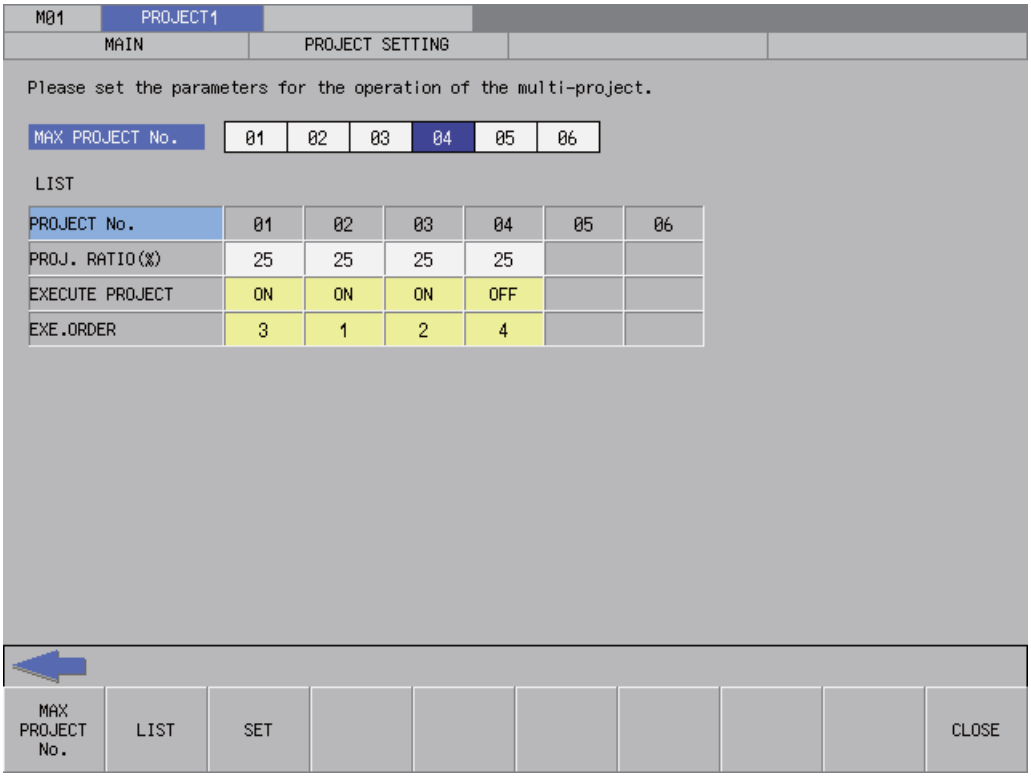


Image of PLC processing execution unit

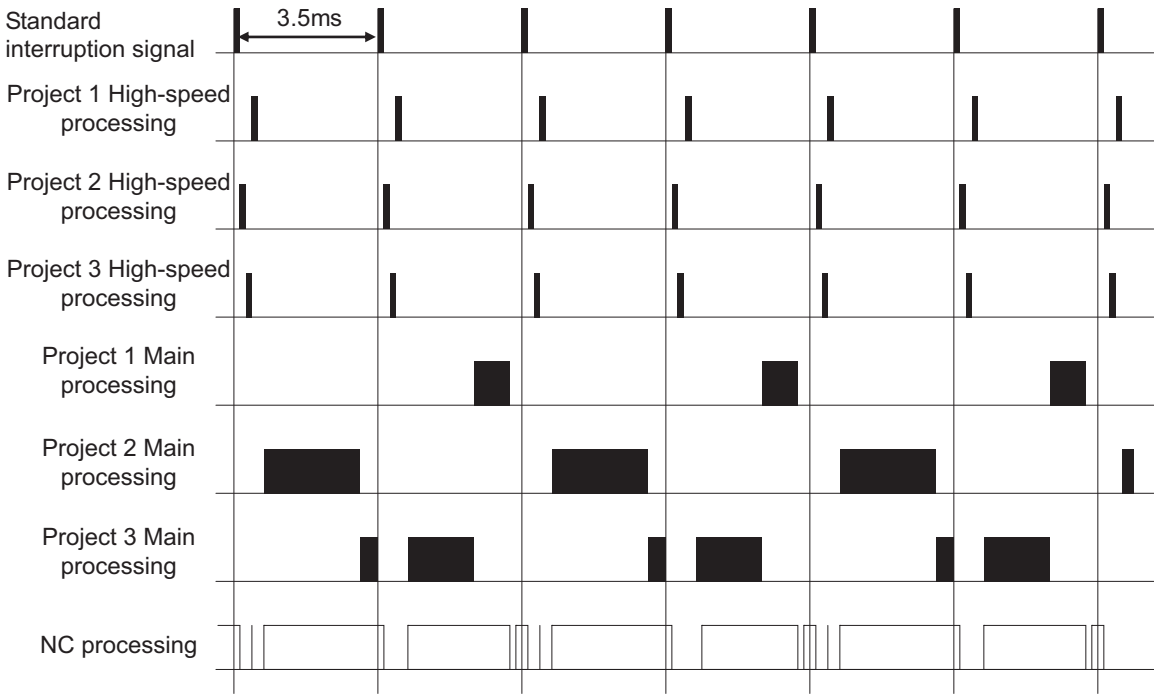
The following is the example of the built-in PLC (built-in edit function) setting screen.



Set the project execution order in a way that does not to have the duplication of the number in the setting range from 1 to 6, regardless of the usable project number. The project starts up from the smaller setting number in numerical order.

The execution order shown here is the case when 3 projects are registered to CNC as in the setting screen above.

When the standard interruption signal is 3.5ms

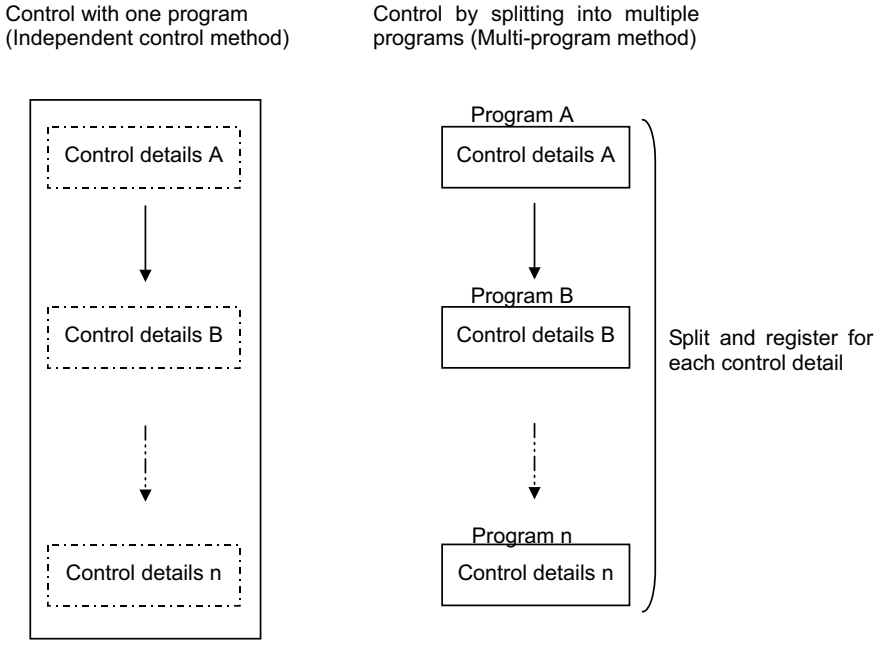


The operation time chart of PLC processing program

2.4 Outline of PLC Processing Program (Two Program Method)

The M800/M80 Series program execution control methods include the conventional method which controls with one program, and the method that splits the program into multiple sections for each control unit.
When splitting into multiple programs, the order for executing the split programs can be designated on the setting screen. This is called the multi-programming function.

Method controlling with one program (conventional method) : Independent program method
Method splitting control into multiple programs : Multi-program method



2.5 Independent Program Method

This method lays importance on compatibility with the conventional models.
One sequence program can be stored. The execution type and head of processing are designated with reserved labels. The execution type and execution order cannot be designated on the setting screen.

- Initialization process (reserved label P4003) : This starts up only once when the power is turned ON.
- High-speed process (reserved label P4001) : This starts up at the standard interrupt cycle.
- Main process (reserved label P4002) : This starts up constantly except during the high-speed process.

2.6 Multi-program Method

Several sequence programs can be registered in the CNC and sequentially executed.
By using this function, the sequence program can be split into each process and developed.
With the multi-program method, the execution type and execution order are designated on the GX Developer setting screen, and the parameter files are sent to the NC.
The execution type and the head of the process cannot be designated with reserved labels.

2.6.1 Number and Types of Registerable Programs

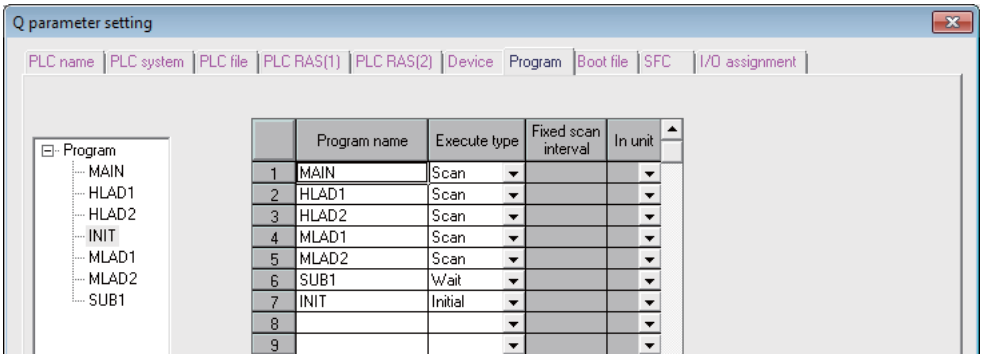
The maximum registrable number of the sequence program differs depending on the models as shown below.
- M800 Series : 120
- M80 Series Type A/Type B, M80W, E80 : 60

* The above is the total number of the whole projects.

Only one execution type can be set to one program. There are 5 kinds of execution type as shown below.
- "Initial" (Initialization process) : This starts up only once when the power is turned ON.
- "Scan" (High-speed process) : This starts up at the standard interrupt cycle.
- "Scan" (Main process) : This starts up constantly except during the high-speed process.
- "Standby" (Standby process) : This is called from the high-speed process or main process.
- "Constant cycle" : This execution type is not used.

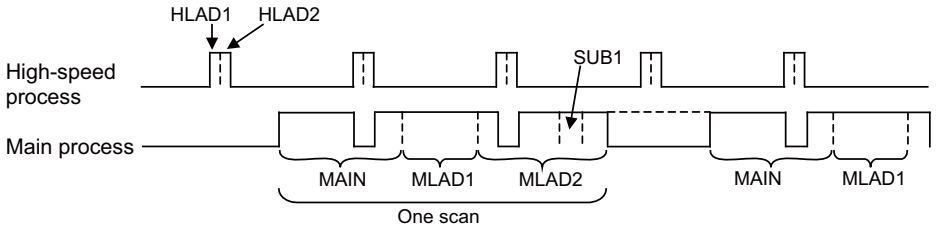
2.6.2 Program Execution Order

Several programs are executed in a predetermined order. They are not executed simultaneously. The order is determined with the development tool (GX Developer or Built-in PLC (built-in edit function)) setting screen. The programs are executed from the smallest number in the same execution type. An example of the setting screen for GX Developer is shown below.



The execution order when seven sequence programs are registered in the CNC, as shown in the above setting screen, is indicated below.

Program name	Execution type	Execution order	Remarks
INIT	Initialization sequence program	1	Starts up only once when the power is turned ON.
HLAD1	High-speed process execution program Execution type is set as "Scan"	1	"Scan type" for which program name starts with "H"
HLAD2		2	
MAIN	Main process sequence programExecution type is set as "Scan"	1	"Scan type" for which program name does not start with "H"
MLAD1		2	
MLAD2		3	
SUB1	Standby sequence program	1	Here, subroutine that is called from MLAD2 with CALL instruction is stored

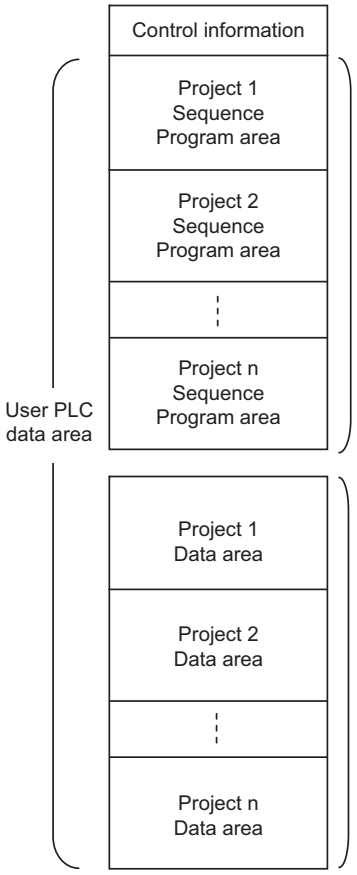


(Note) If the process jumps to END (P4005) in the sequence program, the process will jump to the end of each process (high-speed, main) instead of the end of the program.

2.7 User PLC Data Area Configuration and Size

The approximate configuration and size of user PLC data area are as shown below.
The areas, the sequence program area and the data area of the figure below are created in order from project 1.
The setting of the project No. and the area size of each project can be changed by the multi-project parameter setting. (Refer to "Multi-project Setting Parameter (Device Setting)")

The length of one instruction (step No.) is different from the instructions that are stored in the storage area and the execution area because the sequence program in storage area is converted and stored in the execution area. (Refer to 2.8.2. Instruction code conversion at execution)
Therefore, the size of execution area is ensured to be twice bigger to store the data in the execution area as much as possible even when the storage area is used to the maximum.



←(1) Internal information table of User PLC
(The table is automatically generated.)

←(2) Sequence program storage area
The program can be stored by each project independently.
Thetotal of step No. for all projects that can be stored is as follows.
[Total storage area]
- M800 128K (256K/512K(*1)) step
- M80 Type A, M80W 64K step
- M80 Type B 32K step
- E80 Type A/B 20K step

of which, the execution area is as follows.
[Total execution area]
- M800 56K (512K/1024K(*2)) step
- M80 Type A, M80W 128K step
- M80 Type B 64K step
- E80 Type A/B 40K step

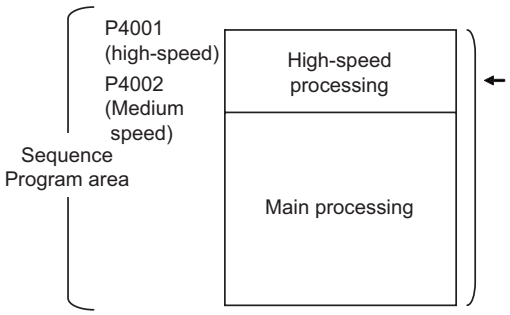
←(3) Data storage area (Other than sequence program)
Each projects data other than the sequence program can be independently stored.
This applies to the following data.
- Alarm messages
- Operator messages
- PLC switches
- Contact/coil comment data
- Symbolic information, etc. (*3)

The total size of the storable data of all projects is as follows.
Total M800 8Mbyte
M80 Type A/B, M80W 2Mbyte
E80 Type A/B 2Mbyte

(*1) 256K/512K step are additional specifications.
(*2) 512K/1024K step are additional specifications.
(*3) These are the files to be written in the NC when you program a label.

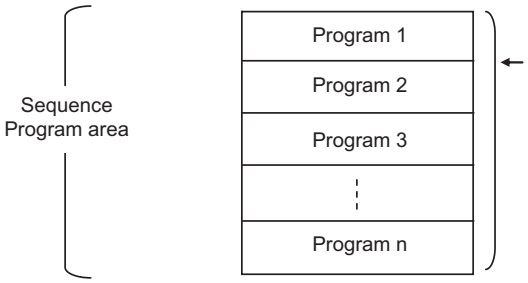
The details of the sequence program area configuration are as follows. The configuration differs according to the program method.

2.7.1 In the Independent Program Method



Sequence program storage area
The program other than main processing is not requirement.
The program order of initialization, high-speed and main is arbitrary.
The storable step No. differs according to each project.

2.7.2 In the Multi-program Method



Sequence program storage area
It is possible to divide and store the initialization, high-speed, and standby processing into multiple programs by the control units.
The storing order of the program is arbitrary.
At least, one main processing needs to exist.
The storable step No. differs according to each project.

2.8 Storing PLC Processing Program and Execution Mode

The user PLC data area storage method and the PLC processing program execution method are explained. User PLC data area is stored in the non-volatile ROM (hereinafter, built-in ROM) and a sequence program is executed according to the following path.

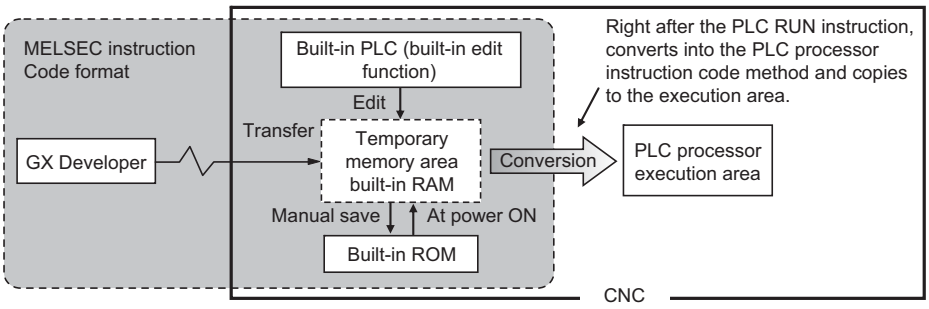
2.8.1 Path from Storage to Execution

(1) During PLC development

Sequence program data transferred from development environment such as GX Developer or built-in PLC (built-in edit function) is stored in the volatile RAM (hereinafter, built-in RAM) for the temporary memory. The sequence program is transferred to the PLC processor execution area before PLC execution, and is then executed.
The built-in RAM in the temporary memory is not held when the power is turned OFF. If the data needs to be held even after the power is turned OFF, it must be stored in the built-in ROM.
There are following two ways to store the data to built-in ROM.
- Storing the sequence program of built-in RAM to the built-in ROM with PLC peripheral development environment (GX Developer)
(Refer to "Writing Sequence Program to ROM of CNC" of "PERIPHERAL DEVELOPMENT ENVIRONMENT: Sequence Program Development" in PLC Development Manual for the details of writing method)
- Storing the sequence program of built-in RAM to the built-in ROM with built-in PLC (built-in edit function)

(2) At power ON

The data is transferred from the built-in ROM to the PLC processor execution area via the temporary memory built-in RAM, and is then executed.



2.8.2 Conversion of Instruction Code at Execution

In the built-in ROM/temporary memory area shown on the left in the figure above, a sequence program is stored in the instruction code format that is compatible with the MELSEC sequencer.
During execution, however, a sequence program is analyzed to optimize the references and/or converted into the PLC processing processor instruction code for the CNC. Thus, the length (number of steps) of an instruction for each instruction changes before and after the conversion. Refer to ""Explanation of Instructions: Instruction List" for details on the number of steps during storage and execution for each instruction.

2.8.3 How to Confirm the Number of Steps at Storage/Execution

The number of steps under the PLC development environment (GX Developer, built-in PLC (built-in edit function)) is usually all displayed as the number of steps at "storage".
The number of steps at execution can be checked with some dedicated methods. Refer to PLC Development Manual for details.

3

Input/Output Signals

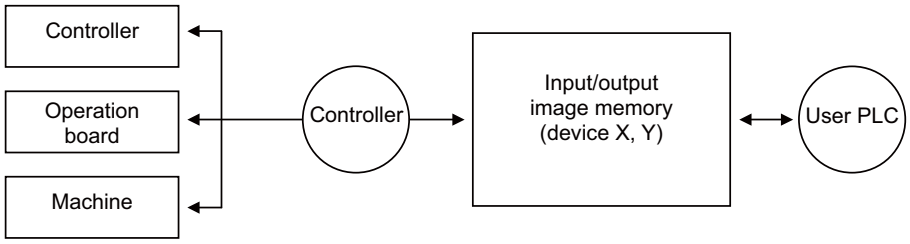
3.1 Input/Output Signal Types and Processing

The input/output signals handled in user PLC are as follows:

(1) Input/output from/to controller
(2) Input/output from/to operation board (Note 1)
(3) Input/output from/to machine

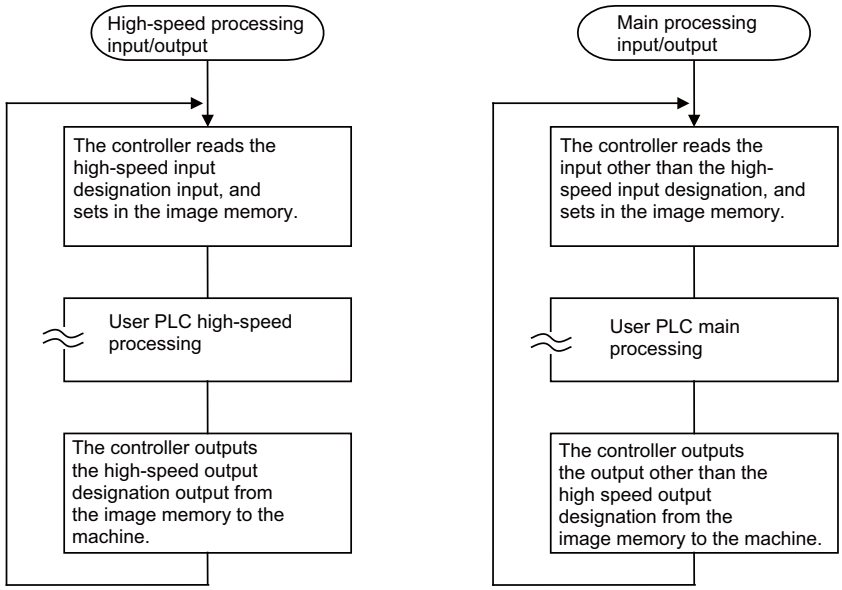
The user PLC does not directly input or output these signals from or to hardware or controller; it inputs or outputs the signals from or to input/output image memory. For the reading and writing with the hardware or controller, the controller will perform the input/output according to the level of the main process or high-speed process.

Concept of input/output processing



(Note 1) The operation board here refers to when the remote I/O is installed on the communication terminal.

Input/output processing conforming to program level



The table below shows whether or not high-speed input/output can be performed.

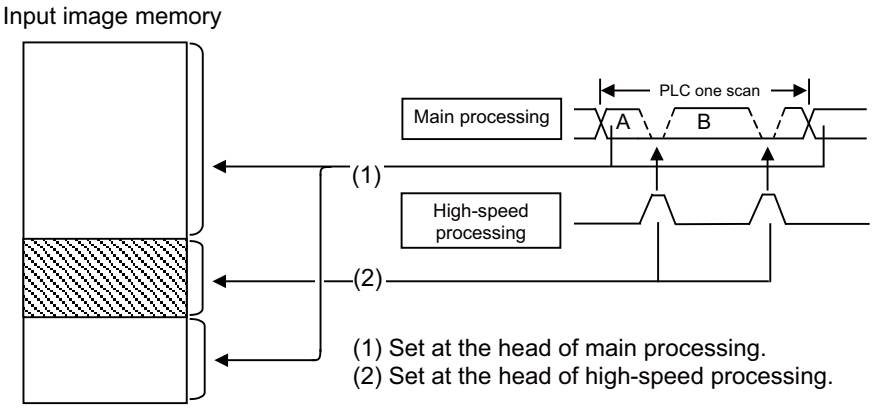
Whether or not high-speed input/output can be performed

	High-speed input specification	High-speed output specification	
Input signal from control unit	x	x	
Output signal to control unit	x	x	
Input signal from machine	o (2-byte units)	x	o : Possible
Output signal to machine	x	o (2-byte units)	x : Not possible
Input signal from operation board	x	x	
Output signal to operation board	x	x	
Input signal from MELSEC when connected to MELSEC	x	x	
Output signal to MELSEC when connected to MELSEC	x	x	

The operation board here refers to when the remote I/O is installed on the communication terminal.

3.2 Handling of Input Signals Designated for High-speed Input

The input/output signals used in user PLC are input/output for each program level as shown in the figure below.
In high-speed processing, input/output signal for which high-speed input or output designation (parameter) is made is input or output each time the high-speed processing program runs. In main processing, signals other than the high-speed input/output designation are input/output.
When high-speed input designation signal is used in main processing, the input signal may change within one scan because high-speed processing whose level is higher than main processing interrupts. Input signal which must not change within one scan should be saved in temporary memory (M), etc., at the head of main processing and the temporary memory should be used in the main program, for example.



The hatched area is high-speed input designation part. Whenever the high-speed processing program runs, data is reset in the hatched area. Thus, the signal in the hatched area may change in main processing (A) and (B) because the high-speed process interrupts between (A) and (B) and re-reads the input signal in the hatched area.

3.3 PLC Device Assignment of Digital Signal (DI/DO)

The input/output signals (analog signal, DI/DO, etc.) are assigned to the PLC devices, and the digital signals (DI/DO) can be assigned to the arbitrary PLC devices by the parameters.
Either "Fixed device assignment" which automatically assigns the signals to fixed PLC devices defined by the system or "Arbitrary device assignment" which user can assign the signals the arbitrary PLC devices by the parameters can be selected by setting the RIO assignment parameter "#53001 RIO dev assign" (selection of RIO device assignment method).

[Fixed Device assignment]: Parameter "#53001 RIO dev assign" is set to "0".
Settings are not required because the assignment to the fixed PLC devices are automatically performed.
Refer to "Fixed Device Assignment" for details.
[Arbitrary Device assignment]: Parameter "#53001 RIO dev assign" is set to "1".
Set the PLC devices which are assigned to the DI/DO of each remote I/O unit station by the parameters.
Refer to "Arbitrary Device Assignment" for details.

3.3.1 Fixed Device Assignment

(1) By setting the parameter "#53001 RIO dev assign" to "0", the PLC device assignment method, which is to be used for input/output of each remote I/O unit station, will be the fixed device assignment.

(2) PLC devices assigned for each remote I/O unit station at the time of the fixed device assignment are as follows:

		Station No.							
Channel No.		1	2	…	8	9	…	63	64
RIO1	Input device	X0000 to X001F	X0020 to X003F	…	X00E0 to X00FF	ZR5000 / ZR5001	…	ZR5108 / ZR5109	ZR5110 / ZR5111
	Output device	Y0000 to Y001F	Y0020 to Y003F	…	Y00E0 to Y00FF	ZR6000 / ZR6001	…	ZR6108 / ZR6109	ZR6110 / ZR6111
RIO2	Input device	X0100 to X011F	X0120 to X013F	…	X01E0 to X01FF	ZR5200 / ZR5201	…	ZR5308 / ZR5309	ZR5310 / ZR5311
	Output device	Y0100 to Y011F	Y0120 to Y013F	…	Y01E0 to Y01FF	ZR6200 / ZR6201	…	ZR6308 /ZR6309	ZR6310 / ZR6311
RIO3	Input device	X0200 to X021F	X0220 to X023F	…	X02E0 to X02FF	ZR5400 / ZR5401	…	ZR5508 / ZR5509	ZR5510 / ZR5511
	Output device	Y0200 to Y021F	Y0220 to Y023F	…	Y02E0 to Y02FF	ZR6400 / ZR6401	…	ZR6508 / ZR6509	ZR6510 / ZR6511

(Note) Do not use the input/output signals of the system-occupied stations of RIO3 and operation panel I/O unit-connected channels.

(3) A part of PLC devices assigned for each station of remote I/O units can input/output signals with PLC high speed by setting the high-speed input/output specification parameters or R registers.
   (a) The devices for inputting/outputting signals with PLC high speed can be set individually for the high-order and the low-order per 16 points for DI and DO of each remote I/O unit station.
   (b) Only devices of the first to eighth stations for each remote I/O channel can input/output signals with PLC high speed. The devices of the ninth to 64th stations input/output with PLC medium speed.
   (c) The parameter and R register numbers for the high-speed input/output designation are as follows:

		Station No.			
Channel No.		1 to 4		5 to 8	
		Parameter No.	R register No.	Parameter No.	R register No.
RIO1	High-speed input specification	# 6457	R7828 low-order	# 6458	R7828 high-order
	High-speed output specification	# 6461	R7830 low-order	# 6462	R7830 high-order
RIO2	High-speed input specification	# 6459	R7829 low-order	# 6460	R7829 high-order
	High-speed output specification	# 6463	R7831 low-order	# 6464	R7831 high-order
RIO3	High-speed input specification	# 6465	R7832 low-order	# 6466	R7832 high-order
	High-speed output specification	# 6473	R7836 low-order	# 6474	R7836 high-order

(Note 1) The above parameters are invalid when the devices have been assigned arbitrarily.
(Note 2) Refer to "High-speed Input/Output Designation Method" for details of the setting method.

High-speed Input/Output Designation Method

High-speed input/output is designated by setting the corresponding bit of the bit selection parameter as shown below.

(1) High-speed input designation

Bit selection parameter	7	6	5	4	3	2	1	0 bit	
#6457	X70 : X7F	X60 : X6F	X50 : X5F	X40 : X4F	X30 : X3F	X20 : X2F	X10 : X1F	X00 : X0F	These bits correspond to the low-order byte (bits 0 to 7) of file register R7828
#6458	XF0 : XFF	XE0 : XEF	XD0 : XDF	XC0 : XCF	XB0 : XBF	XA0 : XAF	X90 : X9F	X80 : X8F	These bits correspond to the high-order byte (bits 8 to F) of file register R7828

If there are multiple remote I/O connection channels, designate RIO2 with the same configuration as RIO1 above.

RIO2 : Designate X100 to X1FF with bit selection parameters #6459 and #6460

RIO3 : Designate X200 to X2FF with bit selection parameters #6465 and #6466

(2) High-speed output designation

Bit selection parameter	7	6	5	4	3	2	1	0 bit	
#6461	Y70 : Y7F	Y60 : Y6F	Y50 : Y5F	Y40 : Y4F	Y30 : Y3F	Y20 : Y2F	Y10 : Y1F	Y00 : Y0F	These bits correspond to the low-order byte (bits 0 to 7) of file register R7830
#6462	YF0 : YFF	YE0 : YEF	YD0 : YDF	YC0 : YCF	YB0 : YBF	YA0 : YAF	Y90 : Y9F	Y80 : Y8F	These bits correspond to the high-order byte (bits 8 to F) of file register R7830

If there are multiple remote I/O connection channels, designate RIO2 with the same configuration as RIO1 above.

RIO2 : Designate Y100 to Y1FF with bit selection parameters #6463 and #6464

RIO3 : Designate Y200 to Y2FF with bit selection parameters #6473 and #6474

- As listed above, one bit corresponds to two bytes (16 points).
- Input or output in which 1 is set in the table is not performed at the main processing program level.
- Although the number of bits set to 1 is not limited, set only necessary ones from viewpoint of overhead.
- High-speed input/output designation corresponds to the bit selection parameter and can be set in the parameter. However, it is recommended to set in a sequence program to prevent a parameter setting error, etc.

(Example) ⊣[MOV H3 R7828]⊢ ..... To designate X00 to X0F, X10 to X1F (bit 0 and 1 for H3)

3.3.2 Arbitrary Device Assignment

Parameter setting for device arbitrary assignment

(1) By setting the parameter "#53001 RIO dev assign" to "1", the assignment method for PLC devices to be used for input/output of each remote I/O unit station becomes arbitrary device assignment.

(2) For arbitrary device assignment, set the PLC devices for input and output to DI/DO (32 points) of each remote I/O unit station by the parameters. Also, set the assignment of the operation panel I/O unit.

(3) Turn the power OFF and ON to enable arbitrary device assignment after the parameter settings.

(4) Set the input/output device assignment and high-speed input/output specification by the parameters for each station of all remote units which have DI/DO function (except safety DI/DO). If all stations have not been set, the alarm "Y05 Initial parameter error" will be issued when the power turns ON.

	Parameter set No. (Note 1)								
Name	#1	…	#64	#65	…	#128	#129	…	#182
Target channel No. #n	#53011	…	#53641	#53651	…	#54281	#54291	…	#54821
Target station No. #n (Note 2)	#53012	…	#53642	#53652	…	#54282	#54292	…	#54822
DI device name #n	#53013	…	#53643	#53653	…	#54283	#54293	…	#54823
DI device No. #n	#53014	…	#53644	#53654	…	#54284	#54294	…	#54824
DO device name #n	#53015	…	#53645	#53655	…	#54285	#54295	…	#54825
DO device No. #n	#53016	…	#53646	#53656	…	#54286	#54296	…	#54826
High-speed input specification #n	#53017	…	#53647	#53657	…	#54287	#54297	…	#54827
High-speed output specification #n	#53018	…	#53648	#53658	…	#54288	#54298	…	#54828

(Note 1) A set of RIO assignment parameters consists of eight parameters (from target channel number to high-speed output specification) for one station.

(Note 2) Arbitrary device assignment cannot be performed for the system-occupied stations of RIO3 and operation panel I/O unit-connected channels.

(5) The PLC devices that are valid for arbitrary device assignment are as follows:

PLC device	Word/Bit	Input	Output	Assignable range	PLC device No. format
X	Bit	○	-	X0000 to X05FF However, X400 to X5FF is invalid when PROFIBUS specification is added.	Hexadecimal
Y	Bit	-	○	Y0000 to Y05FF However, Y400 to Y5FF is invalid when PROFIBUS specification is added.	Hexadecimal
ZR	Word	○	○	ZR5000 to ZR5999 (for input)	Decimal
				ZR6000 to ZR6999 (for output)	

(Note 1) Duplication check is not performed between the PLC devices which are set with machine input/output signal other than the remote I/O such as CC-Link or PROFIBUS and PLC devices which are set with arbitrary device assignment. If the PLC devices have duplicated, NC or PLC ladder can not be carried out correctly. When using machine input/output signal other than the remote I/O, make sure to confirm that the PLC devices do not duplicate the PLC devices set with arbitrary device assignment.

(Note 2) Assignment cannot be performed for the devices corresponding to the system-occupied stations of RIO3. If you connect the operation panel to any channel other than RIO3, assignment is also disabled for the devices corresponding to the system-occupied stations of the said channel.

(6) Even when the RIO assignment parameters are set in the remote I/O unit stations which have the analog input/output and safety DI/DO functions, the input/output is not carried out to the set PLC devices.

(7) Up to 24 stations can be specified for high-speed input/output specification each for input and output. If 25 or more stations are specified, the alarm "Y05 Initial parameter error" will be issued.

(8) High-speed input/output specification can be set by R registers below as well as the RIO assignment parameters.

		Station No.							
Channel No.		1 to 8	9 to 16	17 to 24	25 to 32	33 to 40	41 to 48	49 to 56	57 to 64
RIO1	High-speed input specification	R30544 low-order	R30544 high-order	R30545 low-order	R30545 high-order	R30546 low-order	R30546 high-order	R30547 low-order	R30547 high-order
	High-speed output specification	R30560 low-order	R30560 high-order	R30561 low-order	R30561 high-order	R30562 low-order	R30562 high-order	R30563 low-order	R30563 high-order
RIO2	High-speed input specification	R30548 low-order	R30548 high-order	R30549 low-order	R30549 high-order	R30550 low-order	R30550 high-order	R30551 low-order	R30551 high-order
	High-speed output specification	R30564 low-order	R30564 high-order	R30565 low-order	R30565 high-order	R30566 low-order	R30566 high-order	R30567 low-order	R30567 high-order
RIO3	High-speed input specification	R30552 low-order	R30552 high-order	R30553 low-order	R30553 high-order	R30554 low-order	R30554 high-order	R30555 low-order	R30555 high-order
	High-speed output specification	R30568 low-order	R30568 high-order	R30569 low-order	R30569 high-order	R30570 low-order	R30570 high-order	R30571 low-order	R30571 high-order

(Note 1) Turn the power OFF and ON after the R register settings to enable the settings.
(Note 2) One bit of each R register is equivalent to one station. The high-speed input/output specification can be performed by turning ON the R register bits of the stations to be input or output with PC high speed. To output the 10th station of RIO1 at high speed, for instance, turn bit9 of R30544 ON.
(Note 3) High-speed input/output designation is disabled for the system-occupied stations of RIO3 and operation panel I/O unit-connected channels. Even when the bit6 to bitD of R30552 and R30568 are turned ON, they will be invalid.
(Note 4) The above settings are invalid with fixed device assignment.

(9) In the following cases, the alarm "Y05 Initial parameter error" will be issued when the power is turned ON. The number of the RIO assignment parameter with illegal setting state will be displayed.
(a) The value outside the range of setting has been set to the RIO assignment parameter (except "#53001 RIO dev assign").
(b) Two or more stations of the target channel No. and the target station No. are set redundantly to the RIO assignment parameters.
(Example)
The power is turned ON in a state where the 1st and 2nd station of RIO1 are set redundantly to the RIO assignment parameter #1 to #5 as shown in the table below. (Both the 1st and 2nd stations are connected to NC control unit.)

Parameter set No.#n	Target channel No. #n (parameter No.)	Target station No. #n (parameter No.)	Setting state
1	1 (#53011)	0 (#53012)	RIO1 1st station is set
2	1 (#53021)	1 (#53022)	RIO1 2nd station is set
3	1 (#53031)	1 (#53032)	RIO1 2nd station is set
4	1 (#53041)	0 (#53042)	RIO1 1st station is set
5	1 (#53051)	0 (#53052)	RIO1 1st station is set

Result:
The parameter number (53031) of "Target channel #3" will be displayed on the alarm "Y05 Initial parameter error". Duplication error of RIO1 second station will be detected first because the RIO assignment parameter is checked from the top. Between the parameter set #2 and #3 to which second station of RIO1 are set, parameter set #3 which is the latter will be displayed as the alarm.
(c) A PLC device outside the assignable range has been set to the RIO assignment parameter.
(d) 25 or more stations have been specified with the high-speed input or output with the RIO assignment parameters.

(e) The RIO assignment parameters have not been specified to the remote I/O unit stations with DI/DO functions (except safety DI/DO) that are connected to NC.

(f) Two or more stations of the PLC devices are set redundantly to the RIO assignment parameters.

(Note) However, these (a) to (f) will not be issued with the alarm "Y05 Initial parameter error" in the following cases:

- "0" has been set to the target channel.
- Remote I/O unit with DI/DO function are not connected to the station which has been specified with the target channel and station number.
- The parameter "#1238 set10/bit3" is ON (the input from RIO is ignored).

(Example)

The power is turned ON in a state where the X100 and X200 of PLC device are set redundantly to the RIO assignment parameter #1 to #5 as shown in the table below. (All stations which has been set to the RIO assignment parameters #1 to #5 are connected to NC control unit.)

Parameter set No. #n	DI device name #n (parameter No.)	DI device No. #n (parameter No.)	Setting state
1	X (#53013)	100 (#53014)	X100 is set
2	X (#53023)	200 (#53024)	X200 is set
3	X (#53033)	200 (#53034)	X200 is set
4	X (#53043)	100 (#53044)	X100 is set
5	X (#53053)	100 (#53054)	X100 is set

Result:

The parameter number (53034) of "DI device No. #3" will be displayed on the alarm "Y05 Initial parameter error". Duplication error of X200 will be detected first because the RIO assignment parameter is checked from the top. Between the parameter set #2 and #3 to which the X200 are set, parameter set #3 which is the latter will be displayed as the alarm.

Operating parameter setting screen

(1) RIO assignment parameter setting rule

(a) For arbitrary device assignment, assign PLC devices to all stations which are connected to the remote units with DI/DO function. Devices can be assigned in random order for arbitrary device assignment. It is unnecessary to assign in order of the target channels, target station numbers, PLC devices, etc.

(b) Set the PLC device numbers after setting the PLC device names. A setting error occurs if PLC number is input when the PLC device name is in the unset (blank) state. When a PLC device name is changed, PLC device number of the same parameter set number is cleared to zero.

(c) When setting the bit devices, set the DI and DO device numbers in increments of 32 points. A setting error occurs if device number is not a multiple of 32 (20 for hexadecimal).

(d) When setting the word devices, set the DI and DO device numbers in increments of two words (32 bits). A setting error occurs if the device number is odd.

(e) Set the target channels to "0" for the parameter sets which are not set for device assignment. The setting state of the parameter sets to which "0" has been set for the target channel will not be checked.

(f) The RIO assignment parameter setting values are retained even when the fixed device assignment and arbitrary device assignment are switched.

(2) RIO assignment parameter setting state check

(a) The RIO assignment parameter setting state can be checked without rebooting the power by setting the RIO assignment parameter "Device Setting Check" to "1" when performing the arbitrary device assignment. The RIO assignment parameter setting state will not be checked at the fixed device assignment.

(b) The RIO assignment parameter settings cannot be valid only by inputting "1" to "Device Setting Check". To enable the arbitrary device assignment, turn the power OFF and ON after the RIO assignment parameter settings.

(c) The value of "Device Setting Check" goes back to "0" after the check for the RIO parameter setting state is completed.

(d) The RIO assignment parameter setting state of each remote I/O unit station with the analog input/output and safety DI/DO functions will not be checked.

(e) The setting state of the parameter set which has been set as the station unconnected to the NC control unit will not be checked.

(f) The setting state of the parameter sets of which the target channel number has been set to "0" will not be checked.

4

Explanation of Devices

4.1 Devices and Device No.

When the switch from the single project to the multi-project is carried out, the number of device points that is used per project will be fewer according to the maximum project No.
Refer to "Device Range Setting at Multi-project" for the details of device range when the multi-project is enabled.
The devices are address symbols to identify signals handled in PLC. The device Nos. are serial Nos. assigned to the devices. The device Nos. of devices X, Y, SB, B, SW, W and H are represented in hexadecimal notation. The device numbers of other devices are represented in decimal notation.

4.2 List of Devices

The device range in the following table is the default number of device points set in the project 1 when the multi-project setting or the setting of the number of device points is not performed.

[M8]

Device	Device No.	Unit	Details
X*	X0 to X1FFF (8192 points)	1 bit	Input signal to PLC, Machine input, etc.
Y*	Y0 to Y1FFF (8192 points)	1 bit	Output signal from PLC, Machine output, etc.
M	M0 to M61439 (61440 points)	1 bit	Temporary memory
F	F0 to F2047 (2048 points)	1 bit	Temporary memory (Alarm message interface)
L	L0 to L1023 (1024 points)	1 bit	Latch relay (back up memory)
SM	SM0 to SM2047 (2048 points)	1 bit	Special relay
V	V0 to V511 (512 points)	1 bit	Edge relay
SB	SB0 to SB3FF (1024 points)	1 bit	Special relay
B	B0 to BDFFF (57344 points)	1 bit	Link relay
SW	SW0 to SW3FF (1024 points)	16 bits	Special register
SD	SD0 to SD2047 (2048 points)	16 bits	Special register
T	T0 to T2047 (2048 points)	1 bit/16 bits	Timer (The variable/fixed boundary is set with a parameter.) (Note 2)
ST	ST0 to ST127 (128 points)	1 bit/16 bits	Integrated timer (100ms unit)
C	C0 to C511 (512 points)	1 bit/16 bits	Counter (The variable/fixed boundary is set with a parameter.)
D	D0 to D4095 (4096 points)	16 bits/32 bits	Data register (Register for calculation)
R*	R0 to R32767 (32768 points)	16 bits/32 bits	File register (CNC word interface)
ZR*	ZR0 to ZR13311 (13312 points)	16 bits/32 bits	File register (Input/output signals with the PLC, Machine input/output, etc.)
W	W0 to W2FFF (12288 points)	16 bits/32 bits	Link register
Z	Z0 to Z13 (14 points)	16 bits	Address index
N	N0 to N7 (8 points)	-	Master controller nesting level
P*	P0 to P4095 (4096 points)	-	Label for conditional jump, subroutine call command
K	K-32768 to K32767	-	Decimal constant for 16-bit command
	K-2147483648 to K2147483647	-	Decimal constant for 32-bit command
H	H0 to HFFFF	-	Hexadecimal constant for 16-bit command
	H0 to HFFFFFFFF	-	Hexadecimal constant for 32-bit command

(Note 1) Devices marked with "*" in the device column have designated applications. Do not use devices other than those corresponding to the input/output signals with the machine side (input/output signals of the remote I/O unit), even if it is an undefined vacant device.

(Note 2) Distinction of 10ms timer and 100ms timer is performed by command.
(10ms timer is performed by OUTH command, 100ms timer is performed by OUT command.)

4.3 Device Range Setting at Multi-project

Each device will be categorized to either the common device among projects (common device among projects) or the independent device for each projects (independent device among projects) when using the multi-project function.

(a) Common device among projects
Device is influenced by the access from the multiple projects.
The number of device points is fixed without being affected by the number of projects.
For example, the X/ Y/ R devices are common devices among projects.

(b) Independent device among projects
Device can be used independently in the multiple projects.
In addition, Independent device among projects are categorized into variable points or fixed points device.
- Independent device among projects (Fixed points)
  The number of device points is fixed without being affected by the number of projects.
  For example, the SM/ SD/ Z devices are independent devices among projects (fixed points)
- Independent device among projects (Variable points)
  The maximum number of project*1 is allocated to each project and used.
  For example, the M/ L/ SB devices are independent devices among projects (variable points)
  *1 Refer to "Independent Device among Projects" for the details of maximum number of projects.

The list of device categories is as follows.

(1) Category explanation

Category	Details
Common	Common device among projects
Independent (fixed)	Independent device among projects (fixed points)
Independent (variable)	Independent device among projects (variable points)
Common/independent	Independent device among projects (variable points) However, it is possible to set as the common device among projects from the top. (Refer to "M Device/D Device Commonizing Setting")

(2) List of categories

Device	Category	Number of device points (Maximum number of projects)
X	Common	8192 points
Y	Common	8192 points
M	Common/Independent	61440 points (122880 points)
L	Independent(Variable)	1024 points (2048 points)
F	Common	2048 points
SB	Independent(Variable)	1024 points (2048 points)
B	Independent(Variable)	57344 points (114688 points)
SM	Independent(Fixed)	2048 points
V	Independent(Variable)	256 points (1024 points)
SW	Independent(Variable)	1024 points (2048 points)
SD	Independent(Fixed)	2048 points
T	Independent(Variable)	2048 points (4096 points)
ST	Independent(Variable)	128 points (256 points)
C	Independent(Variable)	512 points (1024 points)
D	Common/Independent	4096 points (8192 points)
R	Common	32768 points
ZR	Common	13312 points
W	Independent(Variable)	12288 points (24576 points)
Z	Independent(Fixed)	14 points
N	Independent(Fixed)	15 points
P	Independent(Fixed)	4096 points

* When the additional specification of "Number of PLC projects: 6" is valid, the number of device points in "( )" (parentheses) becomes valid.

From here on, the independent device among projects and the common device among projects will be described.

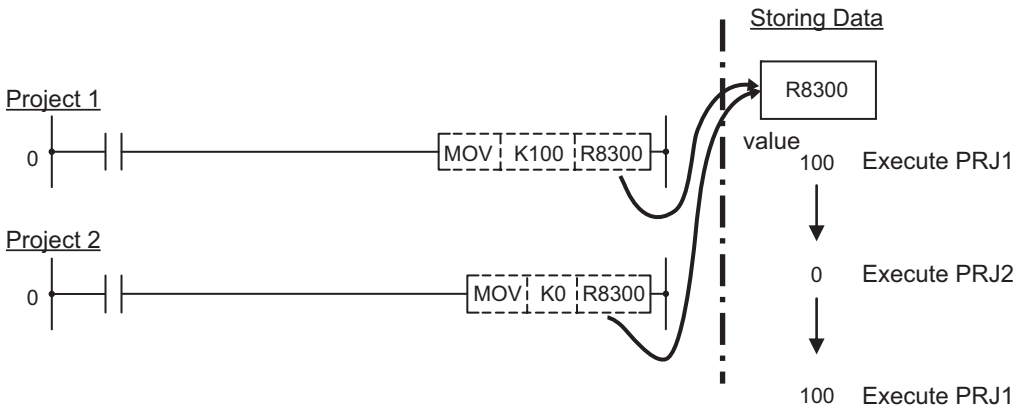
4.3.1 Common Device Among Projects

Devices written below are the ones that are common among projects.
The number of points below can be used from each project without being affected by the number of projects.

Device	Device range	
X	X0 to X1FFF	8192 points
Y	Y0 to Y1FFF	8192 points
F	F0 to F2047	2048 points
R	R0 to R32767	32768 points
ZR	ZR0 to ZR13311	13312 points

(Note) The above devices will not have the independent access for each project.
Therefore, it will be affected by the access from multiple projects.

(Ex.) Write value to R8300 from Project 1 & 2

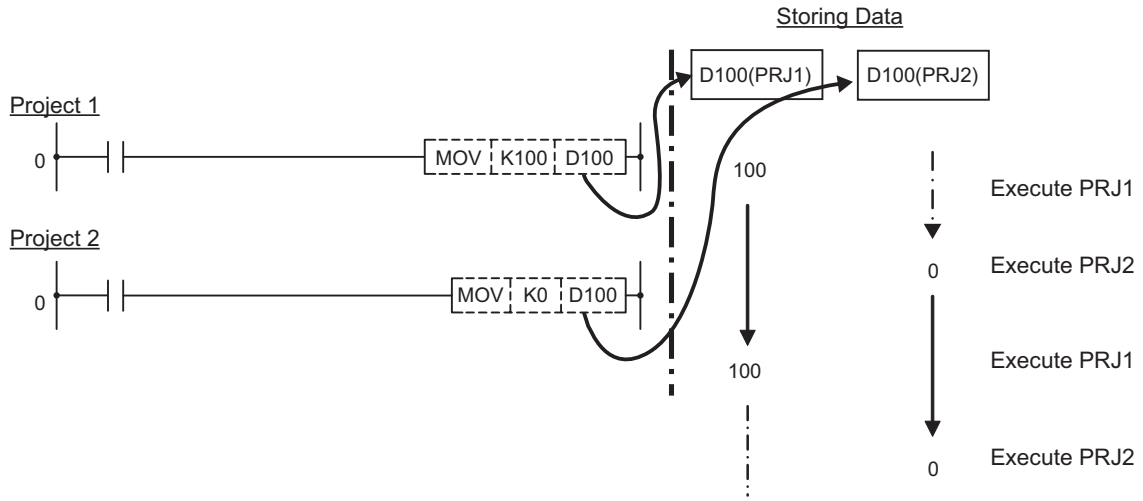


When the multiple projects use a device of the same device number, the output to the device of the project which was executed last will be valid. Consider the execution order of projects thoroughly.

4.3.2 Independent Device Among Projects

These following devices are independent for each project. Therefore, the access among projects will not affect the devices.

(Ex.) Write value to D100 from Project 1 & 2



(1) Independent device among projects (Fixed)
Devices written below are the ones that are independent among projects.
The number of points below can be used from each project without being affected by the number of projects.

Device	Device range	
SM	SM0 to SM2047	2048 points
SD	SD0 to SD2047	2048 points
Z	Z0 to Z13	14 points
N	N0 to N14	15 points
P	P0 to P4095	4096 points

(2) Independent device among projects (Variable)
Devices written below are the ones that are independent among projects.
The points below (maximum number of project) are allocated to each project and used.
Assignment of points to each project is carried out by built-in PLC (built-in edit function).
Refer to "Bit Selection Parameters: Multi-project Setting Parameter (Device Setting)".

Device	Maximum number of projects
M	61440 points (122880 points)
L	1024 points (2048 points)
SB	1024 points (2048 points)
B	57344 points (114688 points)
V	256 points (1024 points)
SW	1024 points (2048 points)
T	2048 points (4096 points)
ST	128 points (256 points)
C	512 points (1024 points)
D	4096 points (8192 points)
W	12288 points (24576 points)

* When the additional specification of "Number of PLC projects: 6" is valid, the number of device points in "( )" (parentheses) becomes valid.

4.3.3 M Device/D Device Commonizing Setting

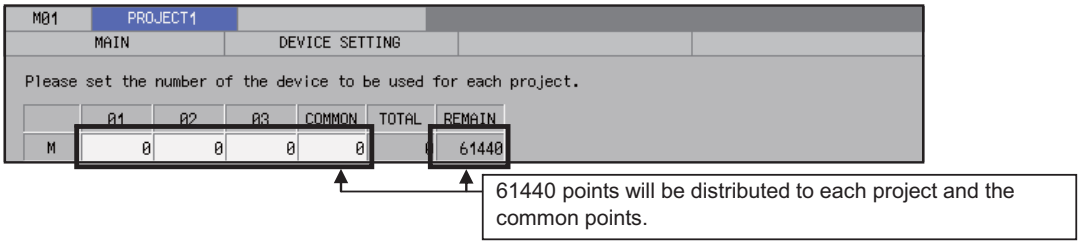
When using the multi-project function, the arbitrary number of points from the head of M device/ D device can be set as the common device among projects. When the commonizing setting is carried out, the amount of points set by the user from the head of device (M0/D0) will be the device (common device) that can be commonly accessed from each project. Other devices will be the ones that are independent among the projects (independent device). The device commonizing setting can be set from the built-in PLC (built-in edit function). (Refer to "Bit Selection Parameters: Multi-project Setting Parameter (Device Setting)")

[Example of setting procedure]

Maximum project No3; M device 10240 points are commonized; remaining points are allocated to each project as independent points.

(Preparation) Confirm the maximum project points

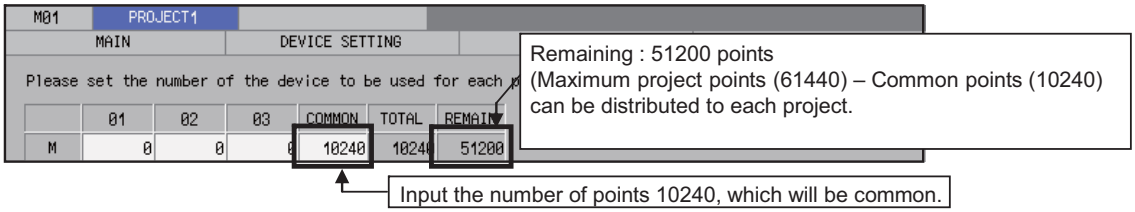
Set "0" to each project and the common points to confirm the maximum allocable number.



(Procedure 1) Setting the common points

Input the number of points "10240" to the common points among projects.

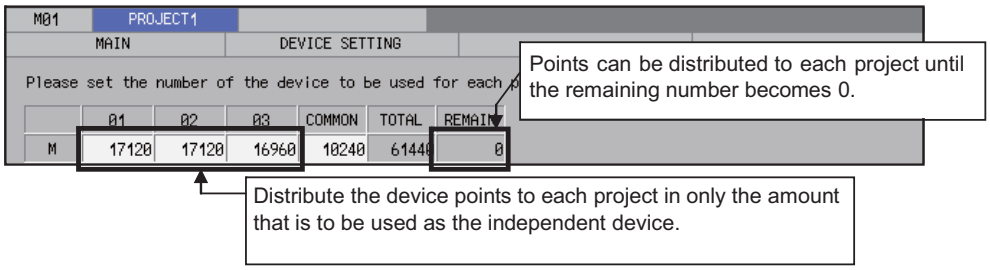
After the input of points, the total number and the remaining number will be updated.



Remaining 51200 points are distributed to each project, only by the amount of points which are used as independent devices.

(Procedure 2) Distribute the remaining points to the independent points.

After the input of the points to each project, the total number and the remaining number will be updated.



(Procedure 3) Reboot the power of CNC

When the setting is carried out as the example shown above, the device range will be as the table shown below.

	Device points	Device range	
		Common M Device	Independent M Device
Project 1	27360 points	M0 to M10239	M10240 to M27359
Project 2	27360 points		M10240 to M27359
Project 3	27200 points		M10240 to M27199

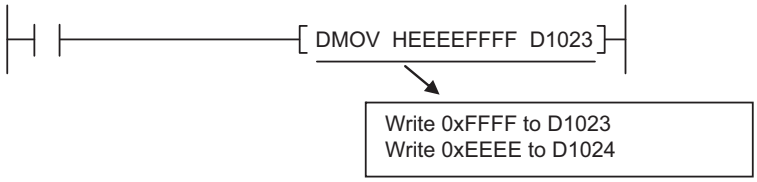
(Note 1) Set "total number of points set to each project + number of projects common points" to fit into the maximum project points. If the CNC is rebooted while the setting value is exceeding the maximum project points, the user PLC alarm 58 will be issued. RUN will not be carried out.

(Note 2) The access check across the common device and the independent device will not be carried out from each PLC instruction. Do not carry out the access across the devices.
If access is carried out across, the device value of the project 1 will be acquired/ changed.

Ex.) In the case where the maximum project No.3; D device points that can be used at each projects are as shown in the table below.

	Project 1	Project 2	Project 3	Project common points	Project maximum points
D device points	1024 points	1024 points	1024 points	1024 points	4096 points

When the below ladder is written to the Project 2 and RUN is carried out, 0xFFFF will be written to D1023 which is common among projects, and the 0xEEEE will be written to D1024 of Project 1.



4.4 Detailed Explanation of Devices

4.4.1 Input/Output X, Y

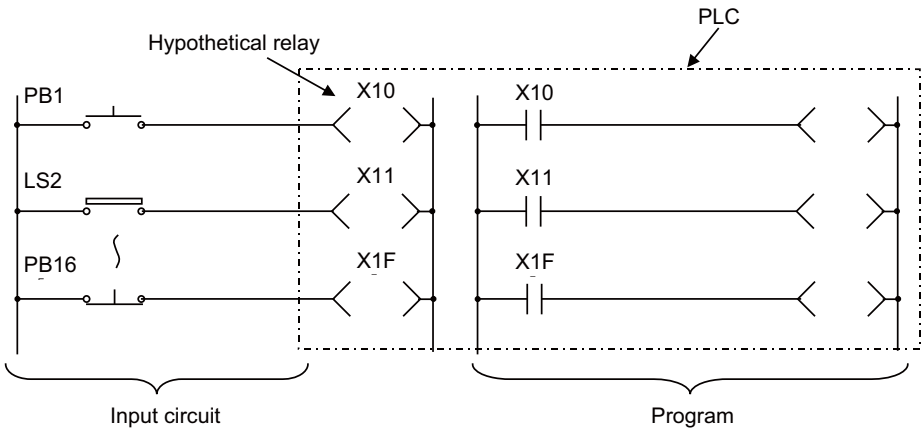
Input/output X and Y are windows for executing communication with the PLC and external device or controller.

Input X

(a)This issued commands or data from an external device such as a push-button, changeover switch, limit switch or digital switch to the PLC.

(b)Assuming that there is a hypothetical relay Xn built-in the PLC per input point, the program uses the "A" contact and "B" contact of that Xn.

(c)There is no limit to the number of "A" contacts and "B" contacts of the input Xn that can be used in the program.



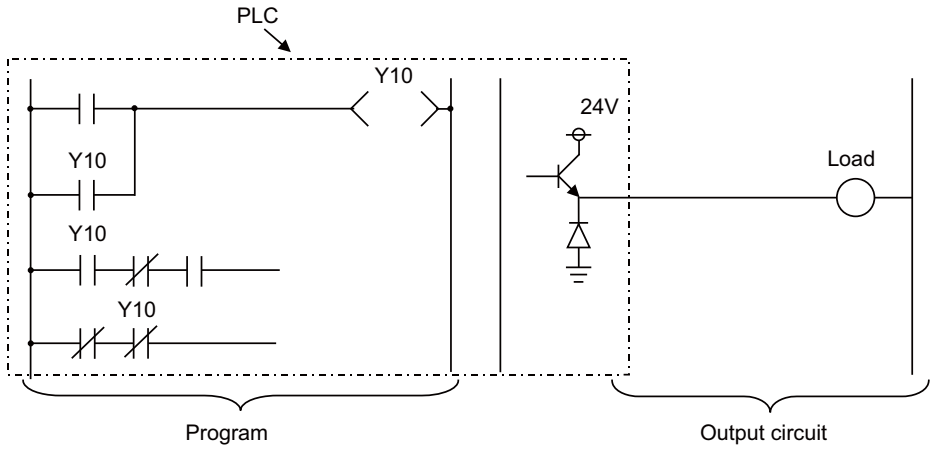
(d)The input No. is expressed with a hexadecimal.

Output Y

(a)This outputs the results of the program control to the solenoid, magnetic switch, signal lamp or digital indicator, etc.

(b)The output (Y) can be retrieved with the equivalent of one "A" contact.

(c)There is no limit to the number of "A" contacts and "B" contacts of the output Yn that can be used in the program.



(d)The output No. is expressed with a hexadecimal.

4.4.2 Internal Relays M and F, Latch Relay L

The internal relay and latch relay are auxiliary relays in the PLC that cannot directly output to an external source.

Internal relay M	
(a)The relay is cleared when the power is turned OFF. (b)There is no limit to the number of "A" contacts and "B" contacts of the internal relays that can be used in the program. (c)The internal relay No. is expressed with a decimal.	

Internal relay F	
Internal relay F is an interface for the alarm message display. Use the bit selection parameter to determine whether to use this relay for the alarm message interface. The target will be all F0 to F1023. This internal relay can be used in the same manner as the internal relay M when not used as the alarm message interface.	

Latch relay L	
(a)The original state is held even when the power is turned OFF. (b)There is no limit to the number of "A" contacts and "B" contacts of the latch relay that can be used in the program. (c)The latch No. is expressed with a decimal.	

4.4.3 Special Relay for Link (SB), Special Register for Link (SW)

Special relay for link (SB)	
(a)This interacts between various kinds of network cards and PLC programs. (b)ON/OFF control is applied due to various factors occurred at the time of data link. By monitoring the special relay for link, abnormal state of data link can be detected.	

Special register for link (SW)	
(a)This interacts between various kinds of network cards and PLC programs. (b)Information at the time of data link is stored. By monitoring the special register for link, abnormal area and the cause can be examined.	

4.4.4 Link Relay B, Link Register W

(1) Link relay B is the bit type device that performs data link with various link functions.
Unused area can be used as the temporary memory, etc.

(2) Link register W is the word type device that performs data link with various link functions.
Unused area can be used as the temporary memory, etc.

Link relay B, link register W	
(a)This relay is cleared when the power is turned OFF. (b)There is no limit in the number that can be used in the program. (c)The relay and register No. are expressed with a hexadecimal.	

4.4.5 Special Relay SM, Special Register SD

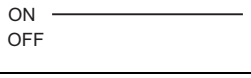
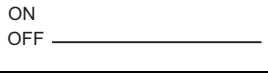
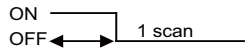
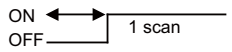
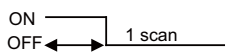
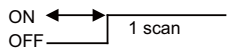
(1) Special relay is the relay whose application is fixed. (i.e. Carry flag of operation result, display request signal to the setting display device, etc.) Do not use the currently unused area from SM0 to SM2047 as the temporary memory.

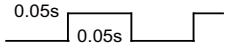
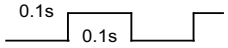
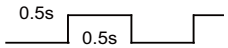
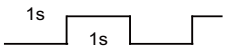
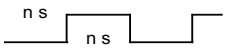
(2) Special register SD is the data register whose application is fixed. (i.e. 1-second counter) Do not use the currently unused area from SD0 to SD2047 as the temporary memory.

Link relay B, link register W	
(a) This relay is cleared when the power is turned OFF. (b) There is no limit in the number that can be used in the program. (c) The relay and register No. are expressed with a decimal.	

(3) Some of the main relays and registers whose applications are fixed are listed below.

Special Relay

Device	Name	Operation	Operation details	Setting side (Set time)
SM0	PLC error	OFF: No error ON: Error	- Turned ON when the PLC alarm (illegal PLC) has occurred. Reset is done by STOP → RUN.	System side（Error）
SM12	Carry flag	OFF: Carry OFF ON: Carry ON	Carry flag used during function instruction.	System side (State change)
SM16	H/W alarm (Temperature rise detection)	OFF: No error ON: Error	Used in some machine types. Refer to "PLC Interface Manual", etc. for details.	System side (State change)
SM17	H/W alarm (DIO 24V illegal)			
SM18	H/W alarm (Power supply error)			
SM64	ATC display request flag	Refer to PLC I/F Manual, etc. for details.	Used in some machine types. Refer to "PLC Interface Manual", etc. for details.	System side (State change)
SM65	Tool life management setting lock			
SM70	Key I/F related			
SM71	In ATC rotation			
SM400	Always ON		- Always ON	System side (Every time END)
SM401	Always OFF		- Always OFF	System side (Every time END)
SM402	After RUN, turned ON by only 1 scan (Medium-speed ladder)		- After RUN, turned ON by only 1 scan. - OFF during STOP. This contact can be used only in the medium-speed ladder.	System side (Every time END)
SM403	After RUN, turned OFF by only 1 scan (Medium-speed ladder)		- After RUN, turned OFF by only 1 scan. - OFF during STOP. This contact can be used only in the medium-speed ladder.	System side (Every time END)
SM404	After RUN, turned ON by only 1 scan (High-speed ladder)		- After RUN, turned ON by only 1 scan. - OFF during STOP. This contact can be used only in the high-speed ladder.	System side (Every time END)
SM405	After RUN, turned OFF by only 1 scan (High-speed ladder)		- After RUN, turned OFF by only 1 scan. - OFF during STOP. This contact can be used only in the high-speed.	System side (Every time END)

Device	Name	Operation	Operation details	Setting side (Set time)
SM410	0.1-second clock		- ON/OFF is repeated by the specified second. - Starts from OFF when the power is turned ON. - The clock operation is continued even in STOP. - Note that the ON-OFF status changes when the designated time has elapsed during the execution of the medium speed ladder.	System side (At high speed ladder processing) *1
SM411	0.2-second clock			
SM412	1-second clock			
SM413	2-second clock			
SM414	2n-second clock		- ON/OFF is repeated according to the second specified with SD414. - Starts from OFF when the power is turned ON. - The clock operation is continued even in STOP. - If SD414 is 0 or smaller value, operates at n=30. - Note that the ON-OFF status changes when the designated time has elapsed during the execution of the medium speed ladder.	System side (At high speed ladder processing) *1

*1: Processing cycle of the high-speed ladder (sequence program) depends on the machine type.

Special Register

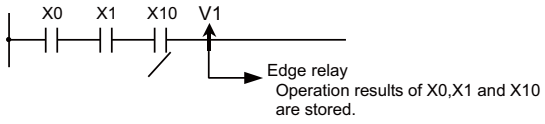
Device	Name	Operation	Operation details	Setting side (Set time)
SD0	PLC error No.	PLC error No.	- Error No. is stored when PLC alarm (illegal PLC) occurs. 0 is set when normal. The error No. is cleared to 0 when executing PLC RUN next time. *1	System side (Error)
SD1	Time of PLC error occurrence	Time of occurrence (Year, month)	- Year (last 2 digits) and moth when SD0 data was updated is stored as the BCD 2-digit code. Upper 8 bits (B15-B8): Year (0-99) Lower 8 bits (B7-B0): Month (1-12)	System side (Error)
SD2		Time of occurrence (Day, hour)	- The day and hour when SD0 data was updated is stored as BCD 2-digit code. Upper 8 bits (B15-B8): Day of month (1-31) Lower 8 bits (B7-B0): Hour (0-23)	
SD3		Time of occurrence (Minute, second)	- The minute and second when SD0 data was updated is stored as BCD 2-digit code. Upper 8 bits (B15-B8): Minute (0-59) Lower 8 bits (B7-B0): Second (0-59)	
SD203	PLC operating status	PLC operating status	Operating status of PLC is stored. During RUN: 0, During STOP: 2	System side (Device read)
SD220	PLC error character string	Character string (15th/16th character)	- A message character string that is equivalent to an error No. is stored when PLC alarm (illegal PLC) occurs. (Diagnosis message displayed on the PLC diagnosis screen.) 0 is set when normal. The message character string is cleared to 0 when executing PLC RUN next time. *1	System side (State change)
SD221		Character string (13th/14th character)		
:		:		
SD226		Character string (3rd/4th character)		
SD227		Character string (1st/2nd character)		

*1: Refer to "List of PLC Alarms" in PLC Development Manual for the details.

Device	Name	Operation	Operation details	Setting side (Set time)
SD290	Device allocation (Same as parameter contents)	Number of points allocated for X	- Stores the number of points currently set for each device (Note that number of allocated points does not always equal to the usable number of points.) SD290: Number of points allocated for X SD291: Number of points allocated for Y SD292: Number of points allocated for M SD293: Number of points allocated for L SD294: Number of points allocated for B SD295: Number of points allocated for F SD296: Number of points allocated for SB SD297: Number of points allocated for V SD298: Number of points allocated for S SD299: Number of points allocated for T SD300: Number of points allocated for ST SD301: Number of points allocated for C SD302: Number of points allocated for D SD303: Number of points allocated for W SD304: Number of points allocated for SW	System side (Initial)
SD291		Number of points allocated for Y		
SD292		Number of points allocated for M		
:		:		
SD302		Number of points allocated for D		
SD303		Number of points allocated for W		
SD304		Number of points allocated for SW		
SD412	1-second counter	Count Nos. of 1 second unit	- After RUN, +1 is added every second of the medium speed ladder. - Count is repeated as follows. 0 → 32767 → -32768 → 0 (decimal) 0 → FFFF → 0 (hexadecimal)	System side (At high speed ladder processing) *1
SD414	2n-second clock set	2n-second clock unit	- Stores the n of 2n-second clock (SM414). (Default value: 30) The setting range is from 1 to 32767.	User side
SD420	Scan counter (Medium-speed ladder)	Count Nos. by 1 scan	- After RUN, +1 is added every 1 scan of the medium speed ladder. - Count is repeated as follows. 0 → 32767 → -32768 → 0 (decimal) 0 → FFFF → 0 (hexadecimal)	System side (Every time END)
SD430	Scan counter (High-speed ladder)	Count Nos. by 1 scan	- After RUN, +1 is added every 1 scan of the high speed ladder. - Count is repeated as follows. 0 → 32767 → -32768 → 0 (decimal) 0 → FFFF → 0 (hexadecimal)	System side (Every time END)
SD520	Current scan time (Medium-speed ladder)	Current scan time (1ms unit)	- Stores the medium speed ladder current scan time in SD520 and SD521. (1ms unit is used for measurement) SD520: ms value is stored (Storage range: 0 to 14000) SD521: μs value is stored (Storage range: 0 to 999) (Example) When the current scan time is 23.6ms, it is stored as follows. SD520=23, SD521=600	System side (Every time END)
SD521	Current scan time (Medium-speed ladder)	Current scan time (1μs unit)		
SD524	Minimum scan time (Medium-speed ladder)	Minimum scan time (1ms unit)	- Stores the minimum value of the medium speed ladder scan time in SD524 and SD525. (1ms unit is used for measurement; 2nd scan and after is the target after RUN.) SD524: ms value is stored (Storage range: 0 to 14000) SD525: μs value is stored (Storage range: 0 to 999)	System side (Every time END)
SD525	Minimum scan time (Medium-speed ladder)	Minimum scan time (1μs unit)		
SD526	Maximum scan time (Medium-speed ladder)	Maximum scan time (1ms unit)	- Stores the maximum value of medium speed ladder scan time in SD526 and SD527. (1ms unit is used for measurement; 2nd scan and after is the target after RUN.) SD526: ms value is stored (Storage range: 0 to 14000) SD527: μs value is stored (Storage range: 0 to 999)	System side (Every time END)
SD527	Maximum scan time (Medium-speed ladder)	Maximum scan time (1μs unit)		

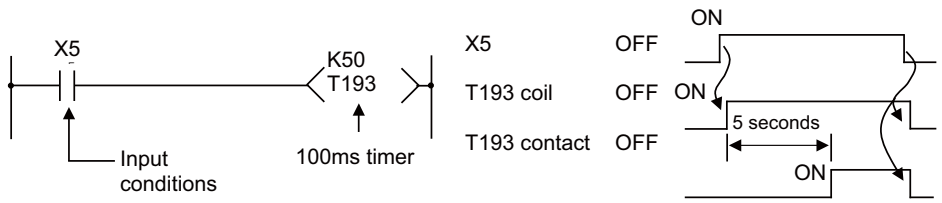
*1: Processing cycle of the high-speed ladder (sequence program) depends on the machine type.

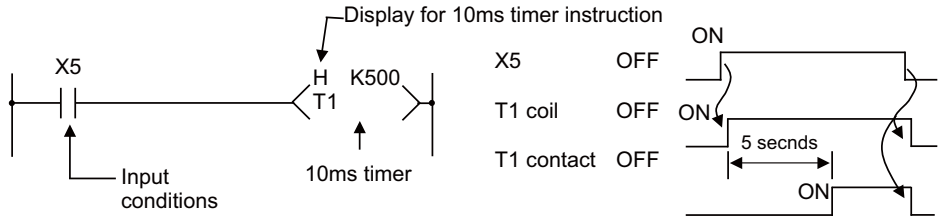
4.4.6 Edge Relay V

Edge relay V	
(a)This stores the operation result (ON/OFF information) from the head of ladder block. (b) This can be used only at contacts. This cannot be used as a coil.	
	
(c)The relay No. is expressed with a decimal.	

4.4.7 Timer T

(1) The 100ms timer and 10ms timer are available for this count-up type timer.
The 100ms timer and 10ms timer are differentiated by the instructions used. Refer to the following explanation on basic instructions for details.

100ms Timer T	
(a)When the input conditions are set, the count starts. When the set value is counted, that timer contact will turn ON. (b)If the input conditions are turned OFF, the 100ms timer count value will be set to 0, and the contact will turn OFF.	
	
(c)The value is set with a decimal, and can be designated from 1 to 32767 (0.1 to 3276.7 s).The data register D or file register R data can be used as the setting value.	

10ms Timer T	
(a)When the input conditions are set, the count starts. When the set value is counted, that timer contact will turn ON. (b)If the input conditions are turned OFF, the 10ms timer count value will be set to 0, and the contact will turn OFF	
	
(c)The value is set with a decimal, and can be designated from 1 to 32767 (0.01 to 327.67 s). The data register D or file register R data can be used as the setting value.	

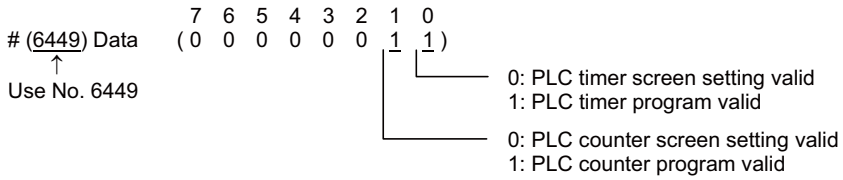
(2) With the device T, the contact/coil is handled as bit device, and the current value is handled as word device. In the function instructions described after, the word device T indicates the current value even if there is no description about it.

(3) Setting the timer setting value from the setting and display unit
The timer T setting value can be set with the following two methods.
- Method to validate the setting value (Kn) programmed with the sequence program (Fixed timer)
- Method to validate the setting value set from the setting and display unit (Variable timer)
(Note that even when this method is used, the setting value (Kn) must be programmed in the sequence program. In this case, the Kn value will be ignored during the operation. When a data register D is used for the setting value, the contents of the data register D will be the setting value regardless of the parameter.)

(a) Methods for setting the number of fixed timer and variable timer points
The number of points of the fixed timer and variable timer in all of the timer T points can be set with the bit selection parameter. This setting is validated when the PLC is restarted.

Variable timer		Bit selection (#6454)				Remarks
Number of points	Range	Bit 3	Bit 2	Bit 1	Bit 0	
0		0	0	0	0	Use all points as fixed timer
100	(0 to 99)	0	0	0	1	Use range other than that shown on left as fixed timer
200	(0 to 199)	0	0	1	0	
300	(0 to 299)	0	0	1	1	
400	(0 to 399)	0	1	0	0	
500	(0 to 499)	0	1	0	1	
600	(0 to 599)	0	1	1	0	
704	(0 to 703)	0	1	1	1	Use 704 points as variable timer

(b) Variable timer validity setting bit on program side
A bit selection and display unit and validate the setting values in the sequence program. This setting is valid when the PLC is restarted. (This bit is valid also for the integrated timer.)



(c) Methods for setting the setting value from the setting and display unit
The timer and counter setting value can be set from the parameter setting screen. Steps 1 to 4 also apply for the counter.

1) The set value is validated even when the PLC is restarting.
2) On the setting screen, only the number of variable timer points set with (a) are valid. The (a) setting is immediately reflected on the display of the settable range.
3) The setting screen values are not affected even if the (b) "variable timer validity setting bit on program side" setting is changed.
4) It is possible to judge whether the setting value is valid within the current storage ladder (whether that timer is used with the setting value (Kn) in the ladder).
5) The timer type (10ms, 100ms) can be judged on the setting screen.
6) Even when the multi-project function is enabled, variable timer/ variable counter are usable only with Project 1. (Project 2 to 6 will use the fixed timer/fixed counter for all points regardless of the setting of bit selection parameter.)
7) When the usable number of timer/counter points is less than the number of variable timer/ variable counter points, which is set by the bit selection parameter, all usable points will be the variable timer/ variable counter.

(d) Setting example of variable timer

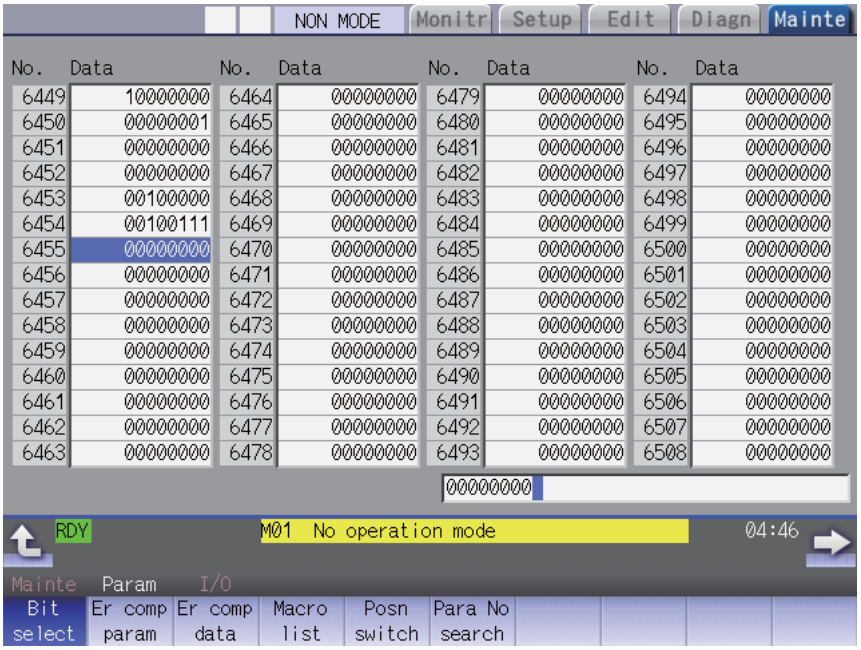
The setting example and operation of 10ms variable timer with the following conditions are shown below.

Program side valid setting bit for variable timer : PLC timer screen setting valid

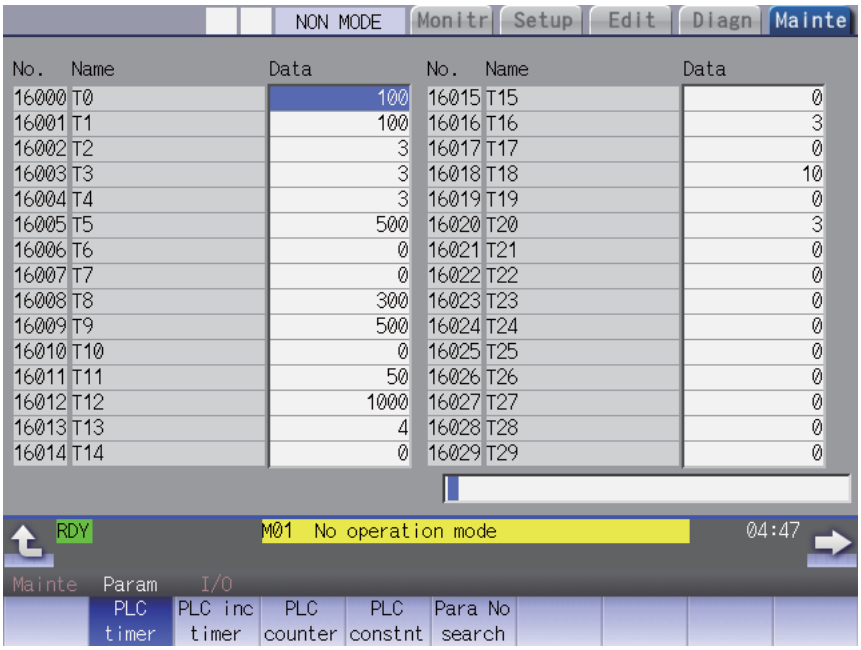
Number of variable timer points : 704

T1 device setting value : 100

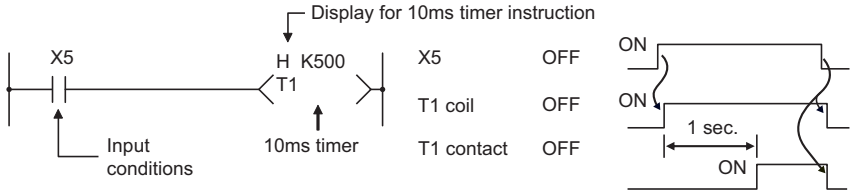
1) Set "PLC timer screen setting valid" to the variable timer valid bit.
Set "704" to the number of variable timer point.



2) Set the setting value "100" to T1 device.

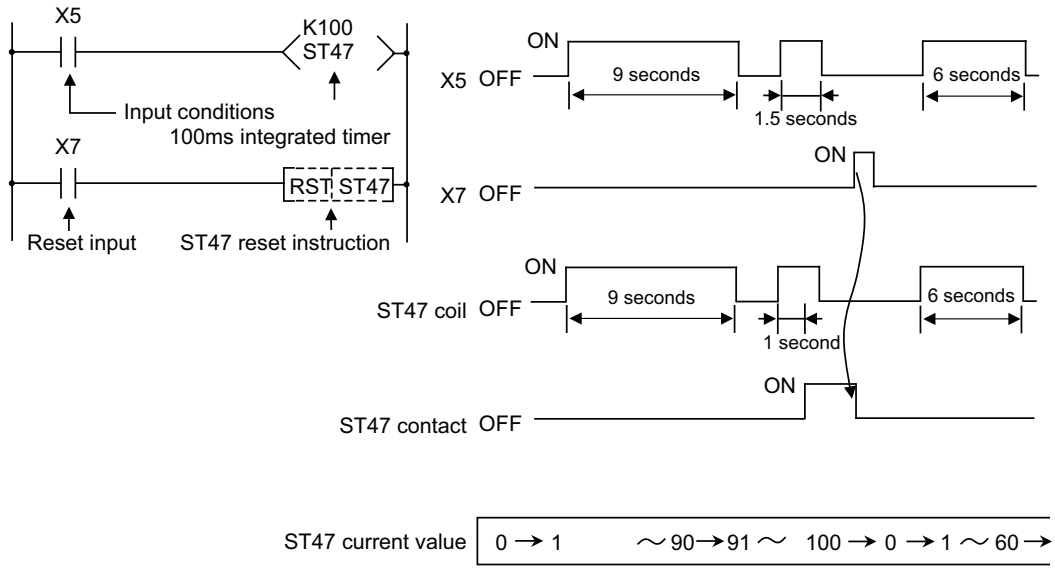


3) The operation of the T1 device timer instruction will be as follows.
(The timer setting value from the sequence program is "500", however it operates on the setting value "100" on the screen.)



4.4.8 Integrated Timer ST

(1) The 100ms integrated timer is available for this count-up type timer.

100ms Integrated timer ST	
(a)When the input conditions are set, the count starts. When the set value is counted, that timer contact will turn ON. (b)Even the input conditions are turned OFF, the 100ms integrated timer current value (count value) will be held, and the contact state will not change. (c)The 100ms integrated timer count value will be set to 0 and the contact will turn OFF when the RST instruction is executed.	
	
(d)The value is set with a decimal, and can be designated from 1 to 32767 (0.1 to 3267.7 s). The data register D or file register R data can be used as the setting value. (e)When the bit selection parameter is set, the 100ms integrated timer current value (count value) will be held even when the power is turned OFF.	

(2) Handling the device ST types

With the device ST, the contact/coil is handled as bit device, and the current value is handled as word device. In the function instructions described after, the word device T indicates the current value even if there is no description about it.

(3) Setting the timer setting value from the setting and display unit

The number of points of the variable and fixed can be set with the bit selection parameter in the same manner as timer T.

Variable integrated timer		Bit selection (#6453)			Remarks
Number of points	Range	Bit 7	Bit 6	Bit 5	
0		0	0	0	Use all points as fixed integrated timer
20	(0 to 19)	0	0	1	Use range other than that shown on left as fixed integrated timer
40	(0 to 39)	0	1	0	
64	(0 to 63)	0	1	1	Use 64 points as variable integrated timer

In the same manner as timer T, a bit selection parameter is provided as a switch for the variable integrated timer to invalidate all of the setting values set from the setting and display unit and validate the setting values in the sequence program. (This bit is used for both the timer T and integrated timer ST.)

4.4.9 Counter C

(1)The counter counts up and detects the rising edge of the input conditions. Thus, the count will not take place when the input conditions are ON.

Counter C	
(a)The value is set with a decimal, and can be designated from 1 to 32767. The data register D or file register R data can be used as the setting value. (b)The counter count value will not be cleared even if the input conditions turn OFF. The counter count value must be cleared with the RST instruction. (c)When the bit selection parameter is set, the counter current value (count value) will be held even when the power is turned OFF. Note that some cannot be held depending on the version of CNC.	

(2)With the device C, the contact/coil is handled as bit device, and the current value (counter value) is handled as word device.
In the function instructions described after, the word device C indicates the current value (counter value) even if there is no description about it.

(3)The counter C setting value can be set with the following two methods.
(a)Method to validate the setting value (Kn) programmed with the sequence program (Fixed counter)
(b)Method to validate the setting value set from the setting and display unit (Variable counter)
(Note that even when this method is used, the setting value (Kn) must be programmed in the sequence program. In this case, the Kn value will be ignored during the operation. When a data register D is used for the setting value, the contents of the data register D will be the setting value regardless of the parameter.)

The number of points of the fixed counter and variable counter in all of the counter C points can be set with the bit selection parameter.

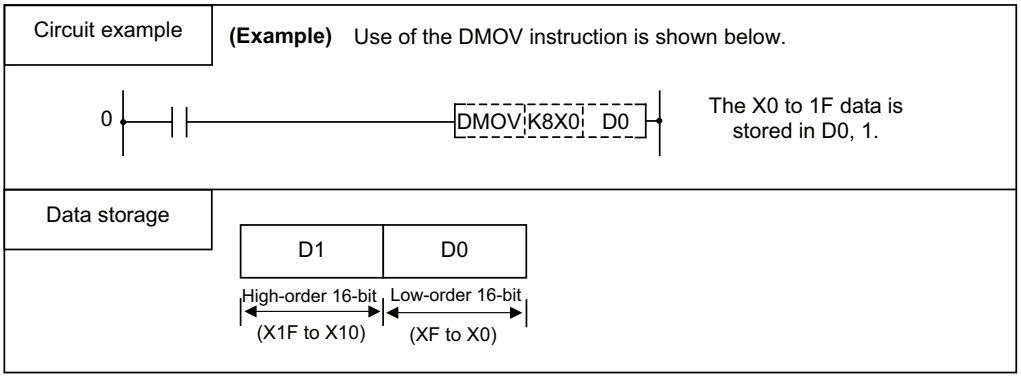
Variable counter		Bit selection (#6454)				Remarks
Number of points	Range	Bit 7	Bit 6	Bit 5	Bit 4	
0		0	0	0	0	Use all points as fixed counter
40	(0 to 39)	0	0	0	1	Use range other than that shown on left as fixed counter
80	(0 to 79)	0	0	1	0	
120	(0 to 119)	0	0	1	1	
160	(0 to 159)	0	1	0	0	
200	(0 to 199)	0	1	0	1	
240	(0 to 239)	0	1	1	0	
256	(0 to 255)	0	1	1	1	Use 256 points as variable counter

A bit selection parameter is provided as a switch for the variable counter to invalidate all of the setting values set from the setting display unit and validate the setting values in the sequence program. (Refer to the explanation on the timer.)

4.4.10 Data Register D

(1)The data register is the memory that stores the data in the PLC.

(2)The data register has a 1-point 16-bit configuration, and can be read and written in 16-bit units.
To handle 32-bit data, two points must be used. The data register No. designated with the 32-bit instruction will be the low-order 16-bit, and the designated data register No. +1 will be the high-order 16-bit.



(3)The data that is stored once in the sequence program is held until other data is stored.

(4)The data stored in the data register is cleared when the power is turned OFF.

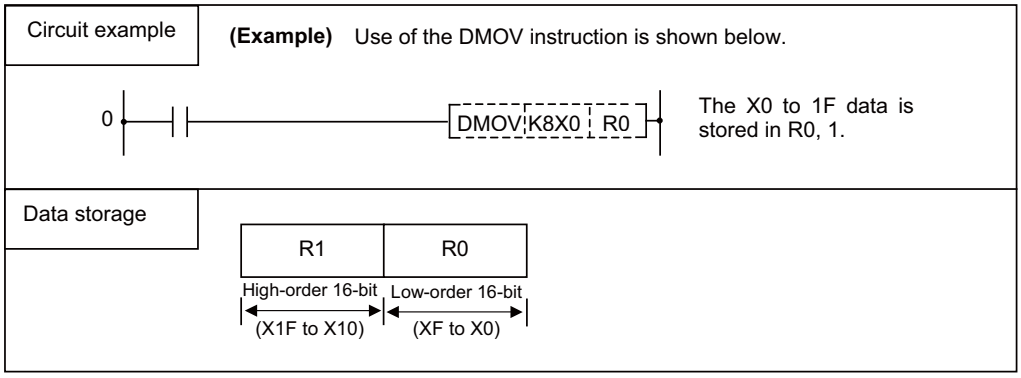
(5)Values that can be stored:

Decimal	-32768 to 32767	For 16-bit instruction(Using Dn)
Hexadecimal	0 to FFFF	
Decimal	-2147483648 to 2147483647	For 32-bit instruction (Using Dn+1, Dn)
Hexadecimal	0 to FFFFFFFF	

(6)Data registers D0 to D2047 are all user release data registers.

4.4.11 File Register R, ZR

(1) As with the data registers, the file registers are memories used to store data. However, there are some that have fixed applications, and those that are released.
The file register has a 1-point 16-bit configuration, and can be read and written in 16-bit units.
To handle 32-bit data, two points must be used. The file register No. designated with the 32-bit instruction will be the low-order 16-bit, and the designated file register No. +1 will be the high-order 16-bit.



(2) The data that is stored once in the sequence program is held until other data is stored.

(3) With the file registers, the following registers are the user release.

R8300 to R9799	Data are not cleared even when the power is turned OFF.
R9800 to R9899	
R18300 to R19799	Data are not cleared even when the power is turned OFF.
R19800 to R19899	
R28300 to R29799	Data are not cleared even when the power is turned OFF.
R29800 to R29899	

The other file registers have fixed applications such as interface of the PLC and CNC, parameter interface, etc., so use according to the application.

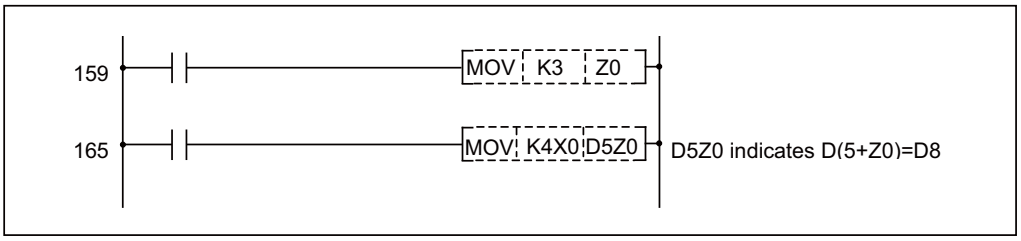
(4) Values that can be stored:

Decimal -32768 to 32767
Hexadecimal 0 to FFFF
} For 16-bit instruction(Using Rn)

Decimal -2147483648 to 2147483647
Hexadecimal 0 to FFFFFFFF
} For 32-bit instruction (Using Rn+1, Rn)

4.4.12 Index register Z

(1)The index register is used as ornaments for the device. *



(2)The index register has a 1-point 16-bit configuration, and can be read and written in 16-bit units.

(3)The data stored in the index register is cleared when the power is turned OFF.

(4)Values that can be stored:Decimal -32768 to 32767

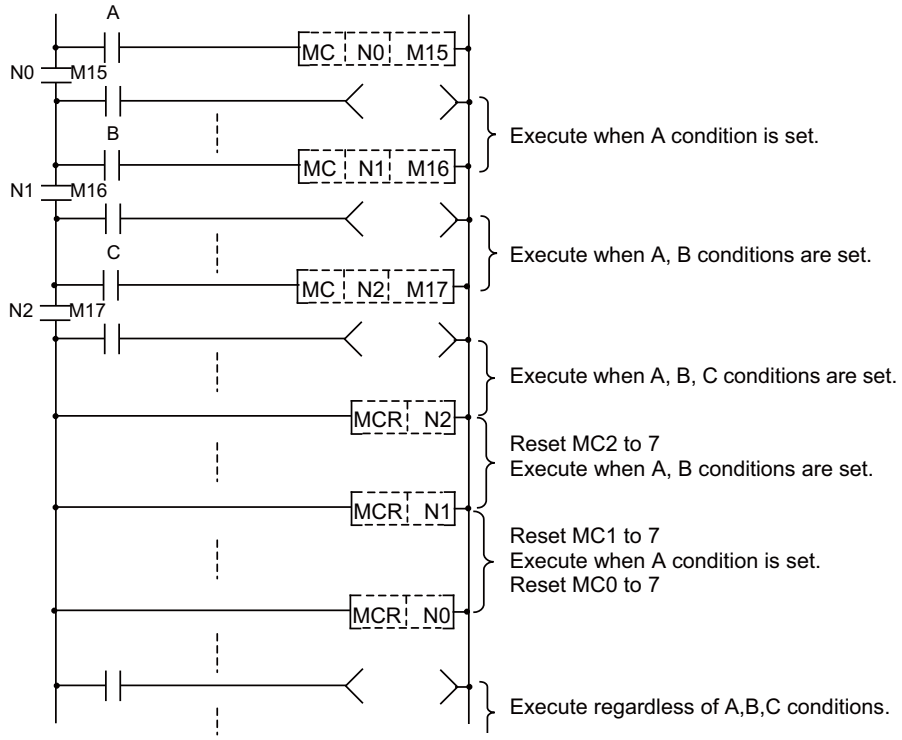
Hexadecimal 0 to FFFF

* Refer to " Explanation of Instructions: Index Modification" for the modifiaction target device.

4.4.13 Nesting N

(1)This indicates the master control nesting structure.

(2)The master control nesting N is used in order from smallest No.



(a)The conditions for each master control to turn ON are as follow.

MC	N0	M15	.....	ON when condition A is ON
MC	N0	M16	.....	ON when conditions A, B are ON
MC	N0	M17	.....	ON when conditions A, B, C are ON

(b)The timer and counter when the master control is OFF is as follows.

- 100ms timer, 10ms timer : The count value is set to 0.
- 100ms integrated timer : The current count value is retained.
- Counter : The current counter value is retained.
- OUT instruction : All turn OFF

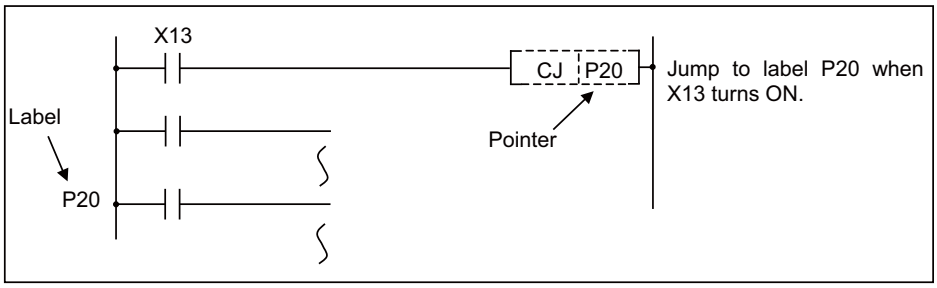
4.4.14 Pointer P

(1)What is a pointer?

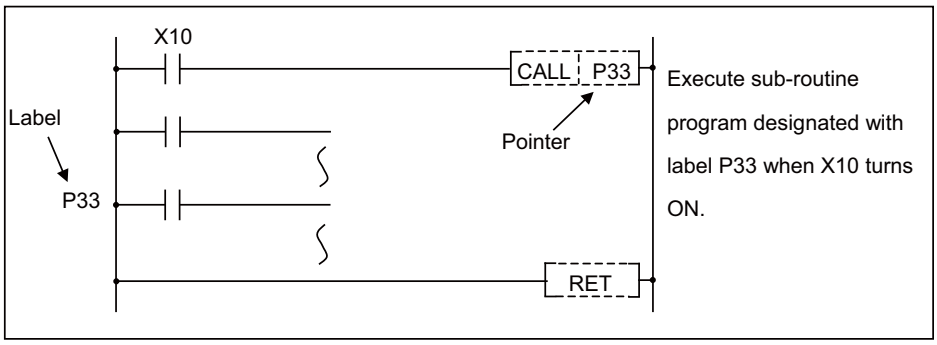
A pointer is a device used with branch instructions. A total of 4096 points is used in all executed programs. The reserved pointers use the addresses from 4000 to 4005 separately.

(2)Pointer applications

(a)Jump instruction (CJ, JMP) jump destination designation and label (Designation of jump destination head)



(b)Subroutine call instruction (CALL) call destination and label (Designation of subroutine program head)



(3)Types of pointers

The details of the pointers differ according to the program method.

(a)Independent program method

The following two types of pointers are used.

- General pointer : Pointer which can jump or call with a jump instruction or subroutine call instruction
- Reserved pointer : Pointer with fixed application, such as a start label

(b)Multi-program method

The following three types of pointers are used.

- Local pointer : Pointer used independently in each program
- Common pointer : Pointer which can be called with subroutine call instruction from all programs being executed
- Reserved pointer : Pointer with fixed application, such as an END label

4.4.14.1 General Pointers

General pointers are pointer which can be used only with the independent program method, which lays importance on compatibility with conventional models.

The general pointer can be used with the jump instructions and subroutine call instructions. The same pointer No. cannot be used.

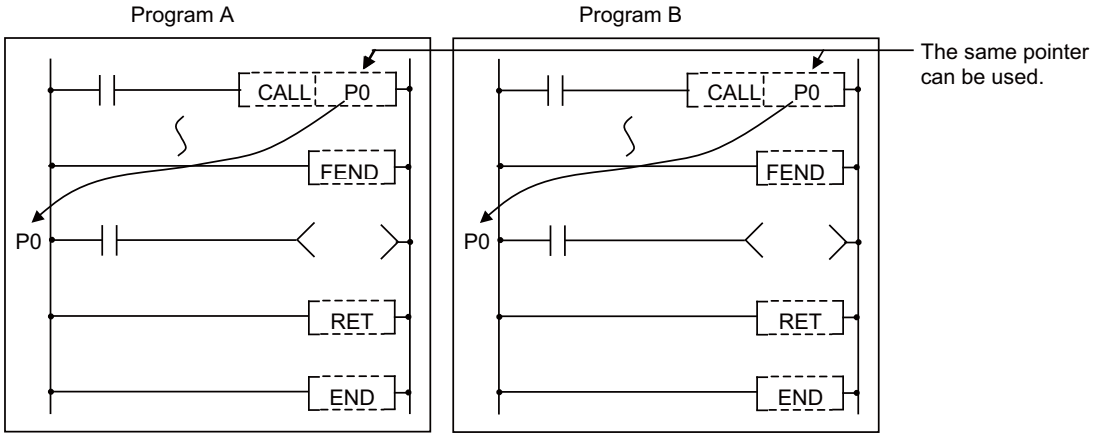
4.4.14.2 Local Pointers

Local pointers are pointers that can be used only with the multi-program method.

(1)What is a local pointer?

(a)A local pointer is a pointer that can be used independently with each program stored in the CNC controller.
The local pointer can be used with the jump instructions and subroutine call instructions.

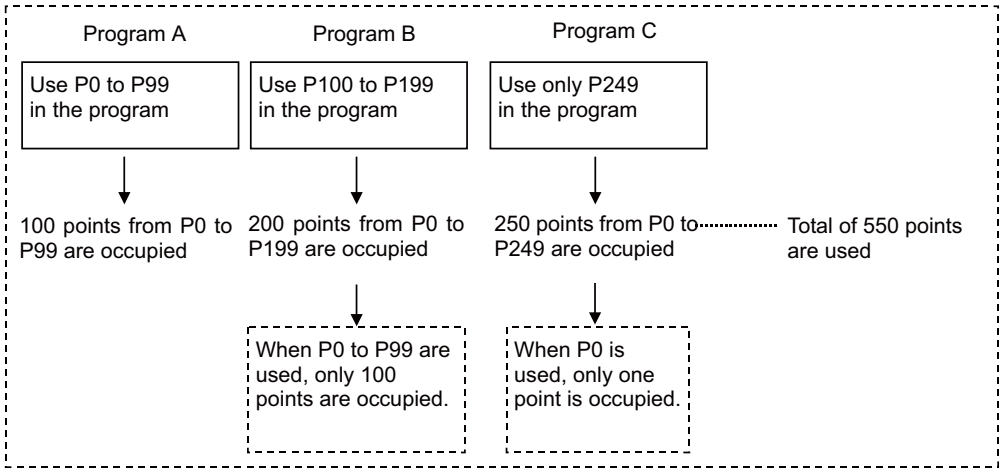
(b)The same pointer No. can be used in each program.
The pointers from P0 to the common pointer usage range setting value (the details described below) can be used.



(2)Concept of number of local pointer points

The local pointers split and use the local pointer area (arbitrarily settable with user settings) in all programs. Up to the maximum No. of local pointers in use can be used in each program. When using the local pointers in multiple programs, start use from P0.

An error will occur if the total of local pointers used in each program exceeds the setting number.



4.4.14.3 Common Pointers

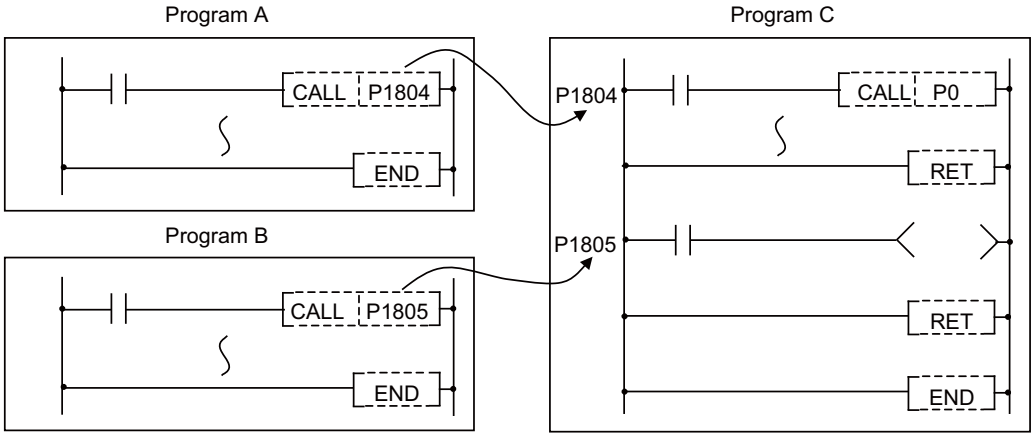
Common pointers are pointers that can be used only with the multi-program method.

(1)What is a common pointer?

(a)A common pointer is a pointer that calls the subroutine program from all programs executed with the CNC controller.

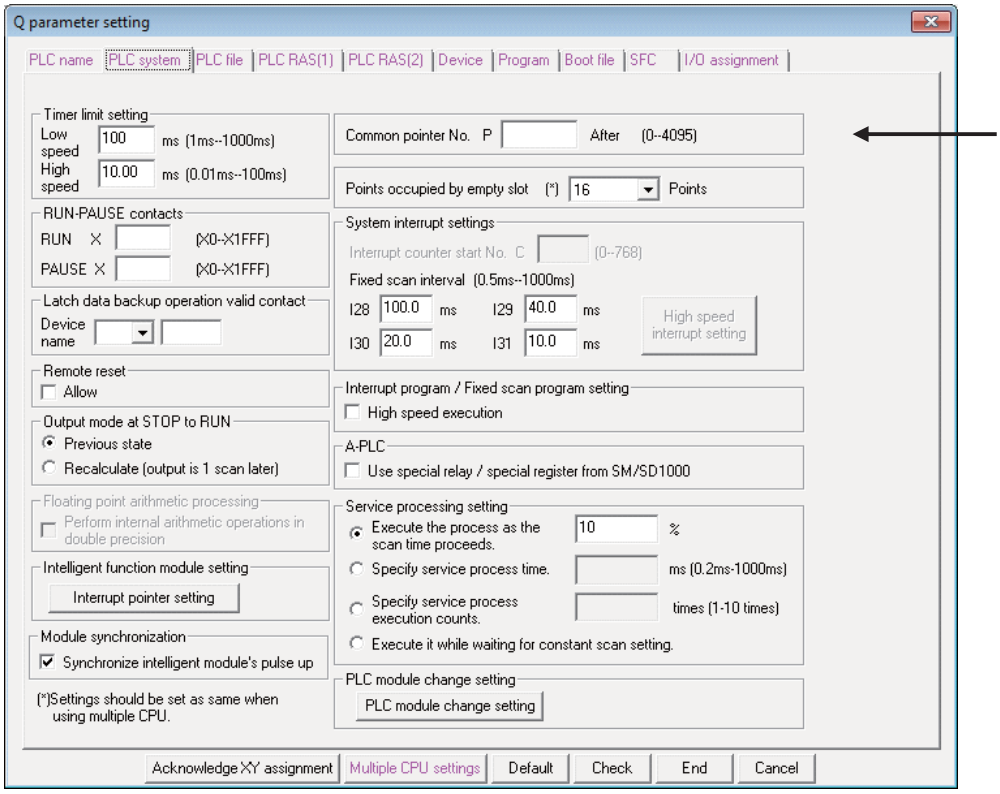
The common pointer can be used only with the subroutine call instruction, and cannot be used with the jump instruction.

(b)The same pointer No. cannot be used as a label.



(2)Common pointer usage range

The common pointer usage range can be set with the GX Developer parameter settings. The range following the set No. is the common pointers. The range that can be set as the head No. of the common pointer is from P0 to P4095. The default value is set to 1800, and from P1800 to P4095 can be used as common pointers.



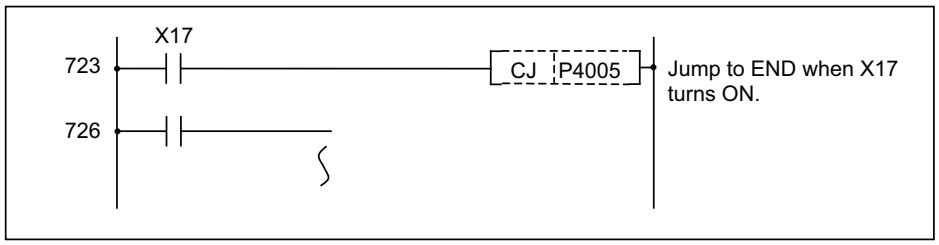
4.4.14.4 Reserved Pointers

Reserved pointers are pointers with fixed applications.

(1)Independent program method

P4001 (high-speed) : Start label for PLC high-speed processing program.
P4002 (medium-speed) : Start label for PLC main (ladder) processing program.
P4003 (initialization) : Start label for PLC initialization processing program.
P4005 (END) : Label indicating END.

(P4005 (END) can be used as a device for the CJ instruction, etc., but cannot be used as a label.
In addition, it cannot be used for a CALL instruction device.)



[CAUTION]

1.Do not omit the P4002 (medium-speed) label even when using only the PLC main processing program.
2.Do not use P4001 (high-speed), P4002 (medium-speed), P4003 (initialization) or P4004 (system reservation) as a CJ instruction or CALL instruction device.
3.Do not program to jump to P** in the PLC high-speed processing program from the PLC main processing program.
4.P** used as a CJ instruction or CALL instruction device must be programmed so that it is in the same program file as the label instruction.

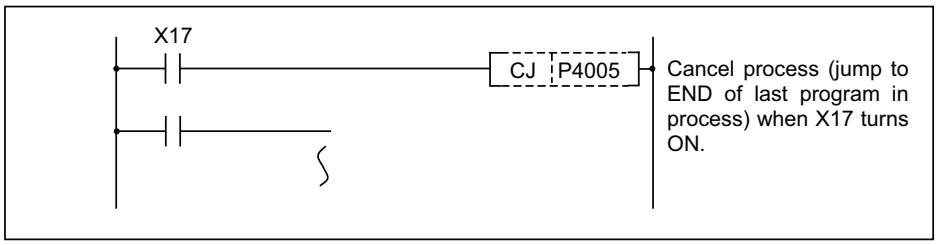
The PLC will not run properly if Cautions 1 through 4 are not observed.

(2)Multi-program method

(a)Label indicating END (P4005)

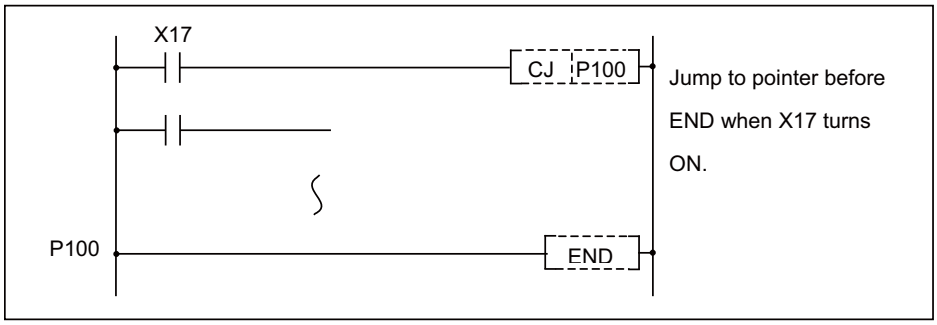
P4005 is used as the CJ instruction jump destination, and cannot be used as a normal label. It also cannot be used as the CALL instruction call destination.
If CJ P4005 is executed when multiple PLC programs are registered with the multi-programming function, the process will jump to the end of all PLC programs (in other words, the scan process is canceled).

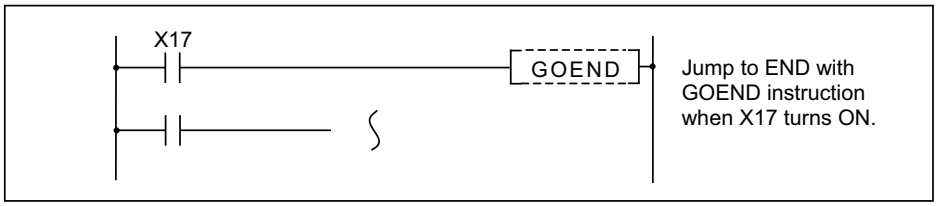
To jump to end of all processes



The following two methods of jumping to the end of each program are available.
- Sets the local pointer right before the END instruction and jumps to that position.
- Executes GOEND instruction.

To jump to the end of the program





[Cautions for pointers in multi-program method]

1.Each process (initialization, high-speed, main) is executed from the head of the program executed at the start of each process.
Thus, the reserved labels for starting, used with the conventional models, cannot be used.

2.The common pointers can be used only with subroutine call instructions, and cannot be used with jump instructions.

3.The labels using the CJ instruction, JMP instruction or CALL instruction as a device must be programmed so that one of the following exists.
- If the pointer is a local pointer, it must exist in the same program file as the used instruction.
- If the pointer is a common pointer, it must exist in one of the registered program files.

The PLC will not run properly if Cautions 1 through 3 are not observed.

4.4.15 Decimal Constant K

(1)The decimal constant can be used in the following ways.

(a)Timer counter setting value : Designate in the range of 1 to 32767.
(b)Pointer No. : 0 to 159
(c)Bit device digit designation : 1 to 8
(d)Basic instruction, function instruction, exclusive instruction value setting
16-bit instruction : -32768 to 32767
32-bit instruction : -2147483648 to 2147483647

(2)The decimal constant is stored by binary value in the PLC.

4.4.16 Hexadecimal Constant H

(1)The hexadecimal constant is used to designate the basic instruction, function instruction and exclusive instruction values.
16-bit instruction : 0 to FFFF
32-bit instruction : 0 to FFFFFFFF

5

Explanation of Instructions

5.1 Instruction Tables

5.1.1 How to Read Instruction Table

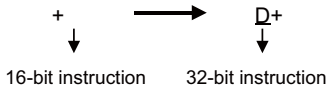
The instruction tables have been made according to the following format.

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
+ (BIN)	16-bit	+	+ S D	(D)+(S)→(D) (BIN)	⎍	3	3
		+P	+P S D		⎍↑	3	7
		+	+ S1 S2 D	(S1)+(S2)→(D) (BIN)	⎍	3/4	4
		+P	+P S1 S2 D		⎍↑	3/4	8
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

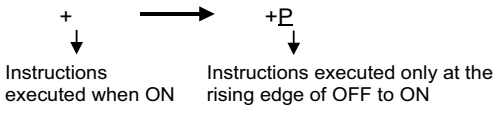
(1) … Classifies instructions according to their application

(2) … Indicates the processing unit of instructions.

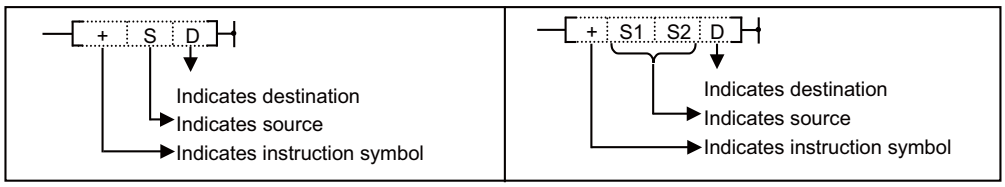
(3) … Indicates the instruction symbol used to enter the instruction in a program
Instruction code is built around the 16-bit instruction, with the following notations used to mark 32-bit instructions, instructions executed only at the rising edge of OFF to ON,
real number instructions, and character string instructions.
- 32-bit instruction o o o The letter "D" is added to the first line of the instruction
(Example)



- Instructions executed only at the rising edge of OFF to ON o o o The letter "P" is appended to the end of the instruction
(Example)

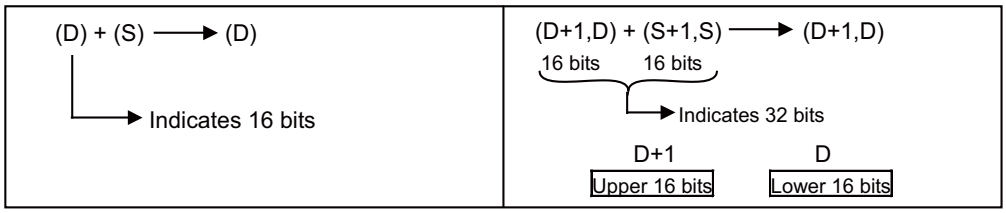


(4) … Shows symbol drawing on the ladder



Destination…….Indicates where data will be sent following operation
Source……Stores data prior to operation

(5) … Indicates the type of processing that is performed by individual instructions



(6) … The details of conditions for the execution of individual instructions are as follows.

Symbol	Execution Condition
No symbol recorded	Instruction executed under normal circumstances, with no regard to the ON/OFF status of conditions prior to the instruction. If the precondition is OFF, the instruction will conduct OFF processing.
	Executed during ON; instruction is executed only while the precondition is ON. If the precondition is OFF, the instruction is not executed and no processing is conducted.
	Executed once at ON; instruction executed only at rising edge when precondition goes from OFF to ON. Following execution, instruction will not be executed and no processing conducted even if condition remains ON.
	Executed once at OFF; instruction executed only at falling edge when precondition goes from ON to OFF. Following execution, instruction will not be executed and no processing conducted even if condition remains OFF.

(7) … Indicates the number of steps when storing each instruction.

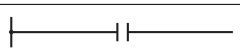
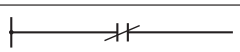
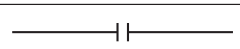
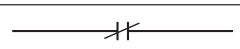
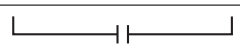
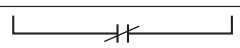
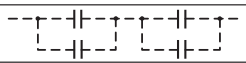
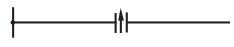
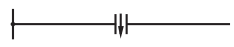
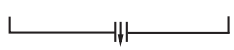
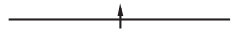
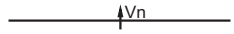
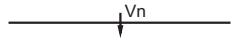
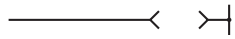
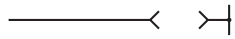
This is the number of steps that is consumed when each instruction is stored in built-in ROM. Refer to "PLC Processing Program:Storing PLC Processing Program and Execution Mode " for details.

When ZR device/ Z device is used for each instruction argument, the number of steps at storage will increase/ decrease from the described contents. Refer to "Number of Steps" for details.

(8) … Indicates the number of steps when executing each instruction.

This is the number of steps that is consumed in the PLC processor execution area when each instruction is executed. The number of steps may be different from that of when stored in built-in ROM. Refer to "PLC Processing Program: Storing PLC Processing Program and Execution Mode " for details.

5.1.2 Basic Instructions

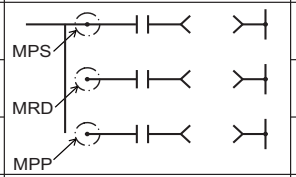
Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
Basic instruction	Bit	LD		Start of logic operation (A contact operation start)		1	1/2 *2
		LDI		Start of logic negation operation (B contact operation start)		1	1/2 *2
		AND		Logical AND (A contact serial connection)		1	1/2 *2
		ANI		Logical AND negation (B contact serial connection)		1	1/2 *2
		OR		Logical OR (A contact parallel connection)		1	1/2 *2
		ORI		Logical OR negation (B contact parallel connection)		1	1/2 *2
		ANB		AND between logical blocks (Parallel connection between blocks)		1	1
		ORB		OR between logical blocks (Parallel connection between blocks)		1	1
		LDP		Starts rising edge pulse operation		1	4
		LDF		Starts falling edge pulse operation		1	4
		ANDP		Rising edge pulse series connection		1	4
		ANDF		Falling edge pulse series connection		1	4
		ORP		Rising edge pulse parallel connection		1	4
		ORF		Falling edge pulse parallel connection		1	4
		INV		Inversion of operation result		1	3
		MEP		Conversion of operation result to rising edge pulse		1	3
		MEF		Conversion of operation result to falling edge pulse		1	3
		EGP		Conversion of operation result to rising edge pulse (Stored at Vn)		1	3
		EGF		Conversion of operation result to falling edge pulse (Stored at Vn)		1	3
		OUT		Device output		1/2 *1	1/2 *2
		OUT T/C		100ms timer/counter output		4	3
		OUT H		10ms timer output		4	3

(To be continued on the next page)

*1: Argument will be 2 steps at F device.

*2: Argument will be 1 step at bit device, 2 steps at word device.
When the machine has the extended index Modification, an argument with an index will be two steps.

Basic instructions (continued)

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
Basic instruction	Bit	SET	SET D	Device set	⎍	1/2 *1	1/2 *2
		RST	RST D	Device reset	⎍	1/2 *1	1/2 *2
		RST T/C	RST D	Timer/counter reset	⎍	4	2
		MC	MC n D	Master control start		2	2
		MCR	MCR n	Master control release		1	1
		PLS	PLS D	Generate one cycle worth of pulses at rising edge of input signal	↑	2	3/4 *3
		PLF	PLF D	Generate one cycle worth of pulses at falling edge of input signal	↓	2	3/4 *3
		FF	FF D	Reversal of device output	↑	2	5
		SFT	SFT D	Device 1-bit shift	⎍	2	1/2 *2
		SFTP	SFTP D		↑	2	6
		MPS		Registration of operation result		1	1
		MRD		Reading of operation results registered in MPS		1	1
		MPP		Reading and resetting of operation results registered in MPS		1	1
		NOP		Ignored (For program deletion or space)		1	1
		NOPLF	NOPLF	Ignored (To change pages during printouts)		1	1
		PAGE	PAGE n	Ignored (Subsequent programs will be controlled from step 0 of page n)		1	1

*1: 2 steps when the argument is F device.

*2: 1 step when the argument is bit device; 2 steps when the argument is word device.
When the machine has the extended index Modification, an argument with an index will be two steps.

*3: When the machine has the extended index Modification, an argument with an index will be four steps.

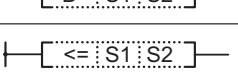
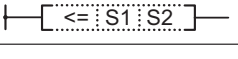
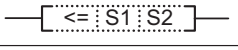
5.1.3 Comparison Operation Instructions

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
=	16-Bit	LD=	[= S1 S2]	Continuity state when (S1) = (S2) Non-continuity state when (S1) ≠ (S2)		3	3
		AND=	[= S1 S2]			3	3
		OR=	[= S1 S2]			3	3
	32-Bit	LDD=	[D= S1 S2]	Continuity state when (S1+1,S1) = (S2+1,S2) Non-continuity state when (S1+1,S1) ≠ (S2+1,S2)		3/4 *1	3/4 *1
		ANDD=	[D= S1 S2]			3/4 *1	3/4 *1
		ORD=	[D= S1 S2]			3/4 *1	3/4 *1
≠	16-Bit	LD<>	[<> S1 S2]	Continuity state when (S1) ≠ (S2) Non-continuity state when (S1) = (S2)		3	3
		AND<>	[<> S1 S2]			3	3
		OR<>	[<> S1 S2]			3	3
	32-Bit	LDD<>	[D<> S1 S2]	Continuity state when (S1+1,S1) ≠ (S2+1,S2) Non-continuity state when (S1+1,S1) = (S2+1,S2)		3/4 *1	3/4 *1
		ANDD<>	[D<> S1 S2]			3/4 *1	3/4 *1
		ORD<>	[D<> S1 S2]			3/4 *1	3/4 *1
>	16-Bit	LD>	[> S1 S2]	Continuity state when (S1) > (S2) Non-continuity state when (S1) ≦ (S2)		3	3
		AND>	[> S1 S2]			3	3
		OR>	[> S1 S2]			3	3
	32-Bit	LDD>	[D> S1 S2]	Continuity state when (S1+1,S1) > (S2+1,S2) Non-continuity state when (S1+1,S1) ≦ (S2+1,S2)		3/4 *1	3/4 *1
		ANDD>	[D> S1 S2]			3/4 *1	3/4 *1
		ORD>	[D> S1 S2]			3/4 *1	3/4 *1
≧	16-Bit	LD>=	[>= S1 S2]	Continuity state when (S1) ≧ (S2) Non-continuity state when (S1) < (S2)		3	3
		AND>=	[>= S1 S2]			3	3
		OR>=	[>= S1 S2]			3	3
	32-Bit	LDD>=	[D>= S1 S2]	Continuity state when (S1+1,S1) ≧ (S2+1,S2) Non-continuity state when (S1+1,S1) < (S2+1,S2)		3/4 *1	3/4 *1
		ANDD>=	[D>= S1 S2]			3/4 *1	3/4 *1
		ORD>=	[D>= S1 S2]			3/4 *1	3/4 *1

(To be continued on the next page)

*1: 1 step is added when either S1 or S2 is a constant number.

Comparison operation instructions (continued)

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
<	16-Bit	LD<		Continuity state when (S1) < (S2) Non-continuity state when (S1) ≧ (S2)		3	3
		AND<				3	3
		OR<				3	3
	32-Bit	LDD<		Continuity state when (S1+1,S1) < (S2+1,S2) Non-continuity state when (S1+1,S1) ≧ (S2+1,S2)		3/4 *1	3/4 *1
		ANDD<				3/4 *1	3/4 *1
		ORD<				3/4 *1	3/4 *1
<=	16-Bit	LD<=		Continuity state when (S1) ≦ (S2) Non-continuity state when (S1) > (S2)		3	3
		AND<=				3	3
		OR<=				3	3
	32-Bit	LDD<=		Continuity state when (S1+1,S1) ≦ (S2+1,S2) Non-continuity state when (S1+1,S1) > (S2+1,S2)		3/4 *1	3/4 *1
		ANDD<=				3/4 *1	3/4 *1
		ORD<=				3/4 *1	3/4 *1

*1: 1 step is added when either S1 or S2 is a constant number.

5.1.4 Arithmetic Operation Instructions

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
+ (BIN)	16-Bit	+	+ S D	(D) + (S) → (D)	⎍	3	3
		+P	+P S D	(BIN)	↑	3	7
		+	+ S1 S2 D	(S1) + (S2) → (D)	⎍	3/4 *1	4
		+P	+P S1 S2 D	(BIN)	↑	3/4 *1	8
	32-Bit	D+	D+ S D	(D+1,D) + (S+1,S) → (D+1,D)	⎍	3/4 *2	3/4 *2
		D+P	D+P S D	(BIN)	↑	3/4 *2	7/8 *2
		D+	D+ S1 S2 D	(S1+1,S1) + (S2+1,S2) → (D+1,D)	⎍	3~5 *3	4/5 *4
		D+P	D+P S1 S2 D	(BIN)	↑	3~5 *3	8/9 *4
- (BIN)	16-Bit	-	- S D	(D) - (S) → (D)	⎍	3	3
		-P	-P S D	(BIN)	↑	3	7
		-	- S1 S2 D	(S1) - (S2) → (D)	⎍	3/4 *1	4
		-P	-P S1 S2 D	(BIN)	↑	3/4 *1	8
	32-Bit	D-	D- S D	(D+1,D) - (S+1,S) → (D+1,D)	⎍	3/4 *2	3/4 *1
		D-P	D-P S D	(BIN)	↑	3/4 *2	7/8 *1
		D-	D- S1 S2 D	(S1+1,S1) - (S2+1,S2) → (D+1,D)	⎍	3~5 *3	4/5 *4
		D-P	D-P S1 S2 D	(BIN)	↑	3~5 *3	8/9 *4

(To be continued on the next page)

*1: 1 step is added when any of the following cases apply.
- When any of S1, S2 or D is a bit device and the device number is other than multiples of 16.
- When any of S1, S2 or D designates the digit other than K4 at the bit device digit designation.
- When any of S1, S2 or D is a bit device and the index modification.
- When the same device is used for S1 and D.

*2: 1 step is added when S is a constant number.

*3: 1 step is added when either S1 or S2 is a constant number.
1 step is added when any of the following cases apply.
- When any of S1, S2 or D is a bit device and the device number is other than multiples of 16.
- When any of S1, S2 or D designates the digit other than K8 at the bit device digit designation.
- When any of S1, S2 or D is a bit device and the index modification.
- When the same device is used for S1 and D.

*4: 1 step is added when either S1 or S2 is a constant number.

Arithmetic operation instructions (continued)

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
* (BIN)	16-Bit	*	[* S1 S2 D]	(S1) × (S2) → (D+1,D)	⎍	3/4 *1	4
		*P	[*P S1 S2 D]	(BIN)	↑	3/4 *1	8
	32-Bit	D*	[D* S1 S2 D]	(S1+1,S1) × (S2+1,S2) → (D+3,D+2,D+1,D)	⎍	3~5 *2	4/5 *3
		D*P	[D*P S1 S2 D]	(BIN)	↑	3~5 *2	8/9 *3
/ (BIN)	16-Bit	/	[/ S1 S2 D]	(S1) ÷ (S2) → Quotient(D), Remainder(D+1)	⎍	3/4 *1	4
		/P	[/P S1 S2 D]	(BIN)	↑	3/4 *1	8
	32-Bit	D/	[D/ S1 S2 D]	(S1+1,S1) ÷ (S2+1,S2) → Quotient(D+1,D), Remainder(D+3,D+2)	⎍	3~5 *2	4/5 *3
		D/P	[D/P S1 S2 D]	(BIN)	↑	3~5 *2	8/9 *3
Four arithmetic operations(BCD)	16-Bit	B+	[B+ S1 S2 D]	(S1) + (S2) → (D)	⎍	4	5
		B+P	[B+P S1 S2 D]	(BCD)	↑	4	9
		B-	[B- S1 S2 D]	(S1) - (S2) → (D)	⎍	4	5
		B-P	[B-P S1 S2 D]	(BCD)	↑	4	9
		B*	[B* S1 S2 D]	(S1) × (S2) → (D+1,D)	⎍	4	5
		B*P	[B*P S1 S2 D]	(BCD)	↑	4	9
		B/	[B/ S1 S2 D]	(S1) ÷ (S2) → Quotient(D), Remainder(D+1)	⎍	4	5
		B/P	[B/P S1 S2 D]	(BCD)	↑	4	9

(To be continued on the next page)

*1: 1 step is added when any of the following cases apply.
- When any of S1, S2 or D is a bit device and the device number is other than multiples of 16.
- When any of S1, S2 or D designates the digit other than K4 at the bit device digit designation.
- When any of S1, S2 or D is a bit device and the index modification.

*2: 1 step is added when S is a constant number.
1 step is added when any of the following cases apply.
- When any of S1, S2 or D is a bit device and the device number is other than multiples of 16.
- When any of S1, S2 or D designates the digit other than K8 at the bit device digit designation.
- When any of S1, S2 or D is a bit device and the index modification.

*3: 1 step is added when either S1 or S2 is a constant number.

Arithmetic operation instructions (continued)

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
+1	16-Bit	INC	INC D	(D) + 1 → (D)	⎍	2	2
		INCP	INCP D		⎍↑	2	6
	32-Bit	DINC	DINC D	(D+1,D) + 1 → (D+1,D)	⎍	2	2
		DINCP	DINCP D		⎍↑	2	6
-1	16-Bit	DEC	DEC D	(D) - 1 → (D)	⎍	2	2
		DECP	DECP D		⎍↑	2	6
	32-Bit	DDEC	DDEC D	(D+1,D) - 1 → (D+1,D)	⎍	2	2
		DDECP	DDECP D		⎍↑	2	6
Complement of 2	16-Bit	NEG	NEG D	• $\overline{(D)}$ → (D) BIN data	⎍	2	2
		NEGP	NEGP D		⎍↑	2	6
	32-Bit	DNEG	DNEG D	• $\overline{(D+1, D)}$ → (D+1, D) BIN data	⎍	2	2
		DNEGP	DNEGP D		⎍↑	2	6

5.1.5 Data Conversion Instructions

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps: Storage	No. of steps: Execution
BCD	16-Bit	BCD	* S1 S2 D	BCD Conversion • (S) → (D) BIN (0 to 9999)	⎍	2/3 *1	3
		BCDP	*P S1 S2 D		⎍↑	2/3 *1	7
	32-Bit	DBCD	D* S1 S2 D	BCD Conversion • (S+1, S) → (D+1, D) BIN (0 to 99999999)	⎍	2~4 *2	3
		DBCDP	D*P S1 S2 D		⎍↑	2~4 *2	7
BIN	16-Bit	BIN	/ S1 S2 D	BIN Conversion • (S) → (D) BCD (0 to 9999)	⎍	2/3 *1	3
		BINP	/P S1 S2 D		⎍↑	2/3 *1	7
	32-Bit	DBIN	D/ S1 S2 D	BIN Conversion • (S+1, S) → (D+1, D) BCD (0 to 99999999)	⎍	2~4 *2	3
		DBINP	D/P S1 S2 D		⎍↑	2~4 *2	7

*1: 1 step is added when any of the following cases apply.
- When any of S1, S2 or D is a bit device and the device number is other than multiples of 16.
- When any of S1, S2 or D designates the digit other than K4 at the bit device digit designation.
- When any of S1, S2 or D is a bit device and the index modification.

*2: 1 step is added when S is a constant number.
1 step is added when any of the following cases apply.
- When any of S1, S2 or D is a bit device and the device number is other than multiples of 16.
- When any of S1, S2 or D designates the digit other than K8 at the bit device digit designation.
- When any of S1, S2 or D is a bit device and the index modification.

5.1.6 Data Transmission Instructions

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps: Storage	No. of steps: Execution
Transmission	16-Bit	MOV	MOV S D	• (S) → (D)	⎍	2/3 *1	3
		MOVP	MOVP S D		↑	2/3 *1	7
	32-Bit	DMOV	DMOV S D	• (S+1,S) → (D+1,D)	⎍	2~4 *2	3/4 *3
		DMOVP	DMOVP S D		↑	2~4 *2	7/8 *3
	16-Bit	CML	CML S D	• (S) → (D)	⎍	2/3 *1	3
		CMLP	CMLP S D		↑	2/3 *1	7
	32-Bit	DCML	DCML S D	• $\overline{(S+1,S)}$ → (D+1,D)	⎍	2~4 *2	3/4 *3
		DCMLP	DCMLP S D		↑	2~4 *2	7/8 *3
Conversion	16-Bit	XCH	XCH D1 D2	• (D1) → (D2)	⎍	3	3
		XCHP	XCHP D1 D2		↑	3	7
	32-Bit	DXCH	DXCH D1 D2	• (D1+1,D1) ↔ (D2+1,D2)	⎍	3	3
		DXCHP	DXCHP D1 D2		↑	3	7
Batch transmission	16-Bit	BMOV	BMOV S D n	(S) → (D), n	⎍	4	4
		BMOVP	BMOVP S D n		↑	4	8
Batch transmission of same data	16-Bit	FMOV	FMOV S D n	(S) → (D), n	⎍	4	4
		FMOVP	FMOVP S D n		↑	4	8
Timer transmission		S.TMOV	S.TMOV S D	Transfer of timer and counter setting value	⎍	6	3

*1: When either S or D is a bit device and the device number is other than multiples of 16, it will be 3 steps.
When either S or D is a bit device and the index modification, it will be 3 steps.
When either S or D designates the digit other than K4 at the bit device digit designation, it will be 3 steps.

*2: 1 step is added when S is a constant number.
1 step is added when any of the following cases apply.
- When either S or D is a bit device and the device number is other than multiples of 16.
- When either S or D designates the digit other than K8 at the bit device digit designation.
- When either S or D is a bit device and the index modification.

*3: 1 step is added when S is a constant number.

5.1.7 Program Branch Instruction

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
Jump	-	CJ	CJ P**	Jump to Pn upon establishment of input condition.	⎍	2	2
		JMP	JMP P**	Jump to Pn unconditionally.		2	2
		GOEND	GOEND	Jump to END instruction upon establishment of input condition.	⎍	1	2
Program end	-	FEND	FEND	End process during sequence program.		1	1
	-	END	END	End sequence program.		1	1
Subroutine call	-	CALL	CALL P**	Execute P** sub-routine program after input conditions are met.	⎍	2	3
	-	CALLP	CALLP P**		↑	2	7
Return	-	RET	RET	Return to main program from subroutine program.		1	1
Repetition	-	FOR	FOR n	Execute the interval between FOR and NEXT for n times.		2	3
	-	NEXT	NEXT			1	3
	-	BREAK	BREAK D P**	Forcibly end the execution of the interval between FOR and NEXT, and jump to the pointer Pn.	⎍	3	4
	-	BREAK P	BREAKP D P**		↑	3	8

5.1.8 Logical Operation Instructions

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps: Storage	No. of steps: Execution
Logical AND	16-Bit	WAND	WAND S D	・(D) ∧ (S) → (D)	⎍	3	3
		WANDP	WANDP S D		⎍↑	3	7
		WAND	WAND S1 S2 D	・(S1) ∧ (S2) → (D)	⎍	3/4 *1	4
		WANDP	WANDP S1 S2 D		⎍↑	3/4 *1	8
	32-Bit	DAND	DAND S D	・(D+1,D) ∧ (S+1,S) → (D+1,D)	⎍	3/4 *2	3/4 *2
		DANDP	DANDP S D		⎍↑	3/4 *2	7/8 *2
		DAND	DAND S1 S2 D	・(S1+1,S1) ∧ (S2+1,S2) → (D+1,D)	⎍	3~5 *3	4/5 *4
		DANDP	DANDP S1 S2 D		⎍↑	3~5 *3	8/9 *4
Logical OR	16-Bit	WOR	WOR S D	・(D) ∨ (S) → (D)	⎍	3	3
		WORP	WORP S D		⎍↑	3	7
		WOR	WOR S1 S2 D	・(S1) ∨ (S2) → (D)	⎍	3/4 *1	4
		WORP	WORP S1 S2 D		⎍↑	3/4 *1	8
	32-Bit	DOR	DOR S D	・(D+1,D) ∨ (S+1,S) → (D+1,D)	⎍	3/4 *2	3/4 *2
		DORP	DORP S D		⎍↑	3/4 *2	7/8 *2
		DOR	DOR S1 S2 D	・(S1+1,S1) ∨ (S2+1,S2) → (D+1,D)	⎍	3~5 *3	4/5 *4
		DORP	DORP S1 S2 D		⎍↑	3~5 *3	8/9 *4

(To be continued on the next page)

*1: 1 step is added when any of the following cases apply.
- When any of S1, S2 or D is a bit device and the device number is other than multiples of 16.
- When any of S1, S2 or D designates the digit other than K4 at the bit device digit designation.
- When any of S1, S2 or D is a bit device and the index modification.
- When S1 and D use the same device.

*2: 1 step is added when S is a constant number.

*3: 1 step is added when either S1 or S2 is a constant number.
1 step is added when any of the following cases apply.
- When any of S1, S2 or D is a bit device and the device number is other than multiples of 16.
- When any of S1, S2 or D is a bit device and the index modification.
- When S1 and D use the same device.

*4: 1 step is added when either S1 or S2 is a constant number

Logical operation instructions (continued)

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps: Storage	No. of steps: Execution
Exclusive OR	16-Bit	WXOR	WXOR S D	• (D) ⩛ (S) → (D)	⎍	3	3
		WXORP	WXORP S D		⎍↑	3	7
		WXOR	WXOR S1 S2 D	• (S1) ⩛ (S2) → (D)	⎍	3/4 *1	4
		WXORP	WXORP S1 S2 D		⎍↑	3/4 *1	8
	32-Bit	DXOR	DXOR S D	• (D+1,D) ⩛ (S+1,S) → (D+1,D)	⎍	3/4 *2	3/4 *2
		DXORP	DXORP S D		⎍↑	3/4 *2	7/8 *2
		DXOR	DXOR S1 S2 D	• (S1+1,S1) ⩛ (S2+1,S2) → (D+1,D)	⎍	3~5 *3	4/5 *4
		DXORP	DXORP S1 S2 D		⎍↑	3~5 *3	8/9 *4
Non-exclusive logical sum	16-Bit	WXNR	WXNR S D	• $\overline{(D) \veebar (S)}$ → (D)	⎍	3	3
		WXNRP	WXNRP S D		⎍↑	3	7
		WXNR	WXNR S1 S2 D	• $\overline{(S1) \veebar (S2)}$ → (D)	⎍	3/4 *1	4
		WXNRP	WXNRP S1 S2 D		⎍↑	3/4 *1	8
	32-Bit	DXNR	DXNR S D	• $\overline{(D+1,D) \veebar (S+1,S)}$ → (D+1,D)	⎍	3/4 *2	3/4 *2
		DXNRP	DXNRP S D		⎍↑	3/4 *2	7/8 *2
		DXNR	DXNR S1 S2 D	• $\overline{(S1+1,S1) \veebar (S2+1,S2)}$ → (D+1,D)	⎍	3~5 *3	4/5 *4
		DXNRP	DXNRP S1 S2 D		⎍↑	3~5 *3	8/9 *4

*1: 1 step is added when any of the following cases apply.
- When any of S1, S2 or D is a bit device and the device number is other than multiples of 16.
- When any of S1, S2 or D is a bit device and the index modification.
- When S1 and D use the same device.

*2: 1 step is added when S is a constant number.

*3: 1 step is added when either S1 or S2 is a constant number.
1 step is added when any of the following cases apply.
- When any of S1, S2 or D is a bit device and the device number is other than multiples of 16.
- When any of S1, S2 or D designates the digit other than K8 at the bit device digit designation.
- When any of S1, S2 or D is a bit device and the index modification.
- When S1 and D use the same device.

*4: 1 step is added when either S1 or S2 is a constant number

5.1.9 Rotation Instructions

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
Right rotation	16-Bit	ROR	ROR D n	b15 (D) b0 SM12 Rotate n bits to right	⎍	3	3/4
		RORP	RORP D n		⎎	3	7/8
		RCR	RCR D n	b15 (D) b0 SM12 Rotate n bits to right	⎍	3	3/4
		RCRP	RCRP D n		⎎	3	7/8
	32-Bit	DROR	DROR D n	(D+1) (D) b31 to b16 b15 to b0 SM12 Rotate n bits to right	⎍	3	3/4
		DRORP	DRORP D n		⎎	3	7/8
		DRCR	DRCR D n	(D+1) (D) b31 to b16 b15 to b0 SM12 Rotate n bits to right	⎍	3	3/4
		DRCRP	DRCRP D n		⎎	3	7/8
Left rotation	16-Bit	ROL	ROL D n	SM12 b15 (D) b0 Rotate n bits to left	⎍	3	3/4
		ROLP	ROLP D n		⎎	3	7/8
		RCL	RCL D n	SM12 b15 (D) b0 Rotate n bits to left	⎍	3	3/4
		RCLP	RCLP D n		⎎	3	7/8
	32-Bit	DROL	DROL D n	(D+1) (D) SM12 b31 to b16 b15 to b0 Rotate n bits to left	⎍	3	3/4
		DROLP	DROLP D n		⎎	3	7/8
		DRCL	DRCL D n	(D+1) (D) SM12 b31 to b16 b15 to b0 Rotate n bits to left	⎍	3	3/4
		DRCLP	DRCLP D n		⎎	3	7/8
Right shift	16-Bit	SFR	SFR D n	b15 bn b0 b15 b0 SM12 0~0	⎍	3	3/4
		SFRP	SFRP D n		⎎	3	7/8
	Device unit	DSFR	DSFR D n	n (D) 0	⎍	3	3
		DSFRP	DSFRP D n		⎎	3	7
Left shift	16-Bit	SFL	SFL D n	b15 bn b0 SM12 b15 b0 0~0	⎍	3	3/4
		SFLP	SFLP D n		⎎	3	7/8
	Device unit	DSFL	DSFL D n	n (D) 0	⎍	3	3
		DSFLP	DSFLP D n		⎎	3	7

5.1.10 Data Processing Instructions

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps: Storage	No. of steps: Execution
Search	16-Bit	SER	SER S1 S2 D	(S1), (S2), n; (D) : Match No.; (D+1) : Number of matches	⎍	5	6
		SERP	SERP S1 S2 D		⎍↑	5	10
	32-Bit	DSER	DSER S1 S2 D	32-bit (S1), (S2), n; (D) : Match No.; (D+1) : Number of matches	⎍	5	6
		DSERP	DSERP S1 S2 D		⎍↑	5	10
Number of bits set to "1"	16-Bit	SUM	SUM S D	b15 (S) b0; (D) : Number of "1"s	⎍	3	3
		SUMP	SUMP S D		⎍↑	3	7
	32-Bit	DSUM	DSUM S D	(S+1) (S); (D) : Number of "1"s	⎍	3	3
		DSUMP	DSUMP S D		⎍↑	3	7
Decode	16-Bit	SEG	SEG S D	(S) b3~b0; (D); 7SEG	⎍	3	3
		SEGP	SEGP S D		⎍↑	3	7
	2n-Bit	DECO	DECO S D n	8→256 decode; (S) n; decode; (D) 2^n bit	⎍	4	4
		DECOP	DECOP S D n		⎍↑	4	8
Encode	2n-Bit	ENCO	ENCO S D n	256→8 encode; (S) 2 bit; encode; (D) n	⎍	4	4
		ENCOP	ENCOP S D n		⎍↑	4	8
Average value	16-Bit	SAVE	S.AVE S D n	16-bit data average value; $\frac{1}{n}\sum_{i=1}^{n}$ (S+i) → (D)	⎍↑	8	4

5.1.11 Other Function Instructions

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps: Storage	No. of steps: Execution
Carry flag set	-	S.STC	S.STC	Carry flag contact (SM12) is turned ON	⎍	4	1
Carry flag reset	-	S.CLC	S.CLC	Carry flag contact (SM12) is turned OFF	⎍	4	1

5.1.12 Exclusive Instructions

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
ATC	-	S.ATC	S.ATC Kn Rn Rm Mn	K1 : Tool No. search	⎍	9	9
				K2 : Tool No. AND operation search			
				K3 : Tool change			
				K4 : Arbitrary position tool change			
				K5 : Forward run of pointer			
				K6 : Reverse run of pointer			
				K7 : Forward run of tool table			
				K8 : Reverse run of tool table			
				K9 : Tool table read			
				K10 : Tool table write			
				K11 : Automatic write of tool table			
ROT	-	S.ROT	S.ROT Kn Rn Rm Mn	K1 : Rotary body index	⎍	9	9
				K3 : Ring counter			

5.2 Data Designation Method

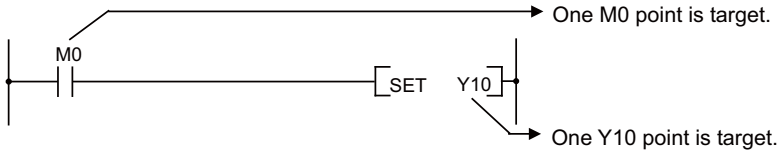
The following three types of data can be used in each instruction.
(1) Bit data
(2) Word (16-bit) data
(3) Double-word (32-bit) data

5.2.1 Bit Data

Bit data is data which handles contacts and coils, etc., in 1-bit units.
"Bit devices" and "bit-designated word devices" can be used for bit data.

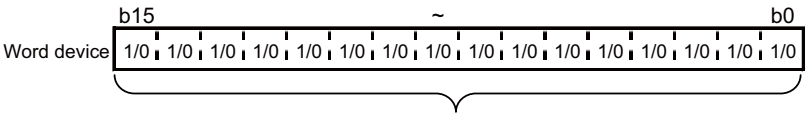
(1) When using bit devices

The bit device is designated with a 1-point unit.



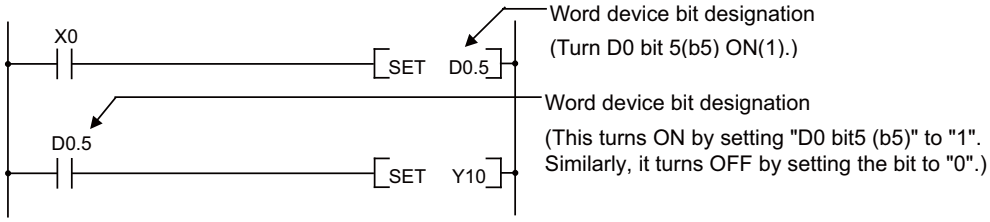
(2) When using word devices

With the word device, when the bit No. is designated, the bit for the designated bit No. can be used as bit data.



Each bit can be used with 1 as ON and 0 as OFF

The word device bit is designated as "word device","bit number".
(The bit No. is designated with a hexadecimal.)
For example, D0 bit 5 (b5) is designated as D0.5, and D0 bit 10 (b10) is designated as D0.A.
Note that the bit designated cannot be used for the timer (T), integrated timer (ST) , counter (C) or Index register (Z).
(Example: Z0.0 is invalid)



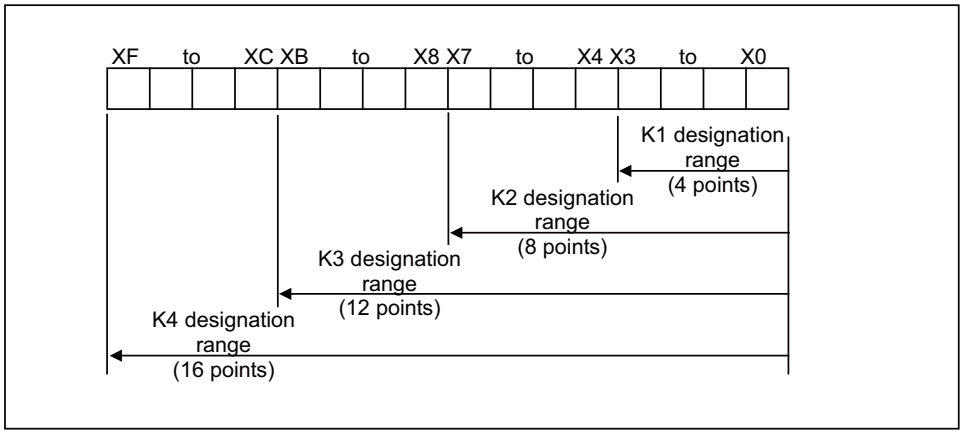
5.2.2 Word (16-bit) Data

Word data is a 16-bit numerical value data used with the basic instructions and applied instructions.
Word devices and digit-designated bit devices can be used with the word data.

(1) When using bit devices

Bit devices can be used as word devices by designating digits.
The bit data digit is designated as "number of digits""bit device head No.".
The digits can be designated between K1 and K4 with a 4-point (4-bit) unit.
The target numbers of points when X0 is designated as the digit are shown below.

- K1X0 --- 4 points X0 to X3 are the target
- K2X0 --- 8 points X0 to X7 are the target
- K3X0 --- 12 points X0 to XB are the target
- K4X0 --- 16 points X0 to XF are the target

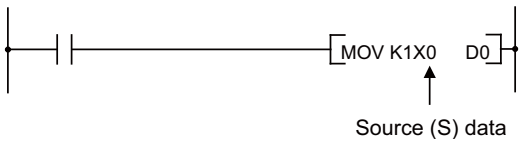


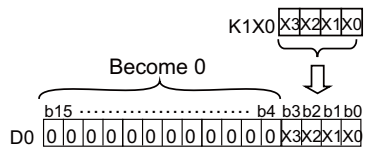
List of Numeric Values that Can Be Dealt with as Source Data for Digit Designation at Source (S) Side

Number of Digits Designated	With 16-Bit Instruction
K1 (4 points)	0 to 15
K2 (8 points)	0 to 255
K3 (12 points)	0 to 4095
K4 (16 points)	-32768 to 32767

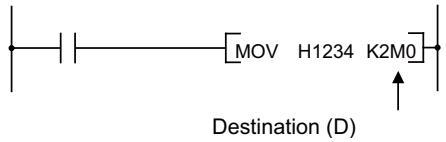
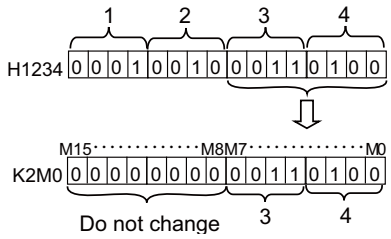
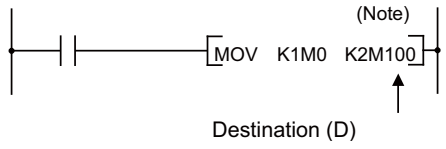
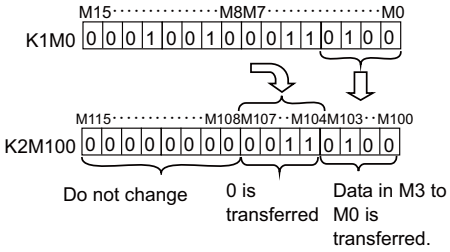
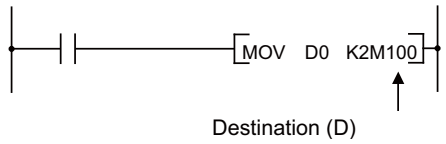
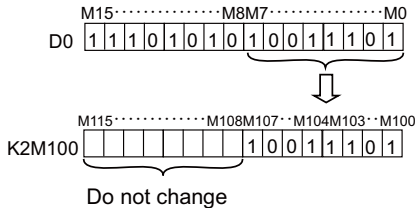
If the source side is a digit-designated bit device, and the destination is a word device, the word device on the destination side will be 0 after the digit-designated bits on the source side.

Ladder Example	Processing
With 16-bit instruction	



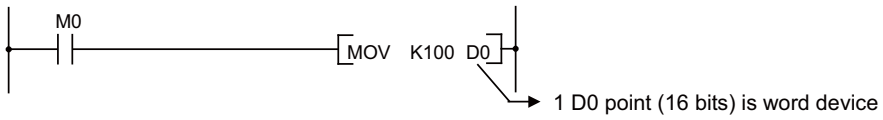


When a digit is designated on the destination (D) side, the No. of points designated by the digit will be the target of the destination side.

Ladder Example	Processing
When source data (S) is a numerical value 	
When source data (S) is a bit device 	
When source data (S) is a word device 	

(2) When using word devices

Word devices are designated in 1-point (16 bits) units.



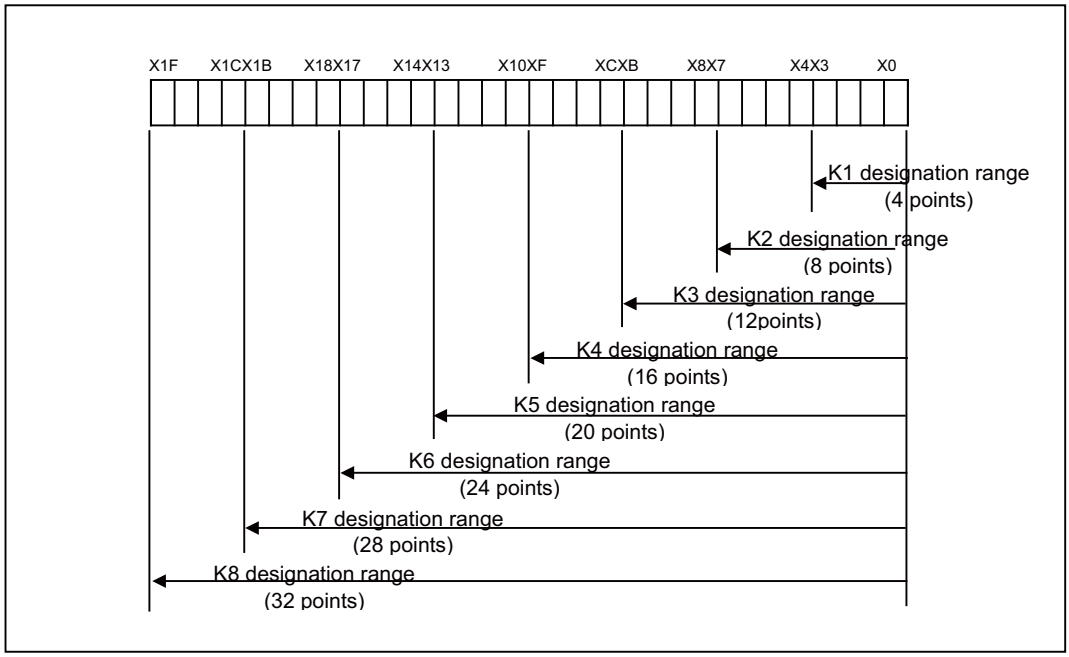
5.2.3 Using Double Word Data (32 bits)

Double word data is 32-bit numerical data used by basic instructions and application instructions.
Word devices and bit devices designated by digit designation can be used as double word data.

(1) When using bit devices

Digit designation can be used to enable a bit device to deal with double word data.
Digit designation of bit devices is done by designating "Number of digits" and "Initial number of bit device".
Digit designation of bit devices can be done in 4-point (4-bit) units, and designation can be made for K1 to K8.
For example, if X0 is designated for digit designation, the following points would be designated:

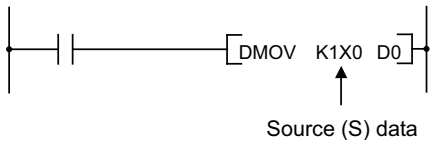
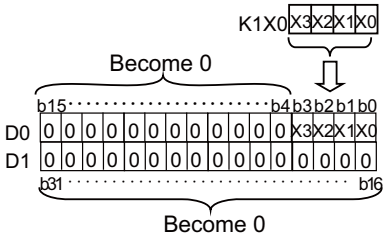
- K1X0 ….. The 4 points X0 through X3 are designated
- K2X0 ….. The 8 points X0 through X7 are designated
- K3X0 ….. The 12 points X0 through XB are designated
- K4X0 ….. The 16 points X0 through XF are designated



List of Numeric Values that Can Be Dealt with as Source Data for Digit Designation at Source (S) Side

Number of Digits Designated	With 32-bit Instructions	Number of Digits Designated	With 32-bit Instructions
K1 (4 points)	0 to 15	K5 (20 points)	0 to 1048575
K2 (8 points)	0 to 255	K6 (24 points)	0 to 16772165
K3 (12 points)	0 to 4095	K7 (28 points)	0 to 268435455
K4 (16 points)	0 to 65535	K8 (32 points)	-2147483648 to 2147483647

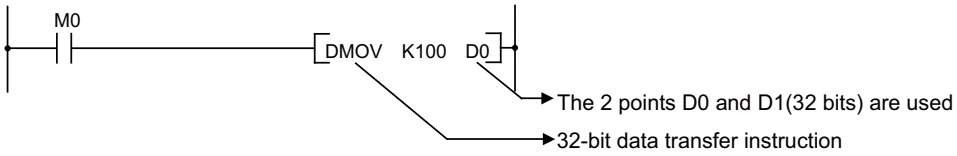
In cases where the source is a bit device designated by digit designation, and the destination is a word device, the word device for the destination becomes 0 following the bit designated by digit designation at the source.

Ladder Example	Processing
With 32-bit Instructions 	

(2) When using word devices

A word device designates devices used by the lower 16 bits of data.

A 32-bit instruction uses (designation device number) and (designation device number + 1).



5.3 Index Modification

Index modification is an indirect setting made by using an index register.
When an index modification is used in a sequence program, the device to be used will be [the device number designated directly] plus [the contents of the index register].
For example, if D2Z1 has been designated, and the content of Z1 is 3, D(2+3), or D5, will be the designated device.

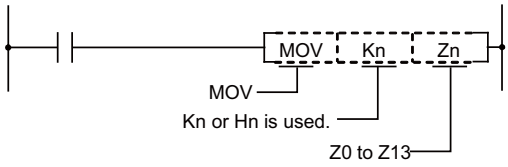
5.3.1 For Models with Extended Index Modification

(1) Index register (Z0 to Z13) can be set from -32768 to 32767 with sign.

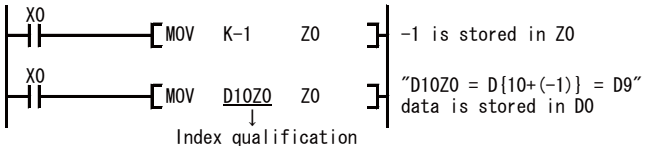
(2) Index modification is available in most instructions. (Refer to each instruction's explanation for specification details of instructions.)

(3) Following is the method for using index register.

(a) Transferring data to index register

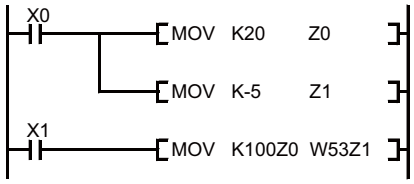
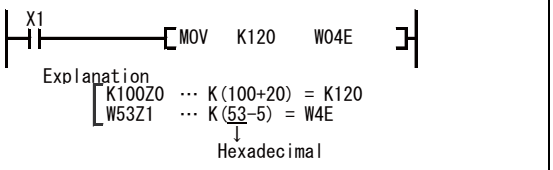
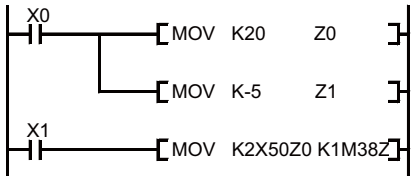
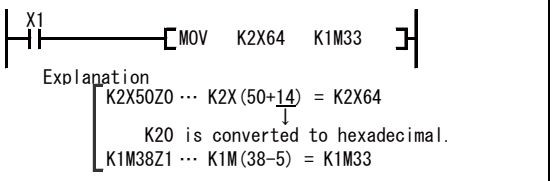
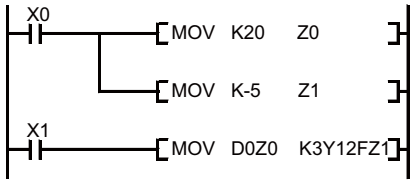
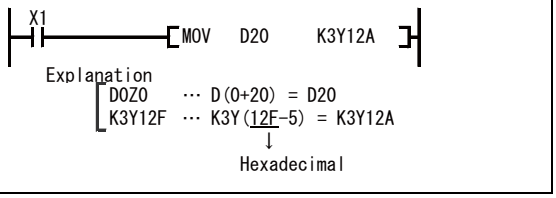


(b) Example of modification



The ladder example with modification and actual processing devices are showed below.

(Example) When Z0 = 20, Z1 = -5

Ladder example	Actual processing device
	
	
	

[Note]
The range check is invalid for device which operates modification during executing sequence program. So, be careful when using modification with index registers which exceeds the device' allowable range. Unexpected type of device might be referred or updated.
When using modification with 16 bit constant, following responses will be taken. Be careful with using beyond the maximum value or bellow the minimum value of 16 bit constant.
- When using larger value than the maximum -> Index modification will be executed on the minimum value. (Z0=1 with K32767Z0 will be considered as K-32768.)
-When using smaller value than the minimum -> Index modification will be executed on maximum value. (Z0=-1 with K-32768Z0 will be considered as K32767.)

(4) Restrictions of modification

Index modification has following restrictions

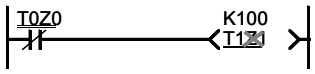
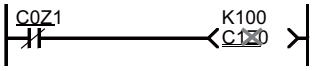
(a) Invalid devices for modification

Devices in following table are invalid for modification.

Devices	Description
K,H	32 bit constant (16 bit constant is available for modification) (Note)
□ . □	Word device bit designation
P	Pointer as a label
N	Master controller nesting level
Z	Index register
T,ST	Timer set value
C	Counter set value

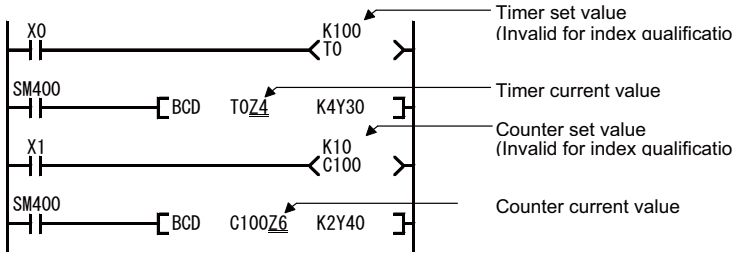
(Note) Constant designation of rotation instruction except for DSFR(P)/DSFL(P) is invalid for modification.

(b) Devices with restriction for index register usage

Devices	Description	Examples
T	- Only Z0 and Z1 can be used for timer contact point. - Not available for timer coil.	
C	- Only Z0 and Z1 can be used for counter contact point. - Not available for counter coil.	

(Remark)

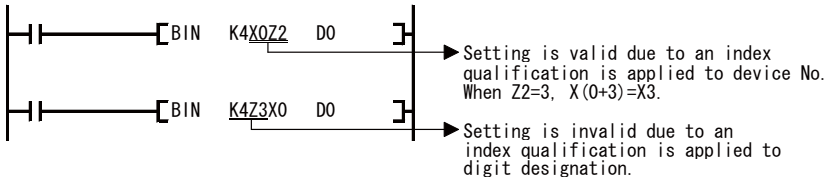
No restriction of index register No. for current value of timer and counter.



(c) Index modification on digit-designated bit device

Digit-designated bit device can be executed modification.

Digit-designated itself cannot be executed modification.



5.4 Operation Error

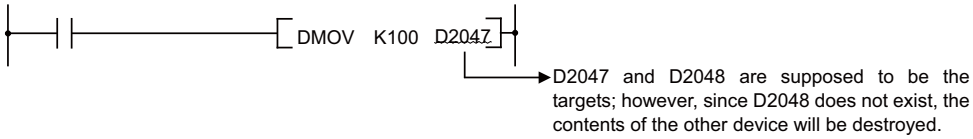
Operation error occurs in the following cases during execution of basic instruction and function instruction.

- In the case where an error described in each instruction's explanation page has occurred:

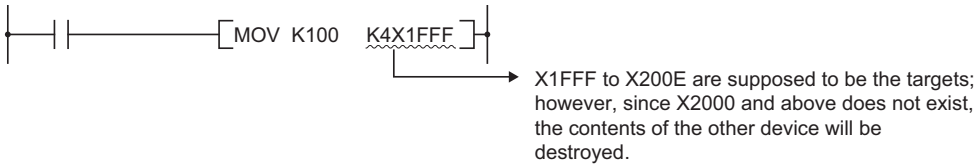
(1) Device range check

The range check for the devices to be used in basic instruction and function instruction is as shown below.

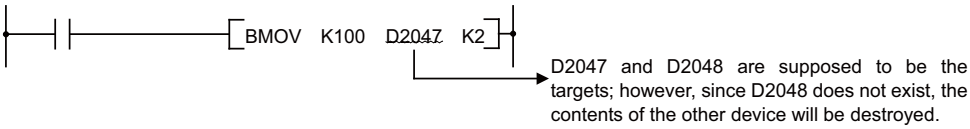
(a) If instruction handles a fixed length of device (MOV, DMOV, etc.), device range check will not be performed. In case that the relevant device range has exceeded, the data is written into another device.
For example, in a case indicated below, where D device is with the maximum 2048 points, error will not occur even if D2047 has been exceeded.



Device range check will not be performed when index Modification is carried out.
Also, device range check will not be performed at the bit device digit designation.
For example, in a case indicated below, error will not occur even if X1FFF has been exceeded.



(b) If instruction handles a variable length of device (BMOV, FMOV, etc. that would specify the number of transfers), device range check will not be performed. In case that the relevant device range has exceeded, the data is written into another device.
For example, in a case indicated below, where D device is with the maximum 2048 points, error will not occur even if D2047 has been exceeded.



(2) Device data check

Device's data check used for the basic instruction and function instruction is as shown below.

(a) BIN data
- Error does not occur even if the operation result is overflowed or underflowed.
  At this time, carry flag does not turn ON either.

(b) BCD data
- Checking as to whether each digit is BCD value (0/ to 9) is performed.
  If the digit is other than 0 to 9 (A to F), an operation error will result.
- Error does not occur even if the operation result is overflowed or underflowed.
  At this time, carry flag does not turn ON either.

5.5 Execution Condition of Instruction

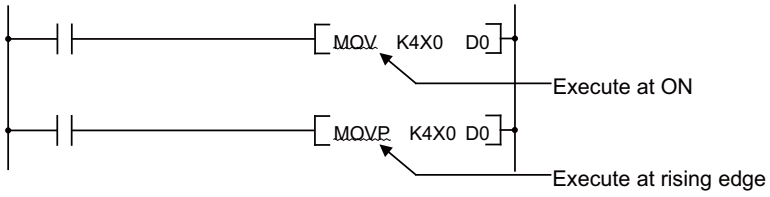
There are the following 4 kinds of execution conditions for basic instruction and function instruction.

- Execute all the time … Instruction executed regardless of device's ON/OFF
  Example: LD X0 , OUT Y10
- Execute at ON … Instruction executed when input condition is turned ON
  Example: MOV instruction, CJ instruction
- Execute at rising edge … Instruction executed only at the rising edge (OFF to ON) of input condition
  Example: PLS instruction, MOVP instruction
- Execute at falling edge … Instruction executed only at the falling edge (ON to OFF) of input condition
  Example: PLF instruction

With coil equivalent basic instruction and function instruction, if "execution at ON" and "execution at rising edge" are both possible with the same instruction, add "P" at the end of instruction to differentiate the execution condition.

- Instruction when executed at ON … Instruction name
- Instruction when executed at rising … edgeInstruction name + P

With MOV instruction, execution at ON and execution at rising edge are specified as shown below.



5.6 Counting Step Number

There are following 2 kinds of step numbers. Refer to "PLC Processing Program: Storing PLC Processing Program and Execution Mode" for details on the sequence program storage and execution.

The number of steps at storage and execution for each instruction is shown in "Instruction Tables".
Instruction list example

Class	Process unit	Instruction sign	Symbol	Process details	Execution condition	No. of steps	
						Storage	Execution
+ (BIN)	16-bit	+	+ S D	(D)+(S)→(D) (BIN)	⎍	3	3
		+P	+P S D		↑	3	7

Execution
Storage

(1) Number of steps during storage
This is the number of steps to be consumed when each instruction is stored in built-in ROM. This is stored in the instruction code format which is compatible with the MELSEC universal model QCPU sequencer.

When ZR/Z device is used, the number of steps will increase/decrease compared to the number of steps described in "Instruction Tables".
When using ZR/Z device, check the number of steps referring to the following.

(a) When using ZR/Z device as argument
When the condition of argument for the following instructions are;
- Word device or constant number
- Device No. being multiple of 16 when the bit device digit designation is used for argument
- K4 for the word designating instruction, K8 for the double word designating instruction at the time of using the bit device digit designation for argument
When these apply, the number of steps that increases/decreases with the argument position using ZR/Z device will differ.

Instruction sign	Device	Argument position	Increased/ decreased steps
LD=,LD<>,LD<,LD<=,LD>,LD>=, AND=,AND<>,AND<,AND<=,AND>,AND>=, OR=,OR<>,OR<.OR<=,OR>,OR>= LDD=,LDD<>,LDD<,LDD<=,LDD>,LDD>=, ANDD=,ANDD<>,ANDD<,ANDD<=,ANDD>, AND>=,ORD=,ORD<>,ORD<.ORD<=, ORD>,ORD>=	Index register Z	S1 or S2	-1
		S1 and S2	-2
	File register ZR	S1 or S2	+1
+, -,+P, -P,D+,D-,D+P,D-P, WAND,WOR,WXOR,WXNR, DAND,DOR,DXOR,DXNR, WANDP,WORP,WXORP,WXNRP, DANDP,DORP,DXORP,DXNRP (2 devices)	Index register Z	D	-1
		S1 and D	-2
	File register ZR	S1	+1
		D	+3
+, -,+P, -P,D+,D -,D+P,D -P, WAND,WOR,WXOR,WXNR, DAND,DOR,DXOR,DXNR, WANDP,WORP,WXORP,WXNRP, DANDP,DORP,DXORP,DXNRP (3 devices) *, *P, /, /P D*, D*P, D/, D/P	Index register Z	S1 and S2 and D	-2
		(S1 or S2) and D	-1
	File register ZR	S1 or S2	+1
		D	+2
INC,INCP,DEC,DECP,DINC,DINCP, DDEC,DDECP	Index register Z	D	-1
	File register ZR	D	+3
MOV,MOVP,DMOV,DMOVP	Index register Z	S and D	-1
	File register ZR	S or D	+1
BCD,BCDP,BIN,BINP,DBCD,DBCDP, DBIN,DBINP,CML,CMLP,DCML,DCMLP	Index register Z	S and D	-1
	File register ZR	S	+1
		D	+2

(b) For the conditions and the instructions that are not specified in (a), the number of steps will increase by 1 step every time ZR device is used.
(The number of steps will not decrease even when the Z device is used.)

(2) Number of steps during execution
This is the number of steps to be consumed when each instruction is executed. When executed, a sequence program is analyzed, and then it optimizes the references and converts into the instruction code for the PLC processing processor which is unique to the CNC. Thus, the length of each instruction (number of step) is varied before and after the conversion.

5.7 Operations when the OUT, SET/RST, or PLS/PLF Instruction of the Same Device is Used

Operations when multiple OUT instructions, SET/RST instructions or PLS/PLF instructions using the same device are executed in one scan are explained.

(1) When the OUT instruction of the same device is used:

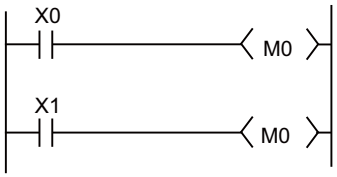
Do not execute the OUT instruction of the same device multiple times within one scan.

When the OUT instruction of the same device is executed multiple times in one scan, a specified device is turned ON/OFF at the time of each execution of OUT instruction, depending on the operation result up to the OUT instruction.

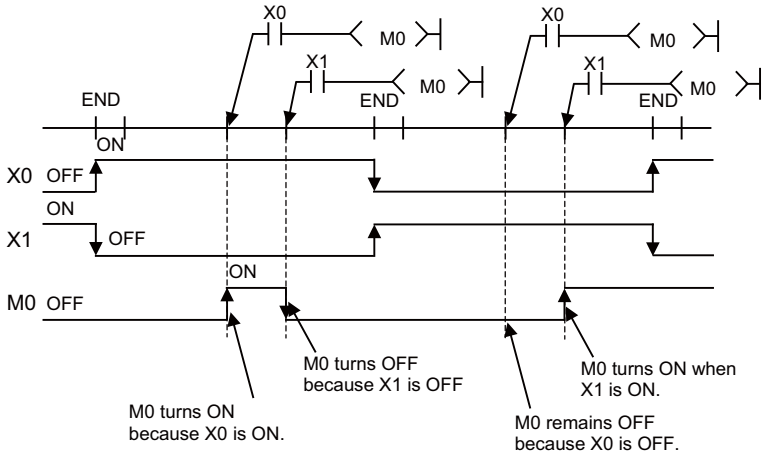
Because ON/OFF of the specified device is determined at the time of each execution of OUT instruction, ON/OFF may be repeated within one scan.

In the ladder example below, the same internal relay (M0) is turned ON/OFF with the input X0 and X1.

[Ladder]



[Timing chart]



In the case of refresh type CPU unit, when output (Y) is specified with OUT instruction, ON/OFF status of the OUT instruction executed at the end of 1 scan is output.

(2) When the SET/RST instruction of the same device is used:

(a) The SET instruction turns a specified device ON when the SET command is ON and it does not operate when the SET command is OFF.

Therefore, when the SET instructions of the same device are executed multiple times within one scan, and if one or more SET commands are ON, the specified device will be turned ON.

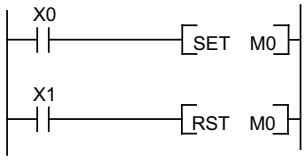
(b) The RST instruction turns a specified device OFF when the RST command is ON and it does not operate when the RST command is OFF.

Therefore, when the RST instructions of the same device are executed multiple times within one scan, and if one or more RST commands are ON, the specified device will be turned OFF.

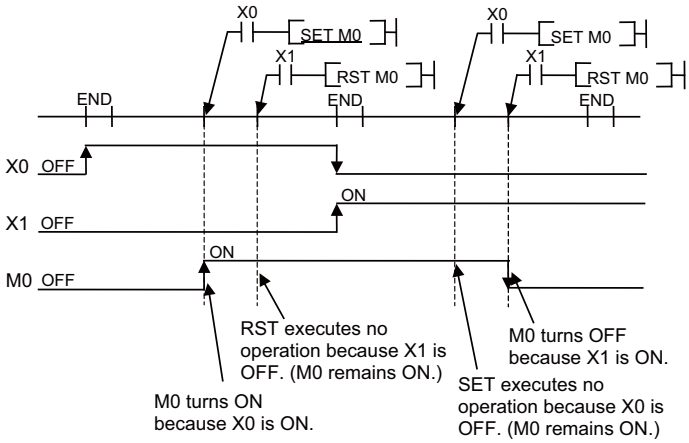
(c) When both the SET instruction and RST instruction of the same device exist within one scan, the SET instruction turns a specified device ON when the SET command is ON, and the RST instruction turns a specified device OFF when the RST command is ON.

When both the SET command and RST command are OFF, the specified device's ON/OFF status does not change.

[Ladder]



[Timing chart]



(3) When the PLS/PLF instruction of the same device is used:

The PLS instruction turns a specified device ON when the PLS command changes from OFF to ON, and it turns a specified device OFF when the PLS command changes in a way other than "from OFF to ON" (*1).

The PLF instruction turns a specified device ON when the PLF command changes from ON to OFF, and it turns a specified device OFF when the PLF command changes in a way other than "from ON to OFF" (*2).

(*1) The way is any one of the following.

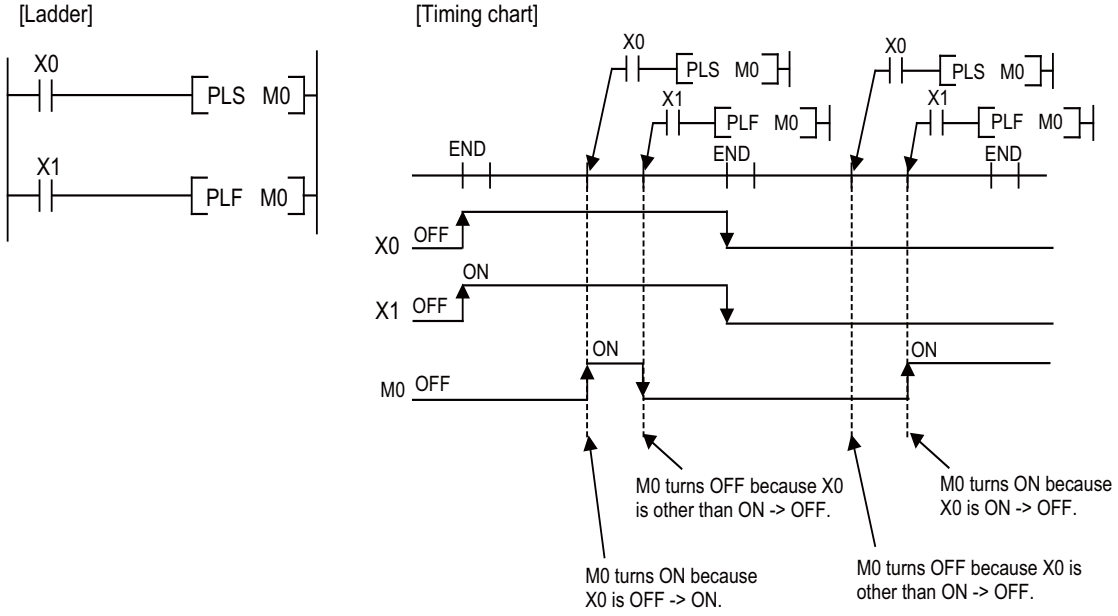
From OFF to OFF, from ON to ON, or from ON to OFF

(*2) The way is any one of the following.

From OFF to OFF, from OFF to ON, or from ON to ON

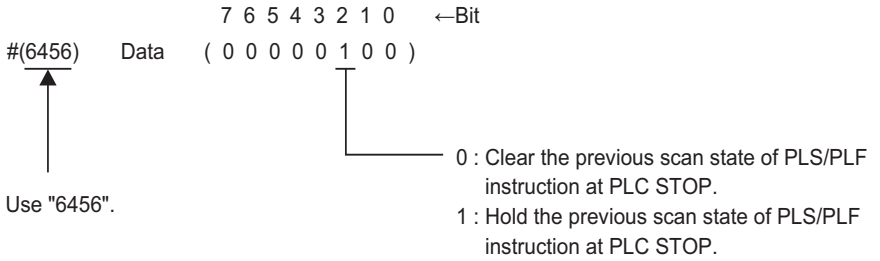
When the PLS/PLF instruction of the same device is executed several times in one scan, all PLS/PLF instructions are executed according to the program sequence. Note that the device turned ON by PLS/PLF instruction may not turn ON for one scan.

The same is true when the device used by the PLS/PLF instruction is identical to any other device as a result of index modification.



5.8 PLS/PLF Instruction Behavior in the State from PLC STOP to RUN

PLS instruction turns ON a specified device for one scan when PLS command changes from OFF to ON, and it turns OFF the specified device in other cases ("OFF to OFF", "ON to ON, or "ON to OFF"). Also, PLF instruction turns ON a specified device for one scan when the PLF command changes from ON to OFF, and it turns OFF the specified device in other cases ("OFF to OFF", "OFF to ON, or "ON to ON").
During PLC STOP, you can set to hold or clear the "previous scan state of PLS/PLF instruction" in the bit selection parameter. This setting is enabled when the PLC restarts.

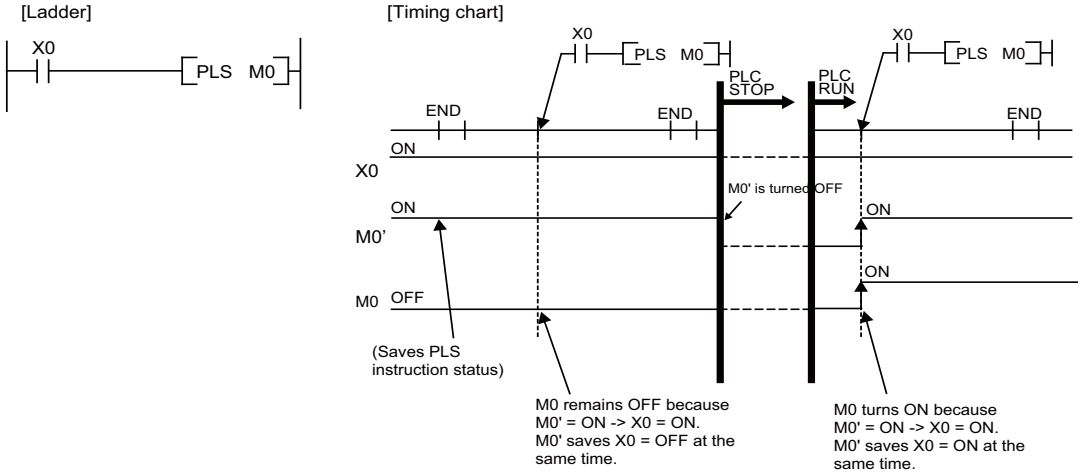


Behaviors of PLS instruction are shown below as an example.

(1) Behaviors while "#6456/bit2" (PLS/PLF instruction Holding PLC in STOP state valid) is set to "0".

Clear "previous scan state of PLS/PLF instruction" at PLC STOP.

When RUN is executed from PLC STOP again, PLS/PLF instruction is executed with the cleared state of "previous scan sate of PLS/PLF instruction". Therefore, even if the contact point of PLS instruction is ON at PLC STOP, the device of one scan PLS instruction argument turns ON when RUN is executed from PLC STOP.

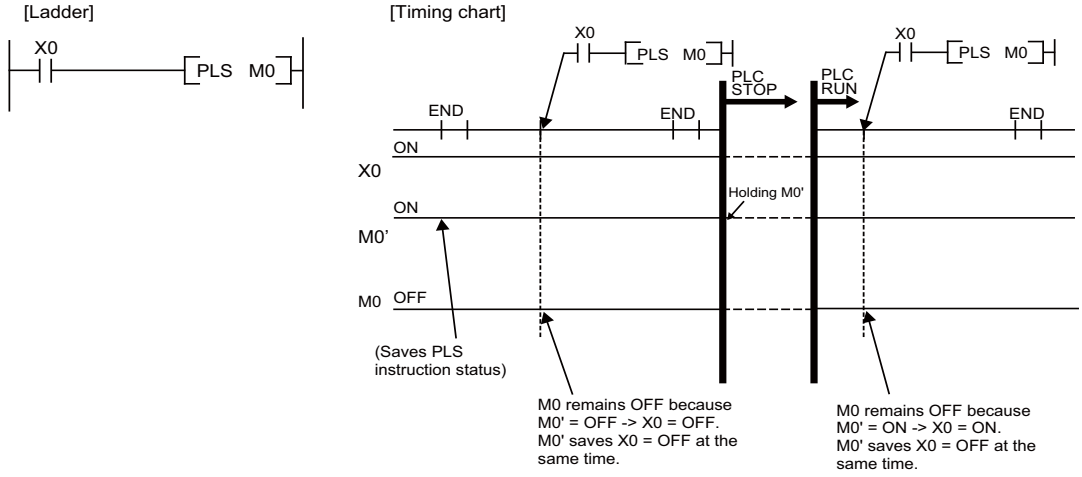


(2) Behaviors while "#6456/bit2" (PLS/PLF instruction Holding PLC in STOP state valid) is set to "1".

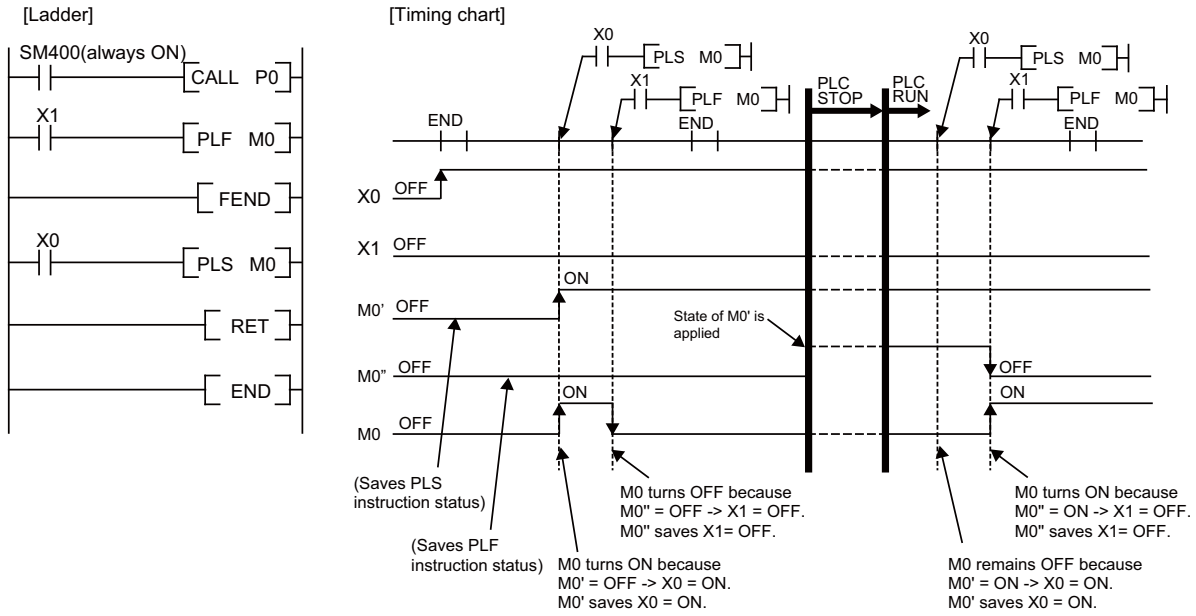
This behaves in the same manner as the M7 Series.

Hold "previous scan state of PLS/PLF instruction" at PLC STOP.

When RUN is executed from PLC STOP again, PLS/PLF instruction is executed with "previous scan state of PLS/PLF instruction" at PLC STOP. Therefore, even if the contact point of PLS instruction is ON at PLC STOP, the device of one scan PLS instruction argument stays OFF when RUN is executed from PLC STOP.

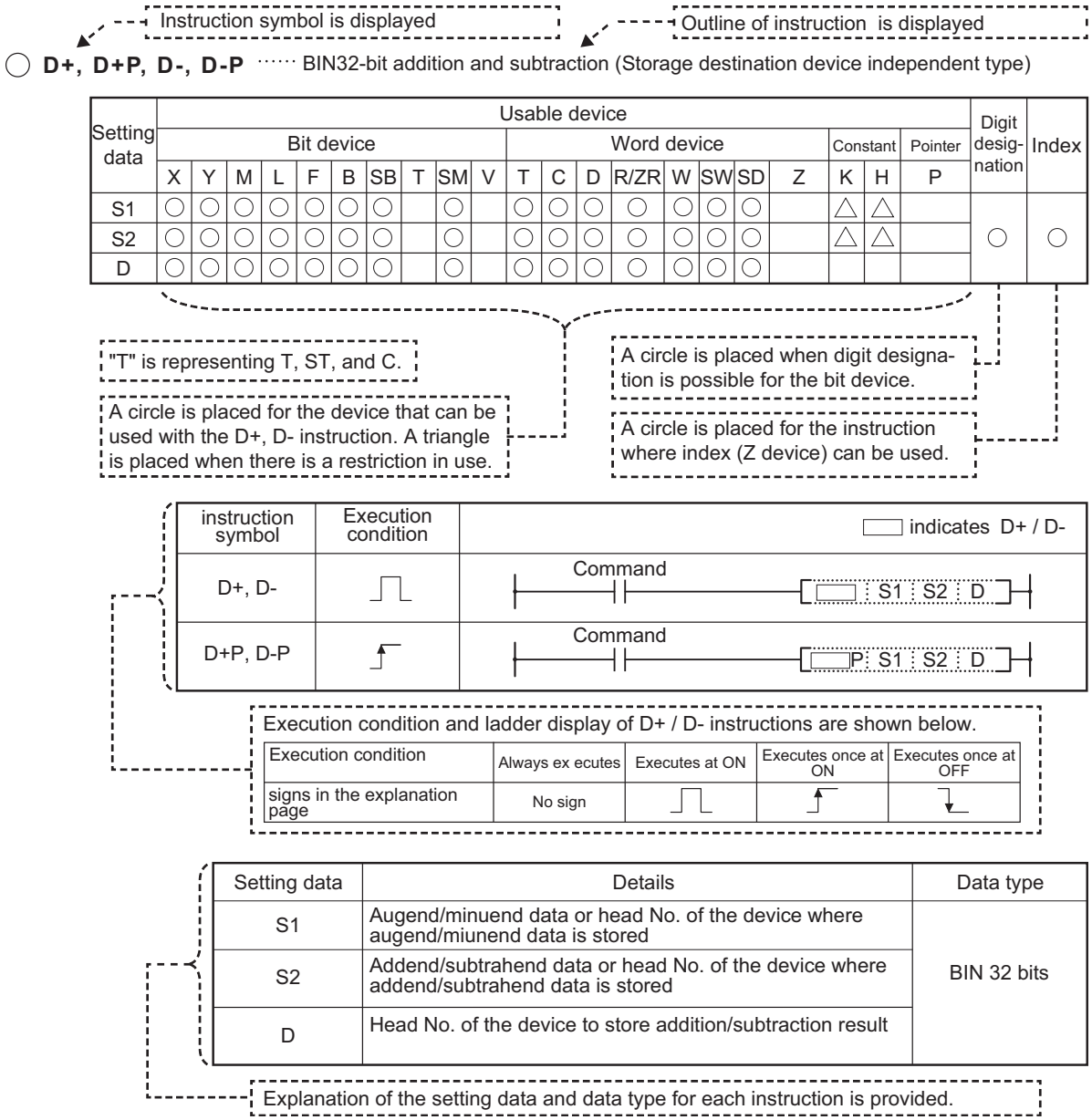


(Note) When setting "#6456/bit2" (PLS/PLF instruction Holding PLC in STOP state valid) to "1" and creating a sequence program which execute PLS/PLF instruction of the same device several times for one scan, this holds the PLS/PLF instruction near the end of sequence program at PLC STOP. (Not the last executed PLS/PLF instruction state.)
Then, when performing PLC RUN again, the held PLS/PLF instruction state is used as the previous scan state.
When a device that is the origin of index modification is used as the argument of any other PLS/PLF instruction, it is regarded as the same device.
Because of this, when creating a sequence program which execute PLS/PLF instruction of the same device several times for one scan, be aware that the PLS/PLF instruction may not behave in a way as intended.
In the multi-project environment, it will be in the same manner as when creating a sequence program to execute PLS/PLF instruction in the each project with the same device of common devices for projects (X, Y, R, ZR, etc.).
In this case, PLS/PLF instruction state which the number of projects is greater is held, and it is used as "previous scan state of the PLS/PLF instruction" of each project.



5.9 How to Read Instruction Tables

The basic instructions and function instructions are explained as follows.



Setting data	Usable device																				Digit designation	Index
	Bit device										Word device								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		△	△		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		△	△		
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○					

instruction symbol	Execution condition	indicates D+ / D-
D+, D-	⎍	Command ⊣⊢ [▭ S1 S2 D]
D+P, D-P	⎍↑	Command ⊣⊢ [▭P S1 S2 D]

Execution condition	Always ex ecutes	Executes at ON	Executes once at ON	Executes once at OFF
signs in the explanation page	No sign	⎍	⎍↑	⎍↓

Setting data	Details	Data type
S1	Augend/minuend data or head No. of the device where augend/miunend data is stored	BIN 32 bits
S2	Addend/subtrahend data or head No. of the device where addend/subtrahend data is stored	
D	Head No. of the device to store addition/subtraction result	

The functions first, then execution conditions, then program examples are described on the following pages.

6

Basic Instructions

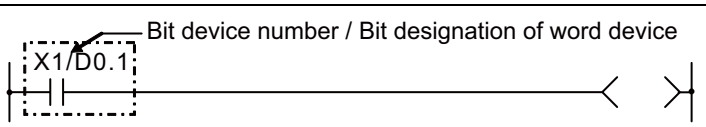
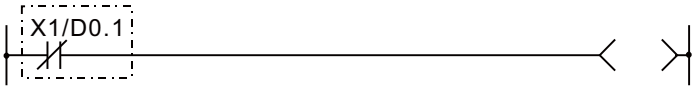
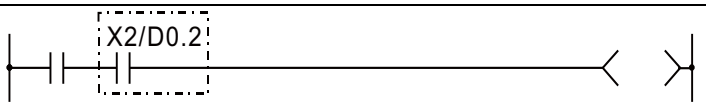
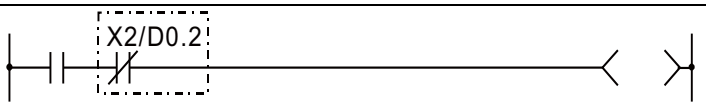
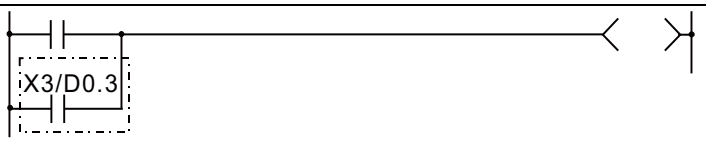
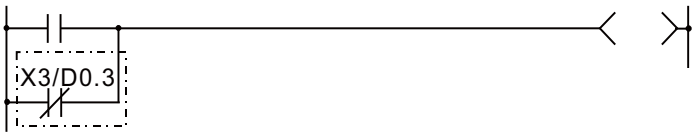
Basic instructions include instructions to describe relay control ladders, etc. They are divided into the following categories.

Instruction	Meaning
Contact instruction	Operation start, series connection, parallel connection
Connection instruction	Ladder block connection, creation of pulses from operation results, store/read operation results
Output instruction	Bit device output, pulse output, output reversal
Shift instruction	Bit device shift
Master control instruction	Master control
Other instructions	Instructions which do not fall into the above categories, such as no operation.

6.1 Contact instruction

○**LD, LDI (Operation start) AND, ANI (Series connection) OR, ORI (Parallel connection)**

Setting data	Usable device																				Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S	○	○	○	○	○	○	○	○	○		○	○	○	○	○	○	○						○

Instruction symbol	Execution condition	
LD		
LDI		
AND		
ANI		
OR		
ORI		

Set Data

Set Data	Meaning	Data Type
S	Devices used as connections	Bit

Functions

LD,LDI

(1) LD is the A contact operation start instruction, and LDI is the B contact operation start instruction. They read ON/OFF information from the designated device (if a word device bit has been designated, this becomes the 1/0 status of the designated bit), and use that as an operation result.

AND,ANI

(1) AND is the A contact series connection instruction, and ANI is the B contact series connection instruction. They read the ON/OFF data of the designated bit device (if a bit designation has been made for a word device, the 1/0 status of the designated bit is read), perform an AND operation on that data and the operation result to that point, and take this value as the operation result.

OR,ORI

(1) OR is the A contact single parallel connection instruction, and ORI is the B contact single parallel connection instruction. They read ON/OFF information from the designated device (if a word device bit has been designated, this becomes the 1/0 status of the designated bit), and perform an OR operation with the operation results to that point, and use the resulting value as the operation result.

[REMARK]
Word device bit designations are made in hexadecimal. Bit b11 of D0 would be D0.B.

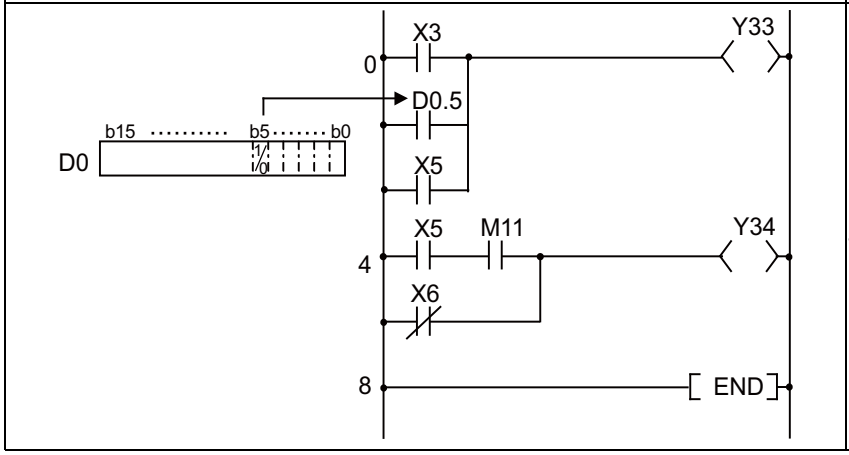
Operation Errors

(1) There are no operation errors with LD,LDI,AND,ANI,OR,or ORI instructions.

Program Example

(1) A program using LD, AND,OR, and ORI instructions.

[Ladder Mode]

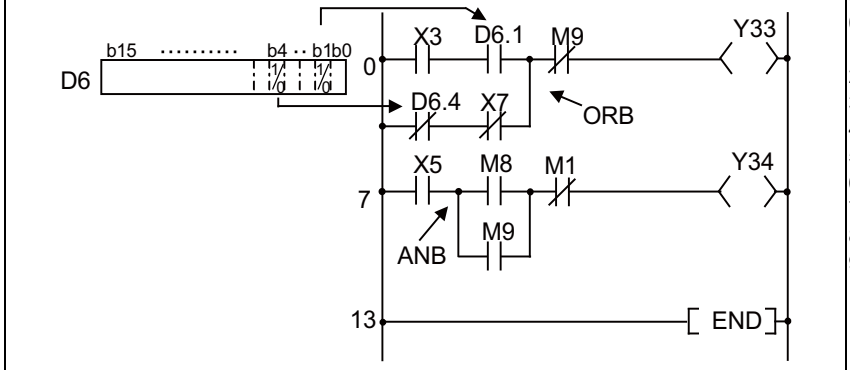


[List Mode]

Steps	Inst.	Device
0	LD	X3
1	ORD0.5	
2	OR	X5
3	OUT	Y33
4	LD	X5
5	AND	M11
6	ORI	X6
7	OUT	Y34
8	END	

(2) A program linking contact points established through the use of ANB and ORB instructions.

[Ladder Mode]

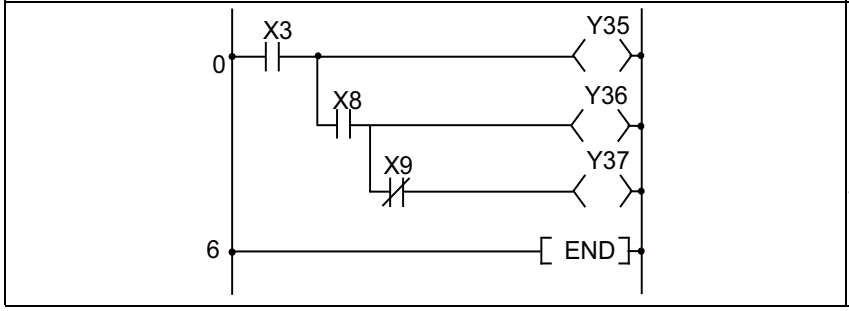


[List Mode]

Steps	Inst.	Device
0	LD	X3
1	AND	D6.1
2	LDI	D6.4
3	ANI	X7
4	ORB	
5	ANI	M9
6	OUT	Y33
7	LD	X5
8	LD	M8
9	OR	M9
10	ANB	
11	ANI	M11
12	OUT	Y34
13	END	

(3) A parallel program with OUT instruction

[Ladder Mode]



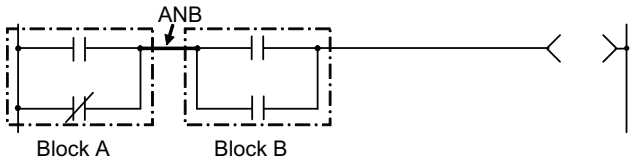
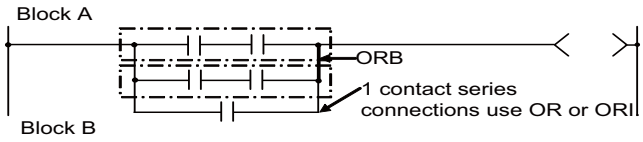
[List Mode]

Steps	Inst.	Device
0	LD	X5
1	OUT	X35
2	AND	X8
3	OUT	Y36
4	ANI	X9
5	OUT	Y37
6	END	

6.2 Connection Instruction

○ANB, ORB ... Ladder block series connections and parallel connections

Setting data	Usable device																				Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		

Instruction symbol	Execution condition	
ANB		
ORI		

Functions

ANB

(1) Performs an AND operation on block A and block B, and takes the resulting value as the operation result.

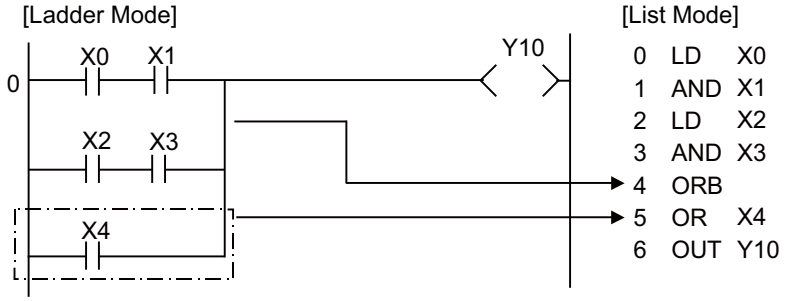
(2) The symbol for ANB is not the contact symbol, but rather is the connection symbol.

(3) When programming in the list mode, up to 7 instructions of ANB and ORB combined (8 blocks) can be used consecutively.

ORB

(1) Conducts an OR operation on block A and block B, and takes the resulting value as the operation result.

(2) ORB is used to perform parallel connections for ladder blocks with two or more contacts.
For ladder blocks with only one contact, use OR or ORI; there is no need for ORB in such cases.



(3) The ORB symbol is not the contact symbol, but rather is the connection symbol.

(4) When programming in the list mode, up to 7 instructions of ANB and ORB combined (8 blocks) can be used consecutively.

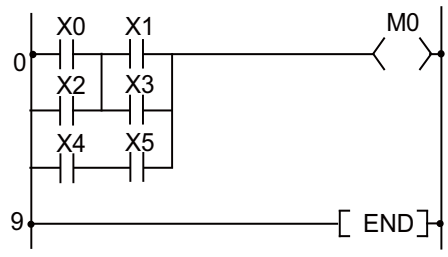
Operation Errors

(1) There are no operation errors with ANB or ORB instructions.

Program Example

(1) A program using ANB and ORB instructions

[Ladder Mode]

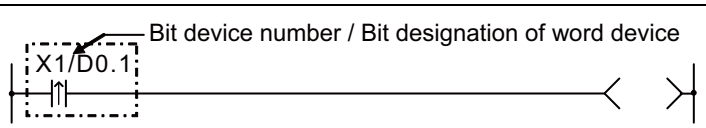
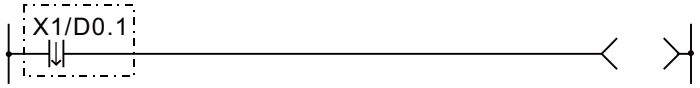
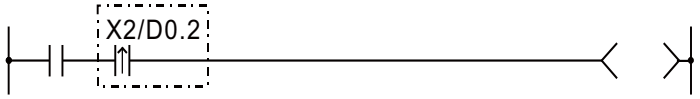
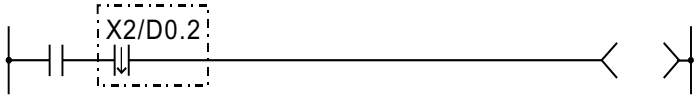
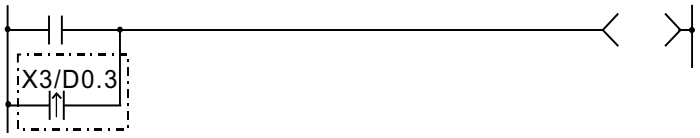
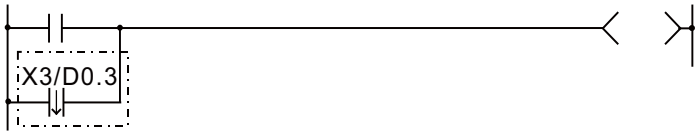


[List Mode]

Steps	Inst.	Device
0	LD	X0
1	OR	X2
2	LD	X1
3	OR	X3
4	ANB	
5	LD	X4
6	AND	X5
7	ORB	
8	OUT	M0
9	END	

○**LDP, LDF, ANDP, ANDF, ORP, ORF ... Pulse operation start, pulse series connection, pulse parallel connection**

Setting data	Usable device																			Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S	○	○	○	○	○	○	○	○	○				○	○	○	○	○						○

Instruction symbol	Execution condition	
LDP		
LDF		
ANDP		
ANDF		
ORP		
ORF		

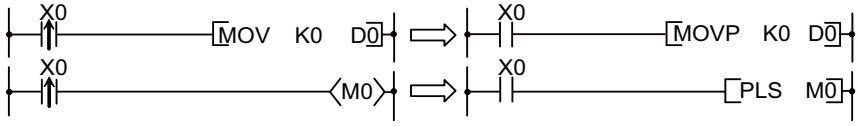
Set Data

Set Data	Meaning	Data Type
S	Devices used as contacts	Bit

Functions

LDP,LDF

(1) LDP is the rising edge pulse operation start instruction, and is ON only at the rising edge of the designated bit device (when it goes from OFF to ON).
If a word device has been designated, it is ON only when the designated bit changes from 0 to 1.
In cases where there is only an LDP instruction, it acts identically to instructions for the creation of a pulse that are executed during ON (□ P).



A ladder using LDP instruction A ladder not using an LDP instruction

(2) LDF is the falling edge pulse operation start instruction, and is ON only at the falling edge of the designated bit device (when it goes from ON to OFF). If a word device has been designated, it is ON only when the designated bit changes from 1 to 0.

ANDP,ANDF

(1) ANDP is a rising edge pulse series connection instruction, and ANDF is a falling edge pulse series connection instruction. They perform an AND operation with the operation result to that point, and take the resulting value as the operation result.
The ON/OFF data used by ANDP and ANDF are indicated in the table below:

Devices Designated by ANDP		ANDP State	Devices Designated by ANDF		ANDF State
Bit Device	Word Device Bit Designation		Bit Device	Word Device Bit Designation	
OFF → ON	0 → 1	ON	OFF → ON	0 → 1	OFF
OFF	0	OFF	OFF	0	
ON	1		ON	1	
ON → OFF	1 → 0		ON → OFF	1 → 0	ON

ORP,ORF

(1) ORP is a rising edge pulse parallel connection instruction, and ORF is a falling edge pulse parallel connection instruction. They perform an OR operation with the operation result to that point and take the resulting value as the operation result.

Devices Designated by ORP		ORP State	Devices Designated by ORF		ORF State
Bit Device	Word Device Bit Designation		Bit Device	Word Device Bit Designation	
OFF → ON	0 → 1	ON	OFF → ON	0 → 1	OFF
OFF	0	OFF	OFF	0	
ON	1		ON	1	
ON → OFF	1 → 0		ON → OFF	1 → 0	ON

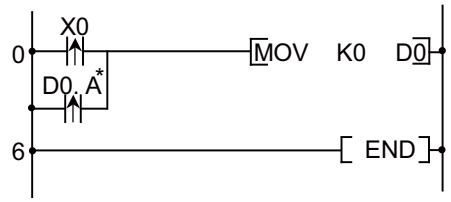
Operation Errors

(1) There are no operation errors with LDP, LDF, ANDP, ANDF, ORP, or ORF instructions.

Program Example

(1) The following program executes the MOV instruction at input X0, or at the rising edge of b10 (bit 10) of data register D0.

[Ladder Mode]



[List Mode]

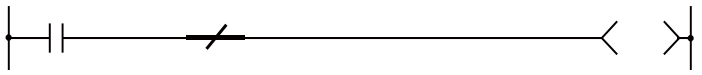
Steps	Inst.	Device
0	LDP	X0
2	ORP	D0. A
4	MOV	K0
		D0
6	END	

[REMARK]

1)* : Word device bit designations are performed in hexadecimal.
Bit b10 of D0 would be D0.A.

○**INV ... Operation results inversion**

Setting data	Usable device																			Digit designation	Index
	Bit device										Word device							Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		

Instruction symbol	Execution condition	
INV		

Functions

Inverts the operation result immediately prior to the INV instruction.

Operation Result Immediately Prior to the INV Instruction.	Operation Result Following the Execution of the INV Instruction.
OFF	ON
ON	OFF

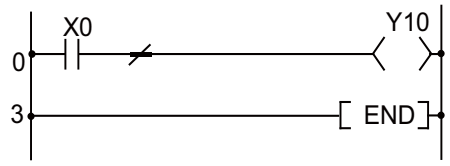
Operation Errors

(1) There are no operation errors associated with the INV instruction.

Program Example

(1) A program which inverts the X0 ON/OFF data, and outputs from Y10.

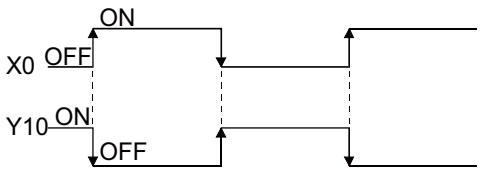
[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X0
1	INV	
2	OUT	Y10
3	END	

[Timing Chart]

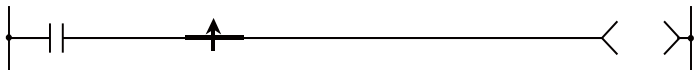
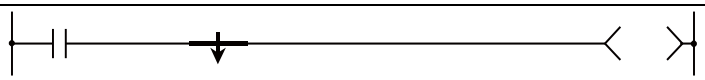


POINT

(1) The INV instruction operates based on the results of calculation made until the INV instruction is given. Accordingly, use it in the same position as that of the AND instruction.
The INV instruction cannot be used at the LD and OR positions.

○**MEP, MEF ... Operation result pulse conversion**

Setting data	Usable device																			Digit desig-nation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		

Instruction symbol	Execution condition	
MEP		
MEF		

Functions

MEP

(1) If operation results up to MEP instruction are rising edge (from OFF to ON), goes ON (continuity state).
If operation results up to MEP instruction are anything other than rising edge, goes OFF (noncontinuity state).

(2) Use of the MEP instruction simplifies pulse conversion processing when multiple contacts are connected in series.

MEF

(1) If operation results up to MEF instruction are falling edge (from ON to OFF), goes ON (continuity state).
If operation results up to MEF instruction are anything other than falling edge, goes OFF (noncontinuity state).

(2) Use of the MEF instruction simplifies pulse conversion processing when multiple contacts are connected in series.

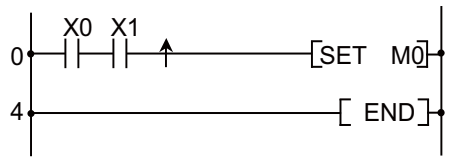
Operation Errors

(1) There are no operation errors associated with the MEP or MEF instructions.

Program Example

(1) A program which performs pulse conversion on the operation results of X0 and X1.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X0
1	AND	X1
2	MEP	
3	SET	M0
4	END	

POINT

(1) The MEP and MEF instructions may not work properly after the pulse conversion of contacts with index in a subroutine program or in a FOR - NEXT instruction.
Use EGP/ EGF instruction when executing a pulse conversion of contact with index in a FOR - NEXT instruction or in a subroutine program.
(2) Because the MEP and MEF instructions operate with the operation results immediately prior to the MEP and MEF instructions, the AND instruction should be used at the same position.
The MEP and MEF instructions cannot be used at the LD or OR position.

○EGP, EGF ... Pulse conversion of edge relay operation results

Setting data	Usable device																			Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
										○													○

Instruction symbol	Execution condition	
EGP		Command Vn
EGF		Command Vn

Set Data

Set Data	Meaning	Data Type
Vn	Edge relay No. where operation results are stored	Bit

Functions

EGP

(1) Operation results up to the EGP instruction are stored in memory by the edge relay (V).

(2) Goes ON (continuity state) at the rising edge (OFF to ON) of the operation result up to the EGP instruction.
If the operation result up to the EGP instruction is other than a rising edge (i.e., from ON to ON, ON to OFF, or OFF to OFF), it goes OFF (non-continuity state).

(3) Use the EGP instruction to execute a pulse operation of programs such as subroutine programs or programs with index modification between FOR and NEXT.

(4) The EGP instruction can be used like an AND instruction.

EGF

(1) Operation results up to the EGF instruction are stored in memory by the edge relay (V).

(2) Goes ON (continuity state) at the falling edge (from ON to OFF) of the operation result up to the EGF instruction.
If the operation result up to the EGF instruction is other than a falling edge (i.e., from OFF to ON,ON to ON, or OFF to OFF), it goes OFF (non-continuity state).

(3) Use the EGF instruction to execute a pulse operation of programs such as subroutine programs or programs with index modification between FOR and NEXT.

(4) The EGF instruction can be used like an AND instruction.

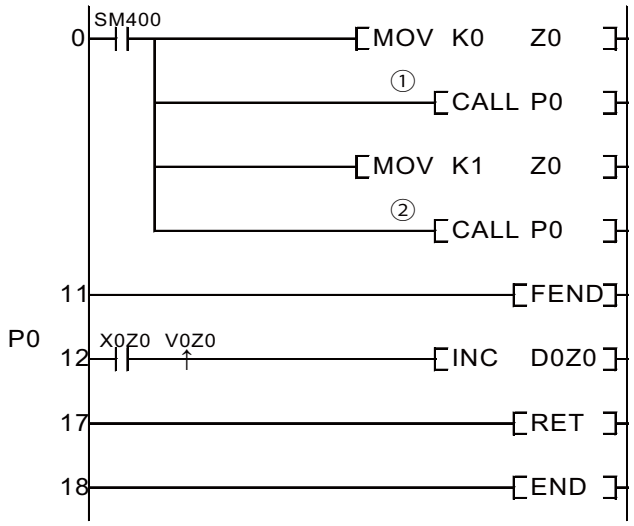
Operation Errors

(1) There are no operation errors associated with the EGP or EGF instructions.

Program Example

(1) Program which uses EGF instruction in sub routine program.

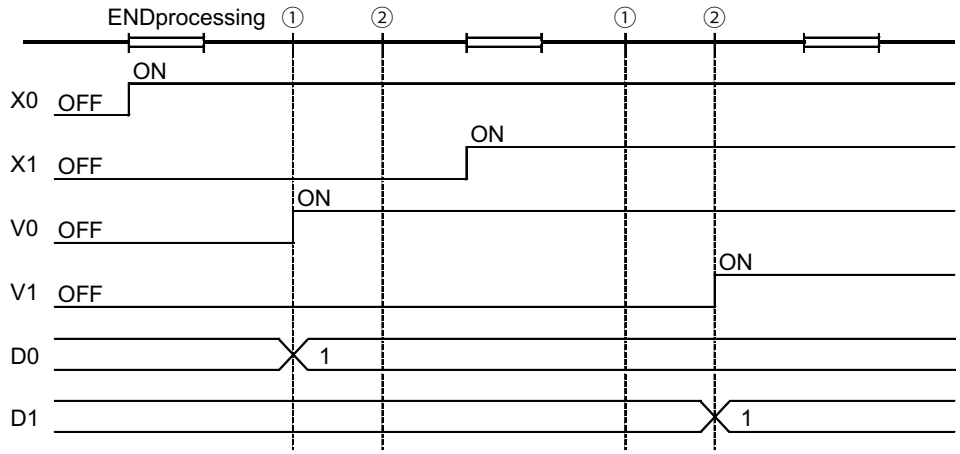
[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	SM400
1	MOV	K0
		Z0
4	CALL	P0
6	MOV	K1
		Z0
9	CALL	P0
11	FEND	
12		P0
13	LD	X0Z0
14	EGP	V0Z0
15	INC	D0Z0
17	RET	
18	END	

[Operation]]

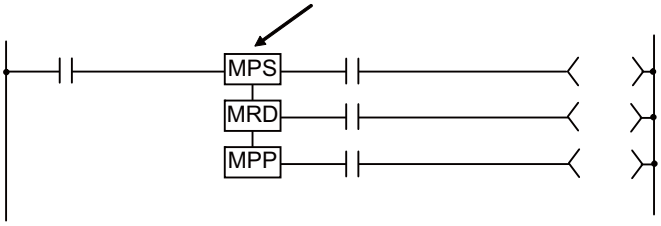


POINT

(1) Because the EGP and EGF instructions operate with the operation results immediately prior to the EGP and EGF instructions, the AND instruction should be used at the same position.
The EGP and EGF instructions cannot be used at the LD or OR position.

○**MPS, MRD, MPP ... Store, read and clear of operation result**

Setting data	Usable device																			Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		

Instruction symbol	Execution condition	
		MPS, MRD, and MPP are not displayed as a part of the ladder display. 

Functions

MPS

(1) Stores in memory the operation result (ON or OFF) immediately prior to the MPS instruction.

(2) Up to 7 MPS instructions can be used successively. However, if an MPP instruction is used in the middle of process, the number of uses calculated for the MPS instruction will be decremented by one.

MRD

(1) Reads the operation result stored for the MPS instruction, and uses that result to perform the operation in the next step.

MPP

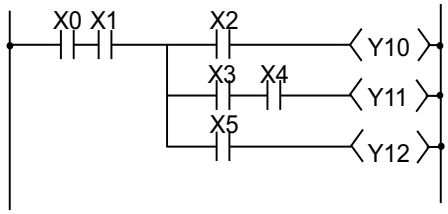
(1) Reads the operation result stored for the MPS instruction, and uses that result to perform the operation in the next step.

(2) Clears the operation results stored by the MPS instruction.

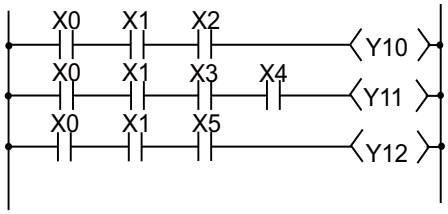
POINT

(1) The following shows ladders both using and not using the MPS, MRD, and MPP instructions.

Ladder using the MPS, MRD, and MPP instructions.



Ladder not using MPS, MRD, and MPP instructions.



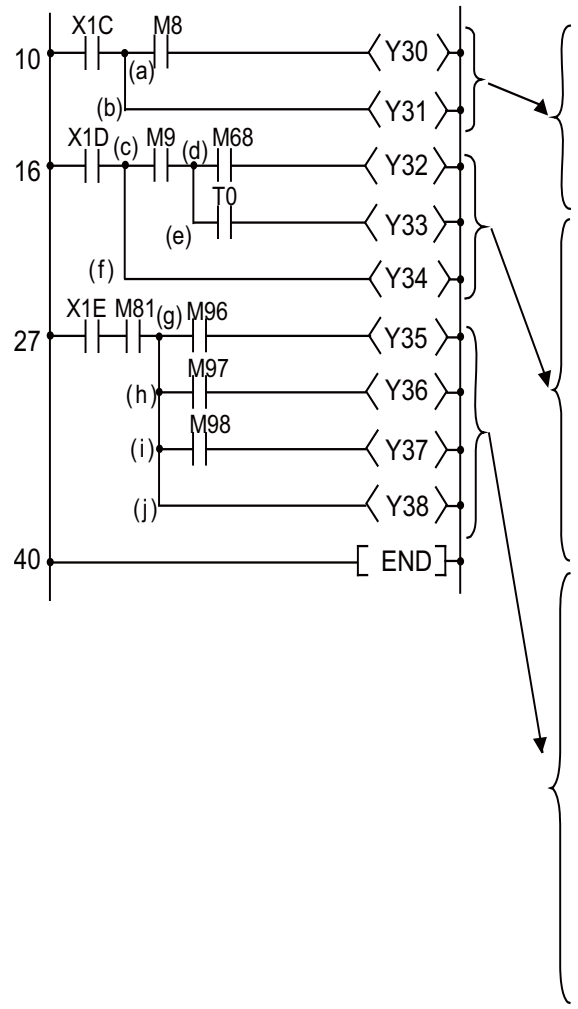
Operation Errors

(1) There are no errors associated with the MPS, MRD, or MPP instructions.

Program Example

(1) A program using the MPS, MRD, and MPP instructions.

[Ladder Mode]



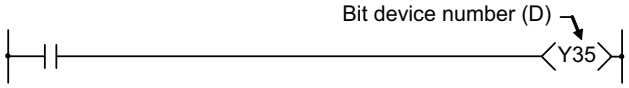
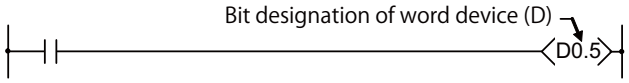
[List Mode]

	Steps	Inst.	Device
	10	LD	X1C
(a)	11	MPS	
	12	AND	M8
	13	OUT	Y30
(b)	14	MPP	
	15	OUT	Y31
	16	LD	X1D
(c)	17	MPS	
	18	AND	M9
(d)	19	MPS	
	20	AND	M68
	21	OUT	Y32
(e)	22	MPP	
	23	AND	T0
	24	OUT	Y33
(f)	25	MPP	
	26	OUT	Y34
	27	LD	X1E
	28	AND	M81
(g)	29	MPS	
	30	AND	M96
	31	OUT	Y35
(h)	32	MRD	
	33	AND	M97
	34	OUT	Y36
(i)	35	MRD	
	36	AND	M98
	37	OUT	Y37
(j)	38	MPP	
	39	OUT	Y38
	40	END	

6.3 Output Instruction

○OUT(Y, M, L, F, B, SB, SM) … Out instructions (Y, M, L, F, B, SB, SM)

Setting data	Usable device																				Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
D	○	○	○	○	○	○	○		○				○	○	○	○	○						○

Instruction symbol	Execution condition	
OUT		
		

Set Data

Set Data	Meaning	Data Type
D	Number of device to be turned ON and OFF	Bit

Functions

(1) Operation results up to the OUT instruction are output to the designated device.

Operation results	When Using Bit Devices			When Bit Designation has been Made for Word Device
	Coil	Contact		Bit Designated
		A Contact	B Contact	
OFF	ON	Non-continuity	Continuity	0
ON	ON	Continuity	Non-continuity	1

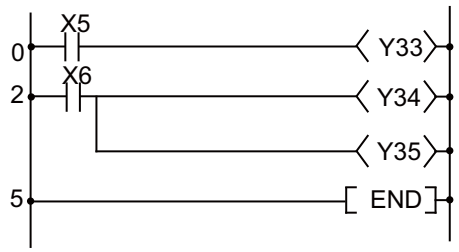
Operation Errors

(1) There are no operation errors associated with the OUT instruction.

Program Example

(1) When bit device is in use

[Ladder Mode]

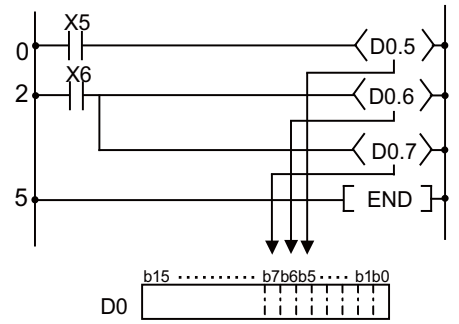


[List Mode]

Steps	Inst.	Device
0	LD	X5
1	OUT	Y33
2	LD	X6
3	OUT	Y34
4	OUT	Y35
5	END	

(2) When bit designation has been made for word device

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X5
1	OUT	D0.5
2	LD	X6
3	OUT	D0.6
4	OUT	D0.7
5	END	

○OUT(T, ST), OUTH(T) ... 100ms, 10ms timer output

Setting data	Usable device																			Digit designation	Index
	Bit device										Word device								Constant	Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
D											○												
Setting value													○	○	○	○	○		○				

Instruction symbol	Execution condition	
OUT T □ (100ms timer) **OUT ST □ (100ms retentive timer)**		Set value (Valid from 1 to 32767) K50 T0
		Set value (Valid from 1 to 32767 of the contents of data register) D10 T0
OUTH T □ (10ms timer)		Set value (Valid from 1 to 32767) Display of 10ms timer output instruction → H K50 T0
		Set value (Valid from 1 to 32767 of the contents of data register) H D10 T0

Set Data

Set Data	Meaning	Data Type
D	Timer number	Bit
Set value	Value set for timer	BIN 16 bits

[REMARK]

(1) Timer values can be set only as a decimal constant (K). Hexadecimal constants (H) cannot be used for timer settings.

(2) The retentive timer (ST) cannot be used for the 10ms timer.

Functions

(1) When the operation results up to the OUT instruction are ON, the timer coil goes ON and the timer counts up to the value that has been set; when the time up state (total numeric value is equal to or greater than the setting value), the contact responds as follows:

A contact	Continuity
B contact	Non-continuity

(2) The following will apply if the calculation result up to OUT instruction changes from ON to OFF.

Type of Timer	Timer Coil	Present Value of Timer	Prior to Time Up		After Time Up	
			A Contact	B Contact	A Contact	B Contact
100ms timer	OFF	0	Non-continuity	Continuity	Continuity	Non-continuity
100ms retentive timer	OFF	Maintains the present value	Non-continuity	Continuity	Continuity	Non-continuity
10ms timer	OFF	0	Non-continuity	Continuity	Continuity	Non-continuity

(3) The contact status of retentive timer after time-up will not be changed until the RST instruction is executed.

(4) A negative number (-32768 to -1) cannot be set as the setting value for the timer.
If a negative value is set for the word device, operation is carried out taking the value as a positive value with no signs.

(5) When 0 is set for the set value, time will be up instantly.

(6) In cases where the OUT instruction is not executed while the OUT instruction is ON due to the JMP instruction, etc., no present value update or contact ON/OFF operation is conducted. Also, if the same OUT instruction is conducted two or more times during the same scan, the present value will be updated for the number of times executed.

POINT

(1) Setting the timer setting value using the setting display device.
The method for setting the value of timer T and retentive timer ST includes the following two ways.
- A method in which the setting value (Kn) programmed by a sequence program is validated. (Fixed timer)
- A method in which the setting value set with the setting display device is validated. (Variable timer)
Refer to "Explanation of Devices:Detailed Explanation of Devices" for details on variable timer.

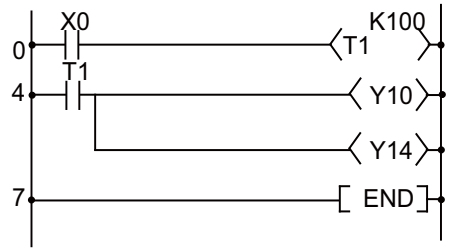
Operation Errors

(1) There are no operation errors associated with the OUT T □ or OUTH T □ instruction.

Program Example

(1) The following program turns Y10 and Y14 ON 10 seconds after X0 has gone ON.

[Ladder Mode]

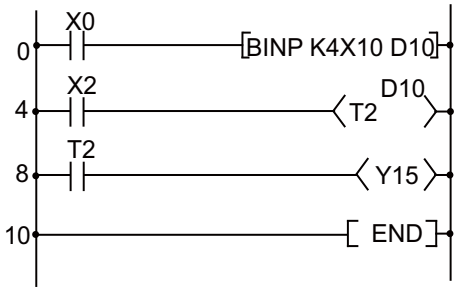


[List Mode]

Steps	Inst.	Device
0	LD	X0
1	OUT	T1
		K100
4	LD	T1
5	OUT	Y10
6	OUT	Y14
7	END	

(2) The following program uses the BCD data at X10 to X1F as the timer's set value.

[Ladder Mode]



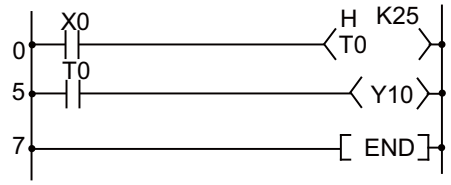
Converts BCD data at X10 to X1F to BIN and stores at D10.
When X2 goes ON, the data stored at D10 is calculated as the set value.
Y15 goes ON when T2 counts up.

[List Mode]

Steps	Inst.	Device
0	LD	X0
1	BINP	K4X10
		D10
4	LDX2	
5	OUT	T2
		D10
8	LD	T2
9	OUT	Y15
10	END	

(3) The following program turns Y10 ON 250ms after X0 has gone ON.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X0
1	OUTH	T0
		K25
5	LD	T0
6	OUT	Y10
7	END	

○**OUT(C) ... Counters**

Setting data	Usable device																			Digit designation	Index
	Bit device										Word device							Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
D												○											
Setting value													○	○	○	○	○		○				

Instruction symbol	Execution condition	
OUT C □		Set value (Valid from 1 to 32767) K50 C0
		Set value (Valid from 1 to 32767 of the contents of data register) D10 C0

Set Data

Set Data	Meaning	Data Type
D	**Counter No.**	**Bit**
Set value	**Counter set value**	**BIN 16 bits**

[REMARK]

(1) Only decimal constant (K) can be used for the counter setting value.
Hexadecimal constant (H) cannot be used for the counter setting value.

Functions

(1) When the operation results up to the OUT instruction change from OFF to ON, 1 is added to the present value (count value) and the count up status (present value = set value), and the contacts respond as follows:

A contact	Continuity
B contact	Non-continuity

(2) Not counted if the operation result is remained ON. (There is no need to perform pulse conversion on count input.)

(3) After "present value ≥ set value" has been realized, the contact state will not be changed until RST instruction is executed, but the present value is further added by +1.
In this case, the present value is added by +1 up to 65535, and then counted up again by +1 from 0.

(4) A negative number (-32768 to -1) cannot be set as the setting value. If a negative value is set for the word device, operation is carried out taking the value as a positive value with no signs. If the set value is 0, the processing is identical to that of when 1 is set.

POINT

(1) Setting the timer setting value using the setting display device.
The method for setting the value of timer T and retentive timer ST includes the following two ways.
- A method in which the setting value (Kn) programmed by a sequence program is validated.
(Fixed timer)
- A method in which the setting value set with the setting display device is validated. (Variable timer)
Refer to "Explanation of Devices:Detailed Explanation of Devices" for details on variable timer.

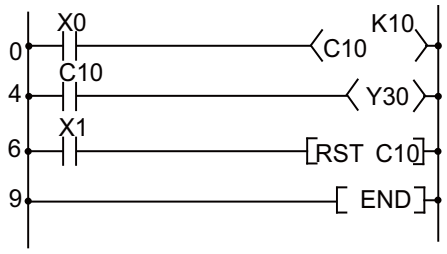
Operation Errors

(1) There are no operation errors associated with the OUT C □ instruction.

Program Example

(1) The following program turns Y30 ON after X0 has gone ON 10 times, and resets the counter when X1 goes ON.

[Ladder Mode]

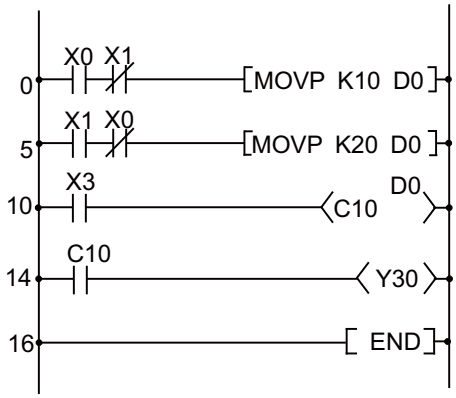


[List Mode]

Steps	Inst.	Device
0	LD	X0
1	OUT	C10
		K10
4	LD	C10
5	OUT	Y30
6	LD	X1
7	RST	C10
9	END	

(2) The following program sets the value for C10 at 10 when X0 goes ON, and at 20 when X1 goes ON

[Ladder Mode]



Stores 10 at D0 when X0 goes ON

Stores 20 at D0 when X1 goes ON

C10 takes data stored at D0 as set value, and counts

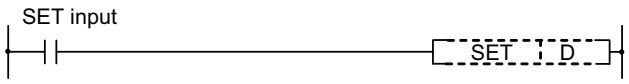
Y30 goes ON when C10 reaches count up state

[List Mode]

Steps	Inst.	Device
0	LD	X0
1	ANI	X1
2	MOVP	K10
		D0
5	LD	X1
6	ANI	X0
7	MOVP	K20
		D0
10	LD	X3
11	OUT	C10
		D0
14	LD	C10
15	OUT	Y30
16	END	

○**SET ... Setting devices (ON)**

Setting data	Usable device																				Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
D	○	○	○	○	○	○	○		○				○	○	○	○	○						○

Instruction symbol	Execution condition	
SET		

Set Data

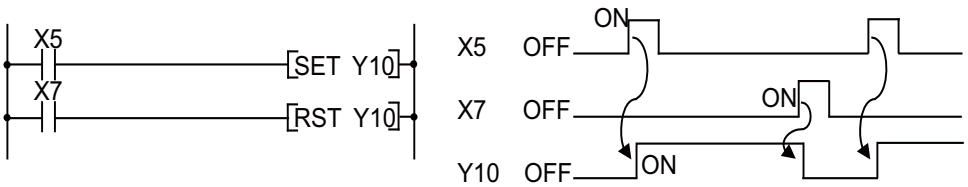
Set Data	Meaning	Data Type
D	Bit device number to be set (ON)	Bit

Functions

(1) When SET input is ON, the designated devices respond as follows:

Device	Device Status
Bit device	Coils and contacts turned ON
Word device	Designation bit set at 1

(2) Devices turned ON will stay ON even if SET input goes to OFF. Devices turned ON by the SET instruction can be turned OFF by the RST instruction.



(3) Device status does not change when SET input is OFF.

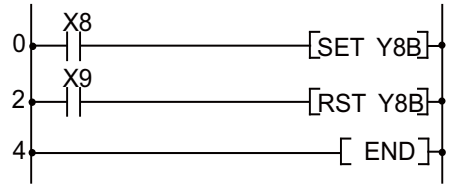
Operation Errors

(1) There are no operation errors associated with the SET instruction.

Program Example

(1) When X8 is turned ON, Y8B is set (turned ON); when X9 is turned ON, Y8B is reset (turned OFF).

[Ladder Mode]

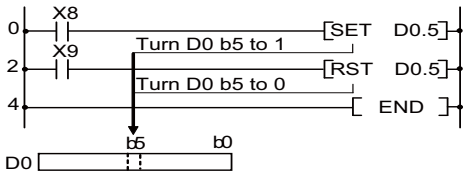


[List Mode]

Steps	Inst.	Device
0	LD	X8
1	SET	Y8B
2	LD	X9
3	RST	Y8B
4	END	

(2) When X8 is turned ON, D0 bit5 (b5) is turned to 1; when X9 is turned ON, D0 bit 5 (b5) is turned to 0.

[Ladder Mode]

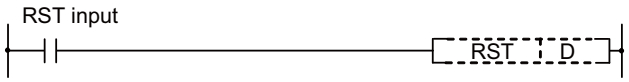


[List Mode]

Steps	Inst.	Device
0	LD	X8
1	SET	D0.5
2	LD	X9
3	RST	D0.5
4	END	

○**RST ... Resetting devices**

Setting data	Usable device																				Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○						○

Instruction symbol	Execution condition	
RST		

Set Data

Set Data	Meaning	Data Type
D	Device No. to be reset	Bit

Functions

(1) Designated devices respond as follows when RST input is turned ON:

Device	Device Status
Bit device	Turns coils and contacts OFF
Timers and counters	Sets the present value to 0, and turns coils and contacts OFF
Word device	Sets value of designated bit to 0

(2) Device status does not change when RST input goes OFF

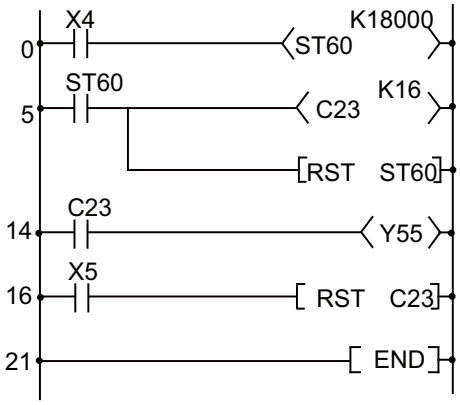
Operation Errors

(1) There are no operation errors associated with the RST instruction.

Program Example

(1) Reset of 100ms retentive timer and counter is executed.

[Ladder Mode]



When ST60 is set for the retentive timer, ST60 is turned ON when X4's ON time reaches 30 minutes.

The number of times when ST60 has turned ON is counted.

When ST60 is turned ON, ST60 is reset.

When C23 counts up, Y55 is turned ON.)

When X5 is turned ON, C23 is reset.

[List Mode]

Steps	Inst.	Device
0	LD	X4
1	OUT	ST60
		K18000
5	LD	ST60
6	OUT	C23
		K16
10	RST	ST60
14	LD	C23
15	OUT	Y55
16	LD	X5
17	RST	C23
21	END	

○**PLS, PLF ... Pulse (1 scan ON)**

Setting data	Usable device																				Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
D	○	○	○	○	○	○	○		○				○	○	○	○	○						○

Instruction symbol	Execution condition	
PLS		Command → PLS D
PLF		Command → PLF D

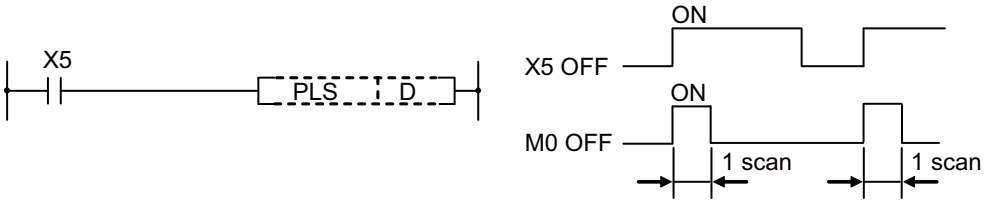
Set Data

Set Data	Meaning	Data Type
D	Pulse conversion device	Bit

Functions

PLS

(1) When PLS instruction is turned OFF to ON, turn specified device ON for 1 scan; otherwise (ON→ON,ON→OFF,OFF→ON), turn OFF.

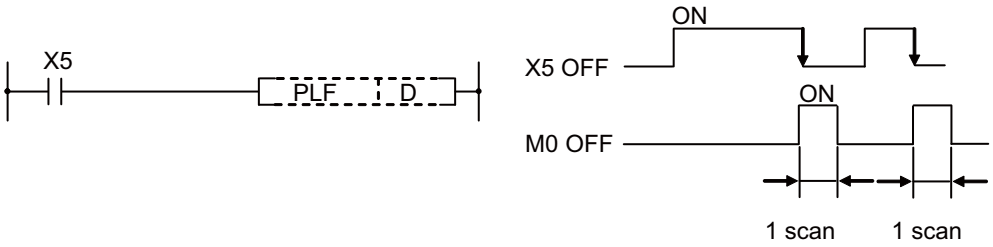


(2) If the RUN key switch is changed from RUN to STOP after the execution of the PLS instruction, the PLS instruction will not be executed again even if the switch is set back to RUN. PLS instruction will be executed if the PLS instruction has been ON when the power was turned ON.

(3) When a latch relay (L) is specified for the PLS instruction, switching power OFF with the latch relay (L) ON and then switching it ON again executes the specified device's 1scan ON.

PLF

(1) When PLF instruction is changed from ON to OFF, the designated device is turned 1 scan ON. For the other cases (OFF→OFF,OFF→ON,ON→ON), the designated device is turned OFF.



(2) Turn the sequence program RUN switch to STOP after PLF instruction. Even if switched to RUN again, PLF instruction will not be executed.

POINT
Note that the device designated by D may be ON more than one scan if the PLS or PLF instruction is jumped by the CJ instruction or if the subroutine program where the PLS/PLF instruction had been executed was not called by the CALL instruction.

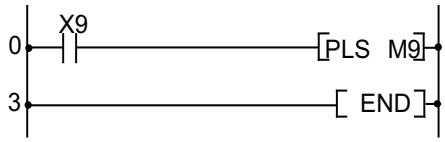
Operation Errors

(1) There are no operation errors associated with the PLS or PLF instructions.

Program Example

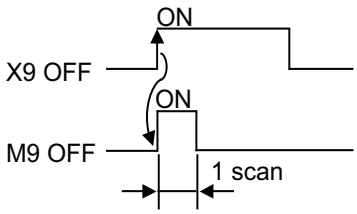
(1) The following program executes the PLS instruction when X9 goes ON.

[Ladder Mode]



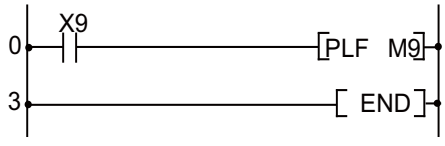
[List Mode]

Steps	Inst.	Device
0	LD	X9
1	PLS	M9
3	END	



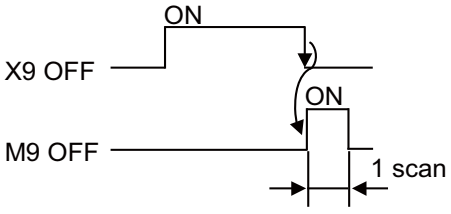
(2) The following program executes the PLF instruction when X9 goes OFF.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X9
1	PLF	M9
3	END	



○**FF ... Reversing the operation result**

Setting data	Usable device																				Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
D	○	○	○	○	○	○	○		○				○	○	○	○	○						○

Instruction symbol	Execution condition	
FF		Command FF D

Set Data

Set Data	Meaning	Data Type
D	Device number to invert	Bit

Functions

(1) The status of the device designated by (D) is inverted when the inversion command goes from OFF to ON.

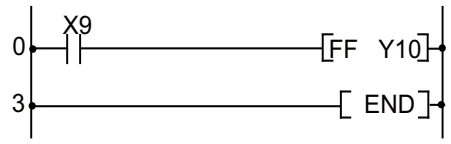
Device	Device Status	
	Prior to FF execution	**After FF execution**
Bit device	**OFF**	ON
	ON	OFF
Bit designation of word device	0	1
	1	0

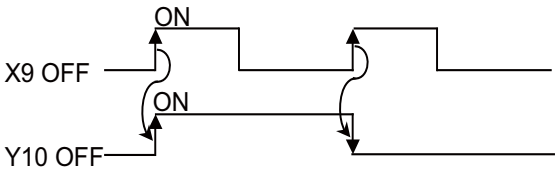
Operation Errors

(1) There are no operation errors associated with the FF instruction.

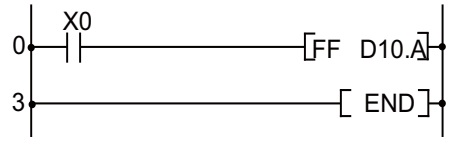
Program Example

(1) The following program inverts the output of Y10 when X9 goes ON.

[Ladder Mode]	[List Mode]
	Steps Inst. Device 0 LD X9 1 FF Y10 3 END



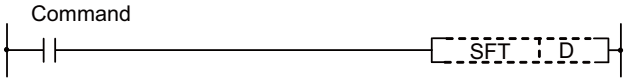
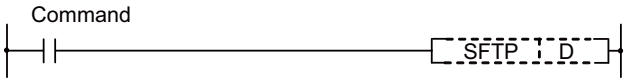
(2) The following program reverses b10 (bit 10) of D10 when X0 goes ON

[Ladder Mode]	[List Mode]
	Steps Inst. Device 0 LD X0 1 FF D10.A 3 END

6.4 Shift Instruction

○**SFT, SFTP ... Device shift**

Setting data	Usable device																				Digit designation	Index
	Bit device										Word device								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
D	○	○	○	○	○	○	○		○				○	○	○	○	○					○

Instruction symbol	Execution condition	
SFT		
SFTP		

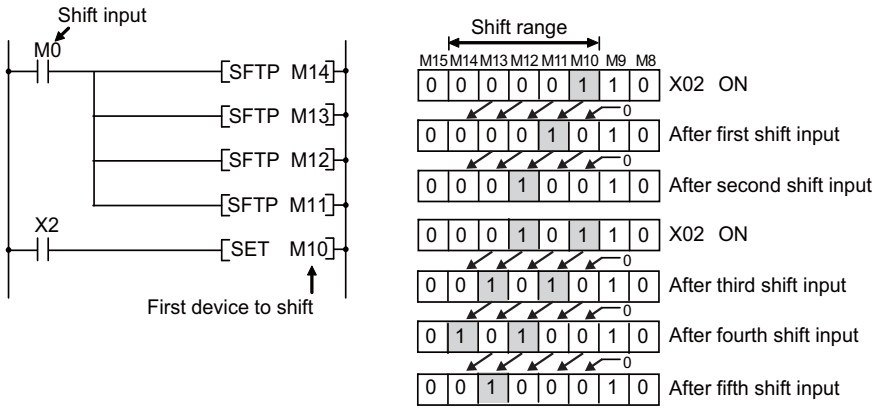
Set Data

Set Data	Meaning	Data Type
D	Number of device to shift	Bit

Functions

(1) When bit device is used

(a) Shifts to a device designated by (D) the ON/OFF status of the device immediately prior to the one designated, and turns the prior device OFF.



*At M8 to 15, "1" indicates ON and "0" indicates OFF.

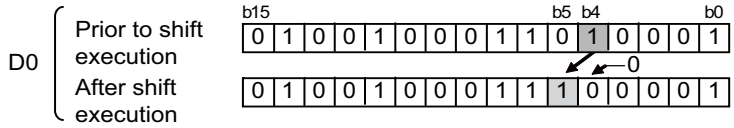
For example, if M11 has been designated by the SFT instruction, when the SFT instruction is executed, it will shift the ON/OFF status of M10 to M11, and turn M10 OFF.

(b) Turn the first device to be shifted ON with the SET instruction.

(c) When the SFT and SFTP are to be used consecutively, the program starts from the device with the larger number.

(2) When word device bit designation is used

(a) Shifts to a bit in the device designated by (D) the 1/0 status of the bit immediately prior to the one designated, and turns the prior bit to 0.
For example, if D0.5 (bit 5 [b5] of D0) has been designated by the SFT instruction, when the SFT instruction is executed, it will shift the 1/0 status of b4 of D0 to b5, and turn b4 to 0.



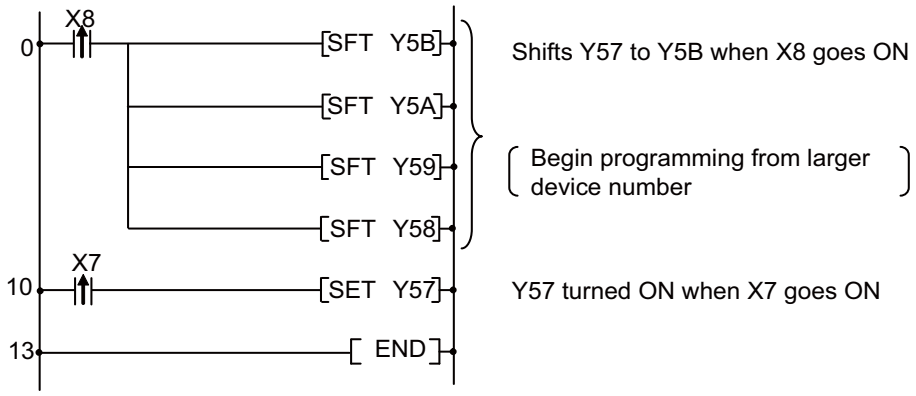
Operation Errors

(1) There are no operation errors associated with the SFT(P) instruction.

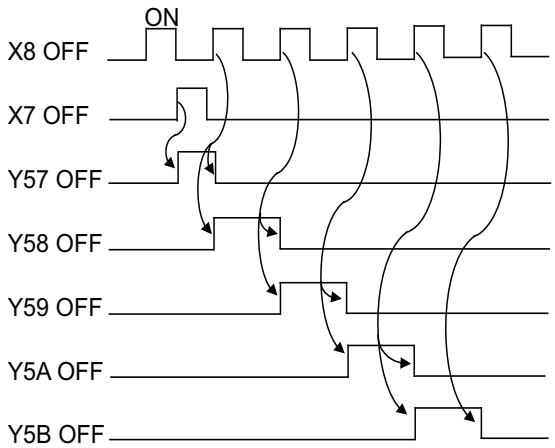
Program Example

(1) The following program shifts Y57 to Y5B when X8 goes ON.

[Ladder Mode]



[Timing Chart]



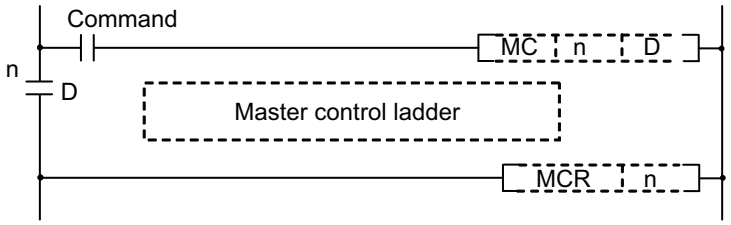
[List Mode]

Steps	Inst.	Device
0	LDP	X8
2	SFT	Y5B
4	SFT	Y5A
6	SFT	Y59
8	SFT	Y58
10	LDP	X7
12	SET	Y57
13	END	

6.5 Master Control Instruction

○MC, MCR ... Setting and resetting the master control

Setting data	Usable device																				Digit designation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	N		
n																					○		
D	○	○	○	○	○	○	○		○				○	○	○	○	○						○

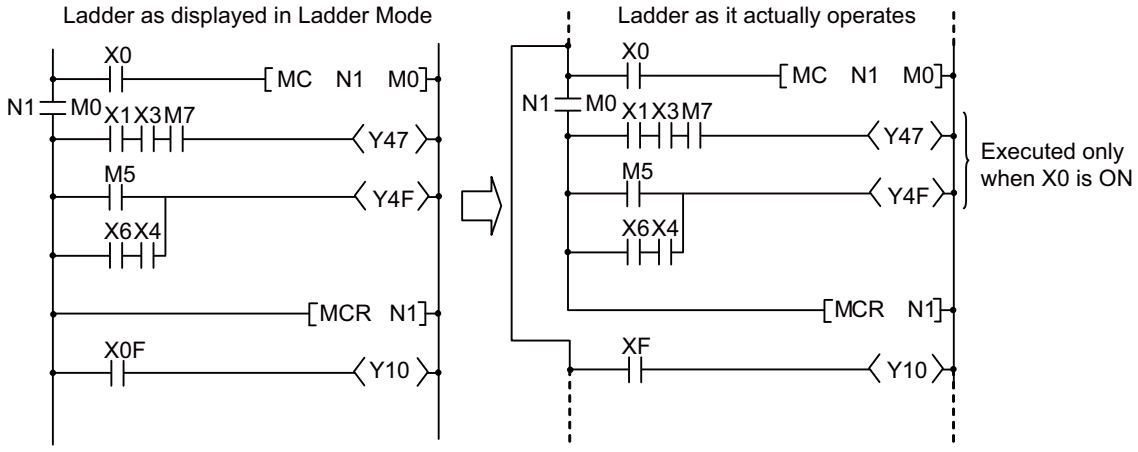
Instruction symbol	Execution condition	
MC		
MCR		

Set Data

Set Data	Meaning	Data Type
n	Nesting (N0 to N7)	Nesting
D	Number of device to turn ON	Bit

Functions

(1) The master control instruction is used to enable the creation of highly efficient ladder switching sequence programs, through the opening and closing of a common bus for ladders.
A ladder using the master control would look as shown below:



MC

(1) If the ON/OFF command of the MC instruction is ON when master control is commenced, the operation result between the MC instruction and MCR instruction will be exactly as the instruction (ladder) shows.
If the MC ON/OFF instruction is OFF, the operation result between MC and MCR instructions will be as follows:

Device	Device Status
100ms, 10ms timer	Count value goes to 0
100ms cumulative timer counter	Current count value is kept as it is.
Devices in OUT instruction	All turned OFF
Devices in the following instructions: SET/RST, SFT function	Maintain current status

(2) Nesting can be used up to 8 times (N0 to 7). When the nesting is used, the nesting number that follows "N" is used in ascending order to execute the MC instruction, while the number is used in descending order to execute the MCR instruction.

(3) Regardless of the MC instruction's ON/OFF state, scan between MC instruction and MCR instruction can be executed.

(4) MC instruction can be used as many times as you wish within one scan by changing devices in the destination D.

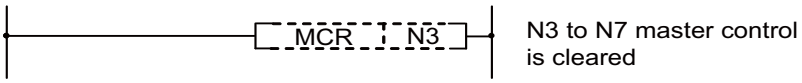
(5) When MC instruction is ON, coil of the device specified in the destination turns ON.

(6) When there is an instruction which does not require any contact instructions (such as FOR, NEXT, or JMP instruction) in the ladder using the master control, the instruction is executed regardless of the execution command of the MC instruction.

MCR

(1) This is the instruction for recovery from the master control, and indicates the end of the master control range of operation.

(2) Specified nesting number that following "N" and after are cleared.



Operation Errors

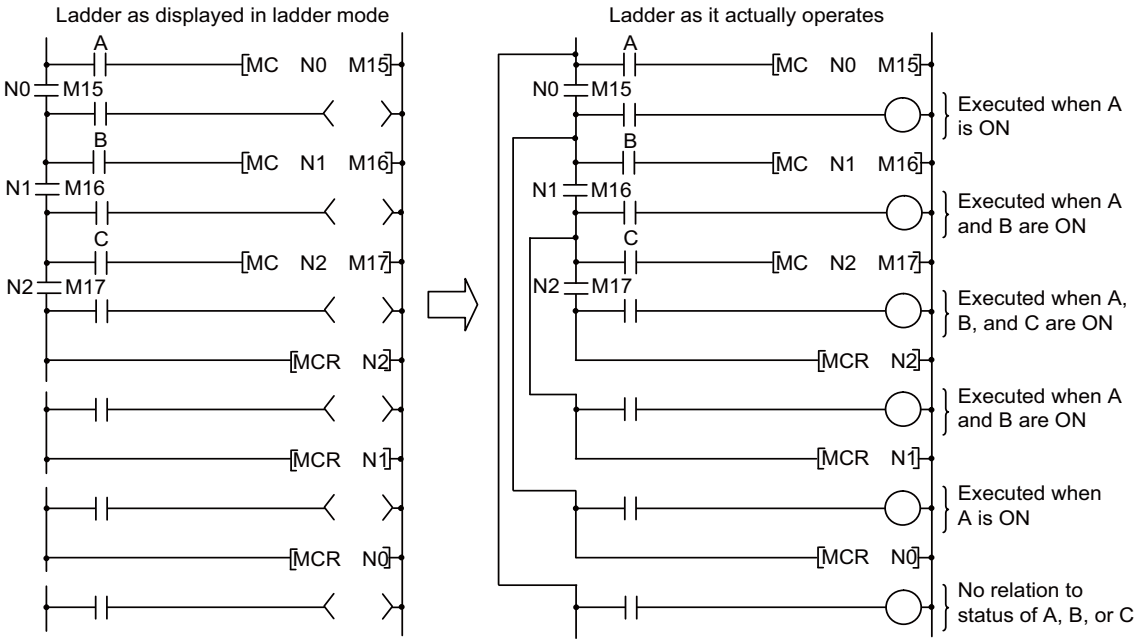
(1) There are no operation errors associated with the MC or MCR instructions.

Program Example

The master control instruction can be used in nesting. The different master control regions are distinguished by nesting (N). Nesting can be used from N0 through N7.

The use of nesting enables the creation of ladders which successively limit the execution condition of the program.

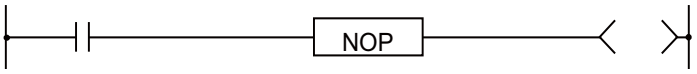
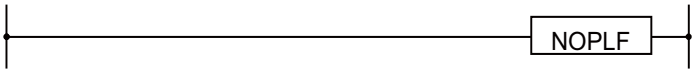
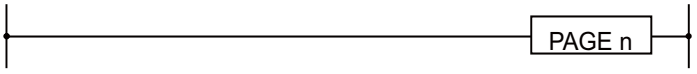
A ladder using nesting would appear as shown below:



6.6 Other Instructions

○NOP, NOPLF, PAGE n ... No operation

Setting data	Usable device																				Digit desig-nation	Index
	Bit device										Word device								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
n																			○				

Instruction symbol	Execution condition	*NOP is not displayed in ladder display.
NOP		
NOPLF		
PAGE n		

Functions

NOP

(1) This is a no operation instruction that has no impact on any operations up to this point.

(2) The NOP instruction is used in the following cases:
  (a) To insert space for sequence program debugging.
  (b) To delete an instruction without having to change the number of steps.
  (Replace the instruction with NOP)
  (c) To temporarily delete an instruction.

NOPLF

(1) This is a no operation instruction that has no impact on any operations up to that point.

(2) The NOPLF instruction is used when printing from a peripheral device to force a page change at any desired location.
  (a) When printing ladders
    - A page break will be inserted between ladder blocks with the presence of the NOPLF instruction.
    - The ladder cannot be displayed correctly if an NOPLF instruction is inserted in the midst of a ladder block.
    Do not insert an NOPLF instruction in the midst of a ladder block.
  (b) When printing instruction lists
    - The page will be changed after the printing of the NOPLF instruction.

(3) See the Operating Manual for the peripheral device in use for more information regarding printouts from peripheral devices.

PAGE n

(1) This is a no operation instruction that has no impact on any operations up to that point.

(2) Programs after PAGEn instruction are controlled as 0 step and after of the specified n-th page. (Peripheral device display, printers, etc.)

(3) If there is no PAGEn instruction, processing begins from page 0.

Operation Errors

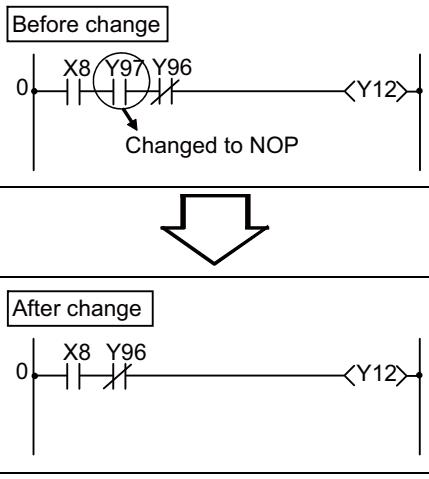
(1) There are no errors associated with the NOP, NOPLF, or PAGE instructions.

Program Example

NOP

(1) Contact closed...Deletes AND or ANI instruction

[Ladder Mode]



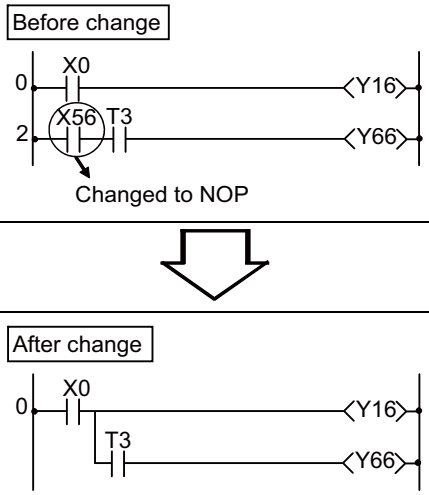
[List Mode]

Steps	Inst.	Device
0	LD	X8
1	AND	Y97
2	ANI	X96
3	OUT	Y12
4	END	

Steps	Inst.	Device
0	LD	X8
1	NOP	
2	ANI	X96
3	OUT	Y12
4	END	

(2) Contact closed...LD, LDI changed to NOP
(Note carefully that changing the LD and LDI instructions to NOP completely changes the nature of ladder.)

[Ladder Mode]

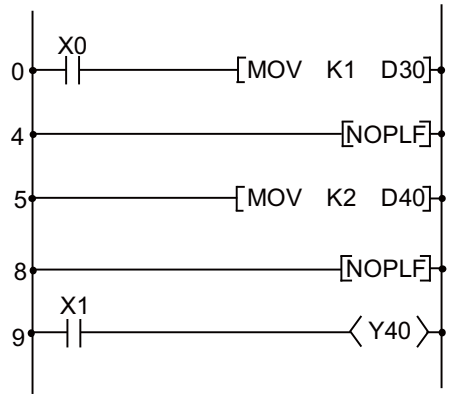


[List Mode]

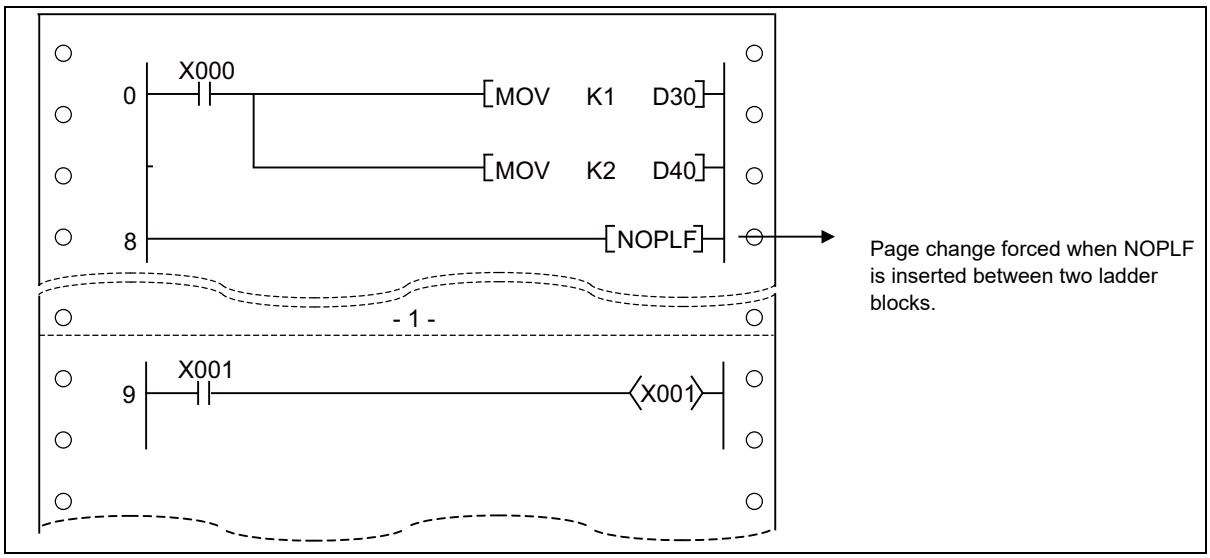
Steps	Inst.	Device
0	LD	X0
1	OUT	Y16
2	LD	X56
3	AND	T3
4	OUT	Y66
5	END	

Steps	Inst.	Device
0	LD	X0
1	OUT	Y16
2	NOP	
3	AND	T3
4	OUT	Y66
5	END	

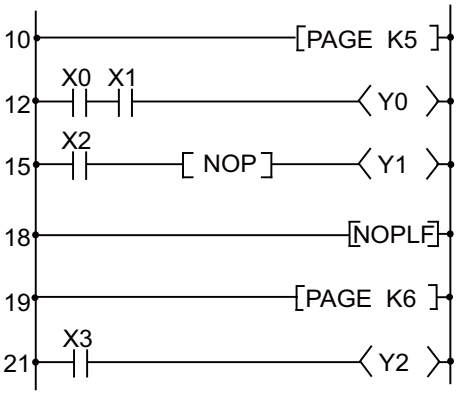
NOPLF

[Ladder Mode]	[List Mode]
	Steps Inst. Device 0 LD X0 1 MOV K1 D30 4 NOPLF 5 MOV K2 D40 8 NOPLF 9 LD X1 10 OUT Y40 11 END

- Printing the ladder will result in the following:



PAGE n

[Ladder Mode]	[List Mode]
	Steps Inst. Device 10 PAGE K5 12 LD X0 13 AND X1 14 OUT Y0 15 LD X2 16 NOP 17 OUT Y1 18 NOPLF 19 PAGE K6 21 LD X3 22 OUT Y2 23

7

Function Instructions

The function instruction includes the following types.

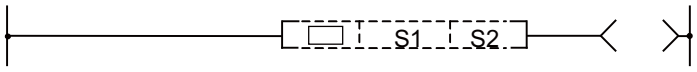
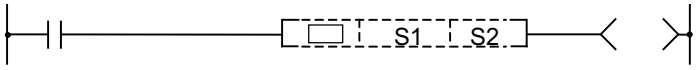
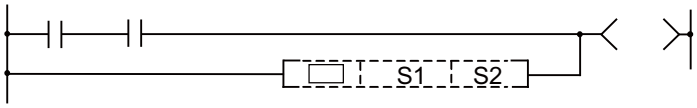
Instruction	Meaning
Comparison operation instruction	Compare data to data
Arithmetic operation instruction	Adds, subtracts, multiplies, divides, increments, or decrements data with other data
Data conversion instruction	Coverts data types
Data transfer instruction	Transmits designated data
Program branch instruction	Program jumps
Logical operation instructions	Logical operations such as logical sum, logical product, etc.
Rotation instruction	Rotation/shift of designated data
Data processing instructions	Data searches, data processing such as decoding and encoding
Other instructions	Instructions which do not fall into the above categories

7.1 Comparison Operation Instruction

○ =, <>, >, <=, <, >= ... 16-bit data comparisons

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	Δ	Δ		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	Δ	Δ			

Δ : S1 and S2 cannot be specified as constant at the same time.

Instruction symbol	Execution condition	indicates the signs =, <>, >, <=, <, >=
LD □		
AND □		
OR □		

Set Data

Set Data	Meaning	Data Type
S1	Comparative data, or device No. where comparative data is stored	BIN 16 bits
S2		

Functions

(1) Treats BIN 16-bit data from device designated by (S1) and BIN 16-bit data from device designated by (S2) as an A contact, and performs comparison operation.

(2) The results of the comparison operations for the individual instructions are as follows:

Instruction Symbol in □	Condition	Comparison Operation Result	Instruction Symbol in □	Condition	Comparison Operation Result
=	S1 = S2	Continuity	=	S1 ≠ S2	Non-continuity
<>	S1 ≠ S2		<>	S1 = S2	
>	S1 > S2		>	S1 ≦ S2	
<=	S1 ≦ S2		<=	S1 > S2	
<	S1 < S2		<	S1 ≧ S2	
>=	S1 ≧ S2		>=	S1 < S2	

(3) In cases where hexadecimal constants have been designated by (S1) and (S2), or when a numerical value (8 to F) where the highest bit (b15) will be 1 has been designated, the value will be read as a negative BIN value number for purposes of the comparison.

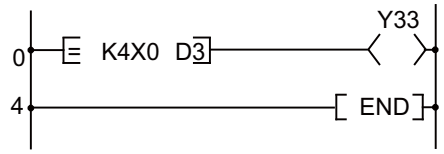
Operation Errors

(1) There are no operation errors associated with the =, <>, >, <=, <, or >= instructions.

Program Example

(1) The following program compares the data at X0 to XF with the data at D3, and turns Y33 ON if the data is identical.

[Ladder Mode]

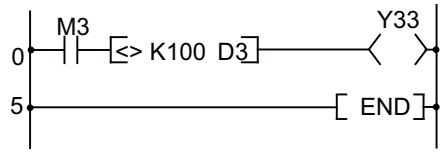


[List Mode]

Steps	Inst.	Device
0	LD=	K4X0
		D3
3	OUT	Y33
4	END	

(2) The following program compares BIN value K100 to the data at D3, and establishes continuity if the data in D3 is something other than 100.

[Ladder Mode]

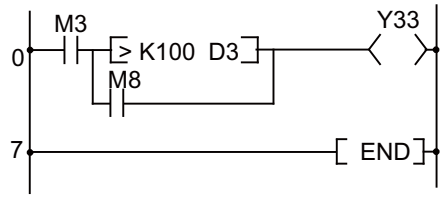


[List Mode]

Steps	Inst.	Device
0	LD	M3
1	AND<>	K100
		D3
4	OUT	Y33
5	END	

(3) The following program compares BIN value K100 to the data at D3, and establishes continuity if the D3 data is less than 100.

[Ladder Mode]

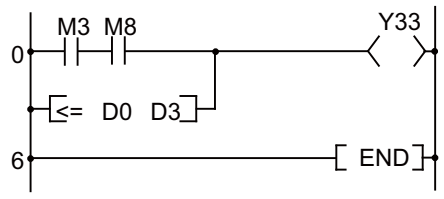


[List Mode]

Steps	Inst.	Device
0	LD	M3
1	LD>	K100
		D3
4	OR	M8
5	ANB	
6	OUT	Y33
7	END	

(4) The following program compares the data in D0 and D3, and if the data in D0 is equal to or less than the data in D3, establishes continuity.

[Ladder Mode]



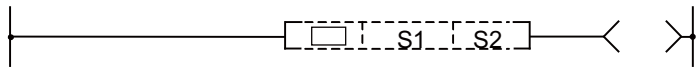
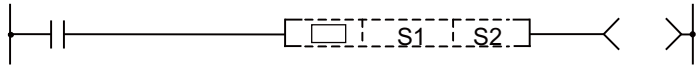
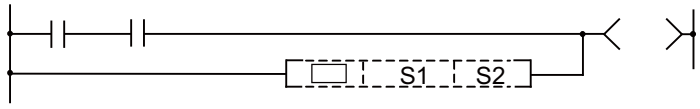
[List Mode]

Steps	Inst.	Device
0	LD	M3
1	AND	M8
2	OR<=	D0
		D3
5	OUT	Y33
6	END	

○ **D=, D<>, D>, D<=, D<, D>= ... 32-bit data comparison**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		Δ	Δ		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		Δ	Δ			

Δ : S1 and S2 cannot be specified as constant at the same time.

Instruction symbol	Execution condition	☐ indicates the signs D=, D<>, D>, D<=, D<, D>=
LD ☐		
AND ☐		
OR ☐		

Set Data

Set Data	Meaning	Data Type
S1	Comparative data, or device No. where comparative data is stored	BIN 32 bits
S2		

Functions

(1) Treats BIN 32-bit data from device designated by (S1) and BIN 32-bit data from device designated by (S2) as an A contact, and performs comparison operation.

(2) The results of the comparison operations for the individual instructions are as follows:

Instruction Symbolin ☐	Condition	Comparison Operation Result	Instruction Symbolin ☐	Condition	Comparison Operation Result
D=	S1 = S2	Continuity	D=	S1 ≠ S2	Non-continuity
D<>	S1 ≠ S2		D<>	S1 = S2	
D>	S1 > S2		D>	S1 ≦ S2	
D<=	S1 ≦ S2		D<=	S1 > S2	
D<	S1 < S2		D<	S1 ≧ S2	
D>=	S1 ≧ S2		D>=	S1 < S2	

(3) In cases where hexadecimal constants have been designated by (S1) and (S2), or when a numerical value (8 to F) where the highest bit (b31) will be 1 has been designated, the value will be read as a negative BIN value number for the purpose of the comparison.

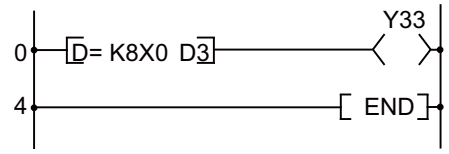
Operation Errors

(1) There are no operation errors associated with the D=, D<>, D>, D<=, D<, or D>= instructions.

Program Example

(1) The following program compares the data at X0 to XF with the data at D3 and D4, and turns Y33 ON if the data is identical.

[Ladder Mode]

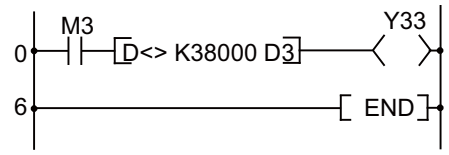


[List Mode]

Steps	Inst.	Device
0	LDD=	K8X0
		D3
3	OUT	Y33
4	END	

(2) The following program compares BIN value K38000 to the data at D3 and D4, and establishes continuity if the data in D3 and D4 is something other than 38000.

[Ladder Mode]

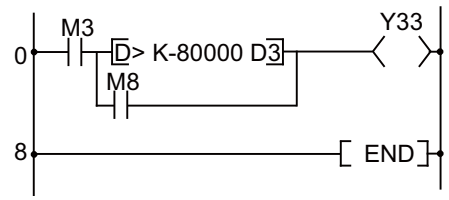


[List Mode]

Steps	Inst.	Device
0	LD	M3
1	ANDD<>	K38000
		D3
5	OUT	Y33
6	END	

(3) The following program compares BIN value K-80000 to the data at D3 and D4, and establishes continuity if the data in D3 and D4 is less than -80000.

[Ladder Mode]

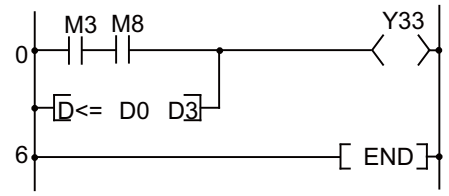


[List Mode]

Steps	Inst.	Device
0	LD	M3
1	LDD>	K-80000
		D3
5	OR	M8
6	ANB	
7	OUT	Y33
8	END	

(4) The following program compares the data in D0 and D1 with the data in D3 and D4, and establishes continuity if the data in D0 and D1 is equal to or less than the data in D3 and D4.

[Ladder Mode]



[List Mode]

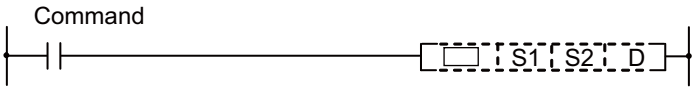
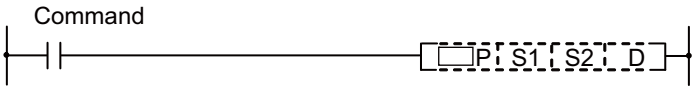
Steps	Inst.	Device
0	LD	M3
1	AND	M8
2	ORD<=	D0
		D3
5	OUT	Y33
6	END	

7.2 Arithmetic Operation Instruction

○ **+, +P, -, -P ... BIN 16-bit addition and subtraction operations**
(Device at storage destination: Independent type)

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	Δ	Δ		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	Δ	Δ			
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○					

Δ : S1 and S2 cannot be specified as constant at the same time.

Instruction symbol	Execution condition	▭ indicates the signs + / -
+, -		
+P, -P		

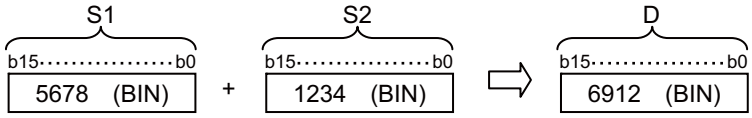
Set Data

Set Data	Meaning	Data Type
S1	Data to be added to or subtracted from, or the first number of the device storing such data	BIN 16 bits
S2	Addition or subtraction data, or first number of device storing addition or subtraction data	
D	First number of device storing addition or subtraction data	

Functions

+

(1) Adds 16-bit BIN data designated by (S1) to 16-bit BIN data designated by (S2) and stores at the device designated by (D).



(2) Values for S1, S2, and D can be designated between -32768 and 32767 (BIN 16 bits).

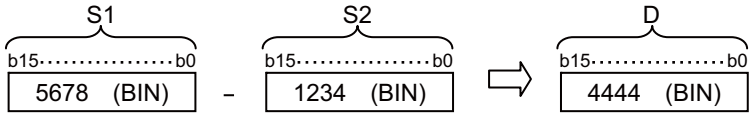
(3) The judgment of whether data is positive or negative is made by the most significant bit (b15).

b15	Judgment (+/-)
0	Positive
1	Negative

(4) The following will happen when an underflow or overflow is generated in an operation result:
The carry flag in this case does not go ON.
- K-32768 - K2 → K32766 ---- A positive value is generated if b15 is 0.
(H7FFF) (H0002) (H8001)
- K-32768 + K-2 → K32766 ---- A positive value is generated if b15 is 0.
(H8000) (HFFFE) (H7FFE)

-

(1) Subtracts 16-bit BIN data designated by (S1) from 16-bit BIN data designated by (S2) and stores the result of the subtraction at the device designated by (D).



(2) Values for S1, S2, and D can be designated between -32768 and 32767 (BIN 16 bits).

(3) The judgment of whether data is positive or negative is made by the most significant bit (b15).

b15	Judgment (+/-)
0	Positive
1	Negative

(4) The following will happen when an underflow or overflow is generated in an operation result:
The carry flag in this case does not go ON.
- K-32768 - K2 → K32766 ---- A positive value is generated if b15 is 0.
(H8000) (H0002) (H7FFE)
- K32767 - K-2 → K-32767 ---- A negative value is generated if b15 is 1.
(H7FFF) (HFFFE) (H8001)

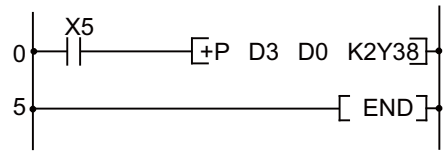
Operation Errors

(1) There are no operation errors associated with the +(P) or -(P) instructions.

Program Example

(1) The following program adds the contents of D3 and the contents of D0 when X5 goes ON, and outputs result to Y38 through 3F.

[Ladder Mode]

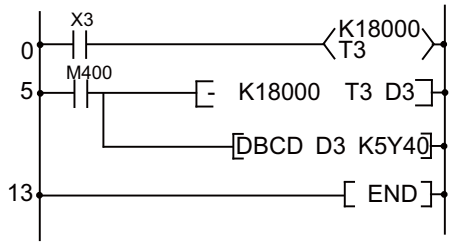


[List Mode]

Steps	Inst.	Device
0	LD	X5
1	+P	D3
		D0
		K2Y38
5	END	

(2) The following program outputs the difference between the set value for timer T3 and its present value to Y40 to 53 by BCD.

[Ladder Mode]

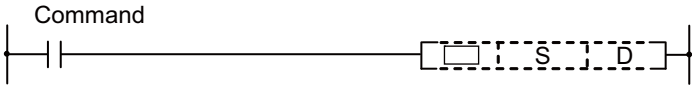
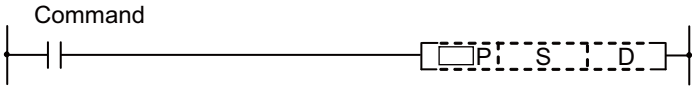


[List Mode]

Steps	Inst.	Device
0	LD	X3
1	OUT	T3
		K18000
5	LD	M400
6	-	K18000
		T3
		D3
10	DBCD	D3
		K5Y40
13	END	

○ **+, +P, -, -P ... BIN 16-bit addition and subtraction operations**
(Device at storage destination: Shared type)

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	○	○		○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○				

Instruction symbol	Execution condition	▭ indicates the signs + / -
+, -		
+P, -P		

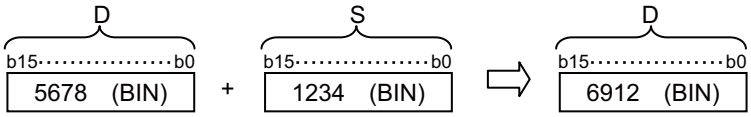
Set Data

Set Data	Meaning	Data Type
S	Addition or subtraction data, or first number of device storing addition or subtraction data	BIN 16 bits
D	First number of device storing data to be added to or subtracted from (Addition or subtraction data is stored in this device.)	

Functions

+

(1) Adds 16 bit BIN data designated by (D) to 16 bit BIN data designated by (S), and stores the result of the addition at the device designated by (D).



(2) The value for (S) and (D) can be designated at between -32768 and 32767 (BIN 16 bits).

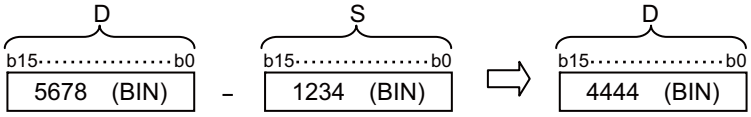
(3) The judgment of whether data is positive or negative is made by the most significant bit (b15).

b15	Judgment (+/-)
0	Positive
1	Negative

(4) The following will happen when an underflow or overflow is generated in an operation result.
The carry flag in this case does not go ON.
- K32767 + K2 → K-32767 ---- A negative value is generated if b15 is 1.
(H7FFF) (H0002) (H8001)
- K-32768 + K-2 → K32766 ---- A positive value is generated if b15 is 0.
(H8000) (HFFFE) (7FFE)

-

(1) Subtracts 16-bit BIN data designated by (D) from 16-bit BIN data designated by (S) and stores the result of the subtraction at the device designated by (D).



(2) The values for (S) and (D) can be designated at between -32768 and 32767 (BIN 16 bits).

(3) The judgment of whether data is positive or negative is made by the most significant bit (b15).

b15	Judgment (+/-)
0	Positive
1	Negative

(4) The following will happen when an underflow or overflow is generated in an operation result.
The carry flag in this case does not go ON.
- K-32768 - K2 → K32766 ---- A positive value is generated if b15 is 0.
(H8000) (H0002) (H7FFE)
- K32767 - K-2 → K-32767 ---- A negative value is generated if b15 is 1.
(H7FFF) (HFFFE) (H8001)

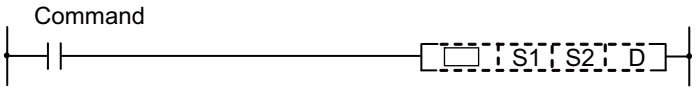
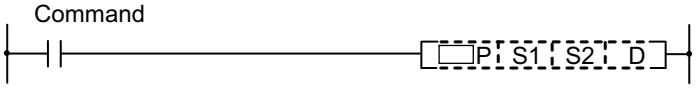
Operation Errors

(1) There are no operation errors associated with the +(P) or -(P) instructions.

○ **D+, D+P, D-, D-P ... BIN 32-bit addition and subtraction operations**
(Device at storage destination: Independent type)

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		Δ	Δ		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		Δ	Δ			
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○						

Δ : S1 and S2 cannot be specified as constant at the same time.

Instruction symbol	Execution condition	▭ indicates the signs D+ / D-
D+, D-		
D+P, D-P		

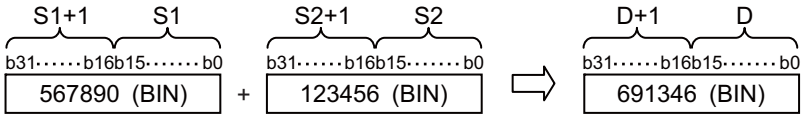
Set Data

Set Data	Meaning	Data Type
S1	Data to be added to or subtracted from, or the first number of the device storing such data	BIN 32 bits
S2	Addition or subtraction data, or number of device storing addition or subtraction data	
D	First number of device storing addition or subtraction data	

Functions

D+

(1) Adds 32-bit BIN data designated by (S1) to 32-bit BIN data designated by (S2), and stores the result of the addition at the device designated by (D).



(2) The values for (S1), (S2) and (D) can be designated at between -2147483648 and 2147483647 (BIN 32 bits).

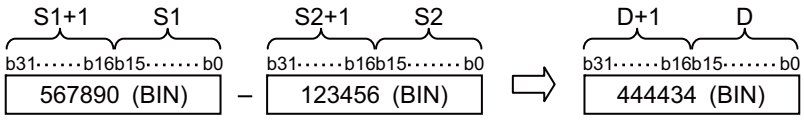
(3) The judgment of whether data is positive or negative is made by the most significant bit (b31).

b31	Judgment (+/-)
0	Positive
1	Negative

(4) The following will happen when an underflow or overflow is generated in an operation result. The carry flag in this case does not go ON.
- K2147483647 + K2 → K-2147483647 ---- A negative value is generated if b31 is 1.
(H7FFFFFFF) (H0002) (H80000001)
- K-2147483648 + K-2 → K2147483646 ---- A positive value is generated if b31 is 0.
(H80000000) (HFFFE) (H7FFFFFFE)

D-

(1) Subtracts 32-bit BIN data designated by (S1) from 32-bit BIN data designated by (S2), and stores the result of the subtraction at the device designated by (D).



(2) The values for (S1), (S2) and (D) can be designated at between -2147483648 and 2147483647 (BIN 32 bits).

(3) The judgment of whether data is positive or negative is made by the most significant bit (b31).

b31	Judgment (+/-)
0	Positive
1	Negative

(4) The following will happen when an underflow or overflow is generated in an operation result. The carry flag in this case does not go ON.
- K-2147483648 - K2 → K2147483646 ---- A positive value is generated if b31 is 0.
(H80000000) (H0002) (H7FFFFFFE)
- K2147483647 - K-2 → K-2147483647 ---- A negative value is generated if b31 is 1.
(H7FFFFFFF) (HFFFE) (H80000001)

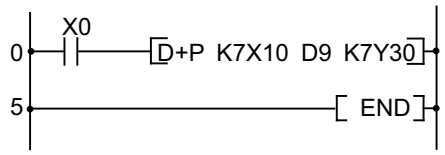
Operation Errors

(1) There are no operation errors associated with the D+(P) or D-(P) instructions.

Program Example

(1) The following program adds 28-bit data from X10 to X2B to the data at D9 and D10 when X0 goes ON,and outputs the result of the operation to Y30 to Y4B.

[Ladder Mode]

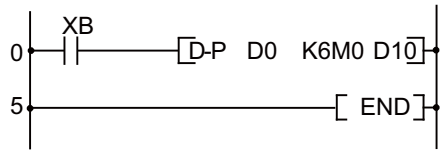


[List Mode]

Steps	Inst.	Device
0	LD	X0
1	D+P	K7X10
		D9
		K7Y30
5	END	

(2) The following program subtracts the data from M0 to M23 from the data at D0 and D1 when XB goes ON, and stores the result at D10 and D11.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X0B
1	D-P	D0
		K6M0
		D10
5	END	

○ **D+, D+P, D-, D-P ... BIN 32-bit addition and subtraction operations**
(Device at storage destination: Shared type)

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		○	○		○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○						

Instruction symbol	Execution condition	▭ indicates the signs D+ / D-
D+, D-		Command — S D
D+P, D-P		Command — P S D

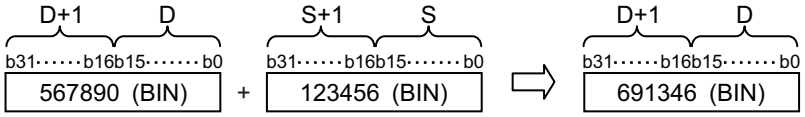
Set Data

Set Data	Meaning	Data Type
S	Head No. of the addition/subtraction data or device in which addition or subtraction data is stored.	BIN 32 bits
D	Head No. of the device in which augend/dividend data is stored. (Addition result is stored in this device.)	

Functions

D+

(1) Adds 32-bit BIN data designated by (D) to 32-bit BIN data designated by (S) and stores at the device designated by (D).



(2) The values for (S) and (D) can be designated at between -2147483648 and 2147483647 (BIN 32 bits).

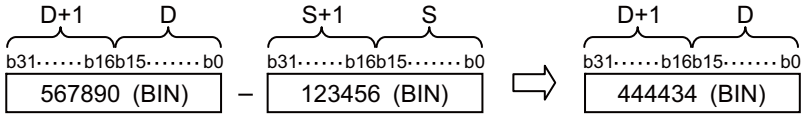
(3) The judgment of whether data is positive or negative is made by the most significant bit (b31).

b31	Judgment (+/-)
0	Positive
1	Negative

(4) The following will happen when an underflow or overflow is generated in an operation result. The carry flag in this case does not go ON.
- K2147483647 + K2 → K-2147483647 ---- A negative value is generated if b31 is 1.
(H7FFFFFFF) (H0002) (H80000001)
- K-2147483648 + K-2 → K2147483646 ---- A positive value is generated if b31 is 0.
(H80000000) (HFFFE) (H7FFFFFFE)

D-

(1) Subtracts 32-bit data designated by (D) from 32-bit data designated by (S) and stores the result of the subtraction at the device designated by (D).



(2) The values for (S) and (D) can be designated at between -2147483648 and 2147483647 (BIN 32 bit).

(3) The judgment of whether data is positive or negative is made by the most significant bit (b31).

b31	Judgment (+/-)
0	Positive
1	Negative

(4) The following will happen when an underflow or overflow is generated in an operation result. The carry flag in this case does not go ON.
- K-2147483648 - K2 → K2147483646 ---- A positive value is generated if b31 is 0.
(H80000000) (H0002) (H7FFFFFFE)
- K2147483647 - K-2 → K-2147483647 ---- A negative value is generated if b31 is 1.
(H7FFFFFFF) (HFFFE) (H80000001)

Operation Errors

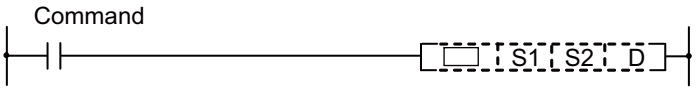
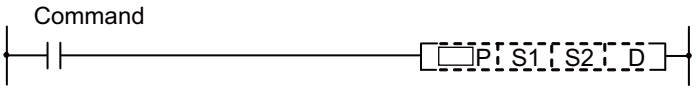
(1) There are no operation errors associated with the D+(P) or D-(P) instructions.

○ ***, *P, /, /P ... BIN 16-bit multiplication and division operations**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	Δ1	Δ1		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	Δ1	Δ1			
D	Δ2	Δ2	Δ2	Δ2	Δ2	Δ2	Δ2		Δ2		○	○	○	○	○	○	○						

Δ1 : S1 and S2 cannot be specified as constant at the same time.

Δ2: This is not available with /(P).

Instruction symbol	Execution condition	☐ indicates the signs * / /
*, /		
*P, /P		

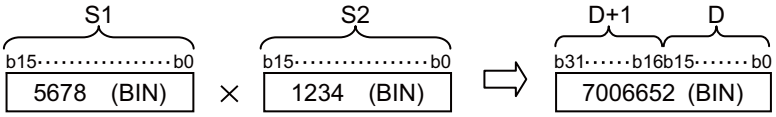
Set Data

Set Data	Meaning	Data Type
S1	Data to be added to or subtracted from, or the first number of the device storing such data	BIN 16 bits
S2	Addition or subtraction data, or first number of device storing addition or subtraction data	
D	First number of device storing addition or subtraction data	BIN 32 bits

Functions

*

(1) Multiplies BIN 16-bit data designated by (S1) and BIN 16-bit data designated by (S2), and stores the multiplication result in the device designated by (D).



(2) If (D) is a bit device, designation is made from the lower bits.
Example K1 --- Lower 4 bits (b0 to 3)
K4 --- Lower 16 bits (b0 to 15)
K8 --- 32 bits (b0 to 31)

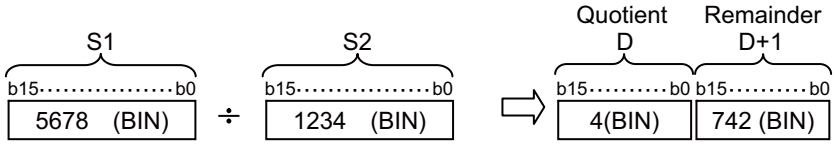
(3) The values for (S1) and (S2) can be designated at between -32768 and 32767 (BIN 16 bits).

(4) Judgments whether (S1),(S2), and (D) are positive or negative are made on the basis of the most significant bit (b15 for (S1) and (S2), and b31 for (D)).

b15/b31	Judgment (+/-)
0	Positive
1	Negative

/

(1) Divides BIN 16-bit data designated by (S1) and BIN 16-bit data designated by (S2), and stores the division result in the device designated by (D).



(2) If a word device has been used, the result of the division operation is stored as 32 bits, and both the quotient and remainder are stored.
Quotient ---- Stored at the lower 16 bits
Remainder --- Stored at the higher 16 bits

(3) The values for (S1) and (S2) can be designated at between -32768 and 32767 (BIN 16 bits).

(4) Judgment whether values for (S1), (S2), and (D) are positive or negative is made on the basis of the most significant bit (b15 for (S1) and (S2), and b31 for (D)).

b15/b31	Judgment (+/-)
0	Positive
1	Negative

(5) When divisor S2 is 0, no operation is carried out.

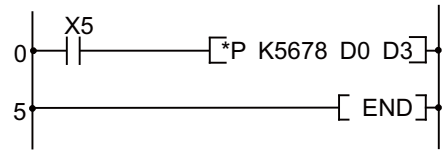
Operation Errors

(1) There are no operation errors associated with the *, *P, /, or /P instructions.

Program Example

(1) When X5 is turned ON, "5678" of BIN and multiplication result of D0 are stored in D3 and D4.

[Ladder Mode]

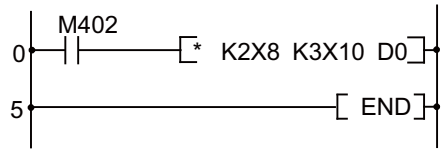


[List Mode]

Steps	Inst.	Device
0	LD	X5
1	*P	K5678
		D0
		D3
5	END	

(2) Multiplication result of BIN data of X8 to XF and BIN data of X10 to X1B is output to D0 and D1.

[Ladder Mode]

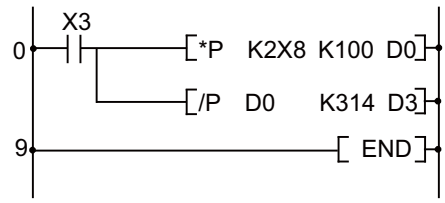


[List Mode]

Steps	Inst.	Device
0	LD	M402
1	*	K2X8
		K3X10
		D0
5	END	

(3) When X3 is turned ON, the data of X8 to XF is divided by 3.14 and the result is output to D3 and D4.

[Ladder Mode]



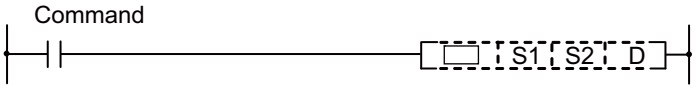
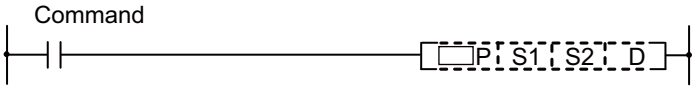
[List Mode]

Steps	Inst.	Device
0	LD	X3
1	*P	K2X8
		K100
		D0
5	/P	D0
		K314
		D3
9	END	

○ **D*, D*P, D/, D/P ... BIN 32-bit multiplication and division operations**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		Δ	Δ		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		Δ	Δ			
D											○	○	○	○	○	○	○						

Δ : S1 and S2 cannot be specified as constant at the same time.

Instruction symbol	Execution condition	▭ indicates the signs D* / D/
D*, D/		
D*P, D/P		

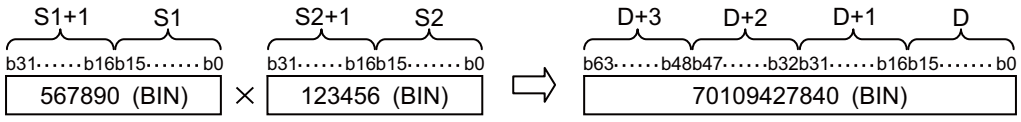
Set Data

Set Data	Meaning	Data Type
S1	Data to be added to or subtracted from, or the first number of the device storing such data	BIN 32 bits
S2	Addition or subtraction data, or first number of device storing addition or subtraction data	
D	First number of device storing addition or subtraction data	

Functions

D＊

(1) Multiplies BIN 32-bit data designated by (S1) and BIN 32-bit data designated by (S2), and stores the multiplication result in the device designated by (D).



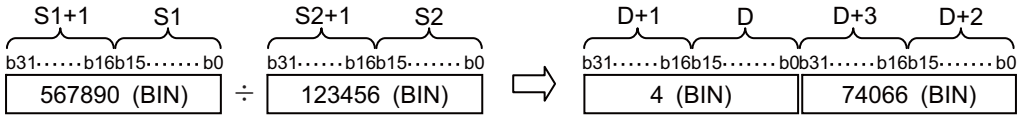
(2) The values for (S1) and (S2) can be designated at between -2147483648 and 2147483647 (BIN 32 bits).

(3) Judgment whether values for (S1), (S2), and (D) are positive or negative are made on the basis of the most significant bit (b31 for (S1) and (S2), and b63 for (D)).

b31/b63	Judgment (+/-)
0	Positive
1	Negative

D/

(1) Divides BIN 32-bit data designated by (S1) and BIN 32-bit data designated by (S2), and stores the division result in the device designated by (D).



(2) If a word device has been used, the result of the division operation is stored as 64 bits, and both the quotient and remainder are stored.
Quotient ---- Stored at the lower 32 bits
Remainder --- Stored at the upper 32 bits

(3) The values for (S1) and (S2) can be designated at between -2147483648 and 2147483647 (BIN 32 bits).

(4) Judgment whether values for (S1), (S2), (D), and (D)+2 are positive or negative is made on the basis of the most significant bit (b31).
(A sign is used with both the quotient and the remainder)

b31	Judgment (+/-)
0	Positive
1	Negative

(5) When divisor S2 is 0, no operation is carried out.

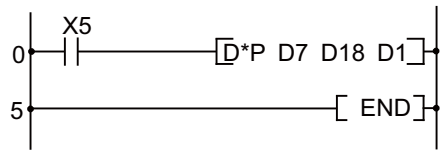
Operation Errors

(1) There are no operation errors associated with the D*, D*P, D/, or D/P instructions.

Program Example

(1) When X5 is turned ON, multiplication result of BIN data of D7 and D8 and BIN data of D18 and D19 is stored in D1 to D4.

[Ladder Mode]

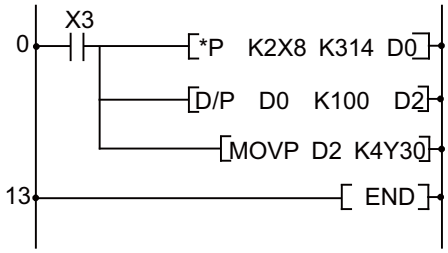


[List Mode]

Steps	Inst.	Device
0	LD	X5
1	D*P	D7
		D18
		D1
5	END	

(2) When X3 is turned ON, the data of X8 to XF is multiplied by 3.14 and the result is output to Y30 to Y3F.

[Ladder Mode]



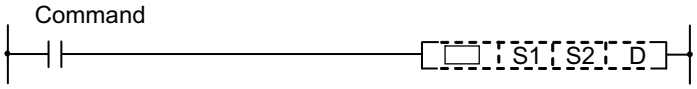
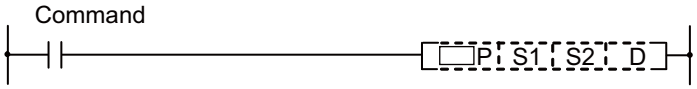
[List Mode]

Steps	Inst.	Device
0	LD	X3
1	*P	K2X8
		K314
		D0
5	D/P	D0
		K100
		D2
10	MOVP	D2
		K4Y30
13	END	

○ **B+, B+P, B-, B-P ... BCD 4-digit addition and subtraction operations**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	Δ	Δ		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	Δ	Δ			
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○					

Δ : S1 and S2 cannot be specified as constant at the same time.

Instruction symbol	Execution condition	□ indicates the signs B+ /BB
B+, B-		
B+P, B-P		

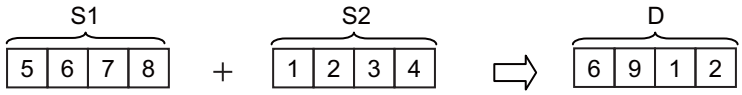
Set Data

Set Data	Meaning	Data Type
S1	Data to be added to or subtracted from, or the first number of the device storing such data	BCD 4-digit
S2	Addition or subtraction data, or the head No. of device storing addition or subtraction data	
D	First number of device storing addition or subtraction data	

Functions

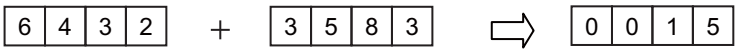
B+

(1) Adds the BCD 4-digit data designated by "S1" and the BCD 4-digit data designated by "S2", and stores the result of the addition at the device designated by "D".



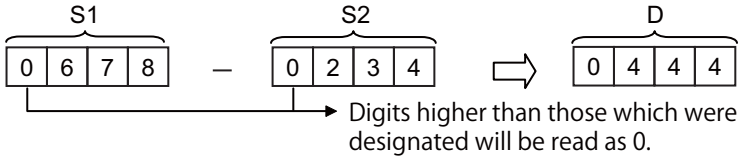
(2) The values for "S1", "S2", and "D" can be specified between 0 and 9999 (BCD 4-digit).

(3) If the result of the addition operation exceeds 9999, the higher bits are ignored. The carry flag in this case does not go ON.



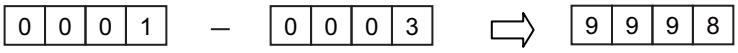
B-

(1) Subtracts the BCD 4-digit data designated by "S1" and the BCD 4-digit data designated by "S2", and stores the result of the subtraction at the device designated by "D".



(2) The values for "S1", "S2", and "D" can be specified between 0 and 9999 (BCD 4-digit).

(3) The following will result if an underflow is generated by the subtraction operation:
The carry flag in this case does not go ON.



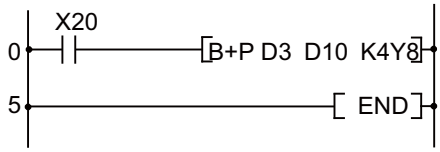
Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- The "S1", "S2" or "D" BCD data is outside the 0 to 9999 range. (Error code: 80)

Program Example

(1) The following program adds the D3 BCD data and the Z1 BCD data when X20 goes ON, and outputs the result to Y8 to Y17.

[Ladder Mode]

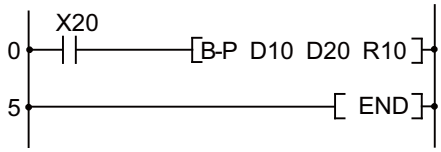


[List Mode]

Steps	Inst.	Device
0	LD	X20
1	B+P	D3
		D10
		K4Y8
5	END	

(2) The following program subtracts the BCD data at D20 from the BCD data at D10 when X20 goes ON, and stores the result at R10.

[Ladder Mode]



[List Mode]

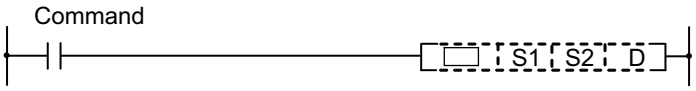
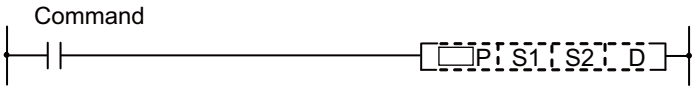
Steps	Inst.	Device
0	LD	X20
1	B-P	D10
		D20
		R10
5	END	

○ **B*, B*P, B/, B/P ... BCD 4-digit multiplication and division operations**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	Δ1	Δ1		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	Δ1	Δ1			
D	Δ2	Δ2	Δ2	Δ2	Δ2	Δ2	Δ2		Δ2		○	○	○	○	○	○	○						

Δ1 : S1 and S2 cannot be specified as constant at the same time.

Δ2: This is not available with B/(P).

Instruction symbol	Execution condition	☐ indicates the signs B* /B/
B*, B/		
B*P, B/P		

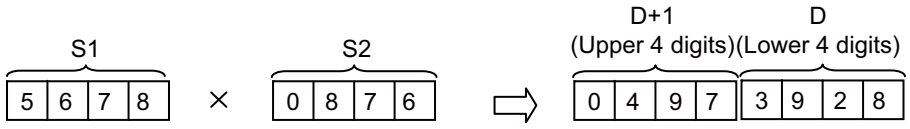
Set Data

Set Data	Meaning	Data Type
S1	Data to be added to or subtracted from, or the first number of the device storing such data	BCD 4-digit
S2	Addition or subtraction data, or the head No. of device storing addition or subtraction data	
D	First number of device storing addition or subtraction data	BCD 8-digit

Functions

B＊

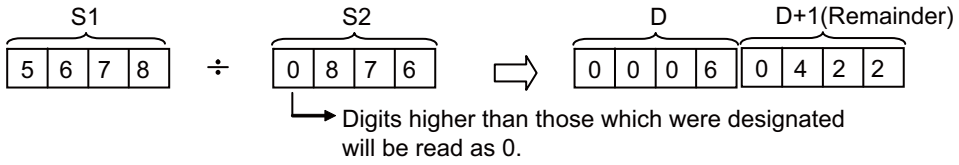
(1) Multiplies BCD 4-digit data designated by "S1" and BCD 4-digit data designated by "S2", and stores the result in the device designated by "D".



(2) Values for "S1" and "S2" can be specified between 0 and 9999 (BCD 4 digits).

B/

(1) Divides BCD 4-digit data designated by "S1" and BCD 4-digit data designated by "S2", and stores the result in the device designated by "D".



(2) 0 to 9999 (BCD 4-digit) for S1, and 1 to 9999 (BCD 4-digit) for S2 can be specified.

(3) Division result (quotient and remainder) is stored by using 32 bits.
Quotient (BCD 4 digits) ---- Stored at the lower 16 bits
Remainder (BCD 4 digits) --- Stored at the upper 16 bits

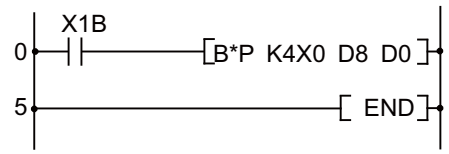
(4) When divisor S2 is 0, no operation is carried out.

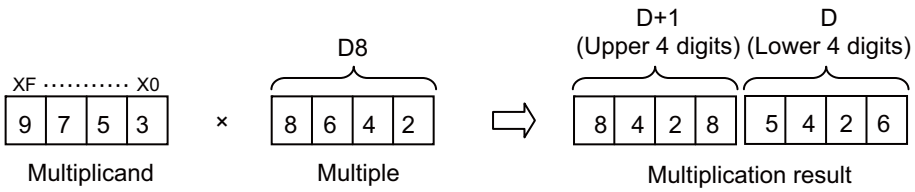
Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- The BCD data of "S1","S2" or "D" is outside the 0 to 9999 range. (Error code: 80)

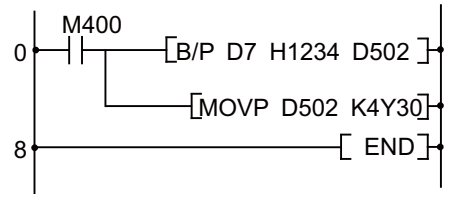
Program Example

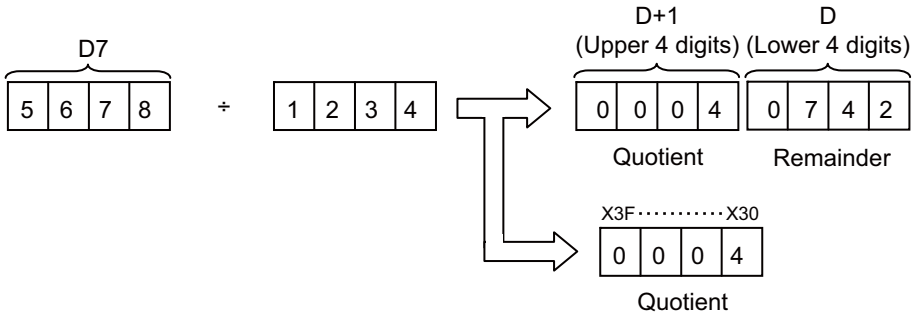
(1) The following program multiplies the BCD data at X0 to XF and the BCD data at D8 when X1B goes ON, and stores the result at D0 and D1.

[Ladder Mode]	[List Mode]		
	Steps	Inst.	Device
	0	LD	X1B
	1	B*P	K4X0
			D8
			D0
	5	END	



(2) The following program divides the BCD data D7 by the BCD data 1234, stores the result at D502 and D503, and at the same time outputs the quotient to Y30 to Y3F.

[Ladder Mode]	[List Mode]		
	Steps	Inst.	Device
	0	LD	M400
	1	B/P	D7
			H1234
			D502
	5	MOVP	D502
			K4Y30
	8	END	



○ **INC, INCP, DEC, DECP ... Incrementing and decrementing 16-bit BIN data**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○				○	○

Instruction symbol	Execution condition	▭ indicates the signs INC/DEC
INC,DEC		Command — D
INCP,DECP		Command — P D

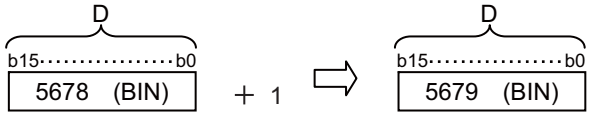
Set Data

Set Data	Meaning	Data Type
D	Head number of device conducting INC (add 1) or DEC (subtract 1) operation	BIN 16 bits

Functions

INC

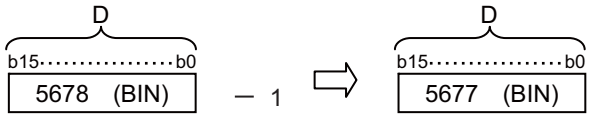
(1) Adds 1 to device designated by "D" (16-bit data).



(2) If the contents of the device designated by "D" were 32767, and the INC or INCP instruction were executed on that device, the value -32768 would be stored in the device designated by "D".

DEC

(1) Subtracts 1 from device designated by "D" (16-bit data).



(2) If the contents of the device designated by "D" were 0, and the DEC or DECP instruction were executed on that device, the value -1 would be stored in the device designated by "D".

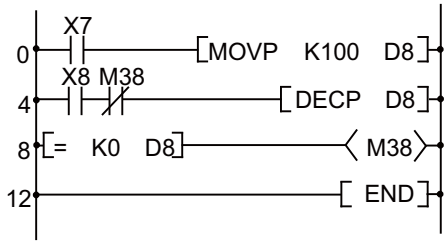
Operation Errors

(1) There are no operation errors associated with the INC(P) or DEC(P) instructions.

Program Example

(1) The following is a down counter program.

[Ladder Mode]



Transfers the value of 100 to D8 when X7 is ON

When M38 is OFF, X8 goes from OFF to ON, and 1 is decremented from D8.
At D8=0, M38 goes ON.

[List Mode]

Steps	Inst.	Device
0	LD	X7
1	MOVP	K100
		D8
4	LD	X8
5	ANI	M38
6	DECP	D8
8	LD=	K0
		D8
11	OUT	M38
12	END	

○ **DINC, DINCP, DDEC, DDECP ... Incrementing and decrementing 32-bit BIN data**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○					○	○

Instruction symbol	Execution condition	▭ indicates the signs DINC/DDEC
DINC,DDEC		Command — D
DINCP,DDECP		Command — P D

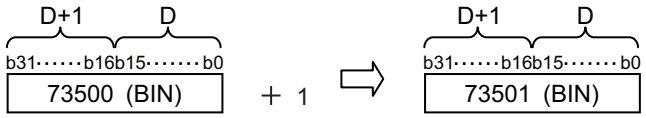
Set Data

Set Data	Meaning	Data Type
D	Head number of device what will execute the DINC (+1) or DDEC (-1) operation	BIN 32 bits

Functions

DINC

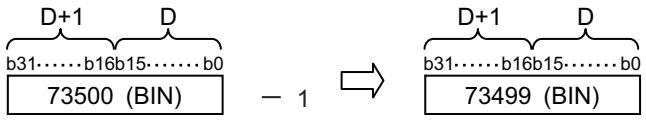
(1) Adds 1 to the device designated by "D" (32-bit data).



(2) If the contents of the device designated by "D" are 2147483647, and the DINC or DINCP instruction is executed, the value -2147483648 will be stored at the device designated by "D".

DDEC

(1) Subtracts 1 from the device designated by "D" (32-bit data).



(2) If the contents of the device designated by "D" are 0, and the DDEC or DDECP instruction is executed, the value -1 will be stored at the device designated by "D".

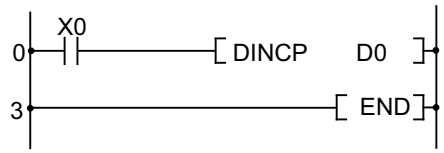
Operation Errors

(1) There are no operation errors associated with the DINC(P) or DDEC(P) instruction.

Program Example

(1) The following program adds 1 to the data at D0 and D1 when X0 is ON.

[Ladder Mode]

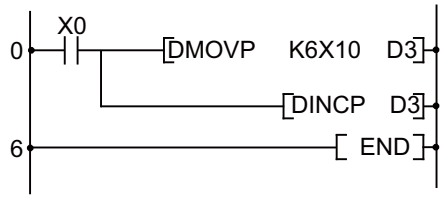


[List Mode]

Steps	Inst.	Device
0	LD	X0
1	DINCP	D0
3	END	

(2) The following program adds 1 to the data set at X10 to X27 when X0 goes ON, and stores the result at D3 and D4.

[Ladder Mode]

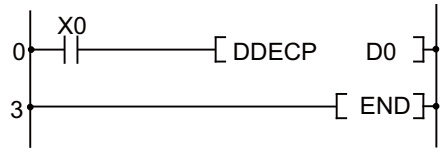


[List Mode]

Steps	Inst.	Device
0	LD	X0
1	DMOVP	K6X10
		D3
4	DINCP	D3
6	END	

(3) The following program subtracts 1 from the data at D0 and D1 when X0 goes ON.

[Ladder Mode]

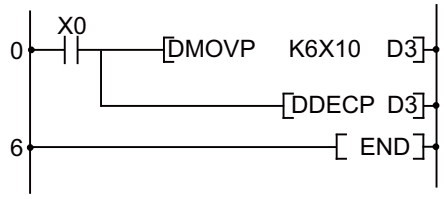


[List Mode]

Steps	Inst.	Device
0	LD	X0
1	DDECP	D0
3	END	

(4) The following program subtracts 1 from the data set at X10 to X27 when X0 goes ON, and stores the result at D3 and D4.

[Ladder Mode]



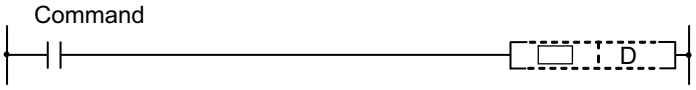
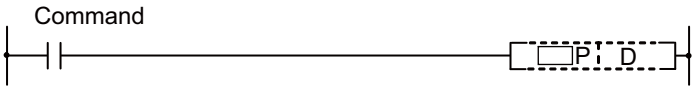
[List Mode]

Steps	Inst.	Device
0	LD	X0
1	DMOVP	K6X10
		D3
4	DDECP	D3
6	END	

○ **NEG, NEGP, DNEG, DNEGP ... Complement of 2 of BIN 16- and 32-bit data (sign reversal)**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ				○	○

Δ : This is not available with DNEG (P).

Instruction symbol	Execution condition	▭ indicates the signs NEG/DNEG
NEG,DNEG		
NEGP,DNEGP		

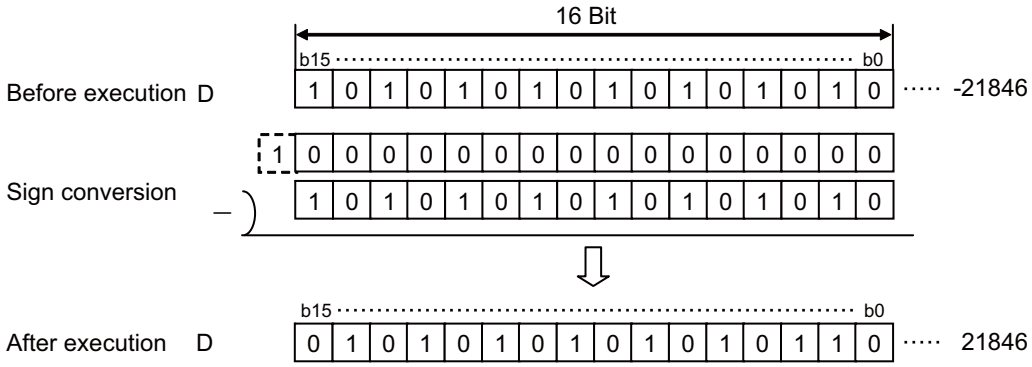
Set Data

Set Data	Meaning	Data Type
D	Head number of the device where data for the complement of 2 operation is stored.	BIN 16/32 bits

Functions

NEG

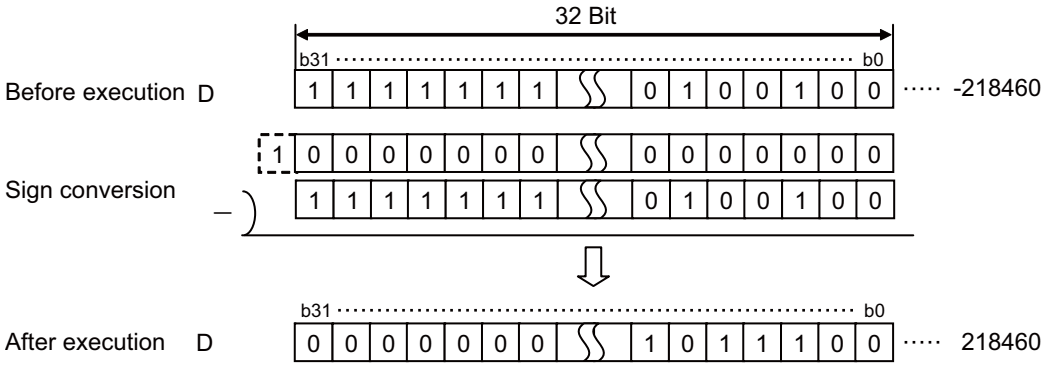
(1) Reverses the sign of the 16-bit device designated by "D" and stores at the device designated by "D".



(2) Used when reversing positive and negative signs.

DNEG

(1) Reverses the sign of the 32-bit device designated by "D" and stores at the device designated by "D".



(2) Used when reversing positive and negative signs.

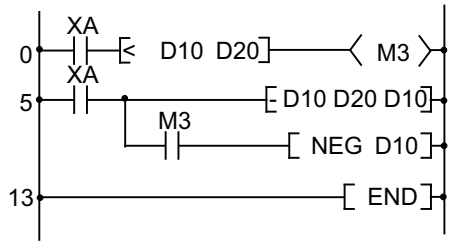
Operation Errors

(1) There are no operation errors associated with the NEG(P) or DNEG(P) instructions.

Program Example

(1) The following program calculates a total for the data at D10 through D20 when XA goes ON, and seeks an absolute value if the result is negative.

[Ladder Mode]



M3 goes ON when D10 is smaller than D20.

Subtracts D20 from D10.

Seeks an absolute value (complement of 2) when M3 is ON

[List Mode]

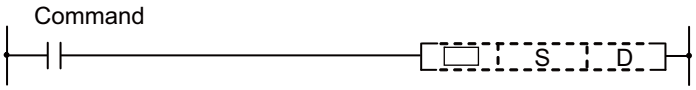
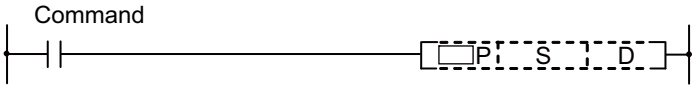
Steps	Inst.	Device
0	LD	XA
1	AND<	D10
		D20
4	OUT	M3
5	LD	XA
6	-	D10
		D20
		D10
10	AND	M3
11	NEG	D10
13	END	

7.3 Data Conversion Instruction

○ **BCD, BCDP, DBCD, DBCDP ... Conversion from BIN data to 4-digit and 8-digit BCD**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ				○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ					

Δ : This is not available with DBCD (P).

Instruction symbol	Execution condition	▭ indicates the signs BCD/DBCD
BCD,DBCD		
BCDP,DBCDP		

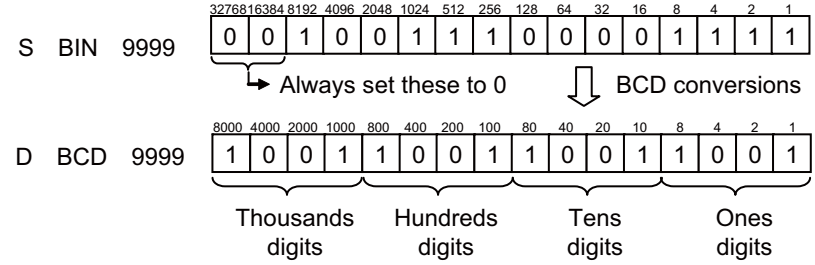
Set Data

Set Data	Meaning	Data Type
S	Head number of the device where BIN data is stored	BIN 16/32 bits
D	Head number of the device that will store BCD data	BCD 4/8 digits

Functions

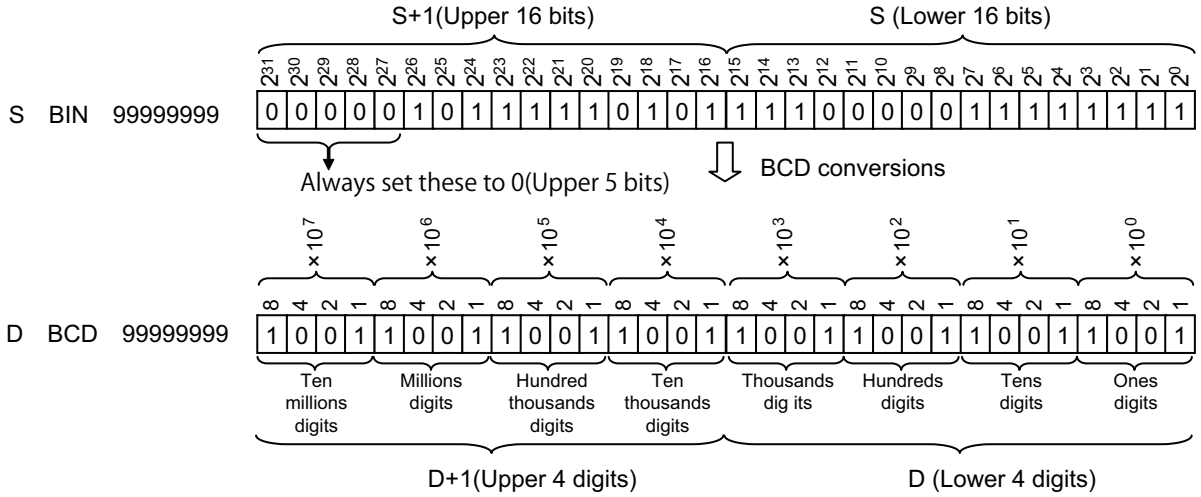
BCD

(1) Converts BIN data (0 to 9999) at the device designated by "D" to BCD data, and stores it at the device designated by "D".



DBCD

(1) Converts BIN data (0 to 99999999) at the device designated by "S" to BCD data, and transfers it at the device designated by "D".

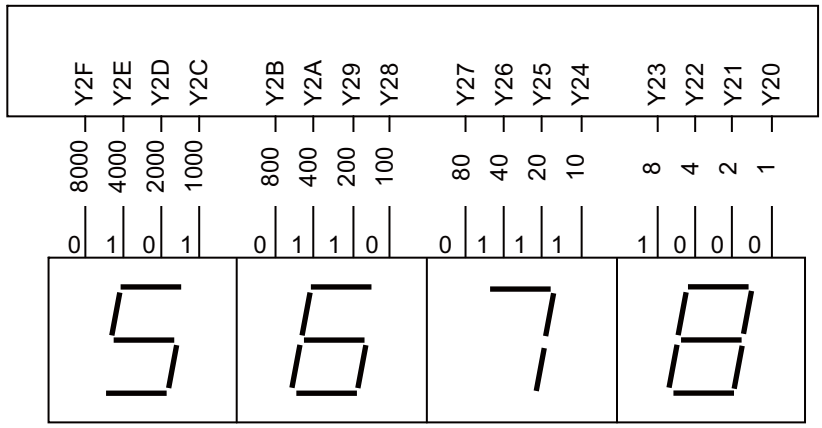


Operation Errors

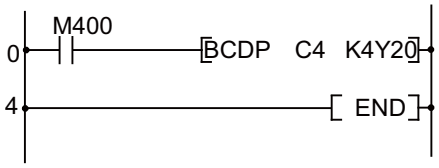
(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- The data at S was not in the 0 to 9999 range when the BCD instruction was issued. (Error code: 80)
- The data at "S"+1 and "S" was not in the 0 to 99999999 range when the DBCD instruction was issued. (Error code: 80)

Program Example

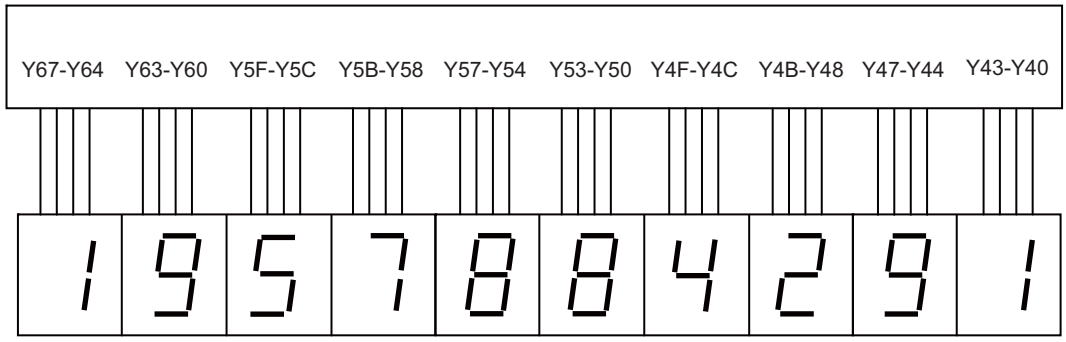
(1) The following program outputs the present value of C4 from Y20 to Y2F to the BCD display device.



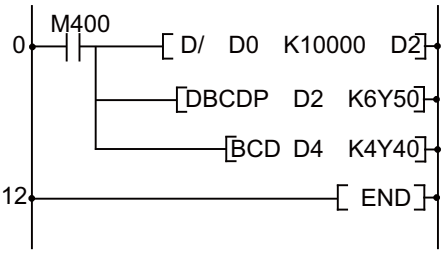
7-element display unit

[Ladder Mode]	[List Mode]
	Steps Inst. Device 0 LD M400 1 BCDP C4 K4Y20 4 END

(2) The following program outputs bit data from D0 to D1 to Y40 to Y67.



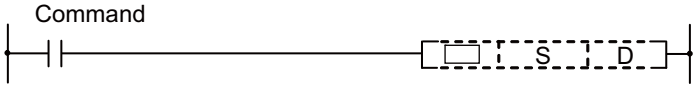
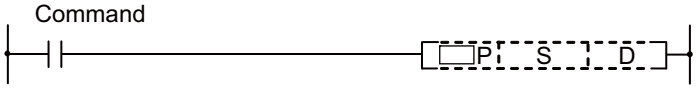
7-element display unit

[Ladder Mode]	[List Mode]
	Steps Inst. Device 0 LD M400 1 D/ D0 K10000 D2 6 DBCDP D2 K6Y50 9 BCD D4 K4Y40 12 END

○ **BIN, BINP, DBIN, DBINP ... Conversion from BCD 4-digit and 8-digit data to BIN data**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ				○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ				

Δ : This is not available with DBIN (P).

Instruction symbol	Execution condition	▭ indicates the signs BIN/DBIN
BIN,DBIN		
BINP,DBINP		

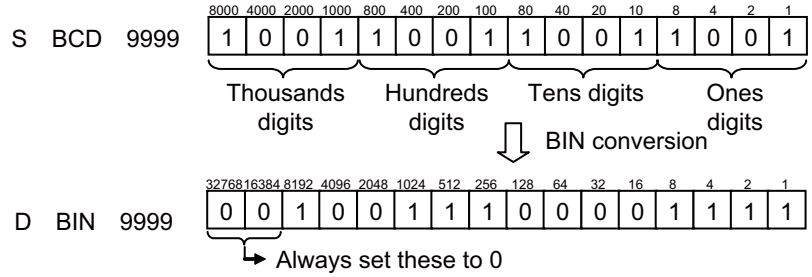
Set Data

Set Data	Meaning	Data Type
S	Head number of device storing BCD data	BCD 4/8 digits
D	Head number of device that will store BIN data	BIN 16/32 bits

Functions

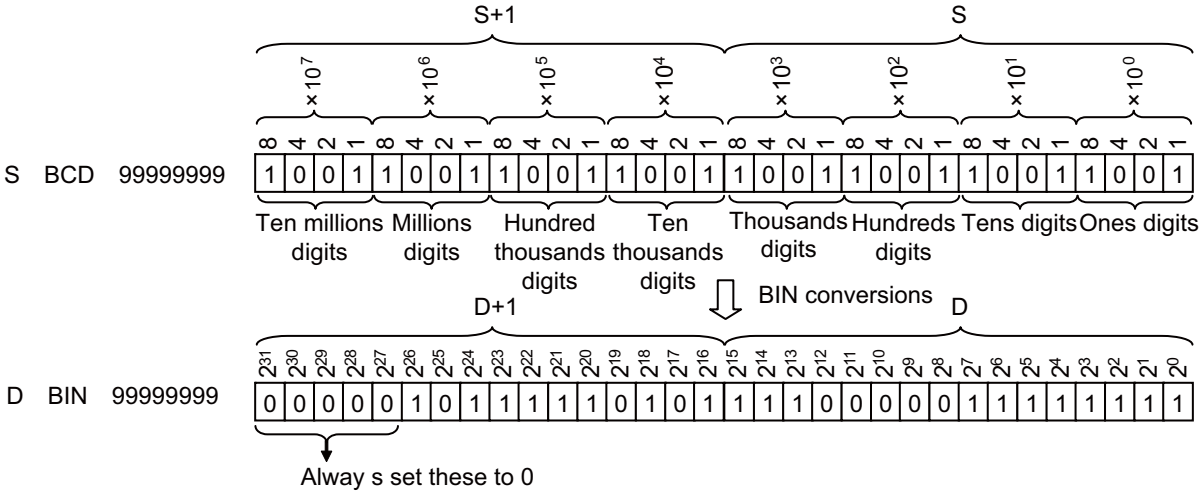
BIN

(1) Converts BCD data (0 to 9999) at device designated by "D" to BIN data, and stores at the device designated by "D".



DBIN

(1) Converts BCD data (0 to 99999999) at device designated by "S" to BIN data, and stores at the device designated by "D".

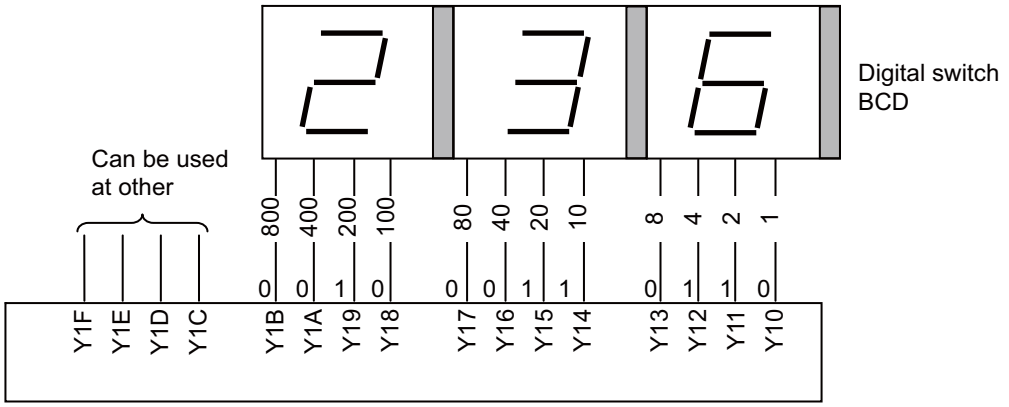


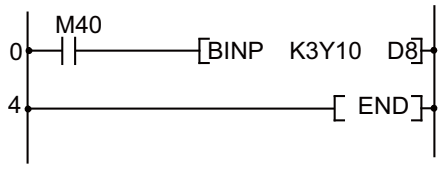
Operation Errors

(1) In the following cases, an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- When values other than 0 to 9 are designated to any digits of "S". (Error code: 81)

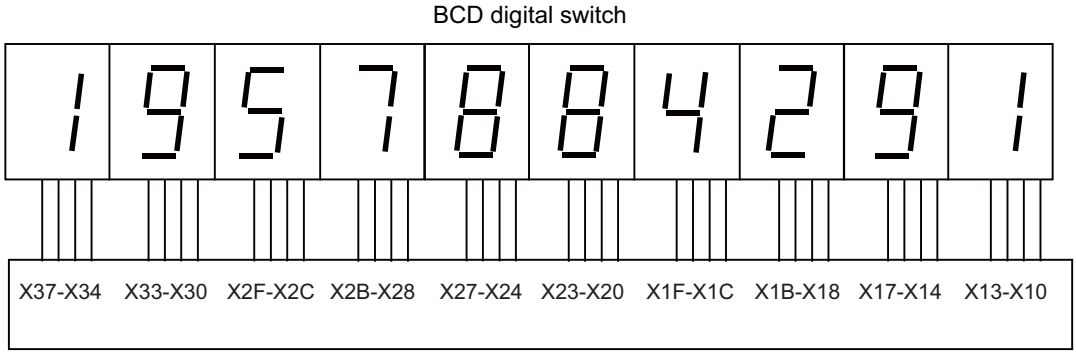
Program Example

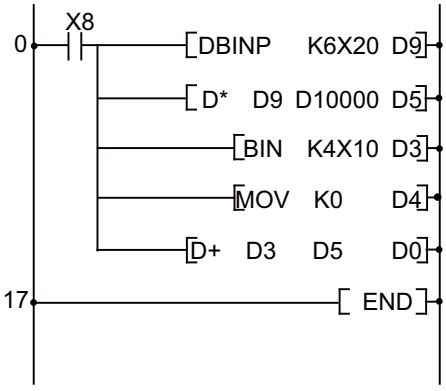
(1) The following program converts the BCD data at Y10 to Y1B to BIN when M40 is ON, and stores it at D8.



[Ladder Mode]	[List Mode]		
	Steps	Inst.	Device
	0	LD	M40
	1	BINP	K3Y10
			D8
	4	END	

(2) The following program converts the BCD data at X10 to X37 to BIN when X8 is ON, and stores it at D0 and D1.



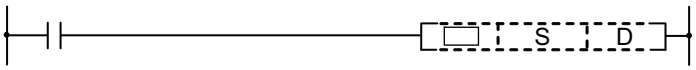
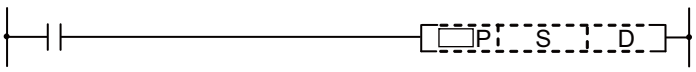
[Ladder Mode]	[List Mode]		
	Steps	Inst.	Device
	0	LD	X8
	1	DBINP	K6X20
			D9
	4	D*	D9
			D10000
			D5
	8	BIN	K4X10
			D3
	11	MOVK0	
			D4
	13	D+	D3
			D5
			D0
	17	END	

7.4 Data Transfer Instruction

○ **MOV, MOVP, DMOV, DMOVP ... 16-bit and 32-bit data transfers**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ	○	○		○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ					

Δ : This is not available with DMOV(P).

Instruction symbol	Execution condition	▭ indicates the signs MOV/DMOV
MOV,DMOV		
MOVP,DMOVP		

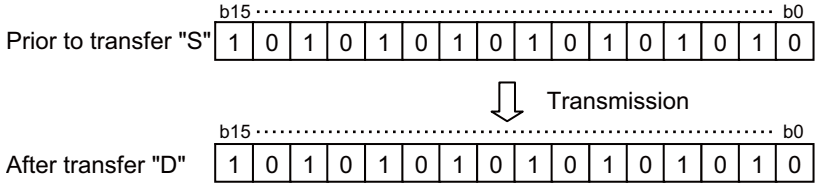
Set Data

Set Data	Meaning	Data Type
S	Transfer data, or number of device storing transfer data	BIN 16/32 bits
D	Number of device to store transferred data	

Functions

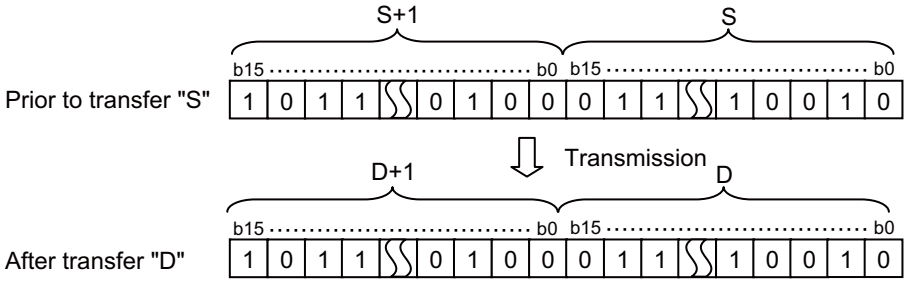
MOV

(1) Transfers the 16-bit data from the device designated by "S" to the device designated by "D".



DMOV

(1) Transfers the 32-bit data from the device designated by "S" to the device designated by "D".



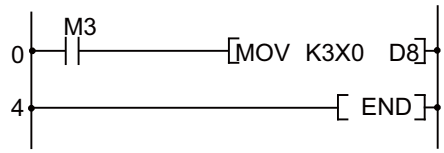
Operation Errors

(1) There are no operation errors associated with the MOV(P) or DMOV(P) instructions.

Program Example

(1) The following program stores input data from X0 to XB at D8.

[Ladder Mode]

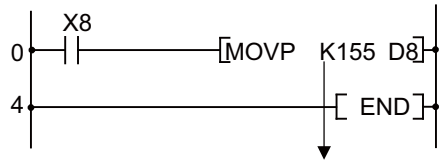


[List Mode]

Steps	Inst.	Device
0	LD	M3
1	MOV	K3X0
		D8
4	END	

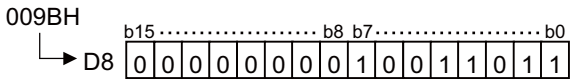
(2) The following program stores the constant K155 at D8 when X8 goes ON.

[Ladder Mode]



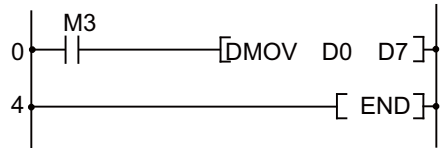
[List Mode]

Steps	Inst.	Device
0	LD	X8
1	MOVP	K155
		D8
4	END	



(3) The following program stores the data from D0 and D1 at D7 and D8.

[Ladder Mode]

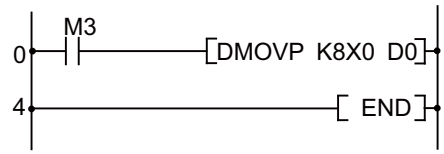


[List Mode]

Steps	Inst.	Device
0	LD	M3
1	DMOV	D0
		D7
4	END	

(4) The following program stores the data from X0 to X1F at D0 and D1.

[Ladder Mode]



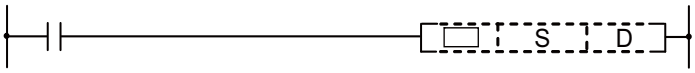
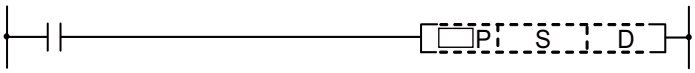
[List Mode]

Steps	Inst.	Device
0	LD	M3
1	DMOVP	K8X0
		D0
4	END	

○ **CML, CMLP, DCML, DCMLP ... 16-bit and 32-bit negation transfers**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ	○	○		○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ					

Δ : This is not available with DCML(P).

Instruction symbol	Execution condition	▭ indicates the signs CML/DCML
CML,DCML		
CMLP,DCMLP		

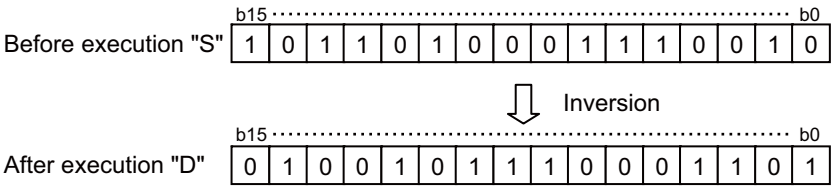
Set Data

Set Data	Meaning	Data Type
S	Data to be inverted, or number of device storing this data	BIN 16/32 bits
D	Number of device that will store results of inversion	

Functions

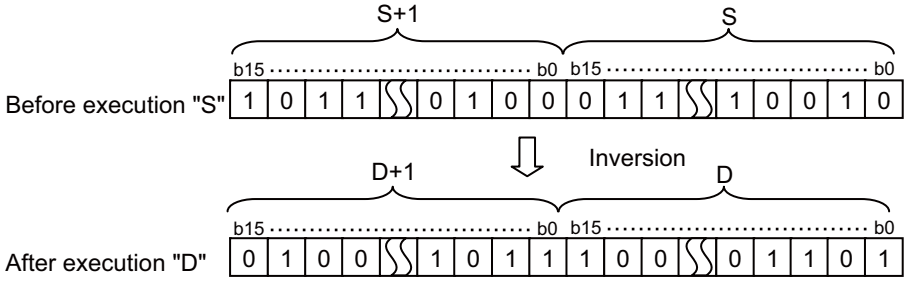
CML

(1) Inverts 16-bit data designated by S bit by bit, and transfers the result to the device designated by "D".



DCML

(1) Inverts 32-bit data designated by S bit by bit, and transfers the result to the device designated by "D".



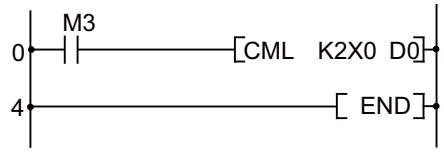
Operation Errors

(1) There are no operation errors associated with the CML(P) or DCML(P) instructions.

Program Example

(1) The following program inverts the data from X0 to X7, and transfers result to D0.

[Ladder Mode]

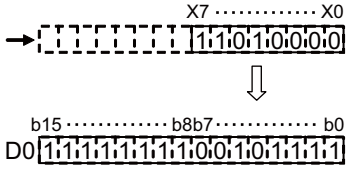


[List Mode]

Steps	Inst.	Device
0	LD	M3
1	CML	K2X0
		D0
4	END	

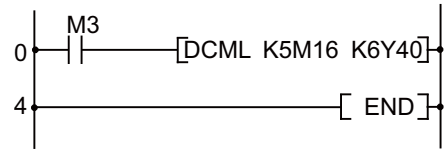
When the number of bits at "S" is less than the number of bits at "D"

These bits are all read as "0".



(2) The following program inverts the data at M16 to M35, and transfers the result to Y40 to Y53.

[Ladder Mode]

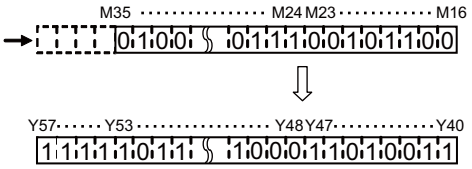


[List Mode]

Steps	Inst.	Device
0	LD	M3
1	DCML	K5M16
		K5Y40
4	END	

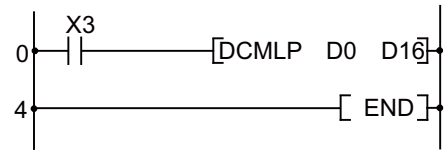
When the number of bits at "S" is less than the number of bits at "D"

These bits are all read as "0".



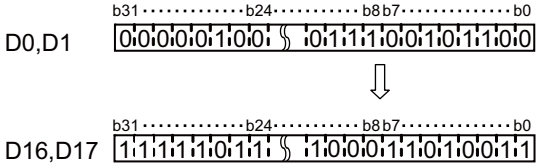
(3) The following program inverts the data at D0 and D1 when X3 is ON, and stores the result at D16 and D17.

[Ladder Mode]



[List Mode]

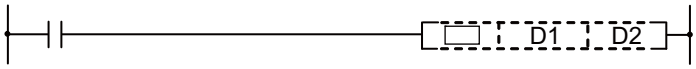
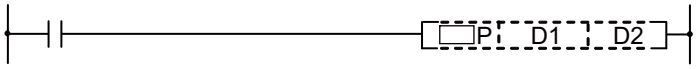
Steps	Inst.	Device
0	LD	X3
1	DCMLP	D0
		D16
4	END	



○ **XCH, XCHP, DXCH, DXCHP ... 16-bit and 32-bit data exchanges**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
D1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ				○	○
D2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ				

Δ : This is not available with DXCH (P).

Instruction symbol	Execution condition	▭ indicates the signs XCH/DXCH
XCH,DXCH		
XCHP,DXCHP		

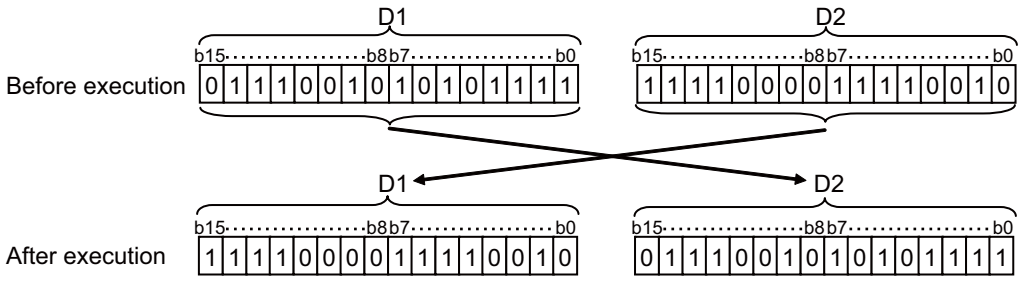
Set Data

Set Data	Meaning	Data Type
D1	Head number of device storing data to be exchanged	BIN 16/32 bits
D2		

Functions

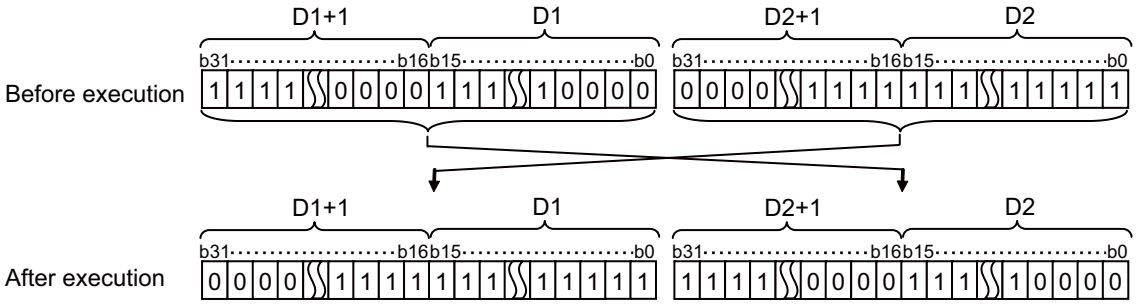
XCH

(1) Conducts 16-bit data exchange between "D1" and "D2".



DXCH

(1) Conducts 32-bit data exchange between "D1"+1, "D1" and "D2"+1, "D2".



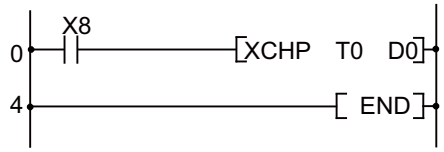
Operation Errors

(1) There are no operation errors associated with the XCH(P) or DXCH(P) instructions.

Program Example

(1) The following program exchanges the present value of T0 with the contents of D0 when X8 goes ON.

[Ladder Mode]

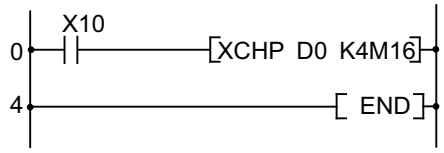


[List Mode]

Steps	Inst.	Device
0	LD	X8
1	XCHP	T0
		D0
4	END	

(2) The following program exchanges the contents of D0 with the data from M16 to M31 when X10 goes ON.

[Ladder Mode]

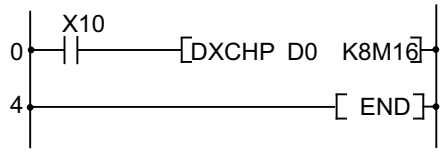


[List Mode]

Steps	Inst.	Device
0	LD	X10
1	XCHP	D0
		K4M16
4	END	

(3) The following program exchanges the contents of D0 and D1 with the data at M16 to M47 when X10 goes ON.

[Ladder Mode]

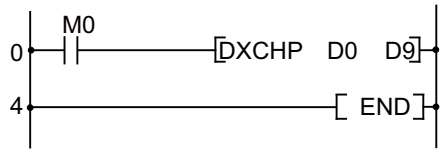


[List Mode]

Steps	Inst.	Device
0	LD	X10
1	DXCHP	D0
		K8M16
4	END	

(4) The following program exchanges the contents of D0 and D1 with those of D9 and D10 when M0 goes ON.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	M0
1	DXCHP	D0
		D9
4	END	

○ **BMOV, BMOVP ... 16-bit data block transfers**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S											○	○	○	○	○	○	○						○
D											○	○	○	○	○	○	○						
n																			○	○			

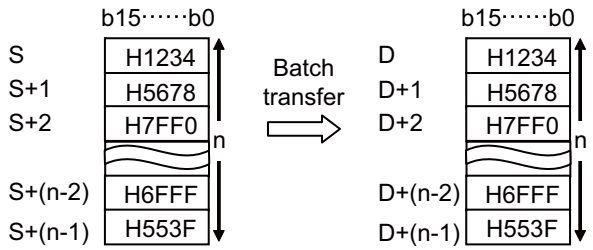
Instruction symbol	Execution condition	
BMOV		Command BMOV S D n
BMOVP		Command BMOVP S D n

Set Data

Set Data	Meaning	Data Type
S	Head number of device storing data to transfer	BIN 16 bits
D	Head number of destination device	
n	Number of transfers	

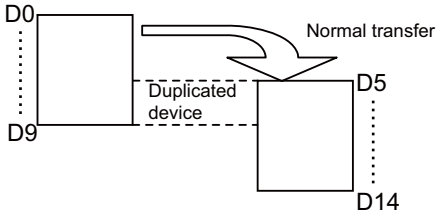
Functions

(1) Batch transfers "n" points of 16-bit data starting from the device designated by "S" to the area of "n" points starting from the device designated by "D".



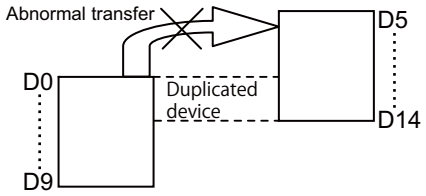
(2) When transfer source and transfer destination are duplicated, the following operations are expected.
(a) Transferring to a smaller device No. results in normal operation.

(Example) When BMOV D0 D5 K10 are executed



(b) Transferring to a larger device No. results in abnormal operation.

(Example) When BMOV D5 D0 K10 are executed



Operation Errors

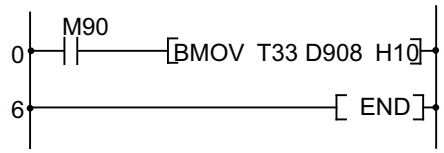
(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- In the case where a part of device area between S/D and n-th device does not exist.
(Error code: 82)

POINT
Note that if the number of devices in the area between S/D and n-th device exceeds the relevant device, error will not occur. (In this case, transferred to the other device, as well.)

Program Example

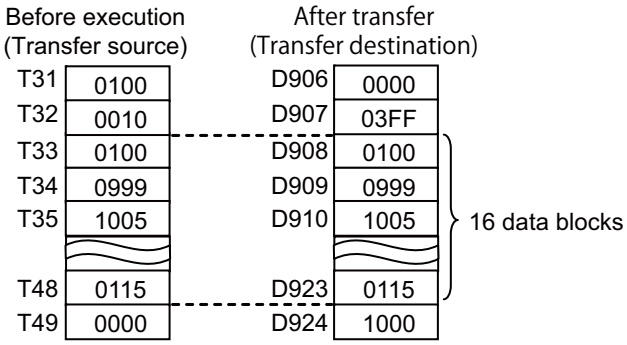
(1) The current value of T33 to T48 is transferred to D908 to D923.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	M90
1	BMOV	T33
		D908
		H10
6	END	



○ **FMOV, FMOVP ... 16-bit identical data batch transfer**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S											○	○	○	○	○	○	○	○	○	○			○
D											○	○	○	○	○	○	○						
n																			○	○			

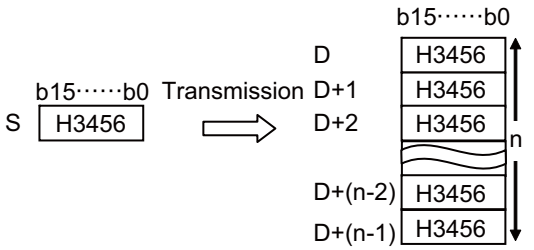
Instruction symbol	Execution condition	
FMOV		Command → FMOV S D n
FMOVP		Command → FMOVP S D n

Set Data

Set Data	Meaning	Data Type
S	S Data to transfer, or head number of device storing data to transfer	BIN 16 bits
D	Head number of destination device	
n	Number of transfers	

Functions

(1) Transfers 16-bit data from device designated by "S" to location n-points from device designated by "D".



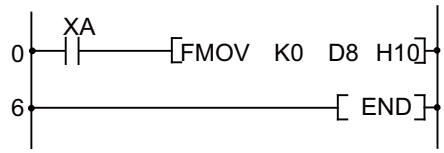
Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- In the case where a part of device area between D and n-th device does not exist. (Error code: 82)

Program Example

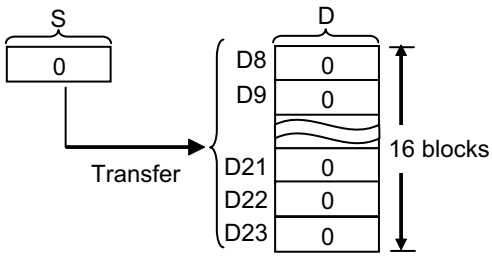
(1) When XA is turned ON, D8 to D23 is reset (cleared).

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	XA
1	FMOV	K0
		D8
		H10
6	END	



○ **S.TMOV ... Transfer of timer and counter setting value**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S											○	○										○
D													○	○	○	○	○					

Instruction symbol	Execution condition	
S.TMOV		Command S.TMOV S D

Set Data

Set Data	Meaning	Data Type
S	No. of timer and counter device to which setting value is transferred.	BIN 16 bits
D	Device No. of the transfer destination	

Functions

(1) The setting value of timer and counter device specified with S is transferred to the device specified with D.
Note that, however, the actual setting value is transferred only if specified with constant.
If the setting value is specified with word device, normal transfer will not be carried out.

Timer setting	Setting value designation method with the timer output instruction		Setting value to be transferred by TMOV	
Fixed timer setting	Constant designation	OUT Tx Kn	○	Constant "n"
	Word device designation	OUT Tx Dn	×	Constant 0(zero)
Variable timer setting	Constant designation	OUT Tx Kn	○	Setting value set with the setting display
	Word device designation	OUT Tx Dn	×	Setting value set with the setting display

[Note]
When this instruction is monitored, the current value is displayed on the timer and counter device specified with S.
If the timer and counter device are used with any function instructions other than above, everything indicates the current value.

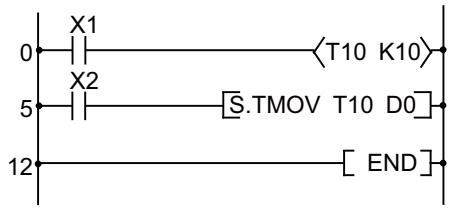
Operation Errors

(1) There are no operation errors associated with the S.TMOV instruction.

Program Example

(1) The setting value of T10 is transferred to D0.

[Ladder Mode]



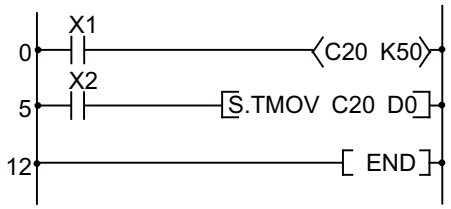
[List Mode]

Steps	Inst.	Device
0	LD	X1
1	OUT	T10
		K10
5	LD	X2
6	S.TMOV	T10
		D0
12	END	

In this example, D0 equals to 10.

(2) The setting value of C20 is transferred to D0.
Condition: Variable timer is set for the counter C20. This is the case where 100 is set for C20, using the setting display device.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X1
1	OUT	C20
		K50
5	LD	X2
6	S.TMOV	C20
		D0
12	END	

In this example, D0 equals to 100.

7.5 Program Branch Instruction

○ **CJ, JMP... Conditional jump**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
P																					○		○

Instruction symbol	Execution condition	
CJ		Command CJ P**
JMP		JMP P**
		Label P** Command

Set Data

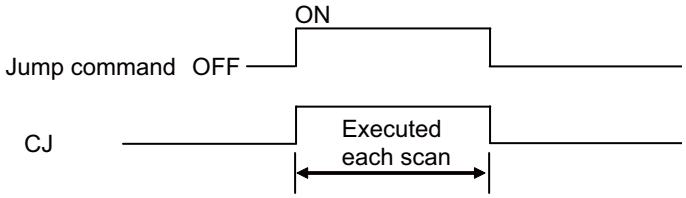
Set Data	Meaning	Data Type
P	Pointer number of jump destination	Device name

Functions

CJ

(1) Executes program of designated pointer number within the same program file when jump command is ON.

(2) Executes next step in program when jump command is OFF.

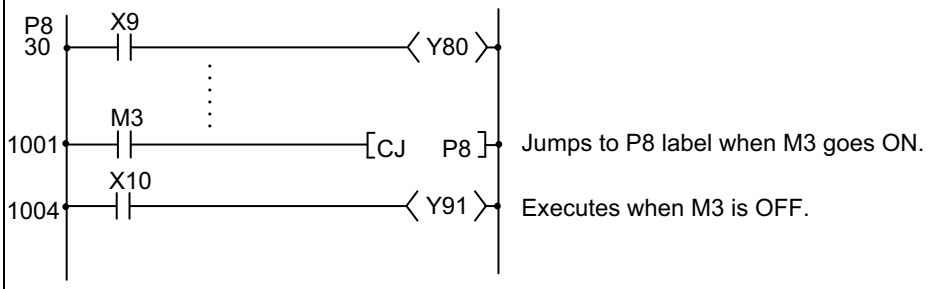


JMP

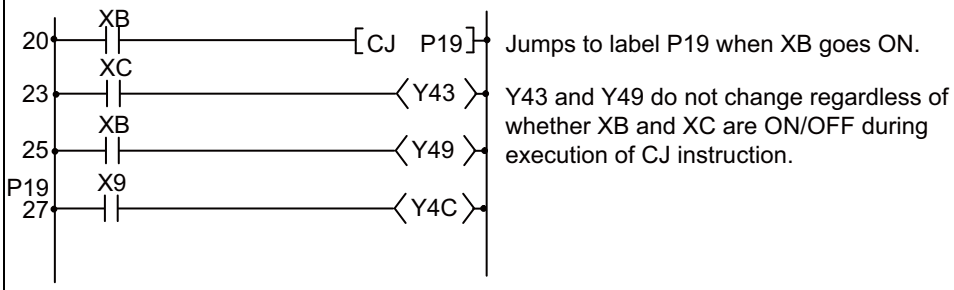
(1) A program of specified pointer No. in the same program file is executed unconditionally.

POINT

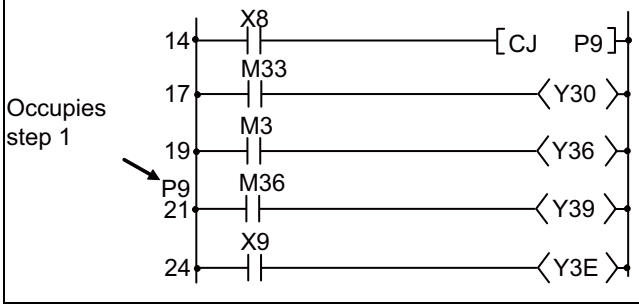
Note the following points when using the jump instruction.
(1) Jump instructions can be used only for pointer numbers within the same program file.
(2) After the timer coil has gone ON, accurate measurements cannot be made if there is an attempt to jump the timer of a coil that has been turned ON using the CJ or JMP instructions.
(3) Scan time is shortened if the CJ or JMP instruction is used to force a jump to the rear.
(4) The CJ and JMP instructions can be used to jump to a step prior to the step currently being executed.



(5) The device to which a jump has been made with CJ or JMP does not change.



(6) The lable (P**) occupies step 1.



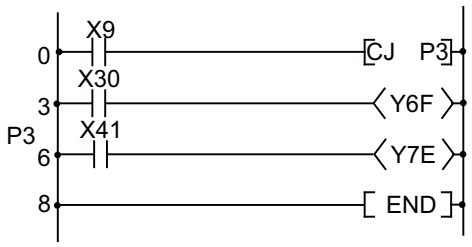
Operation Errors

(1) In the following cases an operation is returned, the error flag (SM0) goes ON, and the error code is stored at SD0.
- A pointer number which is not in use as a label in the same program has been designated.
  (Error code: 20 or 85)
- A common pointer in the other program has been designated.
  (Error code: 20 or 85)

Program Example

(1) The following program jumps to P3 when X9 goes ON.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X9
1	CJ	P3
3	LD	X30
4	OUT	Y6F
5		P3
6	LD	X41
7	OUT	Y7E
8	END	

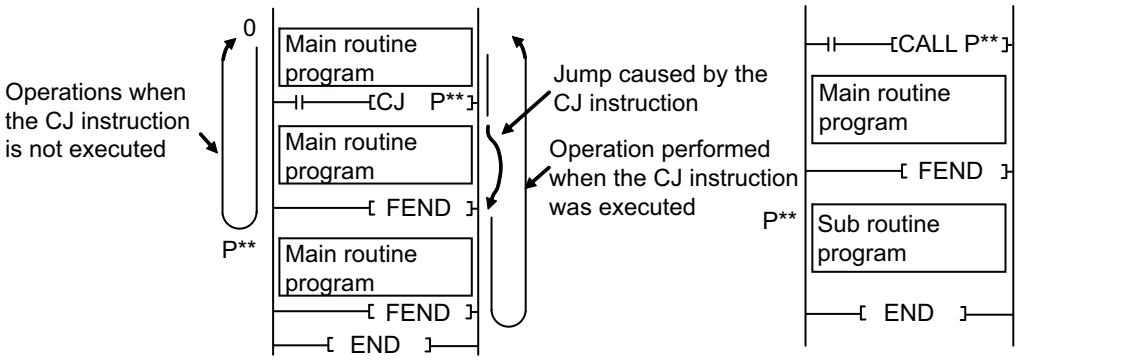
○ **FEND ... Program termination**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		

Instruction symbol	Execution condition	
FEND		FEND

Functions

(1) FEND instruction is used when branching a sequence program operation by CJ instruction, etc., or when dividing between the main routine program and the sub routine program.



(a) When using the CJ instruction (b) When there is a subroutine program

Operation Errors

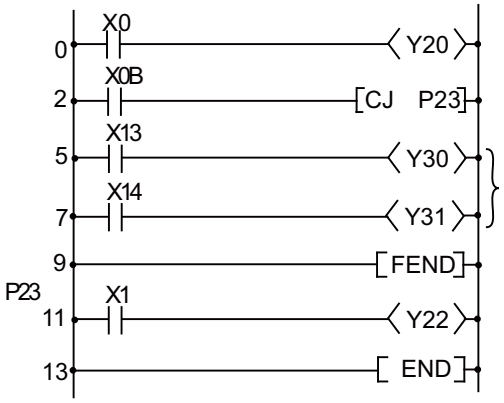
(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.

- A FEND instruction is executed after the execution of the CALL instruction, and before the execution of the RET instruction. (Error code: 26)

Program Example

(1) The following program uses the CJ instruction.

[Ladder Mode]



When XB is ON, jumps to label P23; from P23, executes the next step

Executed when XB is OFF

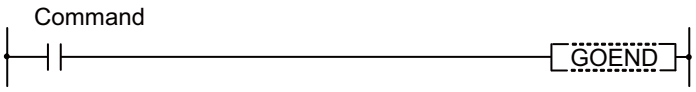
Indicates the termination of the sequence program when XB is OFF

[List Mode]

```
0     LD     X0
      :
      :
9     FEND
10           P23
11    LD     X1
12    OUT    Y22
13    END
```

○ **GOEND ... Jump to END**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		

Instruction symbol	Execution condition	
GOEND		

Functions

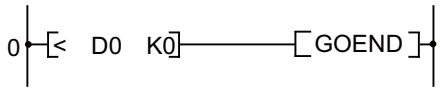
(1) Jumps to FEND or END instruction in the same program file.

Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- A GOEND instruction has been executed after the execution of the CALL instruction, and prior to the execution of the RET instruction. (Error code: 26)

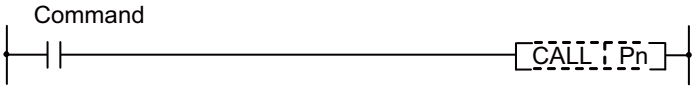
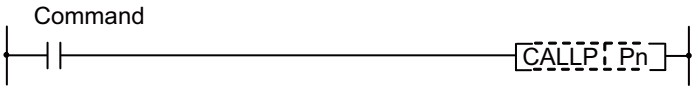
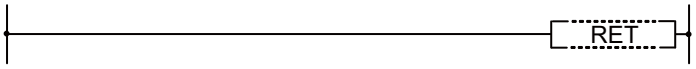
Program Example

(1) The following program jumps to the END instruction if D0 holds a negative number.

[Ladder Mode]	[List Mode]
	Steps Inst. Device 0 LD< D0 K0 3 GOEND

○ **CALL, CALLP, RET ... Sub-routine program calls and return from sub-routine programs**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
P																					○		○

Instruction symbol	Execution condition	
CALL		
CALLP		
RET		

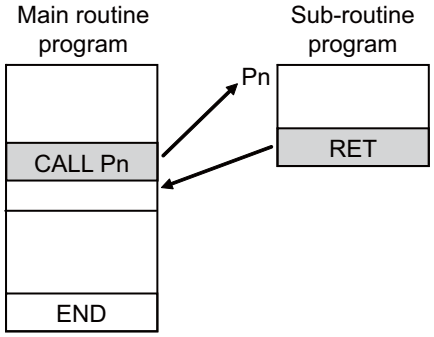
Set Data

Set Data	Meaning	Data Type
Pn	First pointer number of sub-routine program	Device name

Functions

CALL

(1) When the CALL (P) instruction is executed, executes the sub-routine program of the program specified by Pn.



(2) CALL or CALLP instructions can be nested up to 8 deep.

POINT

There are the following two pointer numbers to be set by the CALL(P) instruction.
Refer to "Detailed Explanation of Devices: Pointer P" for details.
- Local pointer
- Common pointer

RET

(1) Indicates end of sub-routine program

(2) When the RET instruction is executed, returns to the step following the CALL(P) instruction which called the sub-routine program.

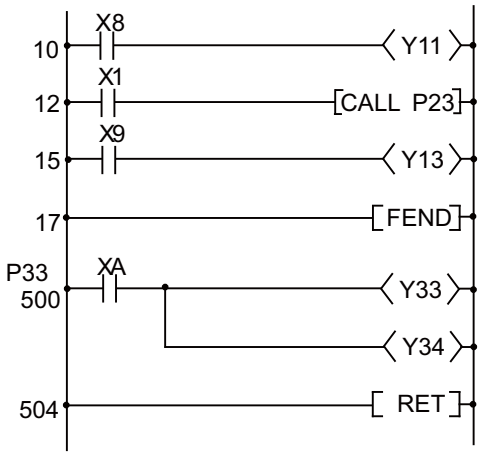
Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- Following the execution of the CALL(P) instruction, an END or FEND instruction is executed before the execution of the RET instruction. (Error code: 26)
- An RET instruction is executed prior to the execution of the CALL (P) instruction. (Error code: 26)
- When stuck area has exceeded due to CALL(P) instruction's nesting, etc. (Error code: 86)

Program Example

(1) The following program executes a sub-routine program when X1 turns ON from OFF.

[Ladder Mode]

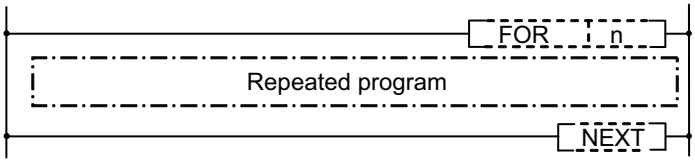


[List Mode]

Steps	Inst.	Device
10	LD	X8
11	OUT	Y11
12	LD	X1
13	CALL	P33
15	LD	X9
16	OUT	Y13
17	FEND	
18		
:		
500		P33
501	LD	XA
502	OUT	Y33
503	OUT	Y34
504	RET	
505		

○ **FOR, NEXT ... FOR to NEXT instruction loop**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
n	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	○	○		○	○

Instruction symbol	Execution condition	
FOR		
NEXT		

Set Data

Set Data	Meaning	Data Type
n	Number of repetitions of the FOR to NEXT loop (from 1 to 32767)	BIN 16 bits

Functions

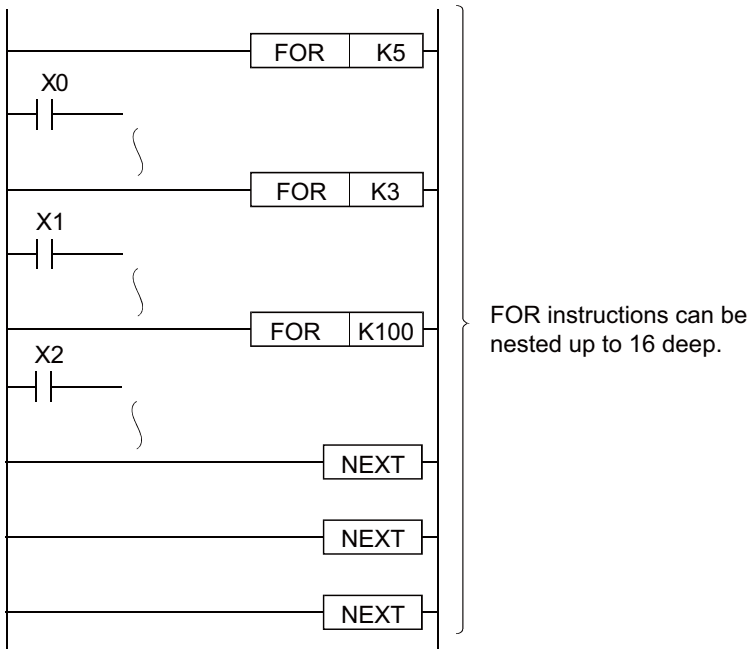
(1) When the processing in the FOR to NEXT loop is executed n-times without conditions, the step following the NEXT instruction will be executed.

(2) The value of n can be designated at between 1 and 32767.
If it is designated at a value of from -32768 to 0, it will be executed as though n=1.

(3) If you do not desire to execute the processing called for within the FOR to NEXT loop, use the CJ instruction to jump.
Setting the repetition times to "0" would not allow you to skip the process between FOR and NEXT instructions.

(4) To force an end to the repetitious execution of the FOR to NEXT loop during the execution of the loop, insert a BREAK instruction. Premature termination with CJ instruction, etc. will result in an operation error.

(5) FOR instructions can be nested up to 16 deep.



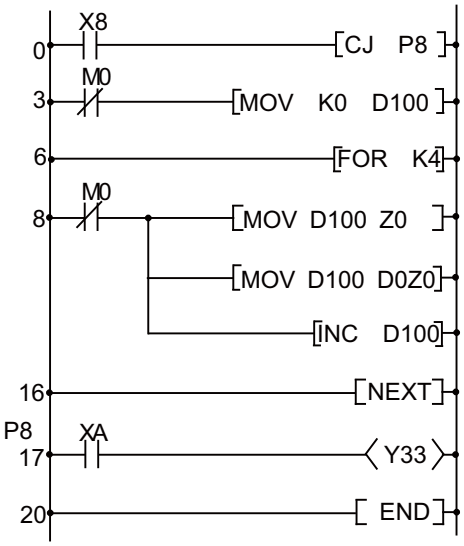
Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- An END (FEND) instruction is executed after the execution of a FOR instruction, but before the execution of a NEXT instruction. (Error code: 31)
- A NEXT instruction is executed prior to the execution of a FOR instruction. (Error code: 31)
- The 17th FOR instruction is encountered when FOR instructions have been nested. (Error code: 30)

Program Example

(1) The following program executes the FOR to NEXT loop when X8 is OFF, and does not execute it when X8 is ON.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X8
1	CJ	P8
3	LDI	M0
4	MOV	K0
		D100
6	FOR	K4
8	LDI	M0
9	MOV	D100
		Z0
12	MOV	D100
		D0Z0
15	INC	D100
16	NEXT	
17		P8
18	LD	XA
19	OUT	Y33
20	END	

[REMARK]

(1) Use an EGP/ EGF instruction to change an index of contacts between FOR and NEXT.

○ **BREAK, BREAKP ... Forced end of FOR to NEXT instruction loop**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○				○	○
P																					○		

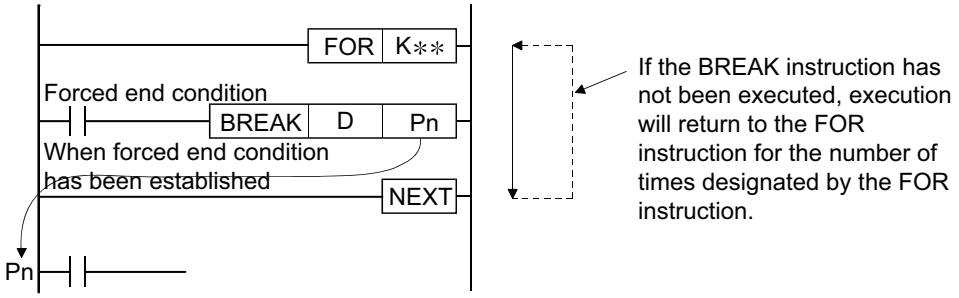
Instruction symbol	Execution condition	
BREAK		Command BREAK D Pn
BREAKP		Command BREAKP D Pn

Set Data

Set Data	Meaning	Data Type
D	Number of device that will store the number of repetitions remaining	BIN 16 bits
Pn	Number of branch destination pointer when the end of processing repetitions.	Device name(Pointer)

Functions

(1) Forces the end of repetition processing based on the FOR to NEXT instruction loop, and shifts to the execution of the pointer designated by Pn.
Only the pointer within the same program file can be specified for Pn.
If a pointer in the other program file is specified for Pn, an operation error is resulted.



(2) The number of repetitions remaining at the point that the FOR to NEXT loop was brought to a forced end is stored at "D".
However, the number of times when the BREAK instruction was executed is also included in the number of repetitions remaining.

(3) The BREAK instruction can be used only during the execution of a FOR to NEXT instruction loop.

(4) The BREAK instruction can be used only when there is only one level of nesting.
If an end is forced when there are multiple nesting levels, execute the same number of BREAK instructions as there are nesting levels.

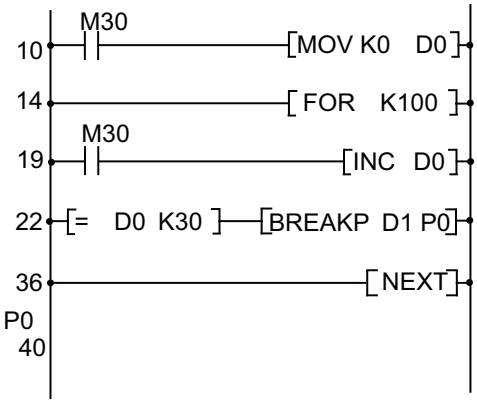
Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- The BREAK instruction is used in a case other than with the FOR to NEXT instruction loop. (Error code: 32)
- The jump destination for the pointer designated by Pn does not exist. (Error code: 85)
- The pointer of another program file is designated for Pn. (Error code: 85)

Program Example

(1) The following program forces the FOR to NEXT loop to end when the value of D2 reaches 30 (when the FOR to NEXT loop has been executed 30 times).

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
10	LD	M30
11	MOV	K0
		D0
14	FOR	K100
19	LD	M30
20	INC	D0
22	LD=	D0
		K30
25	BREAKP	D1
		P0
36	NEXT	
40		P0

[REMARK]

(1) The value 71 is stored at D1 as the remaining number of repetitions when the BREAK instruction is executed.

7.6 Logical Operation Instructions

○ **WAND, WANDP, DAND, DANDP ... Logical products with 16-bit and 32-bit data**
(Device at storage destination: Independent type)

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2	Δ1	Δ1		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2	Δ1	Δ1			
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2					

Δ 1: S1 and S2 cannot be specified as constant at the same time.

Δ 2: This is not available with DAND(P).

Instruction symbol	Execution condition	☐ indicates the signs WAND/DAND
WAND,DAND		Command — ☐ S1 S2 D
WANDP,DANDP		Command — ☐ P S1 S2 D

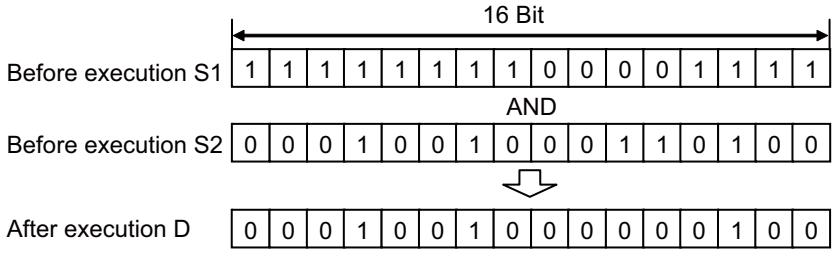
Set Data

Set Data	Meaning	Data Type
S1	Data from which logical product will be determined, or number of devices storing such data	BIN 16/32 bits
S2		
D	Number of devices where logical product operation results will be stored	

Functions

WAND

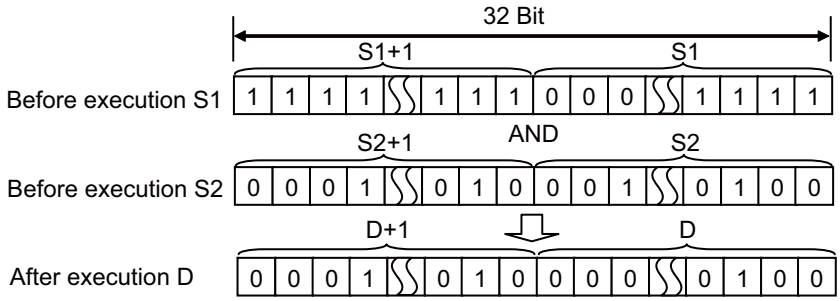
(1) A logical product operation is conducted for each bit of the 16-bit data of the device designated at "S1" and the 16-bit data of the device designated at "S2", and the results are stored in the device designated at "D".



(2) In the case of bit devices, digits above the number designated are processed as 0 in the operation.

DAND

(1) Conducts a logical product operation on each bit of the 32-bit data for the device designated by "S1" and the 32-bit data for the device designated by "D", and stores the results at the device designated by "D".

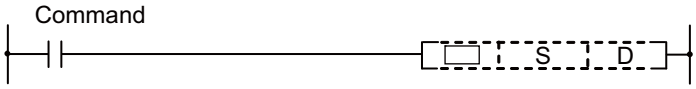
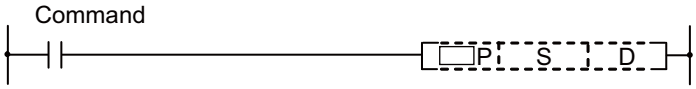


(2) In the case of bit devices, digits other than the number designated are processed as 0 in the operation.

○ **WAND, WANDP, DAND, DANDP ... Logical products with 16-bit and 32-bit data**
(Device at storage destination: Shared type)

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ	○	○		○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ					

Δ : This is not available with DAND(P).

Instruction symbol	Execution condition	▭ indicates the signs WAND/DAND
WAND,DAND		
WANDP,DANDP		

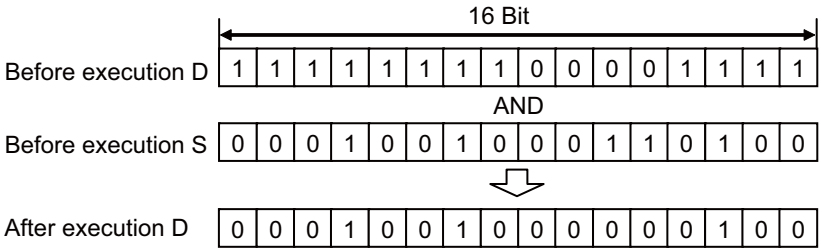
Set Data

Set Data	Meaning	Data Type
S	Data from which logical product will be determined, or number of devices storing such data	BIN 16/32 bits
D		

Functions

WAND

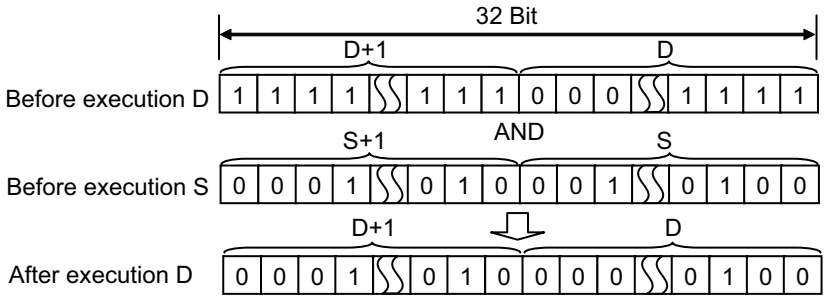
(1) A logical product operation is conducted for each bit of the 16-bit data of the device designated at "D" and the 16-bit data of the device designated at "S", and the results are stored in the device designated at "D".



(2) In the case of bit devices, digits other than the number designated are processed as 0 in the operation.

DAND

(1) Conducts a logical product operation on each bit of the 32-bit data for the device designated by "D" and the 32-bit data for the device designated by "S", and stores the results at the device designated by "D".



(2) In the case of bit devices, digits other than the number designated are processed as 0 in the operation.

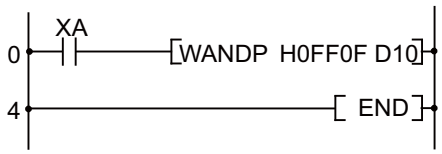
Operation Errors

(1) There are no operation errors associated with the WAND(P) or DAND(P) instructions.

Program Example

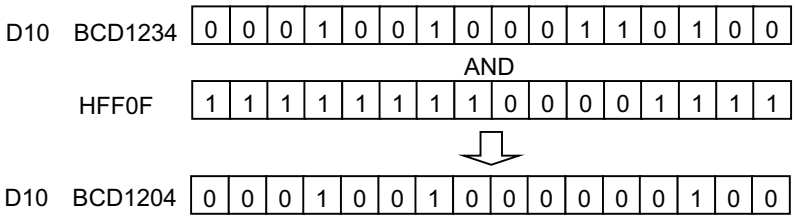
(1) The following program masks the digit in the 10s place of the 4-digit BCD value at D10 (second digit from the end) to 0 when XA is ON.

[Ladder Mode]



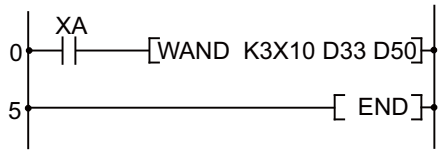
[List Mode]

Steps	Inst.	Device
0	LD	X0A
1	WANDP	H0FF0F
3		D10
4	END	



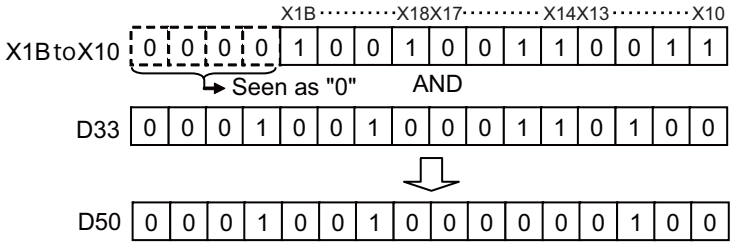
(2) The following program performs a logical product operation on the data from X10 to X1B and the data at D33 when XA is ON, and outputs the results to D50.

[Ladder Mode]



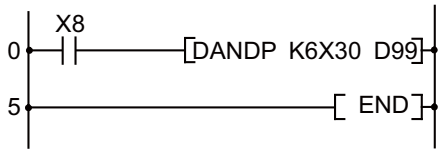
[List Mode]

Steps	Inst.	Device
0	LD	XA
1	WAND	K3X10
		D33
		D50
5	END	



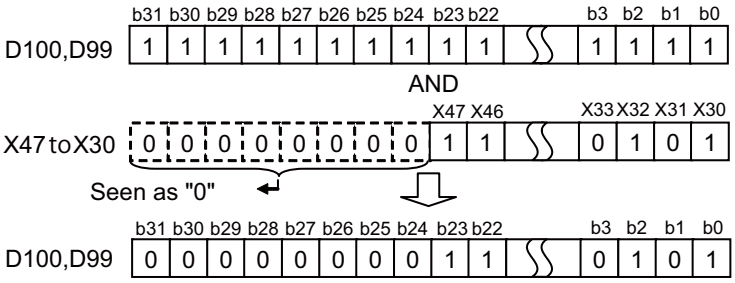
(3) The following program performs a logical product operation on the data at D99 and D100, and the 24- bit data between X30 and X47 when X8 is ON, and stores the results at D99 and D100.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X8
1	DANDP	K6X30
		D99
4	END	

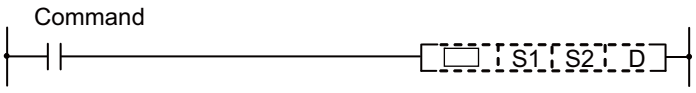
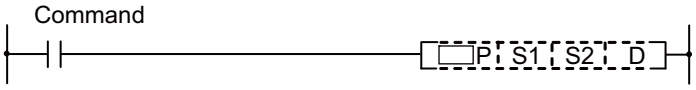


○ **WOR, WORP, DOR, DORP ... Logical sums of 16-bit and 32-bit data**
(Device at storage destination: Independent type)

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2	Δ1	Δ1		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2	Δ1	Δ1			
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2					

Δ 1: S1 and S2 cannot be specified as constant at the same time.

Δ 2: This is not available with DOR(P).

Instruction symbol	Execution condition	☐ indicates the signs WOR/DOR
WOR,DOR		
WORP,DORP		

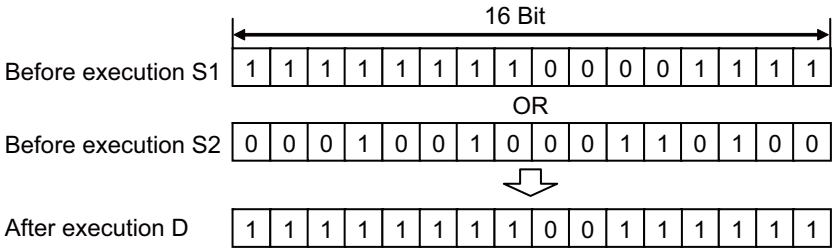
Set Data

Set Data	Meaning	Data Type
S1	The data on which a logical sum operation will be performed, or the number of the devices storing this data	BIN 16/32 bits
S2		
D	Number of devices that will store the results of the logical sum operation	

Functions

WOR

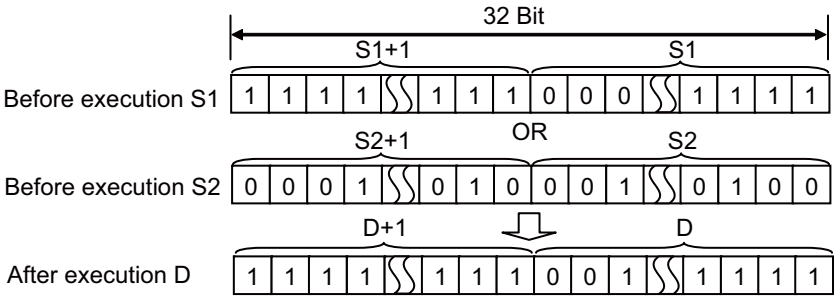
(1) Conducts a logical sum operation on each bit of the 16-bit data of the device designated by "S1" and the 16-bit data of the device designated by "S2", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

DOR

(1) Conducts a logical sum operation on each bit of the 32-bit data of the device designated by "S1" and the 32-bit data of the device designated by "S2", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

○ **WOR, WORP, DOR, DORP ... Logical sums of 16-bit and 32-bit data**
(Device at storage destination: Shared type)

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ	○	○		○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ					

Δ : This is not available with DOR(P).

Instruction symbol	Execution condition	▭ indicates the signs WOR/DOR
WOR,DOR		Command ⊣⊢ ▭ S D
WORP,DORP		Command ⊣⊢ ▭P S D

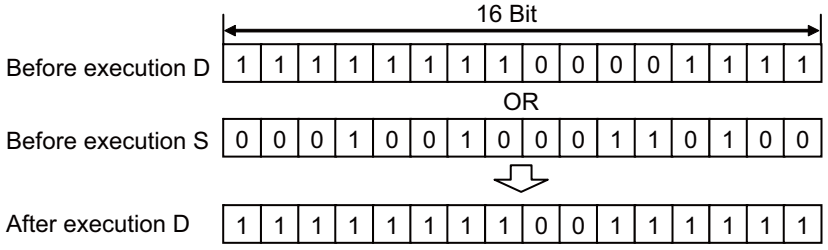
Set Data

Set Data	Meaning	Data Type
S	The data on which a logical sum operation will be performed, or the number of the devices storing this data	BIN 16/32 bits
D		

Functions

WOR

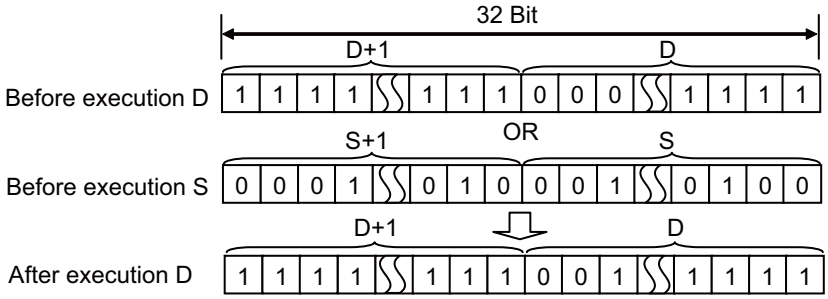
(1) Conducts a logical sum operation on each bit of the 16-bit data of the device designated by "D" and the 16-bit data of the device designated by "S", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

DOR

(1) Conducts a logical sum operation on each bit of the 32-bit data of the device designated by "D" and the 32-bit data of the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

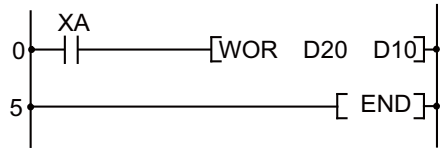
Operation Errors

(1) There are no operation errors associated with the WOR(P) or DOR(P) instructions.

Program Example

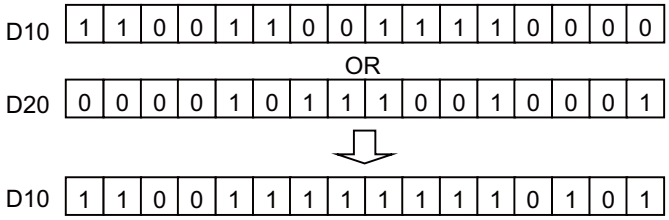
(1) The following program performs a logical sum operation on the data at D10 and D20 when XA goes ON, and stores the results at D10.

[Ladder Mode]



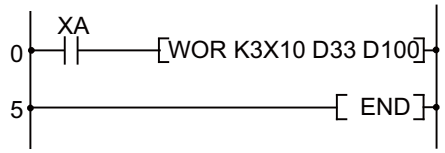
[List Mode]

Steps	Inst.	Device
0	LD	X0A
1	WOR	D20
		D10
4	END	



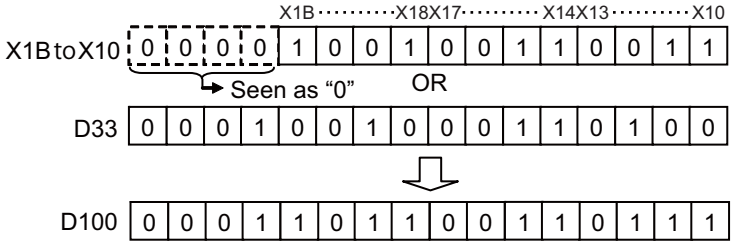
(2) The following program performs a logical sum operation on the data from X10 to X1B, and the data at D33, and outputs the result to D100 when XA is ON.

[Ladder Mode]



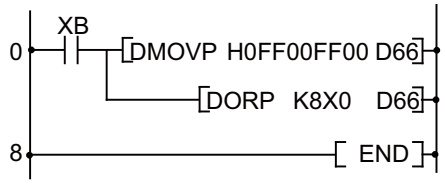
[List Mode]

Steps	Inst.	Device
0	LD	XA
1	WOR	K3X10
		D33
		D100
5	END	



(3) The following program performs a logical sum operation on the 32-bit data from X0 to X1F, and on the hexadecimal value FF00FF00H when XB goes ON, and stores the results at D66 and D67.

[Ladder Mode]



[List Mode]

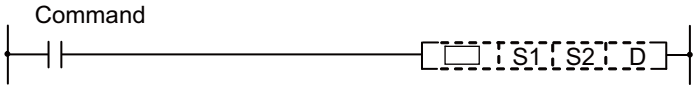
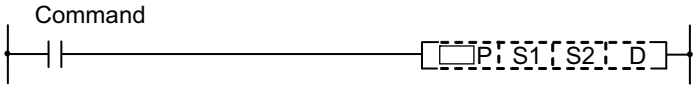
Steps	Inst.	Device
0	LD	X8
1	DMOVP	H0FF00FF00
		D66
5	DORP	K8X0
		D66
8	END	

○ **WXOR, WXORP, DXOR, DXORP ... 16-bit and 32-bit exclusive OR operations**
(Device at storage destination: Independent type)

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2	Δ1	Δ1		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2	Δ1	Δ1			
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2					

Δ 1: S1 and S2 cannot be specified as constant at the same time.

Δ 2: This is not available with DXOR(P).

Instruction symbol	Execution condition	☐ indicates the signs WXOR/DXOR
WXOR,DXOR		
WXORP,DXORP		

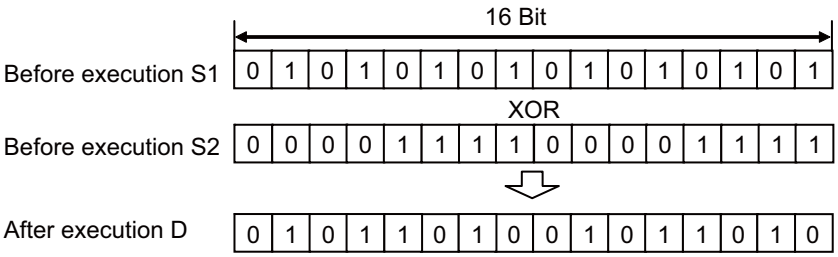
Set Data

Set Data	Meaning	Data Type
S1	Data on which exclusive OR operation will be performed, or number of devices storing such data	BIN 16/32 bits
S2		
D	Number of devices storing data to be EXCLUSIVE ORed	

Functions

WXOR

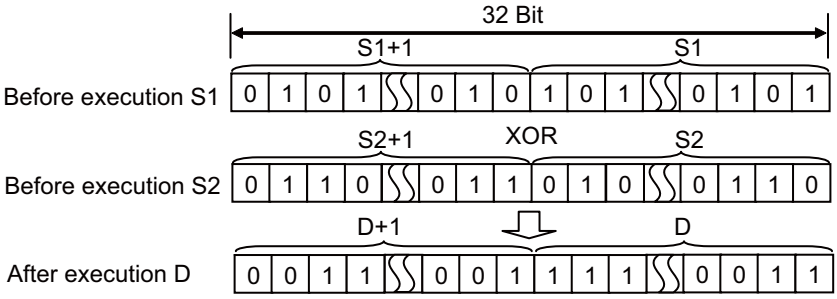
(1) Conducts an exclusive OR operation on each bit of the 16-bit data of the device designated by "S1" and the 16-bit data of the device designated by "S2", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

DXOR

(1) Conducts an exclusive OR operation on each bit of the 32-bit data designated by "S1" and the 32-bit data designated by "S2", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

○ **WXOR, WXORP, DXOR, DXORP ... 16-bit and 32-bit exclusive OR operations**
(Device at storage destination: Shared type)

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ	○	○		○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ				

Δ : This is not available with DXOR (P).

Instruction symbol	Execution condition	▭ indicates the signs WXOR/DXOR
WXOR,DXOR		Command — S D
WXORP,DXORP		Command — P S D

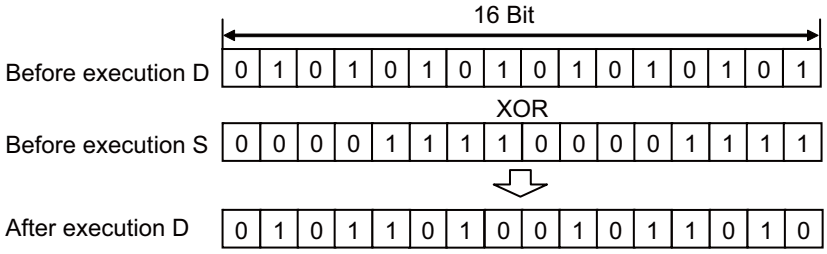
Set Data

Set Data	Meaning	Data Type
S	Data on which exclusive OR operation will be performed, or number of devices storing such data	BIN 16/32 bits
D		

Functions

WXOR

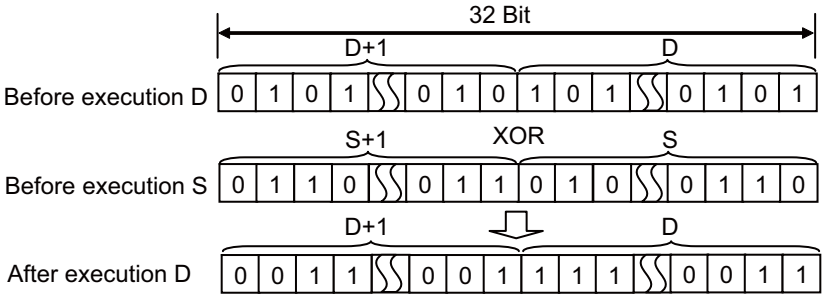
(1) Conducts an exclusive OR operation on each bit of the 16-bit data of the device designated by "D" and the 16-bit data of the device designated by "S", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

DXOR

(1) Conducts an exclusive OR operation on each bit of the 32-bit data designated by "D" and the 32-bit data designated by "S", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

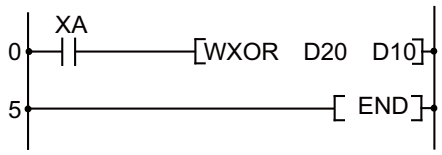
Operation Errors

(1) There are no operation errors associated with the WXOR(P) or DXOR(P) instructions.

Program Example

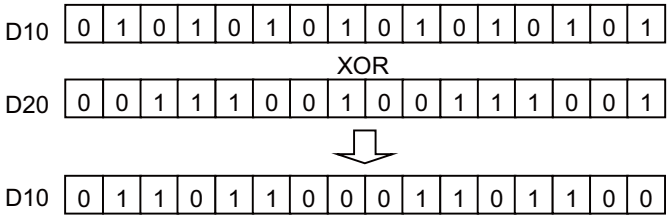
(1) The following program performs an exclusive OR operation on the data at D10 and D20 when XA is ON, and stores the result at D10.

[Ladder Mode]



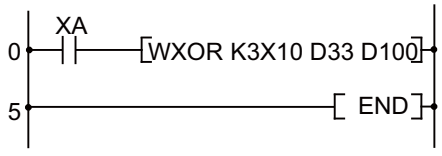
[List Mode]

Steps	Inst.	Device
0	LD	X0A
1	WXOR	D20
		D10
4	END	



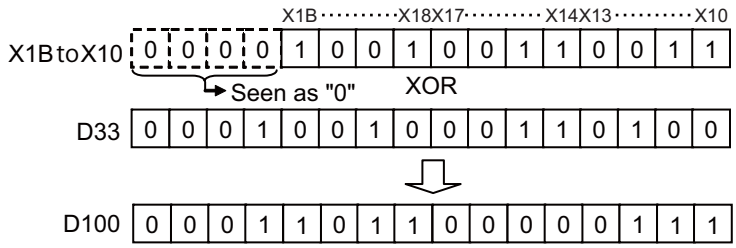
(2) The following program conducts an exclusive OR operation on the data from X10 to X1B and the data at D33 when XA is ON, and outputs the result to D100.

[Ladder Mode]



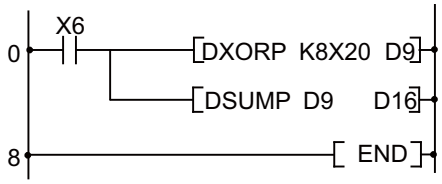
[List Mode]

Steps	Inst.	Device
0	LD	XA
1	WXOR	K3X10
		D33
		D100
5	END	



(3) The following program compares the bit pattern of the 32-bit data from X20 to X3F with the bit pattern of the data at D9 and D10 when X6 is ON, and stores the number of differing bits at D16.

[Ladder Mode]



[List Mode]

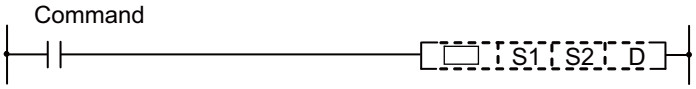
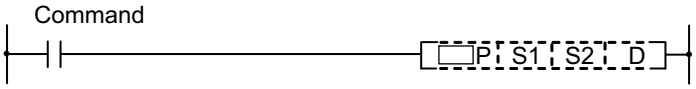
Steps	Inst.	Device
0	LD	X6
1	DXORP	K8X20
		D9
4	DSUMP	D9
		D16
7	END	

○ **WXNR, WXNRP, DXNR, DXNRP ... 16-bit and 32-bit data non-exclusive logical sum operations (Device at storage destination: Independent type)**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2	Δ1	Δ1		○	○
S2	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2	Δ1	Δ1			
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ2					

Δ 1: S1 and S2 cannot be specified as constant at the same time.

Δ 2: This is not available with DXNR(P).

Instruction symbol	Execution condition	☐ indicates the signs WXNR/DXNR
WXNR,DXNR		
WXNRP,DXNRP		

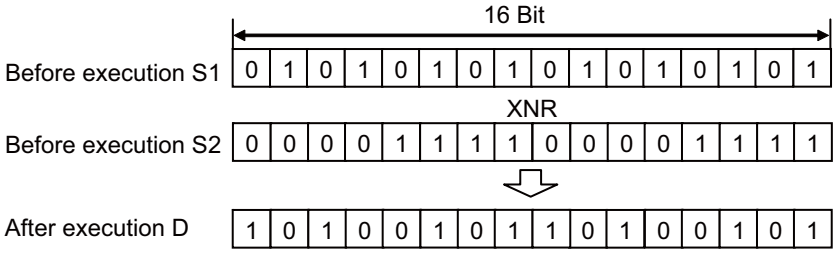
Set Data

Set Data	Meaning	Data Type
S1	Data on which non-exclusive logical sum operation will be performed, or number of devices where such data is being stored	BIN 16/32 bits
S2		
D	Number of devices that will store results of the non-exclusive logical	

Functions

WXNR

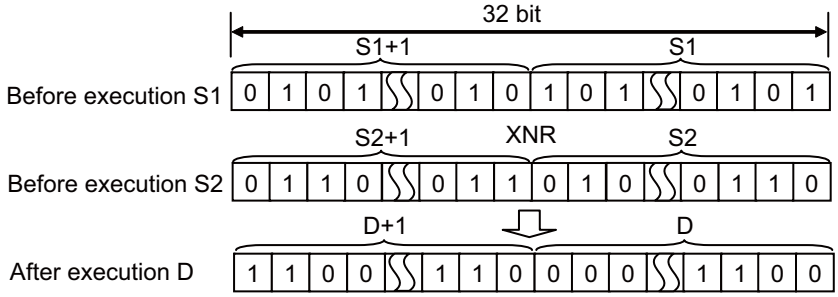
(1) Conducts a non-exclusive logical sum operation on each bit of the 16-bit data of the device designated by "S1" and the 16-bit data of the device designated by "S2", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

DXNR

(1) Conducts a non-exclusive logical sum operation on each bit of the 32-bit data of the device designated by "S1" and the 32-bit data of the device designated by "S2", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

○ **WXNR, WXNRP, DXNR, DXNRP ... 16-bit and 32-bit data non-exclusive logical sum operations (Device at storage destination: Shared type)**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ	○	○		○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ					

Δ: This is not available with DXNR(P).

Instruction symbol	Execution condition	▭ indicates the signs WXNR/DXNR
WXNR,DXNR		Command — S D
WXNRP,DXNRP		Command — P S D

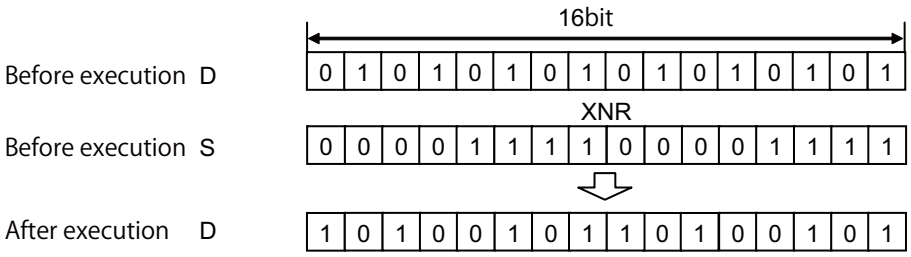
Set Data

Set Data	Meaning	Data Type
S	Data on which non-exclusive logical sum operation will be performed, or number of devices where such data is being stored	BIN 16/32 bits
D		

Functions

WXNR

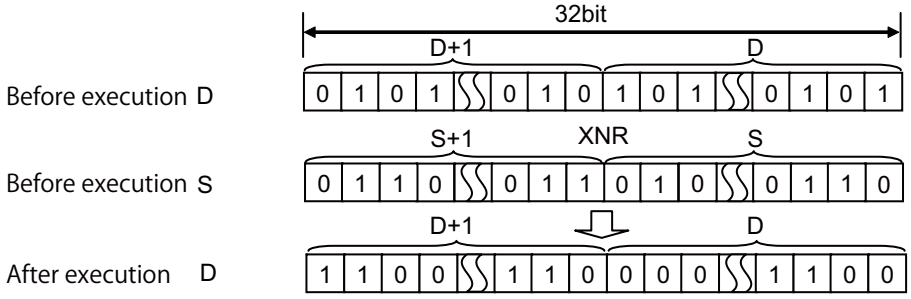
(1) Conducts a non-exclusive logical sum operation on each bit of the 16-bit data of the device designated by "D" and the 16-bit data of the device designated by "S", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

DXNR

(1) Conducts a non-exclusive logical sum operation on each bit of the 32-bit data of the device designated by "D" and the 32-bit data of the device designated by "S", and stores the results at the device designated by "D".



(2) For bit device, the numbers of the digits other than the designated digit are processed as 0 in the operation.

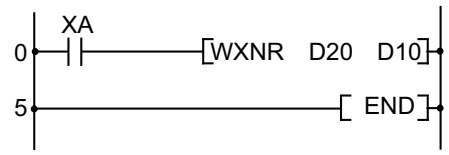
Operation Errors

(1) There are no operation errors associated with the WXNR(P) or DXNR(P) instructions.

Program Example

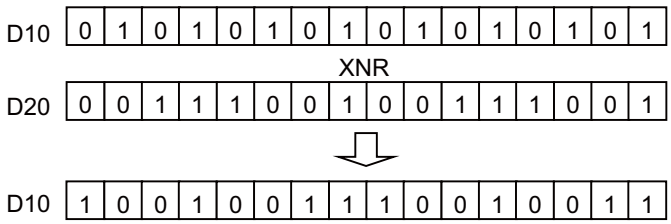
(1) The following program performs a non-exclusive OR operation on the data at D10 and D20 when XA is ON, and stores the result at D10.

[Ladder Mode]



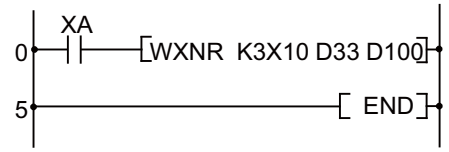
[List Mode]

Steps	Inst.	Device
0	LD	X0A
1	WXNR	D20
		D10
4	END	



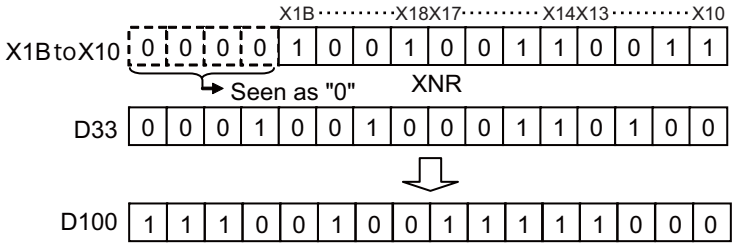
(2) The following program conducts a non-exclusive OR operation on the data from X10 to X1B and the data at D33 when XA is ON, and outputs the result to D100.

[Ladder Mode]



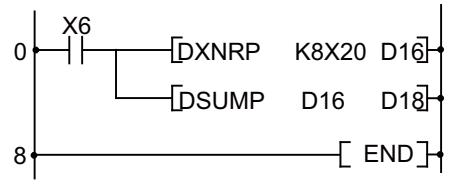
[List Mode]

Steps	Inst.	Device
0	LD	XA
1	WXNR	K3X10
		D33
		D100
5	END	



(3) The following program compares the bit patterns of the 32-bit data located from X20 to X3F with the bit patterns of the data at D16 and D17 when X6 is ON, and stores the same number of bits at D18.

[Ladder Mode]



[List Mode]

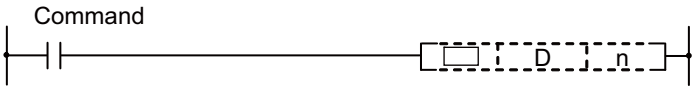
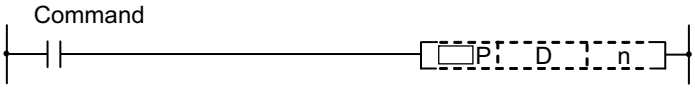
Steps	Inst.	Device
0	LD	X6
1	DXNRP	K8X20
		D16
4	DSUMP	D16
		D18
7	END	

7.7 Rotation Instruction

○ **ROR, RORP, RCR, RCRP ... Right rotation of 16-bit data**

Setting data	Usable devices																				Digit desig-nation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
D											○	○	○	○	○	○	○	○					Δ
n	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	○	○		○	

Δ : Index qualification is not available for constant K/H.

Instruction symbol	Execution condition	▭ indicates the signs ROR/RCR
ROR,RCR		
RORP,RCRP		

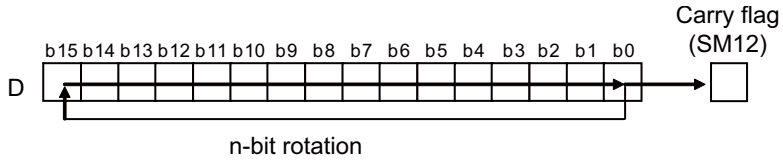
Set Data

Set Data	Meaning	Data Type
D	Initial number of devices to perform rotation	BIN 16 bits
n	Number of rotations (0 to 15)	

Functions

ROR

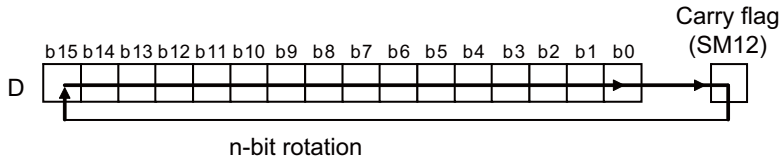
(1) Rotates 16-bit data of the device designated by "D", not including the carry flag, n-bits to the right.
The carry flag is ON or OFF depending on the status prior to the execution of the ROR instruction.



(2) Specify any of 0 to 15 as n. If the value specified as n is 16 or greater, operations will be as follows:
- When n is 16, the value becomes the one when 16-bit rotation was executed.
- When n is 17 or above, the value of D becomes indefinite.

RCR

(1) Rotates 16-bit data of the device designated by "D", including carry flag, n bits to the right.
The carry flag is ON or OFF depending on the status prior to the execution of the ROR instruction.



(2) Specify any of 0 to 15 as n. If the value specified as n is 16 or greater, operations will be as follows:
- When n is 16, the value becomes the one when 16-bit rotation was executed.
- When n is 17 or above, the value of D becomes indefinite.

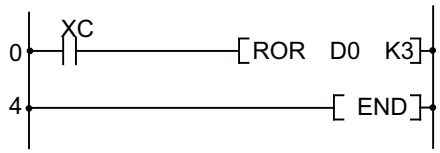
Operation Errors

(1) There are no operation errors associated with the ROR(P) or RCR(P) instructions.

Program Example

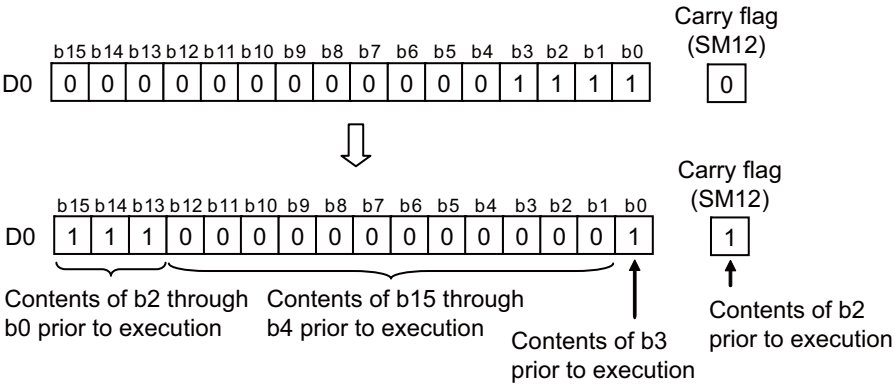
(1) The following program rotates the contents of D0, though not including the carry flag, 3 bits to the right when XC is ON.

[Ladder Mode]



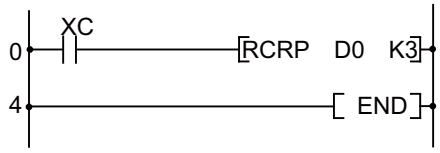
[List Mode]

Steps	Inst.	Device
0	LD	XC
1	ROR	D0
		K3
4	END	



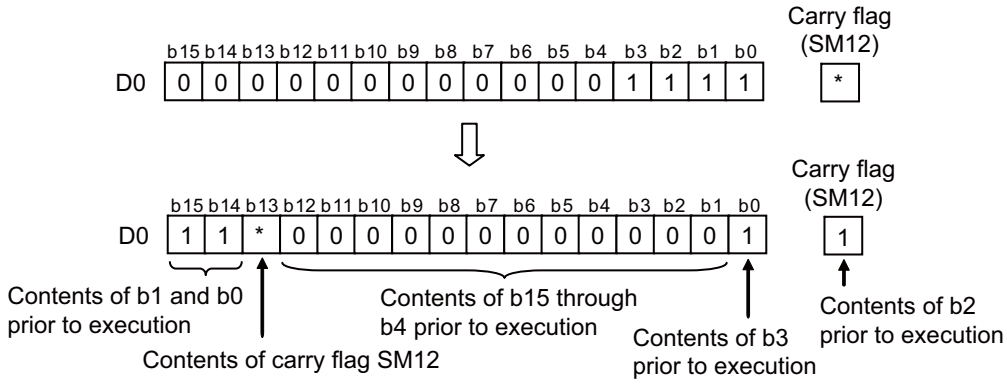
(2) The following program rotates the contents of D0, including the carry flag, 3 bits to the right when XC is ON.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	XC
1	RCRP	D0
		K3
4	END	

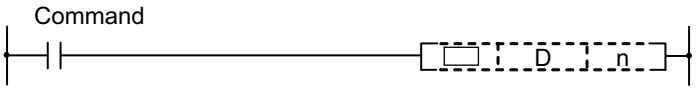
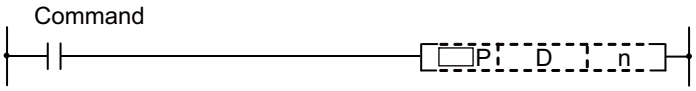


* The carry flag goes ON or OFF depending on its status prior to the execution of RCR.

○ **ROL, ROLP, RCL, RCLP ... Left rotation of 16-bit data**

Setting data	Usable devices																				Digit desig-nation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
D											○	○	○	○	○	○	○	○					Δ
n	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	○	○		○	

Δ : Index qualification is not available for constant K/H.

Instruction symbol	Execution condition	▭ indicates the signs ROL/RCL
ROL,RCL		
ROLP,RCLP		

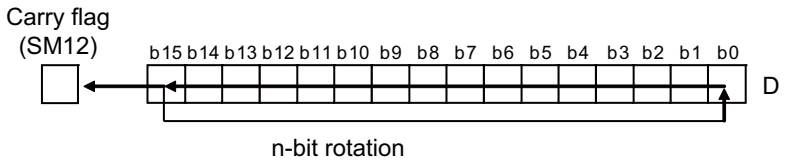
Set Data

Set Data	Meaning	Data Type
D	Initial number of devices to perform rotation	BIN 16 bits
n	Number of rotations (0 to 15)	

Functions

ROL

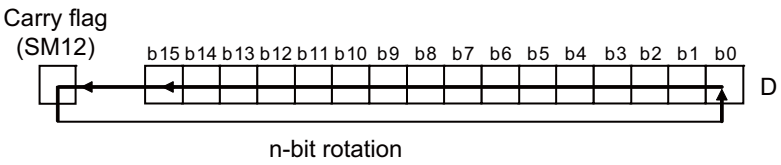
(1) Rotates the 16-bit data of the device designated at "D", not including the carry flag, n-bits to the left. The carry flag goes ON or OFF depending on its status prior to the execution of ROL instruction.



(2) Specify any of 0 to 15 as n. If the value specified as n is 16 or greater, operations will be as follows:
- When n is 16, the value becomes the one when 16-bit rotation was executed.
- When n is 17 or above, the value of D becomes indefinite.

RCL

(1) Rotates the 16-bit data of the device designated by D , including the carry flag, n-bits to the left. The carry flag goes ON or OFF depending on its status prior to the execution of RCL instruction.



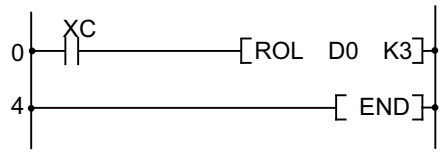
(2) Specify any of 0 to 15 as n. If the value specified as n is 16 or greater, operations will be as follows:
- When n is 16, the value becomes the one when 16-bit rotation was executed.
- When n is 17 or above, the value of D becomes indefinite.

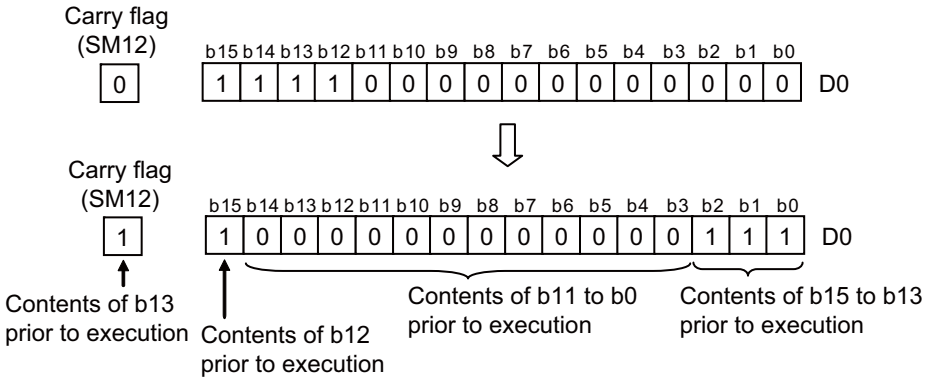
Operation Errors

(1) There are no operation errors associated with the ROL(P) or RCL(P) instructions.

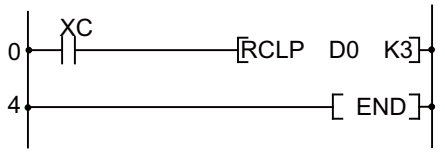
Program Example

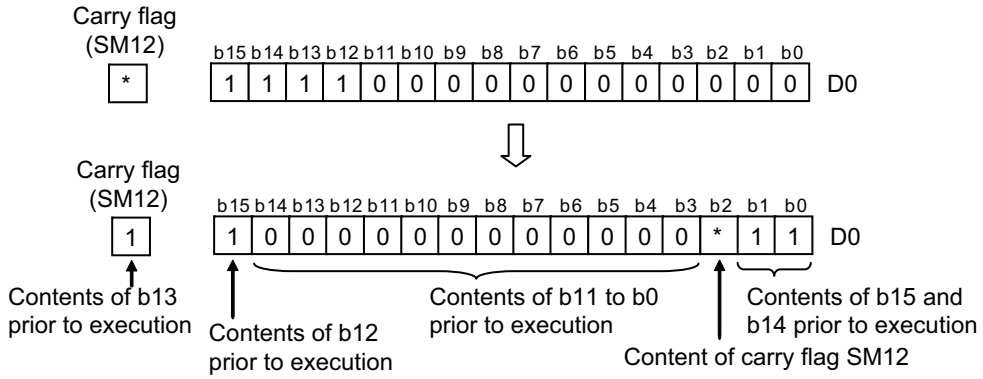
(1) The following program rotates the contents of D0, not including the carry flag, 3 bits to the left when XC is ON.

[Ladder Mode]	[List Mode]
	Steps Inst. Device 0 LD XC 1 ROL D0 K3 4 END



(2) The following program rotates the contents of D0, including the carry flag, 3 bits to the left when XC is ON.

[Ladder Mode]	[List Mode]
	Steps Inst. Device 0 LD XC 1 RCLP D0 K3 4 END



*The carry flag goes ON or OFF depending on its status prior to the execution of RCL.

○ **DROR, DRORP, DRCR, DRCRP ... Right rotation of 32-bit data**

Setting data	Usable devices																				Digit desig-nation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
D											○	○	○	○	○	○	○						Δ
n	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		○	○		○	

Δ : Index qualification is not available for constant K/H.

Instruction symbol	Execution condition	□ indicates the signs DROR/DRCR
DROR,DRCR		Command → □ D n
DRORP,DRCRP		Command → □P D n

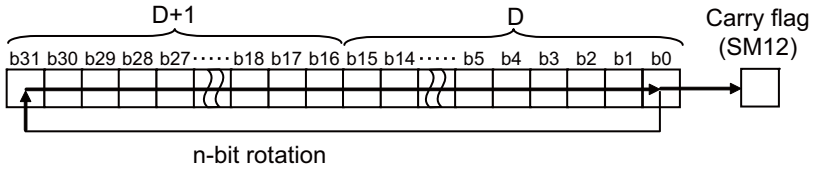
Set Data

Set Data	Meaning	Data Type
D	First device number of devices to perform rotation	BIN 32 bits
n	Number of rotations (0 to 31) 2 words (32 bits) are used for a word device.	BIN 32 bits

Functions

DROR

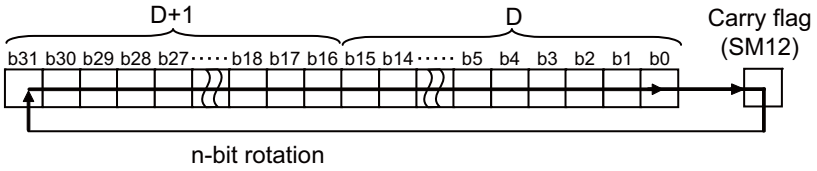
(1) The 32-bit data of the device designated at "D", not including the carry flag, is rotated n-bits to the right.
The carry flag goes ON or OFF depending on its status prior to the execution of the DROR instruction.



(2) Specify any of 0 to 31 as n. If the value specified as n is 32 or greater, the values of D+1 and D become indefinite.

DRCR

(1) Rotates 32-bit data, including carry flag, at device designated by D n bits to the right.
The carry flag goes ON or OFF depending on its status prior to the execution of the DRCR instruction.



(2) Specify any of 0 to 31 as n. If the value specified as n is 32 or greater, the values of D+1 and D become indefinite.

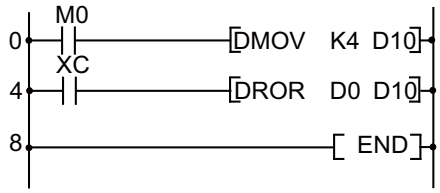
Operation Errors

(1) There are no errors associated with DROR(P) or DRCR(P) instructions.

Program Example

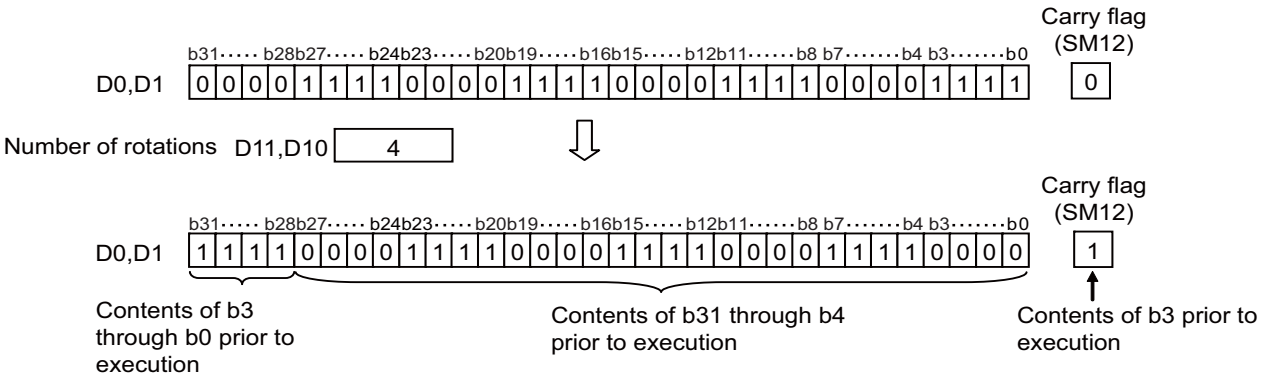
(1) The following program rotates the contents of D0 and D1, not including the carry flag, 4 bits to the right when XC is ON.

[Ladder Mode]



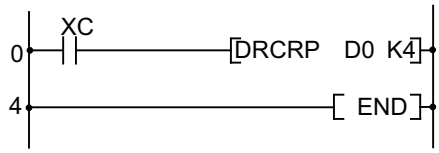
[List Mode]

Steps	Inst.	Device
0	LD	M0
1	DMOV	K4
		D10
4	LD	XC
5	DROR	D0
		D10
8	END	



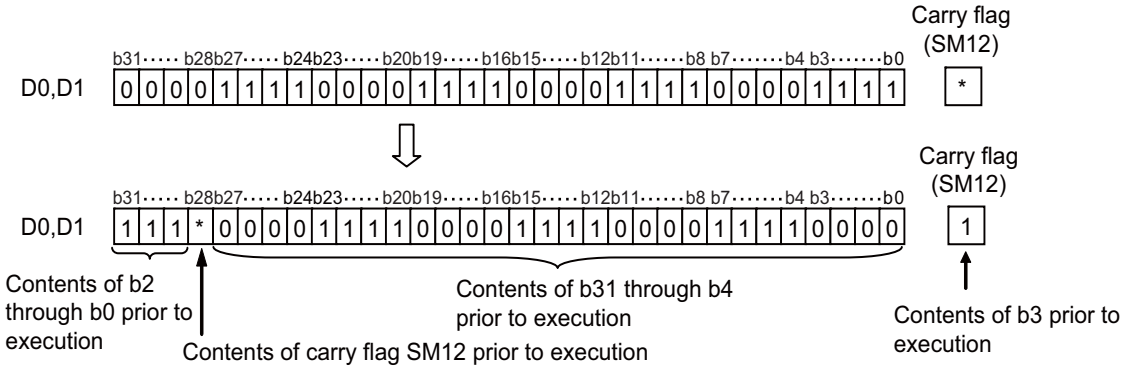
(2) The following program rotates the contents of D0 and D1, including the carry flag, 4 bits to the right when XC is ON.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	XC
1	DRCRP	D0
		K4
4	END	

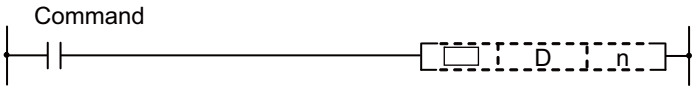
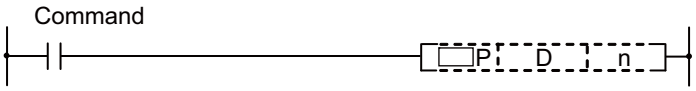


* The carry flag goes ON or OFF depending on its status prior to the execution of the DRCR instruction.

○ **DROL, DROLP, DRCL, DRCLP ... Left rotation of 32-bit data**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
D											○	○	○	○	○	○	○					Δ
n	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○		○	○		○	

Δ : Index qualification is not available for constant K/H.

Instruction symbol	Execution condition	▭ indicates the signs DROL/DRCL
DROL,DRCL		
DROLP,DRCLP		

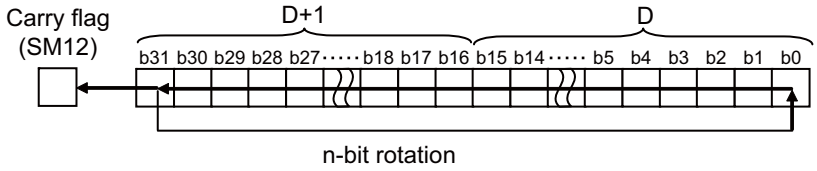
Set Data

Set Data	Meaning	Data Type
D	First device number of devices to perform rotation	BIN 32 bits
n	Number of rotations (0 to 31) 2 words (32 bits) are used for a word device.	BIN 32 bits

Functions

DROL

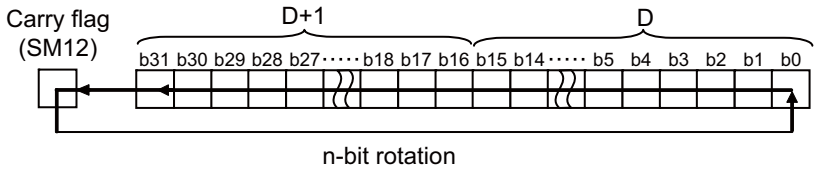
(1) The 32-bit data of the device designated at "D", not including the carry flag, is rotated n-bits to the left.The carry flag goes ON or OFF depending on its status prior to the execution of the DROL instruction.



(2) Specify any of 0 to 31 as n. If the value specified as n is 32 or greater, the values of D+1 and D become indefinite.

DRCL

(1) Rotates 32-bit data, including carry flag, at device designated by D n bits to the left.
The carry flag goes ON or OFF depending on its status prior to the execution of the DRCL instruction.



(2) Specify any of 0 to 31 as n. If the value specified as n is 32 or greater, the values of D+1 and D become indefinite.

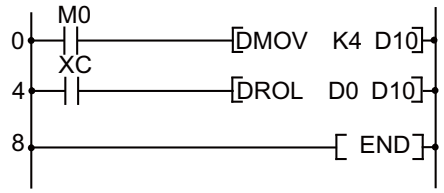
Operation Errors

(1) There are no operation errors associated with the DROL(P) or DRCL(P) instructions.

Program Example

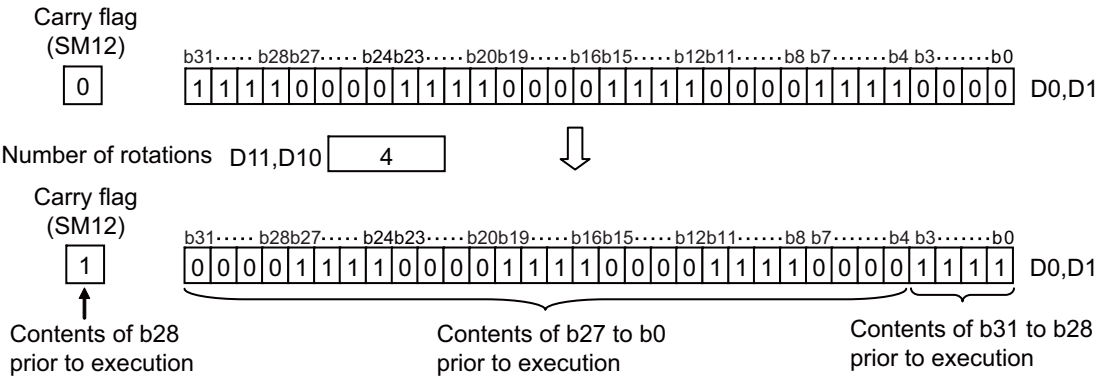
(1) The following program rotates the contents of D0 and D1, not including the carry flag, 4 bits to the left when XC is ON.

[Ladder Mode]



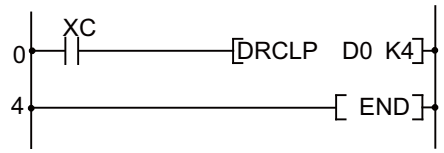
[List Mode]

Steps	Inst.	Device
0	LD	M0
1	DMOV	K4
		D10
4	LD	XC
5	DROL	D0
		D10
8	END	



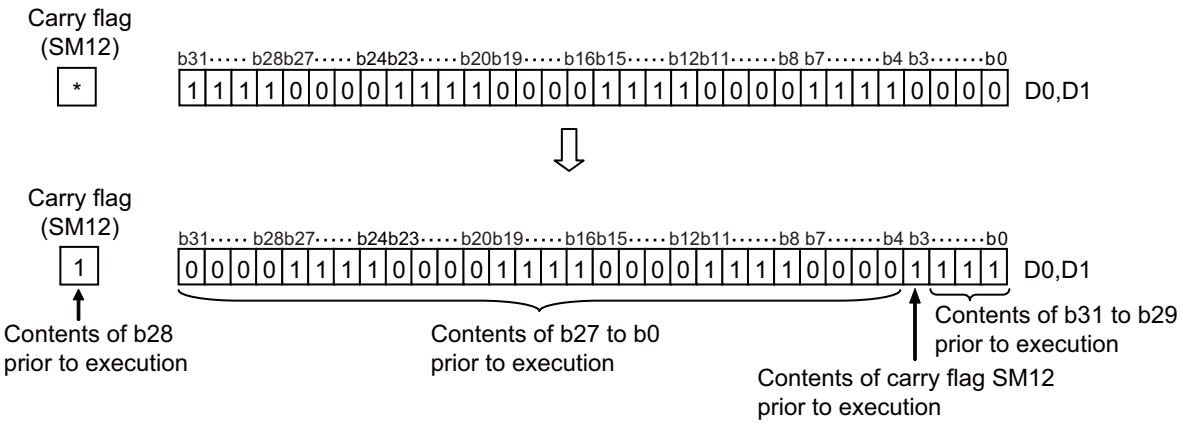
(2) The following program rotates the contents of D0 and D1, including the carry flag, 4 bits to the left when XC is ON.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	XC
1	DRCLP	D0
		K4
4	END	

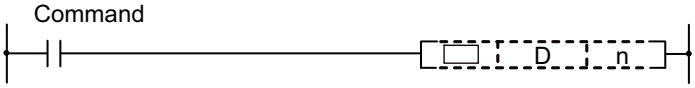
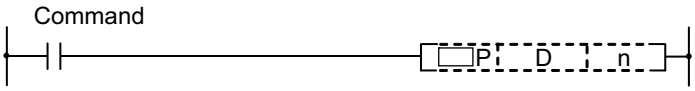


* The carry flag goes ON or OFF depending on its status prior to the execution of the DRCL instruction.

○ **SFR, SFRP, SFL, SFLP ... n-bit shift to right or left of 16-bit data**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○					Δ
n	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○	○	○		○	

Δ : Index qualification is not available for constant K/H.

Instruction symbol	Execution condition	▭ indicates the signs SFR/SFL
SFR,SFL		
SFLP,SFLP		

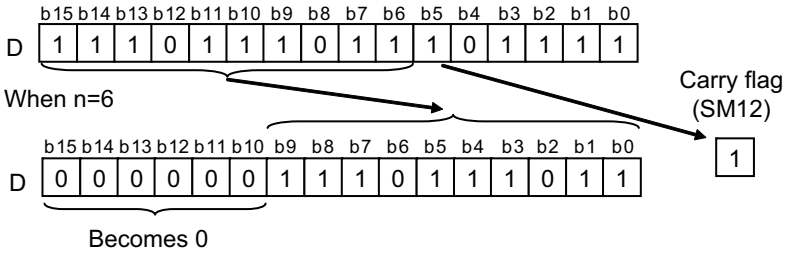
Set Data

Set Data	Meaning	Data Type
D	First device number of devices where shift data is being stored	BIN 16 bits
n	Number of shifts (0 to 15)	

Functions

SFR

(1) Causes a shift to the right by n bits of the 16-bit data from the device designated at "D".



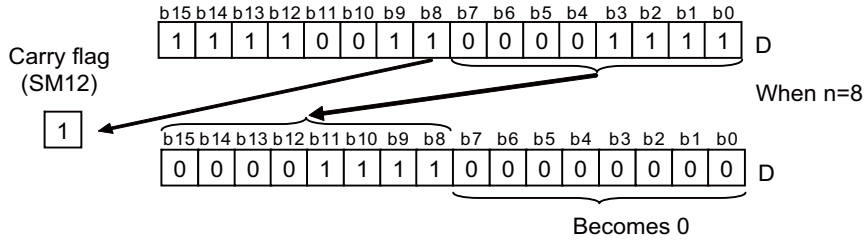
(2) A total of n bits from the upper level become 0.

(3) A shift by the data of the specified digit is conducted when a bit device has been designated at "D". [See Program Example (1)]

(4) Specify any of 0 to 15 as n. If the value specified as n is 16 or greater, operations will be as follows:
- When n is 16, the value becomes the one when 16-bit shifting was executed.
- When n is 17, the value of D becomes indefinite.

SFL

(1) Shifts 16-bit data at device designated by "D" n-bits to the left.



(2) The bits starting at n-bits from lowest bit become 0.

(3) A shift by the data of the specified digit is conducted when a bit device has been designated at "D". [See Program Example (1)]

(4) Specify any of 0 to 15 as n. If the value specified as n is 16 or greater, operations will be as follows:
- When n is 16, the value becomes the one when 16-bit shifting was executed.
- When n is 17, the value of D becomes indefinite.

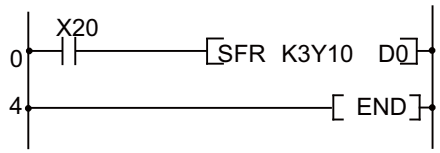
Operation Errors

(1) There are no operation errors associated with the SFR(P) or SFL(P) instructions.

Program Example

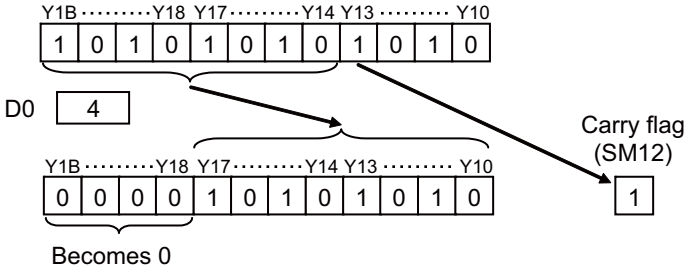
(1) The following program shifts the contents of Y10 to Y1B to the right by the number of bits designated by D0 when X20 goes ON.

[Ladder Mode]



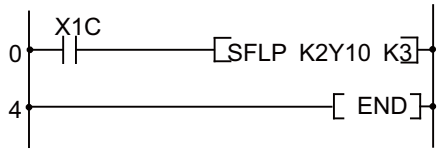
[List Mode]

Steps	Inst.	Device
0	LD	X20
1	SFR	K3Y10
		D0
4	END	



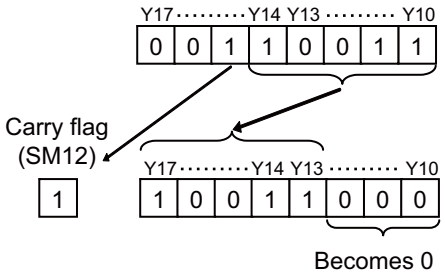
(2) The following program shifts the contents of X10 to X17 3 bits to the left when X1C is ON.

[Ladder Mode]



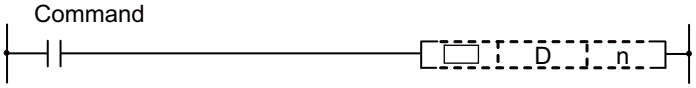
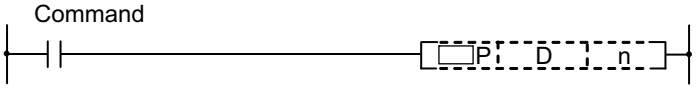
[List Mode]

Steps	Inst.	Device
0	LD	XC
1	SFLP	K2Y10
		K3
4	END	



○ **DSFR, DSFRP, DSFL, DSFLP ... Right/Left shift of word device in batch**

Setting data	Usable devices																				Digit desig-nation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
D											○	○	○	○	○	○	○					○
n																			○	○		

Instruction symbol	Execution condition	▭ indicates the signs DSFR/DSFL
DSFR,DSFL		
DSFLP,DSFLP		

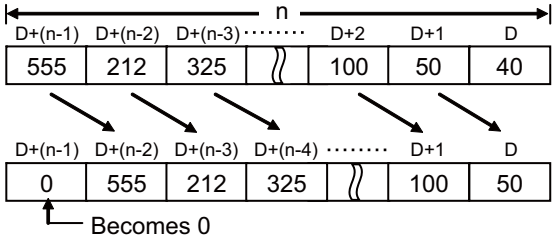
Set Data

Set Data	Meaning	Data Type
D	First device number of devices to shift	BIN 16 bits
n	Number of devices where shift will be conducted	

Functions

DSFR

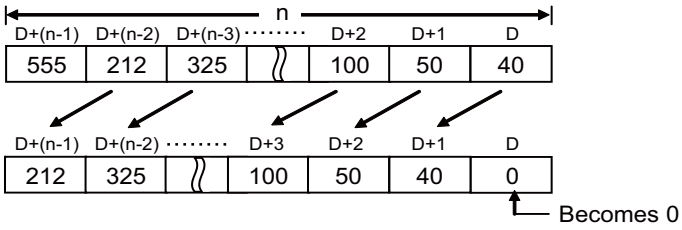
(1) Shifts data n points from device designated by "D" 1 word to the right.



(2) Device designated by "D"+(n-1) becomes 0.

DSFL

(1) Shifts data n points from device designated by "D" 1 word to the left.



(2) Device designated by "D" becomes 0.

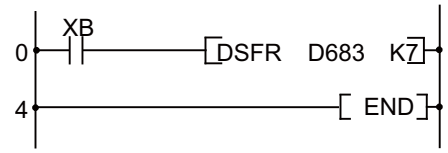
Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- A part of range of the device n-points from the "D" device exceeds the relevant device.
(Error code:82)

Program Example

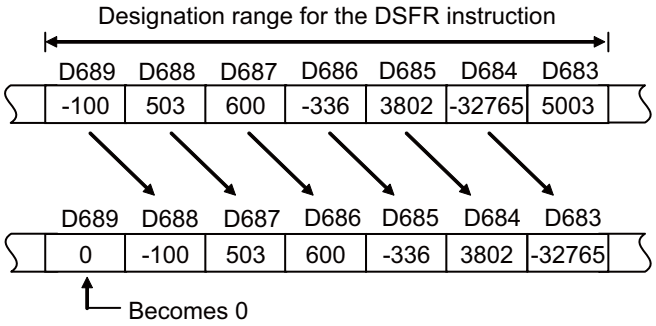
(1) The following program shifts the contents of D683 to D689 to the right when XB is ON.

[Ladder Mode]



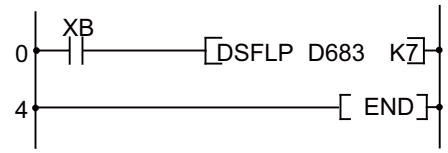
[List Mode]

Steps	Inst.	Device
0	LD	XB
1	DSFR	D683
		K7
4	END	



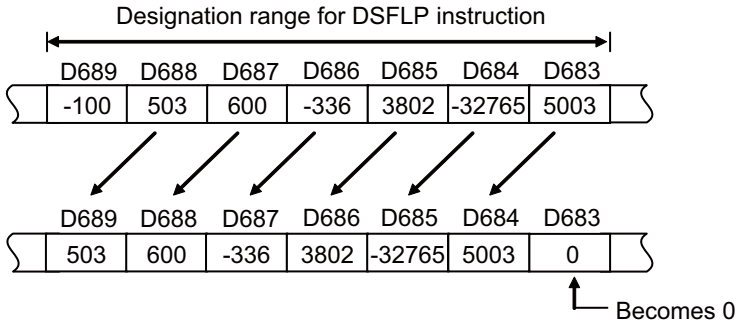
(2) The following program shifts the contents of D683 to D689 to the left when XB is ON.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	XB
1	DSFLP	D683
		K7
4	END	

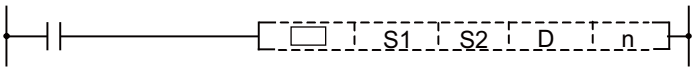
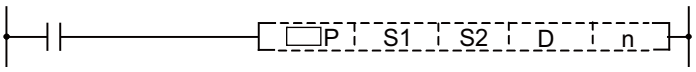


7.8 Data Processing Instructions

○ **SER, SERP, DSER, DSERP ... 16-bit and 32-bit data searches**

Setting data	Usable devices																				Digit desig-nation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S1	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ				○	○
S2											○	○	○	○	○	○	○						
D											○	○	○	○	○	○	○	Δ					○
n	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ	○	○		○	○

Δ : This is not available with DSER(P).

Instruction symbol	Execution condition	☐ indicates the signs SER/DSER
SER,DSER		
SERP,DSERP		

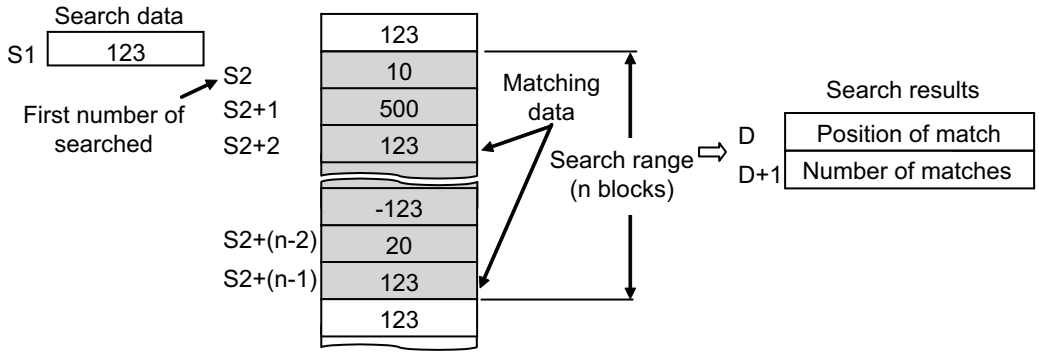
Set Data

Set Data	Meaning	Data Type
S1	First device number of the devices where search data is being stored	Word
S2	First number of the device where data which is an object of search is being stored.	
D	First device number of devices which will store search results	
n	Number of searches	

Functions

SER

(1) Takes the 16-bit data of the device designated at "S1" as the entry code to search for n number of blocks from the 16-bit data from the device designated at "S2".
The number of matches with the entry code is stored at the device designated by "D"+1, and the relative value of the number of points that the device where the first match was found is from S2 is stored at the device designated by "D".

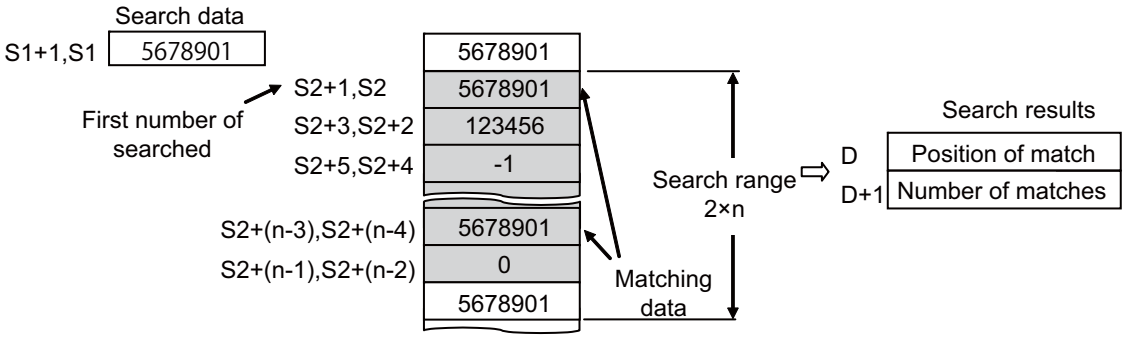


(2) No processing is conducted if n is 0 or a negative value.

(3) If no matches are found in the search, the devices designated at "D" and "D" +1 become "0".

DSER

(1) Takes the 32-bit data of the device designated at "S1+1", "S1" as the entry code to search for n number of blocks (for 2 x n points) in 32-bit unit from the device designated at "S2".
The number of matches with the entry code is stored at the device designated by "D"+1, and the relative value of the number of points that the device where the first match was found is from S2 is stored at the device designated by "D".



(2) No processing is conducted if n is 0 or a negative value.

(3) If no matches are found in the search, the devices designated at "D" and "D" +1 become "0".

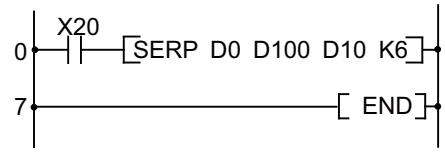
Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- When the area of n number of blocks from the device designated at "S2" does not exist.
(Error code: 82)

Program Example

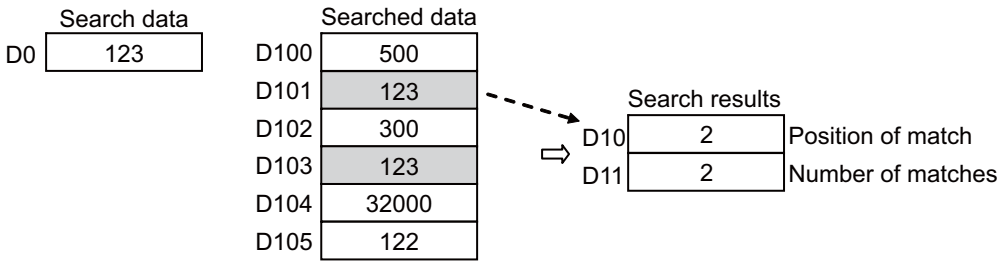
(1) The following program searches D100 to D105 for the contents of D0 when X20 is ON, and stores the search results at D10 and D11.

[Ladder Mode]



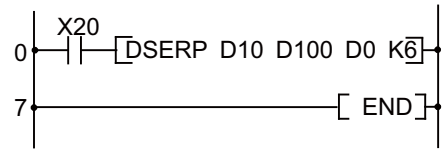
[List Mode]

Steps	Inst.	Device
0	LD	X20
1	SERP	D0
		D100
		D10
		K6
7	END	



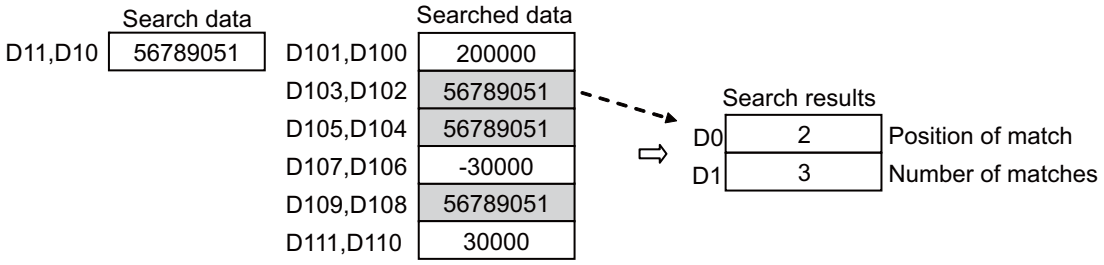
(2) The following program searches D100 to D111 for the contents of D11 and D10 when X20 is ON, and stores the search results at D0 and D1.

[Ladder Mode]



[List Mode]

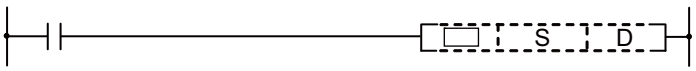
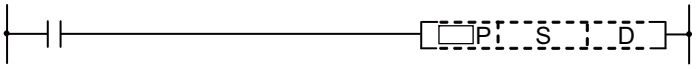
Steps	Inst.	Device
0	LD	X20
1	DSERP	D10
		D100
		D0
		K6
7	END	



○ **SUM, SUMP, DSUM, DSUMP ... 16-bit and 32-bit data bit check**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ				○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	Δ				

Δ : This is not available with DSUM(P).

Instruction symbol	Execution condition	□ indicates the signs SUM/DSUM
SUM,DSUM		
SUMP,DSUMP		

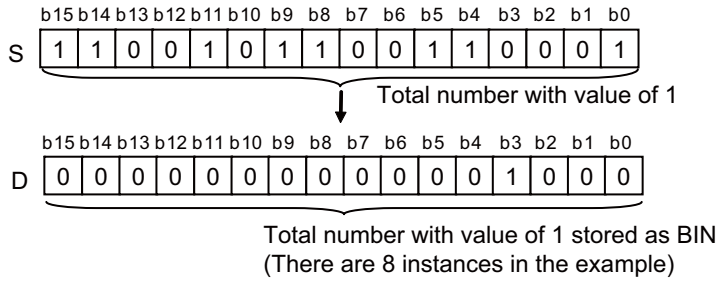
Set Data

Set Data	Meaning	Data Type
S	First device number of devices that will count total number of bits that are at 1	BIN 16/32 bits
D	First device number of devices that will store total number of bits	

Functions

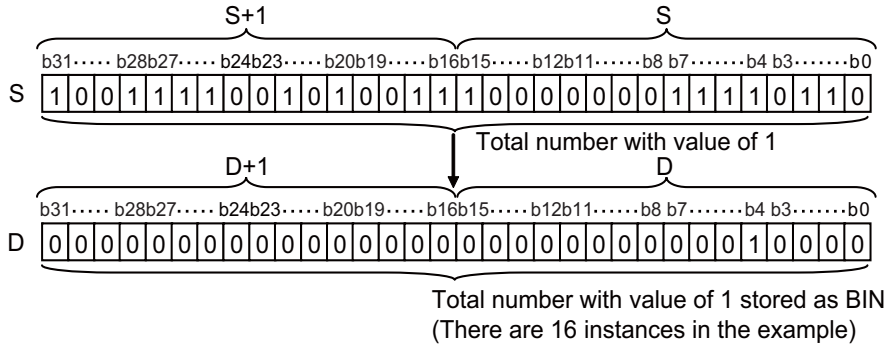
SUM

(1) From the 16-bit data in the device designated by "S", stores the total number of bits that are at 1, in the device designated by "D".



DSUM

(1) From the 32-bit data in the device designated by "S", stores the total number of bits that are at 1, in the device designated by "D".



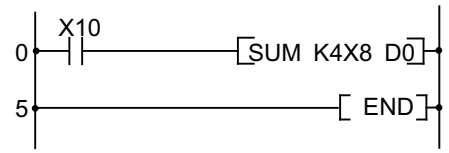
Operation Errors

(1) There are no operation errors associated with the SUM(P) or DSUM(P) instructions.

Program Example

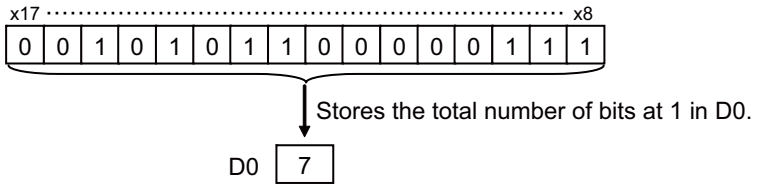
(1) The following program stores the number of bits from X8 to X17 which are ON when X10 is ON at D0.

[Ladder Mode]



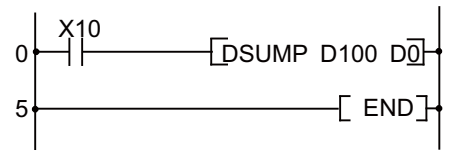
[List Mode]

Steps	Inst.	Device
0	LD	X10
1	SUM	K4X8
		D0
5	END	



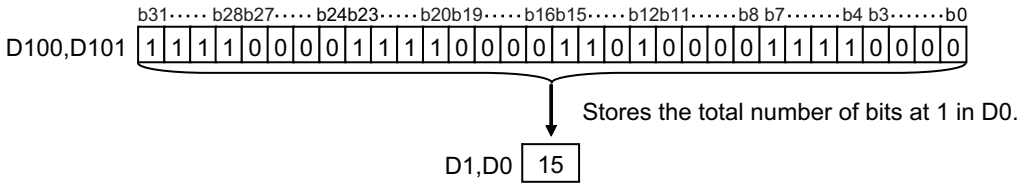
(2) The following program stores the number of bits from D100 and D101 which are ON when X10 is ON at D0.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X10
1	DSUMP	D100
		D0
5	END	



○ **SEG, SEGP ... 7-segment decode**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○				○	○
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○	○				

Instruction symbol	Execution condition	
SEG		SEG S D
SEGP		SEGP S D

Set Data

Set Data	Meaning	Data Type
S	Device number of devices where decoded data is being stored	BIN 16 bits
D	First device number of devices where decoding results are stored	

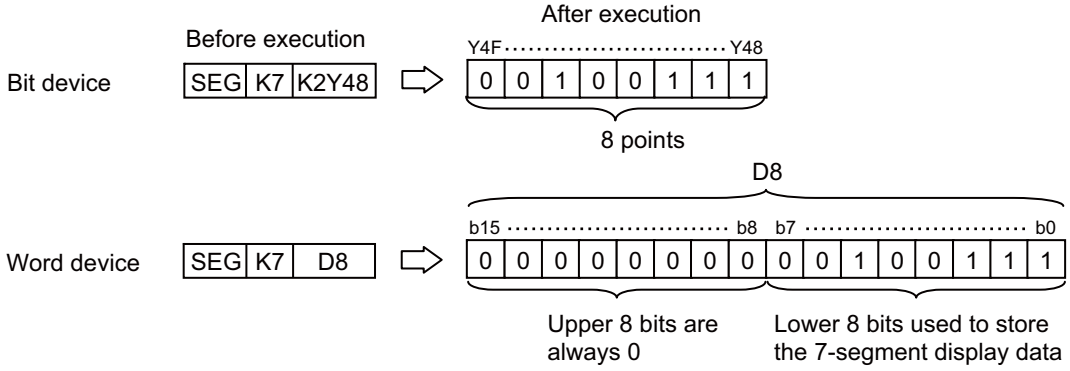
Functions

SEG

(1) Decodes the data from 0 to F designated by the lower 4 bits of S to 7-segment display data, and stores at D.

(2) If "D" is a bit device, indicates the first number of the devices storing the 7-segment display data; if it is a word device, indicates the number of the device that is storing the data.

(3) Storage is done as follows for bit devices and word devices:

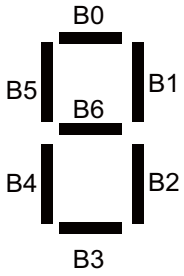


(4) Refer to the next page for the 7-segment display.

Operation Errors

(1) There are no operation errors associated with the SEG(P) instruction.

7-segment decode display

Hex	Bit Pattern	Configuration of 7 Segments	D								Display Data
			B7	B6	B5	B4	B3	B2	B1	B0	
0	0000		0	0	1	1	1	1	1	1	
1	0001		0	0	0	0	0	1	1	0	
2	0010		0	1	0	1	1	0	1	1	
3	0011		0	1	0	0	1	1	1	1	
4	0100		0	1	1	0	0	1	1	0	
5	0101		0	1	1	0	1	1	0	1	
6	0110		0	1	1	1	1	1	0	1	
7	0111		0	0	1	0	0	1	1	1	
8	1000		0	1	1	1	1	1	1	1	
9	1001		0	1	1	0	0	1	1	1	
A	1010		0	1	1	1	0	1	1	1	
B	1011		0	1	1	1	1	1	0	0	
C	1100		0	0	1	1	1	0	0	1	
D	1101		0	1	0	1	1	1	1	0	
E	1110		0	1	1	1	1	0	0	1	
F	1111		0	1	1	1	0	0	0	1	

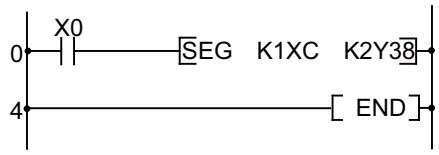
First number of bit device

Lowest bit of word device

Program Example

(1) The following program converts the data from XC to XF when X0 is ON to 7-segment display data and outputs it to Y38 to Y3F.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X0
1	SEG	K1XC
		K2Y38
4	END	

○ **DECO, DECOP ... Decoding from 8 to 256 bits**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S											○	○	○	○	○	○	○	○					
D	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○						
n																			○	○			

Instruction symbol	Execution condition	
DECO		Command DECO S D n
DECOP		Command DECOP S D n

Set Data

Set Data	Meaning	Data Type
S	Number of device where decoded data is stored	BIN 16 bits
D	First device number of devices where decoding results are stored	Device name
n	Valid bit length (1 to 8)	BIN 16 bits

Functions

DECO

(1) Decodes the lower n-bits of the device designated by "S", and stores the results at a location 2n-bits from the device designated by "D".

(2) The value of n can be designated between 1 and 8.

(3) No processing is conducted if n=0, and there are no changes in data for the device designated at "D". When n is 9 or above, the device data specified by D becomes indefinite.

(4) The bit devices specified by D are treated as 1 bit, and the word devices specified by D are treated as 16 bits.

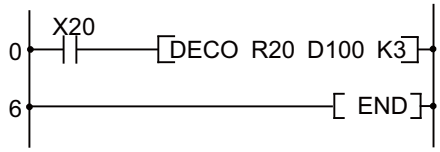
Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- When the area of a part of 2n bit blocks from the device designated at D does not exist.
(Error code: 82)

Program Example

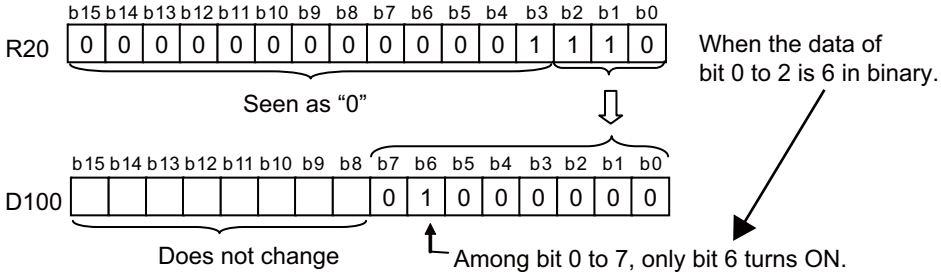
(1) The following program decodes 3 bits of R20 bit 0 to 3 when X20 turns ON and turns D100 corresponding bit to ON.

[Ladder Mode]



[List Mode]

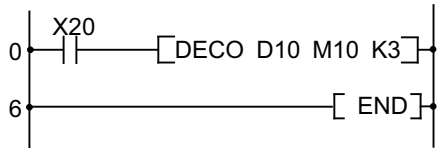
Steps	Inst.	Device
0	LD	X20
1	DECO	R20
		D100
		K3
6	END	



[Note 1] When R20 b0 to b2 is 0, D100 bit 0 turns ON.
[Note 2] D100 data remains the same even when X20 turns OFF.

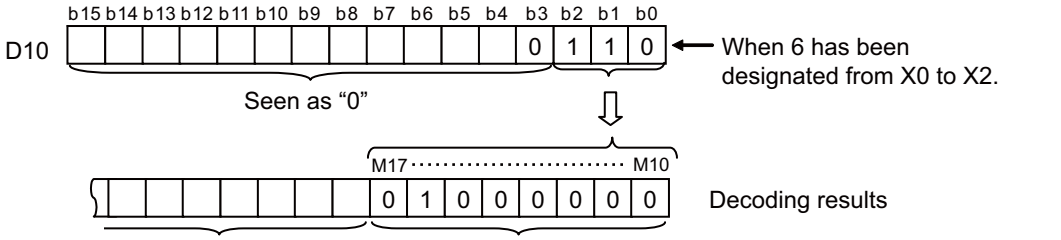
(2) The following program decodes the 3 bits from D10 bit 0 to 2 and stores the results at M10 when X20 is ON.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	X20
1	DECO	D10
		M10
		K3
6	END	



○ **ENCO, ENCOP ... Encoding from 256 to 8 bits**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S	○	○	○	○	○	○	○		○		○	○	○	○	○	○	○						
D											○	○	○	○	○	○	○	○					
n																			○	○			

Instruction symbol	Execution condition	
ENCO		Command ENCO S D n
ENCOP		Command ENCOP S D n

Set Data

Set Data	Meaning	Data Type
S	Number of devices where encoded data is being stored	BIN 16 bits
D	Number of device where encoding results will be stored	
n	Valid bit length (1 to 8)	

Functions

ENCO

(1) 2n bit of the device specified by S is encoded and the result is stored in the lower n bit from the device specified by D as encode data.

(2) The value of n can be designated between 1 and 8.

(3) When n=0, the device data specified by D does not change due to no operation. When n is 9 or above, the device data specified by D becomes indefinite.

(4) As for the devices designated at D, bit devices are treated as 1 bit, and word devices as 16 bits.

(5) If more than 1 bit is at 1, processing will be conducted at the upper bit location.

(6) When the 2n bit blocks data is all 0, "0" is stored in D.

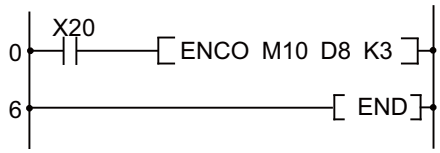
Operation Errors

(1) In the following cases an operation error occurs, the error flag (SM0) turns ON, and an error code is stored at SD0.
- When the area of a part of 2n bit blocks from the device designated at S does not exist.
(Error code: 82)

Program Example

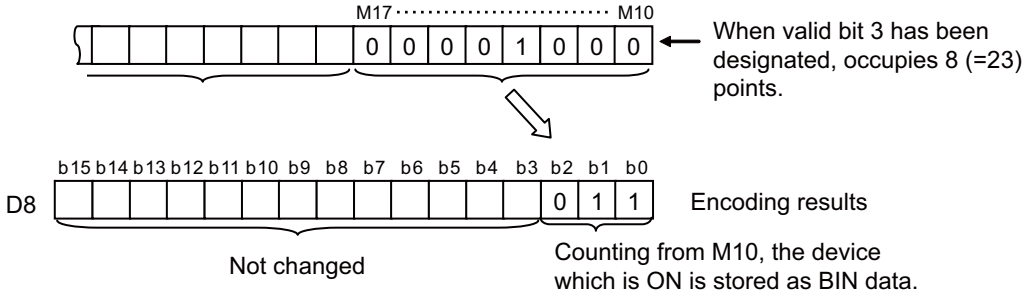
(1) The following program encodes the 3 bits from M10 when X20 is ON, and stores the results at D8.

[Ladder Mode]



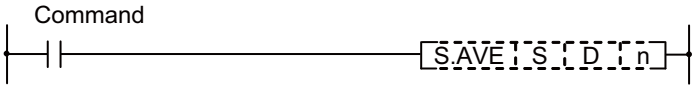
[List Mode]

Steps	Inst.	Device
0	LD	X20
1	ENCO	M10
		D8
		K3
6	END	



○ **S.AVE ... Average value calculation**

Setting data	Usable devices																			Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer		
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P		
S											○	○	○	○	○	○	○	○					○
D											○	○	○	○	○	○	○	○					
n																			○	○			

Instruction symbol	Execution condition	
S.AVE		

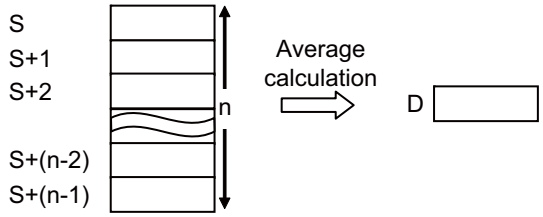
Set Data

Set Data	Meaning	Data Type
S	Head No. of the device whose average is calculated	BIN 16 bits
D	Device No. at the output destination	
n	Average value	

Functions

S.AVE

(1) The average of n points of devices counting from the device specified by S is calculated and output to the device specified by D.



(2) The device specified by S is calculated with signs.

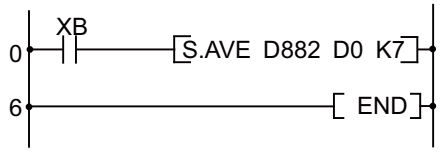
Operation Errors

(1) There are no operation errors associated with the S.AVE instruction.

Program Example

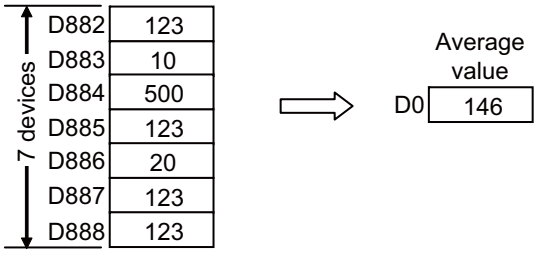
(1) In this program the average of D882 to D888 is calculated when XB turns ON, and the result is output to D0.

[Ladder Mode]



[List Mode]

Steps	Inst.	Device
0	LD	XB
1	S.AVE	D882
		D0
		K7
5	END	



[Note] Digits after the decimal point is truncated.

7.9 Other Instructions

○ **S.STC, S.CLC ... Carry flag set/reset**

Setting data	Usable devices																				Digit designation	Index
	Bit Devices										Word Devices								Constant		Pointer	
	X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R/ZR	W	SW	SD	Z	K	H	P	

Instruction symbol	Execution condition	
S.STC		Command → S.STC
S.CLC		Command → S.CLC

Functions

S.STC

(1) Set (turn ON) the carry flag contact (SM12).

S.CLC

(1) Reset (turn OFF) the carry flag contact (SM12).

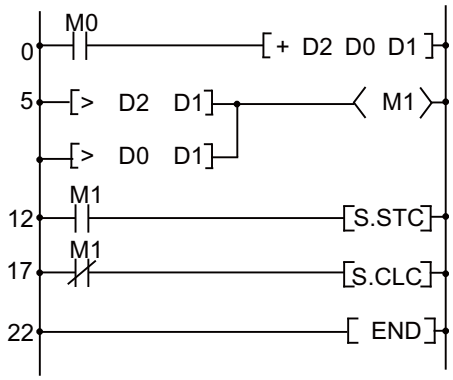
Operation Errors

(1) There are no operation errors associated with the S.STC or S.CLC instructions.

Program Example

(1) In this program, D0 data is added to D2 data when M0 turns ON. The carry flag (SM12) is turned ON if the result exceeds 32767, and turned OFF if 32767 or less.

[Ladder Mode]



Add D2 to D0, and store the result in D1. (D2+D0 → D1)

Turn M1 ON when:
(Summand)>(Addition result) or
(Augend)>(Added result)

Turn ON the carry flag when M1 turns ON

Turn OFF the carry flag when M1 turns OFF

[List Mode]

Steps	Inst.	Device
0	LD	M0
1	+	D2
		D0
		D1
5	LD>	D2
		D1
8	OR>	D0
		D1
11	OUT	M1
12	LD	M1
13	S.STC	
17	LDI	M1
18	S.CLC	
22	END	

8

Exclusive Instructions

PLC exclusive instruction is limited to its application for the processes which may be difficult to perform only with basic instruction or function instruction.

PLC exclusive instructions include:

(1) ATC exclusive instruction (ATC)

With this instruction, ATC, such as magazine index control, tool change by arm, etc. is performed.

ATC exclusive instructions include:

- Tool No. search
- Tool change
- Tool table forward/reverse run
- Pointer (which displays magazine index position) forward/reverse run
- Tool data read/write, etc.

(2) Rotary body control instruction (ROT)

With this instruction, the rotary body's target position and rotation direction are determined, as well as the function as a ring counter is realized.

Based on the output data figured with the tool No. search of ATC exclusive instruction, this instruction is used when controlling the rotary body position such as calculating rotation direction of the magazine and the number of index steps, and the turret.

8.1 ATC Exclusive Instruction

8.1.1 Outline of ATC Control

The ATC (Automatic Tool Change) can be controlled in the following two ways:

(1)Mechanical random control

With the information of magazine position from the machine, and T command, the control method determines the direction of magazine rotation, number of steps, etc. for index of the magazine, according to the given command.
Each tool and magazine tool pot (socket) have a one-on-one corresponding relation.
Usually, the "intermediate pot" that supports the transfer of the tool is provided between the spindle and the magazine.
This control is possible by not using ATC instruction, but ROT instruction only.

(2)Memory random control

With the information of magazine rotation, or magazine position from the machine, the control method controls tool No. stored in the memory. For index of the magazine, the direction of magazine rotation and number of steps, etc., are determined by the given T command and tool No. stored in the memory.
Each tool and magazine tool pot (socket) does not always have a one-on-one corresponding relation.
Usually, the "intermediate pot" is not provided.

8.1.2 ATC Operation

The motions related to ATC operation can be largely divided into the following four motions:

(1)Index of magazine (ATC-K1, K2, K5, K6, K7, K8)
(2)Tool change (arm, or the like is used) (ATC-K3, K4)
(3)Transfer of tool to intermediate pot or arm (Normal function instructions such as MOV, XCH are used.)
(4)Others (ATC-K9, K10, K11)

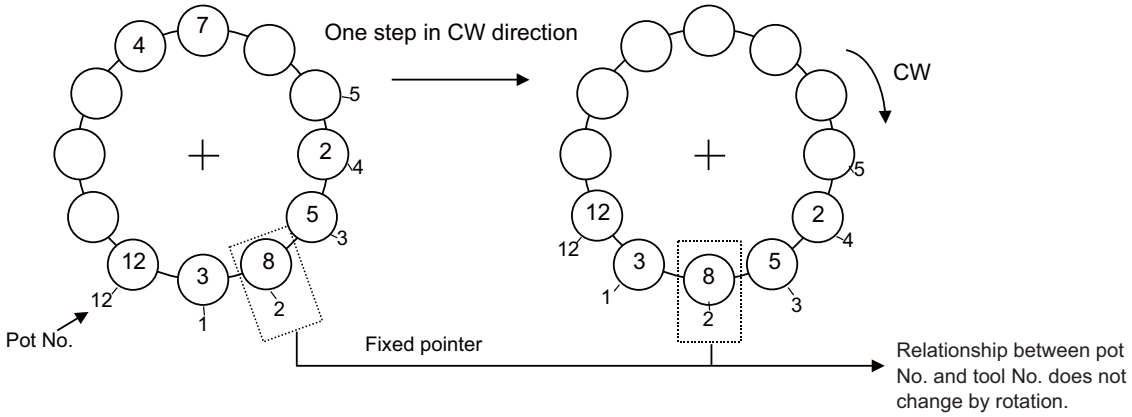
8.1.3 Explanation of Terminology

(1)Pointer

This points out the position where the magazine is indexed. When a tool table in which tool No. are previously recorded is used, the tool table does not rotate with rotation of the magazine and the pointer serves as "ring counter" for control of magazine position.

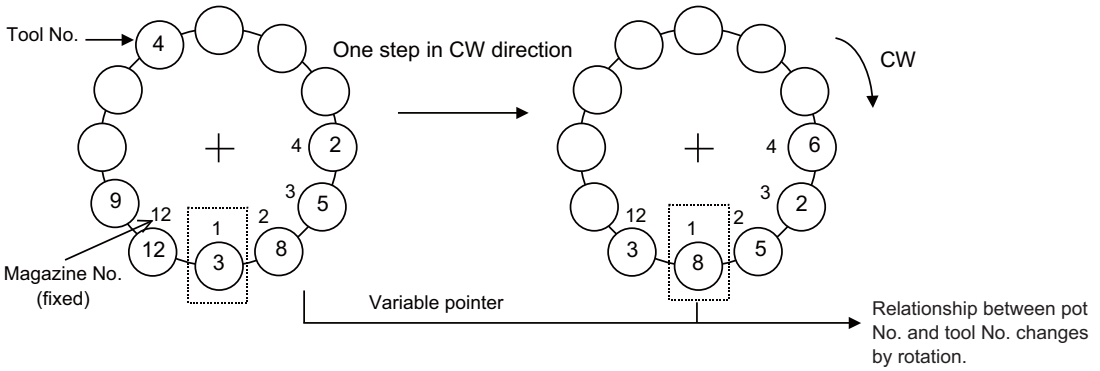
(2)Fixed pointer method

This is the type with tool pots numbered and the relationship between tool pot and tool No. is fixed if the magazine is rotated. When the tool table is rotated, fixed pointer does not functionally differ from variable pointer method.

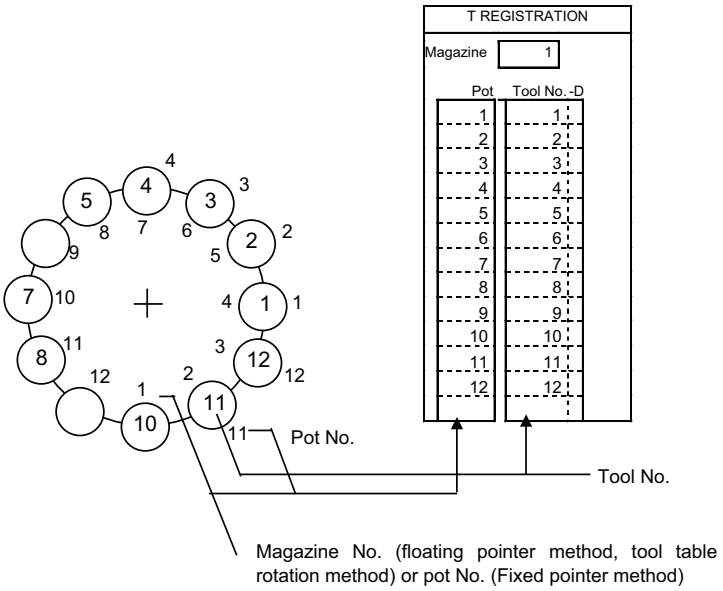


(3)Variable pointer method

This is the type with numbered fixed position on magazine and the relationship between magazine No. and tool No. changes when the magazine rotates.



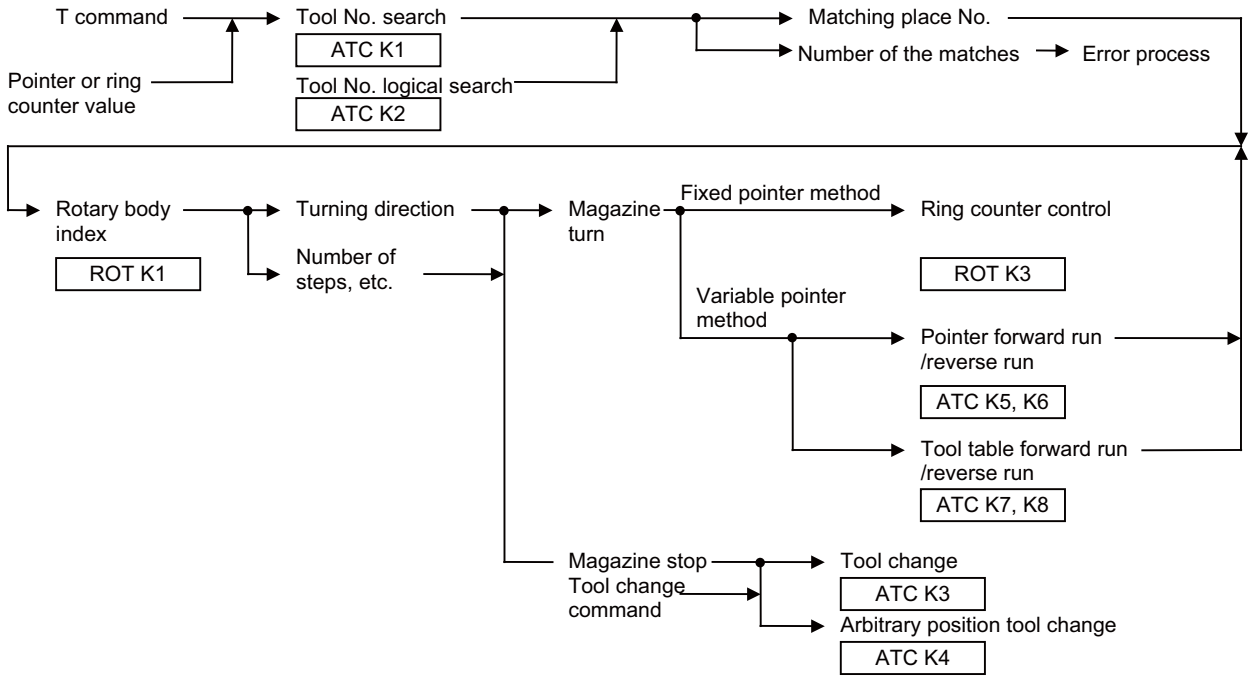
8.1.4 Relationship between Tool Registration Screen and Magazines



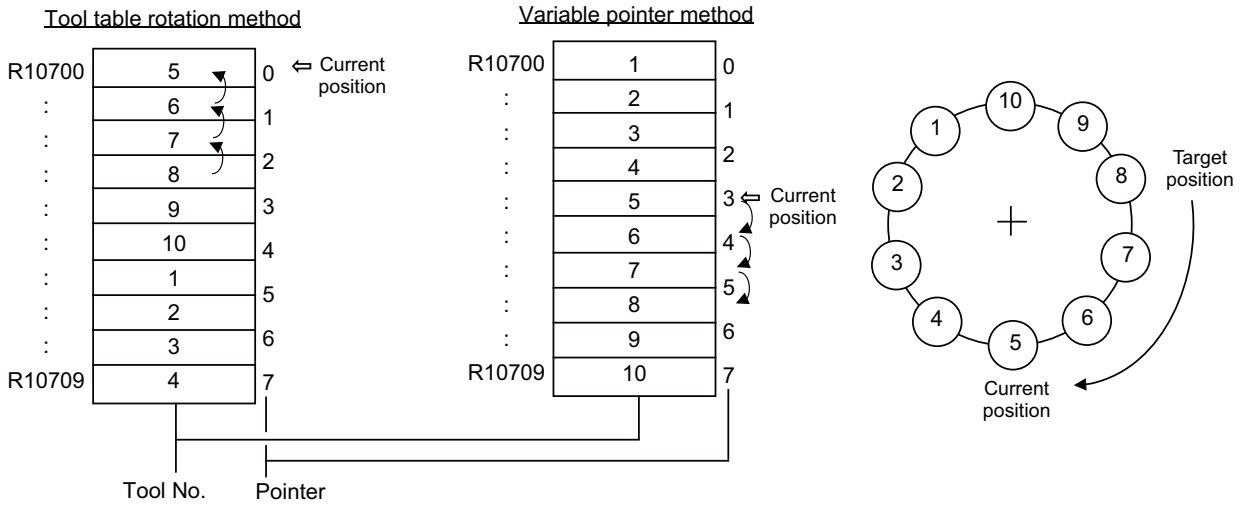
When the floating pointer method or tool table rotation method is selected on the tool registration screen, correspondence display between the magazines and tools changes each time the magazine rotates; when the fixed pointer method is selected, it does not change.

8.1.5 Use of ATC and ROT Instructions

The use order of the ATC and ROT instructions during the T command or tool change command is shown below:



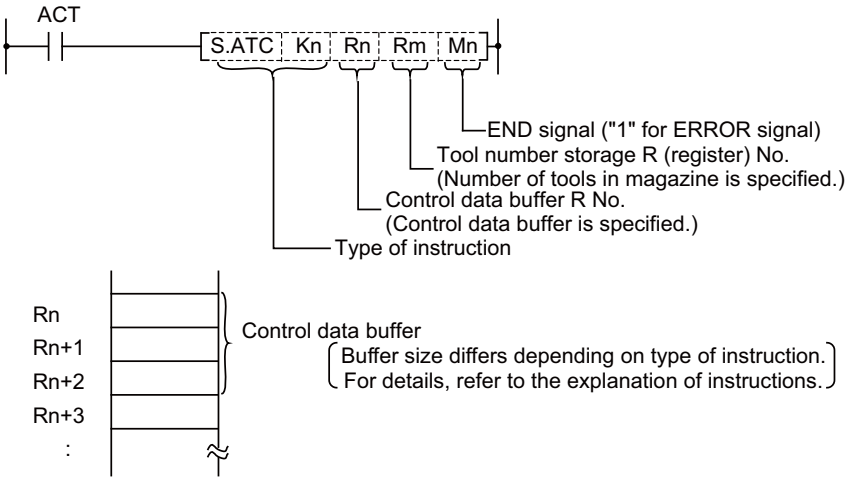
The relationship between the tool number search instruction and rotary body indexing instruction when the tool table rotation method or variable pointer method is used is explained below.



(1) When indexing tool number 8 in the situation given in the above figure.
(a)In the tool table rotation method, the tool number search instruction outputs 3.
(b)In the variable pointer method, the tool number search instruction outputs 7.

(2) The tool number search instruction output result is used by the rotary body indexing instruction to find the rotation direction, the number of steps, etc.
(a)In the tool table rotation system, rotation direction CW and number of steps 3 are found from the relationship between current value 0 (pointer 0) and tool number search output result 3.
(b)In the variable pointer method, rotation direction CW and number of steps 3 are found from the relationship between current value 4 (pointer 4) and tool number search output result 7, as in (a) above.
In the fixed pointer system, the pointer is fixed to 0 and the ring counter of 0 to n-1 (n is the number of magazines) separate from the pointer is controlled. The counter value is used as the current position.

8.1.6 Basic Format of ATC Exclusive Instruction



8.1.7 Instruction List

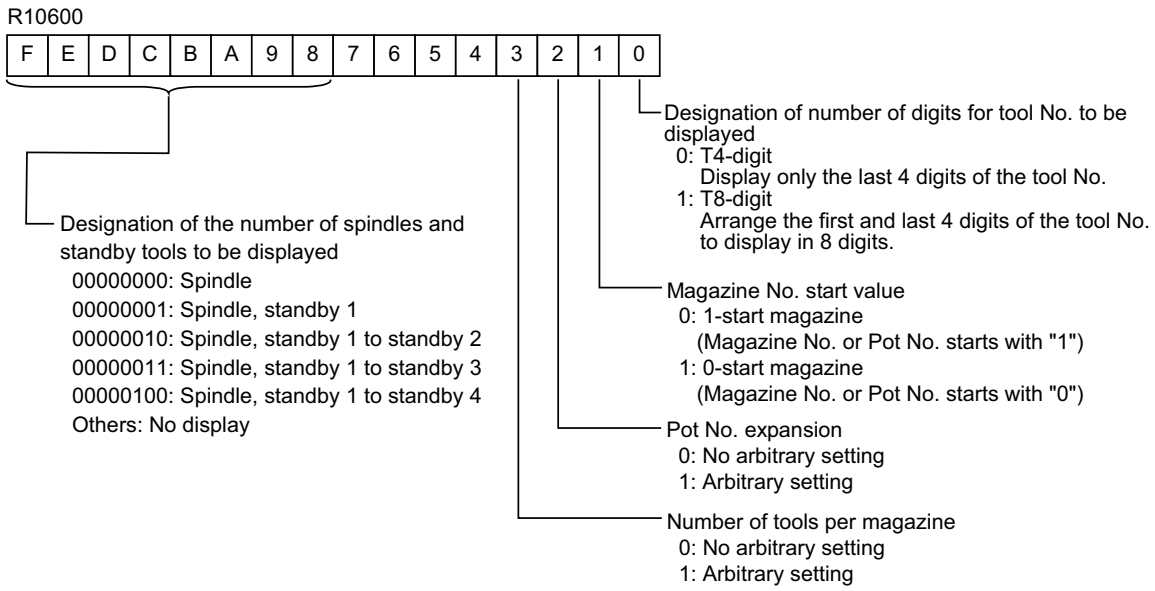
Instruction	Description
S.ATC K1 Rn Rm Mn	Tool No. search
S.ATC K2 Rn Rm Mn	Tool No. logical AND search
S.ATC K3 Rn Rm Mn	Tool change
S.ATC K4 Rn Rm Mn	Arbitrary position tool change
S.ATC K5 Rn Rm Mn	Pointer forward run
S.ATC K6 Rn Rm Mn	Pointer reverse run
S.ATC K7 Rn Rm Mn	Tool table forward run
S.ATC K8 Rn Rm Mn	Tool table reverse run
S.ATC K9 Rn Rm Mn	Tool data read
S.ATC K10 Rn Rm Mn	Tool data write
S.ATC K11 Rn Rm Mn	Automatic tool data write

8.1.8 Control Data Buffer Contents

	Instruction	Rn	Rn+1	Rn+2
1	Tool No. search	R No. to store search data	R No. to which data output	—
2	Tool No. logical AND search	R No. to store search data	R No. to which data output	Logical AND data storage R No.
3	Tool change Ex.: Spindle-Indexposition	R No. to specify the position of tool change	—	—
4	Arbitrary position tool change	R No. to specify the position of tool change	R No. to specify the tool to be changed	—
5	Pointer forward run	—	—	—
6	Pointer reverse run	—	—	—
7	Tool table forward run	—	—	—
8	Tool table reverse run	—	—	—
9	Tool data read	R No. for magazine position (to be read)	R No. to which data read	—
10	Tool data write	R No. for magazine position (to be written)	R No. where data to be written is stored	—
11	Automatic tool data write	R No. to store Initial data	—	—

8.1.9 File Register (R Register) Assignment and Parameters

(1) ATC control parameter contents



For details on the ATC control parameters, refer to "Examples of tool registration screen".

(2) Arbitrary setting of number of tools per magazine (R10600/bit3)
The device assignment method of the magazine tool data is selected.

(a) When not setting arbitrarily
The number of magazine rows is set to the maximum three rows, and the number of tools that can be registered is set to maximum 200 tools/magazine.
The device assignment of the magazine tool data is fixed.
Refer to "Magazine tool data (When not setting arbitrarily)".

(b) When setting arbitrarily
There is a maximum of five magazine rows, and the number of tools that can be registered is a total of 600 tools for all magazines.
The device of the magazine tool data is assigned for the set tools in order from No.1 magazine based on the set number of tools.
Refer to "Magazine tool data (When setting arbitrarily)".

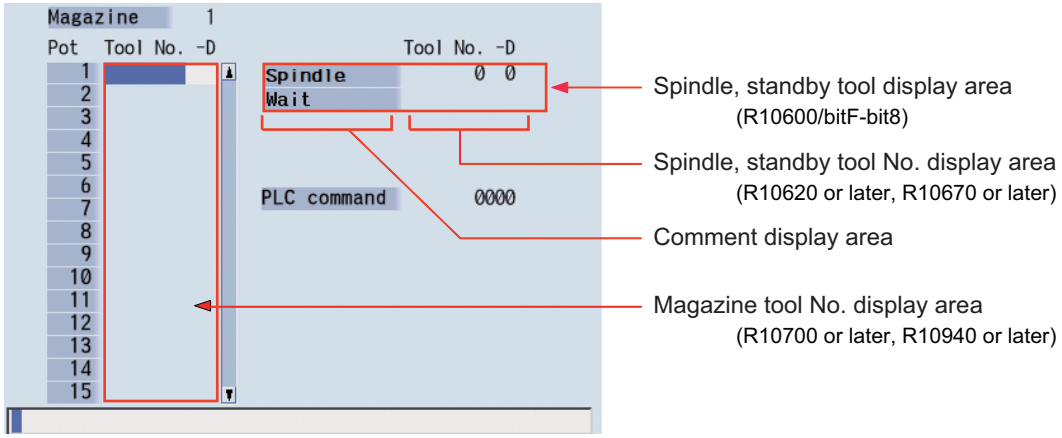
(3) The number of tools per magazine
Regardless of arbitrary setting, set the number of tools to be registered for the magazine, in the following R registers of each magazine.
- No. 1 magazine: R10610
- No. 2 magazine: R10611
- No. 3 magazine: R10612
- No. 4 magazine: R10613
- No. 5 magazine: R10614

If there are any magazines not being used, set the designation register to "0".

(Note 1) If "0" is set, the magazine tool is not displayed.
(Note 2) When the ATC control parameter (R10600/bit3) is set to "1" (Arbitrary setting), the number of tools to be set must be an even number.

(4) Examples of tool registration screen

The following shows the relationship between the display item on the tool registration screen and R device. For operation, refer to the instruction manual.



(a) Spindle tool, standby tool display area

The number of standby tools displayed on the tool registration screen, etc. is specified with the ATC control parameter (R10600/bitF to bit8).

(Example)

When the R10600 setting value is "01xx":

Two rows of spindle tool and standby 1 tool are displayed.

When the R10600 setting value is "03xx":

Four rows of spindle tool and standby 1 tool to standby 3 tool are displayed.

The screen displayed by the menu [Sp-stby] of the Monitor screen is displayed in the same way.

The magazines to be displayed on this screen can be selected with the parameter "#11054 Sp-stby disp type".

0: Fixed to the magazine 1.

1: The magazine to be displayed is selected by the menus [Magazine 1] to [Magazine 5].

(b) Comment display area

To display names such as Spindle/Wait in the comment display area, set "R10603/bit7" to "1".

The display at the comment display area is created using the message creation function.

(Refer to "Peripheral Development Environment (GX Works2)" in "PLC Development Manual".)

(c) Magazine tool No. display area

The number of digits for tool No. to be displayed and the magazine No. start value can be changed according to values of the ATC control parameter (R10600/bit3 to bit0).

[Pot No. expansion (R10600/bit2)]

This function allows the head No. for each magazine to be set freely.

This function is enabled by setting the ATC control parameter (R10600/bit2) to "1".

Set the head No. for each magazine in the following R registers.

- No.1 magazine: R10695
- No.2 magazine: R10696
- No.3 magazine: R10697
- No.4 magazine: R10698
- No.5 magazine: R10699

(Example) Display example of when the magazine head No. is 10 and the number of magazines is 18

MG	TOOL-D	MG	TOOL-D
10		26	
11		27	
12			
∫			

[Magazine No. start value (R10600/bit1)]

When the pot No. is not arbitrarily set ("R10600/bit2" is set to "0"), the head No. for each magazine starts with "1" or "0" according to the ATC control parameter (R10600/bit1).

(Example) Display example of when the number of magazines is 12.

MG	TOOL-D	MG	TOOL-D
1		∫	
2		11	
∫		12	

The magazine No. starts with "1"

MG	TOOL-D	MG	TOOL-D
0		∫	
1		10	
∫		11	

The magazine No. starts with "0"

(5) File registers for ATC control

The file registers used with the ATC are as shown below.

	Corresponding file register (R)										Data type
Magazine	No.1 magazine		No.2 magazine		No.3 magazine		No.4 magazine		No.5 magazine		
T4-digit/T8-digit specifications	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	
ATC control parameter	R10600	<-	<-	<-	<-	<-	<-	<-	<-	<-	
Number of magazines designation	R10610	<-	R10611	<-	R10612	<-	R10613	<-	R10614	<-	BIN
Pointer designation	R10615	<-	R10616	<-	R10617	<-	R10618	<-	R10619	<-	BIN
Spindle tool	R10620	R10620 R10621	R10630	R10630 R10631	R10640	R10640 R10641	R10650	R10650 R10651	R10660	R10660 R10661	BCD
Standby 1 tool	R10621	R10622 R10623	R10631	R10632 R10633	R10641	R10642 R10643	R10651	R10652 R10653	R10661	R10662 R10663	BCD
Standby 2 tool	R10622	R10624 R10625	R10632	R10634 R10635	R10642	R10644 R10645	R10652	R10654 R10655	R10662	R10664 R10665	BCD
Standby 3 tool	R10623	R10626 R10627	R10633	R10636 R10637	R10643	R10646 R10647	R10653	R10656 R10657	R10663	R10666 R10667	BCD
Standby 4 tool	R10624	R10628 R10629	R10634	R10638 R10639	R10644	R10648 R10649	R10654	R10658 R10659	R10664	R10668 R10669	BCD
Spindle tool D	R10670	<-	R10675	<-	R10680	<-	R10685	<-	R10690	<-	BIN
Standby 1 tool D	R10671	<-	R10676	<-	R10681	<-	R10686	<-	R10691	<-	BIN
Standby 2 tool D	R10672	<-	R10677	<-	R10682	<-	R10687	<-	R10692	<-	BIN
Standby 3 tool D	R10673	<-	R10678	<-	R10683	<-	R10688	<-	R10693	<-	BIN
Standby 4 tool D	R10674	<-	R10679	<-	R10684	<-	R10689	<-	R10694	<-	BIN
AUX data	R10604	<-	<-	<-	<-	<-	<-	<-	<-	<-	BIN
Pot head No. for each magazine	R10695	<-	R10696	<-	R10697	<-	R10698	<-	R10699	<-	BIN
Magazine tool data: Pot 1 (MG1):	♦ When not setting arbitrarily Magazine tool data assignment is fixed. Refer to "Arbitrary setting of number of tools per magazine (R10600/bit3)" and "Magazine tool data (When not-setting arbitrarily)" for details. ♦ When setting arbitrarily Magazine tool data assignment varies. Refer to "Arbitrary setting of number of tools per magazine (R10600/bit3)" and "Magazine tool data (When settingarbitrarily)" for details.										
Magazine tool data (Aux. D): Pot 1:											

(6) Magazine tool data (When not setting arbitrarily)

[Magazine tool data]

Pot	No.1 magazine		No.2 magazine		No.3 magazine		No.4 magazine		No.5 magazine		Data type
	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	
Pot 1 (MG1)	R10700	R10700 R10701	R11060	R11060 R11061	R11420	R11420 R11421	-	-	-	-	BCD
Pot 2 (MG2)	R10701	R10702 R10703	R11061	R11062 R11063	R11421	R11422 R11423	-	-	-	-	BCD
Pot 3 (MG3)	R10702	R10704 R10705	R11062	R11064 R11065	R11422	R11424 R11425	-	-	-	-	BCD
:											
Pot n (*1) (MGn)	R10700+ (n-1)	R10700+ 2(n-1) R10701+ 2(n-1)	R11060+ (n-1)	R11060+ 2(n-1) R11061+ 2(n-1)	R11420+ (n-1)	R11420+ 2(n-1) R11421+ 2(n-1)	-	-	-	-	BCD
:											
Pot 119 (MG119)	R10818	R10936 R10937	R11178	R11296 R11297	R11538	R11656 R11657	-	-	-	-	BCD
Pot 120 (MG120)	R10819	R10938 R10939	R11179	R11298 R11299	R11539	R11658 R11659	-	-	-	-	BCD
Pot 121 (MG121)	ZR4000	ZR4000 ZR4001	ZR4240	ZR4240 ZR4241	ZR4480	ZR4480 ZR4481	-	-	-	-	BCD
Pot 122 (MG122)	ZR4001	ZR4002 ZR4003	ZR4241	ZR4242 ZR4243	ZR4481	ZR4482 ZR4483	-	-	-	-	BCD
:											
Pot m (*1) (MGm)	ZR4000+ (m-121)	ZR4000+ 2(m-121) ZR4001+ 2(m-121)	ZR4240+ (m-121)	ZR4240+ 2(m-121) ZR4241+ 2(m-121)	ZR4480+ (m-121)	ZR4480+ 2(m-121) ZR4481+ 2(m-121)	-	-	-	-	BCD
:											
Pot 200 (MG200)	ZR4079	ZR4158 ZR4159	ZR4319	ZR4398 ZR4399	ZR4559	ZR4638 ZR4639	-	-	-	-	BCD

[Magazine tool data (Aux. D)]

Pot	No.1 magazine		No.2 magazine		No.3 magazine		No.4 magazine		No.5 magazine		Data type
	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	
Pot 1	R10940	<-	R11300	<-	R11660	<-	-	-	-	-	BIN
Pot 2	R10941	<-	R11301	<-	R11661	<-	-	-	-	-	BIN
Pot 3	R10942	<-	R11302	<-	R11662	<-	-	-	-	-	BIN
:											
Pot n (*1)	R10940+ (n-1)	<-	R11300+ (n-1)	<-	R11660+ (n-1)	<-	-	-	-	-	BIN
:											
Pot 119	R11058	<-	R11418	<-	R11778	<-	-	-	-	-	BIN
Pot 120	R11059	<-	R11419	<-	R11779	<-	-	-	-	-	BIN
Pot 121	ZR4160	<-	ZR4400	<-	ZR4640	<-	-	-	-	-	BIN
Pot 122	ZR4161	<-	ZR4401	<-	ZR4641	<-	-	-	-	-	BIN
:											
Pot m (*1)	ZR4160+ (m-121)	<-	ZR4400+ (m-121)	<-	ZR4640+ (m-121)	<-	-	-	-	-	BIN
:											
Pot 200	ZR4239	<-	ZR4479	<-	ZR4719	<-	-	-	-	-	BIN

(*1) "n" and "m" indicate the Pot No. (n: 1 to 120, m: 121 to 200)

(7) Magazine tool data (When setting arbitrarily)

The magazine tool data is assigned for the number of tools set in order from No. 1 magazine based on the set number of tools.

(Example) Number of magazines: 5 magazines; Number of tools: 180 tools in each of No.1 magazine and No.2 magazine, 50 tools in each of No.3 to No.5 magazines

[Magazine tool data]

Pot	No.1 magazine		No.2 magazine		No.3 magazine		No.4 magazine		No.5 magazine		Data type
	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	
Pot 1 (MG1)	R10700	R10700 R10701	R11240	R11240 R11241	ZR4000	ZR4000 ZR4001	ZR4150	ZR4150 ZR4151	ZR4300	ZR4300 ZR4301	BCD
Pot 2 (MG2)	R10701	R10702 R10703	R11241	R11242 R11243	ZR4001	ZR4002 ZR4003	ZR4151	ZR4152 ZR4153	ZR4301	ZR4302 ZR4303	BCD
Pot 3 (MG3)	R10702	R10704 R10705	R11242	R11244 R11245	ZR4002	ZR4004 ZR4005	ZR4152	ZR4154 ZR4155	ZR4302	ZR4304 ZR4305	BCD
:											
Pot n (*1) (MGn)	R10700+ (n-1)	R10700+ 2(n-1) R10701+ 2(n-1)	R11240+ (n-1)	R11240+ 2(n-1) R11241+ 2(n-1)	ZR4000+ (n-1)	ZR4000+ 2(n-1) ZR4001+ 2(n-1)	ZR4150+ (n-1)	ZR4150+ 2(n-1) ZR4151+ 2(n-1)	ZR4300+ (n-1)	ZR4300+ 2(n-1) ZR4301+ 2(n-1)	BCD
:											
Pot 49 (MG119)	R10748	R10796 R10797	R11288	R11336 R11337	ZR4048	ZR4096 ZR4097	ZR4198	ZR4246 ZR4247	ZR4348	ZR4396 ZR4397	BCD
Pot 50 (MG120)	R10749	R10798 R10799	R11289	R11338 R11339	ZR4049	ZR4098 ZR4099	ZR4199	ZR4248 ZR4249	ZR4349	ZR4398 ZR4399	BCD
Pot 51 (MG121)	R10750	R10800 R10801	R11290	R11340 R11341	-	-	-	-	-	-	BCD
:											
Pot 179 (MG179)	R10878	R11056 R11057	R11418	R11596 R11597	-	-	-	-	-	-	BCD
Pot 180 (MG180)	R10879	R11058 R11059	R11419	R11598 R11599	-	-	-	-	-	-	BCD

[Magazine tool data (Aux. D)]

Pot	No.1 magazine		No.2 magazine		No.3 magazine		No.4 magazine		No.5 magazine		Data type
	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	T4-digit	T8-digit	
Pot 1	R11060	<-	R11600	<-	ZR4100	<-	ZR4250	<-	ZR4400	<-	BIN
Pot 2	R11061	<-	R11601	<-	ZR4101	<-	ZR4251	<-	ZR4401	<-	BIN
Pot 3	R11062	<-	R11602	<-	ZR4102	<-	ZR4252	<-	ZR4402	<-	BIN
:											
Pot n (*1)	R11060+ (n-1)	<-	R11600+ (n-1)	<-	ZR4100+ (n-1)	<-	ZR4250+ (n-1)	<-	ZR4400+ (n-1)	<-	BIN
:											
Pot 49	R11108	<-	R11648	<-	ZR4148	<-	ZR4298	<-	ZR4448	<-	BIN
Pot 50	R11109	<-	R11649	<-	ZR4149	<-	ZR4299	<-	ZR4449	<-	BIN
Pot 51	R11110	<-	R11650	<-	-	-	-	-	-	-	BIN
:											
Pot 179	R11238	<-	R11778	<-	-	-	-	-	-	-	BIN
Pot 180	R11239	<-	R11779	<-	-	-	-	-	-	-	BIN

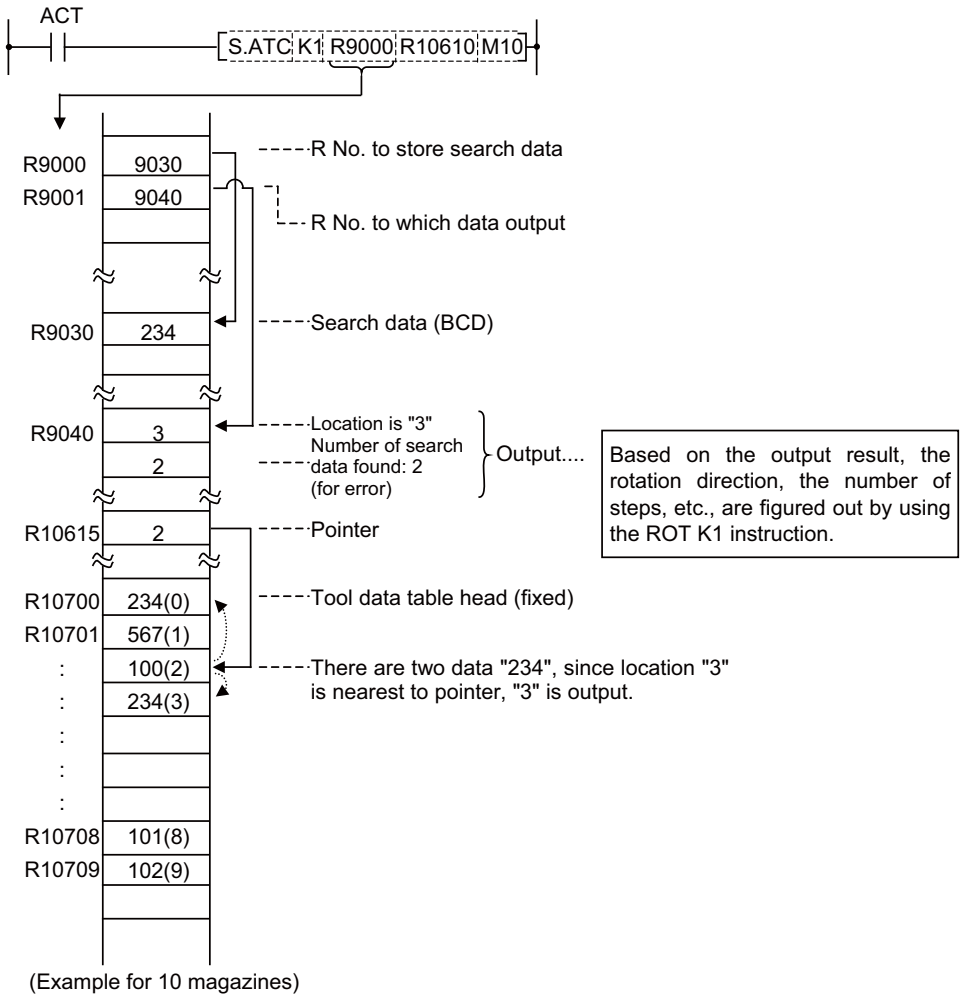
(*1) "n" indicates the Pot No.

8.1.10 Details of Each Instruction

(1)Tool No. search

This instruction is used to search for tool No. stored in the magazine (tool data table).

When the instruction tool No. is found, number of searched data and its location are output. If two or more tool No. are found, the location of tool No. nearest to the pointer is output.



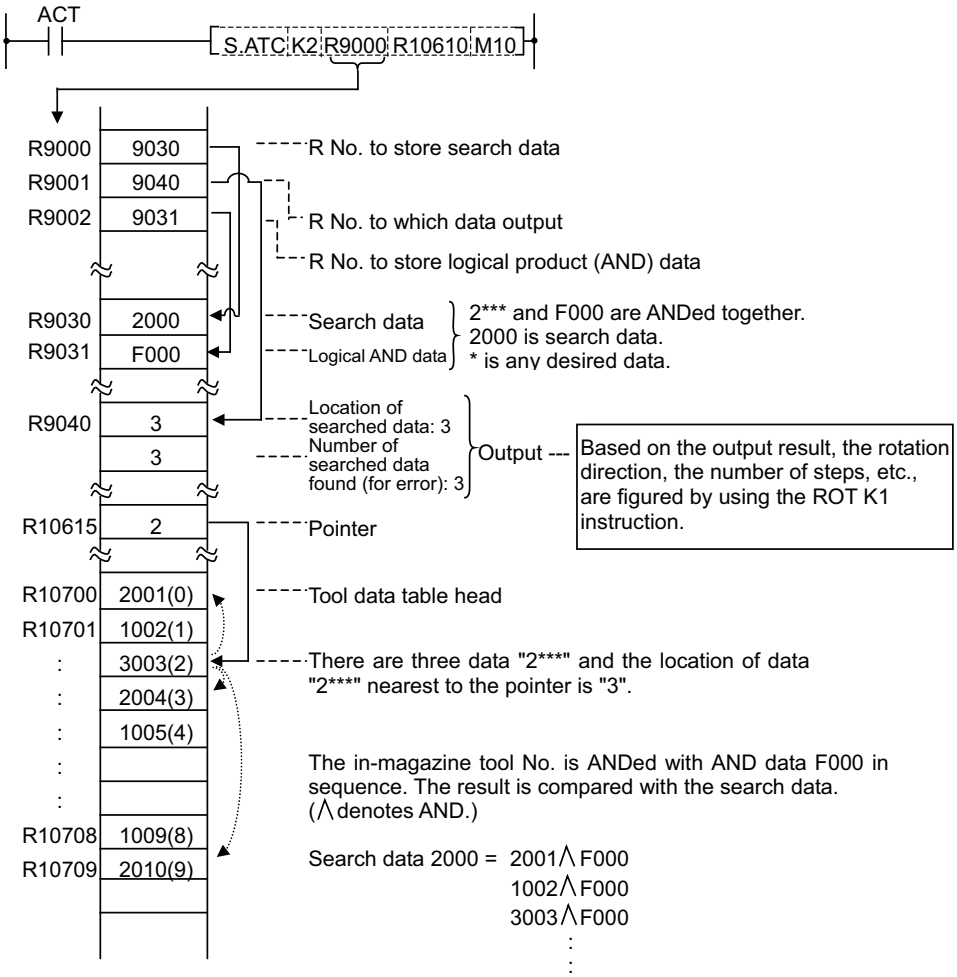
(Note 1) Pointer and location are counted up, like 0,1,2...9, in the tool data table, starting from the tool data table head.

(Note 2) When pointer is not used, R10615 should be set to "0".

(Example) MOV K0 R10615

(2)Tool No. logical product (AND) search

Tool number AND search is the same as the tool number search instruction (ATC K1) in function: search data and in-magazine tool number and AND data are ANDed together for a search.



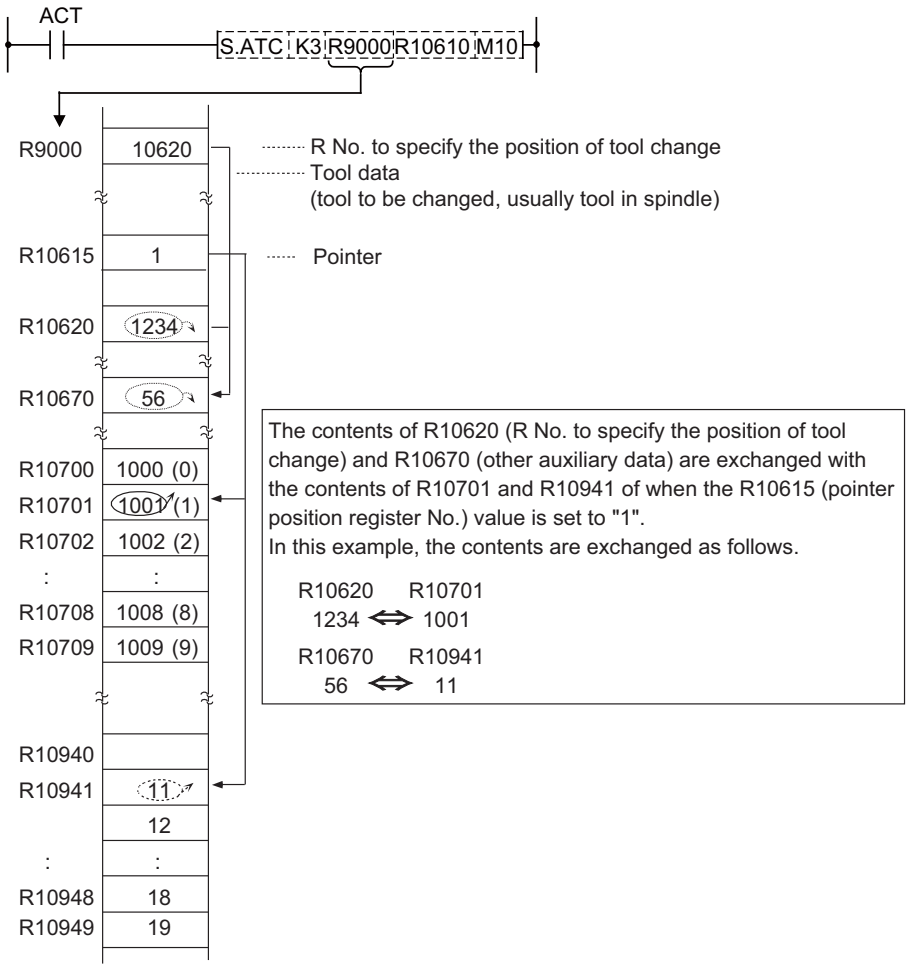
(Note 1) Pointer and location are counted up, like 0, 1, 2 .... 9, in the tool data table, starting from the tool data table head.

(Note 2) When pointer is not used, R10615 should be set to "0".

(Example) MOV K0 R10615

(3)Tool change

When a spindle tool and a magazine index tool are exchanged by the ATC arm, etc., the contents in the memory (R register) must be updated correspondingly.



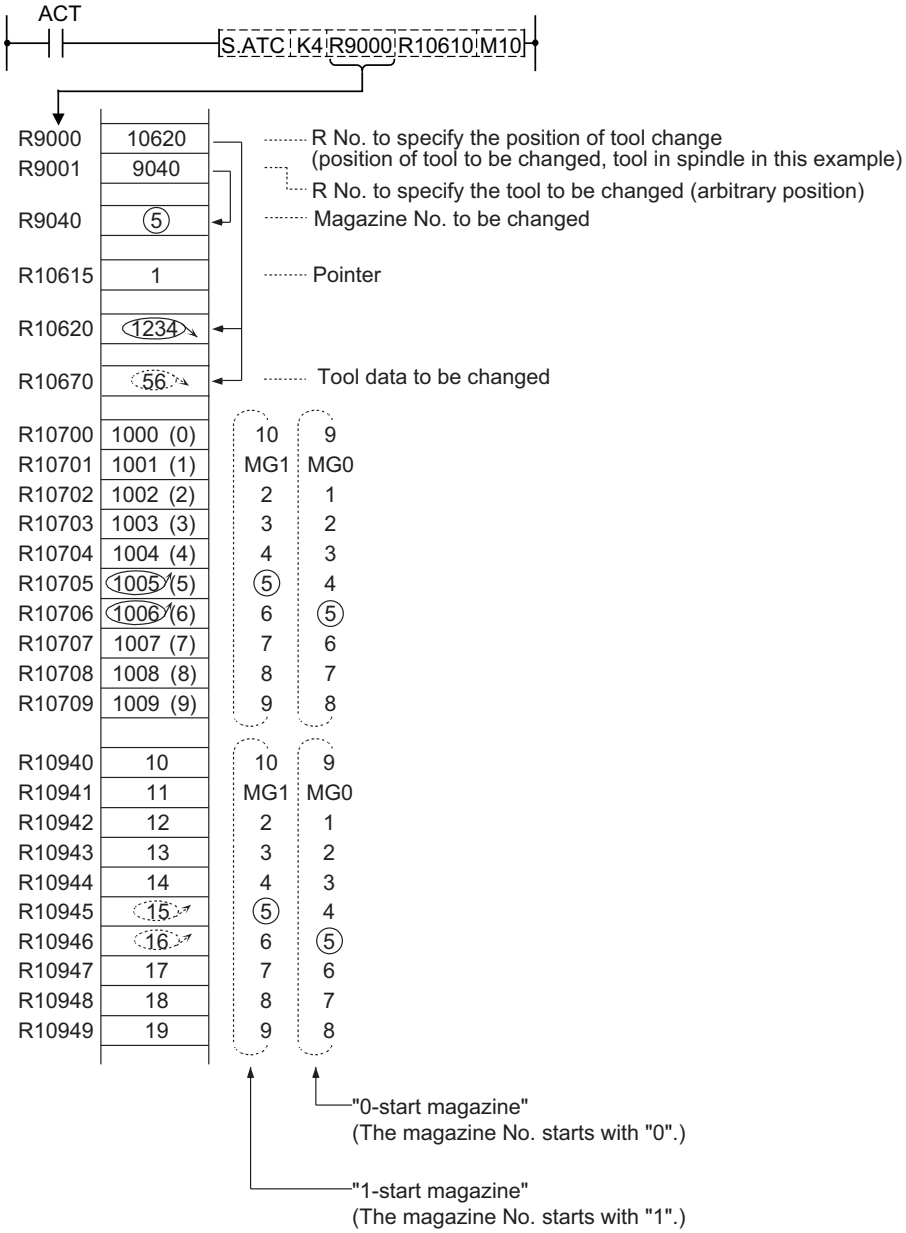
(Example of when the number of magazine tools is not arbitrarily set and it is 10)

(Note) When pointer is not used, R10615 should be set to "0".

(Example) MOV K0 R10615

(4)Arbitrary position tool change

In tool change, a spindle tool and a magazine index tool are usually exchanged with each other. However, there are some cases where the tool change must be performed at a station other than the usual tool change position. An example case is tool change at spare tool change position. This instruction is used in such cases.



(Example of when the number of magazine tools is not arbitrarily set and it is 10)

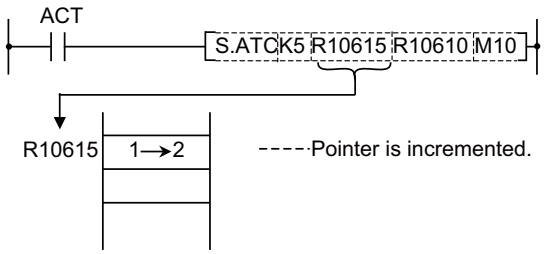
(Note 1) Tool change position differs between when the magazine No. starts with "0" and when it starts with "1". However, the substantial consequence does not differ.

(Note 2) When pointer is not used, R10615 should be set to "0".

(Example) MOV K0 R10615

(5)Pointer forward run

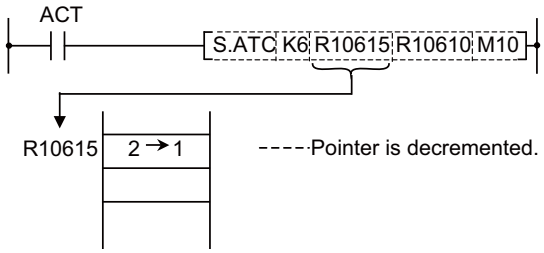
In the ATC control with variable pointer, pointer count is controlled so that it coincides with the actually indexed magazine position when the magazine rotates in forward direction for index.



When a magazine with 10 tools is used, for example, the control sequence is as follows:
0,1,2,3……9,0,1,2……8,9,0,1…
(Note 1) When this instruction is executed, the relationship between magazine No. and tool No., appearing on the tool entry display, changes accordingly.

(6)Pointer reverse run

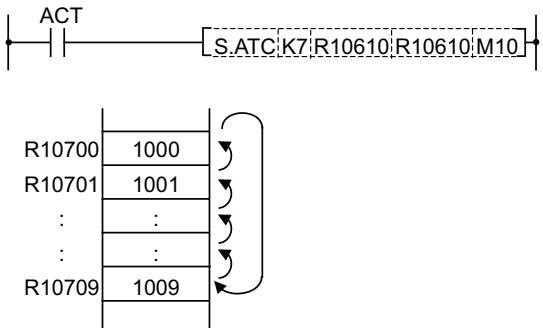
In the ATC control with variable pointer, pointer count is controlled so that it coincides with actually indexed magazine position when the magazine rotates in reverse direction for index.



When a magazine with 10 tools is used, for example, the control sequence is as follows:
2,1,0,9,8……2,1,0,9,8……1,0,9,8…
(Note 1) When this instruction is executed, the relationship between magazine No. and tool No., appearing on the tool entry display, changes accordingly.

(7)Tool table forward run

The tool table rotates in forward direction in accordance with the magazine rotation.

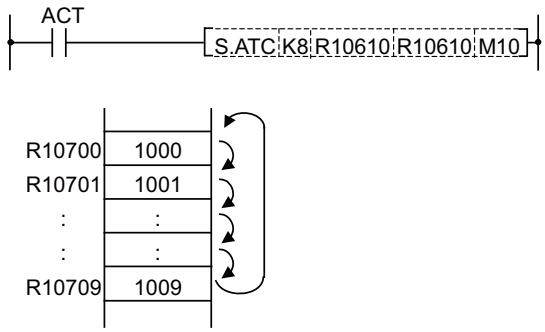


(Note 1) In this control mode, pointer always indicates "0" (tool table head).

(Note 2) When this instruction is executed, the relationship between magazine No. and tool No., appearing on the tool entry display changes accordingly.

(8)Tool table reverse run

The tool table rotates in reverse direction in accordance with the magazine rotation.

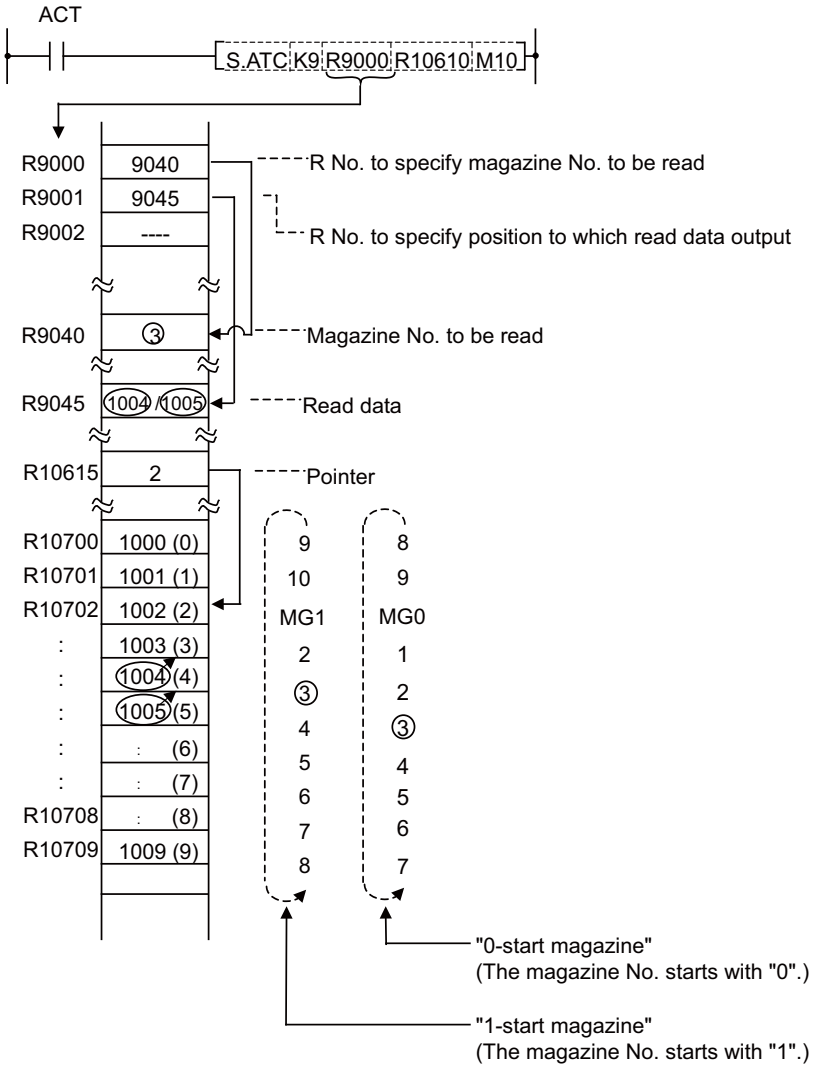


(Note 1) In this control mode, pointer always indicates "0" (tool table head).

(Note 2) When this instruction is executed, the relationship between magazine No. and tool No., appearing on the tool entry display changes accordingly.

(9)Tool data read

This instruction is used to call a specific tool No. in the magazine.



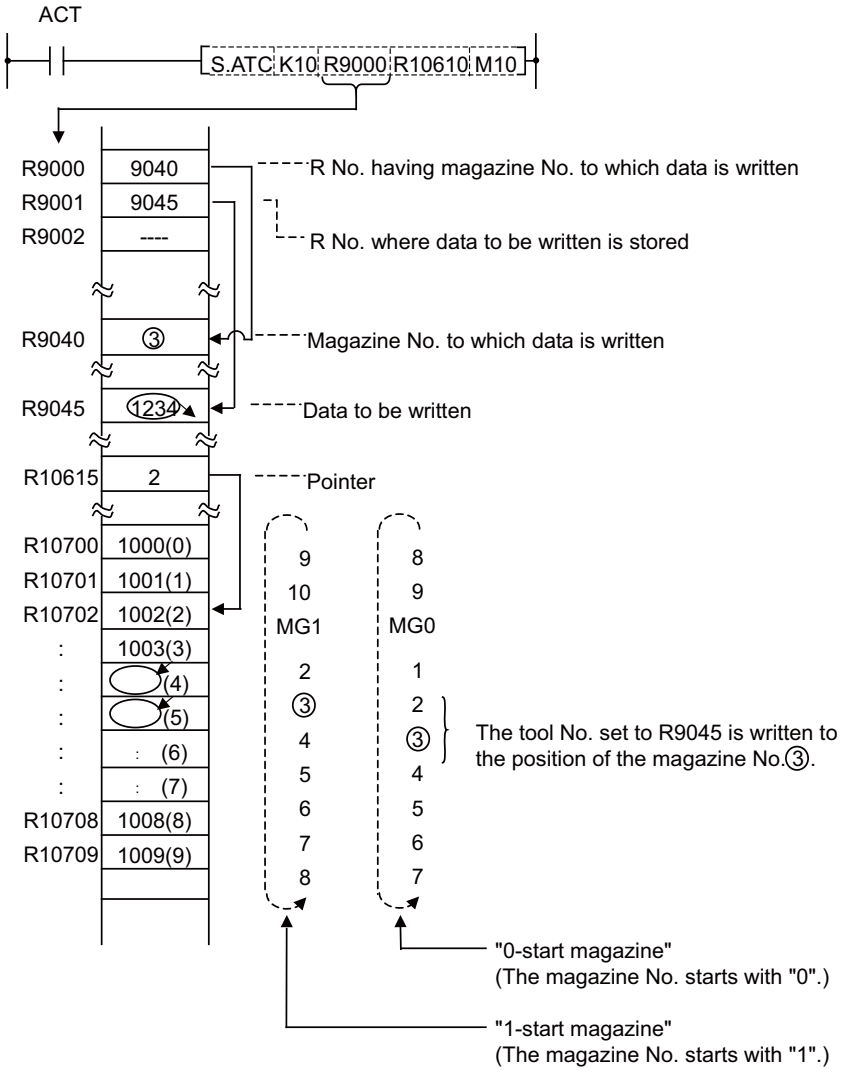
(Note1) Read out data differs between when the magazine No. starts with "0" and when it starts with "1". However, the substantial consequence does not differ.

(Note2) When pointer is not used, R10615 should be set to "0".

(Example) MOV K0 R10615

(10)Tool data write

Instead of setting tool No. through the setting and display unit, the tool No. is entered to each magazine No. set through PLC program.

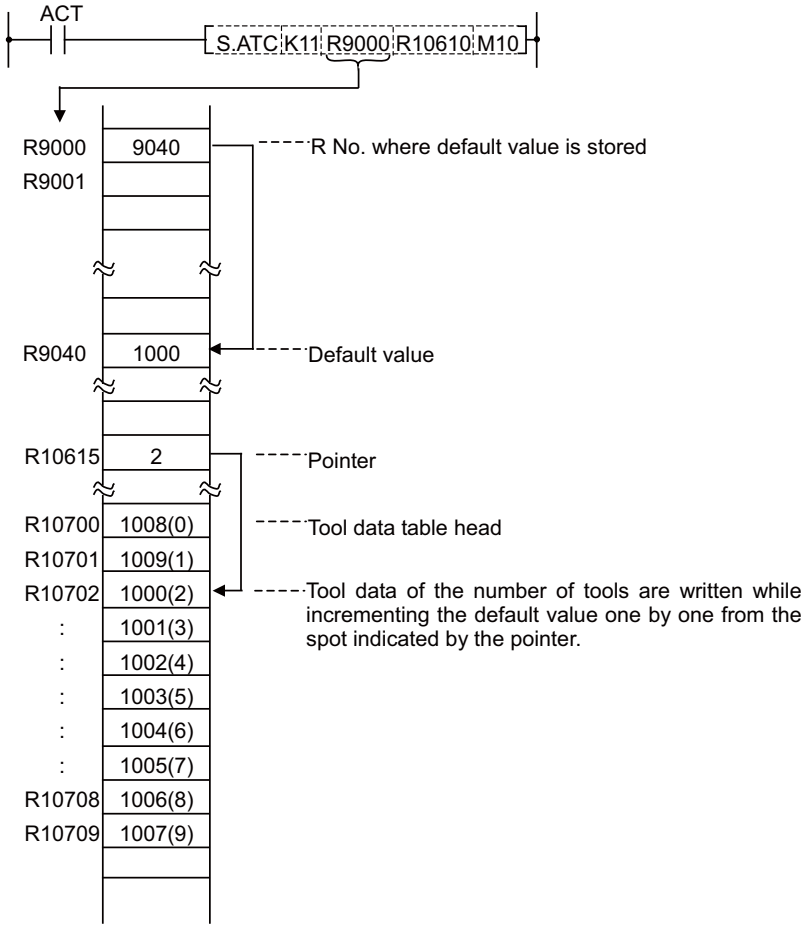


(Note) When pointer is not used, R10615 should be set to "0".

(Example) MOV K0 R10615

(11)Automatic tool data write

All tool Nos. are written (entered) in batch. This instruction is used for initialization, etc.
The data are written one after another for each tool, starting from the default value.



(Note) When pointer is not used, R10615 should be set to "0".

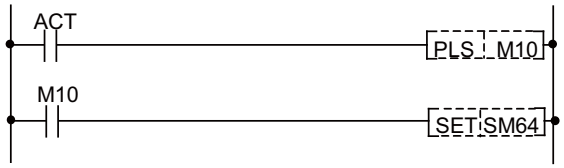
(Example) MOV K0 R10615

8.1.11 Precautions for Using ATC Exclusive Instructions

(1)When tool data is rewritten by ATC or other than ATC instruction, tool registration screen display is not updated. The following processing is required:

- Turn ON special relay SM64 by using the SET instruction.

(Program example)



- SM64 processing is not required for ATC instructions ATC K5, K6 (forward run, reverse run of pointer), ATC K7, K8 (forward run, reverse run of tool table).
- SM64 is set through the use of the user PLC and reset by controller.

8.2 ROT Instructions

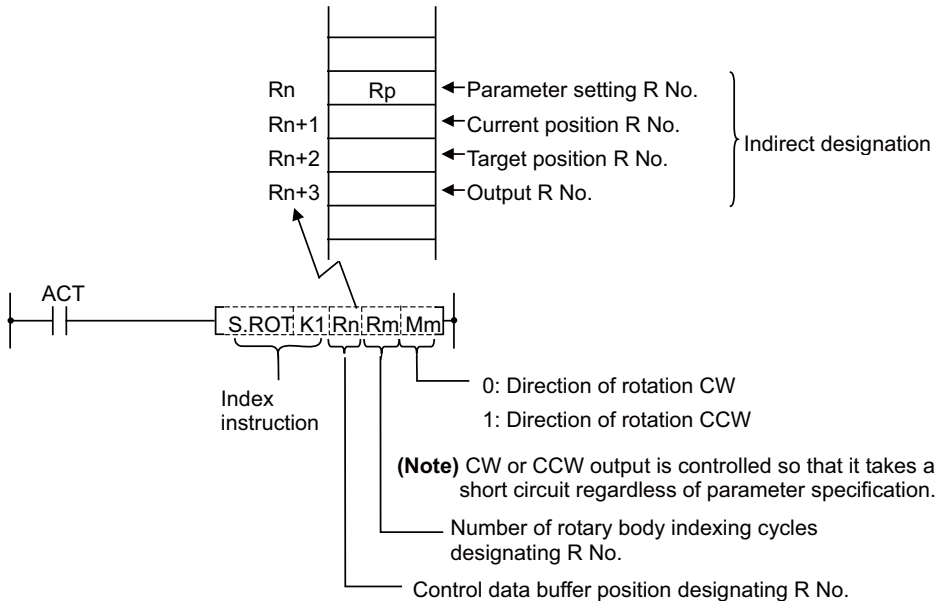
With this instruction, the rotary body's target position and rotation direction are determined, as well as the function as a ring counter is realized.
Based on the output data figured with the tool No. search of ATC exclusive instruction, this instruction is used when controlling the rotary body position such as calculating rotation direction of the magazine and the number of index steps, and the turret.

8.2.1 Instruction List

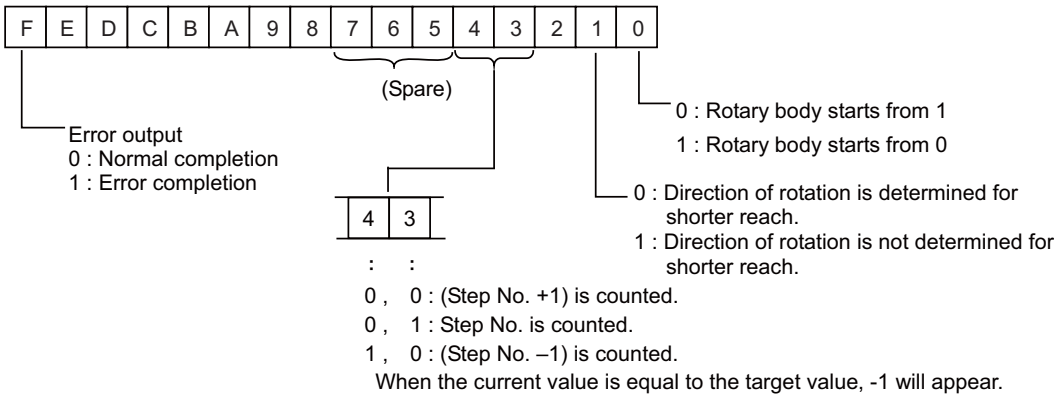
Instruction	Description
S.ROT K1 Rn Rm Mm	Rotary body indexing
S.ROT K3 Rn Rm Mm	Ring counter

(Note 1) Rot instructions are programmed with "S.ROT".

(1) Rotary body indexing
Direction of rotation and number of steps of ATC magazine (or turret) are determined.



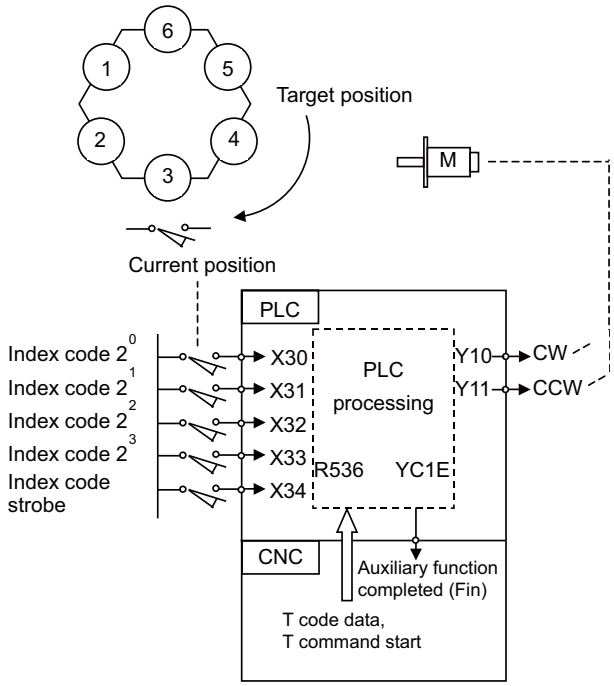
Rp (parameter) contents



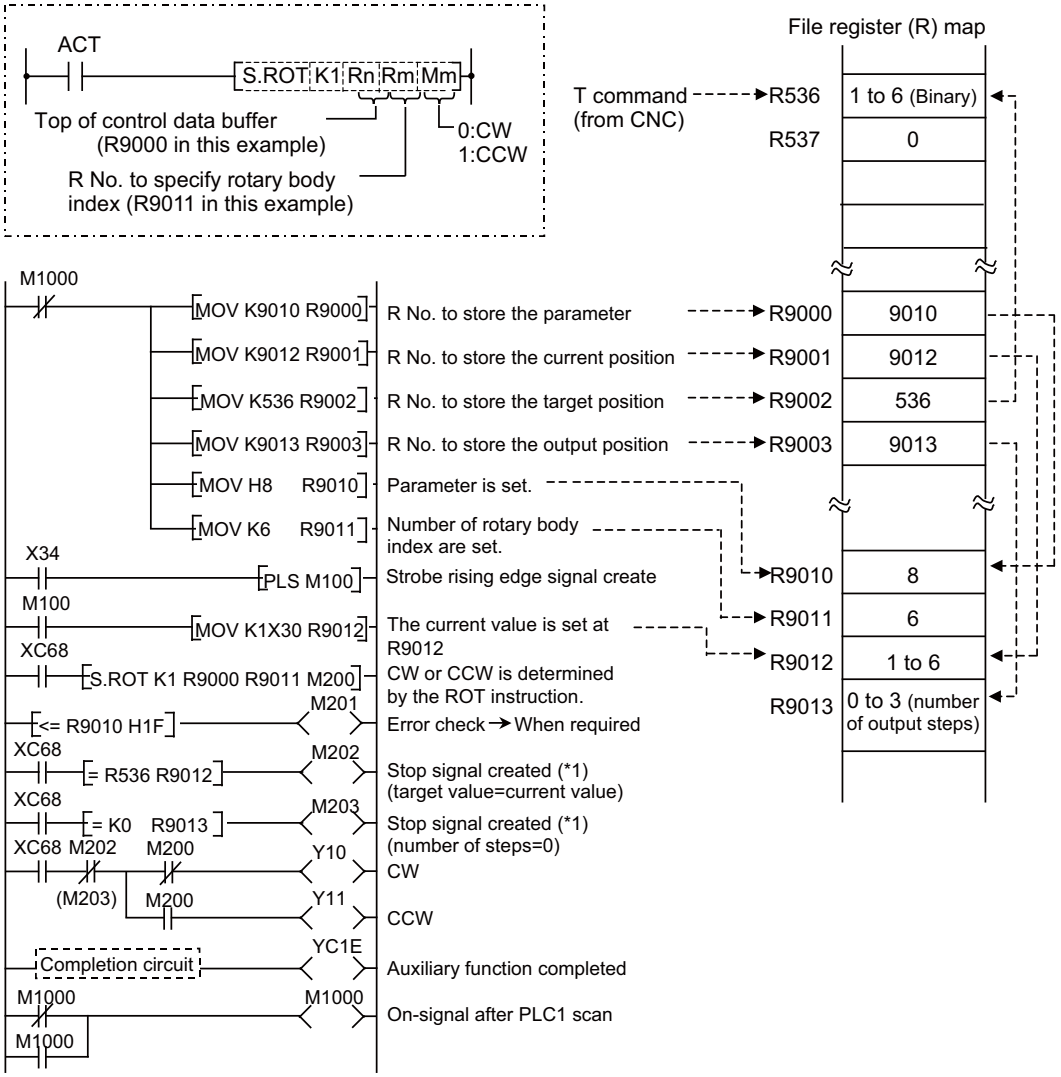
(Note 1) The Index instruction is executed after setting R Nos. to Rn to Rn+3 and writing data in the file registers (R) each corresponding to the R Nos. However, data setting to the parameter (Rp) is done once before execution of the index instruction; this is to prevent the error code from being cleared.

(Note 2) The error code stored in bit F of the parameter (Rp) is not cleared even if the index instruction activating signal (ACT) goes OFF.

(a) Example of rotary body index by ROT K1 instruction
Conditions:
(i)The number of rotary body index is 6.
(ii)The target position is set with the T command. The T command is set with the parameters so that it outputs to the PLC with a binary. (Set base specification parameter Tbin to 1.)



In the example of ladder circuit shown below, the rotation direction is determined by the T command and current position data given by the machine, and the rotary body is rotated in that direction until the target position reaches the current position. When indexing is completed, the auxiliary command completion signal is turned ON.



(Note 1) Either M202 or M203 can be used for a stop signal.

(Note 2) The devices (X, Y, and R) are used in this example for no special purpose. Use any device within the available range.

(Note 3) If a number from 1 to 6 has not been specified for current position data (R9012) before the ROT instruction is activated, an error will occur.

(Note 4) The control data buffer (R9010) are specified as follows:

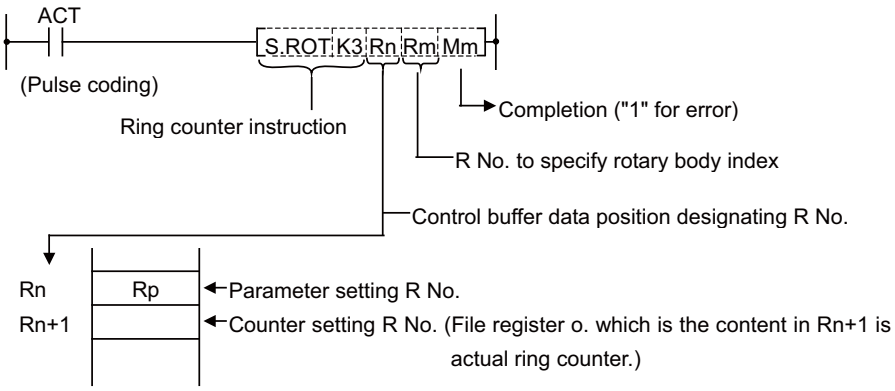
(1)Rotary body starts from 1

(2)Take a short cut.

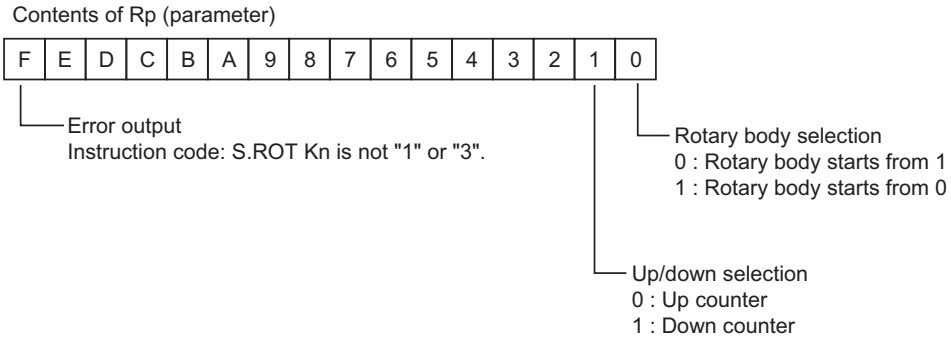
(3)Calculate the number of steps.

(2) Ring counter (Up/down counter)

This instruction is used to control position of rotary body (or turret).



The ring counter is a binary counter; it is used as an up/down counter of "start from 0" or "start from 1" according to the parameter rotary body instruction.



(Note 1) The ring counter instruction is executed after setting R No. to Rn to Rn+1 and specifying data for the parameter.

(Note 2) The error completion (Mm) of the ring counter instruction and the error output in bit F of the parameter (Rp) are cleared when the activating signal (ACT) goes OFF. The activating signal (ACT) of the ring counter instruction is generally pulsed. This makes it hard for the interface diagnostic and ladder monitor programs to detect an error signal. For debugging, therefore, an error hold circuit is provided after the ring count instruction to ease error detection.

9

Parameters

9.1 PLC Constants

The parameters that can be used in user PLC include PLC constants set in the data type. The PLC constants include the basic area and the extended area.

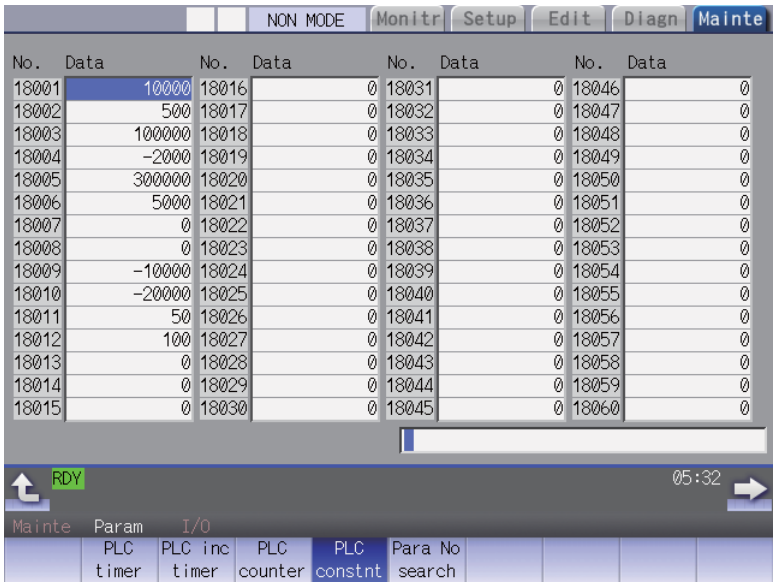
(1) Basic area

Set up data is stored in a file register and is backed up. In contrast, if data is stored in the file register corresponding to PLC constant by using sequence program MOV instruction, etc., it is backed up.
However, display remains unchanged. Display another screen once and then select the screen again.
150 PLC constants are set (the setting range is ±8 digits). (Signed 4-byte binary data)

PLC constant No. and R register correspondence table

Item (# No.)		Corresponding register	Details	Setting range
PLC constant #1 (#18001)	LOW side	R7500	Data type parameters which can be used in user PLC	-99999999 to 99999999 (Signed 8-digit integer)
	HIGH side	R7501		
PLC constant #2 (#18002)	LOW side	R7502		
	HIGH side	R7503		
PLC constant #3 (#18003)	LOW side	R7504		
	HIGH side	R7505		
…		…		
PLC constant #148 (#18148)	LOW side	R7794		
	HIGH side	R7795		
PLC constant #149 (#18149)	LOW side	R7796		
	HIGH side	R7797		
PLC constant #150 (#18150)	LOW side	R7798		
	HIGH side	R7799		

PLC constant setting and display screen



(2) Extended area

Up to 750 PLC constants can be secured by using the user backup area (R8300 to R9799) as the extended area. The extended area start register and number can be set with the parameters. A total of 900 PLC constants can be set with 150 (#18001 to #18150) in the basic area and up to 750 (#18151 to #18900) in the extended area.
Set up data is stored in a file register and is backed up. In contrast, if data is stored in the file register corresponding to PLC constant by using sequence program MOV instruction, etc., it is backed up.
However, display remains unchanged. Display another screen once and then select the screen again.
750 PLC constants are set (the setting range is ±8 digits). (Signed 4-byte binary data)

PLC constant No. and R register correspondence table

Item (# No.)		Corresponding register	Details	Setting range
PLC constant #151 (#18151)	LOW side	R8300 to R9799 The area for the number determined with parameter #1326 is continuously secured.	Data type parameters which can be used in user PLC	-99999999 to 99999999 (Signed 8-digit integer)
	HIGH side			
PLC constant #152 (#18152)	LOW side			
	HIGH side			
PLC constant #153 (#18153)	LOW side			
	HIGH side			
…				
PLC constant #898 (#18898)	LOW side			
	HIGH side			
PLC constant #899 (#18899)	LOW side			
	HIGH side			
PLC constant #900 (#18900)	LOW side			
	HIGH side			

The extended area quantity is set with basic common parameter #1326.

# No.	Item	Details	Setting range
1326	PLC Const Ext. Number	- Set number of PLC constant extension points. - This is valid after the power is turned OFF and ON.	0 to 750

9.2 Bit Selection Parameters

The parameters that can be used in user PLC include bit selection parameters set in the bit type.
Set up data is stored in a file register and is backed up.
When using bit operation in a sequence program, use a word device bit-designation format.
If data is stored in the file register corresponding to bit selection by using the MOV instruction etc., it is backed up. However, display remains unchanged. Once display another screen and again select screen.
The corresponding between the bit selection parameters and file registers is listed below. The setting and display screens are also shown.

Bit selection parameter (# No.)		Corresponding register	Details	Setting range
#1	(#6401)	R7800-Low side	Use bit selection parameters #6401 to #6448 freely.	8 bits
#2	(#6402)	R7800-High side		
#3	(#6403)	R7801-L		
#4	(#6404)	R7801-H		
...		...		
#45	(#6445)	R7822-L		
#46	(#6446)	R7822-H		
#47	(#6447)	R7823-L		
#48	(#6448)	R7823-H		
#49	(#6449)	R7824-L	Bit selection parameter #6449 to #6496 are PLC operation parameters used by the machine tool builder and MITSUBISHI. The contents are fixed.	
#50	(#6450)	R7824-H		
#51	(#6451)	R7825-L		
#52	(#6452)	R7825-H		
...		...		
#93	(#6493)	R7846-L		
#94	(#6494)	R7846-H		
#95	(#6495)	R7847-L		
#96	(#6496)	R7847-H		
#97	(#6497)	R7848-L	Use bit selection parameters #6497 to #6596 freely.	
#98	(#6498)	R7848-H		
#99	(#6499)	R7849-L		
#100	(#6500)	R7849-H		
#101	(#6501)	R7850-L		
#102	(#6502)	R7850-H		
#103	(#6503)	R7851-L		
#104	(#6504)	R7851-H		
#105	(#6505)	R7852-L		
#106	(#6506)	R7852-H		
...		...		
#187	(#6587)	R7893-L		
#188	(#6588)	R7893-H		
#189	(#6589)	R7894-L		
#190	(#6590)	R7894-H		
#191	(#6591)	R7895-L		
#192	(#6592)	R7895-H		
#193	(#6593)	R7896-L		
#194	(#6594)	R7896-H		
#195	(#6595)	R7897-L		
#196	(#6596)	R7897-H		

Contents of bit selection parameters #6449 to #6496

	Symbol name	7	6	5	4	3	2	1	0
0	#6449 R7824 L	Control unit thermal alarm on	Setting and display unit thermal mgmt valid ■	-	Battery alarm / warning detection disabled	Counter C retention	Integrated timer ST retention	PLC counter program valid	PLC timer program valid
1	#6450 R7824 H	-	External alarm message display ■	Alarm/ operator change ■	Full screen display of message ■	-	Operator message valid	0 F method 1 R method	Alarm message valid
2	#6451 R7825 L	-	-	-	-	-	Built-in edit function edit invalid ■	-	Built-in edit function edit valid ■
3	#6452 R7825 H	-	Branch destination label check valid	-	Serial handy terminal communica-tion valid	-	-	-	-
4	#6453 R7826 L	Integrated timer ST Variable/fixed Number of points setting			-	[Ladder Monitor] Menu operation	Message language change code		
5	#6454 R7826 H	Counter C Variable/fixed Number of points setting				Timer T Variable/fixed Number of points setting			
6	#6455 R7827 L	Enable ladder program writing during RUN	Enable ladder program writing during RUN (in high-speed processing)	-	-	Display type switching for operator message	R device access variables decimal point valid region		
7	#6456 R7827 H	-	-	-	Motor insulation degradation detection valid	-	PLC/PLF instruction Holding PLC in STOP state valid	-	-
8	#6457 R7828 L	High-speed input specification 1							
9	#6458 R7828 H								
A	#6459 R7829 L	High-speed input specification 2							
B	#6460 R7829 H								
C	#6461 R7830 L	High-speed output specification 1							
D	#6462 R7830 H								
E	#6463 R7831 L	High-speed output specification 2							
F	#6464 R7831 H								

(Note 1) Be sure to set the bits indicated - and blanks to 0.

(Note 2) Parameters #6481 to #6496 are reserved for debugging by MITSUBISHI.

(Note 3) Functions marked with ■ may not be available for some NC models.

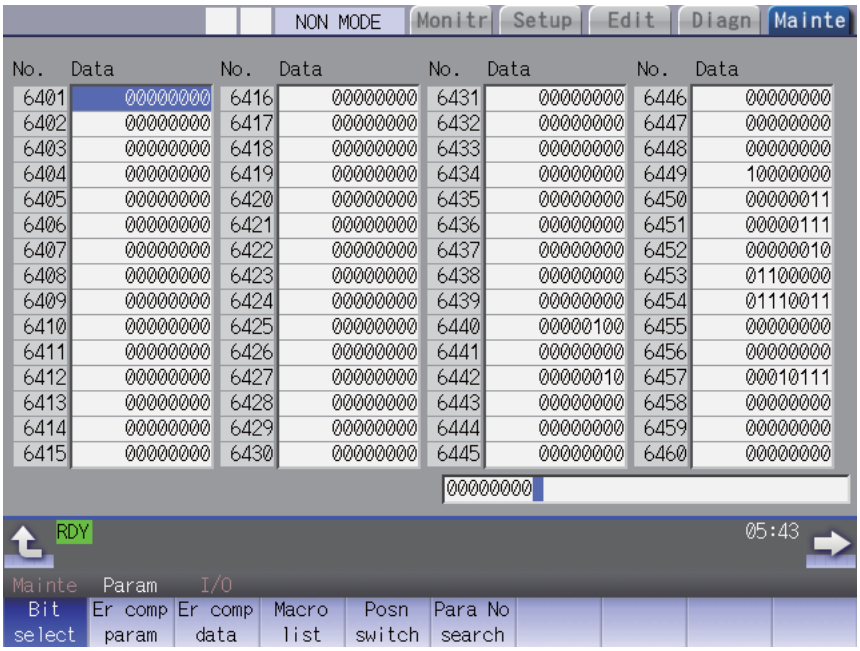
	Symbol name	7	6	5	4	3	2	1	0
0	#6465 R7832 L	High-speed input specification 3							
1	#6466 R7832 H								
2	#6467 R7833 L	High-speed input specification 4							
3	#6468 R7833 H								
4	#6469 R7834 L	-	-	-	-	-	-	-	-
5	#6470 R7834 H	-	-	-	-	-	-	-	-
6	#6471 R7835 L	-	-	-	-	-	-	-	-
7	#6472 R7835 H	-	-	-	-	-	-	-	-
8	#6473 R7836 L	High-speed output specification 3							
9	#6474 R7836 H								
A	#6475 R7837 L	High-speed output specification 4							
B	#6476 R7837 H								
C	#6477 R7838 L	-	-	-	-	-	-	-	-
D	#6478 R7838 H	-	-	-	-	-	-	-	-
E	#6479 R7839 L	-	-	-	-	-	-	-	-
F	#6480 R7839 H	-	-	-	-	-	-	-	-

(Note 1) Be sure to set the bits indicated - and blanks to 0.

(Note 2) Parameters #6481 to #6496 are reserved for debugging by MITSUBISHI.

(Note 3) Functions marked with ■ may not be available for some NC models.

Bit selection screen



9.3 Other Parameters

9.3.1 PLC Startup Condition Switchover

Parameter "#11004 PLCautorun enable" allows PLC to startup at NC startup even if no setting display unit is used. For safety, use this function only for the machine with no NC screen displayed by HMI.

(1) Basic common parameter

# No.	Item		Details	Setting range	Standard value
11004 (PR)	PLCautorun enable	PLC automatic startup valid	Switch starting condition of the PLC. 0: Start PLC after NC screen startup 1: Start PLC at NC startup	0,1	0

(2) Precautions

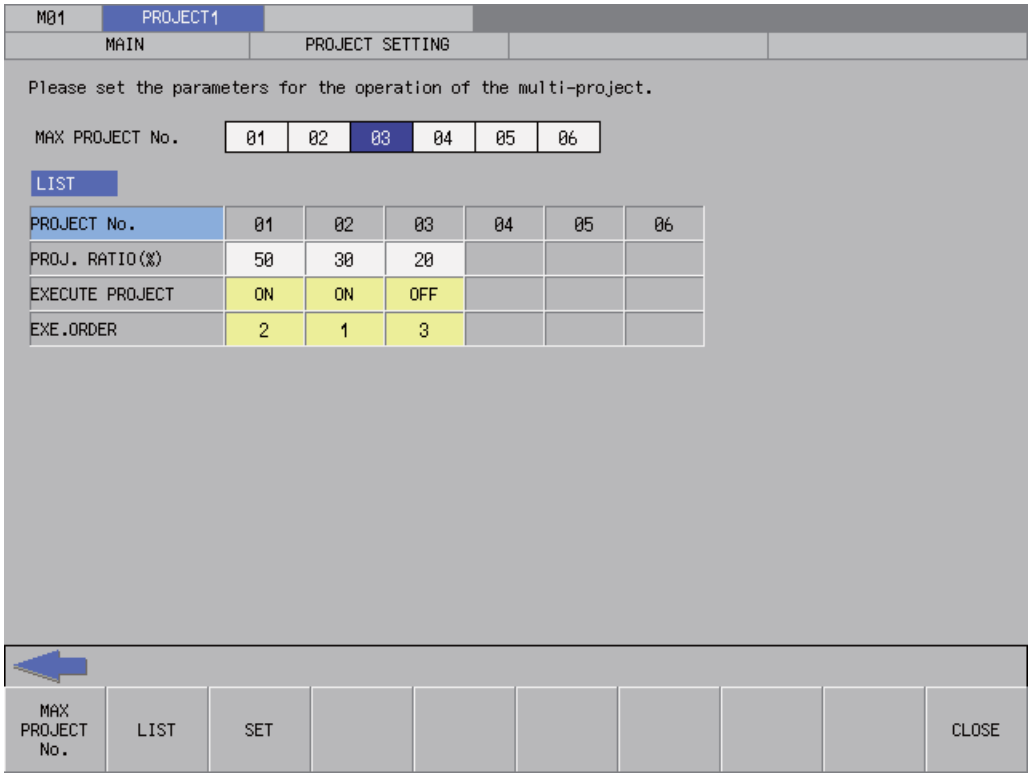
Parameter "#11004 PLCautorun enable" is the parameter prepared on the assumption that the setting and display unit is not used.

For the machine with NC screen displayed, to ensure your safety, always set "#11004 PLCautorun enable" to "0" and start PLC after NC screen startup.

When PLC automatic startup is validated without confirming the pre-operation status on the NC screen, unexpected incident may occur.

9.3.2 Multi-project Setting Parameters (Project Setting)

The parameters that set the multi-project will be described in this section.
Follow these parameter settings and execute the each project in order.
Rebooting CNC is required after the parameter setting.



Parameter name	Default (initial state)	Setting range	Details
Maximum project No	1	1 to 6	Specify the maximum project No. The limit of the project No. that can be set will differ depending on the machine type. (Refer to "Multi-project Function: Range of Usable Project") (Note 1)
Projects ratio	100% to Project 1	0 to 100	For each project being used, specify the size ratio of the sequence program storage area and the data storage area. The total number of project to be used should be set to 100 or less. The size will be set to be in increments of 4 bytes. (If it is not the multiple of 4, the fractions will be rounded off.) The setting cannot be carried out to the section other than the project being used. (Note 2)
Execution project	ON for only Project 1	ON/OFF	Specify the project to be executed. The setting cannot be carried out to the section other than the project being used. (Note 3)
Execution order	Startup from Project 1 in order	1 to the number of the usable projects	Specify the execution order of the project to be executed. Specify this order within the setting range 1 to 6, regardless of the number of project that can be used. (Note 4) The projects start up in the ascending number which is assigned to the projects. When the number of the order is assigned to the section other than execution project, it will be ignored and not be executed. The setting cannot be carried out to the section other than the project being used.

(Example) On M80 Series Type A: with the 64K step (256K byte) program size and the 2M byte data storage area
When the project ratio is set as shown in the above screen shot, the program size and the data storage area size that can be used for each project will be as follows:

	Project 1	Project 2	Project 3
Project ratio	50%	30%	20%
Program size	32K step (128K byte)	19660 step (78640 byte)	13104 step (52416 byte)
Device comment size	1048580 byte (50%)	629144 byte (30%)	419428 byte (20%)

(Note 1) The number of projects that can be used at each machine is determined and the setting value cannot exceed this number limit. It will be the setting error.

(Note 2) The project ratio cannot be set with the smaller size than the currently stored sequence program and data. It will be a setting error. When the change is necessary, make a backup with GX Developer or the built-in PLC (built-in edit function), then format once.

(Note 3) Turning OFF all the projects is not possible. At least one project has to be ON. Otherwise, it will be a setting error.

(Note 4) The setting of the number cannot overlap with each project. It will be the setting error.

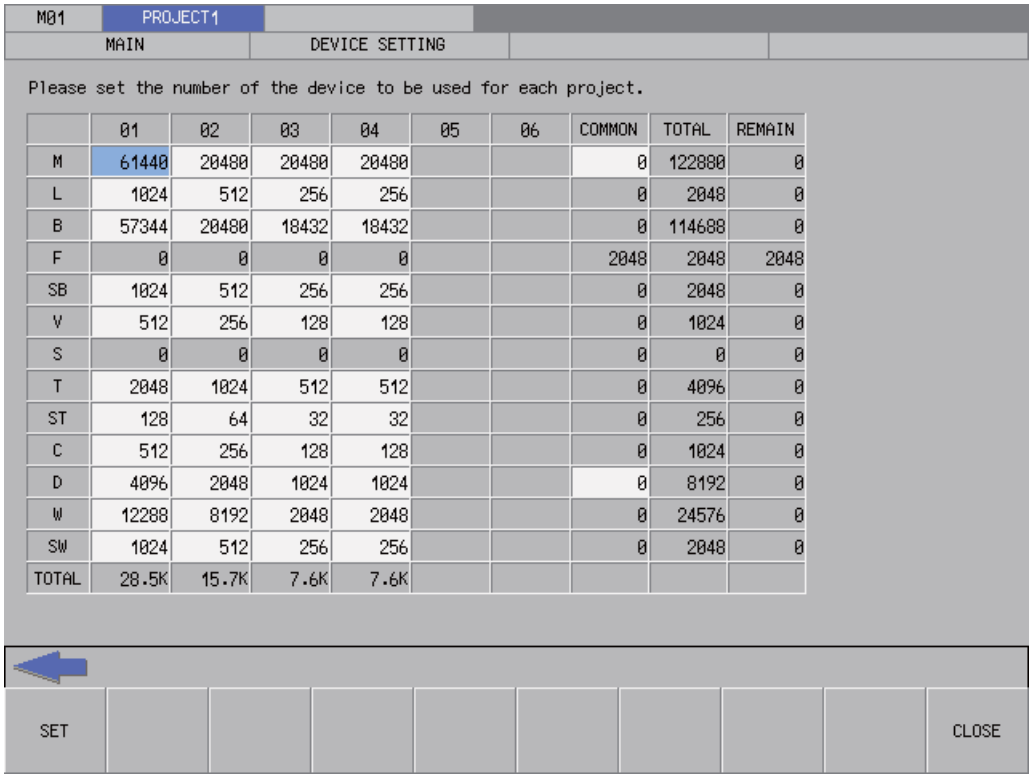
When rebooting CNC, PLC cannot operate RUN if there are mismatches between the above parameter setting and the stored projects. The list of cause for not being able to operate RUN is shown below.

List of cause: inability to operate RUN

Cause	Error details	Remedy
Increasing the maximum number of project	U01 No user ladder	Store the sequence programs corresponding to the increased projects.

9.3.3 Multi-project Setting Parameter (Device Setting)

When setting the multi-project, set the number of the device points that are used in each project.
As for the devices that are not registered in this setting screen, it means that they are the devices that use fixed number of points for each project. (Refer to "Explanation of Devices: Device Range Setting at Multi-project")
Rebooting CNC is required after the parameter setting.



	01	02	03	04	05	06	COMMON	TOTAL	REMAIN
M	61440	20480	20480	20480			0	122880	0
L	1024	512	256	256			0	2048	0
B	57344	20480	18432	18432			0	114688	0
F	0	0	0	0			2048	2048	2048
SB	1024	512	256	256			0	2048	0
V	512	256	128	128			0	1024	0
S	0	0	0	0			0	0	0
T	2048	1024	512	512			0	4096	0
ST	128	64	32	32			0	256	0
C	512	256	128	128			0	1024	0
D	4096	2048	1024	1024			0	8192	0
W	12288	8192	2048	2048			0	24576	0
SW	1024	512	256	256			0	2048	0
TOTAL	28.5K	15.7K	7.6K	7.6K					

Parameter name	Default (Initial state)	Setting range	Details
No. of device points	Refer to "Explanation of Devices: List of Devices"	0 to the maximum no. of projects *1	Set the number of device points that each project uses.
No. of common points	0	0 to the maximum no. of projects *1	From the top of the devices, arbitrary number of points can be set as the common device among projects. For details, refer to "M Device/D Device Commonizing Setting".

There are precautions as follows for the setting of the multi-project parameter (device setting).

[Precautions]

1. Set the number of device points/ number of common points in increments of 16 points.
2. Limit the maximum number of points per bit device to be within 32K.
   However, the maximum number of points per internal relay (M)/ link relay (B) device is to be within 60K.
3. Set the total number of projects which is to be set to 1 device to satisfy the formula below.
   (Number of device points set to each project) + (Number of common points) ≤ Maximum number of projects *1
4. Set the total number of device points which is to be set to 1 project to satisfy the formula below.
   (Bit device capacity) + (Timer, integrated timer, counter capacity) + (Word device capacity) ≤ 29K word
   (a) For the bit device

$$\text{(Bit device capacity)} = \frac{(X + Y + M + L + B + F + SB + V + S)}{16} \text{ (Word)}$$

   (b) For the timer(T), the integrated timer(ST), Counter(C)

$$\text{(Timer, Integrated timer, Counter capacity)} = \frac{(T + ST + C)}{16} \times 18 \text{ (Word)}$$

   (c) For the word device

$$\text{(Word device)} = \frac{(D + W + SW)}{16} \times 16 \text{ (Word)}$$

5. It is not possible to change the number of device points of project which is already stored in the ladder.
   (Requires deleting or formatting)

*1 Refer to "Independent Device among Projects" for the details of maximum number of projects.

9.3.4 Changing Processing Cycle of the High-speed Ladder by the Parameter

Processing cycle of the high-speed ladder can be changed by the parameter "#1261 set33/bit4".

#	Item		Details	Setting range	Default
1261 (PR)	set33/bit4	High-speed ladder execution cycle	Specify the high-speed ladder execution cycle. 0: Default (M7 compatible) 1: Twice the default	0,1	0

(Note 1) For M800/M80 Series S/W C2 version or earlier, "M7 compatible" setting is applied when the parameter is set to "1".

(Note 2) When the parameter "#1291 set33/bit4" is set to the default, the processing cycle of the high-speed ladder varies according to the NC model or the number of part systems.

9.3.5 Initializing Remote I/O at PLC STOP

When "#11769 Remote I/O Clear" is set to "1", values of output devices allocated to the remote I/O unit are initialized to "0" at PLC stop. In this case, signals are not output to remote I/O output.
The devices to be initialized are in the range from Y0000 to Y05FF and from ZR6000 to ZR6999.
Among the above mentioned devices, only the output devices actually allocated to the remote I/O unit are initialized to "0".
For details on remote I/O, refer to "Connection and Setup Manual".

(1) Base common parameter

# No.	Item		Details	Setting range	Average value
11769 (PR)	Remote I/O Clear	Initialization of remote I/O	Select whether to clear the values of RIO output devices at PLC STOP. 0: Retain the outputs of RIO 1: Clear the outputs of RIO	0, 1	0

(2) Precautions

- Note the following points when you stopped the PLC.
  [#11769 Remote I/O Clear = 0]
  PLC output signals are retained; accordingly, the machine may continue to operate.
  [#11769 Remote I/O Clear = 1]
  PLC output signals are disabled; accordingly, the machine may stop abruptly.
- For devices allocated to each unit of field network, initialization methods depend on the parameter settings for each unit.

10

Handling of M, S, T, B Functions

The following abbreviations are used in the subsequent explanations.

- Miscellaneous function (command) M function (command)
- Spindle function (command) S function (command)
- Tool function (command) T function (command)
- 2nd miscellaneous function (command) B function (command)
- Miscellaneous function strobe 1 to 4 MF (MF1, 2, 3, 4)
- Spindle function strobe 1 to 4 SF (SF1, 2, 3, 4)
- Tool function strobe 1 to 4 TF (TF1, 2, 3, 4)
- 2nd miscellaneous function strobe 1 to 4 BF (BF1, 2, 3, 4)
- Miscellaneous function finish 1, 2 FIN1, FIN2
- Miscellaneous Function Command High-speed Output : M function finish 1 to 4 → MFIN(MFIN1,2,3,4)
- Miscellaneous Function Command High-speed Output : S function finish 1 to 6 → SFIN(SFIN1,2,3,4,5,6)
- Miscellaneous Function Command High-speed Output : T function finish 1 to 4 → TFIN(TFIN1,2,3,4)
- Miscellaneous Function Command High-speed Output : 2nd M function finish 1 to 4 → BFIN(BFIN1,2,3,4)

10.1 Command Format

(1) The maximum number of commands that can be issued in one block are shown below.

Function	Maximum number of commands(when released to user)
M function	4 commands
S function	2 or 4 commands (Form : Sn = xxxx)
T function	1 command
B function	1 command

(2) The command can have up to eight digits.

(3) The number of S functions depends on the model.

(4) A program error will not occur even if more commands than the maximum number are issued. The latter commands will be valid.
(EX.) When five T commands are issued though only one T command can be used.

T 01 T 02 T03 T 04 T 05 ;

The last four T commands are valid.

10.2 Miscellaneous Function Finish

After the PLC (machine) finished the specified operations for the M, S, T, B commands output with automatic operation (memory, MDI, or tape) or manual numerical commands from the CNC, the finish signal will be returned to the CNC. However, there are two types of finish signals as shown below. Use these accordingly in one sequence.

(1) FIN1 ... CNC proceeds to next block at falling edge of finish signal (FIN1).

(2) FIN2 ... CNC proceeds to next block at rising edge of finish signal (FIN2).

The details for FIN1 and FIN2 are also described in the explanation of each interface signal.
Examples of the M function are given in the following section.

10.2.1 Operation Sequence

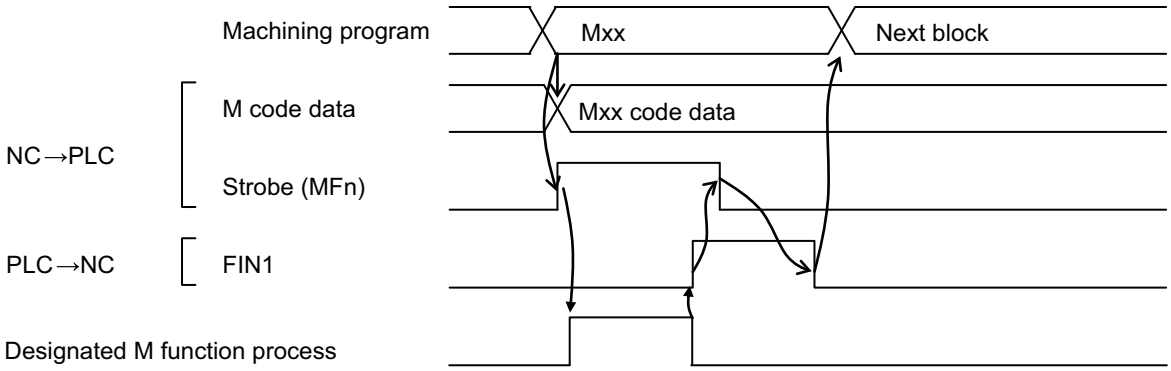
When a miscellaneous command (M, S, T or B), which is set to wait for a finish signal with the parameter (#1401 to #1426), is issued in a machining program, the NC outputs the miscellaneous command code data and the "M function strobe" signal towards the PLC. The NC will complete the miscellaneous command process at the falling edge of the "FIN1" signal or at the rising edge of the "FIN2" signal and will proceed to the next block.

10.2.1.1 Operation sequence with the "FIN1" signal for completing a miscellaneous command

The operation sequence where the "FIN1" signal is used is introduced below.
It is essential to program a sequence process that turns OFF the "FIN1" signal after ensuring an inactivation of the strobe signal.

(1) In the case when completed by "FIN1"

The program proceeds to the next block at the falling edge of "FIN1".

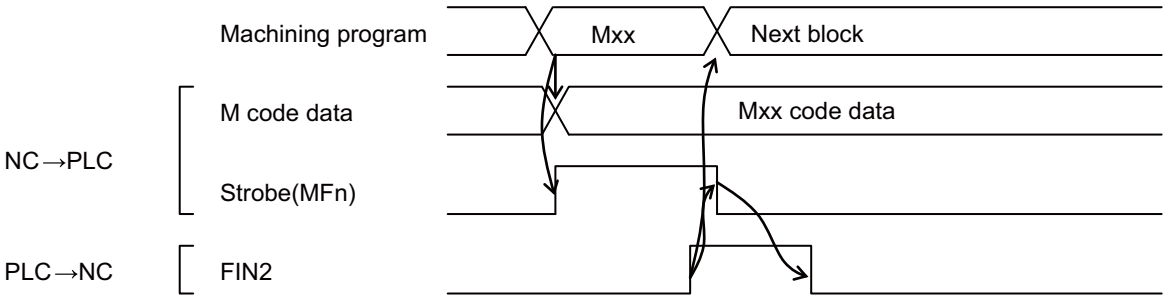


10.2.1.2 Operation sequence with the "M function finish 2" signal (FIN2) for completing a miscellaneous command

The operation sequence where the "FIN2" signal is used is introduced below.
It is essential to program a sequence process that turns OFF the "FIN2" signal after ensuring an inactivation of the strobe signal.

(1) In the case when completed by "FIN2"

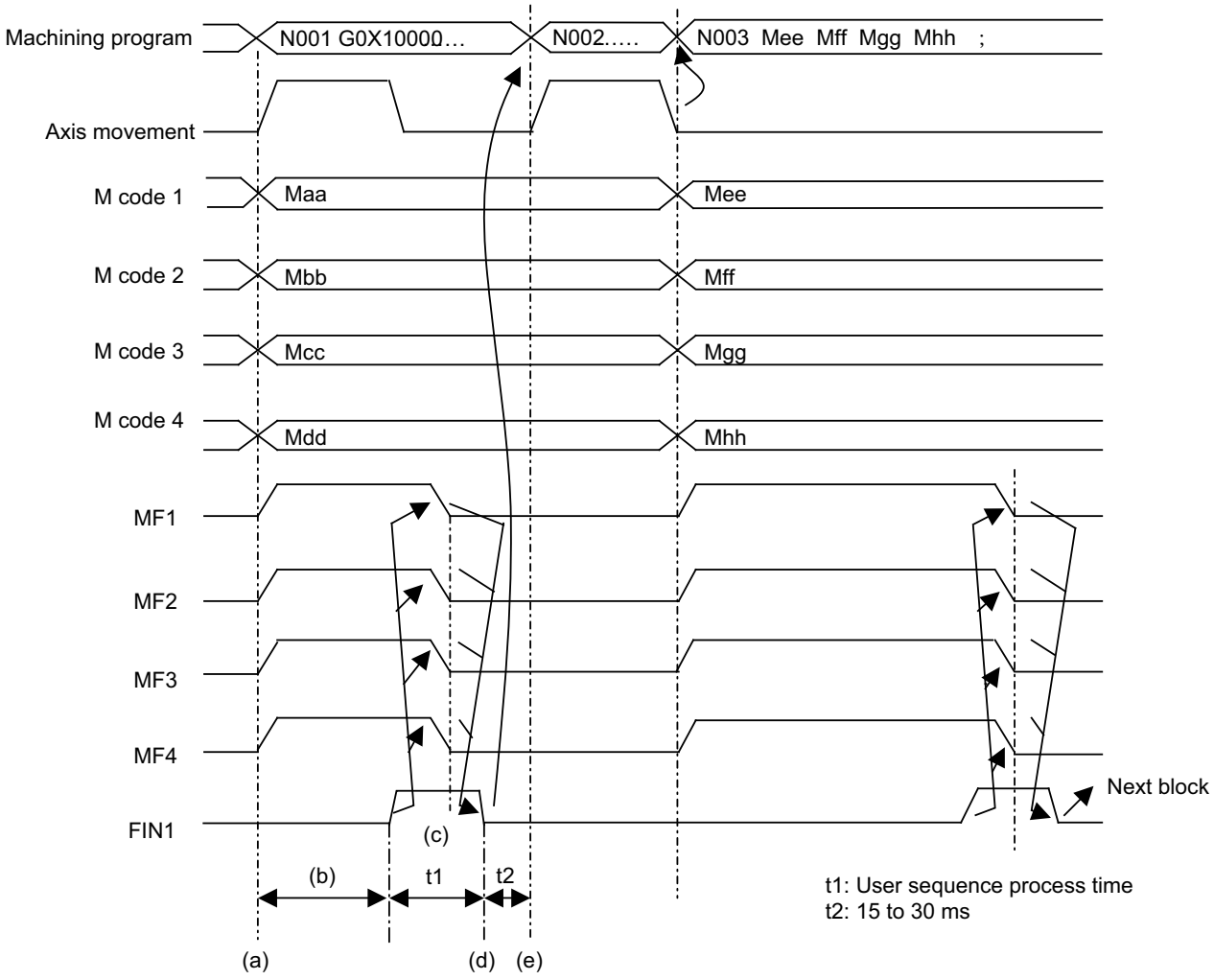
The program proceeds to the next block at the rising edge of "FIN2".



10.2.2 Example of Machining Program

10.2.2.1 Using FIN1 with M Command

```
N001 G0X10000 Maa Mbb Mcc Mdd ;
N002 G0Z-2000;
N003 Mee Mff Mgg Mhh ;
```



[Explanation of operation]

(a) The CNC outputs the M code data n (BCD) and MFn to the PLC (machine).
Refer to the section "Precautions Related to M, S, T, B Functions" for details on the M code data and MF output timing.

(b) The PLC (machine) confirms that the MF signal has turned ON, reads the M code data, and executes the specified operation. Then, it turns FIN1 ON.

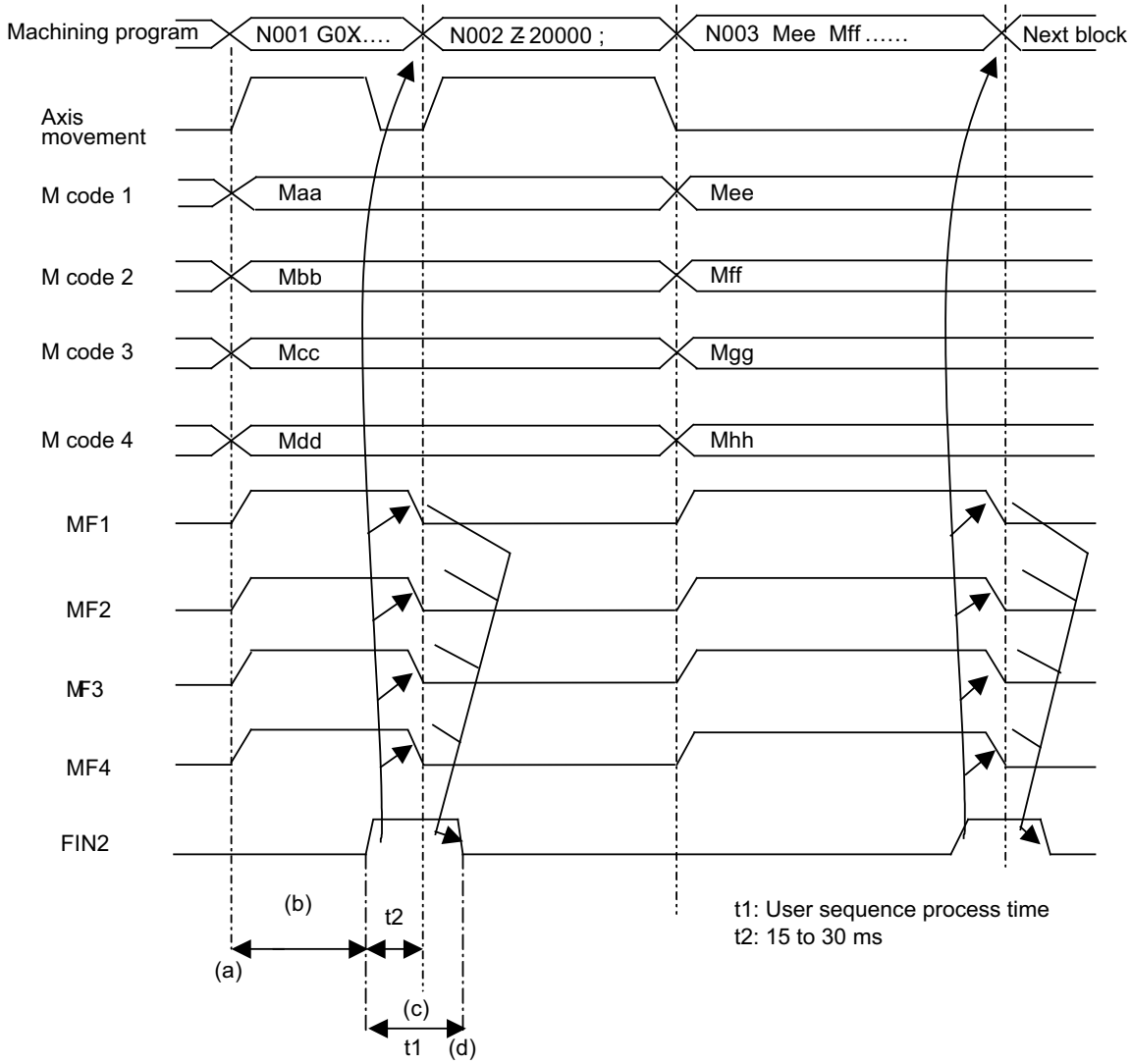
(c) The CNC confirms that FIN1 has turned ON, and then turns MF OFF.

(d) The PLC (machine) confirms that MF has turned OFF, and then turns FIN1 OFF.

(e) The CNC confirms that FIN1 has turned OFF, and then proceeds to the next block.

10.2.2.2 Using FIN2 with M Command

N001 G0X10000 Maa Mbb Mcc Mdd ;
N002 G0Z-20000;
N003 Mee Mff Mgg Mhh ;



[Explanation of operation]

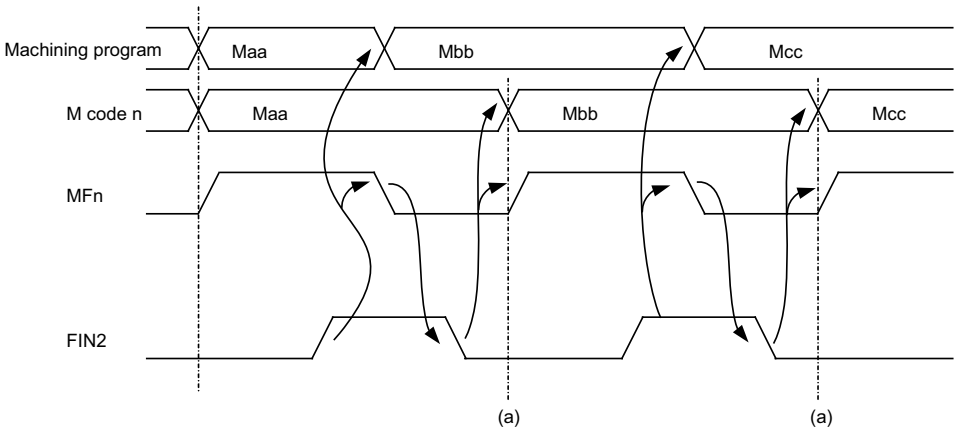
(a) The CNC outputs the M code data n (BCD) and MFn to the PLC (machine).
Refer to the section "Precautions Related to M, S, T, B Functions" for details on the M code data and MF output timing.

(b) The PLC (machine) confirms that the MF signal has turned ON, reads the M code data, and executes the specified operation. Then, it turns FIN2 ON.

(c) The CNC confirms that FIN2 has turned ON, and proceeds to the next block simultaneously with the turning OFF of MF.

(d) The PLC (machine) confirms that MF has turned OFF, and then turns FIN2 OFF.

10.2.2.3 When M Commands Continue (Using FIN2 with M Command)



[Explanation of operation]

The general operation is the same as "8.2.2.2 Using FIN2 with M Command" on the previous page.

(a) The CNC confirms that FIN2 has turned OFF, and then output the next code signal and MF.

10.3 Miscellaneous Command High-speed Output

The miscellaneous command high-speed output shortens a processing time per miscellaneous function. There are two functions that can be selected individually.

(1) Change miscellaneous command completion method
Select one of the following methods by the parameter.
High-speed method (paramter "#1278 ext14/bit1" to 1):
The controller inverts a strobe signal logically at the time of outputting a miscellaneous command. The PLC performs the designated operation and logically inverts the high-speed miscellaneous function finish signal (MFIN1 to 4, SFIN1 to 6, TFIN1 to 4, BFIN1 to 4). The controller completes the miscellaneous function when the strobe signal and the high-speed miscellaneous function finish signal become the same logic level.
Normal method (paramter "#1278 ext14/bit1" to 0):
Conventional method (Refer to "Miscellaneous Function Finish" for details.)

(2) Selecting miscellaneous command completion method
Select whether or not to wait for a finish signal from the PLC using the parameter.
- M command (parameter "#1401 M_mode")
  0 : Not wait for the registered M code (M code registered to the parameters #1411 to #1426) to complete, but wait for the other M codes to complete.
  1 : Wait for the registered M code to complete, but not wait for the other M codes to complete.
- S command (parameter "#1402 S_mode")
  0 : Wait for the completion signal from the PLC.
  1 : Not wait for the completion signal from the PLC.
- T command (parameter "#1403 T_mode")
  0 : Wait for the completion signal from the PLC.
  1 : Not wait for the completion signal from the PLC.
- 2nd miscellaneous command (parameter "#1404 M2_mode")
  0 : Wait for the completion signal from the PLC.
  1 : Not wait for the completion signal from the PLC.

> ⚠ **CAUTION**
>
> **If the method of not waiting for the completion signal is selected for miscellaneous command completion type, the next block may be executed while the miscellaneous command is incomplete.**

The table below shows operational differences between the high-speed method and the normal method. Regarding the sequence process, program an appropriate process for each operation.

	High-speed method (Parameter "#1278 ext14/bit1" = "1")	
	Method that waits for a finish signal from PLC	**Method that does not wait for a finish signal from PLC.**
The shift timing from a miscellaneous function command block to the next block	The program shifts to the next block when the logic level of an M function finish signal changes to the same as of the strobe signal.	When a miscellaneous function command is set not to wait for a finish signal with the parameter, the program shifts to the next block as soon as the strobe signal is output to the PLC. When a miscellaneous function command is set to wait for a finish signal with the parameter, the operation will be the same as of the method that waits for a finish signal from the PLC.
Strobe signal	Logically inverted.	
Operation of the "FIN1"	Not used	
Operation of the "FIN2"	Not used	
Operation of the "High-speed M function finish" signals (MFIN1 to 4, SFIN1 to 6, TFIN1 to 4, BFIN1 to 4)	Required to make the logic level the same as of the strobe signal.	

	Normal method (Parameter "#1278 ext14/bit1" = "0")	
	Method that waits for a finish signal from PLC	**Method that does not wait for a finish signal from PLC.**
The shift timing from a miscellaneous function command block to the next block	The program shifts to the next block at the falling edge of the "FIN1" signal or at the rising edge of the "FIN2" signal.	When a miscellaneous function command is set not to wait for a finish signal with the parameter, the program shifts to the next block as soon as the strobe signal is output to the PLC. When a miscellaneous function command is set to wait for a finish signal with the parameter, the operation will be the same as of the method that waits for a finish signal from the PLC.
Strobe signal	Turns ON.	
Operation of the "FIN1"	At the rising edge of the "FIN1" signal, the NC system turns OFF the strobe signal. It is essential to program a sequence process that turns OFF the "FIN1" signal after ensuring an inactivation of the strobe signal.	
Operation of the "FIN2"	At the rising edge of the "FIN2" signal, the NC system turns OFF the strobe signal. It is essential to program a sequence process that turns OFF the "FIN2" signal after ensuring an inactivation of the strobe signal.	
Operation of the "High-speed M function finish" signals (MFIN1 to 4, SFIN1 to 6, TFIN1 to 4, BFIN1 to 4)	Not used	

10.3.1 Operation Sequence for the High-speed Method

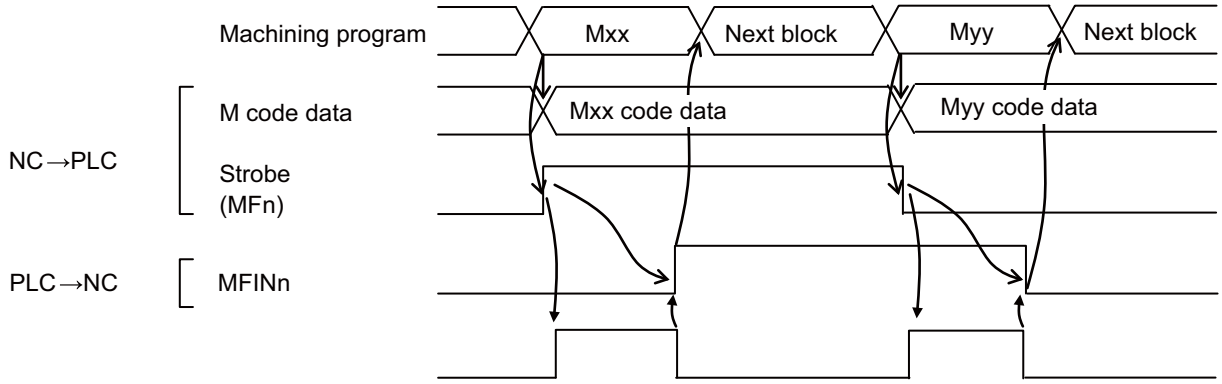
10.3.1.1 Operation Sequence which Waits for a Finish Signal from the PLC during Miscellaneous Command Performance

When a miscellaneous command (M, S, T or B) is issued in a machining program, the NC logically inverts the miscellaneous command code data and the "M function strobe" signal and outputs them towards the PLC. The NC completes the miscellaneous command process and proceeds to the next block when the "M function strobe" signal and the "High-speed M function finish" signal (MFIN1 to 4, SFIN1 to 6, TFIN1 to 4 or BFIN1 to 4) become the same logic level.

The operation sequence where a "High-speed M function finish" signal is used is introduced below.

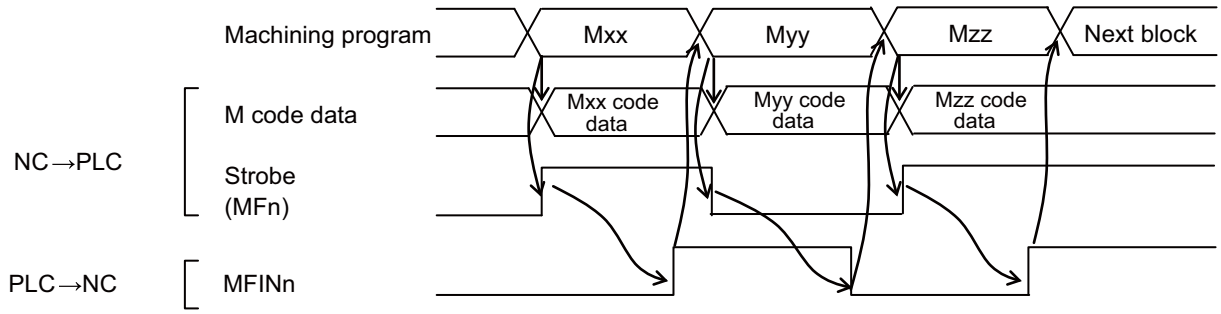
(1) In the case of a miscellaneous function which is completed by a "High-speed M function finish" signal

The miscellaneous command is completed when the "M function strobe" signal and the "High-speed M function finish" signal become the same logic level.



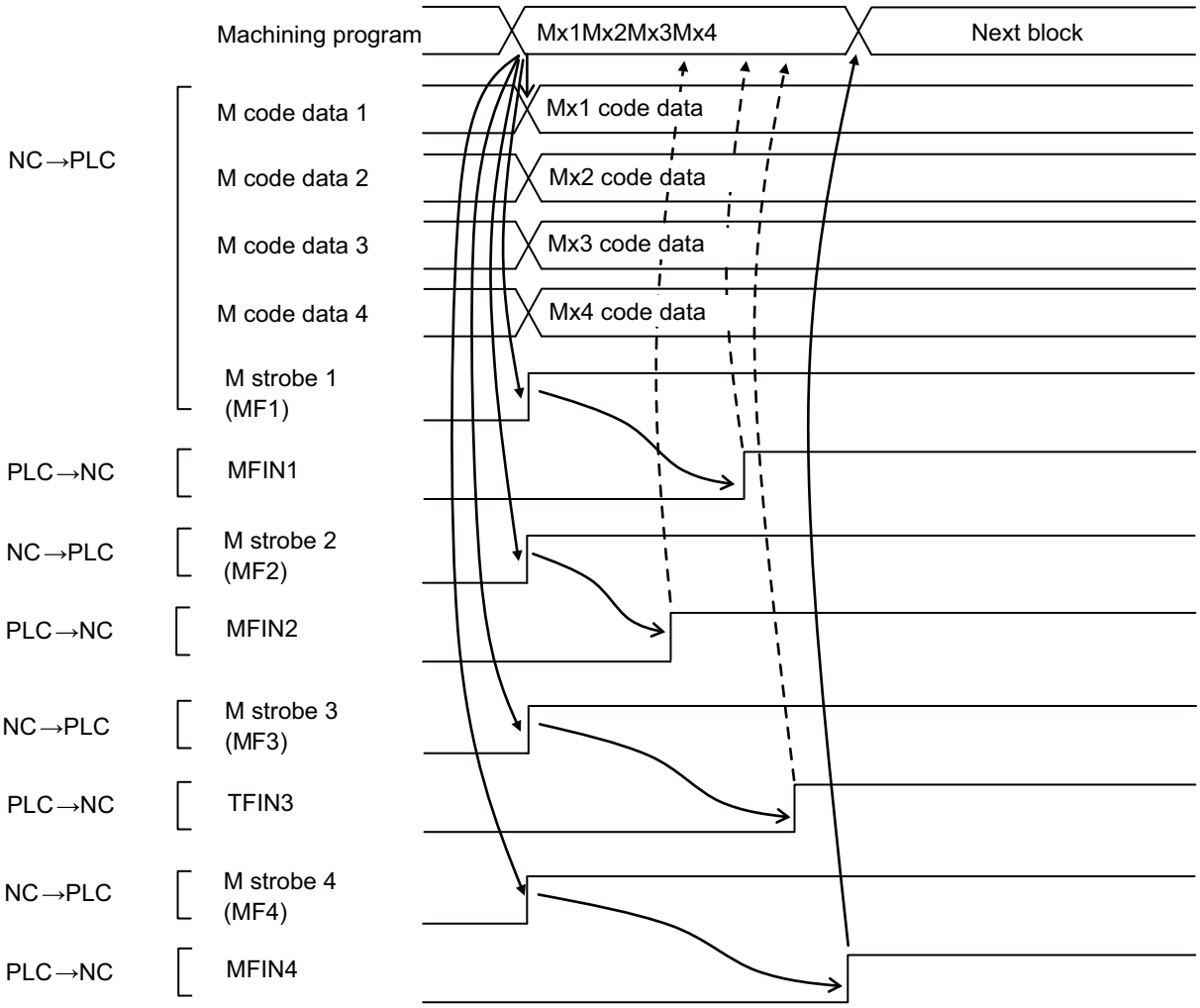
(2) In the case of a series of miscellaneous functions

This sequence process can complete a miscellaneous function by inverting a "High-speed M function finish" signal logically, which shortens the process by one scan per miscellaneous command since it is not necessary to turn ON and OFF the "M function finish" signals.



(3) In the case where one block contains several M codes

If several miscellaneous commands exist within one block, the miscellaneous commands will be completed when all "M function strobe" signals and the "High-speed M function finish" signals become the same logic level.



10.3.1.2 Operation Sequence which does not Wait for a Finish Signal from the PLC during Miscellaneous Command Performance

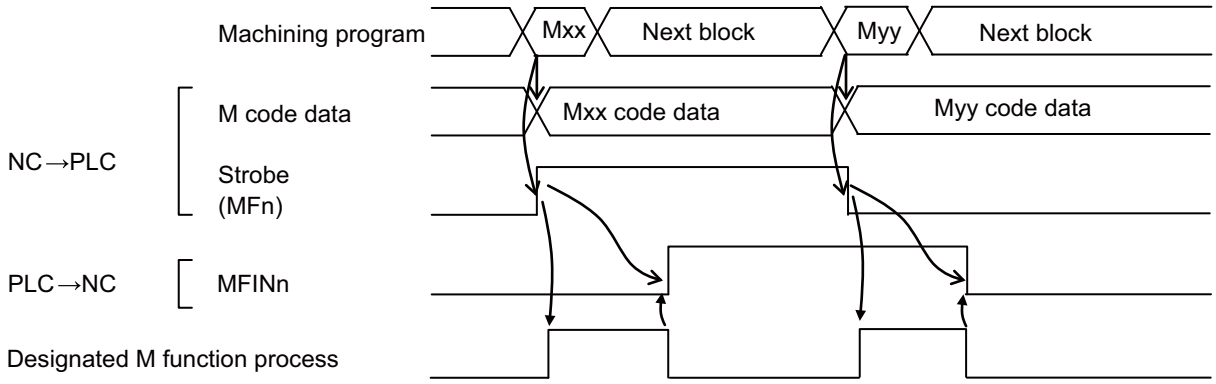
When a miscellaneous command (M, S, T or B), which is set not to wait for a finish signal with the parameter (#1401 to #1426), is issued in a machining program, the NC outputs the miscellaneous command code data and the "M function strobe" signal towards the PLC. As soon as the NC outputs the "M function strobe" signal, it completes the miscellaneous command process and proceeds to the next block.
In the sequence process, it is necessary to perform the "High-speed M function finish" signal process and make the signal's logic level the same as of the strobe signal. If a miscellaneous command is issued in the next block or later before the strobe signal and the "High-speed M function finish" signal become the same logic level, the status will be in "completion standby".

The operation sequence where a "High-speed M function finish" signal is used is introduced below.

Operation sequence when the previous miscellaneous command is completed

(1) In the case where a miscellaneous command output is not waited

The program proceeds to the next block after outputting the "M function strobe" signal.

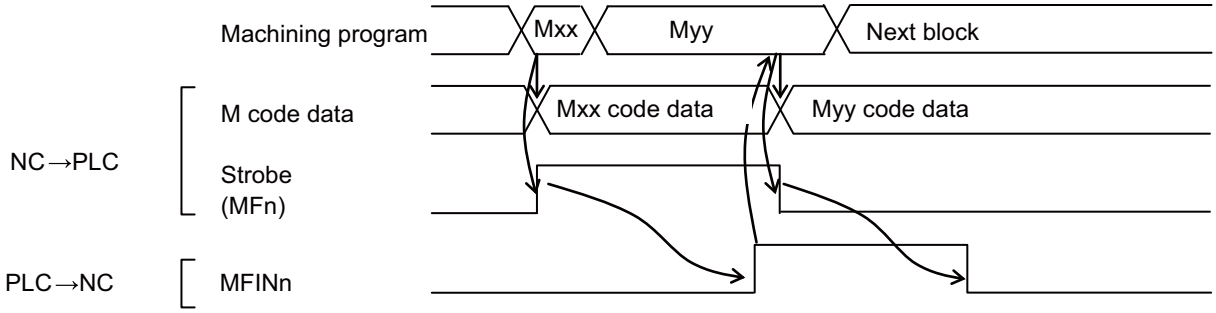


Operation sequence when the previous M command is not completed

When a miscellaneous command is output with the method that does not wait for a finish signal from the PLC, if the previous miscellaneous command (M, S, T or B) is not completed, a completion of the previous miscellaneous command will be waited and then a new command code and a strobe signal will be output.

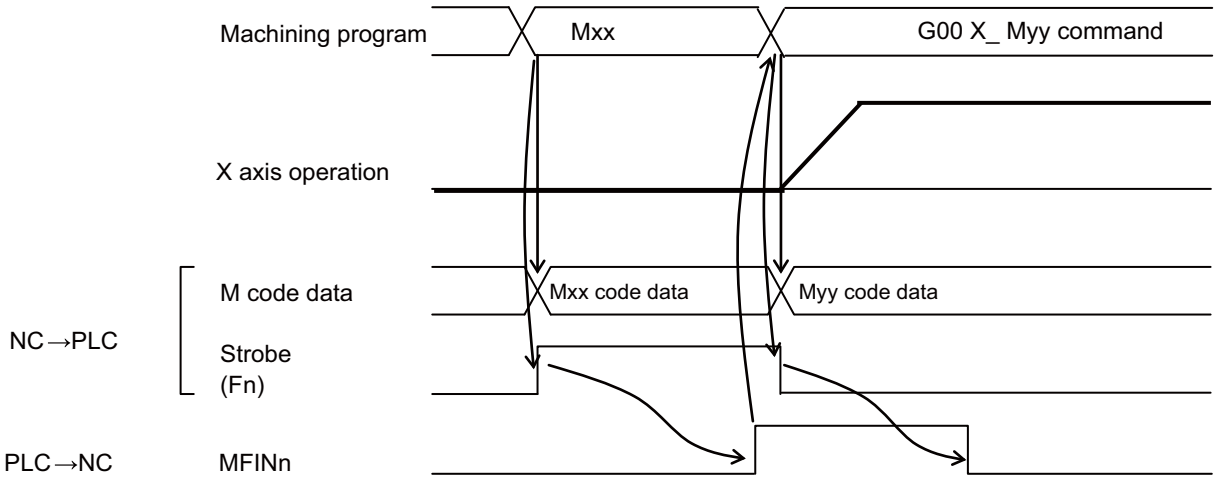
(1) In the case where a miscellaneous command output is waited (A series of miscellaneous commands)

The program proceeds to the next block when the previous miscellaneous command is completed.



(2) In the case where a miscellaneous command output is waited (when a movement command and a miscellaneous command are issued within the same block)

When a movement command and a miscellaneous command are issued within the same block that is next to a miscellaneous command block, the program proceeds to the next block when the previous miscellaneous command is completed.



10.3.2 Operation Sequence for Normal Method

10.3.2.1 Operation Sequence which Waits for Finish Signal from the PLC during Miscellaneous Command Performance

Refer to "M function Finish"

10.3.2.2 Operation Sequence which does not Wait for a Finish Signal from the PLC during Miscellaneous Command Performance

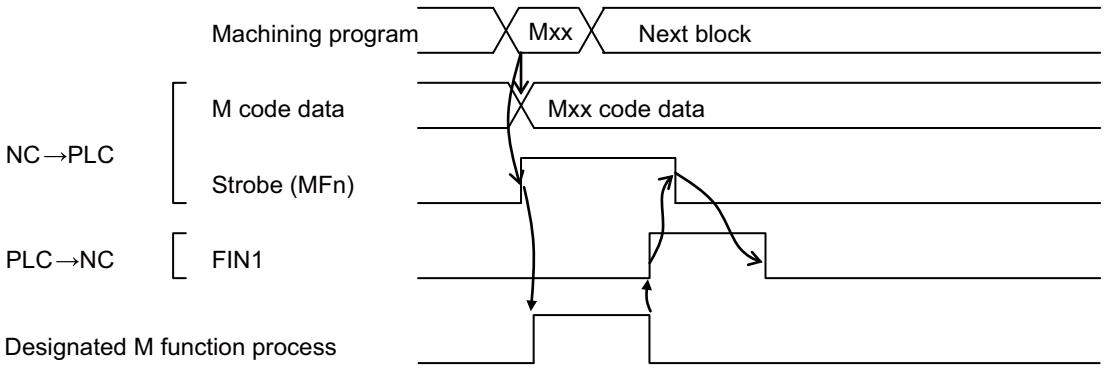
When a miscellaneous command (M, S, T or B), which is set not to wait for a finish signal with the parameter (#1401 to #1426), is issued in a machining program, the NC outputs the miscellaneous command code data and the "M function strobe" signal towards the PLC. As soon as the NC outputs the "M function strobe" signal, it completes the miscellaneous command process and proceeds to the next block.
In the sequence process, it is necessary to perform the "FIN1" signal process or the "FIN2" signal process and make the NC turn OFF the strobe signal. If a miscellaneous command is issued in the next block or later before the strobe signal and the "High-speed M function finish" signal become the same logic level, the status will be in "completion standby".

Operation sequence with the "FIN1" signal for completing a miscellaneous command

The operation sequence where the "FIN1" signal is used is introduced below.
It is essential to program a sequence process that turns OFF the "FIN1" signal after ensuring an inactivation of the strobe signal.

(1) In the case when completed by "FIN1"

The program proceeds to the next block after outputting the "M function strobe" signal. (It is the same as when "FIN2" is enabled).

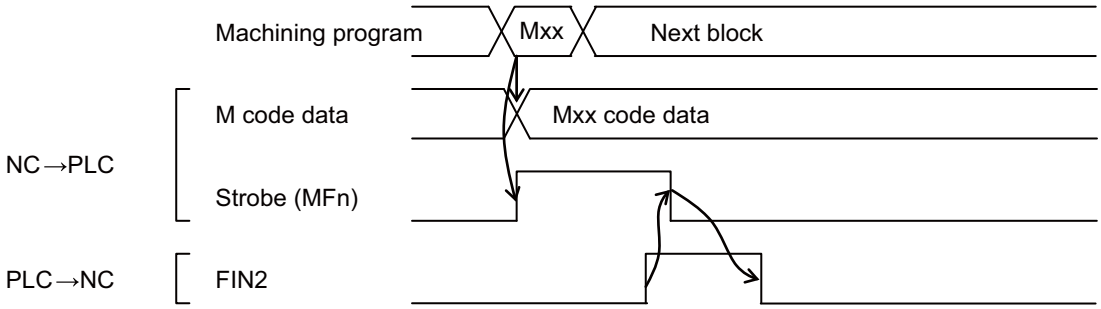


Operation sequence with the "FIN2" signal for completing a miscellaneous command

The operation sequence where the "FIN2" signal is used is introduced below.
It is essential to program a sequence process that turns OFF the "FIN2" signal after ensuring an inactivation of the strobe signal.

(1) In the case when completed by "FIN2"

The program proceeds to the next block after outputting the "M function strobe" signal. (It is the same as when "FIN1" is enabled).

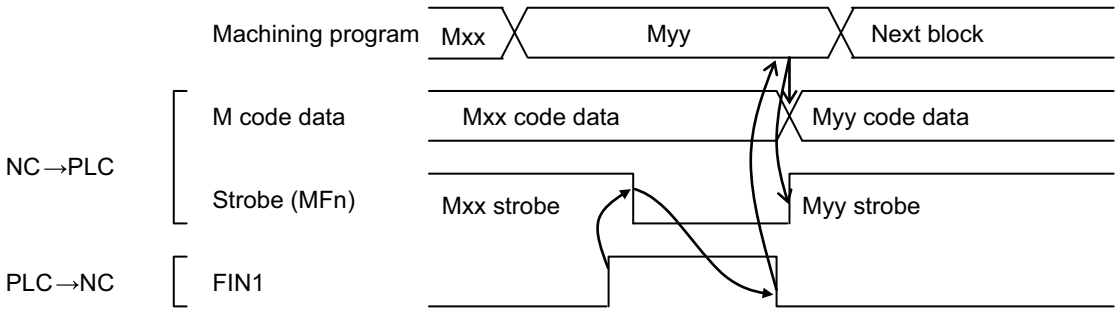


Operation sequence where a series of miscellaneous commands are issued and when a previous miscellaneous command is not completed

When a miscellaneous command is output with the method that does not wait for a finish signal from the PLC, if the previous miscellaneous command (M, S, T or B) is not completed, a completion of the previous miscellaneous command will be waited and then the new command code and a strobe signal will be output.
The operation sequences for "FIN1" and "FIN2" are shown below.

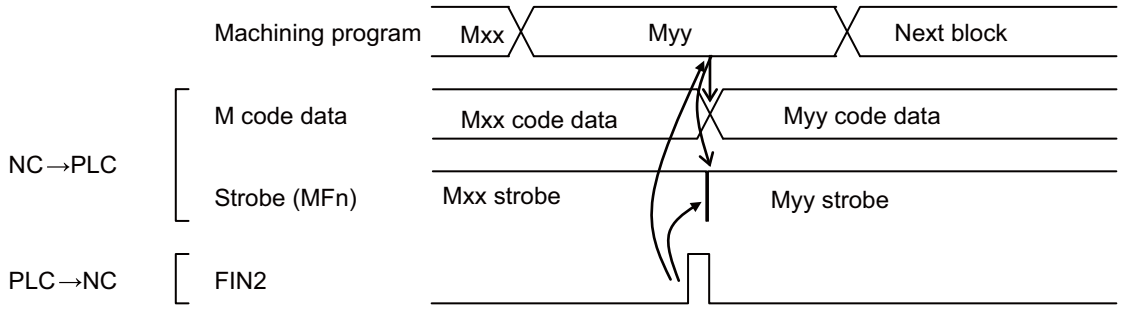
(1) In the case where a miscellaneous command output is waited (When "FIN1" is used)

The program proceeds to the next block when the previous miscellaneous command is completed. (Falling edge of FIN1)



(2) In the case where a miscellaneous command output is waited (When "FIN2" is used)

The program proceeds to the next block when the previous miscellaneous command is completed. (Rising edge of "FIN2")

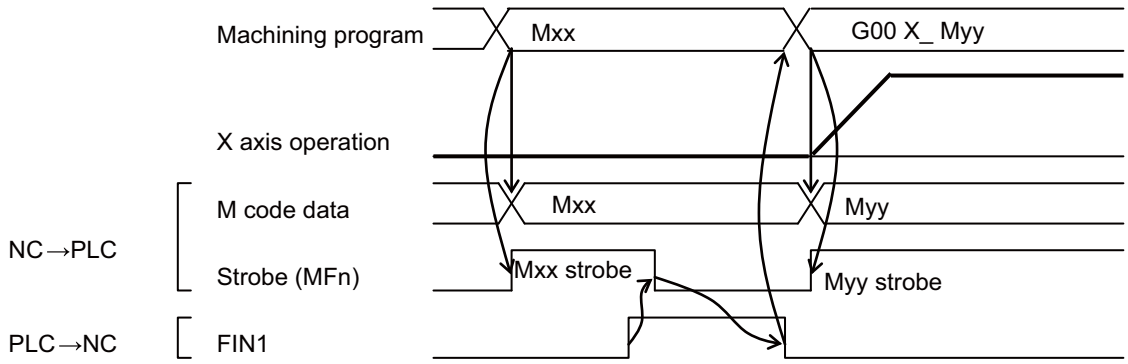


(Caution) Note that if "FIN2" is used as the finish signal with the method that does not wait for a finish signal from the PLC and when the previous M command is not completed yet (the previous strobe signal is still ON), the program will proceed to a new command upon the rising edge of "FIN2"; therefore, the strobe signal stays ON during this whole process.

(3) In the case where a miscellaneous command output is waited (When "FIN1" is used and a movement command and a miscellaneous command are issued within the same block)

When a movement command and a miscellaneous command are issued within the same block that is next to a miscellaneous command block, the program proceeds to the next block when the previous miscellaneous command is completed.

(When "FIN1" is used and a movement command and a miscellaneous command are issued within the same block)



10.3.3 Relation with Other Functions

(1) Dwell/miscellaneous function time override
Special operation registration M codes which are set not to wait for the completion signal do not wait for the completion signal from PLC.
Miscellaneous function time override is disabled.
The special operation registration M codes are set with the parameters (#1411 to #1426).

10.3.4 Precautions and Restrictions

(1) In the method that does not wait for a finish signal from the PLC, if a miscellaneous command is issued with a previous miscellaneous command not completed yet (the previous strobe signal is still ON), the program will proceed to the new miscellaneous command upon the rising edge of FIN2 of the previous command; therefore, the strobe signal stays ON during this whole process. In consequence, the FIN2 signal should be input not as an OUT command but as a SET command (one-shot) in the sequence process. (Refer to "Operation Sequence for Normal Method: Operation sequence where a series of miscellaneous commands are issued and when a previous miscellaneous command is not completed")

(2) In the method that does not wait for a finish signal from the PLC, if a miscellaneous command that does not wait for a finish signal from the PLC and a miscellaneous command that waits for a finish signal from the PLC are both issued within the same block, the program will proceed to the next block after the finish signal from the PLC is received.

(3) Even in the method that does not wait for a finish signal from the PLC, an M code independent command (M00, M01, M02 or M30) waits for a finish signal from the PLC.

10.4 M Code Independent Output

The following four types of M codes output "M code independent output" signal (decode signals) separately from their code signals and MF.
The M code independent output is generally used with the following details, but the CNC outputs only the decode signal, and the operation and finish signal processes, etc., are carried out by the user PLC (machine).

M00: Program stop

<Example of process>The block stop state is entered when M00 is commanded.

M01: Optional stop

<Example of process>The block stop state is entered when M01 is commanded and the optional stop selection switch is selected.

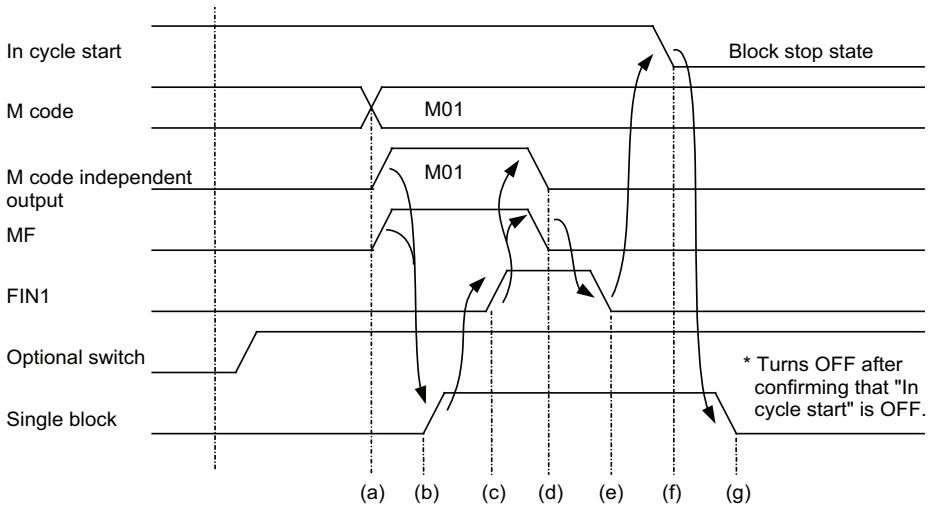
M02, M30: Program end

<Example of process>When M02 or M30 is commanded, "Reset" or "Reset & rewind" is returned to the CNC, and the reset state is entered.

10.4.1 Operation Sequence

The "M code independent output" signal turns ON when M00, M01, M02 or M30 is commanded during automatic operation (memory, MDI or tape) or by the manual numerical command, and turns OFF with the "FIN1", "FIN2", "Reset 1", "Reset 2" or "Reset & rewind" signal.

Example of M01 process (stopping the block with the M01 command)



[Explanation of operation]

(a) The CNC outputs the M code data and MF to the PLC (machine).
Refer to the section "Precautions Related to M, S, T, B Functions" for details on the M code data and MF output timing.

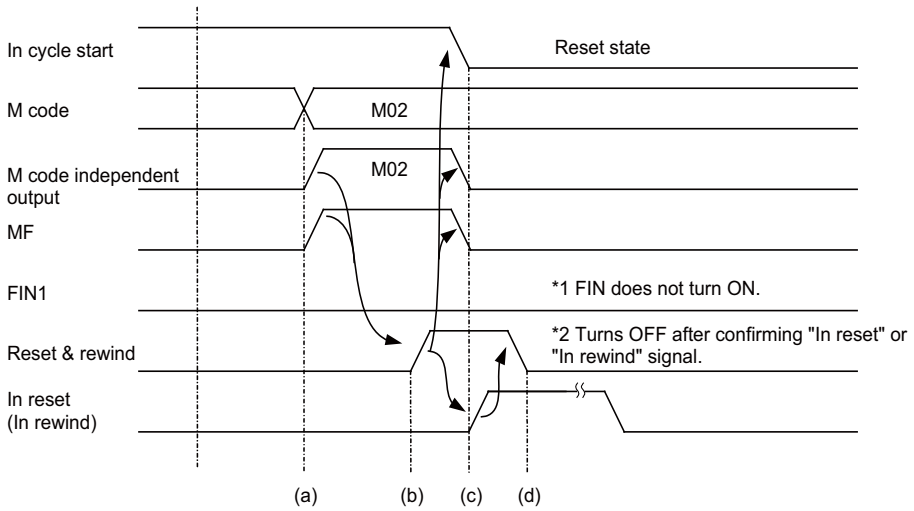
(b)(c) The PLC (machine) confirms that the MF signal has turned ON, and then carries out the specified operation. It then confirms that the "Optional switch" is ON, and then turns "Single block" and "FIN1" ON.

(d)(e) The CNC confirms that FIN1 has turned ON, and then turns the MF and "M code independent output" signal OFF. The PLC (machine) confirms that MF has turned OFF, and then turns FIN1 OFF.

(f) The CNC confirms that FIN1 has turned OFF, and then turns "In cycle start" signal OFF.

(g) The PLC (machine) confirms that "In cycle start" signal has turned OFF, and then turns the "Single block" OFF at the next cycle start.

Example of M02 process (carrying out "Reset & rewind" with M02 command)



[Explanation of operation]

(a) The CNC outputs the M code data and MF to the PLC (machine).
Refer to the section "Precautions Related to M, S, T, B Functions" for details on the M code data and MF output timing.

(b) The PLC (machine) confirms that the MF signal has turned ON, and then carries out the specified operation. It then turns "Reset & rewind" ON.

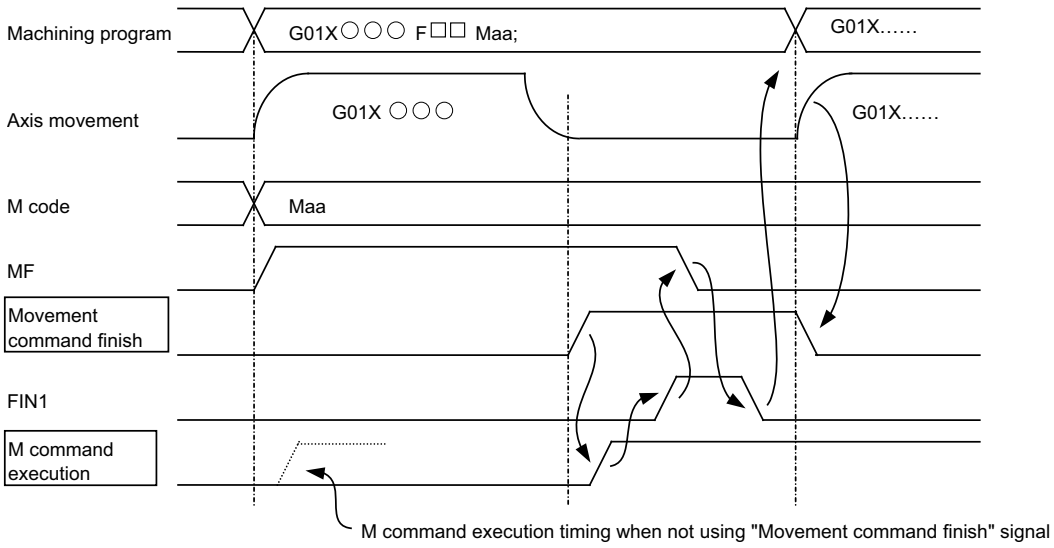
(c) The CNC confirms that "Reset & rewind" has turned ON, then turns MF, "M code independent output" and "In cycle start" OFF, and then starts the rewinding operation.

(d) The PLC (machine) confirms the "In reset" or "In rewind" signals, and then turns the "Reset & rewind" signal OFF.

10.5 Axis Movement and M Commands

If an M command is issued in the same block as a movement command, whether to process the M command simultaneously with the movement command or to process it after the movement is finished, depends on the "Movement command finish (DEN)" signal output from the CNC.

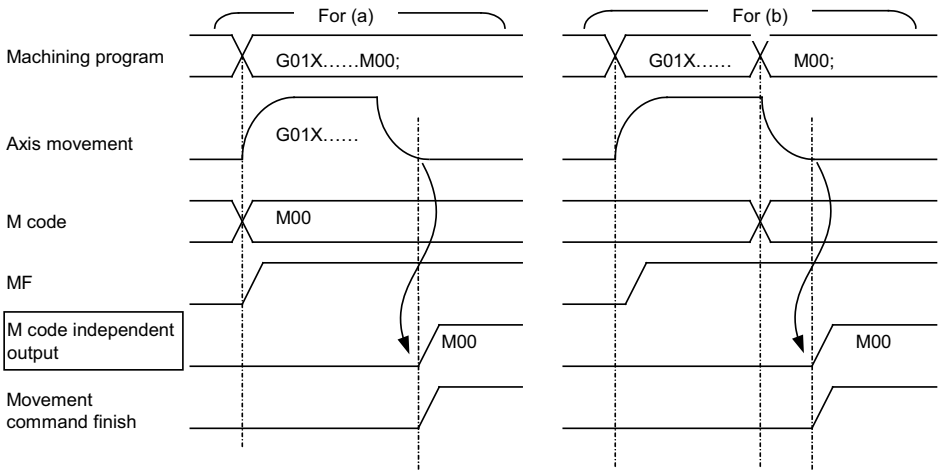
Axis movement and general M command (To execute M command after movement command is finished)



Axis movement and M code independent output command

(a) When the M code independent output command is issued in the same block as a movement command, the M code independent output will be output after the movement command is finished.

(b) Even when the M code independent output command is issued without movement command, it will be output after the axis movement in the previous command block is finished.



(Note 1) Refer to the section "M Code Independent Output" for details on the PLC (machine) process for the M code independent output.

10.6 Precautions

(1) M code data and MF output timing (Also applies to S, T, B signal)
When the built-in PLC is used, the M code data n and MFn are output simultaneously to the user PLC.
When outputting the M code data and MF to the machine with the user PLC of built-in PLC, insert an appropriate time timer on the MF side.

(2) The finish signals (FIN1, FIN2) are commonly used for the M, S, T, B functions, so turn them ON under the conditions where all function operations have been finished.

(3) When the "M function lock" signal (AFL) is turned ON, the M, S, T, B functions (including M commands in fixed cycle) issued during automatic operation (memory, MDI or tape) and manual numerical command, will not be executed. In other words, the code signal, MF, SF, TF and BF signals will not be output (updated). However, when the M code independent output (M00, M01, M02, M30) is commanded, the "M code independent output", "M code data" and MF will be output as usual.

(4) The 2nd miscellaneous (B) function can be selected from address A, B or C using the setup parameters. The "B function" refers to when address "B" is selected.

11

Spindle Control

Spindle speed can be directly controlled by an 8-digit S code command.
When the S command function specifications are valid, the controller selects an appropriate spindle gear stage corresponding to the 8-digit command following the S code and outputs (spindle gear shift command) it to the machine side (PLC). The controller also outputs S command data (analog voltage or serial connection data) corresponding to the gear input (spindle gear select input) and spindle speed specified by the machine side (PLC).

11.1 Related Parameters

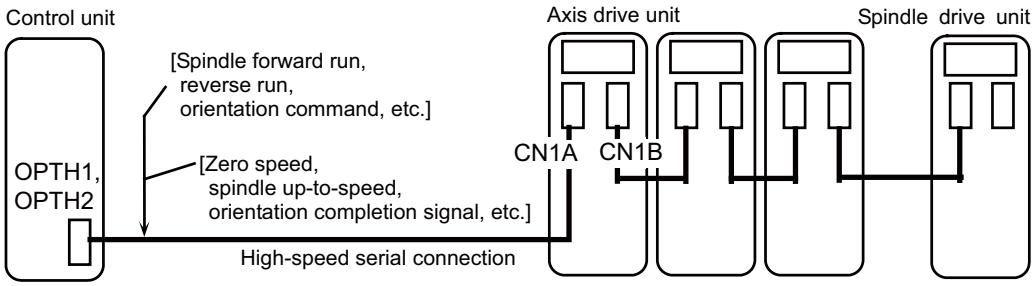
The PLC can have up to four gear stages.
The table below lists the four gear stages and the corresponding parameters.

	Parameters									
Parameter name	**Spindle limit speed**	**Maximum spindle speed**	**Spindle shift speed**	**Tap cycle maximum speed**	**Oriented speed**	**Minimum speed**	**Output signal**		**Input signal**	
Gear stage							**GR2**	**GR1**	**GI1**	**GI2**
1	Slimt1 #3001	Smax1 #3005	Ssift1 #3009	Stap1 #3013	Sori #3021	Smin #3023	0	0	0	0
2	Slimt2 #3002	Smax2 #3006	Ssift2 #3010	Stap2 #3014			0	1	0	1
3	Slimt3 #3003	Smax3 #3007	Ssift3 #3011	Stap3 #3015			1	0	1	0
4	Slimt4 #3004	Smax4 #3008	Ssift4 #3012	Stap4 #3016			1	1	1	1

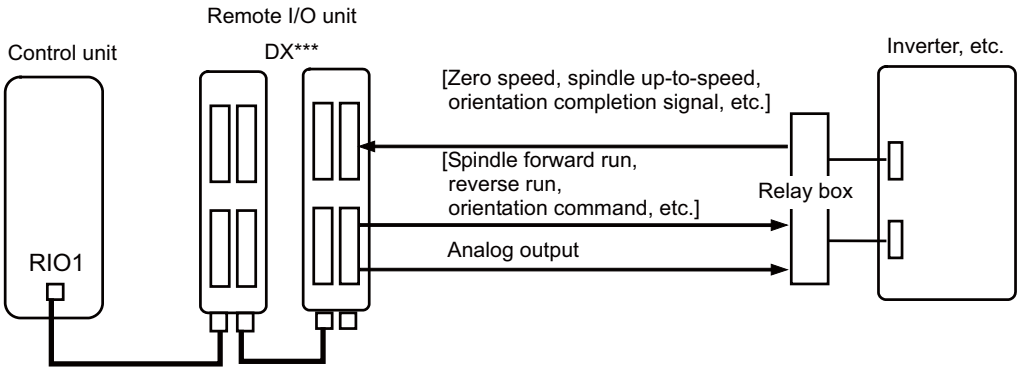
(Note 1) The upper line shows the parameter name, and the bottom line shows the parameter No.
(Note 2) Set the parameter for the gear stage not being used to 0.

11.2 Connection Method

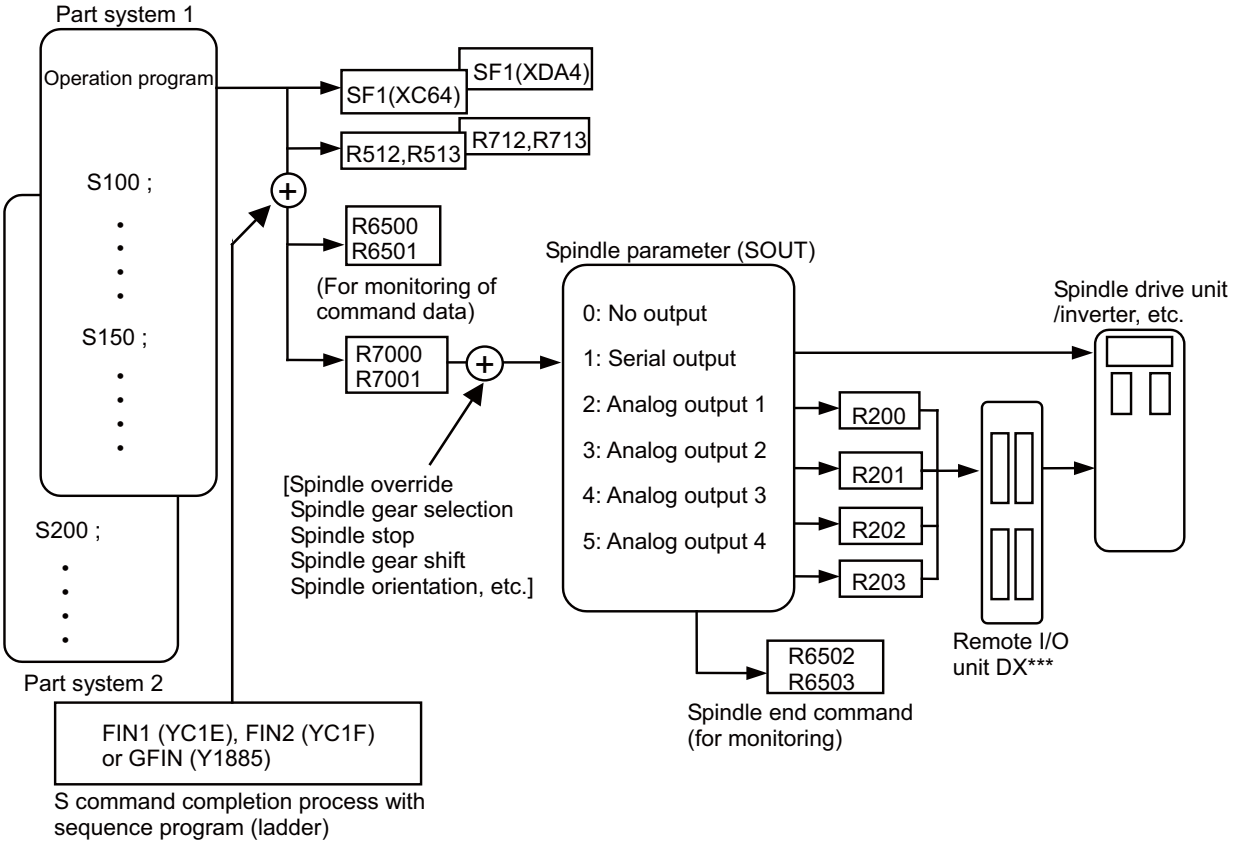
To serially connect the controller and spindle controller



To analog connect the controller and spindle controller



11.3 Flow of Spindle (S) Data



Outline explanation

(1) The spindle command start signal (SF1) is output when the spindle (S) command is issued.
(2) After the designated processes is executed by SF1 with the sequence program, the M function finish or gear shift completion signal is returned to the controller.
(3) Data corresponding to the S command is output to file registers R6500 and R6501 or R7000 or R7001 with the completion signal. The speed is output to R6500, R6501 and R7000, R7001.
(4) The R7000 and R7001 data is transferred to the spindle drive unit with serial communication according to the spindle parameter SOUT value or is transferred to the inverter, etc., as analog voltage via the remote I/O unit.

(Note) If the spindle command is issued from multiple part systems, the command issued later will be applied.

11.4 Selecting Z Phase Detection Method

To enable the Z phase detection operation, set the parameter "#3106 zrn_typ/bit3" to "1".
The Z phase detection method is switched by the setting of the parameter "#3106 zrn_typ/bitC".
The selected Z phase detection method is valid for S command, spindle orientation and spindle position control (spindle/C axis control).
When the parameter "#3106 zrn_typ/bitC" is set to "0", the Z phase detection operation follows the rotation command direction set in "#3106 zrn_typ/bit0".
When the parameter "#3106 zrn_typ/bitC" is set to "1", the Z phase detection operation follows the rotation command direction of each spindle function as in the following table:

Z phase detection operation when the parameter "#3106 zrn_typ/bitC" = "1"

Spindle function	Rotation direction when Z phase is detected
S command	Follows the rotation direction of spindle forward run start (SRN) or spindle reverse run start (SRI).
Spindle orientation	Follows the rotation command direction set in "#3106 zrn_typ/bit2-1" (01: forward run, 10: reverse run). (*1) (*2)
Spindle position control (Spindle/C axis control)	Follows the rotation command direction set in "#3106 zrn_typ/bitA-9" (01: forward run, 10: reverse run). (*1)
G/B spindle synchronization (When spindle orientation is valid for the reference spindle)	Follows the rotation command direction set in "#3106 zrn_typ/bit2-1" (01: forward run, 10: reverse run) of the reference spindle. (*1)
G/B spindle synchronization (When spindle position control is valid for the reference spindle)	Follows the rotation command direction set in "#3106 zrn_typ/bitA-9" (01: forward run, 10: reverse run) of the reference spindle. (*1)

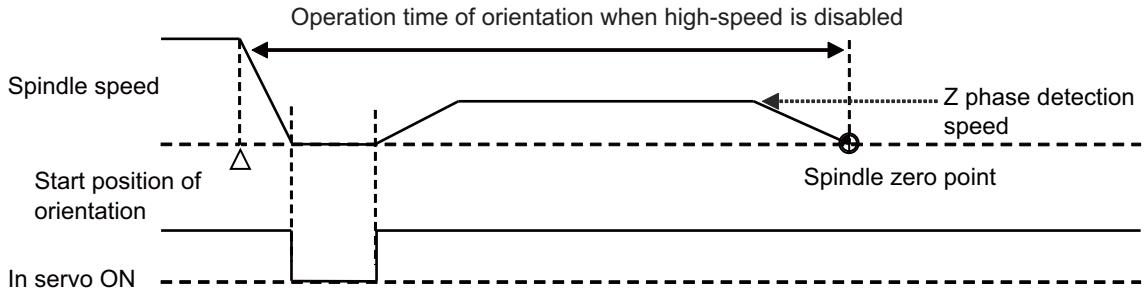
(*1) When the shortcut is set, the Z phase detection operation follows the rotation command direction set in "#3106 zrn_typ/bit0".

(*2) When "#3106 zrn_typ/bitF" is set to "1", the Z phase detection operation follows the rotation command direction set in "#3106 zrn_typ/bit0".

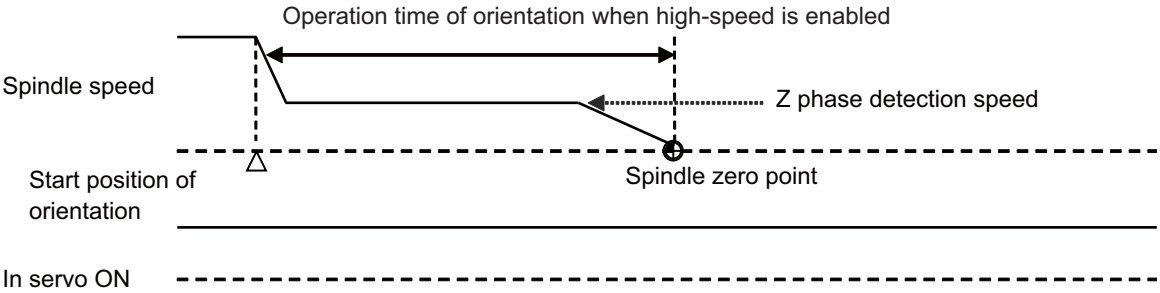
11.5 Proximity Switch Method Orientation

Proximity switch method orientation performs the positioning with the proximity switch position attached to the spindle end as spindle zero point.
There are two methods for proximity switch method orientation: standard method where the servo turns OFF once before the speed decelerates to Z phase detection speed and high-speed method where the servo does not turn OFF.

(1) Standard method
The servo turns OFF once before the speed is decelerated to the Z phase detection speed.



(2) High-speed method
The servo does not turn OFF and the speed keeps moving to the Z phase detection speed.



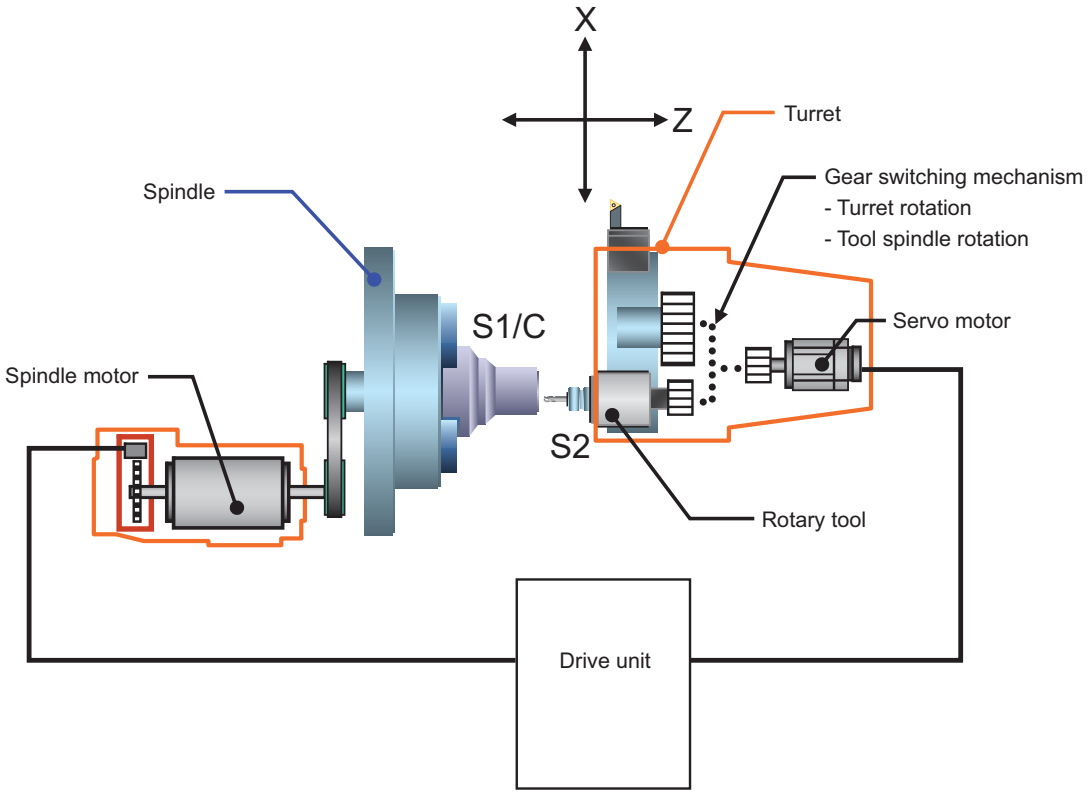
By enabling the high-speed proximity switch method orientation (parameter "#3128 ori_spec/bit1" = "1"), the high-speed function is valid.
The high-speed function is valid only when the proximity switch detection method (parameter "#3106 zrn_typ/bitF" = "1") is valid.

11.6 Spindle-mode Servo Motor Control

11.6.1 Outline

This function controls a spindle using the combination of servo motor and servo drive unit (MDS-E Series) which controls NC axis.
The maximum rotation speed of servo motor is low compared with a spindle motor. However, if the rated output is the same, the machine components can be downsized by using a servo motor to drive tool spindle, etc., because the servo motor is smaller than the spindle motor.
Note that some spindle functions can not be used under the spindle-mode servo motor control.

The figure below is the example of the application.
Normally, the components "spindle drive unit + spindle motor" are needed when cutting, drilling or milling is performed on a lathe with turret type tool selection mechanism, which means two pairs of "spindle drive unit + spindle motor" are needed; one for a main spindle and one for a turret.
However, downsizing of the turret, space-saving of the lathe and cost reduction can be achieved by replacing the turret side spindle drive with a servo motor and using spindle-mode servo motor control.



11.6.2 Glossary

Terms used in this chapter have the following meanings.

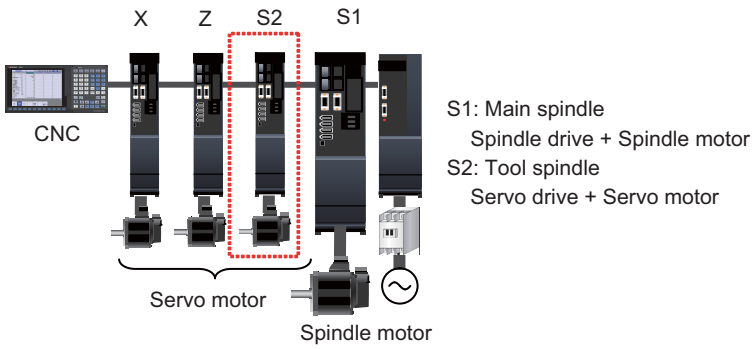
Term	Meanings
Spindle	A spindle composed of spindle drive unit + spindle motor
Spindle-mode servo	A spindle composed of servo drive unit + servo motor

11.6.3 Function Enabling Conditions

The following settings are required to enable this function.

Connection to servo drive unit

Use an optical communication cable to connect the NC to the combination of servo drive unit and servo motor that serves as a spindle-mode servo motor.



Parameter setting

(1) Enter the number of spindles that includes the spindle-mode servo motor in the parameter "#1039 spinno (Number of spindles)", and then turn OFF and ON the power.

(2) Set "1" (Optical digital communication) in the parameter "#3024 sout (spindle connection)".
Set "1" (Enable spindle-mode servo control) in the parameter "#3139 sp_srvdrv (spindle-mode servo control)".
For the spindle specification parameters (#3001~) other than those above, set them in the same manner as for a normal spindle.

(3) Set "360" (deg/rev) in the parameter "#52218 SV018 PIT (Ball screw pitch)".
For the spindle-mode servo parameters (#52001~) other than the above, set them in the same manner as for a normal spindle.

(4) After turning OFF and ON the power, you can control the spindle-mode servo motor as a spindle.

11.6.4 Spindle Features Available for Spindle-mode Servo

The following spindle features can be applied to a spindle-mode servo motor in the same manner as normal spindle.

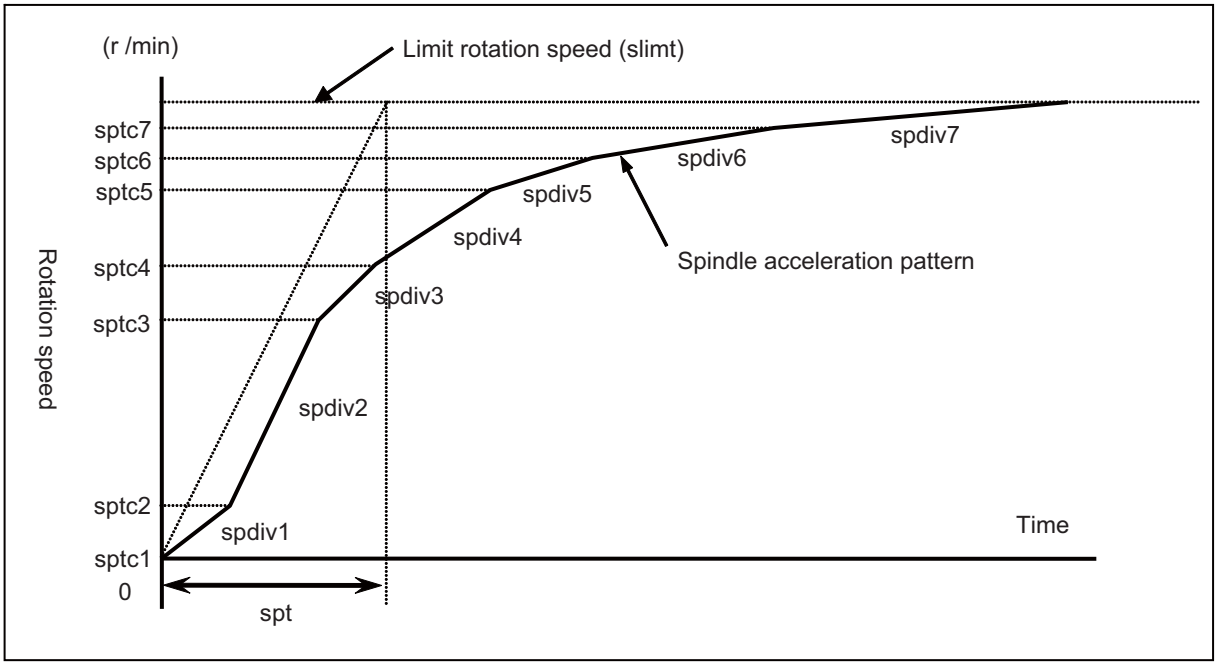
· Spindle rotation command (by S code)
· Forward run/reverse run command
· Encoder input I/F
· Spindle override
· Turret gear change
· Constant surface speed control
· Multiple spindle control
  Multiple spindle control I (Command output destination is determined by spindle selection command)
  Multiple spindle control II (Command output destination is determined by spindle selection signal)
· Spindle orientation
  Orientation
  Multi-point orientation
· Spindle position control (spindle C axis control)
  Zero return type
  Deceleration stop type
· Spindle synchronization control
  Spindle synchronization I (G code method)
  Spindle synchronization II (PLC signal method)
· Tool spindle synchronization I (Polygon)
  Tool spindle synchronization IA (spindle-spindle, polygon)
  Tool spindle synchronization IB (spindle-spindle, polygon)
  Tool spindle synchronization IC (spindle-NC axis, polygon)
· Tool spindle synchronization II (hob cut)
· Spindle speed clamp
· Feed per revolution
· Thread cutting
· Continuous thread cutting
· Variable lead thread cutting
· Circular thread cutting
· Thread cut override
· Variable feed thread cutting
· Synchronous tap cycle
· Dwell (Revolution-based designation)

11.6.5 Spindle Features with Different Operation or Settings from Normal Spindle

Acceleration and deceleration of spindle-mode servo

Unlike the acceleration and deceleration of normal spindle, the spindle-mode servo performs multi-step acceleration and deceleration as illustrated in the figure below when the speed command changes.

Multi-step acceleration deceleration pattern



To specify the acceleration and deceleration of spindle-mode servo motor control, configure the following spindle spec. parameters.

These parameters are also used as multi-step acceleration/deceleration parameters of spindle synchronization control.

"#3001 slimt1 (Limit rotation speed (Gear: 00))" to "#3004 slimt4 (Limit rotation speed (Gear: 11))"

"#3005 smax1 (Maximum rotation speed (Gear: 00))" to "#3008 smax4 (maximum rotation speed (Gear: 11))"

"#3049 spt (Spindle synchronization acceleration/deceleration time constant)"

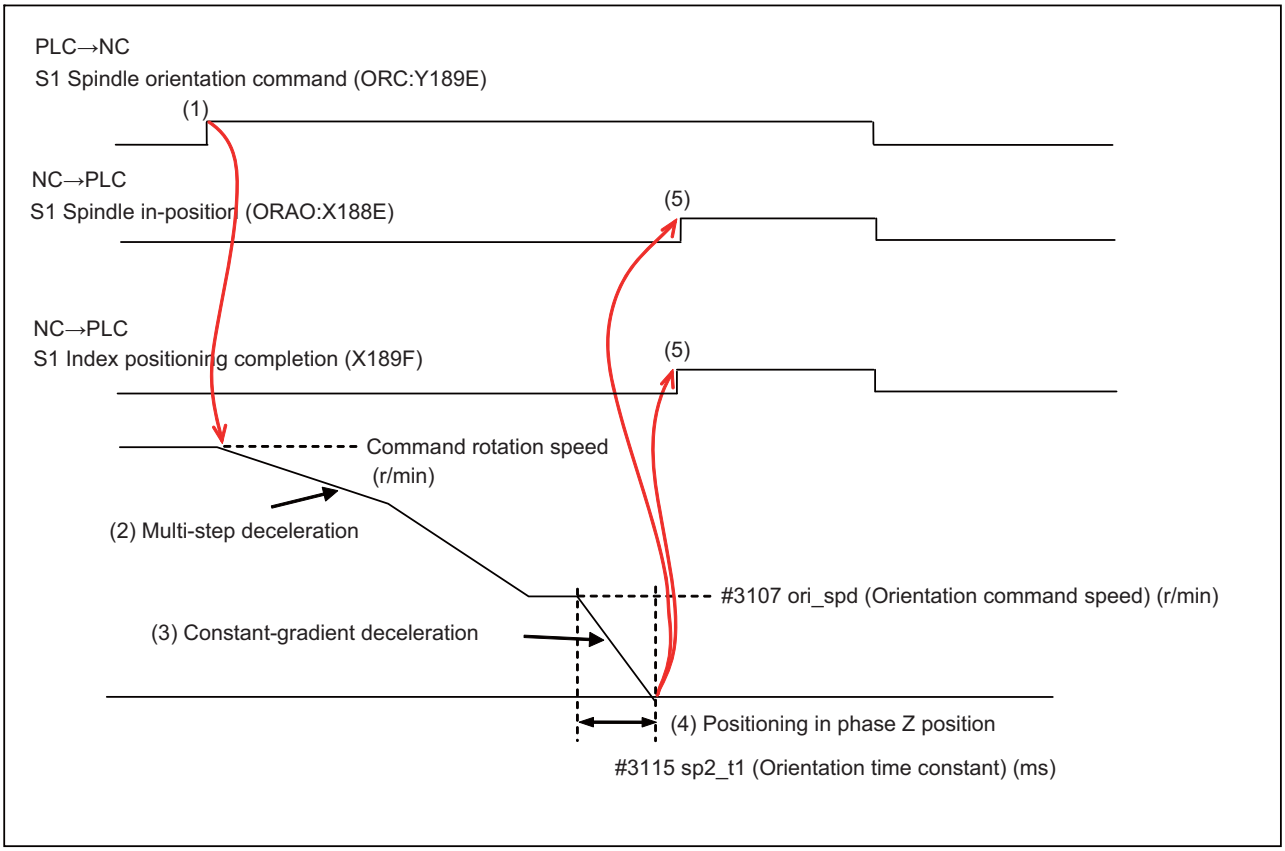
"#3054 sptc1 (Spindle synchronization multi-step acceleration/deceleration changeover speed 1)" to "#3060 sptc7 (Spindle synchronization multi-step acceleration/deceleration changeover speed 7)"

"#3061 spdiv1 (Time constant magnification for changeover speed 1)" to "#3067 spdiv7 (Time constant magnification for changeover speed 7)"

Orientation, C axis zero return and sync tap orientation of spindle-mode servo

If orientation of spindle-mode servo is in the same direction as its rotation, the operation is different from that of normal spindle. As illustrated in the figure below, the spindle-mode servo decelerates multi-step-wise. After reaching the speed "#3107 ori_spd (Orientation command speed)", it decelerates at a constant inclination, and then stops in the orientation position.
It operates in the same manner for zero return (zero return type) of spindle C axis control or of synchronous tap control.

Orientation started during rotation



(1) Turn On Spindle orientation command signal (ORC: Y189E).
(2) Apply multi-step deceleration in the rotation direction to decelerate the motor to the "(#3107 ori_spd (Orientation command speed)". (When "#3106 zrn_type/bit B (Direction of zero point return initiated during spindle rotation)" is "1" (Spindle rotation direction).)
(3) The motor decelerates at a constant inclination during orientation.
Inclination = Limit rotation speed "#3001 slimt1(r/min)" / Time constant "#3115 sp2_t1(ms)"
(4) The motor decelerates to a stop in the servo motor phase-Z position (or in a shifted position if "#3108 ori_sft (Position shift amount for orientation)" is set).
(5) Turn ON Spindle in-position (ORAO:X188E) and Index positioning completion (X189F). (Turn ON Index positioning completion signal only for forward or reverse indexing.)

11.6.6 Example Usage

```
  :
T0101                              ··· Select the polygon tool (Turn the turret through orientation)
G00 X15.
G44.1                              ··· Select the 2nd spindle (Tool spindle S2)
M24 S3000                          ··· Reverse-rotate S2 at 3000(r/min)
G43.1                              ··· Select the 1st spindle (Main spindle S1)
M3 S500                            ··· Forward-rotate S1 at 500(r/min)
M16 M26                            ··· Check S1/S2 has reached the speed (S1: X188D, S2: X18ED)
G114.2 H1 D2 E6 L1 R0              ··· Polygon cut command
G00 X13. Z0.
G95 G01 X5. F0.01                  ··· Polygon cut
G4 X3.
G00 G00 X15.
G113                               ··· Cancel polygon cut

  :
  :

G00 Z15.
T02020                             ··· Select the tap tool (Turn the turret through orientation)
G00 Z5.
G84 X5. Z-5. R5. F1. D2 S500. ,R1  ··· End-face synchronous tapping
  :
  :
```

11.6.7 Relation with Other Functions

(1) Spindle orientation

Spindle-mode servo control does not support mag-sensor (proximity switch) orientation.

(2) Spindle position control (Spindle C Axis Control)

Under spindle-mode servo control, the spindle/C axis parameter switch cannot be performed in parallel with the changeover between spindle and C axis control. Thus set "0" (Not switch) in the parameter "#3114 cax_para_chg" (Spindle/C axis parameter switch). If this parameter is set to "1" (Switch), the operation error (M01 1026) occurs when a C axis changeover command is given.

(3) Coil switch/automatic coil switch

Coil switch is not available for this function, as it is a servo motor.

(4) High-speed synchronous tapping

High-speed synchronous tapping is not available for this function. If this command is given to a spindle-mode servo, the command is treated as a normal synch tap command.

(5) Guide bushing spindle synchronization

Spindle-mode servo cannot be set as "reference spindle for G/B" or "G/B spindle". Thus set "0" in the parameter "#3074 GBsp" (Guide bushing spindle synchronization control). If either reference spindle for G/B ("#3074 GBsp (Guide bushing spindle synchronization control)" is set to "1") or G/B spindle ("#3074 GBsp (Guide bushing spindle synchronization control)" is set to "2") is assigned to a spindle-mode servo, the operation error (M01 G1015) occurs at the turning-ON of "G/B spindle synchronization valid" signal (GBON: Y778).

(6) Increase holding power of spindle

Turning-ON or turning-OFF of "Increase holding power of spindle" signal (EXOBS: Y1893) cannot switch the enable or disable state of disturbance observer.

(7) Load Monitoring I

Spindle-mode servo does not output the spindle cutting torque, estimated spindle disturbance torque or effective spindle torque to the R registers.

11.6.8 Precautions

(1) Disable collision detection for a spindle-mode servo.

Set "0" in the parameter "#2260 SV060 TLMT" (Collision detection level).

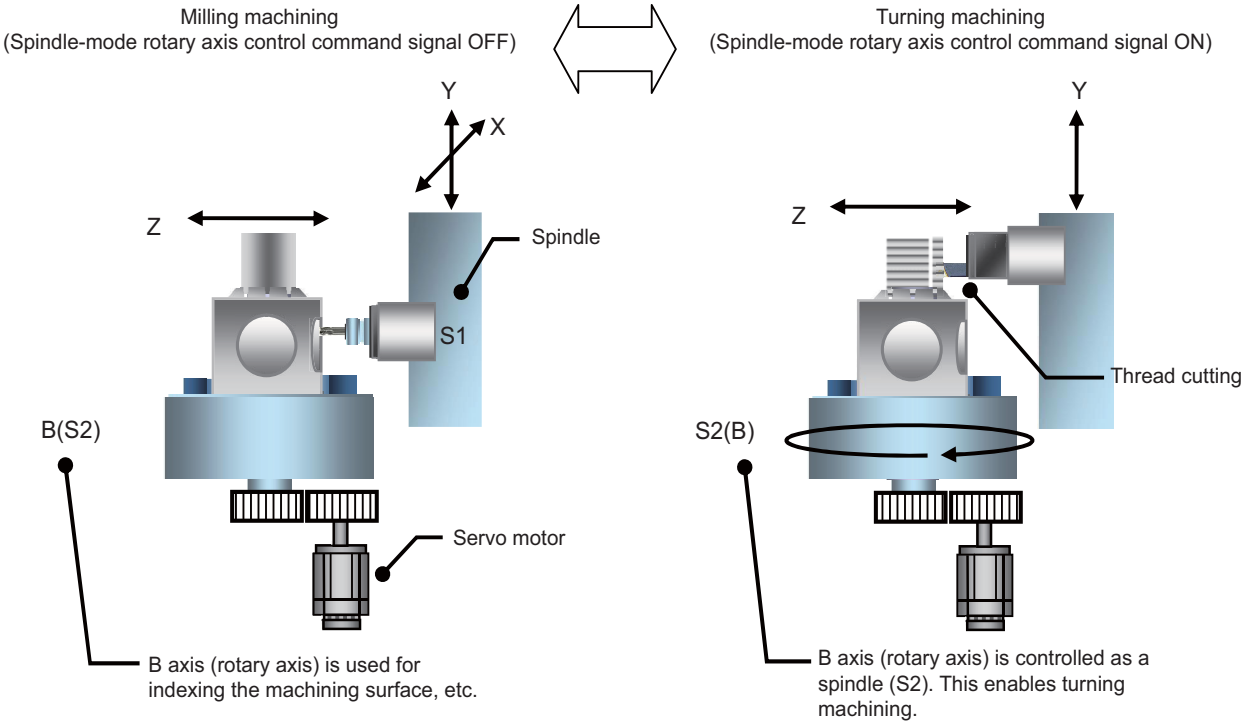
11.7 Spindle-mode Rotary Axis Control

11.7.1 Outline

This function enables a rotary axis driven by a servo motor to be controlled as a spindle. When the spindle-mode rotary axis control command signal is turned ON, the rotary axis is controlled as a spindle. This enables lathe-turning machining, including synchronous feed and thread cutting, to be performed in synchronization with the feedback speed of the rotary axis (spindle-mode rotary axis mode). When the signal is turned OFF, positioning and interpolation commands can be given to the rotary axis (servo axis mode).

The following is the example of the application.

Add S2 as B axis spindle. B axis can be controlled as S2 spindle by setting "2" to B axis parameter "#1020 sp_ax" and setting the same value as the B axis (servo axis) drive unit I/F number to S2 axis parameter "#3031 smcp_no". B axis can be controlled as S2 spindle by turning the spindle-mode rotary axis control command signal ON after being used as B axis for indexing the machining surface. This enables turning machining, including thread cutting.



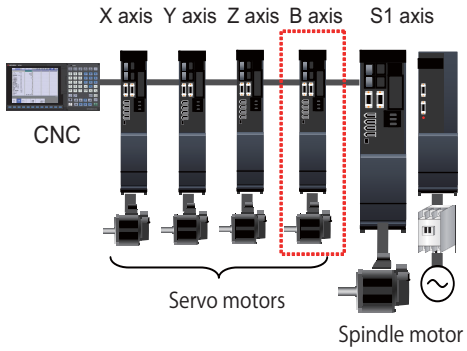
11.7.2 Glossary

Terms used in this chapter have the following meanings.

Term	Meaning
Spindle-mode rotary axis mode	A state where the spindle-mode rotary axis control command signal (ROTSPCn) is ON and so a rotary axis is able to be controlled as a spindle.
Servo axis mode	A state where the spindle-mode rotary axis control command signal (ROTSPCn) is OFF and so a rotary axis is controlled as a normal servo axis.

11.7.3 Function Enabling Conditions

Given below is a configuration example where B axis (S2 spindle) is the objective of spindle-mode rotary axis control.



(1) Specify the number of control axes.

If you enable the spindle-mode rotary axis control, you need to set the spindle. For one servo motor, set one rotary axis and one spindle.

In this example

[#1024(PR)] axisno (number of axes) = 4 (X, Y, Z and B)

[#1039(PR)] spinno = 2 (S1 and S2) Add 1 to the number of spindles.

(2) Configure the parameters to enable the spindle-mode rotary axis control.

	X	Y	Z	B	S1	S2
#1017 rot	0	0	0	1	-	-
#1020 sp_ax	0	0	0	2	-	-
#1021 mcp_no	1001	1002	1003	1004	-	-
#3031 smcp_no	-	-	-	-	1005	1004
#3024 sout	-	-	-	-	1	0

<Servo axis (B axis) settings>

(a) Spindle-mode rotary axis setting

Set the parameter "#1020 sp_ax" (Spindle interpolation) to "2".

When you have changed the setting of the parameter "#1020 sp_ax", turn ON the NC again, then reestablish the zero point.

(b) Rotary axis setting

Set the parameter "#1017 rot" (Rotational axis) to "1".

<Spindle (S2) settings>

(a) Setting of spindle not connected to drive

Set the parameter "#3024 sout" (Spindle connection) to "0".

(b) Setting of spindle-mode rotary axis objective

Set the parameter "#3031 smcp_no" (Drive unit I/F channel No. (spindle)) to be the same as the drive I/F in "#1021 mcp_no" (Drive unit I/F channel No. (servo) of B axis.

(Note) Select the rotation type rotary axis for the rotary axis spindle ("#8213 Rotation axis type" is set to "0" or "1").

(3) Configure the parameters that are needed for the spindle control in the spindle mode.

The following parameters are the minimum requirements for the spindle-mode rotary axis control.

"#3001 slimt1" (Limit rotation speed (Gear: 00))

"#3005 smax1" (Maximum rotation speed (Gear: 00))

"#3049 spt" (Spindle synchronization acceleration/deceleration time constant)

"#3054 sptc1" (Spindle synchronization multi-step acceleration/deceleration changeover speed 1) to "#3060 sptc7" (Spindle synchronization multi-step acceleration/deceleration changeover speed 7)

"#3061 spdiv1" (Time constant magnification for changeover speed 1) to "#3067 spdiv7" (Time constant magnification for changeover speed7)

"#3106 zrn_typ/bitA-9, bit8" (Zero point return specification)

"#3112 cax_spd" (Spindle C axis zero point return speed)

"#3115 sp2_t1" (Time constant in orientation/interpolation mode automatic reference position return (Gear: 00))

11.7.4 Spindle-mode Rotary Axis Control Command

Spindle-mode rotary axis control can be commanded using the spindle-mode rotary axis control command signal (ROTSPC1: YB40).

While the spindle-mode rotary axis control command signal is ON, a rotary axis can be controlled as a spindle. (Spindle-mode rotary axis control mode)

While the spindle-mode rotary axis control command signal is OFF, a rotary axis can be controlled as a servo axis. (Servo axis control mode)

(*) To change the "Spindle-mode rotary axis command" signal, the "Servo OFF" signal of the rotary axis needs to be turned ON (*SVFn=1).

While the spindle-mode rotary axis control mode is ON, an S command is enabled for a servo motor. If a positioning or interpolation command is given during this mode, the operation error (M01 0005) occurs. Before giving a positioning or interpolation command, you need to turn OFF the spindle-mode rotary axis control command signal to cancel the spindle-mode rotary axis control mode.

While the servo axis control mode is ON, the axis does not work as a spindle even if you give it an S command. However, the S command is retained. If you turn ON the spindle-mode rotary axis control command signal, and then turn ON the forward or reverse run signal, the axis rotates at the retained S speed.

You can monitor the status of the spindle-mode rotary axis control mode using the spindle-mode rotary axis control mode signal (ROTSPM1: XB40).

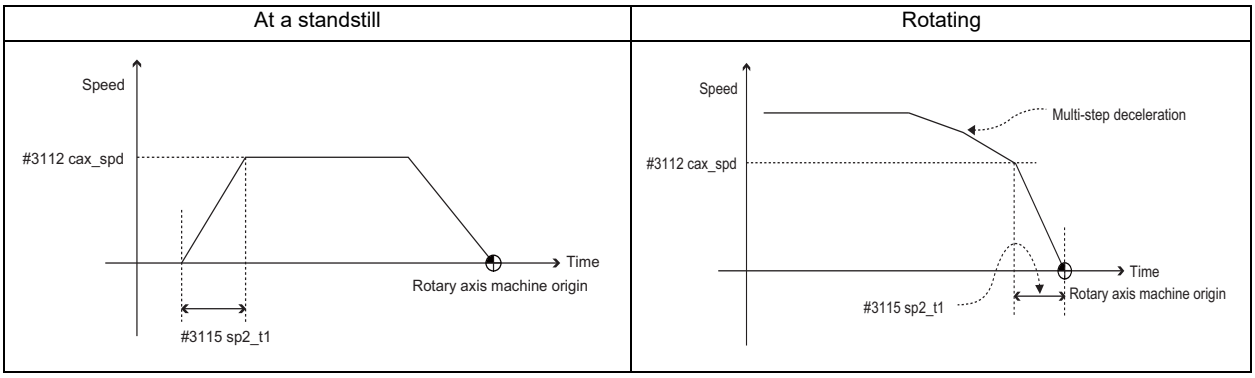
11.7.5 Operations at Switchover from Spindle-mode Rotary Axis to Servo Axis Mode

There are two types operations to be performed when the mode is switched from spindle-mode rotary axis control to servo axis control.

(1) Zero point return type: (Parameter "#3106 zrn_typ/bit8" = "0")

The rotary axis is positioned in its machine zero point by turning OFF the spindle-mode rotary axis control command signal.

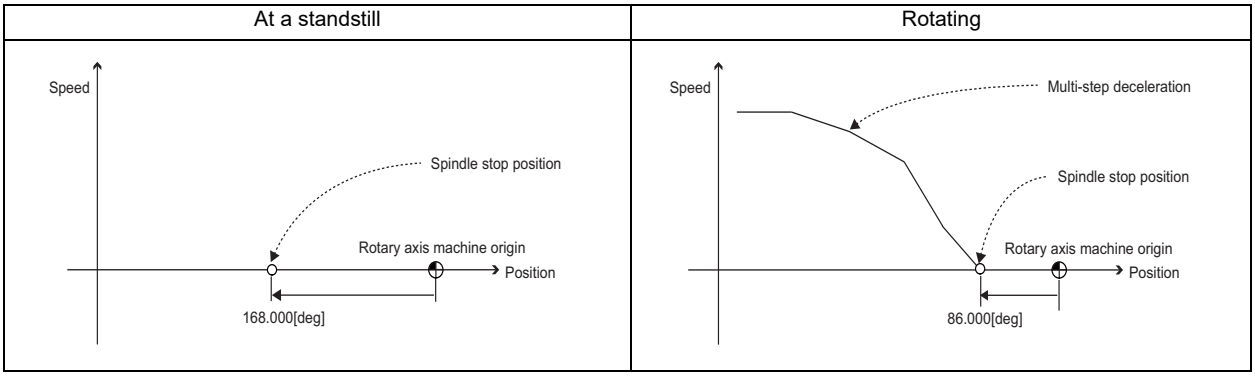
Use the parameters "#3106 zrn_typ/bit9" to "#3106 zrn_typ/bitA" to select the specifications of zero point return (short-cut, forward run or reverse run) when the return is performed while the spindle is at a standstill.



(2) Deceleration stop type: (Parameter "#3106 zrn_typ/bit8" = "1")

When you turn OFF the spindle-mode rotary axis control command signal with the spindle at a stand still, the servo axis control mode is enabled, and the machine value counter shows a position from the machine origin.

When you turn OFF the spindle-mode rotary axis control command signal with the spindle rotating, the spindle decelerates to a stop, and switches to servo axis control mode . The machine value counter shows a position from the machine origin.



11.7.6 Operation when Reset is Input during Spindle-mode Rotary Axis Control

Status of the spindle-mode rotary axis control signal is unchanged after NC reset. However, if you change the ON/OFF of the spindle-mode rotary axis control command signal at the same time as the reset, the control mode is switched. If you turn OFF the spindle-mode rotary axis control command signal at the same time as NC reset during the spindle control mode with the zero point return type selected ("#3106 zrn_typ/bit8" = "0"), the control performs the zero return operation after the reset, and then activates the servo control mode.

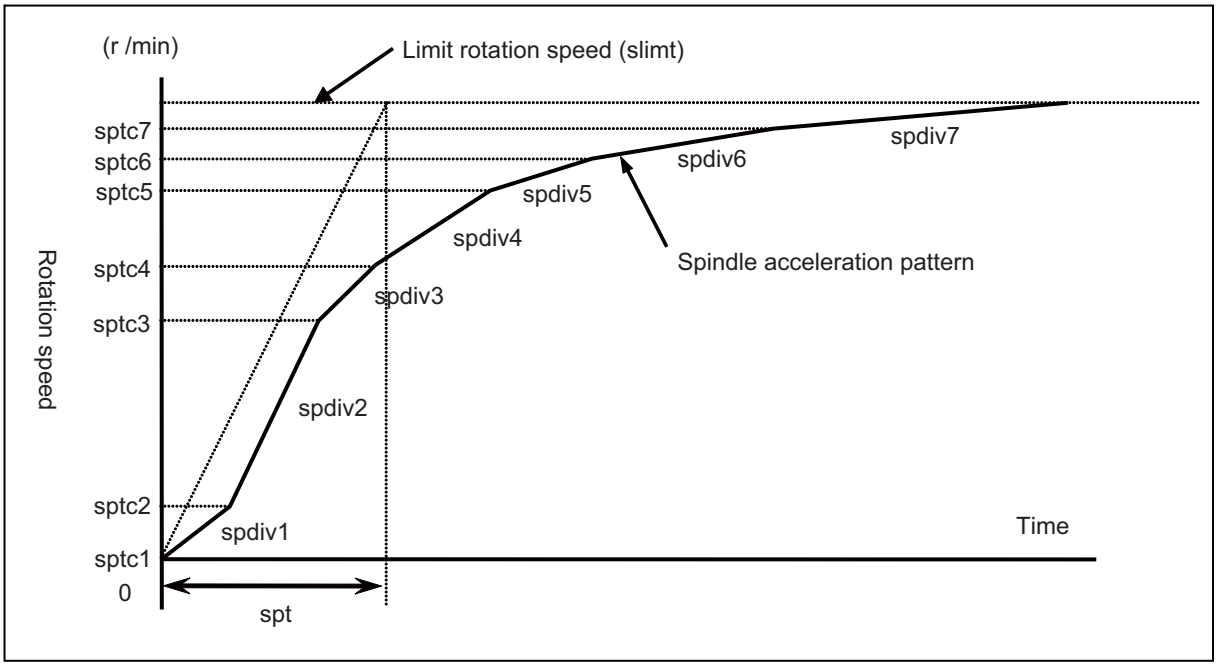
11.7.7 Operation when Emergency Stop is Input during Spindle-mode Rotary Axis Control

Status of the spindle-moder rotary axis control signal is unchanged when emergency stop is executed or cancelled. The control retains the spindle-mode rotary axis control mode.

11.7.8 Acceleration/Deceleration Operation during Spindle-mode Rotary Axis Control

When the command speed changes, multi-step acceleration deceleration is performed as illustrated below.

Multi-step acceleration/deceleration pattern



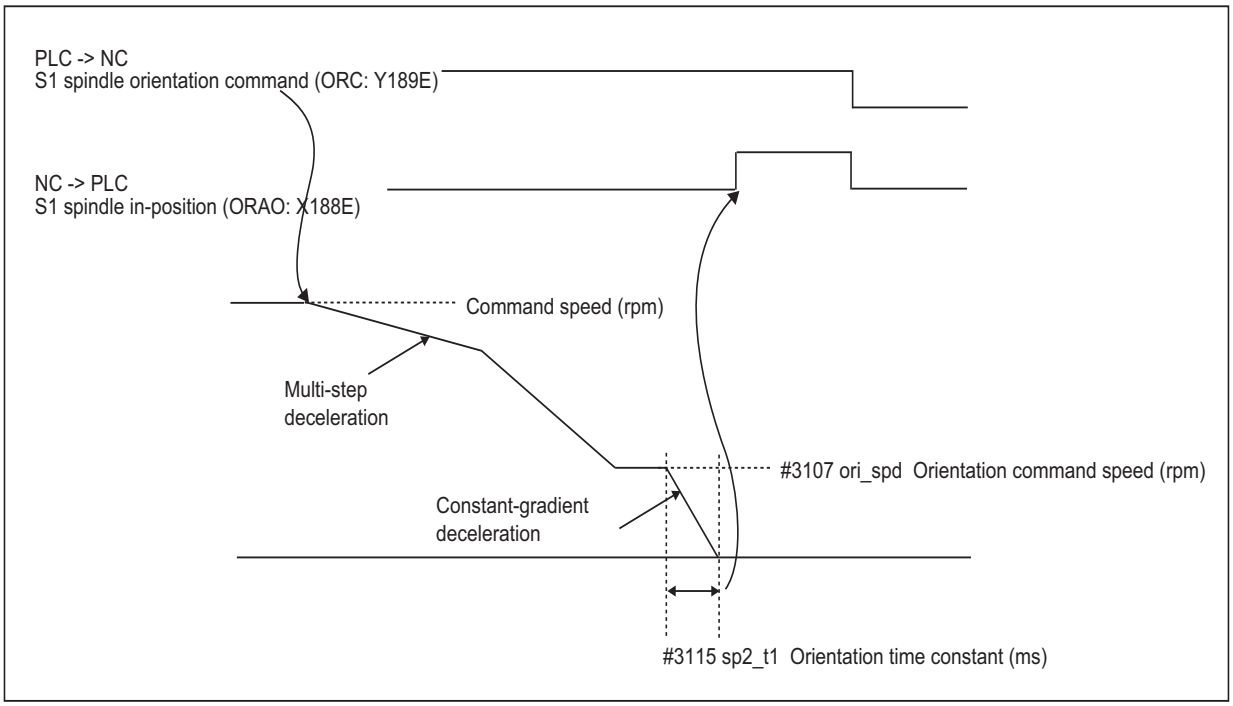
The spindle specification parameters need to be set as follows for the operation of acceleration/deceleration during the spindle-mode rotary axis control. These settings are the same as for the multi-step acceleration/deceleration under spindle synchronization control.

"#3001 slimt1 (Limit rotation speed (Gear: 00))" to "#3004 slimt4 (Limit rotation speed (Gear: 11))"
"#3005 smax1 (Maximum rotation speed (Gear: 00))" to "#3008 smax4 (Maximum rotation speed (Gear: 11))"
"#3049 spt (Spindle synchronization acceleration/deceleration time constant)"
"#3054 sptc1 (Spindle synchronization multi-step acceleration/deceleration changeover speed 1)" to "#3060 sptc7 (Spindle synchronization multi-step acceleration/deceleration changeover speed 7)"
"#3061 spdiv1 (Time constant magnification for changeover speed 1)" to "#3067 spdiv7 (Time constant magnification for changeover speed7)"

11.7.9 Orientation Operation during Spindle-mode Rotary Axis Control Mode

If an orientation command is given during rotation, and the orientation direction is identical to the rotation direction, the spindle decelerates multi-step-wise as illustrated below. After the spindle reaches the speed of "#3107 ori_spd (Orientation command speed)", it decelerates with a constant inclination, and stops in the orientation position.

Orientation that starts during rotation



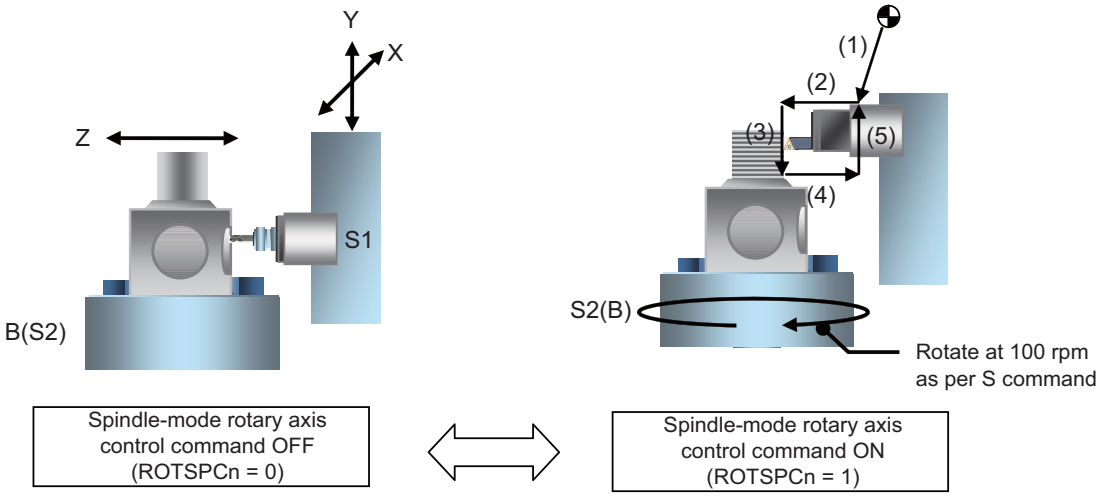
(1) Turn ON the spindle orientation command signal (ORC: Y189E).
(2) Decelerate multi-step-wise to the "#3107 ori_spd (Orientation command speed)" in the rotation direction.
(3) Decelerate with a constant inclination during orientation.
Inclination = Orientation speed #3107 ori_spd (rpm) / Time constant #3115 sp2_t1 (ms)
(4) Decelerate to a stop in the servo motor's machine zero point (or the shifted position if "#3108 ori_sft (Position shift amount for orientation)" is set).
(5) Turn ON the spindle in-position signal (ORAO:X188E).

11.7.10 Functions Available during Spindle-mode Rotary Axis Control Mode

The following functions are available during the spindle-mode rotary axis control.
- Spindle rotation command (S code output)
- Forward run start/Reverse run start command
- Encoder input I/F
- Spindle override
- Constant surface speed control (G96)
- Multiple spindle control II
- Spindle orientation
  Orientation/Multi-point orientation
- Spindle speed clamp (G92)
- Feed per revolution (G95)
- Thread cutting (G33), Continuous thread cutting (G33)
- Synchronous tap cycle, Tap retract
- Spindle oscillation
- Tool spindle synchronization IC (Spindle-NC axis, Polygon)

11.7.11 Example Usage

Machining program	Description	Control mode
:		Servo axis mode (servo axis control)
G00 B100. F100 ;	Perform positioning of B axis	
M14 ;	Turn ON the spindle-mode rotary axis control (ROTSPC=1) for B axis, the 4th axis of $1	Switch command
G90 G28XYZT53 ;	Move to the tool exchange position and select a turning tool.	Spindle-mode rotary axis control mode (spindle control)
G00X0.Y100.Z100. ;	Move to the thread cut start position of Z and Y axes ((1) in the Figure below)	
G43 Z49. H10. ;	Select the Z axis offset and move to the Z axis thread cut start position ((2) in the Figure below)	
M23 S100 ;	Forward-run the 2nd spindle (B axis) at 100 rpm (Multiple spindle control II)	
M200 ;	Confirm that the spindle has reached the speed	
G32 Y80. F1. Q90. ;	Start thread cutting with the thread lead of 1mm ((3) in the Figure below)	
G00 Z100. ;	Retract the tool in the Z axis direction ((4) in the Figure below)	
G00 Y100. ;	Return the tool to the start position ((5) in the Figure below)	
M10 ;	Turn OFF the spindle-mode rotary axis control (ROTSPC=0) for B axis, the 4th axis of $1	Switch command
G00 B180. ;	Perform positioning of B axis	Servo axis mode (servo axis control)
:		



11.7.12 Relation with Other Functions

(1) Orientation
Spindle-mode rotary axis control does not support mag-sensor (proximity switch) orientation. Even when the proximity switch orientation is ON ("#3106 zrn_typ/bitF" = "1"), the orientation is disabled.
When the "Spindle-mode rotary axis command" signal (ROTSPCn: YB40) is turned OFF, the mode is switched to the servo axis mode regardless of the state of the "Spindle orientation command" signal (ORC: Y189E).

(2) Coil switch/automatic coil switch
Coil switch is not available for this function, as this control is for a servo motor.

(3) Increase holding power of spindle
Disturbance observer remains disabled even If you change the Increase holding power of spindle signal (EXOBS: Y1893).

(4) Spindle torque limit
Torque limit remains disabled even if you change the spindle torque limit 1 and 2 signals (TL1: Y189A, TL2: Y189B)

(5) Spindle gear selection
Spindle gear selection remains disabled even if you change the spindle gear selection code1 and 2 signals (GI1: Y1890, GI2: Y1891)

(6) Door interlock I and II
If you turn ON or turn OFF after turning ON the door open I signal during the spindle-mode rotary axis control mode, the status of the spindle-mode rotary axis control mode signal is unchanged. The mode is retained.
Likewise, if you turn ON or turn OFF after turning ON the door open II signal during the spindle-mode rotary axis control mode, the status of spindle-mode rotary axis control mode is unchanged. The mode is retained.

(7) Load monitoring
The spindle-mode rotary axis does not output the spindle cutting torque, estimated spindle disturbance torque or effective spindle torque to the R registers.

(8) Normal line control
If the spindle-mode rotary axis is under normal line control, and you give a circular turning command to the axis while the spindle mode is ON, the program error (P430) occurs.

(9) Spindle synchronization I/II, Tool spindle synchronization IA (Spindle-Spindle, Polygon), Tool spindle synchronization IB (Spindle-Spindle, Polygon)
The spindle-mode rotary axis cannot be commanded as a reference spindle nor a synchronized spindle of the spindle synchronization I/II, tool spindle synchronization IA, or tool spindle synchronization IB. When it is commanded, the operation error (M01 1024) occurs.

(10) Tool spindle synchronization II (Hobbing)
The spindle-mode rotary axis can be commanded as a workpiece axis of the tool spindle synchronization II (Hobbing). When it is commanded as the hob spindle, the operation error (M01 1024) occurs.

11.7.13 Precautions

(1) When using the spindle-mode rotary axis control, disable the collision detection function.
The parameter "#2260 SV060 TLMT" (Collision detection level) needs to be set to "0" to disable the collision detection.

(2) The available spindle speed at the spindle end is up to the maximum (a value obtained by dividing "#2001 rapid" by "#2218 PIT") of the parameter "#3001 slimt1" (Limit rotation speed).
Set the spindle parameters "#3001 slimit1" to "#3004 slimit4" (Limit rotation speed) and "#3005 smax1" to "#3008 smax4" (Maximum rotation speed), so that the motor side speed does not exceed the servo motor's maximum rotation speed.

(3) Even when the servo OFF signal is ON (*SVFn=1) for the rotary axis, the axis remains servo OFF while the spindle forward and reverse run signals are OFF with the spindle-mode rotary axis control signal ON.
If you set the axis to be in servo ON (energized) state with the spindle-mode rotary axis control signal ON, turn ON the spindle forward or reverse run signal.

(4) While the spindle-mode rotary axis control command signal is ON and the servo OFF signal is OFF (*SVFn=0), the axis will not rotate even when the forward or reverse run command is given. Give the forward or reverse run command with servo ON (*SVFn=1).

(5) While the spindle-mode rotary axis control command signal is OFF, the spindle forward and reverse run signals are disabled. If you turn ON the spindle-mode rotary axis control command signal with the forward or reverse run signal ON, you need to re-input (turn OFF and ON) the forward or reverse run signal.

(6) When switching the control mode between spindle-mode rotary axis control and servo axis control, you need to have the zero point established. Establish the zero point of the rotary axis before switching the control mode.
If you turn ON the spindle-mode rotary axis control command with the zero point unestablished, and then give a spindle command, the axis does not function as a spindle.

(7) Change the "Spindle-mode rotary axis control command" signal (ROTSPCn: YB40) in servo ON (*SVFn=1) state.
When the "Spindle-mode rotary axis control command" signal is changed in servo OFF (*SVFn=0) state, the mode can be switched from the servo axis mode to the spindle mode, but not from the spindle mode to the servo axis mode.

(8) When the operation type at switchover from spindle-mode rotary axis control to servo axis control is the zero point return type ("#3106 zrn_typ/bit8" is "0"), positioning to the machine zero point is performed in the unit specified by the output unit of spindle drive unit (#3035 spunit).
When the spindle-mode rotary axis control is used, use the same unit for the following setting units.
- Control unit (#1004 ctrl_unit)
- Output unit of servo drive unit (#1010 srvunit)
- Output unit of spindle drive unit (#3035 spunit)

If a different setting unit is used, there may be an error less than the spindle output unit, on return position.

11.8 Turret Gear Change Control

11.8.1 Outline

This function enables axes in the semi-closed system to select four types of gear ratios which are set to the spindle specification parameters according to the control input from the PLC.

There are differences from normal gear change as follows:

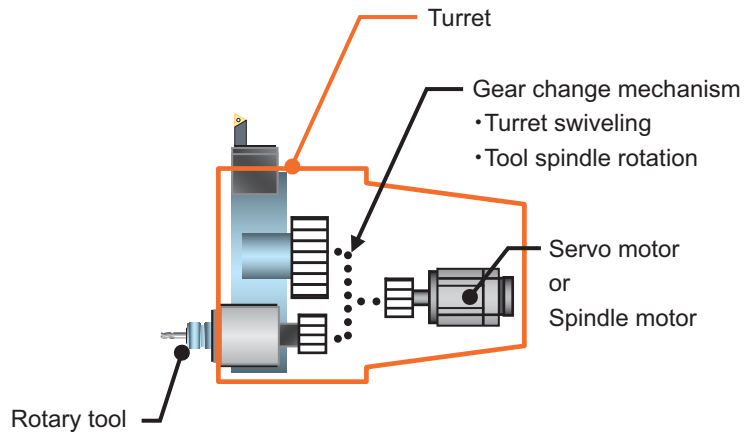
(1) Positioning can be made at the predefined motor side position regardless of the selected gear step during spindle orientation or change to spindle position control (C axis control).

(2) Gears can be changed during the rotation.

Example of application

(1) Gear change between turret swiveling and tool spindle rotation in turret type tool post

For gear change on a turret where the turret swiveling and tool rotation are switched by physical gear using one servo or spindle motor as illustrated below, the positioning to Z-phase position of motor side (orientation) can be made regardless of the selected gear steps by using this function. Consequently, the gears for the physical gear change are engaged and the physical gears can be changed.



(2) Gear change during rotation

For example, the tool for polygon has a tool system in which the reduction gear is for starting torque (cutter + tool folder). If this tool is installed in a tool post that has mechanism which rotates multiple tools by one motor, the gear change is needed when selecting the polygon tool. However, the gear change can be performed during the tool rotation without temporary stop so that the tool change time can be reduced.

(3) Gear change during spindle-mode servo motor control

This function is used when gear change is needed in the spindle-mode servo motor control which controls a servo motor as spindle using the combination of servo drive unit and servo motor.

11.8.2 Function Enabling Conditions

The semi-closed system is required to enable this function.
This is enabled by configuring the spindle as follows.

(1) Set "#43001 sgear_tret (enable turret gear change)" to "1".

(2) Set "#43002 SGRA1 (spindle gear ratio 1)" through "#43005 SGRA4 (spindle gear ratio 4)" and "#43006 SGRB1 (motor shaft gear 1)" through "#43009 SGRB4 (motor shaft gear ratio 4)" to the number of gears on the spindle side and the motor side.

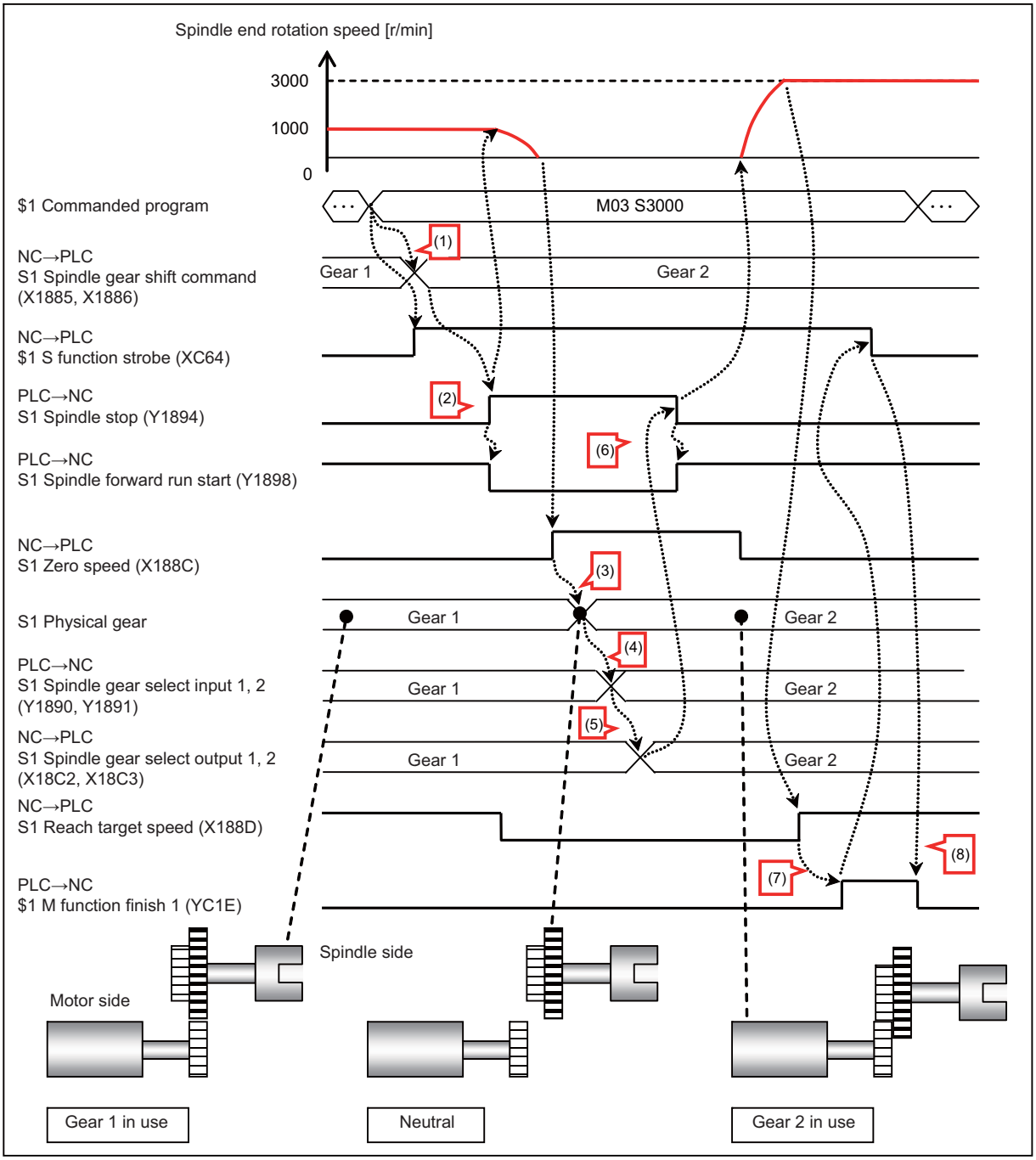
(3) Turn the power off and on again.

11.8.3 Turret Gear Change Control Operation

In accordance with the control input from the PLC (spindle gear selection input 1 and 2: Y1890 and Y1891), select the gear ratio from the four options configured for the spindle specification parameter to change gears. Refer to "PLC Interface Manual" for more information.

The following figures illustrate examples of gear change operations.

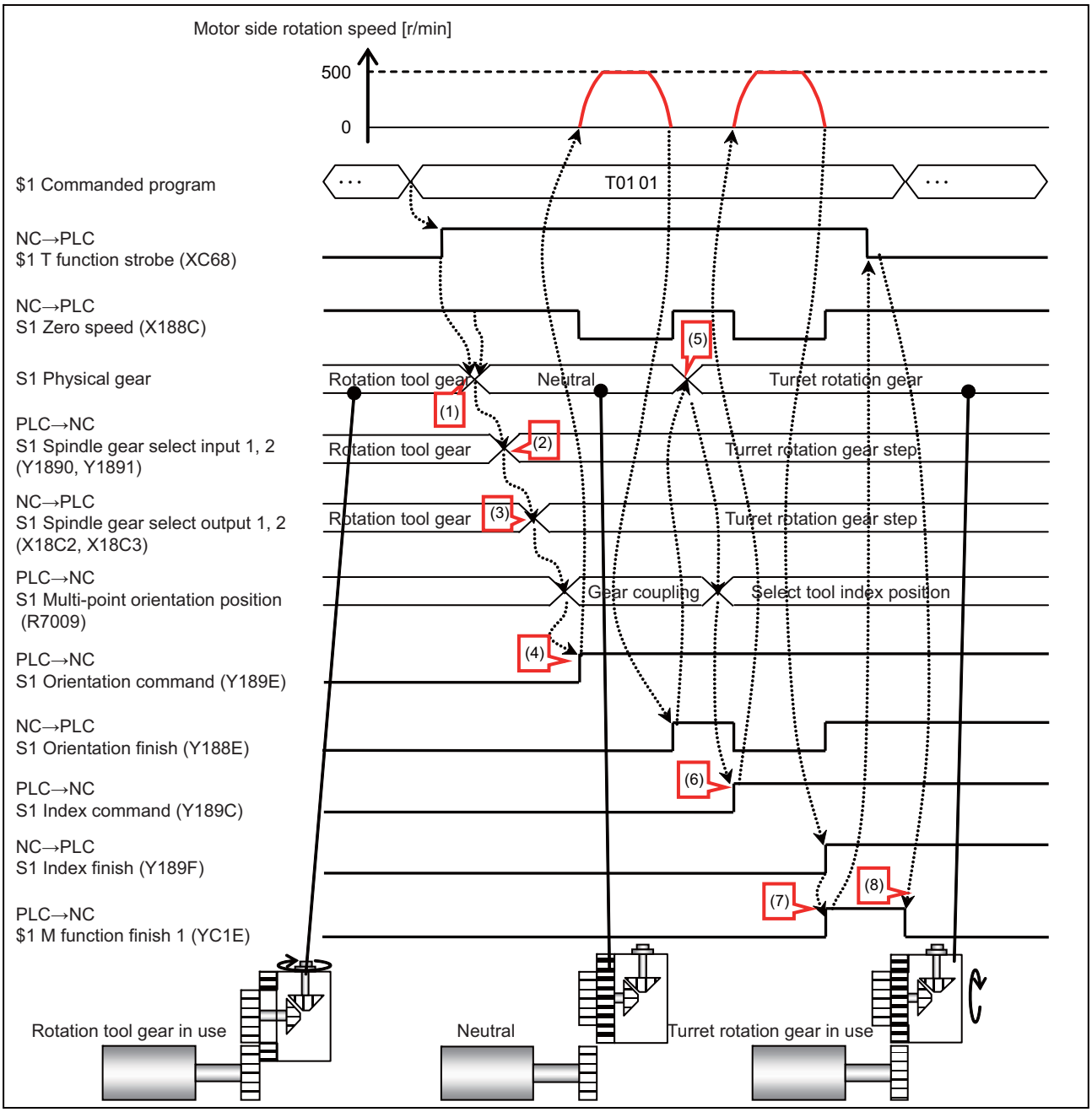
Example of Gear Change Operations when the Spindle is not Operating



	Operator	Operation Details
(1)	NC	Notifies the spindle gear shift command registers (X1885 and X1886) of the optimal gear based on the speed from the S command.
(2)	PLC	Turns the spindle stop (Y1894) ON after confirming that the currently selected physical gear and the spindle gear shift command registers (X1885 and X1886) are different (confirms spindle gear selection input registers 1 and 2 (Y1890 and Y1891)).
(3)	PLC	Changes the physical gear after confirming the zero speed register (X188C).
(4)	PLC	After changing the physical gear, sets the spindle gear selection input registers 1 and 2 (Y1890 and Y1891) with the gear corresponding to the physical gear just changed.
(5)	NC	After completing the gear change, notifies the spindle gear selection output registers 1 and 2 (X18C2 and X18C3) of the gear set to the spindle gear selection input registers 1 and 2 (Y1890 and Y1891).
(6)	PLC	Turns OFF the spindle stop (Y1894) after confirming that the gear change completes.
(7)	PLC	Turns ON miscellaneous function finish 1 (YC1E) after confirming speed arrival (X188D).
(8)	PLC	Turns OFF miscellaneous function finish 1 (YC1E) after confirming that spindle function strobe (XC64) is off.

Example of Gear Change Operations from the Mill to Turret Gear

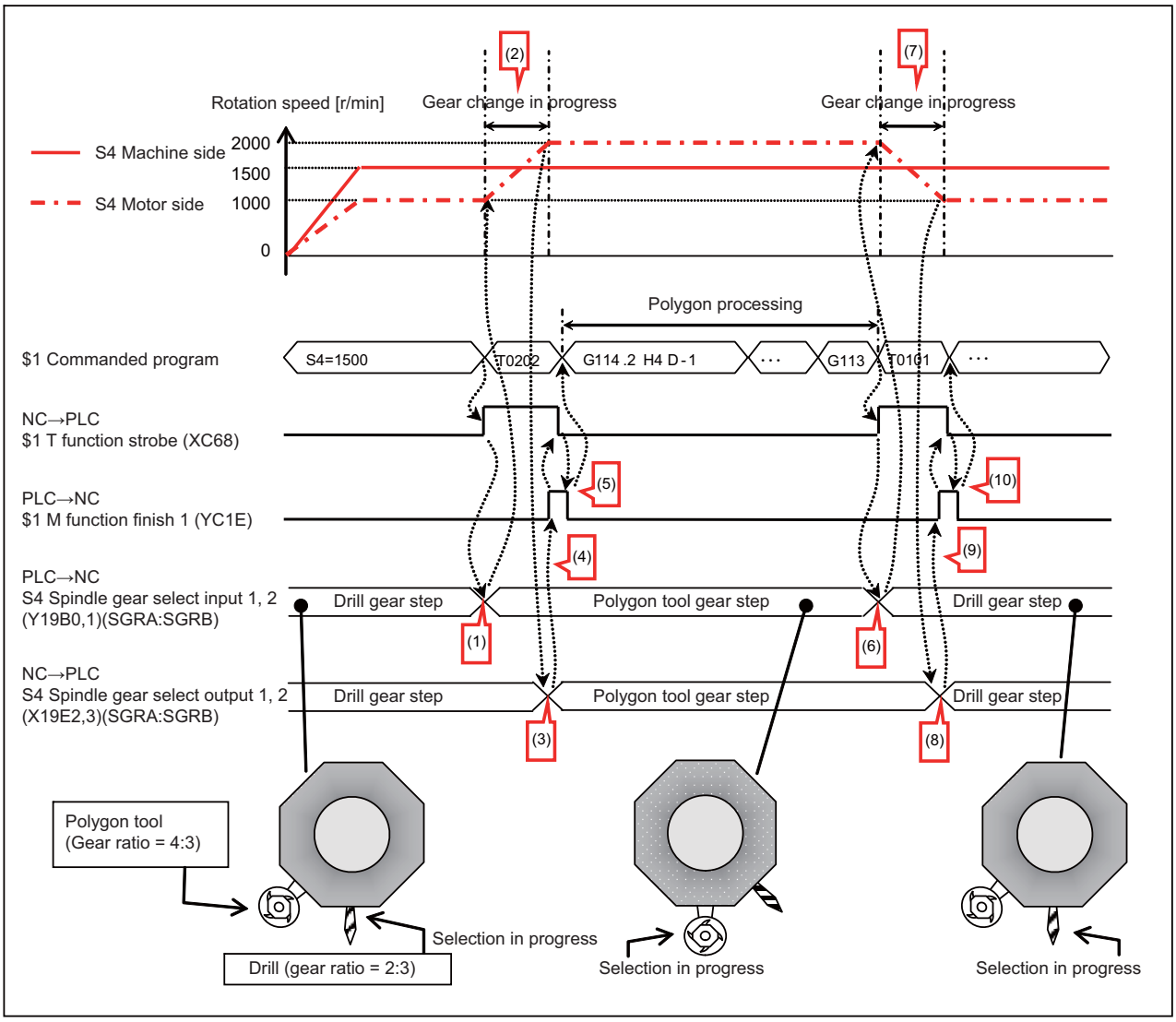
The following example is for a turret tool stand that rotates a turret and tool spindle by changing gears with one motor.



	Operator	Operation Details
(1)	PLC	When the T command is received, confirms the zero speed register (X188C) and changes the physical gear to neutral.
(2)	PLC	Sets the spindle gear selection input registers 1 and 2 (Y1890 and Y1891) with the turret gear.
(3)	NC	After completing the gear change, notifies the spindle gear selection output registers 1 and 2 (X18C2 and X18C3) of the gear set to the spindle gear selection input registers 1 and 2 (Y1890 and Y1891).
(4)	PLC	Sets the consolidated orientation position (R7009) with the gear connect position and turns ON the orientation command (Y189E) to set the positioning to the gear connect position.
(5)	PLC	After confirming the orientation complete register (X188E), changes the physical gear to the turret gear.
(6)	PLC	Sets the consolidated orientation position (R7009) with the selected tool indexing position and turns OFF the indexing command (Y189C) to turn the turret to the selected tool position.
(7)	PLC	Turns ON miscellaneous function finish 1 (YC1E) after confirming the indexing complete register (X189F).
(8)	PLC	Turns OFF miscellaneous function finish 1 (YC1E) after confirming that spindle function strobe (XC64) is off.

Example of Gear Change Operation when the Spindle is Operating

The following example is for a turret tool stand equipped with a turret motor and a spindle motor.



	Operator	Operation Details
(1)	PLC	Rotates the turret with the T command, changes the selected tool from the drill to the polygon tool, sets the spindle gear selection input registers 1 and 2 (Y19B0 and Y19B1) with the polygon cutter gear.
(2)	NC	Acceleration/deceleration is controlled so that the motor side speed is adjusted as appropriate for the polygon tool gear ratio.
(3)	NC	After completing the acceleration/deceleration and gear change process, notifies the spindle gear selection output registers 1 and 2 (X19E2 and X19E3) of the gear set to the spindle gear selection input registers 1 and 2 (Y19B0 and Y19B1).
(4)	PLC	Turns ON miscellaneous function finish 1 (YC1E) after confirming that the gear change completes.
(5)	PLC	Turns OFF miscellaneous function finish 1 (YC1E) after confirming that T function strobe (XC68) is off.
(6)	PLC	Rotates the turret with the T command, changes the selected tool from the drill to the polygon tool, and sets the spindle gear selection input registers 1 and 2 (Y19B0 and Y19B1) with the drill cutter gear.
(7)	NC	Acceleration/deceleration is controlled so that the motor side speed is adjusted as appropriate for the drill tool gear ratio.
(8)	NC	After completing the acceleration/deceleration process and gear change, notifies the spindle gear selection output registers 1 and 2 (X19E2 and X19E3) of the gear set to the spindle gear selection input registers 1 and 2 (Y19B0 and Y19B1).
(9)	PLC	Turns ON miscellaneous function finish 1 (YC1E) after confirming that the gear change completes.
(10)	PLC	Turns OFF miscellaneous function finish 1 (YC1E) after confirming that T function strobe (XC68) is off.

11.8.4 Operation with Other Functions

Allowing/Denying Gear Changes when Related Functions are Operating

The following table lists the operation that occurs when a command to change gears is output while related functions are operating. The operations in the following table also apply when the spindle-mode servo motor control is operating. Gear change commands should only be output when the function is in the "Change" status as listed in the operation column in the following table. Although gear changes can be made during dwell (Revolution-based designation), the feed per revolution, and the constant surface speed control do not output gear change commands during these scenarios as doing so may affect processing.

Name of Function	Status	Operation	Remarks
Spindle speed control (S command) Constant surface speed control	During Z-phase transit operation	Do not change	Changes gears after the speed command arrives when gear change commands were output during the Z-phase transit operation.
	During constant speed	Change	Changing gears while the spindle is operating changes the speed of the spindle, which prevents workpieces from being cut correctly. Do not perform cut processing during gear changes (spindle gear selection input signals 1 and 2 (GI1 and GI2) do not match with the spindle gear selection output signals 1 and 2 (GO1 and GO2)). Changing gears while the spindle is operating could cause the actual spindle speed display on the screen to change in accordance with the gear ratio.
	During acceleration/ deceleration	Do not change	Changes spindle gears after waiting for the stop or constant speed state when gear change commands were output during acceleration/deceleration.
Spindle position control (Spindle C axis)	During C-axis mode	Do not change	Changes spindle gears after waiting for the C-axis mode to cancel when the gear change commands were output during C-axis mode.
Spindle synchronization I/II Tool-spindle synchronization IA/IB/IC (Note)	During stop	Change	—
	During constant speed	Change	Changing gears while the spindle is operating changes the speed of the spindle, which prevents workpieces from being cut correctly. Do not perform cut processing during gear changes (spindle gear selection input signals 1 and 2 (GI1 and GI2) do not match with the spindle gear selection output signals 1 and 2 (GO1 and GO2)). Changing gears while the spindle is operating could cause the actual spindle speed display on the screen to change in accordance with the gear ratio.
	During acceleration/ deceleration	Do not change	Changes spindle gears after waiting for the stop or constant speed state when gear change commands were output during acceleration/deceleration.
	During phase alignment	Do not change	Starts changing gears after phase alignment completes and reperforms phase alignment after the gear change completes when gear selection input signals from a ladder are changed during phase alignment. Reperforms phase alignment after the gear change completes when gear selection input signals from a ladder are changed after phase alignment completes.
Tool-spindle synchronization II (Note)	During synchronization	Do not change	Changes spindle gears after waiting for synchronization to cancel when gear change commands are output during synchronization.
Spindle superimposition control	During spindle superimposition	Do not change	Changes spindle gears after waiting for the spindle superimposition to cancel when gear change commands are output during spindle superimposition.
Spindle orientation/indexing	During operation in this mode	Do not change	Changes spindle gears after waiting for the orientation/indexing mode to cancel when gear change commands are output while the orientation/indexing mode is in operation.

Name of Function	Status	Operation	Remarks
Coil switch	During coil switch operation	Do not change	Changes spindle gears after waiting for the coil switch to complete when gear change commands are output during the coil switch operation.
	Coil switch completion	Change	—
Synchronous tapping cycle/tap cycle/ thread cutting/thread cutting cycle	During synchronization tapping operation During tapping operation During thread cutting operation	Do not change	Changes spindle gears after waiting for the operation in the particular mode to complete when gear change commands are output during the operation of synchronous tapping cycle/tapping cycle/thread cutting.
Fixed cycle for drilling	During drilling operation	Change	Do not output the gear change command during the fixed cycle for drilling. Changing gears during the fixed cycle for drilling changes the speed of the spindle, which may prevent processing from being performed correctly.
Dwell (Revolution-based designation)	During dwell (Revolution-based designation)	Change	Do not output gear change commands during the dwell (Revolution-based designation). Changing gears during the dwell (Revolution-based designation) changes the speed of the spindle, which may prevent the dwell (Revolution-based designation) from being performed correctly.
Feed per revolution (Synchronous feed)	During feed per revolution operation	Change	Do not output the gear change command during the feed per revolution operation. Changing gears during the feed per revolution operation changes the speed of the spindle, which may prevent the feed per revolution operation from being performed correctly.

(Note) The tool-synchronization IC and tool-synchronization II commands cannot change gears for the servo axis and spindle position control C axis.

Operation when Commands are Sent to Related Functions while Changing Gears

The following table lists the operations that occur when a command is sent to related functions while changing gears. The operations in the following table also apply when the spindle-mode servo motor control is operating.

Name of Function	Operation
Spindle speed command (S command) Constant speed command (constant surface speed control) Spindle gear change Spindle position control (During C-axis mode) Spindle synchronization I/II Tool-spindle synchronization IA/IB/IC Tool-spindle synchronization II Spindle superimposition control Spindle orientation/indexing Synchronous tapping cycle/tap cycle Thread cutting/thread cutting cycle	Starts outputting commands after waiting for the gear change to complete when commands are output during gear changes.

Other Related Functions

Name of Function	Conditions
Turret indexing	Turret gear changes are disabled when "#3121 tret (turret indexing)" is set to "1".
Proximity orientation	Turret gear changes are disabled when "#3106 zrn_typ/bit F" is set to "1".
Guide bushing spindle synchronization	Turret gear changes are disabled for the guide bushing spindle synchronization standard axis and the guide bushing spindle. When changing turret gears while the spindle is configured as either a standard axis ("#3074 GBsp" = "1") or guide bushing spindle ("#3074 GBsp" = "2"), the operation error "M01 1015" is generated if the G/B spindle synchronization signal (Y778:GBON) is on.
Synchronous tapping orientation	The synchronous tapping orientation positions at the spindle end. The synchronous tapping orientation positions at the same position when repeatedly performed for the selected gear. When changing gears, it will not position at the same previous position even if the gear is the same.

11.8.5 Precautions

(1) The gear ratio ("#13057 SP057 (GRA1 Spindle Gear Ratio 1) "and "#13061 SP061 (GRB1 Motor Gear Ratio 1)") of the first gear for the spindle parameter is enabled when using the turret gear change control with normal spindles. The gear ratio of the first gear for the spindle parameter is enabled even if a gear has been selected by the turret gear change control. For this reason, configure the gear ratio for the spindle parameter to "1:1".

(2) The gear ratio ("#52201 SV001 PC1 (Motor Gear Ratio)" and "#52202 SV002 PC2 (Spindle Gear Ratio)") for the spindle servo parameter is enabled when using the turret gear change control with spindle servo motors. The gear ratio for the spindle servo parameter is enabled even if a gear has been selected by the turret gear change control. For this reason, configure the gear ratio for the spindle servo parameter to "1:1".

(3) When the turret gear change control is valid (the spindle specification parameter "#43001 sgear_tret" is set to "1"), set the following gear ratio parameters to "1":
- Spindle parameters: #13057 to #13064
- Spindle servo parameters: #52201 to #52202

(4) When you change the setting value of spindle specification parameter "#43002 SGRA1 (Spindle-side gear ratio 1)" to "#43009 SGRA4 (Motor shaft-side gear ratio 4)", gear ratio after the change will be valid from the next time of the gear selection. If you change the gear ratio of the selected step, select the gear step again after selecting another gear step.

11.9 Multiple-spindle Control II

11.9.1 Function and purpose

Multiple-spindle control II is a function that designates which spindle to select with the signals from PLC. The command is issued to the spindle with one S command.

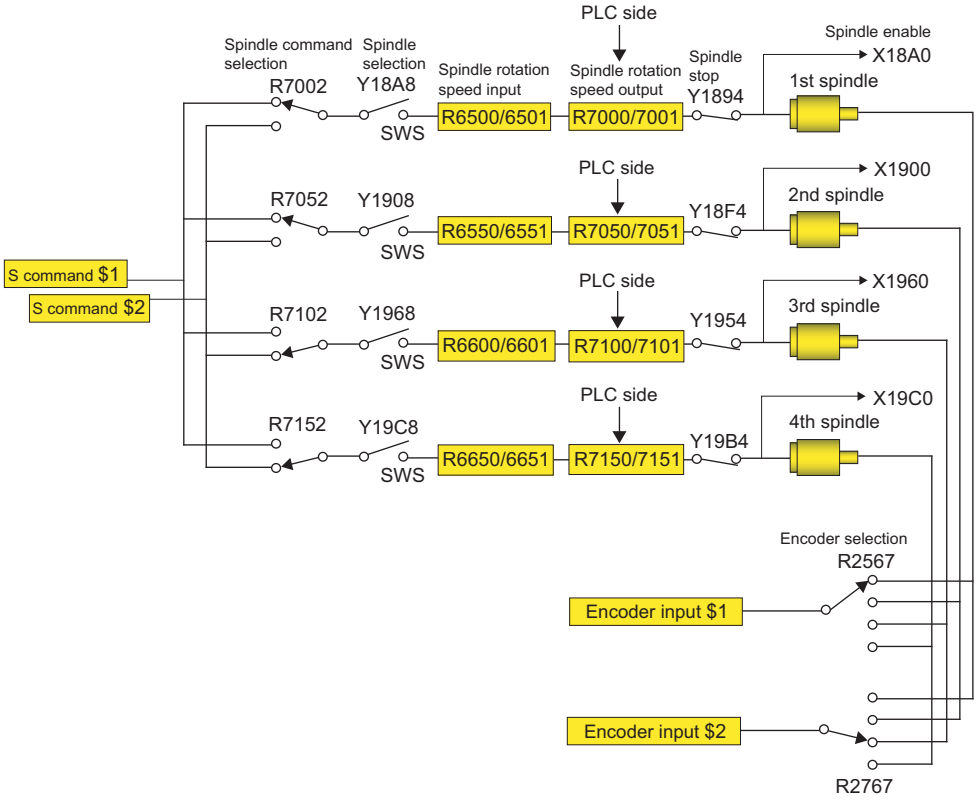
11.9.2 Detailed description

(1) Spindle command selection, spindle selection

The S command to the spindle is output as the rotation speed command to the selected spindle when the spindle selection signal (SWS) from the PLC turns ON. The selected spindle rotates at the output rotation speed. The spindle whose selection is canceled when the spindle selection signal (SWS) turns OFF maintains the speed at which it was rotating at before being canceled. This allows each axis to be simultaneously rotated at differing rotation speeds.

The spindle command selection signal is used to determine which part system each spindle receives the S command from.

<Example of 4 spindles in 2 part systems>



Spindle rotation speed control

There are two methods for spindle rotation speed control. Which to use can be selected by the parameter "#1300 ext36/bit1" (Spindle control for each part system).

Common to part systems (Parameter #1300 ext36/bit1 = 0)

The spindle function (S) command which was last issued to each spindle is valid.

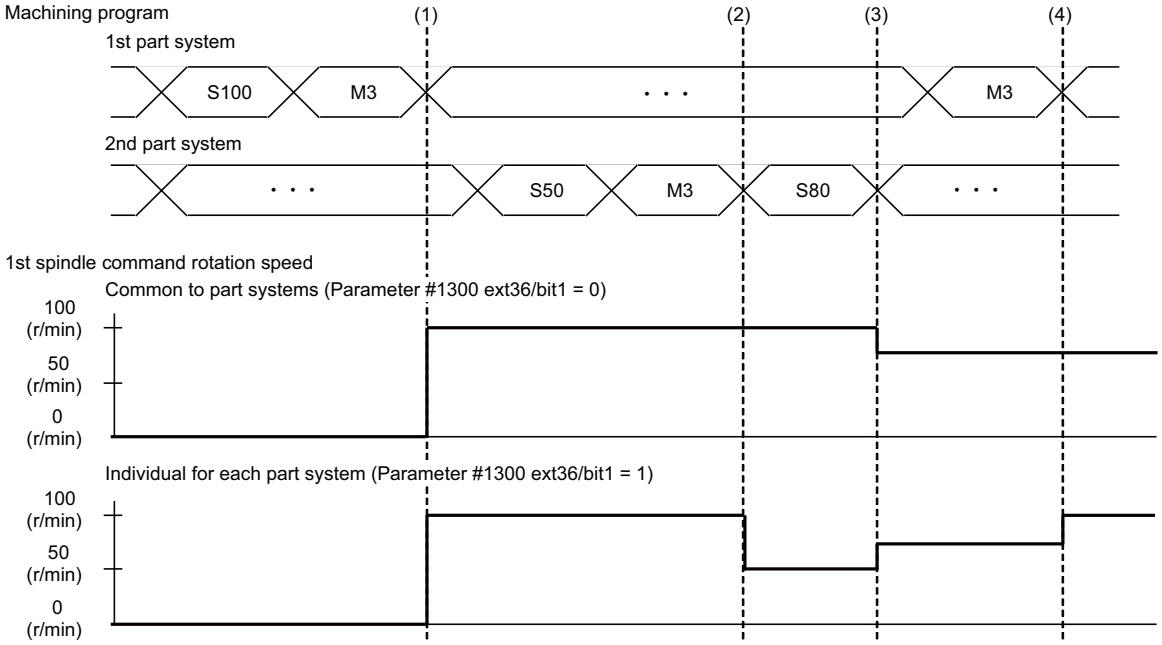
The spindle function (S) command issued in each part system becomes valid when the spindle to control is selected.

Individual for each part system (Parameter #1300 ext36/bit1 = 1)

The spindle function (S) command which was last issued in the part system where each spindle is selected is valid. Even when the part system selected for the spindle is switched, the current rotation speed is held until new spindle function (S) command is given.

Shown below is a timing chart of the 1st spindle command rotation speed when the spindle is used in two different part systems.

M3 command selects the 1st spindle and runs it forward.



(1) M3 command given in the 1st part system rotates the 1st spindle at 100r/min.

(2) M3 command given in the 2nd part system switches the part system selected for the 1st spindle to the 2nd part system. When spindle control is common to part systems, the current rotation speed (100r/min) is retained even though the selected part system is switched. When spindle control is individual for each part system, the rotation speed of the 1st spindle becomes 50r/min, a speed of the spindle function (S) command issued last in the 2nd part system, at the timing of part system switching.

(3) The spindle function (S) command given in the 2nd part system changes the rotation speed of the selected spindle (1st spindle) to 80r/min.

(4) M3 command given in the 1st part system switches the part system selected for the 1st spindle to the 1st part system. When spindle control is common to part systems, the current rotation speed (80r/min) is retained even though the selected part system is switched. When spindle control is individual for each part system, the rotation speed of the 1st spindle becomes 100r/min, a speed of the spindle function (S) command issued last in the 1st part system, at the timing of part system switching.

The following spindle commands are processed individually for each part system while the part system-based spindle control is enabled:

- Spindle function (S) command
- Constant surface speed control (G96)
- Spindle speed clamp (G92)

Operation when the spindle function (S) command and miscellaneous function (M) command are issued in the same block

When a spindle function (S) command is given in the same block as an M code for spindle selection (SWS: Y18A8) or for spindle command selection (SLSP: R7002), you can select the spindle to update the spindle command rotation speed input (R6500/R6501) with the parameter "#1300 ext36/bit3 (Spindle command rotation speed input timing selection)".

Spindle command rotation speed input timing selection: Invalid (parameter #1300 ext36/bit3 = 0)

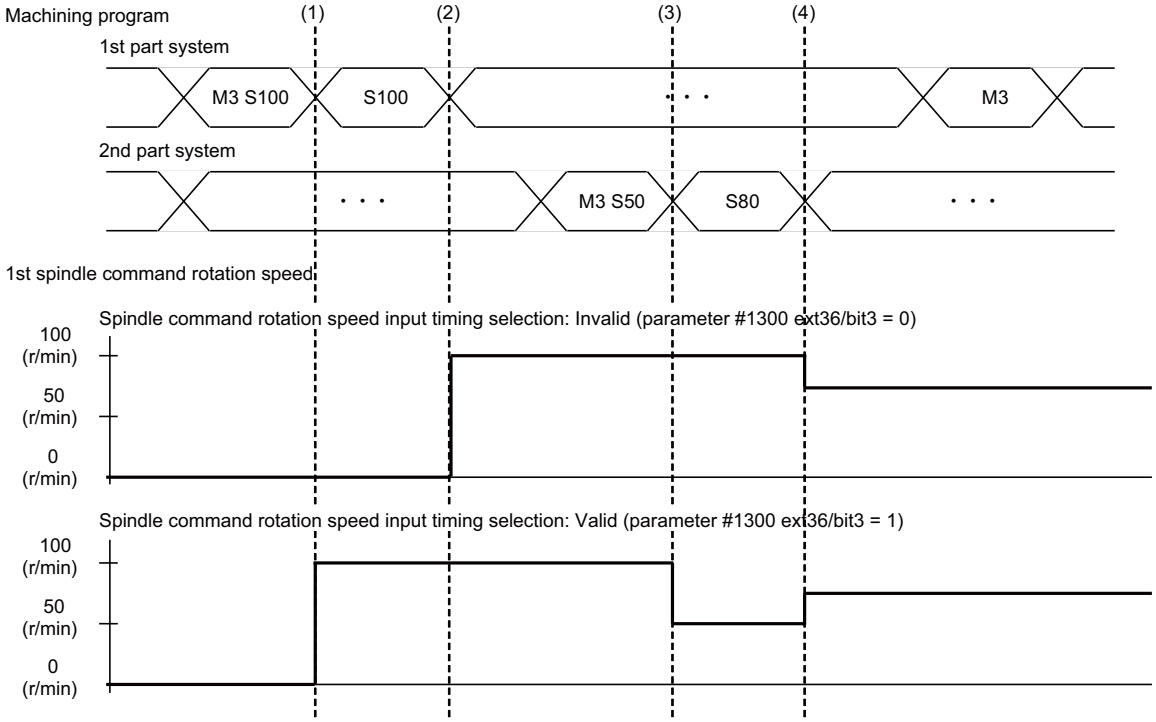
The spindle command rotation speed input (R6500/R6501) is updated for the spindle (the currently selected spindle) before selected in the same block.

Spindle command rotation speed input timing selection: Valid (parameter #1300 ext36/bit3 = 1)

The spindle command rotation speed input (R6500/R6501) is updated for the spindle after selected in the same block.

Shown below is a timing chart of the 1st spindle command rotation speed when the spindle is used in two different part systems.

M3 command selects the 1st spindle and runs it forward.



(1) M3 command, given in the same block as the spindle function (S) command, selects the spindle.
When the spindle command rotation speed input timing selection is invalid, the part system selected for the 1st spindle is switched to the 1st part system, but the 1st spindle remains at a standstill. *
When the spindle command rotation speed input timing selection is valid, the part system selected for the 1st spindle is switched to the 1st part system, and the 1st spindle rotates at the commanded speed of 100r/min at the same time.

(2) When the spindle function (S) command is given in the 1st part system, the rotation speed of the selected spindle (1st spindle) becomes 100r/min.

(3) M3 command, given in the same block as the spindle function (S) command selects the spindle.
When the spindle command rotation speed input timing selection is invalid, the part system selected for the 1st spindle is switched to the 2nd part system, but the 1st spindle remains at the present speed (100r/min). *
When the spindle command rotation speed input timing selection is valid, the part system selected for the 2nd spindle is switched to the 2nd part system, and the 1st spindle rotates at 50r/min at the same time.

(4) When the spindle function (S) command is given in the 2nd part system, the rotation speed of the selected spindle (1st spindle) becomes 80r/min.

* The spindle function (S) command updates the spindle command rotation speed input for the spindle selected before the block.

11.9.3 Relation with other functions

(1) Spindle clamp speed setting (G92)
This is valid only on the spindle selected with the spindle selection signal (SWS).
The spindle not selected with the spindle selection signal (SWS) maintains the speed at which it was rotating before being canceled.
(The spindle clamp speed is maintained with the G92 command.)

(2) Constant surface speed control
Constant surface speed control can be applied on all spindles.
The spindle rotation speed is automatically controlled during constant surface speed control, so when machining with constant surface speed, the spindle selection signal (SWS) for that spindle must be left ON.
The spindle not selected with the spindle selection signal (SWS) maintains the speed at which it was rotating before being canceled.

(3) Thread cutting/synchronous feed
The threads are cut with the spindle selected with the spindle selection signal (SWS). The encoder feedback selected with the encoder selection signal is used.

(4) Synchronous tapping
The synchronous tapping spindle is selected with the spindle selection signal (SWS).
Select the synchronous tapping spindle before issuing the synchronous tapping command. Do not change the synchronous tapping spindle selection signal during the synchronous tapping mode.
If a C axis mode command is issued to the synchronous tapping spindle, the "M01 operation error 1026" will occur. When the C axis command is canceled, the error will be canceled and machining will resume.

(5) Asynchronous tapping
The asynchronous tapping spindle is selected with the spindle selection signal (SWS).
Select the asynchronous tapping spindle before issuing the tapping command. Input a calculation request to change the asynchronous tapping spindle selection. Do not change the asynchronous tapping spindle selection signal during the asynchronous tapping mode.

(6) Tapping retract
The tapping retract spindle is selected with the spindle selection signal (SWS).
Select the spindle for which the tapping cycle execution is stopped before turning the tapping retract signal ON. If tapping retract is executed when a different spindle is selected, the "M01 operation error 1032" will occur. Do not change the spindle selection signal during tapping retract.

(7) Synchronous tapping with analog I/F spindle
When you command the synchronous tapping with analog I/F spindle with this function enabled, select the spindle to command the synchronous tapping with analog I/F spindle with the "Spindle selection" signal (SWS) before the block where the tapping cycle is commanded, then turn the "Recalculation request" signal (CRQ: YC2B) ON.

11.9.4 Restrictions

(1) The S manual numerical value command is invalid when multiple-spindle control II is valid.
(2) Setup parameter "#1199 Sselect" is invalid when multiple-spindle control II is valid.
(3) The spindle control mode changeover G code cannot be used when multiple-spindle control II is valid. A program error (P34) will occur.
(4) The "S1=***" and "S2=***" commands are invalid when multiple-spindle control II is valid. The program error (P33) will occur.
(5) The spindle gear shift command output signal (GR1/GR2) is not output when multiple-spindle control II is valid.

11.10 Spindle Position Control (Spindle/C Axis Control)

11.10.1 Outline

A spindle can be controlled as the rotary axis. After switching the spindle to the rotary axis, the positioning and the interpolation between the spindle and other NC axes can be operated in the same way as the NC axis by executing the position command (the movement command).
The NC axis for controlling the spindle as the rotary axis or the machinery for switching the spindle and NC axis (such as a gear switching machinery) had been necessary for controlling a spindle readily as the rotary axis, but they are not necessary with this function.
There are two method for switching a spindle and a rotary axis: PLC signal method and program command method. The method can be selected with the parameter.
This chapter describes the PLC signal method.
To enable the method, set "#3129 cax_spec/bit0" (Spindle position control selection method) to "0".

11.10.2 Switching Command

The spindle mode and the C axis mode can be switched with the "Servo OFF" signal (*SVFn) ON/OF with PLC ladder. The interpolation operation is enabled by executing the movement command to the C axis in the C axis mode same as NC axis.

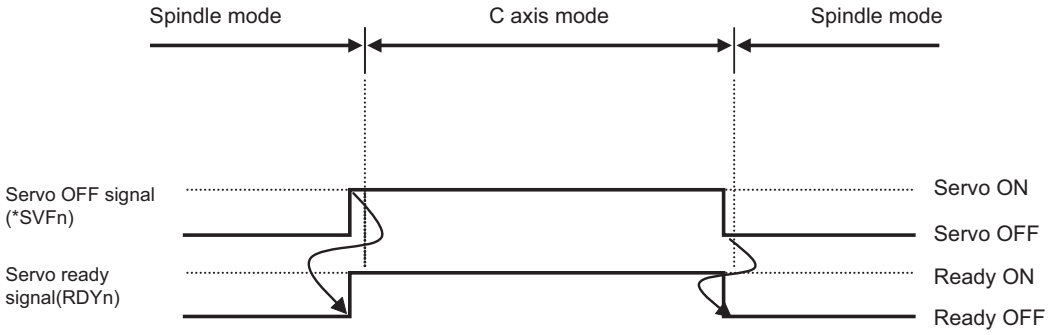
(1) Switching spindle mode to C axis mode
Change the "Servo OFF" signal (*SVFn) OFF to ON.

(2) Switching C axis mode to spindle mode
Change the "Servo OFF" signal (*SVFn) ON to OFF.

(Note 1) The spindle does not operate when switching from C-axis mode to spindle mode while the "Spindle forward run start" signal (SRN) and spindle reverse start signal (SRI) are on. The "Spindle forward run start" signal (SRN) and "Spindle reverse run start" signal (SRI) must be input again.

(Note 2) Turn off the "Servo OFF" signal (*SVFn) after confirming that the C axis has stopped. If the signal is turned OFF while moving, the operation error (M01 0005) is generated.

(Note 3) The state of mode changes is confirmed with the servo ready signal for the spinning axis.



Program Example Spindle S1 and NC axis C are configured

Program example	Mode	Explanation
M03 S1000	Spindle	Command of 1000 r/min with S1 spindle set to forward operation (M03)
:		:
:		:
M14	C axis	Change from the spindle mode to the C-axis mode by turning ON the C-axis servo off signal (M14).
G01X10.C20.F100		During C-axis mode, the S1 axis functions as an NC axis (C axis) command. Interpolation operation with other NC axes is possible.
:		:
M15	Spindle	Change from the C-axis mode to the spindle mode by turning OFF the C-axis servo off signal (M15).
M04 S1500		Command of 1500 r/min with S1 spindle set to reverse operation (M04)
:		:

11.10.3 Change Types

The type of operations to change from spindle mode to C-axis mode includes the zero point return type ("#3106 zrn_typ/bit 8" = "0") and the decelerate and stop type ("#3106 zrn_typ/bit 8" = "1").

(1) Zero point return type ("#3106 zrn_typ/bit 8" = "0")

The zero point return type must be used to change from the spindle mode to the C-axis mode.

Method	#3106 zrn_typ/bit F	Operation Details
Encoder Method	0	When changing to the C-axis mode, returns to the zero point, which is the default Z-phase position.

(2) Decelerate and stop type ("#3106 zrn_typ/bit 8" = "1")

The deceleration stop type includes "No zero point return" and "Zero point return" types. The axis does not move while changing to the C-axis mode. When the zero point return type (default return/initial-only) is selected, the decelerate and stop type ("#3106 zrn__typ/bit 8" = "1") for all spindles will default to the zero point return type (default return/initial-only).

Method	#1226 aux 10 /bit 3	#3129 cax_spec /bit 1	#1260 set 32 /bit 7	Operation Details
No return to origin	0	0	-	The coordinates of the position at which deceleration stops are established with the Z-phase position as the coordinate zero point.
		1	-	The position at which deceleration stops is the coordinate zero point.
Zero point return (default return)	1	-	0	Moves to the C-axis command position after returning to the zero point at the Z-phase position due to the output of the first C-axis move command after changing to the C-axis mode. Returns to the default zero point after changing to the C-axis mode.
Zero point return (initial-only return)		-	1	When changing to the first C-axis mode after turning on the power, the same operation as the zero point return (default return) is performed. The zero point return is not performed after the second and subsequent changes to the C-axis mode. Moves directly to the position per the C-axis command.

11.10.4 Details on operation per type

11.10.4.1 Zero Point Return Type Encoder Method

Method Configuration

Item	Parameter
Zero point return type	#3106 zrn_typ/bit 8=0

(Note) This can be configured for each spindle.

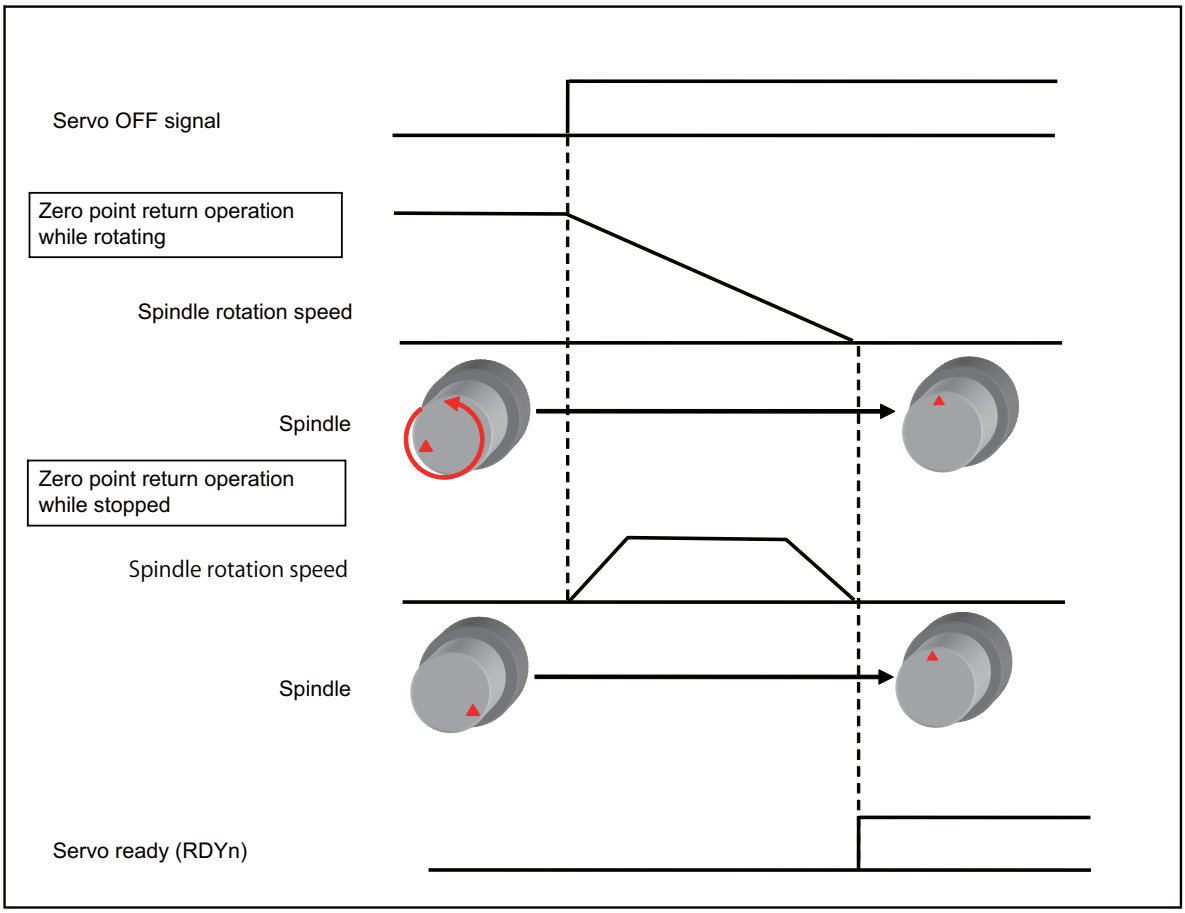
Details of Operation

[Parameters for Zero Point Return Operation]

The zero point return operation is executed with the following parameters.

Item	Parameter
Zero point return speed	#3112 cax_spd
Time constant during acceleration/deceleration	#3115 sp2_t1 through #3118 sp2_t4
Direction of zero point return	#3106 zrn_typ/bit 9, A
Zero point shift amount	#3113 cax_sft
Direction of zero point shift	#3106 zrn_typ/bit 0

[Zero Point Return when Changing to C-axis Mode]



[Speed Pattern During Zero Point Return]

(1) The zero point return from a spindle stop accelerates at a constant slope until it reaches the zero point return speed (#3112 cax_spd) and then decelerates at a constant slope and stops at the zero point (Z phase). (Refer to the following figure "During Stop")

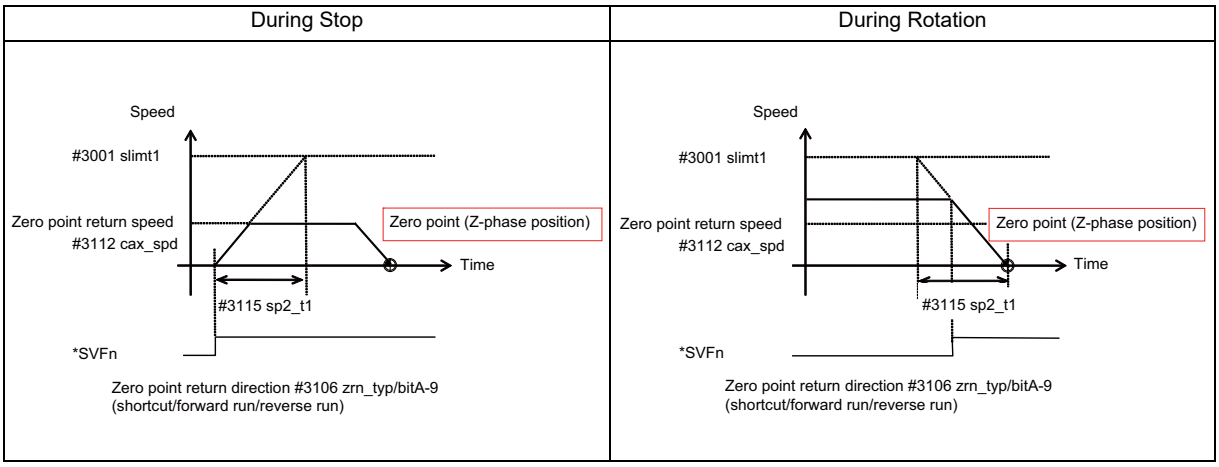
(2) The zero point return from a state of spindle operation operates as follows. (Refer to the following figure "During Rotation")

- When "#3106 zrn_typ/bitD (Interpolation mode selection 1(zero point return initiated during rotation))" is set to "0"
  The zero point return decelerates to a stop to the zero point (Z phase) at a constant inclination.
- When "#3106 zrn_typ/bitD (Interpolation mode selection 1(zero point return initiated during rotation))" is set to "1"
  The zero point return accelerates/decelerates to the zero point return speed with linear acceleration/deceleration pattern ("#3001 slimt1" and subsequent, "#3101 sp_t1" and subsequent) and then decelerates to a stop to the zero point position at a constant inclination.
  When the spindle rotation speed is lower than the zero point return speed or when the zero point return speed is "0", the zero point return stops at the zero point position without accelerating/decelerating to the zero point return speed.

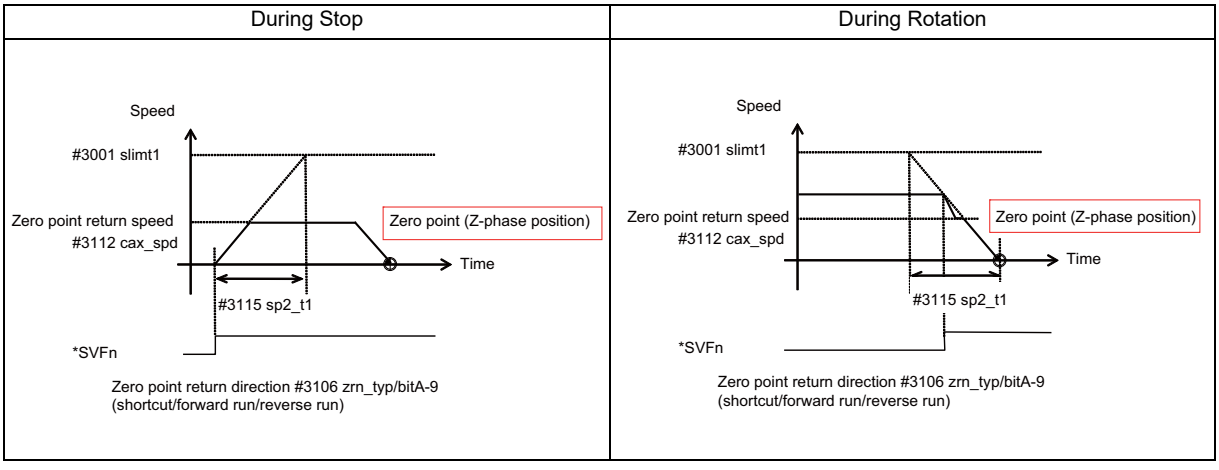
(3) When the Z-phase is not detected, it will be detected by the following operations:

- For the case that "#3106 zrn_typ/bit3 (Phase Z signal detection ON)" is set to "0" (Invalid)
  The Z-phase will be detected by rotating the spindle at the speed set in "#3112 cax_spd (Spindle C axis zero point return speed)".
  After detecting the Z-phase, the C axis zero point return operation is performed.
- For the case that "#3106 zrn_typ/bit3 (Phase Z signal detection ON)" is set to "1" (Valid)
  The Z-phase will be detected by rotating the spindle at the speed set in "#3109 zdetspd (Z-phase detection speed)".
  After detecting the Z-phase, the C axis zero point return operation is performed at the speed set in "#3112 cax_spd (Spindle C axis zero point return speed)".

[When #3106 zrn_typ/bitD = 0]



[When #3106 zrn_typ/bitD = 1]



[Zero Point Return while Spindle is at a Standstil]

(1) Returns to the zero point (Z-phase position) in accordance with the direction of zero point return parameter for the spindle C axis (#3106 zrn_typ/bit A-9).
Directions of rotation include forward, reverse, and shortcut.

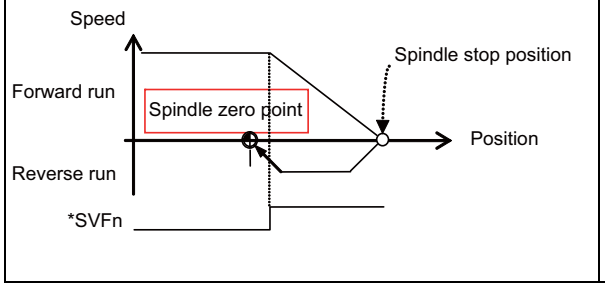
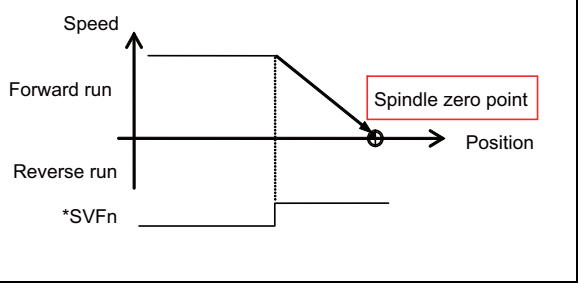
(2) Does not return to the zero point if already positioned at the coordinate zero point. (Z phase has already been passed)

(3) When the Z-phase is not detected, it will be detected by the following operations, and then the C axis changeover operation is performed:
- For the case that t "#3106 zrn_typ/bit3 (Phase Z signal detection ON)" is set to "0" (Invalid)
The Z-phase will be detected by rotating the spindle in the direction set in "#3106 zrn_typ/bitA,bit9 (Spindle/C axis zero return direction)".
When "#3106 zrn_typ/bitA,bit9 (Spindle/C axis zero return direction)" is "00" (shortcut), the Z-phase detection is performed by rotating the spindle in the direction set in "#3106 zrn_typ/bit0 (Z-phase detection direction)".
- For the case that "#3106 zrn_typ/bit3 (Phase Z signal detection ON)" is set to "1" (Valid)
The Z-phase will be detected by rotating the spindle in the direction set in "#3106 zrn_typ/bit0 (Z-phase detection direction)".

[Zero Point Return while Spindle is Rotating]

(1) When the direction of spindle rotation and the direction of zero point return parameter for the spindle C axis (#3106 zrn_typ/bit A-9) are the same or set to shortcut, returns directly to the coordinate zero point (Z-phase position) in the direction of spindle rotation.

(2) When the direction of spindle rotation and the direction of zero point return parameter for the spindle C axis (#3106 zrn_typ/bit A-9) are the different, returns zero point (Z-phase position) in accordance with the direction of zero point return parameter (#3106 zrn_typ/bit A-9).
When the direction of zero point return parameter (#3106 zrn_typ/bit B) is set to "1", returns directly to the zero point (Z-phase position) in the direction of spindle rotation.

#3106 zrn_typ bit A-9 : 10 (Reverse) ＋ Spindle forward state bit B : 0 (Direction of C-axis zero point return)	#3106 zrn_typ bit A-9 : 10 (Reverse) ＋ Spindle forward state bit B : 1 (Direction of spindle rotation)
	

11.10.4.2 Decelerate and Stop Type (No Zero Point Return)

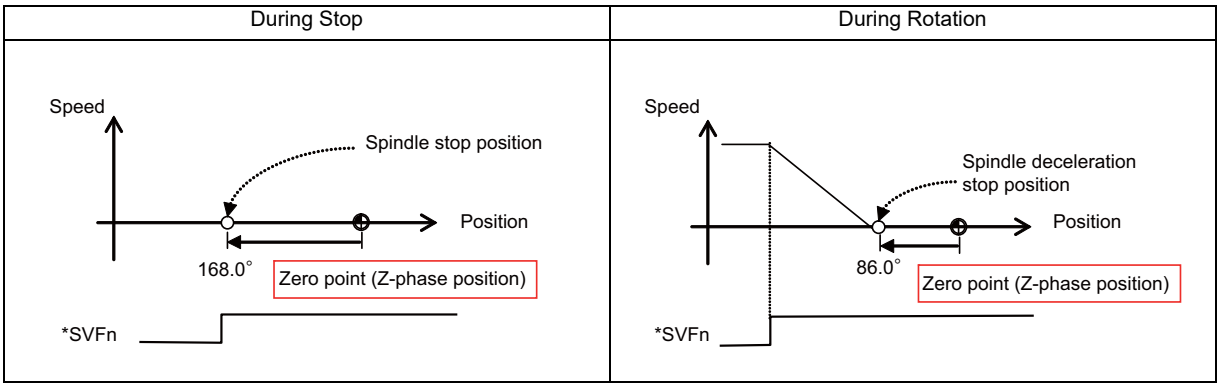
Method Configuration

Item	Parameter
Decelerate and stop type	#3106 zrn_typ/bit 8=1
No return to origin	#1226 aux 10/bit 3=0

(Note) This can be configured for each spindle.

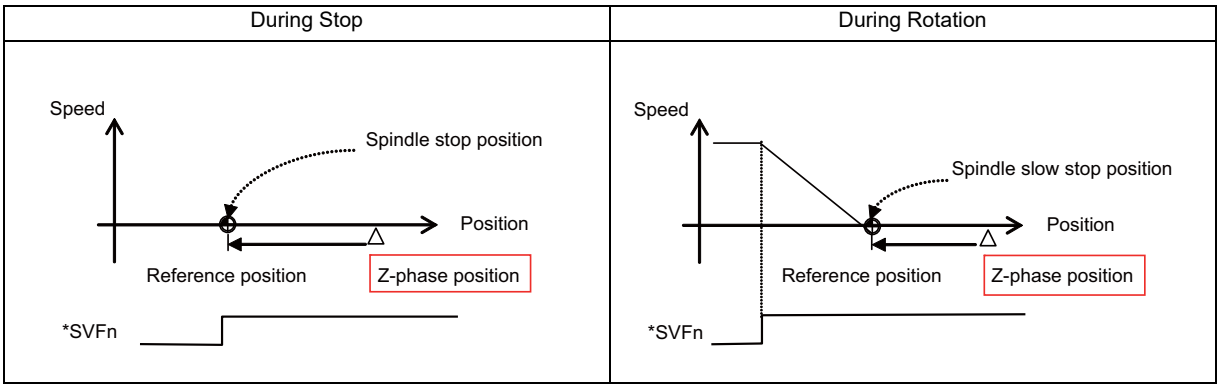
Using Method to Establish Coordinates at Stop Position after Deceleration

Item	Parameter
Coordinate establishment at stop position after deceleration	#3129 cax_spec/bit 1=0



Using Method to Set Stop Position after Deceleration as Coordinate Zero Point

Item	Parameter
Coordinate zero point at stop position after deceleration	#3129 cax_spec/bit 1=1



11.10.4.3 Decelerate and Stop Type (Zero Point Return)

Method Configuration

Item	Parameter
Decelerate and stop type	#3106 zrn_typ/bit8=1
Zero point return	#1226 aux10/bit3=1

(Note) When the zero point return type is selected, spindles set to the decelerate and stop type will all be changed to the zero point return type (default/initial-only).

Detailed operation

Moves to the C-axis command position after returning to the zero point at the Z-phase position due to the output of the first C-axis move command after changing to the C-axis mode.
Returns to the default zero point after changing to the C-axis mode.

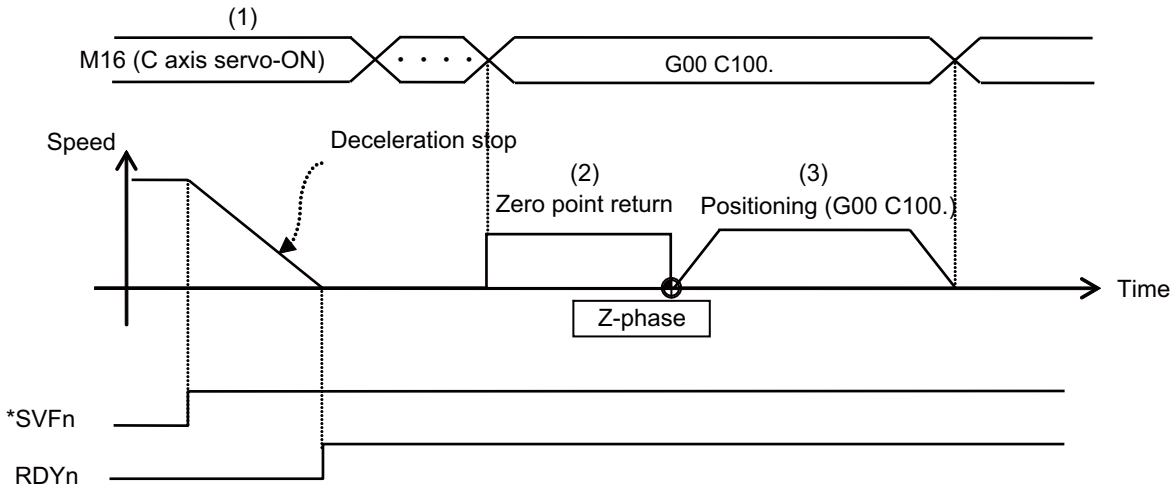
[Parameters for Zero Point Return Operation]
The zero point return operation is executed with the following parameters.

Item	Parameter
Zero point return speed	#2026 G28crp
Time constant during acceleration/deceleration	Step
Direction of zero point return	#3106 zrn_typ/bitA,bit9
Zero point shift amount	#2027 G28sft or #3113 cax_sft (*1)
Direction of zero point shift	#2030 dir (-)

(*1) Select which parameter to use with "#1254 set26/bit4" (Reference of zero point shift distance for spindle/C axis).

[Operation When Changing to the C-axis Mode]
(1) Changes to C-axis mode
(2) Executes the zero point return with the first C-axis move command after the mode change.
(3) Moves to the position specified by the C-axis command.
(4) Changes to the C-axis mode again after changing to the spindle mode.
(5) Executes steps 2 and 3.

The G28 command or manual reference position return can be executed before the automatic insertion of the zero point return at step 2. In this case, the automatic insertion of the zero point return is not performed at step 2.



11.10.5 Precautions

(1) Turning the "servo OFF" signal (*SVFn) OFF while the C axis is moving and changing from the C-axis mode to the spindle mode results in generation of the operation error (M01 0005). Clear the error by performing a reset.

(2) Turning the "servo OFF" signal (*SVFn) ON while power is turned ON will cause the Z-phase detection operation to execute while the power is turned ON and cause the return to origin operation to execute after the Z phase has passed if the zero point return type ("#3106 zrn_typ/bit8" is "0") is enabled.
If the decelerate and stop type ("#3106 zrn_typ/bit8" is "1") is enabled, the Z-phase detection operation is executed by the move command and the positioning operation is executed after the zero point return operation.

(3) When the Z phase detection speed limit is enabled (*1) and S command is made with the Z phase not detected, Z phase detection speed is limited so that it is less than or equal to the S command speed.
(*1) The validity depends on the MTB specifications (parameter "#3106 zrn_typ/bit3" is set to "1" and "#1762 cfgPR12/bit6" is set to "1").

11.10.6 Position Loop Gain Switch

Position loop gain switch of spindle (C axis)

Position loop gain can be switched for each control mode.

(1) For spindle motors
Parameters of position loop gain used in each control mode is shown below.
(Note) Position loop gain in C axis mode (#43095 SP002cax (PGNcax)) is available only for spindle motors.

		C axis mode	Spindle mode		
			Non-interpolation type	Synchronous tapping	Spindle synchronization
Position loop gain	#43095 is set to "0".	#13002 SP002(PGN)	#13001 SP001(PGV)	#13002 SP002(PGN)	#13003 SP003(PGS)
	#43095 is set to other than "0".	#43095 SP002cax(PGNcax)	#13001 SP001(PGV)	#13002 SP002(PGN)	#13003 SP003(PGS)

(2) For spindle-mode servo motors
When spindle-mode servo motor is used as spindle of synchronous tapping or C axis, position loop gain follows the setting of "#52001 SVSPEC" (Spindle-mode servo: Specification).

Switching position loop gain of servo axis (other than C axis)

When an interpolation of C axis and that of servo axis other than C axis are required, including milling machining, the position loop gain of the two axes needs to be the same.
However, when the setting of position loop gain of C axis cannot be the same with the gain of servo axis (#2203 SV003 (PGN1)) due to problems such as spindle inertia, set the same value with the position loop gain of the C axis to the "Position loop gain 1 in spindle synchronous control" (#2249 SV049 (PGN1sp)) of the servo axis. By doing so, gain of servo axis can be switched to position loop gain in spindle synchronization control at the timing of switching C axis, and interpolation can be performed.

Valid/invalid of gain switchover can be set with the parameter "#3129 cax_spec/bit4" (Gain switchover for all the axes within the part system when C axis is selected). When there is even one C axis with the parameter "#3129/bit4" set to "1", the gains of all servo axes excluding C axis are switched as shown in the following table.

Servo parameter			Switchover parameter in C axis mode	
#	Name		#	Name
2203	SV003(PGN1)	↔	2249	SV049(PGN1sp)
2204	SV004(PGN2) when SHG is set	↔	2250	SV050(PGN2sp) when SHG is set
2257	SV057(SHGC) when SHG is set	↔	2258	SV058(SHGCsp) when SHG is set

11.11 Spindle Synchronization Control II

11.11.1 Function and purpose

For spindle synchronization function II, selection of the synchronized spindle and synchronization start, etc., are all designated from the PLC. Refer to the instruction manual issued by the machine tool builder for details.
While this function is running, other spindle synchronization function (Spindle synchronization control I, spindle synchronization control II, tool spindle synchronization IA, tool spindle synchronization IB, tool spindle synchronization II, or spindle superimposition control) cannot be commanded. Similarly, while other spindle synchronization function is running, spindle synchronization control II cannot be commanded. An operation error (M01 1005) occurs then.

11.11.2 Detailed description

(1) Reference spindle and synchronized spindle selection
Select the reference spindle and synchronized spindle for synchronous control from the PLC.

Device No.	Signal name	Abbreviation	Explanation
R7016	Reference spindle selection	-	Select a serially connected spindle to be controlled as the reference spindle. (0: 1st spindle) 1: 1st spindle 2: 2nd spindle 3: 3rd spindle 4: 4th spindle 5: 5th spindle 6: 6th spindle 7: 7th spindle 8: 8th spindle (Note1) Spindle synchronization will not take place if a spindle not connected in serial is selected. (Note2) If "0" is designated, the 1st spindle will be controlled as the reference spindle.
R7017	Synchronized spindle selection	-	Select a serially connected spindle to be controlled as the synchronized spindle. (0: 2nd spindle) 1: 1st spindle 2: 2nd spindle 3: 3rd spindle 4: 4th spindle 5: 5th spindle 6: 6th spindle 7: 7th spindle 8: 8th spindle (Note3) Spindle synchronization will not take place if a spindle not connected in serial is selected or if the same spindle as the reference spindle is selected. (Note4) If "0" is designated, the 2nd spindle will be controlled as the synchronized spindle.

(2) Starting spindle synchronization

The spindle synchronization mode is entered by inputting the spindle synchronization signal (SPSY). The synchronized spindle will be controlled in synchronization with the rotation speed commanded for the reference spindle during the spindle synchronization mode.

When the difference of the reference spindle and synchronized spindle rotation speeds reaches the spindle synchronization rotation speed reach level setting value (#3050 sprlv), the spindle rotation speed synchronization complete signal (FSPRV) will be output.

The synchronized spindle's rotation direction is designated with the spindle synchronization rotation direction designation as the same as the reference spindle or the reverse direction.

Device No.	Signal name	Abbreviation	Explanation
Y18B0	Spindle synchronization	SPSY	The spindle synchronization mode is entered when this signal turns ON.
X18A8	In spindle synchronization	SPSYN1	This notifies that the mode is the spindle synchronization.
X18A9	Spindle rotation speed synchronization complete	FSPRV	This is turned ON when the difference of the reference spindle and synchronized spindle rotation speeds reaches the spindle rotation speed reach level setting value during the spindle synchronization mode. This signal is turned OFF when the spindle synchronization mode is canceled, or when an error exceeding the spindle rotation speed reach level setting value occurs during the spindle synchronization control mode.
Y18B2	Spindle synchronization rotation direction designation	-	Designate the reference spindle and synchronized spindle rotation directions for spindle synchronization. 0: The synchronized spindle rotates in the same direction of the reference spindle. 1: The synchronized spindle rotates in the reverse direction of the reference spindle.

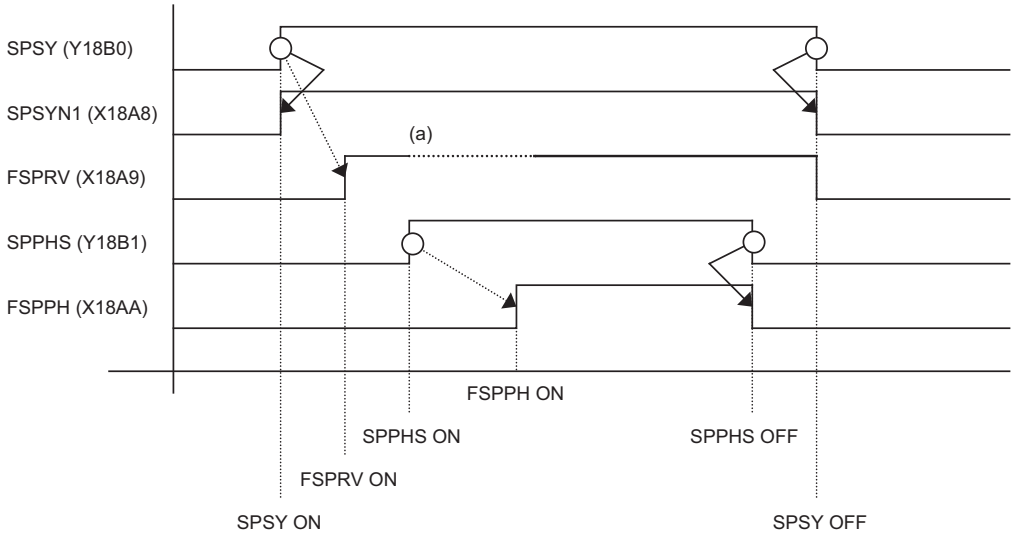
(3) Spindle phase alignment

Spindle phase synchronization starts when the spindle phase synchronization signal (SPPHS) is input during the spindle synchronization mode.

The spindle phase synchronization complete signal is output when the spindle synchronization phase reach level setting value (#3051 spplv) is reached.

The synchronized spindle's phase shift amount can also be designated from the PLC.

Device No.	Signal name	Abbreviation	Explanation
Y18B1	Spindle phase synchronization control	SPPHS	Spindle phase synchronization starts when this signal is turned ON during the spindle synchronization mode. (Note1) If this signal is turned ON in a mode other than the spindle synchronization mode, it will be ignored.
X18AA	Spindle phase synchronization control	FSPPH	This signal is output when the spindle synchronization phase reach level is reached after starting spindle phase synchronization.
R7018	Phase shift amount setting	-	Designate the synchronized spindle's phase shift amount. Unit: 360°/4096



(a) Turns OFF temporarily to change the rotation speed during phase synchronization.

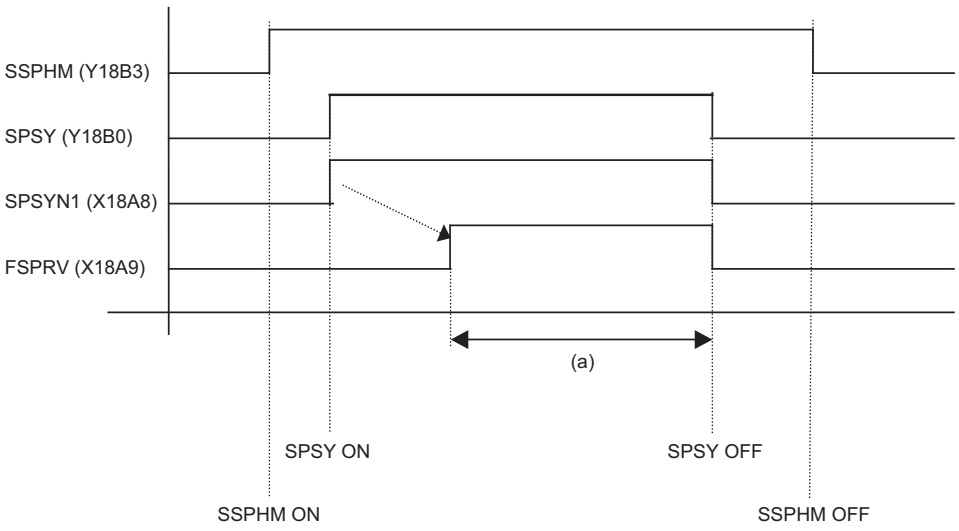
SPSY : Spindle phase synchronization
SPSYN1 : In spindle synchronization
FSPRV : Spindle rotation synchronization complete
SPPHS : Spindle phase synchronization control
FSPPH : Spindle phase synchronization complete

(4) Calculating the spindle synchronization phase shift amount and requesting phase offset

The spindle phase shift amount calculation function obtains and saves the phase difference of the reference spindle and synchronized spindle by turning the PLC signal ON during spindle synchronization. When calculating the spindle phase shift, the synchronized spindle can be rotated with the handle, so the relation of the phases between the spindles can also be adjusted visually.

If the spindle phase synchronization control signal is input while the phase offset request signal (SSPHF) is ON, the phases will be aligned using the position shifted by the saved phase shift amount as a reference. This makes aligning of the phases easier when grasping the material that the shape of one end differs from the other end.

Device No.	Signal name	Abbreviation	Explanation
Y18B3	Phase shift calculation request	SSPHM	If spindle synchronization is carried out while this signal is ON, the phase difference of the reference spindle and synchronized spindle will be obtained and saved.
Y18B4	Phase offset request	SSPHF	If spindle phase synchronization is carried out while this signal is ON, the phase will be aligned using the position shifted by the saved phase shift amount as a basic position.
R6516	Phase difference output	-	The delay of the synchronized spindle in respect to the reference spindle is output. Unit:360°/4096 (Note 1) If either the reference spindle or synchronized spindle has not passed through the Z phase, etc., and the phase cannot be calculated, -1 will be output. (Note 2) This data is output only while calculating the phase shift or during spindle phase synchronization.
R6518	Phase offset data	-	The phase difference saved with phase shift calculation is output. Unit:360°/4096 (Note 3) This data is output only during spindle synchronization.



(a) The phase difference in this interval is saved. (The synchronized spindle can be controlled with the handle.)

SSPHM : Phase shift calculation request
SPSY : Spindle synchronization
SPSYN1 : In spindle synchronization signal
FSPRV : Spindle synchronization complete signal

(Note 1) The phase cannot be aligned while calculating the phase shift.

(Note 2) The synchronized spindle cannot be rotated with the handle when the manual operation mode is set to the handle mode.

(5) Phase error monitor

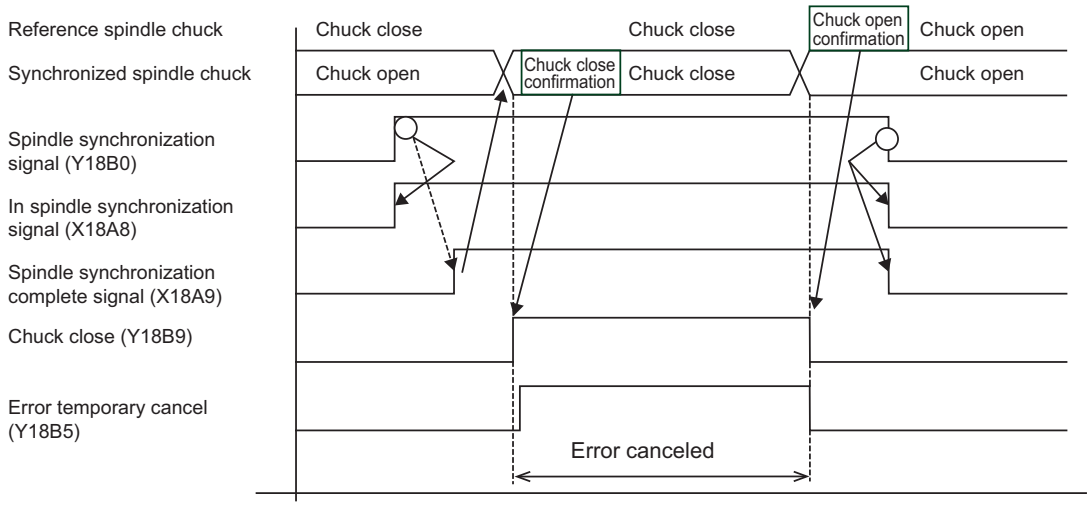
The phase error can be monitored during spindle phase synchronization.

Device No.	Signal name	Abbreviation	Explanation
R6519	Phase error monitor	-	The phase error during spindle phase synchronization control is output as a pulse unit.
R6520	Phase error monitor (lower limit value)	-	The lower limit value of the phase error during spindle phase synchronization control is output as a pulse unit.
R6521	Phase error monitor (upper limit value)	-	The upper limit value of the phase error during spindle phase synchronization control is output as a pulse unit.

(6) Chuck close signal

The synchronized spindle side carries out droop compensation while the chuck is opened, and aligns itself with the reference spindle. However, when the chuck is closed, the droop compensation is added, and the synchronization error with the base increases. Droop compensation is prevented with the chuck close signal and the position where the chuck is grasped is maintained with position compensation.

Device No.	Signal name	Abbreviation	Explanation
Y18B9	Chuck close	-	This turns ON when the chuck is closed. When this signal turns ON, the compensation between the reference spindle and synchronized spindle will change from droop compensation to position compensation.
X18AC	Chuck close confirmation	-	This turns ON when the chuck close signal is received during the spindle synchronization mode.



(Note 1) Use the error temporary cancel only when there is still an error between the spindle and synchronization with the chuck close signal.

(7) Error temporary cancel function

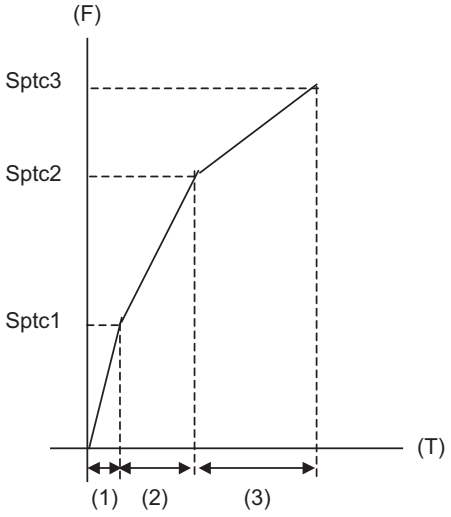
When spindle synchronization is carried out while grasping the workpiece with the reference spindle and rotating, if the chuck is closed to grasp the workpiece with the synchronized spindle, the speed will fluctuate due to external factors and an error will occur. If spindle synchronization is continued without compensating this error, the workpiece will twist.

This torsion can be prevented by temporarily canceling this error.

Device No.	Signal name	Abbreviation	Explanation
Y18B5	Error temporary cancel	SPDRP0	The error is canceled when this signal is ON.

(8) Multi-step acceleration/deceleration

Up to eight steps of acceleration/deceleration time constants for spindle synchronization can be selected according to the spindle rotation speed.



(F) Rotation speed
(T) Time

(1) Time required from stopped state to sptc1 setting rotation speed
spt * (sptc1/maximum rotation speed)
(2) Time required from sptc1 to sptc2 setting rotation speed
spt * ((sptc2-sptc1)/maximum rotation speed) * spdiv1
(3) Time required from sptc2 to sptc3 setting rotation speed
spt * ((sptc3-sptc2)/maximum rotation speed) * spdiv2

11.11.3 Precautions and restrictions

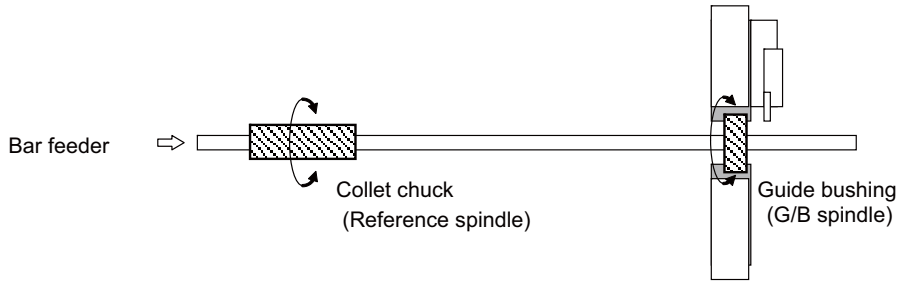
(1) When carrying out spindle synchronization, a rotation command must be issued to both the reference spindle and synchronized spindle. The synchronized spindle's rotation direction will follow the reference spindle rotation direction and spindle synchronization rotation direction designation regardless of whether a forward or reverse run command is issued.
(2) The spindle synchronization control mode will be entered even if the spindle synchronization control signal is turned ON while the spindle rotation speed command is ON. However, synchronous control will not actually take place. Synchronous control will start after the rotation speed command has been issued to the reference spindle, and then the spindle synchronization complete signal will be output.
(3) The spindle rotating with spindle synchronization will stop when emergency stop is applied.
(4) An operation error will occur if the spindle synchronization signal is turned ON while the reference spindle and synchronized spindle designations are illegal.
(5) When the spindle speed is clamped with the maximum rotation speed clamp or with the maximum clamp speed specified by the address S in G92 during spindle synchronization, the clamp value of the reference or synchronized spindle, whichever is smaller, is applied.
(6) Orientation of the synchronized spindle is not possible during the spindle synchronization. To carry out orientation, turn the spindle synchronization signal OFF first.
(7) The rotation speed command is invalid for the synchronized spindle during the spindle synchronization. The commanded rotation speed will be validated after spindle synchronization is canceled.
(8) The constant surface speed control is invalid for the synchronized spindle during the spindle synchronization.
(9) If the phase offset request signal is turned ON before the phase shift is calculated and then spindle phase synchronization is executed, the shift amount will not be calculated.
(10) The spindle Z-phase encoder position parameters are invalid when phase offset is carried out.
(11) If spindle phase synchronization is started while the phase shift calculation request signal is ON, the operation error (M01 1106) will occur.
(12) Turn the phase shift calculation request signal ON when the reference spindle and synchronized spindle are both stopped. If the phase shift calculation request signal is ON while either of the spindles is rotating, the operation error (M01 1106) will occur.
(13) The phase shift amount saved in the NC is held until the next phase shift is calculated. (This value is saved even when the power is turned OFF.)
(14) Always set the "Chuck close". If the "Chuck close" is not set, an excessive load may be applied on the machine or an alarm may occur.
(15) The synchronous tap spindle cannot be designated as the reference or synchronized spindle of the spindle synchronization II.
(The operation error (M01 1007) will occur, which causes automatic operation to pause.)
You cannot command a synchronous tapping that uses the reference spindle or synchronized spindle of spindle synchronization II, either.
(The operation error (M01 1139) will occur, which causes automatic operation to pause.)
(16) Spindle-mode rotary axis cannot be designated as reference spindle or synchronized spindle of spindle synchronization II. (The operation error (M01 1024) will occur, which causes automatic operation to pause.)

11.12 Guide Bushing Spindle Synchronization

11.12.1 Outline

This function is for a machine with a spindle motor to rotate a guide bushing: This function allows the guide bushing spindle motor (hereinafter called G/B spindle) to synchronize with a reference spindle motor (hereinafter called reference spindle).

Spindle motors that are controlled by the spindle drive unit are required (for both reference and G/B spindles) in order to use this function.



(1) Designate a reference spindle and a G/B spindle using the parameter "#3074 GBsp".
(2) When the ladder turns ON the "G/B spindle synchronization valid" (GBON) signal, the reference spindle and the G/B spindle enter the spindle synchronization state. The operation error (M01 1014) occurs if the spindle forward/reverse run start command, orientation command, or C axis servo ON command is issued with the "G/B spindle synchronization valid" (GBON) signal OFF. Turn the "G/B spindle synchronization: temporary cancel" (GBOFF) signal ON in order to control independently each of the reference spindle and the G/B spindle.
(3) The reference spindle and the G/B spindle accelerate/decelerate synchronizing.
(4) The operations according to the combination of reference spindle and G/B spindle are as below:

		G/B spindle (#3074 GBsp=2)		
		Spindle connection	**Spindle-mode servo connection**	**Analog connection**
Reference spindle (#3074 GBsp=1)	**Spindle connection**	Available	N/A (*1)	N/A (*2)
	Spindle-mode servo connection	N/A (*1)	N/A (*1)	N/A (*2)
	Analog connection	N/A (*2)	N/A (*2)	N/A (*2)

(*1) The operation error (M01 1015) occurs when the G/B spindle synchronization signal (GBON:Y778) turns ON.
(*2) The MCP alarm (Y05 3025) occurs at power ON.

(5) To set the gear ratio to the reference spindle or G/B spindle, specify them into the parameter "#13057 SP057 GRA1" and "#13061 SP061 GRB1".
(6) If the parameter "#1039 spinno" is set to "5", make sure to specify the reference spindle and G/B spindle. (For M80 Series only)

11.12.2 Detailed Explanation

11.12.2.1 Operation of G/B Spindle Synchronization

How to Command

(1) Turn the "G/B spindle synchronization valid" (GBON) signal ON using the ladder.
The reference spindle and the G/B spindle enter the spindle synchronization state at the position where the "G/B spindle synchronization valid" (GBON) signal is turned ON, then the "G/B spindle synchronizing mode" (GBMOD) signal and the "G/B spindle synchronization: position control synchronizing" (GBSYN) signal turn ON.

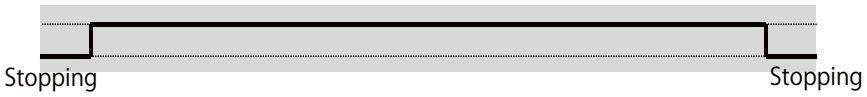
(2) When the Forward run/reverse run start signal of the reference spindle is turned ON,the reference spindle and the G/B spindle accelerate/decelerate to the commanded rotation speed following the spindle synchronization acceleration/deceleration time constant, multi-step acceleration/deceleration changing speed and time constant scale set in the parameters with keeping the synchronous state.
(The multi-step acceleration/deceleration speed to be used is of the spindle whose acceleration calculated from the limit rotation speed and spindle synchronization acceleration/deceleration time constant.)

(3) When the command speed for the reference spindle is changed, acceleration/deceleration is carried out with the reference spindle and the G/B spindle synchronizing even when stopping the reference spindle.

Explanation of Operation

Signal from PLC to CNC

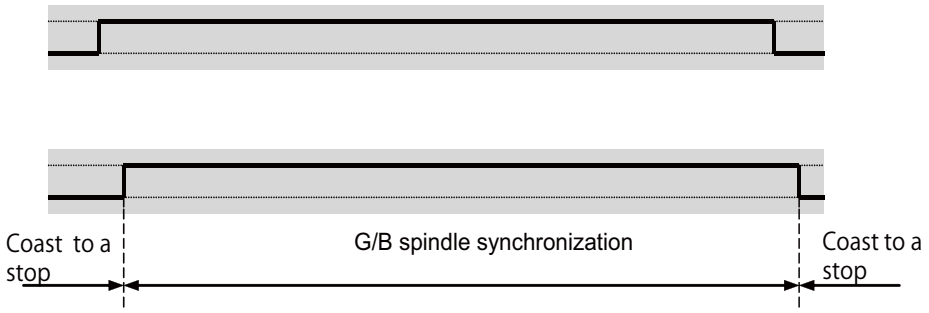
(a) G/B spindle synchronization valid (GBON)



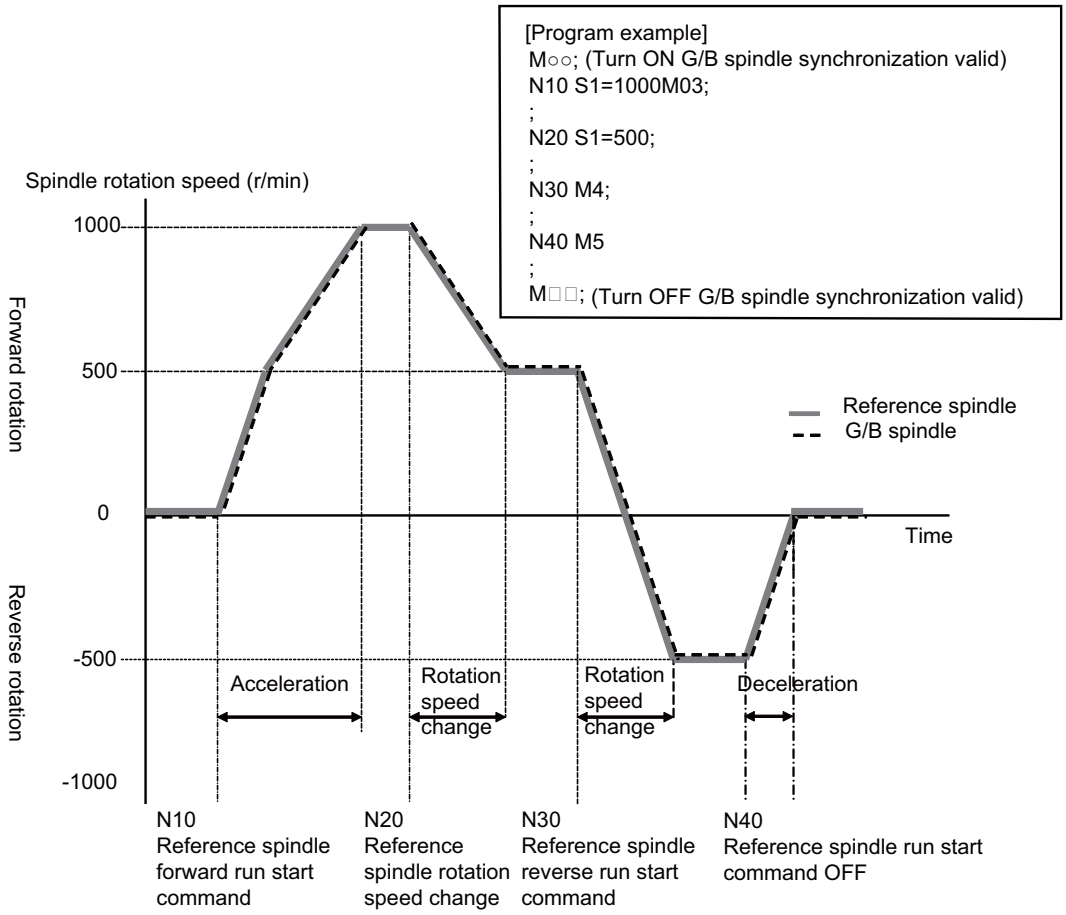
Signal from CNC to PLC

(b) G/B spindle synchronizing mode (GBMOD)

(c) G/B spindle synchronization: position control synchronizing (GBSYN)



<Signal timing chart of G/B spindle synchronization>



<Rotation speed of reference spindle and G/B spindle during G/B spindle synchronization>

11.12.2.2 Phase Alignment of Reference Spindle and G/B Spindle

In order to insert a square bar, it is necessary to align the phases of the reference spindle and the G/B spindle. For the phase alignment, it is necessary to save the phase gap between the reference spindle and the G/B spindle when inserting the bar for the first time. By doing so, inserting the bar becomes easy by turning ON the "G/B spindle synchronization: phase alignment" (GBPHS) signal before inserting the bar to align the relative position of the reference spindle and the G/B spindle that was saved the first time the bar was inserted.
The phase gap that is once saved is available until another phase is saved again.

Saving Phase Gap Between Reference Spindle and G/B Spindle

(1) Insert a square bar in the G/B reference spindle and the G/B spindle.
(2) Turn the "G/B spindle synchronization valid" (GBON) signal ON to rotate the reference spindle.
(3) After the "Z phase passed" (SZPH) signal turns ON, stop the reference spindle. Do not turn OFF the "G/B spindle synchronization valid" (GBON) signal at this point.
(4) After the reference spindle and the G/B spindle stop, turn ON the "G/B spindle synchronization: phase memory" (GBPHM) signal to save the phase gap (relative position) between the reference spindle and the G/B spindle.
(Check the stop state of the reference spindle and the G/B spindle referring to the Zero speed signal.)
(5) After turning OFF the "G/B spindle synchronization: phase memory" (GBPHM) signal, turn OFF the "G/B spindle synchronization valid" (GBON) signal.

Phase Alignment of Reference Spindle and G/B Spindle

(1) After turning ON the "G/B spindle synchronization valid" (GBON) signal, rotate the reference spindle at 300r/min or below.
(2) After the reference spindle enters the steady state, turn ON the "G/B spindle synchronization: phase alignment" (GBPHS) signal.
(Check the steady state referring to the "Spindle up-to-speed" (USO) signal.)
(3) A phase alignment starts targeting the phase gap (relative position) between the reference spindle and the G/B spindle that has been saved.
(4) When the phase alignment is completed, the "G/B spindle synchronization: phase alignment complete" (GBPHF) signal turns ON.
(5) Turn OFF the "G/B spindle synchronization: phase alignment" (GBPHS) signal, and insert the square bar.

Explanation of Operation

Signal from PLC to CNC

(a) G/B spindle synchronization valid (GBON)

(b) G/B spindle synchronization: phase memory (GBPHM)

(c) G/B spindle synchronization: phase alignment (GBPHS)

(d) Forward run start (SRN) or reverse run start (SRI) of reference spindle (S command of 300r/min or below)

Signal from CNC to PLC

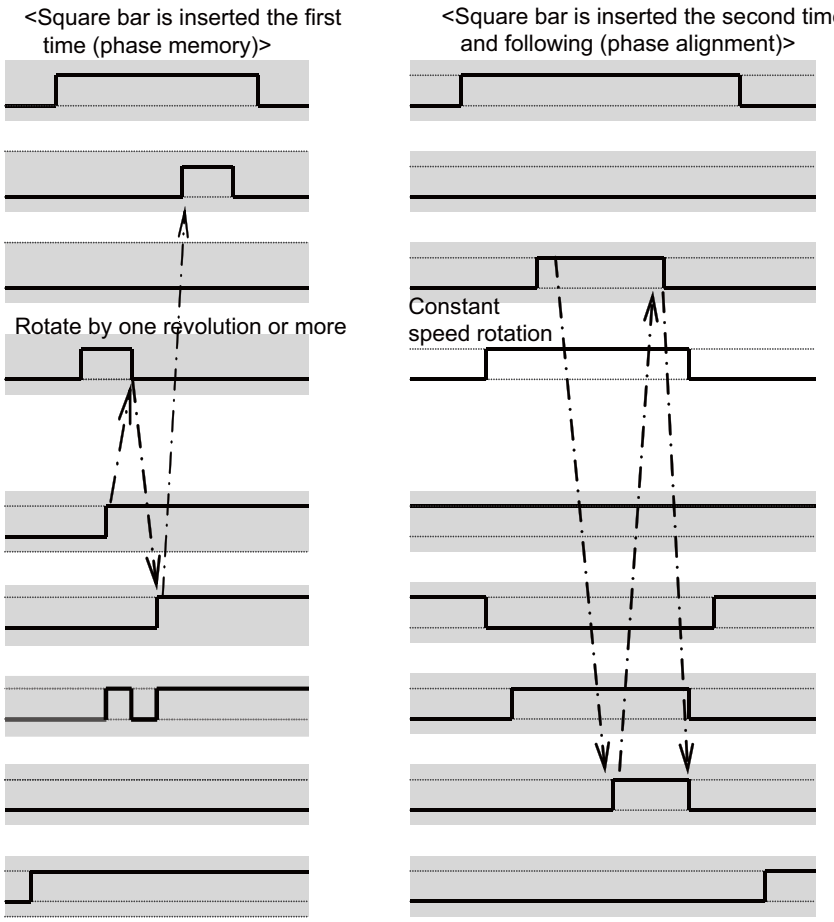
(e) Z phase passed (SZPH) of reference spindle/G/B spindle

(f) Zero speed (ZSO) of reference spindle/G/B spindle

(g) Spindle up-to-speed (USO) of reference spindle/G/B spindle

(h) G/B spindle synchronization: phase alignment complete (GBPHF)

Insertion of square bar



<Signal timing chart of G/B spindle synchronization phase memory/phase alignment>

11.12.2.3 G/B Spindle Synchronization Position Error Compensation

When machining a square bar during G/B spindle synchronization mode, the bar's torsion may cause either of the reference spindle or the G/B spindle the overload alarm (S03 Overload 1 0050) or the over regeneration alarm (S03 Over regeneration 0030, S04 Pw sply: Over regeneration 0073). These alarms can be avoided by turning ON the "G/B spindle synchronization: position error compensation" (GBCMON) signal to compensate the position error caused by the bar's torsion.

Workpiece's torsion is different depending on the area. So turn ON the "G/B spindle synchronization: position error compensation" (GBCMON) signal at every cycle to reexecute a G/B spindle synchronization position error compensation.

How to Command

(1) During G/B spindle synchronization mode, turn ON the "G/B spindle synchronization: position error compensation" (GBCMON) signal when the Chuck close signal turns ON. When turning it ON, make sure that the rotation of the reference spindle and the G/B spindle is in the steady state in order to find the position error compensation amount.

(2) Measure the position error of the reference spindle and the G/B spindle 16 times to start the compensation. The position error compensation amount can be checked with R465. (Unit is pulse,1pulse ≈ 0.088°)

(3) After the measurement is completed, turn ON the "G/B spindle synchronization: position error compensating" (GBPCM) signal.

(4) Cancel the G/B spindle synchronization position error compensation by turning OFF the "G/B spindle synchronization: position error compensation" (GBCMON) signal when the Chuck close signal turns OFF. The G/B spindle synchronization position error compensation can be held by turning ON the "G/B spindle synchronization: keep position error compensation amount signal" (GBCMKP) signal.

Explanation of Operation

Signal from PLC to CNC

(a) G/B spindle synchronization valid (GBON)

(b) G/B spindle synchronization: position error compensation (GBCMON)

(c) G/B spindle synchronization: keep position error compensation amount signal (GBCMKP)

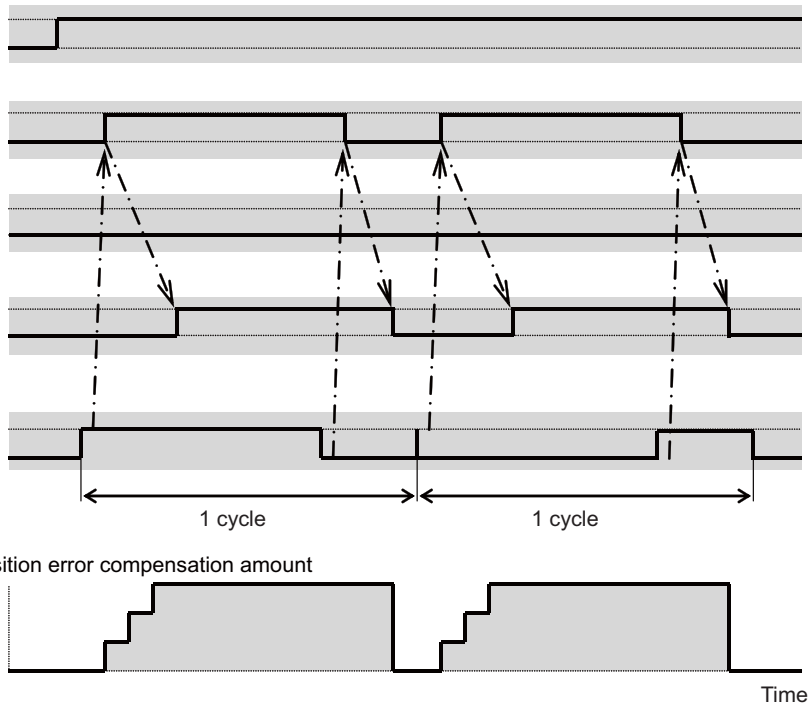
Signal from CNC to PLC

(d) G/B spindle synchronization: position error compensating (GBPCM)

Machine-specific signal

(e) Chuck close of reference spindle

(f) G/B spindle synchronization position error compensation amount



<Timing chart of G/B spindle synchronization position error compensation 1 (Compensation signal ON at chuck close, and the signal turns OFF at chuck open [Keep position error compensation amount signal OFF])>

Signal from PLC to CNC

(a) G/B spindle synchronization valid (GBON)

(b) G/B spindle synchronization: position error compensation (GBCMON)

(c) G/B spindle synchronization: keep position error compensation amount signal (GBCMKP)

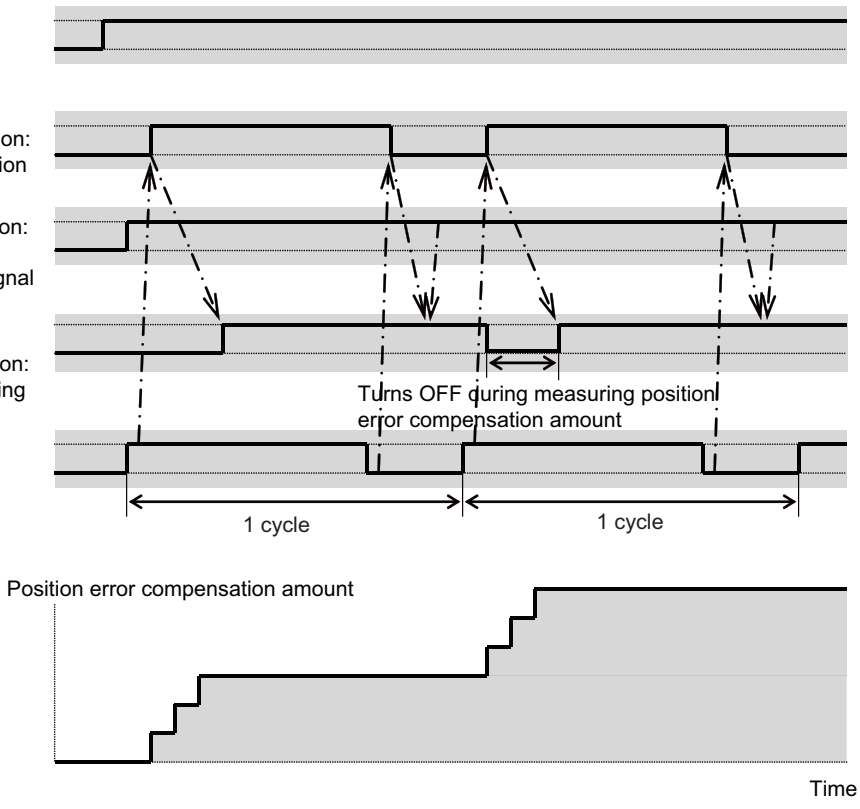
Signal from CNC to PLC

(d) G/B spindle synchronization: position error compensating (GBPCM)

Machine-specific signal

(e) Chuck close of reference spindle

(f) G/B spindle synchronization position error compensation amount



<Timing chart of G/B spindle synchronization position error compensation 2 (Compensation signal ON at chuck close, and the signal turns OFF at chuck open [Keep position error compensation amount signal ON])>

Precautions

(1) If the alarms cannot be avoided even though the "G/B spindle synchronization: position error compensation" (GBCMON) signal is ON, increase the number of times of compensations.
Note that the larger the number of times of compensations is, the longer the measurement time for the position error compensation becomes. In such a case, decrease the number of times of compensations by setting the scale applied to the first compensation.
(R390 | Compensation scale applied to the first compensation | The number of times of compensations |)

(2) The In G/B spindle synchronization position error compensation signal turns OFF:
(a) when both "G/B spindle synchronization: keep position error compensation amount signal" (GBCMKP) signal and "G/B spindle synchronization: position error compensation" (GBCMON) signal are turned OFF
(b) when the G/B spindle synchronization mode is canceled
(c) during measuring the G/B spindle synchronization position error compensation amount.

(3) Even if the "G/B spindle synchronization: position error compensation" (GBCMON) signal is turned OFF during measuring the G/B spindle synchronization position error compensation amount, the signal is not actually turned OFF until the measurement is completed.

(4) The G/B spindle synchronization position error compensation is executed only during the G/B spindle synchronization mode. If the "G/B spindle synchronization: position error compensation" (GBCMON) signal is turned ON not during the G/B spindle synchronization mode, the compensation starts when the G/B spindle synchronization mode starts.

11.12.2.4 Relative Position Error Sampling

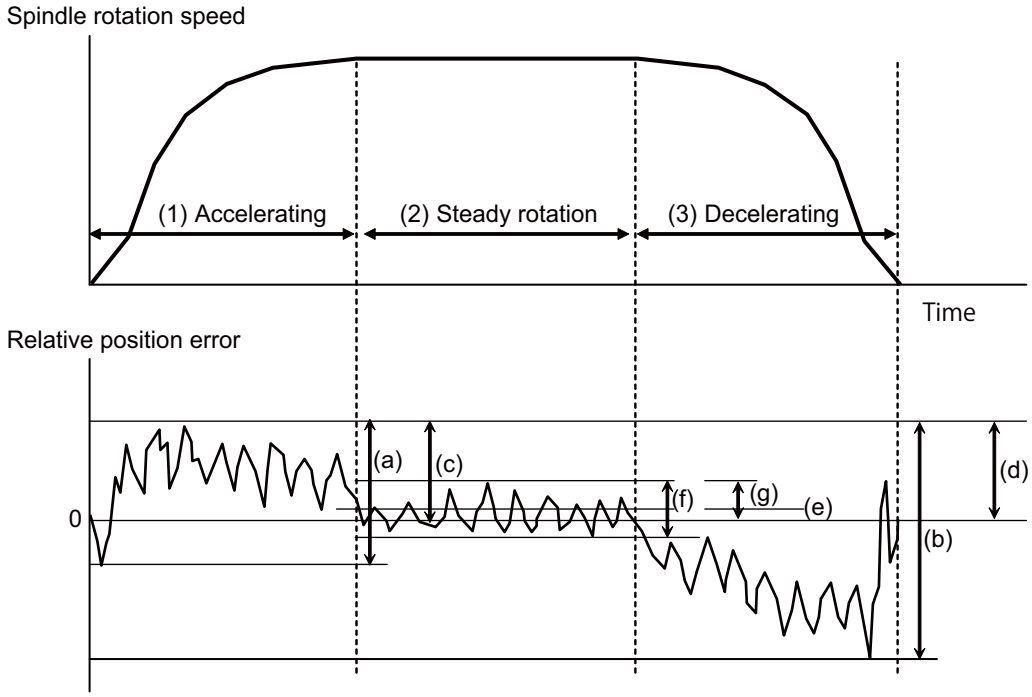
During G/B spindle synchronization mode, the following five values are calculated based on the relative position error between the reference spindle and the G/B spindle, and they are output to the R registers when the state changes between the acceleration/deceleration state and the steady state. (Unit is pulse, 1pulse ≈ 0.088°)

(1) Maximum range of the relative position error during acceleration/deceleration
(2) Maximum value of the relative position error during acceleration/deceleration
(3) Maximum range of the relative position error during the steady state
(4) Maximum value of the relative position error during the steady state
(5) Average value of the relative position error during the steady state

This sampling is constantly carried out during the G/B spindle synchronization mode. It stops when the G/B spindle synchronization mode is canceled.

How to Command

(1) This function is constantly active during G/B spindle synchronization mode. Values are set in the following R registers when the state changes between the acceleration/deceleration state and the steady state.



<Relative position error during G/B spindle synchronization>

<R registers to output the relative position error>

R register		Operation
R460	Maximum range of the relative position error for G/B spindle synchronization	Maximum value ((a) above) of the relative position error is written after the spindle motor completes acceleration. Maximum value ((b) above) of the relative position error is written after the spindle motor decelerates and stops.
R461	Maximum value of the relative position error for G/B spindle synchronization	Maximum value ((c) above) of the relative position error is written after the spindle motor completes acceleration. Maximum value ((d) above) of the relative position error is written after the spindle motor decelerates and stops.
R462	Average value of the relative position error during the steady state for G/B spindle synchronization	Average value ((e) above) of the relative position error is written after the spindle motor completes steady rotation.
R463	Maximum range of the relative position error during the steady state for G/B spindle synchronization	Maximum value ((f) above) of the relative position error is written after the spindle motor completes steady rotation.
R464	Maximum value of the relative position error during the steady state for G/B spindle synchronization	Maximum value ((g) above) of the relative position error is written after the spindle motor completes steady rotation.

(Note) The relative position error is calculated by "Reference spindle's feedback position - G/B spindle's feedback position".

11.12.3 Relation with Other Functions

A: Available A (*n): Available (with restriction) N/A: Not available

Function name	Operation		Remarks
	Reference spindle	G/B spindle	
Synchronous tapping cycle	A(*11)	N/A(*4)	(*4)The operation error (M01 1138) occurs if the G/B spindle is commanded as a synchronous tapping spindle. (*11)When this function is commanded with the Z-phase undetected, Z-phase will be detected by the following operations, and then the zero point return operation ("3106 zrn_typ/bit4 (sync tap zero return or deceleration stop)" is "0") will be executed. The Z-phase detection is performed at the rotation speed set in "#3110 tap_spd (Synchronous tapping zero point return speed)". - For the case that "#3106 zrn_typ/bit3 (Phase Z signal detection ON)" is set to "0" (Invalid) The Z-phase will be detected by rotating the spindle in the direction set in "#3106 zrn_typ/bit6,bit5 (Sync tap zero return direction)". When "#3106 zrn_typ/bit6,bit5 (Sync tap zero return direction)" is "00" (shortcut), the Z-phase detection is performed by rotating the spindle in the direction set in "#3106 zrn_typ/bit0 (Z-phase detection direction)". - For the case that "#3106 zrn_typ/bit3 (Phase Z signal detection ON)" is set to "1" (Valid) The Z-phase will be detected by rotating the spindle in the direction set in "#3106 zrn_typ/bit0 (Z-phase detection direction)".
High-speed synchronous tapping	A(*1)	N/A(*4)	(*1)Normal synchronous tapping (*4) "M01 GB SP sync runs independently 1138" occurs if the G/B spindle is commanded as a synchronous tapping spindle.
Spindle rotation command (forward/reverse)	A(*10)	N/A	(*10) When the spindle rotation command is executed with the Z-phase undetected, Z-phase will be detected by rotating the spindle at the commanded speed and in the direction of the spindle rotation signal (Spindle forward run start (SRN: Y1898) or Spindle reverse run start (SRI: Y1899)) regardless of the setting of "#3106 zrn_typ/bit3 (Z-phase signal detection ON).
Analog spindle I/F Encoder input I/F	N/A	N/A	MCP alarm (Y05 3025) occurs at power ON.
Coil changeover Automatic coil changeover	N/A	N/A	Coil that was selected immediately before turning ON the "G/B spindle synchronization valid" (GBON) is held.
Gear changeover	N/A	N/A	The gear changeover command for the reference spindle or the G/B spindle is invalid.
Turret gear changeover	N/A	N/A	When "G/B spindle synchronization" signal (GBON) is ON, the operation error (M01 1015) occurs.
Constant surface speed control	A	N/A	
Spindle override	A	N/A	

Function name	Operation		Remarks
	Reference spindle	G/B spindle	
Spindle orientation	A(*2)	N/A	(*2)During G/B spindle synchronization, spindle zero point detection with contactless switch and turret indexing cannot be enabled. The operation error (M01 1014) occurs when the "Orientation command" signal is turned ON. When this function is commanded with the Z-phase undetected, Z-phase will be detected by the following operations, and then the orientation operation will be executed. The Z-phase detection is performed at the rotation speed set in "#3107 ori_spd (Orientation command speed)". - For the case that "#3106 zrn_typ/bit3 (Phase Z signal detection ON)" is set to "0" (Invalid) The Z-phase will be detected by rotating the spindle in the direction set in "#3106 zrn_typ/bit2,bit1 (Orientation direction)". When "#3106 zrn_typ/bit2,bit1 (Orientation direction)" is "00" (shortcut), the Z-phase detection is performed by rotating the spindle in the direction set in "#3106 zrn_typ/bit0 (Z-phase detection direction)". - For the case that "#3106 zrn_typ/bit3 (Phase Z signal detection ON)" is set to "1" (Valid) The Z-phase will be detected by rotating the spindle in the direction set in "#3106 zrn_typ/bit0 (Z-phase detection direction)".
Spindle position control (Spindle C axis control)	A(*3)	N/A	(*3)During G/B spindle synchronization, the spindle C axis parameter cannot be changed. The operation error (M01 1014) occurs when servo ON is carried out for C axis. When this function is commanded with the Z-phase undetected, Z-phase will be detected by the following operations, and then the C axis changeover operation will be executed.The Z-phase detection is performed at the rotation speed set in "#3112 cax_spd (Zero point return specifications)". - For the case that "#3106 zrn_typ/bit3 (Phase Z signal detection ON)" is set to "0" (Invalid) The Z-phase will be detected by rotating the spindle in the direction set in "#3106 zrn_typ/bitA,bit9 (Spindle/C axis zero return direction)". When "#3106 zrn_typ/bitA,bit9 (Spindle/C axis zero return direction)" is "00" (shortcut), the Z-phase detection is performed by rotating the spindle in the direction set in "#3106 zrn_typ/bit0 (Z-phase detection direction)". - For the case that "#3106 zrn_typ/bit3 (Phase Z signal detection ON)" is set to "1" (Valid) The Z-phase will be detected by rotating the spindle in the direction set in "#3106 zrn_typ/bit0 (Z-phase detection direction)".
Spindle synchronization control I, Spindle synchronization control II	A	N/A(*5)	(*5)The operation error (M01 1138) occurs if the G/B spindle is commanded as a spindle related to spindle synchronization.
Tool spindle synchronization IA (Spindle-Spindle polygon machining) Tool spindle synchronization IB (Spindle-Spindle polygon machining)	A	N/A(*6)	(*6)The operation error (M01 1138) occurs if the G/B spindle is commanded as a spindle related to tool spindle synchronization IA/IB.
Tool spindle synchronization IC (Spindle-NC axis polygon machining)	A(*7)	N/A(*7)	(*7)The operation error (M01 1138) occurs if the reference spindle or the G/B spindle is commanded as a spindle of tool spindle synchronization IC.

Function name	Operation		Remarks
	Reference spindle	G/B spindle	
Tool spindle synchronization II (Hob machining)	A(*8)	N/A(*9)	(*8)The operation error (M01 0005) occurs and servo ON state is set if the reference spindle is commanded as a workpiece axis and servo OFF is carried out. (*9)The operation error (M01 1138) occurs if the reference spindle or the G/B spindle is commanded as a spindle of tool spindle synchronization II.
Spindle speed clamp	A	N/A	
Tap retract	A	N/A	
Emergency stop	A	A	The reference spindle and the G/B spindle decelerate and stop asynchronously. However,the relative position between the reference spindle and the G/B spindle is not guaranteed. The "G/B spindle synchronizing mode" (GBMOD) signal and the "G/B spindle synchronization: position control synchronizing" (GBSYN) signal turn OFF at an emergency stop.
Axis detachment	N/A	N/A	During G/B spindle synchronization mode, the reference spindle and the G/B spindle cannot be detached. The G/B spindle synchronization mode cannot be turned ON while the reference spindle and the G/B spindle are detached.

11.12.4 Precautions and Restrictions

(1) In the G/B spindle synchronization function, both reference spindle and G/B spindle are required to be controlled by the spindle drive unit.
(2) The lower setting value between the reference spindle and the G/B spindle is used as the limit rotation speed of the G/B spindle synchronization mode signal.
(3) Both reference spindle and G/B spindle coast to a stop when the "G/B spindle synchronization valid" (GBON) signal is OFF.
(4) If the "G/B spindle synchronization valid" (GBON) signal is turned OFF immediately after turning OFF the forward/ reverse run command, the reference spindle and the G/B spindle stop and then enter the coasting status.
(5) Parameters such as of C axis and orientation function follow the spindle synchronization function.
(6) Spindle gear changeover command for the reference spindle and the G/B spindle is disabled.
(7) To specify the gear ration for reference spindle and G/B spindle, specify them into "#13057 SP057 GRA1" and "#13061 SP061 GRB1".
(8) "M01 GB SP sync:Cancel sgnl illegal 1028" occurs if the G/B spindle synchronization temporary cancel signal is turned ON/OFF when the reference spindle or the G/B spindle is in any of the following modes.
- During rotation (when not stopped)
- During tap cycle synchronization mode
- During spindle synchronization mode/tool-spindle synchronization I (polygon machining) mode/tool-spindle synchronization II (hobbing) mode
- During spindle C axis control C axis mode
- During orientation/indexing
(9) "Y05 Initial parameter error 3025" occurs at power ON if one of the reference spindle and the G/B spindle uses a spindle detector that cannot be connected to a spindle drive unit.
(10) If the parameter "#3074 GBsp" is changed in G/B spindle synchronization mode, the changed parameter is enabled when the "G/B spindle synchronization valid" (GBON) signal is turned OFF and ON.
(11) If the reference spindle is commanded as a workpiece axis of tool spindle synchronization II, "M01 Internal interlock axis exists 0005" occurs and servo OFF cannot be carried out for the workpiece axis even when servo OFF is attempted in tool spindle synchronization II mode. Carry out servo OFF after canceling tool spindle synchronization II.
(12) "M01 GB SP sync runs independently 1138" occurs if the reference spindle is commanded as a spindle of tool spindle synchrnization IC.
(13) If the reference spindle is commanded as a synchronous tapping spindle, set the same value in the reference spindle's position loop gain (#13003 SP003) and the tapping axis's axis servo gain (#2017 tap_g).
(14) If the parameter "#1039 spinno" is set to "5", make sure to specify the reference spindle and G/B spindle. When the automatic operation is started without setting the reference spindle or the G/B spindle, the operation error (M01 0137) will occur and the automatic operation cannot be started. Do not change the reference spindle or the G/B spindle to "not set" status during the automatic operation. If they are changed, the operation error (M01 0137) will occur and the automatic operation will be stopped. (For M80 Series only)
(15) When the parameter "#1039 spinno" is set to "5", the guide bushing spindle synchronization temporary cancel cannot be used. When the automatic operation is started during the guide bushing spindle synchronization temporary cancel, the operation error (M01 0137) will occur and the automatic operation cannot be started. (For M80 Series only)
(16) For the reference spindle, when the programmed command method ("#3129 cax_spec/bit2" is set to "1") of spindle position control (spindle/C axis control) is selected, select the spindle mode ("#3129 cax_spec/bit2" is set to "0") as control mode at power ON.
If the power is turned ON when the C axis mode ("#3129 cax_spec/bit2" is set to "1") is selected as control mode at power ON, the operation error (M01 1014) occurs, and the C axis mode cannot be set.

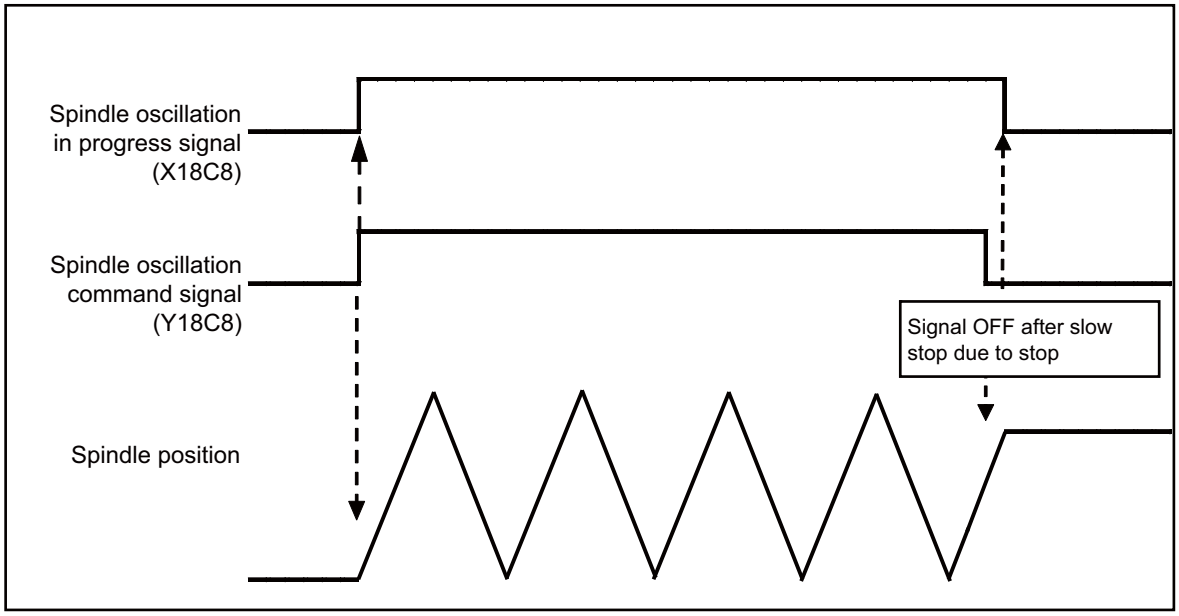
11.13 Spindle Oscillation

11.13.1 Outline

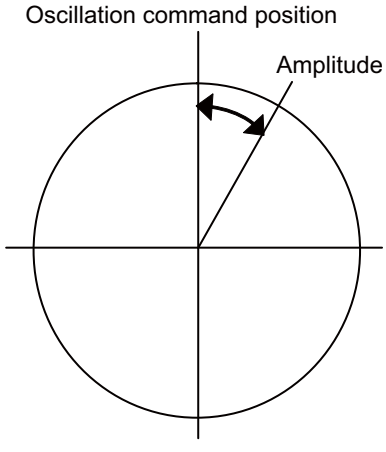
This function reciprocates (oscillates) the spindle at the specified amplitude and frequency.

11.13.2 Detailed Description

Spindle oscillation starts when the spindle oscillation command signal (Y18C8) is turned ON. The spindle decelerates and stops when the spindle oscillation command signal is turned OFF.
The spindle oscillation ON signal (X18C8) is turned ON while the spindle is oscillating.

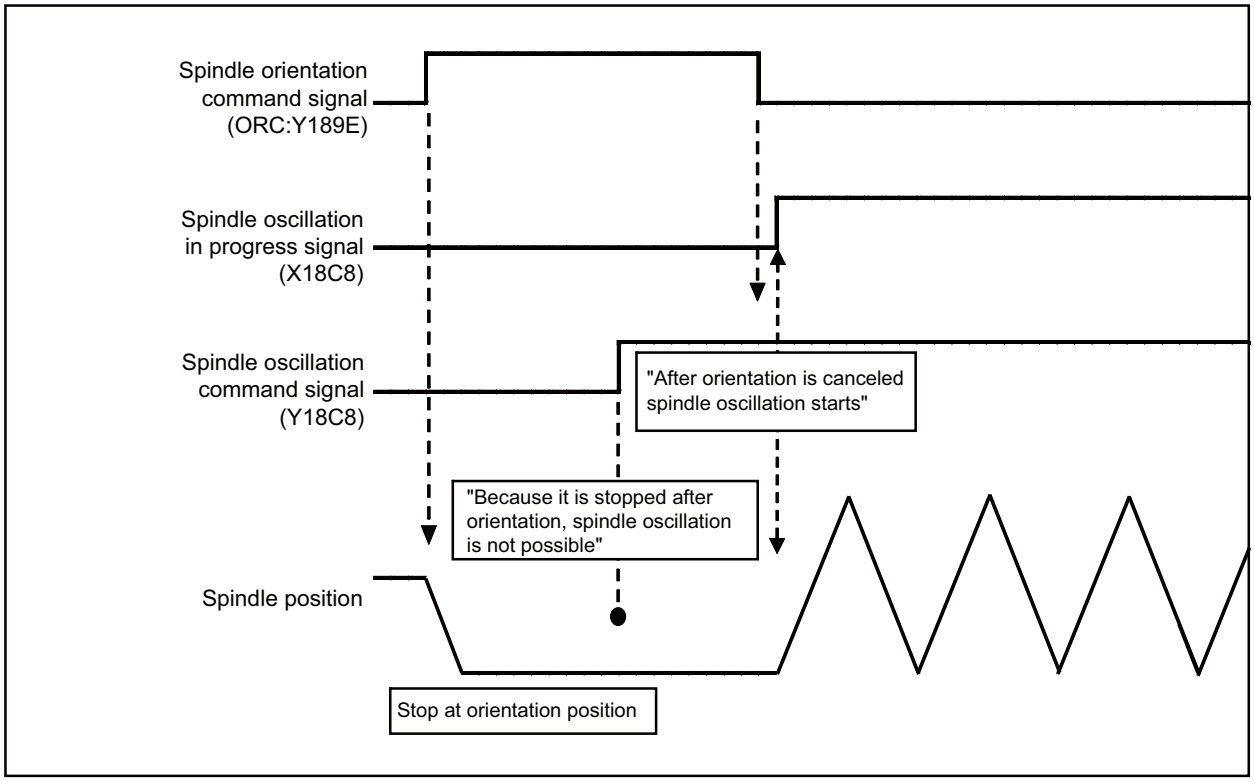


The spindle oscillates in accordance with the spindle oscillation amplitude and spindle oscillation configured to the R registers.



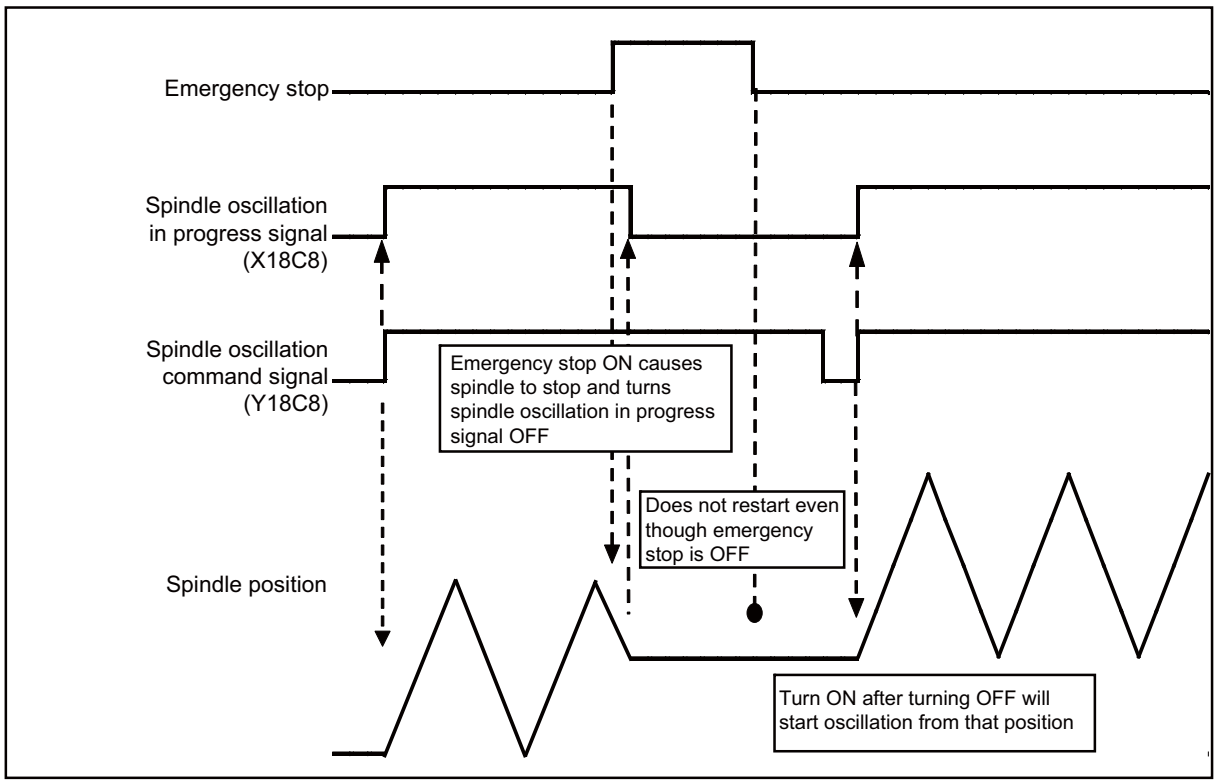
The position of progression in terms of amplitude in the forward direction from the oscillation command position is used as the midway point. The spindle accelerates and decelerates at the rate of speed determined by the amplitude and frequency to move to the midway point and then return to the oscillating command position by accelerating and decelerating at the same rate of speed.
This operation repeats to cause the spindle to oscillate.

When the rotational speed of the spindle calculated from the amplitude and frequency exceeds the maximum rotational speed spindle parameters ("#3005 smax1 Maximum Rotational Speed (gear: 00)" through ("#3008 smax4 Maximum Rotational Speed (gear: 11)"), the spindle cannot oscillate at the configured frequency, which results in generation of the operation error (M01 1110).
If the amplitude and frequency setting is too small, this results in a calculated command value of less than one pulse being output to the spindle amp, which results in generation of the operation error (M01 1110).
As the spindle oscillates in accordance with the configured amplitude and frequency when the spindle oscillation start command is received, the amplitude and frequency of currently executing oscillation does not change when the amplitude and frequency settings change while the spindle is oscillating. To oscillate the spindle at the changed amplitude and frequency, turn the spindle oscillation command signal OFF and ON again.
The starting and stopping of the spindle oscillation is performed with the spindle oscillation command signal level trigger. If spindle oscillation cannot start due to the execution of other functions, spindle oscillation starts after the other function completes.



To restart spindle oscillation when an oscillating spindle has stopped due to an emergency stop or the generation of a spindle alarm, turn the spindle oscillation command signal OFF and ON again.

(Note) Stops and starts of spindle oscillation are executed with the level trigger for the spindle oscillation command signal, but stops and starts of spindle oscillation are executed with the edge trigger for scenarios when emergency stop has been executed. As spindle oscillation restarts from the stopped position, oscillation may not start from the same initial oscillation position.



11.13.3 Operation with Other Functions

The following table lists the restrictions on synchronous operation when other function commands are output during execution of spindle oscillation or when the spindle oscillation command is output during the execution of other functions.

○:Command output allowed Δ:Command output allowed with restrictions
×:Command output not allowed (error generation) -:Exclusive spindle oscillation control not allowed

Name of Function	Command allowed/not allowed		Remarks
	Spindle oscillation (Note 1)	Function executing (Note 2)	
Coil switch	×	○	
Automatic coil switch	-	-	
Encoder input I/F	-	-	
Spindle rotation command (forward/reverse)	Δ (Note 3)	Δ (Note 4)	
S code output	Δ (Note 5)	Δ (Note 6)	
Constant surface speed control	Δ (Note 5)	Δ (Note 6)	
Spindle override	Δ (Note 5)	Δ (Note 6)	
Multiple-spindle control I Multiple-spindle control II	○	○	
Spindle orientation	×	×	
Spindle position control (spindle/C axis)	×	×	
Spindle synchronization I Spindle synchronization II	×	×	
Guide bushing spindle synchronization	×	×	The spindle oscillation command is not allowed when spindle specification parameter #3074 GBsp is set to any value other than "0".
Tool spindle synchronization IA (spindle-spindle and polygon)	×	×	
Tool spindle synchronization IB (spindle-spindle and polygon)	×	×	
Tool spindle synchronization IC (spindle-NC axis and polygon)	×	×	
Tool spindle synchronization II (Hobbing)	×	×	
Spindle speed clamp	Δ (Note 5)	Δ (Note 6)	
Thread cutting (lead/thread number designation)	-	-	
Variable lead thread cutting	-	-	
Synchronous tapping cycle	×	×	
Pecking tapping cycle	×	×	
Deep-hole tapping cycle	×	×	
High-speed synchronous tapping	×	×	
Tapping retract	-	× (Note 7)	
NC reset	Δ (Note 8)	○	
Emergency stop	○	-	

(Note 1) This represents whether function commands are allowed/not allowed while spindle oscillation is in operation. If a command for a function that is not allowed is output while spindle oscillation is in operation, the operation error (M01 1108) is generated.

(Note 2) This represents whether the spindle oscillation command is allowed/not allowed while another function is executing. If the spindle oscillation command is output while a function that is not allowed is executing, the operation error (M01 1109) is generated.

(Note 3) The command can be output, but the function will not operate while spindle oscillation is in operation. The spindle will start rotating at the specified speed after spindle oscillation completes.

(Note 4) The command can be output, but the function will not operate while spindle synchronization is in operation. Spindle oscillation will start after the spindle stops rotating.

(Note 5) The command can be output, but the spindle continues to oscillate while the control related to rotational speed of the function command subsequently output is ignored as the spindle oscillation function causes the spindle to oscillate at a rotational speed calculated from the configured amplitude and frequency.

(Note 6) The command can be output, but the spindle oscillates while the control related to rotational speed of the function command previously output is ignored as the spindle oscillation function causes the spindle to oscillate at a rotational speed calculated from the configured amplitude and frequency.

(Note 7) If the spindle oscillation command is output while the tapping retract enable signal (TRVE: XCA5) is turned ON, the operation error (M01 1109) is generated.

(Note 8) The command can be output, but spindle synchronization continues.

11.13.4 Precautions

(1) The zero speed signal (ZSO: X188C) and spindle speed arrival signal (USO: X188D) may turn ON due to oscillation of the spindle. The spindle forward movement signal (SSRN: X1893) and spindle reverse movement signal (SSRI: X1894) repeatedly turn ON and OFF while the spindle oscillates.

(2) Spindle oscillation does not stop when an NC reset is performed while the spindle is oscillating. To stop oscillation, you must turn OFF the spindle oscillation command signal by performing a reset.

(3) The spindle stops when an emergency stop is performed while the spindle is oscillating. Spindle oscillation will not restart after the emergency stop is cleared.

11.14 Multiple Spindle Synchronization Set Control

11.14.1 Outline

This function is used to combine and control the following spindle control functions simultaneously.
When a certain pair of spindles has been designated for one spindle control function, a different pair of spindles can be used for another spindle control function.

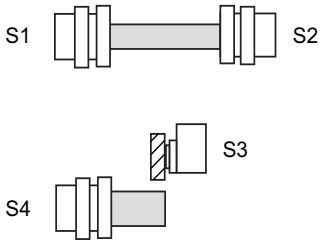
- Spindle synchronization I
- Tool spindle synchronization I A (Spindle-Spindle, Polygon)
- Tool spindle synchronization I B (Spindle-Spindle, Polygon)
- Tool spindle synchronization II (Hobbing)
- Spindle superimposition control

The following spindle control functions can be commanded simultaneously by using the same reference spindle.

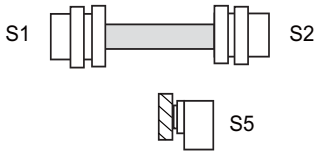
- Spindle synchronization I
- Tool spindle synchronization I A

[Example of lathe system]

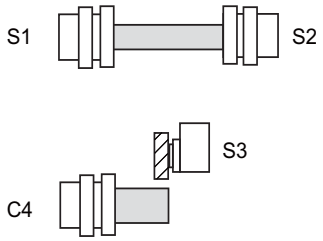
Spindle synchronization I command (S1-S2)
+ Tool spindle synchronization IA command (S3-S4)



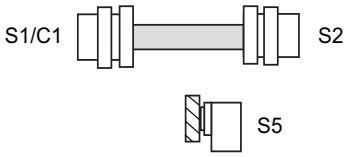
Spindle synchronization I command (S1-S2)
+ Tool spindle synchronization IA command (S1-S5)



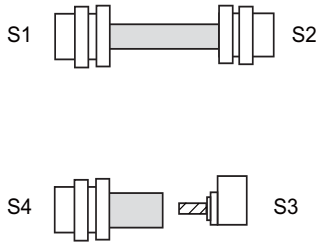
Spindle synchronization I command (S1-S2)
+ Tool spindle synchronization II command (S3-C4)



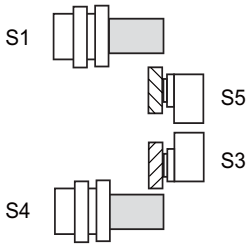
Spindle/C axis synchronization control command (S1/C1-S2)
+ Tool spindle synchronization II command (S5-C1)



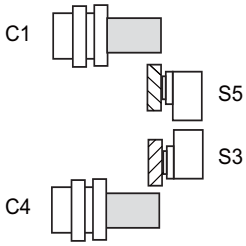
Spindle synchronization I command (S1-S2)
+ Spindle superimposition control command (S4-S3)



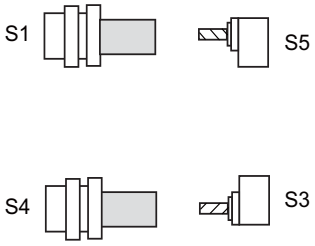
Tool spindle synchronization IA command (S5-S1)
+ Tool spindle synchronization IA command (S3-S4)



Tool spindle synchronization II command (S5-C1)
+ Tool spindle synchronization II command (S3-C4)



Spindle superimposition control command (S1-S5)
+ Spindle superimposition control command (S4-S3)



(Note) The guide bushing spindle synchronization is not included in the multiple spindle synchronization sets.

11.14.2 Function Enabling Conditions

(1) This function can be applied to a lathe system equipped with two or more spindles.
(2) To enable this function, set the parameter "#1440 multi_sp_syn (Multiple spindle synchronization valid)" to "1".
(After setting the parameter, turn OFF and ON the NC power.)
If the parameter "#1440 multi_sp_syn (Multiple spindle synchronization valid)" is set to "0", multiple spindle synchronization commands cannot be issued. (If two or more spindle synchronization commands are given, the operation error (M01 1005) occurs, which stops the automatic operation.)
Note that guide bushing spindle synchronization is not included in the multiple spindle synchronization sets.

11.14.3 Precautions

While the multiple spindle synchronization set control is OFF, the control uses the input/output signals of the 1st spindle. While the multiple spindle synchronization set control is ON, the control uses the signals of the synchronized (or superimposed) spindle for Spindle synchronization control, Tool spindle synchronization control IA (polygon) or Spindle superimposition control, or the signals of the hob (reference) spindle for Tool spindle synchronization II (hob).
(E.g. 1) The PLC interface signals that are used when "G114.1H2D5" is commanded
- While the multiple spindle sync set control is OFF, the control uses the I/O signals of the 1st spindle.
- While the multiple spindle sync set control is ON, the control uses the I/O signals of the 5th spindle.

(E.g. 2) The PLC interface signals that are used when "G114.1H3D9" is commanded
- While the multiple spindle sync set control is OFF, the control uses the I/O signals of the 1st spindle.
- While the multiple spindle sync set control is ON, the control uses the I/O signals of the 3rd spindle.

12

PLC Help Function

To help the user PLC, an exclusive interface is provided between the user PLC and controller.
The function and interface are explained below.

PLC help function examples:

- Tool life management
- External search
- PLC axis control
- External machine coordinate system compensation
- Alarm message display
- Operator message display
- PLC switches
- Key operation by user PLC
- User PLC version display

12.1 Program Format Switch

12.1.1 Outline

"G code switch of program format" ("program format switch" hereafter) is a function designed to switch the program format (G code system) using G codes (G188/G189) or PLC signal. While the switch is active, the control runs a program based on the switched G code system. When you run a lathe-based multi-tasking machine, and if you change the G code system to that of M system, you can use a free-curved surface machining program made with CAM without modifying the program.
This function can be used when "#1254 set26/bit1" is set to "1".

G code method and PLC I/F method are distinguished in the following points:

G code method	This switches by G188/G189 commands in automatic operation. (e.g. to switch the format dynamically for some machining processes)
PLC I/F method	Not in automatic operation (e.g. to enable the state in which the G code system is switched at the time of power up)

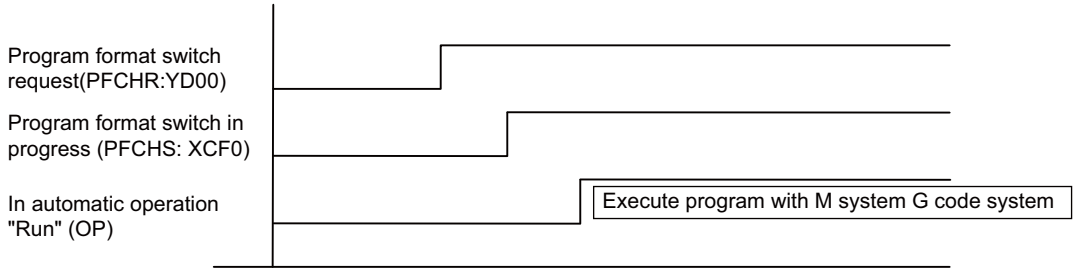
This chapter explains PLC signal method.

12.1.2 Explanation of Function

When the Program format switch request (PFCHR: YD00) turns ON or OFF in the part system designated by the parameter "#1047 G_Chg_En_Sno" during an operation other than automatic operation, the control enables or disables the program format switch.

Program format switch

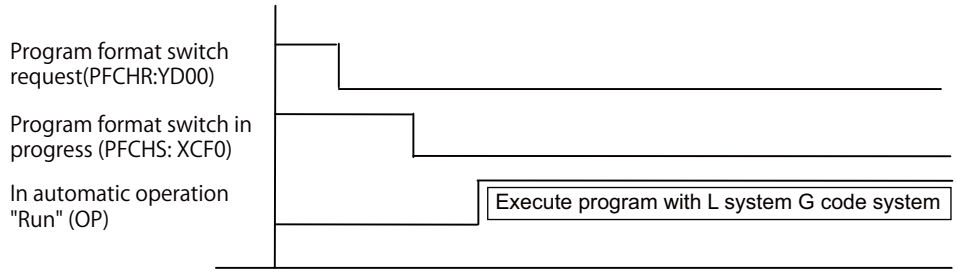
When the Program format switch request signal (PFCHR: YD00) is turned ON, the control switches the program format from L-system to M-system G code system (G code system 1 (Command type 2)). When the switchover of program format is completed, the Program format switch in progress signal (PFCHS: XCF0) turns ON. If you start automatic operation with the Program format switch in progress signal (PFCHS: XCF0) ON, the control runs a program based on the M-system G code system.



(1) If you change the Program format switch request signal (PFCHR: YD00) from OFF to ON during automatic operation (In automatic operation signal "run" (OP: XC12) is ON), the operation error (M01 0215) occurs and the program format switch is not implemented. (Turning OFF of this signal cancels the operation error (M01 0215).)
(2) If you turn ON Program format switch request signal (PFCHR: YD00) and then start automatic operation in any G modal state that disables program format switch, the program error (P29) occurs and automatic operation is not implemented.
(3) After turning ON Program format switch request signal (PFCHR: YD00), wait until Program format switch in progress signal (PFCHS: XCF0) turns ON before you execute automatic operation. Otherwise, it cannot be assured that "the control runs a program based on the switched G code system from the top block of the program".

Program format switch OFF

When the Program format switch request signal (PFCHR: YD00) is turned OFF, the control switches the program format from M-system back to L-system G code system (a system selected by the parameter "#1037 cmdtyp"). When cancel of the program format switch is completed, the Program format switch in progress signal (PFCHS: XCF0) turns OFF. If you start automatic operation with the Program format switch in progress signal (PFCHS: XCF0) OFF, the control runs a program based on the L-system G code system.



(1) If you change the Program format switch request signal (PFCHR: YD00) from ON to OFF during automatic operation (In automatic operation signal "run" (OP: XC12) is ON), the operation error (M01 0215) occurs and the program format switch is not implemented. (Turning OFF of this signal cancels the operation error (M01 0215).)

(2) If you turn OFF Program format switch request signal (PFCHR: YD00) and then start automatic operation in any G modal state that disables program format switch, the program error (P29) occurs and automatic operation is not implemented.

(3) After turning OFF Program format switch request signal (PFCHR: YD00), wait until Program format switch in progress signal (PFCHS: XCF0) turns OFF before you execute automatic operation. Otherwise, it cannot be assured that "the control runs a program based on the G code system at power ON from the top block of the program".

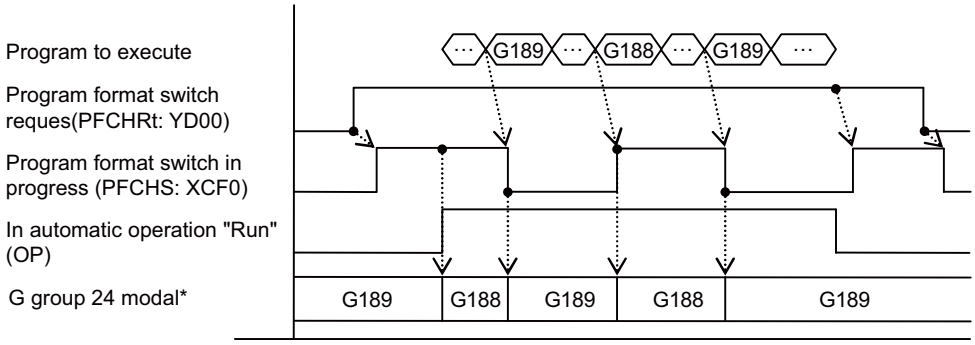
(4) When the parameter "#1319 Grp24_mdrst_off" is "0" and the modal retention reset is performed, the state of the program format switch or the switch cancel is held even if the automatic operation is started with Program format switch request signal (PFCHR: YD00) OFF.

Interaction between G Code and PLC I/F Methods

There are two type of means to switch the program format: G code method (G188/G189) and PLC I/F method (ON/OFF of PFCHR). After you have switched the program format using one of the methods, you can execute cancel of this format switch using another method.

During automatic operation, Program format switch in progress signal (PFCHS: XCF0) is dynamically changed by G188/G189. However, after automatic operation is finished, the signal follows the state of Program format switch request signal regardless of the state at the completion of automatic operation.
[Example] You start automatic operation with PFCHR ON, and then issue G189, which turns OFF PFCHS (Switch cancel status). After the automatic operation is finished, however, PFCHS turns ON (Switched status).

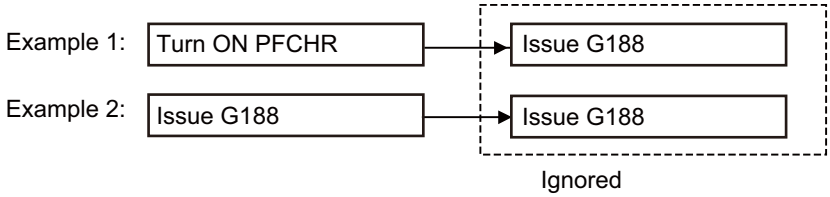
[Operation example]



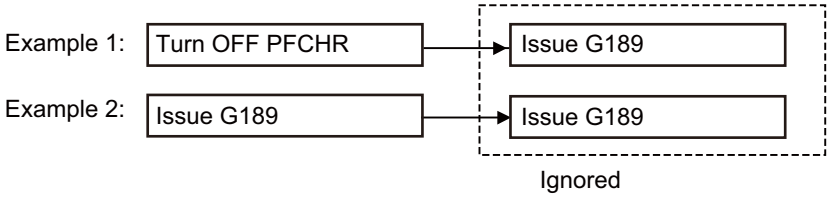
* The G group 24 modal state is refreshed only during automatic operation.

[Note]

(1) If you enable the program format switch (G group 24 modal: G188), and then issue the switch command (G188) again, the command is ignored. (The program format is unchanged.)



(2) If you cancel the program format switch (G group 24 modal: G189), and then issue the cancel command (G189) again, the command is ignored. (The program format is unchanged.)



12.2 Manual Speed Command

In the memory or MDI mode, validate the manual speed command and select any one of handle feed, jog (manual feed) or manual rapid traverse so that the automatic operation is carried out at the feedrate.
With a command in the (-) direction, the program path can be reversed.Note that, however, program path can be reversed only within the currently executing block and not beyond the block.
Whether or not to execute reverse run with a command in the (-) direction is set with the PLC interface.

(1) When giving the manual speed command in multiple part systems, the speed differs depending on the type of the manual speed command.
- Manual speed command (the parameter "#1365 manualFtype" is set to "0")
  Similarly to the case of only one part system, the axis moves with the speed of handle, JOG or manual rapid traverse in multiple part systems.
- Manual speed command 2 (the parameter "#1365 manualFtype" is set to "1")
  For multiple part systems, the axis moves with the speed of handle, JOG or manual rapid traverse which is multiplied by the program command speed ratio.
  The program command speed ratio is each part system's speed ration when the reference program command speed (the fastest program command speed across executing part systems) is 100%.

		Type	
		Manual speed command	**Manual speed command 2**
Feedrate	Handle feed	Feedrate of 1st handle's 1st axis (the handle magnification is for each part system)	Feedrate of 1st handle's 1st axis * program command speed ratio (The handle magnification of the smallest part system No. across the part systems where the manual speed command is valid)
	JOG (manual) feed	JOG feedrate of each part system	The JOG feedrate of the smallest part system No. across the part systems where the manual speed command is valid * program command speed ratio
	Manual rapid traverse	Rapid traverse feedrate of each part system's 1st axis	The rapid traverse feedrate of the smallest part system No. across the part systems where the manual speed command is valid * program command speed ratio
Clamp		For the cutting command: The cutting clamp speed of each axis (#2002 clamp) For the rapid traverse command: The rapid traverse feedrate of each axis (#2001 rapid)	Same as the "Manual speed command" or "program command speed * the setting value of the parameter "#19005"", whichever the smallest.
Reverse run		Stops when it is reached to the block start point for each axis.	When any one of the part systems is reached to the block start point, other part systems also stop.

(Example) For the handle feed of the manual speed command 2
[Each speed]
Feedrate of 1st handle's 1st axis: 4000mm/min
Program command speed of 1st part system: F1000
Program command speed of 2nd part system: F500
Program command speed of 3rd part system: F2000
[Each part system's feedrate by the manual speed command 2]
1st part system: 2000mm/min (program command speed ratio: 50%)
2nd part system: 1000mm/min (program command speed ratio: 25%)
3rd part system: 4000mm/min (program command speed ratio: 100%)

(2) The automatic operation is paused by turning ON this signal during the cycle start.

(3) Command this to the 1st handle's 1st axis for the handle mode, or to the 1st axis for the JOG mode. If it is commanded to the other axis, the error "M01 Internal interlock axis exists 0005" will occur.

(4) When this function is valid, MST or dwell commands are executed the same as in the normal automatic operation. Therefore, if MST is commanded to the same block as the movement block, the program does not move to the next block before the MST command is completed.

(5) The manual speed is clamped when the entered speed exceeds the clamp speed.

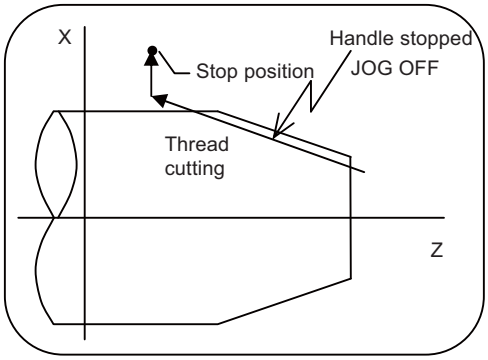
(6) In the creep control of the dog type reference position return, the "reference position return creep speed" is applied regardless of the entered manual speed.

(7) To stop the movement by handle and changed to the automatic operation, turn OFF the "Manual feed command valid" signal and the handle mode, and then execute the cycle start with the memory mode ON.

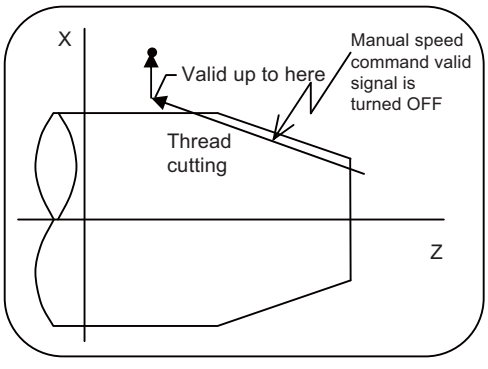
(8) If the cutting override is "0", the movement occurs by the manual speed when other than JOG manual speed command is given. No movement occurs in the JOG mode.

(9) In the synchronous tapping, cuttings follow the commands in the program. The manual speed command does not effect on the operation. Neither stopping the handle move nor turning OFF the JOG mode stops the operation.

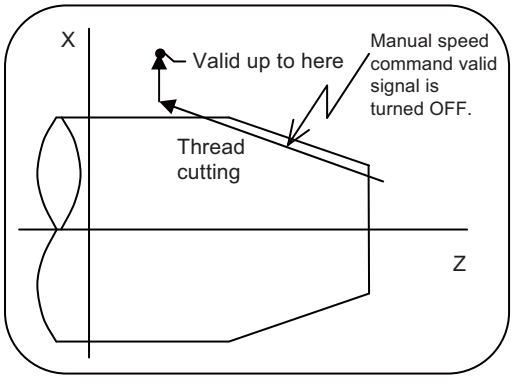
(10) When the parameter "#1247 set19/bit1" (thread cutting operation selection when the manual speed command is valid) is set to "1", the axis moves in accordance with the program command while the thread cutting is in progress or until the next block's end point of where the thread cutting is completed (the G33 mode has ended).
Even if the handle is stopped or the JOG is turned OFF while in this movement, the axis will not stop until it moves to the next block's end point of where the thread cutting is completed.



(11) If the manual speed command valid signal is turned OFF while executing this function, this function becomes invalid even during the axis is traveling. However, in the synchronous tapping or thread cutting, the manual speed command is kept valid until the end of these processes: turning OFF the "Manual speed command valid" signal does not effect on these processes.
When the parameter "#1247 set19/bit1" is set to "1", even if the manual speed command is turned OFF while executing the thread cutting, this signal is valid until the next block's end point of where the thread cutting is completed.

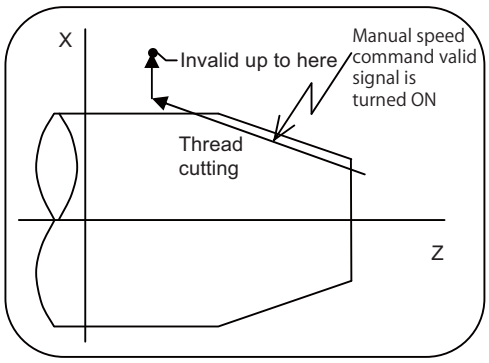


When the parameter "#1247 set19/bit1" is set to "0".



When the parameter "#1247 set19/bit1" is set to "1".

(12) If the manual speed command valid signal is turned ON during the cycle start, the automatic operation is paused. However, even if the manual speed command valid signal is turned ON while executing the thread cutting, the manual speed command is kept invalid until the next block's end point of where the thread cutting is completed.

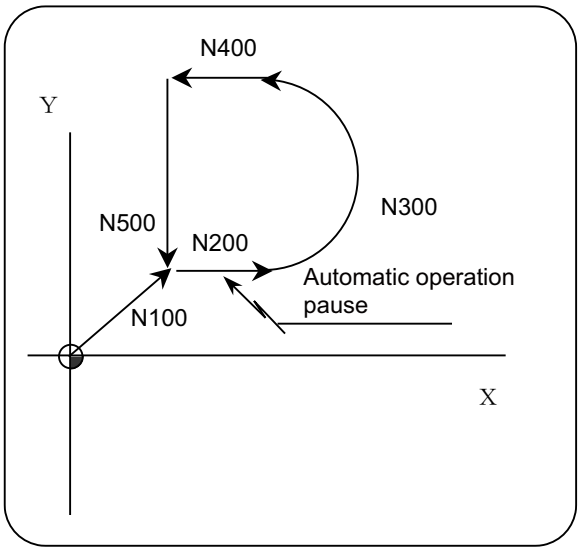


(13) Both manual and automatic interlocks are available when the manual speed command is valid.

Direction designated in the machining program Example) 100/-100 is set for the X direction of the 1st axis	
Program X100	Program X-100
(Forward run)	(Forward run)
Automatic interlock+: Available	Automatic interlock+: Not available
Automatic interlock-: Not available	Automatic interlock-: Available
Manual interlock+: Available	Manual interlock+: Available
Manual interlock-: Not available	Manual interlock-: Not available
(Reverse run)	(Reverse run)
Automatic interlock+: Available	Automatic interlock+: Not available
Automatic interlock-: Not available	Automatic interlock-: Available
Manual interlock+: Not available	Manual interlock+: Available
Manual interlock-: Available	Manual interlock-: Not available

Operation example

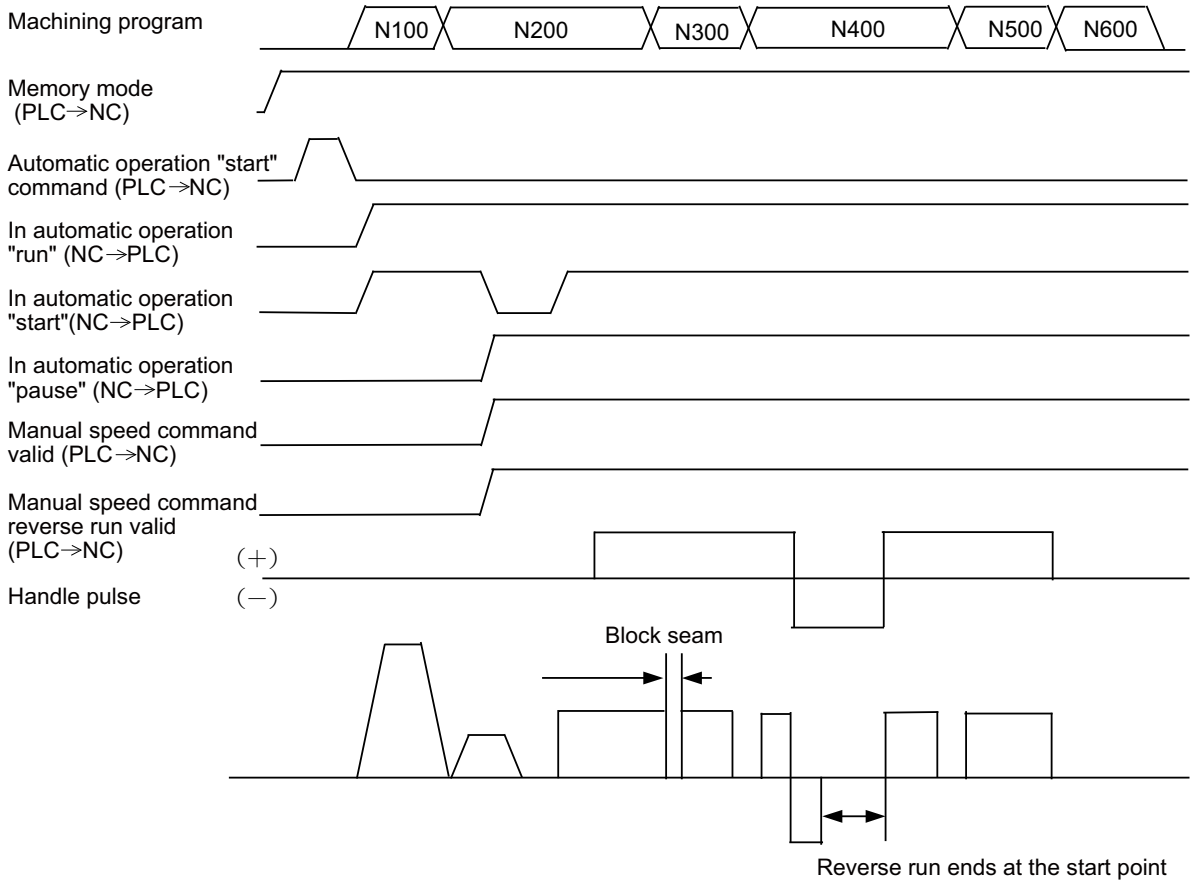
<Machining program>
N100 G91 G0 X10. Y10.
N200 G1 X10. F1000
N300 G3 Y20. J10. F200
N400 G1 X-10. F1000
N500 G1 Y-20.
N600 M30



[Operation example 1

(When giving the manual speed command in automatic operation "run" of a machining program)]

(1) Search a machining program and execute the cycle start in memory mode.
(2) Command the automatic operation pause during the N200 block execution.
(3) Turn ON the "Manual speed command valid" and "Manual speed command reverse run valid" signals, as well as the handle mode. (Keep the memory mode ON.)
(4) When 1st handle is rotated in the (+) direction, the axis moves in the blocks with the handle feedrate.
(5) When the handle is rotated in the (-) direction, the movement is reversed against the program. The reversed movement ends at the block start point. (Cannot return to the previous block.)
(6) The handle, which keeps rotating in the (+) direction after the block has ended, continues the blocks N300 to N500 with the handle feedrate.
(7) Command M30 at N600 block to end the program by NC reset or completion.

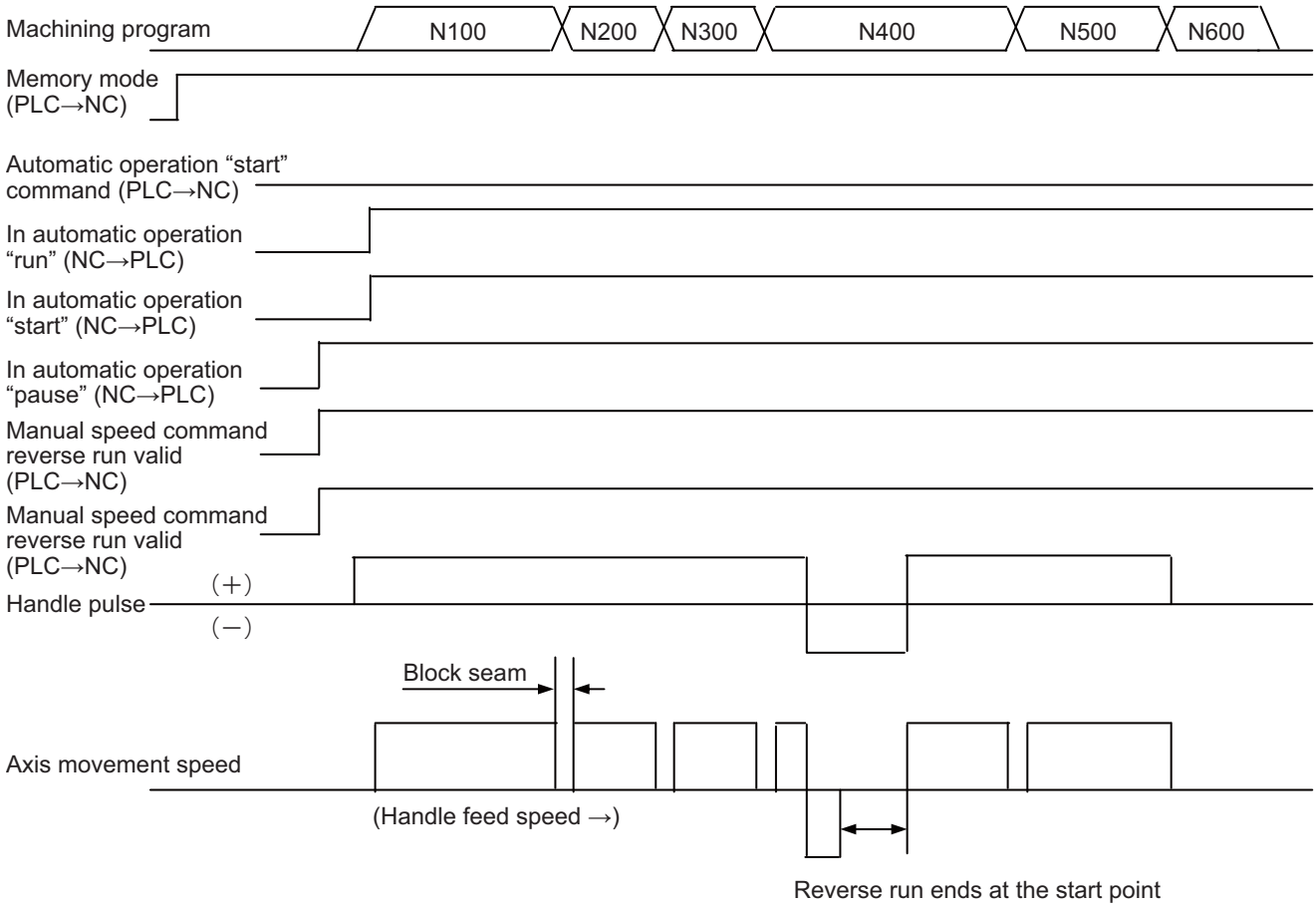


(Note) When the reverse run is not valid, the movement follows the machining program, not the handle feed direction.

[Operation example 2 (When giving the manual speed command at the start of machining program)]

(1) Search the machining program. Turn ON memory mode.
(2) Turn ON memory mode, the "manual speed command valid" signal and handle mode.
(3) When the handle is rotated in the (+) direction, the axis starts to move with the handle feedrate from the head block.

The rest of the operation is same as the operation example 1.



12.2.1 Manual Speed Command (when the parameter "#1365 manualFtype" is set to "0")

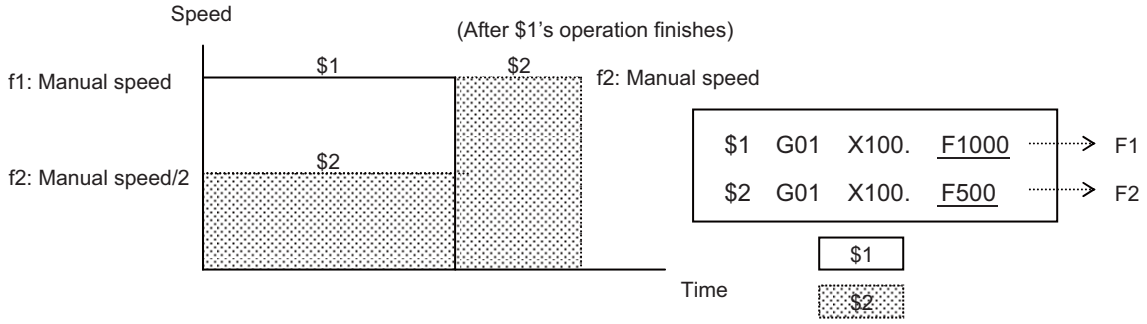
(1) The feedrate is set as follows depending on the manual mode:
- In handle mode
  The feedrate of the 1st handle's 1st axis is applied.
- In JOG mode
  The manual feedrate for each part system is applied.
- In manual rapid traverse mode
  The rapid traverse speed of the 1st axis for each part system is applied.

(2) When a cutting command is given, the feedrate is limited by the cutting clamp feedrate (#2002 clamp) of each axis's parameter.
When a rapid traverse command is given, the feedrate is limited by the rapid traverse feedrate of each axis's parameter.

(3) For the reverse run, the axis stops when it is reached to the block start point in each part system.

12.2.2 Manual Speed Command (when the parameter "#1365 manualFtype" is set to "1")

This command adjusts the handle/JOG/manual feedrate while executing the manual speed command in two or more part systems to the feedrate which matches the ratio of program command of each part system in execution. The ratio is based on the fastest program command speed among the blocks in execution.
This can make the state of progress across part systems to nearly the same state as the normal automatic operation.
"Program F command speed * the setting value of #19005 (%)" limits the feedrate by setting the value in proportion to the program command speed to the parameter "#19005 manual Fcmd2 clamp".



f1 = Manual speed * (F1 / Fm) (Note 1)(Note 2)
f2 = Manual speed * (F2 / Fm) (Note 1)(Note 2)

Note that the feedrate F1 is limited by "F1 * the setting value of #19005 (%)". (Note 3)
The feedrate F2 is limited by "F2 * the setting value of #19005 (%)".(Note 3)

(Note 1) For the part system that the manual speed command is valid, the manual speed is set as follows depending on the manual mode:
- In the handle mode
  The feedrate of 1st handle's 1st axis is applied.
- In the JOG mode
  All part systems whose manual speed command is enabled, the manual feedrate of the smallest number's part system is applied.
- In the manual rapid traverse mode
  All part systems whose manual speed command is enabled, the 1st axis's rapid traverse feedrate of the smallest number's part system is applied.

Across the part systems that the manual speed command is valid, the override of the smallest number's part system is valid.

(Note 2) Fm is the feedrate F1 or F2, whichever is faster.

(Note 3) For the cutting command, the feedrate is limited by the cutting clamp feedrate parameter (#2002 clamp) of each axis.
For the rapid traverse feedrate command, the feedrate is limited by the rapid traverse feedrate parameter (#2001 rapid) of each axis.

(1) The feedrate is set as follows depending on the manual mode:
- In the handle mode
  The feedrate of the 1st handle's 1st axis * program command speed ratio
  (The handle magnification of the smallest number's part system across the part systems that the manual speed command is enabled)
- In the JOG mode
  Among the part systems in which the manual speed command is enabled, the JOG feedrate of the smallest number's part system * program command speed ratio
- In the manual rapid traverse mode
  Among the part systems in which the manual speed command is enabled, the 1st axis's rapid traverse feedrate of the smallest number's part system * program command speed ratio

  (Example) In JOG mode
  - When the "manual speed command valid" signal of the 1st and 2nd part system is ON
    Feedrate = JOG feedrate of the 1st system * program command speed ratio
  - When the "manual speed command valid" signal is ON only for 2nd part system
    Feedrate = JOG feedrate of the 2nd system * program command speed ratio

(2) The feedrate is limited by the following speed, whichever is slower:
- Program command speed * the setting value of #19005 (%)
- For the cutting command, the cutting clamp feedrate parameter (#2002 clamp) of each axis
  For the rapid traverse command, the rapid traverse feedrate parameter (#2001 rapid) of each axis

(3) In the reverse run involving two or more part systems, once any of the part systems reaches to the block start, rest of the part systems also stop.
(Example)

$1 G00 X100. G01 X200. F1000	$2 G00 X50. G01 X200. F1000

- When a reverse run starts at the second block $1:X120. $2:X170.
  When $1 reaches X100. (block start), $2 stops at X150.

A reverse run operation is not applied to a part system that is executing the following types of commands/blocks; G code with which a reverse run is prohibited (such as G33: thread cutting, G04: dwell), or an MSTB block (except for a timing synchronization between part systems with M code).
(Example)

$1 G00 X100. G33 X200.U0.F1.S600 F1000	$2 G00 X50. G01 X200. F1000

- When a reverse run starts at the second block $1:X120. $2:X170.
  In $1, the axis stops. (Reverse run impossible)
  In $2, the axis moves to X50. (block start), then stops.

(4) For the rapid traverse (G0), the axis moves with the composite speed of the rapid traverse axis, and other than G0, the axis moves with the ratio of the command speed across the part systems.

(5) The program command speed ratio is calculated as "S command value * command value F" of the program as the program command speed. S command value is used in the commanded part system.
If S command is "0", the handle/JOG/manual traverse feedrate of the smallest number's part system in which the manual speed command is valid is applied.

(6) If the program command speed is "0", the handle/JOG/manual traverse feedrate of the smallest number's part system in which the manual speed command is valid is applied.

(7) During the forward run, the handle/JOG/manual traverse feedrate of the smallest number's part system in which the manual speed command is valid is applied for thread cutting.
When the parameter "#1247 set19/bit1" is set to "1", the movement speed follows the program command for thread cutting and the movement up to the end point of the next block in which the thread cutting is finished (the G33 mode has ended.).
When performing thread cutting in the 1st part system, the handle speed/JOG/manual traverse feedrate of the 1st part system is applied to other part systems in which thread cutting is not being performed.

(8) If the manual speed command is executed in only one part system, the program command speed ratio becomes "1"; therefore, the handle speed/JOG/manual traverse feedrate of the executed part system is applied. It is possible to limit the feedrate with "Program F command speed * Setting value (%) of #19005".

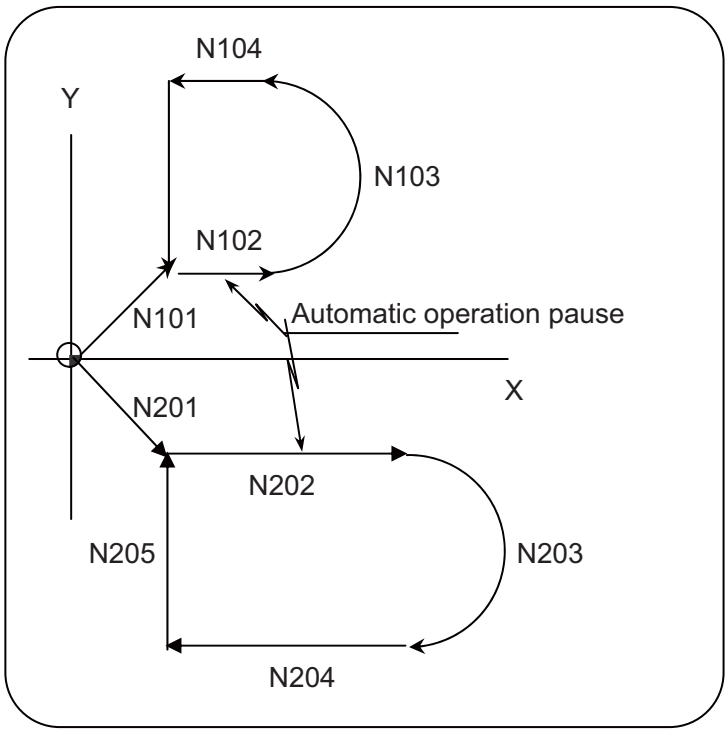
Operation example

<Machining program of 1st part system>

```
N101 G91 G0 X10. Y10.
N102 G1 X10. F100
N103 G3 Y20. J10. F600
N104 G1 X-10. F50
N105 G1 Y-20.
N106 M30
```

<Machining program of 2nd part system>

```
N201 G91 G0 X10. Y-10.
N202 G1 X20. F200
N203 G3 Y-20. J-10. F1200
N204 G1 X-20. F100
N205 G1 Y20.
N206 M30
```



[Operation example 1

(When the manual speed command is enabled at the second block in both the 1st and 2nd part systems)]

(1) Search a machining program and execute the cycle start of the 1st and 2nd part systems in memory mode.

(2) Command the automatic operation pause during the N102, N202 block execution.

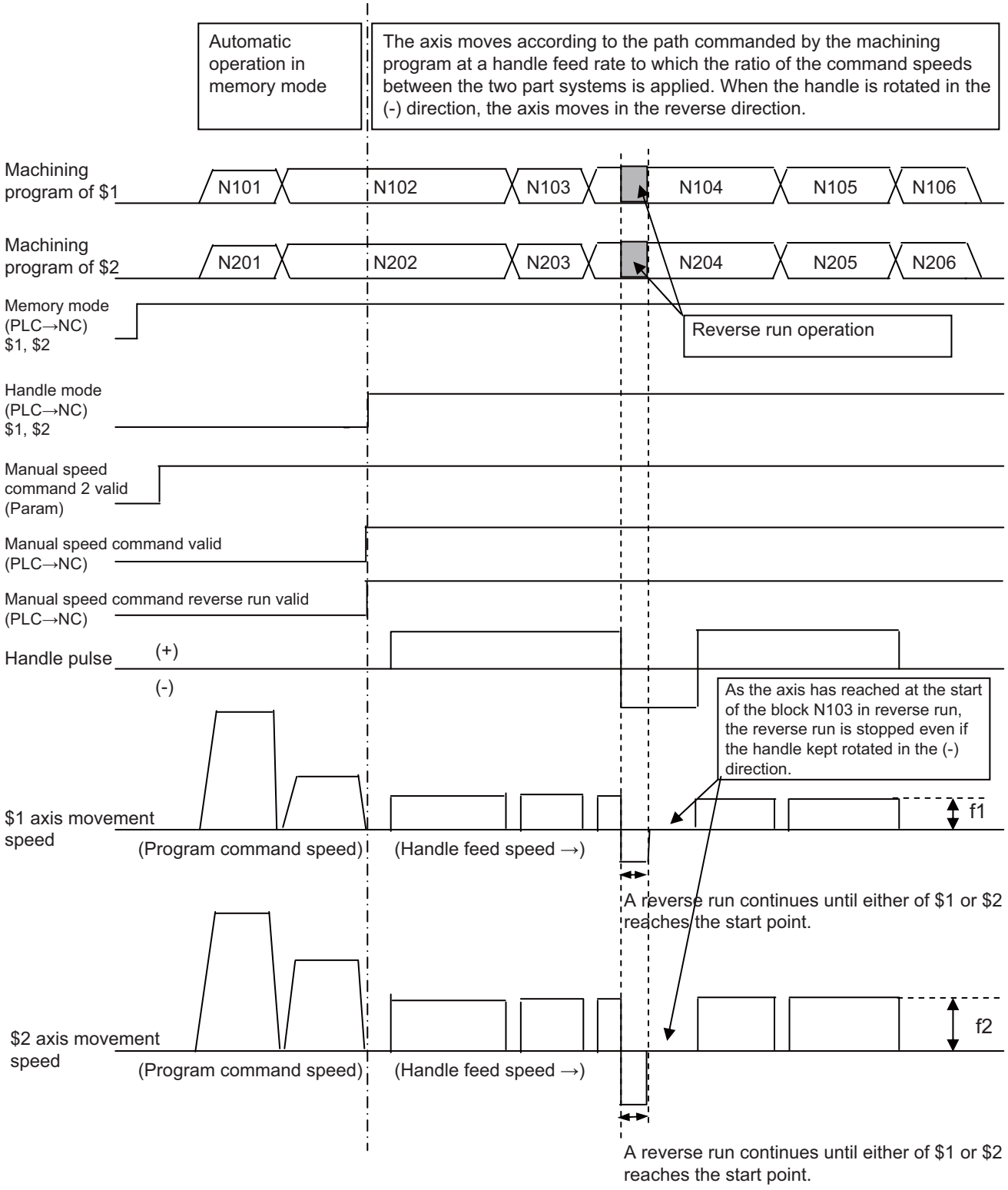
(3) Turn ON the "Manual speed command valid" signal, "Manual speed command reverse run valid" signal, and handle mode of the 1st and 2nd part systems. (Keep the memory mode ON.)

(4) When the 1st handle is rotated in the (+) direction, the axes in the blocks of the 1st and 2nd part systems continue to move at speeds to which the ratio of the automatic operation feed rates is applied to the handle feedrates.
Feedrates of each part system are as below:
(Example) When the handle is rotated with the handle feedrate of 10.0mm/min:
Block N102 of 1st part system, command speed F100...Feedrate is 5.0 [mm/min]
Block N202 of 2nd part system, command speed F200…Feedrate is 10.0 [mm/min]

(5) When the handle is rotated in the (-) direction, the movement is reversed against the program.
In this case, the ratio of the automatic operation feed rates is applied to the handle feed rates.
However, when either of $1 or $2 reaches the block start point, the reversed movements of both part systems end. (Cannot return to the previous block.)

(6) The handle, which keeps rotating in the (+) direction after the block has ended, continues the blocks N103 to N105/N203 to N205 with the handle feed rate.

(7) Command M30 at the N106, N206 blocks to end the program by NC reset or completion.



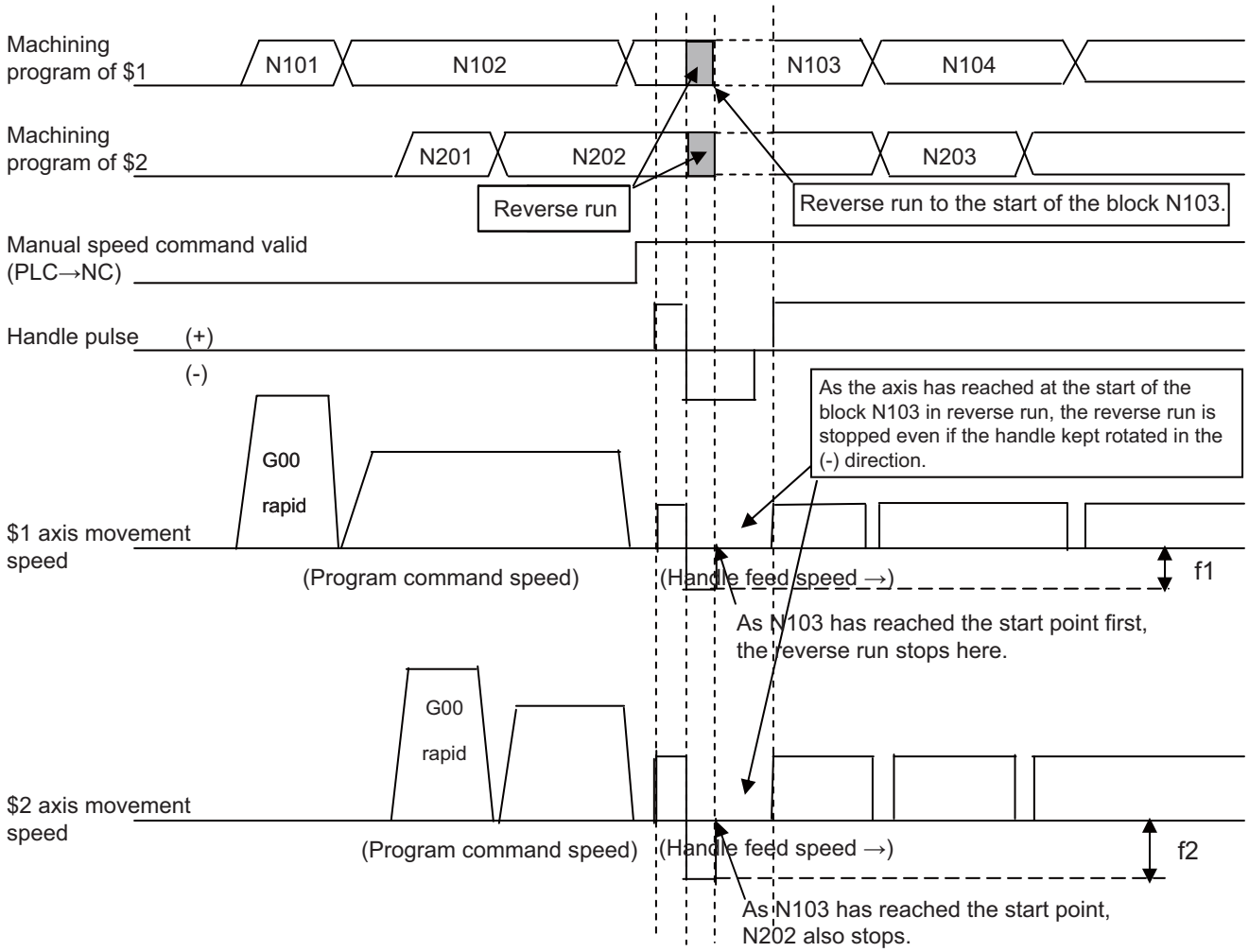
The movement speed value of f1, f2 is calculated by multiplying the command speed ratio between two part systems by the handle speed.

(Note) When the reverse run is not valid, the movement follows the machining program, not the handle feed direction.

[Operation example 2

(When the manual speed command is enabled at the third block of the 1st part system and the second block of the 2nd part system)]

(1) Search a machining program and execute the cycle start of the 1st part system in memory mode.
(2) A while after, execute the cycle start of the 2nd part system.
(3) Command the automatic operation pause during the N103, N202 block execution.
(4) Turn ON the "Manual speed command valid" and "Manual speed command reverse run valid" signals of $1 and $2, as well as the handle mode of $1 and $2. (Keep the memory mode ON.)
(5) When the 1st handle is rotated in the (+) direction, the axes in the blocks of 1st and 2nd part systems continue to move at speeds to which the ratio of the automatic operation feed rates is applied to the handle feedrates. Feedrates of each part system are as below.
(Example) When the handle is rotated with the handle feedrate 10.0 mm/min:
N103 block of 1st part system, command speed F600...Feedrate is 2.0 [mm/min]
N202 block of 2nd part system, command speed F200…Feedrate is 10.0 [mm/min]
(6) In this case, the ratio of the automatic operation feedrates is applied to the handle feedrates. However, when either of $1 or $2 reaches the block start point, the reversed movements of both part systems end. (Cannot return to the previous block.)
(Example) Between the blocks N103 and N202, if the block N103 first reaches the start point, the axis of the block N202 stops even if the block has not been finished.



The movement speed value of f1, f2 is calculated by multiplying the command speed ratio between the two part systems by the handle speed.

Restrictions and precautions regarding manual speed command 2

(1) When using this function involving multiple part systems, the manual mode (handle/JOG/rapid traverse), the manual speed command reverse run valid signal and the manual speed command sign reversed signal must be the same between part systems where the manual speed command is enabled.

(2) When using rapid traverse (G0) in this function, set "#1086 G0Intp" to "0".
If "#1086 G0Intp" is set to "1" (Non-interpolation), the handle speed/JOG/manual rapid traverse rate of the smallest part system No. among the part systems where the manual speed command is enabled is applied to the G0 speed. However, relations of travel paths and travel speeds between part systems may be different from those of an actual automatic operation.

(3) The handle speed/JOG/manual rapid traverse rate of the smallest part system No. between part systems where the manual speed command is enabled is applied to a movement from the intermediate point to the reference position of G28/G30 (reference position return) and a movement from the start point to the intermediate point of G29. These movements are non-interpolation type; therefore, machining conditions (related to travel paths and travel speeds) between part systems may be different from those of an actual automatic operation.

(4) For constant surface speed control, the S command before commanding the constant surface speed control is used.
When constant surface speed control is used, the relation of feedrates between part systems may be different from the ratio of the actual travel speeds of the tools.

(5) For an inverse time feed, the relation of feedrates between part systems may be different from the ratio of the actual travel speeds of the tools.

(6) If a reverse run operation is carried out at a single block stop in any of the part systems, the block which is in the single block stop moves to the next block. The other part systems carry out the reverse run only during the movement.

(7) If any of part systems is in a timing synchronization (a timing synchronization by a ! code or M code, or a timing synchronization with the start point designated (G115/G116)), the rest of the part systems cannot carry out a reverse run.

(8) This function uses the handle speed/JOG/manual rapid traverse rate of the smallest No.'s part system in which the manual speed command is enabled. In the case of using this function in multiple part systems, if the "manual speed command valid" signal is switched (ON - OFF) while the handle/JOG feed is still carried out, the part system which uses the handle/JOG/manual rapid traverse speed may change and the moving axis's feedrate may also change. Switch the manual seed command valid signal after stopping the handle/JOG feed.

12.2.3 Precautions

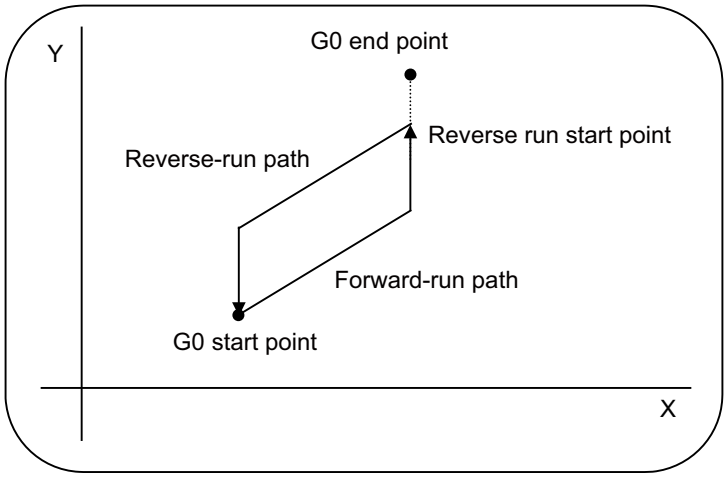
(1) The execution of the manual speed command ignores the cycle start.

(2) If the asynchronous tapping is executed while the manual speed command is valid, the pitch will not be the same as commanded.

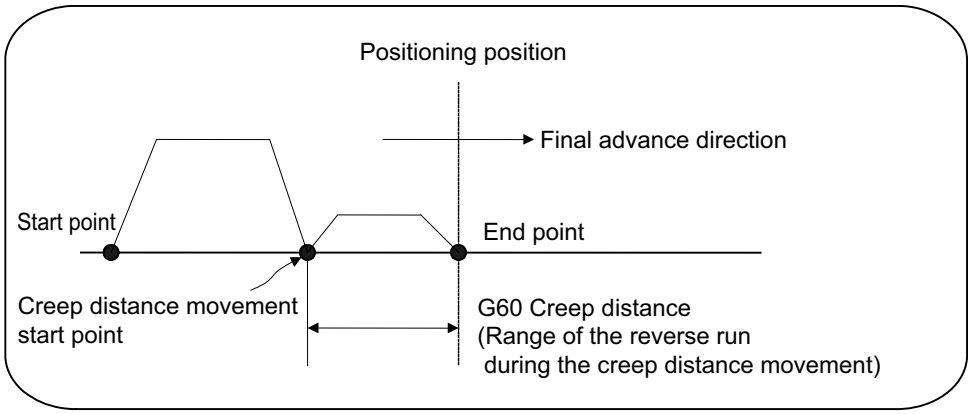
(3) The reverse run cannot be executed in the following operations:
- Dog-type reference position return
- In cutting cycle in the synchronous or asynchronous tap
- In shift amount operation in a fixed cycle
- In tool center point control
- In normal line control
- In milling interpolation/polar coordinate interpolation/cylindrical interpolation
- Thread cutting (G33) .
- Exponential interpolation.
- Spline interpolation.
- NURBS interpolation.
- Tool change position return or 2nd/3rd/4th reference position return (from the intermediate point to the block end).
- Reference position return (G28, G29).

When G28 is commanded, however, the reverse run is available from the start point and to the intermediate point.
When G29 is commanded, the reverse run is available from the intermediate point to the end point

(4) If a forward run has been executed at rapid traverse (G0) with non-interpolation, the reverse run may not have the same path.



(5) During the creep distance movement in the unidirectional positioning (G60), a reverse run ends at the creep distance movement start point.



(6) In the corner chamfering/corner R, a reverse run ends at the start point of the corner chamfering/corner R.
(7) If the 3-dimensional circular interpolation has been carried out beyond the intermediate point, a reverse run ends at the intermediate point.
(8) In the tool compensation, a reverse run is executed within the block of the compensation.
(9) In the fixed cycles, a reverse run is executed for each one block of fixed cycle.
(10) Neither mode of high accuracy control, high-speed high-accuracy control nor high speed machining is available when the manual speed command is valid.
(11) Turn OFF the "Tool length measurement 1" (TLM) signal before starting a machining program with the manual feed command. Otherwise, "M01 Internal interlock axis exists 0005" will occur.

12.2.4 List of Signals

NC->PLC interface signal

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	IN MANUAL SPEED COMMAND VALID		XC48	XD88	XEC8	X1008	X1148	X1288	X13C8	X1508

[Function]

This signal indicates that the "Manual speed command valid" signal has turned ON and the manual speed command is valid in the controller.

[Operation]

This signal turns ON when the "Manual speed command valid" signal has turned ON and the manual speed command has been enabled in NC.

This signal turns OFF when the "Manual speed command valid" signal has turned OFF and the manual speed command has been disabled in NC.

[Related signals]

(1) Manual speed command valid (YC9D)

PLC → NC interface signal

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	TOOL LENGTH MEASUREMENT 1	TLM	YC20	YD60	YEA0	YFE0	Y1120	Y1260	Y13A0	Y14E0

[Function]

"Tool length manual measurement 1" is selected by this signal.

For M system, "Tool length manual measurement 1 and 2" functions are used by this signal.

[Operation]

When the signal (TLM) is turned ON (1), amount of tool length to be corrected is calculated automatically in the controller.

[Caution]

(1) This signal is invalid if the tool length screen is not selected.

(2) Turn this signal OFF before executing a program with manual speed command.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	MANUAL SPEED COMMAND VALID		YC9D	YDDD	YF1D	Y105D	Y119D	Y12DD	Y141D	Y155D

[Function]

This signal is used to run the machining program with handle feedrate or JOG feedrate (manual feedrate).

[Operation]

After this signal is ON, manual speed (handle or manual feedrate) is applied to the axis feedrate in the whole automatic operation: the speed commanded in the program is not used.

If the program has not started, the automatic operation start is executed with handle or manual feedrate.

The manual operation mode decides whether the manual feedrate or handle feedrate is used.

- In handle mode

  The program under operation is executed at the feedrate of the 1st handle, 1st axis.

  During the reset, block stop or pause in the automatic operation mode, the automatic operation starts at the time when the handle feedrate has been commanded.

  When the reverse run is valid, a command in the (+) direction makes the movement as in the program, while a command in (-) direction reverses the movement against the program. The reversed movement, however, is available only within the current block.

- In JOG mode

  The program under operation is executed at the manual feedrate as long as the JOG mode signal is ON for the 1st axis.

  During the reset, block stop or pause in the automatic operation mode, the automatic operation starts at the time when the JOG mode has been turned ON.

  When the reverse run is valid, a command in the (+) direction makes the movement as in the program, while a command in (-) direction reverses the movement against the program. The reversed movement, however, is available only within the current block.

  When the "Rapid traverse" signal is ON, the axis moves at the rapid traverse feedrate.

[Caution]

(1) Turning ON this signal in the automatic operation leads to an automatic operation pause.

(2) While this signal is ON, the "Automatic operation "start" command" signal is not valid.

(3) When the automatic operation is carried out with the manual speed command, the "In automatic operation "pause"" signal is output regardless of the axis movement.

(4) The manual speed command makes the movement follow the command on the 1st axis, even though the other axis is commanded in the program. Any commands to the other axes lead "M01 OPERATION ERROR 0005" (Internal interlock axis exists).

(5) The following G commands or modal make the movement different from that in the normal automatic operation.
G00: The manual feedrate is applied, not the rapid traverse feedrate.
G28: The manual feedrate is applied, not the reference position return feedrate.
G31: The manual feedrate is applied, not the skip feedrate. The movement when the skip signal is input, however, is the same as in the normal operation.
G33, G34 to 36 (L system): The thread cutting (G33), the variable lead thread cutting (G34: L system only), and the arc thread cutting (G35/36: L system only) operate the same as the dry run. The manual feedrate is applied.
(When the parameter "#1247 set19/bit1" is set to "1", it operates according to the program command.)
G95: The feed per rotation operates the same as the dry run.
F1-digit feed: The manual feedrate is applied, not the F1-digit feedrate. The "F1-digit commanded" signal is not output, either.

(6) Only the 1st handle is used. The other handles are ignored.

(7) When this signal is valid, the feedrate is not changed by the Inch/Metric changeover command (G20/G21), nor by the rotary axis command speed tenfold.

(8) The manual interruption and the thread cutting cycle retract are available when this signal is ON. The automatic handle interruption, as well as the manual operation in the manual/auto simultaneous mode, cannot be used on the 1st axis because the axis applies the manual input upon this signal.

[Related signals]

(1) Manual speed command sign reversed (YC9E)
(2) Manual speed command reverse run valid (YC9F)
(3) In automatic operation "pause" (SPL: XC14)
(4) In manual speed command valid (XC48)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	MANUAL SPEED COMMAND SIGN REVERSED		YC9E	YDDE	YF1E	Y105E	Y119E	Y12DE	Y141E	Y155E

[Function]

When the manual speed is commanded, this signal reverses the direction that has been commanded with the handle feed or JOG feed.

[Operation]

When this signal is ON, a speed command in the (+) direction reverses the movement against the program. (Note that this operation is not available unless the reverse run is valid.) A command in the (-) direction makes the movement as commanded in the program.

Manual speed command Reverse run valid	Manual speed command Sign reversed	Movement direction	
		by (+) operation	by (-) operation
OFF	(Invalid)	+	+
ON	OFF	+	-
ON	ON	-	+
In the modals that do not allow the reverse run (thread cutting and synchronous tapping)		+	The operation is ignored

[Caution]

This signal is not valid when the "Manual speed command Reverse run valid" signal is OFF.

[Related signals]

(1) Manual speed command valid (YC9D)
(2) Manual speed command reverse run valid (YC9F)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	MANUAL SPEED COMMAND REVERSE RUN VALID		YC9F	YDDF	YF1F	Y105F	Y119F	Y12DF	Y141F	Y155F

[Function]

This signal allows the manual speed command in the (-) direction to reverse the movement against the program.

[Operation]

When this signal turns ON during the manual speed is commanded, a speed command in the (-) direction in handle or JOG mode reverses the movement against the program.

When this signal is OFF, a command in the (-) direction makes the same movement as commanded in the (+) direction: the movement follows the program.

[Caution]

(1) The reverse run is available within the block in execution. The reversed axis movement stops at the start point of the block in execution.

(2) Unless all the axes stop, this signal cannot be changed ON/OFF. The ON/OFF change of this signal during the axis movement is realized after all the axes have stopped.

(3) The reverse run is not allowed in the following operations. The axis stays stopped if a speed command is given in the (-) direction.

(a) In the reference position return (G28, G29). When G28 is commanded, however, the reverse run is available from the start point and to the intermediate point. When G29 is commanded, the reverse run is available from the intermediate point to the end point.

(b) In cutting cycle in the synchronous or asynchronous tap.

(c) In shift amount operation in a fixed cycle.

(d) In tool center point control.

(e) In normal line control.

(f) In milling interpolation, polar coordinate rotation or cylindrical interpolation.

(g) When the thread cutting command (G33) is given.

(h) In exponential interpolation.

(i) In spline interpolation.

(j) In NURBS interpolation.

(k) In tool change position return or 2nd/3rd/4th reference position return (from the intermediate point to the block end).

[Related signals]

(1) Manual speed command valid (YC9D)

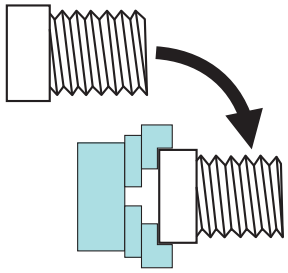
(2) Manual speed command sign reversed (YC9E)

12.3 Thread Recutting

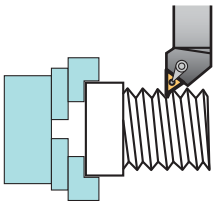
12.3.1 Outline

The function stores a thread groove position and compensates a start position of spindle thread cutting automatically so that the tool can pass along the memorized position of the thread groove at the thread cutting execution. Thread machined workpieces which have problems such as the thread number shortage, striped groove, etc., can be re-chucked and thread re-cut.

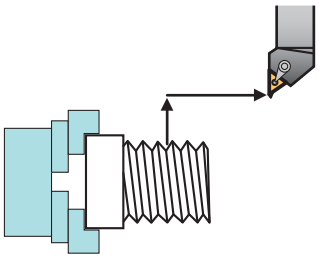
(1) Re-chucking of thread machined workpiece



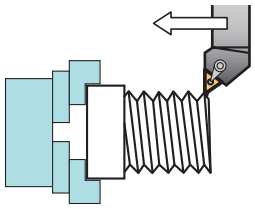
(2) Memorizing thread groove position
(memorizing lead axis and spindle position)



(3) Moving to start position after tool retract



(4) Thread recutting ON and program operation start



The start position of spindle thread cutting is automatically compensated with the memorized position of the lead axis and spindle.

Thread recutting correspondence table

Thread cutting command	Z direction feed thread	X direction feed thread
	Right-handed/Left-handed thread	Scroll thread
Thread cutting	○	○
Continuous thread	Δ (Note 1)	Δ (Note 1)
Variable lead thread	Δ (Note 2)	Δ (Note 2)
Fixed cycle for turning machining	○	○
Compound type fixed cycle for turning machining	Δ (Note 3)	Δ (Note 3)

○: Machinable Δ: Machinable with conditions × : Impossible

Machinable with conditions (Δ)

(Note 1) Continuous thread: Conduct a memorizing of thread recutting position at the groove on the first block of continuous thread.

(Note 2) Variable lead thread: Thread recutting is disable during an automatic operation with thread recutting enabled when the first thread cutting command is the variable lead thread cutting.

(Note 3) Compound type fixed cycle: Re-finishing can be performed to the finished workpiece.
Thread recutting cannot be performed correctly if a memorizing operation is conducted to the finished workpiece.

To perform the thread recutting operation, enable thread recutting and execute the program after describing the thread groove positions. The are two methods of thread recutting, which can be switched using parameters.

Method	Change Parameter #1258 set 30(PR)	Overview of Operation
Mitsubishi HMI method of operation	bit 4 = 0	Use the Mitsubishi HMI to set the thread groove positions and start recutting.
Ladder method of operation	bit 4 = 1	Use the ladder to set the thread groove positions and start recutting.

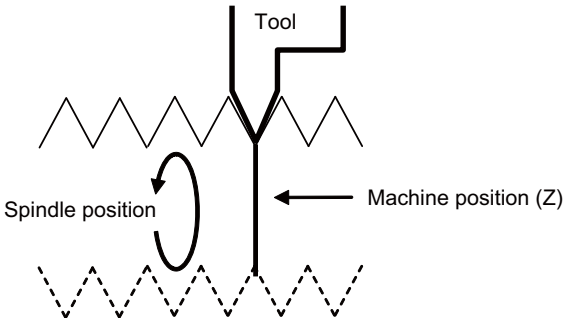
This chapter describes the ladder method of operation.

12.3.2 Detailed Description

12.3.2.1 Method of Operation

Turn ON "#1258 set 30/bit 4" to enable thread recutting via ladder configurations.
Refer to the "PLC Interface Manual" for more information on R register signals.

(1) Install the workpiece to be processed with thread recutting to the spindle that will perform the thread recutting.
(2) Set the R2567 (encoder selection) with the number of the spindle that will perform the thread recutting.
(3) Set the R2626 (thread recutting command) with the lead axis number (bit 8 through bit F) and the storage (bit 0) for the spindle that will perform the thread recutting.
(4) Use manual mode to move the tip of the cutting tool that will perform the thread recutting up to the thread groove in the workpiece.



(5) Turn ON the R2626 (thread recutting command) command execution bit (bit 7) and store the thread recutting position.
→Bit 0 in R648 (thread recutting status) turns ON if operation completes successfully.
If an error occurs, bit 7 in R648 (thread recutting status) and the bit corresponding to the error turns ON.
(6) After confirming R648 (thread recutting status), turn OFF the R2626 (thread recutting command) command execution bit (bit 7).
→Turning OFF the command execution bit (bit 7) turns OFF R648 (thread recutting status).
(7) Turn ON the thread recutting function enable bit (bit F) in R2627 (thread recutting execution operation). Bit F in R649 (thread recutting execution status) turns ON if the thread recutting position is stored.
(8) Disengage the thread cutting tool from the workpiece and then start the program to perform the thread recutting process via cycle operation or a resume search operation to being processing. As a result, the same screw processing as that for the original screws can be performed.
Turn OFF the thread recutting function enable bit (bit F) in R2627 (thread recutting execution operation) after the thread cutting process completes. Bit F in R649 (thread recutting execution status) turns OFF again when this is turned OFF.

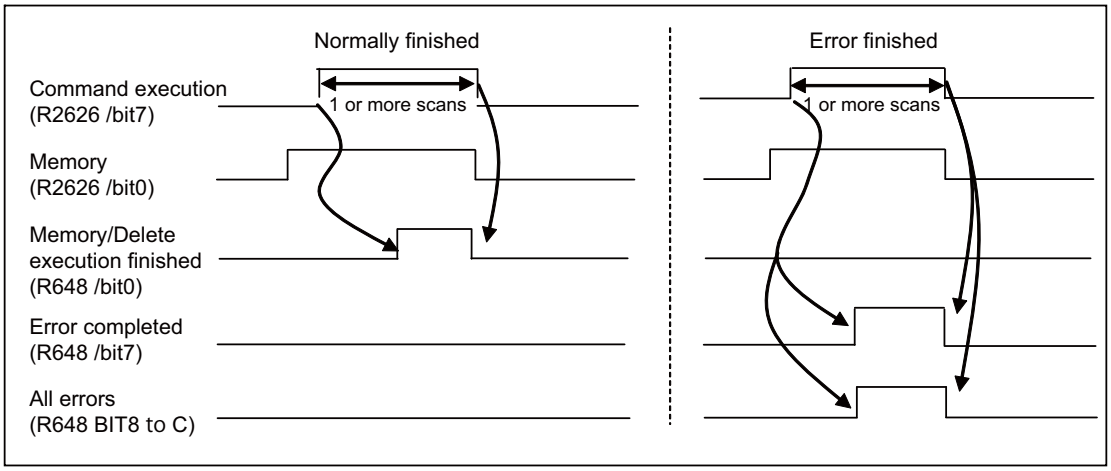
12.3.2.2 Configuring Thread Recutting Spindle Numbers/Thread Recutting Lead Axis Names

Configure the lead axis number in R2626 (thread recutting command) and spindle number in R2567 (encoder selection) before storing the thread recutting position. If the lead axis number in R2626 (thread recutting command) and spindle number in R2567 (encoder selection) are changed while the thread recutting position is stored, the spindle and lead axis will perform the thread recutting.

12.3.2.3 Storing the Thread Recutting Position

The "Operation to Store the Thread Cutting Position" is equivalent to steps 2 through 5 of the "Method of Operation". The thread recutting position record stores the machine position of the lead axis when the tool is aligned with the thread groove and stores the spindle angle. When this information is successfully stored, the thread recutting spindle number is represented by R650 and the thread recutting lead axis number is represented by R651.

<Timing Chart when Executing the Storage Process>



<Conditions for Storing Thread Recutting Positions>
The amount of phase shift during the thread recutting operation is calculated by the first thread cutting block used for the thread recutting process. Thus, if there are multiple screw cutting commands in the processing program, store the thread recutting position at the position of the workpiece corresponding to the first thread cutting block used for the thread recutting process.
Store the thread recutting position after satisfying the following conditions. When attempting to store the thread recutting position if these conditions are not satisfied, the thread recutting position is not stored, and bit 7 in R648 (thread recutting status) and the bit corresponding to the error are turned ON. Confirm and resolve the cause of failure to store the position and then reperform the operation to store the thread recutting position.

Thread Recutting Position Storage Conditions
(1) The zero point of the lead axis is established.
(2) The spindle passes the Z phase after power is turned ON.
(3) Thread recutting process must be in operation (thread recutting status is not "thread recutting in operation").
(4) Cycle start is not in operation.
(5) Spindle is stopped (zero speed).
(6) All axes in the part system to be stored must be stopped.
(7) The lead axis number set in R2626 (thread recutting command) must be within the allowed range.
(8) The spindle number set in R2567 (encoder selection) must be within the allowed range.
(9) Multiple-spindle control II must be selected.

12.3.2.4 Deleting Thread Recutting Positions

<Operation to Delete Thread Recutting Positions>

(1) Set the delete bit (bit 1) in R2626 (thread recutting command).

(2) Turn ON the R2626 (thread recutting command) command execution bit (bit 7) and delete the thread recutting position.

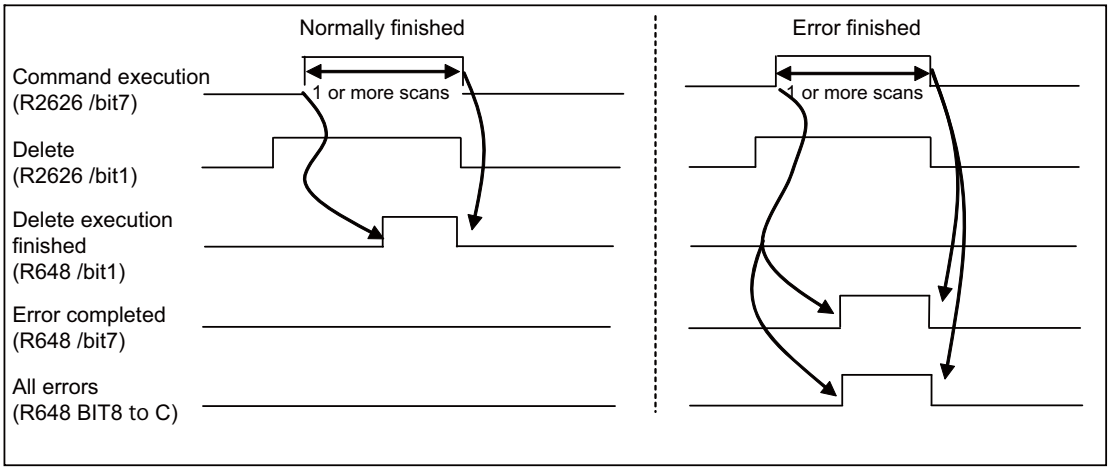
→Bit 1 in R648 (thread recutting status) turns ON if operation completes successfully.

If an error occurs, bit 7 in R648 (thread recutting status) and the bit corresponding to the error turns ON.

Executing the deletion process deletes the thread recutting positions (lead axis machine positions and spindle positions) for this part system. Deleting the thread recutting positions turns OFF the thread recutting enabled bit (bit F) in R649 (thread recutting execution state) and clears R650 (thread recutting spindle number) and R651 (thread recutting lead axis number).

Deletion of thread recutting positions cannot be performed during the thread recutting process. If the thread recutting process is in operation, turn OFF the thread recutting function enable bit (bit F) in R2627 (thread recutting execution operation) and then perform the operation to delete the thread recutting position.

<Timing Chart while Executing Deletions>



12.3.2.5 Transitioning to the Thread Recutting State

Turn ON the thread recutting function enable bit (bit F) in R2627 (thread recutting execution operation). Bit F in R649 (thread recutting execution status) turns ON if the thread recutting position is stored.

The thread recutting process is performed when the thread recutting command is executed while bit F in R649 (thread recutting execution state) is turned OFF. Executing the thread cutting command while bit F in R649 (thread recutting execution state) is turned OFF and bit F in R2627 (thread recutting execution operation) is turned ON results in generation of the operation error (M01 1027).

12.3.2.6 Disabling Thread Recutting Operations

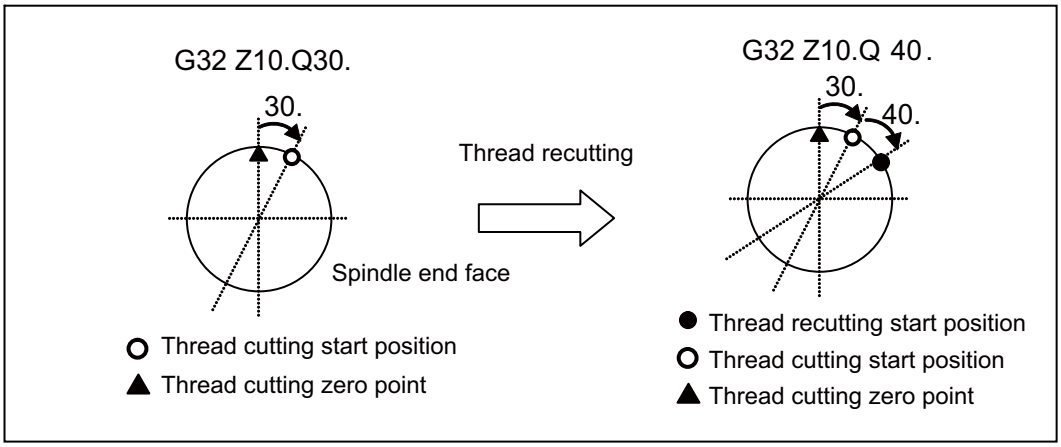
Turning OFF the thread recutting function enable bit (bit F) in R2627 (thread recutting execution operation) while the thread recutting function enabled bit (bit F) in R649 (thread recutting execution state) is on cancels the thread recutting state and causes bit F (thread recutting execution operation) in R649 to turn OFF.

12.3.2.7 Handling of the Shift Amount (Q Command) at the Start of Thread Cutting during the Thread Recutting Process

When thread recutting is enabled, handling of the shift amount (Q command) at the start of thread cutting is changed with "#1258 set 30/bit 5".

(1) "#1258 set 30/bit 5" = "0"
When there is a shift amount (Q command) at the start of thread cutting, the thread cutting start positions for the thread cutting and thread recutting processes become the same. This is configured when performing the same thread cutting process while thread recutting is enabled. This is enabled, for example, when restarting processing after stopping processing due to a tool failure that occurs during thread cutting processing and replacing the tool.

(2) "#1258 set 30/bit 5" = "1"
When there is a shift amount (Q command) at the start of thread cutting, the thread cutting start positions for the thread cutting and thread recutting processes are not the same, and the shift amount (Q command) at the start of thread cutting becomes the shifted position.
This is configured when reperforming processing such as adjustment of thread groove depth after the thread processing. This is enabled for processing that includes adjustment of the thread cutting start position via the Q command on the basis of the start position for the first thread processing. Do not issue the shift amount (Q command) at the start of thread cutting when performing the same thread cutting for the thread recutting process.



12.3.2.8 Calculating the Amount of Correction for Thread Cutting Start Positions for Thread Cutting Blocks in Thread Recutting Mode

Use "#1258 set 30/bit 6" to enable and disable the calculation of the amount of correction for thread cutting start positions from the second thread cutting block while thread recutting is enabled.

(1) "#1258 set 30/bit 6" = "0"
Corrects the spindle angle from stored position information while the initial thread cutting command is output by cycle operation. The second and following thread cutting commands output during cycle operation use the amount of correction obtained from the initial command. For this reason, the second and following thread cutting commands and thread recutting processes can be performed when the state of the initial thread cutting command during cycle operation is stored.

(2) "#1258 set 30/bit 6" = "1"
Corrects the spindle angle from stored position information while the thread cutting command is output during cycle operation. For this reason, processing at the same finishing state for thread recutting can be performed when the finished state of compound type fixed cycle for turning machining is stored. Note, however, that thread recutting processing cannot be performed with the second and following thread cutting commands.

12.3.3 Operation with Other Functions

(1) Fixed cycle for turning machining
Thread recutting can also be performed with the thread cutting cycle (G78) of the fixed cycle for turning machining.

(2) Compound type fixed cycle for turning machining (type II)
Processing at the same finishing state for thread recutting can be performed when the finished state of compound type fixed cycle for turning machining (G76) is stored.
If information was stored at the rough processing state, threads may not be cut correctly.

(3) Continuous thread cutting
Store the position at the thread grooves cut during the first block of continuous threading while performing continuous thread recutting.
Threads may not be cut correctly when the position is stored for the thread grooves from the second block.

(4) Shift amount at start of thread cutting
Handling of the shift amount at the start of thread cutting during the thread recutting operation changes depending on the setting of "#1258 set 30/bit 5".
Refer to Handling of the "Shift Amount (Q Command) at the Start of Thread Cutting during the Thread Recutting Process" for more information.

(5) Thread cutting cycle retraction
The retract operation can also be performed during thread recutting if thread cutting cycle retraction is enabled.

(6) Variable lead thread cutting
When the initial thread cutting command is a variable lead thread cutting command during cycle operation that has enabled thread recutting while "#1258 set 30/bit 6" is set to "0", the operation error (M01 1027) is generated. When the second and following thread cutting command is a variable lead thread cutting command during cycle operation that has enabled thread recutting, the operation error (M01 1027) is not generated, and variable lead thread recutting can be performed.
When the variable lead thread cutting command during cycle operation that has enabled thread recutting while "#1258 set 30/bit 6" is set to "1", the operation error (M01 1027) is generated.

(7) Variable feed thread cutting
Thread recutting can also be performed for variable feed thread cutting.

(8) Arbitrary axis exchange control/mixed control (cross axis control)
Thread recutting can be performed during axis exchange, but the axis exchange cannot be performed for thread recutting lead axes. When there are no lead axes when a thread cutting command is output during thread recutting, the operation error (M01 1027) is generated.

(9) Mirror image
Do not apply mirror images (mirror image by parameter setting, mirror image by external input, mirror image for facing tool posts, and T code mirror image for facing tool posts) for thread recutting lead axes. Thread recutting may not be performed correctly.

(10) Spindle override during thread cutting
Spindle override is enabled during both thread recutting and thread cutting.

(11) Dry run
You can enable and disable dry runs with "#1279 ext 15/bit 4" even during thread recutting operation.

(12) Multiple-spindle control I/II
- "#1258 set 30/bit 4" = "0"
Multiple-spindle control I/II can also be performed when performing thread recutting from the Mitsubishi HMI.
- "#1258 set 30/bit 4" = "1"
Only multiple-spindle control II can be performed when operating thread recutting from the ladders. Thread recutting is not enabled for multiple-spindle control I.

12.3.4 Precautions

(1) Stored positions are deleted when the power is turned OFF. The thread recutting operation must be reperformed from the beginning after the power is turned back ON.

(2) To store the thread groove position, the spindle to be stored after the power is turned ON must be finished with the Z phase detection.

(3) Align the direction of the lead axis during the thread recutting operation with the direction of movement of the original lead axis. When performing a processing in the reverse direction of movement, the area that received thread cutting processing cannot be precisely shaved.

(4) If the axis length (axis with the largest amount of movement) or the amount of movement of the thread recutting lead axis are the same lengths (movement angle: 45 degrees), the lead axis becomes the axis with the smallest axis number.

(5) The thread recutting operation only supports direct acceleration and deceleration and software acceleration and deceleration. Thread recutting cannot be correctly performed if the acceleration/deceleration mode is set to either the primary delay or exponential function acceleration.

(6) Use the tool for performing thread recutting when storing the thread groove position. Threads may not be cut correctly if the stored tools or other processing conditions are different when thread recutting.

12.4 Manual Speed Clamp

12.4.1 Outline

The maximum speed for manual feed can be switched to the rapid traverse rate or the manual feed clamp speed. This function is usable, for instance, when the axis speed needs to be clamped at an arbitrary rate for performing a manual feed with a cutting cover opened.

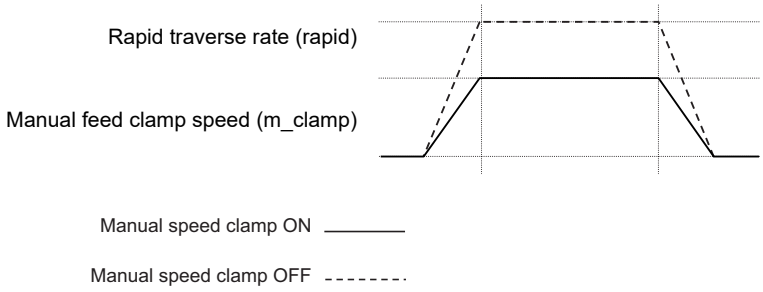
The clamp speed is switched with the parameter or PLC signal.
The manual feed clamp speed can be set to an arbitrary speed with the parameter.
The manual feedrate can be applied for operation modes as follows:

- Jog mode
- Handle mode
- Incremental mode
- Manual reference position return (high-speed) mode

12.4.2 Description of Operation

The manual feed clamp speed can be switched ON/OFF by the parameter and PLC signal.

#1449 m_clamp_on (Manual feed rate clamp ON)	Manual speed clamp ON (MCLAMP: YC76)	Selected max speed parameter (By axis)
0	ON	#2641 m_clamp (Manual feed clamp speed)
	OFF	#2001 rapid (Rapid traverse rate)
1	ON/OFF	#2641 m_clamp (Manual feed clamp speed)



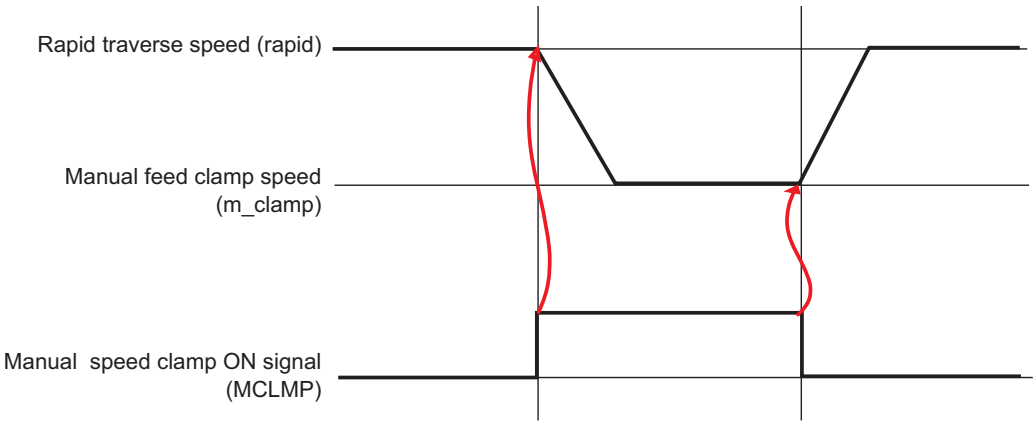
12.4.3 Relation with Other Functions

The manual feed speed clamp is invalid in the following functions.

- Manual reference position return (dog-type)
- Automatic dog-less type reference position return
- Manual arbitrary feed

12.4.4 Precautions

(1) During jog feed, handle feed, incremental feed or manual reference position return (high-speed), the manual speed clamp ON/OFF switch by the "Manual speed clamp ON" signal (MCLMP: YC76) is immediately reflected regardless of the axis movement or its stop.



(2) The manual speed clamp also become effective for the jog or handle feed in the manual/auto simultaneous or handle interrupt in automatic operation mode.

(3) When "#2641 m_clamp" (Manual feed clamp speed) is greater than "#2641 m_clamp" (Manual feed clamp speed), "#2001 rapid" (Rapid traverse speed) is applied regardless of ON/OFF of the manual speed clamp.

(4) The manual feed clamp speed is enabled by the "Manual speed clamp ON" signal (MCLMP: YC76) only for the basic configuration axes of the part system.

12.5 Reservation of Tool Wear Compensation (Lathe System)

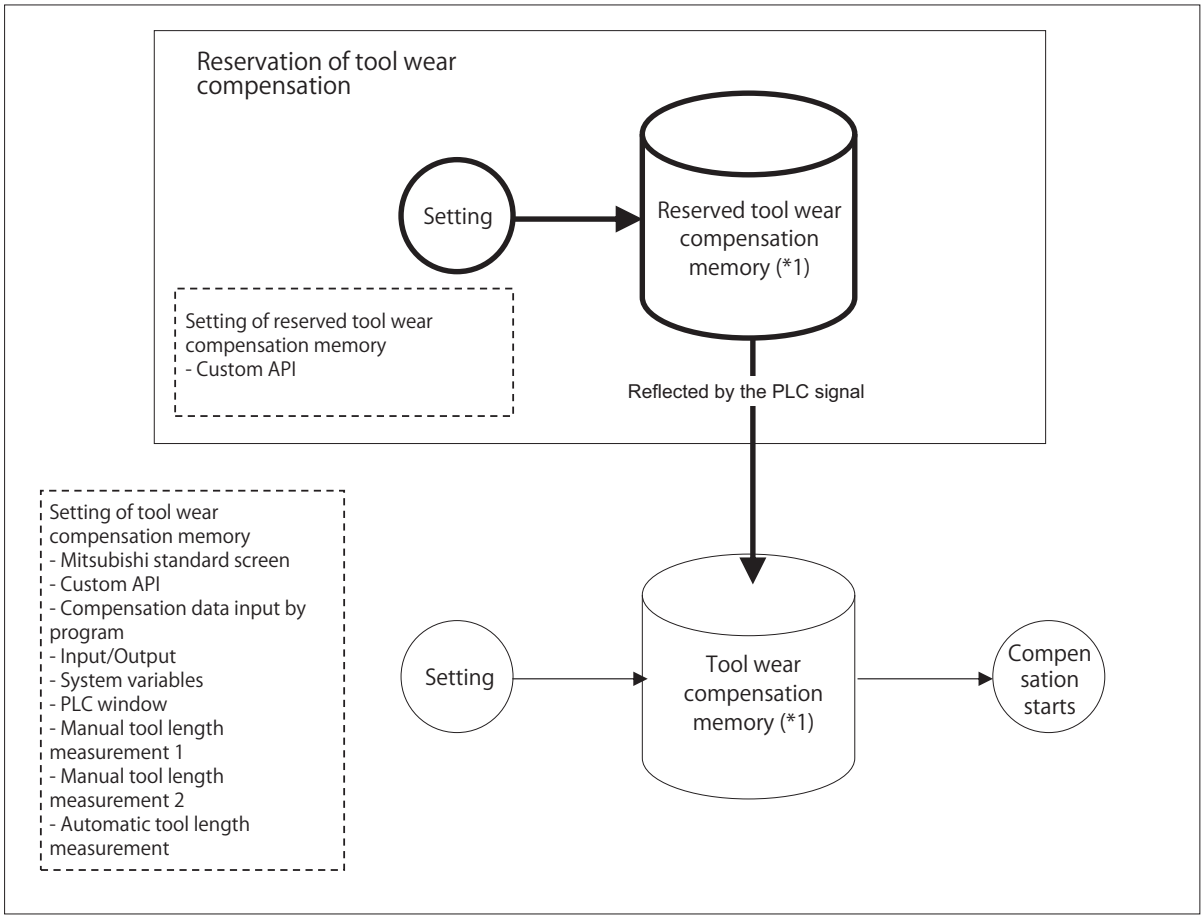
12.5.1 Outline

Setting values of tool wear compensation memory can be reserved using the reserved tool wear compensation memory. By reflecting the reserved value of tool wear compensation memory with the PLC signal, tool wear compensation which is set during the automatic operation can be enabled at the same time. Reserved tool wear compensation memory can be set only from custom API. The parameter setting and the PLC signal enable users to reserve tool wear compensation.

This function is enabled by the following procedure.

(1) Set "#8140 Reserve T wear com" to "1" and turn ON the power again.

(2) After the power is turned ON again, turn ON "Reservation of tool wear compensation" signal (Y1CB8).



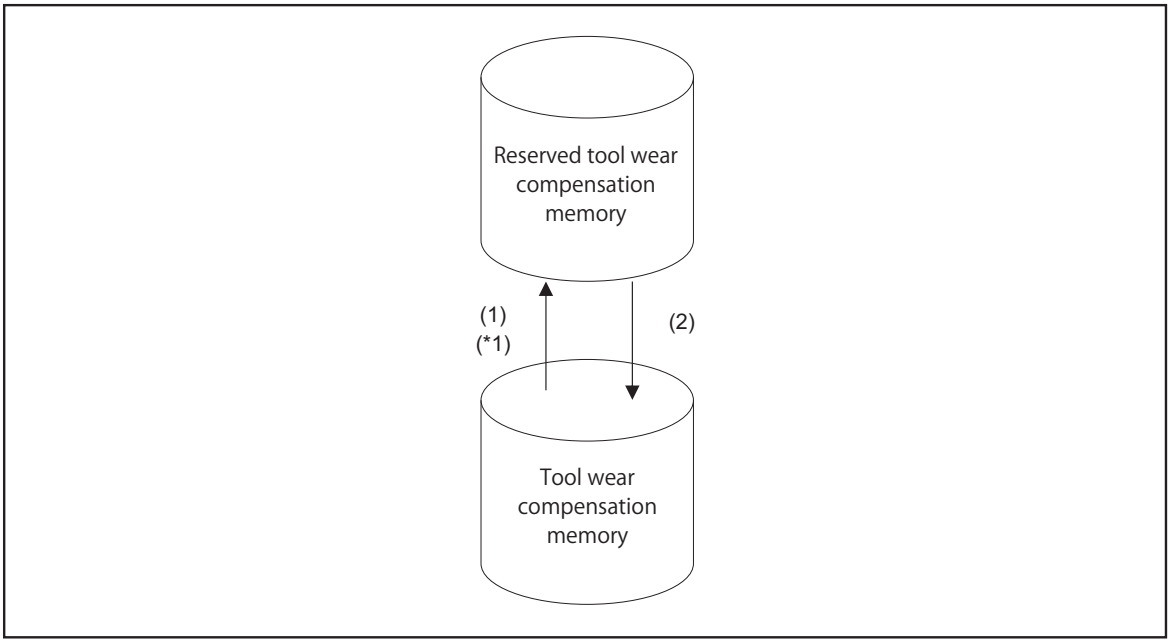
(*1) This function supports the following types of tool wear compensation memories.

Tool wear compensation memory	Reserved tool wear compensation memory
Tool nose wear compensation amount for 1st axis (normally X axis)	Reserved tool nose wear compensation amount for 1st axis (normally X axis)
Tool nose wear compensation amount for 2nd axis (normally Z axis)	Reserved tool nose wear compensation amount for 2nd axis (normally Z axis)
Tool wear compensation amount for additional axis	Reserved tool wear compensation amount for additional axis
Tool wear compensation amount for 2nd additional axis	Reserved tool wear compensation amount for 2nd additional axis
Tool nose radius wear compensation amount	Reserved tool nose radius wear compensation amount

12.5.2 Operation Explanation

(1) When the reserved tool wear compensation memory has never been initialized after setting "#8140 Reserve T wear com" to "1", the contents of the tool wear compensation memory is copied to the reserved tool wear compensation memory and initialized.

(2) The reserved tool wear compensation memory is reflected to the tool wear compensation memory when either of the following operations is performed.
- Turned ON the power again.
- Turned ON the "Reservation of tool wear compensation" signal (YD0F).



(*1) To copy again the contents of the tool wear compensation memory to the reserved tool wear compensation memory after the initialization of (1), reset "#8140 Reserve T wear com" to "0" and turn ON the power again. Then set "#8140 Reserve T wear com" to "1", and turn ON the power again.

Setting Reserved Tool Wear Compensation Memory

Item	Section No.	Sub-section No.
Reserved tool nose wear compensation amount for 1st axis	14	13000 + compensation No.
Reserved tool nose wear compensation amount for 2nd axis	14	14000 + compensation No.
Reserved tool wear compensation amount for additional axis	14	15000 + compensation No.
Reserved tool nose radius wear compensation amount	14	16000 + compensation No.
Reserved tool wear compensation amount for 2nd additional axis	14	17000 + compensation No.

Reserved tool wear compensation memory can be set only from the custom API.
Reserved tool wear compensation amount can be read or write by designating section No., sub-section No. and part system No.
(Caution) When "#1051 MemTol" (Tool compensation memory common for part systems) is set to "1", a part system cannot be specified.

12.5.3 Usage Examples

(Example) When you execute a machining program from the top to M99 without rewriting tool wear compensation memory, and then rewrite the tool wear compensation memory during repetition of the program.

(1) Set the parameter "#8140 Reserve T wear com" to "1", then turn ON the power again.
(2) Turn ON the "Reservation of tool wear compensation" signal (Y1CB8).
(3) Perform continuous operation of the following machining program.

O1 ;	
N01 G28 X0. Y0. Z0. ;	
N02 T0101 ;	Start compensation on Tool 1
N03 G01 X100. Y200. Z300. F1000 ;	
N04 G01 X0. Y0. Z0. ;	
N05 T0202 ;	Start compensation on Tool 2
N06 G01 X100. Y200. Z300. F1000 ;	
N07 G01 X0. Y0. Z0. ;	
N08 T0303 ;	Start compensation on Tool 3
N09 G01 X100. Y200. Z300. F1000 ;	
N10 G01 X0. Y0. Z0. ;	
N11 T0101 ;	Start compensation on Tool 1
N12 G01 X100. Y200. Z300. F1000 ;	
N13 G01 X0. Y0. Z0. ;	
N14 T0000 ;	Cancel tool compensation
N15 M50 ;	Turn ON the "Request for reflecting reserved tool wear compensation" signal (YD0F) (*1)
N16 M99 ;	Return to N01
%	

(*1) Assume that M50 command turns ON "Request for reflecting reserved tool wear compensation" signal (YD0F) through the ladder logic.

(4) Set the reserved value between the N01 and the N14 blocks.
(5) All the reserved values set between the N01 and the N14 blocks are reflected simultaneously in the tool wear compensation memory at the N15 block.

12.5.4 Caution

(1) The tool offset change history is updated when the reserved tool wear compensation memory has been reflected in the tool wear compensation memory.
(2) When the tool compensation data is deleted by deleting all tools, the reserved tool wear compensation data is also deleted simultaneously.

12.6 Workpiece Coordinate System Shift

Carry out the automatic setting for the workpiece coordinate system shift amount using the "Workpiece measurement" signal.

12.6.1 Operation Method

(1) Carry out the reference position return. If the workpiece is measured without establishing the reference position return, the operation message "Meas axis not returned to ref. position" appears. However, when the setup workpiece coordinate system shift screen is not displayed, the message will not appear.
After the power is turned ON, carry out the dog-type reference position to establish the coordinate system. In the absolute position detection specification, configure the initial setting in advance if the absolute position is not established.

(2) Set the mode selection switch to the manual mode (handle, jog, rapid traverse, or step).

(3) Set the "Tool length measurement" signal (YC21) to "1". "On mea" is displayed on the setup workpiece coordinate system shift screen.

(4) Select whether to measure the workpiece coordinate system shift amount on the main spindle side or sub-spindle side by using the "Tool presetter sub-side valid" signal (YCDA).
Hold the status of this signal until the workpiece coordinate system shift amount measurement with the selected tool is completed.

(5) Issue the T command by MDI operation, etc., then select tool.
Set the selected tool compensation No. in R register. The R register to be set differs according to parameter setting and the state of the "Tool presetter sub-side valid" signal. Set the tool length data and wear data for the tool being used beforehand.

(6) If the workpiece end face does not need to be cut, carry out positioning to the measurement position.
If the workpiece end face has not been cut, cut the workpiece end face slightly to even it. Do not move the tool in the Z axis direction after cutting the workpiece end face.

(7) Input the "Workpiece measurement" signal (Y9E1). The Z axis external workpiece coordinate offset data is automatically calculated from the tool compensation data of the used tool and the machine value at the point this signal is input. The results are set as the data.

<Details on automatic calculation expression>
The workpiece coordinate system shift amount is automatically calculated with the following expression:
When the parameter "#8709 Ext work sign rvs" is set to "0".

Workpiece coordinate system shift amount = Machine coordinate value - Tool compensation data

When the parameter "#8709 Ext work sign rvs" is set to "1"

Workpiece coordinate system shift amount = - (Machine coordinate value - Tool compensation data) * (-1)

Select the tool compensation data used for the measurement with the parameter "#1226 aux10/bit0".

#1226 aux10/bit0	Tool compensation data
0	Tool length data + nose wear data
1	Tool length dat

<Compensation No. of selected tool>
The compensation number of the tool length and nose wear data used for automatic calculation is determined by the PLC ladder.

(Note 1) When the compensation No. is "0", the compensation amount will be calculated as "0".

(Note 2) If the compensation No. exceeds the number of specified offset sets, the operation message "Offset No. not found" appears. However, when the setup workpiece coordinate system shift screen is not displayed, the message will not appear.

(Note 3) If the calculation result exceeds the setting range, the operation message "Data range error" appears. However, when the setup workpiece coordinate system shift screen is not displayed, the message will not appear.

(Note 4) If the data protection is valid, the operation message "Data protect" appears. However, when the setup workpiece coordinate system shift screen is not displayed, the message will not appear.

(Note 5) Measurement is disabled for the part system with one-axis structure. The operation message "Can't measure" is displayed. However, when the setup workpiece coordinate system shift screen is not displayed, the message will not appear.

(Note 6) Whether to use the main side or sub-side is selected with the "Tool presetter sub-side valid" signal (YCDA). (OFF: Main side, ON: Sub-side)

(Note 7) Set the compensation No. in R register by the BCD code.

(8) Set the "Tool length measurement" signal to OFF.
The measurement of the workpiece coordinate system shift amount is completed.

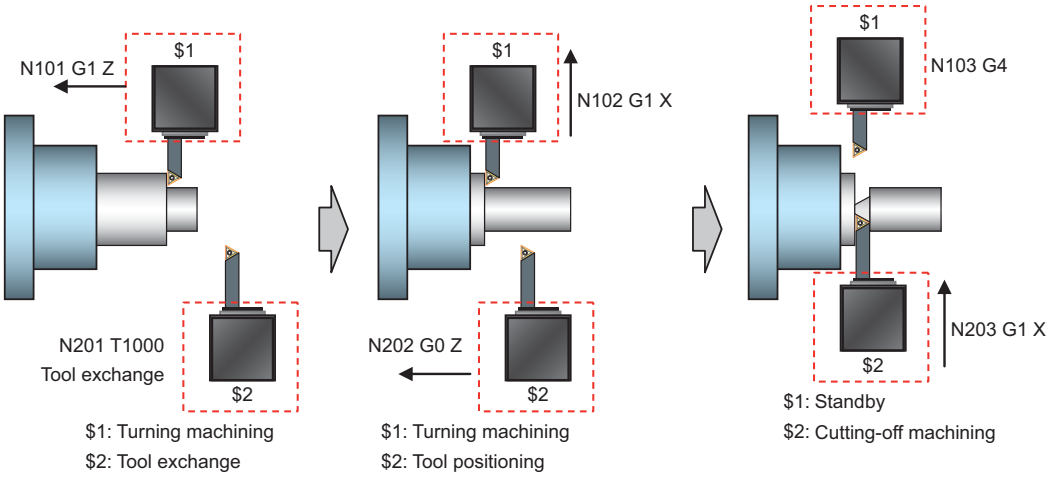
12.6.2 Precautions

(1) When the automatic setting is carried out for the workpiece coordinate system shift amount without displaying the setup workpiece coordinate system shift screen, the message is not displayed even if an error occurs.

12.7 Manual Arbitrary Reverse Run (Program Check Operation)

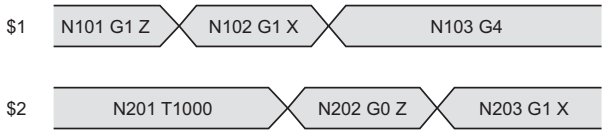
The manual arbitrary reverse run can be performed by controlling the feedrate being in the automatic operation in the memory or MDI mode in proportion to the manual feedrate by jog or the rotation speed by manual handle.
This function allows a program to run the executed blocks backward (reverse run) after the block stop in the automatic operation. The buffer correction of the program can be performed after reverse run to a desired point and the corrected program can be run.

Example of machining operation

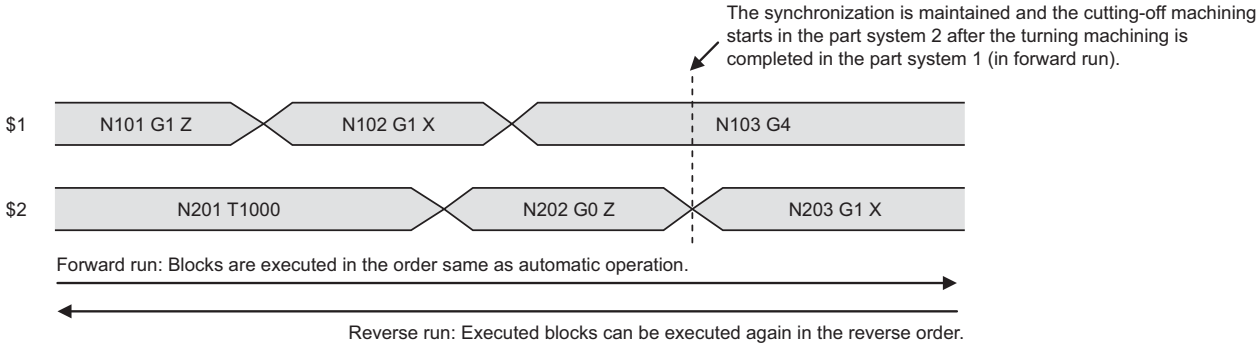


$1: Part system 1
$2: Part system 2

Timing diagram in override 100%



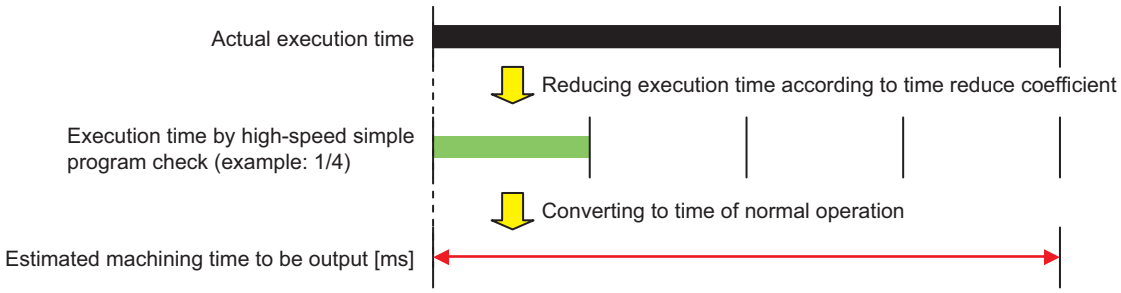
Timing diagram in manual arbitrary reverse run



The total operation time is increased in the timing diagram for the manual arbitrary reverse run, however the synchronization between part systems can be maintained and the cutting-off machining starts after the turning machining is completed in forward run. The synchronization between part systems is maintained in both forward and reverse run.

12.8 High-speed Simple Program Check

This function checks whether a program error occurs by operating the machining program without the axes movements.
The estimated machining time can be checked in time shorter than the actual execution time of the machining program.
This function is valid with the "High-speed simple program check" signal ON .
The machining program is operated in the reduced time according to the coefficient which is set to the time reduce coefficient.
The estimated machining time of the machining program is output to time measurement output.
The miscellaneous command code which outputs strobes can be allocated arbitrarily with the parameter during the high-speed simple program check.



12.8.1 Function Enabling Conditions

This function is enabled/disabled using PLC signals. (The following signals are common part system signals.)

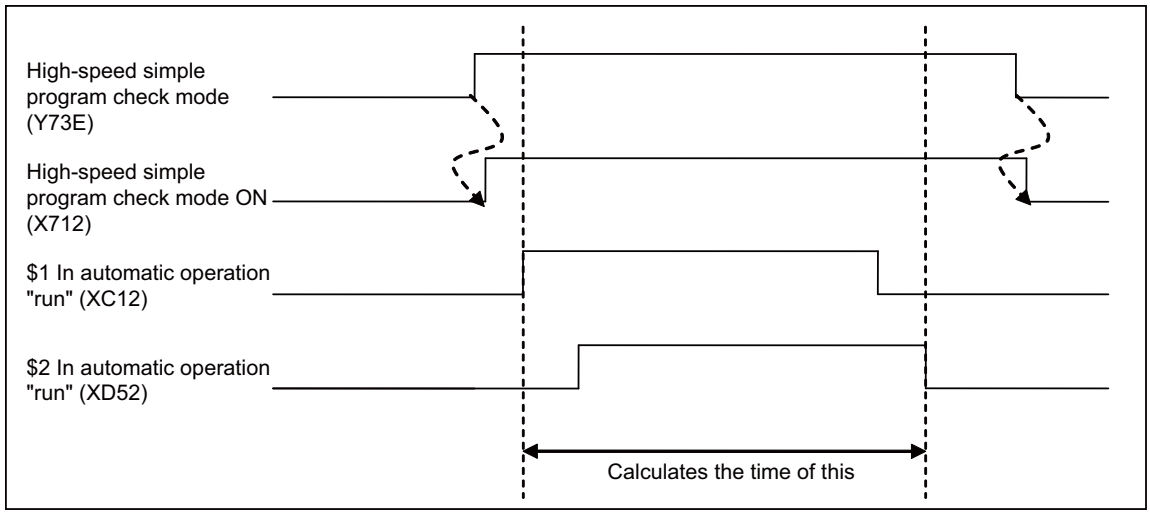
Input/output	Device No.		Signal name	Description
NC → PLC	Y73E	SMLK	High-speed simple program check mode	Turning this signal ON turns ON the high-speed program check ON signal.
NC → PLC	X712	SMLKO	High-speed simple program check mode ON	When this signal is on, the high-speed simple program check function is enabled.
NC → PLC	R378		Time reduction coefficient	This reduces the execution time of the high-speed simple program check.

12.8.2 Starting the High-speed Simple Program Check

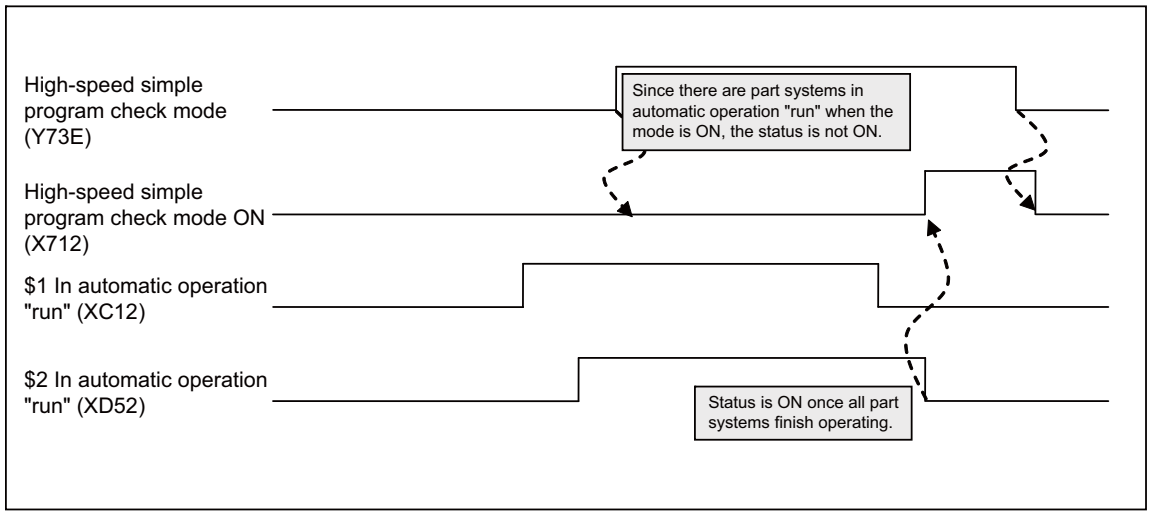
Inputting the high-speed simple program check mode signal (Y73E) while the memory mode or MDI mode for the operable part system is on turns ON the high-speed simple program check mode ON signal (X712).
When the high-speed simple program check mode ON signal (X712) is on, the execution status of the processing programs can be confirmed without having to operate the machine by starting cycle operation.

The processing program can be executed at a speed (2^n speed factor) in accordance with the time reduction coefficient (R378), which reduces the execution time of the processing program. However, programs operate at the same speed regardless of the time reduction coefficient if certain specific functions such as high-speed machining mode I/II are enabled. When changing the high-speed simple program check mode signal during cycle operation, operation occurs in accordance with the mode at the start of operation until operation ends.

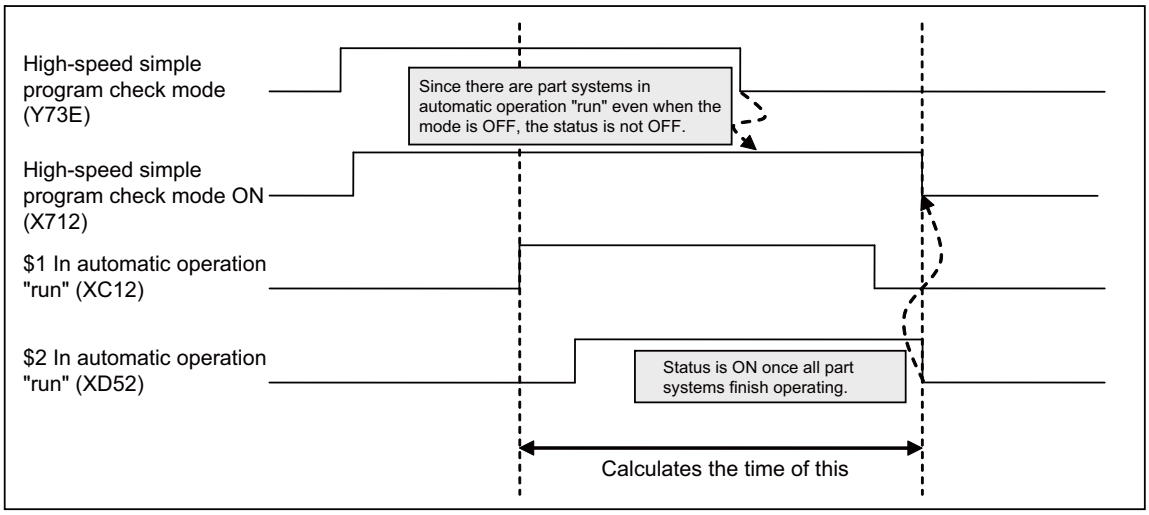
(1) Operation sequence (operation procedure)
In order to operate with the high-speed simple program check function enabled, start cycle operation after turning ON the high-speed simple program check mode signal (Y73E) and confirming that the high-speed simple program check mode ON signal (X712) has turned ON.



(2) Operation sequence (turning ON the high-speed simple program check mode signal (Y73E) while any part system is in cycle operation).
When the high-speed simple program check mode signal (Y73E) is on while any part system is in cycle operation, the mode ON signal (X712) does not turn ON at that moment. The mode ON signal (X712) turns ON at the timing when operation of all part systems end.



(3) Operation sequence (turning OFF the high-speed simple program check mode signal (Y73E) while any part system is in cycle operation).
When starting cycle operation while the high-speed simple program check mode ON signal (X712) is already turned ON and the high-speed simple program check mode signal (Y73E) is turned OFF during operation in the high-speed simple program check mode, the mode ON signal (X712) stays on until operation of all part systems ends.



Movement Time

Movement time can be reduced by setting the time reduction coefficient (R378) during operation of the high-speed simple program check.
The movement time listed in the following table applies when using this function and operating the movement block executing at T[s].

Time reduction coefficient	Movement Time
0	T
1	T×(1/2)
2	T×(1/4)
3	T×(1/8)
4	T×(1/16)
5	T×(1/32)

The time reduction coefficient setting is enabled at the timing in which all part systems have initially started while the high-speed simple program check mode ON signal (X712) is turned ON.
If the time reduction coefficient changes while any part system is in cycle operation, the change will not become effective until operation of all part systems ends.

Miscellaneous Command Output Function

Output of miscellaneous commands during the high-speed simple program check can be enabled/disabled with parameters.

Enabling/disabling of the miscellaneous command output is set when the related parameters and PLC signals satisfy the conditions listed in the following table.

<table>
<tr><td colspan="2" rowspan="3"></td><td colspan="2">Miscellaneous function lock (AFL) disabled</td><td colspan="2">Miscellaneous function lock (AFL) enabled</td></tr>
<tr><td colspan="2">#1278 ext 14/bit 5</td><td colspan="2">#1278 ext 14/bit 5</td></tr>
<tr><td>1</td><td>0</td><td>1</td><td>0</td></tr>
<tr><td rowspan="2">#1405
M_mode (SMLK)</td><td>0</td><td>M code configured to "#1451 M[M031-000] (SMLK)" through "#1466 M[M511-480] (SMLK)": M output enabled
Otherwise: M output disabled</td><td rowspan="8">Miscellaneous function output disabled</td><td colspan="2" rowspan="8">Miscellaneous function output disabled</td></tr>
<tr><td>1</td><td>M code not configured to "#1451 M[M031-000] (SMLK)" through "#1466 M[M511-480] (SMLK)": M output enabled
Otherwise: M output disabled</td></tr>
<tr><td rowspan="2">#1406
S_mode (SMLK)</td><td>0</td><td>S output disabled</td></tr>
<tr><td>1</td><td>S output enabled</td></tr>
<tr><td rowspan="2">#1407
T_mode (SMLK)</td><td>0</td><td>T output disabled</td></tr>
<tr><td>1</td><td>T output enabled</td></tr>
<tr><td rowspan="2">#1408
M2_mode (SMLK)</td><td>0</td><td>M2 (B) output disabled</td></tr>
<tr><td>1</td><td>M2 (B) output enabled</td></tr>
</table>

(Note 1) When miscellaneous function output is enabled while the high-speed simple program check is in operation, the program issues a strobe for all enabled signals and waits for completion from the PLC.

(Note 2) The miscellaneous command code is also output during the high-speed simple program check by enabling miscellaneous function output, and so miscellaneous functions operate by the reception of signals from ladders. Be aware of the configuration details of miscellaneous function codes enabled for output.

(Note 3) When "#1405 M_mode (SMLK)" is set to "1", be aware of the configuration details as M codes larger than M511 will be output.

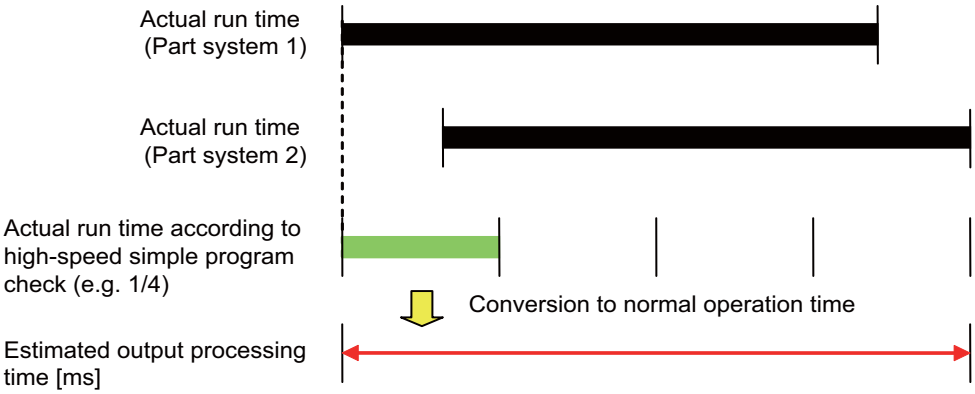
(Note 4) Miscellaneous functions will not be output regardless of the setting of "#1278 ext 14/bit 5" when the miscellaneous function lock (AFL) is enabled.

(Note 5) The miscellaneous function command high-speed output option is selected when the miscellaneous command code configured with miscellaneous function output enabled matches the miscellaneous command code configured to the miscellaneous function command high-speed output parameter.

(Note 6) When miscellaneous command output is disabled, the miscellaneous command block is not included in the estimated processing time.

12.8.3 Estimated Processing Time

The estimated processing time for processing programs during the high-speed simple program check is output to the time measurement output registers (R372 and R373).
The unit of measurement for the estimated processing time is [ms].
The estimated processing time is the time from the start of program operation until the operation ends due to an NC reset of all part systems. (Refer to the following figure.)
The estimated processing time is calculated and output with the execution time during actual operation regardless of the setting of the time reduction coefficient (R378).
The estimated processing time will result in error for programs that operate with single operation mode turned ON.
Turn OFF single operation mode when measuring the estimated processing time.



12.8.4 Coordinate Position Check

This function is used to confirm that machine positions match for the operation start and end times of processing programs when creating processing programs with reduced execution times by omitting reference point returns through the alignment of operation start positions, or when creating the same workpiece by continuously repeating the same program.
Differences between coordinate positions (workpiece coordinate position and command-machine coordinate position) at the start and end times of processing programs can be checked when the NC reset signal is input during the high-speed simple program check.
The coordinate position check is executed when the high-speed simple program check and coordinate position check enabled signal (X713) is turned ON.
The high-speed simple program check and coordinate position check enabled signal (X713 is turned ON by turning ON the high-speed simple program check and coordinate position check enable signal (Y76B) during the high-speed simple program check.

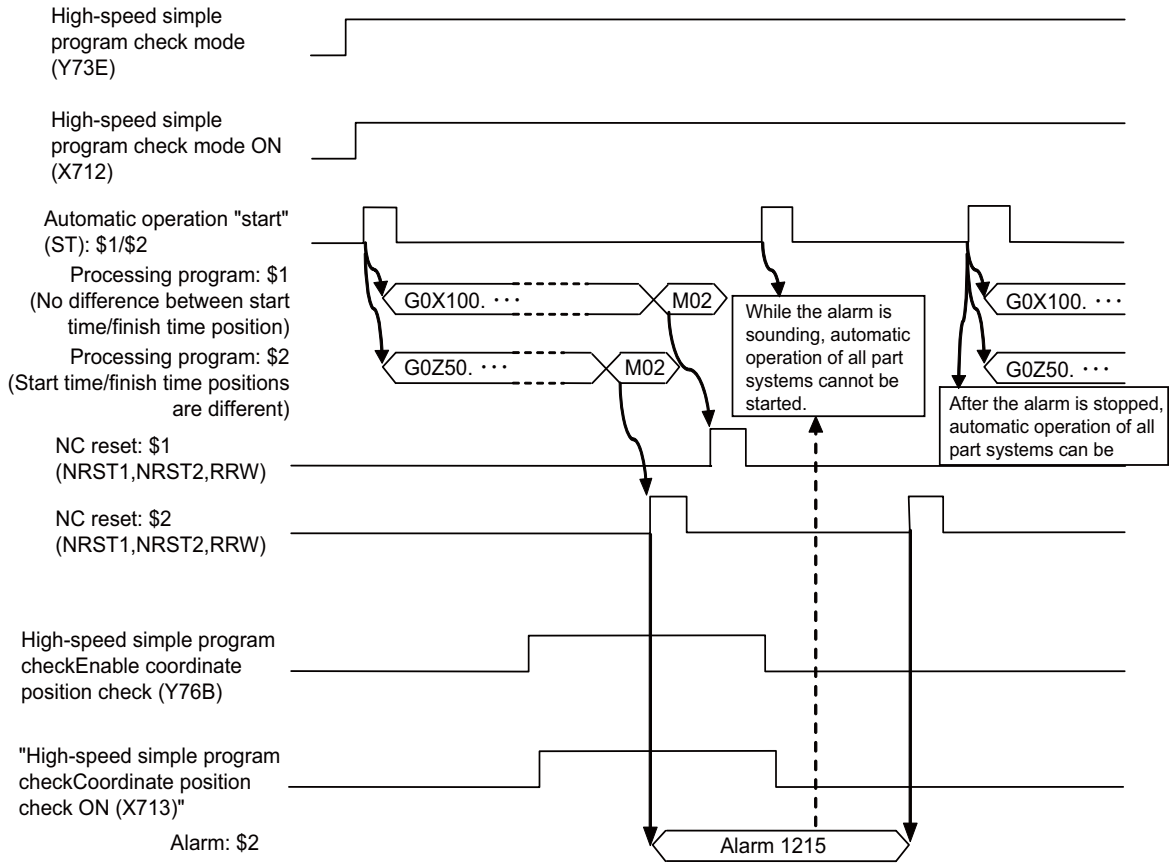
Input/output	Device No.		Signal name	Description
NC → PLC	Y76B	SPSC	High-speed simple program check Coordinate position check enable	The coordinate position check enabled signal is turned ON during the high-speed simple program check by turning ON this signal during the high-speed simple program check.
PLC → NC	X713	SPSCO	High-speed simple program check Coordinate position check enabled	While this signal is turned ON, the coordinate position difference check is enabled during the high-speed simple program check.

When there are differences between the start and end times of processing programs, the following operation errors are generated.
When differences occur simultaneously for workpiece coordinate positions and machine coordinate positions, only the operation error (M01 1215) appears.

- Workpiece coordinate position: (M01 1215 [Name of axis] [Part system])
- Machine coordinate position: (M01 216 [Name of axis] [Part system])

Cycle operation for all part systems cannot start while operation errors have been generated. Clear the operation errors before starting cycle operation.
The operation error will not clear if the high-speed simple program check mode signal (Y73E) is turned OFF and some other mode is selected.
Operation errors are cleared by performing an NC reset.
The coordinate position check only checks control axes (Note 2) in the main part system when the main part system (Note 1) NC reset signal is input. The coordinate position check is not performed for sub part systems (Note 3).
(Note 1) Refers to the first upstream part system in the flow of sub part system calls.
(Note 2) Refers to axes for which the part system has control rights.
(Note 3) Refers to part systems started by the sub part system start command. (Normal cycle operation is disabled.)

[Timing Chart Example]
Alarms are generated during part system 2



Axis Check Settings

The axes to which the coordinate position check are applied are specified by the axis parameters within user parameters.

Axes are specified by turning the parameter ON (1) for axes you want to check and turning the parameter OFF (0) for axes you do not want to check.

- Workpiece coordinate position: #8226 Workpiece position check
- Command-machine coordinate position check: #8227 Machine position check

12.8.5 Operation with Other Functions

Name of Function	Operation	Remarks
Spindle C-axis function	The display of workpiece values update for the C axis via the machine lock when spindle mode is selected (C-axis servo off). When there is an axis set to the spindle/C axis, this function can be executed only in the spindle mode. If the automatic operation is started in the C axis mode, the operation error (M01 1026) occurs.	
Spindle function (S command)	When "#1278 ext 14/bit 5" is set to "0", the spindle function strobe is not output. When "#1278 ext 14/bit 5" is set to "1", enabling/disabling the output of the spindle function strobe is switched by the setting of parameter "#1406 S_mode (SMLK)".	
Tool functions (T command)	When "#1278 ext 14/bit 5" is set to "0", the tool function strobe is not output. When "#1278 ext 14/bit 5" is set to "1", enabling/disabling the output of the T function strobe is switched by the setting of parameter "#1407 T_mode (SMLK)".	
Miscellaneous function (M command)	When "#1278 ext 14/bit 5" is set to "0", the miscellaneous function strobe is not output. When "#1278 ext 14/bit 5" is set to "1", enabling/disabling the output of the miscellaneous function strobe is switched by the setting of parameter "#1405 M_mode (SMLK)".	
2nd miscellaneous functions	When "#1278 ext 14/bit 5" is set to "0", the 2nd miscellaneous function strobe is not output. When "#1278 ext 14/bit 5" is set to "1", enabling/disabling the output of the second miscellaneous function strobe is switched by the setting of parameter "#1408 M2_mode (SMLK)".	
Machine coordinate system	This updates the display of workpiece values. The machine position is not updated.	
Automatic 1st reference position return	The high-speed return option is selected for the zero point return unfinished state. The display of workpiece values are updated for the zero point return unfinished state, but the 1st reference position arrival signal is not output.	
2nd, 3rd, and 4th reference position return	The display of workpiece values are updated for the zero point return unfinished state, but the second through fourth reference position arrival signals are not output.	
Miscellaneous function lock	All miscellaneous function lock commands are not output during the miscellaneous function lock.	
Position information	The endpoint coordinates of the previous block, machine coordinates, workpiece coordinates, and tool compensation amounts can be read. The skip coordinates are produced from the reading of the endpoint position of the previous block. The servo deviation amount is not read.	
Sub part system control I (G122)	The coordinate position check is not executed even if the coordinate position check is enabled and there are control axes in the sub part system and the sub part system has been started or at the timing of a reset.	
Sub part system control II (G144)	The coordinate position check is not executed even if the coordinate position check is enabled and there are control axes in the sub part system and the sub part system has been started or at the timing of a reset.	
Programmable in-position check	The programmable in-position check is disabled.	
Automatic error detection	The automatic error detection is disabled.	
High-speed machining mode I/II	Programs operate at the same speed regardless of the time reduction coefficient during the high-speed machining mode.	
High-speed, high-accuracy control 1/2	Programs operate at the same speed regardless of the time reduction coefficient during the high-speed, high-accuracy mode.	
High-accuracy spline interpolation Spline interpolation	Programs operate at the same speed regardless of the time reduction coefficient during spline interpolation.	
NURBS interpolation	Programs operate at the same speed regardless of the time reduction coefficient during NURBS interpolation.	
Direct command mode	Programs operate at the same speed regardless of the time reduction coefficient during the direct command mode.	
Tool life management	Tool life data is not counted.	
Position switch	The position check is not executed.	
External deceleration	External deceleration is disabled.	
Tool exchange position return	This updates the display of workpiece values. The tool exchange position return signal is not output.	
Load monitoring	Load monitoring is not executed.	
Spindle synchronization command Tool-spindle synchronization I Tool-spindle synchronization II	Phase alignment is not executed when the spindle synchronization command, tool-spindle synchronization I command, or tool-spindle synchronization II command are output with phase alignment commands. The spindle synchronization mode is canceled after a reset.	

Name of Function	Operation	Remarks
Skip (G31) Torque skip (G160)	Output of skip signals are output.	

12.8.6 Precautions

(1) Servo off signals are ignored while the high-speed simple program check mode signal is turned ON.

(2) Automatic machine lock signals are ignored while the high-speed simple program check mode signal is turned ON.

12.9 Manual Numerical Value Command

For each S, M, T, G and B command, the data type to output to PLC program is designated by parameters "#12006 Mbin" (M binary), "#12008 Sbin" (S binary), "#12010 Tbin" (T binary) and "#12012 Bbin" (B binary). The output data type and the manual numerical value command setting/output range are shown below.

<table>
<tr><th></th><th></th><th>BCD</th><th>Unsigned binary</th><th>Signed binary</th></tr>
<tr><td rowspan="4">Output range</td><td>S</td><td>-99999999 to 99999999 (*1)</td><td rowspan="4">0 to 99999999</td><td rowspan="4">-99999999 to 99999999</td></tr>
<tr><td>M</td><td rowspan="3">0 to 99999999</td></tr>
<tr><td>T</td></tr>
<tr><td>B</td></tr>
<tr><td rowspan="4">Setting range</td><td>S</td><td colspan="3" rowspan="4">-99999999 to 99999999 (*2)</td></tr>
<tr><td>M</td></tr>
<tr><td>T</td></tr>
<tr><td>B</td></tr>
</table>

(*1) Even if the parameter "#12008 Sbin" (S binary) is set to "0" (BCD), the signed binary output is applied to S. BCD output is not applied.

(*2) If a negative value is set when the data type is "BCD type" or "Unsigned binary type", a value converted into positive value is output to PLC program.

Add a "-" sign before the value to set a negative value. The display will be a positive value.
A value larger than the limit rotation speed (parameters "#3001 slimt1" to "#3004 slimt4") or the maximum rotation speed (parameters "#3005 smax1" to "#3008 smax4") cannot be output for S. Select a gear with "Spindle gear selection input" of Y device.
For details on flow of S data, refer to "Flow of Spindle (S) Data".
For details on storage destination of manual numerical commands and process sequence, refer to "Handling of M, S, T, B Functions".

12.10 Arbitrary Reverse Run

This function allows a program to run the executed blocks backward (hereinafter called "reverse run") after the block stop in the automatic operation.
The following steps are available:
- Execute the reverse run to the point to go back,
- Run the reversed blocks again following the program (hereinafter called "forward run") and
- Continue the remaining blocks from the point of the interruption.

Maximum 200 blocks can be executed in the reverse run.
Only the 1st to 3rd axes of each part system can be used for this function.

Term definition

The following terms are used in this section.

Term	Definition
Reverse run information	Data of the program blocks that have been executed under the conditions written later in "(1) Saving the reverse run data" in the "Reverse run information" column.
Reverse run	Running the executed blocks backward based on the reverse run information. A reverse run starts at the specified point in a block, ends at the specified point in one previous block.
Forward run	Running the program again from the reverse run end point to the start point based on the reverse run data.
Reverse run control	Execution of the reverse/forward run.

Reverse run information

(1) Saving the reverse run data

When all the following conditions are met, NC saves the data of the executed program blocks as reverse run information.
The conditions differ according to the setting value of the parameter "#1338 rev data save trg".

#1338 rev data save trg	Conditions
0	"Reverse run control mode" (RVMD) signal is ON The program is under the memory or MDI mode During the valid G code modal written later in the "Valid G codes" column
1	Under the macro interrupt (M96) command "Reverse run control mode" (RVMD) signal is ON The program is under the memory or MDI mode During the valid G code modal written later in the "Valid G codes" column

NC saves the data of the latest 200 blocks as reverse run information. If a block has moved before 200th, the reverse run information of the block is deleted accordingly.
Movements in the reverse/forward run are not saved as reverse run information.
The reverse run information is not saved in the program check or restart search.

(2) Clearing the reverse run information

NC initializes the reverse run information if one of the following is executed.
- "Reverse run control mode" (RVMD) signal is turned OFF and ON
- "NC reset 1" (NRST1) signal is turned ON
- "NC reset 2" (NRST2) signal is turned ON
- "Reset & rewind" (RRW) signal is turned ON

Valid G code

Only the specified G codes allow the reverse run. Valid G codes are shown below.

The G codes out of the list are invalid. Do not execute the reverse run to the invalid G codes.

G code group	Valid/Invalid	Valid G code (default G code if invalid)
00	○	G04, G52*, G53*, G60, G65, G92*, G92.1*, M96(ION), M97(I0F), M98(G22) (Note 2), M99* (G23*)
01	○	GO0, G01, G02, G03
02	○	G17
03	○	G90, G91
04	×	G23(G23.1)
05	×	G94, G95 (Note 3) (According to the modal when the reverse run information is started to be stored.)
06	○	G20, G21
07	×	G40
08	×	G49
09	×	G80
10	×	G98
11	○	G50, G51
12	○	G54, G55, G56, G57, G58, G59, G54.1
13	×	G64
14	○	G66, G66.1, G67
15	×	G40.1(G15)
16	×	G69(G69.1)
17	×	G97
18	×	G15
19	○	G50.1, G51.1, (G62)
21	×	G07.1 OFF, G13.1(G11)

(Note 1) Insert G04; before the G code with "*".

(Note 2) The figure rotation cannot be executed with M98(G22).

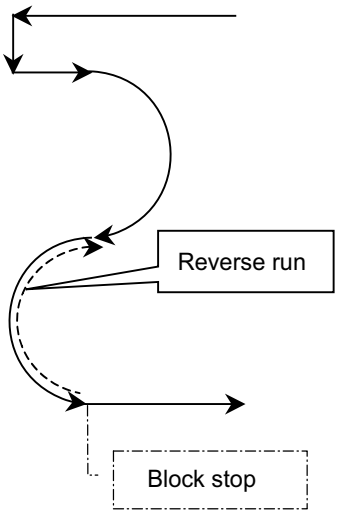
(Note 3) In G95 modal, the reverse/forward run is executed with "the last commanded speed * spindle speed (mm/rev)"

(Note 4) The G codes in "( )" are used for M2 format.

Reverse run

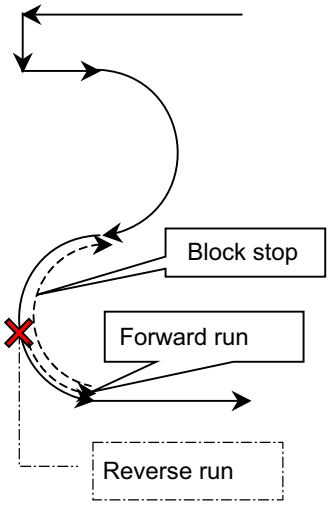
(1) When the "Automatic operation "start" command" (ST) signal is turned ON and OFF under all the following conditions, NC starts the reverse run based on the reverse run information. The same conditions are required to start the reverse run during the forward run.
- "Reverse run control mode" (RVMD) signal is ON
- In the automatic operation stop: "In automatic operation "run"" (OP) is ON, "In automatic operation "start"" (STL) is OFF, "In automatic operation "pause"" (SPL) is OFF
  or in the automatic operation pause: "In automatic operation "run"" (OP) is ON, "In automatic operation "start"" (STL) is OFF, "In automatic operation "pause"" (SPL) is ON
- The "Reverse run" (VRV) signal is ON

(2) If the "Automatic operation "start" command" signal is turned ON and OFF during the automatic operation stop, the reverse run starts from the block stop point.




```
N01 G90 G54 X0 Y0 ;
N02 G91 G01 X50. F500 ;
N03 Y-20. ;
N04 X20. ;
N05 G02 Y-50. R25. ;
N06 G03 Y-50. R25. ;
N07 G01 X30. ;
M02 ;
```

(3) If the "Automatic operation "start" command" signal is turned ON and OFF during the automatic operation pause, the reverse run starts after the execution for the remaining distance of the command. Therefore, the reverse run usually must be started during the automatic operation stop.




```
N01 G90 G54 X0 Y0 ;
N02 G91 G01 X50. F500 ;
N03 Y-20. ;
N04 X20. ;
N05 G02 Y-50. R25. ;
N06 G03 Y-50. R25. ;
N07 G01 X30. ;
M02 ;
```

(4) The following shows the movement when the "Reverser run" (VRV) signal is turned ON/OFF in different operation states.

Operation	Movement
The "Reverse run" signal is turned ON/OFF during the automatic operation	The setting value of the parameter "#1338 rev data save trg" decides as follows. 0: The movement stops immediately. A block stop is executed. The next cycle start executes the reverse/forward run according to the "Reverse run" signal. 1: The movement does not stop immediately. A block stop or block pause is required to execute the reverse run. The next cycle start after the block stop executes the reverse/forward run according to the "Reverse run" signal. The next cycle after the block pause runs the remaining distance before executing the reverse/forward run following the "Reverse run" signal.
The "Reverse run" signal is turned ON during the block pause	The next cycle runs the remaining distance before executing the reverse/forward run following the "Reverse run" signal.
The "Reverse run" signal is turned ON during the block stop	The next cycle executes the reverse/forward run following the "Reverse run" signal.

(5) In the following case, NC outputs "M01 OPERATION ALARM (0119)", decelerates and stops the movement.
- All the saved reverse run information have been consumed in the reverse run
- In the normal operation (not in the reverse/forward run) while the "Reverse run control mode" signal is ON, 8 consecutive blocks with no movement have been detected.

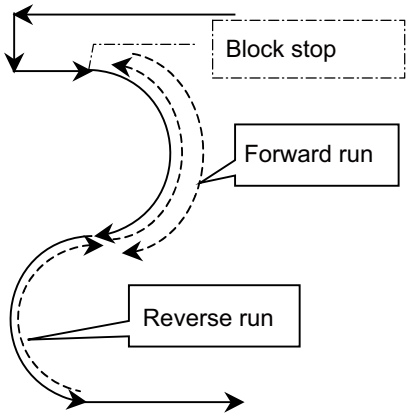
(6) The "Automatic operation "pause"" (*SP) signal and the "Single block" (SBK) signal are available in the reverse run.

(7) If the following signals are turned ON during the reverse run, NC resets the whole automatic operation.
- "NC reset 1" (NRST1)
- "NC reset 2" (NRST2)
- "Reset & rewind" (RRW)

Forward run

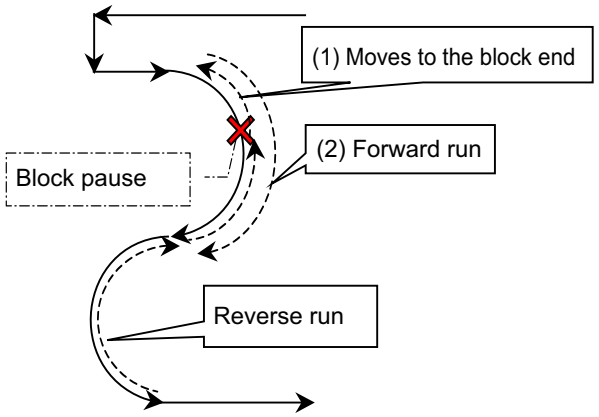
(1) When the "Automatic operation "start" command" (ST) signal is turned ON and OFF under all the following conditions, NC starts the forward run based on the reverse run information.
- "Reverse run control mode" (RVMD) signal is ON
- In the automatic operation stop: "In automatic operation "run"" (OP) is ON, "In automatic operation "start"" (STL) is OFF, "In automatic operation "pause"" (SPL) is OFF
or in the automatic operation pause: "In automatic operation "run"" (OP) is ON, "In automatic operation "start"" (STL) is OFF, "In automatic operation "pause"" (SPL) is ON
- The "Reverse run" (VRV) signal is OFF

(2) If the "Automatic operation "start"" signal is turned ON and OFF during the automatic operation stop, the forward run starts from the block stop point.




```
N01 G90 G54 X0 Y0 ;
N02 G91 G01 X50. F500 ;
N03 Y-20. ;
N04 X20. ;
N05 G02 Y-50. R25. ;
N06 G03 Y-50. R25. ;
N07 G01 X30. ;
M02 ;
```

(3) If the "Automatic operation "start" command" signal is turned ON and OFF during the automatic operation pause, the forward run starts after the execution for the remaining distance of the command. Therefore, the forward run usually must be started during the automatic operation stop.

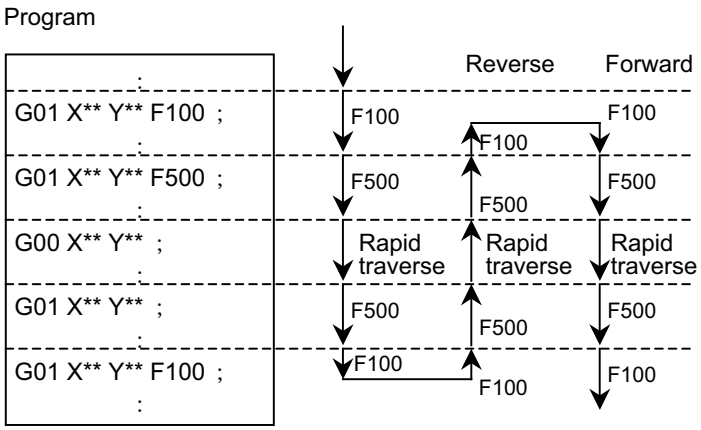



```
N01 G90 G54 X0 Y0 ;
N02 G91 G01 X50. F500 ;
N03 Y-20. ;
N04 X20. ;
N05 G02 Y-50. R25. ;
N06 G03 Y-50. R25. ;
N07 G01 X30. ;
M02 ;
```

(4) After the forward run has completed to the block where the reverse run had started, the movement continues to execute the remaining machining programs that had been automatically stopped. If the "Single block" signal is ON, the movement stops at each block end.
(5) The "Automatic operation "pause" command" (*SP) signal and the "Single block" (SBK) signal are available in the forward run.
(6) If the following signals are turned ON during the forward run, NC resets the whole automatic operation.
- "NC reset 1" (NRST1)
- "NC reset 2" (NRST2)
- "Reset & rewind" (RRW)

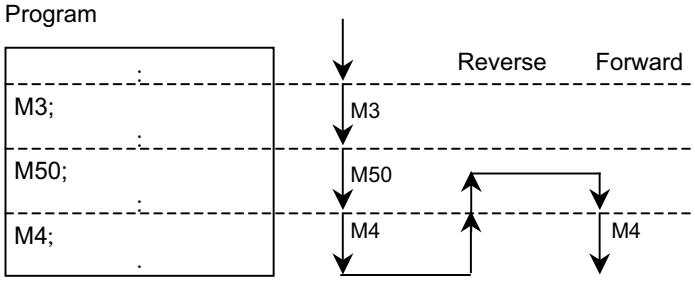
Feedrate (F) in the reverse/forward run

The reverse/forward run applies the feedrate specified with F command in the normal operation. Cutting feed override, rapid traverse override and dry run can be used on the F command.



M command in the reverse/forward run

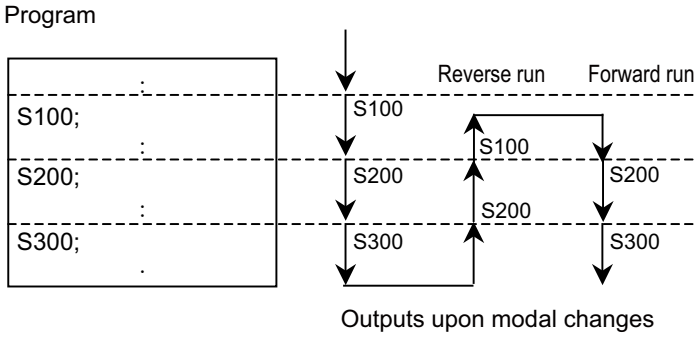
If any M command is given at the reverse run start and later on, NC does not output the "M code data" signal (R504 to R511) or the "M function strobe" (MFn) signal.
In the forward run, M code data is output according to the program. Then the "M function strobe" signal is turned ON. Note that only the last one M command is output when the several M commands are given to a block. Note also that no M command is output from the M command block where the forward run has started.



No M code output during the reverse run

S, T and 2nd miscellaneous function command in the reverse/forward run

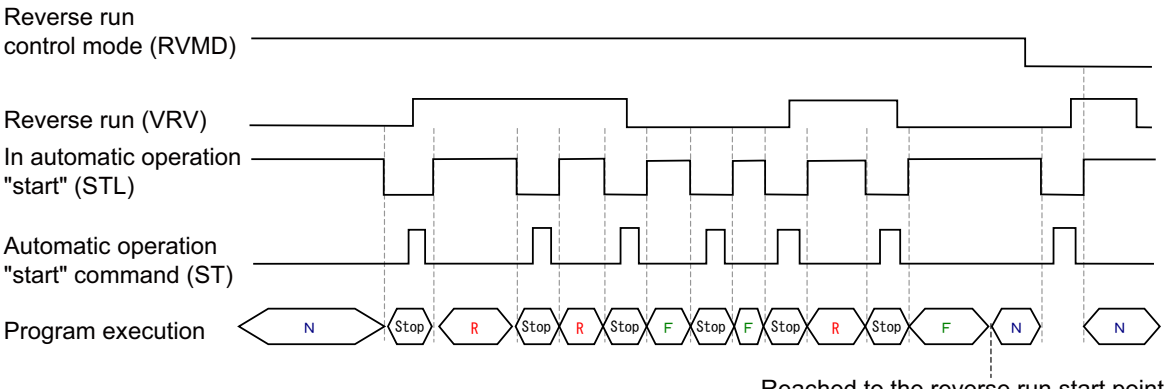
In the reverse run, NC outputs an S command only upon a change of the modal value: the S command with the changed modal value is output to "S code data" (R512 to R519) and then the "S function strobe" (SFn) signal is turned ON.
In the forward run, NC outputs S commands to "S code data" according to the program, and then turns ON the "S function strobe" signal.
T command and 2nd miscellaneous command are also output only upon changes of the value: each code data is output and each strobe signal is turned ON.



Outputs upon modal changes

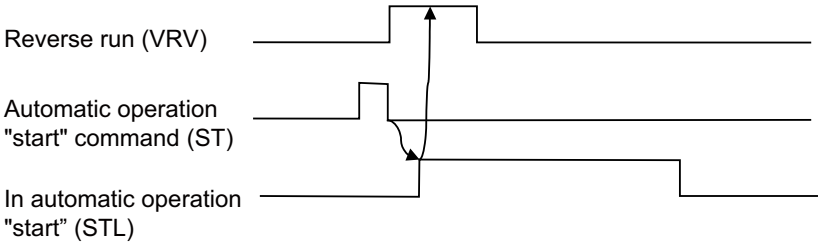
Timing chart

Reverse/forward run with the "Reverse control mode" and "Reverse run" signals



N: Normal operation
R: Reverse run
F: Forward run

How the "Reverse run" signal works with the signals for the operation start



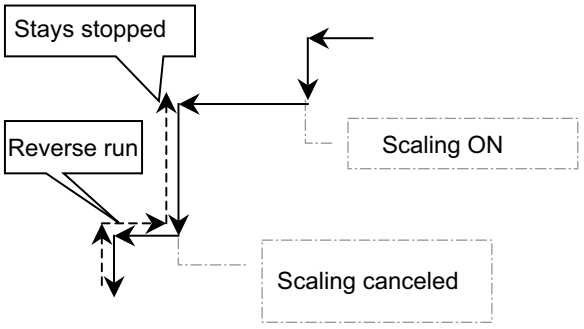
Do not turn OFF the signal STL when the reverse run has started.

Restrictions

(1) A buffer correction to the block for the reverse/forward run is not allowed in the reverse run control (reverse/forward run). The buffer correction is available to the blocks after the block where the reverse run starts.

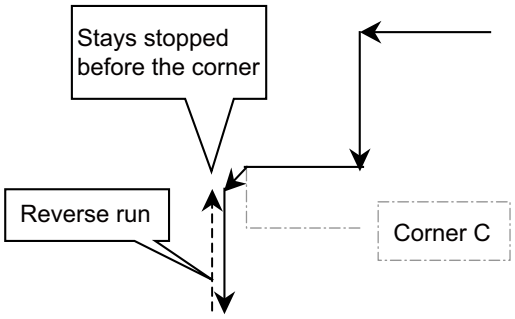
(2) If a collation and stop has been executed in the normal operation, a reverse run control (reverse/forward run) stops at the verification point in the block. On the other hand, if no collation and stop has been executed in the block in the normal operation, the collation and stop cannot be executed at the verification point specified during the reverse run control.

(3) Execute a scaling (G51) command before turning ON the "Reverse run control mode" signal. If the command is executed during the reverse run, the movement stops and stays at the reverse run start point in the block before the scaling command.




```
N01 G90 X10. ;
N02     Y  -10. ;
N03 G51 X10. Y-10. P2. ;
N04     X  -20. ;
N05     Y  -20. ;
N06 G50 ;
N06     X  -30. ;
N07     Y  -30. ;
N06     X  -40. ;
N07     Y  -40. ;
M02 ;
```

(4) Corner R/C, linear angle command and geometric command are not successfully executed during the reverse run. Corner R/C stays stopped before the corner.




```
N01 G91 X100. ;
N02     Y  -100. ;
N03     X  -100. ,C10. ;
N04     Y  -100. ;
M02 ;
```

(5) The consecutive number of "blocks with no movement" must be 7 or less in the program to be executed in the reverse run control mode. When containing 8 or more blocks, insert G04;(dwell) before the 8th block. When the number of "blocks with no movement" reaches 8 in a row in the reverse run control mode, the alarm "M01 Reverse run impossible 0119" occurs.

(6) Be sure to insert a G04;(dwell) block before G92, G52 and G53 commands.

(7) When using a sub program in the program executed in the reverse run control mode, insert a G04;(dwell) block before each block of sub program call (M98) and sub program return (M99).

(8) This function cannot be used with the reference position retract. Turning ON the "Reference position retract" (RTN) signal in the reverse run control mode clears the reverse run information.

(9) "M code independent output" (M00, M01, M02 and M30) signals are not output in the reverse run.

(10) Only the linear-type rotary axis can be under the reverse run control.

(11) Do not turn ON/OFF the "Optional block skip" (BDTn) signal under the reverse run control (in the reverse/forward run). The path after the change is the same as in the normal operation.
(12) The axis movement, which has been executed in other modes than memory and MDI modes (in MDI interrupt, manual operation or macro interrupt for example) under the reverse run control, must be returned before the reverse run starts. Unless the movement is returned, the reverse run of the program starts with the current position regarded as end point of the last block that has been executed in the memory or MDI mode.
(13) Tool life is not changed by the reverse run control (reverse/forward run).
(14) The reverse run control cannot be used with the PLC interrupt. Do not use the "PLC interrupt" (PIT) signal under the reverse run control.

Using macro interrupt

(1) Outline

The macro interrupt function helps starting the reverse run in the middle of the block.
Using the macro interrupt, which employs a user macro function, will be useful when a tool has broken: this helps moving the tool from where it has broken to the point where the tool is changed, and then returning it to the program path after the tool change.
An interrupt program has to instruct to move the tool to the tool change position, as well as to return it to the program path.

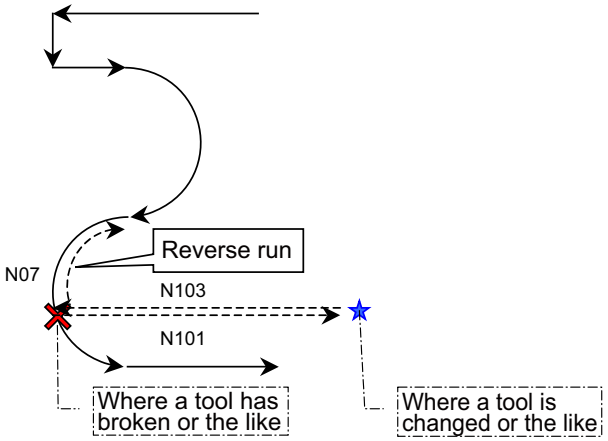
Use the parameter "#1113 INT_2"(Interrupt type 2 validity) to decide where to interrupt. Set "0" to the parameter to execute the macro interrupt in the middle of the block.

(2) Operation example

<To return the tool to the interruption point and start a cycle again>

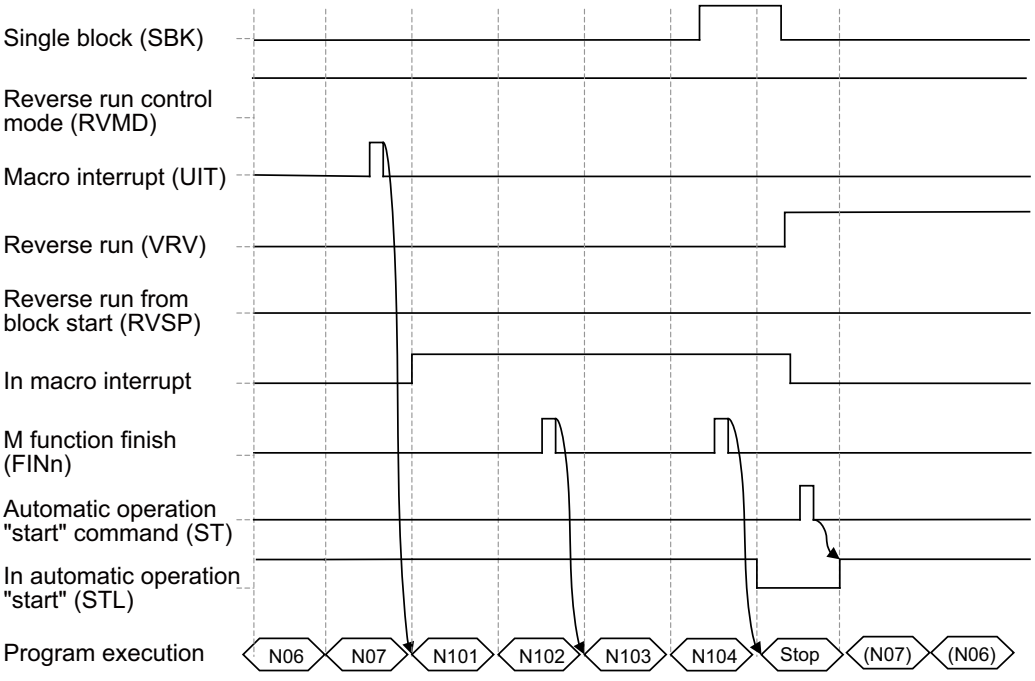
Keep the "Reverse run from block start" (RVSP) signal OFF when starting a reverse run.

To execute a reverse run after returning from the macro program, carry out a block stop when returning, turn ON the "Reverse run" (VRV) signal and then start the cycle. When the reverse run is not executed, the block stop is not required.




```
N01 G90 G54 X0 Y0 ;
N02 M96 P1001 ;
N03 G91 G01 X50. F500 ;
N04 Y-20.
N05 X20.
N06 G02 Y50. R25. ;
N07 G03 Y50. R25. ;
N08 G01 X30. ;
M97 ;
M02 ;
```

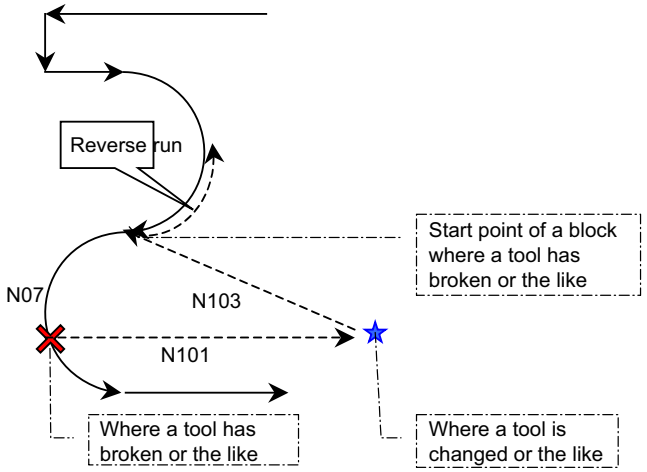
```
O1001 ;
#101=#5001#102=#5002
N101 G90 X70. ;
N102 M0 ;
N103 G90 G53 X#101 Y#102;
N104 M0 ;
G04 ;
M99 ;
```



Reverse run in "( )"
Forward run in "[ ]"

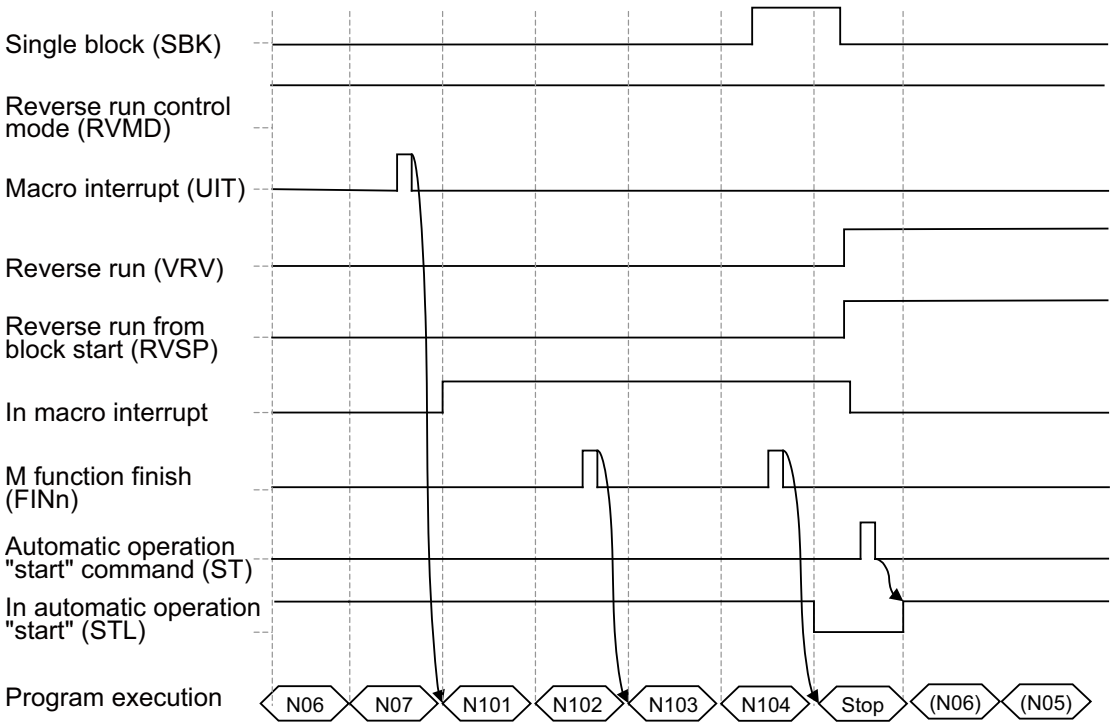
<To return to the start point in the block under the interruption and start a reverse run>

Turn ON the "Reverse run from block start" (RVSP) signal when starting the reverse run.




```
N01 G90 G54 X0 Y0 ;
N02 M96 P1002 ;
N03 G91 G01 X50. F500 ;
N04 Y-20.
N05 X20.
N06 G02 Y-50. R25. ;
N07 G03 Y-50. R25. ;
N08 G01 X30. ;
M97 ;
M02 ;
```

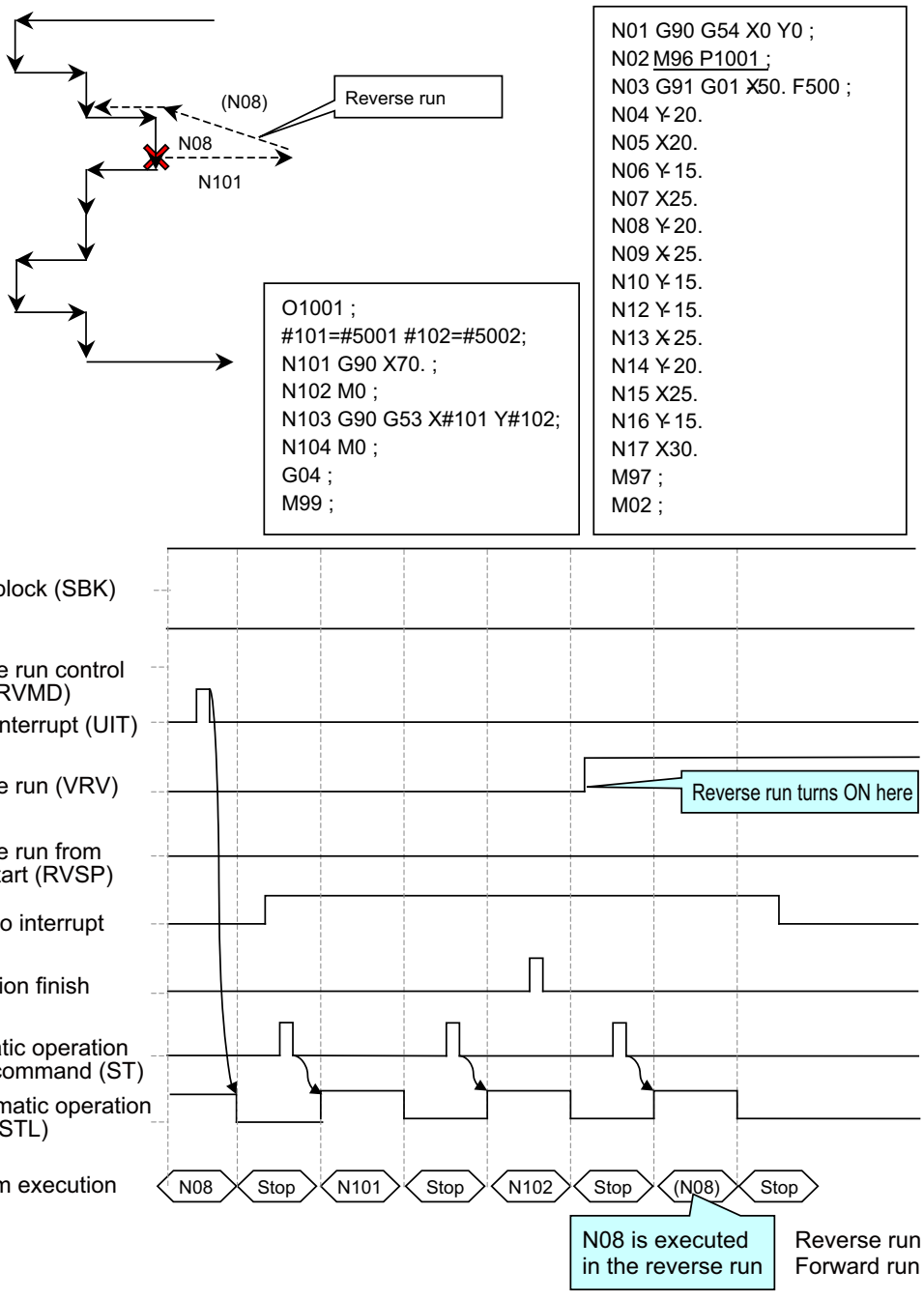
```
O1002 ;
#101=#5121 #102=#5122;
N101 G90 X70. ;
N102 M0 ;
N103 G90 G53 X#101 Y#102;
N104 M0 ;
G04 ;
M99 ;
```



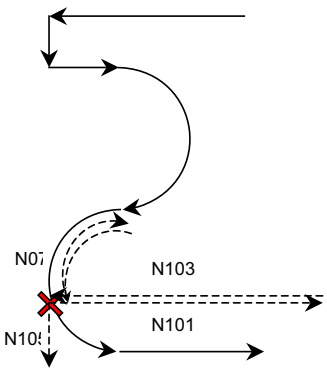
(3) Precautions

(a) Make sure to start a reverse run on the point (or the block start point) where the interruption occurs.

If a reverse run starts with a block stop in a macro interrupt program, the movement seems to start at the point (or the block start point) where the interruption occurs.

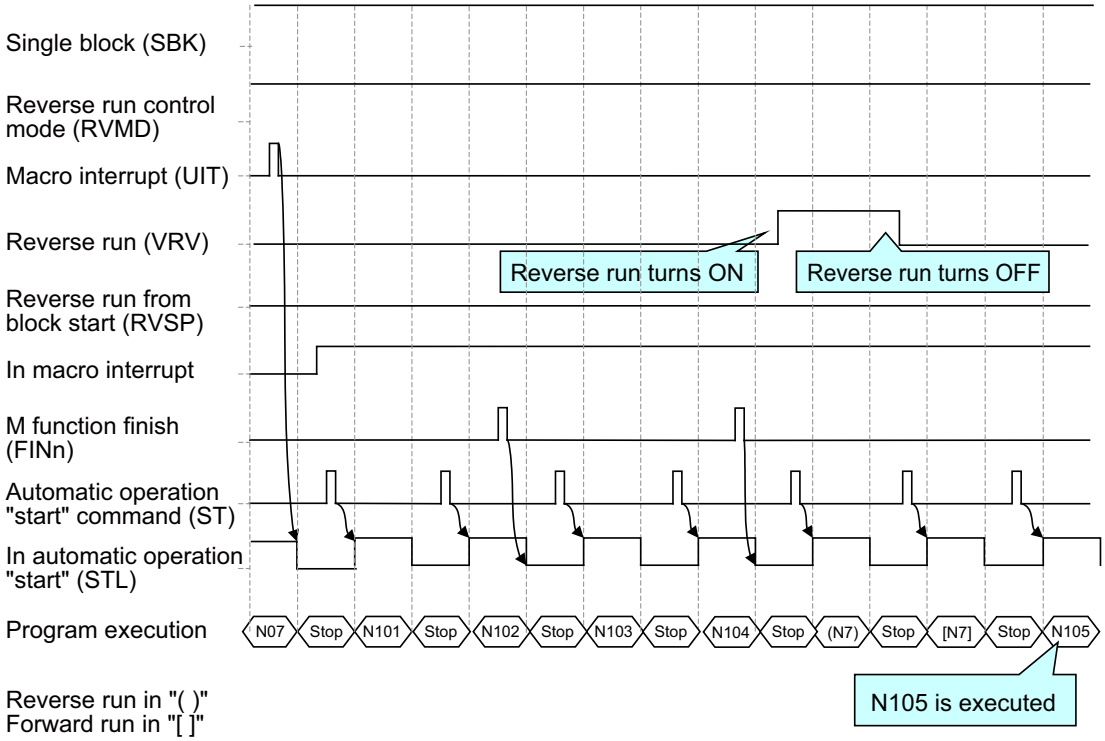


(b) In a macro interrupt program, start a reverse run at the point (or the block start point) where the interruption occurs and which a M99 (complete sub program) block follows.
If a reverse run has started with a block stop in the macro interrupt program, the movement returns to the interruption start point in the forward run, and then jumps to the next block of the reverse run start block in the macro interrupt program.




```
N01 G90 G54 X0 Y0 ;
N02 M96 P1002 ;
N03 G91 G01 X50. F500 ;
N04 Y-20.
N05 X20.
N06 G02 Y50. R25. ;
N07 G03 Y50. R25. ;
N08 G01 X30. ;
M02 ;
```

```
O1002 ;
#101=#5001 #102=#5002;
N101 G90 X70. ;
N102 M0 ;
N103 G90 G53 X#101 Y#102;
N104 M0 ;
N105 G01 Y20. ;
G04 ;
M99 ;
```



(c) While the reverse run is executed, the "Macro interrupt" signal is ignored.

System variable

The following shows the system variables used in the reverse run control.

(1) Position information

Position information Axis No.	End point coordinate of block immediately before	Start point coordinate of block with a macro interrupt	End point coordinate of block with a macro interrupt
1	#5001	#5121	#5141
2	#5002	#5122	#5142
3	#5003	#5123	#5143
:	:	:	:
n	#5000 + n	#5120 + n	#5140 + n
Reading during movement	Yes	Yes	Yes

(2) Reverse run information

Variable number	Usage	Description	Range
#31100	Number of available blocks for reverse run	+1 added number of the blocks that retained the reverse run information while the "Reverse run control mode" signal was ON	0 to 201
#31101	Counter of available blocks for reverse run	Number of available blocks for reverse run (value of #31100) when the "Reverse run" signal turned ON to start. Turns "0" when the forward run has been executed for all the blocks. Shows "0" in the normal operation.	0 to 201

PLC → NC interface signal

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	REVERSE RUN	VRV	YC27	YD67	YEA7	YFE7	Y1127	Y1267	Y13A7	Y14E7

[Function]

This signal is used to select reverse/forward run in the arbitrary reverse run.

[Operation]

Forward run is executed when this signal is OFF.

Reverse run is executed when this signal is ON.

This signal is available only in the reverse run control mode.

[Related signals]

(1) Reverse run from block start (RVSP: YD08)

(2) Macro interrupt priority (RVIT: YD09)

(3) Reverse run control mode (RVMD: YD0A)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	REVERSE RUN FROM BLOCK START	RVSP	YD08	YE48	YF88	Y10C8	Y1208	Y1348	Y1488	Y15C8

[Function]

This signal is used to designate where a reverse run starts in the arbitrary reverse run.

[Operation]

When this signal is OFF, a reverse run starts from the block stop point.

When this signal is ON, a reverse run starts from the start point of the block where the movement stopped.

Return to the start point for the reverse run from block start, turn this signal ON, and then start an automatic operation.

Keep this signal ON until the "In auto operation "start"" signal (STL) turns ON.

This signal is available only in the reverse run control mode.

[Related signals]

(1) Macro interrupt priority (RVIT: YD09)

(2) Reverse run control mode (RVMD: YD0A)

(3) Reverse run (VRV: YC27)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	MACRO INTERRUPT PRIORITY	RVIT	YD09	YE49	YF89	Y10C9	Y1209	Y1349	Y1489	Y15C9

[Function]

In the arbitrary reverse run, turning ON the "Macro interrupt" (UIT) signal executes a block stop during the reverse run. Then this signal is used to select the operation when an automatic operation is started while the "Reverse run" (VRV) signal is OFF.

[Operation]

When this signal is OFF, a forward run is executed with the falling edge of the "Automatic operation "start" command" signal.

When this signal is ON, a macro interrupt program is executed with the falling edge of the "Automatic operation "start" command" signal.

This signal is available only in the reverse run control mode.

[Related signals]

(1) Reverse run from block start (RVSP: YD08)
(2) Reverse run control mode (RVMD: YD0A)
(3) Reverse run (VRV: YC27)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	REVERSE RUN CONTROL MODE	RVMD	YD0A	YE4A	YF8A	Y10CA	Y120A	Y134A	Y148A	Y15CA

[Function]

This signal is used to save the reverse run information used for the reverse run control in the arbitrary reverse run.

[Operation]

When this signal is ON, the reverse run information is saved.

Turn this signal ON at the start of the block where the reverse run control is executed. Turn it OFF when resetting.

Turn ON the "Recalculation request" signal (CRQ) when turning ON this signal.

Unless the recalculation is requested, the reverse run information does not include the block that has been created by pre-reading.

[Related signals]

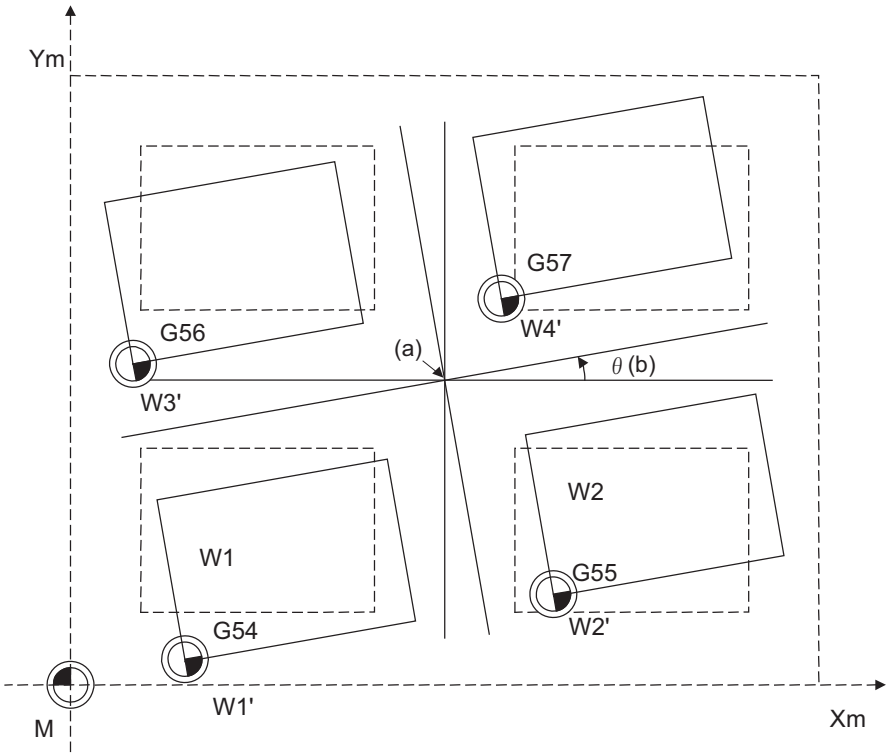
(1) Reverse run from block start (RVSP: YD08)
(2) Macro interrupt priority (RVIT: YD09)
(3) Reverse run (VRV: YC27)
(4) Recalculation request (CRQ: YC2B)

12.11 Coordinate Rotation by Parameter

12.11.1 Outline

If a deviation occurs between the workpiece alignment line and machine coordinate system's coordinate axis when the workpiece is mounted, the machine can be controlled by rotating the machining program coordinates according to the workpiece alignment line deviation. The coordinate rotation amount and the center of the rotation can be set with the parameters. The parameters can also be set with the G10 command.

In this manual, the coordinate system after the rotation by the parameter coordinate rotation is referred to as "rotation coordinate system".



(a) Center of rotation (b) Rotation angle

(1) As for the coordinate rotation center position, designate the position on the machine coordinate system.
(2) All workpiece coordinate systems from G54 to G59 and G54.1 rotate with the rotation command. The machine coordinate system does not rotate.
(3) When the parameter is set, the setting value will be valid at the following timing:

Automatic operation	After the parameter is set, the setting value will be valid from the next block.
Manual operation	After the parameter is set, the setting value will be valid if the PLC signal (Coordinate rotation by parameter: Manual feed coordinate system) is ON.

For the details on the operations during the automatic operation and the coordinate rotation functions, refer to the programming manual.

12.11.2 Function Enabling Conditions

(1) The parameter "#8116 CoordRotPara invd" is set to "0".
(2) The parameter "#8627 Coord rot angle" is set. Alternatively, "#8625 Coord rot vctr(H)" and "#8626 Coord rot vctr(V)" are set.

12.11.3 Description of Operation during the Manual Operation

For the movement direction in the manual operation (jog feed, incremental feed and manual handle feed) during coordinate rotation by parameter, "the movement in the machine coordinate system direction" or "the movement in the coordinate system direction rotated with coordinate rotation by parameter" can be designated with the PLC signal ("Coordinate rotation by parameter: Coordinate switch for manual feed" signal (YC7F)).

When any one of the three basic axes is in the state of the soft limit, manual machine lock or simultaneous operation of manual and automatic modes in the manual operation during coordinate rotation by parameter, the three basic axes are set to the following:

Soft limit	Put the three basic axes into the soft limit state.
Manual machine lock	Put the three basic axes into the manual machine lock state.
Simultaneous operation of manual and automatic modes	Put the three basic axes into the simultaneous operation of manual and automatic modes.

12.11.4 PLC Interface

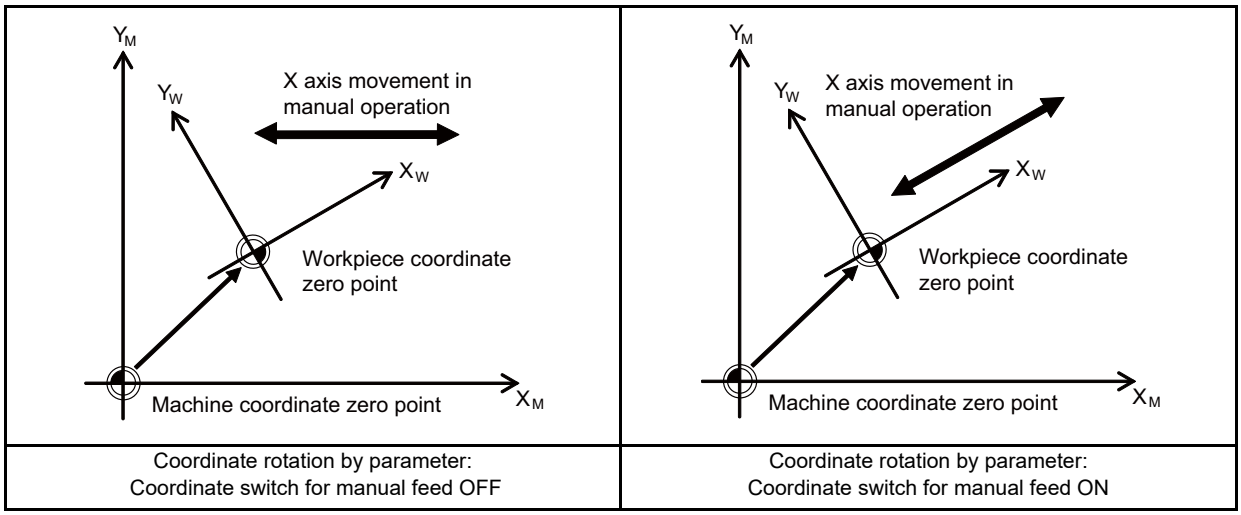
Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	COORDINATE ROTATION BY PARAMETER: MANUAL FEED COORDINATE SYSTEM [M8]		XC5F	XD9F	XEDF	X101F	X115F	X129F	X13DF	X151F

[Function]

This signal notifies the coordinate system which operates with the manual operation (jog feed, incremental feed and manual handle feed) during the coordinate rotation by parameter.

[Operation]

When this signal is turned OFF, the manual operation will be operated with the machine coordinate system.
When this signal is turned ON, the manual operation will be operated with the coordinate system rotated by the coordinate rotation by parameter.
When the coordinate rotation by parameter is invalid, this signal will be turned OFF even though the Coordinate rotation by parameter: Coordinate switch for manual feed (YC7F) is turned ON.



Coordinate rotation by parameter: Coordinate switch for manual feed OFF	Coordinate rotation by parameter: Coordinate switch for manual feed ON

[Related signals]

(1) Coordinate rotation by parameter: Coordinate switch for manual feed (YC7F)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	COORDINATE ROTATION BY PARAMETER: COORDINATE SWITCH FOR MANUAL FEED [M8]		YC7F	YDBF	YEFF	Y103F	Y117F	Y12BF	Y13FF	Y153F

[Function]

This signal specifies whether or not the manual operation (jog feed, incremental feed, manual handle feed) operates with the coordinate system rotated by the coordinate rotation by parameter.

[Operation]

When this signal is turned OFF, the manual operation will be operated with the machine coordinate system.
When this signal is turned ON, the manual operation will be operated with the coordinate system rotated by the coordinate rotation by parameter.

[Related signals]

(1) Coordinate rotation by parameter: Manual feed coordinate system (XC5F)

12.12 Chopping

With this function, the chopping axis constantly moves back and forth independently of the program operation during executing the machining program.

NC → PLC interface signal

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	IN CHOPPING START	CHOP	XC80	XDC0	XF00	X1040	X1180	X12C0	X1400	X1540

[Function][Operation]

This signal turns ON in the state of chopping start.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	BASIC POSITION→ UPPER DEAD POINT PATH FLAG	CHP1	XC81	XDC1	XF01	X1041	X1181	X12C1	X1401	X1541

[Function][Operation]

This signal turns ON while moving from the basic position to the upper dead center point.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	UPPER DEAD POINT → BOTTOM DEAD POINT PATH FLAG	CHP2	XC82	XDC2	XF02	X1042	X1182	X12C2	X1402	X1542

[Function][Operation]

This signal turns ON while moving from the upper dead center point to the bottom dead center point.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	BOTTOM DEAD POINT → UPPER DEAD POINT PATH FLAG	CHP3	XC83	XDC3	XF03	X1043	X1183	X12C3	X1403	X1543

[Function][Operation]

This signal turns ON while moving from the bottom dead center point to the upper dead center point.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	UPPER DEAD POINT → BASIC POSITION PATHBASIC POSITION PATH	CHP4	XC84	XDC4	XF04	X1044	X1184	X12C4	X1404	X1544

[Function][Operation]

This signal turns ON while moving from the upper dead center point to the basic position.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	IN CHOPPING MODE	CHPMD	XC85	XDC5	XF05	X1045	X1185	X12C5	X1405	X1545

[Function][Operation]

This signal turns ON in the state of chopping mode.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	STROKE COMPENSATION COMPLETION		XC86	XDC6	XF06	X1046	X1186	X12C6	X1406	X1546

[Function][Operation]

This signal turns ON when the difference between the commanded stroke and the actual stroke has reached the tolerance specified with the parameter (#2080 chwid) as a result of compensation of the commanded position.

When speed fluctuates, such as when movement is stopped or chopping control data is changed, this signal is turned OFF.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	CHOPPING COMPENSATION UPDATED PREVENTED	CHPRCC	XC7F	XDBF	XEFF	X103F	X117F	X12BF	X13FF	X153F

[Function]

This signal indicates that the machine is in the state where it does not update the chopping compensation amount.

[Operation]

While this signal is turned ON:

- The chopping compensation amount is not updated.
- The stroke compensation completion signal does not OFF.

When the control data is updated, turn this signal OFF and then update the chopping compensation amount.

[Related signals]

(1) Chopping compensation update prevention request (CHPRCR:YCD7)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	CHOPPING ERROR NO.		R554	R754	R954	R1154	R1354	R1554	R1754	R1954

[Function]

This signal notifies the user PLC of the alarm details when an alarm occurs during chopping operation.

[Operation]

Chopping error No. and the details are as shown below.

Error No.	Details	Classification
0	No error	-
1	Number of cycles for chopping is zero. (Operates when the number of cycles is 1)	A
2	The speed exceeds the cutting feed clamp speed. (The feedrate is clamped at the cutting feed clamp speed.)	A
3	The acceleration determined based on the parameter exceeds the value of parameter "#2002 clamp" or "#2141 chtL". (The number of cycles decreases because the acceleration is clamped at "#2002 clamp" or "#2141 chtL".)	A
4	The number of cycles exceeds 1056/min. (The number of cycles for chopping is clamped at 1056/min.)	A
5	Chopping axis zero point return is not completed.	B
6	Chopping override is zero.	B
7	Commanded axis is the chopping axis.	B
8	The bottom dead center point position is zero.	B
9	The chopping axis is a manual feed axis.	B
10	Interlock	B
11	Stored stroke limit or stroke end	B
12	The function that cannot be used concurrently is valid. [M8]	B
13	An interference is detected in the interference check III, or an entry in the interference alarm area occurs. [M8]	B
20	There is no specification for chopping. Or, the chopping function cannot be used.	-
21	Chopping control data area exceeds the R register area designated for the chopping control data. Chopping control data area and compensation amount record area are overlapped. Compensation amount record area exceeds R register's backup area (R8300 to R9799). ("Rm + 14 × N sets + 4" exceeds 9799)	C
22	Multiple chopping axes are specified by the PLC interface.	C
23	Chopping axis is not specified by either PLC interface or parameter.	C
24	Compensation method is set to other than 0/1.	C
25	The mode for the compensation value fixed method is set to other than "0" (playback mode) or "1" (record mode).	C
26	Data No. for the control data is a negative value.	C
27	Chopping axis's "#2081 chclsp" (Chopping clamp speed) and "#2002 clamp" (Cutting clamp speed) are both set to "0".	C
28	Chopping axis was changed during chopping operation. (Chopping axis cannot be changed during chopping.)	C
29	Rotary axis was specified as chopping axis.	C
30	Rapid traverse override valid/invalid is set to other than "0" (invalid) or "1" (valid).	A
31	The setting unit of the chopping override is set to other than "0" (1%) or "1" (0.01%). [M8]	A

Classification A:	The error is retained during chopping operation. The error is cleared at the rising edge of the "Chopping parameter valid" signal (YC34) after the chopping control data is corrected, or when the NC is reset.
Classification B:	The error is cleared after the alarm factor is removed, or when the NC is reset.
Classification C:	The error is cleared at the falling edge of the "Chopping parameter valid" signal (YC34), or when the NC is reset. The chopping control data is not enabled when this alarm occurs. [M8]

[Related signals]

(1) Chopping signal (CHPS:YC30)

PLC → NC interface signals

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	CHOPPING	CHPS	YC30	YD70	YEB0	YFF0	Y1130	Y1270	Y13B0	Y14F0

[Function]

This signal validates the chopping function.

[Operation]

The chopping mode is entered at the rising edge of this signal.

[Caution]

(1) To use synchronous control and chopping together, turn this signal (YC30) ON or OFF during synchronous operation. When the synchronous operation is started for the axis in chopping operation, the operation error (M01 1036) occurs, and the synchronous operation is not started. When the synchronous operation is ended while the synchronous operation and the chopping are used together, the operation error (M01 1270) occurs, and all the axes decelerate and stop. [M8]

(2) When the synchronous control is performed, designate only master axis as the chopping axis. If the slave axis is designated as the chopping axis and the chopping is started, the operation error (M01 1272) occurs and the chopping operation is not performed. [M8]

(3) Simple synchronous control and chopping cannot be used together. For the axis to be used for the simple synchronous control, do not set and start the chopping. [M8]

(4) In the loader-dedicated part system, chopping cannot be used. Even when the "Chopping" signal (YC30) is turned ON in the loader-dedicated part system, the mode is not changed to the chopping mode, and an error is output to the "Chopping error No." signal (R554).

(5) With C80 series, synchronous control and chopping cannot be used together. [C80]

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	CHOPPING PARAMETER VALID		YC34	YD74	YEB4	YFF4	Y1134	Y1274	Y13B4	Y14F4

[Function]

This signal enables the chopping control data assigned to R register.

[Operation]

The control data set to the R registers are validated at the rising edge of this signal (YC34). These R registers are designated by the "Chopping control data address" signal (R2587).

This signal (YC34) must be turned OFF after confirming that the "Chopping start ready completion" bit of the control status (Rn) in the control data is turned ON.

The "chopping start ready completion" is included in the control status of the copping control data.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	CHOPPING COMPENSATION UPDATE PREVENTION REQUEST	CHPRCR	YCD7	YE17	YF57	Y1097	Y11D7	Y1317	Y1457	Y1597

[Function] [Operation]

The chopping compensation amount is not updated while this signal (YCD7) is ON.

[Related signals]

(1) Chopping compensation update prevented (CHPRCC)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	CHOPPING OVERRIDE	CHPOV	R2503	R2703	R2903	R3103	R3303	R3503	R3703	R3903

[Function]

This signal is used to designate the override value for the operation between the upper dead center and the bottom dead center of the chopping axis.

[Operation]

(1) Set the override value (0% to 100%) for the operation between the upper dead center and the bottom dead center with a numerical value.
If a value outside the range is set, the override value is 100%.

(2) Select the setting unit 1% or 0.01% with the control data "the setting unit of the chopping override".
(Example) When the setting unit is 1% and R2503 is set to "100" (0x0064), the override value is 100%.
When the setting unit is 0.01% and R2503 is set to "10000" (0x2710), the override value is 100%.

(3) When the override value is set to "0", the operation error (M01 0150) occurs.

(4) As for the override value for the operation between the basic position and the upper dead center, select valid or invalid with the control data "rapid traverse override valid/invalid". When it is valid, rapid traverse override (code method or value-setting method) is performed.

[Related signals]

(1) Chopping (CHPS: YC30)
(2) Chopping parameter valid (YC34)
(3) Chopping control data address (R2587)
(4) Rapid traverse override method selection (ROVS: YC6F, R2502)
(5) Rapid traverse override code 1, 2 (ROV1, ROV2: YC68, YC69)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	CHOPPING CONTROL DATA ADDRESS		R2587	R2787	R2987	R3187	R3387	R3587	R3787	R3987

[Function][Operation]

This signal designates the chopping control data head No. (R register No.) assigned to R register.
R register area that can be used for assigning the chopping control data is as shown below.
R8300 to R9768 (Backup area)
R9800 to R9886 (Non back up area)

[Caution]

(1) Setting error occurs if an odd number is set.

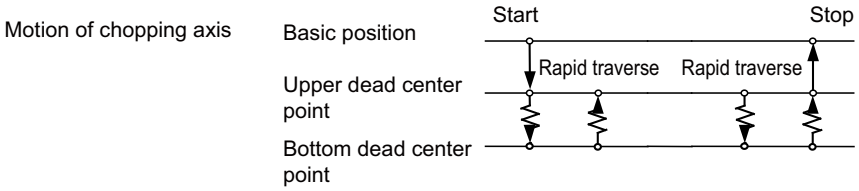
(2) When the backup area is used, set the area ahead of the compensation amount record area (#1324 chop_R).

(3) Error occurs if the chopping control data overlaps with the other part system or the compensation amount record area.

Chopping operation start

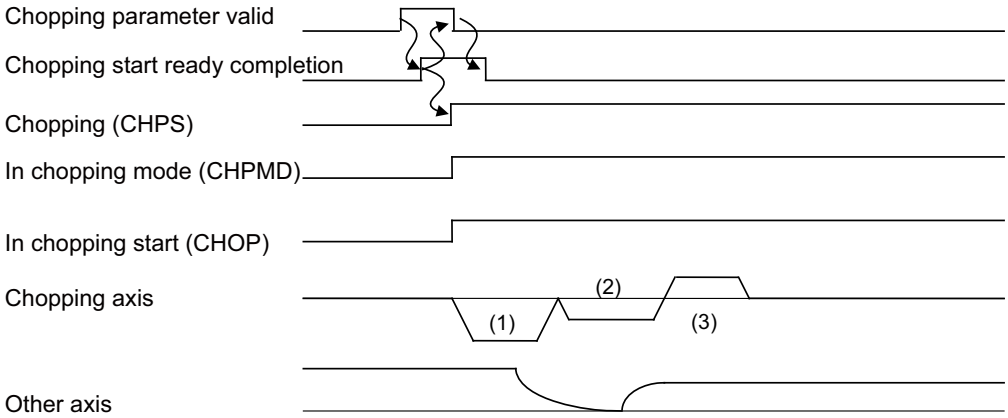
The chopping mode is entered at the rising edge of the "Chopping" signal (CHPS), and the chopping operation is started based on the position determined with the program, etc.
The chopping control sequence is the following.

- When the chopping axis is not moving, chopping is started immediately.
- When the chopping axis is moving, chopping is valid from the next block in the automatic mode, and an operation alarm will occur in the manual mode.

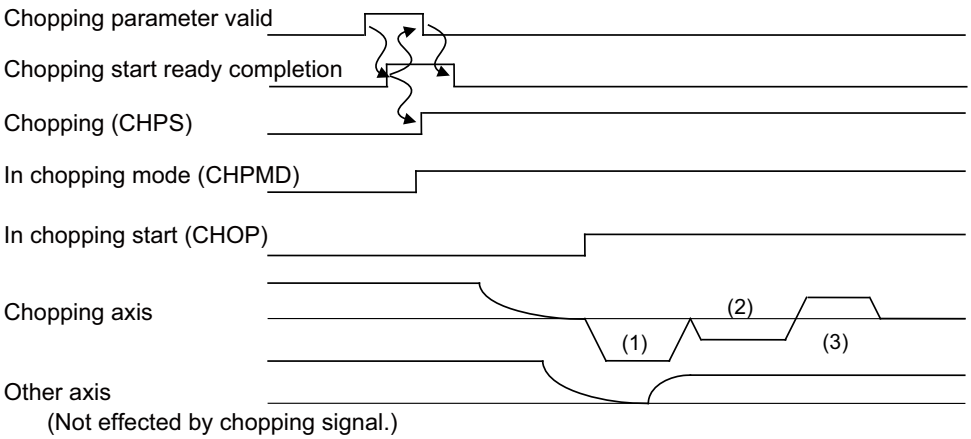


(1) In automatic mode

(a) When the chopping axis is not moving:



(b) When the chopping axis is moving:

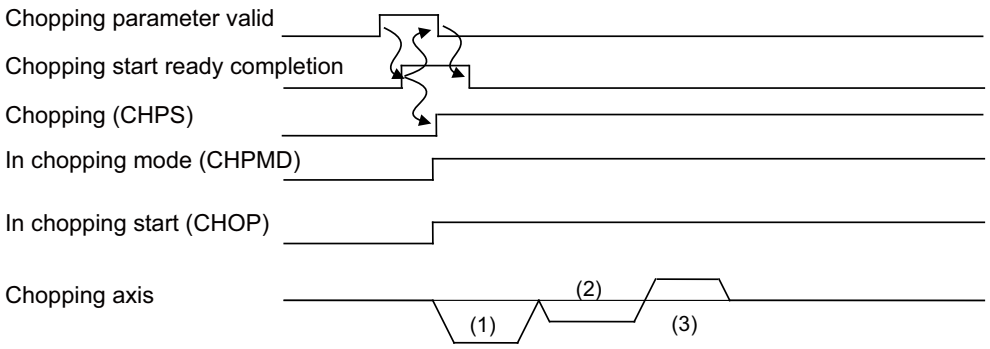


The "In chopping start" is entered after the chopping axis movement has been completed.

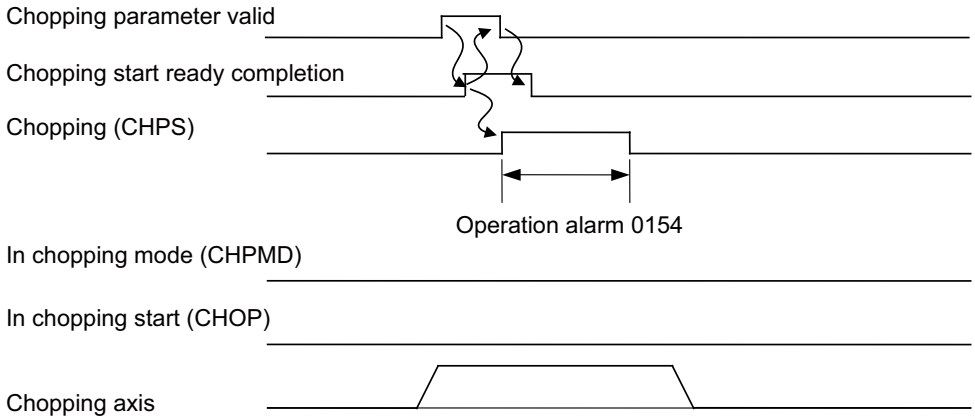
(2) In manual mode

In the jog and step mode, when the chopping axis is not moving, the chopping operation is started at the rising edge of the "Chopping" signal.If the "Chopping" signal is turned ON when the chopping axis is moving, the OPERATION ALARM 0154 will occur, and the chopping will not be started.(Rising edge of the "Chopping" signal is ignored.)

(a) When the chopping axis is not moving:



(b) When the chopping axis is moving:

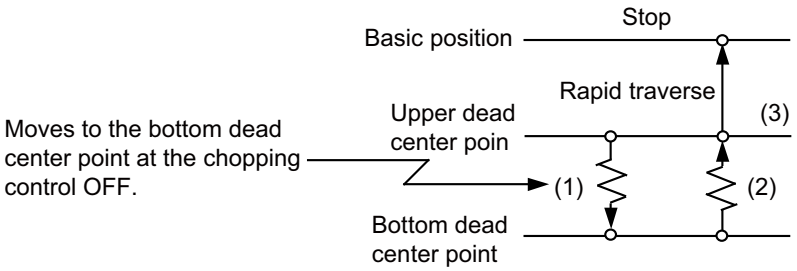


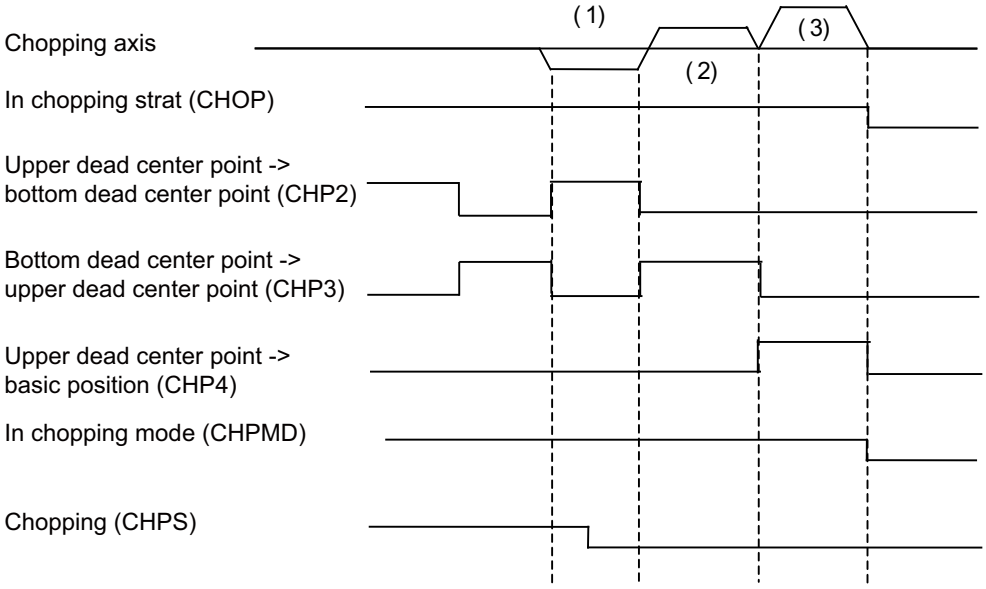
In the handle mode, when the chopping axis is not selected for the handle axis, the chopping operation is started at the rising edge of the "Chopping" signal.
If the "Chopping" signal is turned ON when the chopping axis is selected for the handle axis, the OPERATION ALARM 0154 will occur, and the chopping will not be started.

Chopping operation stop

The chopping operation is stopped at the falling edge of the "Chopping" signal from the PLC.
The chopping axis moves to the basic position with the rapid traverse after executing the chopping operation to the upper dead center point.
The chopping axis once moves to the bottom dead center point even in the middle of moving from the upper dead center point to the bottom dead center point.

Stopping motion of chopping axis

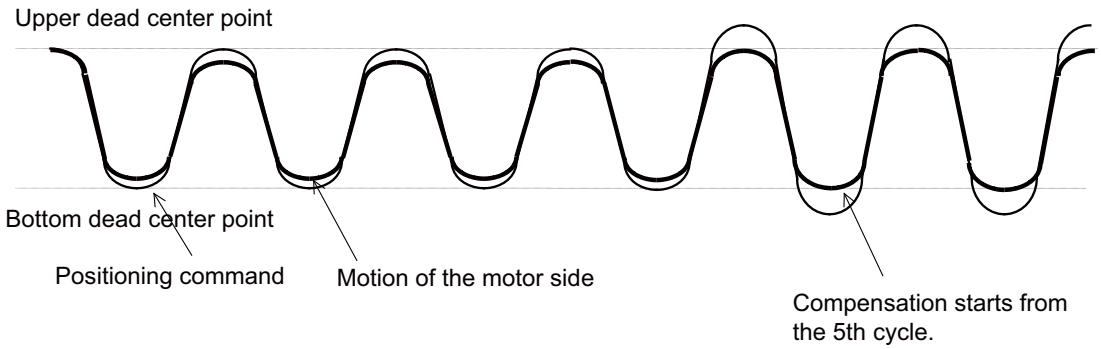




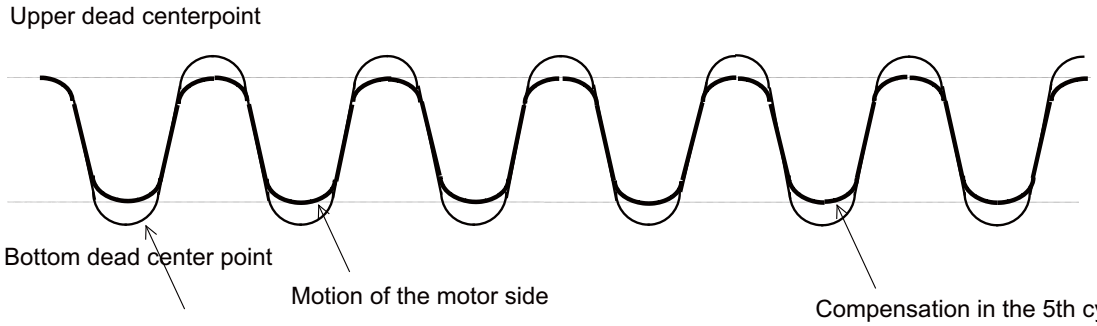
The "In chopping start" and the "In chopping mode" signals are turned OFF after returning to the basic position completes.

Chopping compensation method

Because this function involves high-speed repetitive motions, the positioning method allowing compensation based on the calculation from the machinery operation (feedback position of the motor side) is adapted, rather than the method using in-position check. Compensation amount used for positioning is calculated every 4 cycles from the start of chopping operation, based on the difference between the commanded position and feedback position. Then the compensation amount is added to the positioning command for the next cycle so that the difference between the commanded position and feedback position will disappear. (Compensation value sequential update method)



However, with this method, if the grindstone contacts with the workpiece, the chopping width before and after compensation may be differed, and which may affect the machining surface. In this case, the compensation value fixed method is appropriate.
With the compensation amount fixed method, compensation amount based on a dry run operation is recorded in advance so that, in the real operation, compensation is carried out from the first positioning to the bottom dead center point using the compensation amount recorded earlier.



Positioning command:
Select the compensation value fixed method and set the compensation amount so that compensation is carried out from the first bottom dead center point position since the operation has started.

The stroke compensation completion signal is output when the difference between the commanded stroke and the actual stroke has reached the tolerance specified with the parameter (#2080 chwid).

(1) Compensation value sequential update method

Every chopping command starts with "0" compensation amount. Compensation amount is calculated every 4-cycle chopping operation, and then the compensation is carried out.

<Prevent From Updating the Chopping Compensation Amount>

With the compensation value sequential update method, the stroke normally fluctuates by changing the speed of chopping operation. Turn the stroke compensation completion signal OFF to update the compensation amount automatically.

However, if the amount of change in the chopping operation is small and the fluctuation of the stroke is small, it might not need to update the compensation amount.

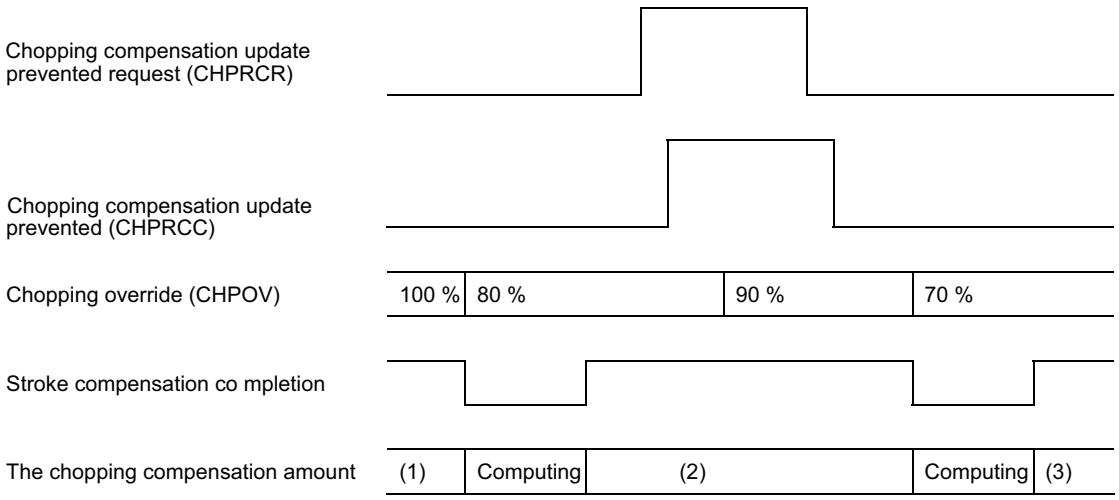
Use "Chopping compensation update prevented request" signal (CHPRCR) in this situation.

"Chopping compensation update prevented" signal (CHPRCC) is turned ON when the "Chopping compensation update prevented request" signal (CHPRCR) is turned ON.

While "Chopping compensation update prevented" signal (CHPRCR) is turned ON:

- The chopping compensation is not updated.
- The stroke compensation completion signal does not turn OFF.

When the control data is updated, turn "Chopping compensation update prevented request" signal (CHPRCR) OFF and then update the chopping compensation amount.



(1): Chopping compensation amount when the chopping override (CHPOV) is worth 100 %.
(2): Chopping compensation amount when the chopping override (CHPOV) is worth 80 %.
(3): Chopping compensation amount when the chopping override (CHPOV) is worth 70 %.

(2) Compensation value fixed method

Compensation amount fixed method includes the record mode and the playback mode.

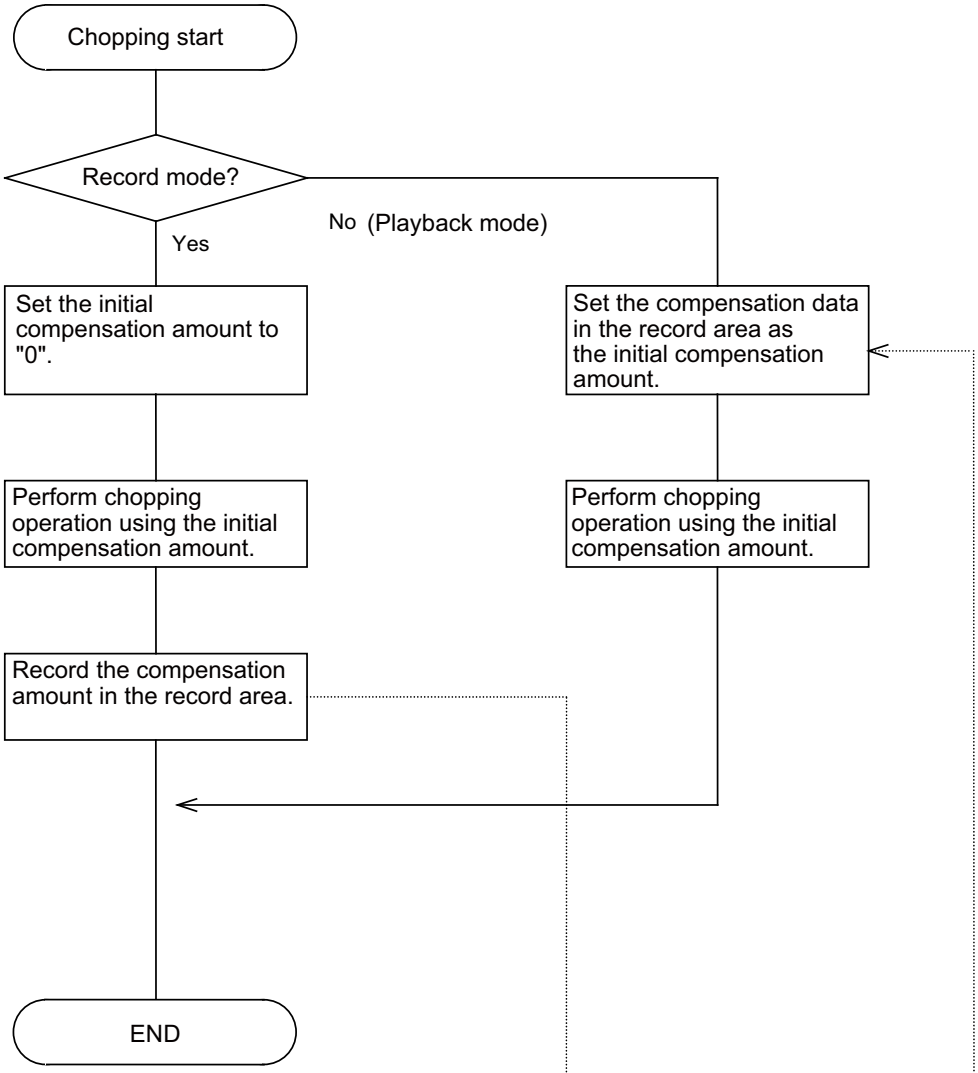
<Record mode>

- Override, command axis, upper/bottom dead center point position, number of cycles, and compensation amount are recorded as the chopping control data.
- Compensation amount record area is specified with R register.
- Compensation amount record area is determined by the number of R registers to be secured.
  14 consecutive R registers are required for 1 set of record.
- Compensation amount is always updated in the record mode.

<Playback mode>

- Chopping operation is started using the data (override, command axis, upper/bottom dead center point position, number of cycles, compensation amount) recorded in the record mode.
  Compensation amount is not calculated during playback mode.

<The operation of the compensation amount fixed method>



Compensation amount record area (R register: For N sets)

	Error status	Completion status	Command - Feedback
0	Override | Axis | Up dead pt. | Bottom dead pt. | No. of cycles | Compen. amnt (Width) | Compen. amnt (Ctr) | (Open to user)		
1	Override | Axis | Up dead pt. | Bottom dead pt. | No. of cycles | Compen. amnt (Width) | Compen. amnt (Ctr) | (Open to user)		
N-2	Override | Axis | Up dead pt. | Bottom dead pt. | No. of cycles | Compen. amnt (Width) | Compen. amnt (Ctr) | (Open to user)		
N-1	Override | Axis | Up dead pt. | Bottom dead pt. | No. of cycles | Compen. amnt (Width) | Compen. amnt (Ctr) | (Open to user)		

14 R registers are required per one set.
For N sets, the number of R registers required is 14*N+4.

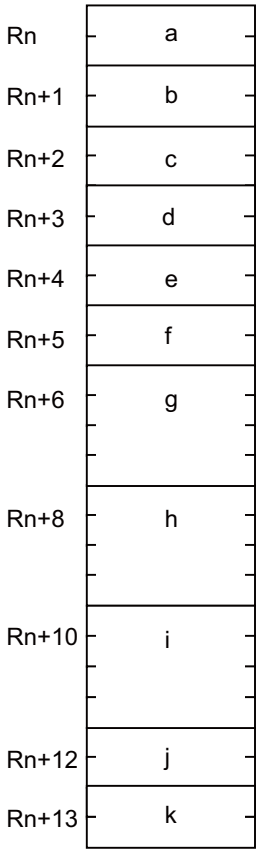
Chopping control data

Rn is specified with the PLC device (chopping control data address).

Data to be used differs depending on whether the compensation value sequential update method is applied or compensation amount fixed method is applied.

Update : Specify with the compensation value sequential update method

Fixed : Specify with the compensation value fixed method



a:	Control status	(Rn)	Update	Method
	bit3 : Chopping start ready completion This turns OFF at the falling edge of the chopping parameter valid signal. bitF : Error occurred This turns ON if an alarm occurrs when the chopping parameter valid signal is turned ON. The details of error is notified with bit9 to C. (Note) bit9 : Chopping error bitA : Chopping specifications is not available bitB : Compensation method is set to other than 0/1 bitC : Multiple chopping axes are specified			
b:	Not used	(Rn+1)	Update	Fixed
c:	Compensation method	(Rn+2)	Update	Fixed
	0000(HEX) : Compensation value sequential update method 0001(HEX) : Compensation value fixed method			
d:	The setting unit for the chopping override	(Rn+3)	Sequential update	Fixed
	0000(HEX): 1 % (unit) 0001 (HEX): 0.01 % (unit)			
e:	Rapid traverse override valid/invalid	(Rn+4)	Update	
	This sets the rapid traverse override valid/invalid in respect to the movement speed between the basic position and the upper dead center point. 0 : Invalid 1 : Valid			
f:	Chopping axis designation	(Rn+5)	Update	
	bit0 : 1st axis bit1 : 2nd axis : : bit7 : 8th axis		Select any one of the existing axes using bit. When no axis is specified, the axis whose base specification parameter "chop_ax" is "1" (the smallest No. of axis) within the same part system is selected.	
	bit8 to F : Not used (Set to "0".)			
g:	Upper dead center point	(Rn+6[low], Rn+7[high])	Update	
	This sets the movement amount of basic position -> upper dead center point with the code. Use the setting and display unit (#1003 iunit) for setting.			
h:	Bottom dead center point	(Rn+8[low], Rn+9[high])	Update	
	This sets the distance of upper dead center point -> bottom dead center point with the code. Use the setting and display unit for setting.			
i:	Number of cycles	(Rn+10[low], Rn+11[high])	Update	
	This sets the number of cycles for chopping cycle. (Unit: Number of cycles/min)			
j:	Operation mode with the compensation value fixed method	(Rn+12)		Fixed
	0000(HEX) : Playback mode 0001(HEX) : Record mode			
k:	Data No.	(Rn+13)		Fixed
	This specifies what number data (n-th data) from the head of the record area (specified by the parameter) to be used. (Both the record mode and playback mode must be specified. 1st data area is specified with 0.)			

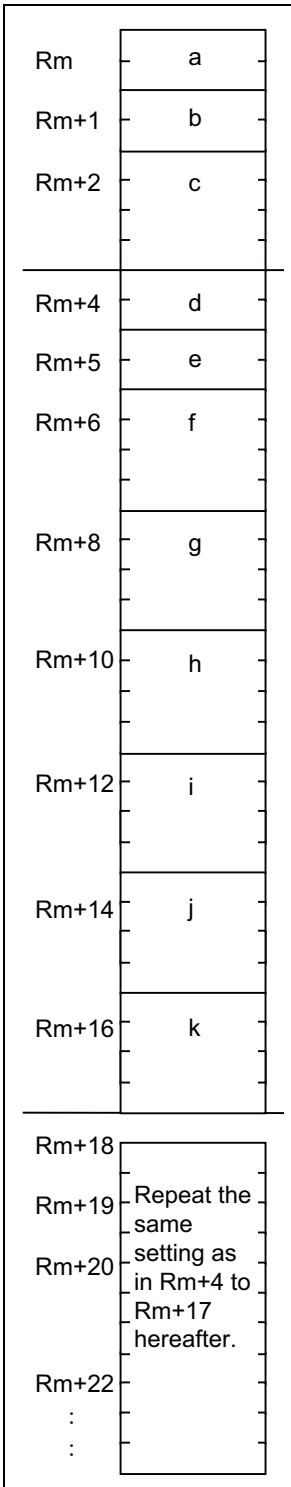
(Note) If an alarm occurs when the chopping parameter valid signal is turned ON, Rn bit is turned ON. Alarm details is output to the chopping error No. (R554), as well.

Rn bit	Error	Cause
BITA BITF	Option error	There is no specification for chopping.
BITB BITF	Compensation method error	Compensation method is set to other than 0(Compensation value sequential update type) or 1(Compensation value fixed type).
BITC BITF	Illegal number of axes error	Multiple chopping axes are specified by the PLC interface.
BIT9 BITF	Chopping error	Part system commanded by PLC interface is not valid.
		Chopping axis is not specified by either PLC interface or parameter.
		Rotary axis is specified as the chopping axis.
		Rapid traverse override valid/invalid is set to other than 0(invalid) or 1(valid).
		Data No. of the control data is a negative value.
		Compensation amount record area exceeds R register backup area (R8300 to R9799). ((Rm+14xN sets+4) > 9799.)
		The mode for the compensation value fixed method is set to other than 0(playback mode) or 1(record mode).
		Number of cycles is 0 or less, or over 1056. (If 0 or less, 1 is applied. If exceeds 1056, 1056 is applied.)
		Acceleration determined by the parameter exceeds clamp/chtL. (The number of cycles is reduced.)
		When the chopping axis is changed during chopping operation. (Chopping axis is not changed during chopping.)
		F(feedrate) exceeds the clamp speed. (The speed is clamped to the clamp speed (#2081 chclsp).)
		Chopping axis's #2081 chclsp (chopping clamp speed) and #2002 clamp (cutting clamp speed) are both set to "0".

The error bit shown above is not turned ON in the following cases. However, chopping error No. is output.
- Control data area exceeds the R register area designated for the control data.
- Control data area and compensatioin amount record area are overlapped.

Chopping control data: Compensation amount record area (Dedicated for compensation value fixed method)

Rm is specified with the parameter (#1324 chop_R).



a:	Error status (in playback mode)		(Rm)
	bit0 : This is turned ON when the difference between the motor side feedback amplitude width and the commanded width has exceeded the tolerance set with the parameter (#2080 chwid).		
b:	Chopping compensation amount record completion status (in record mode)		(Rm+1)
	bit0 : "1" at completion of recording bit1 : "1" when recording is not completed		
c:	Command - Feedback		(Rm+2[low], Rm+3[high])
	[In playback mode] Difference between the motor side feedback amplitude width and the commanded width is stored when the difference has exceeded the tolerance set with the parameter (#2080 chwid). [In record mode] Difference between command and feedback is stored every time the compensation amount is calculated.		
d:	Rapid traverse override valid/invalid		(Rm+4)
	Set the rapid traverse override valid/invalid in respect to the movement speed between the basic position and upper dead center point. 0 : Invalid 1 : Valid		
e:	Chopping axis designation		(Rm+5)
	bit0 : 1st axis bit1 : 2nd axis : : bit7 : 8th axis		Select any one of the existing axes using bit. When no axis is specified, the axis whose base specification parameter "chop_ax" is "1" (the smallest No. of axis) within the same part system is selected.
	bit8 to F : Not used (Set to "0".)		
f:	Upper dead center point		(Rm+6[low], Rm+7[high])
	Set the movement amount of basic position -> upper dead center point with the code. Use the setting and display unit (#1003 iunit) for setting.		
g:	Bottom dead center point		(Rm+8[low], Rm+9[high])
	Set the distance of upper dead center point -> bottom dead center point with the code. Use the setting and display unit for setting.		
h:	Number of cycles		(Rm+10[low], Rm+11[high])
	Set the number of cycles for chopping cycle. (Unit: Number of cycles/min)		
i:	Compensation amount (Width)		(Rm+12[low], Rm+13[high])
	Compensation amount to be added to the chopping upper/bottom dead center point command. In the playback mode, this is used for amplitude compensation. When started with the record mode, this is automatically stored.		
j:	Compensation amount (Center)		(Rm+14[low], Rm+15[high])
	Compensation amount to be added to the chopping upper/bottom dead center point command. In the playback mode, this is used for compensating the center of amplitude. When started with the record mode, this is automatically stored.		
k:	Data to be opened		(Rm+16[low], Rm+17[high])
	Use this for managing the compensation amount record area, etc. by using ladder of the user.		

Procedures for setting the chopping control data

(1) Set the chopping control data to R register.

(2) Turn the chopping parameter valid signal ON.

Chopping control data is written into the current parameter area inside the NC at the rising edge of the chopping parameter valid signal and is reflected to the chopping operation.

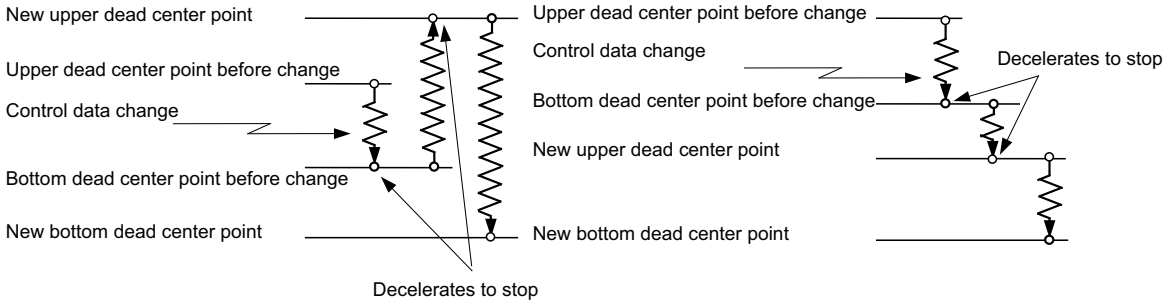
Turn the chopping parameter valid signal OFF after confirming that the chopping start ready completion signal in the control status (Rn) within the chopping control data is turned ON.

Setting the chopping control data during chopping

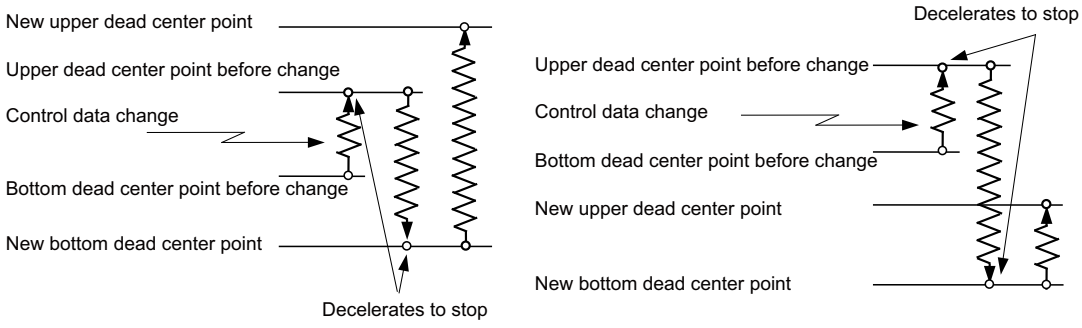
Chopping control data can be set during chopping.

When the chopping parameter valid signal is turned ON, the chopping axis decelerates to stop once at the upper or bottom dead center point to be changed. As soon as decelerating to stop, chopping operation is carried out with the changed chopping control data.

The upper and bottom dead center points are switched while moving from the upper dead center point to the bottom dead center point.



The upper and bottom dead center points are switched while moving from the bottom dead center point to the upper dead center point.



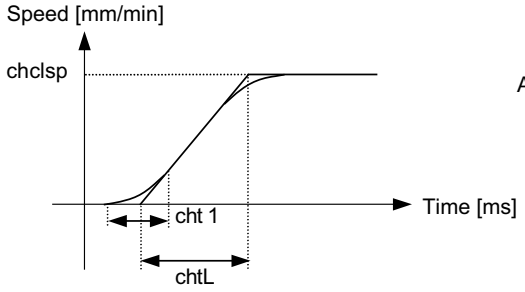
Chopping control data can be changed at any time in the chopping start state. Checking the NC side status or considering the timing is not necessary.

Chopping axis cannot be changed during chopping operation.

(Note) When the chopping parameter valid signal is turned ON, the chopping axis decelerates to stop once even if the chopping control data has not been changed, and which may result in longer cycle time.

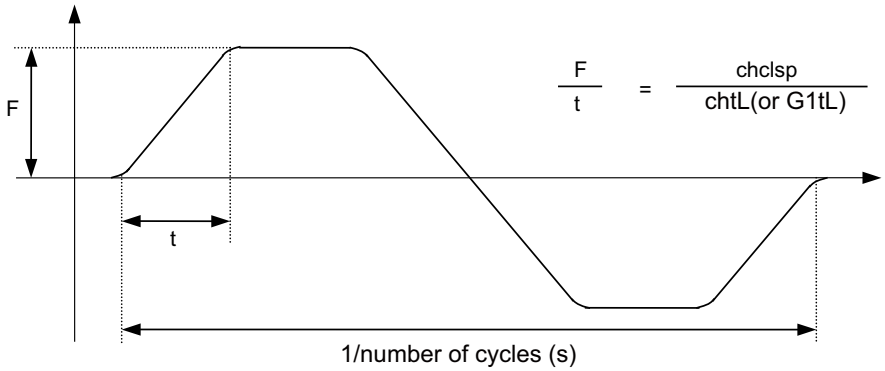
Chopping feedrate

The chopping axis feedrate is clamped at the chopping axis clamp speed (#2081 chclsp). When "0" is set to the chopping clamp speed, the chopping axis feedrate is clamped at the G1 clamp speed (#2002 clamp). The acceleration/ deceleration time constant is set with chopping axis acceleration/deceleration time constant (#2141 chtL). When "0" is set to the chopping axis acceleration/deceleration time constant, the chopping axis linear acceleration/deceleration time constant (#2007 G1tL) is used.



$$\text{Acceleration } \alpha = \frac{\text{chclsp}}{\text{chtL(or G1tL)}}$$

When the upper dead center point, bottom dead center point and number of cycles are set with chopping control data, the speed pattern in which acceleration a is "clamp speed/time constant" will be commanded to the servo drive unit.

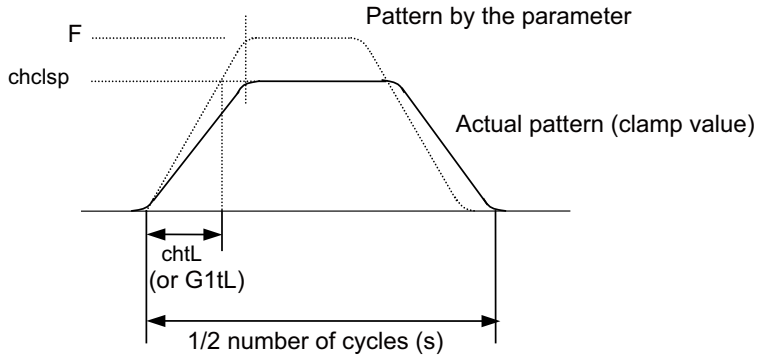


$$\frac{F}{t} = \frac{\text{chclsp}}{\text{chtL(or G1tL)}}$$

When the specified chopping control data is illegal, the alarm is returned to the buffer (Rn). In the following cases, the number of cycles or feedrate is converted into the value controllable with NC (clamp value) upon occurrence of the alarm.

(1) When the number of cycles is 0:
Number of cycles is 1/min.

(2) When F exceeds chclsp:
The following indicates that F exceeds chclsp when the speed pattern is calculated based on the acceleration of chclsp/chtL. (The number of cycles becomes smaller than that of specified.)



(3) When the number of cycles is 1056/min or more:
The number of cycles is clamped at 1056/min.

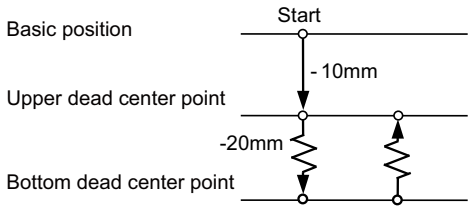
Setting example for the compensation value sequential update method

The following data is set using R8300 to R8311 as buffer area.

Data	Decimal	HEX	Setting details
Rapid traverse override valid/invalid	1	0001	Valid
Chopping axis designation	4	0004	1st part system Z axis (3rd axis)
Upper dead center point (increment amount from the basic position)	-10000	FFFFD8F0	-10000 (setting and display unit)
Bottom dead center point (increment amount from the upper dead center point)	-20000	FFFFB1E0	-20000 (setting and display unit)
Number of cycles	50	00000032	50/min

R8300	0000	Control status
R8301	0000	Not used
R8302	0000	Compensation method (Compensation value sequential update method)
R8303	0000	Setting unit for the override (1%)
R8304	0001	Rapid traverse override valid
R8305	0004	Chopping axis designation
R8306	D8F0 FFFF	Upper dead center point
R8308	B1E0 FFFF	Bottom dead center point
R8310	0032 0000	Number of cycles

Chopping axis operation

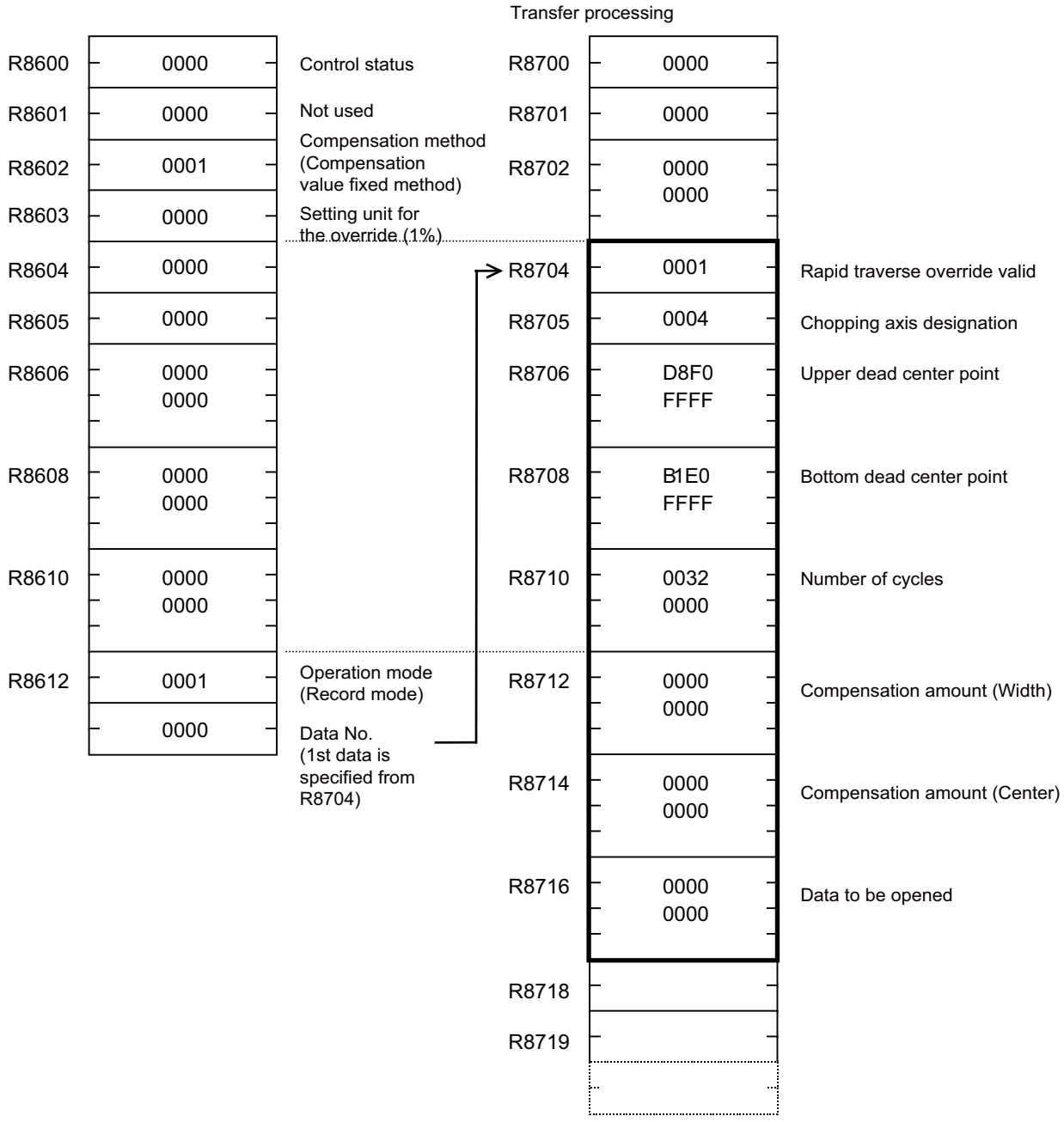


Setting example for the compensation value fixed method

The following data is set using R8600 to R8613 as buffer area.

R8700(#1324 chop_R = 8700) is used for the compensation amount record area.

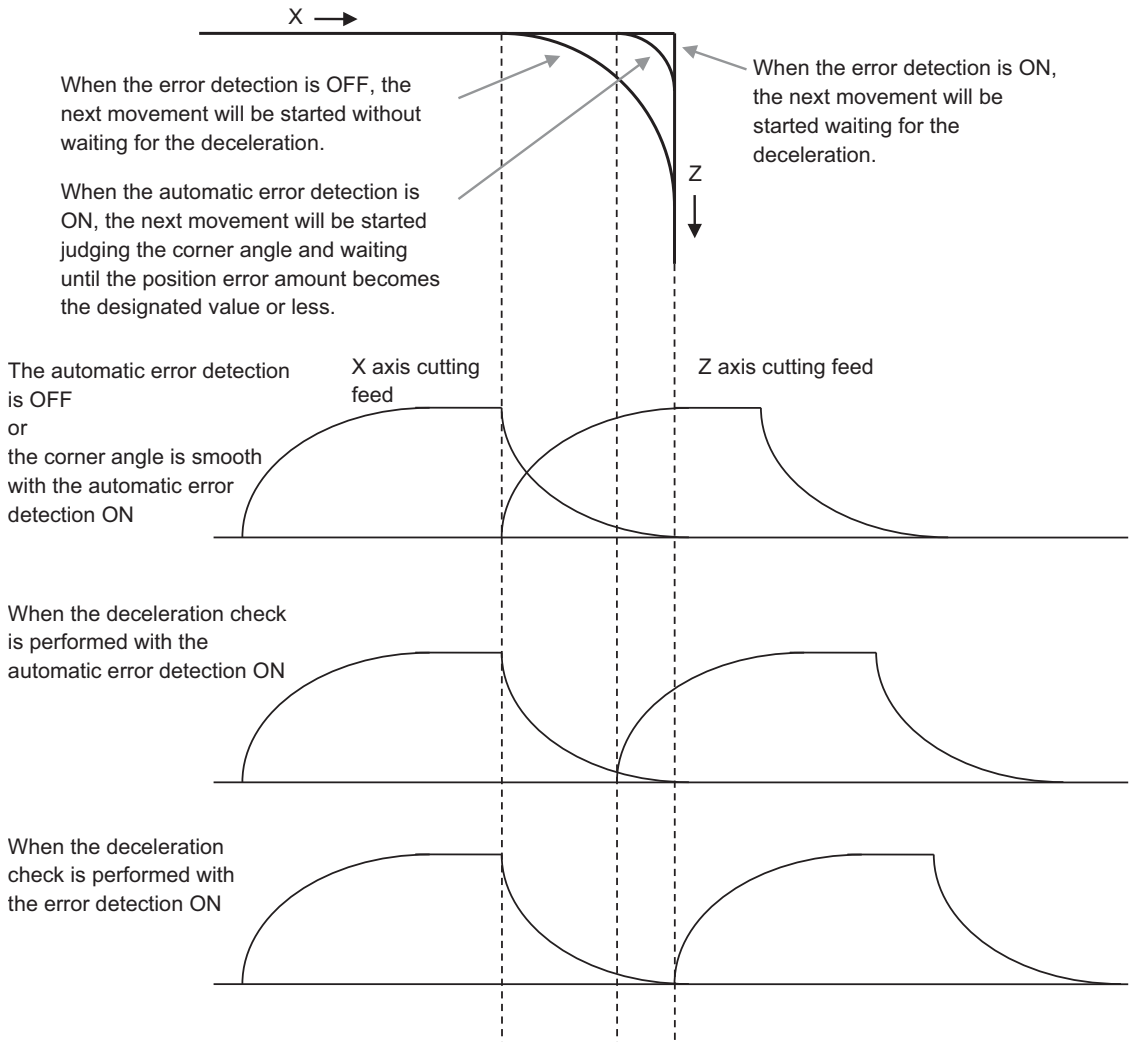
Data	Decimal	HEX	Setting details
Rapid traverse override valid/invalid	1	0001	Valid
Chopping axis designation	4	0004	1st part system Z axis (3rd axis)
Upper dead center point (increment amount from the basic position)	-10000	FFFFD8F0	-10000 (setting and display unit)
Bottom dead center point (increment amount from the upper dead center point)	-20000	FFFFB1E0	-20000 (setting and display unit)
Number of cycles	50	00000032	50/min



12.13 Automatic Error Detection

12.13.1 Outline

The cutting at corner area (the continuous blocks with different movement directions) may have rounding because of acceleration/deceleration or servo response delay. Turning ON the error detection increases the edge accuracy; however, the cycle time will be longer as the deceleration check is performed in every cutting block.
Using this function, the timing for starting the next cutting block is controlled (waited) until the amount of position error at the corner area becomes equal to or less than the parameter value in order to cut edges with high accuracy. The timing for starting the next block is controlled when the result of corner angle calculation is smaller than the parameter value, and it is not controlled when the result of corner angle calculation is larger than the parameter value. The basis whether the result value is large or not can be set by the parameter.
Using this function, the high-accurate edge cutting can be performed without too much extending the cycle time.



12.13.2 Function Enabling Conditions

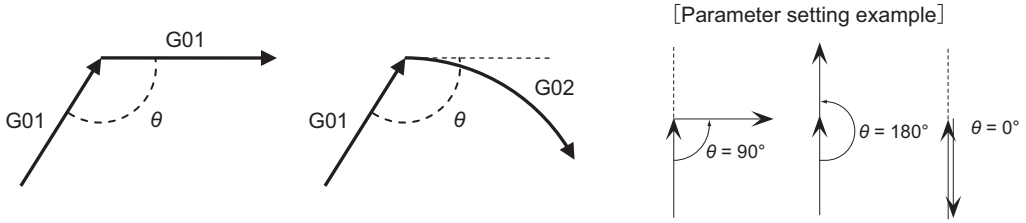
This function is switched to ON/OFF with the PLC signals.
This function is ON when the error detection signal (ERD) is OFF and the automatic error detection signal (AUTED) is ON.
The normal error detection is prioritized when the error detection signal (ERD) is ON.

This function works at the corner of linear interpolation (G01) or circular interpolation (G02, G03).
This function does not work during the exact stop check (G61) or when the exact stop check (G09) command exists in the same block.
(G01 → G01, G01 → G02/03, G02/G03 → G01, G02/G03 → G02/G03)

12.13.3 Description of Operation

(1) Corner angle calculation control

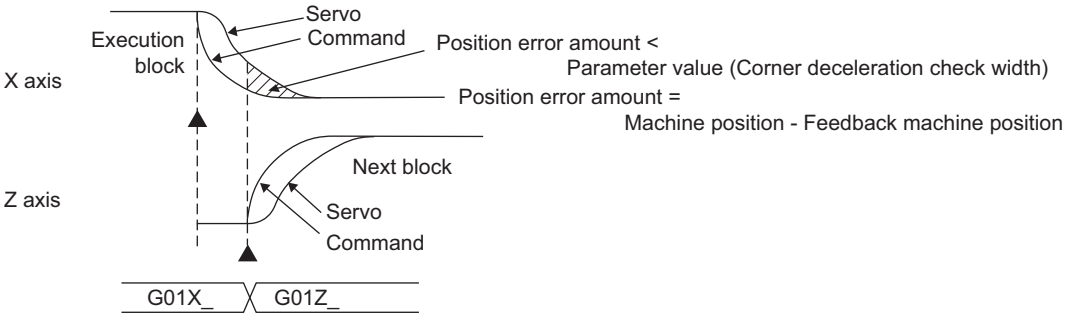
The timing for starting the next cutting block is controlled only when the corner angle θ (interior angle) calculated for consecutive cutting blocks is equal to or smaller than the parameter value (*1).
The timing for starting the next cutting block is not controlled when the corner angle is larger than the parametervalue.
Angle calculation is performed for the plane axis selected with the plane selection command. Angle calculation is not performed for the rotational axes.



(*1) Corner deceleration check angle

(2) Start timing control

Checking the amount of error is started after deceleration starts in the currently executed block. The next cutting block starts when the amount of error (remaining distance after composition) between the machine position of the target axis and the feedback machine position becomes equal to or less than the parameter value (*1).



(*1) Corner deceleration check width

12.13.4 Relation with Other Functions

(1) Milling mode
This function is disabled for a movement command which is in the milling mode.

(2) Tool compensation
For tool compensation or nose R compensation, the corner angle is calculated for the compensated block.

(3) Control axis synchronization (G125), Control axis superimposition (G126), Arbitrary axis exchange (G140, G141, and G142), Arbitrary axis superimposition (G156)
When control axis synchronization (G125), control axis superimposition (G126), arbitrary axis exchange (G140, G141, G142), or arbitrary axis superimposition (G156) takes place in another part system, there may be delay in a block next to cutting block of the part system to which the axes related to the said functions belong.

(4) Automatic machine lock
This function is disabled for an axis to which automatic machine lock is applied.

(5) High-accuracy control mode
The high-accuracy control enables machining with high corner-edge accuracy. Do not use this function during the high-accuracy control mode.

(6) High-speed machining mode
This function is disabled during the high-speed machining mode.

12.13.5 Precautions

(1) As the comparison between the corner deceleration check width parameter and the position error amount is performed at every constant time, the timing for starting the next block will be a little later than the set parameter value.

(2) This function is valid from a block next to the one where the automatic error detection signal is turned ON.

(3) When the angle of corner with a circular interpolation command is calculated, the tangential direction of the circular command's start or end point is treated as the travel direction.

(4) For the fine segment block with a high feedrate, the timing for starting the next block may be delayed.

(5) When the recalculation request ($1:YC2B to $8:Y14EB) is input with the PLC signal, the timing for starting the next block is delayed.

12.14 External Machine Coordinate System Compensation

External machine coordinate system compensation is executed by setting compensation data (absolute amount) in the PLC file register (R) for each axis.
Thus, the compensation timing is when PLC rewrites file register (R) compensation data. Necessary condition, timing, etc., are set by user PLC.
The interface between user PLC and CNC is shown below.

File register	Details	File register	Details
R5700,5701	$1 compensation data 1st axis	R5716,5717	$2 compensation data 1st axis
R5702,5703	$1 compensation data 2nd axis	R5718,5719	$2 compensation data 2nd axis
R5704,5705	$1 compensation data 3rd axis	R5720,5721	—
R5706,5707	$1 compensation data 4th axis	R5722,5723	—
R5708,5709	—	R5724,5725	—
R5710,5711	—	R5726,5727	—
R5712,5713	—	R5728,5729	—
R5714,5715	—	R5730,5731	—

(Note)File registers for $1 are used for models with no part systems.

Data in file registers (R5700 to R5731) is not backed up. If it must be backed up, use back-up file registers (R8300 to R9799).

(Note)The maximum delay to compensation is (one user PLC scan + 15ms). However, smoothing time constant and servo follow delay are not contained.

12.15 Tool Life Management (Machining Center System)

12.15.1 Summary

Tool life management function enables uniform quality machining by managing tool life and exchanging tools at proper timing.
This function manages tool life by comparing the time (or the number of cuttings) of each tool which is set before machining and the cumulative cutting hours (or the cumulative number of cuttings).
When a tool has reached the end of its tool life, the signal is output to notify users.

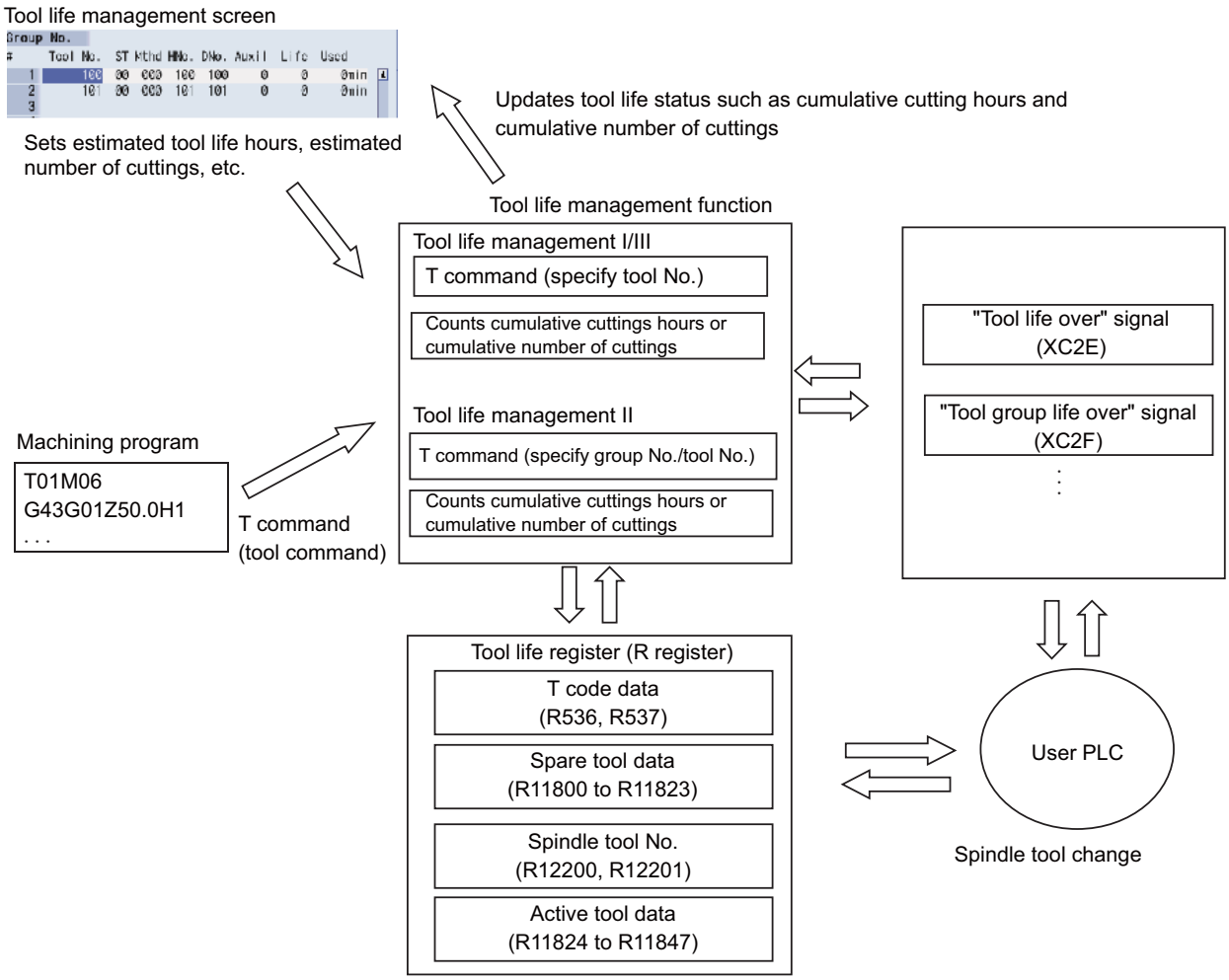
"Cumulative cutting hours" indicates the length of time the tool was engaged in cutting, while "cumulative number of cuttings" indicates the number of times the tool was mounted on the spindle.
You can specify which method to monitor the tool life by setting the lowest one-digit number of "Method" on the tool life management screen.

There are three types of tool life management: I, II and III.
The function which notifies that the tool reaches the end of its tool life is featured in tool life management I and III.
Tool life management II features the following functions, in addition to the said notification function:
- Automatic spare tool selection
- The compensation data management for each tool

The type of the tool life management can be selected by the parameter "#1096 T_Ltype".

The tool life management function is enabled when the following conditions are satisfied.
- The parameter "#1103 TLife" is set to "1" (Validate the tool life management.)
- "Tool life management input" signal (TLF1: YC8B) is ON
- "Usage data count valid" signal (TCEF: YC8A) is ON

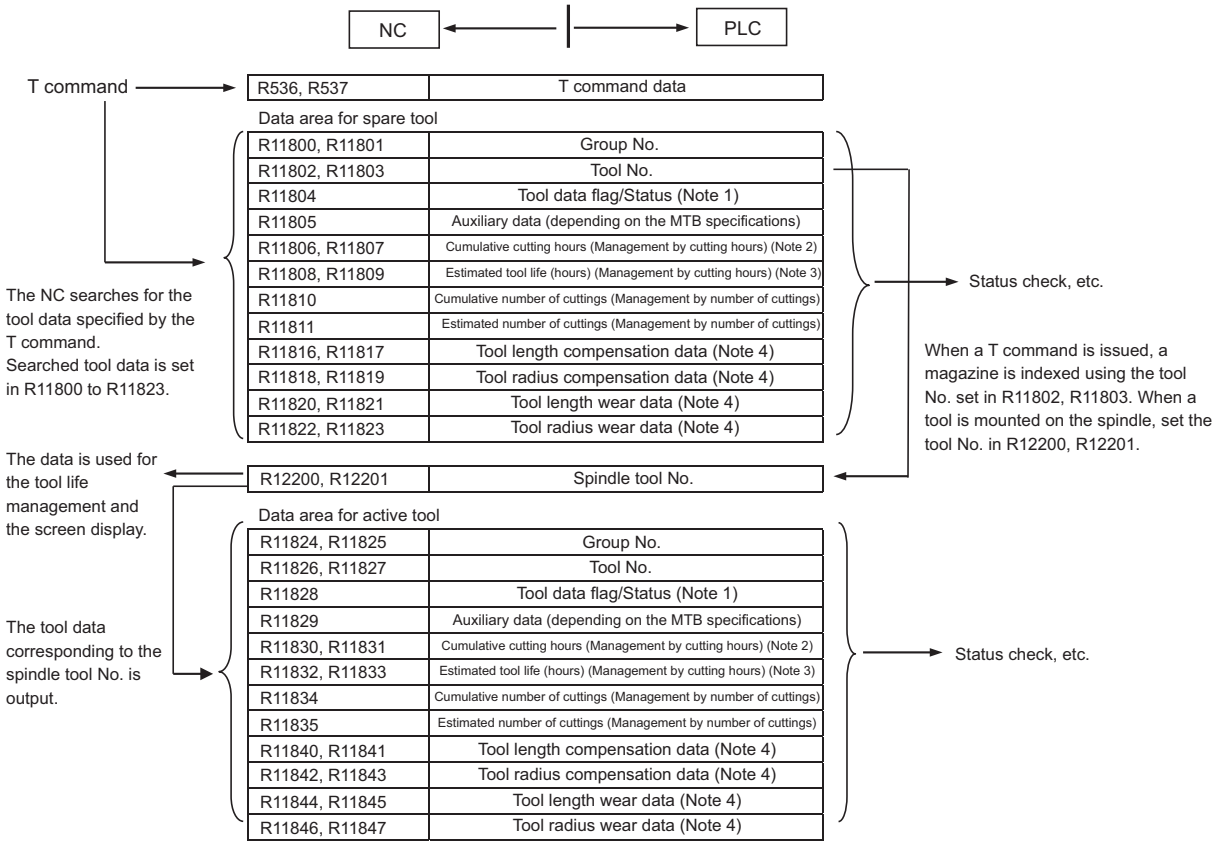
This section describes PLC control of the tool life management function.
Tool life management data can be registered on the tool life management screen. For details, refer to "Instruction Manual".


Tool life management screen
Group No.
Tool No. ST Mthd HNo. DNo. Auxil Life Used
1 100 00 000 100 100 0 0 0min
2 101 00 000 101 101 0 0 0min
3
Sets estimated tool life hours, estimated number of cuttings, etc.
Updates tool life status such as cumulative cutting hours and cumulative number of cuttings
Tool life management function
Tool life management I/III
T command (specify tool No.)
Counts cumulative cuttings hours or cumulative number of cuttings
Tool life management II
T command (specify group No./tool No.)
Counts cumulative cuttings hours or cumulative number of cuttings
Machining program
T01M06
G43G01Z50.0H1
. . .
T command (tool command)
"Tool life over" signal (XC2E)
"Tool group life over" signal (XC2F)
Tool life register (R register)
T code data (R536, R537)
Spare tool data (R11800 to R11823)
Spindle tool No. (R12200, R12201)
Active tool data (R11824 to R11847)
User PLC
Spindle tool change

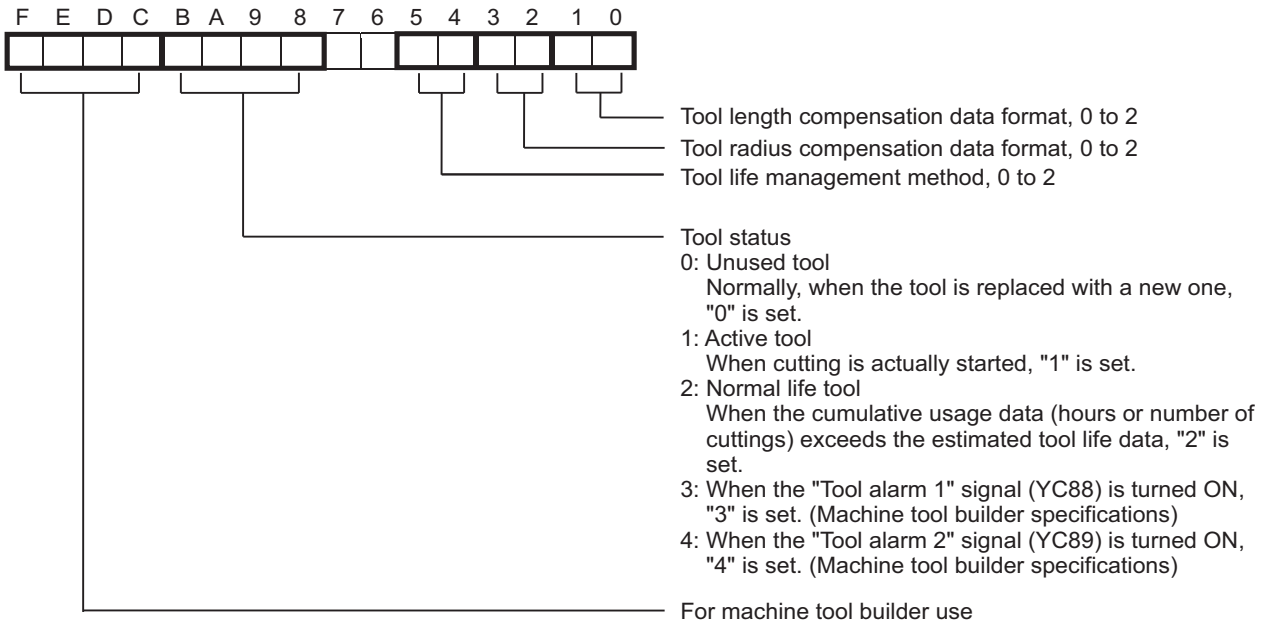
12.15.2 Tool Data Flow (R Register)

Tool life management registers contain the spare tool data (R11800 to R11823) and the active tool data (R11824 to R11847).
The tool data specified by a T command is output to the data area for spare tool.
The tool data corresponding to the spindle tool No. is output to the data area for active tool.

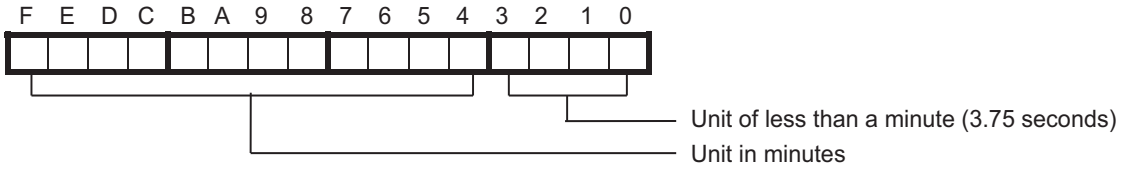
Tool Data Flow (R register)



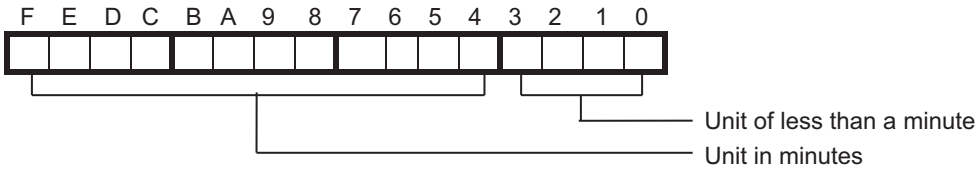
(Note 1) Details of the file registers for the tool data flag/status of the spare tool and that of the active tool are as follows:



(Note 2) Details of the cumulative cutting hours of the spare tool and that of the active tool are as follows:



(Note 3) Details of the estimated tool life (hours) of the spare tool and that of the active tool are as follows:



(Note 4) The following compensation amounts, which are set in "HNo." or "DNo." on the tool life management screen, are set.

Tool compensation type	Tool length compensation	Tool radius compensation	Tool length wear	Tool radius wear
I	Compensation amount in "HNo."	Compensation amount in "DNo."	-	-
II	Tool length in "HNo."	Tool radius in "DNo."	Tool length wear in "HNo."	Tool radius wear in "DNo."
III	Tool length Z in "HNo."	Nose R in "DNo."	Z wear in "HNo."	R wear in "DNo."

12.15.3 Operation when a T Command (Tool Command) is Executed

(1) When a T command is issued, the specified number in the command is handled as a tool No., then T code data (R536, R537) and the "T function strobe" signal (XC68) are output.

(2)

[Tool life management I/III]

The tool data which corresponds to the tool No. in the tool life management data is output to the R register for the spare tool (R11800 to R11823).

- The tool No. is output to the R register for the tool No. of the spare tool (R11802, R11803) as it is.
- The group No. to which the tool is registered is output to the R register for the group No. (R11800, R11801). For the tool life management III, "1" is output.

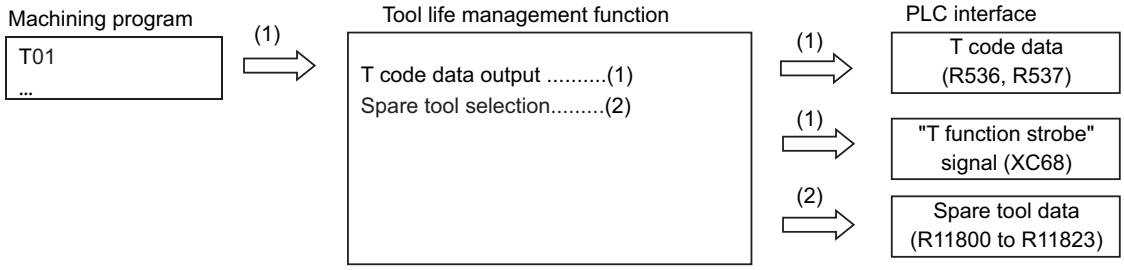
[Tool life management II]

After the T command is checked, the spare tool is selected.

The spare tool corresponding to the T command (a group No./a tool No. to which the same type of the tool is registered) is selected by the spare tool selection function. And then the tool data which corresponds to the spare tool No. in the tool life management data is output to the R register for the spare tool (R11800 to R11823).

- The selected tool No. is output to the R register for the tool No. of the spare tool (R11802, R11803).
- The group No. to which the tool is registered is output to the R register for the group No. (R11800, R11801).

(Note) When there is no tool (or group) specified by the T command, "-1" is set in the R register for the group No. of the spare tool (R11800, R11801). The value specified in the T command is set in the R register for the tool No. (R11802, R11803).

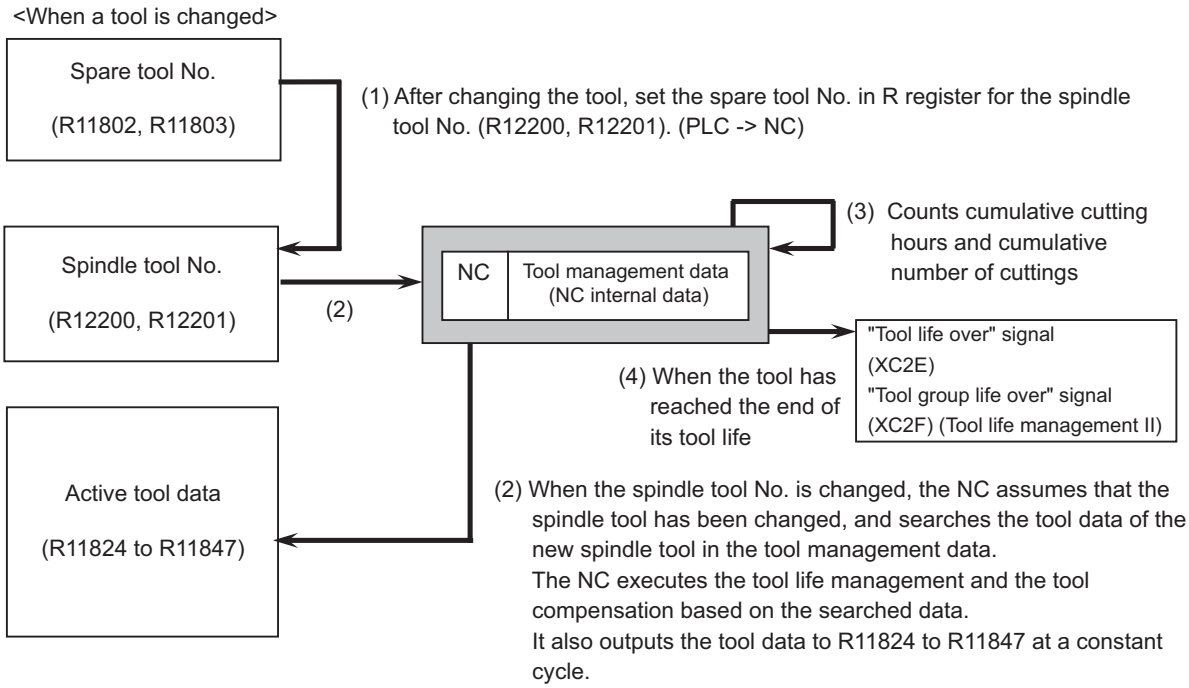


12.15.4 Operation when Spindle Tool is Changed

After a spindle tool is changed, usage of the tool is monitored by cumulating the number of cuttings or the cutting hours. When the spindle tool has reached the end of its tool life, the "Tool life over" signal (XC2E) is output.
For the tool life management II, the setting how and when the cumulative number of mountings or cuttings will be incremented can be set by the parameter "#1277 ext13/bit0". The condition to output "tool group life over (XC2F)" signal will be changed accordingly.

(1) When the spindle tool is changed with the tool change command (e.g. M06), set the spare tool No. (which is set in R11802, R11803) in the R register for tool No. of the spindle tool (R12200, R12201) by the user PLC processing. (For examples of user PLC processing, see "User PLC Processing".)
(2) The tool data corresponding to the tool No. of the spindle tool is output to the R register for the active tool (R11824 to R11847) at constant intervals.
(3) Based on the spindle tool data registered in the tool life management data, the cumulative cutting hours or cumulative number of cuttings for the spindle tool is counted.
(4) When the spindle tool has reached the end of its tool life, the "Tool life over" signal (XC2E) is output. When all the tools in the group have reached the end of their tool lives, the "Tool group life over" signal (XC2F) is output. (Tool life management II)

(Note) When the group No. for active tool which was output to R11824, R11825 is as follows, the tool data is exempt from the tool life management.
- Tool life management I/II: "-1"
- Tool life management III: a value other than "1"
In this case, the tool No. for active tool which was output to R11826-R11827 is the same No. as that specified in R12200, R12201. The NC does not count cumulative cutting hours and cumulative number of cuttings of the spindle tool.



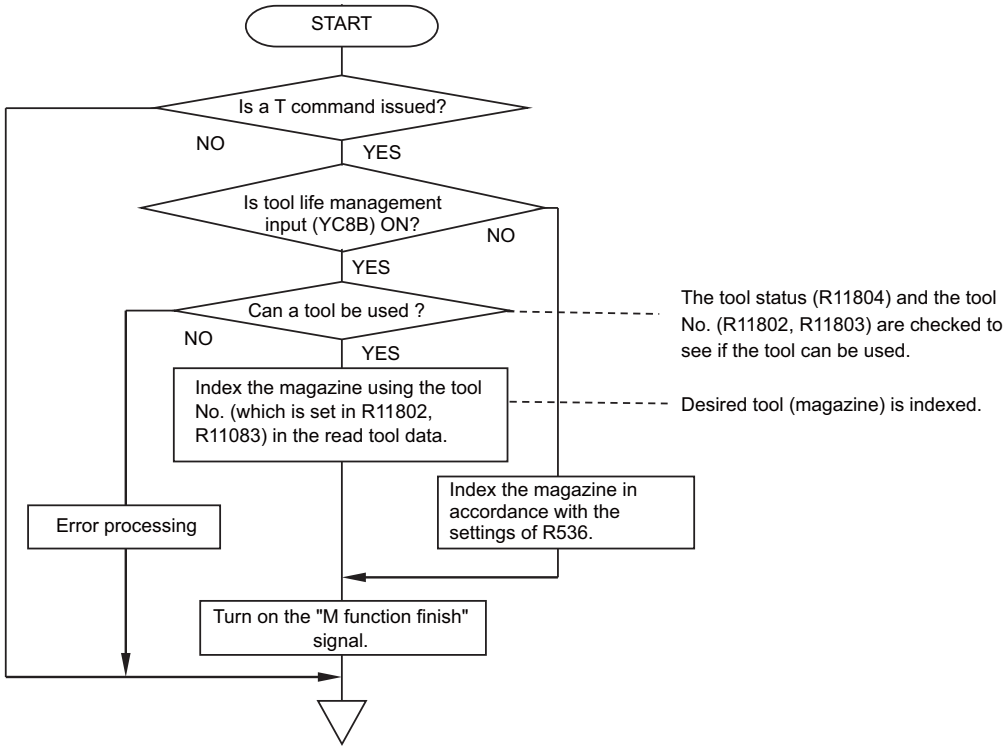
12.15.5 Operation when a Tool has Reached the End of its Tool Life

When the tool exceeds the estimated tool life (hours) or the estimated number of cuttings, the "Tool life over" signal (XC2E) is output.
For the tool life management II, when all the tools in the group have reached the end of their tool lives, the "Tool group life over" signal (XC2F) is output.
When the "Tool life over" signal or the "Tool group life over" signal is output, operations (e.g. automatic operation) do not stop. These signals can be temporarily canceled by the "Temporary cancel of tool life expiration ON" signal (XC2C) or the "Temporary cancel of tool group life expiration ON" signal (XC2D).
For details, refer to "PLC Interface Manual".

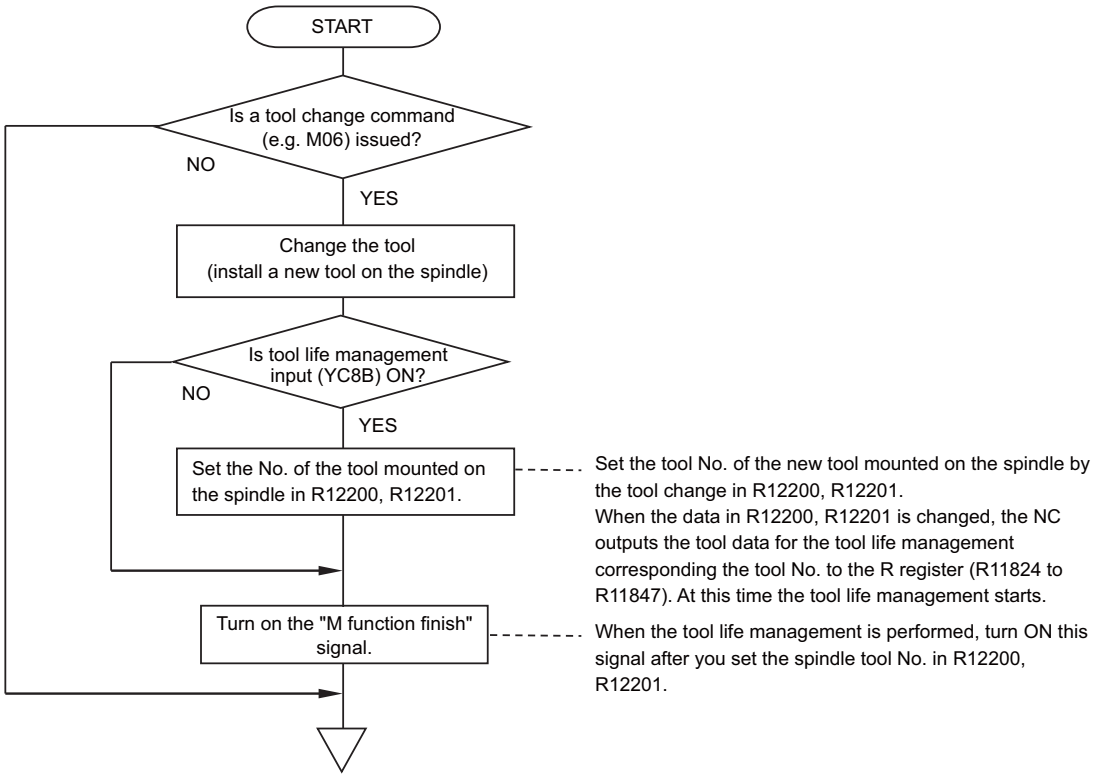
12.15.6 User PLC Processing

The flowcharts below show the examples of PLC processing of the tool change by a T command and by a tool change command (e.g. M06):

(a) Example when a T command is issued



(b) Example when a tool change command is issued



12.16 Tool Life Management (Lathe System)

12.16.1 Summary

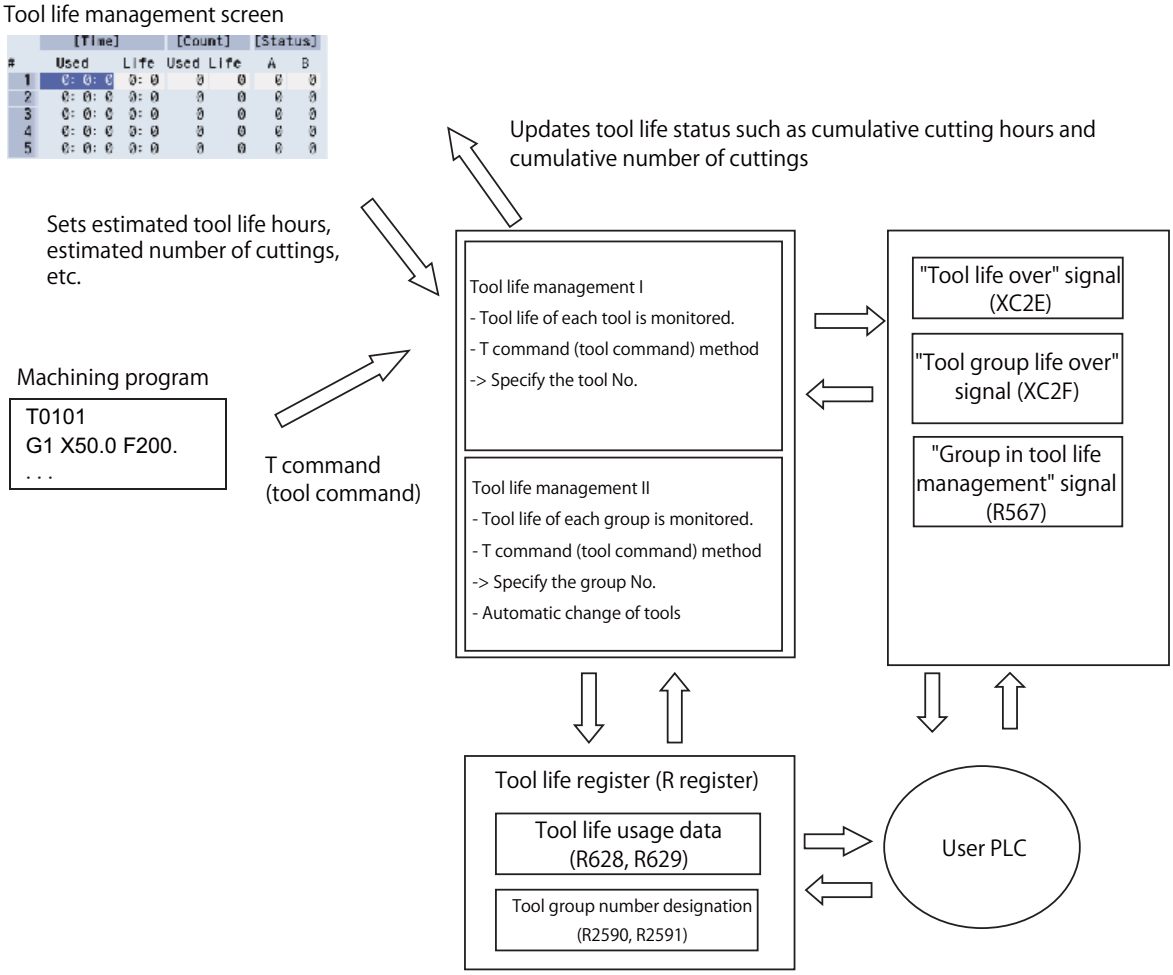
Tool life management function enables uniform quality machining by managing tool life and exchanging tools at proper timing.
This function manages tool life by comparing the time (or the number of cuttings) of each tool which is set before machining and the cumulative cutting hours (or the cumulative number of cuttings).
When a tool has reached the end of its tool life, the signal is output to notify users.

There are two types of tool life management: I and II.
The function which notifies that the tool reaches the end of its tool life is featured in tool life management I.
Tool life management II features the following functions, in addition to the said notification function:
- Automatic spare tool selection
- The compensation data management for each tool

The type of the tool life management can be selected by the parameter "#1096 T_Ltype".

The tool life management function is enabled when the following conditions are satisfied.
- The parameter "#1103 TLife" is set to "1" (Tool life management is enabled.)
- "Usage data count valid" signal (TCEF: YC8A) is ON

This section describes PLC control of the tool life management function.
Tool life management data can be registered on the tool life management screen. For details, refer to "Instruction Manual".



12.16.2 Operation when a Tool has Reached the End of its Tool Life

When the cumulative cutting hours has reached estimated tool life (hours) or when the cumulative number of cuttings has reached estimated number of cuttings, the "Tool life over" signal (XC2E) turns ON by the T command which is issued after the said situation.

For the tool life management I, when the tool which has not reached the end of its tool life yet, the "Tool life over" signal (XC2E) turns OFF.

For the tool life management II, when the status of all the tools, which are registered in the arbitrary group, become "Normal life tool", the "Tool group life over" signal (XC2F) turns ON.

12.17 Change the Area of Stored Stroke Limit I

12.17.1 Explanation of Function

This function allows you to change the area of stored stroke limit I to be the one set in R registers for each axis. Turning ON the "Stored stroke limit I : Change request" (SLMC) signal will change the stored stroke limit area. The area of stored stroke limit I is allowed to be changed during automatic operation. The present setting of stored stroke limit I can be checked using the R registers.

> **⚠ Note**
>
> **Do not generate any collision by the change of the tool entry prohibited range when using this function.**

(1) How to use

(a) Set the parameter "#1278 ext14/bit2" to "1", to enable change of stored stroke limit I area.

(b) Specify the No. of R register to be used for designating the area of stored stroke limit I in the parameter "#2190 OT_Rreg".

(c) Specify the area of stored stroke limit I in the R registers you selected in (b).

(d) Turn ON the "Stored stroke limit I : Change request" (SLMC) signal (YB60 to YB7F). This changes the area of stored stroke limit I for the axis corresponding to the signal.

(e) Changing the area of stored stroke limit I is carried out independently for each axis. If you want to change the settings of two or more axes at a time, turn ON the Stored stroke limit 1 change request signals of the target axes within one cycle of user PLC.

(f) The R registers for checking allows you to confirm that the area change has normally been completed. For the sake of safety, it is advisable to confirm that the change has normally been done before allowing movement.

(2) Setting the range for change of stored stroke limit I area

The area of stored stroke limit I is specified using the R registers in user area. Which R registers to use is specified by the parameter "#2190 OT_Rreg". The value set in this parameter serves as the start number, and eight R registers are used for setting/checking of one axis. If stored stroke limit I is unused, set this parameter to "0". The values to be set in the R registers must follow the PLC unit (#1005).

R register	Item		Description
RA	Soft limit I (Setting)	OT-	OT-set (L)
RA+1			OT-set (H)
RA+2		OT+	OT+set (L)
RA+3			OT+set (H)
RA+4	Soft limit I (Check)	OT-	OT-check (L)
RA+5			OT-check (H)
RA+6		OT+	OT+check (L)
RA+7			OT+check (H)

(Note) RA is set by the parameter "#2190 OT_Rreg" individually for each axis. Make sure that there is no overlap among the R registers you use.

(3) Available R registers

Listed below are the R registers that can be used to set the area of stored stroke limit I.
Choose an R register from which eight consecutive R registers are available.

User area	R8300 to R9799	1500 points of back up area
	R9800 to R9899	100 points of non-back up area
	R18300 to R19799	1500 points of back up area
	R19800 to R19899	100 points of non-back up area
	R28300 to R29799	1500 points of back up area
	R29800 to R29899	100 points of non-back up area

(Note that the No. of start R register must be an even number.)

Setting example) When you use non-backup areas for two axes (X and Z) of each of the 1st and 2nd part systems

Parameter	X1	Z1	X2	Z2
#2910 OT_Rreg	9800	9808	19800	19808

Item	X1	Z1	X2	Z2
OT-set	R9800/R9801	R9808/R9809	R19800/R19801	R19808/R19809
OT+set	R9802/R9803	R9810/R9811	R19802/R19803	R19810/R19811
OT-check	R9804/R9805	R9812/R9813	R19804/R19805	R19812/R19813
OT+check	R9806/R9807	R9814/R9815	R19806/R19807	R19814/R19815

(4) Available setting range

When setting the R register values, make sure to follow the PLC unit specified by #1005. The available setting ranges are as listed below.

PLC unit (#1005)	Available setting range (mm)	Available setting range (R register value)
B	-99999.999 to 99999.999	0xFA0A1F01 to 0x05F5E0FF
C	-99999.9999 to 99999.9999	0xC4653601 to 0x3B9AC9FF
D	-21474.83648 to 21474.83647	0x80000000 to 0x7FFFFFFF
E	-2147.483648 to 2147.483647	0x80000000 to 0x7FFFFFFF

(5) Execution of change

When the "Stored stroke limit I : Change request" (SLMC) signal (YB60) is turned ON, the stored stroke limit area you specified in R registers becomes active. Change of the stored stroke limit I area is conducted only at the rising edge of the "Stored stroke limit I : Change request" (SLMC) signal (YB60). Thus make sure to specify the area of stored stroke limit I in R registers before turning ON the "Stored stroke limit I : Change request" (SLMC) signal (YB60).

(6) Operation at power ON

After power ON, the settings of the parameters "#2013 OT-" and "#2014 OT+" take effect until the "Stored stroke limit I : Change request" (SLMC) signal (YB60) is turned ON. If you want to use the same area as that applied during power OFF when the power is turned ON, enable this operation through user PLC (make a backup at a change, and set it at power ON).

12.17.2 Usage Example

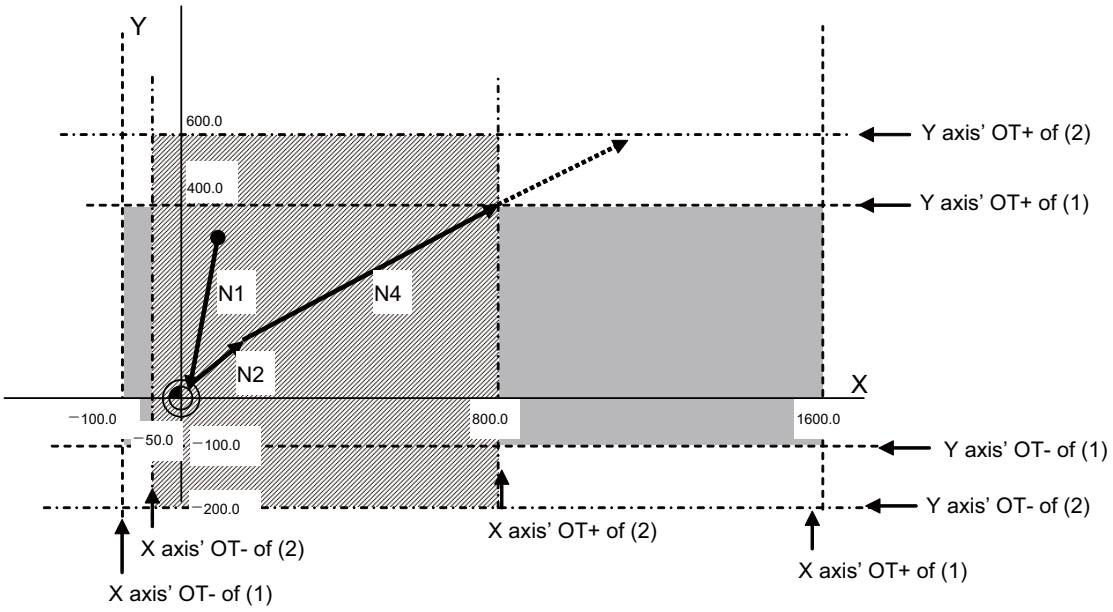
Illustrated below is an operation example when you change the area of stored stroke limit I for X and Y axes using the stored stroke limit I area change at a T command.
(To present the relation with the set values in an easy-to-understand manner, both X and Y axes are handled as radius designation axes in this example.)

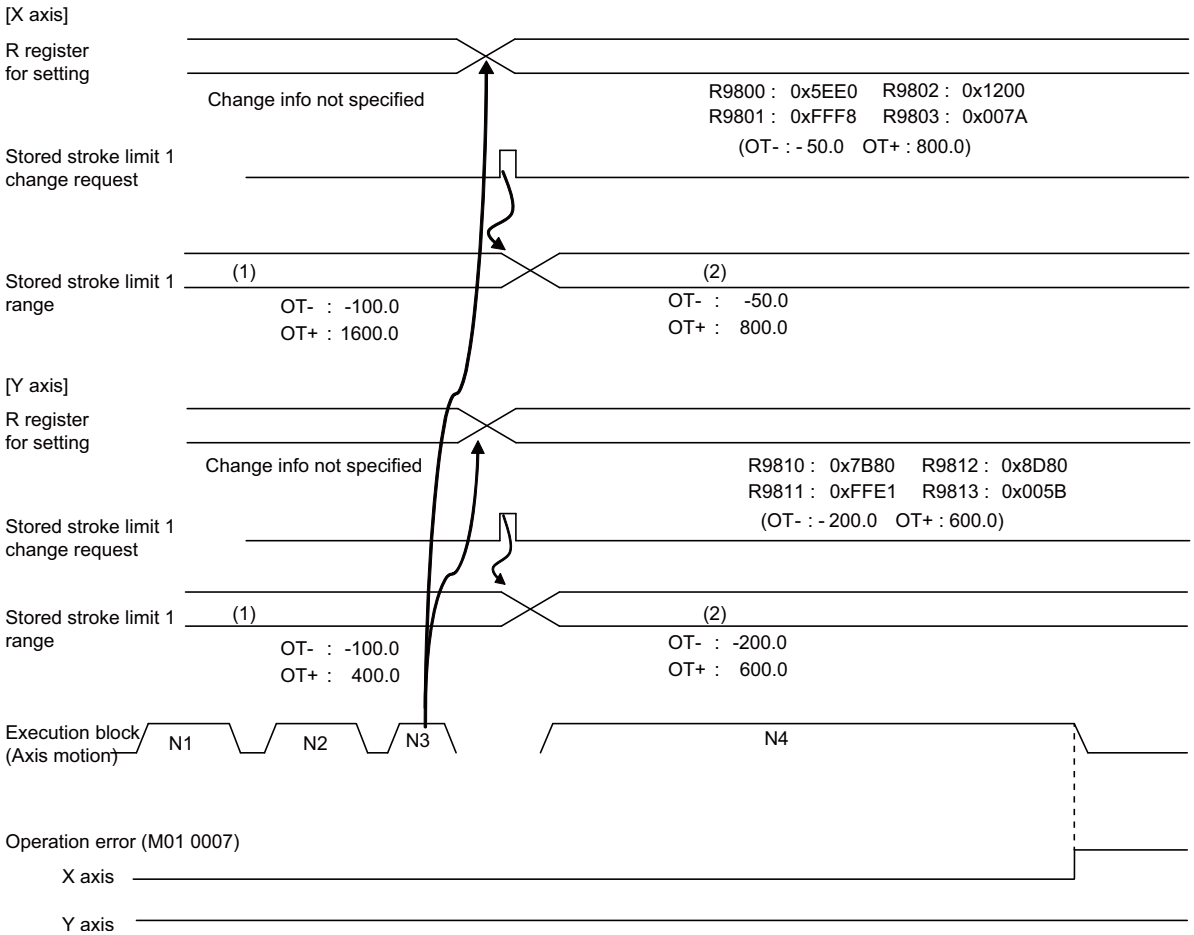
[Parameter settings]

#1005(plcunit)	: C
#1278(ext14)bit2	: ON
#2190(OT_rrag)	: Xaxis_9800
	Yaxis_9810
#2013(OT-)	: -100.0(X), -100.0(Y)
#2014(OT+)	: +1600.0(X), 400.0(Y)

[Machining program]

```
N1 G90 G28 XY
N2 G00 X100.0  Y100.0
N3 T1010
N4 G01 X1000. Y500.
N5 G01 X200.
```





(1) The range specified by parameters takes effect until the "Stored stroke limit I : Change request" signal (SLMC) is turned ON.

(2) After the "Stored stroke limit I : Change request" signal (SLMC) is turned ON, the soft limit 1 range is changed.

In this example, the stored stroke limit + of X axis changes to 800.0, and the operation error (M01 0007) occurs before this limit.

12.17.3 Cautions

(1) For an axis whose parameter "#2190 OT_Rreg" is set to "0", or an axis whose prohibition area includes any R register outside the user area, the stored stroke limit I area coincides with the settings of the parameters "#2013 OT-" and "#2014 OT+". Changing the area of stored stroke limit I is disabled for these axes.

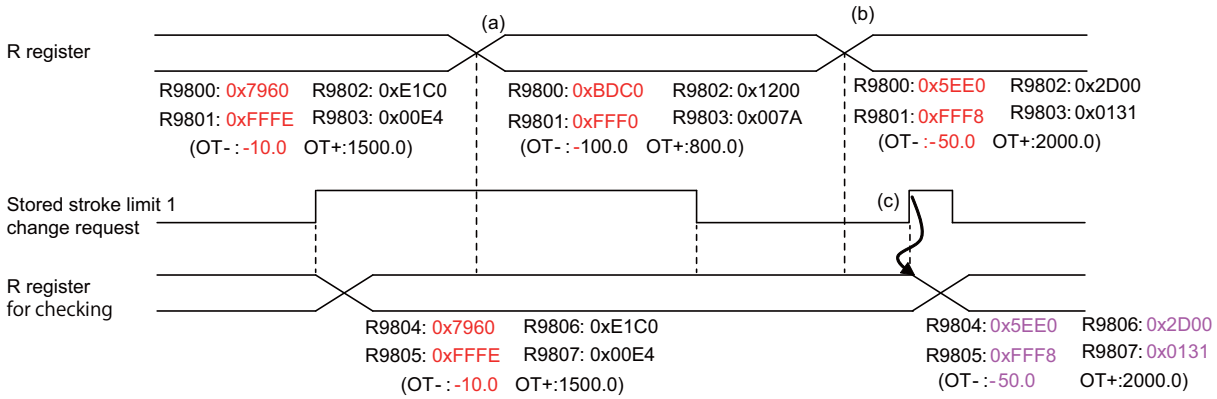
(2) If the area of stored stroke limit I is changed, the settings of the parameters "#2013 OT-" and "#2014 OT+" are unchanged.

(3) If you change the area of stored stroke limit I and this causes the present position to be included in the prohibition area, it is not until axis movement starts that the operation error (M01 0007) occurs. After occurrence of this error (M01 0007), it is still possible to move the tool manually in a direction opposite to the prohibition area (direction of pulling out the tool).

(4) Even when changing the area of stored stroke limit I is enabled, this change will not affect the operation of the other stored stroke limit function (IB, IC, II or IIB) or barrier function (chuck or tailstock barrier). The narrower movable range is applied to operation.

(5) After changing the area of stored stroke limit I, you need to turn OFF and ON the power. Otherwise you are unable to set the changed area back to the parameters. If needed, enable the same values as the parameter settings to be set in the R registers.

(6) If you change the values of R registers in which the range of stored stroke limit I has been set, with the "Stored stroke limit I : Change request" (SLMC) signal (YB60) ON, the area of stored stroke limit I is unchanged. Only at the rising edge of the "Stored stroke limit I : Change request" (SLMC) signal (YB60), the area of stored stroke limit I is changed.



(a) Change the setting values of R registers. (Area of Soft limit I is not yet changed in this state.)

(b) Change the setting values of R registers. (Area of Soft limit I is not yet changed in this state.)

(c) Area of Stored stroke limit I is changed at the rising edge of "Stored stroke limit I : Change request" signal (SLMC).

(7) If you attempt a change of stored stroke limit I area while an identical value (other than zero) is set in OT- and OT+ (R register settings), stored stroke limit I will be disabled. In this case, the minimum of the R register setting is output to OT- of the R register for checking, and the maximum of the R register setting is output to OT+.

(8) If the stored stroke limit you have set is exceeding the range of the R registers for checking, the values to be set in these R registers are clamped at the setting limit.

(9) To the R registers for checking, the setting range of stored stroke limit I is output. The setting values of other function such as stored stroke limit II are not output to these R registers.

(10) For an axis specified as a diameter designation axis, also use a radius value when setting the R registers.

(11) You are unable to cancel the operation error (M01 0007) by widening the area of stored stroke limit I. Thus cancel the error first, and then move the axis.

12.18 Interference Check III

12.18.1 Outline

Interference check III is designed to prevent interference between interfering objects by checking the relative relation of the interfering objects.
One interfering object can be defined with 1 to 16 solids.
You are able to define up to 128 interfering objects and up to 256 solids.

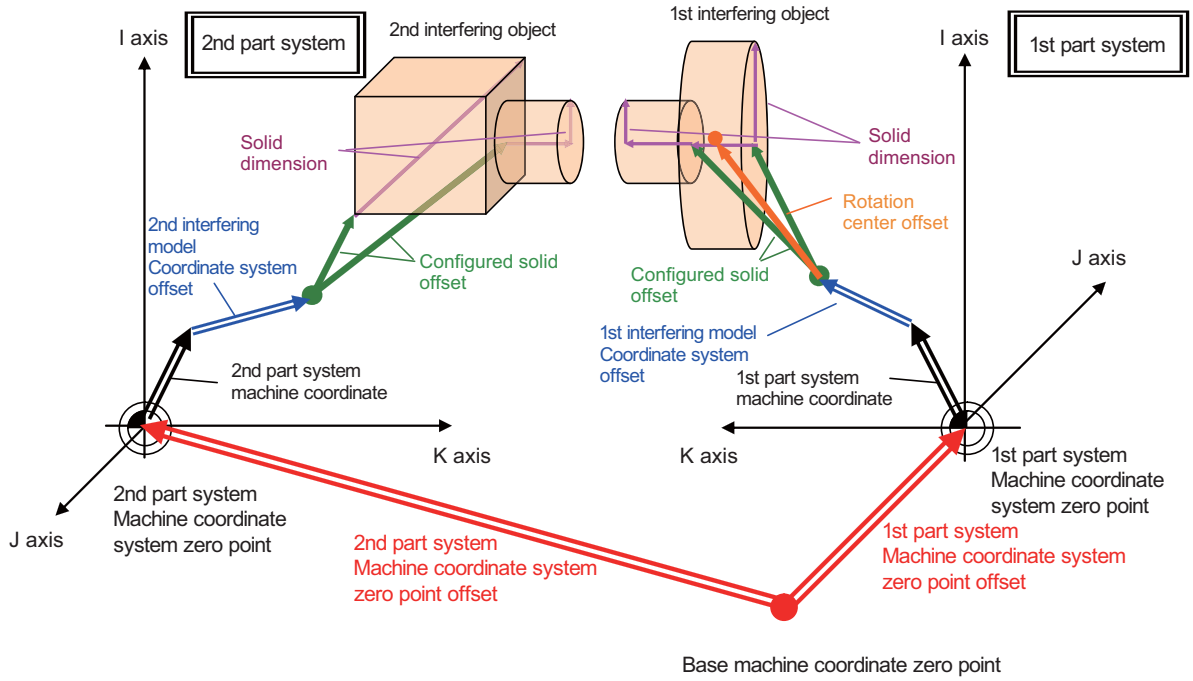
Solid / Interfering object	Number of pieces
The number of solid definitions	256
The number of interfering object definitions	128
The number of solids that can be used in one interfering object	16

For the interference check, you are able to select up to 16 out of 128 interfering objects. The number of solids that can be used within the selected interfering object is 42 pieces.

Solid/interfering object to perform interference check	Number of pieces
The number of interfering objects for which interference check can be performed	16
The number of solids which can be used in interfering objects to perform interference check	42

Select 16 interfering objects to perform the interference check with R register or system variables.
After you select an interfering object to use, enable the interfering selection using "Interference check III: Enable interfering object selection data" signal (Y769) or the enable interference check III setting data command (G186).
After the interfering object selection is enabled, turn ON the "Interference check III: Interference check III mode" signal (Y76A) to start the interference check.

For the solids, two kinds of shapes, cuboids and cylinders, can be defined.
It is also possible to define the rotated solid for one of the I J K axes of the solid.
For the interfering object, up to 2 axes can be defined as rotary axes.
You are able to define more than one interfering object with one-rotary axis, and one interfering object with two-rotary axis within 16 interfering objects to perform the interference check.
You are not able to define the interfering object with one-rotary axis and interfering object with two-rotary axis at the same time.
2 kinds of areas can be defined for an interference area defined as the interfering object: an area where interference must be avoided surely (interference alarm area) and an area where interference should be mitigated (interference warning area).



Term	Details
Solid	An object which forms the interfering object. You can select a cuboid and cylinder for the shape. Up to 256 solids can be defined in the entire system.
Interfering object	An object comprised of 1 to 16 solids. Up to 128 objects can be defined in the entire system. You can perform the interference check by selecting 16 out of 128 objects.
Solid definition	Defines the shape and dimension of the solid. You can make the setting by entering a solid and interfering object definition file (OBSTACLE.DAT).
Interfering object definition	Defines an interfering object comprised of the combination of 1 to 16 solids. You can make the setting by entering the solid and interfering object definition file (OBSTACLE.DAT).
Solid and Interfering object definition file	A data file in which solid definition and interfering object definition are incorporated. The file name is "OBSTACLE.DAT".
Interfering object selection	Selects 16 interfering objects to perform interference check out of 128 interfering objects. You can make the setting with R register or system variables.
Interfering object data	A generic term in which the solid and interfering object definition file and interfering object selection are joined together.
Interfering model coordinate	A coordinate system to be used in defining and selecting the interfering objects. Interference check is performed in a machine coordinate system.

With this function, the interference check is performed in the orthogonal coordinate system.
Even when the inclined axis control is used, the interference check is performed in the orthogonal coordinate system.
Thus, if you set an axis which is not parallel with I/J/K axis of the basic machine coordinate system as an interfering object control axis, you are not able to check the interference correctly.

12.18.2 Instructions for Use

Follow the procedure below to perform the interference check.

(1) Set "1" in the base Common Parameter (#1488 ITF3 valid).

(2) Create the solid and interfering object definition file (OBSTACLE.DAT).
With the solid and interfering object definition file (OBSTACLE.DAT), up to 256 solids and up to 128 interfering objects are defined.

(3) Enter the solid and interfering object definition file (OBSTACLE.DAT).
Enter the file from the input/output screen of HMI.

(4) Specify the interfering object selection. (R register or system variables)
In the interfering selection, you select 16 interfering objects to perform the interference check out of 128 interfering objects which are defined with the solid and interfering object definition file. (OBSTACLE.DAT)
You can use up to 42 solids in the 16 interfering objects.

(5) Enable the interfering object selection with the enable interference check III setting data command (G186) or the "Interference check III: Enable interfering object selection data" signal (Y769).
At the timing when these are enabled, the consistency check between the interfering object definition and interfering object selection is performed.
When no mistake is found in the setting, the "Interference check III: Interfering object selection data setting completed" signal (X771) is turned ON.
When a mistake is found in the setting, an operation error that corresponds to the mistake is output, and the setting error information is output to R142 to R149.

(6) Turn ON the "Interference check III: Interference check III mode" signal (Y76A) to start the interference check.
While the "Interference check III: Interference check III mode" signal (Y76A) is ON, the interference check is performed.

12.18.3 Interference Alarm Area and Interference Warning Area

Set an area where interference must be avoided surely (interference alarm area), and an area where interference should be mitigated (interference warning area) for each solid.
(Set the areas in the configured solid specification of interfering object definition and interfering object specification of interfering object selection, which are described later.)

Situation when the interference alarm occurred		Operation error No.	Register where the setting alarm information is output
(1)	The entry of an interfering object into the interference alarm area is detected while the interference check III mode is enabled, the axis will stop just before the entry.	(M03 0001) (*1) (*2) (*3) (*5)	R139, R672 ,R673
(2)	An interfering object has already entered the interference alarm area when the interference check III mode is enabled.	(M03 2002) (*1) (*2)	R140, R674, R675
(3)	An interfering object, which is enabled by the "Interference check III: Enable interfering object selection data" signal (Y769), has already entered the interference alarm area while the interference check III mode is valid.		
(4)	An interfering object, which is enabled by the enable interference check III setting data command (G186), has already entered the interference alarm area while the interference check III is valid.		
(5)	An object enters the interference warning area while the interference check III mode is enabled. (*4)	(M03 2003) (*1) (*2)	R138, R670, R671
(6)	An interfering object has already entered the interference warning area when the interference check III mode is enabled.		

(*1) This alarm is output to the part systems which control the axes set in the interfering object definition "interfering object IJK control axes" and "IJK rotary axes".

(*2) For all axes which belong to the part systems in which this alarm is output, the axis exchange cannot be performed.
If the mixed control command (G110) is given, the operation error (M01 1035) is output, and if the arbitrary axis exchange command (G140) is given, the operation error (M01 1101) is output.

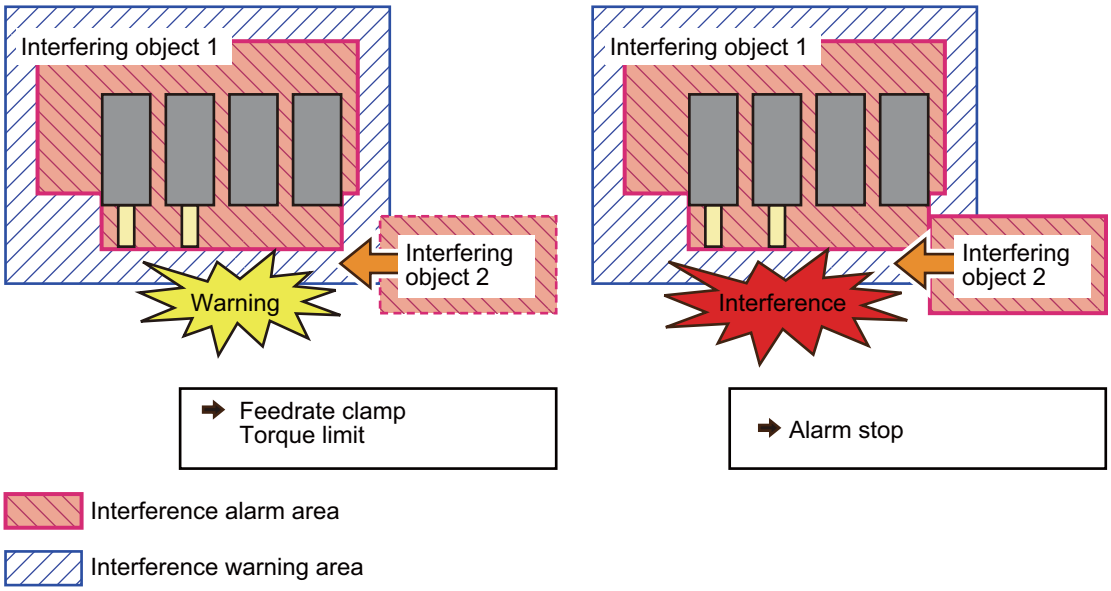
(*3) The relative relation between interfering objects is being checked during the occurrence of this alarm as well. If the axis travel command (manual operation/automatic operation) is given during the occurrence of this alarm, the alarm is canceled and the axis moves unless the entry to the interference alarm area is detected.

(*4) In the case an interfering object enters the interference warning area while the interference check III mode is enabled, the feedrate is automatically clamped and the torque is limited to mitigate an impact of the clash. These actions taken when the interfering object enters the interference warning area are specified using the following parameters.

The action when the interfering object enters the interference warning area	Parameter setting
The torque is limited or not.	Axis specification parameter "#2661 ITF3_ILMT"
Whether the feedrate is automatically clamped for all the axes in all the part systems or only for the part system related to the interference warning.	Basic common parameter "#1487 ITF3_ Spec"
Feedrate clamp (For an axis in which the setting value of feedrate clamp parameter is "0", speed clamp is not performed.)	Axis specification parameter "#2662 ITF3_Clamp"

(*5) While the operation error (M03 0001) is being generated, data for interfering object selection cannot be modified.

<Operation example>



12.18.4 Interfering object selection

Select 16 interfering objects to use in the interference check III with system variables or R register.
When selecting an interfering object, specify the specification of the selected interfering object and interfering model coordinate system offset 1.
The write command to the system variables (#40000 to #40097) is only possible in the machine tool builder macro programs (O100010000 to O199999998).

When selecting an interfering object, specify the specification of the selected interfering object and interfering model coordinate system offset 1.

System variable	R register	Item	Details	Setting range (unit) Upper: System variable Lower: R register
#40000	R20304	Interfering object enable/ disable designation	Set enable/disable for each interfering object. Bit designation (0: enable 1: disable) bit0: Disable 1st interfering object : bitF: Disable 16th interfering object	0 to 65535 (decimal) 0x0000 to 0xFFFF (hexadecimal)
#40001	R20305	Spare		0 0
#40002	R20306	1st interfering object selection	Select interfering object definition No. to use.	0 to 128 (0: not selected) 0 to 128 (0: not selected)
#40003	R20307	1st interfering object specification	In the configured solid specification of the interfering object definition, specify alarm area/warning area/ solid setting invalid of the solid in which switching method is selected. 0, 1: Alarm area 2: Warning area 3: Solid setting invalid	0 to 3 0 to 3
#40004	R20308 (L) R20309 (H)	1st interfering model coordinate system I axis offset 1	Set the interfering model coordinate system offset with a radius value. (I axis direction) (*1)	-99999.999 to 99999.999 (mm) (radius value)
#40005	R20310 (L) R20311 (H)	1st interfering model coordinate system J axis offset 1	Set the interfering model coordinate system offset with a radius value. (J axis direction) (*1)	-99999999 to 99999999 (μm) (radius value)
#40006	R20312 (L) R20313 (H)	1st interfering model coordinate system K axis offset 1	Set the interfering model coordinate system offset with a radius value. (K axis direction) (*1)	
:	:			
#40077	R20426	16th interfering object selection	Same as above	Same as above
#40078	R20427	16th interfering object specification selection	Same as above	Same as above
#40079	R20428 (L) R20429 (H)	16th interfering model coordinate system I axis offset 1	Same as above	Same as above
#40080	R20430 (L) R20431 (H)	16th interfering model coordinate system J axis offset 1	Same as above	Same as above
#40081	R20432 (L) R20433 (H)	16th interfering model coordinate system K axis offset 1	Same as above	Same as above

System variable	R register	Item	Details	Setting range (unit) Upper: System variable Lower: R register
#40082	R20434	1st interfering object Interference check III: Specifying disabled interference object	Select an interfering object that you do not check the interference with the 1st interfering object. bit0: Disable 1st interfering object (inaction data) bit1: Disable 2nd interfering object : bitF: Disable 16th interfering object	0 to 65535 (decimal) 0x0000 to 0xFFFF (hexadecimal)
#40083	R20435	2nd interfering object Interference check III: Specifying disabled interference object	Select an interfering object that you do not check the interference with the 2nd interfering object. bit0: Disable 1st interfering object bit1: Disable 2nd interfering object (inaction data) : bitF: Disable 16th interfering object	0 to 65535 (decimal) 0x0000 to 0xFFFF (hexadecimal)
:	:			
#40097	R20449	16th interfering object Interference check III: Specifying disabled interference object	Select an interfering object that you do not check the interference with the 16th interfering object. bit0: Disable 1st interfering object bit1: Disable 2nd interfering object : bitF: Disable 16th interfering object (inaction data)	0 to 65535 (decimal) 0x0000 to 0xFFFF (hexadecimal)

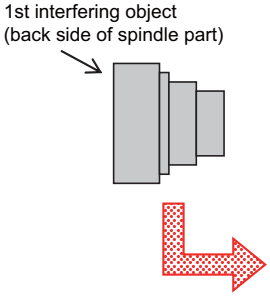
(*1) The interference model coordinate system offset is the sum of the interference model coordinate system offsets 1 and 2.

<Interference check III: designation of disabled interference object>

(Example) In the case that you do not check the interference between 1st interfering object and 2nd interfering object "R20434 (#40082): 0x0002(disable 2nd interfering object)" or "R20435 (#40083): 0x0001(disable 1st interfering object)"

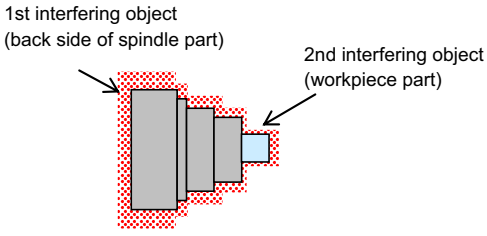
Since each interfering object is designated to perform the interference check, the setting of the interference check III: specifying disabled interference object is repeated, but if either one is disabled setting, the interference check is not performed.

[Back side of spindle part (without a workpiece)]



[Back side of spindle part(with a workpiece)]

R register	Setting value	
R20434	0x0002	Interference between 1st and 2nd interfering objects disabled.



By specifying the interference III disabled between the back side of spindle part (1st interfering object) and work piece part(2nd interfering object), these 2 parts are treated as one interfering object.

12.18.5 Interfering Object Data Enable Command (Y769, X771) and Mode Valid Command (Y76A, X772)

Interfering Object Data Enable Command

The interfering object selection made by system variables or R register is enabled with G code or PLC device.
For the details on G codes, refer to the programming manual.

(1) Command with G code
By giving the enable interference check III setting data command (G186), the interfering object selection is enabled.

(2) Command with PLC device
By turning ON the "Interference check III: Enable interfering object selection data" signal (Y769), the interfering object selection is enabled.
Once the interfering object selection is enabled, the "Interference check III: Interfering object selection data setting completed" signal (X771) is turned ON.
After you confirm that the "Interference check III: Interfering object selection data setting completed" signal (X771) is turned ON, turn OFF the "Interference check III: Enable interfering object selection data" signal (Y769).
The "Interference check III: Interfering object selection data setting completed" signal (X771) will be turned OFF together with the "Interference check III: Enable interfering object selection data" signal (Y769).

[Consistency check between interfering object definition and interfering object selection]
When turning ON the enable interference check III setting data command (G186) or the interference check III: Enable interfering object selection data (Y769), the consistency check between interfering object definition and interfering object selection is performed.

Consistency check (interfering object definition)		Operation error No.	Register where the setting error information is output
(1)	In the interfering object definition, if you set a non-existent axis (an axis which is not set by the base axis specification parameter (#1022 axname2)) for IJK control axes, or you set IJK axes which do not belong to the same part system.	（M03 2001）	R142 - R149
(2)	In the interfering object definition, if you set the rotation angle of 2 or more axes for the configured solid definition No. of a cylinder.	（M03 2002）	R142 - R149
(3)	In the interfering object definition, if you set the rotation angle of 2 or more axes for configured solid definition No. of a cuboid.	（M03 2003）	R142 - R149
(4)	In the interfering object definition, if you set a non-existent axis (an axis which is not set by the base axis specification parameter (#1022 axname2)) for I/J/K rotary control axes, or you set a linear axis.	（M03 2004）	R142 - R149
(5)	In the interfering object definition, if you specify a configured solid which cannot be set as the interfering object in which 2 rotary axes are set.	（M03 2005）	R142 - R149
(6)	In the interfering object definition, if you specify a configured solid which cannot be set as the interfering object in which 1 rotary axis is set.	（M03 2006）	R142 - R149

Consistency check (interfering object selection)		Operation error No.	Register where the setting error information is output
(1)	In the interfering object selection, if the total of the number of configured solids of selected interfering object exceed 42.	（M03 1002）	-
(2)	In the interfering object selection, if the interfering model coordinate system offset 1 exceeds the setting range.	（M03 3001）	R141
(3)	In the interfering object selection, if you select a one-rotary-axis object and two-rotary-axis object at a time or , you select two or more two-rotary axis objects.	（M03 3002）	R141

In the case that the alarms occur due to the consistency check, all axes in all part system will stop.
You are able to cancel the alarm by redefining the interfering object data (after correcting the interfering object data, perform the "Interference check III: Enable interfering object selection data" signal (Y769) or the enable interference check III setting data command (G186)), or resetting all part systems (except for sub part system 2).
You are not able to perform the automatic operation and manual operation until you reset all part systems (except for subpart system 2).
In the case the alarm occurs due to the consistency check, the interfering data will not be updated. For the interference check between interfering objects, the interfering data enabled last time is continuously used.

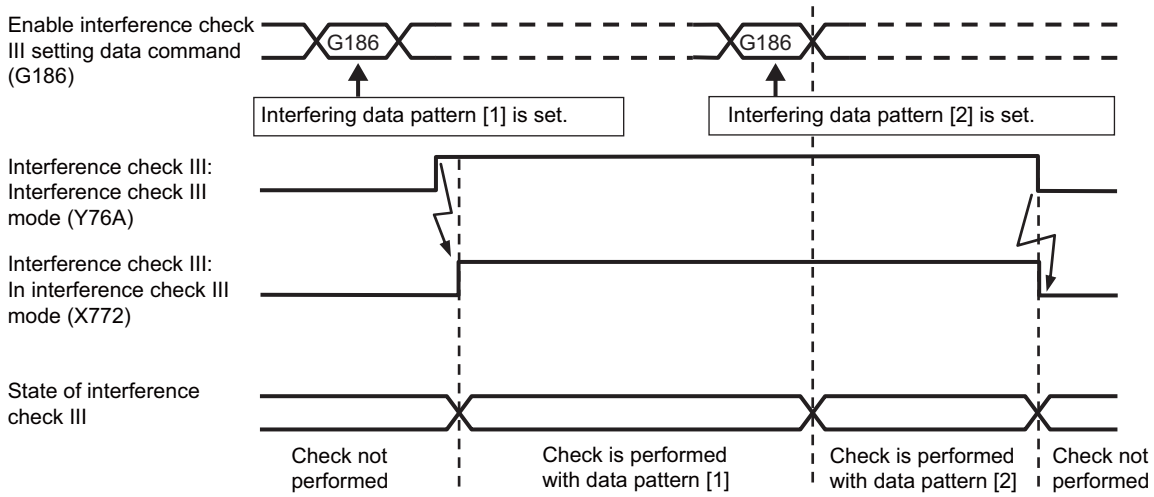
Mode Enable Command

While the "Interference check III: Interference check III mode" signal (Y76A) is ON after the "Interference check III: Enable interfering object selection data" signal (Y769) or the enable interference check III setting data command (G186) is executed, the interference check between interfering objects is performed. While the interference check III is being executed, the "Interference check III: In interference check III mode" signal (X772) is turned ON.
After NC power is turned ON, if the interference check III mode is turned ON without executing the "Interference check III: Enable interfering object selection data" signal (Y769) or the enable interference check III setting data command (G186) even once, the operation error (M03 1001) occurs.

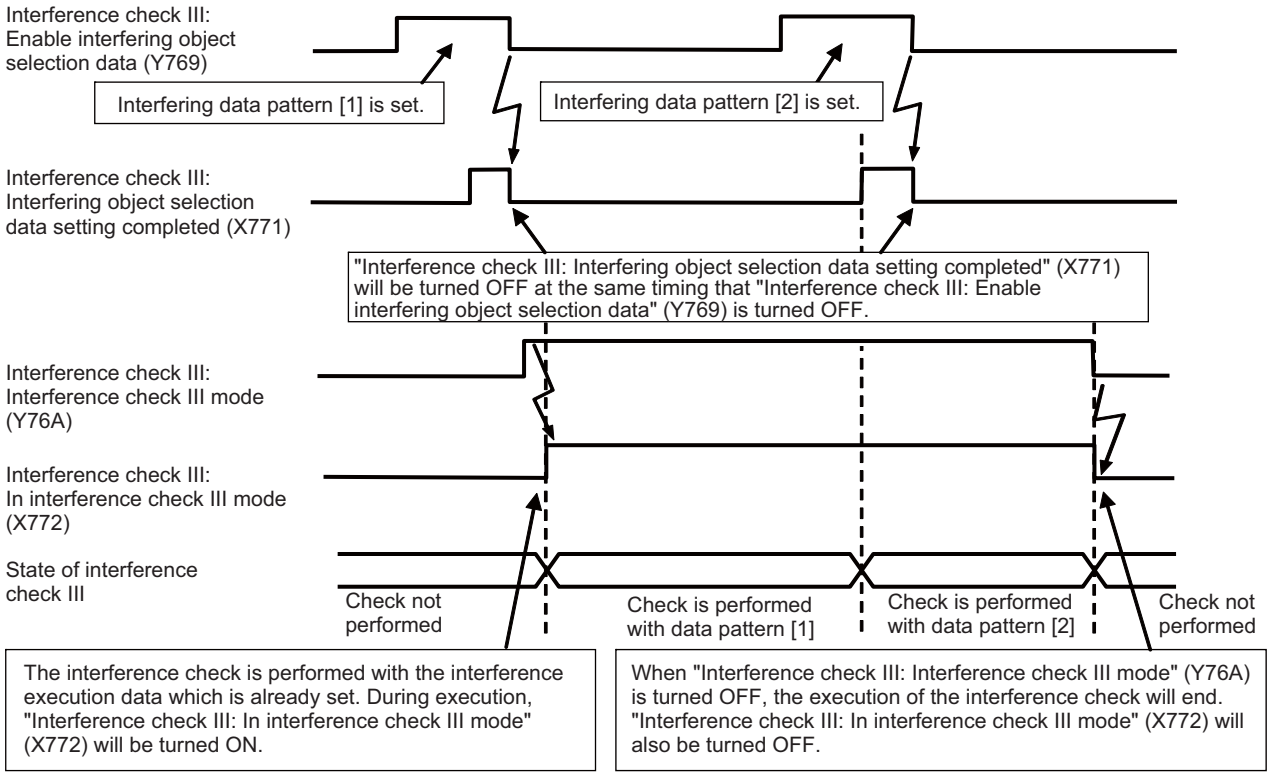
Timing Chart

The timing when the interfering object data and interference check III mode are enabled is described below.

[In the case interfering object data is enabled with G code]



[In the case interfering object is enabled with PLC device]



If you turn OFF and ON the "Interference check III: mode" signal, the interfering data you set lastly is used for the interference check between interfering objects.

12.18.6 Relation with other Functions

(1) High-speed Simple Program Check
Even though machine lock is applied to all axes during the high-speed simple program check, the check is performed.
During the high-speed simple program check, the operation error (M03 1001) may occur at a position different from actual operation.

(2) Automatic Machine Lock
During the automatic machine lock, the check is not performed.

(3) Manual Machine Lock
During the manual machine lock, the check is not performed.

(4) Program Restart
During the program restart search, the check is not performed.
After the program restart search, the check is performed.

(5) Graphic Check
During the graphic check, the check is not performed.

(6) 3D Interference Check
The 3D machine interference check cannot be used with the interference check III.

(7) Manual Arbitrary Reverse Run
A program cannot be run backward prior to the enable interference check III setting data command (G186).

(8) Arbitrary Reverse Run
If the enable interference check III setting data command (G186) is run backward, the interference data at the reverse run is enabled, instead of returning to the interference data at forward run.

(9) Inclined Axis Control
During the inclined axis control, the check is performed in orthogonal coordinate system instead of the basic machine coordinate system.

(10) Direct Command Mode
If the "Interference check III: mode" signal (Y76A) is turned ON during the direct command mode (G5 P4), the operation error (M01 0157) occurs.
If the direct command mode (G5 P4) is commanded during the "Interference check III: mode" signal (Y76A), the operation error (M01 0157) occurs.

(11) Torque Limitation Skip
Even during the torque limitation stop, the check is performed.
When performing the torque limitation skip, turn OFF the "Interference check III: mode" signal (Y76A) or disable the interference between interfering objects applied by the interfering object selection "nth interfering object interference check III: specifying disabled interfering object (R20434 to R20449 or #40082 to #40097)".

(12) Constant Torque Control
Even during the constant torque control, the check is performed.
When performing the constant torque control, turn OFF the "Interference check III: mode" signal (Y76A) or disable the interference between interfering objects applied by the interfering object selection "nth interfering object interference check III: specifying disabled interfering object (R20434 to R20449 or #40082 to #40097)".

12.18.7 Precautions

(1) For the operation error (M03 0003), if the interfering object has deviated from the interference warning area, you can cancel the alarm by resetting the NC or turning OFF the "Interference check III: mode" signal.

(2) During the operation error (M03 0003), a torque limit and feedrate clamp are constantly performed.
In the case that the torque limit execution command (axis specification parameter "#2661 ITF3_ILMT") is turned OFF when an interfering object enters the interference warning area, or the C axis of spindle/C axis control, the torque limit is not executed.
During the torque limit being applied when an interfering object enters the interference warning area, the in current limit signal (X900-X907) is NOT turned ON.
If the setting value of clamp speed is "0" when an interfering object enters the interference warning area, the feedrate clamp is not executed.

(3) If you wish to cancel the torque limit and feedrate clamp during the operation error (M03 0003) , turn OFF the "Interference check III: mode" signal.

(4) "M03 Interference detection 0001" can be canceled by reset.

(5) You are able to cancel the operation error (M03 0001) by resetting the NC or turning OFF the "Interference check III: mode" signal.

(6) You are able to cancel the operation error (M03 0002) by turning OFF the "Interference check III: mode" signal. Resetting the NC does not cancel the alarm.

(7) When the entry to the interference alarm area is detected, the axis travel is stopped just before the entry.
For the stop position, the distance between interfering objects when stopped may be "0" since the position varies depending on the axis feedrate and axis travel amount. Define an interfering object (solid) with applying the clearance amount in accordance with the use conditions such as overshoot operation of machine when stopped.

(8) In the high-speed high-accuracy control (high-speed machining mode/high-accuracy control/spline interpolation etc.) a path in accordance with the tolerance amount is created to make a machining program commanded with micro segments faster and smoother. Thus, a difference arises between the path on which the interference check III is performed and the path on which the tool actually passes.
When using the high-speed high-accuracy control (high-speed machining mode/high-accuracy control/spline interpolation etc.) together with the interference check III, define the interfering object (solid) with applying the clearance amount in accordance with the path difference caused by the tolerance amount.

(9) You are able to select the axis which stops when the operation error (M03 0001 or M03 0002) is detected, using the parameter "#1444 otsys" (Stop all part systems at OT).

#1444 = 0	All the axes in the part system which controls the axes set in the interfering object definition "interfering object I J K control axes" and "I J K rotary axes" will stop.
#1444 = 1	All axes in all part systems will stop.

(10) If the operation errors (M03 0002) is detected between fixed interfering objects (interfering objects in which the interfering object definition "interfering object I J K control axes" and "I J K rotary axes" are not set), the alarm is output to the part system1.

(11) When inputting the interfering object selection with system variables, the system variables in which the command range is integer is set in R register with the value after the decimal point being ignored.
When inputting any value out of the setting range in #40000 to #40097, the low 16 bits of the inputted value is set in R register.
When inputting #0<empty> in #40000 to #40097, "0" is set in R register.

(12) If you have made a write command to system variable (#40000 to #40097) in a program except for the machine tool builder macro program, the program error (P241) occurs.

(13) If you perform the interference check III during the high-speed simple program check, the operation error (M03 0001) may occur at a position different from the actual operation.

(14) If you set more than one interfering object which includes rotary axis setting as one interfering object using the interfering check III: specifying disabled interfering object, only the interfering object in which a rotary axis is set will be in rotating operation, checking the interference between the interfering objects.

(15) If the operation error (M03 0001) occurs, cancel it by moving the interfering object to the retracting direction with the linear axis.

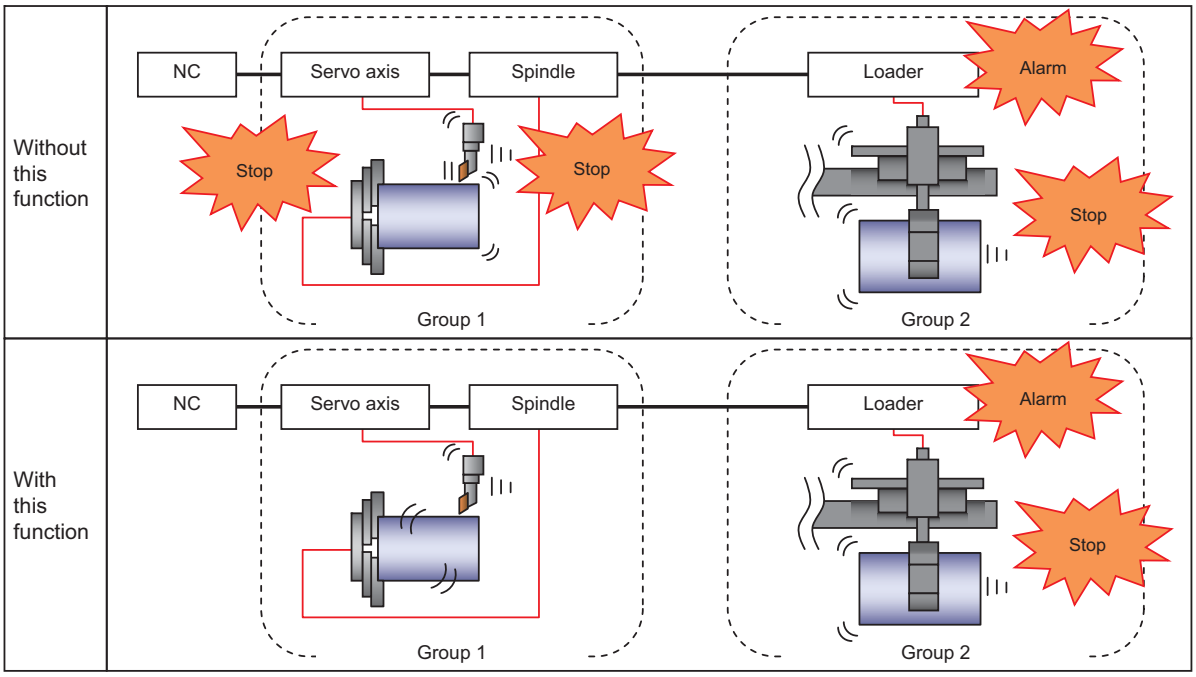
(16) The interference check III cannot be applied to PLC axes. In the case of NC axis/auxiliary axis switching, the check is available.

(17) The unit to be used in the solid and interfering object definition file (OBSTACLE.DAT) is millimeters (3 digits after the decimal point) fixed.
(18) In the interference check III, interference is checked with 0.1 μm unit regardless of the control unit.
(19) At the occurrence of the operation error (M03 0001), all the axes in the part system in which the alarm has occurred will stop. If the entry to the interference alarm area is not detected by the subsequent axis travel command (manual operation/automatic operation), the operation error (M03 0001) will be cancelled and the axes will travel.
Depending on the relative positional relation between interfering objects or the feedrate of axes, the axis can travel further to the interfering direction from the stopped position (a direction to which the interfering objects interfere).
Even if the axis moves toward the interfering direction, it will stop before entering the interference alarm area.

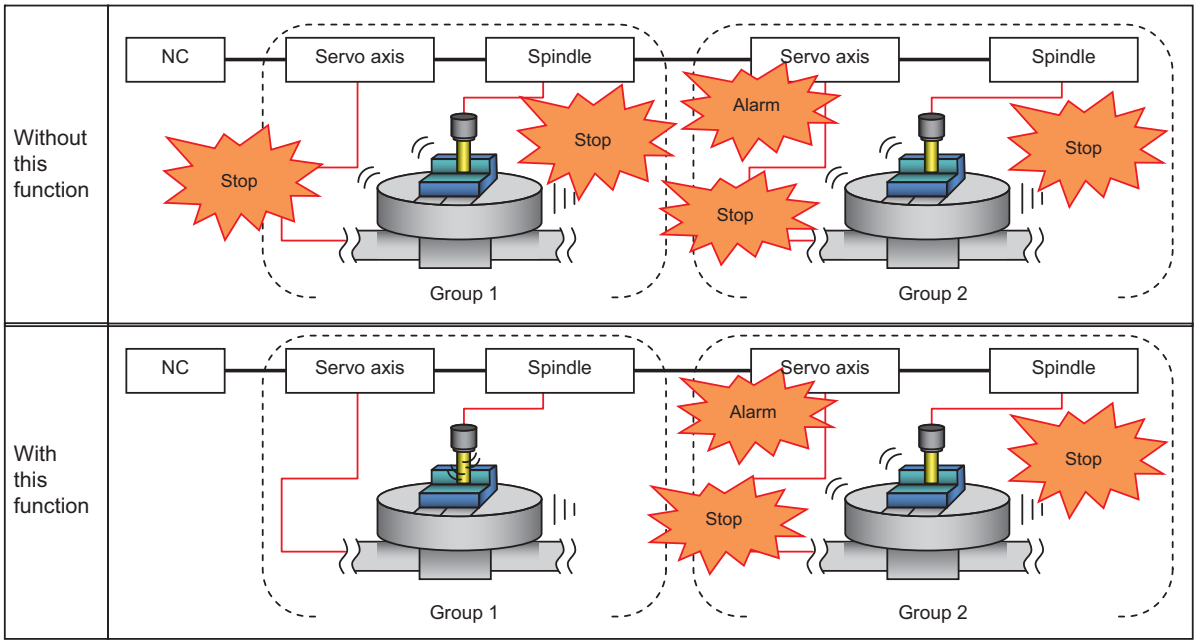
12.19 Machine Group-based Alarm Stop

12.19.1 Outline

When an alarm occurs for an axis, this function performs an alarm stop only for the axes in a machine group to which the axis belongs. When this function is used in a lathe system, even though an alarm occurs for the loader axis, the operation can be continued if the servo axis and the spindle have been set in a different machine group from the loader axis as illustrated below. Without this function, the alarm stop is performed for all the axes when an alarm occurs.



Likewise, when this function is used in a machining center system, the axes belonging to a different machine group from the axis for which an alarm has occurred can continue the operation as illustrated below. Without this function, the alarm stop is performed for all the axes when an alarm occurs.



(Note) The machining group number can be set for each servo axis and spindle in this function, and incorrect setting may lead to accidents. Set the machine group number with enough care.

12.19.2 Function Enabling Conditions

The following settings are required to enable this function.

(1) Set "1" in "#1471 mgralmstp (Enable machine groupwise alarm stop)".

(2) Set the machine group number as follows.

<Servo axis>

1) Set the machine group number of each axis in "#1605 mgrnum (Machine group No.)".

2) When the machine group number is set to "0", the axes will decelerate and stop even if an alarm occurs in any machine group.

<Spindle>

1) There are two types of setting methods to set the machine group number as a single or multiple machine groups. The types can be switched by "#3195 mgrsptyp (Spindle's machine group setting type)".
- 0 : Set single machine group number
- 1 : Set multiple machine group number

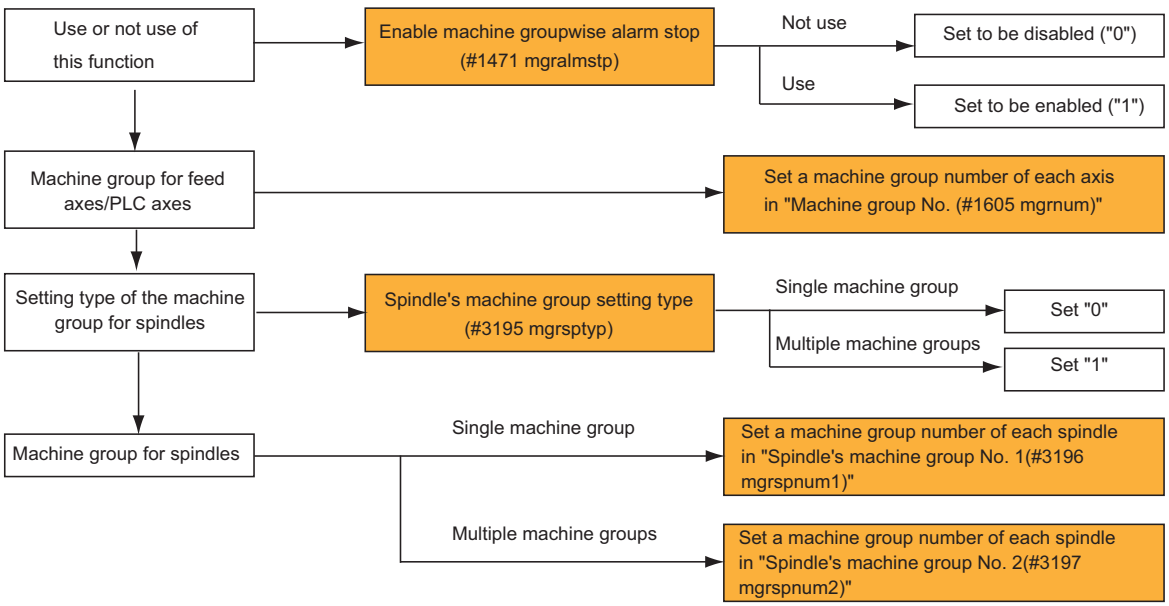
2) When "0" is set in "#3195 mgrsptyp (Spindle's machine group type)" , set the machine group number in "#3196 mgrspnum1 (Spindle's machine group No. 1)".
When "0" is set in "#3196 mgrspnum1 (Spindle's machine group No. 1)", the spindle decelerates and stops even if an alarm occurs in any machine group.

3) When "1" is set in "#3195 mgrsptyp (Spindle's machine group type)", set the machine group number in "#3197 mgrspnum2 (Spindle's machine group No. 2)".
When "00" is set in "#3197 mgrspnum2 (Spindle's machine group No. 2)", the spindle continues the operation even if an alarm occurs in any machine group. If you want to make the spindles to decelerate and stop for all machine groups, set "FF" in "#3197 mgrspnum2 (Spindle's machine group type)".

(3) The group settings of the machine group number become effective when the power is turned OFF and ON again after entering the parameter values.

(4) When all axes are set to the same machine group, the function is invalid.

<Flow chart of the validity condition settings>



12.19.3 Basic Operation

(1) When an alarm occurs for an axis, this function decelerates and stops the axes in a machine group where the axis belongs. Operations of the other machine groups are given below.

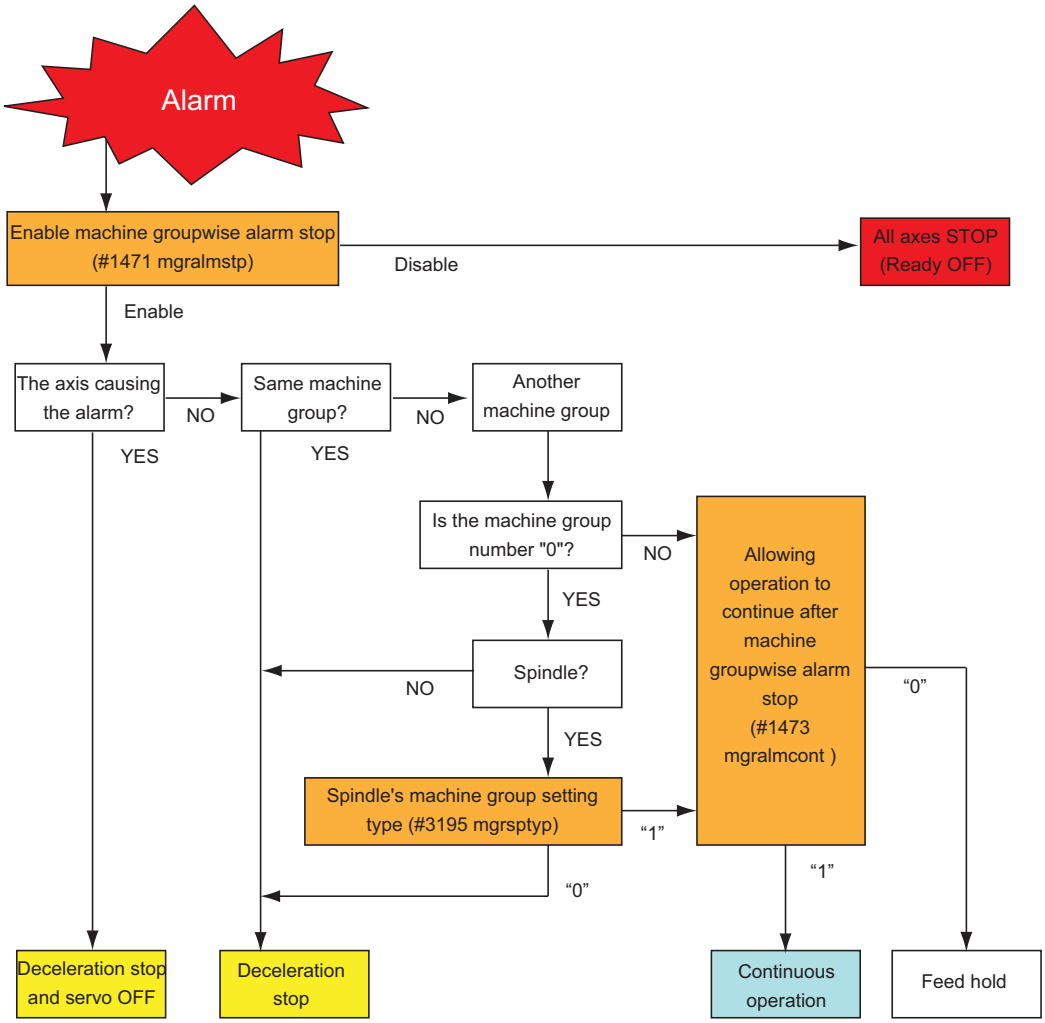
1) Operations of the axes in different machine groups can be switched to either the feed hold or continuous operation.

2) Operations of the axes in different machine groups are set by "#1473 mgralmcont (Allowing operation to continue after machine groupwise alarm stop)".

- 0 : Feed hold
- 1 : The operation is allowed to continue.

(2) Refer to the previous paragraph "Function Enabling Conditions" for how to set the "Enable machine groupwise alarm stop" and "Machine group No.".

<Basic operation of this function>



12.19.4 Operation after Machine Group-based Alarm Stop

(1) Operations of another machine groups after Machine groupwise alarm stop are as follows.

1) The allowance of the automatic operation by the cycle start can be switched.

2) Whether to operate automatically by the cycle start is set by "#1472 mgralmrestart (Allowing automatic operation to start after machine groupwise alarm stop)".

- 0 : Not allow automatic operation to start after machine groupwise alarm stop
- 1 : Allow automatic operation to start after machine groupwise alarm stop

3) When "#1472 mgralmrestart (Allowing automatic operation to start after machine groupwise alarm stop)" is set to "0", an operation error (M01 0137) occurs if you execute the automatic operation by the cycle start.

(2) The manual operation for the axes of another machine groups are available regardless of the parameter after machine groupwise alarm stop.

(Example) When an alarm occurs at each machine group in the circumstance that the multiple machine group numbers are set in optical channels:

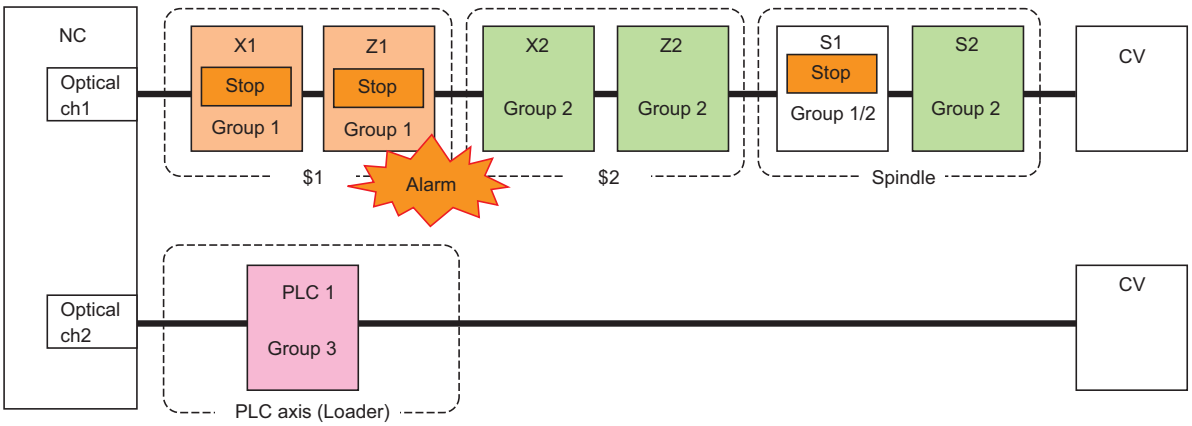
<Axis parameter>

#	Item		1st axis	2nd axis	3rd axis	4th axis	PLC1
1022(PR)	axname2	2nd axis name	X1	Z1	X2	Z2	-
1605(PR)	mgrnum	Machine group No.	1	1	2	2	3

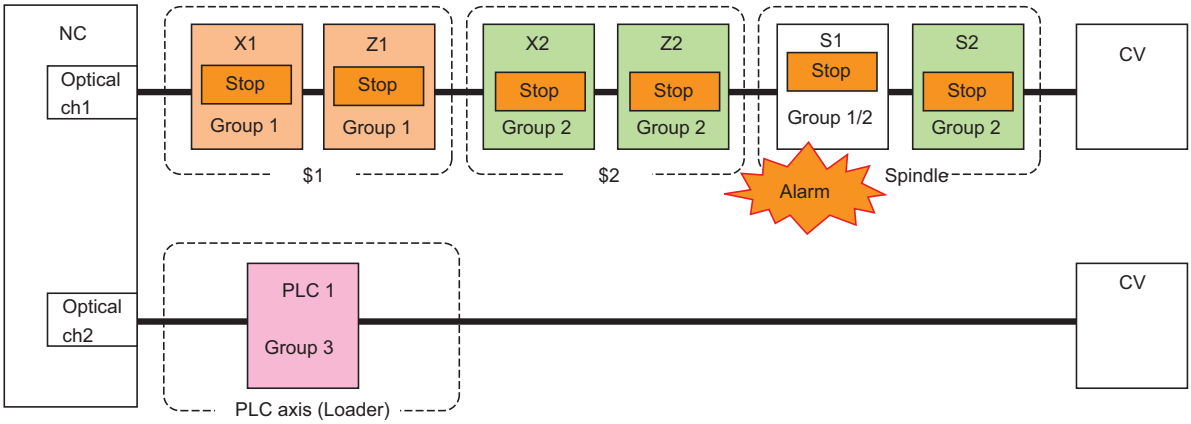
<Spindle parameter>

#	Item		S1	S2
3195(PR)	mgrsptyp	Spindle's machine group setting type	1	1
3196(PR)	mgrspnum1	Spindle's machine group No. 1	0	0
3197(PR)	mgrspnum2	Spindle's machine group No. 2	03	02

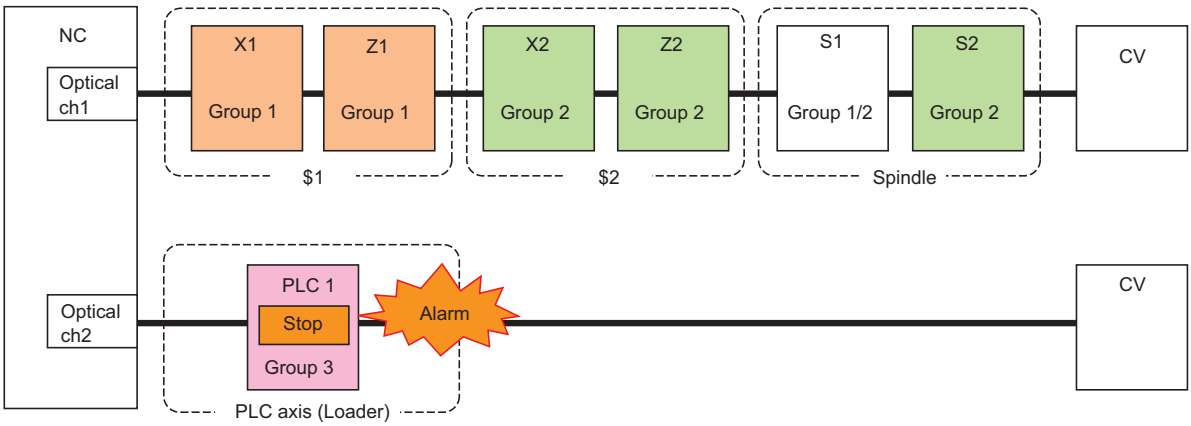
When an alarm occurs at Z1 axis, the axes/spindles which belong to the machine group 1 perform the alarm stop. However, the other axes/spindles/PLC axes are able to continue the operation without the alarm stop.



When an alarm occurs at S1 spindle, the axes/spindles which belong to the machine group 1 and 2 perform the alarm stop. However, other PLC axes are able to continue the operation without the alarm stop.



When an alarm occurs at PLC1 axis, the PLC1 axis which belong to the machine group 3 performs the alarm stop. However, other axes/spindles/PLC axes are able to continue the operation without the alarm stop.



12.19.5 Target Alarms

The target alarms for machine groupwise alarm stop are as follows.

Servo/Spindle alarm

Alarm class	Resetting methods	Alarm No.	Name
S01	PR (After removing the cause of the alarm, reset the alarm by turning the NC power ON again.)	0010	Insufficient voltage
		0016	Init mag pole pos detect err
		0017	A/D converter error
		001B	Machine side dtc: Error 1
		001C	Machine side dtc: Error 2
		001D	Machine side dtc: Error 3
		001E	Machine side dtc: Error 4
		001F	Machine side dtc: Commu error
		0023	Excessive speed error
		0027	Machine side dtc: Error 5
		0028	Machine side dtc: Error 6
		0029	Machine side dtc: Error 7
		002A	Machine side dtc: Error 8
		002B	Motor side dtc: Error 1
		002C	Motor side dtc: Error 2
		002D	Motor side dtc: Error 3
		002E	Motor side dtc: Error 4
		002F	Motor side dtc: Commu error
		0030	Over regeneration
		0031	Overspeed
		0033	Overvoltage
		0034	NC-DRV commu: CRC error
		0035	NC command error
		0036	NC-DRV commu: Commu error
		0038	NC-DRV commu: Protocol error 1
		0039	NC-DRV commu: Protocol error 2
		003A	Overcurrent
		003D	Pw sply volt err acc/dec
		0041	Feedback error 3
		0042	Feedback error 1
		0043	Feedback error 2
		0045	Fan stop
		0046	Motor overheat
		0048	Motor side dtc: Error 5
		0049	Motor side dtc: Error 6
		004A	Motor side dtc: Error 7
		004B	Motor side dtc: Error 8
		008A	Drivers commu data error 1
		008B	Drivers commu data error 2

Alarm class	Resetting methods	Alarm No.	Name
S03	NR (After removing the cause of the alarm, reset the alarm by inputting the NC RESET key.)	004C	Current err mag pole estim
		004E	NC command mode error
		004F	Instantaneous power interrupt
		0050	Overload 1
		0051	Overload 2
		0052	Excessive error 1
		0053	Excessive error 2
		0054	Excessive error 3
		0056	Commanded speed error
		0058	Collision detection 1: G0
		0059	Collision detection 1: G1
		005A	Collision detection 2
		005F	External contactor error
S04	AR (After removing the cause of the alarm, reset the alarm by turning the NC and drive unit power ON again.)	0022	Encoder data error
		003E	Magnet pole pos detect err

M8 Smart Safety alarm

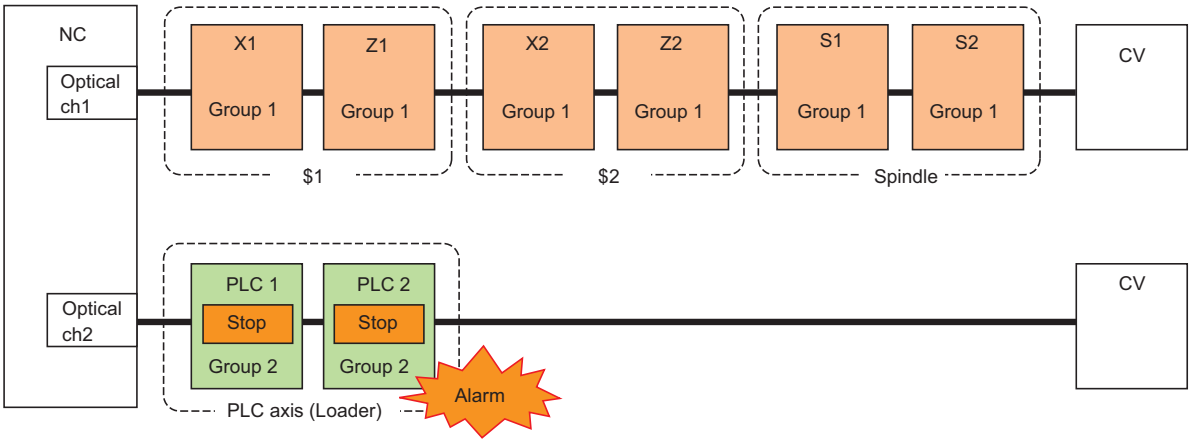
Alarm class	Alarm No.	Name
V05	0001	SLS speed error
	0002	SLS deceleration error
	0003	SLP position error
	0004	SOS speed error
	0005	SOS position deviation error
	0006	SOS travel distance error
	0007	SS1 deceleration error
	0008	SS2 deceleration error
V02	0001	Encoder error
V07	0002	DRV safe circuit error

12.19.6 Usage example

Usage example 1 for lathe

When the machine group is set by channel:

When an alarm occurs at PLC2 axis of machine group 2, the axes in the machine group 2 where the alarm occurred are stopped. However, other axes of machine group 1 are able to continue the operation.



<Condition>

- NC type : Lathe

<Basic system parameter>

#	Item		$1	$2	PLC
1001(PR)	SYS_ON	System validation setup	1	1	1
1002(PR)	axisno	Number of axes	2	2	2

<Basic common parameter>

#	Item		Data
1039	spinno	Number of spindles	2

<Basic axis specification parameter>

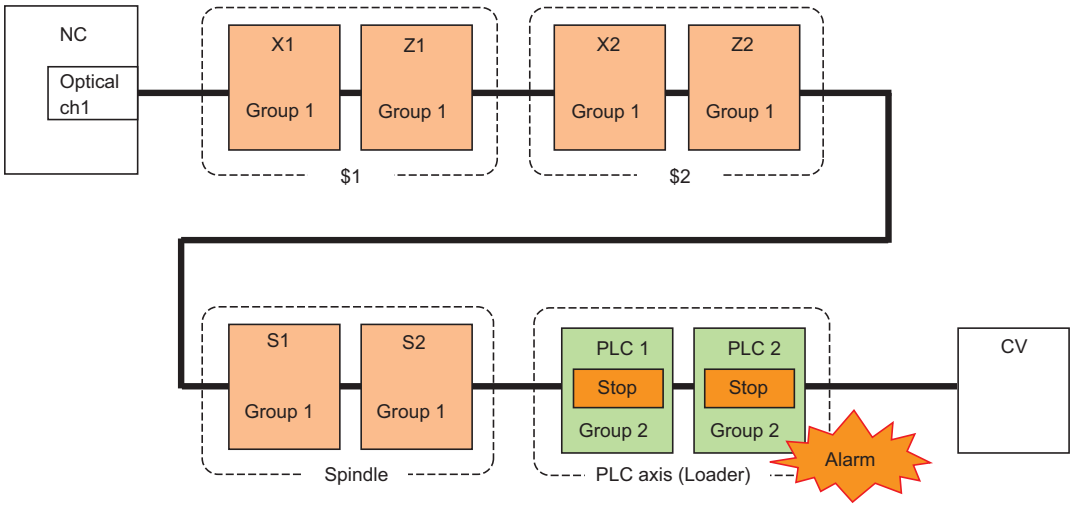
#	Item		1st axis	2nd axis	3rd axis	4th axis	PLC1	PLC2
1013(PR)	axname	Axis name	X	Z	X	Z	-	-
1021(PR)	mcp_no	Drive unit I/F channel No. (servo)	1001	1002	1003	1004	2001	2002
1022(PR)	axname2	2nd axis name	X1	Z1	X2	Z2	-	-
1605(PR)	mgrnum	Machine group No.	1	1	1	1	2	2

<Spindle specification parameter>

#	Item		S1	S2
3031(PR)	smcp_no	Drive unit I/F channel No.(spindle)	1005	1006
3195(PR)	mgrsptyp	Spindle's machine group setting type	0	0
3196(PR)	mgrspnum1	Spindle's machine group No. 1	1	1
3197(PR)	mgrspnum2	Spindle's machine group No. 2	00	00

Usage example 2 for lathe

When a number of machine groups are set in one channel:
When an alarm occurs at PLC2 axis of machine group 2, the axes in the group 2 where the alarm occurred are stopped. However, other axes of machine group 1 are able to continue the operation.



<Condition>
- NC type : Lathe

<Basic system parameter>

#	Item		$1	$2	PLC
1001(PR)	SYS_ON	System validation setup	1	1	1
1002(PR)	axisno	Number of axes	2	2	2

<Basic common parameter>

#	Item		Data
1039	spinno	Number of spindles	2

<Basic axis specification parameter>

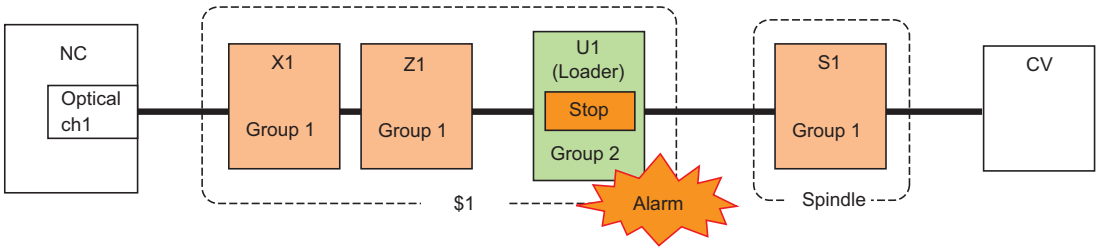
#	Item		1st axis	2nd axis	3rd axis	4th axis	PLC1	PLC2
1013(PR)	axname	Axis name	X	Z	X	Z	-	-
1021(PR)	mcp_no	Drive unit I/F channel No. (servo)	1001	1002	1003	1004	1007	1008
1022(PR)	axname2	2nd axis name	X1	Z1	X2	Z2	-	-
1605(PR)	mgrnum	Machine group No.	1	1	1	1	2	2

<Spindle specification parameter>

#	Item		S1	S2
3031(PR)	smcp_no	Drive unit I/F channel No.(spindle)	1005	1006
3195(PR)	mgrsptyp	Spindle's machine group setting type	1	1
3196(PR)	mgrspnum1	Spindle's machine group No. 1	0	0
3197(PR)	mgrspnum2	Spindle's machine group No. 2	01	01

Usage example 3 for lathe

When a number of machine groups are set in one part system:
When an alarm occurs at U1 axis of machine group 2, the axes in the group 1 are able to continue the operation although the axes in the machine group 2 where the alarm occurred are stopped.
However, when an alarm occurred at the one of all axes to interpolate within one part system, all interpolated axes are stopped regardless of the machine group setting.



<Condition>
- NC type : Lathe
<Basic system parameter>

#	Item		$1	$2
1001(PR)	SYS_ON	System validation setup	1	0
1002(PR)	axisno	Number of axes	3	-

<Basic common parameter>

#	Item		Data
1039	spinno	Number of spindles	1

<Basic axis specification parameter>

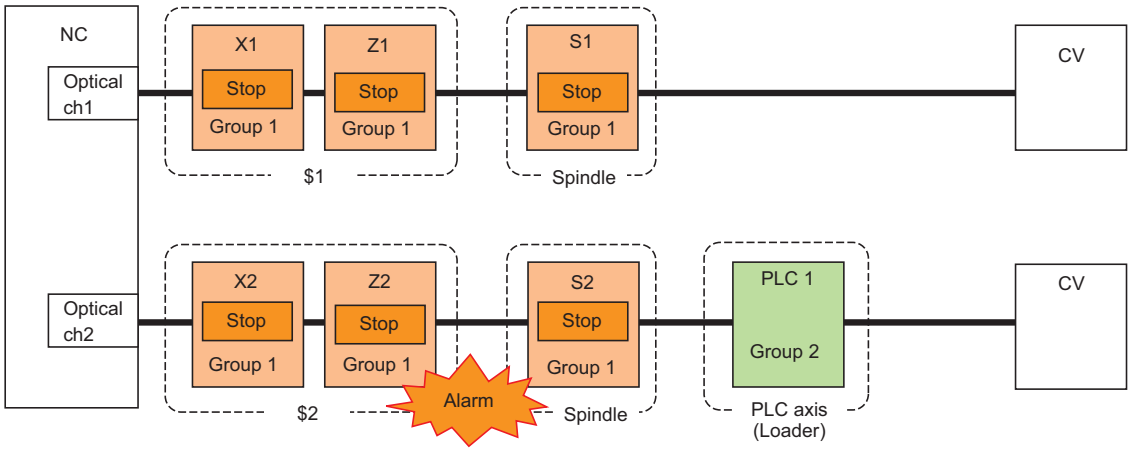
#	Item		1st axis	2nd axis	3rd axis
1013(PR)	axname	Axis name	X	Z	U
1021(PR)	mcp_no	Drive unit I/F channel No. (servo)	1001	1002	1003
1022(PR)	axname2	2nd axis name	X1	Z1	U1
1605(PR)	mgrnum	Machine group No.	1	1	2

<Spindle specification parameter>

#	Item		S1
3031(PR)	smcp_no	Drive unit I/F channel No.(spindle)	1004
3195(PR)	mgrsptyp	Spindle's machine group setting type	0
3196(PR)	mgrspnum1	Spindle's machine group No. 1	1
3197(PR)	mgrspnum2	Spindle's machine group No. 2	00

Usage example 4 for lathe

When a machine group number is set across a number of optical channels:
When an alarm occurs at Z2 axis of machine group 1, the axes which belong to the group 1 perform the alarm stop.
However, the other axis, PLC1 is able to continue the operation without the alarm stop because it belongs to the group 2.



<Condition>
- NC type : Lathe
<Basic system parameter>

#	Item		$1	$2
1001(PR)	SYS_ON	System validation setup	1	1
1002(PR)	axisno	Number of axes	2	2

<Basic common parameter>

#	Item		Data
1039	spinno	Number of spindles	2

<Basic axis specification parameter>

#	Item		1st axis	2nd axis	3rd axis	4th axis	PLC1
1013(PR)	axname	Axis name	X	Z	X	Z	-
1021(PR)	mcp_no	Drive unit I/F channel No. (servo)	1001	1002	2001	2002	2004
1022(PR)	axname2	2nd axis name	X1	Z1	X2	Z2	-
1605(PR)	mgrnum	Machine group No.	1	1	1	1	2

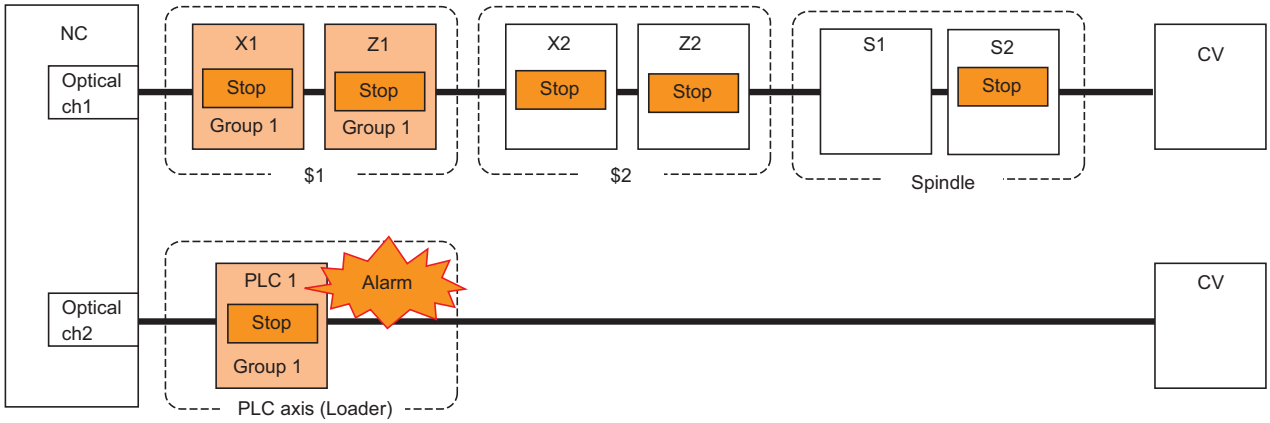
<Spindle specification parameter>

#	Item		S1	S2
3031(PR)	smcp_no	Drive unit I/F channel No.(spindle)	1003	2003
3195(PR)	mgrsptyp	Spindle's machine group setting type	1	1
3196(PR)	mgrspnum1	Spindle's machine group No. 1	0	0
3197(PR)	mgrspnum2	Spindle's machine group No. 2	01	01

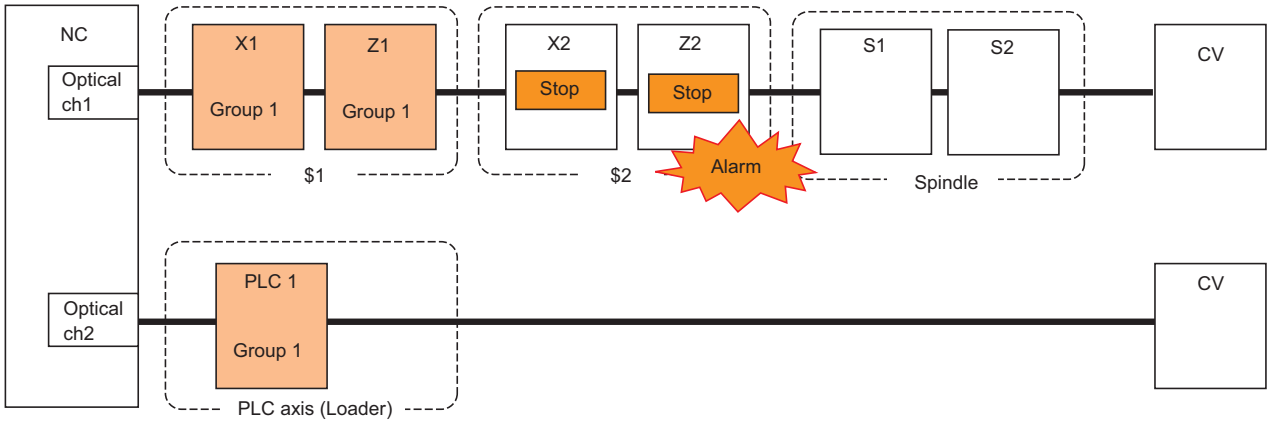
Usage example 5 for lathe

When a machine group number is set to "0":

When an alarm occurs at PLC1 axis, the axes in the machine group 1 and those which are set to "0" and "FF" in the spindle machine group numbers perform the alarm stop. Although the S1 spindle is the machine group number "0", S1 continues the operation because "#3197 mgrspnum2 (Spindle machine group No. 2)" is set to "00".



When an alarm occurs at Z2 axis, only the axes which are set to "0" and "FF" in the machine group numbers perform the alarm stop. Although the S1 spindle is the machine group "0", S1 continues the operation because "#3197 mgrspnum2 (Spindle machine group No. 2)" is set to "00".



<Condition>
- NC type : Lathe
<Basic system parameter>

#	Item		$1	$2
1001(PR)	SYS_ON	System validation setup	1	1
1002(PR)	axisno	Number of axes	2	2

<Basic common parameter>

#	Item		Data
1039	spinno	Number of spindles	2

<Basic axis specification parameter>

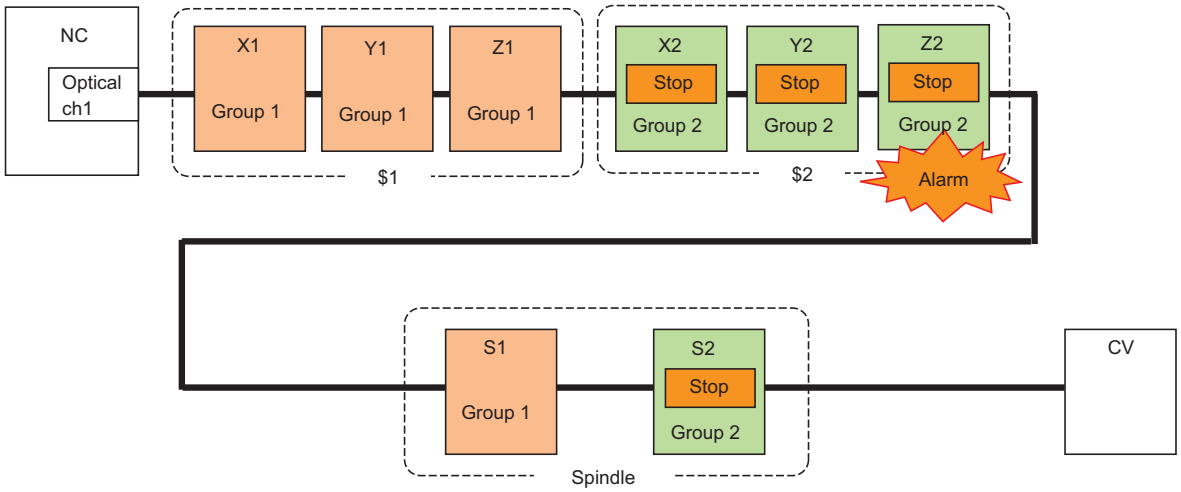
#	Item		1st axis	2nd axis	3rd axis	4th axis	PLC1
1013(PR)	axname	Axis name	X	Z	X	Z	-
1021(PR)	mcp_no	Drive unit I/F channel No. (servo)	1001	1002	1003	1004	2001
1022(PR)	axname2	2nd axis name	X1	Z1	X2	Z2	-
1605(PR)	mgrnum	Machine group No.	1	1	0	0	1

<Spindle specification parameter>

#	Item		S1	S2
3031(PR)	smcp_no	Drive unit I/F channel No.(spindle)	1005	1006
3195(PR)	mgrsptyp	Spindle's machine group setting type	1	1
3196(PR)	mgrspnum1	Spindle's machine group No. 1	0	0
3197(PR)	mgrspnum2	Spindle's machine group No. 2	00	FF

Usage example for machining center with 2 part systems

When a number of machine groups are set in one channel:
When an alarm occurs at Z2 axis of machine group 2, the axes in the group 2 where the alarm occurred are stopped. However, other axes of machine group 1 are able to continue the operation.



<Condition>
- NC type : Machining center system
<Basic system parameter>

#	Item		$1	$2
1001(PR)	SYS_ON	System validation setup	1	1
1002(PR)	axisno	Number of axes	3	3

<Basic common parameter>

#	Item		Data
1039	spinno	Number of spindles	2

<Basic axis specification parameter>

#	Item		1st axis	2nd axis	3rd axis	4th axis	5th axis	6th axis
1013(PR)	axname	Axis name	X	Y	Z	X	Y	Z
1021(PR)	mcp_no	Drive unit I/F channel No. (servo)	1001	1002	1003	1004	1005	1006
1022(PR)	axname2	2nd axis name	X1	Y1	Z1	X2	Y2	Z2
1605(PR)	mgrnum	Machine group No.	1	1	1	2	2	2

<Spindle specification parameter>

#	Item		S1	S2
3031(PR)	smcp_no	Drive unit I/F channel No.(spindle)	1007	1008
3195(PR)	mgrsptyp	Spindle's machine group setting type	0	0
3196(PR)	mgrspnum1	Spindle's machine group No. 1	1	2
3197(PR)	mgrspnum2	Spindle's machine group No. 2	00	00

12.19.7 Machine Group-based PLC Interlock

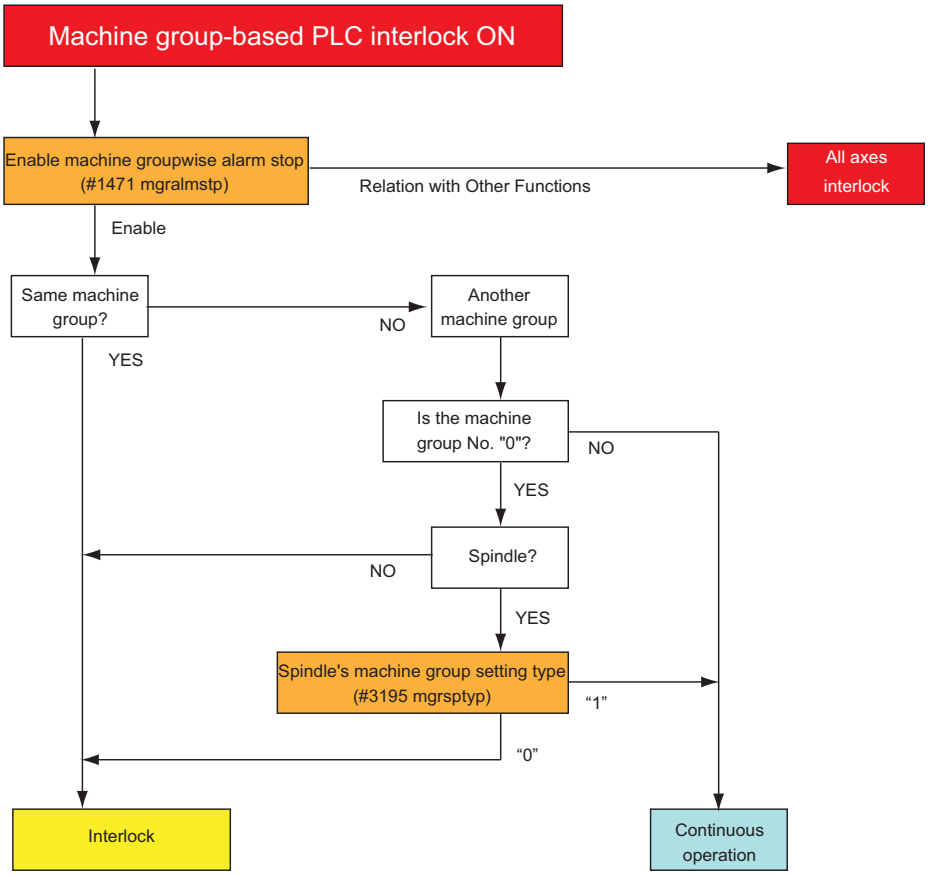
(1) Interlock is enabled by turning ON "Machine group-based alarm stop: Machine group-based PLC interlock signal (GQMEG1:YBE0)" as follows. (The spindles are stopped with the rotation speed "0".)
   1) The machine group-based PLC interlock can be switched to either all axes interlock or machine group-based interlock.
   2) Set the value in "#1471 mgralmstp (Enable machine groupwise alarm stop)".
      - 0 : Interlock for all axes.
      - 1 : Interlock for machine group-based.

(2) The signal "Machine group-based alarm stop: Machine group-based PLC interlock ON signal (GQEMG01: XBE0)" in the interlocked machine group axes are turned ON by the machine group-based PLC interlock function.

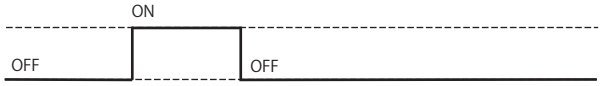
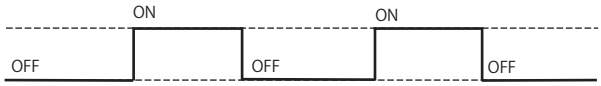
(3) When turning ON "PLC emergency stop signal (QEMG:YC2C)", all axes perform the emergency stop regardless of the setting value in "#1471 mgralmstp (Enable machine groupwise alarm stop)". Also, "Machine group-based alarm stop: Machine group-based PLC interlock ON signal (GQEMG01: XBE0)" is turned ON.

(4) Refer to "Function Enabling Conditions" for the settings of "Machine group-based alarm stop ON" and "Machine group No.".

<Operation of machine group-based PLC interlock>



<Timing chart of machine group-based PLC interlock>

PLC output signal	Machine group-based alarm stop: Machine group-based PLC interlock (GQMEG1:YBE0)	
	PLC emergency stop (QMEG:YC2C)	
PLC input signal	Machine group-based alarm stop: Machine group-based PLC interlock ON (GQEMG01: XBE0)	

12.19.8 Relation with Other Functions

(1) Set the related axes in a same machine group when using the function which relates the axes of different part systems such as mixed control (cross axis control), arbitrary axis exchange, control axis superimposition, or control axis synchronization between part systems.

(2) Set the related axes in a same machine group when using the function which synchronize with the spindle such as spindle synchronization control I, tool spindle synchronization I (polygon), or tool spindle synchronization (hobbing) .

(3) When using the function which relates inclined axis control and synchronous control, set the related axes as follows.

(a) Set the axes related to the inclined axis control and synchronous control to a same machine group.

(b) If those are not set in the same group, an MCP alarm (Y51 0039) will occur regardless of the validity of inclined axis control and synchronous control when the power is ON.

12.19.9 Precautions

(1) When more than one axis shares the brake output at the multi-axis drive unit (V2/V3), set the all axes within the unit to the same machine group.

12.20 Diagnosis Data Output

12.20.1 Outline

Diagnosis data output is a function designed to output the information on when to exchange the life-limited parts of the NC and its peripherals. The information, which is output to ZR registers, can be used for preventive maintenance, including lifetime prediction.

12.20.2 Function Details

The output data is automatically reset at the time of replacing the specific product (NC unit, drive or motor). (Note)
If you have replaced the part (battery, etc.) only, you can reset the data by writing 0 in the ZR register. After the reset, reboot the NC.

(Note) To avoid any unintended reset at a tentative replacement, the control performs automatic reset upon the first NC startup after 24 hours have passed after the replacement.
Using the ZR register value, you can adjust the length of time from replacement until data clear.

Table below shows the data items to be output.
The control outputs the information for each servo axis or spindle. The information of spindle C axis is output to the spindle's ZR registers. The information of a spindle-mode servo axis is also output to the spindle's ZR registers.

Category		Data item	Unit	Auto reset	ZR register	Details
NC	Control	Battery exchange	min	At NC exchange	ZR12404 ZR12405	Length of time the battery for the NC unit memory has been used.
Drive	Drive unit	Battery exchange (for each servo axis)	hr	At drive exchange	ZR12608 ZR12609 to ZR12670 ZR12671	Length of time the battery for the drive unit memory has been used.
		Battery exchange (for each spindle)			ZR12688 ZR12689 to ZR12702 ZR12703	
	Motor	Cumulative travel distance (for each servo axis)	m/rev	None	ZR12946 ZR12947 to ZR13008 ZR13009	Accumulated travel distance of each motor For a rotary axis, the number of revolutions is output.
		Insulation resistance (for each servo axis)	MΩ	At motor exchange	ZR12784 ZR12785 to ZR12846 ZR12847	Insulation resistance of each motor (only for drive unit E/EH Series) 0 to 100MΩ (Zero means less than 1MΩ) If your drive unit does not support this function, or if the data has not been obtained from the drive unit, -1 (0xFFFFFFFF) is output.
		Battery exchange (for each spindle)			ZR12848 ZR12849 to ZR12862 ZR12863	

12.21 Alarm Message Display

The details of the alarms which occur during the sequence (user PLC) process can be displayed on the setting and display unit.

Up to four alarm messages can be displayed simultaneously on the alarm diagnosis screen. The maximum message length in one message is 46 characters.

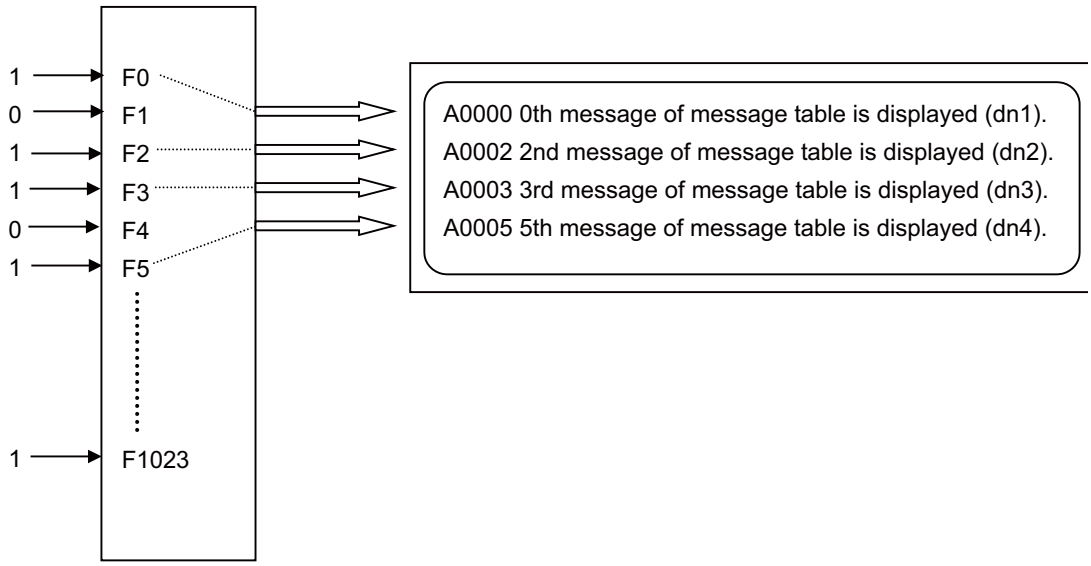
Format	Alarm message
Max. number of messages	1024 messages
Max. data length	46 bytes per message
Number of Display messages	Max. 4 messages
Interface	F type / R type (supplementary information designated)
Available language	8 languages
Store method	User PLC attached data

12.21.1 Interface

The alarm message display interface is available in the two types: F type in which temporary memory F is used for message display request and R type in which file register (R) is used for message display request. Either type is selected by using a parameter.

(1) F type interface

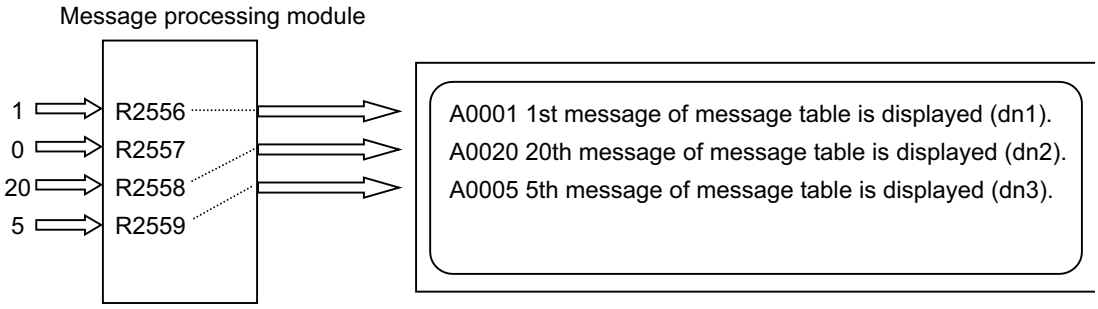
This interface applies to 1024 points of temporary memory F0 to F1023.
If temporary memory F is used as the alarm interface, do not use it for another purpose.



The highest priority is assigned to the F0 signal. The message corresponding to Fn set to "1" is fetched from the message table and displayed in order starting at F0. If no messages are prepared or Fn without prepared message is set to "1", the message "USER PLC ERROR n" is displayed.

(2) R type interface

This interface applies to file registers R2556 to R2559. The numeric value (binary) contained in each of the R registers indicates the position of the message to be displayed in the message table.
The message is cleared by setting the R register to 0.



The messages are displayed starting at the message corresponding to R2556 from top to bottom.
Since message display is cleared by setting the R register to 0, No. 0 in the table message cannot be used in the R type.
If m without prepared message is set in the R register, the message "USER PLC ERROR m" is displayed.

12.21.2 Linking with Multi-project

Create messages by using a text file format or PLC development software (GX Developer).
This chapter explains the operations that are performed when the PLC message files created by the PLC development software (GX Developer) are stored in multiple projects while the multi-project function is valid.

The PLC alarm message interface is a common device between projects.
When the PLC message files are stored in multiple projects and the indexes of the alarm messages overlap, the message of the project with a smaller project No. will be displayed as a priority.

Therefore, when the PLC alarm messages are used in multi-project environment, the method to divide the interfaces per project in advance is recommended as follows:

[Example procedure to create]

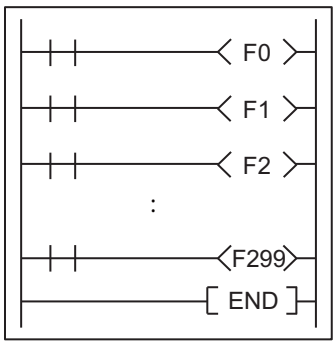
(1) Decide the interfaces to be used per project (example of F type).
Project 1: Use F0 to F299
Project 2: Use F300 to F599
Project 3: Use F600 to F899

(2) Create PLC message files according to the divided interfaces.

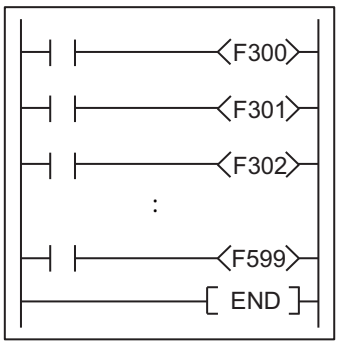
Project 1 Message file	Project 2 Message file	Project 3 Message file
;A, 0, 10, Project1 Msg001; : ;A, 298, 10, Project1 Msg299; ;A, 299, 10, Project1 Msg300; NOPLF END	;A, 300, 20, Project2 Msg001; : ;A, 598, 20, Project2 Msg299; ;A, 599, 20, Project2 Msg300; NOPLF END	;A, 600, 30, Project3 Msg001; : ;A, 898, 30, Project3 Msg299; ;A, 899, 30, Project3 Msg300; NOPLF END

(3) Create ladder circuits according to the divided interfaces.

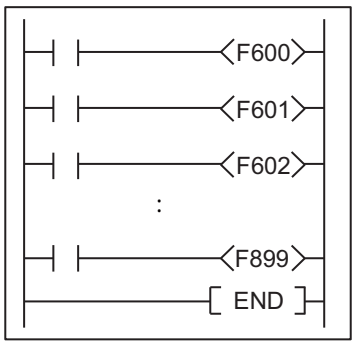
Project 1 Ladder file



Project 2 Ladder file



Project 3 Ladder file



Parameters related to PLC alarm messages

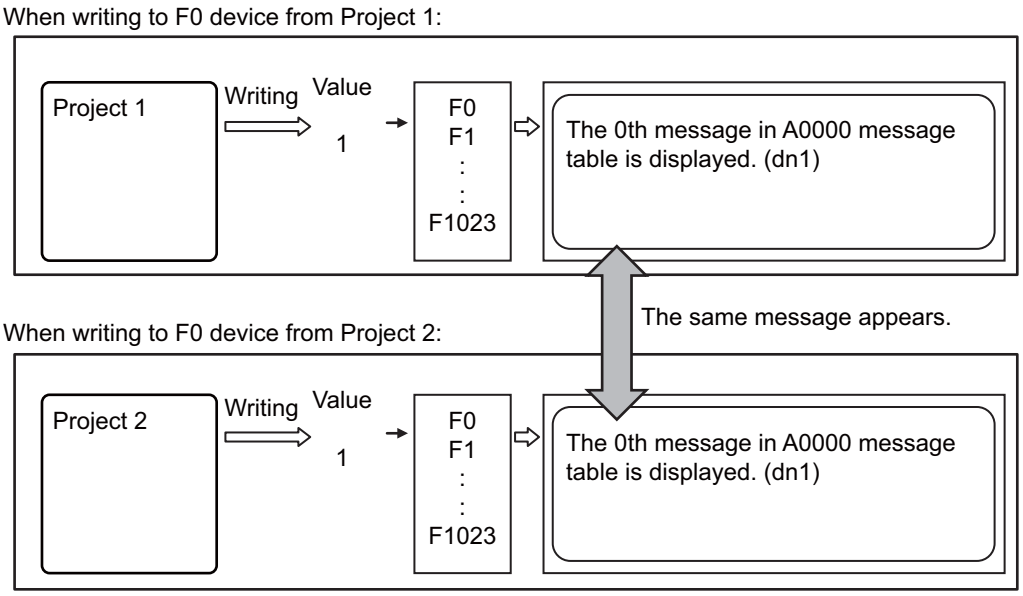
Switching the parameters related to PLC alarm messages is common to all projects.

When the parameters described in "Parameters" in this chapter are set, the same setting is applied to all projects.

Interface

The temporary memory (F) and the file register (R) are common devices to all projects (the devices which are affected by the access from multiple projects).

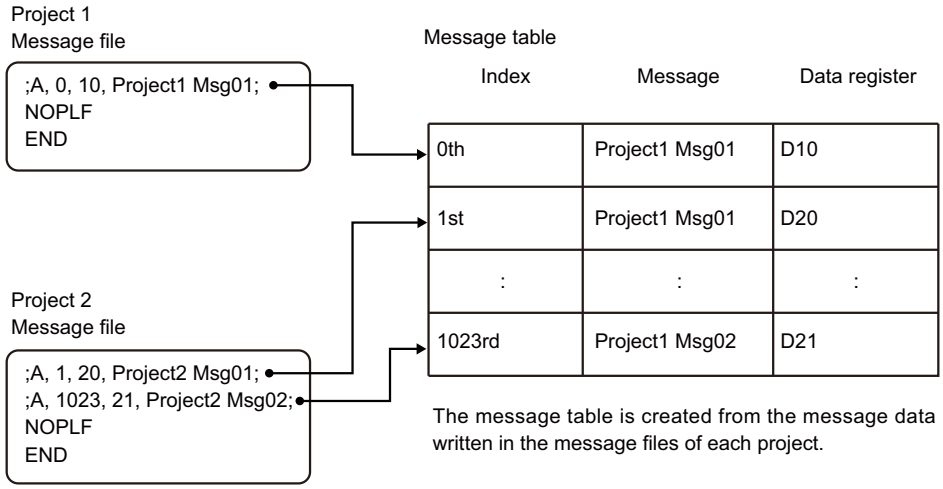
Therefore, even when a value is written from any project to the temporary memory (F) or the file register (R) which is the interface of the alarm messages, the common alarm message appears.



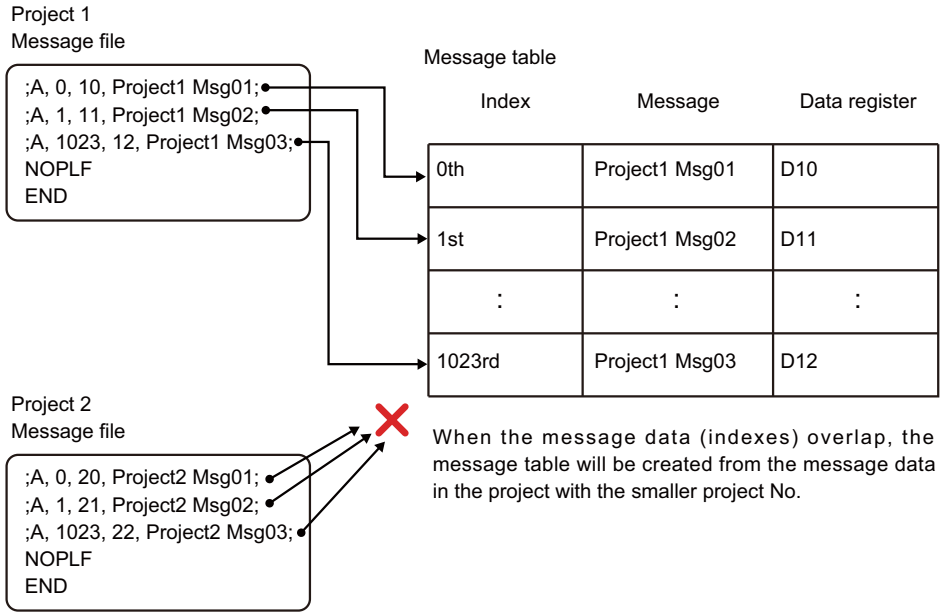
Message table

When the message files are stored in multiple projects, one message table will be created by combining the alarm message data in the message files of each project.
When the alarm message data with the same index are written in multiple projects, the alarm message of the message file stored in the project with the small project No. will be displayed.

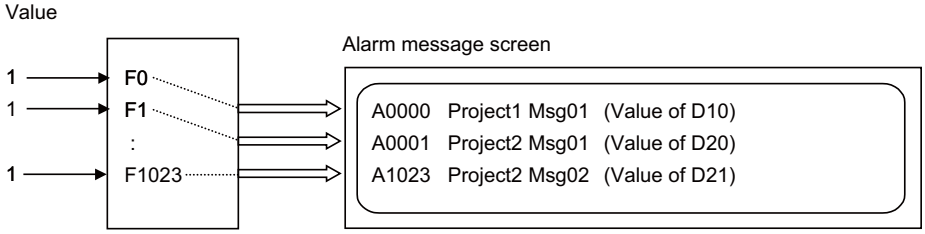
(Example 1) When the message data do not overlap:



(Example 2) When the message data overlap:



When the message is stored as in (Example 1) above, the following is displayed on the alarm message screen (example of F type):



Supplementary information display

The supplementary information can be displayed after the message regardless of the F type or R type. (Refer to "Supplementary information display" in this chapter.)

The supplementary information indicates the contents of data register which is specified individually when creating alarm messages.
When the data register is set as independent device among projects (a device which can be used in multiple projects independently), the contents of the register of Project 1 are always displayed while the multi-project function is active, regardless of the message file storage destination.

If you want to display data of any project other than Project 1, set the data register as common device among projects (a device which is affected by the access from multiple projects). (For details, refer to the section regarding the setting of devices in common in "Chapter 3 Explanation of Devices".)

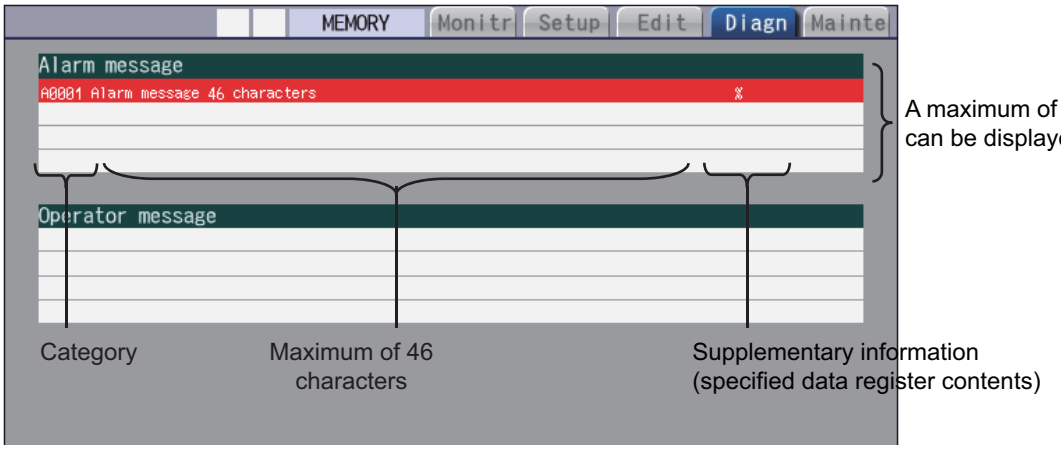
12.21.3 Screen Display

Screen display depends on the message type as described below.

[Alarm message type]

Up to 4 sets of the category, message (up to 46 characters) and the supplementary information can be displayed.

Example of setting and display unit display



(1) Category display

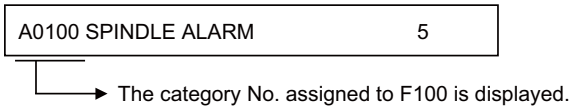
The category is displayed before the message to be displayed regardless of the F type or R type. (A000, A0002, etc. of the F type and R type.)

For F type, the categories are assigned as follows: A0000 for F0, A0001 for F1, etc., and A1023 is displayed for F1023.

For R type, the categories are displayed according to the message table numbers set to R2556, R2557, R2558 and R2559.

When 20 is set to R2558, for instance, the category is displayed as A0020.

(Example) To display the message assigned to F100 in F type

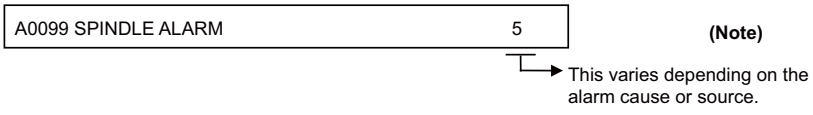


(2) Supplementary information display (Only for Alarm message type)

Supplementary information can be displayed following the message to be displayed regardless of the F or R type. (dn1 to dn4 of the F type and R type.)

For example, one typical alarm message is prepared and supplementary information can be used to indicate the alarm source or cause.

(Example)When spindle alarm occurs, the message "SPINDLE ALARM" is displayed and the alarm source or cause is indicated by the supplementary information.



For the classification No., the contents of each data register specified in alarm message preparation are displayed. Data register D0 cannot be specified.

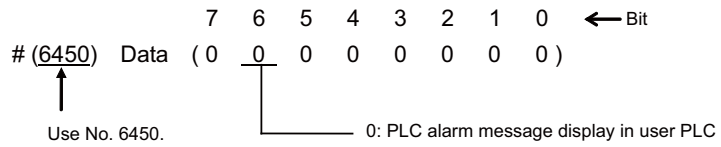
(Note) The display of the supplementary information by cause is updated when an alarm message display changes. It is not updated if only the contents (dn1 to dn4) of the specified data register (Dn1 to Dn4) change. If the contents of the specified data register are 0, no supplementary information is displayed.

12.21.4 Message Creation

Create messages by using a text file format or PLC development software (GX Developer).
According to the description format, set the number of characters for one message and the number of messages to be prepared, then enter message data.
The maximum length of an alarm message is 46 characters.
A maximum of 1024 alarm messages can be prepared. For details, refer to PLC Development Manual.

12.21.5 Parameters

(1) PLC alarm message selection parameter
[Bit selection parameter screen]



The operation is as the following depending on the bit state of the bit selection #6450.

Bit 6 = 0

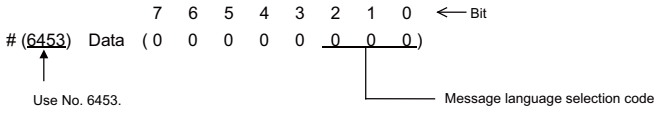
The PLC alarm message in the user PLC is displayed as usual.

Bit 6 = 1

Do not set this value, which clears the display of PLC alarm message.

(2) Language selection parameter
There are two methods for the message data language selection. Method 2 (Method linked with language selection on the setting and display screen) is recommended although both methods are available.
Method 1: Specify with 3 bits of bit selection parameter #6453 bit 0 to 2. (Language selection method using PLC alone)
Method 2: Specify with display language selection parameter (Base specifications parameter #1043) (Method linked with language selection on the setting and display screen)
Each method has a different storage method. Refer to "PEROHERAL DEVELOPMENT ENVIRONMENT: Common Items: File Name" for details.
The parameter specifications where method 1 (Language selection method using PLC alone) is applied is shown below.

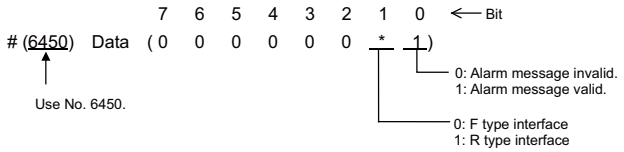
[Bit selection parameter screen]



No	Bit	Notes
	2 1 0	
#6453	0 0 0	The language 1 is displayed.
	0 0 1	The language 2 is displayed.
	0 1 0	The language 3 is displayed.
	0 1 1	The language 4 is displayed.
	1 0 0	The language 5 is displayed.
	1 0 1	The language 6 is displayed.
	1 1 0	The language 7 is displayed.
	1 1 1	The language 8 is displayed.

(3) F or R type selection parameter
Set the parameter on the bit selection screen of PLC parameter (setup para).

[Bit selection parameter screen]



[Reference] #6450 corresponds to the high-order byte of the file register R7824.

(4) Changing the alarm message display format
The display format for the alarm message can be switched with the parameter "#11021 PLC mesg disp type".

12.22 Operator Message Display

When a condition to inform the operator of a message occurs, an operator message can be displayed independently of an alarm message.

A maximum of 55 characters can be displayed for the operator message in one line on the PLC message screen. When the message cannot fit on one line, the message is displayed over two lines.

Up to 4 operator messages can be displayed at a time.

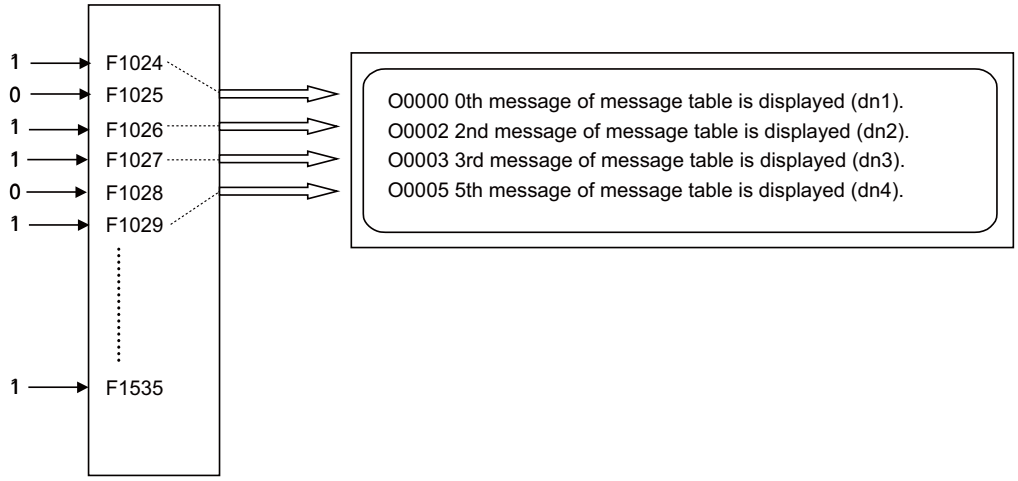
Format	Operator message
Max. number of messages	512 messages
Max. data length	60 bytes per message
Number of display messages	Max. 4 messages
Interface	F type / R type (supplementary information designated)
Store method	User PLC attached data

12.22.1 Interface

The operator message display interface is available in the two types: F type in which temporary memory F is used for message display request and R type in which file register (R) is used for message display request. Either type is selected by using a parameter.

(1) F type interface

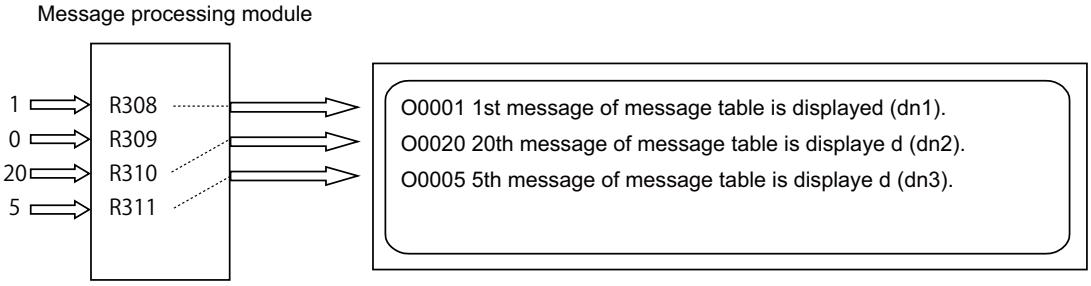
This interface applies to 512 points of temporary memory F1024 to F1535.
The F range of the alarm message I/F can be changed with the parameter "11058 plc_opemsg0" (Operator messages display device. Note that if it is used as the operator interface, do not use it for another purpose.



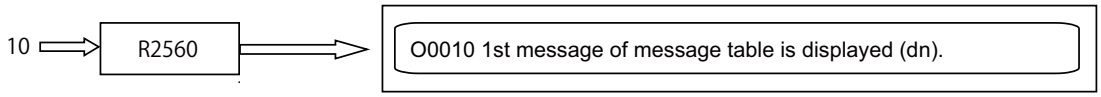
The highest priority is assigned to the F1024 signal. The message corresponding to Fn set to "1" is fetched from the message table and displayed in order starting at F1024. If no messages are prepared or Fn without prepared message is set to "1", the message "USER PLC ERROR n" is displayed.

(2) R type interface

This interface applies to file registers R308, R309, R310 and R311. The numeric value (binary) contained in each of the R registers indicates the position of the message to be displayed in the message table.
The message is cleared by setting the R register to 0. Therefore, the number "0" in the operator message table cannot be displayed.



The messages are displayed from R308, R309, R310 and R311 in order.
Since message display is cleared by setting the R register to 0, No. 0 in the table message cannot be used in the R type.
If m without prepared message is set in the R register, the message "USER PLC ERROR m" is displayed.
R2560 is also able to display an operator message by setting the No. of the operator message table.
R2560 can be used regardless of F type or R type.



The 1st line displays the operator message specified by R2560.
While the message of R2560 is being displayed, the 2nd or subsequent line shows the message specified by R308, R309, R310, R311 or F type.

12.22.2 Linking with Multi-project

Create messages by using a text file format or PLC development software (GX Developer).
This chapter explains the operations in case that the PLC message files created by the PLC development software (GX Developer) are stored in multiple projects when multi project function is valid.

The PLC operator interface is a common device between projects.
When the PLC message files are stored in multiple projects and the indexes of the operator messages overlap, the message of the project with a smaller project No. will be displayed as a priority.

Therefore, when the PLC operator messages are used in multi-project environment, the method to use the interface by dividing it per project in advance is recommended as follows:

[Example procedure to create]

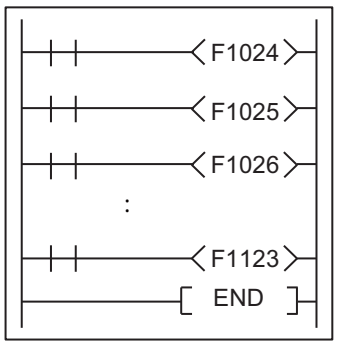
(1) Decide the interface to be used per project (example of F type).
Project 1: Use F1024 to F1123
Project 2: Use F1124 to F1223
Project 3: Use F1224 to F1323

(2) Create PLC message file to conform to the divided interface.

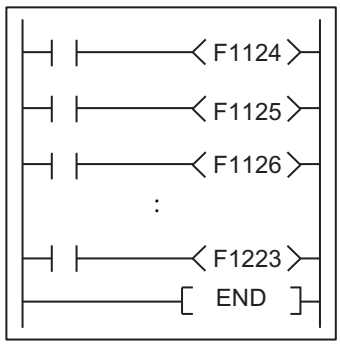
Project 1 Message file	Project 2 Message file	Project 3 Message file
;O, 0, 10, Project1 Msg001; : ;O, 98, 10, Project1 Msg099; ;O, 99, 10, Project1 Msg100; NOPLF END	;O, 100, 20, Project2 Msg001; : ;O, 198, 20, Project2 Msg099; ;O, 199, 20, Project2 Msg100; NOPLF END	;O, 200, 30, Project3 Msg001; : ;O, 298, 30, Project3 Msg099; ;O, 299, 30, Project3 Msg100; NOPLF END

(3) Create ladder circuit to conform to the divided interface.

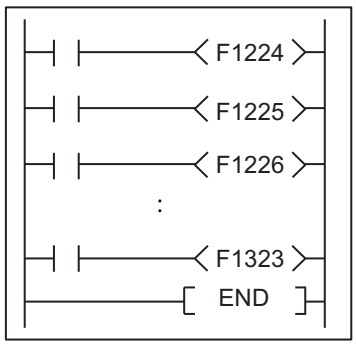
Project 1 Ladder file



Project 2 Ladder file



Project 3 Ladder file

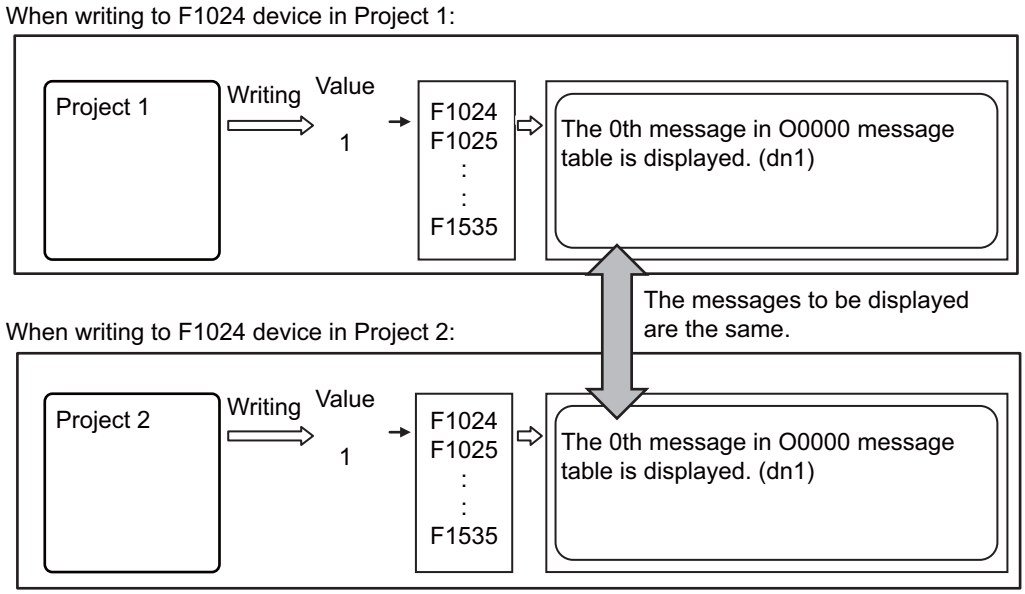


Parameters related to operator messages

Switching parameters related to operator messages are common among all projects.
When the parameters described in "Parameters" are set, the same setting will be applied to all projects.

Interface

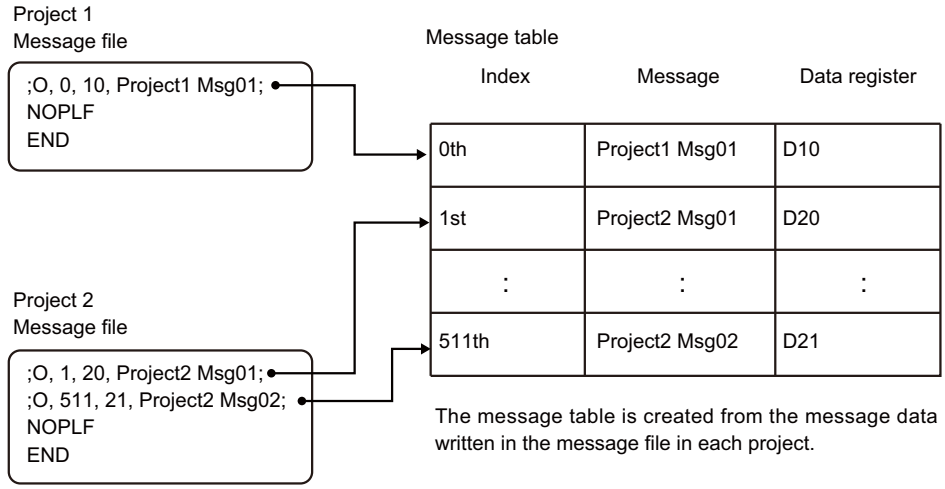
The temporary memory (F) and the file register (R) are common devices among projects (the devices which are affected by the access from multiple projects).
Therefore, even when the value is written from any project to the temporary memory (F) or the file register (R) which is the interface of the alarm messages, the common operator messages will be displayed.



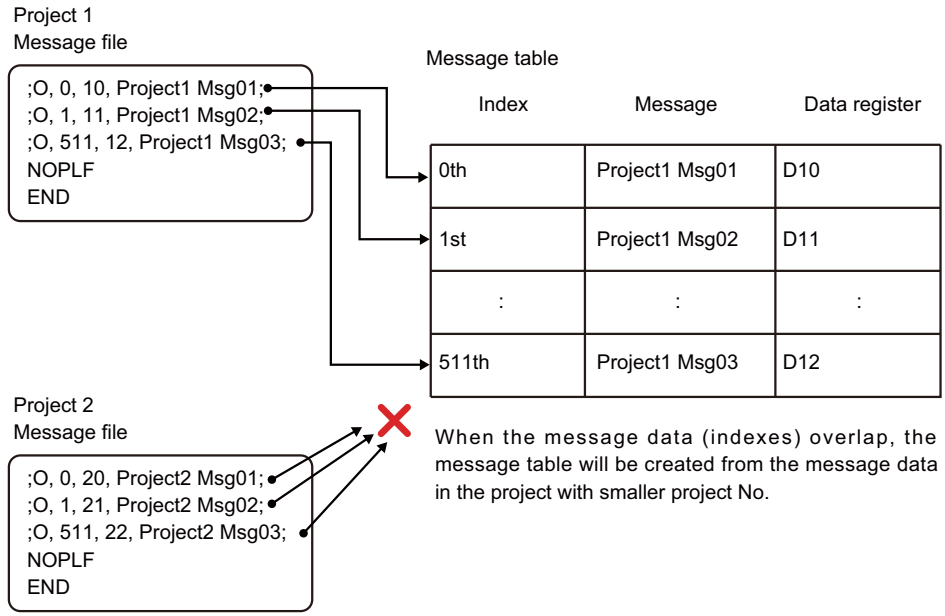
Message Table

When the message file is stored in multiple projects, one message table will be created by combining the operator message data in the message file of each project.
When the operator message data with the same index in multiple projects are written, the message of the message file stored in the project with small project No. will be displayed.

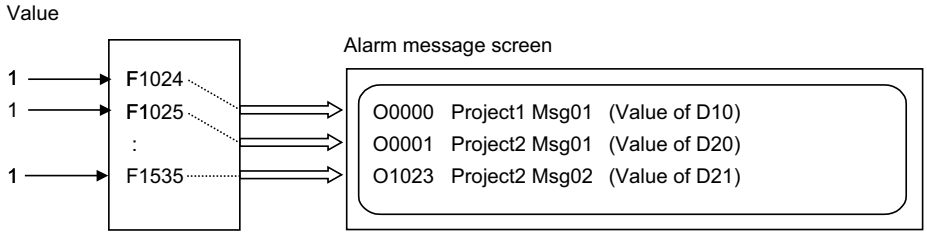
(Example 1) When the message data do not overlap:



(Example 2) When the message data overlap:



When the message is stored as in (Example 1) above, the following will be displayed on the alarm message screen (example of F type):



Supplementary information display

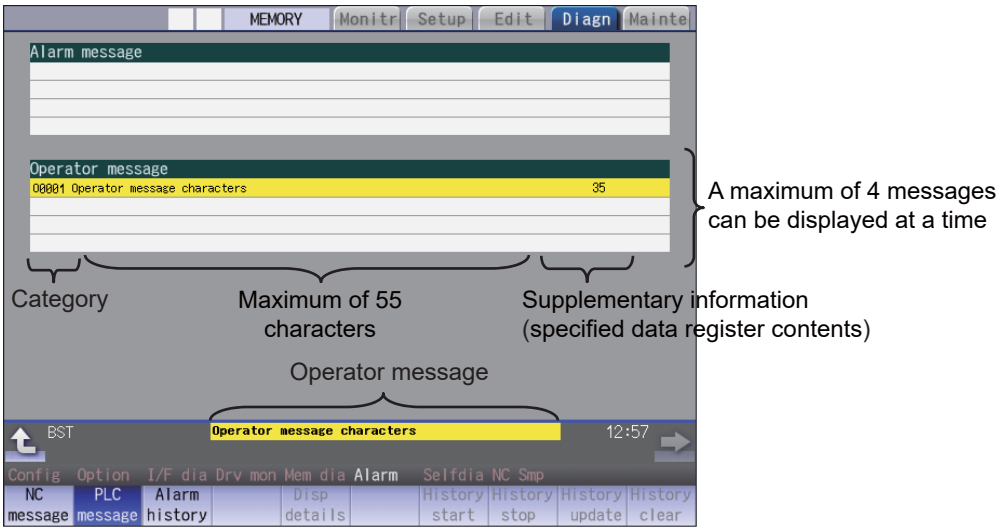
The supplementary information can be displayed after the message to be displayed regardless of the F type or R type. (Refer to "Supplementary information display" in this chapter.)

For the supplementary information, the contents of each data register specified in alarm message preparation are displayed.
When the data register is set as independent device among projects (the device which can be used in multiple projects independently), the contents of the data register which is displayed when the multi project function is valid will be the contents of data register in project 1.

When you want to display other than the project 1, set the data register to the common device among projects (the device which is affected by the access from multiple projects).(For details, refer to the section regarding the device commonizing setting in "Chapter 3 Explanation of Devices".)

12.22.3 Screen Display

Up to 4 sets of the category, message (up to 55 characters) and the classification No. can be displayed.
When the message cannot be in one line, it is displayed over two lines.
If the alarm message at the screen bottom is longer than 40 characters, the display method can be selected by the parameter "#11021 PLC mesg dip type", as to whether to display the first 40 characters or divide the message into two.
Example of setting and display unit display



(1) Category display
The category is displayed before the message to be displayed. The category indicates the message table number of the displayed message. For example, when the first message of the message table is displayed, the category is displayed as O0001.

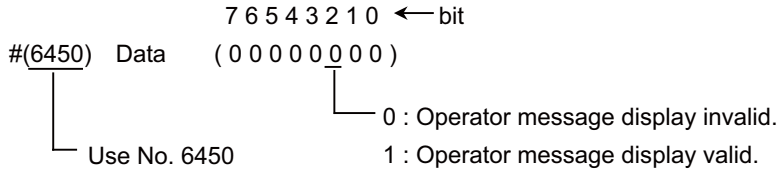
(2) Supplementary information display
The supplementary information displays the contents of the data register which is individually specified in operator message preparation. The data register D0 cannot be specified. Refer to "PLC Development Manual" for the details.
(Note) Supplementary information display is updated when the category (message table No. displayed) change. It is not updated if only the contents of the specified data register (Dn) change. To change Classification No. display only, F device or R register must be cleared to 0. If the contents of the specified data register are 0, no supplementary information is displayed.

12.22.4 Operator Message Preparation

Create messages by using a text file format or PLC development software (GX Developer).
According to the description format, set the number of characters for one message and the number of messages to be prepared, then prepare message data.
The maximum length of an operator message is 60 characters. A maximum of 512 operator messages can be prepared.
For details, refer to PLC Development Manual.

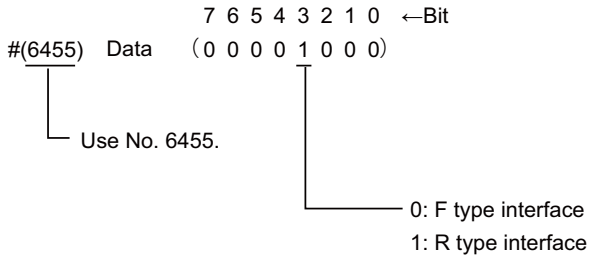
12.22.5 Parameter

(1) Operator Message Display Validity Parameter
Set the parameter on the bit selection screen of PLC parameter (setup para).
[Bit selection parameter screen]



[Reference] #6450 corresponds to the high-order byte of file register R2924.

(2) F or R type selection parameter
Set the parameter on the bit selection screen of PLC parameter (setup para).
[Bit selection parameter screen]

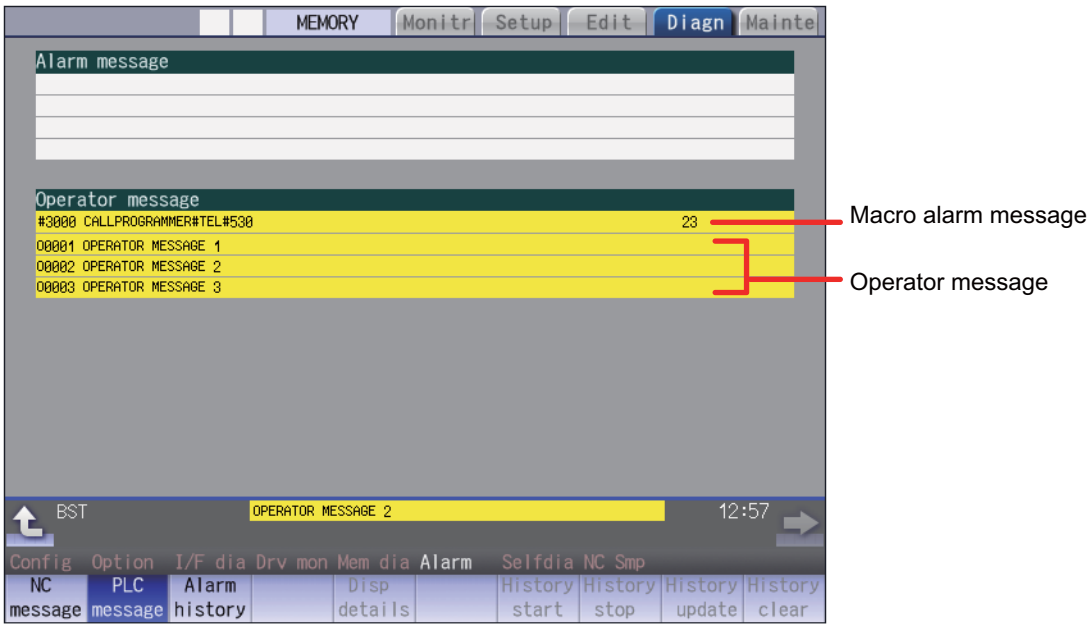


(3) Changing the operator message display format
The display format for the operator message can be switched with the parameter "#11021 PLC mesg disp type".

12.22.6 Relation with Other Function

Macro alarm message(#3000, #3006)

The macro alarm message is displayed in the first line of the operator message area.
If you use R2560 to display an operator message, the message which is output later will be displayed.
While the macro alarm message is displayed, up to three operator messages in F or R type can be displayed.
When a macro alarm message specified using machining program is displayed, all spaces are to be deleted.



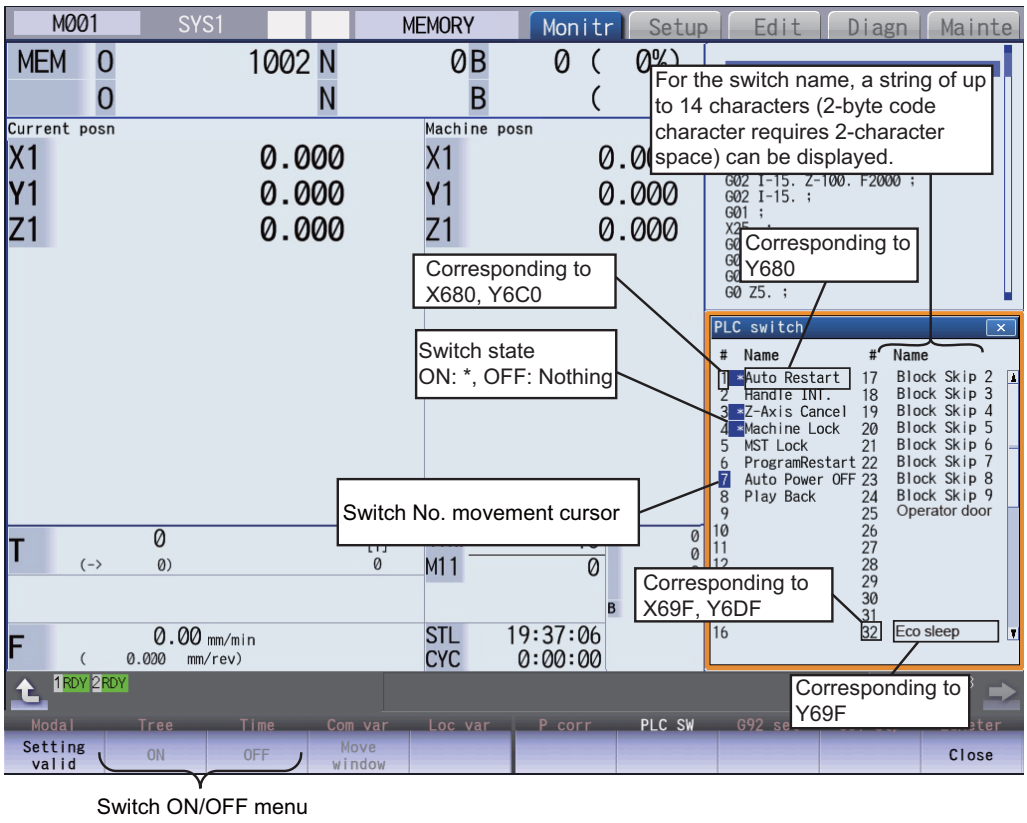
When variable #3000 is issued in the machining program, the message of the alarm No. specified by variable No. #3000 is extracted from the message file to be displayed. (Note that variable No. #3006 cannot be used to extract the corresponding message.)
In advance, describe the data such as macro alarm message No. and message itself in the message file, and import the file into the NC.
For details on creating a message file, refer to "PLC Development Manual".

12.23 PLC Switches

Similar function to machine operation switches can be provided by using the controller setting and display unit. The switches can be turned ON and OFF from the PLC Switch screen or the user PLC.
For M800 Series, 32 points of PLC switches are provided by default. The number of points can be extended up to 64 points or up to 96 points depending on the specifications.
For M80 Series, 64 points of PLC switches are provided. For E80 Series, 32 points of PLC switches are provided.
The reverse operation of the input signal by the PLC switch reverse signals works only for the available switches.
Even though the PLC switch reverse signals of the disabled switch is turned ON, the input signal is not reversed.
Up to 96 points PLC switches can be named, regardless of the status of additional specifications.

12.23.1 Explanation of Screen

The screen is explained below.



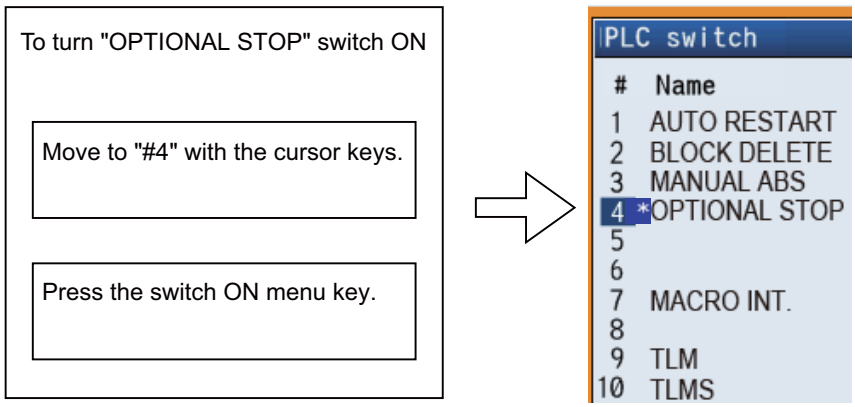
(Note 1) When you press PAGE, the previous 32 items appear and when you press PAGE, the next 32 items appear. In either case, the switch No. movement cursor moves to the first item.
When the switch No.1 (#1) is displayed, the cursor does not move.
When the last page is displayed, the cursor also does not move.

(Note 2) Press the "Setting valid" menu key to move the switch No. movement cursor with the cursor movement keys [↑] and [↓].
When the number of the switch is 32 points or more, and the cursor movement key [↓] is pressed while the switch No. movement cursor is on the last switch No. of the page, an item will be scrolled and the next No. will be displayed.
However, when the last page is displayed, the first page will be displayed and the cursor will move to the switch No.1 (#1)
When the switch No. movement cursor is on the top of the page and the cursor movement key [↑] is pressed, an item will be scrolled and the previous No. will be displayed.
However, the switch No. movement cursor is on the switch No.1 (#1), and the cursor movement key [↑] is pressed, the last page will be displayed and the cursor will move to the last switch No.

12.23.2 Explanation of Operation

To turn ON or OFF a switch, press the "setting valid" key, move to arbitrary No. with the cursor of #No., then press "ON" or "OFF" menu key.

Depending on the state of the switch, its input device X is turned ON or OFF and accordingly the switch mark indicates the ON or OFF state.



To display the switch validity state, etc., the switch name can be highlighted. To do this, turn ON or OFF output device Y corresponding to the switch name.

Reversing signal Y can reverse the switch ON/OFF states. When reversing signal Y is activated, the ON/OFF state of the corresponding switch and device X is reversed.

The corresponding table of the switch No., input device X, highlight output device Y, and reversing signal Y is listed below:

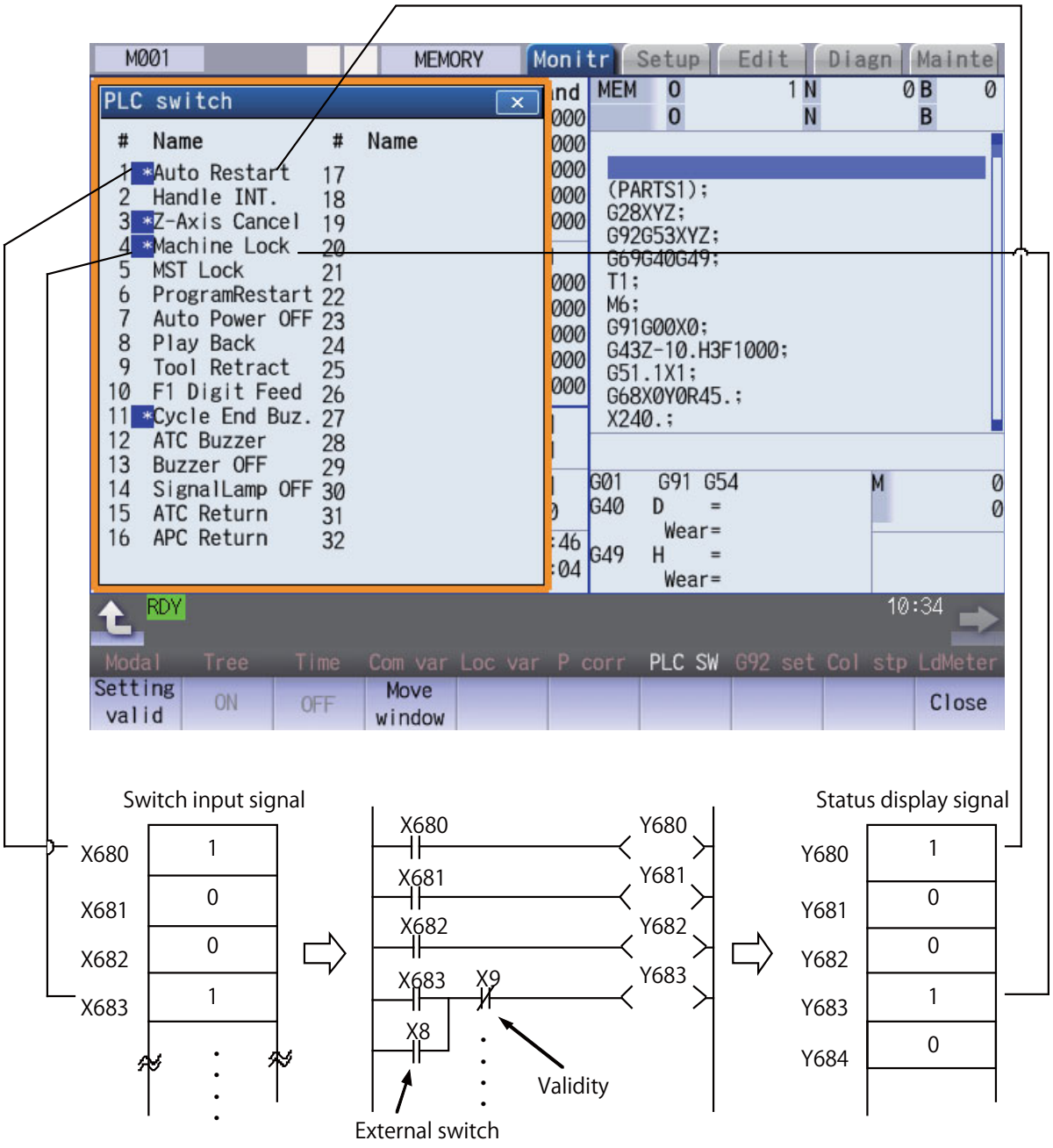
Switch No.	Corresponding device			Switch No.	Corresponding device			Switch No.	Corresponding device			Switch No.	Corresponding device		
	Input X	Output Y	Reverse Y		Input X	Output Y	Reverse Y		Input X	Output Y	Reverse Y		Input X	Output Y	Reverse Y
#1	X680	Y680	Y6C0	#17	X690	Y690	Y6D0	#33	X6A0	Y6A0	Y6E0	#49	X6B0	Y6B0	Y6F0
#2	X681	Y681	Y6C1	#18	X691	Y691	Y6D1	#34	X6A1	Y6A1	Y6E1	#50	X6B1	Y6B1	Y6F1
#3	X682	Y682	Y6C2	#19	X692	Y692	Y6D2	#35	X6A2	Y6A2	Y6E2	#51	X6B2	Y6B2	Y6F2
#4	X683	Y683	Y6C3	#20	X693	Y693	Y6D3	#36	X6A3	Y6A3	Y6E3	#52	X6B3	Y6B3	Y6F3
#5	X684	Y684	Y6C4	#21	X694	Y694	Y6D4	#37	X6A4	Y6A4	Y6E4	#53	X6B4	Y6B4	Y6F4
#6	X685	Y685	Y6C5	#22	X695	Y695	Y6D5	#38	X6A5	Y6A5	Y6E5	#54	X6B5	Y6B5	Y6F5
#7	X686	Y686	Y6C6	#23	X696	Y696	Y6D6	#39	X6A6	Y6A6	Y6E6	#55	X6B6	Y6B6	Y6F6
#8	X687	Y687	Y6C7	#24	X697	Y697	Y6D7	#40	X6A7	Y6A7	Y6E7	#56	X6B7	Y6B7	Y6F7
#9	X688	Y688	Y6C8	#25	X698	Y698	Y6D8	#41	X6A8	Y6A8	Y6E8	#57	X6B8	Y6B8	Y6F8
#10	X689	Y689	Y6C9	#26	X699	Y699	Y6D9	#42	X6A9	Y6A9	Y6E9	#58	X6B9	Y6B9	Y6F9
#11	X68A	Y68A	Y6CA	#27	X69A	Y69A	Y6DA	#43	X6AA	Y6AA	Y6EA	#59	X6BA	Y6BA	Y6FA
#12	X68B	Y68B	Y6CB	#28	X69B	Y69B	Y6DB	#44	X6AB	Y6AB	Y6EB	#60	X6BB	Y6BB	Y6FB
#13	X68C	Y68C	Y6CC	#29	X69C	Y69C	Y6DC	#45	X6AC	Y6AC	Y6EC	#61	X6BC	Y6BC	Y6FC
#14	X68D	Y68D	Y6CD	#30	X69D	Y69D	Y6DD	#46	X6AD	Y6AD	Y6ED	#62	X6BD	Y6BD	Y6FD
#15	X68E	Y68E	Y6CE	#31	X69E	Y69E	Y6DE	#47	X6AE	Y6AE	Y6EE	#63	X6BE	Y6BE	Y6FE
#16	X68F	Y68F	Y6CF	#32	X69F	Y69F	Y6DF	#48	X6AF	Y6AF	Y6EF	#64	X6BF	Y6BF	Y6FF

Switch No.	Corresponding device			Switch No.	Corresponding device		
	Input X	Output Y	Reverse Y		Input X	Output Y	Reverse Y
#65	X1C40	Y1C40	Y1C60	#81	X1C50	Y1C50	Y1C70
#66	X1C41	Y1C41	Y1C61	#82	X1C51	Y1C51	Y1C71
#67	X1C42	Y1C42	Y1C62	#83	X1C52	Y1C52	Y1C72
#68	X1C43	Y1C43	Y1C63	#84	X1C53	Y1C53	Y1C73
#69	X1C44	Y1C44	Y1C64	#85	X1C54	Y1C54	Y1C74
#70	X1C45	Y1C45	Y1C65	#86	X1C55	Y1C55	Y1C75
#71	X1C46	Y1C46	Y1C66	#87	X1C56	Y1C56	Y1C76
#72	X1C47	Y1C47	Y1C67	#88	X1C57	Y1C57	Y1C77
#73	X1C48	Y1C48	Y1C68	#89	X1C58	Y1C58	Y1C78
#74	X1C49	Y1C49	Y1C69	#90	X1C59	Y1C59	Y1C79
#75	X1C4A	Y1C4A	Y1C6A	#91	X1C5A	Y1C5A	Y1C7A
#76	X1C4B	Y1C4B	Y1C6B	#92	X1C5B	Y1C5B	Y1C7B
#77	X1C4C	Y1C4C	Y1C6C	#93	X1C5C	Y1C5C	Y1C7C
#78	X1C4D	Y1C4D	Y1C6D	#94	X1C5D	Y1C5D	Y1C7D
#79	X1C4E	Y1C4E	Y1C6E	#95	X1C5E	Y1C5E	Y1C7E
#80	X1C4F	Y1C4F	Y1C6F	#96	X1C5F	Y1C5F	Y1C7F

(Note 1) Input devices X hold the state even if power is turned OFF.

(Note 2) Switches #33 to #64 are available when 64 points of switches are provided.
Switches #65 to #96 are available when 96 points of switches are provided.

12.23.3 Signal Processing

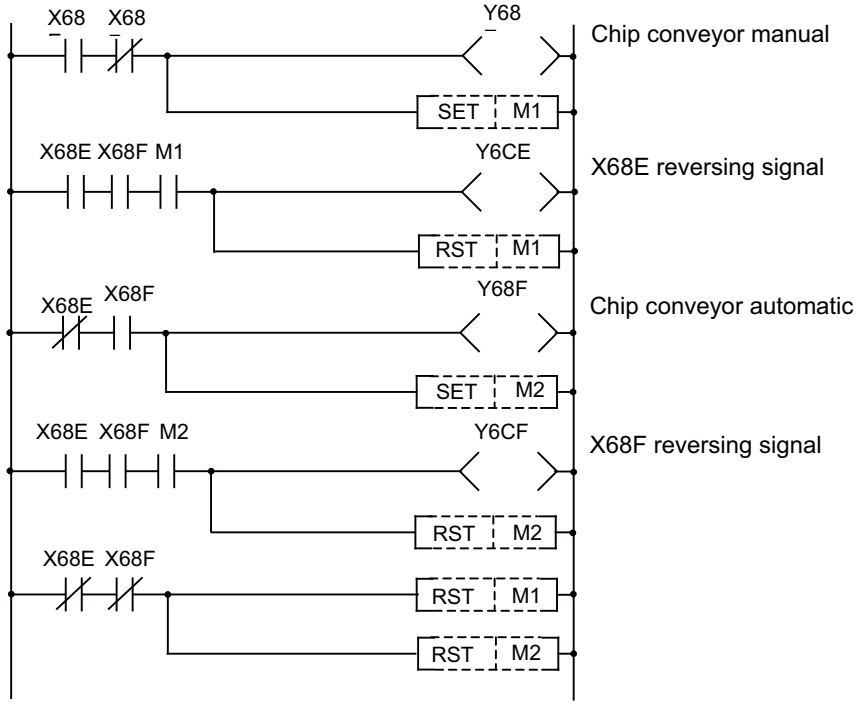


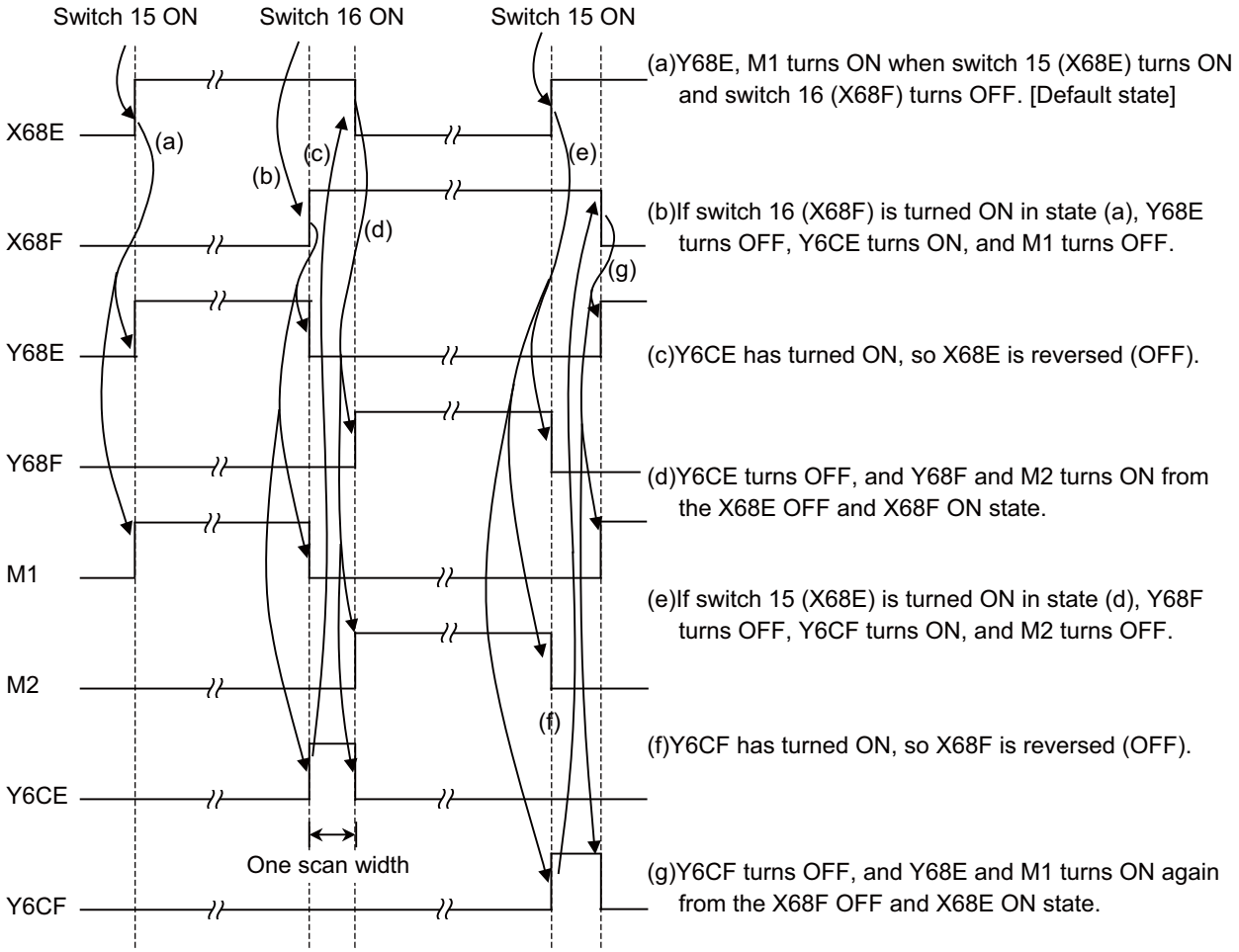
- When setting is done on the PLC switch screen, the input device X corresponding to the specified switch No. is turned ON or OFF to switch over the switch state.
- When reversing signal Y is turned ON from the user PLC, its corresponding input device X and the switch state are reversed. Reversing signal Y is reset immediately after the CNC reverses the input device X and the switch state. It is turned ON by one pulse (scan) only also in the user PLC. In either case, when output device Y is set to ON based on the input device X state, the corresponding switch name is highlighted.

The following shows an example of operation of reversing signal Y from the user PLC.

(1) Two-point switch

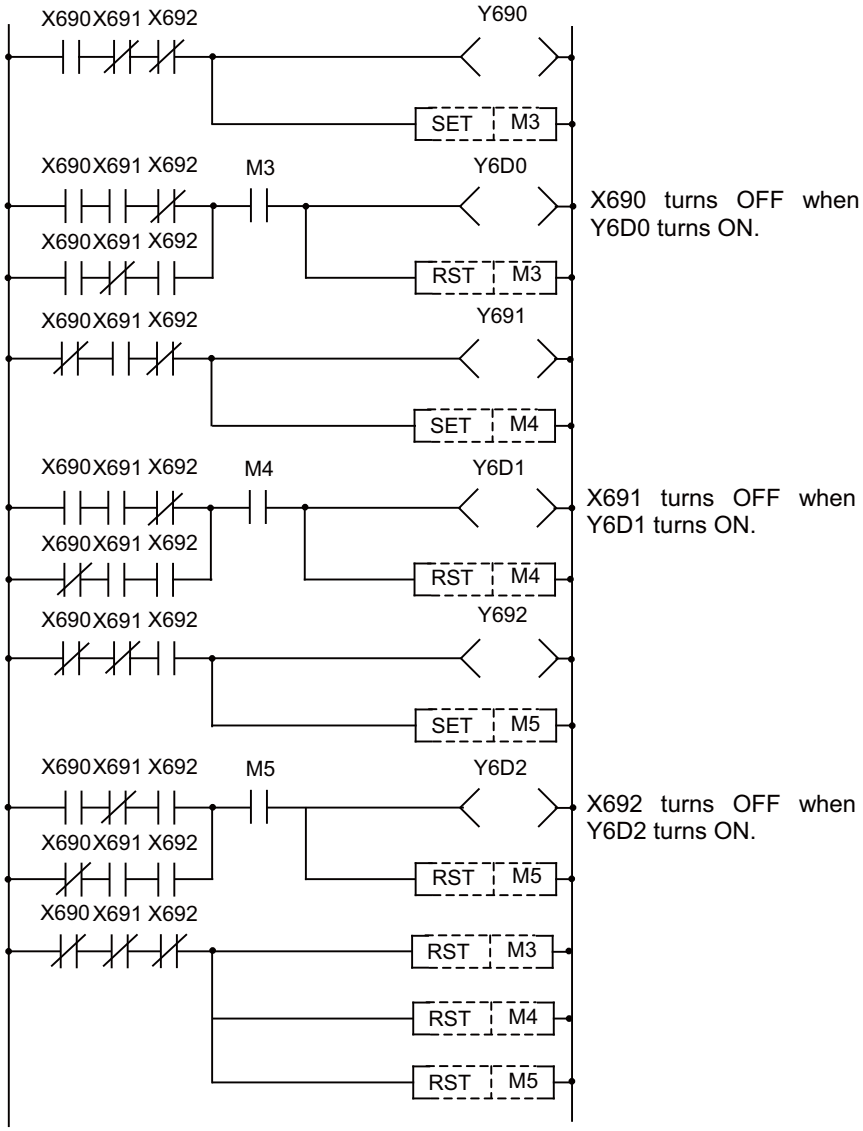
(Example) When two opposite switches, chip conveyer manual and chip conveyer automatic, are provided;





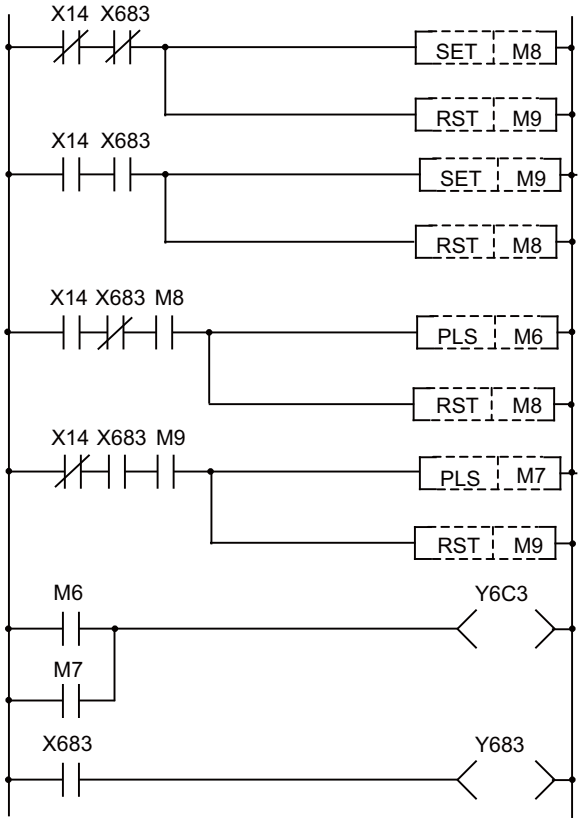
(2) Three-point switch

(Example) When three opposite switches 17, 18, and 19 are provided;



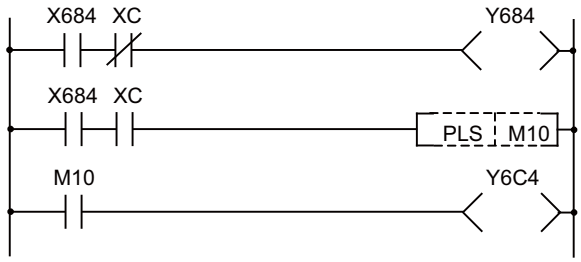
(3) External switch and PLC switch

(Example 1) When an external optional stop switch (X14) is provided;



Under sequence control in the above example, the switch marks on the PLC switch screen can be operated from both external and PLC switches.

(Example 2) When an external switch (XC) that inhibits a PLC switch handle interrupt is provided;



Under sequence control in the above example, when the external switch (XC) is ON, the PLC switch for a handle interrupt cannot be turned ON.

12.23.4 Switch Name Preparation

Prepare PLC switch names by using a text file format or PLC development software (GX Developer).
According to the description format, set the number of characters for one switch name and the number of points for switches, then prepare switch name data. The maximum length of a switch name is 14 characters. A maximum of 96 switch names (#1 to #96) can be prepared regardless of the number of switches.

(Note) With 32 points of switches, a maximum of 32 points are displayed on the PLC switch screen display and are available for input signal reversing with the PLC switch reverse signals.

For details, refer to "PLC Development Manual".

12.23.5 Non-display of the PLC Switch

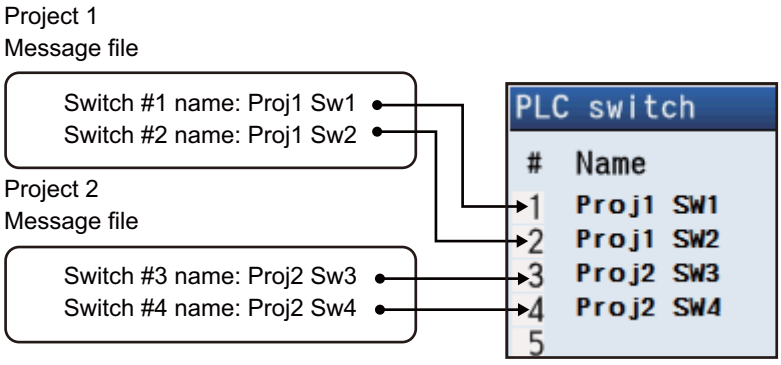
A PLC switch name can be hidden.
To hide the PLC switch name, turn ON the "PLC switch non-display" signal (ZR) corresponding to each switch name.
When the PLC switch name is hidden, the switch No. movement cursor can still move to the hidden switch No., but the menu keys [ON] and [OFF] are grayed out and cannot be turned ON/OFF.
Even when you turn ON the "PLC switch reversed display" signal Y of the hidden switch No., the switch name is not highlighted.

12.23.6 Linking with Multi-project

This chapter explains the operations in case that the PLC message files created by the PLC development software (GX Developer) are stored in multiple projects when multi-project function is valid.

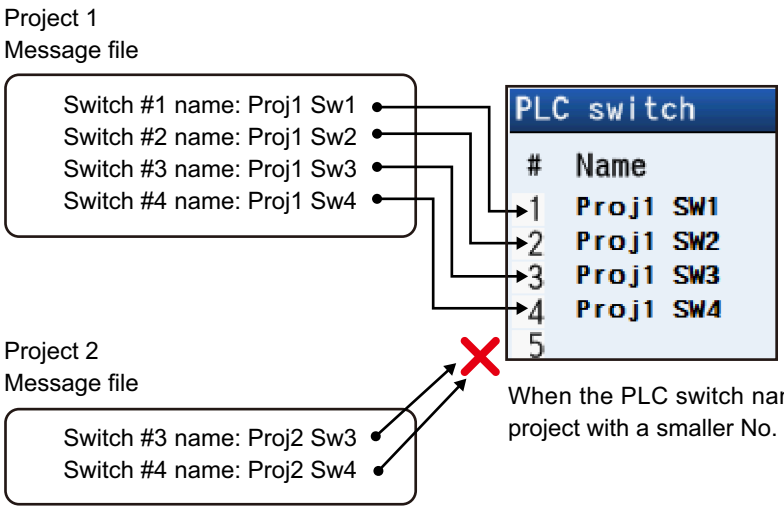
When the message files are stored in multiple projects, the combination of the PLC switch name written in the message file in each project will be displayed.
When the same PLC switch name is written in multiple projects, the PLC switch name of the message file stored in the project with small No. will be displayed.

[When the PLC switch names do not overlap]



The PLC switch names described in message files of each project are combined and displayed.

[When the PLC switch names overlap]



When the PLC switch names overlap, the name of the project with a smaller No. will be displayed.

Therefore, when the PLC switches are used in multi-project environment, the method to use the switches by dividing them per project in advance is recommended as follows:

[Example procedure to create]

(1) Decide the switches to use for each project
Project 1:Use the switches #1 to #10
Project 2:Use the switches #11 to #20
Project 3:Use the switches #21 to #30

(2) Create PLC message files according to the divided switches

Project 1 Message file	Project 2 Message file	Project 3 Message file
Switch #1 Name:Prj1 Sw1 Switch #2 Name:Prj1 Sw2 : Switch #10 Name:Prj1 Sw10	Switch #11 Name:Prj2 Sw1 Switch #12 Name:Prj2 Sw2 : Switch #20 Name:Prj2 Sw10	Switch #21 Name:Prj3 Sw1 Switch #22 Name:Prj3 Sw2 : Switch #30 Name:Prj3 Sw10

(3) Create ladder circuits for each project according to the divided switches

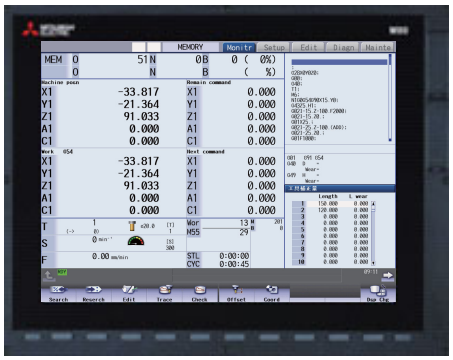
12.24 GOT Connection

12.24.1 Outline

This function connects and communicates between Mitsubishi Graphic Operation Terminal (GOT) and Mitsubishi Electric CNC.
Only GOT2000 series can be connected. Soft GOT 2000 can be connected, too.
There are two connection methods for GOT connection, Ethernet connection and CC-Link connection.

Operation and monitoring from GOT to PLC device of the NC can be performed, and GOT can be used as a sub monitor of peripheral operation panel or NC operation panel.

M8 series



Operation of PLC device

Monitoring PLC device

GOT2000 series



12.24.2 Enabling Conditions

To use GOT connection function, the NC parameter setting is required.

When using Ethernet connection

Use SLMP server function of NC to connect.
Set the parameter "#1489 SLMP_on" to "1" and then restart the unit. After restarted, SLMP server function is valid.
When SLMP server function is invalid, the connection between NC and GOT cannot be performed.

When using CC-Link communication function

Set "CC-Linkparam 1" and "CC-Linkparam 2" properly and then restart the unit.
After restarted, the parameter setting is reflected.

12.24.3 Connectable GOT Models

Connectable GOT models are as follows.

Connection method	Connection protocol	Connectable model
Ethernet connection	SLMP	GT21, GT25, GT27, SoftGOT2000 *1
CC-Link connection	CC-Link	GT25, GT27 *2

*1 For devices which can use Ethernet connection and have SLMP client function only.
*2 CC-Link connection unit needs to be mounted.

12.24.4 Available GOT Function

Available functions on GOT when connected with the NC differ depending on GOT model or connection method. For details, refer to each GOT manual.
"GOT2000 Series User's Manual (Hardware) SH-081194"
"GOT2000 Series User's Manual (Utility) SH-081195"
"GOT2000 Series User's Manual (Monitor) SH-081196"
"GOT2000 Series Connection Manual (Mitsubishi Electric Products) SH-081197"
"GOT2000 Series Connection Manual (Non-Mitsubishi Electric Products 1) SH-081198ENG"
"GOT2000 Series Connection Manual (Non-Mitsubishi Electric Products 2) SH-081199ENG"
"GOT2000 Series Connection Manual (Microcomputers, MODBUS/Fieldbus Products, Peripherals) SH-081200ENG"
"GT SoftGOT2000 Version1 Operating Manual SH-081201ENG"
"GT Designer3 (GOT2000) Screen Design Manual SH-081220"

12.24.5 Device Range Accessible from GOT

The following table shows PLC device type and device range accessible from GOT.

PLC device	Accessible range	When using multi-project function (When the additional specification of 6 PLC projects is valid)		Details
		Accessible range	Project total maximum points	
M	M0 to M61439(61440 points)	M0 to M61439	122880 points	Temporary memory
SM	SM0 to SM2047(2048 points)	SM0 to SM2047	2048 points	Special relay
L	L0 to L1023(1024 points)	L0 to L2047	2048 points	Latch relay
F	F0 to F2047(2048 points)	F0 to F2047	2048 points	Temporary memory
V	V0 to V511(512 points)	V0 to V1023	1024 points	Edge relay
X	X0 to X1FFF(8192 points)	X0 to X1FFF	8192 points	Input signal to PLC
Y	Y0 to Y1FFF(8192 points)	Y0 to Y1FFF	8192 points	Output signal from PLC
B	B0 to BDFFF(57344 points)	B0 to B1BFFF	114688 points	Link relay
SB	SB0 to SB3FF(1024 points)	SB0 to SB7FF	2048 points	Special relay
D	D0 to D4095(4096 points)	D0 to D8191	8192 points	Data register
SD	SD0 to SD2047(2048 points)	SD0 to SD2047	2048 points	Special register
R	R0 to R32767(32768 points)	R0 to R32767	32768 points	File register
ZR	ZR0 to ZR13311(13312 points)	ZR0 to ZR13311	13312 points	File register
W	W0 to W2FFF(12288 points)	W0 to W5FFF	24576 points	Link register
SW	SW0 to SW3FF(1024 points)	SW0 to SW7FF	2048 points	Special register
TI	TI0 to TI2047(2048 points)	TI0 to TI4095	4096 points	Timer (coil)
TO	TO0 to TO2047(2048 points)	TO0 to TO4095	4096 points	Timer (contact)
TA	TA0 to TA2047(2048 points)	TA0 to TA4095	4096 points	Timer (present value)
CI	CI0 to CI511(512 points)	CI0 to CI1023	1024 points	Counter (coil)
CO	CO0 to CO511(512 points)	CO0 to CO1023	1024 points	Counter (contact)
CA	CA0 to CA511(512 points)	CA0 to CA1023	1024 points	Counter (present value)
STI	STI0 to STI127(128 points)	STI0 to STI255	256 points	Integrated timer (coil)
STO	STO0 to STO127(128 points)	STI0 to STO255	256 points	Integrated timer (contact)
STA	STA0 to STA127(128 points)	STI0 to STI255	256 points	Integrated timer (present value)

When setting the device which does not exit in the NC to GOT object, the object is not displayed on GOT. Unrelated object may not be displayed on GOT screen.
By setting the number of reading device points to "1" with the setting of GOT connected device or SoftGOT communication setting, the phenomenon that the unrelated object is not displayed can be prevented; however, the communication load becomes large.

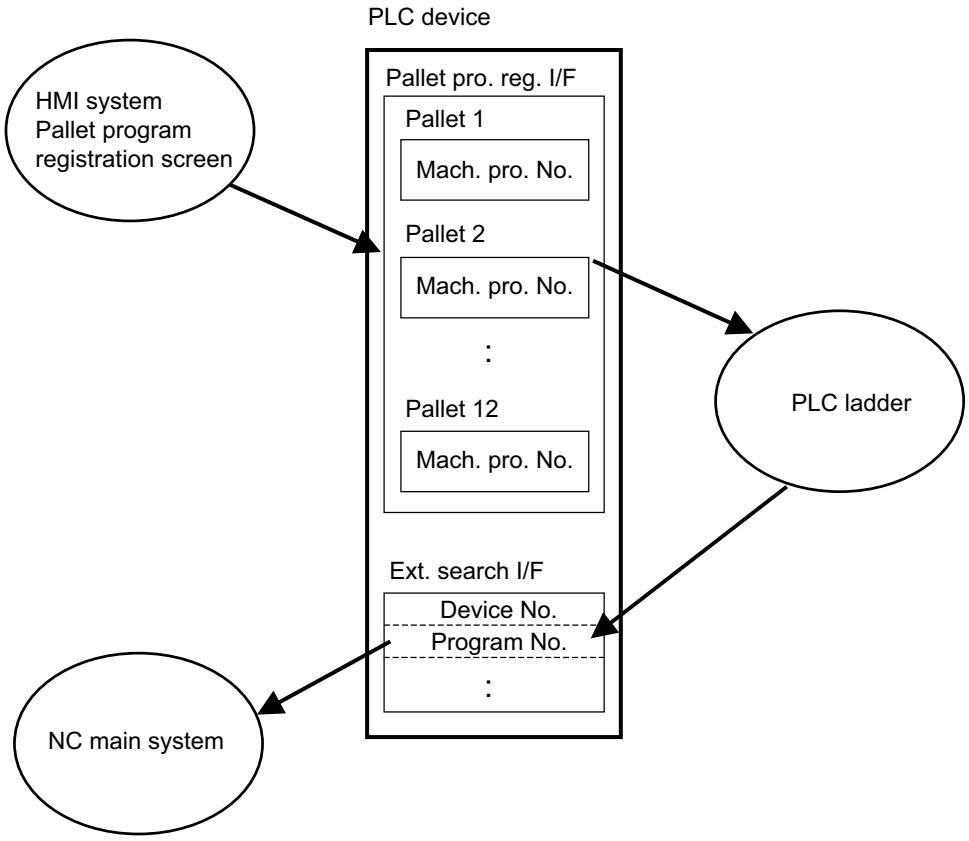
12.25 Pallet Program Registration

The pallet program registration function allows machining programs to be registered to each pallet of the automatic pallet changer (hereinafter APC) and supports setups of the machining.
Operation search for the registered program is executed by the PLC ladder using the external function.
This function is applicable to the machining center.

Operations

Machining programs are registered to each pallet in the "pallet program registration" screen under the group of setup screen.
Registered programs are output to the PLC devices.
As required, PLC ladder executes an external search by referring to the program No. registered in each pallet.
The number of pallets that can be registered differs depending on to which screen the pallets are registered.

- Standard pallet registration screen: Max. 2 pallets
- Pallet 4 page registration screen: Max. 12 pallets



Pallet registration function data flow

NC → PLC interface signal

Device	Signal name	
	Standard pallet registration screen	Pallet 4 page registration screen
X758	Spare	Pallet program registration Ext. workpiece coordinate transfer completion

Cont.	Signal name	Abbrev.	Common($)
A	PALLET PROGRAM REGISTRATION EXT. WORKPIECE COORDINATE TRANSFER COMPLETION [M8]		X758

[Function][Operation]

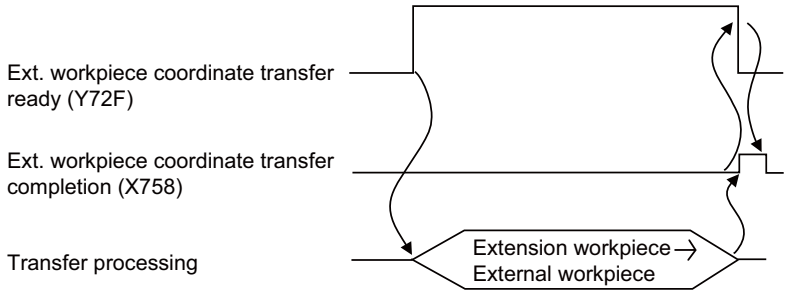
Completion of transfer from extension workpiece coordinate to external workpiece coordinate offset (EXT) during pallet 4 page registration is displayed.

This signal turns ON at the completion of transfer processing.

This signal turns OFF when external workpiece coordinate transfer ready is turned OFF.

The transferred external workpiece coordinate offset (EXT) will be effective as soon as when this signal is turned ON.

[Timing chart]



[Related signals]

(1) Pallet program registration Ext. workpiece coordinate transfer ready (Y72F)

Screen data is output to the following PLC devices.

Device	Signal name	
	Standard pallet registration screen	Pallet 4 page registration screen
R2100	Pallet program search valid/invalid state 0: Invalid 1: Valid	Pallet program search valid/invalid state 0: Invalid 1: Valid
R2101	Continuous start valid/invalid state 0: Invalid 1: Valid	Continuous start valid/invalid state 0: Invalid 1: Valid
R2102	Spare	Pallet registration specification 0: Standard pallet registration screen 1: Pallet 4 page registration screen
R2103	Spare	Number of valid pallets (Setting range: 2 to 12)
R2110	Pallet 1 Machining program device No. 0: Memory 1: HD 2: DS 3: FD 4: Memory card	Pallet 1 0° Machining program device No. 0: Memory 1: HD 2: DS 3: FD 4: Memory card
R2111	Pallet 1 Machining valid/invalid state 0: Invalid 1: Valid	Pallet 1 0° Machining valid/invalid state 0: Invalid 1: Valid
R2112,R2113	Pallet 1 Machining program No.	Pallet 1 0° Machining program No.
R2114	Pallet 1 Auxiliary data	Pallet 1 0° Auxiliary data
R2115	Spare	Spare
R2116	Pallet 2 Machining program device No. 0: Memory 1: HD 2: DS 3: FD 4: Memory card	Pallet 1 90° Machining program device No. 0: Memory 1: HD 2: DS 3: FD 4: Memory card
R2117	Pallet 2 Machining valid/invalid state 0: Invalid 1: Valid	Pallet 1 90° Machining valid/invalid state 0: Invalid 1: Valid
R2118,R2119	Pallet 2 Machining program No.	Pallet 1 90° Machining program No.
R2120	Pallet 2 Auxiliary data	Pallet 1 90° Auxiliary data
R2121	Spare	Spare
R2122	Spare	Pallet 1 180° Machining program device No. 0: Memory 1: HD 2: DS 3: FD 4: Memory card
R2123	Spare	Pallet 1 180° Machining valid/invalid state 0: Invalid 1: Valid
R2124,R2125	Spare	Pallet 1 180° Machining program No.
R2126	Spare	Pallet 1 180° Auxiliary data
R2127	Spare	Spare
R2128	Spare	Pallet 1 270° Machining program device No. 0: Memory 1: HD 2: DS 3: FD 4: Memory card
R2129	Spare	Pallet 1 270° Machining valid/invalid state 0: Invalid 1: Valid
R2130,R2131	Spare	Pallet 1 270° Machining program No.
R2132	Spare	Pallet 1 270° Auxiliary data

Device	Signal name	
	Standard pallet registration screen	Pallet 4 page registration screen
R2133	Spare	Spare
R2134	Spare	Pallet 2 0° Machining program device No. 0: Memory 1: HD 2: DS 3: FD 4: Memory card
R2135	Spare	Pallet 2 0° Machining valid/invalid state 0: Invalid 1: Valid
R2136,R2137	Spare	Pallet 2 0° machining program No.
R2138	Spare	Pallet 2 0° Auxiliary data
R2139	Spare	Spare
R2140	Spare	Pallet 2 90° Machining program device No. 0: Memory 1: HD 2: DS 3: FD 4: Memory card
R2141	Spare	Pallet 2 90° Machining valid/invalid state 0: Invalid 1: Valid
R2142,R2143	Spare	Pallet 2 90° Machining program No.
R2144	Spare	Pallet 2 90°Auxiliary data
R2145	Spare	Spare
R2146	Spare	Pallet 2 180° Machining program device No. 0: Memory 1: HD 2: DS 3: FD 4: Memory card
R2147	Spare	Pallet 2 180° Machining valid/invalid state 0: Invalid 1: Valid
R2148,R2149	Spare	Pallet 2 180° Machining program No.
R2150	Spare	Pallet 2 180° Auxiliary data
R2151	Spare	Spare
R2152	Spare	Pallet 2 270° Machining program device No. 0: Memory 1: HD 2: DS 3: FD 4: Memory card
R2153	Spare	Pallet 2 270° Machining valid/invalid state 0: Invalid 1: Valid
R2154,R2155	Spare	Pallet 2 270° Machining program No.
R2156	Spare	Pallet 2 270° Auxiliary data
R2157	Spare	Spare
R2158 to R2397	Spare	Data for pallet 3 to 12 can be registered in the same manner.

PLC → NC interface signal

Device	Signal name	
	Standard pallet registration screen	Pallet 4 page registration screen
Y72E	Pallet program registration In APC execution 0: In place 1: In execution	Pallet program registration In APC execution 0: In place 1: In execution
Y72F	Spare	Pallet program registration Ext. workpiece coordinate transfer ready 0: Transfer not ready 1: Transfer ready After the signals relating to pallet information in the machine and index plane of the pallet in the machine are set, PLC sets this signal. When this signal is turned to "1", NC system transfers the extension workpiece coordinate offset data to external workpiece coordinate offset (EXT).

Cont.	Signal name	Abbrev.	Common($)
A	PALLET PROGRAM REGISTRATION EXT. WORKPIECE COORDINATE TRANSFER READY [M8]		Y72F

[Function][Operation]

When transferring external workpiece coordinate offset (EXT) in the pallet 4 page registration, turn this signal ON. NC starts transfer processing at the rising edge of this signal.

When the external workpiece coordinate transfer completion signal is turned ON, turn this signal OFF.

It takes approx. 8ms from the start to the end of transfer processing. If the transfer completion signal is not turned ON even after 8ms has passed since the transfer ready signal was turned ON, reconsider the value of R register 4100 and 4102.

NC turns the external workpiece coordinate transfer completion signal OFF at the falling edge of this signal.

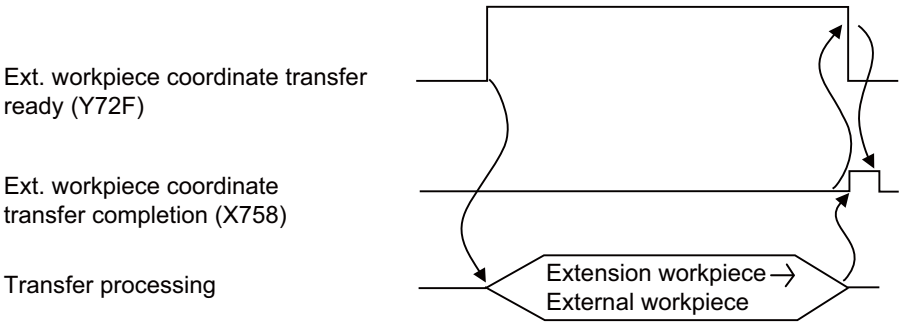
When turning the transfer ready signal ON from the machining program, recalculation request and M function finish (FIN1 or FIN2) must be turned ON after the external workpiece coordinate transfer completion signal is turned ON.

When recalculation is not requested, operation of the pre-read machining program will be carried out using the external workpiece coordinate offset prior to the change.

When M function has been completed before transfer is completed, the external workpiece coordinate offset data to be used in the machining program will not be changed from the one prior to the change until the transfer completion signal is turned ON.

This signal must be turned ON while the external workpiece coordinate transfer completion signal is OFF.

[Timing chart]



[Related signals]

(1) Pallet program registration Ext. workpiece coordinate transfer completion (X758)

Device	Signal name	
	Standard pallet registration screen	Pallet 4 page registration screen
R4100	Pallet information in the machine bit0 :ON - Pallet 1 in the machine bit1 :ON - Pallet 2 in the machine : bit11:ON Pallet 12 in the machine	Pallet information in the machine bit0 :ON - Pallet 1 in the machine bit1 :ON - Pallet 2 in the machine : bit11:ON - Pallet 12 in the machine
R4101	Auxiliary function 0: Not available, 1: Available	Auxiliary function 0: Not available, 1: Available
R4102	Spare	Index plane of the pallet in the machine 0:0°, 1:90°, 2:180°, 3:270°
R4103	Spare	Machining valid/invalid setting disabled (For pallet details) 0: Invalid (Machining setting enabled) 1: Valid (Machining setting disabled)
R2111	Spare (PLC → NC setting not possible on the standard pallet registration screen)	Pallet 1 0° Machining valid/invalid state 0: Invalid 1: Valid
R2117	Spare (PLC → NC setting not possible on the standard pallet registration screen)	Pallet 1 90° Machining valid/invalid state 0: Invalid 1: Valid
R2123	Spare	Pallet 1 180° Machining valid/invalid state 0: Invalid 1: Valid
R2129	Spare	Pallet 1 270° Machining valid/invalid state 0: Invalid 1: Valid
R2135	Spare	Pallet 2 0° Machining valid/invalid state 0: Invalid 1: Valid
R2141	Spare	Pallet 2 90° Machining valid/invalid state 0: Invalid 1: Valid
R2147	Spare	Pallet 2 180° Machining valid/invalid state 0: Invalid 1: Valid
R2153	Spare	Pallet 2 270° Machining valid/invalid state 0: Invalid 1: Valid
		Machining data for pallet 3 to 12 can be registered in the same manner.

Precautions

(1) Only the program with a file name using decimal number (1 to 99999999) can be registered.Program in HD, DS, FD and memory card can be registered besides one in NC memory; however, the program is limited to the one in root directory.

(2) Number of pallets to be registered:
- Standard pallet registration screen: Max. 2 pallets
- Pallet 4 page registration screen: Max. 12 pallets

(3) Error message appears according to the PLC device value regardless of the operation status.

(4) The setting range for auxiliary function data is -32768 to 32767.

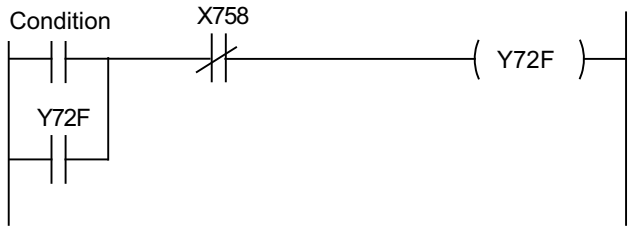
(5) The parameter "#11001 APC type (APC screen display type selection)" and "#11002 Valid pallet num (Number of pallets designation)" are set to R register 912/913 only at the power ON.

(6) When external workpiece coordinate transfer ready (Y78F) is turned ON/OFF without a break, transfer is carried out, but the transfer completion signal (X758) will not be output.

(7) This function is available only in the 1st part system, no matter which part system it is operated in.

Usage example

An example of ladder when external workpiece coordinate offset (EXT) is transferred in the pallet 4 page registration is given below.



12.26 Simple Inclined Surface Machining Command

12.26.1 Outline

In a lathe with three orthogonal axes and one rotary axis on the tool side, this function enables simultaneous 4-axis control milling on an inclined surface along workpiece end face.
To facilitate machining on an inclined surface, this function uses three commands: simple inclined surface control (G176), simple tool center point control (G174), and tool axis direction control (G53.1) as follows. The tool axis direction can be turned at right angles to the inclined surface by issuing the tool axis direction control command (G53.1) after the simple inclined surface control command (G176). When G174 is given after G176, the direction of tool length is compensated in accordance with the tool angle.
For a machine configured with a turret, this function allows you to use any tool on the turret to carry out simple inclined surface machining.

(1) Simple inclined surface control (G176)

G176 enables a new coordinate system (called "feature coordinate system") to be defined. Feature coordinate system is obtained by rotating and parallel translating a plane using the X, Y and Z axes configuring the workpiece coordinate system as a rotary axis. Consequently, there is no need to calculate the coordinate position in accordance with the inclined surface angle. This simplifies creation of a machining program.

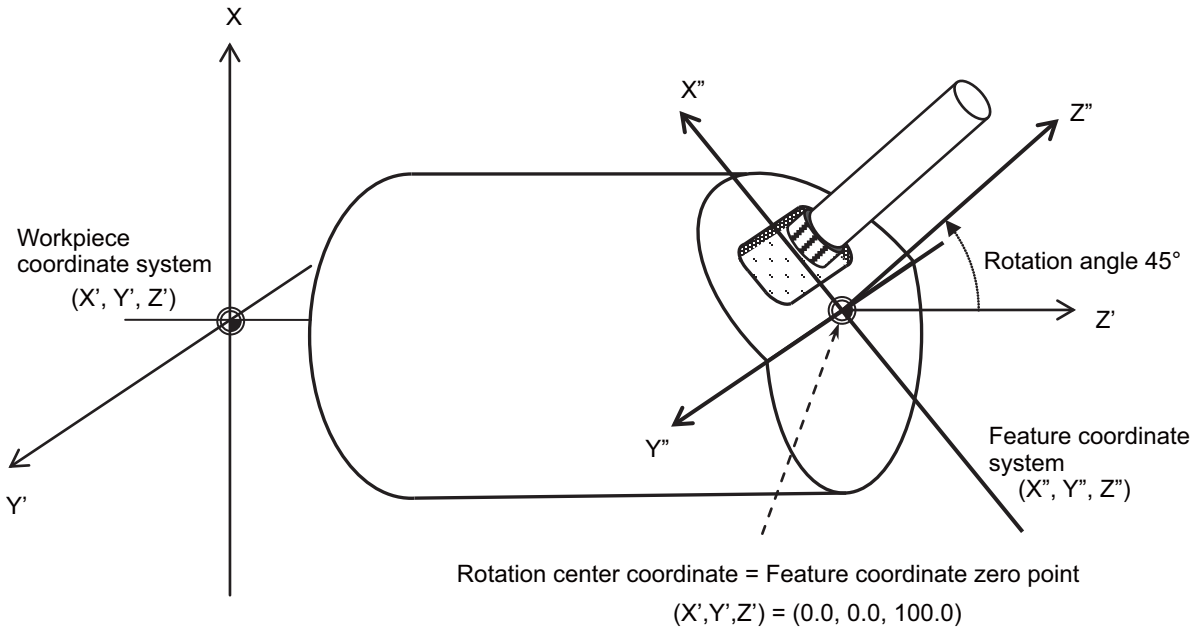
(2) Simple tool center point control (G174)

G174 allows a tool length offset in the tool axis direction even when the tool axis direction is not parallel to the orthogonal coordinate system after rotation of the rotary axis. Consequently, the nose of the tool mounted on the rotary axis can be kept in the programmed position at all times. This simplifies creation of a complicated-shape machining program.

(3) Tool axis direction control (G53.1)

G53.1 aligns the tool with the + Z direction of the feature coordinate system. This eliminates the need for you to mind the feature coordinate system's direction or tool axis' rotation direction, resulting in greater ease of programming.

Feature coordinate system



For details of each G code command, refer to the programming manual.

12.26.2 How to apply tool axis rotation angle compensation amount (G174)

If you want to perform simple tool center point control (G174) or tool axis direction control (G53.1) using a tool that is not parallel to Z (-) of the machine coordinate system while the tool axis rotation angle is at 0 degree, the simple tool center point control (G174) or tool axis direction control (G53.1) can be implemented by specifying the tool axis rotation angle compensation amount (offset angle).
This is effective, for instance, when you use any tool mounted on a turret for machining.

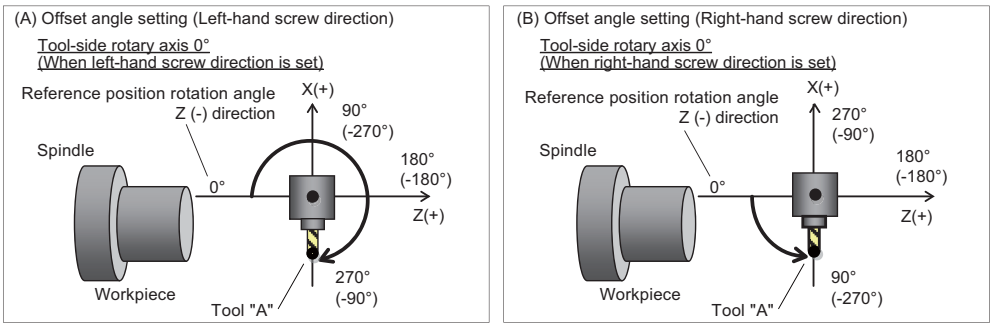
There are two types of methods, offset angle designation method and rotary axis position automatic-read method, to apply the tool axis rotation angle compensation amount.
Use the parameter "#1450 5axis_Spec/bit1" (Using G174 tool axis rotation angle as compensation amount) to select the method.

(1) Offset angle designation method ("#1450 5axis_Spec/bit1" is 0)

There are two offset angle designation methods: program command method and PLC signal method.
- The program command method can be designated using the R address of the simple tool center point control (G174) or tool axis direction control (G53.1).
- The PLC signal method can be designated using the R register (TANGOFS :R2634 to R2635).

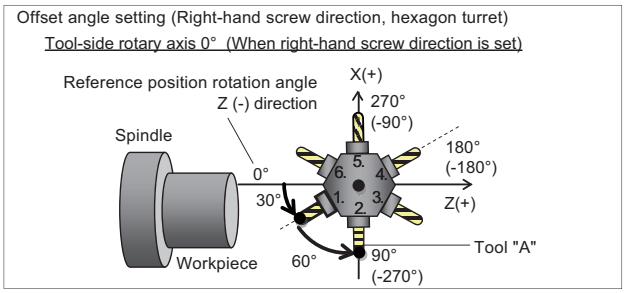
The offset angle can be designated using the total value of the angle specified in the program command method and that specified in the PLC signal method when the simple tool center point control (G174) or tool axis direction control (G53.1) is commanded.
The offset angle must be designated using the status in which the tool axis rotation angle is at 0 degree, as the standard.
Note that the offset angle varies depending on the tool rotary axis's rotation direction (*1).

When you use a tool of which the center point is in the X axis negative direction of the machine coordinate system and "#1450 5axis_Spec/bit3" (Select specifications of rotation direction parameter) is set to "0" (disabled), the offset angle is set as follows:
- When the tool rotary axis rotation direction is set to left-hand screw direction (*2) (#7933 DIR_T2 = 0), the offset angle is set to 270 degrees. (Refer to (A) in the following figure.)
- When the tool rotary axis rotation direction is set to right-hand screw direction (*3) (#7933 DIR_T2 = 1), the offset angle is set to 90 degrees. (Refer to (B) in the following figure.)



When you use any tool with the hexagon turret and "#1450 5axis_Spec/bit3" (Select specifications of rotation direction parameter) is set to "0" (disabled), the offset angle is set as follows:
- When the tool rotary axis rotation direction is set to right-hand screw direction, the tool A's offset angle is set to 90 degrees. (Refer to the following figure.)

For the R registers (R2634 to R2635), designate the reference tool's offset angle, 30 degrees (30000).
For the R address of the G174/G53.1 command block, designate the offset angle 60 degrees (G176 R60./G53.1 R60.) from the standard tool.
- The offset angle can be designated using only either the R address in the G174/G53.1 command block or the R register (R2634 to R2635). In this case, set 0 degree (0) to the one that is not selected.



In the R address of the G174/G53.1 block and R register, specify the tool angle relative to the reference position rotation angle when the tool axis rotation angle is at 0 degree. Thus, even when the tool axis rotation angle rotates and the tool axis rotation angle of the target tool is not at 0 degree, make sure to designate the offset angle at which the tool axis rotation angle is at 0 degree, for the tool axis rotation angel compensation amount.

(*1) The rotation direction setting depends on the MTB specifications (parameter "#7933 DIR_T2").
(*2) CW direction viewing from the Y axis negative direction toward the positive direction
(*3) CCW direction viewing from the Y axis negative direction toward the positive direction

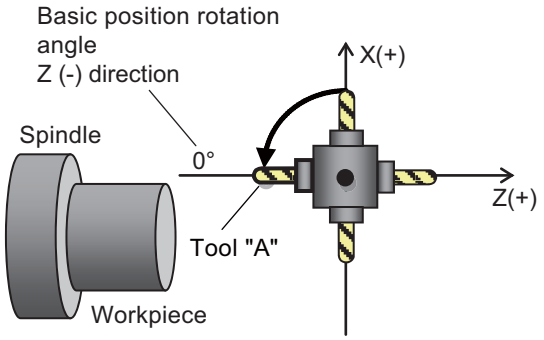
(2) Rotary axis position automatic-read method (#1450 5axis_Spec/bit1: 1)

The tool-side rotary axis position when Simple tool center point control (G174) or tool axis direction control (G53.1) command is given is treated as the tool axis rotation angle compensation amount.
Direct the tool you use toward the reference position rotation angle (Z(-) of the machine coordinate system) before issuinga G174/G53.1 command.

(Example) If you use a tool (Tool A) that is at 90 (-270) degrees relative to the reference position rotation angle while "#1450 5axis_Spec/bit3" (Select specifications of rotation direction parameter) is set to "0" (disabled) and "#7933 DIR_T2" is set to "1" (right-hand screw direction (*1)), use the following machining program.

(Machining program example)	
T1010 ;	
G00 X0. Z0. B90. ;	Direct the tool (Tool A) toward Z(-) of machine coordinate system (See the figure below.)
G92 B0. ;	Coordinate system setting
G174 ;	Simple tool center point control command
G01 X100. B45. F1000 ; :	
G175 ;	Simple tool center point control cancel

(*1) CCW direction viewing from the Y axis negative direction toward the positive direction



Rotate the target tool by the basic position rotation angle, then issue G174/G53.1 command.

Setting of tool axis rotation angle compensation amount (when "#1450 5axis_Spec/bit1" is "1")

When commanding the simple tool center point control (G174) after canceling the tool center point control modal (G174) or when re-commanding the tool axis direction control (G53.1), rotate the target tool up to the "reference position rotation angle" again, and then command the simple tool center point control (G174) or tool axis direction control (G53.1).

12.26.3 Combination with Other Functions

Arbitrary Axis Exchange (G140, G141, G142)

Refer to the chapter "Applying the Rotary Axis Configuration Parameter".

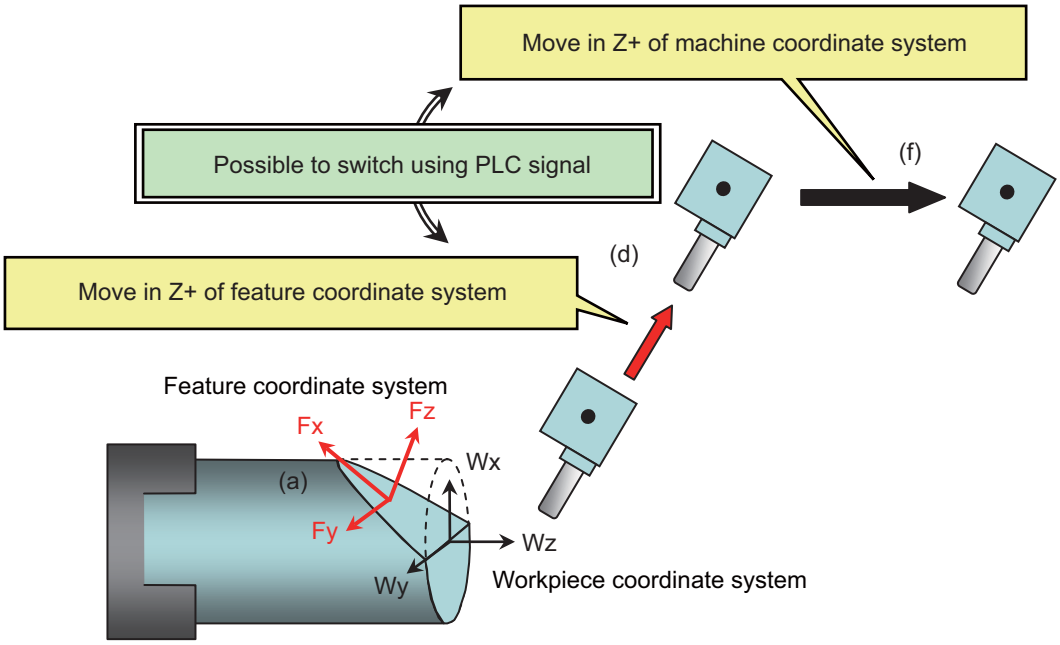
Inclined Axis Control

When the inclined axis control is active (YC35:ON), do not issue a command that causes the inclined axis to move during Simple inclined surface control (G176) or Simple tool center point control (G174).

Three-dimensional Manual Feed

[Manual feed in feature coordinate system]

When the parameter #7912 (NO_MANUAL) is 0, and you perform manual feed in the Simple inclined surface control modal status, the feed can be done in the feature coordinate axis direction. In addition, when you use the PLC output signals YD1A (3D manual feed [JOG,INC] in feature coordinate system) and YD1D (3D manual feed [1st handle] in feature coordinate system), you can switch the axial direction between the feature coordinate and machine coordinate systems.



(Operation example)

(1) Activate memory/MDI mode and command Simple inclined surface control (G176) through a program.
(2) Use Reset 1 (#1151 rstint = 0) to reset the NC with the feature coordinate system retained.
(3) Change the mode to handle, and select the feature coordinate system (turn ON the PLC output signal YD1D).
(4) Select the Z+ direction of the handle.
→ The axis moves in Z+ direction of the feature coordinate system.
(5) Select the machine coordinate system (turn OFF the PLC output signal YD1D).
(6) Select the Z+ direction of the handle.
→ Axis moves in Z+ of the machine coordinate system.

At this time, the NC retains the feature coordinate system. Thus, by selecting the feature coordinate system again (turning ON the PLC signal YD1D), you can move the axis in the feature coordinate axis direction.
If you wish to cancel the feature coordinate system, switch the mode to memory/MDI, and issue the Inclined surface control cancel command (G69.1) through a program.

[Counter display during manual feed]

<Inclined surface coordinate position counter>

The inclined surface coordinate position counter indicates a machine position relative to the feature coordinatesystem.

While inclined surface control command is OFF, the counter indicates a machine position relative to the work coordinate system.

However, while the manual absolute switch signal is OFF, the counter is not updated.

Manual absolute switch signal	Inclined surface machining command	Selected coordinate system	Inclined surface coordinate position counter
ON	ON	Feature coordinate system	Indicates a machine position with respect to the feature coordinate system
		Other than feature coordinate system	
	OFF	Feature coordinate system	Indicates a machine position with respect to the work coordinate system
		Other than feature coordinate system	
OFF	ON/OFF	-	Not updated

<Manual interruption amount counter>

While Simple inclined surface control command is active, the manual interruption amount counter indicates a manual interruption relative to the feature coordinate system.

While Simple inclined surface control command is OFF, the counter indicates a manual interruption relative to the machine coordinate system.

However, while the manual absolute switch signal is ON, the counter is not updated.

Manual absolute switch signal	Inclined surface machining command	Selected coordinate system	Manual interruption amount counter
ON	ON/OFF	-	Not updated
OFF	ON	-	Indicates an interruption amount relative to the feature coordinate system
	OFF	Machine coordinate system	Indicates an interruption amount relative to the machine coordinate system

Handle interrupt function in automatic operation mode during simple inclined surface machining

When setting the parameter "1284 ext20/bit6 (Automatic operation handle interruption during inclined surface machining)" to "1", the automatic operation handle interruption can be used.

When handle interrupt in automatic operation mode is executed, make sure to turn OFF the manual ABS switch.

When handle interrupt in automatic operation mode is executed in the following cases, the alarm (M01 0185) occurs:

- When the parameter "#1145 I_abs (Manual ABS parameter)" is set to "0" and the manual ABS switch is turned ON
- When the parameter "#1061 intabs (Manual ABS updating)" is set to "1" for any of the axes of the part system while the parameter "#1145 I_abs (Manual ABS parameter)" is set to "1"

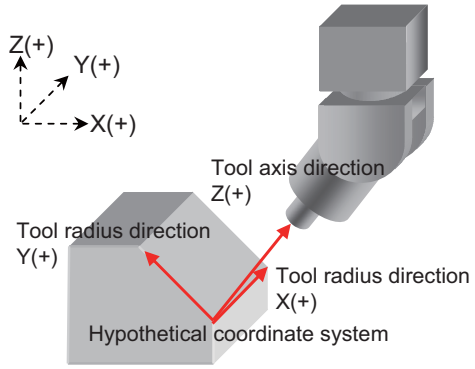
12.27 3-Dimensional Manual Feed

12.27.1 Outline

By selecting the hypothetical coordinate system to be machined, axis can be moved with manual feed (JOG, HANDLE or INCREMENTAL) in the coordinate system with the 3-dimensional manual feed function.
When a travel command is executed in the hypothetical coordinate system, the NC can move more than one axis according to the tool orientation and table inclination, which facilitates the setup process.

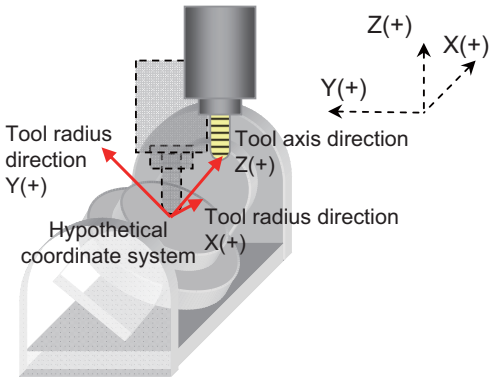
This function has two feed modes: "Feed in hypothetical coordinate system" and "Rotation with the tool tip as the center".
A travel command to linear axis is processed as a feed in hypothetical coordinate system, so the manual feed is carried out in hypothetical coordinate system.
A travel command to rotary axis is processed as a rotation with the tool tip as the center. The commanded rotary axes and the three linear axes are used to perform the manual feed while maintaining the positional relationship between the workpiece and tool tip.

[Tool tilt A-C axis]



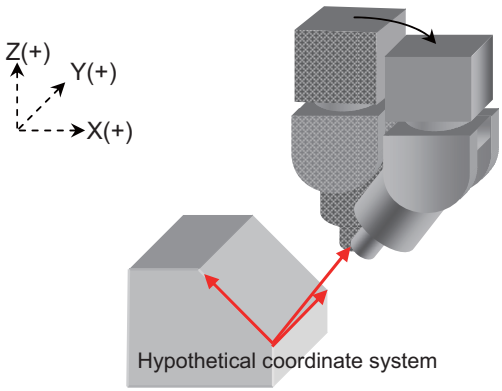
Linear axis travel command:
Feed in hypothetical coordinate system

[Table tilt A-C axis]



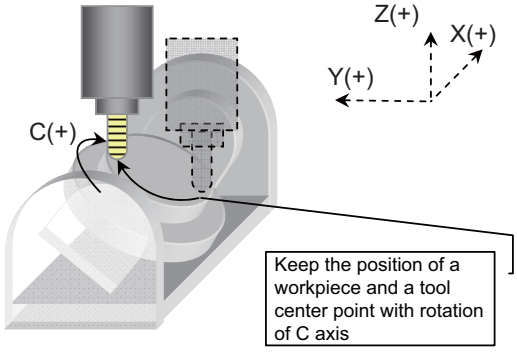
Linear axis travel command:
Feed in hypothetical coordinate system

[Tool tilt A-C axis]



Rotary axis travel command:
Rotation with the tool tip as the center

[Table tilt A-C axis]



Rotary axis travel command:
Rotation with the tool tip as the center

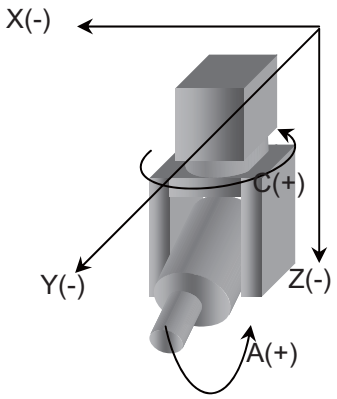
12.27.2 System Configuration

(1) Machine Configuration

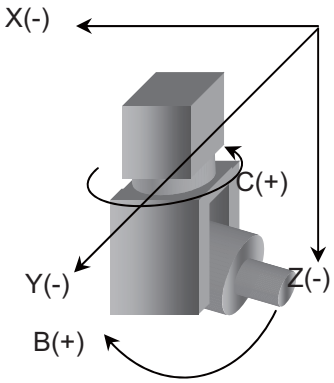
This function is available in the machine whose orthogonal axis is installed with ISO polarity. For combined type, the rotary axis can be installed with both ISO polarity and non-ISO polarity. For details, refer to "Applying the Rotary Axis Configuration Parameter".
This function is compatible with each of the tool tilt, table tilt and combined types of machine configuration.

(a) Tool tilt

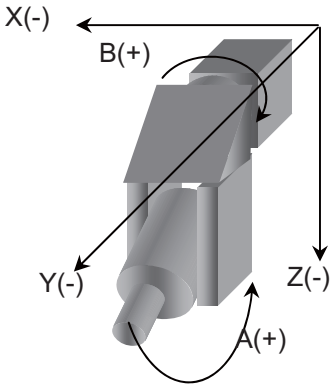
[A-C axis]



[B-C axis]

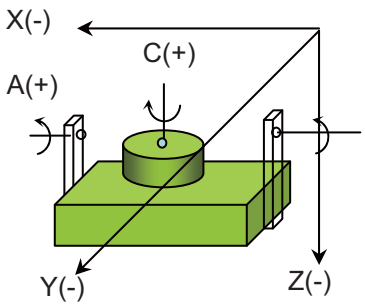


[A-B axis]

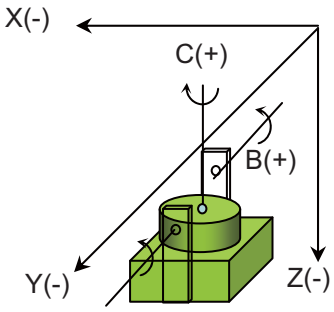


(b) Table tilt

[A-C axis]

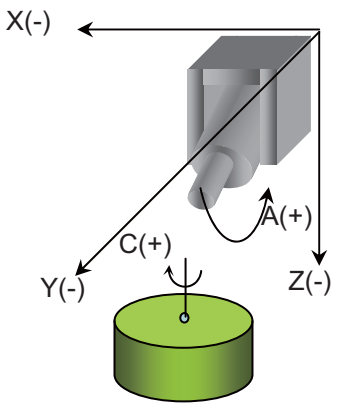


[B-C axis]

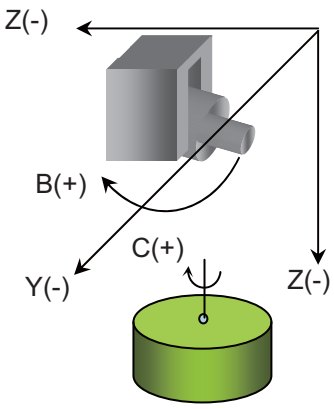


(c) Combined

[A-C axis]



[B-C axis]



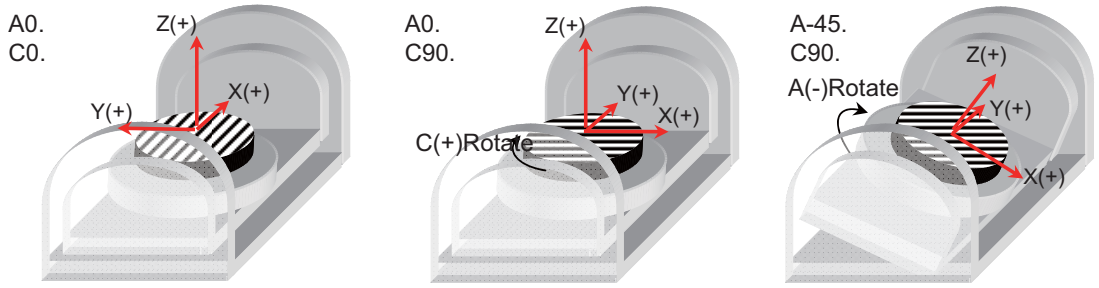
(2) Hypothetical Coordinate System

There are three types of hypothetical coordinate system: table coordinate system, feature coordinate systemand tool axis coordinate system.

(a) Table coordinate system

On table tilt type machines, axes move with the rotation of the rotary axis in the coordinate system fixed on the table.

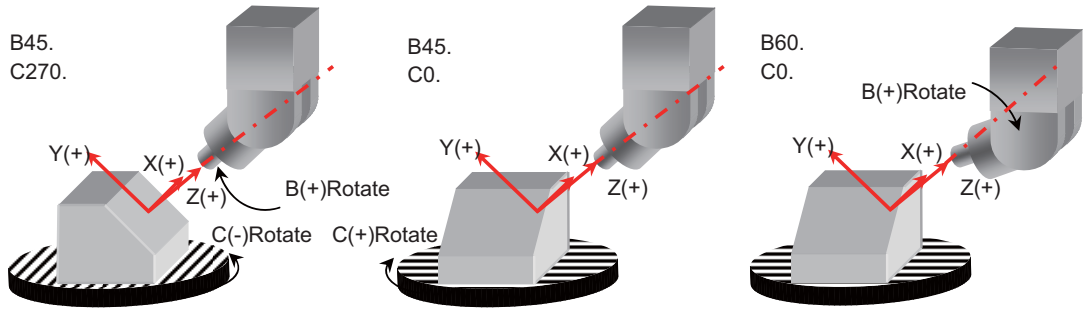
(Example) Table tilt A-C axis



(b) Feature coordinate system

On all types of machines, the coordinate system does not move with the rotation of the rotary axis in the coordinate system executing a program command such as the inclined surface machining command.

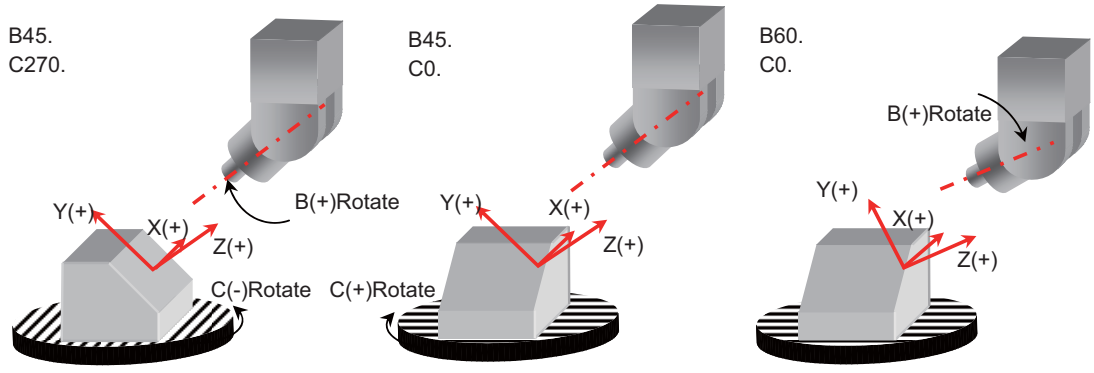
(Example) Combined tilt B-C axis



(c) Tool axis coordinate system

On tool tilt/combined tilt type machines, axes move with the rotation of the tool axis in the coordinate system in which the Z axis direction becomes parallel to that of the tool axis.

(Example) Combined tilt B-C axis



12.27.3 Detailed Specifications

When a hypothetical coordinate system is selected using a PLC signal during manual feed (jog, incremental or handle mode) or at handle interrupt in automatic operation, manual feed can be performed in the selected coordinate system.

This function has two feed modes: "Feed in hypothetical coordinate system" and "Rotation with the tool tip as the center".

"Feed in hypothetical coordinate system" is applied to a linear axis travel command. The manual feed is carriedout in hypothetical coordinate system using the three linear axes.

Tool tilt (feed direction after A axis rotates by +45° and C by -90°)

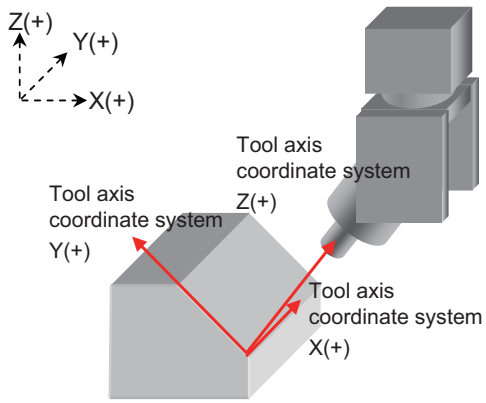
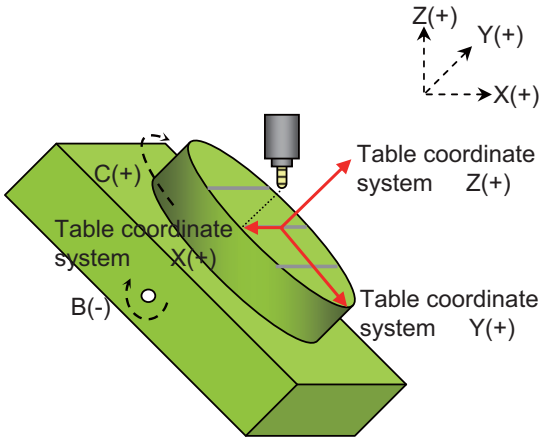


Table tilt (after B axis rotates by -45° and C by +90°)



"Rotation with the tool tip as the center" is applied to a rotary axis travel command. The manual feed is carried out using the rotary axes and the three linear axes so that the positional relationship between the workpiece and tool tip can be kept.

Tool tilt (feed direction when C axis rotates by +90°)

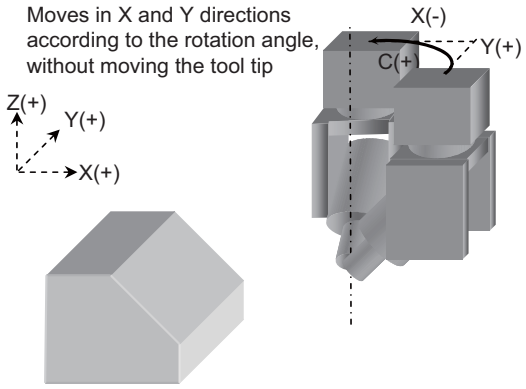
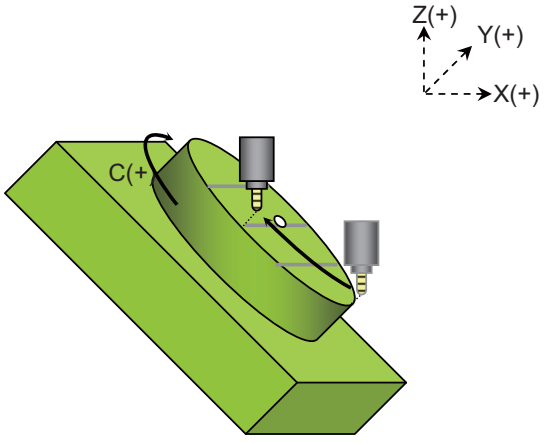


Table tilt (feed direction when C axis rotates by +90°)



Select the hypothetical coordinate system from among the table, feature or tool axis coordinate system.
If not selected, standard manual feed and interruption are carried out in the machine coordinate system.

12.27.3.1 Requirements for 3-Dimensional Manual Feed

When all of the following requirements are met, the 3-dimensional manual feed is carried out.

(1) The rotary axis configuration parameter "#7912 NO_MANUAL" is "0" (3-dimensional manual feed is valid).
(2) Selected mode is either jog, incremental or handle.
(3) A hypothetical coordinate system is being selected.Or,"Rotation with the tool tip as the center" is being selected.
(4) Not in a state where axis travel is disabled; such as during alarm occurrence, during manual interlock, and when the axis has reached the soft limit, etc.

12.27.4 Operation Example:Feed in Hypothetical Coordinate System

A linear axis travel command is processed as "Feed in hypothetical coordinate system". Manual feed is performed in a hypothetically defined coordinate system using three linear axes.

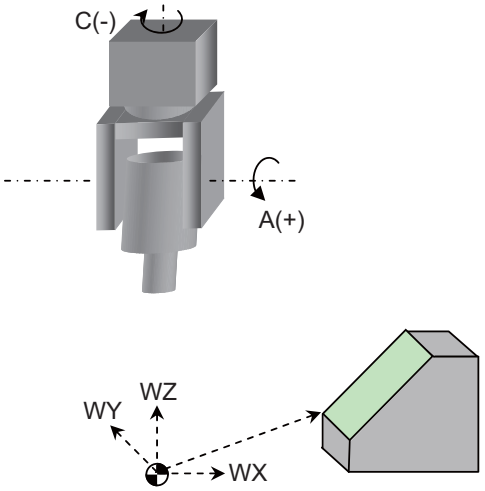
12.27.4.1 Coordinate System Selection - Tool Axis Coordinate System Example

Axis travel is performed in each direction of the tool axis coordinate system.The below example is the operation with the 1st handle in the tool tilt type A-C axis configuration.

[Operation step]

(1) Select the handle mode.

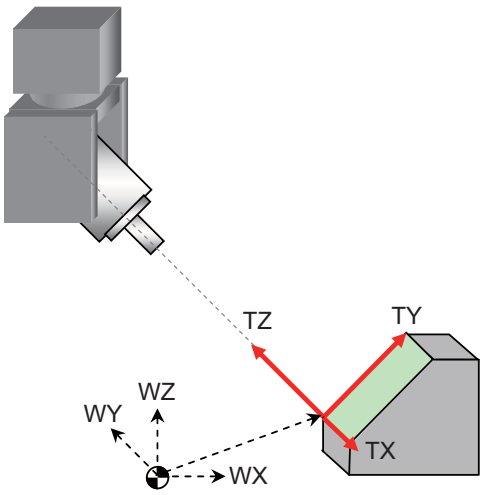
(2) Travel in the Z axis direction by 220. from the workpiece coordinate zero point.
Rotate around the A axis by +45° and around the C axis by -90°.



Workpiece coordinate system:WX,WY,WZ
Tool axis coordinate system:TX,TY,TZ

	Workpiece coordinate	Tool axis movement
X	0.000	0.000
Y	0.000	0.000
Z	220.000	220.000
A	45.000	45.000
C	270.000	270.000

(3) Select the tool axis coordinate system (YD1B/1, YD1C/0, YD1D/0) as a hypothetical coordinate system.
(4) Travel in the TX, TY and TZ directions of the tool axis coordinate system.



X+1.motion			Y+1.motion			Z+1.motion		
	Workpiece coordinate	Tool axis movement		Workpiece coordinate	Tool axis movement		Workpiece coordinate	Tool axis movement
X	0.000	**1.000**	X	**0.707**	0.000	X	**-0.707**	0.000
Y	**-1.000**	0.000	Y	0.000	**1.000**	Y	0.000	0.000
Z	220.000	220.000	Z	**220.707**	220.000	Z	**220.707**	**221.000**
A	45.000	45.000	A	45.000	45.000	A	45.000	45.000
C	270.000	270.000	C	270.000	270.000	C	270.000	270.000

12.27.4.2 Coordinate System Selection - Table Coordinate System Example

Axis travel is performed in each of the X, Y and Z directions on the rotating table surface.
The below example is the operation with the 1st handle in the table tilt type B-C axis configuration.

[Operation step]

(1) Select the handle mode.

(2) Select the table coordinate system as a hypothetical coordinate system. (Turn ON YD1C, and turn OFF YD1B and YD1D.)

(3) Travel in the X direction by 100. and in the Z axis direction by 50. from the workpiece coordinate zero point. Rotate around the C axis by +90° and around the B axis by -45°.

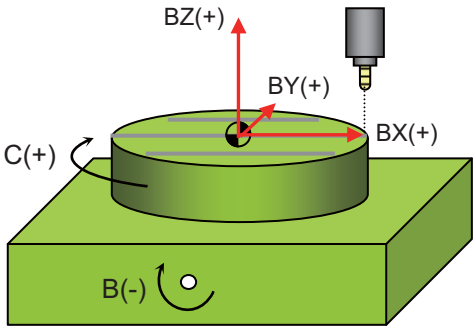
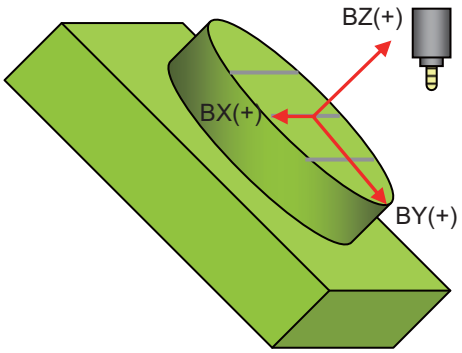


Table coordinate system:BX,BY,BZ

C motion after X and Z motion		
	Workpiece coordinate	Table coordinate
X	100.000	0.000
Y	0.000	100.000
Z	50.000	50.000
B	0.000	0.000
C	90.000	90.000

B motion		
	Workpiece coordinate	Table coordinate
X	100.000	0.000
Y	0.000	35.355
Z	50.000	106.066
B	-45.000	-45.000
C	90.000	90.000

(4) Travel in the BX,BY and BZ directions of the table coordinate system.



X+1.motion		
	Workpiece coordinate	Table coordinate
X	100.000	**1.000**
Y	**-1.000**	35.355
Z	50.000	106.066
B	-45.000	-45.000
C	90.000	90.000

Y+1.motion		
	Workpiece coordinate	Table coordinate
X	**100.707**	0.000
Y	0.000	**36.355**
Z	**49.293**	106.066
B	-45.000	-45.000
C	90.000	90.000

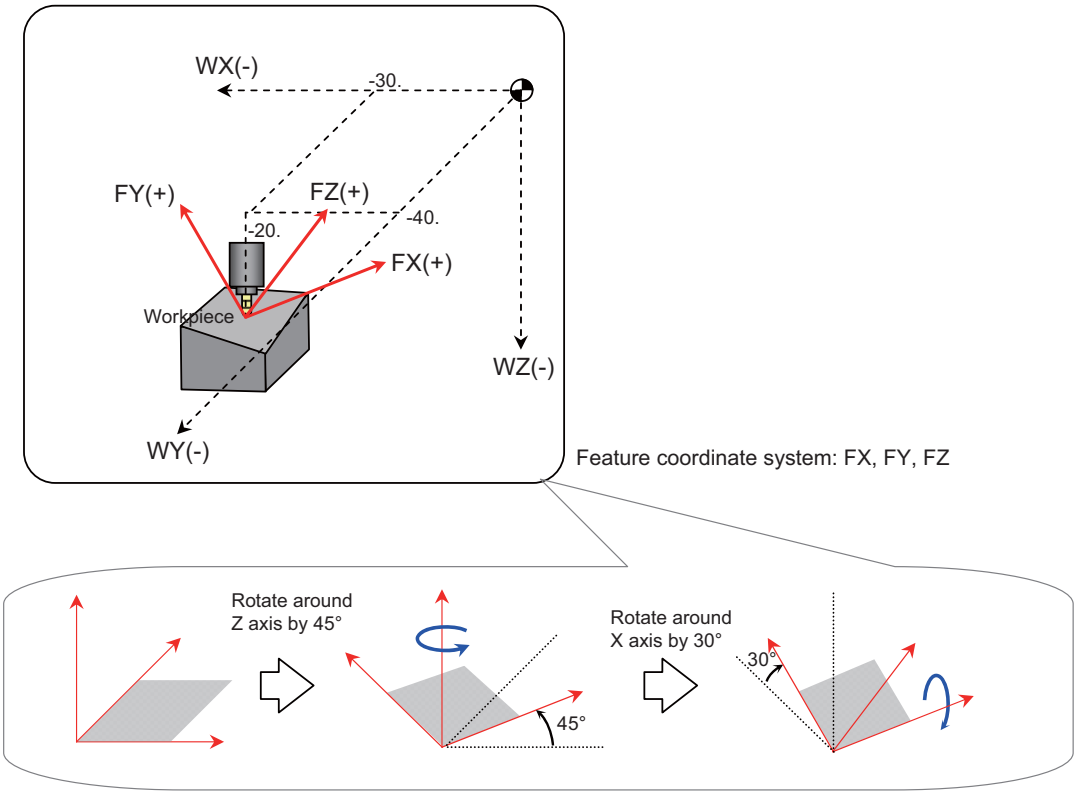
Z+1.motion		
	Workpiece coordinate	Table coordinate
X	**100.707**	0.000
Y	0.000	35.355
Z	**50.707**	**107.066**
B	-45.000	-45.000
C	90.000	90.000

12.27.4.3 Coordinate System Selection - Feature Coordinate System Example

Axis travel is performed in each of the X, Y and Z directions of the feature coordinate system that has been defined for Workpiece installation error compensation or Inclined surface machining function.
The below example is the operation with the 1st handle when a feature coordinate system is defined using the G code.

[Operation step]

(1) Define a feature coordinate system in the MDI mode.
G68.2 X-30. Y-40. Z-20 I45. J30.K0
(2) Select the handle mode.
(3) Travel in the X direction by -30., in the Y direction by -40. and in the Z direction by -20.
(4) Select the feature coordinate system as a hypothetical coordinate system. (Turn ON YD1D, and turn OFF YD1B and YD1C.)
(5) Travel in the FX, FY and FZ directions of the inclined surface.



X+1.motion			Y+1.motion			Z+1.motion		
	Workpiece coordinate	Inclined surface coordinate		Workpiece coordinate	Inclined surface coordinate		Workpiece coordinate	Inclined surface coordinate
X	**-29.293**	**1.000**	X	**-30.612**	0.000	X	**-29.647**	0.000
Y	**-39.293**	0.000	Y	**-39.388**	**1.000**	Y	**-40.353**	0.000
Z	-20.000	0.000	Z	**-19.500**	0.000	Z	**-19.134**	**1.000**
A	0.000	0.000	A	0.000	0.000	A	0.000	0.000
C	0.000	0.000	C	0.000	0.000	C	0.000	0.000

(Motion vector on WK coordinate)
X: 1/√2 = +0.707
Y: 1/√2 = +0.707
Z: -

(Motion vector on WK coordinate)
X: √3/2*1/(-√2) = -0.612
Y: √3/2*1/√2 = +0.612
Z: 1/2 = +0.5

(Motion vector on WK coordinate)
X: 1/2*1/√2 = +0.353
Y: 1/2*1/(-√2) = -0.353
Z: √3/2 = +0.866

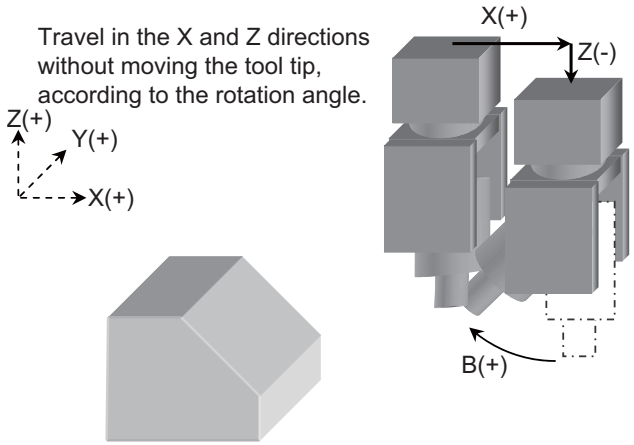
12.27.5 Rotation with Tool Tip as Center

A rotary axis travel command is processed as "Rotation with the tool tip as the center". Manual feed is carried out using the rotary axes and the three linear axes so that the positional relationship between the workpiece and tool tip can be kept.

12.27.5.1 Machine Configuration - Tool Tilt Example

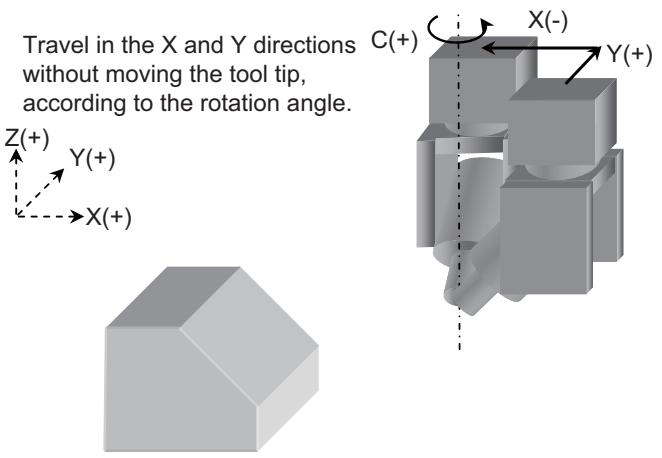
Tool orientation is changed without moving the tool tip.
The below example is the operation with the 1st handle in the tool tilt type B-C axis configuration, when #7936 (Height axis rotation center offset) is set to "10.".

[Operation step]
(1) Select the handle mode.
(2) Turn ON the "Tool center point rotation" signal (YD27).
(3) Confirm the "In tool center point rotation" signal (XD27).
(4) Select the tool axis coordinate system as a hypothetical coordinate system. (Turn ON YD1B, and turn OFF YD1C and YD1D.)
(5) Set "#8043 Tool HDL FD OFS".
(6) Rotate around the B axis by +45°.



	Workpiece coordinate	Tool axis movement
X	7.071	0.000
Y	0.000	0.000
Z	-7.071	0.000
B	45.000	45.000
C	0.000	0.000

(7) Rotate around the C axis by 90°.



	Workpiece coordinate	Tool axis movement
X	0.000	0.000
Y	7.071	0.000
Z	-7.071	0.000
B	45.000	45.000
C	90.000	90.000

12.27.5.2 Machine Configuration - Table Tilt Example

The tool moves so that the positional relationship between the workpiece and tool tip is kept.
The below example is the operation with the 1st handle in the table tilt type B-C axis configuration.

[Operation step]

(1) Select the handle mode.
(2) Turn ON the "Tool center point rotation" signal (YD27).
(3) Confirm the "In tool center point rotation" signal (XD27).
(4) Select the table coordinate system as a hypothetical coordinate system. (Turn ON YD1C, and turn OFF YD1B and YD1D.)
(5) Travel in the X direction by 100., and in Z by 100. from the workpiece coordinate zero point.
(6) Set "#8043 Tool HDL FD OFS".
(7) Rotate around the B axis by -45°.

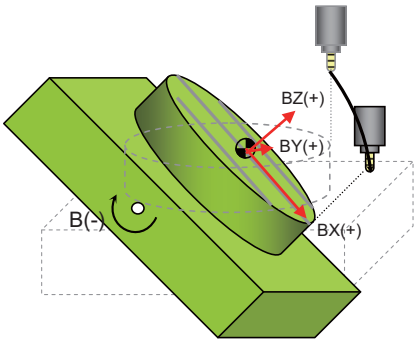
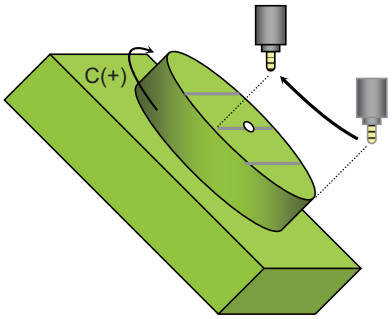


Table coordinate system:BX,BY,BZ

	Workpiece coordinate	Table coordinate
X	100.000	100.000
Y	0.000	0.000
Z	100.000	100.000
B	0.000	0.000
C	0.000	0.000

X	**141.421**	100.000
Y	0.000	0.000
Z	**0.000**	100.000
B	**-45.000**	-45.000
C	0.000	0.000

(8) Rotate around the C axis by +90°.



	Workpiece coordinate	Table coordinate
X	**70.711**	100.000
Y	**-100.000**	0.000
Z	**70.711**	100.000
B	-45.000	-45.000
C	**90.000**	90.000

12.27.5.3 Tool Length Offset Amount

The length (tool length offset amount) from the tool tip to the holder edge is required for the tool to move keeping the positional relationship between a workpiece and the tool tip in "Rotation with the tool tip as the center".
Use an offset amount of the tool length offset command (G43/G44) for automatic operation.
Use the machining parameter "#8043 Tool HDL FD OFS" for manual feed.
When the tool length offset amount is "0", the tool moves keeping the positional relationship between a workpiece and the holder edge in "Rotation with the tool tip as the center"; therefore, if a tool is actually mounted, interference with a workpiece, etc. may occur.

12.27.6 Feed Amount Reset

If any of the following conditions is met, the manual interruption amount is reset. Thus, Manual interrupt amount counter and Tool axis movement counter are cleared.

(1) Dog-type reference position return is completed
(2) Emergency stop is cancelled
    - External emergency stop button ON ' OFF
    - PLC emergency stop signal ON ' OFF
(3) Reset & Rewind signal is ON when the parameter "#8173 Hold intr amount" is set to "0"
(4) NC Reset 1 or NC Reset 2 signal is ON when the parameter "#8173 Hold intr amount" is set to "0"
(5) The axis to which G92 has been given during automatic operation
(6) The axis to which Origin set or Origin zero has been commanded
(7) Any of the coordinate system selection signals has changed, regardless of the present operation mode

12.27.7 Position Display Counter

Position display counter indicates as follows during the 3-dimensional manual feed.

(1) Tool axis travel amount

This counter indicates the tool's travel amount in the tool axis coordinate system.
Note, however, that this counter is not updated in one of the following cases.

- When a selected hypothetical coordinate system is not tool axis coordinate system
- When the manual absolute is ON

Manual absolute	Selected coordinate system	Tool axis travel amount
ON	-	Not update
OFF	Tool axis coordinate system	A travel amount in the tool axis coordinate system is displayed
	Others	Not update

(2) Table coordinate system counter

This counter indicates the position in the table coordinate system.
Note, however, that this counter is not updated while the manual absolute is OFF.

Manual absolute	Selected coordinate system	Table coordinate system counter
ON	Tool axis coordinate system	A position in the table coordinate system is displayed.
	Others	
OFF	-	Not update

(3) Inclined surface counter

This counter indicates the position in the feature coordinate system.
While the inclined surface machining command is disabled, a position in the workpiece coordinate system is displayed instead.
Note, however, that this counter is not updated while the manual absolute is OFF.

Manual absolute	Inclined surface machining command	Selected coordinate system	Feature coordinate system counter
ON	ON	Feature coordinate system	A position in the feature coordinate system is displayed.
		Others	
	OFF	Feature coordinate system	A position in the workpiece coordinate system is displayed.
		Others	
OFF	-	-	Not update

(4) Manual interruption amount

While the inclined surface machining command is enabled, this counter indicates a manual interruption amount in the feature coordinate system.

If a hypothetical coordinate system is being selected while the inclined surface machining command is disabled, a position in the selected hypothetical coordinate system is displayed.

If a hypothetical coordinate system is not selected while the inclined surface machining command is disabled, a position in the machine coordinate system is displayed.

Note, however, that this counter is not updated while the manual absolute is ON.

Manual absolute	Inclined surface machining command	Selected coordinate system	Manual interruption amount
ON	-	-	Not update
OFF	ON	-	An interruption amount in the feature coordinate system is displayed.
	OFF	Selected	An interruption amount in the selected coordinate system is displayed.
		Not selected	An interruption amount in the machine coordinate system is displayed.

12.27.8 Signal List

12.27.8.1 Hypothetical Coordinate System Selection

For each manual mode and handle to use, this signal is used to select the hypothetical coordinate system, in which the 3-dimensional manual feed is carried out.

It is possible to set different coordinate systems for each mode or handle.

The 1st to the 3rd handles are available.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	3D manual feed (JOG, INC) in tool axis coordinate system	MJCT	YD18	YE58	YF98	Y10D8	Y1218	Y1358	Y1498	Y15D8
A	3D manual feed (JOG, INC) in table coordinate system	MJCB	YD19	YE59	YF99	Y10D9	Y1219	Y1359	Y1499	Y15D9
A	3D manual feed (JOG, INC) in feature coordinate system	MJCF	YD1A	YE5A	YF9A	Y10DA	Y121A	Y135A	Y149A	Y15DA

[Function]

This signal is used to select the hypothetical coordinate system in which the 3D manual feed is carried out.

It is possible to set different coordinate systems for each mode or handle.

[Operation]

This signal is used to select the coordinate system in which the 3D manual feed is carried out by jog feed or incremental feed.

[Related signals]

(1) Jog mode (J: YC00)

(2) Incremental mode (S: YC02)

(3) Tool center point rotation (TCPRC: YD27)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	3D manual feed (1st handle) in tool axis coordinate system	MH1CT	YD1B	YE5B	YF9B	Y10DB	Y121B	Y135B	Y149B	Y15DB
A	3D manual feed (1st handle) in table coordinate system	MH1CB	YD1C	YE5C	YF9C	Y10DC	Y121C	Y135C	Y149C	Y15DC
A	3D manual feed (1st handle) in feature coordinate system	MH1CF	YD1D	YE5D	YF9D	Y10DD	Y121D	Y135D	Y149D	Y15DD

[Function]

This signal is used to select the hypothetical coordinate system, in which the 3D manual feed is carried out.

It is possible to set different coordinate systems for each mode or handle.

[Operation]

This signal is used to select the coordinate system in which the 3D manual feed is carried out on the 1st handle axis.

[Related signals]

(1) 1st handle axis selection code (HS11 to HS116:YC40 to 4)

(2) 1st handle valid (HS1S:YC47)

(3) Tool center point rotation (TCPRC:YD27)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	3D manual feed (2nd handle) in tool axis coordinate system	MH2CT	YD1E	YE5E	YF9E	Y10DE	Y121E	Y135E	Y149E	Y15DE
A	3D manual feed (2nd handle) in table coordinate system	MH2CB	YD1F	YE5F	YF9F	Y10DF	Y121F	Y135F	Y149F	Y15DF
A	3D manual feed (2nd handle) in feature coordinate system	MH2CF	YD20	YE60	YFA0	Y10E0	Y1220	Y1360	Y14A0	Y15E0

[Function]

This signal is used to select the hypothetical coordinate system, in which the 3D manual feed is carried out.
It is possible to set different coordinate systems for each mode or handle.

[Operation]

This signal is used to select the coordinate system in which the 3D manual feed is carried out on the 2nd handle axis.

[Related signals]

(1) 2nd handle axis selection code (HS21 to HS216:YC48 to C)
(2) 2nd handle valid (HS2S:YC4F)
(3) Tool center point rotation (TCPRC:YD27)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	3D manual feed (3rd handle) in tool axis coordinate system	MH3CT	YD21	YE61	YFA1	Y10E1	Y1221	Y1361	Y14A1	Y15E1
A	3D manual feed (3rd handle) in table coordinate system	MH3CB	YD22	YE62	YFA2	Y10E2	Y1222	Y1362	Y14A2	Y15E2
A	3D manual feed (3rd handle) in feature coordinate system	MH3CF	YD23	YE63	YFA3	Y10E3	Y1223	Y1363	Y14A3	Y15E3

[Function]

This signal is used to select the hypothetical coordinate system, in which the 3D manual feed is carried out.
It is possible to set different coordinate systems for each mode or handle.

[Operation]

This signal is used to select the coordinate system in which the 3D manual feed is carried out on the 3rd handle axis.

[Related signals]

(1) 3rd handle axis selection code (HS31 to HS316:YC50 to 4)
(2) 3rd handle valid (HS3S:YC57)
(3) Tool center point rotation (TCPRC:YD27)

(Note 1) If more than one bit among the three hypothetical coordinate system selection bits is turned ON, the operation alarm "M01 5-ax manual feed coord sys err 0231" is output. This alarm disables both automatic and manual operations.
To cancel this alarm, turn OFF all the hypothetical coordinate system selection bits, or select only one bit (turn OFF the other two bits).

(Note 2) If you select the hypothetical coordinate system with the rotary axis configuration parameter "#7912 NO_MANUAL" set to "1" (3-dimensional manual feed is disabled), standard manual feed is carried out.

(Note 3) If you select the hypothetical coordinate system without the additional specifications of the 3-dimensional manual feed, the operation error occurs. However, by setting the parameter "#1262/bit2" to "1", the error is hid and the axis feed on the machine coordinate can be performed.

(Note 4) If you have changed the hypothetical coordinate system during axis movement, the axis decelerates and stops.

12.27.8.2 Selected Coordinate System Output

For each manual mode and handle to use, this signal is used to inform of the hypothetical coordinate system in which the 3-dimensional manual feed is carried out.

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$5	$7	$8
A	Tool axis coordinate system in 3D manual feed (JOG,INC)	MJST	XD18	XE58	XF98	X10D8	X1218	X1358	X1498	X15D8
A	Table coordinate system in 3D manual feed (JOG,INC)	MJSB	XD19	XE59	XF99	X10D9	X1219	X1359	X1499	X15D9
A	Feature coordinate system in 3D manual feed (JOG,INC)	MJSF	XD1A	XE5A	XF9A	X10DA	X121A	X135A	X149A	X15DA

[Function]

This signal indicates the coordinate system in which the 3D manual feed is carried out by the jog or incremental feed. When this signal is ON, jog feed or incremental feed is carried out in the coordinate system of the signal.

[Operation]

This signal turns ON when:

(1) The hypothetical coordinate system for the 3D manual feed (JOG, INC) has been selected during jog feed or incremental feed.

This signal turns OFF when:

(1) The hypothetical coordinate selection for the 3D manual feed (JOG, INC) is turned OFF.

(2) The jog feed or incremental feed mode is turned OFF.

[Related signals]

(1) In jog mode (JO:XC00)

(2) In incremental mode (SO:XC02)

(3) 3D manual feed (JOG,INC) in tool axis coordinate system

(4) 3D manual feed (JOG,INC) in table coordinate system

(5) 3D manual feed (JOG,INC) in feature coordinate system

(6) In tool center point rotation (TCPRS:XD27)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$5	$7	$8
A	Tool axis coordinate system in 3D manual feed (1st handle)	MH1ST	XD1B	XE5B	XF9B	X10DB	X121B	X135B	X149B	X15DB
A	Table coordinate system in 3D manual feed (1st handle)	MH1SB	XD1C	XE5C	XF9C	X10DC	X121C	X135C	X149C	X15DC
A	Feature coordinate system in 3D manual feed (1st handle)	MH1SF	XD1D	XE5D	XF9D	X10DD	X121D	X135D	X149D	X15DD

[Function]

This signal indicates the coordinate system in which the 3D manual feed is carried out on the 1st handle axis.

When this signal is ON, the feed on the 1st handle axis is carried out in the coordinate system of the signal.

[Operation]

This signal turns ON when:

(1) The 1st handle feed is valid, the axis selection signal is ON and the hypothetical coordinate system for 3D manual feed (1st handle) is selected.

This signal turns OFF when:

(1) The selection of the hypothetical coordinate system for 3D manual feed (1st handle) is turned OFF.

(2) The 1st handle valid signal is turned OFF.

(3) The axis selection signal is turned OFF.

[Related signals]

(1) 1st handle axis selection code (HS11 to HS116:YC40 to 4)

(2) 1st handle valid (HS1S:YC47)

(3) 3D manual feed (1st handle) in tool axis coordinate system

(4) 3D manual feed (1st handle) in table coordinate system

(5) 3D manual feed (1st handle) in feature coordinate system

(6) In tool center point rotation (TCPRS:XD27)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$5	$7	$8
A	Tool axis coordinate system in 3D manual feed (2nd handle)	MH2ST	XD1E	XE5E	XF9E	X10DE	X121E	X135E	X149E	X15DE
A	Table coordinate system in 3D manual feed(2nd handle)	MH2SB	XD1F	XE5F	XF9F	X10DF	X121F	X135F	X149F	X15DF
A	Feature coordinate system in 3D manual feed (2nd handle)	MH2SF	XD20	XE60	XFA0	X10E0	X1220	X1360	X14A0	X15E0

[Function]

This signal indicates the coordinate system in which the 3D manual feed is carried out on the 2nd handle axis.

When this signal is ON, the feed on the 2nd handle axis is carried out in the coordinate system of the signal.

[Operation]

This signal turns ON when:

(1) The 2nd handle feed is valid, the axis selection signal is ON and the hypothetical coordinate system for 3D manual feed (2nd handle) is selected.

This signal turns OFF when:

(1) The selection of the hypothetical coordinate system for 3D manual feed (2nd handle) is turned OFF.

(2) The 2nd handle valid signal is turned OFF.

(3) The axis selection signal is turned OFF.

[Related signals]

(1) 2nd handle axis selection code (HS21 to HS216:YC48 to C)

(2) 2nd handle valid (HS2S:YC4F)

(3) 3D manual feed (2nd handle) in tool axis coordinate system

(4) 3D manual feed (2nd handle) in table coordinate system

(5) 3D manual feed (2nd handle) in feature coordinate system

(6) In tool center point rotation (TCPRS:XD27)

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$5	$7	$8
A	Tool axis coordinate system in 3D manual feed (3rd handle)	MH3ST	XD21	XE61	XFA1	X10E1	X1221	X1361	X14A1	X15E1
A	Table coordinate system in 3D manual feed (3rd handle)	MH3SB	XD22	XE62	XFA2	X10E2	X1222	X1362	X14A2	X15E2
A	Feature coordinate system in 3D manual feed (3rd handle)	MH3SF	XD23	XE63	XFA3	X10E3	X1223	X1363	X14A3	X15E3

[Function]

This signal indicates the coordinate system in which the 3D manual feed is carried out on the 3rd handle axis.

When this signal is ON, the manual feed on the 3rd handle axis is carried out in the coordinate system of the signal.

[Operation]

This signal turns ON when:

(1) The 3rd handle feed is valid, the axis selection signal is ON and the hypothetical coordinate system for 3D manual feed (3rd handle) is selected.

This signal turns OFF when:

(1) The selection of the hypothetical coordinate system for 3D manual feed (3rd handle) is turned OFF.

(2) The 3rd handle valid signal is turned OFF.

(3) The axis selection signal is turned OFF.

[Related signals]

(1) 3rd handle axis selection code (HS31 to HS316:YC50 to 4)

(2) 3rd handle valid (HS3S:YC57)

(3) 3D manual feed (3rd handle) in tool axis coordinate system

(4) 3D manual feed (3rd handle) in table coordinate system

(5) 3D manual feed (3rd handle) in feature coordinate system

(6) In tool center point rotation (TCPRS:XD27)

(Note 1) If more than one bit, among the bits for selecting hypothetical coordinate system for each manual feed, has turned ON, all the selected coordinate system outputs for each manual feed do not turn ON.

(Note 2) When the rotary axis configuration parameter "#7912 NO_MANUAL" is set to "1" (3-dimensional manual feed is invalid), the selected coordinate system output signal does not turn ON.

(Note 3) If a hypothetical coordinate system is selected without the additional specifications of the "3-dimensional manual feed", the selected coordinate system output signal does not turn ON.

12.27.8.3 Tool Center Point Rotation

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$6	$7	$8
A	Tool center point rotation	TCPRC	YD27	YE67	YFA7	Y10E7	Y1227	Y1367	Y14A7	Y15E7

[Function]

This signal informs the operation of the rotation axis of 3D manual feed (JOG/incremental/handle).

[Operation]

It operates with keeping the positional relationship of tool center point looking from the workpiece, when the rotation axis of 3D manual feed (JOG/incremental/handle) is operated.

<table>
<tr><th colspan="5">Input</th><th colspan="2">output</th></tr>
<tr><th rowspan="2">#7912
NO_MANUAL</th><th colspan="3">Hypothetical coordinate system selection signal</th><th>Tool center point rotation signal</th><th rowspan="2">Selection coordinate system</th><th rowspan="2">Tool center point rotary valid/invalid</th></tr>
<tr><th>YD18</th><th>YD19</th><th>YD1A</th><th>YD27</th></tr>
<tr><td rowspan="4">Valid</td><td colspan="3" rowspan="2">All 0</td><td>0</td><td rowspan="2">Machine coordinate system selection</td><td>Invalid</td></tr>
<tr><td>1</td><td>Valid</td></tr>
<tr><td colspan="3" rowspan="2">Only any one of them is 1</td><td>0</td><td rowspan="2">In accordance with the hypothetical coordinate system selection signal</td><td>Invalid</td></tr>
<tr><td>1</td><td>Valid</td></tr>
<tr><td colspan="3">Other than above</td><td>0 / 1</td><td colspan="2">The operation error (M01 0231)</td></tr>
<tr><td>Invalid</td><td>0/1</td><td>0/1</td><td>0/1</td><td>0 / 1</td><td>Machine coordinate system selection</td><td>Invalid</td></tr>
</table>

[Related signals]

(1) 3D manual feed (JOG, INC) in tool axis coordinate system (MJCT:YD18)
(2) 3D manual feed (JOG, INC) in table coordinate system (MJCB:YD19)
(3) 3D manual feed (JOG, INC) in feature coordinate system (MJCF:YD1A)
(4) 3D manual feed (1st handle) in tool axis coordinate system (MH1CT:YD1B)
(5) 3D manual feed (1st handle) in table coordinate system (MH1CB:YD1C)
(6) 3D manual feed (1st handle) in feature coordinate system (MH1CF:YD1D)
(7) 3D manual feed (2nd handle) in tool axis coordinate system (MH2CT:YD1E)
(8) 3D manual feed (2nd handle) in table coordinate system (MH2CB:YD1F)
(9) 3D manual feed (2nd handle) in feature coordinate system (MH2CF:YD20)
(10) 3D manual feed (3rd handle) in tool axis coordinate system (MH3CT:YD21)
(11) 3D manual feed (3rd handle) in table coordinate system (MH3CB:YD22)
(12) 3D manual feed (3rd handle) in feature coordinate system (MH3CF:YD23)

12.27.8.4 Tool Center Point Rotation Output

Cont.	Signal name	Abbrev.	$1	$2	$3	$4	$5	$5	$7	$8
A	In tool center point rotation	TCPRS	XD27	XE67	XFA7	X10E7	X1227	X1367	X14A7	X15E7

[Function]

This signal informs the operation of the rotation axis of 3D manual feed (JOG/incremental/handle).

[Operation]

This signal informs that it operates with keeping the positional relationship of tool center point looking from the workpiece, when the rotation axis of 3D manual feed (JOG/incremental/handle) is operated.

[Related signals]

(1) Tool axis coordinate system in 3D manual feed (JOG,INC)
(2) Table coordinate system in 3D manual feed (JOG,INC)
(3) Feature coordinate system in 3D manual feed (JOG,INC)
(4) Tool axis coordinate system in 3D manual feed (1st handle)
(5) Table coordinate system in 3D manual feed (1st handle)
(6) Feature coordinate system in 3D manual feed (1st handle)
(7) Tool axis coordinate system in 3D manual feed (2nd handle)
(8) Table coordinate system in 3D manual feed (2nd handle)
(9) Feature coordinate system in 3D manual feed (2nd handle)
(10) Tool axis coordinate system in 3D manual feed (3rd handle)
(11) Table coordinate system in 3D manual feed (3rd handle)
(12) Feature coordinate system in 3D manual feed (3rd handle)

12.27.9 Cautions

(1) Speed clamp

Apply a speed limit so that the rapid traverse rate or cutting feed clamp speed is not exceeded by the speed calculated by distributing the travel amount in the hypothetical coordinate system among each machine axis direction.

Clamp the rotary axis feedrate so that the manual feedrate of a linear axis does not exceed the linear axis feedrate of "Rotation with the tool tip as the center" with the JOG/incremental feed. When using the handle feed, clamp the rotary axis feedrate so that the linear axis feedrate does not exceed the rapid traverse rate (#2001 rapid) or cutting feed clamp speed (#2002 clamp).

(2) Acceleration, Deceleration and time constant

Set the same cutting feed acceleration/deceleration type and same time constant for all the axes involved in the 3-dimensional manual feed (They have to be the same, because the interpolation is made using the travel amounts distributed to each axis).

(3) Feed amount

The incremental feed amount and handle feed amount by one pulse are expressed with the feed amount in the composite direction of the selected coordinate system. When Initial inch is selected, the increment is in one inch unit.

(4) Restart after alarm restoration

When the operation error "M01 Multi ax for 5-ax manual feed 0230" or "M01 5-ax manual feed coord sys err 0231" occurs during axis movement, the moving axis decelerates and stops. The axis does not restart movement even after the alarm has been cancelled.

If you want to resume the axis movement, give the command to the axis again.

(5) Magnification

The available range of the incremental feed magnification is between 1 and 100000.

The magnification for handle feed is between 1 and 1000. If a speed is clamped, the number of pulses and the axis' travel amount do not match. In this case, however, the counter display and the machine position value are matched.

(6) Machine lock

For an axis to which the manual machine lock signal is ON, the [Machine position] counter is locked. If a travel command is given to the manual machine lock axis, axis travel is made by the travel amounts distributed to each axis, but the manual machine lock axis itself does not move.

(7) Feed axis

The axis Nos. specified for the 3-dimensional manual feed (jog, incremental or handle mode) are the same as those for normal manual feed.

However, the 3-dimensional manual feed is enabled only for the axes that have been set in the rotary axis configuration parameters.

Linear axes:

X axis in the hypothetical coordinate system: The axis set in #7900(RCDAX_I)

Y axis in the hypothetical coordinate system: The axis set in #7901(RCDAX_J)

Z axis in the hypothetical coordinate system: The axis set in #7902(RCDAX_K)

Rotary axes:

- Tool tilt type

  The axes set in #7922(ROTAXT1) and #7932(ROTAXT2)

- Combined type

  The axes set in #7932(ROTAXT2) and #7952(ROTAXW2)

- Table tilt type

  The axes set in #7942(ROTAXW1) and #7952(ROTAXW2)

The example below is when the handle feed (1st handle) is carried out in the tool tilt type configuration equipped with 8 NC axes (XYZUVWAC) by setting the 1st, 2nd and 3rd axes as linear axes, and 7th and 8th axes as rotary axes in the 1st part system.

$1	Abbrev.	Details	Setting
YC40	HS11	1st handle axis selection code 1	See below
YC41	HS12	1st handle axis selection code 2	See below
YC42	HS14	1st handle axis selection code 4	See below
YC43	HS18	1st handle axis selection code 8	See below
YC44	HS116	1st handle axis selection code 16	0
YC47	HS1S	1st handle valid	1
YD18	MH1CT	3-dimensional manual feed (1st handle) in tool axis coordinate system	See below
YD19	MH1CB	3-dimensional manual feed (1st handle) in table coordinate system	See below
YD1A	MH1CF	3-dimensional manual feed (1st handle) in feature coordinate system	See below

Corresponding handle axis No.	YD27	YD18	YD19	YD1A	YC43	YC42	YC41	YC40	Condition
X axis (1st axis) selected	0/1	0	0	0	0	0	0	1	Normal manual feed
Y axis (2nd axis) selected	0/1	0	0	0	0	0	1	0	
Z axis (3rd axis) selected	0/1	0	0	0	0	0	1	1	
U axis (4th axis) selected	0/1	0	0	0	0	1	0	0	
V axis (5th axis) selected	0/1	0	0	0	0	1	0	1	
W axis (6th axis) selected	0/1	0	0	0	0	1	1	0	
A axis (7th axis) selected	0	0	0	0	0	1	1	1	
	1	0	0	0	0	1	1	1	Tool center point rotation
C axis (8th axis) selected	0	0	0	0	1	0	0	0	Normal manual feed
	1	0	0	0	1	0	0	0	Tool center point rotation
X axis (1st axis) selected	0/1	Either one of these is 1			0	0	0	1	Feed in hypothetical coordinate system
Y axis (2nd axis) selected	0/1	Either one of these is 1			0	0	1	0	
Z axis (3rd axis) selected	0/1	Either one of these is 1			0	0	1	1	
U axis (4th axis) selected	0/1	Either one of these is 1			0	1	0	0	Normal manual feed
V axis (5th axis) selected	0/1	Either one of these is 1			0	1	0	1	
W axis (6th axis) selected	0/1	Either one of these is 1			0	1	1	0	
A axis (7th axis) selected	0	Either one of these is 1			0	1	1	0	
	1	Either one of these is 1			0	1	1	1	Tool center point rotation
C axis (8th axis) selected	0	Either one of these is 1			1	0	0	0	Normal manual feed
	1	Either one of these is 1			1	0	0	0	Tool center point rotation

(8) Spindle position control (spindle/C axis)

When using the axis set for Spindle/C axis as a rotary axis to perform tool center point rotation control, start the 3-dimensional manual feed in C axis mode. When the 3-dimensional manual feed is started in spindle mode, if Tool center point rotation signal (TCPRC:YD27) turns ON, the operation error (M01 0186) occurs.

When performing the 3-dimensional manual feed again, perform the NC reset before starting the 3-dimensional manual feed.

12.27.10 Relation with Other Function

12.27.10.1 Relation with Tool Handle Feed & Interrupt Function

The "3-dimensional manual feed" function can be used together with the "Tool handle feed & interrupt" function.
When the conditions for both functions are met, the 3-dimensional manual feed is given priority.
The handle feed operation is the same between the two functions for the tool tilt type machine configuration. Note, however, that the operation is different between them for the table tilt and combined type configurations.

The list below shows the combination of the parameters and signals and the corresponding operation (the signals below are for $1).

3-dimensional manual feed		Tool handle feed & interrupt		Operation (Note2)		
3-dimensional manual feed is invalid #7912 NO_MANUAL	Hypothetical coordinate system selection(Note1) JOG :YD18 to YD1A HDL1:YD1B to YD1D HDL2:YD1E to YD20 HDL3:YD21 to YD23	Tool handle invalid #7904 NO_TIP	Tool handle mode YC5E	A	B	C
0	0	0	0	○		
0	0	0	1		○	
0	0	1	0	○		
0	0	1	1		○ (Note3)	
0	1	0	0			○
0	1	0	1			○
0	1	1	0			○
0	1	1	1			○
1	0	0	0	○		
1	0	0	1		○	
1	0	1	0	○		
1	0	1	1		○ (Note3)	
1	1	0	0	○		
1	1	0	1		○	
1	1	1	0	○		
1	1	1	1		○ (Note3)	

(Note1) This is based on the assumption that the device bits suitable for the mode, handle No. and selected coordinate system are turned ON.

(Note2) A: Standard manual feed
B: Tool handle feed & interrupt when handle is selected, or standard manual feed when a method other than handle is selected
C: 3-dimensional manual feed

(Note3) The tool handle mode is being selected, although the tool handle is disabled. Thus the axis does not move by handle operation. (No alarm occurs)
In a mode other than handle mode, standard manual feed is carried out.

12.27.10.2 Multiple-Axis Synchronization Control

3-dimensional manual feed coordinate system cannot be selected during multiple-axis synchronization control. The operation error (M01 0186) occurs.

12.27.10.3 Relation with Other Functions

(1) When the conditions for the 3-dimensional manual feed are not met, and no alarm is output, the standard jog feed, incremental feed, handle feed, handle interruption and tool handle feed & interrupt functions are usable as before.
(2) In the case of manual jog or incremental feed, the speed is limited under the cutting clamp speed. In the case of manual handle feed, the speed is limited below the rapid traverse clamp speed.
(3) During External deceleration, the feed rate drops below the external deceleration rate.
(4) When interruption is made during dwell, the dwell count operation is stopped to carry out the interruption. When the interruption is complete, the dwell count operation is resumed.
(5) When the manual ABS switch is OFF, a position in the workpiece or local coordinate system is deviated by the manual feed amount or interruption amount.
(6) When the dog-type reference position return is complete, the manual interruption amount is cancelled.
(7) The manual interruption amount is cancelled by NC reset 1, NC reset 2 or Reset & Rewind.
(8) When Emergency stop is cancelled, the manual interruption amount is also cancelled.
(9) When G92 or Origin set is executed, the manual interruption amount of the commanded axis is cancelled.
When setting the values, select either tool tip or tool base using the parameter.
(10) If there is any moving axis whose Stroke end signal is ON, the operation error (M01 0006) is output, which disables both the 3-dimensional manual feed and interruption.
When the signal of any of the moving axes turns ON, all the manually fed axes decelerate and stop.
(11) The 3-dimensional manual feed and interruption are enabled within the soft limit range of each axis.
If any moving axis has exceeded the soft limit range, the operation error (M01 0007) is output, which disables both the 3-dimensional manual feed and interruption.
When any of the moving axes is at the soft limit, all the manually fed axes decelerate and stop before crossing over the limit.
(12) If there is any moving axis whose Manual interlock signal is ON, the operation error (M01 0004) is output, which disables both the 3-dimensional manual feed and interruption.
When the signal of any of the moving axes turns ON, all the manually fed axes decelerate and stop.
(13) If there is any moving axis whose Servo OFF signal is OFF, the operation error (M01 0005) is output, which disables both the 3-dimensional manual feed and interruption.
When the signal of any of the moving axes turns OFF, all the manually fed axes decelerate and stop.
(14) If there is any moving axis whose Control axis detachment signal is ON, the operation error (M01 0005) is output, which disables both the 3-dimensional manual feed and interruption.
When the signal of any of the moving axes turns ON, all the manually fed axes decelerate and stop.
(15) Do not include a chopping axis in the 3-dimensional manual feed.
If it is included, the travel amount of the chopping axis is ignored.
(16) If synchronization control is used together with this function, set the master axis No. to the rotary axis configuration parameters. If you set the slave axis No., the operation fails. Note that the slave axis also has to return to the zero point.
(17) Manual arbitrary feed is executed in the machine coordinate system, even when a hypothetical coordinate system is being selected for the 3-dimensional manual feed.
(18) Do not carry out the 3-dimensional manual feed while Manual arc feed is enabled.
If Manual arc feed is enabled while a hypothetical coordinate system is being selected for the 3-dimensional manual feed, or if a hypothetical coordinate system is selected for the 3-dimensional manual feed while Manual arc feed is being enabled, the operation error (M01 0231) is output.
(19) If you carry out the 3-dimensional manual feed while the "Simultaneous operation of manual and automatic modes" function is being enabled, turn ON the "Manual/automatic simultaneous valid axis" signal of the three linear axes and two rotary axes that are set in the rotary axis configuration parameters.
Note that if you have failed to turn ON this signal for all the three linear axes and two rotary axes, the distributed manual travel amount is superimposed on the travel amount for automatic operation, and the movement may fail to be along the hypothetical coordinate system.
(20) The setting of the rotary axis configuration parameter "#7912 NO_MANUAL" can be read out using the "Parameter input by program" function or system variables. The read value is the one at the point of execution.

(21) The setting of the rotary axis configuration parameter "#7912 NO_MANUAL" (Selection of the "3-dimensional manual feed" function) can be changed using the "Parameter file input" or "Parameter input by program" function or system variables.

(22) The automatic operation handle interruption is not available for a rotary axis with the 3-dimensional manual feed. If a travel command is given to a rotary axis, the interruption to the rotary axis is ignored.

(23) When the automatic operation handle interruption is used with the 3-dimensional manual feed, this function limits the travel feedrate of the interruption axis (the automatic movement feedrate + the interruption feedrate by manual pulse generator) so as not to exceed the clamp speed of the axis.
The speed is clamped to the cutting feed clamp speed during cutting feed, and clamped to the rapid traverse clamp speed during rapid traverse feed.

(24) When manual tool length measurement or workpiece position measurement is carried out while a hypothetical coordinate system is being selected for the 3-dimensional manual feed, the operation error (M01 0231) is output.

(25) The values in the machine coordinate system are displayed on the play back edit screen, even when a hypothetical coordinate system is being selected for the 3-dimensional manual feed.

(26) Spindle synchronous control I/Spindle synchronous control II can command the 3-dimensional manual feed using the C axis under spindle synchronization control.

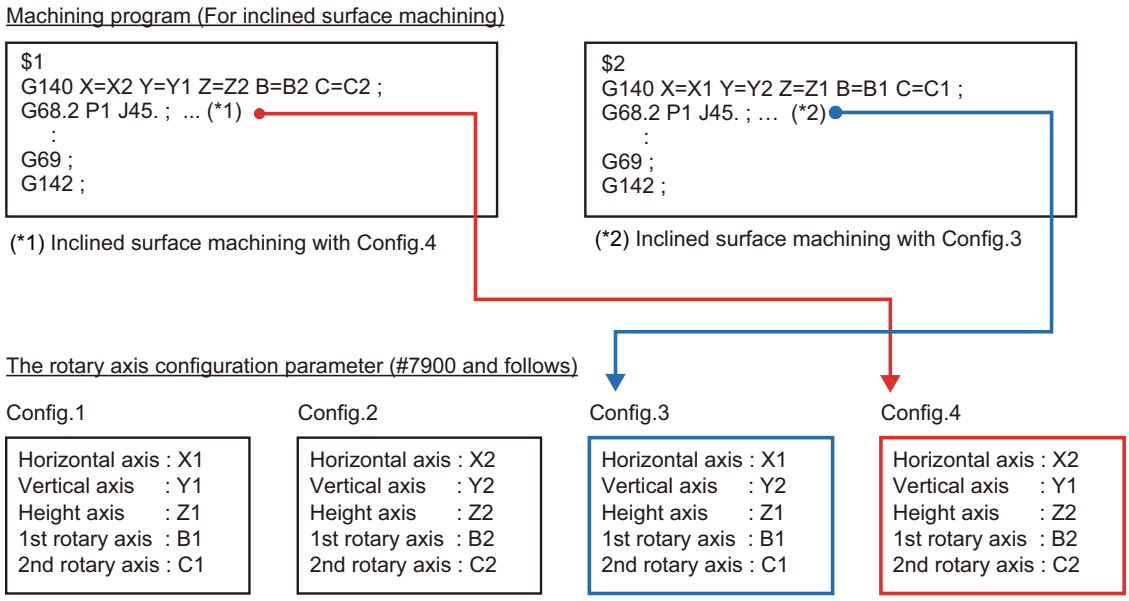
(27) For the combination with arbitrary axis exchange, refer to the chapter "Applying the Rotary Axis Configuration Parameter".

12.28 Applying the Rotary Axis Configuration Parameter

On a multi-tasking machine, one rotary tool may be shared with multiple part systems. In this case, arbitrary axis exchange control and mixed control which an arbitrary axis between part systems can be exchanged freely are used.
When operating a specific function (*1) in combination with arbitrary axis exchange (G140) command and mixed control I/II commands, the rotary axis configuration parameter need to be set with the 2nd axis name. Set the parameter "#1450 5axis_Spec/bit0" (axis name setting method of rotary axis configuration parameter) to "1", and set the axis configuration with the second axis name (e.g.: A1, B2) to operate these functions in the rotary axis configuration parameter (from #7900).
When "#1450 5axis_Spec/bit0" is set to "0" (Set by axis name), an operation error or a program error occurs if these functions are performed after the arbitrary axis exchange.
You can specify the configurations up to the number of valid part systems (max. 4) for the rotary axis configuration parameter.
When multiple configurations are specified, these functions can be performed with different axis configurations.

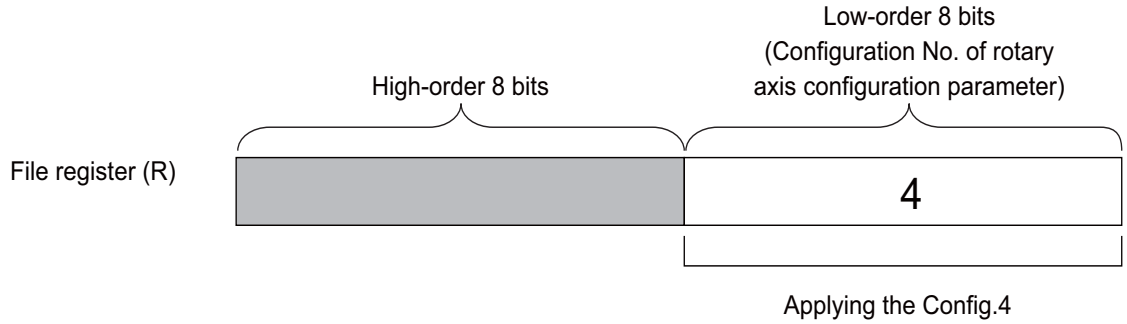
(*1) This indicates the following functions:
- Inclined surface machining command
- Simple inclined surface machining command
- Rotation center error compensation
- Tool center point control (Can be combined with arbitrary axis exchange only)
- 3-dimensional manual feed (Can be combined with arbitrary axis exchange only)

By applying the rotary axis configuration parameter whose configuration is that all the existing axes in the part system have been set, the target function with the axis configuration in the part system after the axes exchange is available.



You can check the rotary axis configuration parameters being applied with rotary axis configuration parameter output (R656).
If there are no applying rotary axis configuration parameters, NC notifies "0" on the rotary axis configuration parameter No. (R656/low-order 8 bits). If the target function is performed under this situation, an operation error or a program error occurs.

Rotary axis configuration parameter output (R656($1) NC→PLC)



Application method of rotary axis configuration parameter

There are following types to apply the rotary axis configuration parameter. You can switch the application methods with parameter "#1450 5axis_Spec/bit2" (Application of rotary axis configuration parameters).
Specify the "automatic selection method" if the rotary axis configuration parameter, which matches the axis configuration when executing the target function, can be determined uniquely. Specify the "PLC signal method" if the parameter cannot be determined uniquely and you want to designate the parameter to apply.

(1) Automatic selection method (#1450 5axis_Spec/bit2 : 0)
For the specified rotary axis configuration parameter, the configuration that all the axes in the commanded part system are specified is searched in the order of own part system, $1, $2 and subsequent part system at the time of following three.
- Power ON
- NC reset
- Arbitrary axis exchange control (G140/G141/G142) command
- Mixed control I/II command

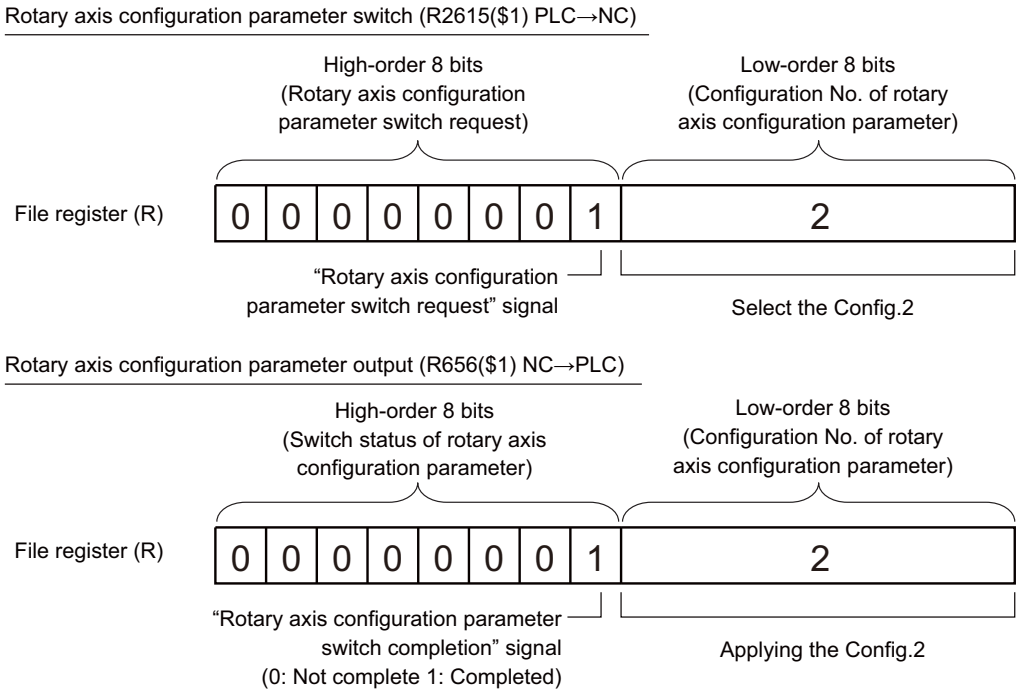
The configuration of the rotary axis configuration parameter matched first will be applied.

Axis configuration in the part system			Rotary axis configuration parameter (combined tilt)				
Axis order	$1			Config.1	Config.2	Config.3	Config.4
1	X2		#7900 RCDAX_I	X1	X2	X2	X1
2	Y2		#7901 RCDAX_J	Y1	Y2	Y2	Y1
3	Z2		#7902 RCDAX_K	Z1	Z2	Z2	Z1
4	C1		#7930 SLCT_T2	2	2	2	2
5	B2		#7932 ROTAX_T2	B1	B2	B2	B1
			#7950 SLCT_W2	3	3	3	3
			#7952 ROTAX_W2	C1	C2	C1	C2

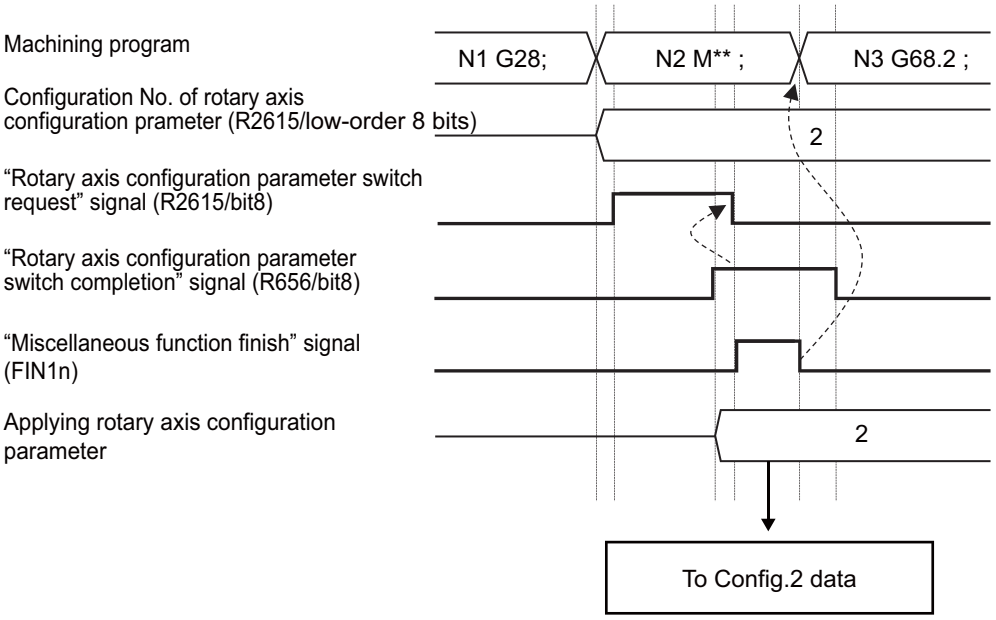
(2) PLC signal method (#1450 5axis_Spec/bit2 : 1)

When "Rotary axis configuration parameter switch request signal (R2615/bit8)" turns ON (0→1), configuration set in "Configuration No. of rotary axis configuration parameter (R2615/low-order 8 bits)" will be switched. Turn ON the "Rotary axis configuration parameter switch request signal" by M command or T command.

When switching the rotary axis configuration parameters is completed, "Rotary axis configuration parameter switch completion signal (R656/bit8)" is turned ON. After you checked the "Rotary axis configuration parameter switch completion signal" is turned ON, turn OFF the "Rotary axis configuration parameter switch request signal". Then, the "Rotary axis configuration parameter switch completion signal" is turned OFF.



Timing chart



Axis configuration in the part system (No.2 to No.6 blocks)			**Rotary axis configuration parameter (combined tilt)**				
Axis order	**$1**			**Config.1**	**Config.2**	**Config.3**	**Config.4**
1	X1		#7900 RCDAX_I	X1	**X1**	X2	X2
2	Y2		#7901 RCDAX_J	Y1	**Y2**	Y2	Y1
3	Z1		#7902 RCDAX_K	Z1	**Z1**	Z2	Z2
4	C1		#7930 SLCT_T2	2	**2**	2	2
5	B1		#7932 ROTAX_T2	B1	**B1**	B2	B2
			#7950 SLCT_W2	3	**3**	3	3
			#7952 ROTAX_W2	C1	**C1**	C1	C2

Operation when the rotary axis is set with non-ISO polarity

For combined type 5-axis machine, the following functions can be used in the machine whose rotary axis is installed with either ISO polarity or non-ISO polarity.
(5-axis machine other than combined type supports only the rotary axis installed with ISO polarity.)
- Inclined surface machining command (G68.2/G68.3)
- Tool axis direction control command (G53.1/G53.6)
- Tool center point control command (G43.4/G43.5)
- 3-dimensional manual feed

[Definition of ISO polarity]
"ISO polarity" means that the movement direction and rotation direction of the axis follows the right-hand orthogonal coordinate system (the coordinate system which is defined in ISO standard).
"Non-ISO polarity" means that the movement direction and rotation direction of the axis follows the left-hand orthogonal coordinate system.
To use the rotary axis installed with reverse ISO polarity, set the following parameters.
(1) Set the parameter "#1450 5axis_Spec/bit3" to "1".
(2) Set the parameter, which corresponds to non-ISO polarity axis, between "#7923 DIR_T1", "#7933 DIR_T2", "#7943 DIR_W1", and "#7953 DIR_W2" to "1".

When all the rotary axes are installed with ISO polarity, set the parameter "#1450 5axis_Spec/bit3" to "0".

[Note]
There are following restrictions to use the rotary axis installed with non-ISO polarity.
- When the inclined surface machining command (G68.2 P10) is issued, the program error (P934) occurs.
- When the inclined surface machining command (G68.2/G68.3), tool axis direction control command (G53.1/G53.6), or tool center point control command (G43.4/G43.5) is issued in a machine other than combined type, the program error (P934) occurs.
- When the 3-dimensional manual feed is commanded on a machine other than combined type, the operation alarm (M01 0186) occurs.

Precautions

(1) After turning ON the power, resetting the NC, emergency stop, or issuing the arbitrary axis exchange control (G140/G141/G142) or mixed control I/II command, the state will be that rotary axis configuration parameter is not applied. Therefore, issue the function targeted for the combination after applying the rotary axis configuration parameter.

(2) Rotary axis configuration parameter is switched when "Rotary axis configuration parameter switch request signal (R2615/bit8)" turns ON (0→1). If you want to switch again after the configuration switch, set the configuration No. for rotary axis configuration parameter and turn OFF and ON the "Rotary axis configuration parameter switch request signal".

(3) If the axes set to the designated rotary axis configuration parameter do not exist all in the part system at the time of switching the rotary axis configuration, the operation error (M01 0186) occurs.

(4) If "Rotary axis configuration switch request signal" is turned ON during the function targeted for the combination, the operation error (M01 0187) occurs.

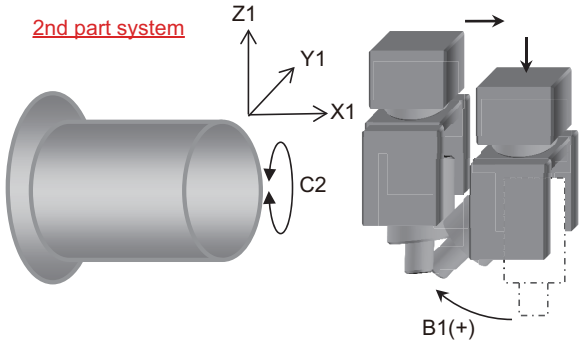
(5) Regardless of the setting for "#1450 5axis_Spec/bit2" (Application of rotary axis configuration parameters), "Configuration No. of rotary axis configuration parameter (R656/lower 8 bits)" will be output. However, "Rotary axis configuration parameter switch completion signal (R656/bit8)" will be turned ON only when the setting of "#1450 5axis_Spec/bit2" is "1" (PLC signal method).

(6) When using the tool center point control, also be careful with the following points:
  (a) If the arbitrary axis exchange command (G140) is issued during the tool center point control, the program error (P942) occurs.
  (b) If any axis of the part system where tool center point control is active has become an exchange target axis, the operation error (M01 1101) occurs. This alarm is canceled by reset.
  (c) After the arbitrary axis exchange, the rotary axis prefiltering is disabled.
  (d) If you use the graphic check to draw the tool center point control command issued after the arbitrary axis exchange, the graphic check draws a machining path from which the arbitrary axis exchange command is ignored.

(7) When using the inclined surface machining/simple inclined surface machining command, also be careful with the following points:
  (a) When the reset of modal retention (#1151 rstint = 0) is performed during the inclined surface machining or simple inclined surface machining mode, the rotary axis configuration parameters applied at the time of reset continue to be applied after the reset.
  (b) When the NC reset is performed with the setting (#1210 RstGmd/bitF=1) which retains the inclined surface machining modal during simple inclined surface control (G176), the rotary axis configuration parameters applied at the time of reset continue to be applied after the reset.
  (c) For the graphic check drawn the inclined surface machining command/simple inclined surface machining command after the axis exchange, the drawing will be that the machining path which axis exchange command is ignored.
  (d) Use the 3-dimensional manual feed when you take out the tool used for inclined surface machining command/simple inclined surface machining command.

Usage example:

Perform 3-dimensional manual feed (tool center point rotation) using the axes exchanged from 1st part system to 2nd part system (X1, Y1, Z1, and B1)



(8) When the rotation center error compensation function is used, note the following conditions as well.

(a) Precautions when the parameter "#1450 5axis Spec/bit5" (Rotation center error compensation: restraint of machine movement) is set to "1".

- When the rotary axis configuration parameter is switched due to a reset or an emergency stop, the machine may move because the rotation center error compensation function is immediately enabled in the configuration after the parameter is switched.
- The rotary axis configuration parameter may not be applied during the rotation center error compensation. In this case, the "Rotation center error compensation in progress" signal (RCEI: XD15) is turned OFF because the rotation center error compensation becomes invalid (compensation amount is "0").

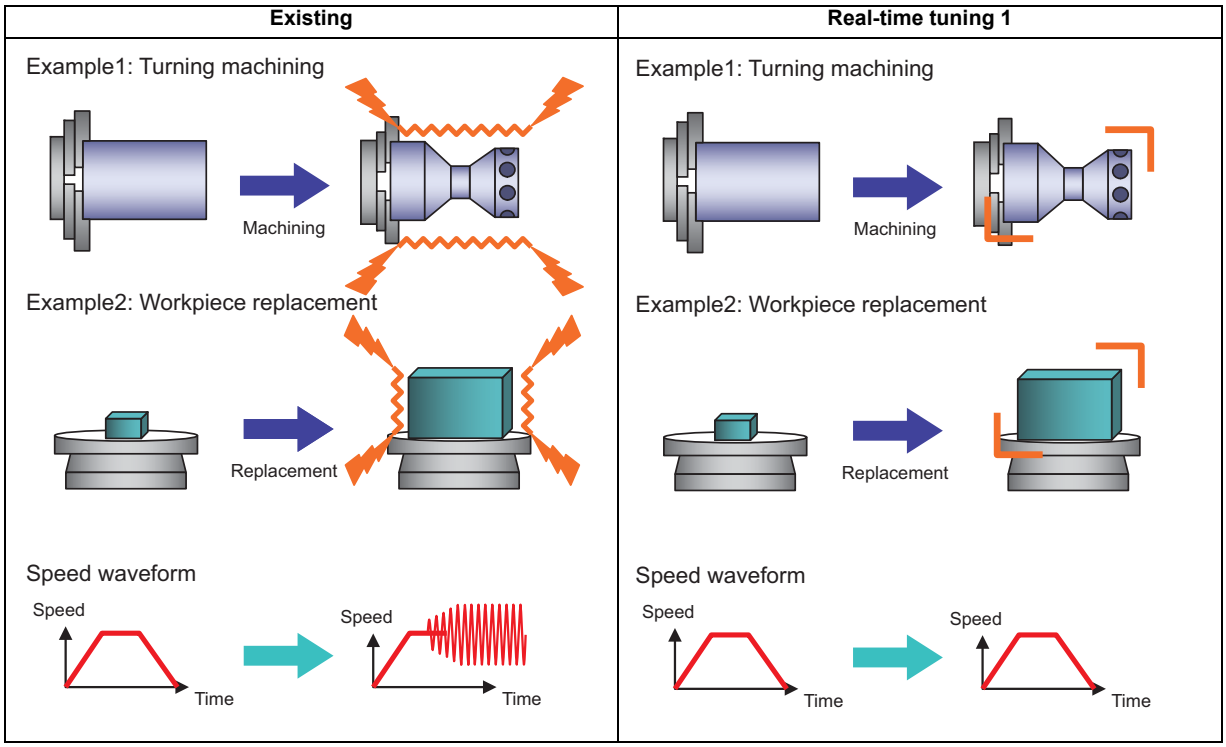
(b) When the "Rotation center error compensation enabled" signal (RCEE: YD15) is turned ON without applying the rotary axis configuration parameter, the operation error (M01 0186) occurs. However, if the parameter "#1450 5axis Spec/bit5" is set to "1", this alarm is not output.

(c) When the "Rotary axis configuration parameter switch request" signal (R2615/bit8) is turned ON during the rotation center error compensation, the operation error (M01 0187) occurs. However, if the parameter "#1450 5axis Spec/bit5" is set to "1", this alarm is not output.
When the parameter "#1450 5axis Spec/bit5" is set to "1", if the rotary axis configuration parameter is switched, the machine may move because the rotation center error compensation function is immediately enabled in the configuration after the parameter is switched. For the sake of safety, issue this command at the position where the rotary axis angle is 0°.

12.29 Real-Time Tuning 1 (Speed Gain)

12.29.1 Outline

This function estimates the inertia (or workpiece weight) of mechanical system and changes the speed control gain automatically according to the estimation results to suppress mechanical vibration.
For example, this suppresses vibration caused when a large workpiece becomes smaller in turning machining as illustrated in Example 1 below. This function also suppresses vibration caused when a workpiece that is relatively small for the table is replaced by a larger one as illustrated in Example 2 below.
Using this function, users can expect suppression of vibration caused by inertia fluctuation, as well as reduction of machining time through adaptation of appropriate speed control gain.
This function also commands a stop of speed control gain change and displays the estimated inertia ratio and magnification of speed control gain (ratio of the changed speed control gain to the initially set gain).



12.29.2 Function Enabling Conditions

In order to utilize this function, the following conditions shall be met in every servo axis and spindle motor. This function allows us to determine whether making the function valid or invalid in every axis and spindle.

<Servo axis>

(1) Set the parameters as follows.

Parameter	Method of setting
#2205 VGN1 (Speed loop gain 1)	Setting under the condition without a workpiece
#2206 VGN2 (Speed loop gain 2)	Setting under the condition without a workpiece
#2237 JL (Load inertia scale)	Setting load inertia ratio under the condition without a workpiece. (Rotary motor: 100 or over) (Linear motor: inertia weight or over)
#2399 RTGM (Real-time tuning: maximum adaptive gain multiplier)	Set the value which is NOT zero
#2400 RTJX (Real-time tuning: maximum adaptive inertia ratio)	Set the value larger than #2237

(2) "Real-time tuning 1: Speed control gain changeover hold-down command signal (VGHLDC1: YB80)" is OFF.

When meeting the above valid conditions, the speed control gain is switched in response to inertia.

- In case that machine resonance is induced when mounting a workpiece, set the resonance filter in advance. (Related parameters: #2233, #2238, #2246, #2287, #2288)
- If the estimated load inertia ratio is larger than "#2400 RTJX (real-time tuning: maximum adaptive inertia ratio)",the magnification of speed control gain will be the value set in "#2399 RTGM (real-time tuning: maximum adaptive gain multiplier)"
- If the estimated load inertia ratio is smaller than "#2237 JL (load inertia scale)", the magnification of speed control gain will be 1[time].
- If not meeting the conditions, the speed control gain based on "#2205 VGN1 (speed loop gain1)" or "#2208 VGN2 (speed loop gain 2)" will be adapted in operation.

<Spindle>

(1) Set the parameter as follows.

Parameter	Method of setting
#13005 VGN1 (Speed loop gain 1)	Setting under the condition without a workpiece
#13008 VGN2 (Speed loop gain 2)	Setting under the condition without a workpiece
#13037 JL (Load inertia scale)	Setting load inertia ratio under the condition without a workpiece.
#13199 RTGM (Real-time tuning: maximum adaptive gain multiplier)	Set the value which is NOT zero
#13200 RTJX (Real-time tuning: maximum adaptive inertia ratio)	Set the value larger than #13037

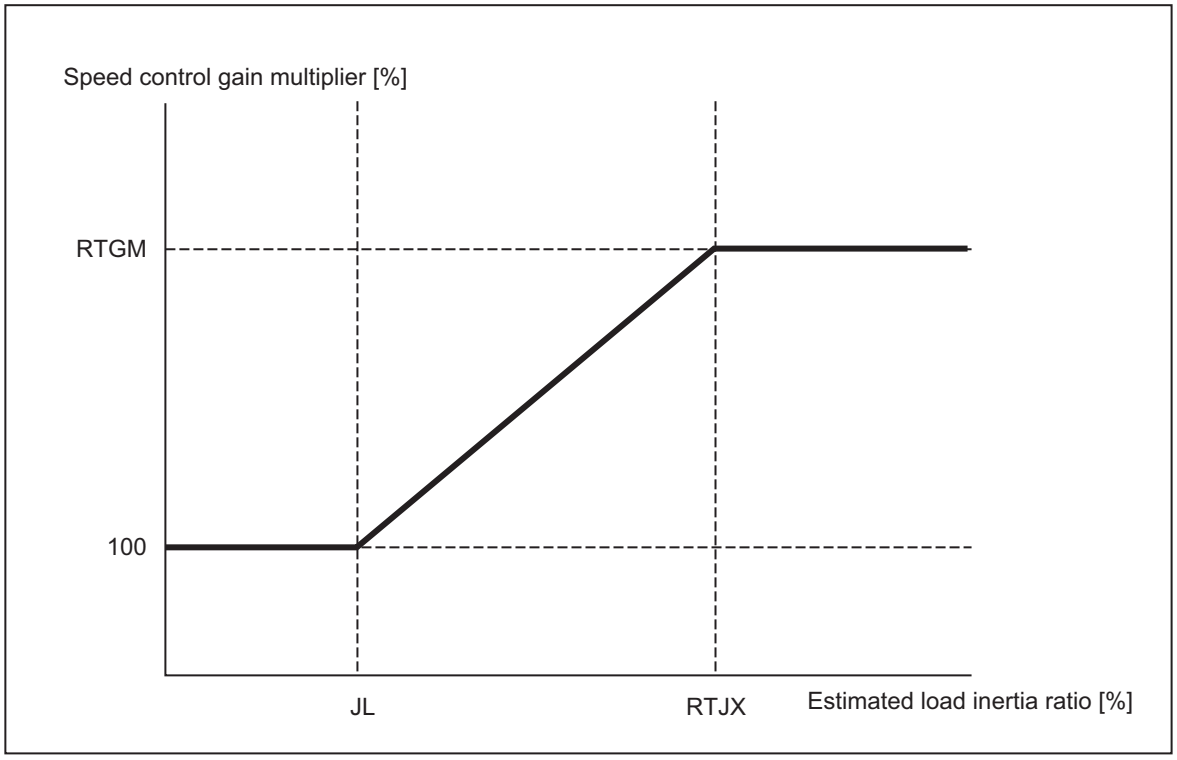
(2) Set the parameter according to the spindle mode. (When power is turned OFF and ON, it is switched to valid or invalid)

Parameter		Spindle mode		
		Non-interpolation	Interpolation	Spindle synchronization
#13035 SFNC3/bit6 (Spindle function 3)	0	×	○	×
	1	○	○	×
#13036 SFNC3/bit4 (Spindle function 4)	0	×	○	×
	1	×	○	○
○ :function valid ×:function invalid				

(3) "Real-time tuning 1: Speed control gain hold-down command (VGHLDC: Y18CA)" signal is OFF.

When meeting the above valid conditions, the speed control gain is switched in response to inertia.

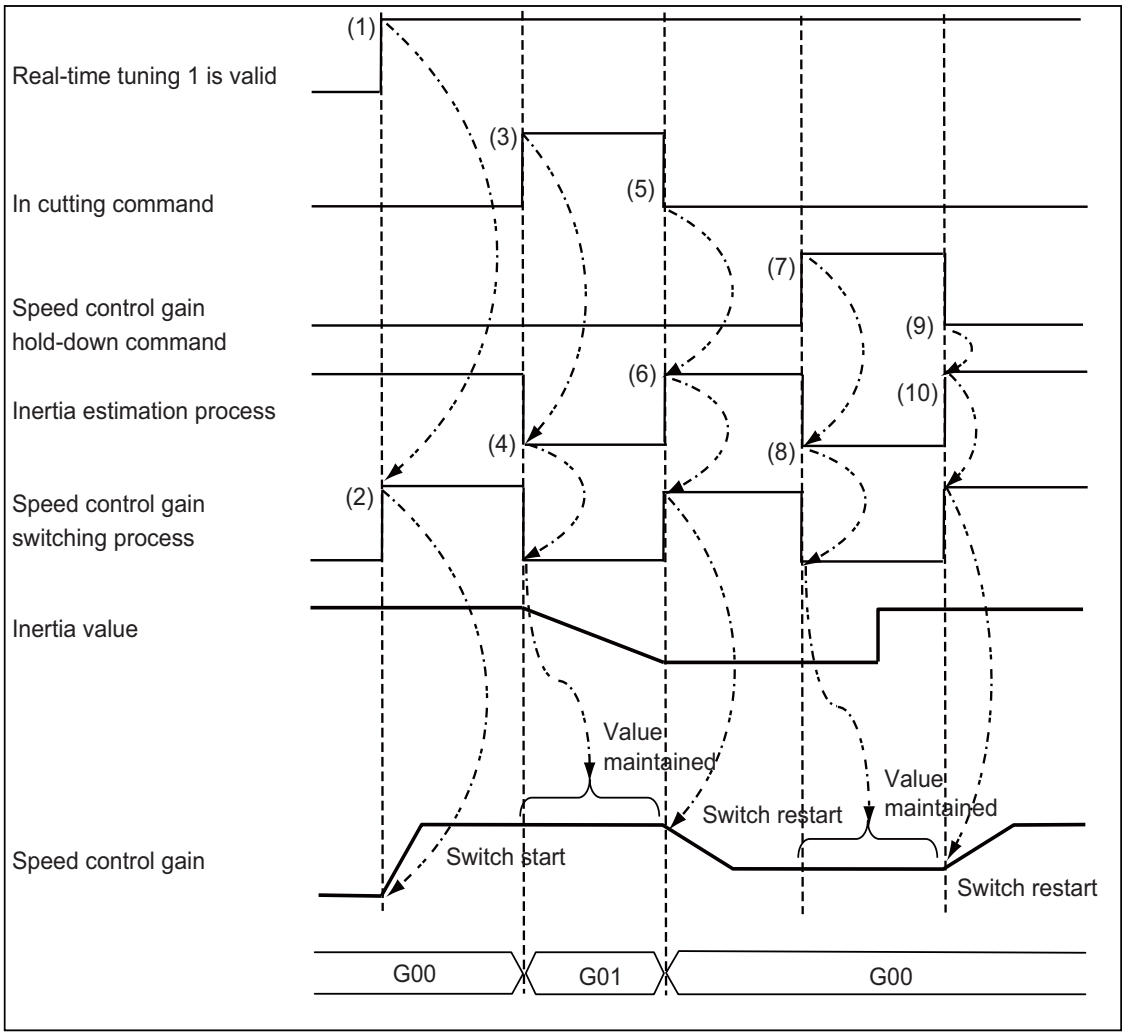
- In case that machine resonance is induced when mounting a workpiece, set the resonance filter in advance. (Related parameters: #2233, #2238, #2246, #2287, #2288 (for servo axis), #13034, #13038, #13046, #13087, #13088 (for spindle))
- If the estimated load inertia ratio is larger than "#13200 RTJX (real-time tuning: maximum adaptive inertia ratio)",the magnification of speed control gain will be the value set in "#13199 RTGM (real-time tuning: maximum adaptive gain multiplier)"
- If the estimated load inertia ratio is smaller than "#13037 JL(load inertia scale)", the magnification of speed control gain will be 1[time].
- If not meeting the conditions, the speed control gain based on "#13005 VGN1 (speed loop gain 1)" or "#13008 VGN2 (speed loop gain 2)" will be adapted in operation.



12.29.3 Description of Operation

- When the function of real-time tuning 1 is validated, the speed control gain is switched according to the estimated inertia size.
- During the cutting command (during modal), the value of speed control gain is retained. Once the modal command is removed, the speed control gain switching is resumed.
- If you do not want to validate the speed control gain switching, turn ON the signal "Real-time tuning 1: Speed control gain hold-down command (VGHLDC:Y18CA)". If you want to resume the speed control gain switching, turn OFF the signal "Real-time tuning 1: Speed control gain hold-down command (VGHLDC:Y18CA)".

Operation example is shown below.



(1) Enable the real-time tuning 1 function.
(2) The speed control gain switching is initiated and the speed control gain is switched according to the estimated inertia size.
(3) Validate cutting command.
(4) Inertia estimation process is stopped and the estimated inertia value is retained. Along with this, the speed control gain switching process is stopped and the speed control gain value is retained as well.
(5) The cutting command is finished and the modal is removed.
(6) The inertia estimation and gain switching processes are resumed.
(7) Turn ON the signal "Real-time tuning 1: Speed control gain hold-down command (VGHLDC:Y18CA)".
(8) Inertia estimation process is stopped and the estimated inertia value is retained. Along with this, the speed control gain switching process is stopped and the speed control gain value is retained as well.
(9) Turn OFF the signal "Real-time tuning 1: Speed control gain hold-down command (VGHLDC:Y18CA)".
(10) The inertia estimation and gain switching processes are resumed.

12.29.4 Precautions

(1) For linear motors, set the value of weight inertia or larger in "#2237 JL (load inertia scale)".
If the value smaller than that of weight inertia is set, the speed control gain switching becomes invalid but the value which is not 100% may be displayed in the "Gain mag." on drive monitor screen.

12.30 Real-Time Tuning 2 (Rapid Traverse Time Constant)

12.30.1 Outline

This function estimates the inertia of workpiece and optimizes the operation acceleration/deceleration time constant automatically according to the estimation results.This allows the cycle time to be reduced when the inertia of workpiece fluctuates considerably.

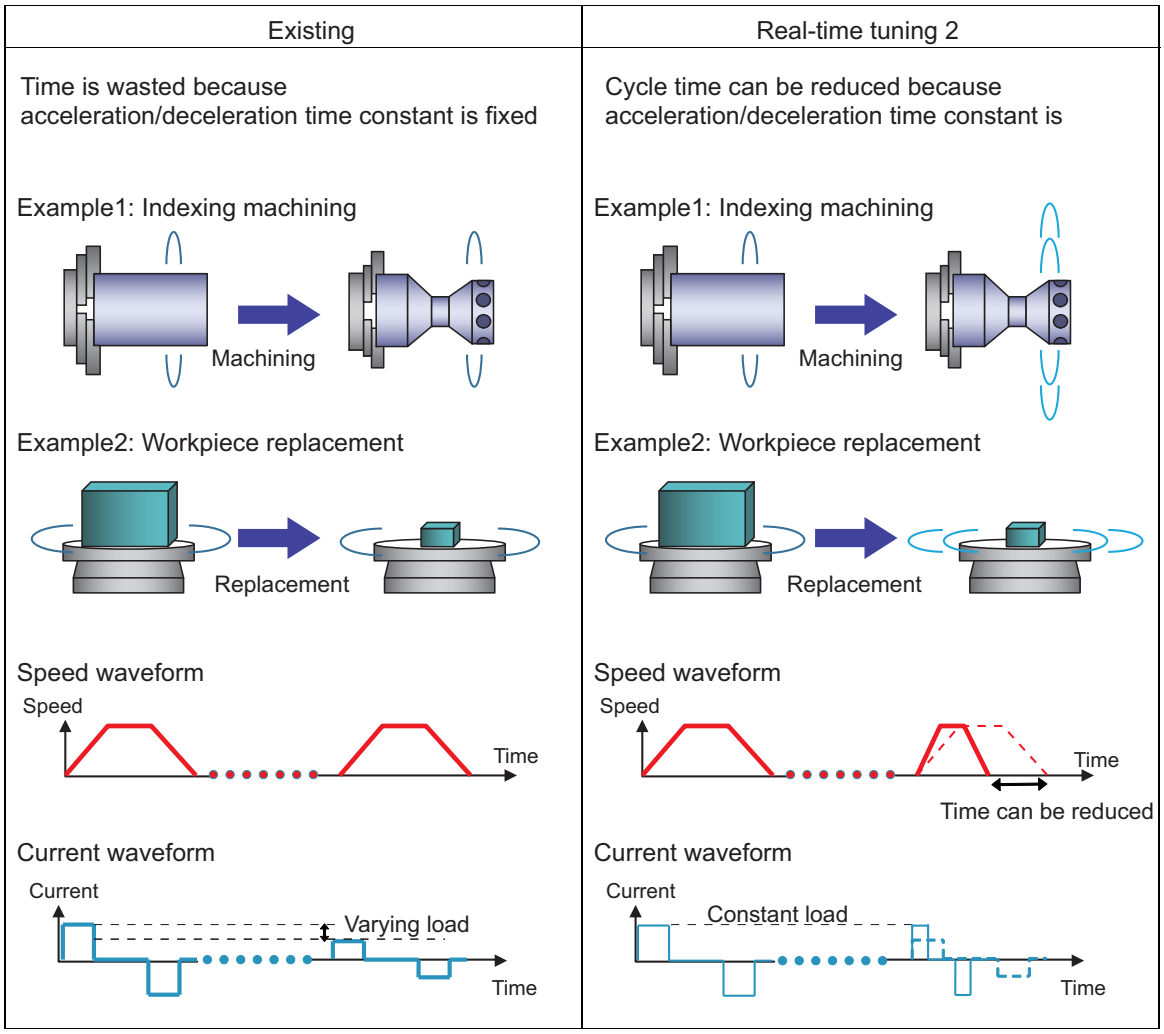
This function is useful when the inertia of workpiece fluctuates considerably during machining as illustrated in Example 1: Indexing machining and Example 2: Workpiece replacement on the rotary table below.

In Example 1, the inertia of workpiece is reduced gradually as machining progresses. In Example 2, the inertia of workpiece on the rotary table is reduced by workpiece replacement. When the inertia of workpiece is large in Example 1 or Example 2, the machine tool is required to be operated at a low acceleration to suppress the vibration for the workpiece and overload for the motor. On the other hand, when the inertia of workpiece is smaller, the operation at a higher acceleration is available. In other words, acceleration/deceleration time constant can be reduced when the inertia of workpiece is smaller.

In the existing specifications, the operation acceleration/deceleration time constant is fixed regardless of the inertia of workpiece, which wastes time because a large time constant is applied even if the inertia of workpiece is small.

This function enables the operation with optimum acceleration/deceleration time constant according to the inertia of the workpiece. Therefore, machining is performed while reducing the acceleration/deceleration time constant in Example 1 or Example 2, which leads to a shorter tact time.

Furthermore, the large inertia workpiece is not machined with small acceleration/deceleration time constant since the optimum time constant is adjusted automatically. This enables suppression of vibration and overload.



12.30.2 Function Enabling Conditions

To use this function, it is necessary to satisfy the [Condition 1] and [Condition 2] as shown below.
[Condition 1]: Parameter conditions which enable this function for the ON/OFF of the command mode and high-accuracy control mode.
[Condition 2]: Parameter conditions which are required to calculate the optimum acceleration/deceleration time constant from the estimated inertia ratio.
This function is invalid for the axis which does not satisfy both [Condition1] and [Condition 2].
<Condition 1>

The following conditions have to be satisfied according to the ON/OFF of the target command mode and high-accuracy control mode.

Command mode	High-accuracy control mode	Valid condition
G0 (Positioning)	OFF	(1) "#2651 RT2G0 (RT2: Enable switching of G0 acce/dece time constant)" is set to "1"
	ON	
G1 (Cutting feed)	OFF	(1) "#2652 RT2G1 (RT2: Enable switching of G1 acce/dece time constant)" is set to "1" (2) "#1427 RT2AftG1 (Enable switching of acce/dece time constant after G1 interpolation)" is set to "1"
	ON	(1) "#2652 RT2G1 (RT2: Enable switching of G1 acce/dece time constant)" is set to "1" (2) Variable-acceleration pre-interpolation acceleration/deceleration is enabled

<Condition 2>

The following parameters have to satisfy the valid conditions

Parameter	Valid condition	Setting example
#2237 JL (Load inertia scale)	For rotary motor: 100 or over For linear motor: Larger than the gross mass of the moving sections under the condition without a workpiece	Set load inertia ratio (gross mass of the moving sections)under the condition without a workpiece.
#2400 RTJX (Real-time tuning: maximum adaptive inertia ratio)	Set the value larger than #2237	Set estimated max inertia ratio (gross mass of the moving sections).

12.30.3 Description of Operation

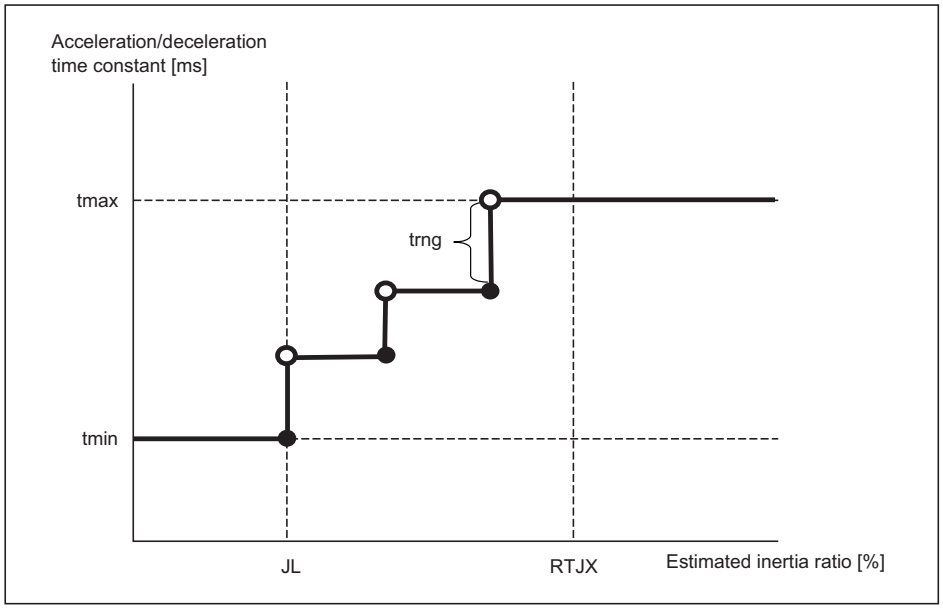
The derivation of optimum time constant and the timing for switching to optimum time constant of this function are described below.When this function is enabled, the parameters are switched to the optimum time constant internally based on the obtained estimated inertia ratio.

Parameter	Remark
#2004 G0tL (G0 time constant)	
#2007 G1tL (G1 time constant)	
#2158 G1btlx (Per-axis pre-interpolation cutting feed time constant)	Only when variable-acceleration pre-interpolation acceleration/deceleration is enabled.

Derivation of optimum time constant

The optimum time constant is derived based on the relation between the estimated inertia ratio and the optimum time constant as shown below.

Relation between the estimated inertia ratio and the optimum time constant



tmax: Maximum value of switching time constant
tmin: Minimum value of switching time constant
trng: Time constant changeover range
JL: Load inertia scale
RTJX: Real-time tuning: maximum adaptive inertia ratio

Variable definitions in each case are given below.

tmax Maximum value of switching time constant	tmin Minimum value of switching time constant	trng Time constant switching range
#2004 G0tL (G0 time constant)	#2653 RT2G0tL (RT2: Minimum value of G0 acce/dece time constant)	#2656 RT2G0rng (RT2: Changing amount of G0 acce/dece time constant)
#2007 G1tL (G1 time constant)	#2654 RT2G1tLA (RT2: Minimum value of acce/dece time constant after G1 interpolation)	#2657 RT2G1rngA (RT2: Changing amount of acce/dece time constant after G1 interpolation)
#2158 G1btlx (Per-axis pre-interpolation cutting feed time constant)	#2655 RT2G1tLB (RT2: Minimum value of acce/dece time constant before G1 interpolation)	#2658 RT2G1rngB (RT2: Changing amount of acce/dece time constant before G1 interpolation)

Also, when the following conditions are satisfied, the acceleration/deceleration time constant is switched to the maximum value of switching time constant "tmax" or the minimum value of switching time constant "tmin".

(1) When the estimated inertia ratio exceeds "#2400 RTJX" (Real-time tuning: maximum adaptive inertia ratio), the acceleration/deceleration time constant will be the maximum value of switching time constant "tmax". (Refer to "Relation between the estimated inertia ratio and optimum time constant" as shown in the previous figure)

(2) When the estimated inertia ratio is smaller than "#2237 JL" (Load inertia scale), the acceleration/deceleration time constant will be the minimum value of switching time constant "tmin". (Refer to "Relation between the estimated inertia ratio and optimum time constant" as shown in the previous figure)

(3) When tmin ≥ tmax, the acceleration/deceleration time constant will be the maximum value of switching time constant "tmax".

(4) When tmax- tmin ≤ trng, the acceleration/deceleration time constant will be the maximum value of switching time constant "tmax".

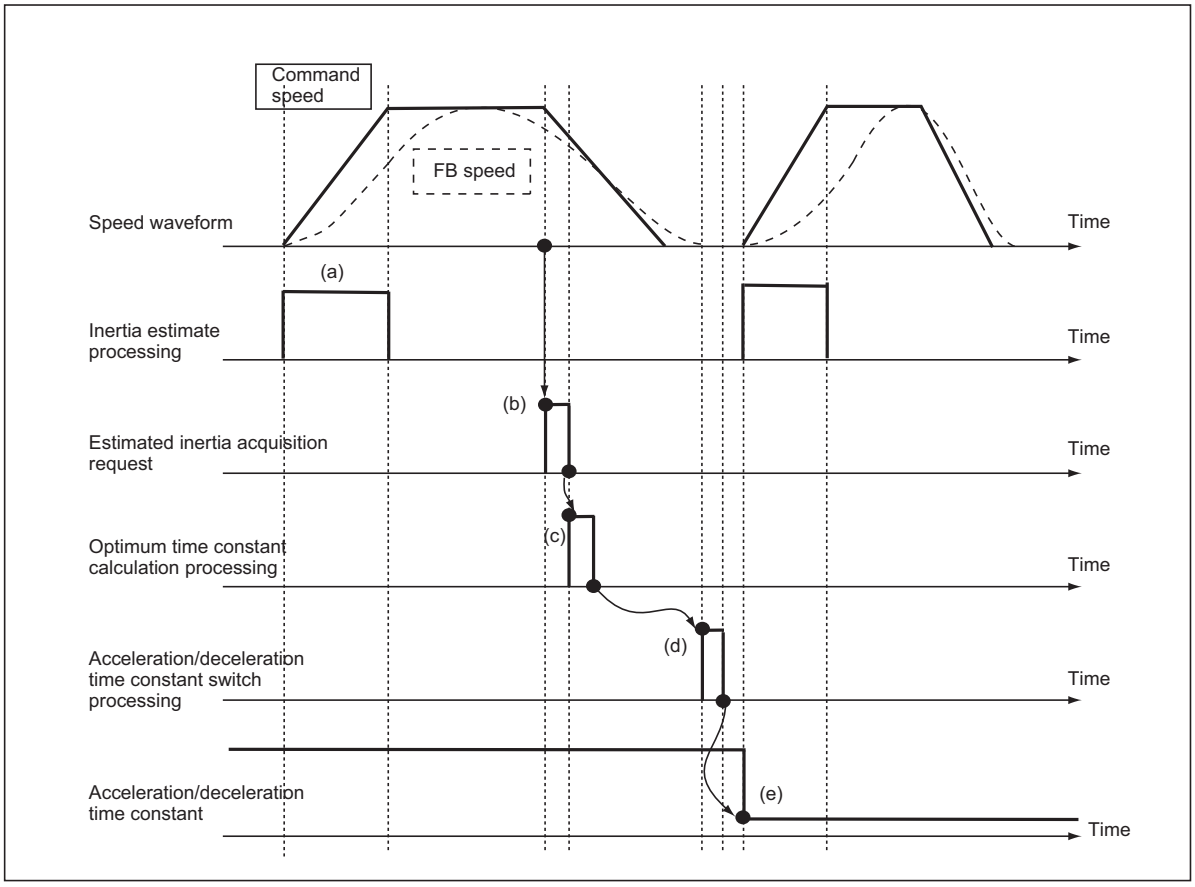
(5) When the value of tmax, tmin or trng is changed, the acceleration/deceleration time constant will be the maximum value of switching time constant "tmax".

The setting values of "#2004 G0tL" (G0 time constant), "#2007 G1tL" (G1 time constant) and "#2158 G1btlx" (Per-axis pre-interpolation cutting feed time constant) are not changed.

Timing for switching to optimum time constant

When this function is enabled, the timing for switching the target acceleration/deceleration time constant to the optimum time constant is after the smoothing zero of the target axis for switching the time constant. At this time, the acceleration/deceleration time constant of all target axes are switched internally.

The operation example is given below.



(a) Do the inertia estimation processing to calculate the estimated inertia ratio when completing the interpolation of positioning operation in the drive. The calculated estimated inertia ratio is retained its value until next inertia estimation processing.

(b) When the speed command from the NC becomes smoothing zero, the NC gives the acquisition request of estimated inertia ratio to the drive to obtain the estimated inertia ratio.

(c) When the estimated inertia ratio this time and the time constant calculation completed last time are different from the estimated inertia ratio last time, the optimum time constant calculation processing is performed to obtain the optimum time constant.

(d) When the optimum time constant calculation processing is completed and when the target axis for switching acceleration/deceleration time constant is not in operation, the optimum time constant switch processing is performed.

(e) When the acceleration/deceleration time constant switch processing is completed, the speed command followed by the acceleration/deceleration time constant is output from the NC.

The acceleration/deceleration time constant is not switched in the following cases.

(1) When the derivative calculation of the optimum time constant is not completed.(The derivative calculation of the optimum time constant will be executed at the next timing for the switch, and then the acceleration/ deceleration time constant will be changed.)

(2) When the inertia estimation is stopped.

The acceleration/deceleration time constant is set to the maximum value of time constant in the following cases. (Acceleration/deceleration time constant reset)

(1) When the acceleration/deceleration time constant reset signal is commanded by PLC signal.

(2) When "#1428 RT2rst (time constant reset) is set to "1".(The acceleration/deceleration time constant will be the maximum value of time constant at the time of reset commanded.)

12.30.4 Usage Example

This function commands with the PLC signal after the "Function Enabling Conditions" are satisfied.

(1) Acceleration/deceleration in automatic switchover

This is a function to switch the acceleration/deceleration time constant to the optimum time constant automatically.
When this function is enabled, the acceleration/deceleration time constant is switched to the optimum time constant every time after the smoothing zero of G9 command speed for the target axis.

(2) Acceleration/deceleration in manual switchover

This is a function to switch the acceleration/deceleration time constant to the optimum time constant manually.
When this function is enabled, the acceleration/deceleration time constant is switched to the optimum time constant after the smoothing zero of G9 command speed for the target axis.

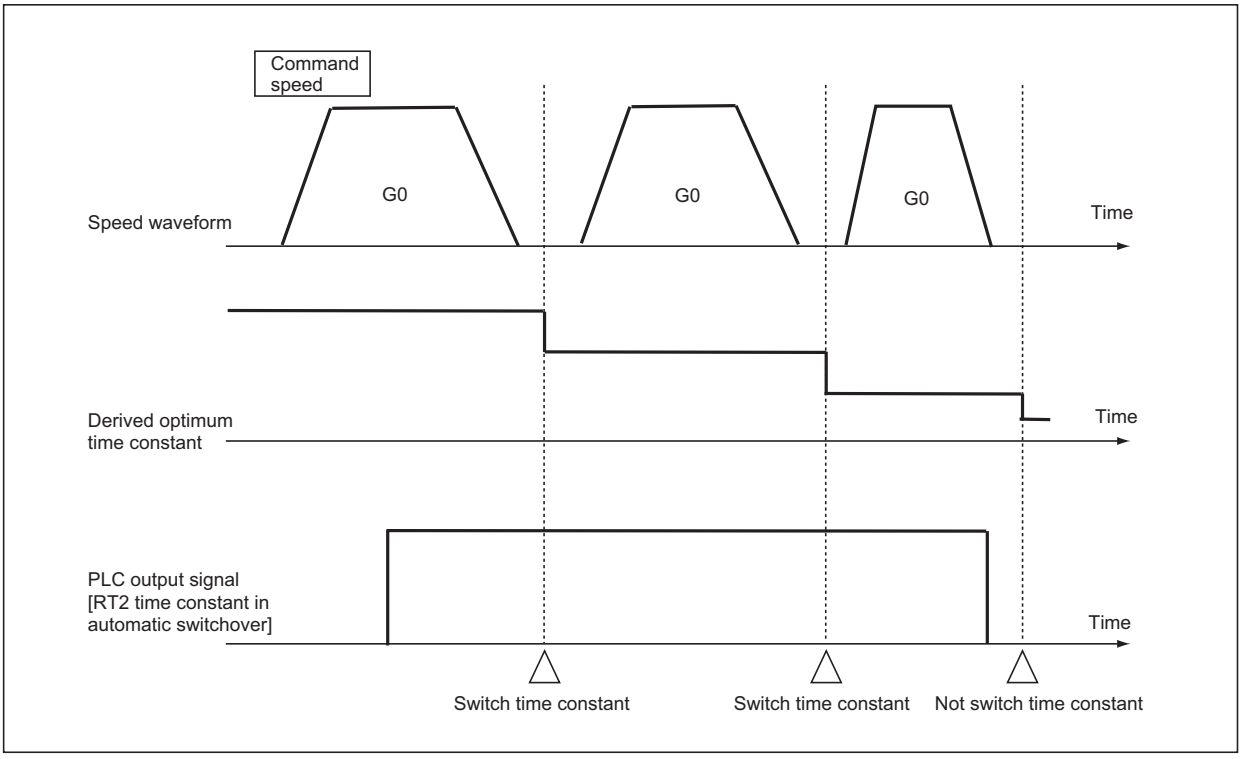
(3) Acceleration/deceleration reset

This is a function to switch the acceleration/deceleration time constant to the maximum value of switching time constant "tmax".
When this function is enabled, the acceleration/deceleration time constant is switched to the maximum value of switching time constant after the smoothing zero of G9 command speed for the target axis.

For these three functions, the validity/invalidity of each function is determined by ON/OFF of the PLC output signals. How to use each function is as follows.

Acceleration/deceleration time constant in automatic switchover

When turning ON the signal "Real-time tuning 2: acceleration/deceleration time constant in automatic switchover (RT2CHGA:YD0C)", the acceleration/deceleration time constant can be switched to the optimum time constant automatically at the available timing to switch.
When this signal is OFF, the acceleration/deceleration time constant is not switched to the optimum time constant even if it is the available timing to switch.



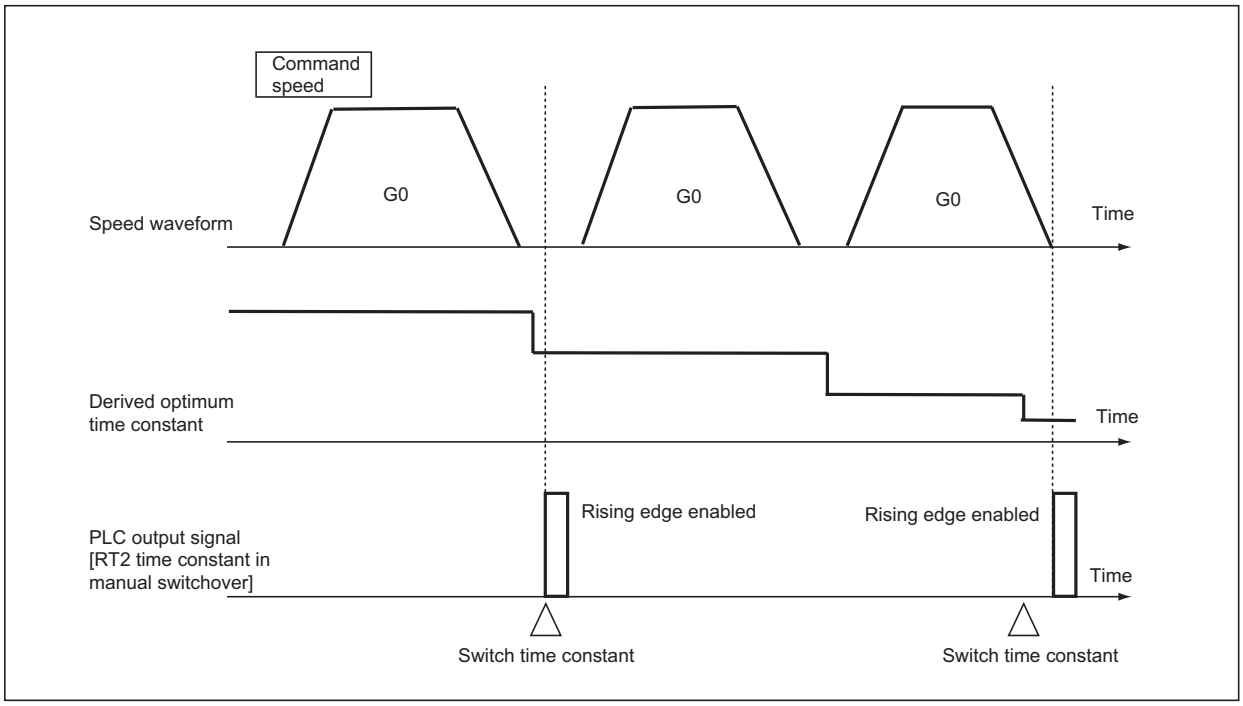
Acceleration/deceleration time constant manual switching

When turning ON the signal "Real-time tuning 2: acceleration/deceleration time constant in manual switchover (RT2CHGM:YD0D)", the acceleration/deceleration time constant can be switched to the optimum time constant manually.

This signal is available only at the rising edge.

If the time constant cannot be changed at the rising edge of this signal, this function retains the switch request of that time internally, and then the time constant is switched to the optimum time constant at the available timing to switch.

When this signal is OFF, acceleration/deceleration time constant is not switched.



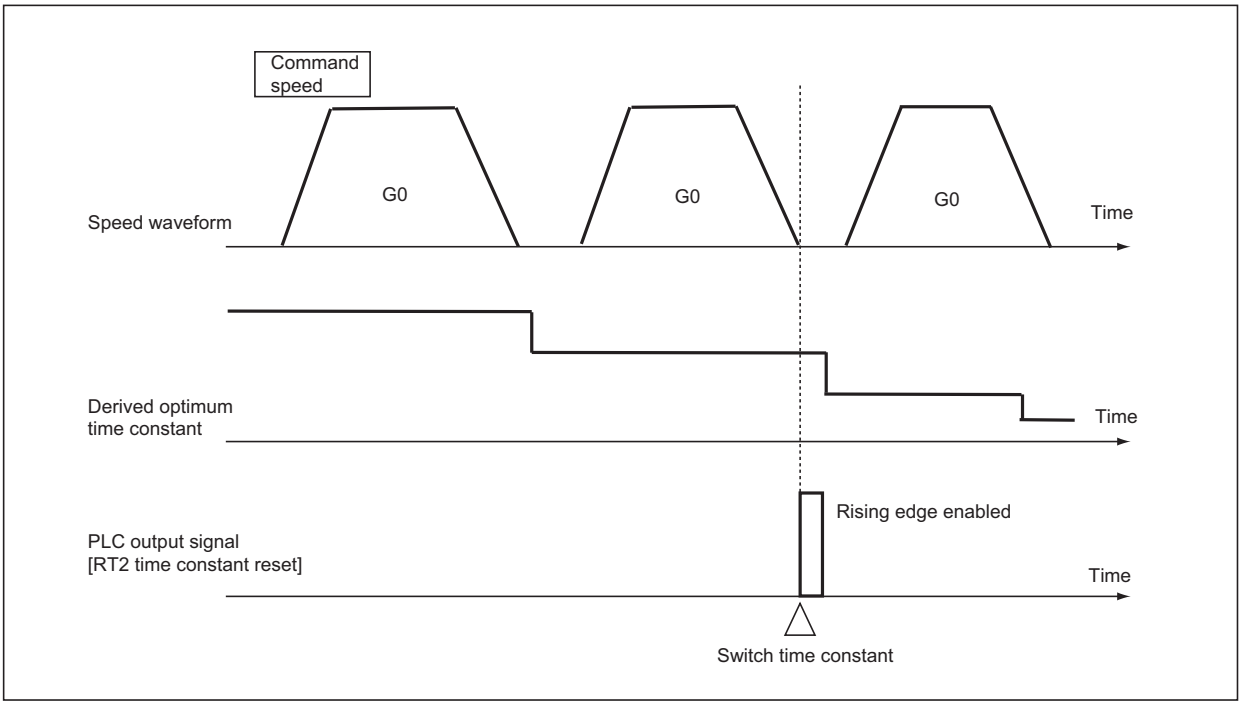
Reset acceleration/deceleration time constant

When turning ON "Real-time tuning 2: Acceleration/deceleration time constant reset (RT2RST:YD0E)", the acceleration/deceleration time constant is switched to the maximum value of switching time constant "tmax". (Refer to "Relation between the estimated inertia ratio and the optimum time constant")

This signal is available only at the rising edge.

If the time constant cannot be changed at the rising edge of this signal, this function retains the switch request of that time internally, and then the time constant is switched to the maximum value of switching time constant at the available timing to switch.

When this signal is OFF, acceleration/deceleration time constant is not switched.



12.30.5 Precautions

(1) This function is applied only to servo axes.

(2) This function is not applied during soft acceleration/deceleration (when soft acceleration/deceleration is selected by "#2003 smgst" (acceleration and deceleration modes).

(3) This function is invalid during control axis superimposition.

(4) While the "machining condition selection" function is in use, the acceleration/deceleration time constant switch is not executed by this function.

(5) While "Real-time tuning 1" is invalid, the acceleration/deceleration time constant switch is not executed by this function.

12.31 Constant Torque Control

12.31.1 Outline

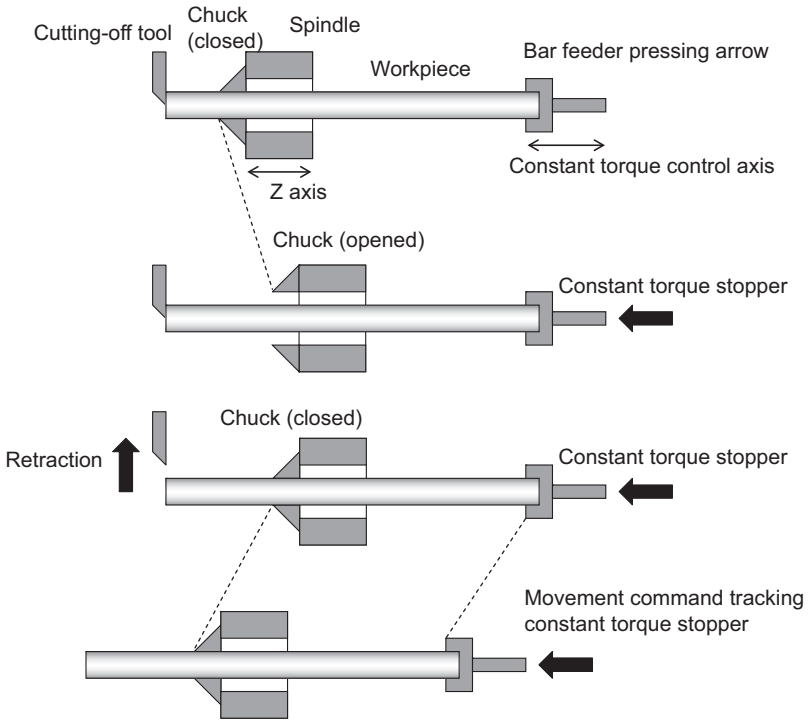
(1) Constant torque control

By setting "Constant torque control request axis" signal to ON from PLC, the servo motor of the designated axis outputs torque set by the parameter in a constant direction. By using this function for a servo motor which drives a bar feeder, the bar feeder can press the workpiece with constant torque regardless of whether it is during movement, stop, or acceleration/deceleration.

By setting "Proportional torque stopper control request axis" signal (R2620) to ON from PLC, proportional torque stopper control enables a servo motor of the designated axis to generate torque set by the parameter in the stopper direction. When position droop is generated, the motor generates torque in proportion to the position droop in the stopper direction to keep the stopper position.

(Note) Do not cancel the constant torque control or the proportional torque stopper control for an axis moving under manual or automatic operation. Otherwise the fixed workpiece, fixed turret, etc., may get loose, and it is dangerous.

Example of constant torque control



(2) Droop cancel under constant torque control

Droop cancel under constant torque control cancels the position droop generated during constant torque control without moving an axis.

Note that the droop cancel under constant torque control must be commanded while the axis is pressed against the workpiece, etc.

(3) Proportional constant torque control

Proportional torque stopper control generates constant torque in the stopper direction according to the value designated to the parameter. When position droop is generated, the motor generates torque in proportion to the position droop in the stopper direction and to keep the stopper position.

12.31.2 Description of Operation

Constant Torque Control

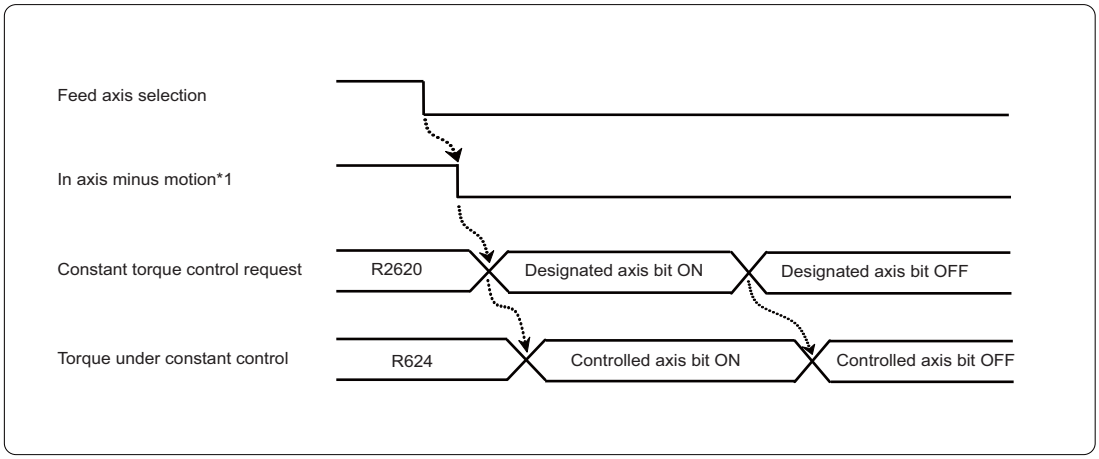
Constant torque control outputs a constant amount of torque in a single direction in accordance with the value configured by "2296 SV096 (TQC) (Constant torque stopper control)". As axis movement is performed by servo drive to ensure a constant servo motor torque, the position of the NC command is not changed and only the feedback position is updated. Therefore, differences in command positions and feedback positions (hereinafter, referred to as position droop) occurs during constant torque control. This position droop is cleared when the constant torque control is canceled once the axial movement via the servo driver reaches the NC command position.
To clear the position droop without causing axial movement, you can use the constant torque control droop cancel function.

[Operation Procedure]

(1) Confirm that the axis receiving constant torque control from the PLC has stopped (Note 1) and then set the constant torque control request axis signal register (R2620/lower 8 bits) with the axis bits. (Multiple axes can be specified)
(2) As the PLC sets the constant torque control request axis signal, the servo motor for the specified axis outputs a constant amount of torque in a single direction in accordance with the values configured to "2296 SV096 (TQC) (constant torque stopper control)" for the specified axis.
(3) The NC outputs axis bits to the constant torque control request axis signal register (R624/lower 8 bits) at the PLC during constant torque control.
(4) To cancel constant torque control, confirm that the PLC has stopped the axis (Note 1) and then turn OFF the axis bits for the constant torque control request axis.
(5) The specified axis moves to the NC command position due to the PLC turning OFF the constant torque control request axis signal.

(Note 1) To stop the axis, make sure that both the positive and negative signals (MVP and MVM: X7C0 through X7EF) are turned OFF during movement of the specified axis.

[Operation Sequence]



Droop Cancel under Constant Torque Control

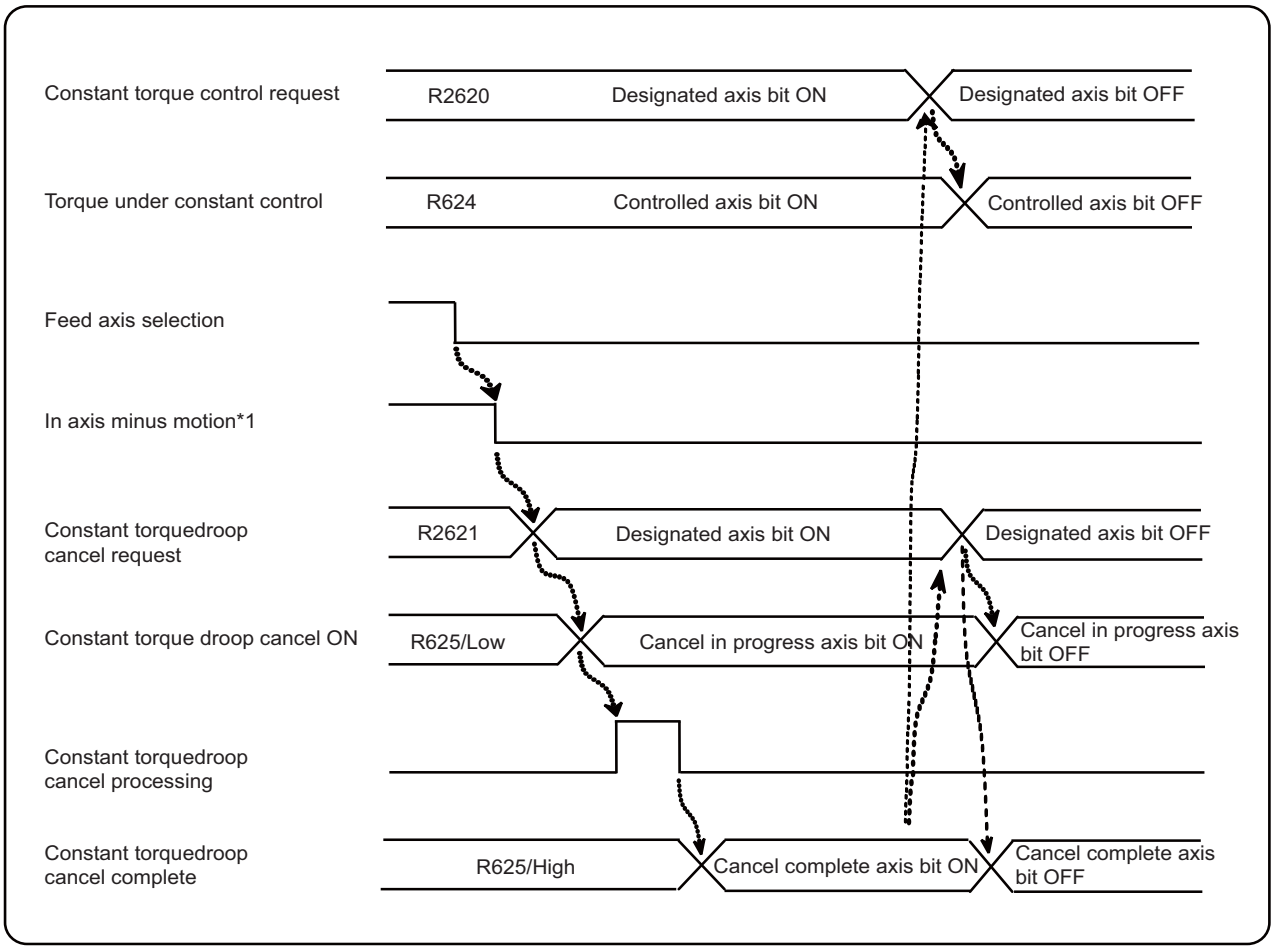
The droop cancel under constant torque control function enables position droop produced during constant torque control to be canceled without moving the axis.
Make sure the axis is in abutment with the workpiece before outputting the command for the droop cancel under constant torque control.

[Operation Procedure]

(1) Confirm that axis receiving constant torque control from the PLC has stopped (Note 1) and then set the constant torque droop cancel request axis signal register (R2621/lower 8 bits) with the axis bits. (Multiple axes can be specified)
(2) The NC cancels the position droop for the specified axis and updates the command position due to the PLC setting the constant torque droop cancel request axis signal.
(3) The NC outputs the axis bits to the constant torque droop cancel axis ON signal register (R625/lower 8 bits) at the PLC while the constant torque droop cancel control is in operation.
(4) The NC outputs the axis bits to the constant torque droop cancel axis complete signal register (R625/upper 8 bits) at the PLC once the constant torque droop cancel control completes.
(5) To cancel the constant torque droop cancel control, the PLC confirms that the constant torque droop cancel process has complete and then outputs the axis bits for the constant torque droop cancel request axis and the constant torque control request axis.

(Note 1) To stop the axis, make sure that both the positive and negative signals (MVP and MVM: X7C0 through X7EF) are turned OFF during movement of the specified axis.

[Operation Sequence]



Proportional Torque Stopper Control

Proportional torque stopper control outputs a constant amount of torque in a pressing direction in accordance with the value configured by "2296 SV096 (TQC) (Constant torque stopper control)". When position droop is produced, torque that is proportional to the position droop is generated in the pressing direction to maintain the pressing position.

[Operation Procedure]

(1) Confirm that axis receiving proportional torque stopper control from the PLC has stopped (Note 1) and then set the proportional torque stopper control request axis signal register (R2620/upper 8 bits) with the axis bits. (Multiple axes can be specified)

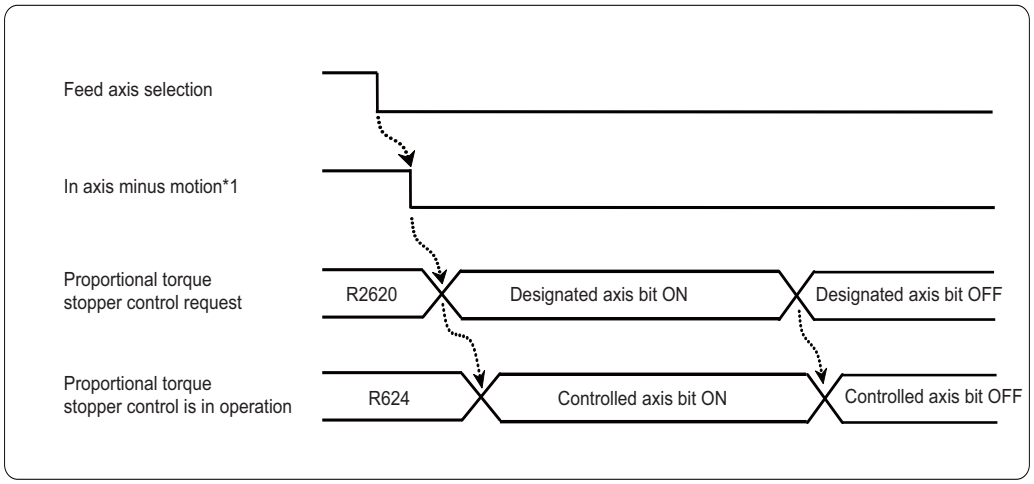
(2) As the PLC sets the proportional torque stopper control request axis signal, the servo motor for the specified axis outputs a constant amount of torque in a pressing direction in accordance with the values configured to "2296 SV096 (TQC) (constant torque stopper control)" for the specified axis.

(3) The NC outputs axis bits to the proportional torque stopper control axis ON signal register (R624/upper 8 bits) at the PLC while the proportional torque stopper control is in operation.

(4) To cancel proportional torque stopper control, confirm that the PLC has stopped the axis (Note 1) and then turn OFF the axis bits for the proportional torque stopper control request axis.

(Note 1) To stop the axis, make sure that both the positive and negative signals (MVP and MVM: X7C0 through X7EF) are turned OFF during movement of the specified axis.

[Operation Sequence]



12.31.3 Operation with Other Functions

(1) Torque limitation skip
Outputting the torque skip command to an axis while the constant torque control or proportional torque stopper control is in operation results in the generation of a program error (P595).

(2) Stroke end and stored stroke limit
If the axis reaches the stroke end while the constant torque control or proportional torque stopper control is in operation, the constant torque control or proportional torque stopper control is canceled.

(3) Servo amp related functions
The following servo amp related functions are disabled for axes under the stroke end while the constant torque control or proportional torque stopper control. The stroke end while the constant torque control or proportional torque stopper control is canceled if any of the following servo amp related functions are executing.
Collision detection function, notch filter function, disturbance observer function, machine correction, current offset, lost motion compensation, overshoot correction, OMR-FF, acceleration FF, and OMR-DD

(4) Peripheral tools (NC Analyzer 2)
Do not use the ATS function for axes under the constant torque control or proportional torque stopper control. The M-series excitation torque will be added to the constant torque.

(5) Emergency stop
The deceleration and stop control will not function correctly as constant torque is generated by the constant torque control or proportional torque stopper control. Disable (0: Dynamic stop) the emergency stop deceleration and stop control "#2217 SV017 SPEC 1/bit 2" for axes under the constant torque control or proportional torque stopper control.

(Note 1) Disable the deceleration and stop control for other axes within the same unit as well as when using multi-axis drive units.
Do not connect axes to a power supply when using the constant torque control or proportional torque stopper control. The emergency stop deceleration and stop control is disabled throughout the same part system when axes are connected to a power supply.

12.31.4 Precautions

(1) The NC command position and feedback position are different while constant torque control is in operation. Do not apply constant torque control to axes actually processing workpieces. Set "2296 SV096 (TQC) (Constant torque stopper control)" to "0" for axes that are not to receive the constant torque control and proportional torque stopper control.

(2) The constant torque control cannot operate on axes for which the "2296 SV096 (TQC) (constant torque stopper control)" is set to "0". Instead, the operation error (M01 1114) is generated. The operation error can be cleared by performing a reset or turning OFF the bits for which the constant torque control request axis signal error is generated.

(3) The proportional torque stopper control cannot operate on axes for which the "2296 SV096 (TQC) (constant torque stopper control)" is set to "0". Instead, the operation error (M01 1115) is generated. The operation error can be cleared by performing a reset or turning OFF the bits for which the proportional torque stopper control request axis signal error is generated.

(4) The constant torque control cannot operate on axes currently moving due to manual operation or cycle operation. Instead, the operation error (M01 1114) is generated. The operation error can be cleared by performing a reset or turning OFF the bits for which the constant torque control request axis signal error is generated. The constant torque control cannot be canceled by manual operation or cycle operation if axes are currently under the constant torque control. Instead, the operation error (M01 1114) is generated. The constant torque control will cancel and the operation error will clear after completion of the movement command or by a reset.

(5) The proportional torque stopper control cannot operate on axes currently moving due to manual operation or cycle operation. Instead, the operation error (M01 1115) is generated. The operation error can be cleared by performing a reset or turning OFF the bits for which the proportional torque stopper control request axis signal error is generated. The command to transition to the proportional torque stopper control also cannot be output. Instead, the operation error (M01 1115) is generated.

(6) The proportional torque stopper control cannot operate on axes under the constant torque control. Instead, the operation error (M01 1115) is generated. The constant torque control cannot operate on axes under the proportional torque stopper control. Instead, the operation error (M01 1114) is generated.

(7) The droop cancel under constant torque control cannot operate on axes not under constant torque control. The droop cancel under constant torque control cannot operate on axes currently moving due to manual operation or cycle operation. Instead, the operation error (M01 1116) is generated. The operation error can be cleared by performing a reset or turning OFF the bits for which the constant torque droop cancel request axis signal error is generated.

(8) Axes under the droop cancel under constant torque control cannot move move due to manual operation or cycle operation. Instead, the operation error (M01 1117) is generated. The operation error is cleared by performing a reset. Note that the droop cancel under constant torque control is not canceled.

(9) The constant torque control or proportional torque stopper control is not canceled even if an emergency stop is performed while the constant torque control or proportional torque stopper control is in operation. Note, however, that the droop cancel under constant torque control does cancel if an emergency stop is performed while the droop cancel under constant torque control is in operation. Note that the droop cancel under constant torque control is not re-enabled after the emergency stop is cleared. You must turn the request signal OFF and ON again.

(10) The constant torque control or proportional torque stopper control is not canceled even if a servo off signal is output for axes under the constant torque control or proportional torque stopper control. Servo off signals also cannot be output for axes under droop cancel under constant torque control.

(11) When changing the "2296 SV096 (TQC) (constant torque stopper control)", "#2297 SV097 (TCout) (constant torque control torque clear slope)", and "2298 SV098 (TCup) (output slope of constant torque stopper control)", rewrite the servo parameters for the specified axes before turning ON the proportional torque stopper control request signal.

(12) Adjust the detection amplitude for axes to receive constant torque control or proportional torque stopper control to prevent false detections of excessive variance alarms due to play produced during the pressing process as well as false detections of abnormality in detected magnetic position alarms.

(13) Do not perform the constant torque control or proportional torque stopper control for superimposed or synchronized reference axes. Synchronization between part systems may be lost as the synchronized axis is not updated with the axial movement caused by constant torque or proportional press torque.

12.32 Circular Feed in Manual Mode

12.32.1 Outline

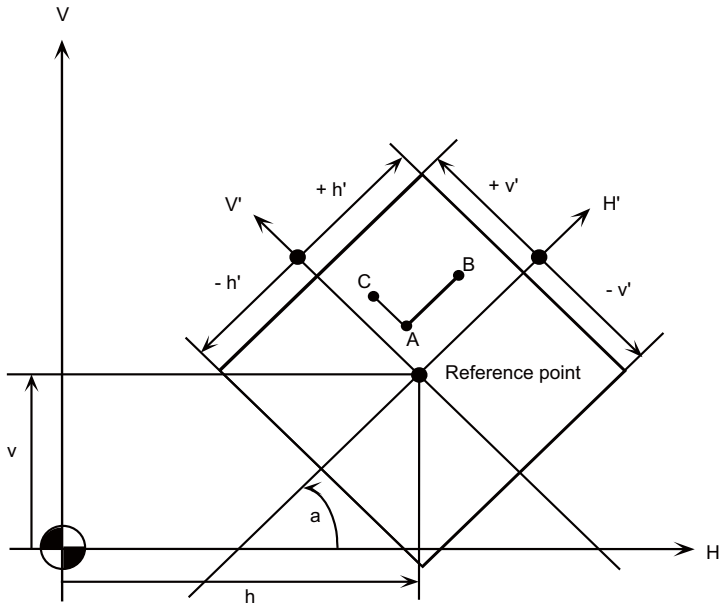
By specifying a hypothetical coordinate on the machine coordinate system from the user PLC, oblique linear interpolation or circular interpolation is executed with jog feed, handle feed, manual rapid traverse or incremental feed of the two axes designated by plane selection. When a rotary axis is specified, the operation is ignored.

In this chapter, the horizontal axis is described as "H axis" and the vertical axis is as "V axis".
H axis and V axis are determined by setting values of the following parameters and R registers.

- "#1026 base_I" (Base axis I)
- "#1027 base_J" (Base axis J)
- "#1028 base_K" (Base axis K)
- R2636 bitE, bitF (plane selection mode)

12.32.2 Explanation of operation

Oblique linear interpolation



When the circular feed in manual mode (oblique linear interpolation) is valid:
- Jog/handle feed of H axis results in the movement in parallel with H' axis (see above).
- Jog/handle feed of V axis results in the movement in parallel with V' axis (see above).

a: Gradient angle
h, v: Reference point coordinate
±h': H' travel range
±v': V' travel range
These are set in the R registers.

The following shows how to enable the circular feed in manual mode.
(1) Select either JOG mode or handle mode.
(2) Set the coordinates of reference point (h, v), gradient angle (a), moving range (± h', ± v'), operation mode (linear), and plane to the specified R register.
(3) Turn ON the "Circular feed in manual mode valid" signal.

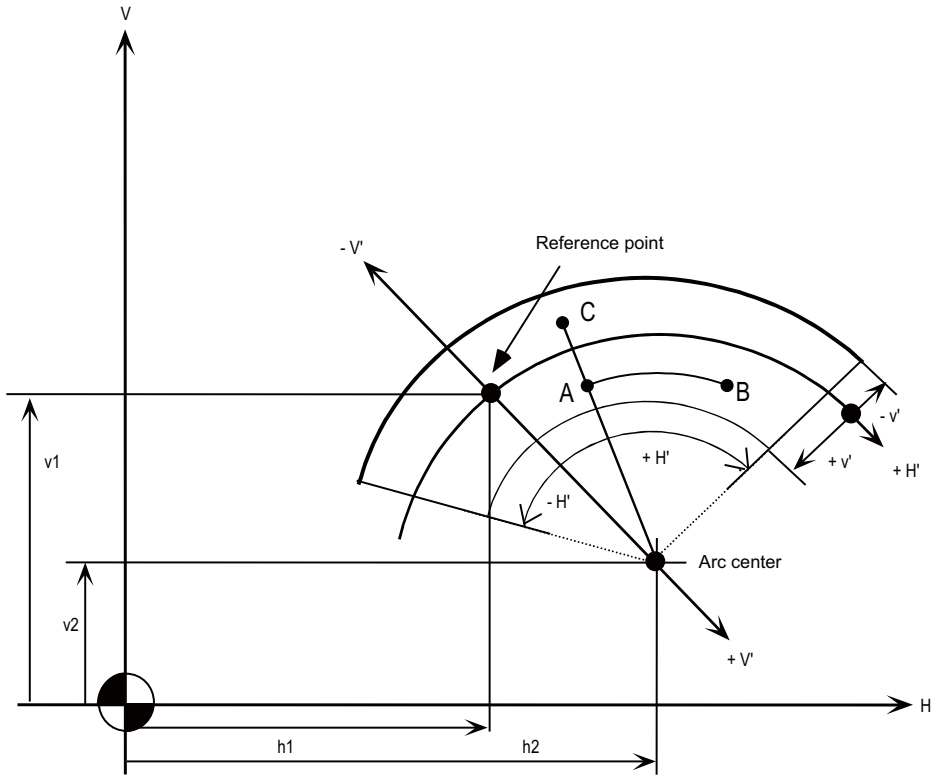
When circular feed in manual mode is performed while the axis is moving with JOG feed or handle feed, both H axis and V axis automatically stop, and then circular feed in manual mode is enabled.

[Operation example]

- When handle feed is performed in the "+" direction of H axis at the current position (point "A"), the axis position moves to point "B".
  Following this operation, when handle feed is performed in the "-" direction of H axis at point "B", the axis position moves to point "A".
- When handle feed is performed in the "+" direction of V axis at the current position (point "A"), the axis position moves to point "C".
  Following this operation, when handle feed is performed in the "-" direction of V axis at point "C", the axis position moves to point "A".

Circular interpolation

By specifying a hypothetical coordinate on the machine coordinate as shown in the figure below, jog/handle feed can be executed on the hypothetical coordinate.



When the circular feed in manual mode (circular interpolation) is valid:
- Jog/handle feed of H axis results in the movement along the arc whose radius is the distance from the arc center to the current position.
- Jog/handle feed of V axis results in the movement on the line connecting the current position and the arc center.

h1, v1: Reference point coordinate
h2, v2: Arc center coordinate
±h': H' travel range
±v': V' travel range
These are set in the R registers.

The following shows how to enable the circular feed in manual mode.
(1) Select either JOG mode or handle mode.
(2) Set the coordinates of reference point (h1, v1), gradient arc center (h2, v2), moving range (± h', ± v'), operation mode (arc), and plane to the specified R register.
(3) Turn ON the "Circular feed in manual mode valid" signal.

When circular feed in manual mode is performed while the axis is moving with JOG feed or handle feed, both H axis and V axis automatically stop, and then circular feed in manual mode is enabled.

[Operation example]

- When handle feed is performed in the "+" direction of H axis at the current position (point "A"), the axis position moves to point "B".
  Following this operation, when handle feed is performed in the "-" direction of H axis at point "B", the axis position moves to point "A". The movement is done along the circumference of the arc whose radius is the distance from the arc center to the current position (point "A").
- When handle feed is performed in the "-" direction of V axis at the current position (point "A"), the axis position moves to point "C".
  Following this operation, when handle feed is performed in the "+" direction of V axis at point "C", the axis position moves to point "A".

Jog/handle synchronous mode during circular feed in manual mode

Jog/handle synchronous mode can be designated during circular feed in manual mode. Operations during jog/handle synchronous mode are as follows.

(1) Oblique linear interpolation

<When handle feed is designated during JOG feed operation>

When the designation is for the handled axis, JOG feed will still be applied.

When the designation is for the other axis, both JOG and handle feeds will be applied for respective axes. G0 time constant will be applied in the handle feed.

<When JOG feed is designated during handle feed operation>

When the designation is for the handled axis, JOG feed will be applied instead of handle feed.

When the designation is for the other axis, handle feed will still be applied.

When JOG feed is performed on H axis and V axis at the same time when the gradient is 90° or 270°, only JOG feed on H axis is processed.

When the gradient is 180°, both JOG and handle feeds are processed on respective axes. G0 time constant will be applied on the handle feed.

(2) Circular interpolation

<When handle feed is designated during JOG feed operation>

When the designation is for the handled axis, JOG feed will still be applied.

When the designation is for the other axis, both JOG and handle feeds will be applied for respective axes. G0 time constant will be applied in the handle feed.

<When JOG feed is designated during handle feed operation>

When the designation is for the handled axis, JOG feed will be applied instead of handle feed.

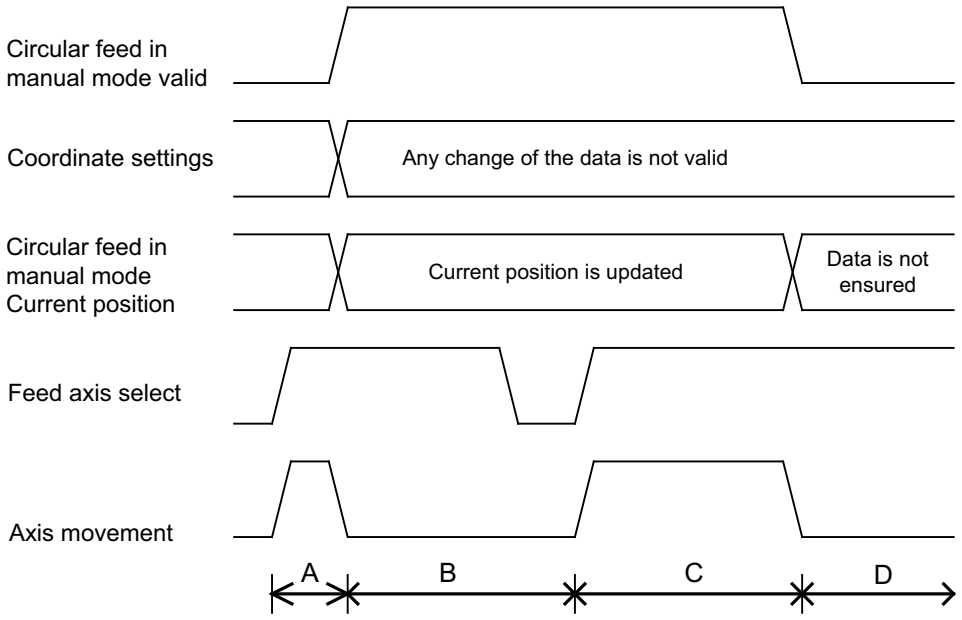
When the designation is for the other axis, handle feed will still be applied. G0 time constant will be applied in the handle feed.

12.32.3 Precautions

(1) This function is available in the JOG or handle mode, manual rapid traverse and incremental feed.
(2) This function works for the H axis and V axis. This function cannot be used for the other NC axes and PLC axis. When this function is valid, all the axes other than H axis and V axis move as usual.
(3) When the manual interlock is applied to either H or V axis, the movement of both axes stops.
(4) The following cases do not allow the circular feed in manual mode. In these cases, all axes cannot be moved until the "Circular feed in manual mode valid" signal is turned OFF.
  (a) Either H axis or V axis is in machine lock. (In this case, even machine lock is not performed.)
  (b) The reference position return of either H axis or V axis is not completed.
  (c) Either H axis or V axis is in servo OFF.
  (d) Either H axis or V axis is detached.
  (e) The CNC is in one of the following states.
    - In automatic operation (OP)
    - Emergency stop
    - Reset
  (f) The current position is outside of the specified travel range.
  (g) The setting value which is specified with R register is illegal.
(5) Executing the automatic operation turns this function invalid. In this case, all axes cannot be moved until the "Circular feed in manual mode valid" signal is turned OFF.
(6) When this function is used, the feedrates is clamped so that the resultant speed of H axis and V axis does not exceed the slower traverse rate of the two axes.
(7) When this function is ON and the either axis is moving beyond the travel range, both axes stop.
(8) When this function is ON, if a change of the travel range makes the current position out of the range, both H and V axes cannot be moved until the range is amended to include the current position.
(9) When the status of the "Circular feed in manual mode valid" signal is changed, the axis being moved in the manual mode temporarily stops for safety.
(10) When the movement on V axis is made with the current position and the arc center overlapped in the linear-arc mode, the movement is done along the minimum travel area of the H axis.
(11) Circular feed in manual mode is disabled when the gradient between H axis and V axis is 0 degree in the linear-linear mode. In this case, both H axis and V axis cannot be moved until the "Circular feed in manual mode valid" signal (YC7E) is turned OFF.

12.32.4 Timing chart

The timing chart for the circular feed in manual mode is shown below.



A: Moves in the normal mode.
B: Stops for the coordinate change.
C: Moves on the hypothetical coordinate that has been set.
D: Stops for the coordinate change.

(Note) Not only H and V axes but also the other axes stop during the coordinate change.

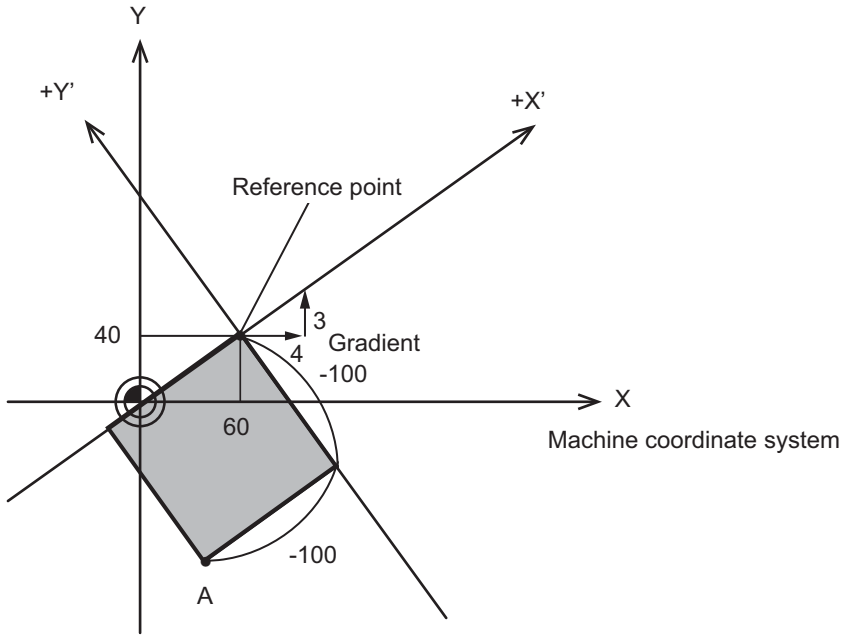
12.32.5 Usage example

A concrete example with PLC setting increment type "B" and using a metric system is shown below.

When performing oblique linear interpolation with the mirror image disabled

Device	Signal name	Data (HEX)	Data (DEC)
R2636, R2637	Circular feed in manual mode: Operation mode data	0001, 0000	X-Y plane, Linear-Linear
R2644, R2645	Circular feed in manual mode: Reference point H data	D4C0, 0001	120000 (*1)
R2648, R2649	Circular feed in manual mode: Reference point V data	3880, 0001	80000 (*1)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	0000, 0000	0 (*1)
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	F2C0, FFFC	-200000 (*1)
R2660, R2661	Circular feed in manual mode: Travel range V (+) data	0000, 0000	0 (*1)
R2664, R2665	Circular feed in manual mode: Travel range V (-) data	F2C0, FFFC	-200000 (*1)
R2668, R2669	Circular feed in manual mode: Gradient/arc center H data	0004, 0000	4 (*1)
R2672, R2673	Circular feed in manual mode: Gradient/arc center V data	0003, 0000	3 (*1)

(*1) The reference point coordinates, travel range, arc center coordinates and gradient are designated with the unit obtained by multiplying "0.5" to PLC setting increment.



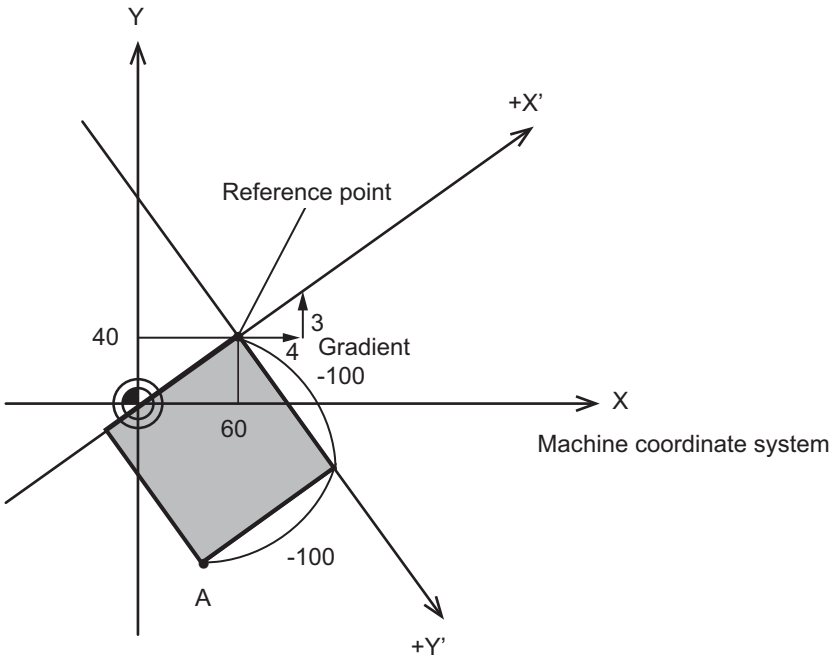
Mirror image using "Y' " axis as a symmetry axis		Disabled
Travel range on the hypothetical coordinates	+X'	0
	-X'	-100
	+Y'	0
	-Y'	-100
Current position (point "A")		-100, -100

When performing oblique linear interpolation with the mirror image enabled

Device	Signal name	Data (HEX)	Data (DEC)
R2636, R2637	Circular feed in manual mode: Operation mode data	0101, 0000	X-Y plane, Linear-Linear (Mirror image using "Y' " axis as a symmetry axis is enabled).
R2644, R2645	Circular feed in manual mode: Reference point H data	D4C0, 0001	120000 (*1)
R2648, R2649	Circular feed in manual mode: Reference point V data	3880, 0001	80000 (*1)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	0000, 0000	0 (*1)
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	F2C0, FFFC	-200000 (*1)
R2660, R2661	Circular feed in manual mode: Travel range V (+) data	0000, 0000	0 (*1) (*2)
R2664, R2665	Circular feed in manual mode: Travel range V (-) data	F2C0, FFFC	-200000 (*1) (*2)
R2668, R2669	Circular feed in manual mode: Gradient/arc center H data	0004, 0000	4 (*1)
R2672, R2673	Circular feed in manual mode: Gradient/arc center V data	0003, 0000	3 (*1)

(*1) The reference point coordinates, travel range, arc center coordinates and gradient are designated with the unit obtained by multiplying "0.5" to PLC setting increment.

(*2) Disable the mirror image in the settings.



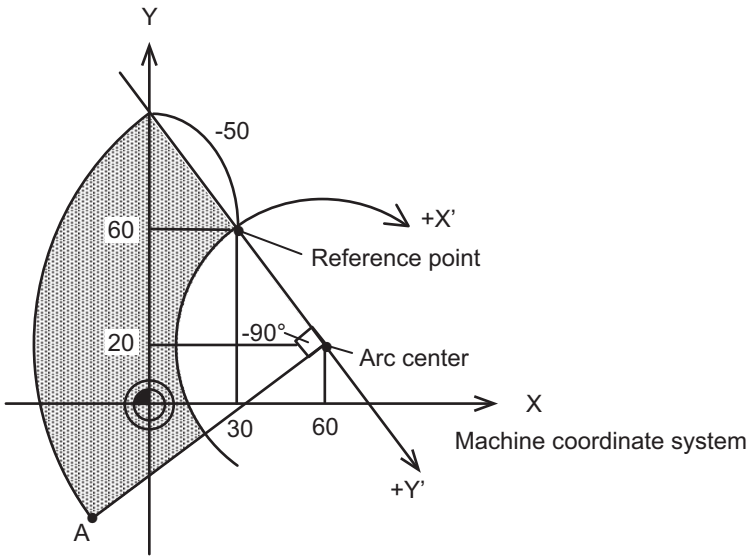
Mirror image using "Y' " axis as a symmetry axis		Disabled
Travel range on the hypothetical coordinates	+X'	0
	-X'	-100
	+Y'	0
	-Y'	-100
Current position (point "A")		-100, -100

The current position is output with the mirror image of "Y' " axis disabled.

When performing circular interpolation with the mirror image disabled

Device	Signal name	Data (HEX)	Data (DEC)
R2636, R2637	Circular feed in manual mode: Operation mode data	0002, 0000	X-Y plane, Arc-Linear (Clockwise direction is regarded as the "+" (positive) direction of the "X' " axis.)
R2644, R2645	Circular feed in manual mode: Reference point H data	EA60, 0000	60000 (*1)
R2648, R2649	Circular feed in manual mode: Reference point V data	D4C0, 0001	120000 (*1)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	0000, 0000	0 (*1)
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	40E0, FFFD	-180000 (*1)
R2660, R2661	Circular feed in manual mode: Travel range V (+) data	0000, 0000	0 (*1)
R2664, R2665	Circular feed in manual mode: Travel range V (-) data	7960, FFFE	-100000 (*1)
R2668, R2669	Circular feed in manual mode: Gradient/arc center H data	D4C0, 0001	120000 (*1)
R2672, R2673	Circular feed in manual mode: Gradient/arc center V data	9C40, 0000	40000 (*1)

(*1) The reference point coordinates, travel range, arc center coordinates and gradient are designated with the unit obtained by multiplying "0.5" to PLC setting increment.



Mirror image using "Y' " axis as a symmetry axis		Disabled
Travel range on the hypothetical coordinates	+X'	0°
	-X'	-90°
	+Y'	0
	-Y'	-50
Current position (point "A")		270°, -50

Clockwise direction is regarded as the "+" (positive) direction of the "X' " axis.
Arc center direction is regarded as the "+" (positive) direction of the "Y' " axis.

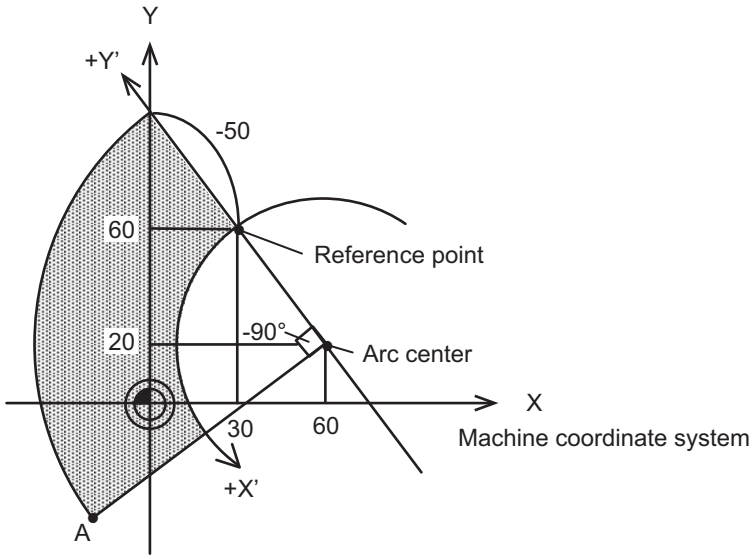
When performing circular interpolation with the mirror image enabled

Device	Signal name	Data (HEX)	Data (DEC)
R2636, R2637	Circular feed in manual mode: Operation mode data	0103, 0000	X-Y plane, Arc-Linear (Counter clockwise direction is regarded as the "+" (positive) direction of the "X' " axis. Mirror image using Y axis as a symmetry axis is enabled.)
R2644, R2645	Circular feed in manual mode: Reference point H data	EA60, 0000	60000 (*1)
R2648, R2649	Circular feed in manual mode: Reference point V data	D4C0, 0001	120000 (*1)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	0000, 0000	0 (*1) (*2)
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	40E0, FFFD	-180000 (*1) (*1)
R2660, R2661	Circular feed in manual mode: Travel range V (+) data	0000, 0000	0 (*1) (*2)
R2664, R2665	Circular feed in manual mode: Travel range V (-) data	7960, FFFE	-100000 (*1) (*3)
R2668, R2669	Circular feed in manual mode: Gradient/arc center H data	D4C0, 0001	120000 (*1)
R2672, R2673	Circular feed in manual mode: Gradient/arc center V data	9C40, 0000	40000 (*1)

(*1) The reference point coordinates, travel range, arc center coordinates and gradient are designated with the unit obtained by multiplying "0.5" to PLC setting increment.

(*2) Specify the axis so that the clockwise direction is "+" direction of "X' " axis.

(*3) Disable the mirror image in the settings.



Mirror image using "Y' " axis as a symmetry axis		Valid
Travel range on the hypothetical coordinates	+X'	0°
	-X'	-90°
	+Y'	0
	-Y'	-50
Current position (point "A")		270°, -50

Counter clockwise direction is regarded as the "+" (positive) direction of the "X' " axis.

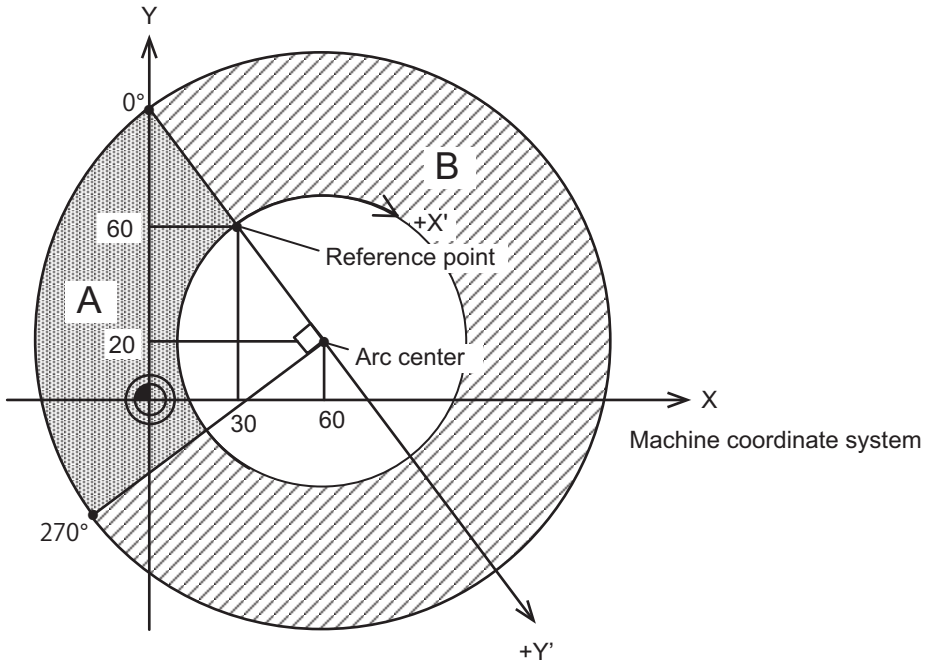
The direction opposite to the arc center is regarded as the "+" (positive) direction of the "Y' " axis.

The current position is output with the clockwise direction of the "X' " axis as "+" direction and the mirror image of "Y' " axis disabled.

When operating the CNC by switching the travel range in arc interpolation performed by specifying an angle

Device	Signal name	Data (HEX)	Data (DEC)
R2636, R2637	Circular feed in manual mode: Operation mode data	0002, 0000	X-Y plane, Arc-Linear (Clockwise direction is regarded as the "+" (positive) direction of the "X' " axis.)
R2644, R2645	Circular feed in manual mode: Reference point H data	EA60, 0000	60000 (*1)
R2648, R2649	Circular feed in manual mode: Reference point V data	D4C0, 0001	120000 (*1)
R2660, R2661	Circular feed in manual mode: Travel range V (+) data	0000, 0000	0 (*1)
R2664, R2665	Circular feed in manual mode: Travel range V (-) data	7960, FFFE	-100000 (*1)
R2668, R2669	Circular feed in manual mode: Gradient/arc center H data	D4C0, 0001	120000 (*1)
R2672, R2673	Circular feed in manual mode: Gradient/arc center V data	9C40, 0000	40000 (*1)

(*1) The reference point coordinates, travel range, arc center coordinates and gradient are designated with the unit obtained by multiplying "0.5" to PLC setting increment.



Mirror image using "Y' " axis as a symmetry axis		Invalid
Travel range on the hypothetical coordinates	+Y'	0
	-Y'	-50

Clockwise direction is regarded as the "+" (positive) direction of the "X' " axis.
Arc center direction is regarded as the "+" (positive) direction of the "Y' " axis.

■ Example where the travel range is "A" in the figure 1

Device	Signal name	Data (HEX)	Data (DEC)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	0000, 0000	0
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	40E0, FFFD	-180000

■ Example where the travel range is "A" in the figure 2

Device	Signal name	Data (HEX)	Data (DEC)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	FC80, 000A	720000
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	3D60, 0008	540000

■ Example where the travel range is "B" in the figure 1

Device	Signal name	Data (HEX)	Data (DEC)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	3D60, 0008	540000
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	0000, 0000	0

■ Example where the travel range is "B" in the figure 2

Device	Signal name	Data (HEX)	Data (DEC)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	40E0, FFFD	-180000
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	0000, 0000	0

■ Example where the travel range is the sum of "A" and "B" in the figure 1

Device	Signal name	Data (HEX)	Data (DEC)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	FC80, 000A	720000
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	0000, 0000	0

■ Example where the travel range is the sum of "A" and "B" in the figure 2

Device	Signal name	Data (HEX)	Data (DEC)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	3D60, 0008	540000
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	40E0, FFFD	-180000

■ Example where the travel range is not set

Device	Signal name	Data (HEX)	Data (DEC)
R2652, R2653	Circular feed in manual mode: Travel range H (+) data	0000, 0000	0
R2656, R2657	Circular feed in manual mode: Travel range H (-) data	0000, 0000	0

Setting example of plane selection

Device	Signal name	Data (HEX)	Plane to be selected
R2636, R2637	Circular feed in manual mode: Operation mode data	0001, 0000	X-Y plane, Linear-Linear The axes used for JOG feed or handle feed are the 1st and 2nd axes of the NC axes.
		4001, 0000	X-Y plane, Linear-Linear The axes used for JOG feed or handle feed are H axis and V axis.
		8001, 0000	Z-X plane, Linear-Linear The axes used for JOG feed or handle feed are H axis and V axis.
		C001, 0000	Y-Z plane, Linear-Linear The axes used for JOG feed or handle feed are H axis and V axis.

12.33 PLC Axis Control

This function allows an independent axis to be controlled with commands from the user PLC, separately from the NC control axis.

12.33.1 Specifications

Item	Details
Simultaneous control axes	The PLC control axis is controlled independently of the NC control axis. Simultaneous start of multiple PLC axes is possible.
Command unit	Least command increment (Note 1) 0.001mm (0.0001 inch) 0.0001mm (0.00001 inch) 0.00001mm (0.000001 inch) 0.000001mm (0.0000001 inch)
Feedrate	0 to 1000000 mm/min (0 to 100000 inch/min) (The speed is fixed regardless of the unit system.)
Movement commands	Incremental value commands from the current position. Absolute value commands of the machine coordinate system. 0 to ±99999999 (Note 1)
Operation modes	Rapid traverse, cutting feed Jog feed (+), (-) Reference position return feed (+), (-) Handle feed
Backlash compensation	Provided
Stroke end	Provided
Soft limit	Provided
Rotation axis commands	Provided Absolute value commands.....Rotation amount within one rotation (Rotates the remainder of the rotation amount divided by rotational axis division count.) Incremental commands.....Rotates the commanded rotation amount.
Inch/mm changeover	Not provided Command to match the feedback unit.
Position encoder	Encoder (absolute position detection also possible)

(Note 1) The following units are used for the input/output data in PLC axis control according to the parameter "#1005 plcunit" setting.

Setting value	Unit
B	0.001mm (0.0001inch)
C	0.0001mm (0.00001inch)
D	0.00001mm (0.000001inch)
E	0.000001mm (0.0000001inch)

The screen display changes as follows according to the parameter "#1003 iunit" setting.

Setting value	Unit	Display
B	0.001mm (0.0001inch)	Displays up to three digits after the decimal point
C	0.0001mm (0.00001inch)	Displays up to four digits after the decimal point
D	0.00001mm (0.000001inch)	Displays up to five digits after the decimal point
E	0.000001mm (0.0000001inch)	Displays up to six digits after the decimal point

(Note 2) The unit system is split into the display (iunit) and control data (plcunit), so when confirming the effective value of the PLC axis control data on the screen, set the display unit (iunit) to the same unit as the control data unit (plcunit).

Other restrictions

(1) There is no mirror image, external deceleration or machine lock function.
(2) Rapid traverse override, cutting override and dry run control are not possible.
(3) Automatic operation start, automatic operation stop, reset and interlock NC controls are invalid for PLC control axes.
The same control can be realized using an interface dedicated for PLC axis control.
(4) There is no dedicated emergency stop. The emergency stop is valid in the same manner as the NC control axis.

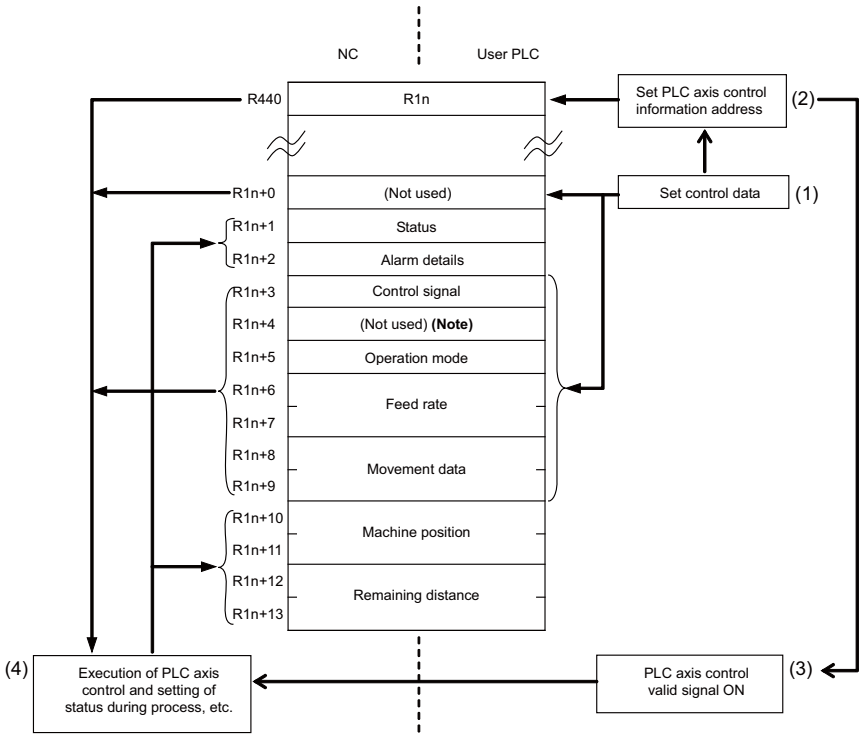
12.33.2 Detailed Explanation

The flow of the process during PLC axis control execution is shown below.

(1) The user PLC sets the control data in the R register.
(2) The user PLC sets the PLC axis control information address in the R register.
(3) The user PLC turns the PLC axis control valid signal ON.
(4) The NC executes PLC axis control based on the control data.

During PLC axis control, the status, alarm details, machine position and remaining distance are set in the R register.

Flow of PLC axic control for 1st PLC axis in single mode



(Note) Refer to "(4) Axis specification" in "Details of PLC Axis Control Information Data" for the explanation of unused register No. R1n+4.

12.33.3 PLC Interface

The PLC and NC interface is carried out by turning ON the PLC axis control valid signal or the PLC axis control buffering mode valid signal after the PLC sets the control information data in the R register.
The operation is executed in single mode if the PLC axis control valid signal is ON, executed in buffering mode if the PLC axis control buffering mode valid signal is ON.
Single mode and buffering mode cannot be operated simultaneously. An alarm (command mode overlap) occurs when the valid signal of either mode is turned ON while the other mode is operating. Note that the alarm does not cancel the operation in the first active mode.

Refer to "Single Mode" and "Buffering Mode" for the details of each mode. For the details of alarms, refer to "(2) Alarm Details" in "Details of PLC Axis Control Information Data".

(1) PLC axis control valid signal
The PLC axis control process is executed in single mode with the control information data while the PLC axis control valid signal is ON.
The reset state is activated when the PLC axis control valid signal is turned OFF. In this case, the axis control is reset only once; when the ON signal is turned OFF.

Signal name	PLC axis No.							
	1st axis	2nd axis	3rd axis	4th axis	5th axis	6th axis	7th axis	8th axis
PLC axis control valid	Y770	Y771	Y772	Y773	Y774	Y775	Y776	Y777

(2) PLC axis control buffering mode valid signal
When the PLC axis control buffering mode valid signal is ON, the PLC axis control is executed upon the control information data in buffering mode.
If the PLC axis control buffering mode valid signal is turned OFF, the axis control is reset. In this case, the axis control is reset only once; when the ON signal is turned OFF.

Signal name	Common for all axes
PLC axis control buffering mode valid	Y723

(3) PLC axis control information address
The PLC axis control information address stores head R registers of the control information for each PLC axis.

Signal name	PLC axis No.							
	1st axis	2nd axis	3rd axis	4th axis	5th axis	6th axis	7th axis	8th axis
PLC axis control information address	R440	R441	R442	R443	R444	R445	R446	R447

(Note 1) The following R registers can be used.
R8300 to R9799 (Area backed up by battery)
R9800 to R9899 (Area not backed up by battery)
R18300 to R19799 (Area backed up by battery)
R19800 to R19899 (Area not backed up by battery)
R28300 to R29799 (Area backed up by battery)
R29800 to R29899 (Area not backed up by battery)
(Note 2) If the setting value of R register is out of range or odd number, the target PLC axis turns invalid.
(Note 3) In the following explanations, the R register Nos. stored in the PLC axis control information address are indicated as R1n for the 1st axis, R2n for the 2nd axis, R3n for the 3rd axis, and R4n for the 4th axis, R5n for the 5th axis, R6n for the 6th axis.

(4) PLC axis control buffering mode information address

The PLC axis control buffering mode information address stores head R registers of the buffering mode control information for each PLC axis. (Note 1)

Signal name	Common for all axes
PLC axis control buffering mode information address	R448

(Note 1) The following R registers can be used.
R8300 to R9799 (Area backed up by battery)
R9800 to R9899 (Area not backed up by battery)
R18300 to R19799 (Area backed up by battery)
R19800 to R19899 (Area not backed up by battery)
R28300 to R29799 (Area backed up by battery)
R29800 to R29899 (Area not backed up by battery)

(Note 2) If the setting value of R register is out of range or odd number, the target PLC axis turns invalid.

(Note 3) In the following explanations, the R register Nos. stored in the PLC axis control buffering mode information address are indicated with Rn. The PLC axis control information data arrangement follows the arrangement of "R1n" and others, which is referred in "(3) PLC axis control information address".

(5) PLC axis control information data

The control information data is stored in the R register value indicated by the PLC axis control information address and the subsequent register values before starting the PLC axis control process.
The control information data arrangement is shown below.

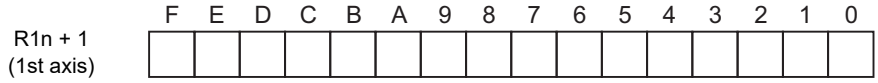
Signal name	PLC axis No.					
	1st axis	2nd axis	3rd axis	4th axis	5th axis	6th axis
(Not used)	R1n+0	R2n+0	R3n+0	R4n+0	R5n+0	R6n+0
Status	R1n+1	R2n+1	R3n+1	R4n+1	R5n+1	R6n+1
Alarm details	R1n+2	R2n+2	R3n+2	R4n+2	R5n+2	R6n+2
Control signal	R1n+3	R2n+3	R3n+3	R4n+3	R5n+3	R6n+3
Axis specification (Note)	R1n+4	R2n+4	R3n+4	R4n+4	R5n+4	R6n+4
Operation mode	R1n+5	R2n+5	R3n+5	R4n+5	R5n+5	R6n+5
Feedrate	R1n+6	R2n+6	R3n+6	R4n+6	R5n+6	R6n+6
	R1n+7	R2n+7	R3n+7	R4n+7	R5n+7	R6n+7
Movement data	R1n+8	R2n+8	R3n+8	R4n+8	R5n+8	R6n+8
	R1n+9	R2n+9	R3n+9	R4n+9	R5n+9	R6n+9
Machine position	R1n+10	R2n+10	R3n+10	R4n+10	R5n+10	R6n+10
	R1n+11	R2n+11	R3n+11	R4n+11	R5n+11	R6n+11
Remaining distance	R1n+12	R2n+12	R3n+12	R4n+12	R5n+12	R6n+12
	R1n+13	R2n+13	R3n+13	R4n+13	R5n+13	R6n+13

(Note) Axis specification is valid only for buffering mode.

12.33.4 Details of PLC Axis Control Information Data

(1) Status

The status is set by the NC to indicate the execution status of this function instruction and the status of the axis being controlled.



bit0:busy	Command processing		bit8:oper	Option error
1:den	Axis movement completed		9:	
2:move	Axis moving		A:	
3:SA	Servo ready		B:	
4:svon	Servo ON		C:	
5:ZP	Reference position reached		D:	
6:IMP	In in-position		E:ALM2	Axis in control alarm
7:WAIT	Axis movement wait		F:ALM1	Control information data designation alarm

bit 0: busy Command processing

This turns ON when the command is being processed.

The next command is not received while this bit is ON.

The next command to be issued is received while this bit is OFF.

bit 1: den Axis movement completed

This bit turns ON when the initialization and commanded movement are completed.

This bit stays OFF during movement, even when an interlock is applied.

This bit turns ON at reset or servo OFF, or when PLC axis control valid is "0".

bit 2: move Axis moving

This bit turns ON when the machine is moving, and turns OFF when the machine is stopped.

bit 3: SA Servo ready

This bit turns ON when the servo is ready.

It turns OFF during emergency stops and servo alarms.

bit 4: svon Servo ON

This bit turns OFF when a servo OFF signal is output.

It also turns OFF during emergency stops and servo alarms.

Machine movement is possible when this signal is ON.

bit5: ZP Reference position reached

This bit turns ON when the reference position is reached after completion of a reference position return.

It turns OFF when the machine moves.

bit 6: IMP In in-position

This bit turns ON when the PLC axis is in the in-position state, and turns OFF when not in the in-position state.

bit7: WAIT Axis movement wait

This bit turns ON in the buffering mode while completion of the axis movement of the preceding block is being waited for. It turns OFF when the previous block movement is completed and the movement of the next block begins.

bit 8: oper Option error

This bit turns ON when an attempt is made to execute PLC axis control when there is no PLC axis control additional specification.

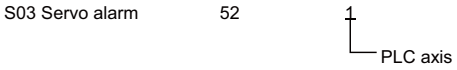
bit E: ALM2 Axis in control alarm

This bit turns ON when an alarm occurs (such as a servo alarm) during execution of axis control. Axis control cannot be executed while this bit is ON.

After the cause of the alarm has been removed, turn the bit OFF by outputting a reset signal, setting PLC axis control valid signal to 0, or turning the power OFF then ON again.

(Note) When servo alarm occurs, the same alarms appear in the screen as for NC control axes. Set the PLC 1st axis to "1", and the PLC 2nd axis to "2".

Example: When a servo alarm occurs for the PLC 1st axis



bit F: ALM:1 Control information data designation alarm

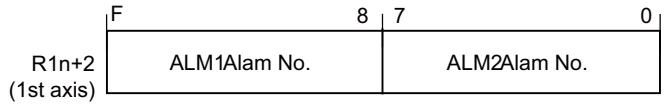
This bit turns ON when the designated details of the control information data are illegal. When an alarm occurs for the simultaneous operation of buffering mode and single mode, the mode designated later is not executed and the mode designated first continues processing.

PLC axis control is not executed when any other alarm occurs. Turn the bit OFF by correcting the data, outputting a reset signal, or setting PLC axis control valid signal to 0.

(Note) The status of the PLC axis, to which the PLC axis control valid signal is ON, is automatically updated.

(2) Alarm details

The alarm Nos. of status ALM1 and ALM2 are set.



The details of each alarm No. are shown below.

ALM1 (Control information data designation alarm)

Alarm No.	Details
01	Control signal illegal (A signal other than a registered control signal has been commanded.)
02	Axis No. illegal
03	Operation mode illegal (0 to 6)
04	Movement data range exceeded -99999999 to +99999999
05	
06	
07	
10	Reference position return not complete (absolute value command not possible)
11	
12	Command modes overlap (Note 1)
13	
14	Operation mode illegal during high-speed simple program check (PLC axis, which was in the jog feed mode, handle feed mode, or reference position return mode, was started in the high-speed simple program check mode.)
15	Operation mode illegal during manual arbitrary reverse run (PLC axis, which was in the jog feed mode, handle feed mode, or reference position return mode, was started in the manual arbitrary reverse run mode.)
20	Operation mode mismatch during synchronous control
21	During synchronous control (command is not possible)

(Note 1) This alarm occurs before the simultaneous operation of single mode and buffering mode.

(Note 2) The alarm details of the PLC axis, to which the PLC axis control valid signal is ON, are automatically updated.

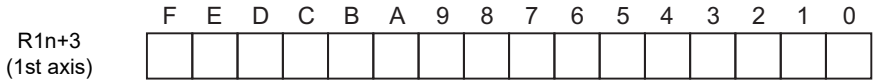
ALM2 (Axis in control alarm)

Alarm No.	Details
0	Servo alarm (Alarm No. is displayed in the PLC axis monitor screen. Refer to the Drive Unit Maintenance Manual for details.)
1	Z-phase not passed
2	Soft limit (+)
3	Soft limit (-)
4	Stroke end (+)
5	Stroke end (-)

(Note) The alarm details of the PLC axis, to which the PLC axis control valid signal is ON, are automatically updated.

(3) Control Signals (PLC axis control information data)

Control signals such as start, interlock, reset, axis removal and axis removal 2 are designated for the PLC axis.



bit0: Start	bit8: Absolute value command
1: Interlock	9:
2: Reset	A:
3: Servo OFF	B:
4: Axis removal	C:
5: Axis removal 2	D:
6:	E:
7:	F:

bit 0: Start

Starting begins at the rising edge (OFF -> ON) of the start signal, based on the control information data.
The axis does not move during interlock, servo OFF, axis removal and axis removal 2.
Movement starts after interlock, servo OFF, axis removal and axis removal 2 are canceled.
Start is invalid during resetting.

bit 1: Interlock

The moving PLC axis executes a deceleration stop when the interlock signal turns ON.
The stopped PLC axis will resume movement when the interlock signal turns OFF (is canceled).

bit 2: Reset

The PLC axis is reset when the reset signal turns ON.
Moving PLC axes will execute a deceleration stop.
Commands and controls are invalid during resetting.
If the reset signal turns ON during an alarm occurrence, the alarm will be cleared.

bit 3: Servo OFF

The PLC axis will execute a deceleration stop and its servo will turn OFF when the servo OFF signal turns ON.
Whether the PLC axis movement is compensated during servo OFF can be selected in the basic specification parameter "#1064 svof".
A servo ON status will result when the power is turned ON.

bit4: Axis removal

The axis will execute a deceleration stop, and a servo OFF status will result, when the axis removal signal turns ON.
A servo ON status will result and the stopped PLC axis will resume movement when the axis removal signal turns OFF (is canceled).
Axis removal is validated when either this signal or machining parameter and axis parameter "#8201 Axis Removal" is validated.
The reference position return will become incomplete when the axis is removed. Therefore, a dog-type reference position return must be completed again when starting with an absolute value command.

bit 5: Axis removal 2

The axis will execute a deceleration stop, and a servo OFF/ready OFF status will result, when the axis removal 2 signal turns ON.
A servo ON/ready ON status will result for the stopped PLC axis when the axis removal 2 signal turns OFF (is canceled).A restart must be executed to start the movement again.
Position control cannot be carried out while the axis removal 2 signal is ON. However, position detection is possible so the position will not be lost.

bit 8: Absolute value command

Turn this bit ON when the movement data is commanded in absolute values.
When this bit is OFF, the commands will be processed as incremental value commands.

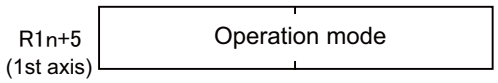
(4) Axis specification
PLC axis No. is designated.



0: 1st axis
1: 2nd axis
2: 3rd axis
3: 4th axis
4: 5th axis
5: 6th axis
6: 7th axis
7: 8th axis

Only buffering mode allows the axis specification upon this data.
Single mode, which provides the PLC axis control valid signal for each axis, does not allow the axis specification upon this data.

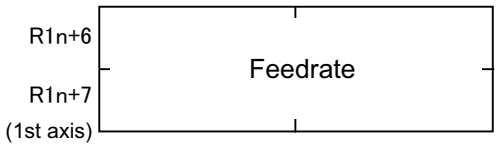
(5) Operation Mode
The operation mode for the PLC axis is designated.
For example, in the handle mode, R1n+5=6 (DATA) is set.



(Numeric value data)
0: Rapid traverse (G0)
1: Cutting feed (G1)
2: Jog feed (+)
3: Jog feed (-)
4: Reference position return (+)
5: Reference position return (-)
6: Handle feed

The axis movement will not be affected by changing the operation mode, even while the axis is moving.
The new operation mode is validated at the next start.

(6) Feedrate
When the operation mode is cutting feed or jog feed (operation mode, register = 1 to 3), the PLC axis feedrate is designated with a binary code.

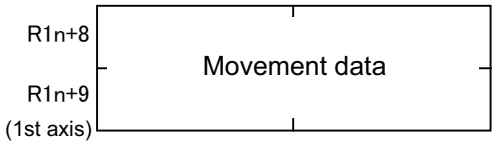


Designation value : 1 to 1000000 mm/min. (0.1 to 100000 inch/min.)

(Note 1) The speed unit is fixed regardless of the unit system set with the command unit.
(Note 2) The feedrate designated in the parameters is used for the rapid traverse mode and reference position return mode.
(Note 3) The feedrate can be changed during axis movement. In that case, a feedrate data (R1n + 6, 7) can be changed directly.

(7) Movement Data

When the operation mode is rapid traverse or cutting feed, the movement data is designated with a binary code.

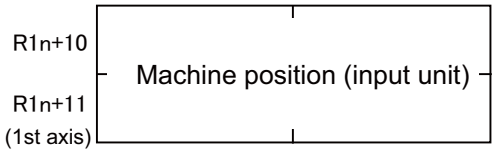


Designation value : 0 to 99999999

(Note 1) Refer to the explanations in "Specifications" "#1003 iunit" and "#1005 plcunit" for details on the unit.
(Note 2) The movement data is classified as follows by the absolute value command flag (bit 8) of the command signal.
Absolute value command flag = 0: Incremental value from the current position
Absolute value command flag = 1: Absolute value of the machine coordinate system
(Note 3) If the movement amount is changed during axis movement, the new movement amount will be validated at the next start.

(8) Machine Position

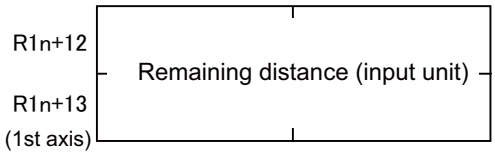
The machine position output to the machine system is expressed. The machine position becomes the Rfp (reference position) when the reference position is reached.



(Note 1) Refer to the explanations in "Specifications" "#1003 iunit" and "#1005 plcunit" for details on the unit.
(Note 2) The machine position of the PLC axis, to which the PLC axis control valid signal is ON, is automatically updated.

(9) Remaining Distance

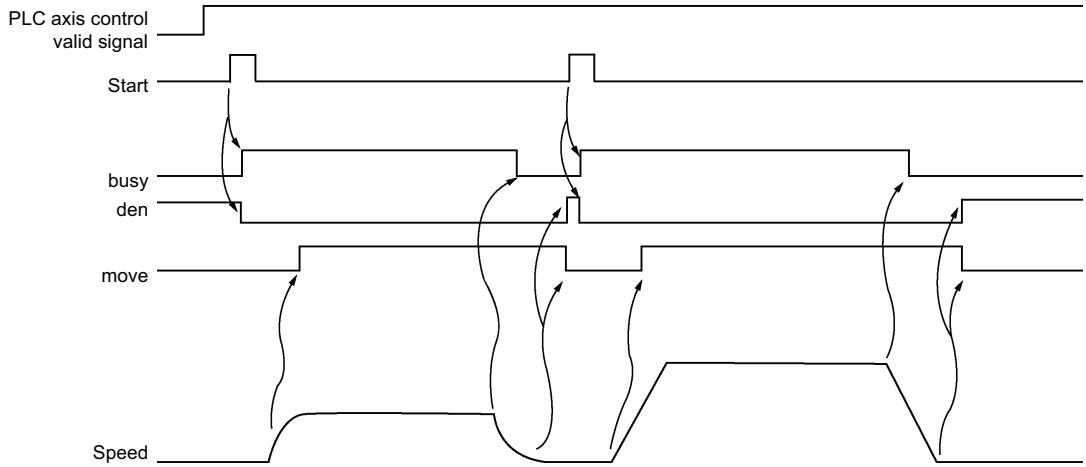
The remaining distance of the movement data output to the machine system is expressed.



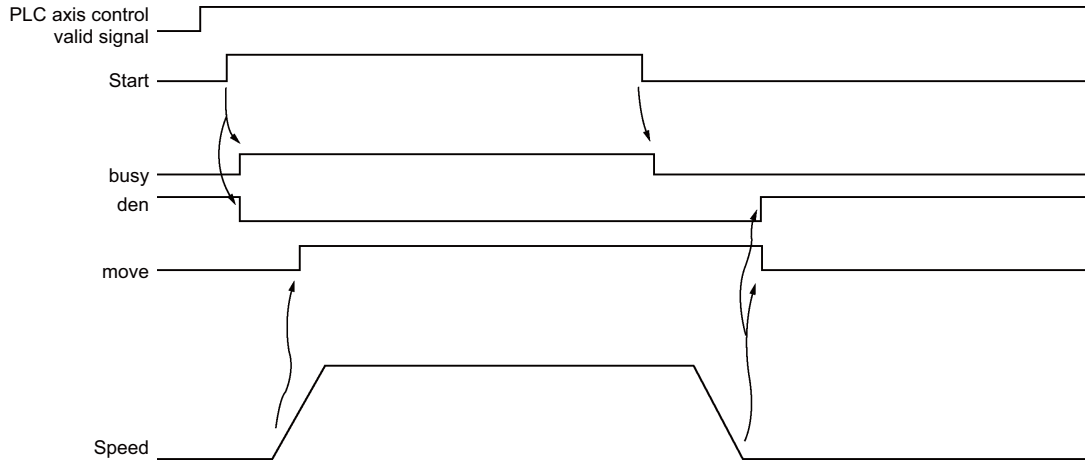
(Note 1) Refer to the explanations in "Specifications" "#1003 iunit" and "#1005 plcunit" for details on the unit.
(Note 2) The remaining distance of the PLC axis, to which the PLC axis control valid signal is ON, is automatically updated.

12.33.5 Timing Chart

(1) For rapid traverse and cutting feed mode



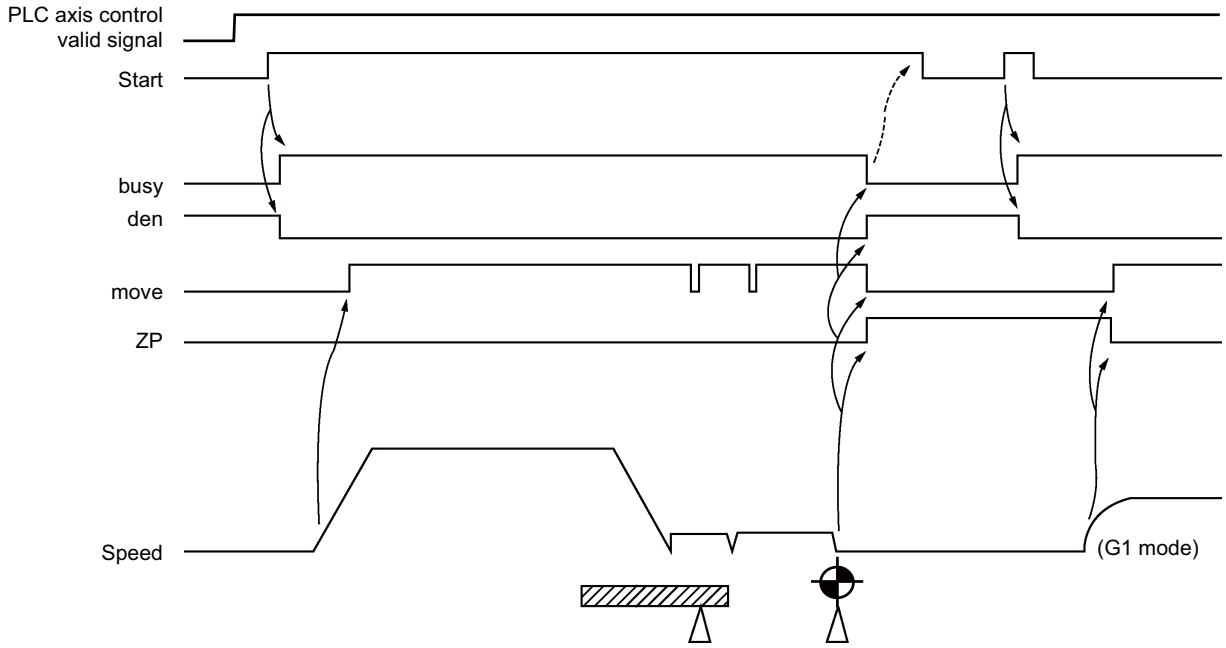
(2) For jog feed mode



(Note) The axis moves by jog feed only during start ON.

(3) For reference position return feed mode

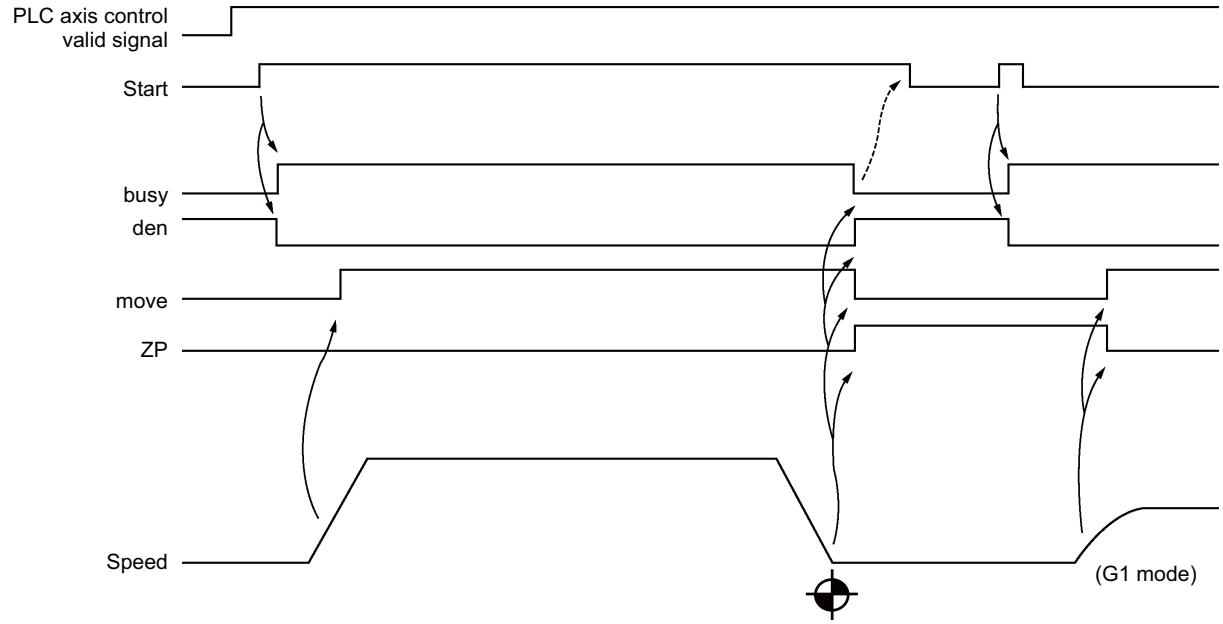
(a) Dog-type reference position return



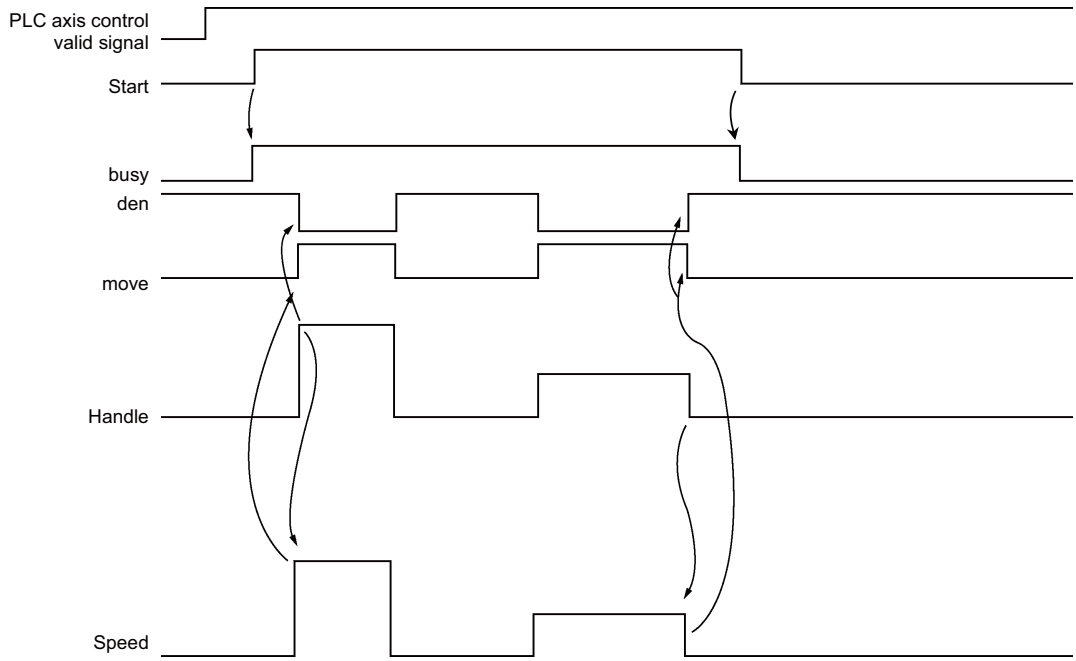
(Note 1) The axis moves by reference position return feed only during start ON. Turn the start OFF after confirming that the reference position has been reached.

(Note 2) The first reference position return after the power is turned ON is always dog-type. All returns after that are high-speed reference position returns.

(b) High-speed reference position return

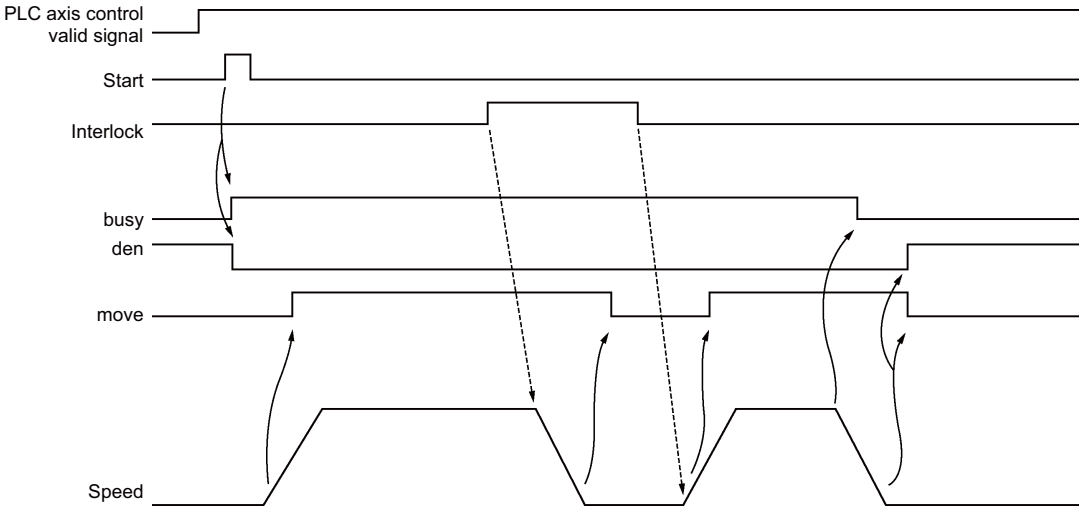


(4) For handle feed mode

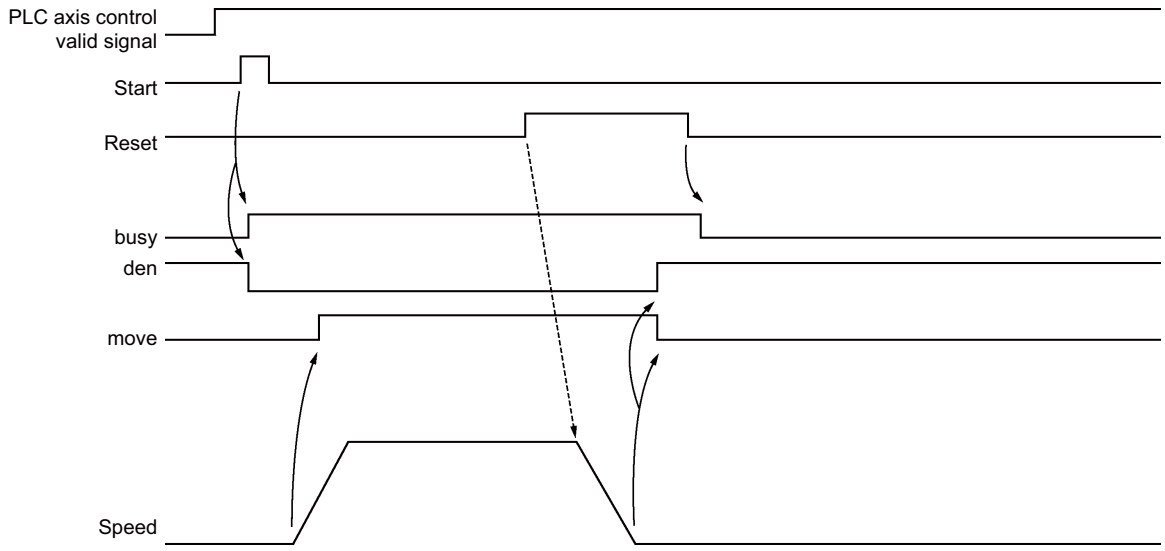


(Note) Handle feed is possible only during start ON.

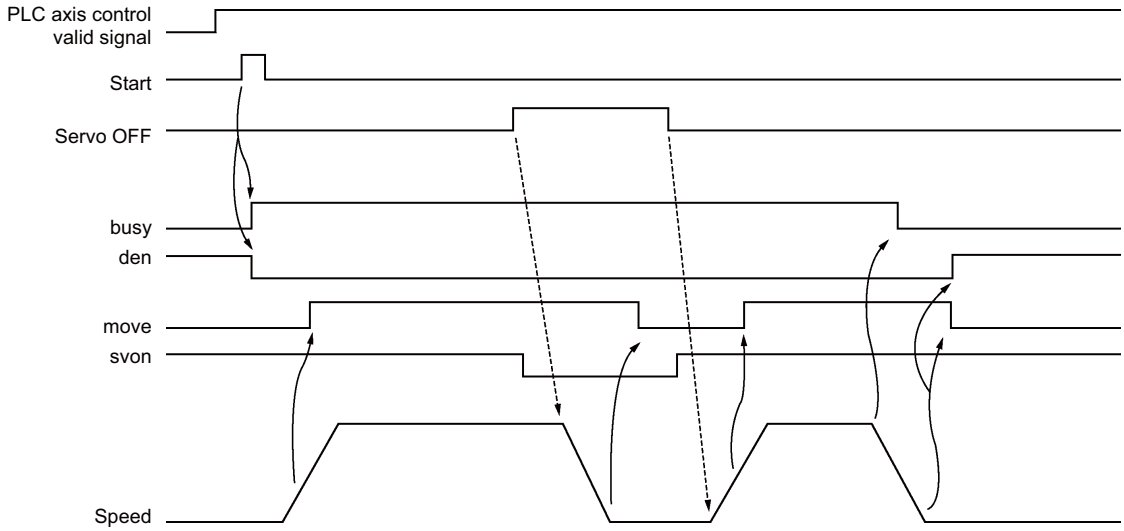
(5) When the interlock signal is ON (= 1)



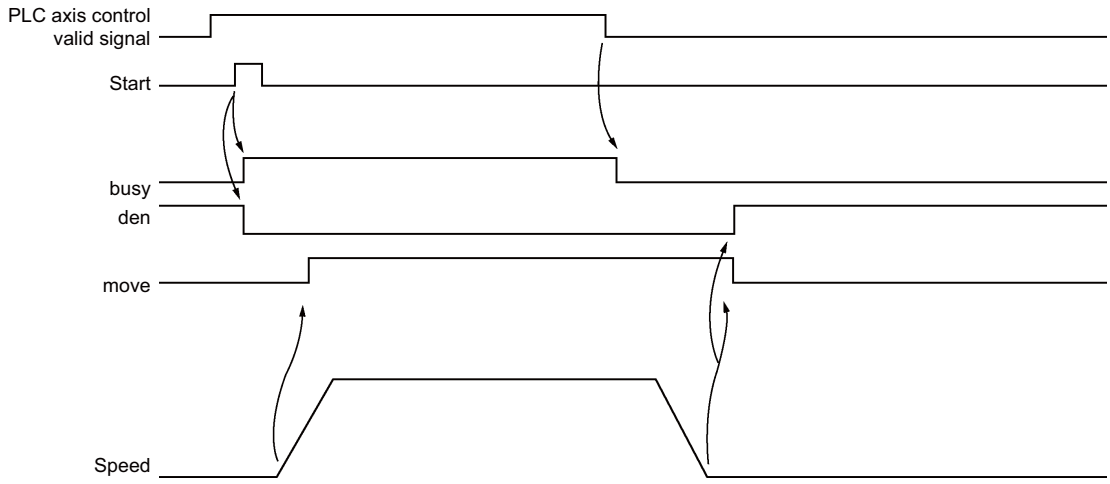
(6) When the reset signal is ON (= 1)



(7) When the servo OFF signal is ON (= 1)



(8) When the PLC axis control valid signal is OFF (= 0)



12.33.6 Reference Position Return Near Point Detection

Set the near point dog signal of the PLC axis reference position return for the following devices in the PLC.

Device No.		Signal name
Y718	*PCD1	PLC axis near point detect 1st axis
Y719	*PCD2	PLC axis near point detect 2nd axis
Y71A	*PCD3	PLC axis near point detect 3rd axis
Y71B	*PCD4	PLC axis near point detect 4th axis
Y71C	*PCD5	PLC axis near point detect 5th axis
Y71D	*PCD6	PLC axis near point detect 6th axis
Y71E	*PCD7	PLC axis near point detect 7th axis
Y71F	*PCD8	PLC axis near point detect 8th axis

(Note) The responsiveness when the dog signal is set in PLC middle-speed processing is worse than when set in PLC high-speed processing.

12.33.7 Handle Feed Axis Selection

The axis is designated for the following devices when handle feed is carried out with a PLC axis.

Device No.		Signal name
Y720	HS1P	PLC axis 1st handle valid
Y721	HS2P	PLC axis 2nd handle valid
Y722	HS3P	PLC axis 3rd handle valid

When Y720, Y721, Y722 are ON, each handle changes to PLC axis dedication.
YC40 to YC44, YC47, YC48 to YC4C, YC4F, YC50 to YC54 and YC57 used with the normal control device are used to select each handle axis.
PLC axes are counted as PLC such as first axis and second axis. Therefore, if you will operate the first handle in the first axis of PLC, turn ON Y720, YC40 to YC44 and YC47.

(Note) The handle feed magnification is also used for NC control axes.

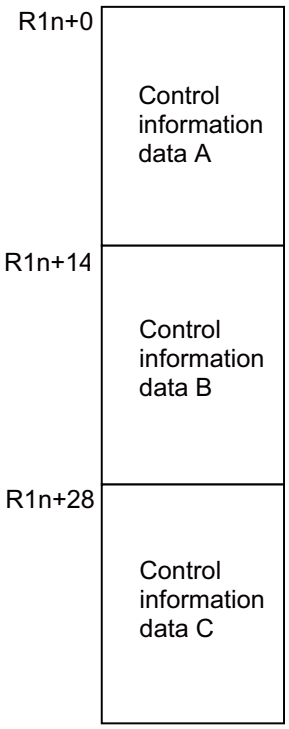
12.33.8 Single Mode

In the single mode, the command to PLC axis (control information data) is set in one block. Only one command is used for the PLC axis control.

12.33.9 Buffering Mode

In the buffering mode, the PLC axis command (control information data) is commanded to several blocks. This enables smooth changeover of commands.
Axis specifications can be set to each control information data. Up to three axes can be controlled in sequence. (Refer to "G1→ G1→ G0→ G1 (two axes)" in "(2)Timing Chart".)

(1) Control information data

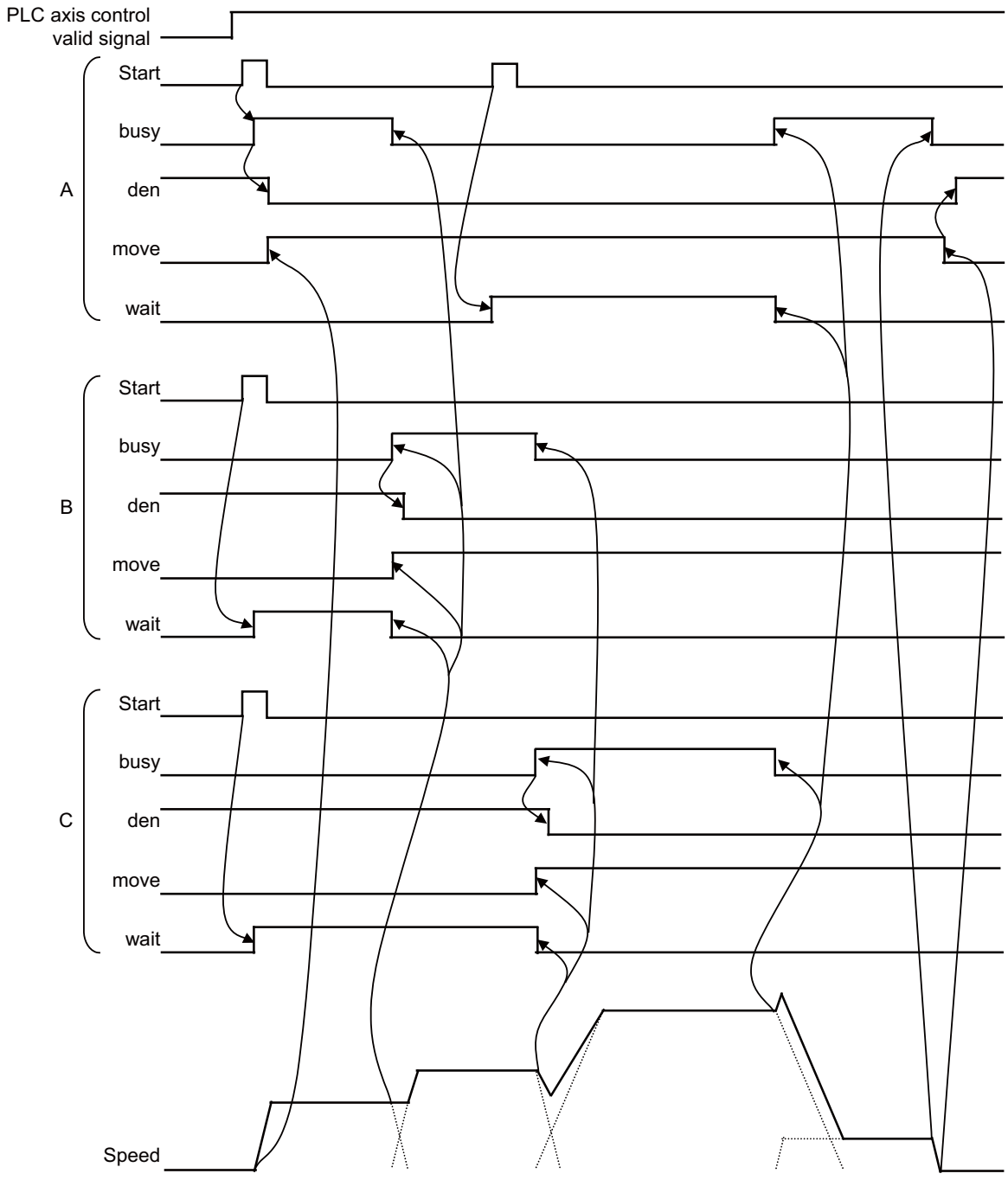


The control data for the buffering mode is set in three blocks.
The contents of each control information data have the same configuration as the normal control information data.
When executing, the axis is moved in the order that each control information is started.
When the movement is completed, the movement for the next block starts.
(If the start signals are turned ON simultaneously, the blocks are executed in the order of A, B and C.)

(Note) Only one set of the buffering mode can be commanded. If two or more sets are commanded simultaneously, the sets commanded later will cause an alarm.

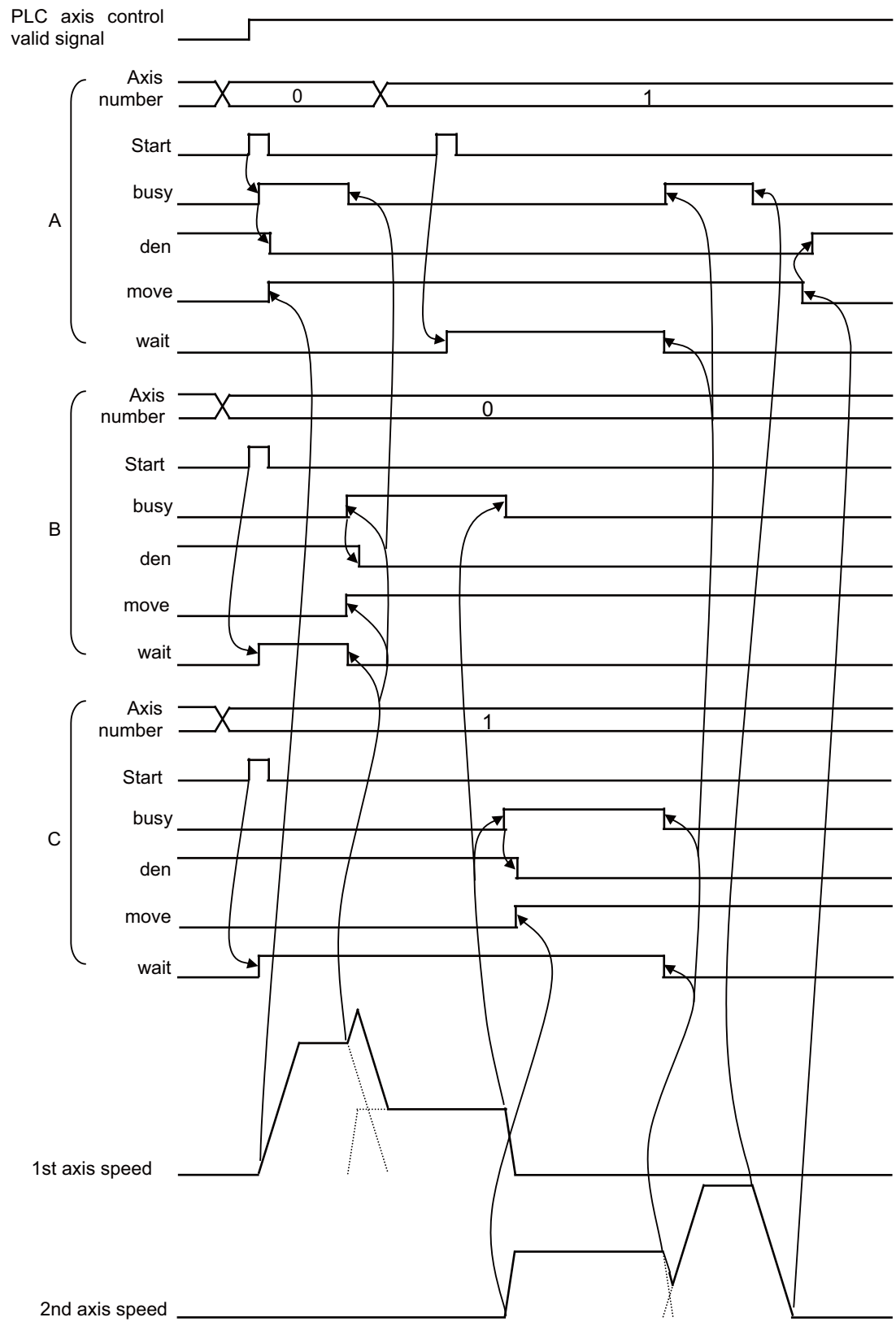
(2) Timing chart

G1→G1→G0→ G1 (same axis)



(Note) Change and start the data after the busy signal turns OFF.
Starting while the busy signal is ON will be ignored.

G1→ G1→ G0→ G1 (two axes)



12.33.10 PLC Axis Monitor

The PLC axis operation status can be confirmed by checking the PLC section on the servo monitor.

12.33.11 Constant-Gradient Acceleration/Deceleration

Linear acceleration/deceleration of the rapid traverse command and cutting feed command is performed with a constant gradient. Cycle time can be reduced in the constant-gradient acceleration/deceleration method than the constant-time acceleration/deceleration method.

Detailed description

When the following conditions are met, constant-gradient acceleration/deceleration of PLC axis is enabled.

- Rapid traverse command (G00) or cutting feed command (G01) is specified in the automatic operation mode.
- The acceleration and deceleration mode (#2003 smgst) is set to linear acceleration/deceleration or soft acceleration/deceleration.

(Note) In the following cases, constant-gradient acceleration/deceleration of PLC axis is disabled.

- In the buffering mode
- When jog feed, reference position return or handle feed is specified

The constant-gradient acceleration/deceleration and constant-time acceleration/deceleration can be switched with the following parameters.

#1307 G0acc_plc (PLC axis G00 constant-gradient acceleration/deceleration valid)

#1308 G1acc_plc (PLC axis G01 constant-gradient acceleration/deceleration valid)

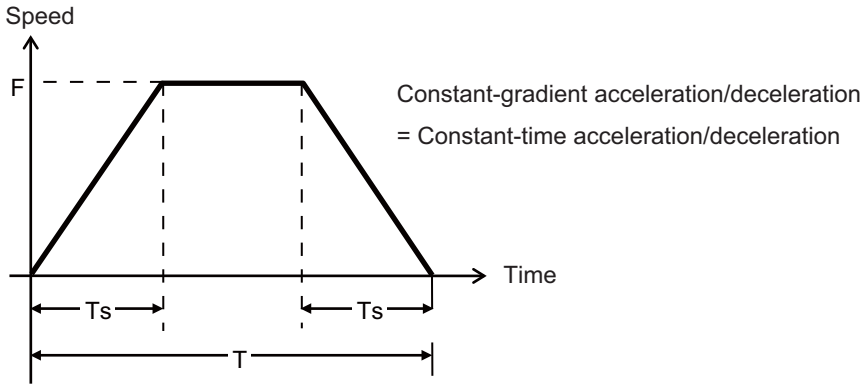
0: Constant-time acceleration/deceleration

1: Constant-gradient acceleration/deceleration

The acceleration/deceleration patterns are as follows when the constant-gradient acceleration/deceleration is performed.

■ Rapid traverse command

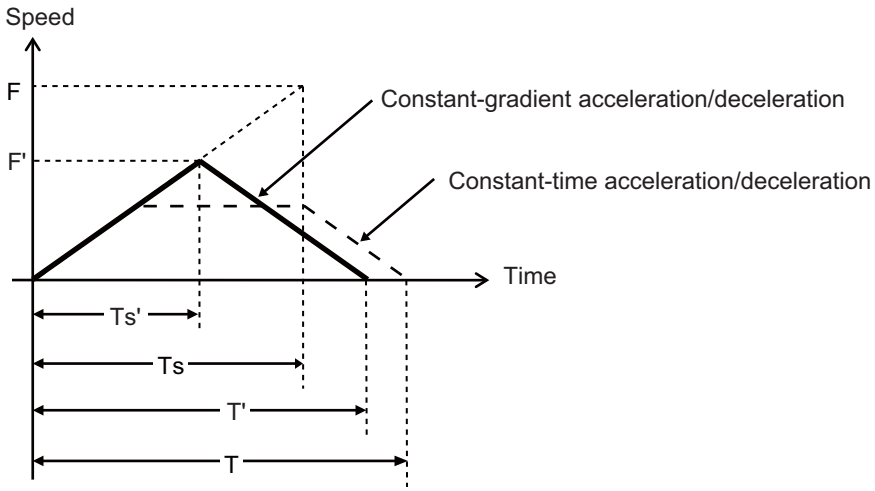
(1) When the movement command is longer than the acceleration/deceleration distance



F : Rapid traverse rate (# 2001 rapid)
Ts : Acceleration/deceleration time (#2004 G0tL)
T : Movement time

The acceleration/deceleration with a constant gradient is the same as that with constant time.

(2) When the interpolation distance is shorter than the acceleration/deceleration distance

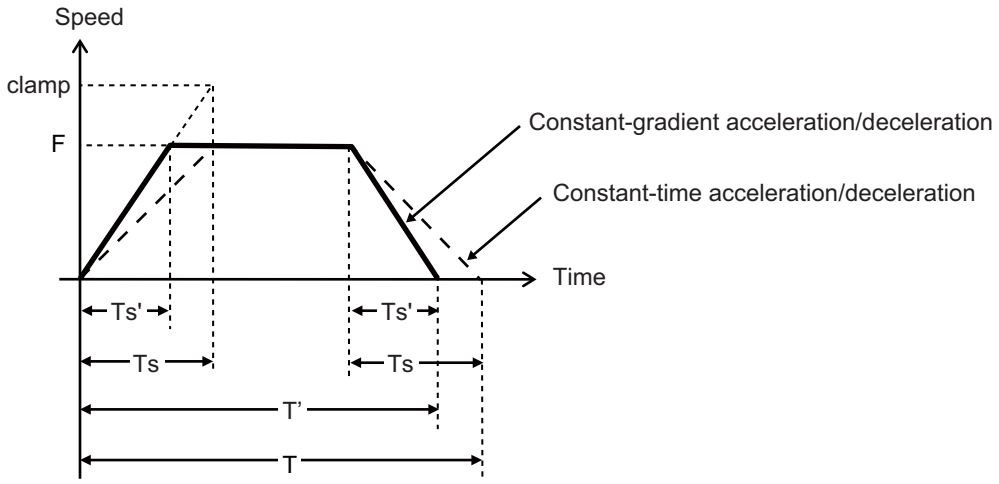


F : Rapid traverse rate (# 2001 rapid)
F' : Feedrate in constant-gradient acceleration/deceleration
Ts : Acceleration/deceleration time (#2004 G0tL)
Ts' : Acceleration/deceleration time in constant-gradient acceleration/deceleration
T : Movement time in constant-time acceleration/deceleration
T' : Movement time in constant-gradient acceleration/deceleration

Acceleration/deceleration is performed with a gradient determined with the rapid traverse rate "F" and the time constant "Ts".
(T - T') is the improvement effect of the cycle time.

■ Cutting feed command

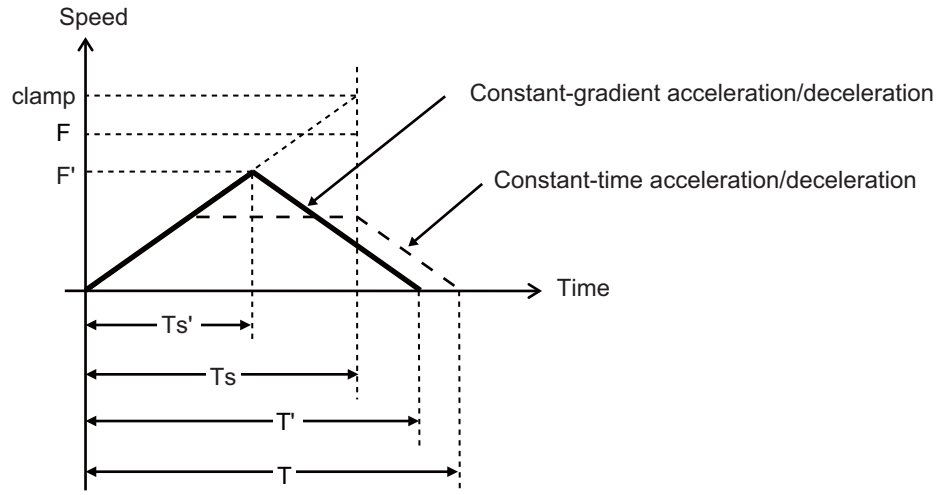
(1) When the movement command is longer than the acceleration/deceleration distance



clamp	:	Cutting feedrate for clamp function (#2002 clamp)
F	:	Command speed
Ts	:	Acceleration/deceleration time (#2007 G1tL)
Ts'	:	Acceleration/deceleration time in constant-gradient acceleration/deceleration
T	:	Movement time in constant-time acceleration/deceleration
T'	:	Movement time in constant-gradient acceleration/deceleration

Acceleration/deceleration is performed with a gradient determined with the cutting feedrate for clamp function "clamp" and the time constant "Ts".
(T - T') is the improvement effect of the cycle time.
When the speed is changed during movement, the feedrate is clamped at the feedrate "F" at the start.

(2) When the interpolation distance is shorter than the acceleration/deceleration distance



clamp : Cutting feedrate for clamp function (#2002 clamp)
F : Command speed
F' : Feedrate in constant-gradient acceleration/deceleration
Ts : Acceleration/deceleration time (#2007 G1tL)
Ts' : Acceleration/deceleration time in constant-gradient acceleration/deceleration
T : Movement time in constant-time acceleration/deceleration
T' : Movement time in constant-gradient acceleration/deceleration

Acceleration/deceleration is performed with a gradient determined with the cutting feedrate for clamp function "clamp" and the time constant "Ts".
(T - T') is the improvement effect of the cycle time.
When the speed is changed during movement, the feedrate is clamped at the feedrate "F'" at the start.

12.33.12 Absolute Position Detection

The absolute position of the PLC axis can be detected in the same manner as the NC control axis.
The initial setting operations are the same as the NC control axis. However, the following restrictions apply to the absolute position detection with the PLC axis.

(1) Automatic initialization is not possible.
(2) The verify function cannot be used.
(3) The near zero-point signal cannot be output.

12.33.13 Device Random Assignment

The device random assignment can be performed on PLC axis similar to NC control axis.
Select the validity of the device random assignment of the PLC axis with the parameter "#1246 set18/bit7".

		#1246 set18/bit7	
		ON	**OFF**
#1226 aux10/bit5	ON	NC axis random device assignment valid	
	OFF	PLC axis random device assignment valid	PLC axis random device assignment invalid
		NC axis random device assignment invalid	

When this function is valid, the devices which were arbitrarily allocated becomes invalid by inputting the "PLC axis near-point dog ignored" signal (R279) or "PLC axis OT ignored" signal (R255).
(By turning the bit ON of the corresponding axis, the device which is randomly allocated to the axis will be ignored.)

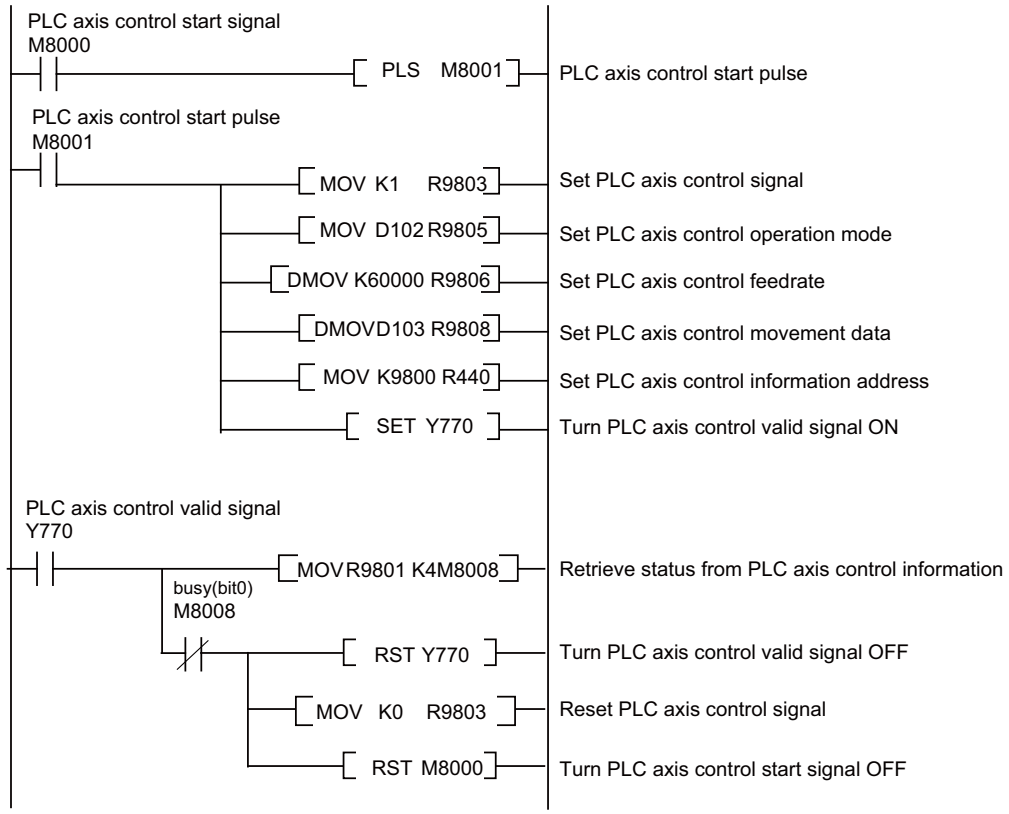
F	E	D	C	B	A	9	8	7	6	5	4	3	2	1	0

bit0 : 1st axis
bit1 : 2nd axis
: :
bit7 : 8th axis

When the parameters "#2073" to "#2075" are valid, do not set the same device number.
(When the device random assignment is valid for the NC control axis, do not set the same device No. as the ones set in the parameters ("#2073" to "#2075") of the NC control axes. If the same device number exists, an emergency stop occurs.

12.33.14 Usage Example

The following shows an example of the PLC axis control ladder for the 1st PLC axis in single mode.



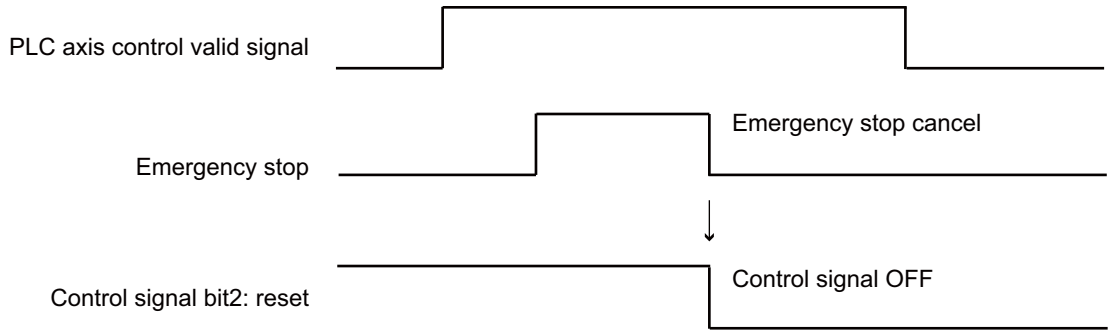
Control data	Setting value
Control signal	Start
Operation mode	D102 value
Feedrate	60mm/min
Movement data	D103 value (Value multiplied by plcunit unit.)

12.33.15 Precautions

(1) When either of a master axis or slave axis of synchronous control is in NC axis mode of NC axis/PLC axis switchover, an alarm occurs if "Start" is input (turning the "R1n+3/bit0" ON) in the "Control Signals" (PLC axis control information data) of the master axis or slave axis. (Alarm No. "20" is input in the "Alarm" (PLC axis control information data).)

(2) When both the master axis and slave axis of synchronous control are in PLC axis mode of NC axis/PLC axis switchover, an alarm occurs if any of the following operations is carried out. (Alarm No. "21" is input in the "Alarm" (PLC axis control information data).)
- When "Start" is input (turning the "R1n+3/bit0" ON) to the "Control Signals" (PLC axis control information data) of the slave axis
- When an axis of the PLC axis mode is returned to the reference position

(3) If the reset input (control signal bit2) for PLC axis remains ON when the emergency stop is canceled during PLC axis control, the "Emergency stop CVIN" (the external emergency stop function for power supply) may not be canceled. To cancel the emergency stop, turn OFF the reset input (control signal bit2).



12.34 PLC Axis Indexing

12.34.1 Functions

PLC axis indexing is used to move the PLC axis to the positioning destination or an arbitrary coordinate position. This function is applied to tool exchange and magazine control.

[Positioning command methods]

(1) Station method

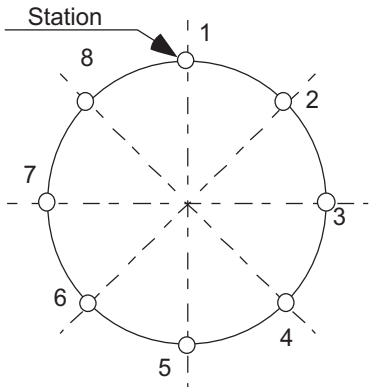
The axis will be positioned to the destination (station) that has been decided.

There are two assigning methods: Uniform assignment and arbitrary coordinate assignment.

- Uniform assignment

One rotation (360°) of the rotary axis will be equally divided to determine the stations.

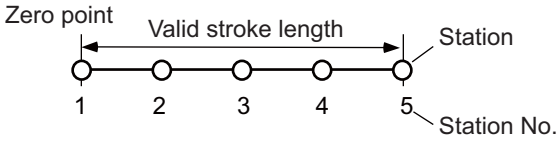
(Maximum number of divisions: 360)



[Setting 8 stations (8 divisions)]

[For linear axis]

A valid stroke will be equally divided to determine the station. (Maximum number of divisions: 359)



[Setting 5 stations]

- Arbitrary coordinate assignment

A station will be assigned to an arbitrary coordinate set in each table

(2) Arbitrary coordinate designation method

An arbitrary coordinate will be directly designated in PLC program for positioning.

[Operation functions]

- Automatic mode
  Stations will be determined automatically.
- Manual mode
  Stations will be determined manually.
  While the start signal is ON, the axis will be rotated at a constant speed. When the start signal is OFF, the axis will be positioned at the nearest station.
- JOG mode
  The axis will be rotated at constant speed.
- Incremental feed
  The axis will be moved by the designed amount.
- Manual handle feed
  The axis will be moved by the manual pulse generator.
- Reference position return
  The axis will be positioned at the reference position.

[Feed functions]

- Feed rate selection
  Automatic mode and manual mode can have each four different feed rates to be designated in the PLC program.
- Acceleration/deceleration method
  Four different combination can be set from the acceleration/deceleration patterns (linear or S-pattern acceleration/deceleration) and the acceleration/deceleration time constants. The combination will be selected in the PLC program.
  Select acceleration/deceleration type with parameter: the acceleration/deceleration with constant time or the one with a constant angle of inclination.
- Short-cut control
  A least movement distance is automatically judged when a rotary axis is rotated.

12.34.2 Programming and Setting

12.34.2.1 Operation Function: Automatic Mode

The axis is positioned automatically.
The axis will be positioned at the designated station by turning ON Operation start (ST).
The arbitrary position command operation is also available: the positioning can be carried out to any position other than a station by directly commanding the positioning coordinates from the PLC. (Refer to the explanations of the arbitrary coordinate designation method.)

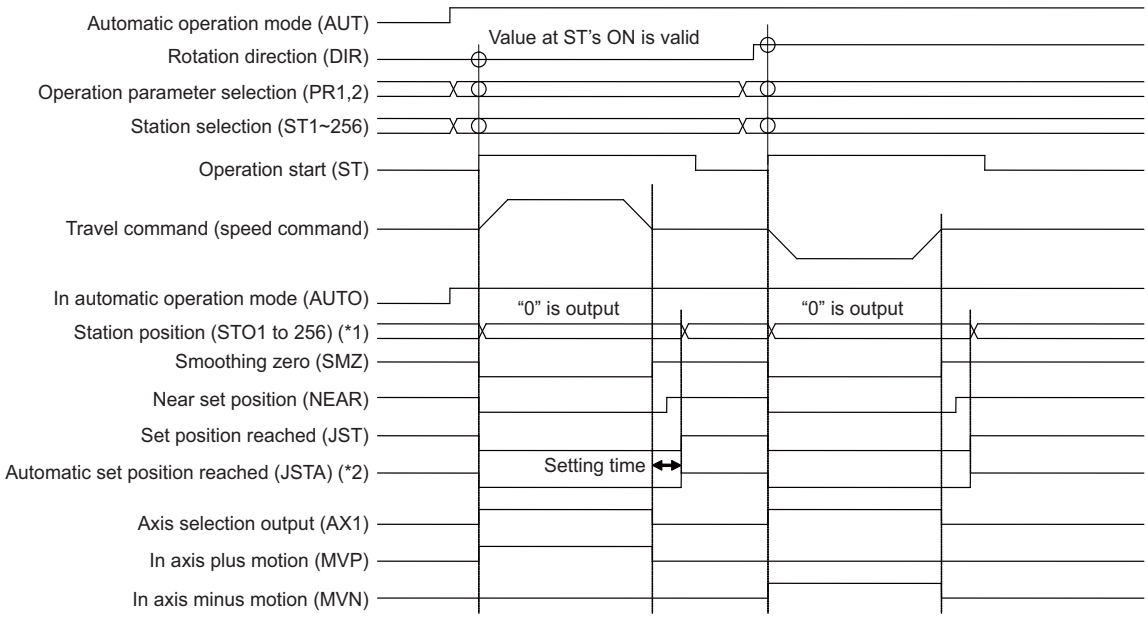
[Preparation]

Set the following signals before operation.

Abbreviation	Signal name	Explanations
AUT	Automatic operation mode	Use this signal to select automatic operation mode. Setting two different operation modes at the same time will cause an error ("M01 0101 Aux ax no operation mode"). Keep this signal ON during automatic mode.
DIR	Rotation direction	Set the rotation direction based on the direction of station No. assignment. This signal setting is not available when short-cut control is enabled.
PR1, PR2	Operation parameter selection 1, 2	The operation will be issued at the automatic operation speed (aux_Aspeed) and acceleration/deceleration time constant(aux_timeN.1, aux_timeN.2) of the selected operation group.
ST1 to ST256	Station selection 1 to 256	Set the station Nos. to be used for positioning. Setting "0" (special station No.) will start the special operation mode.

[Operation]

Turning ON Operation start (ST) starts the automatic operation.



[Automatic operation mode]

- Turn OFF Operation start (ST) when the positioning has been completed.
  Turning OFF Operation start (ST) during the positioning makes the axis be positioned at the nearest station from the current position.
- The following signals will be output when the positioning has been completed:
  Automatic set position reached (JSTA), Set position reached (JST), Near set position (NEAR), and Station position (STO1 to STO256).

(*1) The operation of station position (STO1 to STO256) represents the one when "#12801 aux_Cont1/bit5" is OFF. When "#12801 aux_Cont1/bit5" is ON, the nearest station No. will be output (Station No. constantly output). The previous station No. will be output if the axis is on somewhere between two stations.

(*2)The operation of Automatic set position reached (JSTA) represents the one when "#12802 aux_Cont1/bit3" is OFF.
If "#12802 aux_Cont1/bit3" is ON, turning OFF Operation start (ST) will turn OFF the Automatic set position reached
(JSTA) as well. (JSTA will be interlocked with the start signal.)

(Note) When the torque limit value of the operation parameter group selected at turning-ON of operation start is set to "0", the operation error (M01 0167) occurs and the axis movement by the cycle operation cannot be performed.

POINT

1.Setting time is required from when the travel commands become zero (SMZ=1) until the positioning is completed. The setting time will be lengthen if a set position output width is narrower than required. Therefore, set required positioning accuracy in the set position output width.

2.If the start signal is turned OFF during positioning, the axis will be positioned at the nearest coming station. In this case, the Automatic set position reached (JSTA) signal will not be output.

⚠ CAUTION

The rotation direction will be determined by the combination of the following: operation mode, input control signal "Rotation direction (DIR)", parameter "#12802 aux_Cont1.bit9 Rotation direction in the shortcut direction" and "#1018 ccw". At operation start, pay careful attention to the motor rotation direction. When operating the servomotor for the first time, the motor should be operated as a single unit to confirm the operation, etc.

[Designating the shortcut control]

This function automatically judges the direction for the least rotation when positioning the axis to a station in automatic mode.

When the shortcut control is enabled ("#12802 aux_Cont1/bit9" is set to "1"), the axis will be rotated and positioned in the direction for the least rotation. (The rotation angle will be below 180 degrees.)

If 180 degrees rotation is required, rotate the axis in the direction set with the parameter "#1018 ccw".

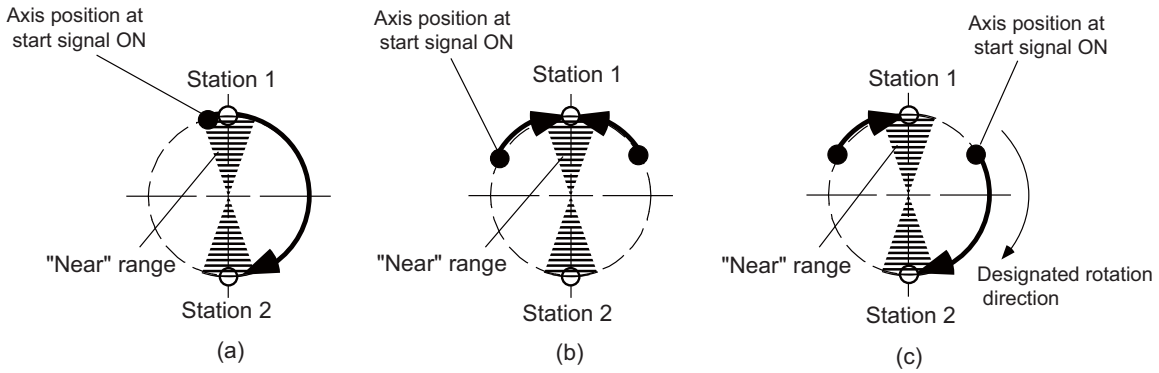
(Note) The parameter "#8213 Rotation axis type" is disabled in PLC axis indexing.

[Special operation with special station No.]

A special operation with one-station rotation will be carried out when station No. 0 is designated and the Operation start (ST) signal is ON. At this time, the operation will differ depending on whether the machine position is inside or outside the "near" range.

(1) For rotation axis

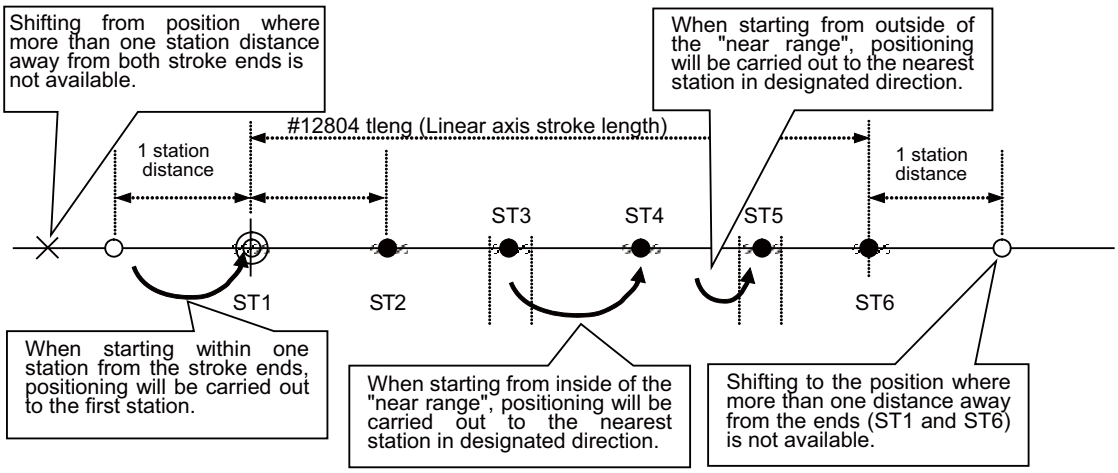
	Station No.	Machine position at start	#12802 aux_Cont1.bit9	Positioning operation
(a) (b) (c)	**0**	Inside the "near" range	-	Positioning is carried out to the next station in the designated rotation direction.
		Outside of the "near" range	1	Positioning is carried out to the nearest station in the shortcut rotation direction.
			0	Positioning is carried out to the nearest station in the designated rotation direction.



[Special operation of rotation axis]

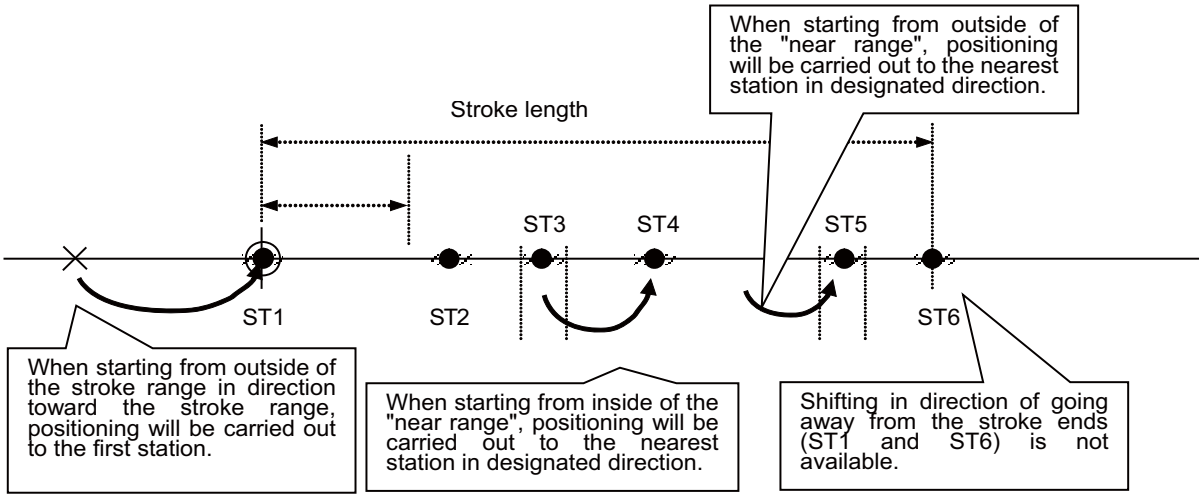
(2) For linear axis

(a) When uniform assignment is applied



[Special operation of linear axis in uniform assignment]

(b) When arbitrary coordinate assignment is applied



[Special operation of linear axis in arbitrary coordinate assignment]

[Operation with arbitrary coordinate designation]

Positioning is carried out to an arbitrary position other than stations by directly commanding the positioning coordinates from the PLC.

Set the coordinates as the control command position (R8054/R8055 for the 1st axis).

Command increment and command range depend on the "#1005 plcunit" setting.

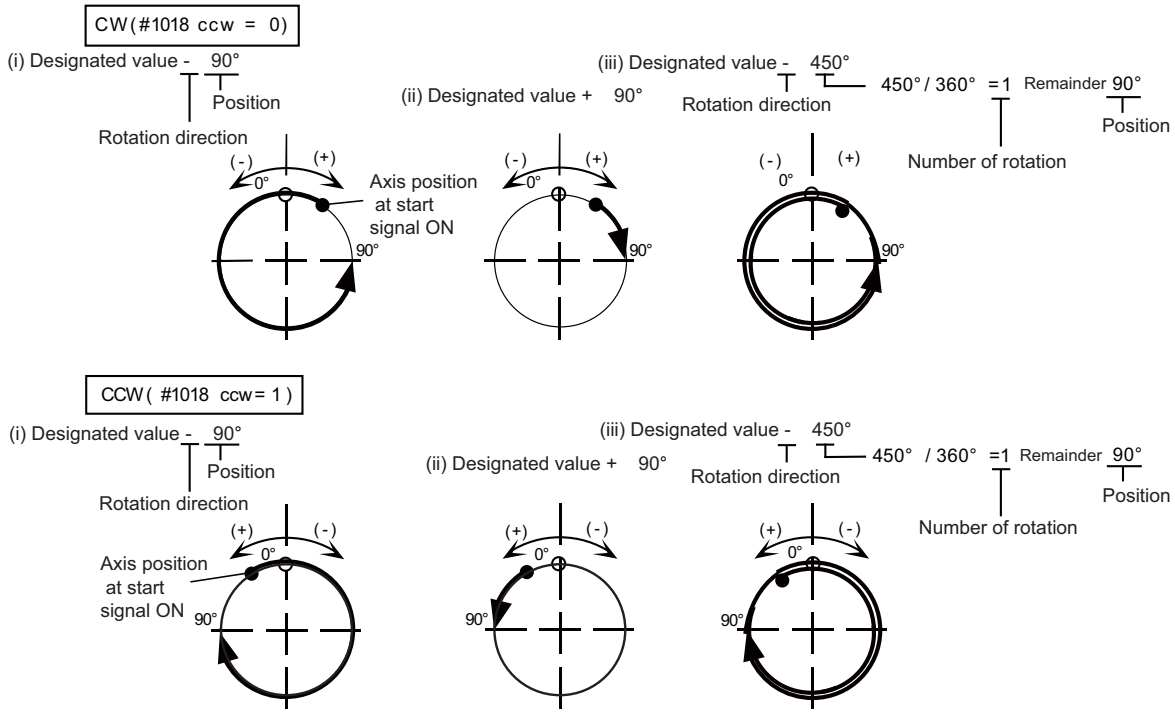
#1005 plcunit setting value	increment	Setting range
B	0.001 (°or mm)	-2147483.648 to 2147483.647 (°or mm)
C	0.0001 (°or mm)	-214748.3648 to 214748.3647 (°or mm)
D	0.00001 (°or mm)	-21474.83648 to 21474.83647 (°or mm)
E	0.000001 (°or mm)	-2147.483648 to 2147.483647 (°or mm)

(Note) Inch/metric command is enabled by the "#1040 M_inch" setting.

Set the following signal in addition to the general automatic mode setting before the operation start.

Abbreviation	Signal name	Explanations
STS	Arbitrary coordinate designation enabled	The positioning destination input from the PLC will be enabled. Keep this signal ON during arbitrary coordinate designation operation.

When rotation axis is used and "#12802 aux_Cont1/bitE" is set to "1", the rotation will be in the arbitrary coordinate command sign direction. The sign of designation represents the rotation direction. Positioning will be carried out based on the absolute value.
When the rotation is more than 360 degrees, the commanded angle is divided by 360 degrees: the quotient will be the number of the rotation and the remainder will be the actual position.



POINT

1.When the Operation start signal(ST) is tuned OFF during arbitrary coordinate designation, the axis will immediately decelerate to a stop.

2.In arbitrary coordinate designation,the signals of Automatic set position reached (JSTA), Set position reached (JST), and Near set position (NEAR) will be output in respect to the commanded positioning destination.

3.Keep the Arbitrary coordinate designation enabled signal(STS) ON until the positioning is completed. Although the positioning will be continued after the STS signal is turned OFF, the signals related to the set position (including JSTA, JST, NEAR) will be output with the usual station method.

4.When the rotation direction is in the arbitrary coordinate designation sign direction, setting ±360°will bring the same action as that with 0°designated.

12.34.2.2 Operation Function: Manual Mode

The axis is positioned manually.
Turning ON Operation start (ST) signal moves the axis; turning the signal OFF places the axis at the nearest station position.

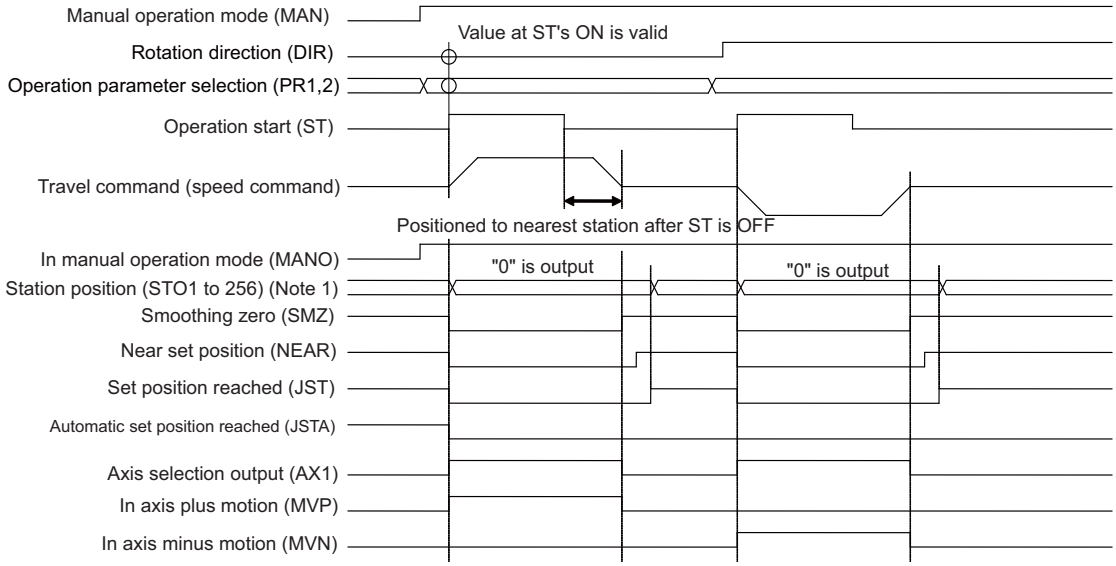
[Preparation]

Set the following signals before operation.

Abbreviation	Signal name	Explanations
MAN	Manual operation mode	Use this signal to select manual operation mode. Setting two different operation mode at the same time will cause an error ("M01 0101 Aux ax no operation mode"). Keep this signal ON during manual mode.
DIR	Rotation direction	Set the rotation direction based on the direction of station No. assignment. This signal setting is not available when short-cut control is enabled.
PR1, PR2	Operation parameter selection 1, 2	The operation will be issued at the manual operation speed (Mspeed) and acceleration/deceleration time constant (timeN.1 and timeN.2) of the selected operation group.

[Operation]

Turning ON Operation start (ST) moves the axis in the designated direction.
The axis will be positioned at next station by turning OFF Operation start (ST).



[Manual operation mode]

- The travel command will be output and the axis will be positioned to the next station even after Operation start (ST) is turned OFF.
- The following signals will be output when the positioning has been completed:
  Set position reached (JST), Near set position (NEAR) and Station position (STO1 to STO256)

	aux_Cont2/bit4=0 (Uniform assignment)		aux_Cont2/bit4=1 (Arbitrary coordinate assignment)
Point of ST's OFF	Within one stroke from both ends	One stroke or further from both ends	Out of both ends
In moving into stroke range	Positioned at the nearest stroke end	Stopped immediately	Positioned at the nearest stroke end
In moving out of the stroke range	Stopped immediately	Stopped immediately	Stopped immediately

(Note) When the torque limit value of the operation parameter group selected at turning-ON of operation start is set to "0", the operation error (M01 0167) occurs and the axis movement by the manual operation cannot be performed.

12.34.2.3 Operation Function: JOG Mode

The axis is moved at a constant speed.

Turning Operation start (ST) ON moves the axis; turning the signal OFF causes the axis immediately decelerate to stop.

[Preparation]

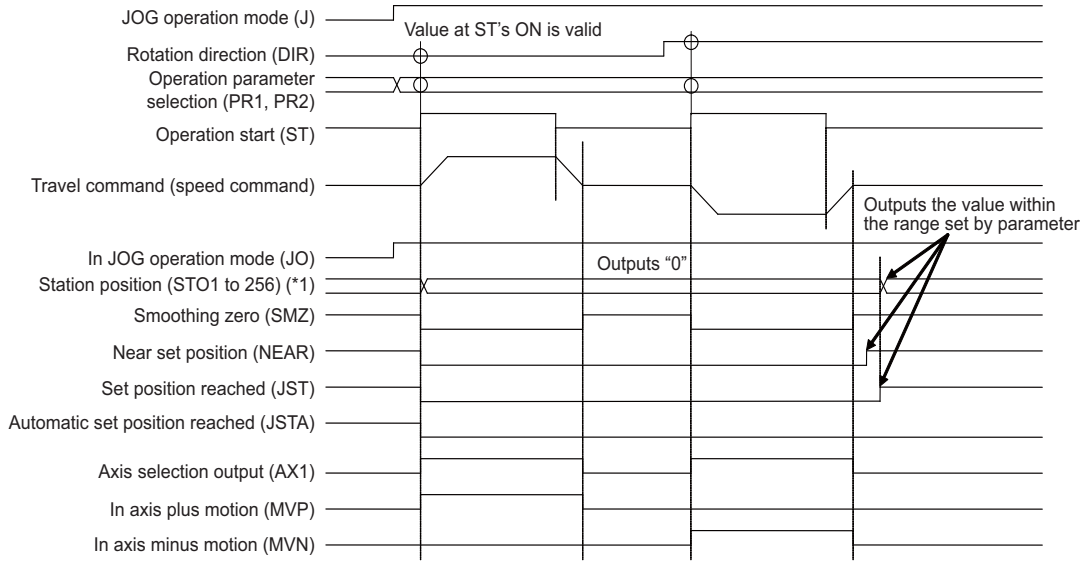
Set the following signals before operation.

Abbreviation	Signal name	Explanations
J	JOG operation mode	Use this signal to select JOG operation mode. Setting two different operation mode at the same time will cause an error ("M01 0101 Aux ax no operation mode"). Keep this signal ON during JOG mode.
DIR	Rotation direction	Parameter "#1018 ccw" also reverses the rotation direction.
PR1, PR2	Operation parameter selection 1, 2	The operation will be carried out at manual operation speed (Mspeed) of the selected operation group.

[Operation]

Turning ON Operation start (ST) moves the axis in the designated direction.

Turning the signal OFF causes the axis immediately decelerates to stop.



[JOG mode]

(*1)The operation of station position (STO1 to STO256) represents the one when "#12801 aux_Cont1.bit5" is OFF. When "#12801 aux_Cont1.bit5" is ON, the nearest station No. will be output (Station No. constantly output). The forward station No. will be output if the axis is on somewhere between two stations.

(Note) When the torque limit value of the operation parameter group selected at turning-ON of operation start is set to "0", the operation error (M01 0167) occurs and the axis movement by the jog operation cannot be performed.

POINT

1.Set position reached (JST) signal will be output if the motor stops within the set position output width of a particular station.

2.In JOG operation mode, Automatic set position reached (JSTA) signal will not be turned ON when the machine is positioned at a station.

12.34.2.4 Operation Function: Incremental Feed

The axis is moved by the designated amount.
Turning Operation start (ST) ON feeds the axis by the constant amount.

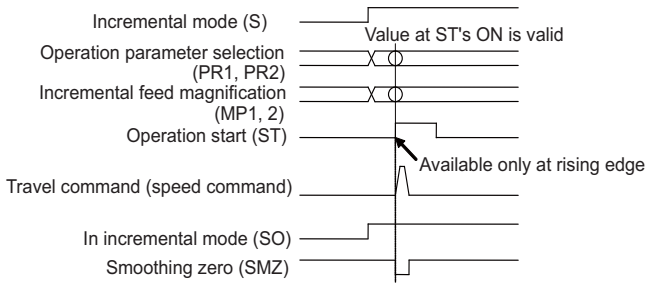
[Preparation]

Set the following signals before operation.

Abbreviation	Signal name	Explanations
S	Incremental mode	Use this signal to select incremental mode. Setting two different operation mode at the same time will cause an error ("M01 0101 Aux ax no operation mode").
DIR	Rotation direction	Parameter "#1018 ccw" also reverses the rotation direction.
PR1, PR2	Operation parameter selection 1, 2	Accelerated/decelerated will be carried out with the accelerate/decelerate time constant of selected operation group.
MP1, MP2	Incremental feed magnification 1, 2	Select the feed amount per movement.

[Operation]

Turn ON Operation start (ST). If this signal is turned OFF during the movement, the axis moves for the designated feed amount before stopping.



[Incremental feed operation]

(Note) When the torque limit value of the operation parameter group selected at turning-ON of operation start is set to "0", the operation error (M01 0167) occurs and the axis movement by the incremental feed operation cannot be performed.

12.34.2.5 Operation Function: Manual Handle Feed

The axis is moved by the manual pulse generator.

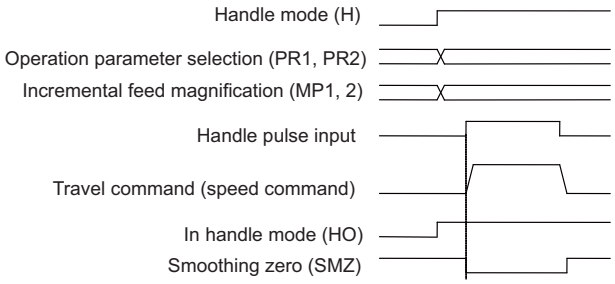
[Preparation]

Set the following signals before operation.

Abbreviation	Signal name	Explanations
H	Handle mode	Use this signal to select handle mode. Setting two different operation modes at the same time will cause an error "M01 0101 Aux ax no operation mode". The handle input will be prioritized for PLC axis indexing by turning this signal ON.
PR1, PR2	Operation parameter selection 1, 2	Select the operation parameter group.
MP1, MP2	Incremental feed magnification 1, 2	Select the travel amount per handle pulse (notch).

[Operation]

Handle pulse input will be prioritized for PLC axis indexing by turning ON the Handle feed operation mode selection (H). Therefore, the NC axis will not move. Confirm the In handle feed operation mode (HO) signal is ON before inputting the handle pulses.



[Handle mode]

DIR signal is invalid in handle mode.

(Note) When the torque limit value of the operation parameter group selected at switchover to Handle feed operation mode selection (H) is set to "0", the operation error (M01 0167) occurs and the axis movement by the handle feed operation cannot be performed.

POINT

If there are two or more handles, the 1st handle will be enabled.

12.34.2.6 Operation Function: Reference Position Return

Reference position return is executed.
PLC axis indexing allows the reference position return at high-speed which returns the axis to the machine coordinate zero point determined by the absolute position initialization set.
Refer to the section of "absolute position initialization set" for the details of the method.
Manual operation speed set in the selected operation parameter group will be applied in the reference position return.
(Note) Dog-type reference position return is not available for the axis used in PLC axis indexing.

[Preparation]

Set the following signals before operation.

Abbreviation	Signal name	Explanations
ZRN	Reference position return mode	Use this signal to select reference position return mode. Setting two different operation modes at the same time will cause an error "M01 0101 Aux ax no operation mode".

[Operation]

Turning ON Operation start (ST) starts the reference position return.

(Note) When the torque limit value of the operation parameter group selected at turning-ON of operation start is set to "0", the operation error (M01 0167) occurs and the axis movement by the reference position return at high-speed cannot be performed.

POINT

1. An operation error (M01 0003) will occur when the axis is moved in opposite direction to the reference position in high-speed reference position return. Make sure to move the axis in correct direction.

2. An operation error (M01 0024) will occur when the reference position return is executed while an absolute position detection-related alarm is shown.

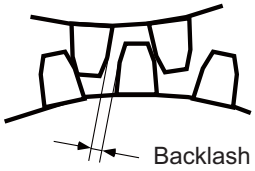
3. An operation error (M01 0025) will occur when the reference position return is executed in the absolute position initialization setting.

4. The axis will be returned to the basic machine coordinate system zero point by the reference position return in PLC axis indexing. Settings for "#2037 G53ofs Reference position #1" to "#2040 #4_rfp Reference position #4" will not be concerned.

12.34.2.7 Machine Compensation Function: Backlash Compensation

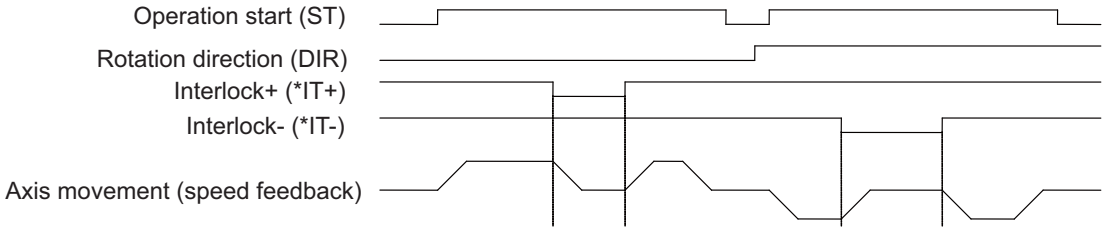
This function compensates the error (backlash) when the movement direction is reversed.

When the axis movement direction is reversed, the compensation amount set in the parameter "#2011 G0back (G0 backlash)" will be automatically added to the travel amount. The compensation amount will not be added to the machine coordinates. The actual machine position will be compensated.
When the power is turned ON, the axis will move to the direction set in "#2030 dir (-) (Reference position direction (-))".
Modification of backlash amount is enabled during axis movement.
Backlash compensation does not work on the axis movement in servo OFF state.



12.34.2.8 Protection Function: Interlock

This function cancels the axis movement with a signal input and immediately leads the servomotor to deceleration stop.
For feed in the plus direction, turning ON Interlock+ (*IT+) cancels the axis movement and decelerates the motor to stop. For
feed in the minus direction, turning ON Interlock- (*IT-) results the same. The signals are B contact. The axis moves again
when the interlock is turned OFF. The feedrate and acceleration/deceleration time constant follows the setting of the selected
operation parameter group.

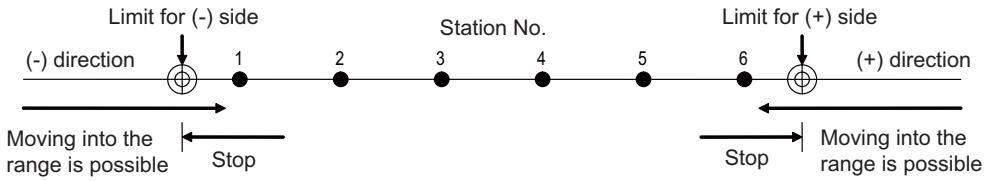


[Interlock]

12.34.2.9 Protection Function: Stored Stroke Limit

Movable range is set for linear axis to prevent the shaft end from clashing into the machine.
This function is available only for axis whose reference position is established.
Command values must be within the set value in any operation mode. When the machine is stopped by the stored stroke limit function, an operation error "M00 0007 Aux ax soft limit" will occur. The operation error will be canceled by shifting the error axis in opposite direction. When machine locates out of the movable range, only the travel command toward the movable range is permitted.

To activate this function, set limit positions both in plus and minus direction with corresponding parameters.
The movable range will be the narrower one confined either by "#2013 OT- and #2014 OT+" or by "#8204 OT-CHECK-N and 8205 OT-CHECK-P". However, when "#8202 OT-CHECK OFF" is set to "1", the setting of "#8204 OT-CHECK-N and #8205 OT-CHECK-P" is invalid.
Setting "#8210 OT INSIDE" is invalid in PLC axis indexing.
For rotation axis, the area confined by the parameters, excluding zero point, will be prohibited.
In setting prohibited area for two or more axes using stroke limit IB and the like, note that the prohibited area will be disabled if those axes include PLC indexing axis.



[Stored stroke limit]

POINT

In actual operation, the axis stops a little before reaching to the set position.

12.34.2.10 Protection Function: Servo OFF

This function releases the servo lock.
To use an external force such as a mechanical clamp for machine lock, stop the servo control and disable the torque output for the deflection caused by the external force. When the servo OFF state is entered, Servo ready (RDY) will be turned OFF. Turn OFF Motor brake control output (MBR) as well and activate motor brakes.

When Servo OFF	#1064 svof	Explanations
Error not corrected	0	The travel amount during servo OFF will become the droop. When the servo is turned ON again, the machine will return to the servo OFF position. An alarm will occur if the droop that occurs during servo OFF exceeds the excessive error detection width.
Error corrected	1	The travel amount during servo OFF will not become the droop; the machine position (command position) will be updated. Thus, when the servo is turned ON again, the machine will stop at the position to which it moved.

Machine decelerates to stop by turning OFF the Servo OFF signal during movement, and starts moving again by turning ON the Servo OFF signal while the Operation start signal is ON. In JOG mode, machine will not start moving after the following operation: deceleration to stop by the Servo OFF signal, turning OFF the Operation start signal, then turning ON the Servo OFF signal. The machine will be positioned at next station in manual/automatic mode.

12.34.2.11 Miscellaneous Function: Feedrate Override

The feedrate set in the parameter will be effective after multiplied by override (%). Override, ranging from 0 to 100% and commanded in 1% units, is valid for all movement except that in the handle mode. The override is invalidated when the Override valid (OVR) signal is OFF; the feedrate in the parameter will be instantly effective.
The override command is designated with a 7-bit binary (OV1 to OV64). The override is handled as 100% if the command exceeds 100%. If a 0% override is commanded, the axis will decelerate to stop, causing an operation error "M01 0103 Aux ax feedrate 0".

12.34.2.12 Miscellaneous Function: Position Switch

This function sets virtual dog switches (position switches) on the coordinate set by the parameter instead of setting dog switches on the machine's axis. PLC interface signals are output when the axis has reached the position.

Position switches (PSW1 to PSW15) can be set on 15 points at maximum for each axis. The area for each position switch is set
with the parameters ("#12871 aux_PSW1dog1", "#12872 aux_PSW1dog2" to "#12899 aux_PSW15dog1", and "#12900 aux_PSW15dog2").
The parameter ("#12870 aux_PSWcheck") has two options for the machine position; the machine position without droop in the command system or the machine feedback position (actual machine position) including droop.

12.34.2.13 NC axis Control Selection

NC axis can be controlled with the PLC axis indexing interfaces.
The signal's ON/OFF selects which controls the axis; PLC or NC.
NC controls the axis with machining programs.
PLC controls the axis with PLC axis indexing interfaces.

[Preparation]

Use "#12800 chgauxno" to set the NC axis which can be operated under PLC axis control.
Refer to the section of "Set up" for the settings.

[Signals for the control selection]

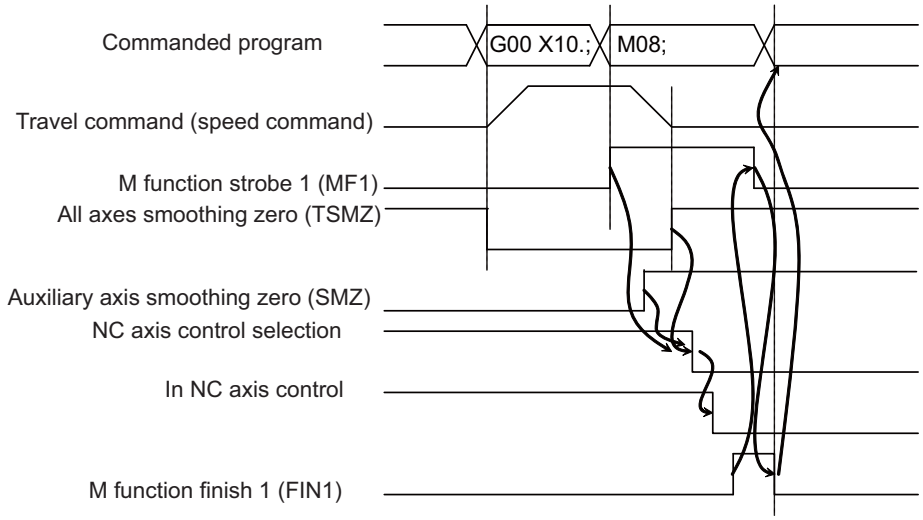
Signal name	Explanations
NC axis control selection n-th axis	Select the control method of the NC axis which can be operated under PLC control. 0: PLC control 1: NC control
In NC axis control n-th axis	This signal indicates the control status (NC control or PLC control) of the NC axis which can be operated under PLC control. 0: PLC control 1: NC control

[Changing process]

(1)Changing NC control to PLC control

When changing NC control to PLC control in the program execution, confirm the smoothing zero is set for all the axes in the part system before making the sequence program for NC axis control selection.

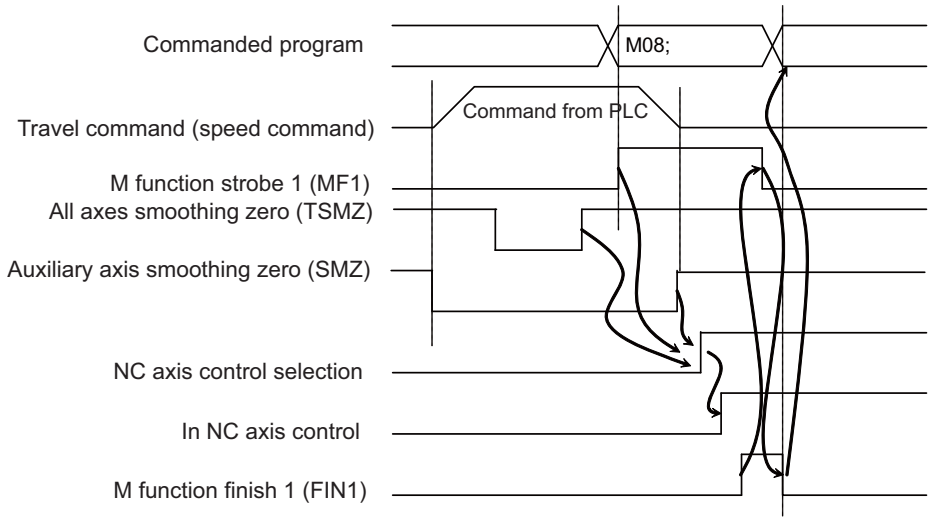
(Example) Changing NC control to PLC control with M code



(2)Changing PLC control to NC control

When changing PLC control to NC control in the program execution, confirm the smoothing zero is set for the PLC indexing axes in the part system before making the sequence program for NC axis control selection.

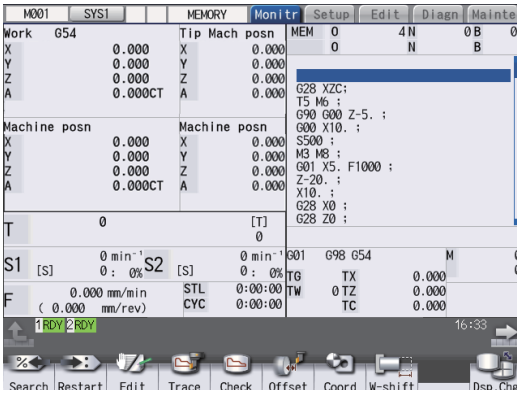
(Example) Changing PLC control to NC control with M code



[Operation screen]

Operation screen shows the NC axis name when NC/PLC control selection is allowed.
The status "CT" will be displayed besides the counter display of the axis under PLC control.

(Example) Display of an axis, applicable to NC/PLC control selection, under PLC control



The NC axis coordinate value counter will be updated even in PLC control.

(Note 1) Origin set, counter set, playback and workpiece position measurement are invalid for the axis in PLC control.

(Note 2) The characters are prioritized as follows when displayed beside the counter. Thus, "CT" may not be displayed even if the axis is under PLC control.

Priority High "><" (Axis removal)
: "][" (Servo OFF)
: "#1", etc. (Reference position reached)
: "MR" (Mirror image)
Priority Low "CT" (In PLC control)

[Status output]

Servo ready status, servo alarms and so on will be output to the operation status signal with R register even if the axis is under NC control. The output signals are follows:

Signals	Abbreviation	Signal name
AUXST1/bit0	RDY	Servo ready
AUXST1/bit1	INP	In-position
AUXST1/bit2	SMZ	Smoothing zero
AUXST1/bit4	MVP	In axis plus motion
AUXST1/bit5	MVM	In axis minus motion
AUXST1/bit6	TLQ	In torque limit
AUXST1/bitB	MA	Controller ready completion
AUXST1/bitC	SA	Servo ready completion
AUXST2/bit8	AL1	Alarm 1
AUXST2/bit9	AL2	Alarm 2
AUXST4/bitB	NST	Start not possible

Status signals other than above will be OFF during NC axis control.

[Zero point return]

After zero point return has been executed under NC control or PLC control, the system regards that zero point return has also been done under the other control.

[Restrictions]

(1) NC axis which is applicable to PLC control (the NC axis for which the axis No. in PLC axis indexing has been set with "#12800 chgauxno") cannot be used as primary/secondary axis in synchronous control. Setting the axis in "Synchronization control operation method (R2589)" as primary/secondary axis causes an operation error "M01 1036 Synchro ctrl setting disable".

(2) The axis under spindle's contour control, which has been set in "#1020 sp_ax", cannot be assigned as the NC axis applicable to PLC control. If the axis is assigned, "S02 Initial parameter error 12800" will occur at the power ON.

(3) PLC axis indexing interfaces cannot be used for absolute position initialization set when the NC axis is operated in PLC control by the machine without PLC axis. Complete the absolute position initialization set under NC control.

(4) H/W OT of NC axis is invalid when operating NC axis under PLC control.

(5) Manual operation in NC's manual mode is invalid when operating NC axis under PLC control. (Operation error "M01 Aux axis changeover error" will occur.)

[Caution]

(1) Commanding from machining program to NC axis under PLC control causes a program error "P32 Illegal address" and stops the operation.

(2) Axis movement by PLC axis indexing does not work by turning ON "Operation start (ST)" under NC control. That causes "Start not possible (AUXST4.bitB)" ON as status.

(3) Turning OFF "NC axis control selection n-th axis" while moving NC axis (n-th axis) with machining program command stops the machining program and causes an operation error "M01 0166 Aux axis changeover error".

(4) Changing "NC axis control selection N-th axis" during any axis movement causes an operation error. The axis will decelerate to stop if "NC axis control selection n-th axis" is changed during its movement.

(5) When PLC control is changed to NC control, the movement amount in the PLC control will be regarded as manual interrupt amount.

(6) Current limit value and excessive error width of NC axis will be enabled immediately after the change from PLC control to NC control.

(7) The change from NC control to PLC control will not immediately enable the current limit value and excessive error width: enables the ones of the operation parameter's group which has been selected at the Operation start (ST) ON.

(8) Alarms for NC axis under PLC control will be output to NC part system.

12.34.3 Setup

12.34.3.1 Initial Parameter Settings: Selecting Axes to Use in PLC Axis Indexing (#12800)

Select axes to use in PLC axis indexing.
Both PLC axis and NC axis can be used in PLC axis indexing.
Select NC control or PLC control in "NC axis control selection n-th axis" when using NC axis.
(Changing the control, such as the use of NC control in program operation and PLC control in other operations, is allowed.)

[Axis specification parameter]

#	Item		Explanations	Setting range
12800	chgauxno (PR)	PLC axis indexing axis No.	Set the axis to use in PLC axis indexing. Set "0" to the axes to use as NC axis or regular PLC axis.	0 to 8:(M800 series) 0 to 4:(M80 series) 0 to 1:(E80 series)

(Example 1) When using 2nd and 3rd PLC axes in PLC axis indexing
Number of part systems: 1
Number of NC axes: 5
Number of PLC axes: 4

[Base system parameters]

	$1	$2	PLC
#1001 SYS_ON	1	0	1
#1002 axisno	5	0	4

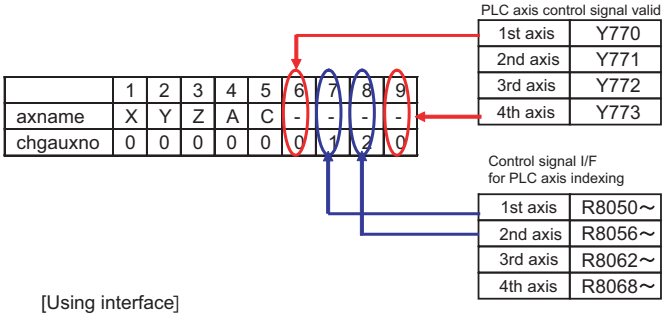
[Base axis specification parameters]

	1	2	3	4	5	6	7	8	9
#1013 axname	X	Y	Z	A	C	-	-	-	-

[PLC axis indexing parameters]

	X	Y	Z	A	C	-	-	-	-
#12800 chgauxno	0	0	0	0	0	0	1	2	0

In the setting above, two axes are set to be used in PLC axis indexing.
1st axis in PLC axis indexing: 2nd PLC axis
2nd axis in PLC axis indexing: 3rd PLC axis



[Using interface]

POINT

Skip "#1044 auxno" in this function.

(Example 2) When using 2nd and 3rd PLC axes, 4th and 5th NC axes in PLC axis indexing
Number of part systems: 1
Number of NC axes: 6
Number of PLC axes: 4

[Base system parameters]

	$1	$2	PLC
#1001 SYS_ON	1	0	1
#1002 axisno	6	0	4

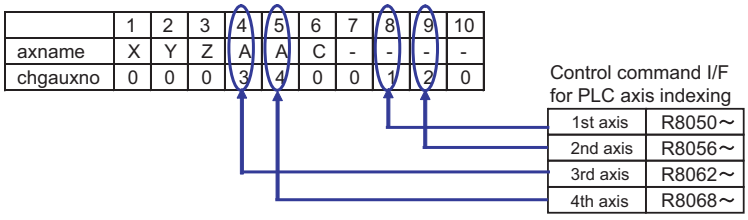
[Base axis specification parameters]

	1	2	3	4	5	6	7	8	9	10
#1013 axname	X	Y	Z	A	A	C	-	-	-	-

[PLC axis indexing parameters]

	X	Y	Z	A	A	C	-	-	-	-
#12800 chgauxno	0	0	0	3	4	0	0	1	2	0

In the setting above, four axes are set to be used in PLC axis indexing.
1st axis in PLC axis indexing: 2nd PLC axis
2nd axis in PLC axis indexing: 3rd PLC axis
3rd axis in PLC axis indexing: 4th NC axis
4th axis in PLC axis indexing: 5th NC axis



[Using interface in PLC axis indexing]

When using NC axis in PLC axis indexing, selecting NC/PLC control with "NC control selection n-th axis" signal is required other than the settings above.

POINT

Multiple NC axes can have the same axis name, although the commands from the machining program are valid when only one axis is under NC control. When the multiple NC axes are under the control, the machining program will stop and cause a program error "P11 Illegal axis address" or "P32 Illegal address".

12.34.3.2 Initial Parameter Settings: Setting the Control Parameter 1

Set each control parameter.

#	Abbreviation	Parameter name	Explanations	Setting range (Increment)
12802	aux_Cont1 (PR)	Control parameter 1	Set this in hexadecimal format. The bits that are not explained here must be set to "0".	

Bit	Details in "0" setting	Details in "1" setting
0		
1		
2		
3	Automatic set position reached signal does not interlock with Operation start signal	Automatic set position reached signal interlocks with Operation start signal
4	Automatic set position reached signal is turned ON again	Automatic set position reached signal isn't turned ON again
5	Station No. Output within fixed position	Station No. Constantly output
6		
7		
8		
9	Rotation direction determined by operation control signal (DIR)	Rotation direction in the shortcut direction
A		
B		
C		
D		
E	Rotation direction in operation control signal (DIR) or in the shortcut direction	Rotation direction in the arbitrary position command sign direction
F	Stopper direction is in the positioning direction	Stopper direction is in the sign direction of the stopper amount

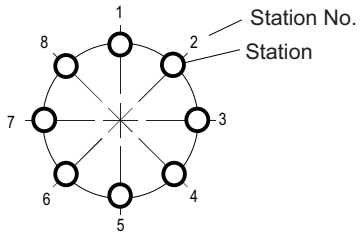
12.34.3.3 Initial Parameter Settings: Setting Stations (#12801 to #12805, #12850 to #12868)

Set the positioning destinations (stations).
When assigning stations with equally-spaced intervals: Uniform assignment
When assigning stations to arbitrary coordinates: Arbitrary coordinate assignment

[Uniform assignment setting]

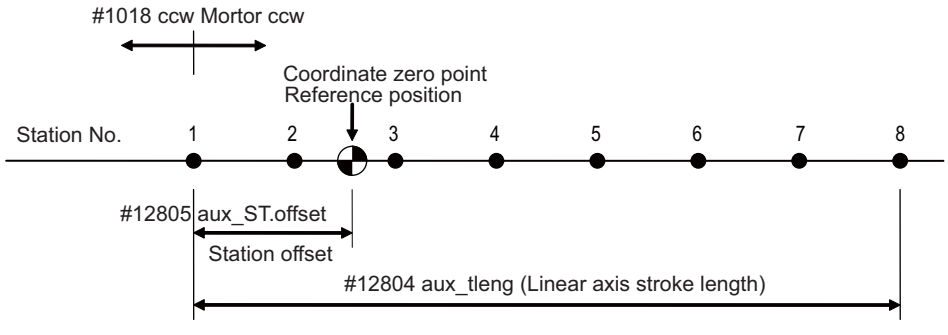
Uniform assignment will be selected by turning OFF "#12803 aux_Cont2.bit4".
The assignment divides one rotation (360°) of rotary axis, and equally divides the designated range of linear axis. The divided points will be stations.
Station Nos. will be assigned automatically in ascending order. The one closer to the reference position (zero point) gets smaller No.

(1) For rotation axis
Set the number of division points of one rotation (360°) (number of stations) to the parameter "#12801 aux_station1(Number of indexing stations)". The number of stations must be an integral number from 2 to 360. Station 1 will be assigned on the reference position. Station 2 onwards will be assigned in order in the motor CW
(forward) direction.



[Uniform assignment for rotation axis]

(2) For linear axis
Decide the interval of stations based on the linear axis stroke length and the number of stations to evenly assign the
stations. Station 1 will be assigned on the shifted position by amount of "#12805 aux_ST.offset (Station offset)"
from the coordinate zero point (coordinate position = 0). Station 2 onwards will be positioned in order in the assignment direction ("#1018 ccw"). Thus, the last station will be assigned on the coordinate which is linear axis
stroke length (set in "#12804 aux_tleng") away from station 1.



When the number of stations is 8 (the number of divisions is 7)

[Uniform assignment for linear axis]

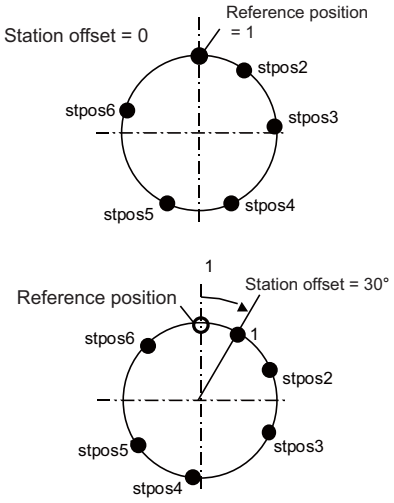
(3) Related parameters

#	Abbreviation	Parameter name	Explanations	Setting range (Increment)
12803	aux_Cont2 (PR)	Control parameter 2	Set this parameter in hexadecimal format. The bit that are not explained here must be set "0". bit4 0: Uniform assignment 1: Arbitrary coordinate assignment	
12801	aux_station (PR)	Number of indexing stations	Set the number of stations. For linear axis, this value is expressed by: number of divisions = number of stations -1.	2 to 360
12804	aux_tleng (PR)	Linear axis stroke length	Set the movement stroke length for linear axis. This parameter is meaningless at the arbitrary coordinate assignment or arbitrary coordinate command.	0.001 to 99999.999 mm
12805	aux_ ST.offset	(Station offset)	Set the distance (offset) between the reference position and station 1.	-99999.999 to 99999.999 ("°" or "mm")

[Arbitrary coordinate assignment setting]

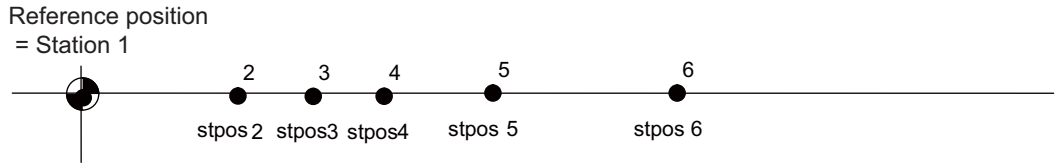
Arbitrary coordinate assignment will be selected by turning ON "#12803 aux_Cont2.bit4".
The number of stations for arbitrary coordinate assignment is 20 at maximum.
Station 1 will be assigned on the coordinate zero point (coordinate position = 0). Stations 2 to 20 are set with the parameters "#12850 aux_stpos2" to #12868 aux_stpos20".
Setting an offset amount in "#12805 aux_ST.offset(Station Offset)" shifts the stations 1 to 20 by the offset amount.
(Note) The set values (coordinate positions) of stations 2 to 20 does not need to be in ascending order.

(1) For rotation axis

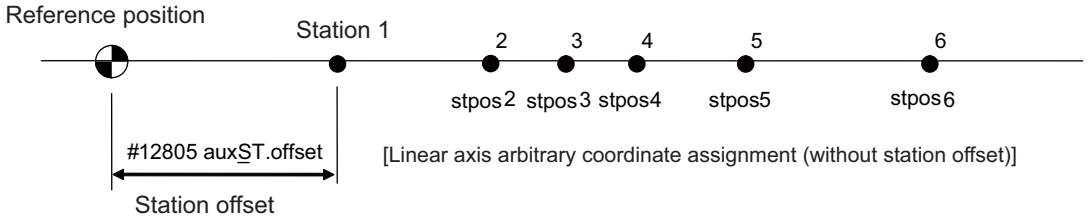


[Arbitrary coordinate assignment for rotation axis]

(2)For linear axis



[Linear axis arbitrary coordinate assignment (with station offset)]



[Linear axis arbitrary coordinate assignment (without station offset)]

(3) Related parameters

#	Abbreviation	Parameter name	Explanations	Setting range (Increment)
12803	aux_Cont2 (PR)	Control parameter 2	Set this parameter in hexadecimal format. The bit that is not explained here must be set "0". bit4 0: Uniform assignment 1: Arbitrary coordinate assignment	
12805	aux_ ST.offset	Station offset	Set the distance (offset) between the reference position and station 1.	-99999.999 to 99999.999 ° (mm)
12850	aux_stpos2	Station 2 coordinate	Set the coordinate value for each station when arbitrary coordinate assignment is selected. The station 1 coordinate value is fixed at "0.000" (machine coordinate zero point).	-99999.999 to 99999.999 ° (mm)
12851	aux_stpos3	Station 3 coordinate		
12852	aux_stpos4	Station 4 coordinate		
12853	aux_stpos5	Station 5 coordinate		
12854	aux_stpos6	Station 6 coordinate		
12855	aux_stpos7	Station 7 coordinate		
12856	aux_stpos8	Station 8 coordinate		
12857	aux_stpos9	Station 9 coordinate		
12858	aux_stpos10	Station 10 coordinate		
12859	aux_stpos11	Station 11 coordinate		
12860	aux_stpos12	Station 12 coordinate		
12861	aux_stpos13	Station 13 coordinate		
12862	aux_stpos14	Station 14 coordinate		
12863	aux_stpos15	Station 15 coordinate		
12864	aux_stpos16	Station 16 coordinate		
12865	aux_stpos17	Station 17 coordinate		
12866	aux_stpos18	Station 18 coordinate		
12867	aux_stpos19	Station 19 coordinate		
12868	aux_stpos20	Station 20 coordinate		

[Setting for station No. automatic assignment direction]

The station No. assignment direction can be selected with parameters.

#1018 ccw	Explanations
0	Assign the station Nos. in the motor rotation CW direction. When forward run is selected in Rotation direction (DIR), the motor rotates in the CW direction (in the station No. increment direction).
1	Assign the station Nos. in the motor rotation CCW direction. When forward run is selected in Rotation direction (DIR), the motor rotates in the CCW direction (in the station No. increment direction).

By turning ON the power again after changing the "#1018 ccw" setting, the set station positions will be modified.

POINT

Changing the "#1018 ccw" setting in absolute position detection system requires the initial setting. Set this parameter before the initial setting.

[Precautions]

(1) Special operation by special station No. (0) is invalid in arbitrary coordinate assignment. This will cause an operation error "M01 165 Aux uneven index sta No. ilgl".

(2) To set more than 20 coordinates in the arbitrary coordinate assignment, execute the positioning with arbitrary coordinate commands.

(3) If two or more station Nos. have the same coordinate, the smallest station No. will be output when the axis stays within the station neighborhood in non-automatic operation mode.

(4) The smallest station No. will also be output when the axis is at the same distance from two or more stations.

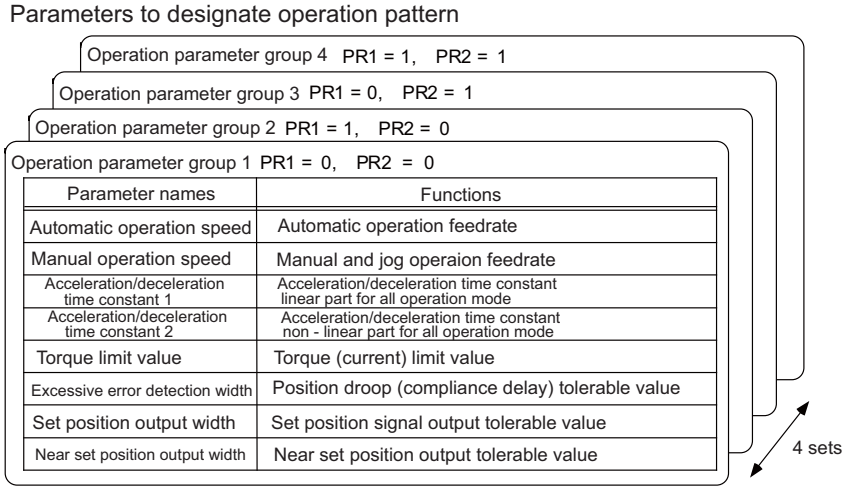
(5) Zero point setting

Auxiliary axis (MR-J2-CT) and PLC axis indexing have the following differences in operation.

	Auxiliary axis (MR-J2-CT)	PLC axis indexing
Dog-less type	Coordinate zero point will be decided first and reference position will be decided by parameter. Setting a station offset does not shift the coordinate zero point (station 1 position): it shifts the reference position instead. In this case, a zero point setting in absolute position screen is required to shift the coordinate zero point.	Coordinate zero point will be decided first, which will be the reference position as well. Setting a station offset sets the station 1 on the position an offset amount away from the original position.

12.34.3.4 Initial Parameter Settings: Setting Operation Parameter Groups (#12810 to #12848)

The axis is positioned automatically.
The axis will be positioned at the designated station by turning ON Operation start (ST).
The arbitrary position command operation i Four operation parameter groups can be set in total. By selecting any group with Operation parameter selection 1, 2 (PR1, PR2) from the PLC before operation, the operating conditions can be changed to match the machine status each time. There are also operation modes such as stopper positioning control, in which the drive unit automatically selects the operation parameter group and controls the machine.



[Feedrate setting]

Set the machine speeds as feedrate in the parameters separately for automatic operation and manual operation. Since the electronic gear automatically calculates the motor speed, the setting can be done without being concerned with gear ratio, pitch, encoder resolution, etc.

No.	Abbreviation	Parameter name	Explanations	Setting range (Increment)
12810	aux_Aspeed1	Operation parameter group 1 Automatic operation speed	Set the feedrate in automatic operation when the operation parameter group is selected. "#12810 aux_Aspeed1" is regarded as the clamp value for the automatic operation speeds and manual operation speeds of all operation groups.	1 to 100000 °/min (mm/min)
12820	aux_Aspeed2	Operation parameter group 2 Automatic operation speed		
12830	aux_Aspeed3	Operation parameter group 3 Automatic operation speed		
12840	aux_Aspeed4	Operation parameter group 4 Automatic operation speed		
12811	aux_Mspeed1	Operation parameter group 1 Manual operation speed	Set the feedrate in manual and JOG operations when the operation parameter group is selected.	1 to 100000 °/min (mm/min)
12821	aux_Mspeed2	Operation parameter group 2 Manual operation speed		
12831	aux_Mspeed3	Operation parameter group 3 Manual operation speed		
12841	aux_Mspeed4	Operation parameter group 4 Manual operation speed		

POINT

"Operation parameter group 1 automatic operation speed" (aux_Aspeed1) functions as clamp speed in all operations. A feedrate exceeding aux_Aspeed1 cannot be commanded.

[Setting the acceleration/deceleration pattern and time constant]

Set the automatic operation mode acceleration/deceleration type in the parameter "#1361 aux_acc".

(1) Acceleration/deceleration with constant time: When "#1361 aux_acc"= "0"
Acceleration/deceleration pattern will be fixed with the time constant aux_timeN.1 and aux_timeN.2 in operation parameter group N (N= 1 to 4).
(2) Acceleration/deceleration with a constant angle of inclination: When "#1361 aux_acc" = "1"
Acceleration/deceleration pattern will be with the inclination decided by "Operation parameter group 1 automatic operation speed" (#12810 aux_Aspeed1) and "Acceleration/deceleration time constant 1, 2" (aux_timeN.1, aux_timeN.2) in the operation parameter group N (N= 1 to 4).

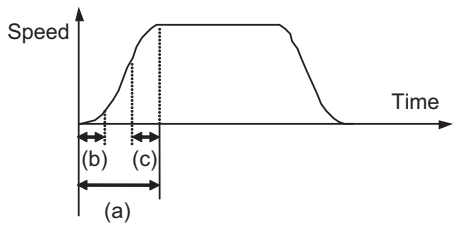
Set the automatic operation mode acceleration/deceleration pattern in "Operation parameter group N acceleration/ deceleration type" (aux_smgstN).

(1) Linear acceleration/deceleration: Set "1" in "#128N8 aux_smgstN"
(2) S-pattern acceleration/deceleration: Set "F" in "#128N8 aux_smgstN"

However, when "Acceleration/deceleration time constant 2" (aux_timeN.2) is set to "1", linear acceleration/ deceleration will be applied regardless of "Acceleration/deceleration type" (aux_smgstN).

As for the acceleration/deceleration time constant in each of the groups, set a linear acceleration/deceleration time up to the clamp speed (aux_Aspeed1) in "Acceleration/deceleration time constant 1" (aux_timeN.1). When the operation speed is less than the clamp speed, acceleration/deceleration will be carried out with the same inclination. In this case, set "1" (default value) in acceleration/deceleration time constant 2 (aux_time.2).

When S-pattern acceleration/deceleration is applied, set a total acceleration/deceleration time (both in non-linear and linear parts) to "Acceleration/deceleration time constant 1", and set a acceleration/deceleration time in non-linear part to "Acceleration/deceleration time constant 2".



(a) : Acceleration/deceleration time constant 1 set value
(b)+(c) : Acceleration/deceleration time constant 2 set value ((b) and (c) are each half of the set value)

In handle feed mode, execute linear acceleration/deceleration using "Acceleration/deceleration time constant 2" (aux_timeN.2) only.

No.	Abbreviation	Parameter name	Explanations	Setting range (Increment)
12812	aux_time1.1	Operation parameter group 1 Acceleration/deceleration time constant 1	Set the linear acceleration/deceleration time for "Operation parameter group 1 automatic operation speed" (clamp speed) when "operation parameter group n" is selected. When this is set with "Acceleration/deceleration time constant 2", S-pattern acceleration/ deceleration will be carried out. In this case, this parameter determines the acceleration/deceleration time of the linear part. When operating at a speed less than the clamp speed: if "#1361 aux_acc" is set to "0", the axis will accelerate/decelerate with the time constant set in this parameter; if "#1361 aux_acc" is set to "1", the axis will accelerate/decelerate at the constant inclination determined by this parameter and "aux_Aspeed1".	1 to 4000ms
12822	aux_time2.1	Operation parameter group 2 Acceleration/deceleration time constant 1		
12832	aux_time3.1	Operation parameter group 3 Acceleration/deceleration time constant 1		
12842	aux_time4.1	Operation parameter group 4 Acceleration/deceleration time constant 1		
12813	aux_time1.2	Operation parameter group 1 Acceleration/deceleration time constant 2	Set this parameter for S-pattern acceleration/ deceleration. Set the total time of the non-linear parts in the S-pattern acceleration/deceleration. When "1" is set, linear acceleration/deceleration will be carried out	1 to 4000ms
12823	aux_time2.2	Operation parameter group 2 Acceleration/deceleration time constant 2		
12833	aux_time3.2	Operation parameter group 3 Acceleration/deceleration time constant 2		
12843	aux_time4.2	Operation parameter group 4 Acceleration/deceleration time constant 2		
12818	aux_smgst1 (PR)	Operation parameter group 1 Acceleration/deceleration type	Select the acceleration/deceleration type when "operation parameter group n" is selected. 1: Linear acceleration/deceleration F: S-pattern acceleration/deceleration	1,F
12828	aux_smgst2 (PR)	Operation parameter group 2 Acceleration/deceleration type		
12838	aux_smgst3 (PR)	Operation parameter group 3 Acceleration/deceleration type		
12848	aux_smgst4 (PR)	Operation parameter group 4 Acceleration/deceleration type		

POINT

As for acceleration/deceleration time constants, set acceleration/deceleration times up to the clamp speed (aux_Aspeed1).

When the operation speed is less than the clamp speed, acceleration/deceleration will be carried out with the same inclination as that at the clamp speed.

[Setting the torque limit value]

Set an individual torque limit value (current limit value) to each operation parameter group.

No.	Abbreviation	Parameter name	Explanations	Setting range (Increment)
12814	aux_TL1	Operation parameter group 1 Torque limit value	Set the motor output torque limit value when "operation parameter group n" is selected. At the default value, the torque is limited at the maximum torque of the motor specifications. Set the default value when torque limiting is not required.	1 to 500%
12824	aux_TL2	Operation parameter group 2 Torque limit value		
12834	aux_TL3	Operation parameter group 3 Torque limit value		
12844	aux_TL4	Operation parameter group 4 Torque limit value		

[Setting the excessive error detection width]

Set an excessive error alarm detection width to each operation parameter group.

An alarm is detected when the position droop (between position command and feedback) exceeds the setting value. The standard setting value is calculated from the feedrate using the following equation. The excessive error alarm can occur easily when the load inertia is large or the auto-tuning response is lowered. Raise the excessive error detection width in these cases.

OD(N) = Aspeed(N) / 1000 (°or mm)

No.	Abbreviation	Parameter name	Explanations	Setting range (Increment)
12815	aux_OD1	Operation parameter group 1 Excessive error detection width	Set the excessive error detection width when "operation parameter group n" is selected. The excessive error alarm (S03 0052) will be detected when the position droop becomes larger than this setting value.	0 to 32767°(mm)
12825	aux_OD2	Operation parameter group 2 Excessive error detection width		
12835	aux_OD3	Operation parameter group 3 Excessive error detection width		
12845	aux_OD4	Operation parameter group 4 Excessive error detection width		

[Setting the output width of signals related to the set position]

Set the following signals: Set position reached (JST) which indicates the machine has completed positioning, detection width of Automatic set position reached (JSTA), and detection width of Near set position (NEAR) which indicates that the machine is near to any stations.

No.	Abbreviation	Parameter name	Explanations	Setting range (Increment)
12816	aux_just1	Operation parameter group 1 Set position output width	Set position reached (JST) indicates that the machine position stays at any one of the stations. During automatic operation, Automatic set position reached (JSTA) is detected under the same conditions. Set the tolerable values at which these signals are output when each operation parameter group is selected. These signals turn OFF when the machine position is away from the station by more than this value.	0.000 to 99999.999°(mm)
12826	aux_just2	Operation parameter group 2 Set position output width		
12836	aux_just3	Operation parameter group 3 Set position output width		
12846	aux_just4	Operation parameter group 4 Set position output width		
12817	aux_near1	Operation parameter group 1 Near set position output width	The signal indicating that the machine position stays near to one of the stations is the near set position (NEAR) signal. Set the tolerable values at which this signal is output when each operation parameter group is selected. Generally set the tolerable value larger than set position output width. Operations are related to special commands when Station selection is set to "0".	0.000 to 99999.999°(mm)
12827	aux_near2	Operation parameter group 2 Near set position output width		
12837	aux_near3	Operation parameter group 3 Near set position output width		
12847	aux_near4	Operation parameter group 4 Near set position output width		

12.34.3.5 Initial Parameter Settings: Setting Position Switches (#12870 to #12900)

Set the position switch area. 15 types of position switches, PSW1 to PSW15, can be set.

<table>
<tr><th>No.</th><th>Abbreviation</th><th>Parameter name</th><th>Explanations</th><th>Setting range (Increment)</th></tr>
<tr><td>12870</td><td>aux_PSWcheck</td><td>PSW detection method</td><td>Set this parameter in hexadecimal format. The bits that are not explained here must be set to "0".
<table>
<tr><th>bit</th><th>Position switch</th><th>Details in "0" setting</th><th>Details in "1" setting</th></tr>
<tr><td>0</td><td>PSW1</td><td rowspan="16">The position switch output will be judged by the machine position of the command system.</td><td rowspan="16">The position switch output will be judged by machine feedback position (actual position).</td></tr>
<tr><td>1</td><td>PSW2</td></tr>
<tr><td>2</td><td>PSW3</td></tr>
<tr><td>3</td><td>PSW4</td></tr>
<tr><td>4</td><td>PSW5</td></tr>
<tr><td>5</td><td>PSW6</td></tr>
<tr><td>6</td><td>PSW7</td></tr>
<tr><td>7</td><td>PSW8</td></tr>
<tr><td>8</td><td>PSW9</td></tr>
<tr><td>9</td><td>PSW10</td></tr>
<tr><td>A</td><td>PSW11</td></tr>
<tr><td>B</td><td>PSW12</td></tr>
<tr><td>C</td><td>PSW13</td></tr>
<tr><td>D</td><td>PSW14</td></tr>
<tr><td>E</td><td>PSW15</td></tr>
<tr><td>F</td><td></td></tr>
</table></td><td></td></tr>
<tr><td>12871
12872</td><td>aux_PSW1dog1
aux_PSW1dog2</td><td>PSW1 area setting 1
PSW1 area setting 2</td><td rowspan="13">When the machine is positioned at the area determined by the area settings 1 and 2, the position switch of the corresponding No. will turn ON.
Whether the value of setting 1 is larger than setting 2 (or vice versa) does not affect the position switch operation.
For rotation axes, the output turns ON in the area excluding 0.000 degree.</td><td rowspan="13">-99999.999 to 99999.999°(mm)</td></tr>
<tr><td>12873
12874</td><td>AUX_PSW2dog1
aux_PSW2dog2</td><td>PSW2 area setting 1
PSW2 area setting 2</td></tr>
<tr><td>12875
12876</td><td>aux_PSW3dog1
aux_PSW3dog2</td><td>PSW3 area setting 1
PSW3 area setting 2</td></tr>
<tr><td>12877
12878</td><td>aux_PSW4dog1
aux_PSW4dog2</td><td>PSW4 area setting 1
PSW4 area setting 2</td></tr>
<tr><td>12879
12880</td><td>aux_PSW5dog1
aux_PSW5dog2</td><td>PSW5 area setting 1
PSW5 area setting 2</td></tr>
<tr><td>12881
12882</td><td>aux_PSW6dog1
aux_PSW6dog2</td><td>PSW6 area setting 1
PSW6 area setting 2</td></tr>
<tr><td>12883
12884</td><td>aux_PSW7dog1
aux_PSW7dog2</td><td>PSW7 area setting 1
PSW7 area setting 2</td></tr>
<tr><td>12885
12886</td><td>aux_PSW8dog1
aux_PSW8dog2</td><td>PSW8 area setting 1
PSW8 area setting 2</td></tr>
<tr><td>12887
12888</td><td>aux_PSW9dog1
aux_PSW9dog2</td><td>PSW9 area setting 1
PSW9 area setting 2</td></tr>
<tr><td>12889
12890</td><td>aux_PSW10dog1
aux_PSW10dog2</td><td>PSW10 area setting 1
PSW10 area setting 2</td></tr>
<tr><td>12891
12892</td><td>aux_PSW11dog1
aux_PSW11dog2</td><td>PSW11 area setting 1
PSW11 area setting 2</td></tr>
<tr><td>12893
12894</td><td>aux_PSW12dog1
aux_PSW12dog2</td><td>PSW12 area setting 1
PSW12 area setting 2</td></tr>
<tr><td>12895
12896</td><td>aux_PSW13dog1
aux_PSW13dog2</td><td>PSW13 area setting 1
PSW13 area setting 2</td><td></td><td></td></tr>
<tr><td>12897
12898</td><td>aux_PSW14dog1
aux_PSW14dog2</td><td>PSW14 area setting 1
PSW14 area setting 2</td><td></td><td></td></tr>
<tr><td>12899
12900</td><td>aux_PSW15dog1
aux_PSW15dog2</td><td>PSW15 area setting 1
PSW15 area setting 2</td><td></td><td></td></tr>
</table>

12.34.3.6 Absolute Position Zero Point Initialization Set: Machine End Stopper Method

This method determines the absolute position basic point by pushing the axis against the machine, etc.

[Selecting machine end stopper method]

Set "1" to "#2049 type (Absolute position detection method)" and turn ON the power again.

[Initial setting]

Set suitable values for the stopper method when setting a torque limit value ("#2054 clpush (Current limit (%))") and an excessive error detection width ("#2253 SV053 OD3").

[Operation and performance]

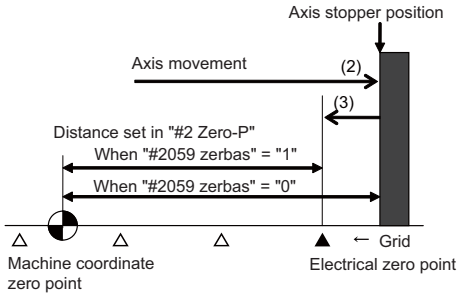
(1) Turn ON the following signals to enable the absolute position reference position basic point initialization set mode.

Abbreviation	Signal name	Explanations
AZS	Zero point initialization mode	The absolute position basic point initialization mode will be entered. This mode will be kept until the NC is turned OFF.

(2) Move the axis in jog or handle feed until the axis is pushed against the stopper without machine. When the torque (current) reaches the limit value due to this pushing, In torque limit (TLQ) will be output, and the position will be saved as the "absolute position basic point".

(3) Move the axis in the direction opposite to the pushing direction. When the axis reaches the first grid point, the axis automatically stops, and the absolute position coordinates will be established.
When "#2059 zerbas(Select zero point parameter and basic point)"is set to "1", "absolute position basic point" is set to the electrical zero point (grid) instead of the pushed position.

(4) In this state, the absolute position basic point will be the coordinate zero point.
To set the absolute position coordinate zero point to a position other than the pushing position or electrical zero point, move the machine coordinate zero point with the parameter "#2 Zero-P".



[Machine end stopper method]

12.34.3.7 Absolute Position Zero Point Initial Setting: Marked Point Alignment Method

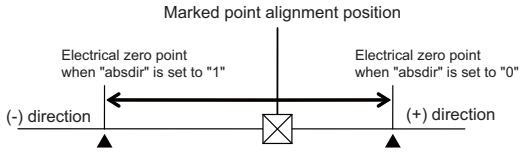
This method determines the absolute position basic point by aligning the axis to the marked point on the machine.

[Selecting the marked point alignment method]

Set "2" to "#2049 type (Absolute position detection method)" and turn ON the power again.

[Initial setting]

Set "#2050 absdir (Basic point of Z direction)" with the direction of the grid point, which is an electrical zero point, from the marked point alignment position.



[Operation and performance]

(1) Turn ON the following signals to enable the absolute position reference position basic point initialization set mode.

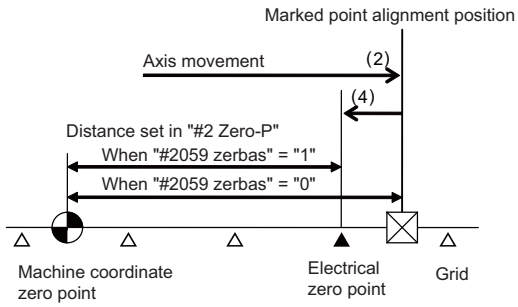
Abbreviation	Signal name	Explanations
AZS	Zero point initialization mode	The absolute position basic point initialization mode will be entered. This mode will be kept until the NC is turned OFF.

(2) Move the axis to the desired "absolute position basic point" in jog handle or incremental feed.

(3) Turn ON the Reference point setting (ZST) signal.

(4) Using jog, handle or incremental feed, move the axis in the direction of the grid to be an electrical zero point.
When the axis will automatically stop at the grid to be an electrical zero point, then the absolute position coordinates will be established. When "#2059 zerbas (Select zero point parameter and basic point)"is set to "1", the "absolute position basic point"
will be set to the electrical zero point (grid) instead of the Reference point setting position.

(5) In this state, the absolute position basic point will be the coordinate zero point.
To set the absolute position coordinate zero point to a position other than the one where Reference point setting (ZST)is ON or the electrical zero point, move the machine coordinate zero point with "#2 Zero-P".



[Reference point setting method]

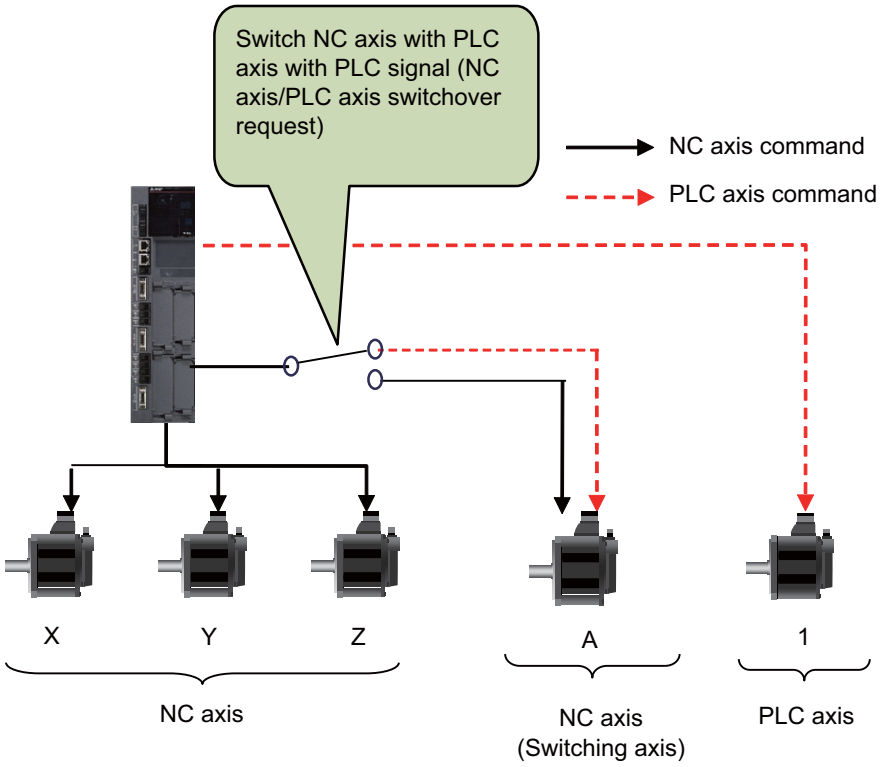
12.34.4 Test Operation in Auxiliary Axis Test Screen

The absolute position setting and test operations can be carried out by separating the axis control from PLC using the auxiliary axis test screen. As for the operation details, refer to "MITSUBISHI CNC 700/70 Series Instruction Manual" (IB-1500042(ENG)).

12.35 NC Axis/PLC Axis Switchover

12.35.1 Outline

This function is to use one drive unit by switching the control from the NC or the PLC dynamically. The function of the NC axis can be used during the NC axis control and the function of the PLC axis can be used during the PLC axis control respectively. A part of function or signal of the NC axis can also be used during the PLC axis control.
This function can be used for NC axis only.
The axis where this function is used needs to be set the PLC axis No. of the switching destination to the parameter "#2187 chgPLCax".
Only the unused PLC axis No. can be set to the switching destination.The same PLC axis No. cannot be set to the multiple switching axes.
The number of axes where this function can be used is the number obtained by subtracting the number of PLC-exclusive axes from the maximum number of PLC axes.



The following shows the meaning of terms used in this chapter.

Terms	Meanings
Switching axis	Axis to perform NC axis/PLC axis switchover (Axis whose parameter "#2187 chgPLCax" was set to PLC axis No.)
PLC axis mode In PLC axis control NC axis/PLC axis switchover in process	In the state that the switching axis can be operated as PLC axis (NC axis/PLC axis switchover in process (XBC0) = ON)
NC axis mode In NC axis control	In the state that the switching axis can be operated as NC axis (NC axis/PLC axis switchover in process (XBC0) = OFF)
Control mode	Switching axis mode (PLC axis mode/NC axis mode)
PLC-exclusive axis	Axis other than switching axis to control with user PLC command

12.35.2 Details

Example of parameter setting

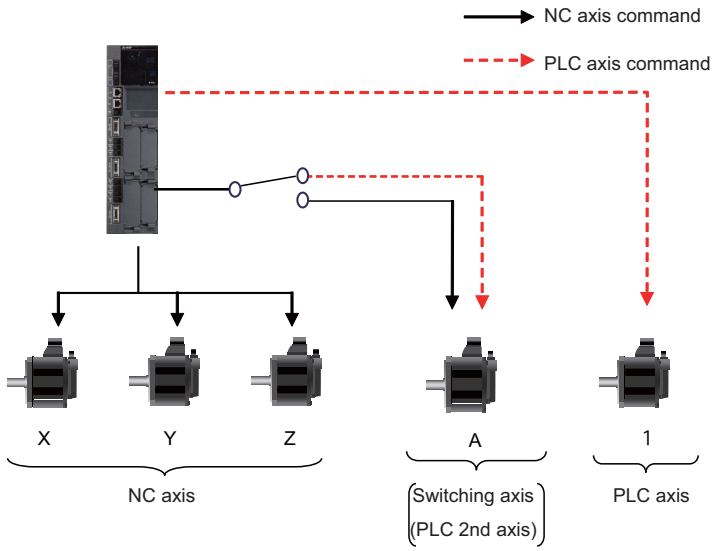
Assuming there are 3 NC-exclusive axes, 1 PLC-exclusive axis and 1 switching axis, and if the 4th NC axis is switched to the 2nd PLC axis, set the PLC axis No. "2" which is switched to the A axis side as the following.
For this example, when "1" is set to the parameter "#2187 chgPLCax", the alarm (Y05 2187) occurs when the power is turned ON. When the axis is changed to the PLC axis, the command is issued using the 2nd I/F of the PLC axis.

	$1	PLC
#1001 syson	1	1
#1002 axisno	4	1

	1	2	3	4	5
#1013 axname	X	Y	Z	A	1
#1021 mcp_no	1001	1002	1003	1004	1005
#2187 chgPLCax	0	0	0	2	0

PLC axis I/F

Signal name	PLC axis No.		
	1st axis (Set "R1n" to R440.)	2nd axis (Set "R2n" to R441.)	…
Not used	R1n + 0	R2n + 0	
Status	R1n + 1	R2n + 1	
Alarm details	R1n + 2	R2n + 2	
Control signal	R1n + 3	R2n + 3	
Axis specification	R1n + 4	R2n + 4	
Operation mode	R1n + 5	R2n + 5	
Feedrate	R1n + 6, 7	R2n + 6, 7	
Movement data	R1n + 8, 9	R2n + 8, 9	
Machine position	R1n + 10, 11	R2n + 10, 11	
Remaining distance	R1n + 12, 13	R2n + 12, 13	



Switching axes

Switching between NC axis and PLC axis can be performed with NC axis/PLC axis switchover request signal (NPCHGREQn:YBC0). When controlling as PLC axis, turn ON the signal and when controlling as NC axis, turn OFF the signal.

Also, this signal outputs the current control mode to NC axis/PLC axis in switchover signal (NPCHGMODn:XBC0). For PLC axis mode, turn ON the signal and for NC axis mode, turn OFF the signal.

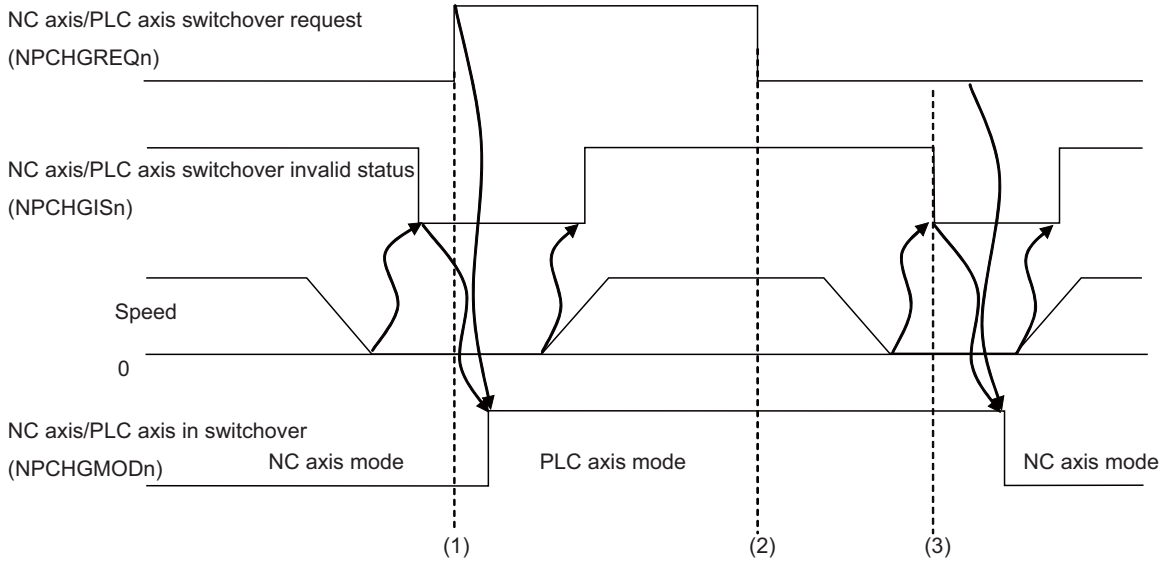
However, if the switching condition is not satisfied (NC axis/PLC axis switchover invalid status signal (NPCHGIS:XBA0) is turned ON), when NC axis/PLC axis switchover request signal (NPCHGREQn:YBC0) is turned ON/OFF, the operation error (M01 1250) (*) occurs and the switching is not performed.

NC axis/PLC axis switchover invalid status signal is turned ON when the valid axis of the NC/PLC axis switching is in the following conditions.

- While the axis is in motion (*)
- When the movement is stopped by the override zero or feed hold
- During the Servo OFF
- While the axis is being removed
- While the axis is stopped for interlock
- During the current limit
- During the droop cancel
- During the H/W OT or soft limit
- During the manual machine lock
- The reference axis or superimposed axis that is under the control axis superimposition
- The reference axis or synchronized axis that is under the control axis synchronization between part systems
- The chopping axis during the chopping
- The rotary tool axis during the tool spindle synchronization IC (spindle-NC axis, polygon)
- The workpiece axis during the tool spindle synchronization II (hobbing)
- The axis of the part system which is during the high-speed machining mode II/high-speed high-accuracy control II

* When travel command is given to multiple axes in one program block, and the switchover target axis is at a stop after the completion of movement, the switchover is disabled if any other axis is still moving.

* When the operation error (M01 1250) occurs, NC axis name is displayed regardless of the control mode.



(1) The NC axis/PLC axis switchover request signal is turned OFF to ON, and the NC axis/PLC axis switchover invalid status signal is OFF (switching is permitted). Therefore the axis changes over to the PLC axis mode and the NC axis/PLC axis in switchover is turned ON.

(2) The NC axis/PLC axis switchover request signal is turned OFF, but the NC axis/PLC axis switchover invalid status signal is ON (switching is prohibited). Therefore the axis does not change over to the NC axis mode and the operation error (M01 1250) occurs.

(3) The NC axis/PLC axis switchover invalid status signal is turned OFF when the axis movement is completed. And then it is switched to the NC axis mode, and the NC axis/PLC axis in switchover signal is turned ON.

Command from outside the mode

If PLC axis command (command from PLC axis I/F) is issued to the axis in NC axis mode, PLC axis command is ignored and NC axis command continues. Moreover, when the command is issued by the buffering mode, the subsequent buffer commands are all ignored.

When manual feed command is issued from NC axis to the axis in PLC axis mode, the operation error (M01 0005) (*) occurs. Then the NC axis command is ignored, and the PLC axis command continues. Also, if the movement command is issued by the program, the program error (P32) occurs, and the program is stopped. However, movement commands to the other NC axes and parameter input by program do not cause any alarms.

* When the operation error (M01 0005) occurs, the NC axis No. is displayed.

Unit system

For the switching axis, the unit of movement data or machine position, etc. on PLC axis I/F follows the PLC unit (#1005 plcunit) and PLC axis command (inch) (#1042 pcinch) of PLC axis. Other units (such as machine position of Drv monitor or parameter setting) are the same as NC axis.

Also, changing command unit system with G20/G21 is invalid for the movement data or machine position, etc. on PLC axis I/F.

Speed display

For the speed (F) on operation screen, the speed of the axis in PLC axis mode is not displayed. When the other axes are simultaneously moving, the composite speed of the axis which is not in PLC axis mode is displayed.

Coordinate system

Position command during the PLC axis mode is issued using positions on the machine coordinate of the NC axis.

When the axis is moved by PLC axis, the machine values, workpiece coordinates and relative values of the NC axis are updated.

Also, the NC axis workpiece coordinates are updated when workpiece coordinates are changed with G54, etc., during the PLC axis mode.

Tool compensation

If the axis is switched to the PLC axis as keeping the tool compensation amount, including the length and radius compensation valid in the NC axis mode, the compensation amount is retained. However, when the axis in the PLC axis mode is moved by the compensation amount, the program error (P32) occurs.

When the axis in the PLC axis mode is returned to zero point, the compensation amount is cleared.

Valid signals in PLC axis mode

In NC axis mode, all PLC axis signals are invalid; however, in PLC axis mode, part of NC axis signals is valid.
The following shows the NC axis signals which are valid even in PLC axis mode.

Control signals

Signal name	Abbreviation	Device No.
Zero point initialization set mode	AZSn	Y960 to Y967 (Part system 1)
Zero point initialization set mode	ZSTn	Y980 to Y987 (Part system 1)
Vertical axis pull-up prevention request	-	YAE0 to YAE7 (Part system 1)
OT ignored	-	R248, R249
Near-point dog ignored	-	R272, R273
Ball screw thermal displacement compensation Offset amount	-	R400 (1st axis)
Ball screw thermal displacement compensation Max. compensation amount	-	R401 (1st axis)
External machine coordinate system offset data	-	R5700 to R5715 (Part system 1)

Status signals

Signal name	Abbreviation	Device No.
Servo ready	RDYn	X780 to X787 (Part system 1)
Axis selection	AXn	X7A0 to X7A7 (Part system 1)
In axis plus motion	MVPn	X7C0 to X7C7 (Part system 1)
In axis minus motion	MVMn	X7E0 to X7E7 (Part system 1)
Near reference position	NRFn	X880 to X887 (Part system 1)
Zero point initialization set completed	ZSFn	X8C0 to X8C7 (Part system 1)
Zero point initialization set error completed	ZSEn	X8E0 to X8E7 (Part system 1)
NC axis up-to-speed	ARRFn	X940 to X947 (Part system 1)
Reference position establishment	-	X9E0 to X9E7 (Part system 1)
Ext. machine coordinate system offset data illegal	ECILn	XA40 to XA47 (Part system 1)
Vertical axis pull-up prevented	-	XA60 to XA67 (Part system 1)
Ball screw thermal displacement compensation Compensation amount	-	R72 to R75
Initialization incompletion	-	R575 (Part system 1)
Machine position	-	R4500 to R4529 (Part system 1)
Feedback machine position	-	R4628 to R4657 (Part system 1)
Servo deflection amount	-	R4756 to R4771 (Part system 1)
Motor rotation speed	-	R4820 to R4835 (Part system 1)
Motor load current	-	R4884 to R4899 (Part system 1)
Servo motor temperature	-	-
Servo alarm/warning No.	-	R5332 to R5339 (Part system 1)

12.35.3 Relation with Other Functions

Function name	Specification
External deceleration	The axis in PLC axis mode does not become the external deceleration speed even if the External deceleration + signal (*+EDT1 to 8) or External deceleration - (*-EDT1 to 8) signal is turned OFF.
Speed monitor	Speed is monitored as NC axis even in PLC axis mode.
Absolute value initialization set	Even in PLC axis mode, the absolute value initialization set is performed using Zero point initialization set mode signal (AZSn) and Zero point initialization set start (ZSTn). PLC axis signals are used to start the axis or etc. even while the axis in PLC axis mode is being initialized.
High-accuracy control	The axis in PLC axis mode does not perform the high-accuracy control.
Acceleration/deceleration with a constant angle of inclination	Some parameters to be used are different depending on NC axis mode or PLC axis mode. NC axis mode #1200 G0_acc, #1201 G1_acc PLC axis mode #1307 G0acc_plc, #1308 G1acc_plc
Machine error compensation (backlash error compensation, pitch error compensation, thermal expansion error compensation, external machine error compensation)	The compensation amount set for NC axis is valid even in PLC axis mode.
Stroke End (Over Travel)	The axis is stopped with stroke end signal of NC axis even in PLC axis mode. Also, as it is in NC axis/PLC axis switchover invalid status during stroke end, cancel the alarm before executing the switching. If the alarm of stroke end or soft limit occurs for the axis in PLC axis mode, the alarm (T01 0106) occurs and the cycle start cannot be performed. If the limit alarm occurs for the axis in PLC axis mode during the cycle start, the alarm (T02 0202) occurs and the program stops.
Soft limit	This is valid even in PLC axis mode. Also, as it is in NC axis/PLC axis switchover invalid status during soft limit, cancel the alarm before executing the switching. The alarm can be canceled by resetting each control mode. However, the soft limit IB and IIB are canceled with the reset of NC axis regardless of control mode. If the alarm of soft limit occurs for the axis in PLC axis mode, the alarm (T01 0106) occurs and the cycle start cannot be performed. If the limit alarm occurs for the axis in PLC axis mode during the cycle start, the alarm (T02 0202) occurs and the program stops. When the axis is moved from outside of the limit range to within the range in PLC axis mode, the clamp with the parameter "#2021 out_f" is not performed and it is operated with the commanded speed.
Stroke end/Reference position return near point detection	The signals (fixed/arbitrary assignment) of NC axis are used even in PLC axis mode. The signals of PLC axis are not used.
Position switch (PSW)	The PSW set for NC axis is valid even in PLC axis mode.
PLC window	The data is read or written by specifying the NC axis No. to the axis No. even in PLC axis mode. When PLC axis No. is specified, the alarm "Data type illegal" occurs.
Parameter input by program	This can be executed even in PLC axis mode.
Origin zero set	This cannot be executed in PLC axis mode.
Vertical axis pull-up	This is valid even in PLC axis mode.
PLC axis indexing Spindle/C axis Inclined axis Inclined surface machining Tool center point control	These cannot be used for the switching axis. If the parameter was set to use the switching axis with the function on the left, the alarm (Y05 2187) occurs when NC is turned ON.
Control axis superimposition I and II Arbitrary axis superimposition	The axis in PLC axis mode cannot be specified to the reference axis or superimposed axis. The operation error (M01 1004) occurs when the superimposition starts. The reference axis or superimposed axis in superimposition cannot be switched to PLC axis mode. If NC axis/PLC axis switchover request is turned ON, the operation error (M01 1250) occurs. For the part system including the reference axis and superimposed axis, stop all axes before starting or ending the superimposition. The condition to stop all axes includes the axis in PLC axis mode.

Function name	Specification
Control axis synchronization between part systems I and II	The axis in PLC axis mode cannot be used with control axis synchronization between part systems. The operation error (M01 1037) occurs when the synchronization starts. The reference axis or the synchronized axis in synchronization cannot be switched to PLC axis mode. If NC axis/PLC axis switchover request is turned ON, the operation error (M01 1250) occurs. For the part system including the reference axis and synchronized axis, stop all axes before starting or ending the synchronization. The condition to stop all axes includes the axis in PLC axis mode.
Chopping	The axis in PLC axis mode cannot be specified to the chopping axis. The operation error (M01 0154) occurs when the chopping starts. The axis in chopping cannot be switched to PLC axis mode. If NC axis/PLC axis switchover request is turned ON, the operation error (M01 1250) occurs.
Tool spindle synchronization IC (Polygon)	The axis in PLC axis mode cannot be specified to the tool rotary axis. The operation error (M01 0005) occurs when the polygon starts. The tool rotary axis cannot be switched to PLC axis mode while the polygon is executed. If NC axis/PLC axis switchover request is turned ON, the operation error (M01 1250) occurs.
Tool spindle synchronization II (Hobbing)	The axis in PLC axis mode cannot be specified to the workpiece axis. The operation error (M01 0005) occurs when the hobbing starts. Also, the axis in PLC axis mode is out of the subject of hob retract (hob retract is not performed). The workpiece axis cannot be switched to the PLC axis mode while the hobbing is executed. If NC axis/PLC axis switchover request is turned ON, the operation error (M01 1250) occurs.
High-speed machining mode II High-speed high-accuracy control II	High-speed machining mode II or High-speed high-accuracy control II cannot be executed in the part system including the axis in PLC axis mode. The program error (P29) occurs when High-speed machining mode II or High-speed high-accuracy control II starts. The axis in the part system where High-speed machining mode II or High-speed high-accuracy control II is being executed cannot be switched to the PLC axis mode. If NC axis/PLC axis switchover request is turned ON, the operation error (M01 1250) occurs.
Mixed control (cross axis control)	The axes can be switched with mixed axis control either in NC axis mode or PLC axis mode. After switching the axes with mixed axis control, the switching axis can be switched to NC axis mode or PLC axis mode. Even when the axis in PLC axis mode is moving, the switching axes with mixed control can be performed.
Arbitrary axis exchange control	Whether in NC axis or PLC axis mode, the axes can be switched with the arbitrary axis exchange control. After switching the axes with the arbitrary axis exchange control, the mode of the switched axes can be changed to NC axis or PLC axis. When the arbitrary axis exchange command is given during PLC axis mode while the target axis is moving, the exchange is performed immediately if the exchange is between part systems, or is performed after the axis movement is completed if the exchange is within a part system. Even if the axis to switch is a non-control axis, the mode can be switched between NC axis and PLC axis.

12.35.3.1 Synchronous Control

Synchronous control can be performed to the axis where NC axis/PLC axis switchover is performed either in NC axis mode or PLC axis mode.

To execute the synchronous control using the NC axis/PLC axis switchover target axis, both master and slave axes where the synchronous control is performed need to be the NC axis/PLC axis switchover target axes.

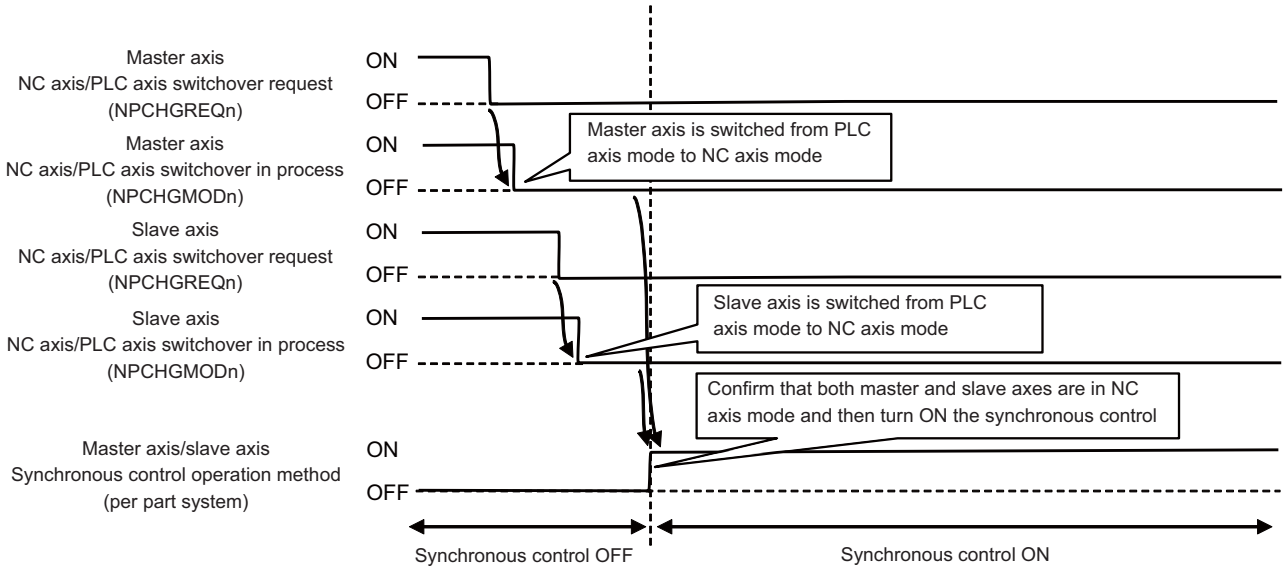
When the synchronous control using the NC axis/PLC axis switchover target axis is started, both master axis and slave axis need to be in NC axis mode. If the synchronous control start is commanded while either of the axes is in PLC axis mode, the operation error (M01 1036) occurs.

During the synchronous control between NC axis/PLC axis switchover target axes, the control modes of master axis and slave axis need to be matched.

When the movement command (automatic operation/manual operation) is issued to the master axis as NC axis, the control modes of both master and slave axes need to be NC axis mode.

When commanded to the master axis as PLC axis, the control modes of both master and slave axes need to be PLC axis mode.

If the control modes are not matched, the alarm occurs when the movement command to the master axis is issued.



Operation procedure

(1) When starting synchronous control
  (a) Set the control modes of both master and slave axes to NC axis mode.
  (b) Start synchronous control.
    At this time, if either of the axes is in PLC axis mode, the operation error (M01 1036) occurs.

(2) When moving the axis in PLC axis mode
  (a) Set the control modes of both master and slave axes to PLC axis mode.
  (b) Issue PLC axis control command to master axis.
    → Slave axis is moved synchronizing with master axis.
    When PLC axis command is issued to slave axis, the alarm No. 21 is output to PLC axis control information data.
    If either of the axes is in NC axis mode, the alarm No. 20 is output to PLC axis control information data.

(3) When moving the axis in NC axis mode
  (a) Set the control modes of both master and slave axes to NC axis mode.
  (b) Issue NC axis command (automatic operation/manual operation) to master axis.
    → Slave axis is moved synchronizing with master axis.
    If NC axis command (automatic operation/manual operation) is issued to slave axis and the automatic operation command is issued, the program error (P32) occurs. The manual operation command is ignored.
    When either of the axes is in PLC axis mode, the program error (P32) occurs if the automatic operation command is issued, and the operation error (M01 0005) occurs if the manual operation command is issued.

(4) When moving the axis in correction mode
  (a) Set the control modes of both master and slave axes to NC axis mode.
  (b) Select the handle mode or manual arbitrary feed.
  (c) Turn ON the correction mode.
    → When the correction mode is valid, "CORRECTION MODE" is displayed at the display position of control mode.
    At this time, when either axis is in PLC axis mode, the correction mode is invalid.
  (d) Issue NC axis command (manual operation) to one of the master axis or slave axis which is to be moved.
    → Only the selected axis of either master or slave axis is moved.

(5) When canceling synchronous control
  (a) Complete the movement of both master and slave axes.
  (b) Cancel synchronous control.

*1 When two sets of synchronous control is executed, the control modes of those two synchronous control do not need to be matched.

*2 When zero point return is executed for an axis that is subject to synchronous control while the axis is in PLC axis mode, the alarm No. 21 is output to the PLC axis control information data, whether or not the synchronous control is valid.

*3 Even when both master and slave axes are in PLC axis mode, synchronous error automatic correction function at servo ON can be performed.

12.35.4 Caution

(1) When there are as many non-switchable PLC-exclusive axes as the maximum number of PLC axes, this function cannot be used. When the said condition is satisfied with the parameter "#2187 chgPLCax" set to nonzero, the alarm (Y05 2187) occurs at the power ON. When the number of PLC-exclusive axes is smaller than the maximum number of PLC axes, this function can be used even if the total of NC axes, PLC axes and spindles reaches the maximum number of control axes.

(2) For the switching axis in PLC axis mode, when the control mode of PLC axis is set to single mode same as PLC-exclusive axis, turn ON PLC axis control valid signal (Y770), and when switched to buffering mode, turn ON PLC axis control buffering mode valid signal (Y723). When these signals are OFF, the command is ignored.

(3) The status signal on PLC axis I/F is updated only in PLC axis mode, but not updated in NC axis mode. However, the slave axis under synchronous control is not updated even in PLC axis mode. Therefore, when switching PLC axis control to NC axis control, as the status signal retains the value immediately before switching, do not use the status signal in NC axis mode.

(4) At the time the 1st to 4th reference positions are reached, when switching to PLC axis control, the 1st to 4th reference position arrival signals are turned OFF.

(5) When the switching axis is set to Dog-type absolute position detection system (parameter "#2049 type" = "3"), perform the zero point initialization set on NC axis. During NC Axis/PLC axis switchover, the movement command of the initialization set is ignored. The zero point return on PLC axis after the zero point is established, the high-speed reference point return is performed.

(6) When the parameter is set, soft limit IB and IIB are valid even during PLC axis switchover. The alarm cannot be canceled with PLC axis reset. It can be canceled with NC side reset regardless of the control mode.

(7) When switching NC axis and PLC axis using M code, confirm that the mode is switched (ON or OFF of NC axis/PLC axis in switchover signal is switched) before turning ON miscellaneous function finish signal.

(8) The movement amount in PLC axis mode is treated as manual interrupt amount.

(9) When moving the axis in correction mode of synchronous control, set all the synchronous control axes to NC axis mode.

12.36 External Search

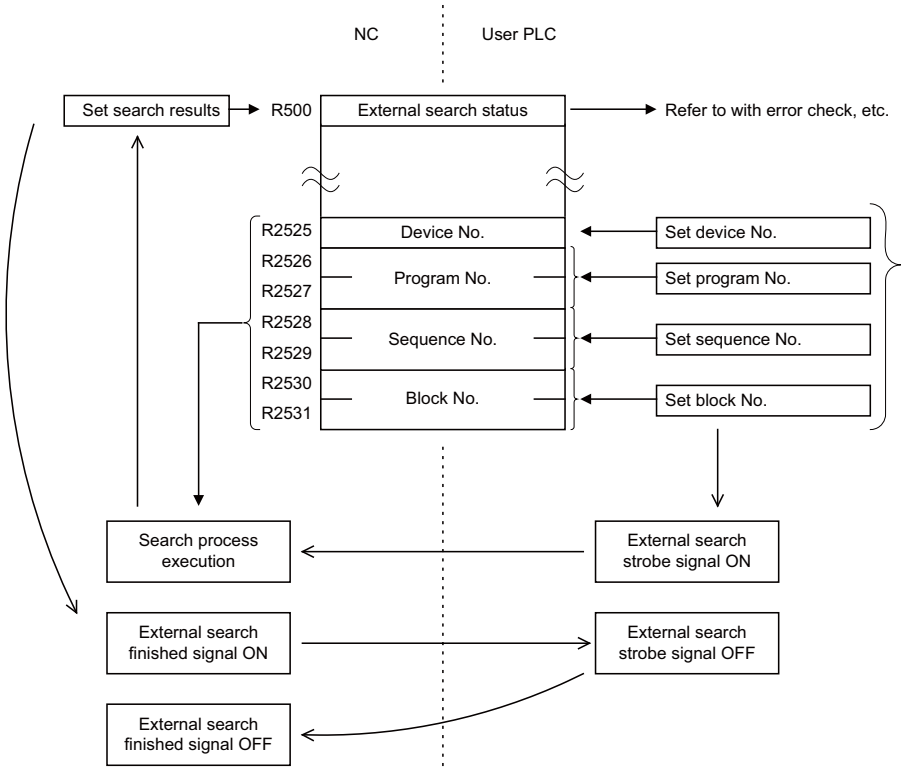
External search is a function that searches the machining program according to the machining program storage device, program No., sequence No. and block No. designated from the user PLC.

12.36.1 Detailed Explanation

The flow of the external search execution process is given below.

(1) The user PLC sets the device, program No., sequence No. and block No.
(2) The user PLC sets the external search strobe signal ON.
(3) The NC searches for the target machining program from the designated device, program No., sequence No. and block No.
(4) The NC sets the search results as the external search status.
(5) The NC turns the external search finished signal ON.
(6) The user PLC turns the external search strobe signal OFF.
(7) The NC turns the external search finished signal OFF.

Flow of external search process for 1st part system



12.36.2 PLC→NC Interface Signal

Signal name	Part system No.			
	1st part system	2nd part system	3rd part system	4th part system
External search device No.	R2525	R2725	R2925	R3125
External search program No.	R2526 R2527	R2726 R2727	R2926 R2927	R3126 R3127
External search sequence No.	R2528 R2529	R2728 R2729	R2928 R2929	R3128 R3129
External search block No.	R2530 R2531	R2730 R2731	R2930 R2931	R3130 R3131
External search strobe	YC1D	YD5D	YE9D	YFDD

(1) External search device No.

The device storing the machining program to be searched is designated with a No.
When a front SD card is selected in M800S/M80 series, select either "2" or "4" for the device number.
When a rear SD card is selected in M800S/M80 series, select "1" for the device number.
When a front USB port of the display unit is selected, select "6" for the device number.
HD operation with industrial personal computer (IPC) connection can be specified only for M80 Series.
To enable HD operation with industrial personal computer, the following parameter settings are required.
- Set "#1760 cfgPR10/bit2" (Enable HD mode on IPC) to "1"
- IP address of industrial personal computer to connect to "#11005 PC IP address" (IP address setting)

Device number	Device
0	Memory
1	Display unit-side high-speed program server
2	Memory card , front SD card
3	-
4	Control unit-side high-speed program server
5	Tape (RS232C)
6	Front USB port of display unit
7	HD for industrial personal computer (D: \NCFILE)

(2) Program No.

Designate the No. of the machining program to be searched as a binary. 1 to 99999999 (8 digits)

(3) Sequence No.

Designate the sequence No. of the machining program to be searched as a binary. 1 to 99999999 (8 digits)

(4) Block No.

Designate the block No. as a binary. 0 to 999999999 (9 digits)

(5) External search strobe

The NC starts the external search at the rising edge of this signal.
The block specified with program No. (R2526), sequence No. (R2528) and block No. (R2530) are searched.
When either or both of the program No. and sequence No. are omitted, the operation differs as shown in the table below.

Program No. (R2526)	Sequence No. (R2528)	Start point to search the block No. (R2530)
Designated	Designated	Designated sequence No. for designated program
Designated	Not designated (*1)	Head of designated program
Not designated (*1)	Designated	Designated sequence No. in currently selected program
Not designated (*1)	Not designated (*1)	Error: 4 Refer to the section of "External search status" (R500).

(*1) "Not designated" indicates that the value of the signal is "0" (OFF).

12.36.3 NC→PLC Interface Signal

Signal name	Part system No.							
	1st part system	2nd part system	3rd part system	4th part system	5th part system	6th part system	7th part system	8th part system
External search finished	XC1D	XD5D	XE9D	XFDD	X111D	X125D	X139D	X14DD
External search status	R500	R700	R900	R1100	R1300	R1500	R1700	R1900

(1) External search finished

This turns ON when the external search is finished. This also turns ON when an error occurs.

This signal turns OFF when the "External search strobe signal" is turned OFF from the user PLC.

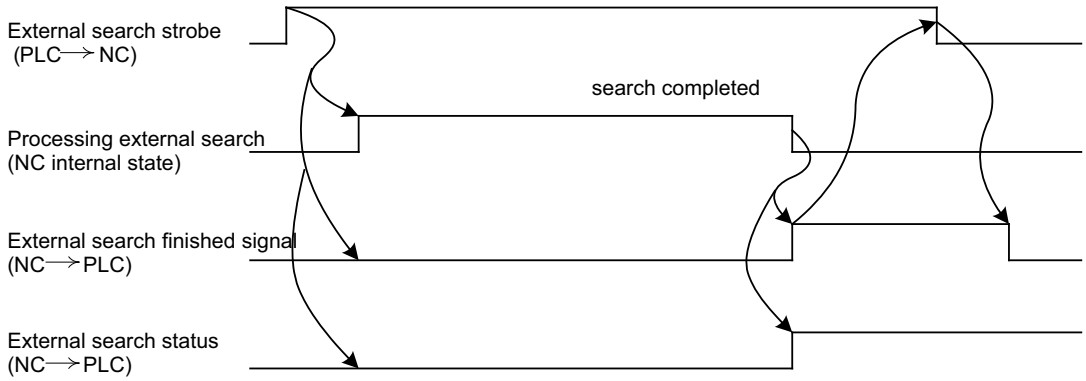
(2) External search status

The status at the end of the external search is output.

Refer to "External search status".

Timing Chart

The timing chart for the external search is shown below.



External Search Status

The correspondence of the external search status values and details output from the NC based on the external search is shown below.

External search status value	Details	Remedy
0	Normally finished	-
1	Operation search is being carried out	Wait for other function's operation search to finish before searching.
2	Search was attempted while external search was invalid.	Stop the program before searching. Cancel the emergency stop or reset before searching.
3	Any non-existent or inoperative device has been designated.	Confirm the presence of the device, and that the device is within the specifications
4	The program file is not designated	Designate the program No. or sequence No.
5	The block with the designated program No., sequence No. or block No. was not found	Check the machining program.
6	-	-
7	The designated device does not support the batch program search across all part systems.	Designate a device which supports the batch program search across all part systems.

Signal name	Part system No.							
	$1	$2	$3	$4	$5	$6	$7	$8
External search: Program return completed	XCEA	XE2A	XF6A	X10AA	X11EA	X132A	X146A	X15AA
External search: Program return complete status	R501	R701	R901	R1101	R1301	R1501	R1701	R1901

(1) Program return completed

This signal turns ON when the program return is completed by inputting the program return signal. This also turns ON when an error occurs.

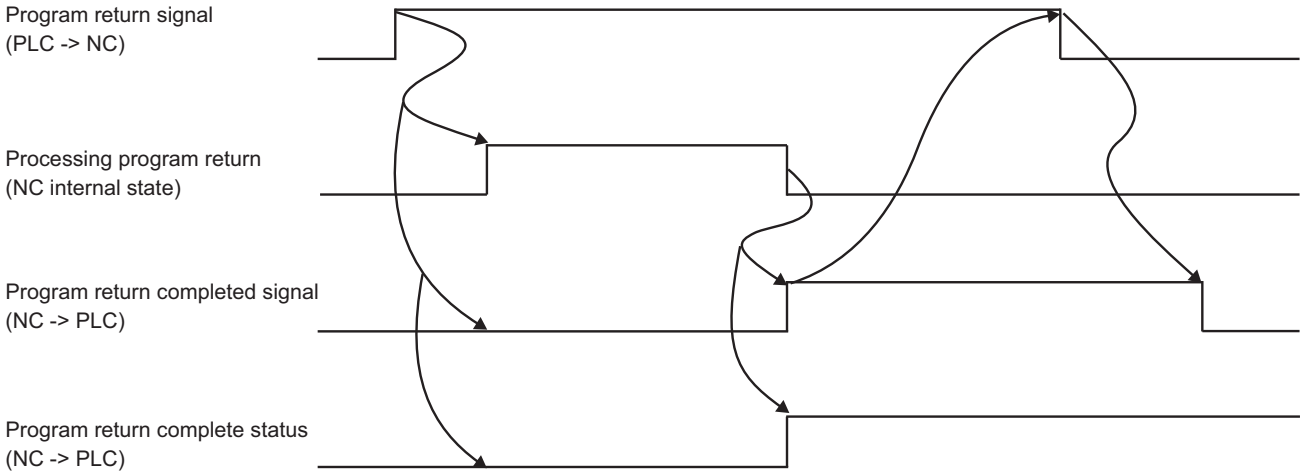
This signal turns OFF when the program return signal is turned OFF from the user PLC.

(2) Program return complete status

This signal outputs the status of when the program return completed signal is ON.

Timing Chart

The timing chart for the program return is shown below.



Program return complete status

The correspondence of the program return complete status values and details output from the NC based on the result of returning to the machining program before the external search is shown below.

Status value	Details	Remedy
0	Normally finished	--------
1	Function is invalid	Check the parameter setting
2	Program return was attempted during the operation, reset, or emergency stop.	Input the signal after stopping the program operation. Confirm the cancellation of the emergency stop or reset, and then input the signal.
3	Program return is disabled because the external search has not been performed or due to any restriction.	Execute the external search first, and then input the signal. Do not execute a function that is restricted after the external search.

12.36.4 Returning to the Previous Machining Program before the External Search

The control returns to the previous machining program selected before the external search with the return method set in the parameter.The control stores the machining program selected before the external search when executing the external search.
When returning to the previous machining program, the control restores the modal information stored at the external search.
When the return is enabled by the parameter setting, and the externally searched program is finished in M99, the NC reset is automatically executed.

Usage

Select the return method from the followings.
- Reset (reset 1, reset & rewind) (Note) Not return by reset 2
- Program return signal

(1) Relation between the parameter settings and behaviors

		Return by program return signal	
		ext24(bit3) = 1	ext24(bit3) = 0
Return by reset	ext24(bit2) = 1	Return by reset or program return signal	Return by reset
	ext24(bit2) = 0	Return by program return signal	Not return

Since the return is enabled by reset when the parameter "#1288 ext24/bit2" is set to "1", it is possible to return to the previous machining program before the external search automatically if the machine specification is to perform reset upon execution of the program end M02 or M30.Since the return is enabled by the program return signal when the parameter "#1288 ext24/bit3" is set to "1", it is possible to return to the previous machining program before the external search with the switch or ladder.

(2) Usage example

Condition: Parameter "#1288 ext24/bit2" is set to "1" (Return is enabled by reset) and the program end of the externally searched program is M99

Step	Details	Operation
(1)	Program operation for workpiece machining	Workpiece machining by pressing the CycleStart button
(2)	External search for pallet exchange program	Press the pallet exchange button
(3)	Program operation for pallet exchange	Pallet exchange for next workpiece by pressing the CycleStart button
(4)	Return to the program which was operated at (1) for workpiece machining	Unnecessary (Return to the program for workpiece machining automatically)
(5)	Program operation for workpiece machining	Workpiece machining by pressing the CycleStart button

Restrictions

The following restrictions are imposed on return to the previous program before the external search.

(1) When the following operations are performed after completing the external search, this function cannot return to the stored program.
- Operation search
- Restart search
- Check search (foreground)
- Search & start

(2) When the following function is executed after completing the external search or while the externally searched program is running, the control fails to return to the stored program.
- Macro interruption

(3) Program can be returned to the one before external search is performed when the stored device is in either of the following conditions.
- Either the device of the program which was executing before the external search or the device of the program for external search is a memory.
- The device of the program which was executing before the external search and the device of the program for external search is the same.

For device types, refer to "(1) External search device No." of "12.35.2 PLC → NC Interface Signal".

12.36.5 Precautions

(1) Even if the external search strobe is already OFF when the NC finishes the external search, the external search finished signal will turn ON for one cycle of the user PLC.

(2) Note the following points to return to the previous program before the external search.
   (a) While the parameter "#1288 ext24/bit2" is "1", the control returns to the stored program if you execute reset before or during the operation of the externally searched program.
   (b) While the parameter "#1288 ext24/bit2" is "1", the control returns to the stored program at the time of cancelling emergency stop.
   (c) While the parameter "#1288 ext24/bit3" is "1", the control fails to return to the stored program during the operation even if the program return signal is input.
   (d) When the external search is carried out in the condition that the previous program before the external search is unsearched, the program becomes unsearched state after returning.
   (e) When the next operation is executed after returning from the externally searched program, and if the stored program is absent due to deletion, etc., the program error (P232) occurs.
   (f) Even if you execute external search continuously, the control returns to the previous program before the first external search.
   (g) If you turn the power OFF after running the externally searched program, the control returns to the last searched program before the external search when the power is turned ON again.
   (h) Do not execute external search or return to the stored program in the condition that axes configuration is changed by a mixed control command.
   (i) Restart search cannot be executed for an externally searched program. If attempted, the operation message "Search error" appears. It is possible to execute the restart search for a program other than externally searched programs by the program number designation.
   (j) When the externally searched program is edited and saved, the control fails to return to the stored program. However, if the editing was canceled without saving, the control can return to the stored program.

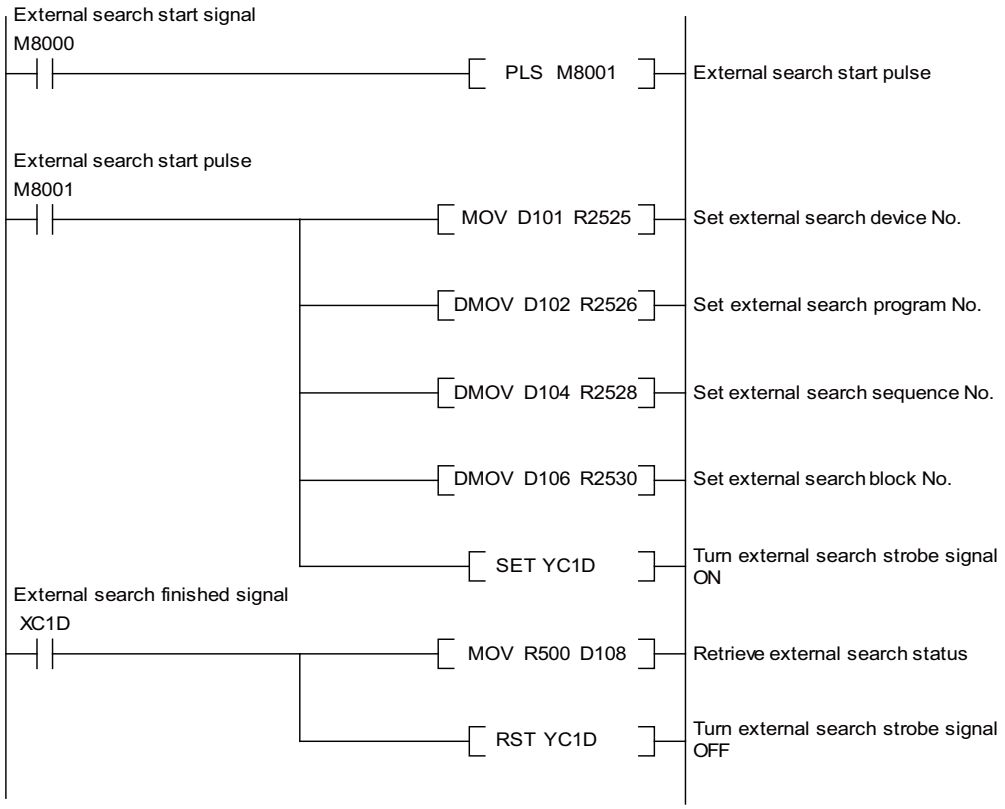
(3) When you perform an operation search by designating a block No., it can be set by the parameter "#1760 cfgPR10/bit5" whether the block which consists of comment only is counted as one block. When the parameter is set to "0", the comment block is counted as one block.
Set the parameter to "1" to count the comment block as same as the automatic operation.

(Example) When an operation search is performed by the sequence No. 1 and the block No. 2
Sequence Nos. and the block Nos. vary as indicated in the following table depending on the setting of the parameter. Thus, the different block is searched.
When "#1760 cfgPR10/bit5" is set to "0", the block (a) is searched.
When "#1760 cfgPR10/bit5" is set to "1", the block (b) is searched.

Program	#1760 cfgPR10/bit5 = 0		#1760 cfgPR10/bit5 = 1	
	Sequence No.	Block No.	Sequence No.	Block No.
N01;	N1	B0	N1	B0
(COMMENT1);	N1	B1	-	-
G28 X0Y0Z0; .....(a)	N1	B2	N1	B1
G0 X10.; .....(b)	N1	B3	N1	B2
M30;	N1	B4	N1	B3

12.36.6 Usage Example

An example of the external search ladder for 1st part system is shown below.



12.36.7 Relation with Other Functions

Control Unit-side High-speed Program Server Mode

If there is no specification for the control unit-side high-speed program server mode, you cannot designate "4" (high-speed program server) as the external search device No.

If you designate it and execute the external search, the external search status will be "3" (any non-existent or inoperative device has been designated).

Display Unit-side High-speed Program Server Mode

If there is no specification for the display unit-side high-speed program server mode, you cannot designate "1" as the external search device No.

If you designate it and execute the external search, the external search status will be "3" (any non-existent or inoperative device has been designated).

Operation Search Related Function

In case that you enable returning to the previous program before external search and then execute a search operation such as operation search, the control fails to return to the previous program before the external search.

Macro Interrupt

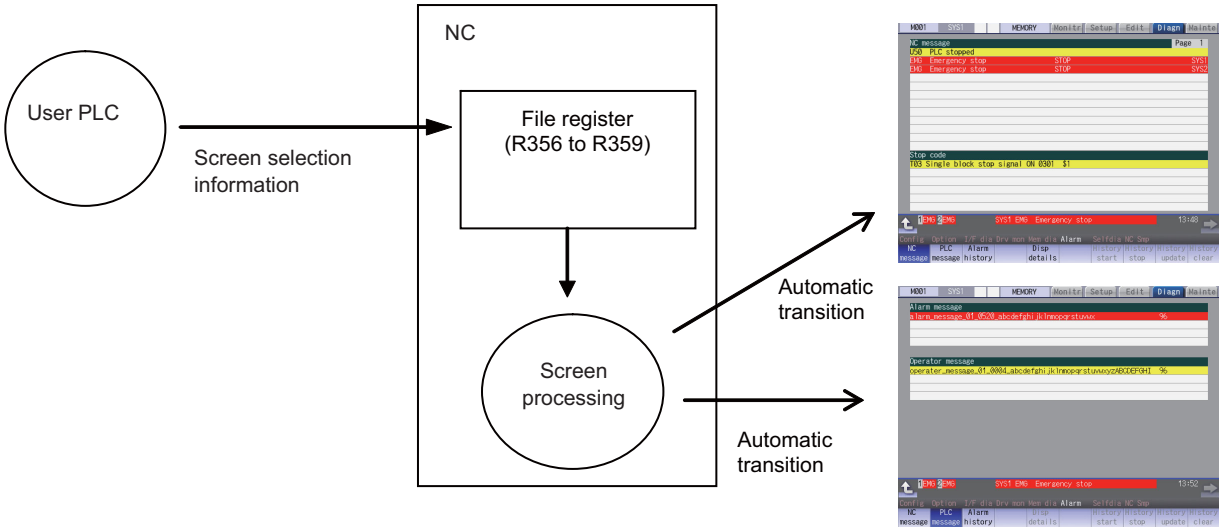
In case that you enable returning to the previous program before external search and then execute a macro interruption after completing the external search or while the externally searched program is running, the control fails to return to the previous program before the external search.

HD operation with industrial personal computer

When HD operation with industrial personal computer is disabled, you cannot designate "7" as the external search device No. (R2525). If you designate it and execute the external search, the external search status (R500) will be "3" (any non-existent or inoperative device has been designated).

12.37 Direct Screen Selection

The direct screen selection is the function to control the screen transition of NC screens by the user PLC.
An arbitrary NC screen can be selected by setting the screen selection information to file register.
The following each screen can be selected as the screen transition direction: Monitor screen, Setup screen, Edit screen, Diagnosis screen, Maintenance screen and Customization screen.



12.37.1 Screen Selection Information

The descriptions of the screen selection information (file registers) are shown below.

Register No.	Description		Setting value
R356	Selection requirement/completion data		0: Initial state 1: Screen selection requirement 4: Screen selection completion 8: There is no application for the screen selection requirement
R357	Selection requirement	Function No.	Set "4" to move to the alarm message display screen.
R358		Main menu No.	Set "6" to move to the alarm message display screen.
		Screen No.	Set "6001" to move to No. 6001 screen on the Customization screen.
R359		Sub menu No.	Set "1" to move to the NC alarm display screen or "2" to the PLC alarm display screen.
		Window No.	Set "8002" to display No. 8002 window on the Customization screen.

(1) User PLC confirms that the initial state ("0") is set to R356, the selection requirement/completion data.
(2) User PLC also sets the function No. (to R357), main menu (or the menu/screen of the Customization screen) No. (to R358) and sub menu No. (or the window No. of the Customization screen) (to R359), then enters "1" in R356, the selection requirement/completion data.
(3) NC confirms the screen selection requirement and then sets the screen selection completion ("4") to the selection requirement/completion data (R356) to execute the screen transition.
(4) User PLC confirms the screen selection completion ("4") in R356 and then initializes the data (to "0").

(Note 1) Setting the function No. is necessary. Without this No., the screen transition is not executed.
(Note 2) If the main menu No. (or the menu/screen of the Customization screen) has not been set (stays "0"), the function No. designates the screen transition. The screen transition is as same as when each function key has been pressed.
(Note 3) When the sub menu No. has been set, the main menu No. has also to be set. Unless the main menu is set, the transition is as same as when only the function No. is set.
(Note 4) When the window No. is set, the window with the designated window No. appears after the screen transition (after the designated screen display if the screen No. is designated). Even when the screen No. is not set (0), the window can be displayed by setting the window No.
(Note 5) When either the function No., main menu No. (or screen No.) or sub menu No. (or window No.) is out of range, the screen transition is not executed. Then the selection requirement/completion data (R356) remains "1".

Value of Function No. (R357)

Screen	Function No.
Monitor screen	1
Setup screen	2
Edit screen	3
Diagnosis screen	4
Maintenance screen	5
SFP screen	9
F0 screen	10
Window display	13
Window selection	14

(Note) When 9, 10, 13 and 14 is set to the function No., DIRECT_SCREEN item of config.ini needs to be set to "1".

Value of Main Menu/Screen Menu (R358) and Sub Menu/Window No. (R359)

The contents to designate in R358/R359 differ depending on the designated function No.

[Setting range when the DIRECT_SCREEN of config.ini is "0"]

Screen	Value of R357	Value of R358	Value of R359
Monitor screen	1	Main menu (0 to 30)	Sub menu (0 to 70)
Setup screen	2		
Edit screen	3		
Diagnosis screen	4		
Maintenance screen	5		

[Setting range when DIRECT_SCREEN of config.ini is "1" and the menu is designated]

Screen	Value of R357	Value of R358	Value of R359
Monitor screen	1	Main menu (0 to 30)	Sub menu (0 to 70)
Setup screen	2		
Edit screen	3		
Diagnosis screen	4		
Maintenance screen	5		
SFP screen	9	Menu (0 to 10)	Fixed to "0"
F0 screen (*1)	10		
Window display	13		
Window selection	14		

(*1) When F0 screen is designated, the Customization screen is always displayed regardless of the on-board ON parameter (#6451).

[Setting range when DIRECT_SCREEN of config.ini is "1" and the screen/window No. is designated]

Screen	Value of R357	Value of R358	Value of R359
Monitor screen	1	Main menu (0 to 30)	Window No. of the Customization screen (8000 to 9999) (*2)
Setup screen	2		
Edit screen	3		
Diagnosis screen	4		
Maintenance screen	5		
SFP screen	9	Screen No. (0 and 6000 to 7999)	Window No. (0, 6000 to 9999)
F0 screen (*1)	10		
Window display	13		
Window selection	14		

(*1) When F0 screen is designated, the Customization screen is always displayed regardless of the on-board ON parameter (#6451).

(*2) The window of designated No. can be displayed only when the Customization screen is displayed using the NC Designer Interpreter method/Compilation method which was designated with the main menu of R358.

The main menu No. and the sub menu No. on the Monitor to Maintenance screens can be designated using the position from the left end of menu.
If you designate a menu which is the switch destination of the menu switch (F12 key), add "Number of menu switches x 10".
For the menu No. of a Customization screen, designate the menu key No.

Standard HMI screen
Menu No. = Number of menu switches x 10 + Position from the left end of menu (1 to 10)
Customization screen
Menu No. = Menu key No. (1 to 10)

When a menu is not designated, designate "0".
When "0" is designated to the main menu No., the sub menu No. is treated as "0".
(Note 1) The menu No. is always designated from the first page.
(Note 2) When the third page is designated to the menu there are only two pages (ex. 21), the first page is a target menu page because of switching the menu twice.
(Note 3) On the Customization screen, menu changeover cannot be designated. The designated menu key is notified as a key event (KeyPress/KeyRelease event).

Menu No.	Key code to be notified		Menu No.	Key code to be notified
1	GK_F1		6	GK_F6
2	GK_F2		7	GK_F7
3	GK_F3		8	GK_F8
4	GK_F4		9	GK_F9
5	GK_F5		10	GK_F10

(Note 4) Designate the screen No. or window No. of each screen, using the offset No. of the module to display + screen (window) No.
Do not designate a window No. for screen No., and vice versa.
The offset No. is necessary to designate the screen (window) No. even if they are in the same project.
Screen (window) No. = offset of the module + screen (window) No.

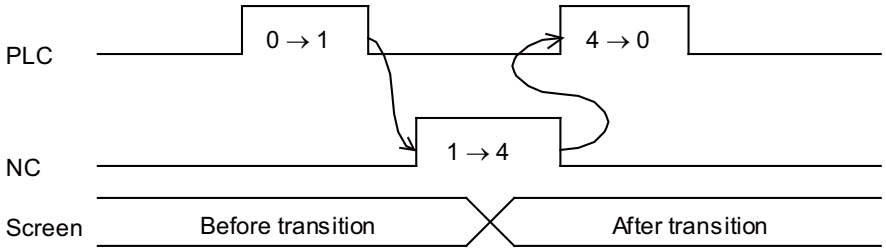
[MODULE] NUM=1 MODULE_NAME01=CUSTOM_A.DLL PAGE_OFFSET01=6500	When the 2nd window of CUSTOM_A.DLL is designated 6500 + 2 = 6502

Target No.	No. range
Function No.	1 to 5, 9, 10, 13 and 14
Main menu No.	0 to 30
Sub menu No.	0 to 70
Menu No.	0 to 10
Screen No.	0 and 6000 to 7999
Window No.	0 and 6000 to 9999 (*1)

(*1) The No. range for the Monitor screen, Setup screen and Edit screen is 0 and 8000 to 9999.

12.37.2 Timing Chart

The timing chart of the selection requirement/completion data is shown below.



(1) The screen selection completion (R356 = 4) is set after the screen transition.
(2) If the screen transition cannot be performed, the selection completion data (R356) may remain to be "1". Therefore, if there is no change over 2 seconds after the screen selection request (R356) is set to "1", set the signal to "0" with the PLC.

12.37.3 Precautions

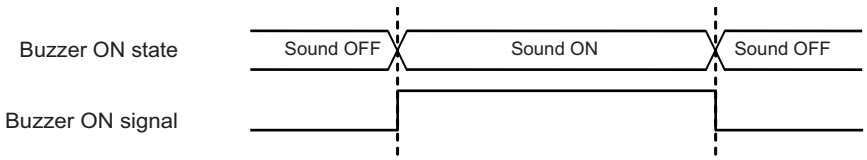
(1) The operation when the screen selection requirement while executing some processing on the screen is as same as when the key where the screen transition is generated (ex. function key) is pressed. Examples are shown below.
   (a) File editing on the Edit screen:
      The screen transits after confirming save.
   (b) Inputting/Outputting:
      The screen transits at once. Input/Output is operated on the background at this time.
   (c) During buffer correction:
      The screen transits at once. The content during buffer correction is not saved.
   (d) During operation search:
      The screen transits after finishing operation search.
(2) If the screen transition cannot be performed, no specific error is displayed or set, and the selection completion data (R356) remains to be "1". Therefore, if there is no change over 2 seconds after the screen selection request (R356 = 1), set it to "0" with the PLC. However, when the application software which requests the direct screen selection cannot be found, R356 will be set to "8".
(3) The transition to the screen where the password input is necessary to display is possible only when the password is input.
(4) If you made the setting of displaying the previously opened screen for a Customization screen, the last displayed screen will be displayed when the screen is moved to the Customization screen by designating the function No.
(5) When DIRECT_SCREEN of config.ini is "1", the following cautions are required:
   (a) When the screen is displayed by designating the window No,, close all the windows which are currently displayed.
   (b) While the modal window is displayed, the screen transition with the direct screen selection function cannot be performed.
   (c) The screen or window is not notified of the key events that are exclusive for screen transition or screen (window) display.
   (d) On the Customization screen side, the direct screen selection function cannot be suppressed.

12.37.4 Restrictions

(1) This signal is used only for the transition to each of Monitor, Setup, Edit, Diagnosis and Maintenance screens or any Customization screen. No screen transition is performed for a Customization screen of the executable file registration method.
(2) When a target main menu designation or window No. designation is not processed, the sub menu or the window No. is not designated.
(3) When a Customization menu is designated to the target main menu, the sub menu is not designated.
When a Customization menu is designated, the sub menu should designate "0". However, the window can be switched by designating the window No. when the NC Designer interpreter method/compilation method Customization window is displayed by the menu designation.
(4) When transition to the same window screen is executed, the target window screen is shut once, and is displayed again.
(5) The direct screen selection function displaying "NCDesigner interpreter method" screen by the Customization cannot correspond because there is no macro for the notification to a designated window.
(6) The menu No. (R358) setting by the direct screen selection switches the screen for the menu configuration when the menu selection parameter "#11032" is set to "0" or "1". Therefore, the screen may be switched to the screen which is not intended by MTB.
(7) When F0 screen is designated, the Customization screen is always displayed regardless of the on-board ON parameter (#6451).
(8) While NAVI Mill/Lathe is being displayed, the screen transition may not be executed depending on the operation status.

12.38 Buzzer Sound Control

This function activates a buzzer mounted on the NC keyboard by operating the PLC device (buzzer sound control (Y1C83)).
The buzzer will be activated when the PLC device is turned ON, and be deactivated when the PLC device is turned OFF.
This is effective in applications of sounding a buzzer such as during the alarm occurrence, or for the program operation end notification.
This function also activates a buzzer when the user parameter "#8126 Disable op tone" is set to "1".
This can be used when the NC keyboard is mounted.

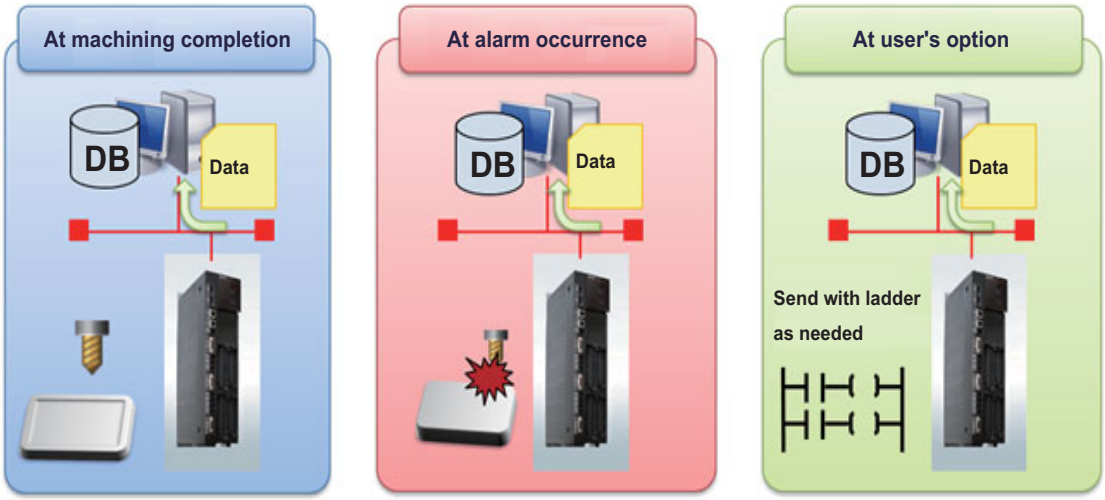


While the buzzer is activated by the PLC signal, the buzzer keeps sounding even when any of the following operations is performed:

- Screen capture operation
- Key operation
- Reset button operation
- Touchscreen operation

12.39 MES Interface Library

MES interface library function enables to link the CNC internal data with the database of information system (manufacturing execution system).
For example, it becomes possible to carry out the production management, traceability, etc. from the registered information by registering the information at the time of machining completion, alarm occurrence or user's option to the database as shown by the figure below. Also it is possible to operate the registered data in the database from the CNC.
Conventionally, data were acquired from an external computer (information system) to CNC by monitoring constantly. However, using MES interface library function, it is possible to connect the database directly without a communication gateway and to communicate the data between the CNC and database at a necessary timing.
This function is supported on CNC, and the function range is from obtaining the information at the time of machining completion, alarm occurrence or user's option to sending it to database. Screen application of database and external computer must be prepared by user side.



12.40 Power Consumption Computation

12.40.1 Outline

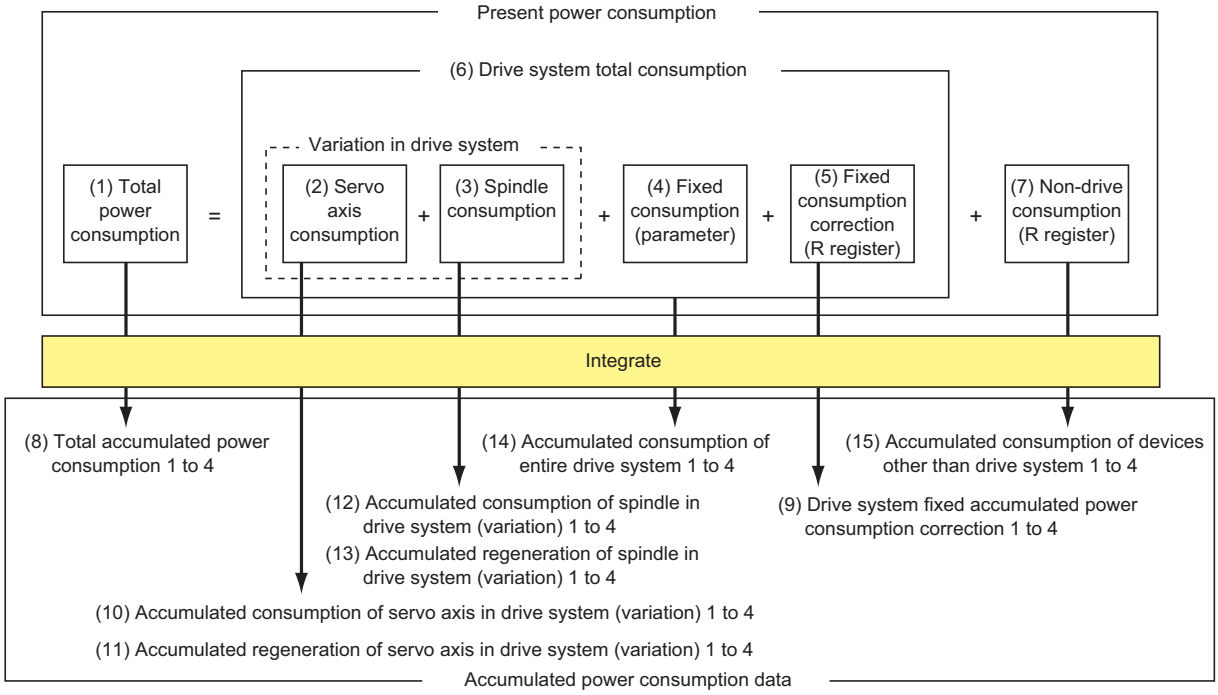
This function enables you to obtain the present power consumption and accumulated power consumption.
Power consumption means the sum of the power consumed by the drive system for rotating and moving servo axes and spindles, and that consumed by the other electrical equipment of the machine.
The present power consumption indicates the instantaneous power consumption, while the accumulated power consumption indicates the integrated value of the present power consumption.

<Present power consumption>

While the power is ON, you can obtain the present power consumption data (1) to (7) as shown below.

<Accumulated power consumption>

You can obtain the following accumulated power consumption data (8) to (15) while the power is ON that are accumulated in accordance with the signals "Power consumption computation: Enable consumption accumulation 1 to 4" (Y724 to 7: IPCE1 to 4) and "Power consumption computation: Clearing consumption accumulation 1 to 4" (Y700 to 3: IPCC1 to 4).

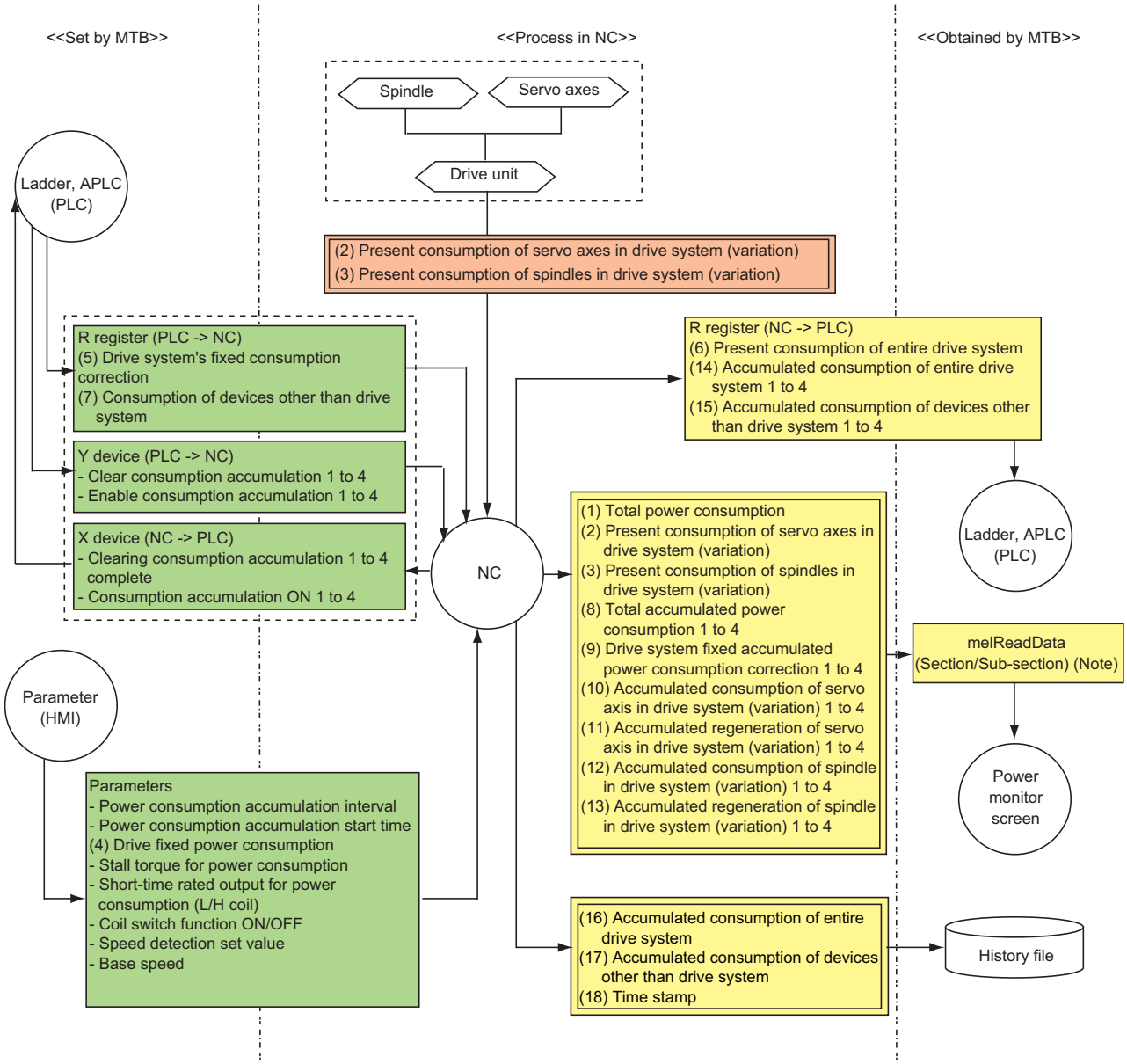


<Accumulated power consumption history>

You can obtain the following data obtained in accordance with "#1371 PwrIntegIntvl" (Power consumption accumulation interval) and "#1392 StartTimeIPC" (Power consumption accumulation start time), as a file.

Item	Correspondence with the above figure
(16) Accumulated consumption of entire drive system	Integrated value of "(6) Drive system total consumption"
(17) Accumulated consumption of devices other than drive system	Integrated value of "(7) Non-drive consumption"
(18) Time stamp (Accumulation start time)	-

As the figure below illustrates the flow of the power consumption computation process. The items (1) to (18) in this figure correspond to the items given in the previous page.



(Note) The use of custom API library function (melReadData) allows you to obtain the present power consumption data and accumulated power consumption data.

12.40.2 Power Consumption Computation Setting

When you calculate the present power consumption, accumulated power consumption 1 to 4 or accumulated power consumption history, you need to set the following parameters, R registers and control data (X and Y devices). The data to set and the control data are listed as follows.

Data to set

(1) Parameter

Parameter No.		Parameter name	Need to set		
			Present power consumption	Accumulated power consumption 1 to 4	Accumulated power consumption history
Base common	#1256	(set28/bit2) Change current FB (load) output unit	○	○	○
	#1371	Power consumption accumulation interval [hr]	-	○	○
	#1372	Fixed drive system power consumption [W]	○	○	○
	#1392	Power consumption accumulation start time [time]	-	-	○
	#1393	Efficiency for power consumption computation [%]	○	○	○
Axis spec.	#2189	Stall torque for power consumption [N・m]	○	○	○
Spindle spec.	#3146	Short-time rated output for power consumption (L-coil) [W]	○	○	○
	#3147	Short-time rated output for power consumption (H-coil) [W]	○	○	○
	#3168	Stall torque of spindle-mode servo motor for power computation [N・m]	○	○	○
Spindle	#13018	(SP018/bit5) Coil switch function ON/OFF	○	○	○
	#13028	(SP028) Speed detection set value [r/min]	○	○	○
	#13134	(SP134) Base speed [r/min]	○	○	○
	#13228	(SP228/bit 0 to 2) Load display selection	○	○	○

(2) R register (PLC -> NC)

No.	Abbrev	Register name	Need to set		
			Present power consumption	Accumulated power consumption 1 to 4	Accumulated power consumption history
R304,5	NDPC	Consumption of devices other than drive system [W]	○	○	○
R306,7	DFPCC	Drive system's fixed consumption correction [W]	○	○	○

Control data

(1) X device (NC -> PLC)

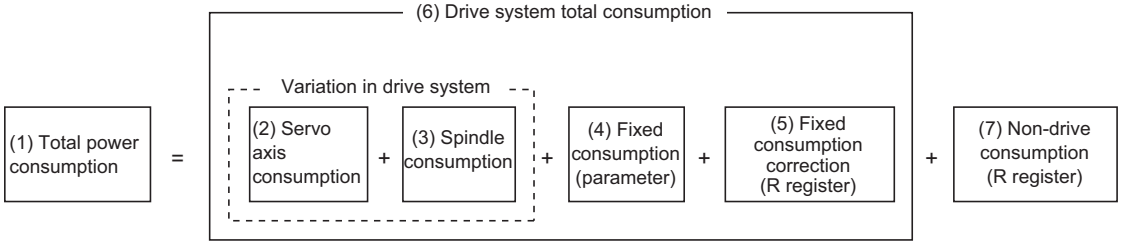
No.	Abbrev	Device name	Need to set		
			Present power consumption	Accumulated power consumption 1 to 4	Accumulated power consumption history
X700 to X703	IPCEI1 to 4	Consumption accumulation ON 1 to 4	-	○	-
X708 to X70B	IPCCC1 to 4	Clearing consumption accumulation 1 to 4 complete	-	○	-

(2) Y device (PLC -> NC)

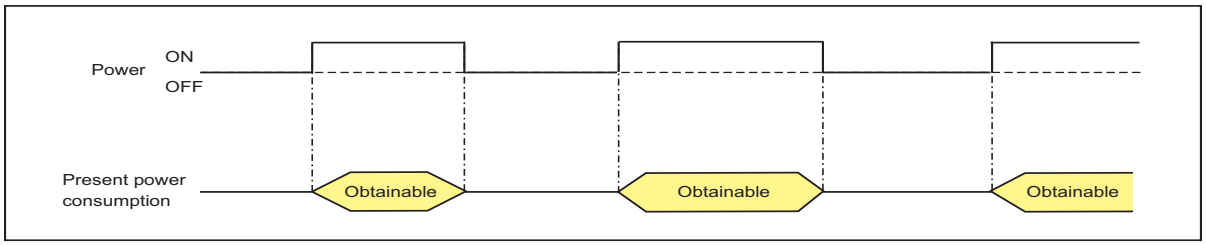
No.	Abbrev	Device name	Need to set		
			Present power consumption	Accumulated power consumption 1 to 4	Accumulated power consumption history
Y700 to Y703	IPCC1 to 4	Clearing consumption accumulation 1 to 4	-	○	-
Y724 to Y727	IPCE1 to 4	Enable consumption accumulation 1 to 4	-	○	-

12.40.3 Present Power Consumption

During the power ON, you can obtain the present power consumptions (1) to (7) as illustrated in Figure below. Among the values, a plus means power consumption, while a minus means power regeneration.



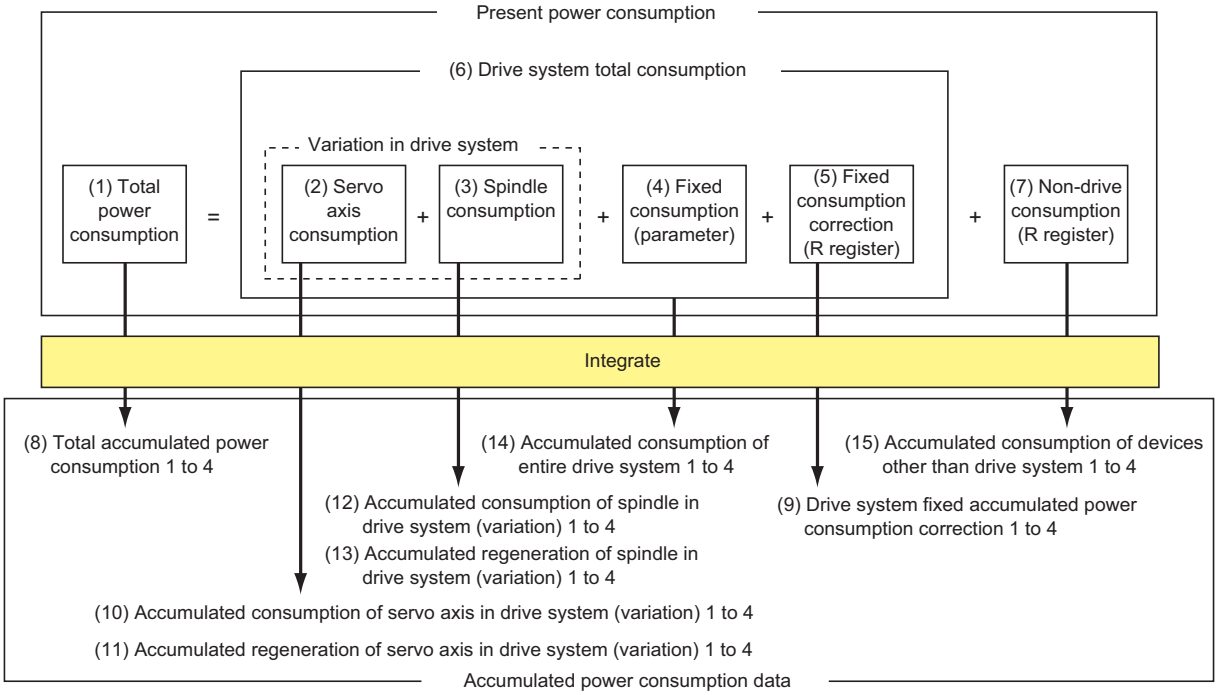
Illustrated below is a timing chart of the operation to obtain the present consumption data.



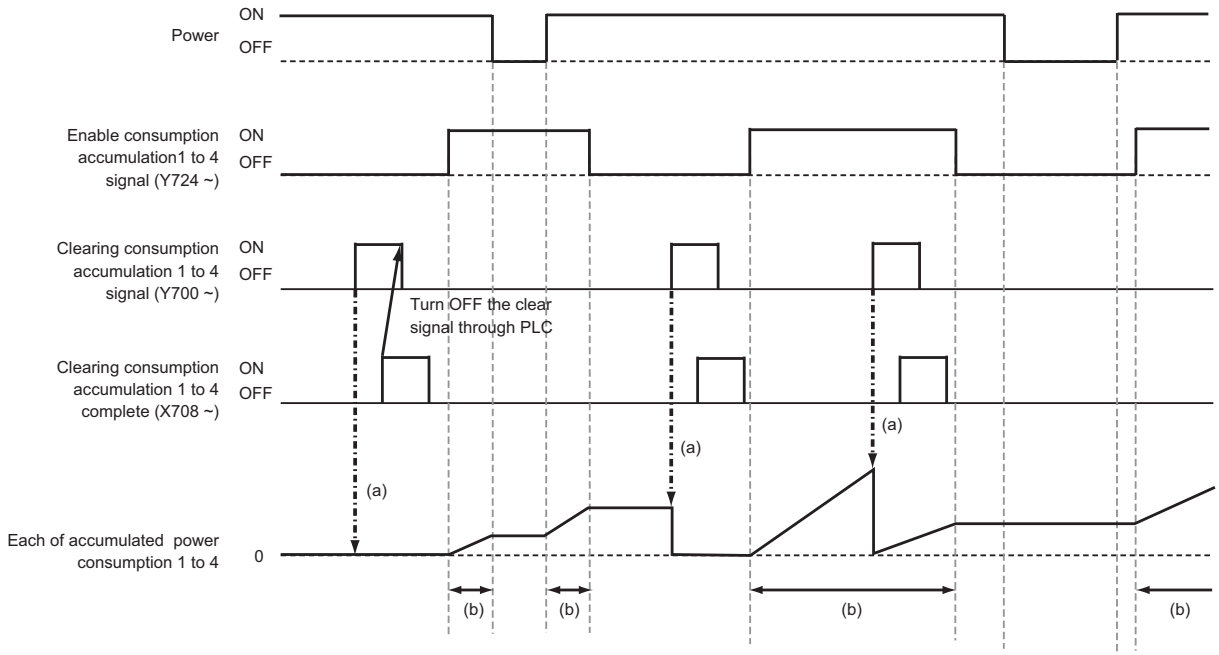
12.40.4 Accumulated Power Consumption 1 to 4

You can obtain the following accumulated power consumption data (8) to (15) while the power is ON that are accumulated in accordance with the signals "Power consumption computation: Enable consumption accumulation 1 to 4" (Y724 to 7: IPCE1 to 4) and "Power consumption computation: Clearing consumption accumulation 1 to 4" (Y700 to 3: IPCC1 to 4).

Among the values, a plus means power consumption, while a minus means power regeneration. Note however that the regeneration power (3) and (5) are expressed with positive values.



Illustrated below is a timing chart of the operation to obtain the accumulated power consumption data.



<Operation details>

(a) At the rising edge of the signal "Power consumption computation: Clearing consumption accumulation 1 to 4" (Y700 to 3: IPCC1 to 4), each of Accumulated power consumption 1 to 4 is cleared.

(b) While the power and the "Power consumption computation: Enable consumption accumulation 1 to 4" (Y724 to 7: IPCE1 to 4) are both ON, each of Accumulated power consumption 1 to 4 is integrated.

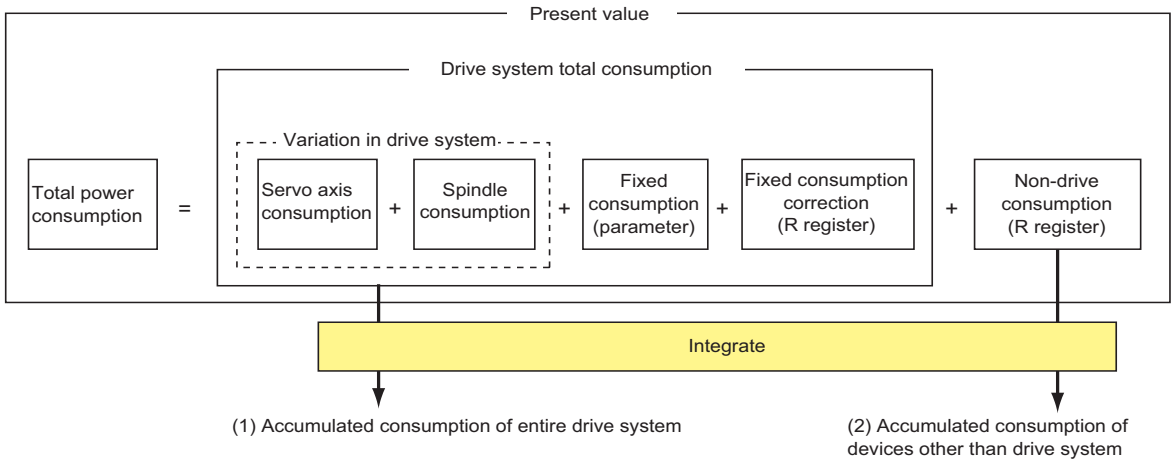
<Operation by PLC>

When the PLC turns ON the signal "Power consumption computation: Clearing consumption accumulation 1 to 4" (Y700 to 3: IPCC1 to 4), the "Power consumption computation: Clearing consumption accumulation 1 to 4 complete" (X708 to B: IPCCC1 to 4) is input to the PLC. Then the PLC turns OFF the "Power consumption computation: Clearing consumption accumulation 1 to 4" (Y700 to 3: IPCC1 to 4).

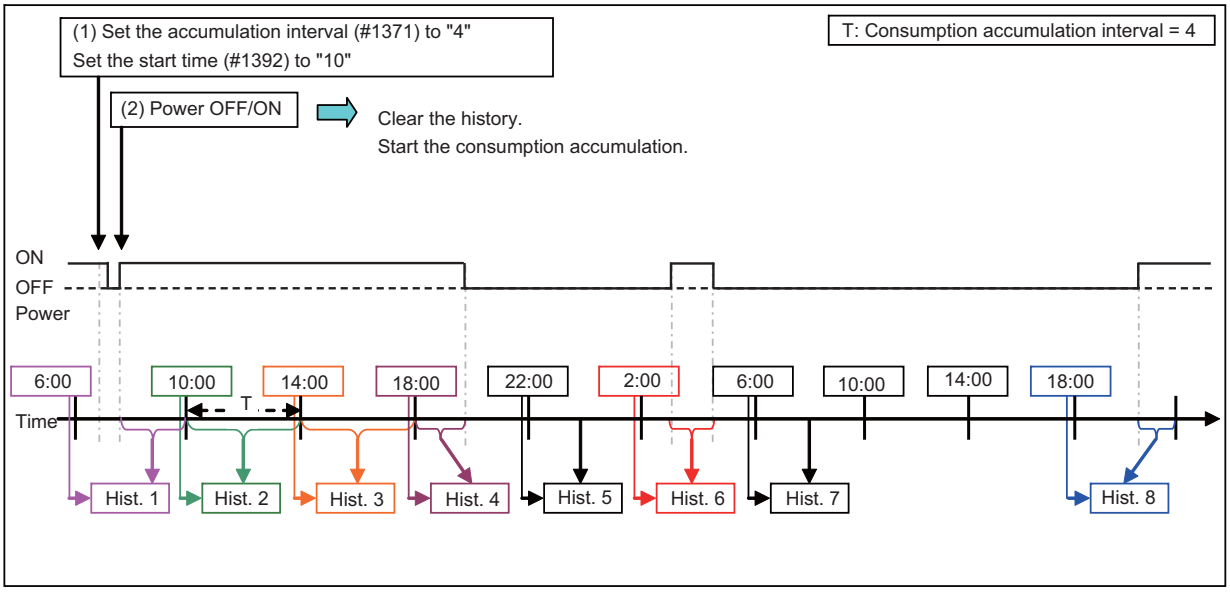
When the "Power consumption computation: Clearing consumption accumulation 1 to 4" (Y700 to 3: IPCC1 to 4) is turned OFF, the "Power consumption computation: Clearing consumption accumulation 1 to 4 complete" (X708 to B: IPCCC1 to 4) signal is also turned OFF.

12.40.5 Accumulated Power Consumption History

According to the parameters "#1371 PwrIntegIntvl" (Power consumption accumulation interval) and "#1392 StartTimeIPC" (Power consumption accumulation start time), the control records the accumulated power consumption (1) and (2) as shown in the figure below and the time stamp (Accumulation start time) in a file so that the accumulation data can be obtained as an accumulated consumption history file. Among the values, a plus means power consumption, while a minus means power regeneration.
The signals "Power consumption computation: Enable consumption accumulation 1 to 4" (Y724 to 7: IPCE1 to 4) are not used for creating the accumulated power consumption history.



Illustrated below is a timing chart of the operation to obtain the accumulated power consumption history data.



<How to start creating accumulated power consumption history>

(1) Set the "#1371 PwrIntegIntvl" (Power consumption accumulation interval) in the range of 0 to 999 [hr]. Also set the "#1392 StartTimeIPC" (Power consumption accumulation start time) in the range of 0 to 23 [o'clock]. It is not possible to specify the date with this parameter.

(2) Turn the power OFF and ON again. If you have changed the parameter setting in (1), the accumulated power consumption history is cleared, and new consumption accumulation is started. If you set the "#1371 PwrIntegIntvl" (Power consumption accumulation interval) to 0 [hr], however, the accumulation will not start.

<Operation details of accumulated power consumption history>

When creating the accumulated power consumption history starts, the time stamp (Accumulation start time) is recorded in the first history data.

After that, the accumulation continues during the power ON.

If the present time reaches the "#1371 PwrIngegIntvl" (Power consumption accumulation interval), it moves on to the next history data, records the time stamp (Accumulation start time) and performs accumulation.

Note however that if you never turn ON the power before reaching the "#1371 PwrIntegIntvl" (Power consumption accumulation interval) as "Hist. 5" and "Hist. 7" in the timing chart previously indicated, the accumulated consumption of "0" is recorded in the history data.

If you never turn ON the power before reaching the "#1371 PwrIntegIntvl" (Power consumption accumulation interval) for two or more history data in a row, as between "6:00 to 18:00" in the timing chart previously indicated, only the top data ("Hist." 7 in the timing chart) is recorded.

Changing the accumulated power consumption history-related parameter

If you change the "#1371 PwrIntegIntvl" (Power consumption accumulation interval) or "#1392 StartTimeIPC" (Power consumption accumulation start time) and then turn OFF/ON the power, the accumulated power consumption history is cleared, and new accumulated consumption history starts to be created.

If you do not turn OFF/ON the power after changing the parameter, the history is not cleared, and also the parameter change is not reflected.

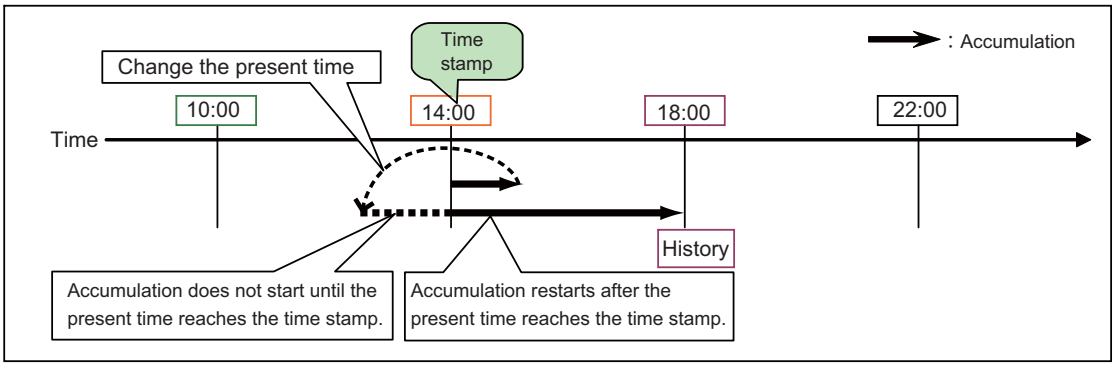
If you turn OFF and ON the power with the "#1371 PwrIntegIntvl" (Power consumption accumulation interval) set to "0", new accumulated power consumption history is not created after the clearance of the existing history.

Changing the date or time of the NC

If you change the time or date of the NC, the accumulation is resumed at the changed time. Thus the accumulated power consumption can increase or decrease by that amount.

Note that if you change the time or date backward across the time of "#1371 PwrIntegIntvl" (Power consumption accumulation interval) as illustrated in the figure below, accumulation does not start until the new time or date reaches the time stamp (Accumulation start time).

So, if accumulated power consumption history is not obtained, the time stamp (Accumulation start time) may be set ahead of the present time. If you want to perform consumption accumulation properly, change the "#1371 PwrIntegIntvl" (Power consumption accumulation interval) or the "#1392 StartTimeIPC" (Power consumption accumulation start time), turn OFF and ON the power to obtain new history.

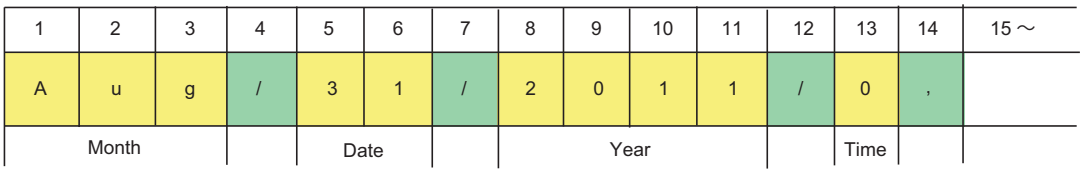


Accumulated power consumption history data

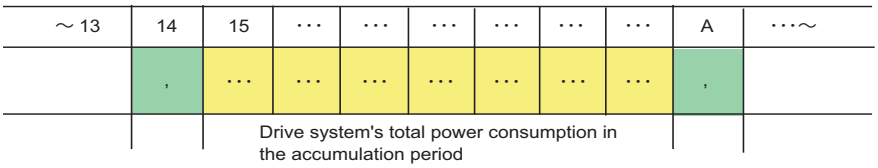
You can obtain the accumulated power consumption history under the following file name.
<File format and name>

Format	File name
CSV	M01:\LOG\PWCSP.CSV

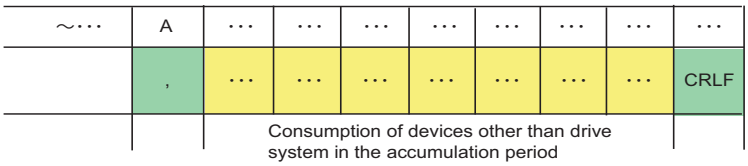
<Time stamp (Accumulation start time)>
Time stamp (Accumulation start time) is made up of "Month" (3 alphanumeric characters)/"Date" (variable number of characters)/"Year (western calendar)"/"Time" (variable number of characters) and the delimiter ",(comma)".



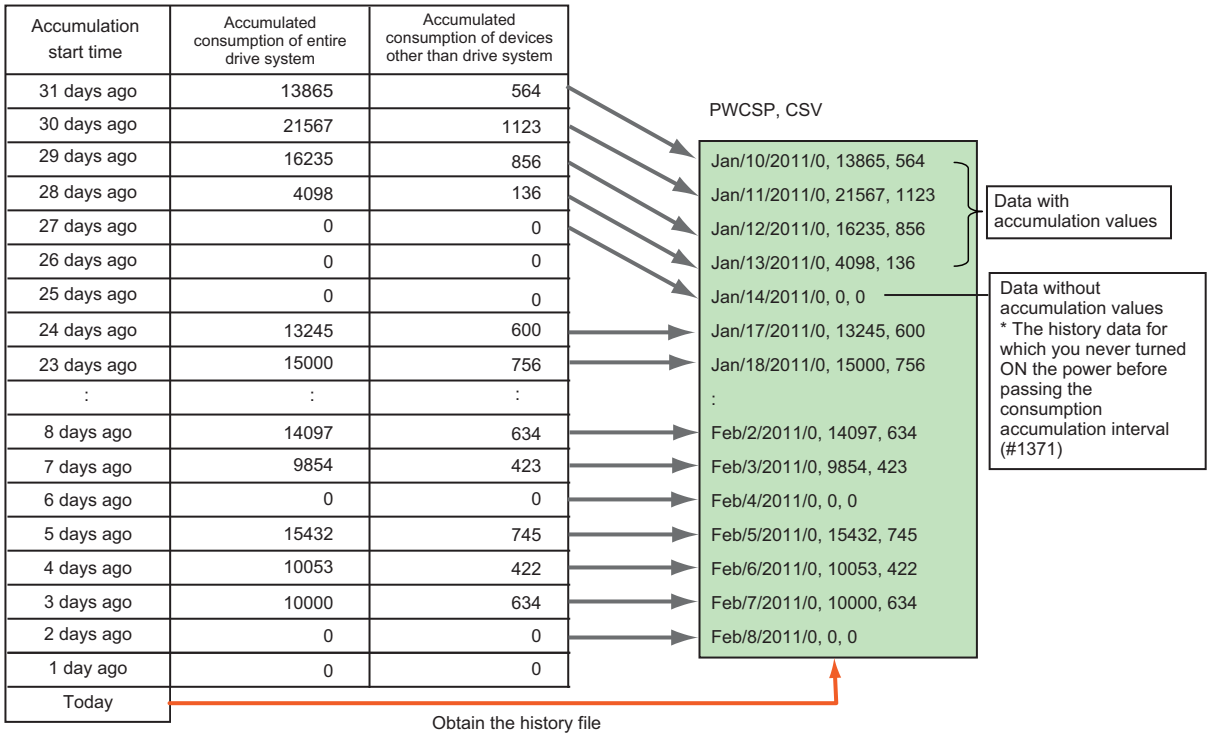
<Drive system's total power consumption in the accumulation period>
The drive system's total power consumption in the accumulation period [Wh] is recorded with "Drive system's total power consumption in the accumulation period (integer)" (variable number of characters) and the delimiter ",(comma)". The data range is from -2147483648 to 2147483647 [Wh].
If the accumulated value exceeds the minimum or maximum of the data range, the value is clamped to each limit.



<Consumption of devices other than drive system in the accumulation period>
The consumption of devices other than drive system in the accumulation period [Wh] is recorded with "Consumption of devices other than drive system in the accumulation period (integer)" (variable number of characters). The last data is a line-feed. The data range is from -2147483648 to 2147483647 [Wh].
If the accumulated value exceeds the minimum or maximum of the data range, the value is clamped to each limit.



<Example of accumulated power consumption history file>
When the "#1371 PwrIntegIntvl (Power consumption accumulation interval)" is set to "24", and the "#1392 StartTimeIPC (Power consumption accumulation start time)" is set to "0":



<Number of history data>
The data with accumulation values can be obtained up to 48 pieces. If the number of pieces to record exceeds 48, the latest data is always recorded. At this time, you can include the data without accumulation values in the middle of the history data.
However, if two or more data without accumulation values come in a row, only the top data (the data with the oldest time stamp) is displayed. The maximum number of history data is 96.
If you record the data with accumulation value and data without accumulation value alternatively, it reaches the maximum value. The top data (the data with the oldest time stamp) of the history file is always the data with accumulation value.
<Display of history data>
History data is displayed in a chronologically ascending order of the time stamp (Accumulation start time).
If up to the Nth history data have been recorded, the (N+1)th and subsequent data are not displayed. (N = 1 to 95)

12.40.6 Relation with Other Functions

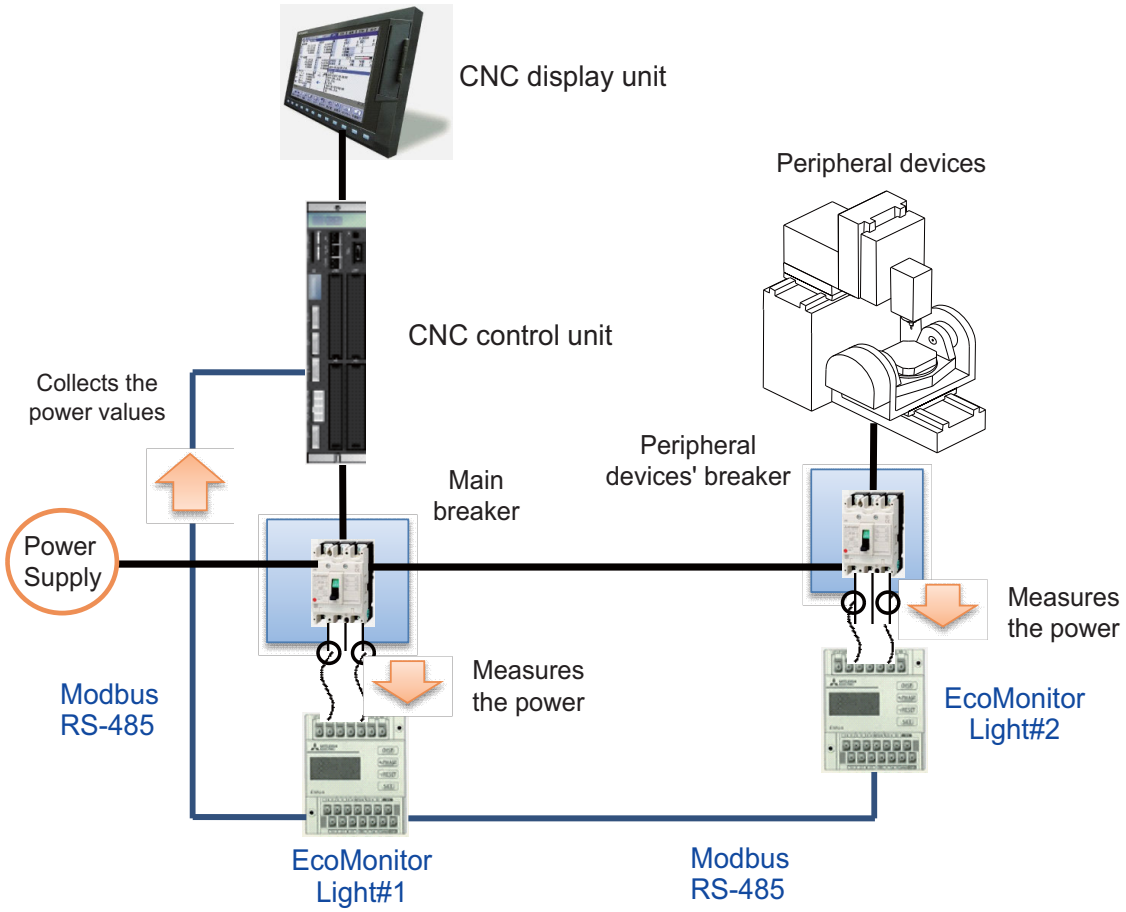
(1) Spindle position control (spindle/C axis)
The spindle power consumption covered by spindle position control (spindle C axis) can be calculated as the drive system spindle power consumption in any mode.
(2) Spindle-mode servo motor control
The spindle-mode servo axis power consumption can be calculated as the drive system spindle power consumption.
(3) NC axis/PLC axis switchover
The NC axis/PLC axis switchover axis power consumption can be calculated as the drive system servo axis power consumption in any mode.
(4) PLC axis
The PLC axis power consumption is not included in the variation in drive system. Take this into consideration in "#1372 DrvBasePwr" (Fixed drive system power consumption).
(5) PLC axis indexing
The PLC indexing axis power consumption is not included in the variation in drive system when it is used as an auxiliary axis based on the PLC axis. In addition, it can be calculated as the drive system servo axis power consumption when the NC axis is used as an auxiliary axis.

12.40.7 Precautions

(1) When you clear each of accumulated power consumption 1 to 4, and if you turn ON and then OFF the "Power consumption computation: Clearing consumption accumulation 1 to 4" (Y700 to 3: IPCC1 to 4) without checking the ON status of the "Power consumption computation: Clearing consumption accumulation 1 to 4 complete" (X708 to B: IPCCC1 to 4), accumulated power consumption 1 to 4 may not be cleared.
(2) If a spindle has the spindle/C axis control, the power consumed during C axis control is not calculated as the servo axis power consumption, but as the spindle power consumption.
(3) Set "#13228 SP228 SFNC8/bit0 to bit2" (Load display selection) to "011" (Load display High-cycle).
If you enter "000" (Normal), the power consumption is not properly calculated.
(4) If you turn OFF and ON the power with "#1371 PwrIntegIntvl" (Power consumption accumulation interval) set to "0", Accumulated power consumption is cleared.
(5) When computing data obtained by using the custom API library function (melReadData), make sure that data to be computed does not contain data obtained by section/sub-section (NC to HMI) designation and data obtained by R register (NC to PLC) designation at the same time. Failure to do so may result in a large error. To make the error smaller, use the same data designation method.
(6) If you change the NC date and time, change "#1371 PwrIntegIntvl" (Power consumption accumulation interval) or "#1392 StartTimeIPC" (Power consumption accumulation start time), and turn OFF and ON the power to start creating new history.
Correct values may not be entered in history data before and after changing the date and time.
(7) Even if you turn OFF and ON the power while accumulated power consumption history is being obtained, accumulated power consumption 1 to 4 and accumulated power consumption history before turning OFF the power are held. However, when "#1371 PwrIntegIntvl" (Power consumption accumulation interval) is set to "0", accumulated power consumption 1 to 4 are not held. In addition, when this parameter is set to "0", accumulated power consumption history is not obtained.
(8) When you change "#1371 PwrIntegIntvl" (Power consumption accumulation interval) or "#1392 StartTimeIPC" (Power consumption accumulation start time) and then turn OFF and ON the power, the accumulated power consumption history is cleared, and new accumulated power consumption history starts to be created.
(9) Set the unit output to 0.01% as the current FB (load) value output unit. The accuracy is higher than when the unit output is set to 1%.
(Set "#1256 set28/bit2" to "1".)

12.41 EcoMonitorLight Connection

EcoMonitorLight connection is a function to enable NC system to collect and manage the electric power of the machine tool which is measured by the Mitsubishi energy measuring unit "EcoMonitorLight".
The electric power (mainly consumed and regenerated power) of entire machine tool and peripheral devices can be measured by connecting EcoMonitorLight to the main breaker of the machine tool or the breaker of the peripheral devices (motor, coolant, etc.) which configure the machine tool. EcoMonitorLight can transmit each measured power value to external devices with serial communication. By establishing serial communication (Modbus) between the NC unit and EcoMonitorLight using a serial cable, the NC system can collect the power values of the entire machine tool and peripheral devices measured by EcoMonitorLight.
Consequently, the electric power in the machine tool can be finely managed, which enables energy-saving operation.



Power measurement by EcoMonitorLight and power collection by NC system

Up to 16 EcoMonitorLights are connectable in M8 Series.
The following two things are available with this function.

- Power values measured with EcoMonitorLight at a constant frequency (consumed and regenerated power values) are collected.
  Machine tool of consumed and regenerated power values can be collected from predetermined R register.
- Power values, which are measured with EcoMonitorLight by user operation other than the power values mentioned above, are collected.
  When inputting the information about the collection destination of EcoMonitorLight to R register, power values can be collected from the predetermined R register.

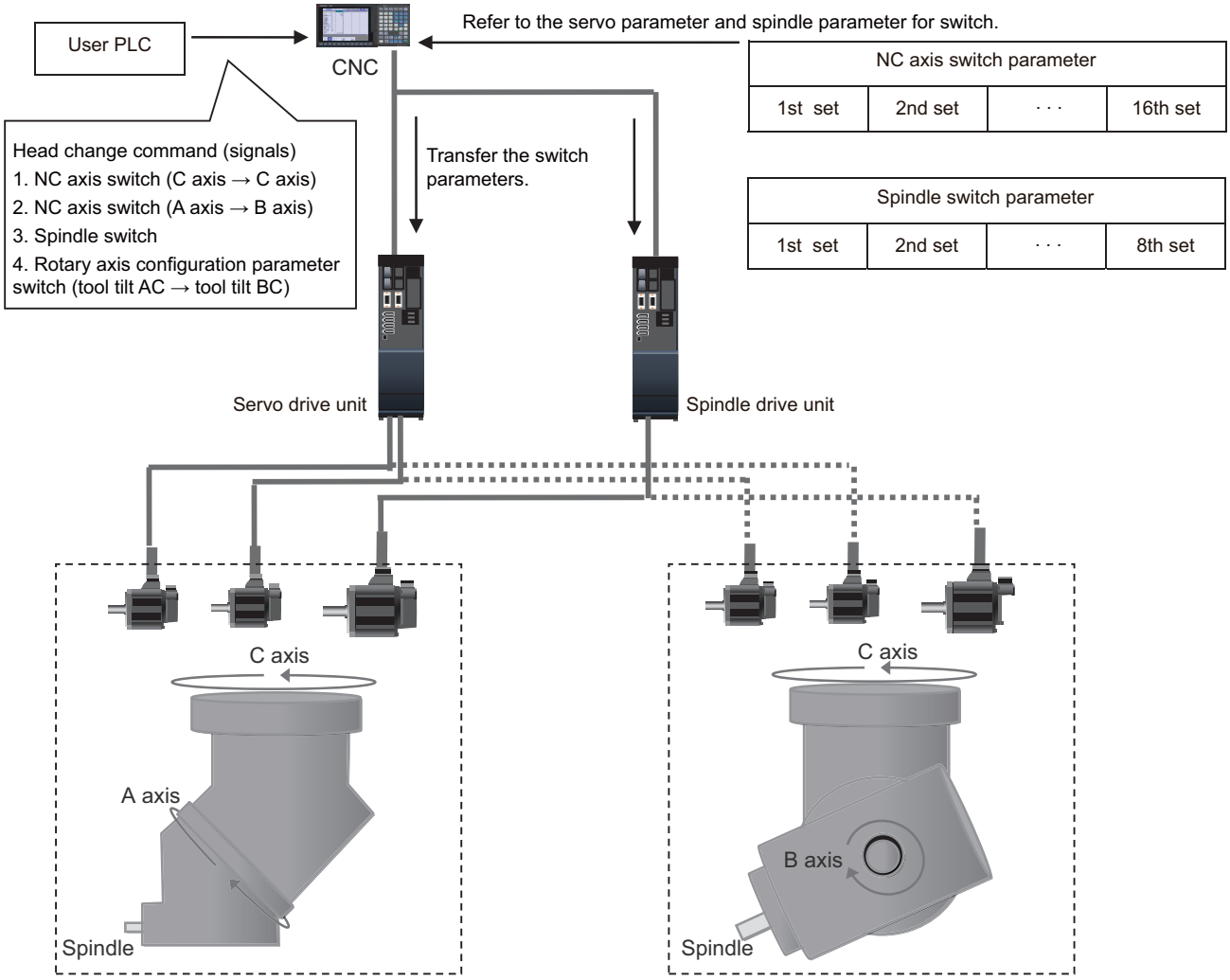
12.42 Tool Head Hot Swapping

12.42.1 Outline

This is a function to perform machining by detaching the tool head connected to the machine temporarily and attaching another tool head.
When the tool head side includes the drive sections of the rotary axis and the spindle, the tool head can be changed without turning off the NC and the drive units. In that case, the servo parameter of the rotary axis and the spindle parameter of the spindle can be changed according to the tool head to be used. When the rotary axis configuration differs depending on the tool head, the rotary axis configuration parameter can be changed.

This function is used by commanding a combination of the following three types of PLC signals. The combination of the signals needs to be selected according to the specifications of the machine head.
- NC axis switch
- Spindle switch
- Rotary axis configuration parameter switch (available only for the first part system)

[Image of tool head change including two rotary axes and spindle]

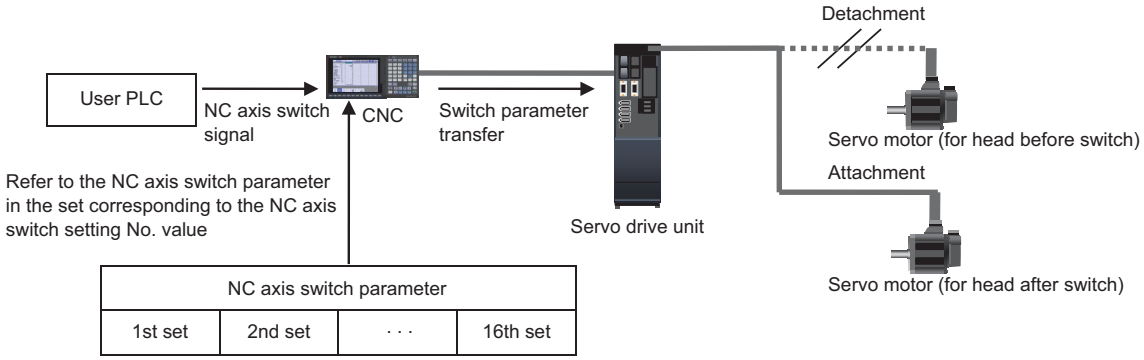


12.42.2 Function Details

12.42.2.1 NC axis Switch

NC axis switch operation

NC axis switch is a function that connects a different servo motor than before detaching the axis by changing the servo parameter while the axis is being detached.
NC axis switch is made by setting a different servo parameter for each servo motor (up to 16 sets) in the NC axis switch parameters beforehand and setting the NC axis switch parameter set No. (NC axis switch setting No.) and the switch request signal in the "Tool head hot swapping: NC axis switch" signal (R25684).
The execution status is output to the "Tool head hot swapping: NC axis switch status" signal (R25012) while the NC axis switch is being executed and when it is finished.
After the NC axis switch is finished, the NC axis loses the zero point. Therefore, the zero point establishment operation is necessary.
When the NC power is turned OFF after the NC axis switch is finished, the NC axis remains switched and therefore the NC axis switch parameter values are used for the initial communication with the drive unit when the power is turned OFF and ON.



NC axis switch parameter

■ Servo parameters for switch

The servo parameters to be transferred to the drive unit that is connected to the servo motor after the NC axis switch can be changed by setting values corresponding to the servo parameter "#2201 SV001" or later, in "#71001 SV001" or later. These parameters can be held (up to 16 sets), and the parameters in the set specified with the "NC axis switch setting number" of "Tool head hot swapping: NC axis switch" signal (R25684), are applied when the switch is made.

#	Name	Description	Setting range
71001	SV001	This parameter is used for the servo motor switched by NC axis switch. The parameter corresponds to the servo parameter #2201.	The range is the same as #2201.
71002	SV002	This parameter is used for the servo motor switched by NC axis switch. The parameter corresponds to the servo parameter #2202.	The range is the same as #2202.
		:	
71256	SV256	This parameter is used for the servo motor switched by NC axis switch. The parameter corresponds to the servo parameter #2456.	The range is the same as #2456.

■ Switch axis name

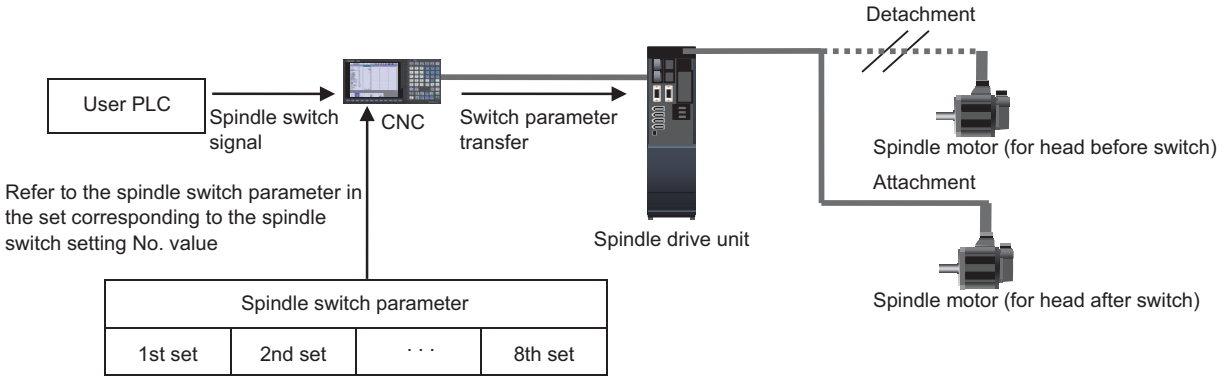
To change the axis name for specifying the servo motor after the NC axis switch in the machining program, set an axis name in "#71257 Hotaxname". If the command address changes in the machining program as a result of changing the head used, set this parameter so the machining program can be run without modifying the program.
Note that the axis name appearing on the screen is not changed.

#	Name	Operation	Setting range
71257	Hotaxname	Specify by two characters the name of the axis to be changed in NC axis switchover. The first character must be a letter because it is used as a command address. The second character must be a number.	Two digits between A to Z and 1 to 9 (When “0” is set, no change is made)

12.42.2.2 Spindle Switch

Spindle switch operation

Spindle switch is a function that connects a different spindle motor than before detaching the spindle by changing the spindle parameter while the spindle is being detached.
Spindle switch is made by setting a different spindle parameter for each spindle motor (up to 8 sets) in the spindle switch parameters beforehand and setting the spindle switch parameter set No. (spindle switch setting No.) and the switch request signal in the "Tool head hot swapping: Spindle switch" signal (R7026).
The execution status is output to the "Tool head hot swapping: Spindle switch status" signal (R6547) while the spindle switch is being executed and when it is finished.
When the NC power is turned OFF after the spindle switch is finished, the spindle remains switched and therefore the spindle switch parameter values are used for the initial communication with the drive unit when the power is turned OFF and ON.



Spindle switch parameter

■ Spindle parameters for switch

The spindle parameters to be transferred to the drive unit that is connected to the spindle motor after the spindle switch can be changed by setting values corresponding to the spindle parameter "#13001 SP001" or later, in "#71501 SP001" or later. These parameters can be held (up to 8 sets), and the parameters in the set specified with the "Spindle switch setting number" of "Tool head hot swapping: Spindle switch" signal (R7026), are applied when the switch is made.

#	Name	Description	Setting range
71501	SP001	This parameter is used for the spindle motor switched by spindle switch. The parameter corresponds to the spindle parameter #13001.	The range is the same as #13001.
71502	SP002	This parameter is used for the spindle motor switched by spindle switch. The parameter corresponds to the spindle parameter #13002.	The range is the same as #13002.
		:	
71740	SP240	This parameter is used for the spindle motor switched by spindle switch. The parameter corresponds to the spindle parameter #13240.	The range is the same as #13240.

12.42.2.3 Rotary Axis Configuration Parameter Switch

Rotary axis configuration parameter switch operation

To attach a head for performing a five-axis machining operation with a different rotary axis configuration by tool head hot swapping, it can be done by using the PLC designation method in the rotary axis configuration parameter switch function. Refer to the specification manual on the tool center point control for the details on the "Rotary axis configuration parameter switch" signal (R2615). Five-axis control can be performed by using the rotary axis configuration parameter switch according to each head configuration even when attaching a head with a different rotary axis configuration, tilt angle, etc.
For systems where the tool head hot swapping specification is available, the rotary axis configuration parameter used for the switch can be used by setting configuration parameter of the part system that is not valid, and a total of up to 8 sets including the configuration parameters in the valid part system can be held.
(Example) To use four types of configuration in one part system, set the rotary axis configuration parameters for the part systems 2 to 4, in addition to the usual rotary axis configuration parameter for the part system 1.

To use this function, it is necessary to satisfy all the conditions below.

- A value is set in "#1022 2nd Axis Name".
- "#1450 5axis_Spec/bit0" is set to "1" (the axis names of the rotary axis configuration parameter are set in "2nd Axis Name").
- "#1450 5axis_Spec/bit2" is set to "1" (PLC designation method is used for the rotary axis configuration parameter switch).
- The rotary axis configuration parameter is set according to the setting value of the "2nd Axis Name".

When making a rotary axis configuration parameter switch according to the tool head hot swapping specification, the orthogonal axis configuration parameter cannot be changed. When making the switch by specifying a configuration parameter of the part system that is not valid, where the orthogonal axis setting differs, the orthogonal axis setting is not applied.

[Settings]

Axis name setting (1-part system)

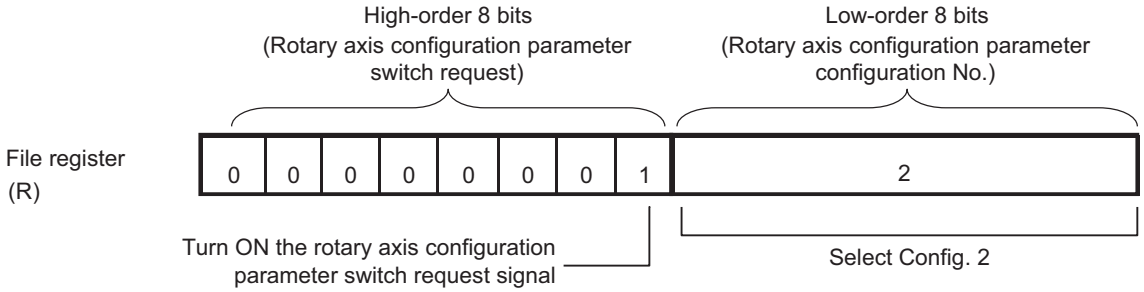
Axis order	#1022
1	X1
2	Y1
3	Z1
4	B1
5	C1

Rotary axis configuration parameter (tool tilt type)

	Config.1	Config.2
#7900 RCDAX_I	X1	X1
#7901 RCDAX_J	Y1	Y1
#7902 RCDAX_K	Z1	Z1
#7920 SLCT_T1	3	3
#7922 ROTAX_T1	C1	C1
#7930 SLCT_T2	2	1
#7932 ROTAX_T2	B1	A1

Config.1: Set according to the axis configuration of the part system
Config.2: Set the configuration for switch

["Rotary axis configuration parameter switch" signal (R2615)]



12.42.2.4 Tool Head Exchange Use Example

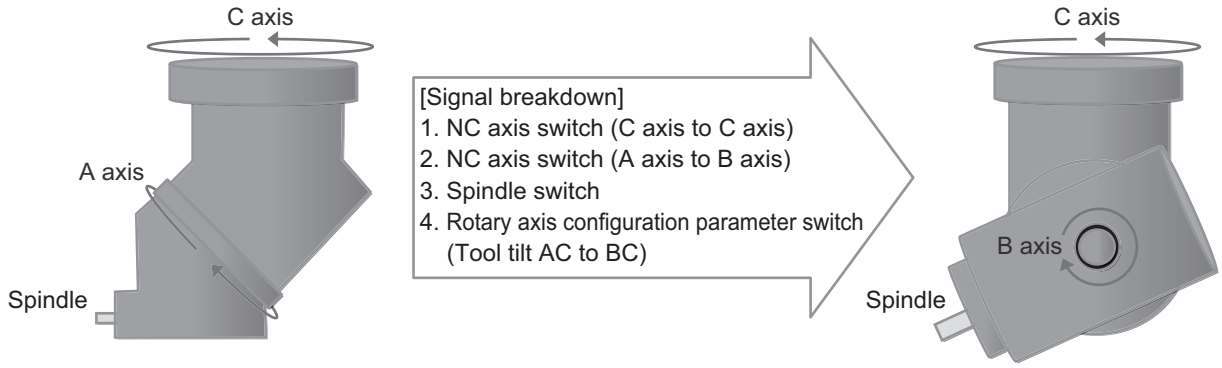
To actually make the tool head exchange, signals must be selected according to the head to be switched.

The following abbreviated names are used for the signals dedicated to the tool head hot swapping in this section.

Name in this section	Official signal name	Device No.
NC axis switch	Tool head hot swapping: NC axis switch	R25684 to R25715
NC axis switch status	Tool head hot swapping: NC axis switch status	R25012 to R25043
Spindle switch	Tool head hot swapping: Spindle switch	R7026 to R7376
Spindle switch status	Tool head hot swapping: Spindle switch status	R6547 to R6897

Example 1: When swapping to a head with a different rotary axis configuration

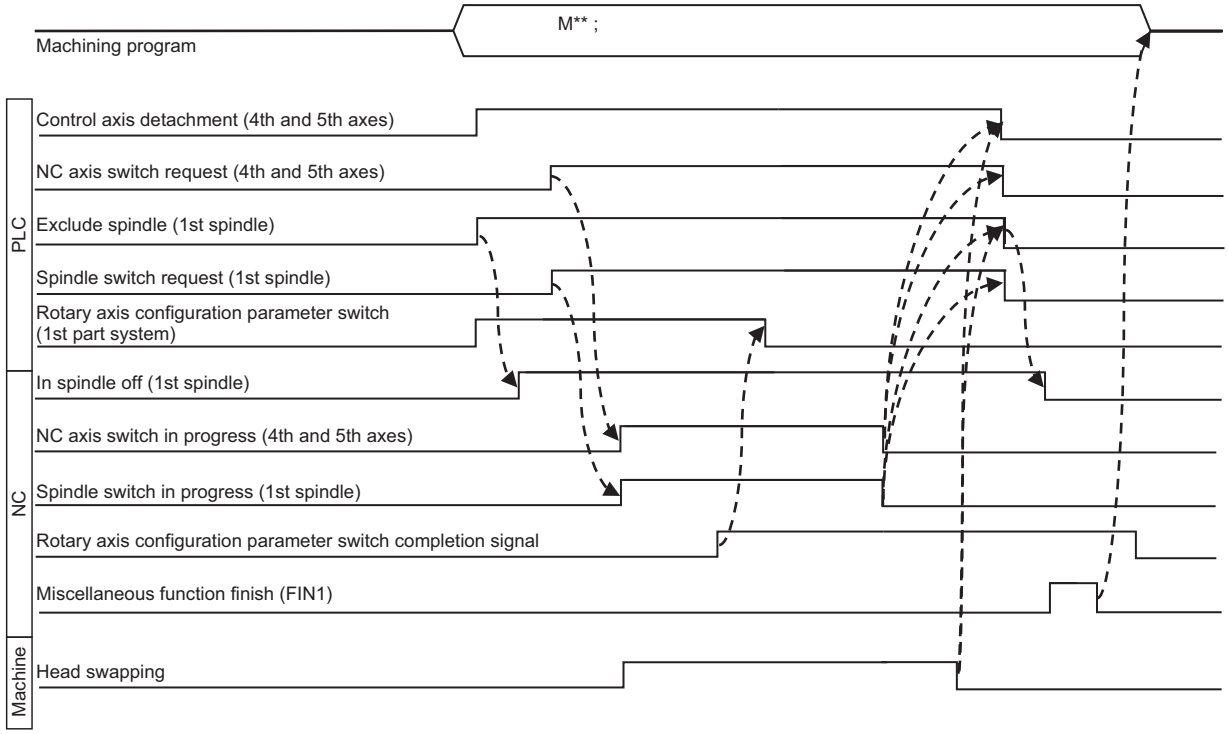
For a head swapping with the rotary axis configuration parameter changed, give the head swapping instruction by making all switches – NC axis switch for the two rotary axes, spindle switch, and rotary axis configuration parameter switch.



An example for the signals used to make the head swapping is as follows.

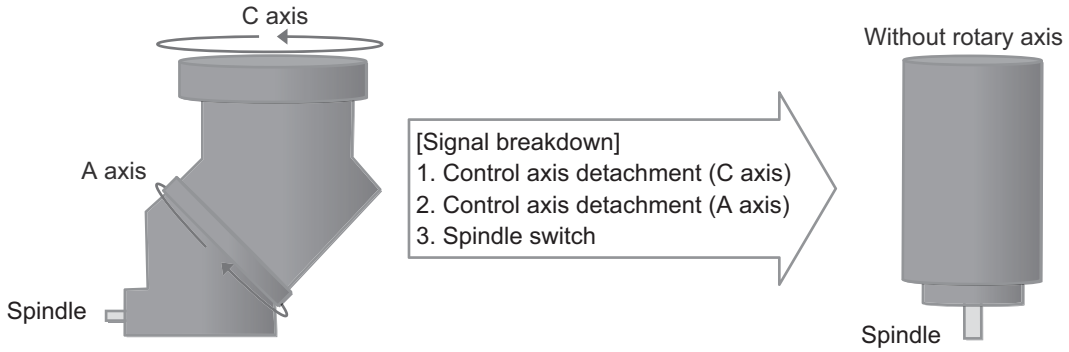
Signal name	Device No.	Value to set	Supplement
Control axis detachment 4th axis	Y783	1	The 4th axis is not controlled.
NC axis switch 4th axis	R25687	0x0101	Make the NC axis switch for the 4th axis using the NC axis switch parameter in the 1st set.
Control axis detachment 5th axis	Y784	1	The 5th axis is not controlled.
NC axis switch 5th axis	R25688	0x0102	Make the NC axis switch for the 5th axis using the NC axis switch parameter in the 2nd set.
Exclude spindle 1st spindle	Y18BF	1	The spindle is not controlled.
Spindle switch 1st spindle	R7026	0x0101	Make the spindle switch using the spindle switch parameter in the 1st set.
Rotary axis configuration parameter switch	R2615	0x0102	Make the rotary axis configuration parameter switch using the rotary axis configuration parameter in the 2nd set.

The following figure shows an example of a timing chart when a head swapping is made using the M code, where the rotary axis configuration parameter changes in a tool head composed of the rotary axes for the 4th axis and the 5th axis, and the 1st spindle.



Example 2: When swapping to a head with a small number of control axes

When making the switch from a head including two rotary axes (the 4th and the 5th axes are rotary axes) to a head including no rotary axis, do not make the NC axis switch but only the axis detachment and spindle switch. Note that the rotary axis configuration parameter switch does not need to be made.

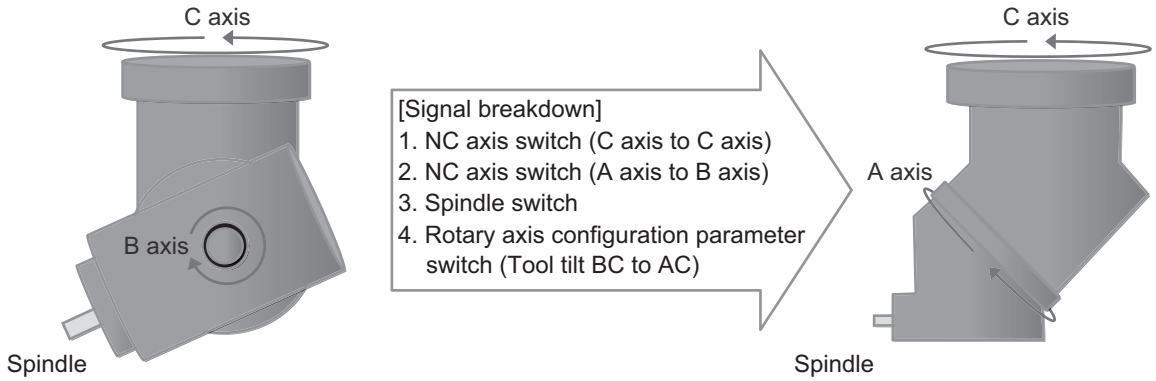


An example for the signals used to make the head swapping is as follows.

Signal name	Device No.	Value to set	Supplement
Control axis detachment 4th axis	Y783	1	The 4th axis is not controlled.
Control axis detachment 5th axis	Y784	1	The 5th axis is not controlled.
Exclude spindle 1st spindle	Y18BF	1	The spindle is not controlled.
Spindle switch 1st spindle	R7026	0x0103	Make the spindle switch using the spindle switch parameter in the 3rd set.

Example 3: When restoring the status before the head swapping

To restore the status before the head swapping from the status where a different head is connected by head swapping, set the "NC axis switch setting number" and "spindle switch setting number" to "0" and then make the switch.



An example for the signals used to make the head swapping is as follows.

Signal name	Device No.	Value to set	Supplement
Control axis detachment 4th axis	Y783	1	The 4th axis is not controlled.
NC axis switch 4th axis	R25687	0x0100	Make the NC axis switch for the 4th axis using the usual servo parameter.
Control axis detachment 5th axis	Y784	1	The 5th axis is not controlled.
NC axis switch 5th axis	R25688	0x0100	Make the NC axis switch for the 5th axis using the usual servo parameter.
In spindle off 1st spindle	Y18BF	1	The spindle is not controlled.
Spindle switch 1st spindle	R7026	0x0100	Make the spindle switch using the usual spindle parameter.
Rotary axis configuration parameter switch	R2615	0x0101	Make the rotary axis configuration parameter switch using the rotary axis configuration parameter in the 1st set.

12.42.3 Relation with Other Functions

12.42.3.1 NC Axis Switch-related Functions

- Synchronous control
  To make the head swapping including synchronously controlled master and slave axes, make the NC axis switch by specifying both the master and slave axes.
- Arbitrary axis exchange control
  Arbitrary axis exchange and NC axis switch cannot be made at the same time. If the NC axis switch is made for the axes of a part system where an arbitrary axis exchange is being made, the operation error (M01 1260) occurs. Furthermore, if an arbitrary axis exchange is made while an axis exchanged by NC axis switch exists, the program error (P501) occurs.
- Absolute position detection
  The NC axis switch cannot be made for the absolute position detection axis. The setting value in "#2049 type" for the axis for which the NC axis switch is made must be "0".
- Axis name extension
  If the NC axis switch is made for the name extension axis when the axis name extension is enabled, and the command address is changed by "#71257 Hotaxname", the change is reflected in the 1st character.
  (Example) When the switch axis name "B2" is set for the axis with the extension axis name "AS" and the switch is made, the command address is "BS".
- Program restart
  When the axis name is changed by NC axis switch while the program is running, the program restart by specifying a block before the change cannot be performed.
- Spindle position control (spindle/C axis control)
  The NC axis switch cannot be made for the NC axis for which the spindle position control (spindle/C axis control) is enabled. When the NC axis switch request is made for the NC axis for which the spindle position control is enabled, the operation error (M01 1260) occurs.
- Spindle-mode rotary axis control
  The NC axis switch cannot be made for the NC axis for which the spindle-mode rotary axis control is enabled. When the NC axis switch request is made for the NC axis for which the spindle-mode rotary axis control is enabled, the operation error (M01 1260) occurs.
- Graphic check
  When the axis name is changed by NC axis switch, the graphic check function cannot be used at the same time.
- 3D machine interference check
  When the configuration of a head to be connected is switched by NC axis switch, the 3D machine interference check cannot be used at the same time.

12.42.3.2 Spindle Switch-related Functions

- Spindle position control (spindle/C axis control)
  The spindle switch cannot be made for the spindle for which the spindle position control (spindle/C axis control) is enabled. When the spindle switch request is made for the spindle for which the spindle position control is enabled, the operation error (M01 1261) occurs, and the 1st part system stops running.
- Spindle-mode servo motor control
  The spindle switch cannot be made for the spindle for which the spindle-mode servo control is enabled. When the spindle switch request is made for the spindle for which "#3139 sp_srvdrv" is set to "1", the operation error (M01 1261) occurs, and the 1st part system stops running.
- Spindle-mode rotary axis control
  The spindle switch cannot be made for the spindle for which the spindle-mode rotary axis control is enabled. When the spindle switch request is made for the spindle for which the spindle-mode rotary axis control is enabled, the operation error (M01 1261) occurs, and the 1st part system stops running.

- Spindle synchronization control/tool spindle synchronization control
  When making the spindle switch for the spindle that uses the following functions, cancel the synchronization first and then make the spindle switch.
  - Spindle synchronization I
  - Spindle synchronization II
  - Tool spindle synchronization IA (Spindle-Spindle, Polygon)
  - Tool spindle synchronization IB (Spindle-Spindle, Polygon)
  - Tool spindle synchronization IC (Spindle-NC axis, Polygon)
  - Tool spindle synchronization II (Hobbing)

12.42.3.3 Rotary Axis Configuration Parameter Switch-related Functions

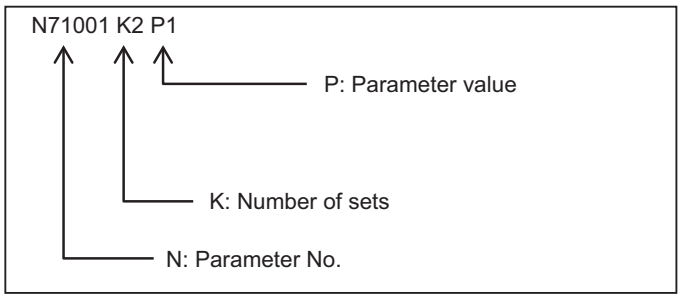
When using the following functions with a machine that uses this function, make the rotary axis configuration parameter switch while these functions are not running. When the rotary axis configuration parameter switch request is made while these functions are running, the operation error (M01 0187) occurs, and the switch cannot be made.

- Tool center point control
- Inclined surface machining command
- Workpiece installation error compensation
- Tool length compensation along the tool axis
- Simple inclined surface machining command
- 3-dimensional tool radius compensation (tool's vertical-direction compensation)
- 3-dimensional manual feed
- Tool handle feed & interruption
- R-Navi

12.42.3.4 Parameter Input/Output

- NC axis switch parameter/spindle switch parameter
  File input/output can be performed in the following format for the NC axis switch and spindle switch parameters. Note that output can be performed only with systems where this function specification is available.

```
N71001K1P1
N71002K1P1
N71003K1P33
N71004K1P0
N71005K1P100
:
N71001K2P1
N71002K2P1
N71003K2P33
N71004K2P0
N71005K2P100
:
N71501K1P15
N71502K1P33
N71503K1P15
N71504K1P0
N71505K1P150
:
N71501K2P0
N71502K2P0
N71503K2P0
N71504K2P0
:
```



- Rotary axis configuration parameter
  Eight sets of rotary axis configuration parameters are output with a system where this function specification is available, and the number of parameters identical to the number of valid part systems are output with a system where this function specification is not available.

12.42.4 Precautions

(1) To make the NC axis switch and spindle switch, the target NC axis or spindle must be in a detached status. If the switch request is made for the NC axis or spindle that is not in a detached status, the target NC axis or spindle is not switched and the switch parameter is not transferred. Note that the switch operation starts if the NC axis or spindle for which the switch request is ON is detached.

(2) The setting values for the axis specification parameter, spindle specification parameter, etc. are not changed by NC axis switch and spindle switch. If the axis specification parameter and spindle specification parameter must be changed as a result of the tool head swapping, perform the modification operation separately using parameter input by program, etc.

(3) Perform the NC axis switch and spindle switch operation according to the signal timing chart. In particular, if the detachment is canceled while the NC axis switch or spindle switch is not finished, the servo error (S01 0039) occurs.

(4) For machines where the head swapping is made using this function, set the number of axes according to the configuration with the maximum number of control target axes. When using a head with a smaller number of axes by head swapping, make sure the unused axes are in a detached status.

(5) The NC axis switch is a function dedicated to the rotary axes included in the tool head. Therefore, the NC axis switch signal is disabled for the linear axis.

(6) To make the rotary axis configuration parameter switch as a result of the tool head swapping, the machine configuration must be tool tilt type. If the switch is made by specifying a configuration other than the tool tilt type, the operation error (M01 0186) occurs.

(7) The automatic adjustment function of NC Analyzer cannot adjust the NC axis switch parameter and spindle switch parameter.

(8) The rotary axis configuration parameter switch in this function can be used only for the 1st part system; therefore, use the "Rotary axis configuration parameter switch" signal (R2615).

(9) The configuration used for the rotary axis configuration parameter switch in this function must be set for the part system other than the valid part systems. For example, when using it in a 2-part system, set the configuration for the switch in this function in the 3rd part system or after that.

(10) The full-closed loop and semi-closed loop setting switch of the servo drive unit cannot be made by NC axis switch. Do not make the switch using the full-closed and semi-closed loop settings of the NC axis switch parameter that differ from the settings of the servo parameter in use.

(11) The values of "In-use NC axis switch setting number" (R25012/low-order 8 bits) and "In-use spindle switch setting number" (R6547/low-order 8 bits) are held in SRAM.BIN of the data backed up using the NC data backup function. To restore the backed-up data, do it while the same motor as when backup was obtained is connected.

(12) To make the switch to a configuration including an axis that was in a detached status when the power is turned ON, give the NC axis switch instruction for that axis and then cancel the axis detached status. If the axis detached status is canceled without giving the NC axis switch instruction, the initial parameter error (S02) occurs.

(13) If the initial parameter error (S02) occurs in the NC axis or spindle for which the NC axis switch or spindle switch is made, correct the NC axis switch parameter (#71001 and later) and the spindle switch parameter (#71501 and later) rather than the servo parameter (#2201 and later) and the spindle parameter (#13001 and later).

12.43 Brake Wear Diagnostics

12.43.1 Outline

This function diagnoses the wear state of a brake installed on each axis of the machine tool.
When a machine runs for a long time, the brake body and the fitting hub are gradually worn. The degree of brake wear is diagnosed by measuring the amounts of rattling and slipping which increase as the wear progresses.

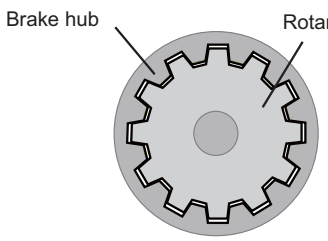
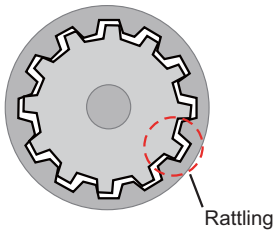
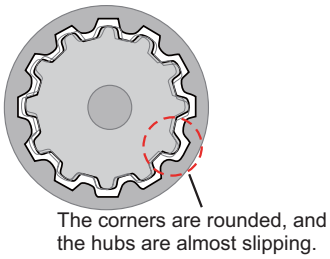
The three levels of Normal, Caution and Warning are output as the diagnosis result.

Normal state	The rattling of the brake is within the normal range.
Caution state	PLC is informed that the brake is in the caution state. Automatic operation is possible.
Warning state	PLC is informed that the brake is in the warning state. Automatic operation is not possible.

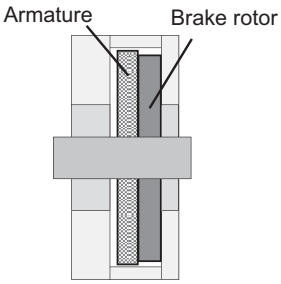
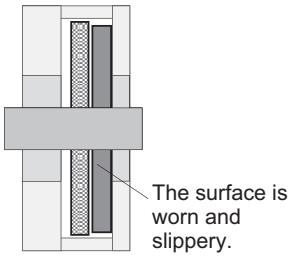
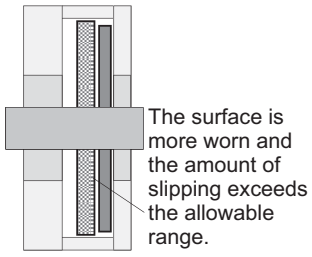
By executing this function periodically, the amounts of rattling and slipping caused by the brake wear can be maintained within the proper range.
All the diagnosis results are output to PLC. By combination with PLC program, it is possible to inform users of the time to change the brake before it is broken.

This function has a timer function. After a certain period of time has passed since the diagnosis, a signal prompting the next diagnosis is output to PLC. This makes periodic brake wear diagnosis by combination with PLC program.

[Wear state and diagnosis result of brake fitting hub]

Normal state	Caution state	Warning state
		

[Wear state and diagnosis result of brake rotor and armature]

Normal state	Caution state	Warning state
		

[Term]

Terms used in this function explanation have the following meanings.

Term	Description
Brake effectiveness	Ability to stop movement of the axis when brake is applied
Warning state	State where the brake is worn and the amount of rattling/slipping exceeds the allowable amount when the brake is applied The axis might not stop even when the brake is applied. Automatic operation is not possible.
Caution state	State before it turns to the warning state The brake is worn and the amount of rattling/slipping has started increasing. <Note> • Whether or not automatic operation is possible in this state depends on the MTB specifications.
Excessive error detection width for brake wear diagnostics	Excessive error detection width during brake wear diagnostics It is switched at the start of the brake wear diagnostics, and returns to the value of "#2223 SV023 OD1" (Excessive error detection width during servo ON) at the end.
Brake wear diagnostics interval	Time from when the brake wear diagnostics is normally completed till when the signal ("Brake wear diagnostics: Diagnosis incomplete (control axis)" signal (ZR9604, ZR9605)) prompting the next diagnosis turns ON
Brake wear diagnostics result alarm	Alarm that occurs when an error is detected in a brake as a result of the brake wear diagnostics There are the following two types. • Operation error (M01 0371) • Operation warning (M50 5006)

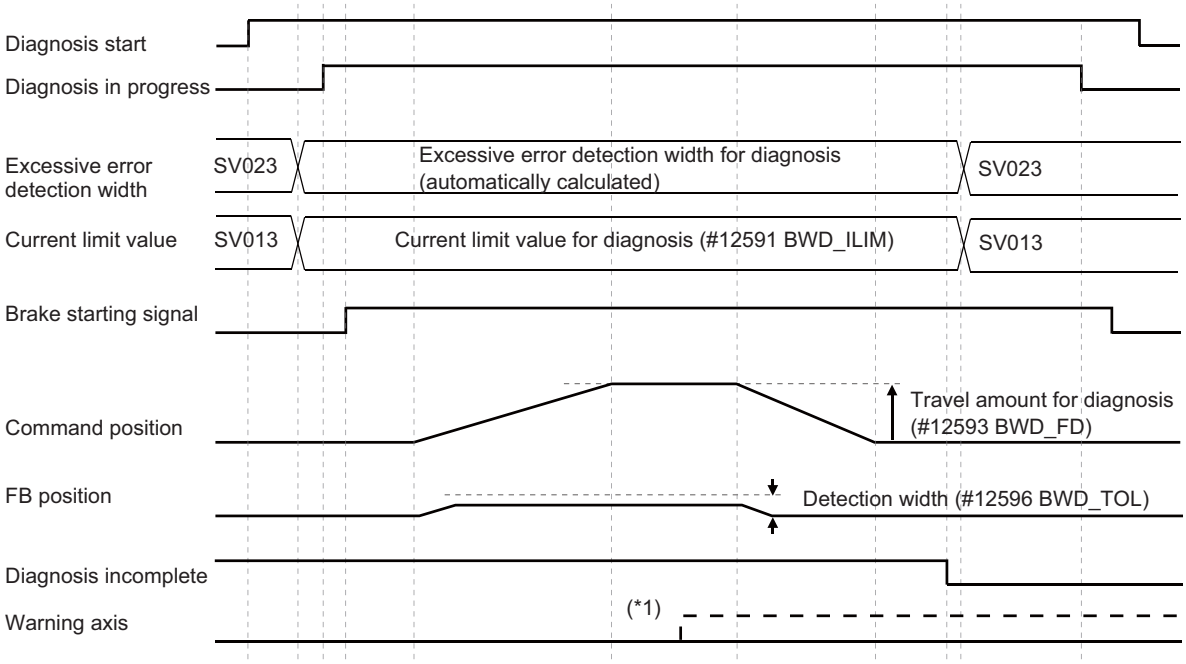
12.43.2 Function Details

This function is executed for each axis by using PLC signals.

When the diagnosis start is commanded, the current limit value and the excessive error detection width are changed to values for diagnosis. While the brake is applied, the movement command for diagnosis is output to the target axis from the NC unit. The brake wear state is diagnosed by measuring the change amount at the FB position according to the movement command.

The current limit value, movement command direction and movement amount for diagnosis are defined with parameters by MTB. To periodically perform the diagnosis, it is possible to set the brake wear diagnostics interval to output a notification prompting the next diagnosis according to the time that has passed since the last diagnosis.

[Operation sequence of brake wear diagnostics]



(*1) It turns ON when the diagnostics result is in the caution state or warning state.

12.43.2.1 Function Enabling Conditions

This function can be executed only for servo axis where "#12590 BWD_Enable" (Brake wear diagnostics ON) is enabled.
There are the following two methods depending on the brake connection method.

Method	Description
External relay circuit method (#12590 BWD_Enable = 1)	This is available for both external brake and motor brake. Execute it for an axis where a brake that can be controlled by RIO signals is mounted.
In-drive-unit control circuit method (#12590 BWD_Enable = 2)	This is available for motor brake only. Execute it for an axis where a motor brake is mounted and brake control is available Depending on the motor brake control method, the brake is applied simultaneously to all the axes connected to the same drive unit. For details on drive unit for this method, refer to [In-drive-unit control circuit method].

This function is not available in a system where the smart safety observation is enabled. When the smart safety observation is enabled, use the safe brake test (SBT).

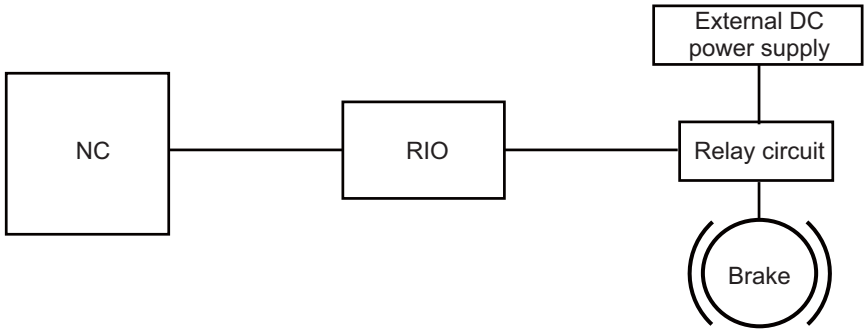
[External relay circuit method]

The machine configuration expected in this method is as follows.

(1) External brake

Wire the relay circuit for brake control by RIO between the DC power supply for brake unit control and the brake.

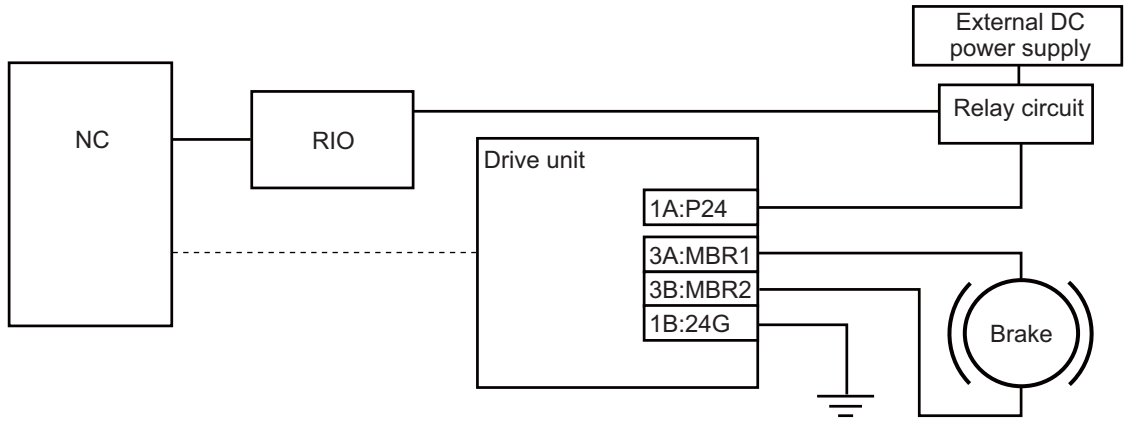
[Machine configuration example of motor with external brake]



(2) Motor brake

Wire the relay circuit for brake control by RIO between the DC power supply for brake unit control and the servo drive unit.

[Machine configuration example of motor with motor brake]



<Note>

- This is an example of wiring when a brake of one axis is driven. For details of the motor brake wiring, refer to your drive unit instruction manual.

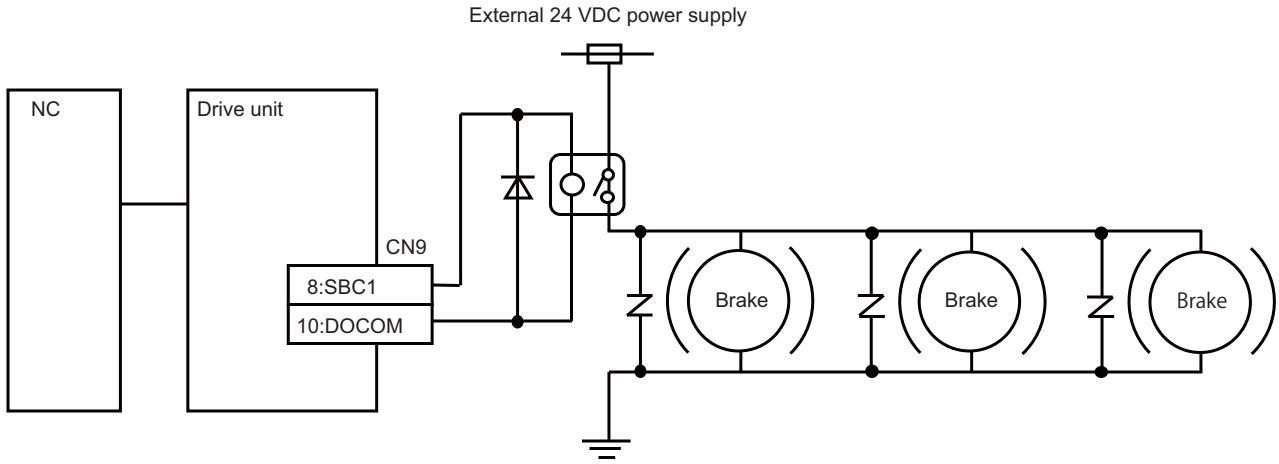
[In-drive-unit control circuit method]

There are two types of this method: common control method and axis selection control method.
Correspondence with drive unit is as follows.

Model	Common control method	Axis selection control method
MDS-E/EH Series	○	×
MDS-EM/EMH Series	○	×
MDS-EJ/EJH Series	○	○

(Note) The in-drive-unit control circuit method is supported by drive units for MDS-E/EH/EJ/EJH/EM/EMH Series software version BE or later.
When a non-supported drive unit is used, the operation error (M01 0373) occurs.

The following is an example of the machine configuration expected in this method. (When brakes of two or more axes are driven)
Connectors to be connected and necessary wiring depend on the drive unit. Refer to your drive unit instruction manual.

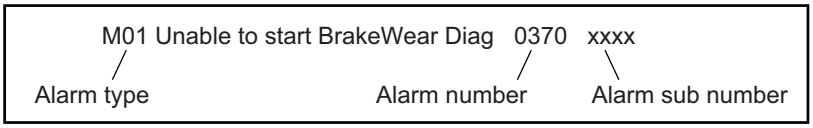


(1) Common control method
In this method, the brakes are controlled simultaneously for all the axes connected to the same drive unit. Therefore, the brakes are applied to axes for which brake wear diagnostics is not available.

(2) Axis selection control method
In this method, the brake wear diagnostics is available for axes selected with the parameter "#2281 SV081/bit8". To perform the brake wear diagnostics for non-selected axes, start the brake wear diagnostics at the same time as the axes connected to the same drive unit and selected with the parameter "#2281 SV081/bit8". If the brake wear diagnostics is performed only for the non-selected axes, an accurate diagnosis cannot be started because no brake is applied. The operation error (M01 0373) appears.

Requirements for brake wear diagnostics start

The brake wear diagnostics function can be executed when all the following conditions are satisfied.
If the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned from OFF to ON while any of the conditions is not satisfied, the operation error (M01 0370) occurs.
When an alarm occurs, the alarm sub number indicates the cause of the alarm.



The number in brackets () at the end of each following item is the alarm sub number.

(1) Entire system
- Smart safety observation is disabled. (1001)
- All the part systems are not in automatic operation. (0001)

(2) Part system where there is a target axis for brake wear diagnostics
- There is no axis in arbitrary axis exchange control. (0007)
- There is no axis in mixed control. (0008)

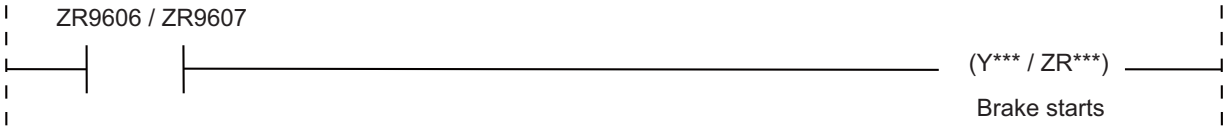
(3) Target axis for brake wear diagnostics
- "#12590 BWD_Enable" (Brake wear diagnostics ON) is "1" or "2".
  (An operation error does not occur. The diagnosis start signal is ignored.)
- "#12591 BWD_ILIM" (Brake wear diagnostics current limit value) is not "0". (0009)
- "#12593 BWD_FD" (Brake wear diagnostics command travel amount) is not "0". (0009)
- "#12594 BWD_FDRATE" (Brake wear diagnostics feedrate) is not "0". (0009)
- The setting value of "#12596 BWD_TOL(Warning)" is larger than that of "#12597 BWD_TOL(Caution)". (0009)
- The "Brake wear diagnostics: Alarm reset (control axis)" signal (ZR9602, ZR9603) is OFF. (1003)
- The axis is in servo ON state. (0003)
- The axis is in in-position. (0002)
- The "Reference position establishment" signal is ON. (000A)
- The axis is not in the current limit. (0004)
- The axis is not a slave axis in the synchronous control. (0005)
- The axis is not a related axis in superimposition control. (0006)
- The axis is not a PLC axis. (1002)
- The axis is not during coordinate rotation. (1004)
- The axis is not in control as an auxiliary axis. (1005)
- The axis is not an inclined axis on which the inclined axis control is enabled. (1007)
- The axis is not a secondary axis in multiple-axis synchronization control. (1008)
- The axis is not a related axis in control axis synchronization between part systems. (100B)
- The axis is not a main axis or sub axis for simple synchronous control. (000B)

(Note) Even when the "Brake wear diagnostics: Diagnosis incomplete (control axis)" signal (ZR9604, ZR9605) is OFF, the brake wear diagnostics can be executed.

Creation of ladder for brake wear diagnostics

The "Brake wear diagnostics: Diagnosis in progress (control axis)" signal (ZR9606, ZR9607) from NC to PLC is ON while the brake wear diagnostics is performed.
With the external relay circuit method, MTB needs to create signal processing logic to apply brake while this signal is ON.

[Example of signal processing logic for brake wear diagnostics]



12.43.2.2 Parameter setting method

To use this function, parameters to define operations of brake wear diagnostics need to be set.
The following describes preparation of them.

Definition of brake wear diagnostics operation

Specifications of the brake wear diagnostics operation are defined by the parameter settings.

(1) "#12593 BWD_FD" (Brake wear diagnostics command travel amount) / "#12594 BWD_FDRATE" (Brake wear diagnostics feedrate)
In brake wear diagnostics, the movement command for brake wear diagnostics is output while the brake of the axis for diagnosis is applied.
Set the movement amount for diagnosis from the brake wear diagnostics start position in #12593 and the movement speed in #12594. (After the brake wear diagnostics is ended, the command position returns to the position at the start of diagnosis.)
When "0" is set in the command movement amount or command speed, an alarm occurs at the start of brake wear diagnostics. (The brake wear diagnostics does not start.)

(2) "#12596 BWD_TOL(Warning)" (Brake wear diagnostics allowable travel amount (Warning))
Set the threshold value (change amount from start of brake wear diagnostics to FB position) to detect the warning state of brake wear state, in #12596. The setting unit is mm. To define it with the amount of hub rattling, set the distance converted from the ball screw pitch and the number of hub teeth to the mm unit.
When "0" is set, the allowable movement amount is 100 mm.

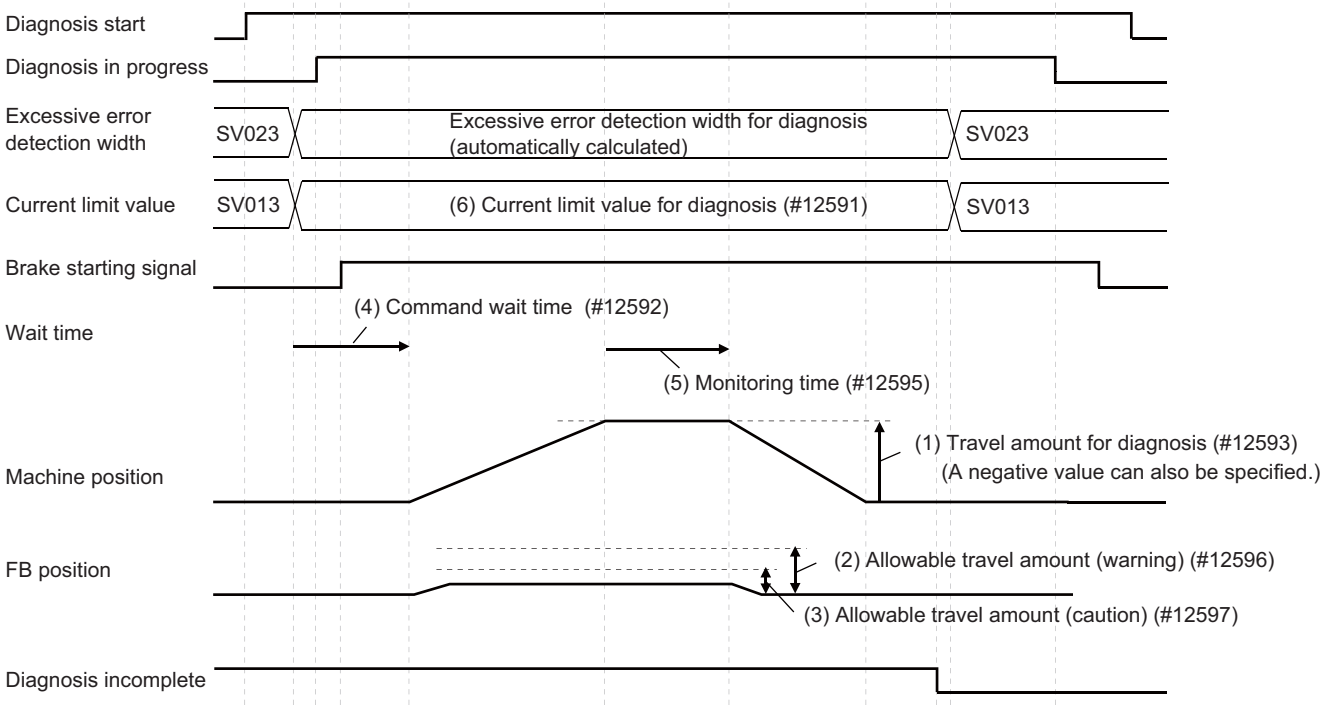
(3) "#12597 BWD_TOL(Caution)" (Brake wear diagnostics allowable travel amount (Caution))
Set the threshold value (change amount from start of brake wear diagnostics to FB position) to detect the caution state of brake wear state, in #12597. The setting unit is mm. To define it with the amount of hub rattling, set the distance converted from the ball screw pitch and the number of hub teeth to the mm unit.
<Note>
- When a larger value than #12596 is set or "0" is set, the diagnosis of the caution state is not performed.

(4) "#12592 BWD_CMDWT" (Brake wear diagnostics command wait time)
Set the time until the movement command for diagnosis starts after NC receives the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601). The setting unit is ms.
When "0" is set, the command wait time is 400 ms.
With the in-drive-unit control circuit method, when any of "1" to "199" is set, the command wait time is 200 ms.

(5) "#12595 BWD_OBTIM" (Brake wear diagnostics monitoring time)
After the movement command for brake wear diagnostics reaches the endpoint position, the command position is kept and change of the FB position can be monitored. Set the monitoring time in #12595. The setting unit is ms.
When "0" is set, the monitoring time is 1000 ms.

(6) "#12591 BWD_ILIM" (Brake wear diagnostics current limit value)
The current limit value of the target axis for diagnosis is changed during brake wear diagnostics.
Set a value that the load current value for brake wear diagnostics is added to the current value required to keep the machine stop state, in #12591. The setting unit is the scale (%) applied to the stall rated current.
When "0" is set, an alarm occurs at the start of brake wear diagnostics. (The brake wear diagnostics does not start.)

[Relation between brake wear diagnostics operation and parameters]



Excessive error detection width for brake wear diagnostics

After the brake wear diagnostics starts, NC automatically converts the excessive error detection width to a value for brake wear diagnostics.
When the brake wear diagnostics ends or is canceled, NC returns the excessive error detection width to the value of excessive error detection width during servo ON (#2223 SV023).
The excessive error detection width for brake wear diagnostics is the sum of "#2223 SV023" and "#12593 BWD_FD". (*1)
(*1) "#2223 SV023" is the excessive error detection width during servo ON.
"#12593 BWD_FD" is the brake wear diagnostics command travel amount.

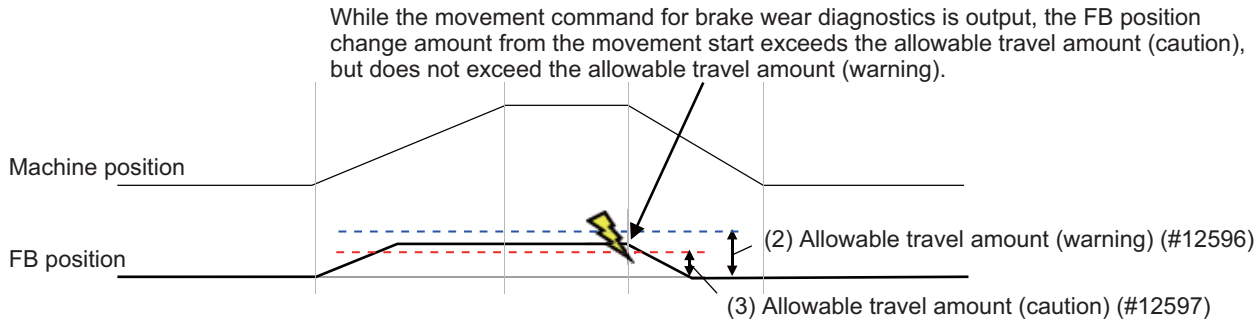
(Note) When a parameter related to excessive error detection width is set as any of the following, the excessive error detection is not performed in brake wear diagnostics.
- The excessive error detection width during servo ON (#2223 SV023) is "0".
- The calculated excessive error detection width for brake wear diagnostics is larger than the excessive error detection width maximum value 32767 mm.
(The maximum value of the calculated excessive error detection width for brake wear diagnostics is 32767 mm regardless of the setting of "#2284 SV084/bitC" (Excessive error detection width unit).)

Definition of criteria to judge brake wear state

The brake wear state is judged by the movement amount of the FB position while brake is applied in brake wear diagnostics. The following two error states are judged by this function.

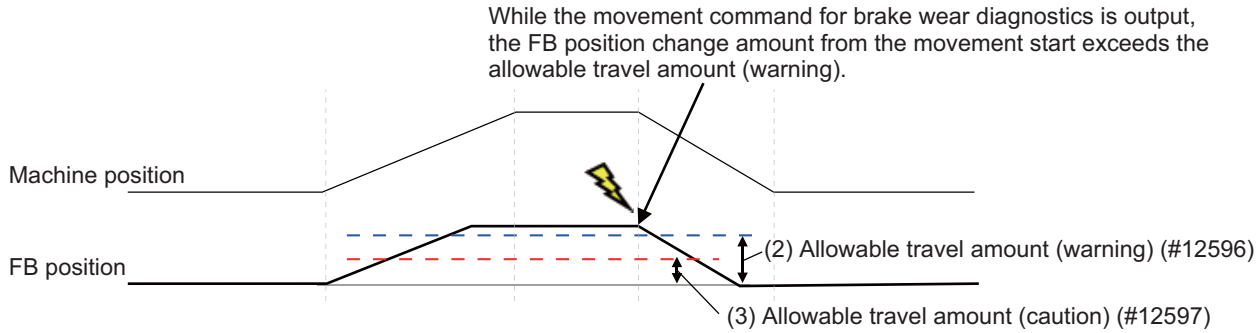
(1) Operation warning (M50 5006) "Brake wear diagnostics (caution)"
The movement amount of the FB position while brake is applied exceeds the value of "#12597 BWD_TOL(Caution)" (Brake wear diagnostics allowable travel amount (Caution)).
This indicates that the wear of the brake/hub has progressed and the brake maintenance/change time is close. Automatic operation is possible.

[Judgment of brake wear diagnostics (caution)]



(2) Operation error (M01 0371) "Brake wear diagnostics (warning)"
The movement amount of the FB position while brake is applied exceeds the value of "#12596 BWD_TOL(Warning)" (Brake wear diagnostics allowable travel amount (Warning)).
This indicates that the wear of the brake/hub exceeds the allowable amount to continue the automatic operation. Automatic operation is not possible until the brake wear diagnostics is performed again and the result is normal. While this alarm is issued, the axis can be moved only in manual mode.

[Judgment of brake wear diagnostics (warning)]



(Note 1) The alarms and warnings that occurred in brake wear diagnostics are recorded in the alarm history.
(Note 2) The "Brake wear diagnostics: Diagnosis incomplete (control axis)" signal (ZR9604, ZR9605) is not turned OFF because the diagnosis is not normally completed.

Brake wear diagnostics interval

This function has a timer function to prompt execution of brake wear diagnostics periodically. After the system has been operated for a certain period of time since the brake wear diagnostics, a signal prompting the next diagnosis ("Brake wear diagnostics: Diagnosis incomplete (control axis)" signal (ZR9604, ZR9605)) is output to PLC.
The periodic execution of brake wear diagnostics can inform users that the brake maintenance/change time is close before the brake effectiveness is lost.

(1) Parameter setting ("#11386 BWD_INT" (Brake wear diagnostics interval))
Set the time interval until the next diagnosis is prompted after the brake wear diagnostics. The setting unit is [hour (h)]. The target to be counted is system operation time.
<Note>
- When "0" is set, the interval is set to 8 hours.

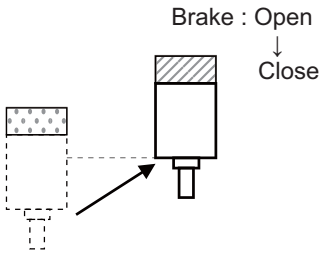
(2) Detailed operation
After a certain period of time (the time set in #11386) has passed since the last brake wear diagnostics is normally completed, the "Brake wear diagnostics: Diagnosis incomplete (control axis)" signal (ZR9604, ZR9605) turns ON.

(3) Operation at power ON
Whether or not the brake wear diagnostics is turned to the incomplete state at power ON of NC can be selected with "#11387 BWD_INIT_NF" (Brake wear diagnostics incomplete state at power-on).
(a) When #11387 is "0"
When NC is turned ON, the brake wear diagnostics is always in incomplete state (the state is the same as after the interval time has passed).
Even when NC is turned ON before the interval time has passed after the last brake wear diagnostics is normally completed, the brake wear diagnostics is in incomplete state.
(b) When #11387 is "1"
When NC is turned ON, the brake wear diagnostics is not in incomplete state. The cumulative operation time after the brake wear diagnostics, is carried over between the power OFF and ON. After the time set in #11386 has passed, the brake wear diagnostics is in incomplete state.

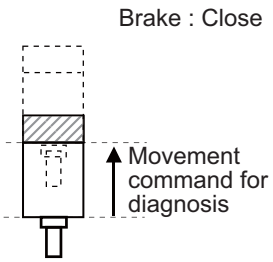
(Note) Even when the "Brake wear diagnostics: Diagnosis incomplete (control axis)" signal (ZR9604, ZR9605) is ON, NC does not suppress the program operation. Whether or not automatic operation is possible in the state that the brake wear diagnostics is incomplete can be determined by the sequence program created by MTB.

12.43.2.3 Operation Procedure, Operation Sequence

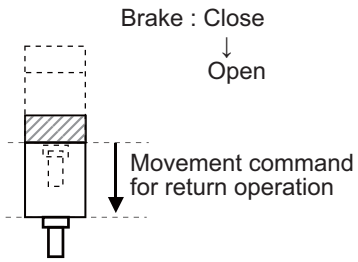
This function operates as follows.



[Step1]
Move to the brake wear diagnostics start position.
Then, apply the brake.
(External relay circuit method: Ladder)



[Step2]
Output the movement command for diagnosis while the brake is applied.
Measure the FB position change amount.
(NC operation)

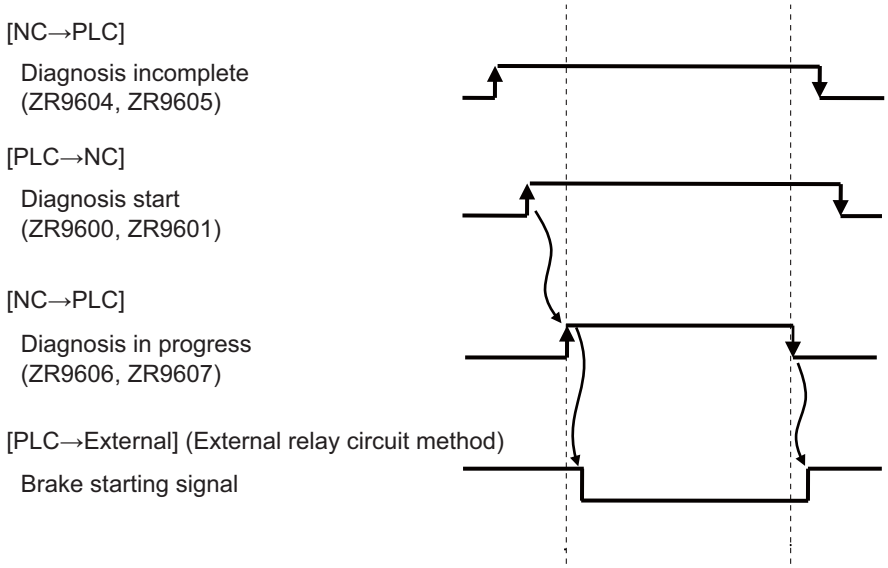


[Step3]
Return the command till the brake wear diagnostics start position. (NC operation)
Then, release the brake.
(External relay circuit method: Ladder)

(1) Move the axis to the brake wear diagnostics execution position (where the actual machining is not performed but the stroke for diagnosis operation can be kept).
<Note>
- Keep a clearance of brake wear diagnostics command travel amount (#12593 BWD_FD) or more.

(2) Apply the brake.
(3) Start the diagnosis.
(4) When the diagnosis is completed, turn OFF the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601).

[Operation sequence of brake wear diagnostics]



Release of brake wear diagnostics result alarm

The brake wear diagnostics result alarm can be released with the following two procedures.

(Release method 1) Perform the brake wear diagnostics again after the brake treatment, and complete it in a state that the diagnostics result is normal.

(1) Move the axis to a safe position in manual mode.
(2) Turn the NC OFF.
(3) Perform treatment of the brake where an error occurs.
(4) Turn the NC ON.
(5) Turn ON the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) to start the brake wear diagnostics.

When the brake wear diagnostics is completed and the result is normal, the following signals are turned OFF.

- "Brake wear diagnostics: Servo axis in warning (control axis)" signal (ZR9736, ZR9737) (bit of the diagnosis target axis is turned OFF)
- "Brake wear diagnostics: Warning No. (system common)" signal (ZR9738) (which is turned to "0")
- "Brake wear diagnostics: Diagnosis incomplete (control axis)" signal (ZR9604, ZR9605) (bit of the diagnosis target axis is turned OFF)

(Release method 2) Input the "Brake wear diagnostics: Alarm reset (control axis)" signal (ZR9602, ZR9603).

(1) Turn OFF the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601).
(2) Input the "Brake wear diagnostics: Alarm reset (control axis)" signal (ZR9602, ZR9603).

The following signals are turned OFF.

- "Brake wear diagnostics: Servo axis in warning (control axis)" signal (ZR9736, ZR9737)
- "Brake wear diagnostics: Warning No. (system common)" signal (ZR9738)

(Note) The "Brake wear diagnostics: Diagnosis incomplete (control axis)" signal (ZR9604, ZR9605) is not turned OFF because the diagnosis is not normally completed.

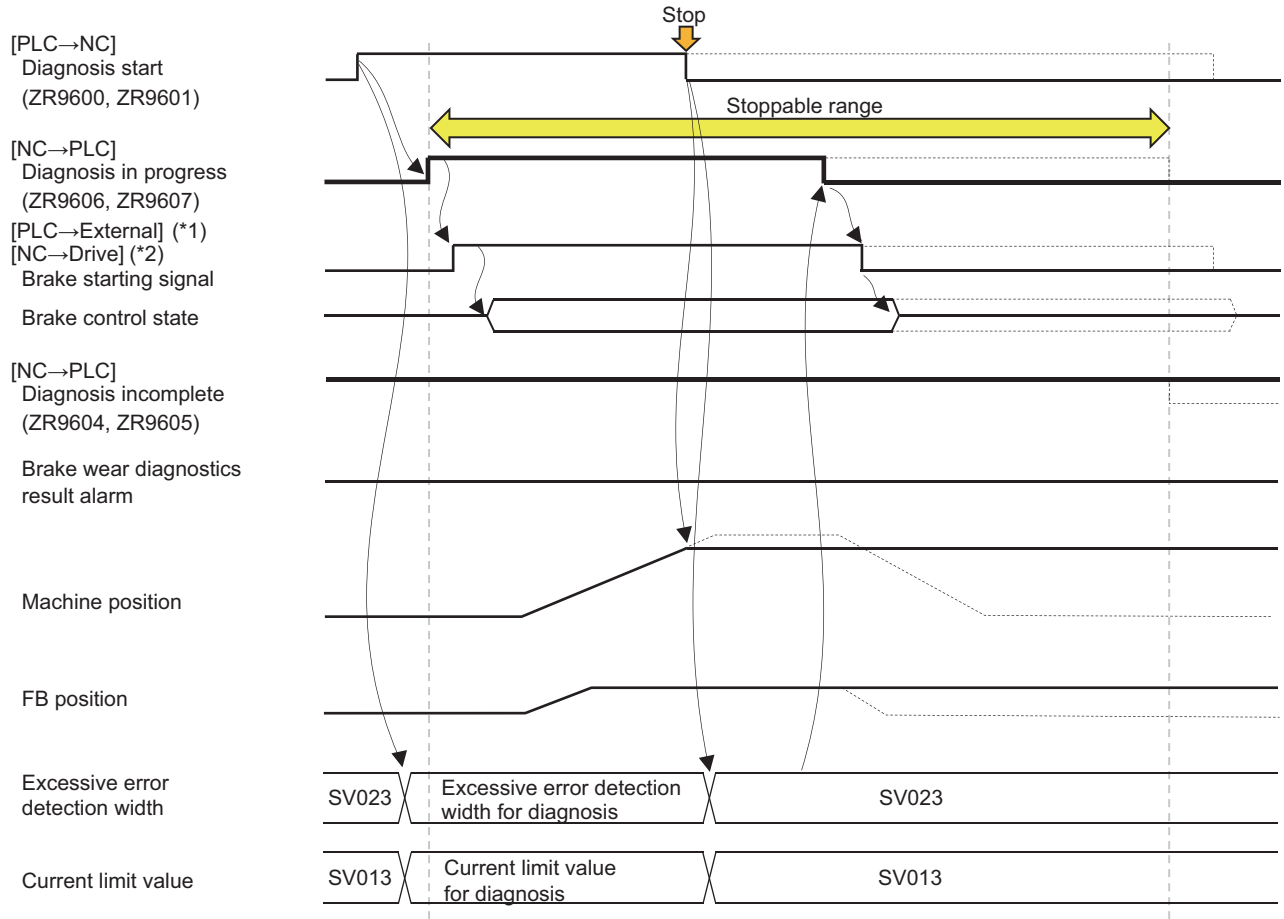
Stop of brake wear diagnostics

Brake wear diagnostics can be stopped while the operation sequence of brake wear diagnostics is executed (the signal of brake wear diagnostics in progress is ON).
Due to the stop of brake wear diagnostics, the current limit value and the excessive error detection width return to the values before the brake wear diagnostics start, and the "Brake wear diagnostics: Diagnosis in progress (control axis)" signal (ZR9606, ZR9607) turns OFF.
When the brake wear diagnostics is stopped, the brake wear diagnostics result alarm is not updated, the brake wear diagnostics incomplete signal is not released, and the interval time is not updated.
By turning the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) from OFF to ON after the stop, the brake wear diagnostics is performed from the beginning again.

(1) Stop of brake wear diagnostics by PLC signal
(Stop method 1) Turn OFF the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601).
(Stop method 2) Turn ON the NC reset signal of the part system to which the target axis for brake wear diagnostics belongs.

(2) Forcible stop of brake wear diagnostics
When an emergency stop or servo alarm occurs, the brake wear diagnostics is forcibly ended.
Even when the emergency stop is released or the alarm is released, the brake wear diagnostics is not restarted.
When a PR servo alarm occurs, brake wear diagnostics cannot be performed until the NC is turned ON again.

[Operation of when brake wear diagnostics is stopped]



(*1) External relay circuit method
(*2) In-drive-unit control circuit method

Simultaneous execution of brake wear diagnostics on multiple axes

Brake wear diagnostics can be executed simultaneously on multiple axes.

(1) Brake wear diagnostics can be started simultaneously (executed parallelly) on multiple axes.
For example, when the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of X axis and Z axis is turned ON simultaneously, the brake wear diagnostics of both axes starts simultaneously and is performed parallelly.

[Operation specifications of when brake wear diagnostics is executed on multiple axes simultaneously]
When the brake wear diagnostics of multiple axes is executed simultaneously, the NC performs the diagnosis on all the axes at the same timing.
The maximum setting value of "#12592 BWD_CMDWT" (Brake wear diagnostics command wait time) among the axes in diagnosis is applied, which is the same for "#12595 BWD_OBTIM" (Brake wear diagnostics monitoring time).

When the command movement amount, the command speed and the acceleration/deceleration time constant are different depending on the axis, the command output completion timing is different.
When the brake wear diagnostics is executed on multiple axes simultaneously, the operation is performed in accordance with the axis whose command output completion timing is the latest so that the start timing of axis movement amount monitoring is the same among the axes.

(2) When there is an axis where brake wear diagnostics is being executed in the system, the brake wear diagnostics on the axis needs to be completed before brake wear diagnostics is started on the other axes.
For example, when the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of Z axis is turned ON while brake wear diagnostics is performed on X axis, the operation error (M01 0370 000B) occurs and the brake wear diagnostics of Z axis does not start. (The brake wear diagnostics of X axis is continued.)

12.43.2.4 Similar Function

As a function to diagnose the brake effectiveness, there is safe brake test (SBT) of smart safety observation.
Brake wear diagnostics is a lower function of safe brake test (SBT).

[Specification comparison table between brake wear diagnostics and safe brake test (SBT)]

Item	Brake wear diagnostics	Safe brake test (SBT)
Safety authentication	Not supported	Supported
Dedicated device	Unnecessary	Safety RIO unit Safety expansion card (M80)
Distinction of external brake and motor brake	Not distinguished Only one brake can be diagnosed for one axis.	Distinguished The external brake and the motor brake respectively have an interface (effective parameters, SBT start signal, SBT incomplete signal) for one axis, and can be controlled separately.
Judgment result of brake test / brake diagnosis (type of brake error)	Two levels (warning, caution)	One level (warning)
Diagnosis of PLC axis	Impossible	Possible

12.43.3 Relation with Other Functions

(1) Smart safety observation

When smart safety observation is enabled, brake wear diagnostics is disabled.
When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON, the operation error (M01 0370 1001) occurs.
[Enabling conditions of smart safety observation]
Safety observation and smart safety observation are enabled, and "#1481 Enable S-Safety" is "1".

(2) Safety observation

When safety observation is enabled, brake wear diagnostics is enabled.
[Enabling conditions of safety observation]
Safety observation and smart safety observation are enabled, and "#1481 Enable S-Safety" is "0".

(3) Override

The movement command for an axis in brake wear diagnostics is output at the command speed with the override fixed to 100%. Even when the rapid traverse override value is changed, it is ignored.

(4) Dry run

The dry run function is disabled for an axis in brake wear diagnostics. Even when the "Dry run" signal (DRN) is turned ON, it is ignored.

(5) Interlock

Manual interlock for an axis in brake wear diagnostics is enabled. When the "Manual interlock" signal (*+MITn/*-MITn) of the target axis for brake wear diagnostics is turned OFF, the axis decelerates and stops, and the brake wear diagnostics is temporarily stopped. (The current limit value, the excessive error detection width and the "Brake wear diagnostics: Diagnosis in progress (control axis)" signal (ZR9606, ZR9607) in brake wear diagnostics are carried over.)
When the "Manual interlock" signal (*+MITn/*-MITn) is turned ON again, the brake wear diagnostics is resumed at the state immediately before the stop. Automatic interlock in brake wear diagnostics is disabled. Even when the "Automatic interlock" signal (*+AITn/*-AITn) is turned OFF, it is ignored.

(6) Machine lock

Machine lock for an axis in brake wear diagnostics is disabled. Even when the "Automatic machine lock" signal (AMLKn) and the "Manual machine lock" signal (MMLKn) are turned ON, they are ignored.

(7) Stroke end and stored stroke limit

The checks of stroke end and stored stroke limit for an axis in brake wear diagnostics are enabled. Even when the axis does not move due to the brake, if the command position for brake wear diagnostics is within the prohibited area, an alarm occurs.

(8) Synchronous control

(a) Synchronous operation method

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the master axis is turned ON, the slave axis starts moving at the same time as when the master axis moves by brake wear diagnostics. At this time, as for the movement parameter for brake wear diagnostics, the setting value for the master axis is referred to.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the slave axis is turned ON, the operation error (M01 0370) occurs.

(b) Independent operation method of master axis

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the master axis is turned ON, the brake wear diagnostics of the master axis is started. (The brake wear diagnostics of the slave axis is not started.)

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the slave axis is turned ON, the brake wear diagnostics of the slave axis is started. At this time, as for the movement parameter for brake wear diagnostics, the setting value for the slave axis is referred to. (The brake wear diagnostics of the master axis is not started.)

(c) Independent operation method of slave axis

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the master axis is turned ON, the operation error (M01 0370) occurs.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the slave axis is turned ON, the operation error (M01 0370) occurs.

(d) Synchronous control mode OFF

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the master axis is turned ON, the brake wear diagnostics of the master axis is started. (The brake wear diagnostics of the slave axis is not started.)

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the slave axis is turned ON, the brake wear diagnostics of the slave axis is started. At this time, as for the movement parameter for brake wear diagnostics, the setting value for the slave axis is referred to. (The brake wear diagnostics of the master axis is not started.)

(9) Multiple-axis synchronization control

(a) In multiple-axis synchronization control

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the master axis is turned ON, the slave axis starts moving at the same time as when the master axis moves by brake wear diagnostics. At this time, as for the movement parameter for brake wear diagnostics, the setting value for the master axis is referred to.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the slave axis is turned ON, the operation error (M01 0370) occurs.

(b) In multiple-axis synchronization control cancel

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the master axis is turned ON, the brake wear diagnostics of the master axis is started. (The brake wear diagnostics of the slave axis is not started.)

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) of the slave axis is turned ON, the brake wear diagnostics of the slave axis is started. At this time, as for the movement parameter for brake wear diagnostics, the setting value for the slave axis is referred to. (The brake wear diagnostics of the master axis is not started.)

(10) Control axis synchronization between part systems

Brake wear diagnostics cannot be started for an axis in control axis synchronization between part systems.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON for an axis related to control axis synchronization between part systems, the operation error (M01 0370) occurs.

(11) Mixed control

When there is an axis in mixed control in the part system including the target axis for brake wear diagnostics, the brake wear diagnostics cannot be started.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON for an axis in the part system where there is an axis in mixed control, the operation error (M01 0370) occurs.

(12) Arbitrary axis exchange control

When there is an axis in arbitrary axis exchange control in the part system including the target axis for brake wear diagnostics, the brake wear diagnostics cannot be started.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON for an axis in the part system where there is an axis in arbitrary axis exchange control, the operation error (M01 0370) occurs.

(13) Control axis superimposition, Arbitrary axis superimposition

The brake wear diagnostics cannot be started for an axis related to superimposition.

When "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON for an axis related to superimposition, the operation error (M01 0370) occurs.

(14) Mirror image

When "#8211 MIRR. IMAGE" is "1" or the "Mirror image n-th axis" signal (Y7C0 or later) is ON, compensation by mirror image is not performed and brake wear diagnostics is executed.

(15) Interference check III, 3D machine interference check, Interference check between part systems

When machine interference is detected due to movement by brake wear diagnostics, the interference check error occurs and the brake wear diagnostics operation is stopped.

(16) PLC axis control, PLC axis indexing, NC axis/PLC axis switchover

Brake wear diagnostics is not available for PLC axis, PLC indexing axis, axis in PLC axis mode of NC axis/PLC axis switchover axis.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON, the operation error (M01 0370) occurs.

(17) Inclined axis control

Brake wear diagnostics can be executed for the base axis of inclined axis control.

When the inclined axis control is enabled, the brake wear diagnostics cannot be started for the inclined axis.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON for an axis where "#2071 s_axis" is set to "1" while the "Inclined axis control valid" signal is ON, the operation error (M01 0370) occurs.

To start the brake wear diagnostics for the inclined axis, turn OFF the "Inclined axis control valid" signal, and then start the brake wear diagnostics.

(18) Coordinate rotation by parameter

Brake wear diagnostics cannot be started for an axis where coordinate rotation by parameter is enabled.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON for an axis where coordinate rotation by parameter is enabled, the operation error (M01 0370) occurs.

(19) Chopping

Brake wear diagnostics cannot be started for an axis in chopping mode because it is not in in-position state.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON for an axis in chopping mode, the operation error (M01 0370) occurs.

Turn OFF the chopping mode, and then start the brake wear diagnostics.

(20) Servo OFF

Brake wear diagnostics cannot be started for an axis in servo OFF.

When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON for an axis in servo OFF, the operation error (M01 0370) occurs.

(21) Manual feed (Jog feed, Incremental feed, Handle feed)

Manual feed commands are ignored during brake wear diagnostics.
Brake wear diagnostics cannot be started for an axis in manual feed because it is not in in-position state.
When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON for an axis in manual feed, the operation error (M01 0370) occurs.

(22) Manual speed clamp

When the brake wear diagnostics feedrate (#12594 BWD_FDRATE) is faster than the manual clamp speed, the speed is clamped at the manual clamp speed.

(23) NC Analyzer2

Brake wear diagnostics cannot be started during communication between NC Analyzer2 and NC.
To execute the brake wear diagnostics, do not use NC Analyzer2.

(24) Simple synchronous control

Brake wear diagnostics cannot be started for an axis set as the main axis or sub axis in simple synchronous control.
When the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is turned ON for an axis in simple synchronous control, the operation error (M01 0370 000B) occurs.

12.43.4 Precautions

(1) When there is an axis in brake wear diagnostics (*1) in the system, automatic operation cannot be started in all the part systems. When the "automatic operation "start" command" signal (ST) is turned ON, the stop code (T01 0167) occurs.

(2) When there is an axis in brake wear diagnostics (*1) in the part system, the movement command in manual operation mode is ignored in the part system.

(3) When there is an axis in brake wear diagnostics (*1) in the part system, the operation mode in the part system cannot be changed until brake wear diagnostics for all the axes is completed. (The operation mode at the start of the brake wear diagnostics is continued.)
(Example) Even when brake wear diagnostics is started for an axis in the part system in handle mode and the mode of the part system is changed to jog mode, the screen display and PLC output signal are still handle mode. After the brake wear diagnostics is completed, they are changed to jog mode.

(4) When brake wear diagnostics is executed simultaneously for multiple axes in the part system and the brake wear diagnostics result of an axis is an error (the operation error (M01 0371) or operation warning (M50 5006) occurs), the axis cannot be moved until the brake wear diagnostics for the other axes in the part system is completed.

(5) Start brake wear diagnostics from the position where the target axis for diagnosis does not interfere with the machine or reach the stroke end even when the brake wear diagnostics command travel amount "#12593 BWD_FD" is kept.

(6) For the axis under the spindle position control (Spindle/C axis control) or spindle-mode rotary axis control, brake wear diagnostics is not executed even in the servo axis control mode.
The "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) is ignored.

(7) The in-drive-unit control circuit method is supported by drive units for MDS-E/EH/EJ/EJH/EM/EMH Series software version BE or later.
When a non-supported drive unit is used, the operation error (M01 0373) occurs.

(*1) "Axis in brake wear diagnostics" indicates an axis where the "Brake wear diagnostics: Diagnosis start (control axis)" signal (ZR9600, ZR9601) and the "Brake wear diagnostics: Diagnosis in progress (control axis)" signal (ZR9606, ZR9607) are ON.

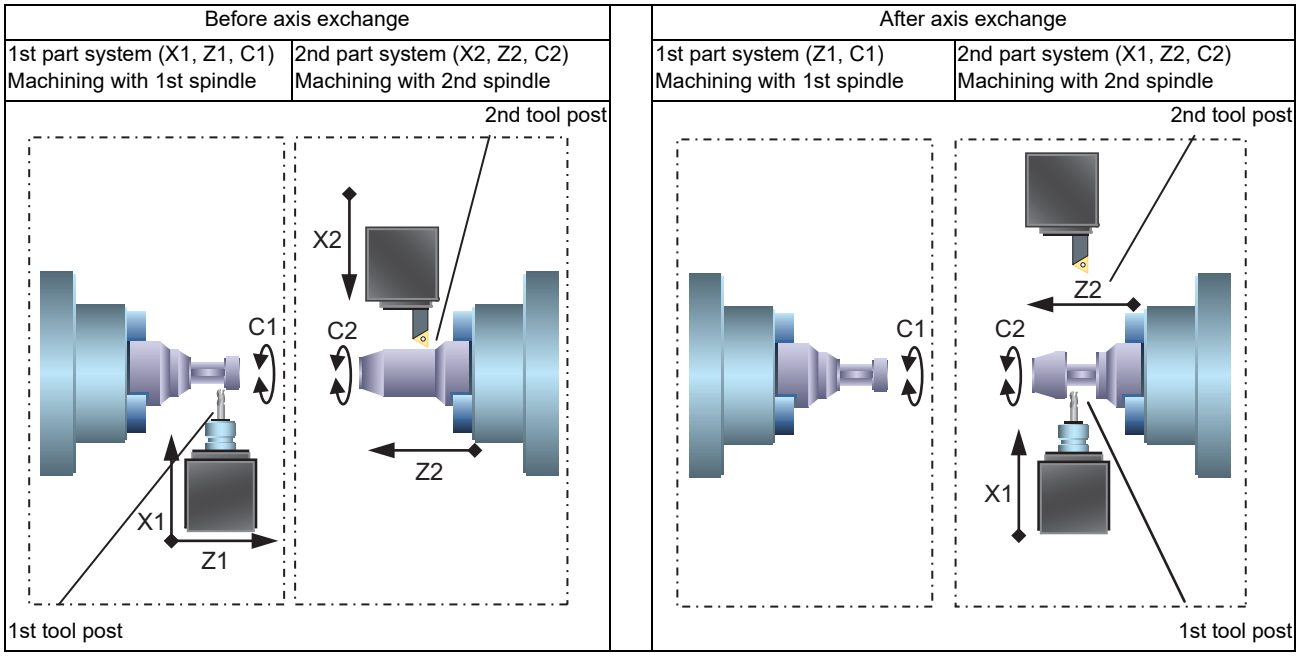
13

Multi-axis and Multi-part System

13.1 Arbitrary Axis Exchange Control

An arbitrary axis can be exchanged freely across part systems in the multiple part systems.
The machining can be freer in the multiple part systems by exchanging an axis which can be commanded for machining programs in each part system.
This makes it possible to perform operations which are not possible with regular axis configurations: for instance, tools which are provided only on the 1st part system can be used for machining on the 2nd part system.
This function cannot be used with the mixed control (cross axis control).
Refer to "Programming Manual" for the details of the function.

(Example) Lathe System:Using X1 axis in part system 2



Command format

Arbitrary axis exchange command

Commands the arbitrary axis exchange by G140.

G140 command address = axis address command address = axis address...;	
Command address	: Designate the command address used in commands such as the movement command with one alphabetical character set to the parameter after the arbitrary axis exchange command (G140).
Axis address	: Designate the axis name for arbitrary axis exchange with two alphanumeric characters set to the parameter.

Arbitrary axis exchange return command

Returns the control right of the axis, exchanged by the previous arbitrary axis exchange command (G140) in the commanded part system, to the state before the axis exchange.

```
G141 ;
```

Reference axis arrange return command

Returns the control right of the axis, exchanged by the arbitrary axis exchange command (G140) in the commanded part system, to the power-on state.

```
G142 ;
```

(Note) For G code list 6 and 7, replace G140, G141 and G142 with G165, G166 and G167.

13.1.1 CNC Control Signals and CNC Status Signals

The CNC control signal and CNC status signal per axis are used for basic axis placement.
For this reason, outputting the optional axis exchange command (G140), optional axis exchange return command (G141), and basic axis placement return command G142) will not change the axis to which the signals correspond.
The CNC control signal and CNC status signal for all axes are applicable.

The following table lists examples of the CNC control signal and CNC status signal per axis.

- PLC input signal (bit type: X***)

Signal name	Abbreviation	Device No.			
		$1	$2	$3	$4
Servo ready First through eighth axis	RDY1 through 8	X780 through X787	X788 through X78F	X790 through X797	X798 through X79F
:		:	:	:	:
Clamp command First through eighth axis		XA80 through XA87	XA88 through XA8F	XA90 through XA97	XA98 through XA9F

- PLC input signal (bit type: R***)

Signal name	Abbreviation	Device No.			
		$1	$2	$3	$4
Machine position First through eighth axis		R4500 through R4531	R4532 through R4563	R4564 through R4595	R4596 through R4627
:		:	:	:	:
Actual machining time First through eighth axis		R5524 through R5531	R5532 through R5539	R5540 through R5547	R5548 through R5555

- PLC output signal (bit type: Y***)

Signal name	Abbreviation	Device No.			
		$1	$2	$3	$4
Control axis detachment First through eighth axis	DTCH1 through 8	Y780 through Y787	Y788 through Y78F	Y790 through Y797	Y798 through Y79F
:		:	:	:	:
Clamp complete First through eighth axis		YB00 through YB07	YB08 through YB0F	YB10 through YB17	YB18 through YB1F

- PLC output signal (bit type: R***)

Signal name	Abbreviation	Device No.			
		$1	$2	$3	$4
Ext. machine coordinate system offset data First through eighth axis		R5700 through R5715	R5716 through R5731	R5732 through R5747	R5748 through R5763
:		:	:	:	:
Target machining time First through eighth axis		R6116 through R6123	R6124 through R6131	R6132 through R6139	R6140 through R6147

The CNC control signal and CNC status signal per axis include a total of 32 axes (8 axes per part system x 4 part systems). Signals are allocated to the axes in accordance with the configuration of "#1603 PLCdev_no (axis device allocation number)".
For this reason, using the assigned signals enable commands to be given to a system with 5 or more part systems or to a system with 9 or more axes per part system.

13.2 Control Axis Superimposition II

There are two types of control axis superimposition according to command method: Control axis superimposition I and Control axis superimposition II.

Control axis superimposition I: G command

Control axis superimposition II: PLC signal command

For selection, set the base specifications parameter "#1280 ext16/bit7".

This chapter explains different points from the control axis superimposition I.

For the functions of the control axis superimposition, refer to the chapter of the control axis superimposition in "M800/M80/E80/C80 Series Programming Manual (Lathe System)".

13.2.1 Command Method

(1) Superimposition start command

Issue a superimposition start command in the following procedure.

(a) Set the reference axis corresponding to the superimposed axis using the parameter "#2089 bsax_pl".

(b) Set the movement direction of the superimposed axis corresponding to the movement of the reference axis using the parameter "#2143 polor".

0: Move in the same direction as that of the reference axis

1: Move in the opposite direction from that of the reference axis

(c) The superimposition control starts at a rising edge (0→1) of a PLC signal (PILE1 to PILE8) corresponding to the superimposed axis.

(2) Superimposition end command

The superimposition control by PLC signal is canceled at a falling edge (1→0) of the PLC signal (PILE1 to PILE8) corresponding to the superimposed axis.

13.2.2 Precautions

(1) The control axis superimposition by PLC signal is enabled only when "#1280 ext16/bit7" is "0".
If the parameter "#1280 ext16/bit7" is "1", the superimposition control request signals (PILE1 to PILE8) will be ignored.

(2) The superimposition control request signals (PILE1 to PILE8) will be ignored, if any of them is input without the additional specifications.

(3) When the parameter "#1450 5axis_Spec/bit5" is set to "0", if the control axis superimposition is commanded during the rotation center error compensation, the operation error (M01 1004) occurs.

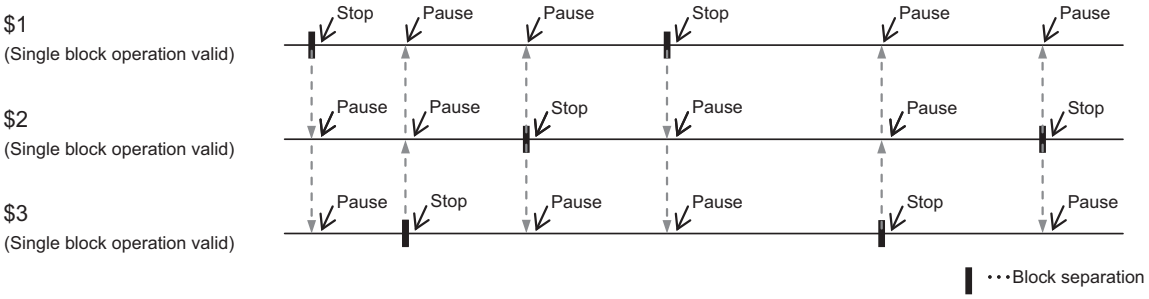
(4) An axis whose parameter "#2071 s_axis" (Inclined axis selection) is not "0" cannot be designated as reference axis nor superimposed axis.
An alarm (Operation error 1044) will occur if the superimposition control request signal is turned ON for such an axis.

(5) An axis whose parameter "#1205 G0bdcc" (Acceleration and deceleration before G0 interpolation) is not "0" cannot be designated as reference axis nor superimposed axis. An alarm (Operation error 1044) will occur if the superimposition control request signal is turned ON for such an axis.

13.3 Single Block between Part Systems

Single block operation between Part Systems is the function for executing single block operation while maintaining the synchronization among the part systems when two or more part systems are operated in the multi-part system. When one part system has been stopped by single block stop, the other part systems pause in the cycle operation.
In the normal single block, the synchronization among the part systems differs from the synchronization during the continuous operation because the other part systems continue the operation without stop even when a part system is stopped by single block stop, and the tool interference could occur in some cases. The synchronization between part systems can be maintained the same as the continuous operation by the single block operation between Part Systems. Valid/invalid can be switched with the PLC signal.

(Example) 3 part systems lathe



Stop: Single block stop
Pause: Cycle operation pause
$1: Part system 1
$2: Part system 2
$3: Part system 3

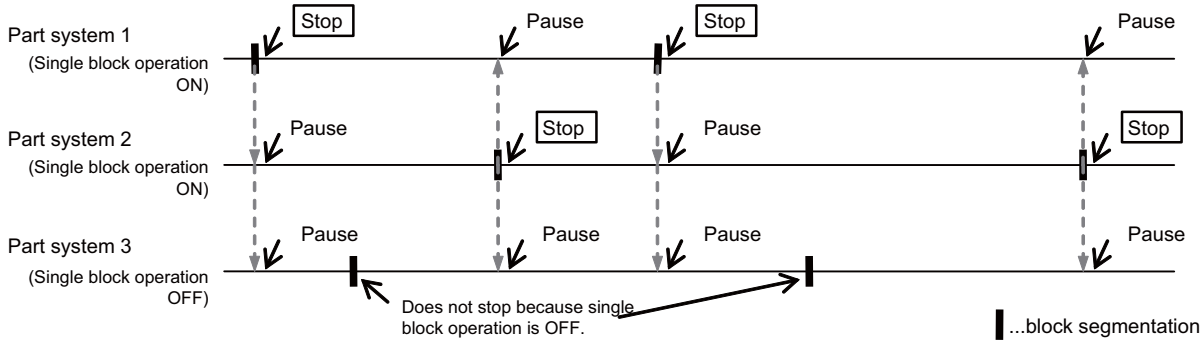
13.3.1 Function Enabling Conditions

This function in enabled for multi-part system specifications of two or more part systems.
This function is enabled when single block operation is active for any part system. This function is not enabled when all part systems are operating continuously.

13.3.2 Description of Operation

Operation to Disable Stopping of Single Block Operations

Single block operation can be specified per part system, which enables cycle operation of other part systems to be suspended by stopping single block operation for one part system and enables cycle operation of other part systems to be suspended by stopping single block operation for any part system.

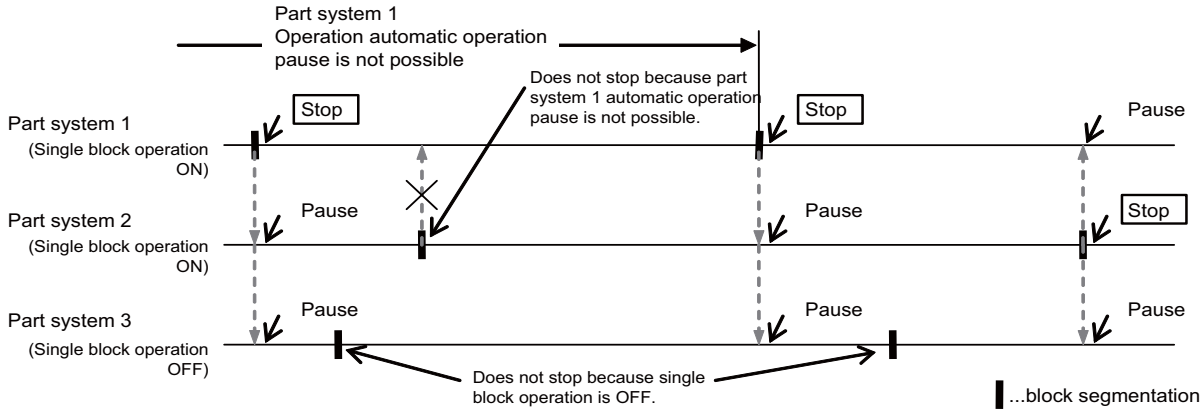


For the following scenario, the stopping of single block operation is disabled and so single block operation does not stop.

(1) During cycle operation such as a fixed cycle.
The block that operates in single block mode differs depending on the particular cycle.
Refer to the cycle section in the "Programming Manual".
(2) During tapping mode.
(3) During single block stop control by system variable #3003/bit 0.

Operation of the Cycle Operation Suspension Disabled State

When a part system other than the part system for which single block operation is attempting to be stopped is in the cycle operation suspension disabled state (tapping, thread cutting, or cycle operation suspension disabled by system variable #3004/ bit 0), the corresponding single block continues to operate uninterrupted, and the cycle operation of other part systems is also not suspended. For the next scenario in which any part system is attempting to stop single block operation, if a part system other than the part system attempting to stop single block operation is in the cycle operation suspension enabled state, single block operation stops, and the cycle operation of other part systems is also suspended.

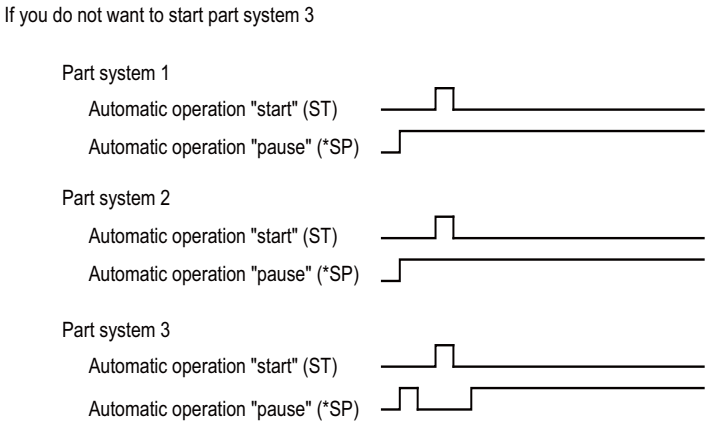


In this case, the system enters the cycle operation suspension disabled state and so cycle operation is not suspended.

(1) Cutting feed is in operation during a fixed tapping cycle.
(2) During tapping mode.
(3) During thread cutting.
(4) Cycle operation suspension control is in operation by the system variable #3004/bit 0.

Cycle Operation Startup after Stopping Single Block Operation and Cycle Operation Suspension

Start cycle start for all part systems after stopping single block operation or suspending cycle start while operating single block between part systems. In order to maintain synchronization between part systems, the single block cannot progress until all part systems are running in cycle start mode. The operation error (M01 1045) is generated. If you do not want to start a particular part system, turn OFF (while in the cycle start suspended state) the cycle start suspension signal (*SP) for that part system and start cycle start.



13.3.3 Operation with Other Functions

(1) The synchronization between part systems OFF is enabled with part systems for which single block between part systems is disabled. Cycle operation is not suspended for other part systems even if the single block operation is stopped. Cycle operation is not suspended when single block operation is stopped for other part systems.

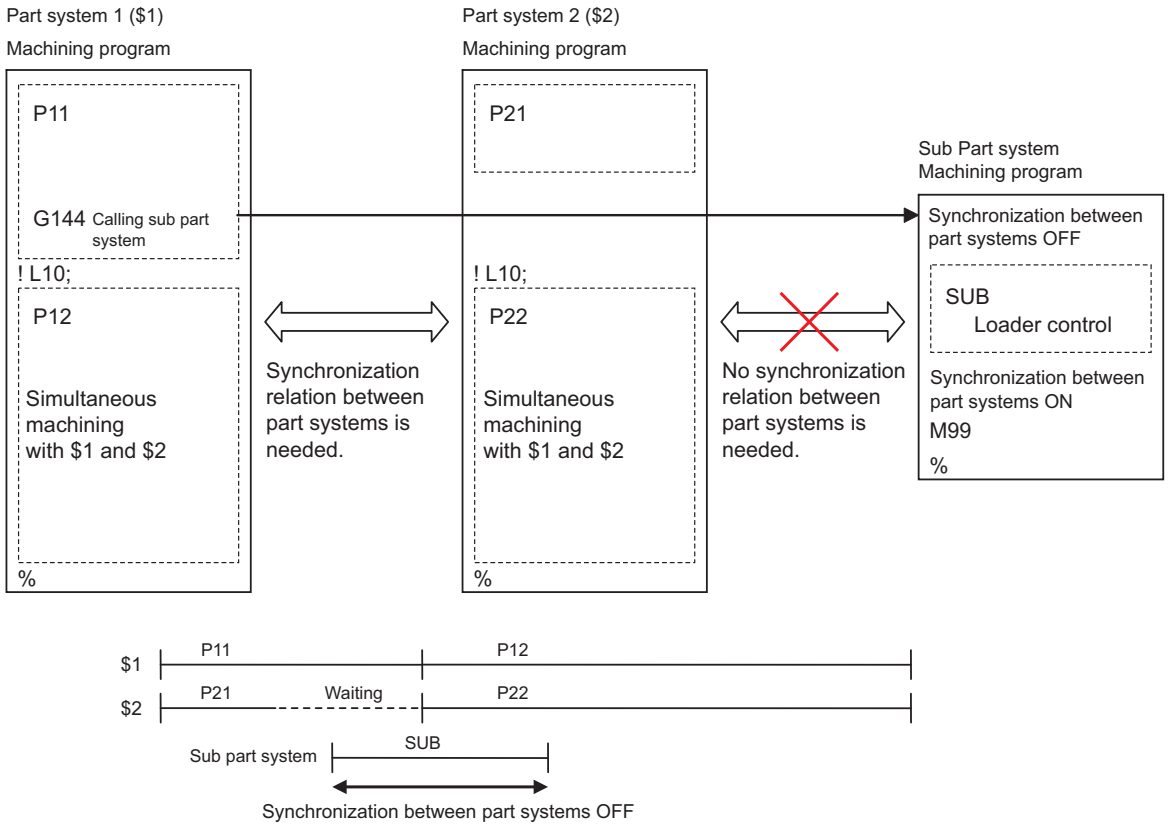
(2) Sub part systems under sub part system control I/II are also subject to single block between part systems. Turn ON the synchronization between part systems OFF to disable single block between part systems operation for sub part systems.

(3) During manual arbitrary reverse run, operation will continue in the single block between part systems enabled state even if the single block between part systems enable signal is turned OFF.

13.4 Synchronization between Part Systems OFF

Synchronization between part systems and feedrate change are turned OFF in a part of a machining program to eliminate a synchronization between part systems by single block operation between part systems or variation of a machining program feedrate by dry run. This function is effective mainly in blocking the cycle operation pause or feedrate variation in only some of part systems when the sub part system control II function is being used. When loader control and ATC control which are operated independently of machining are performed with a sub program or sub part system control, this function enables a operation with synchronization between part systems in machining part systems and an independent operation in sub part systems.

ON/OFF can be switched with the system variable or the PLC signal.



The behaviors with synchronization between part systems OFF is as follows:

Single block function between part systems	- The pause is not made from other part systems. - The other part systems do not pause with block stop.
Dwell/miscellaneous function time override	- Override is invalid.

13.4.1 Description of Operation

System Variable Control

By assigning values to system variables #3003 and #3004, you can enable and disable various functions.

(1) #3003/bit 3: Synchronization between part systems OFF
Part systems for which #3003/bit 3 is turned ON are not affected by the synchronization between part systems function. Here, the synchronization between part systems does not operate with part systems for which the #3003/ bit 3 is turned ON.

Synchronization between part systems	Part systems for which #3003/ bit 3 is turned ON	Part systems for which #3003/ bit 3 is turned OFF
Single block between part systems	Single block between part systems disabled Cycle operation of other part systems is not suspended when single block operation is stopped. Cycle operation is not suspended even if single block operation is stopped for other part systems.	Single block between part systems enabled (Note 1) The single block between part systems is enabled for part systems, excluding those for which the #3003/bit 3 is turned ON.
Dwell/miscellaneous function time override	Dwell/miscellaneous function time override disabled The dwell time and miscellaneous function finish wait time are not applied to the override.	Dwell/miscellaneous function time override enabled (Note 2) The dwell time and miscellaneous function finish wait time are applied to the override.

(Note 1) The single block between part systems must be enabled by external signals.
(Note 2) The dwell/miscellaneous function time override function must be enabled by parameter (#1436 mstsyn).

(2) #3004/bit 4: Dry run disabled
Dry runs are disabled with part systems for which #3004/bit 4 is turned ON.

PLC Control

The synchronization between part systems OFF function is not only a system variable, but can also function as a command by using the following PLC signals. Operation using PLC signals is the same as when using system variables.

PLC Signals										Corresponding system variable
Signal name	Signal abbreviation	$1	$2	$3	$4	$5	$6	$7	$8	
Synchronization between part systems OFF	MSYNC	YCF8	YE38	YF78	Y10B8	Y11F8	Y1338	Y1478	Y15B8	#3003 bit 3
Dry run invalid	DRNC	YCFA	YE3A	YF7A	Y10BA	Y11FA	Y133A	Y147A	Y15BA	#3004 bit 4

13.4.2 Operation with Other Functions

(1) Sub part system control II

When performing sub part system calls, signals such as the cutting feed override and rapid traverse override signals in sub part systems are used as main part system signals, but the synchronization between part systems OFF (MSYNC) signal and the dry run disabled (DRNC) signal are used as sub part system signals.

When a sub part system completes, #3003 and #3004 are reset to "0".

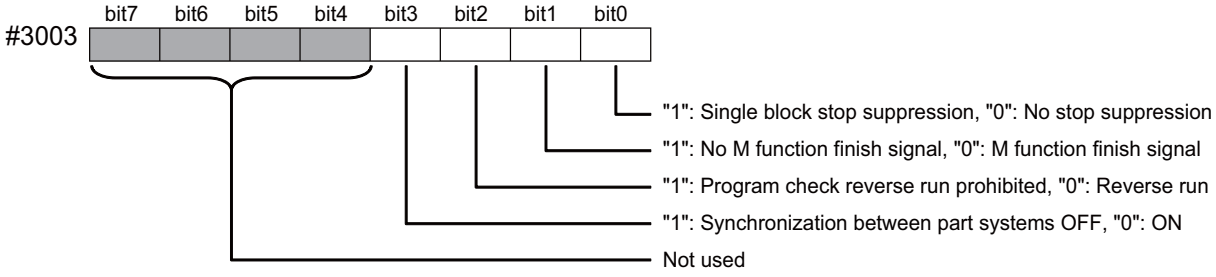
13.4.3 Precautions

(1) Functions are disabled when system variables or PLC signals are turned ON.

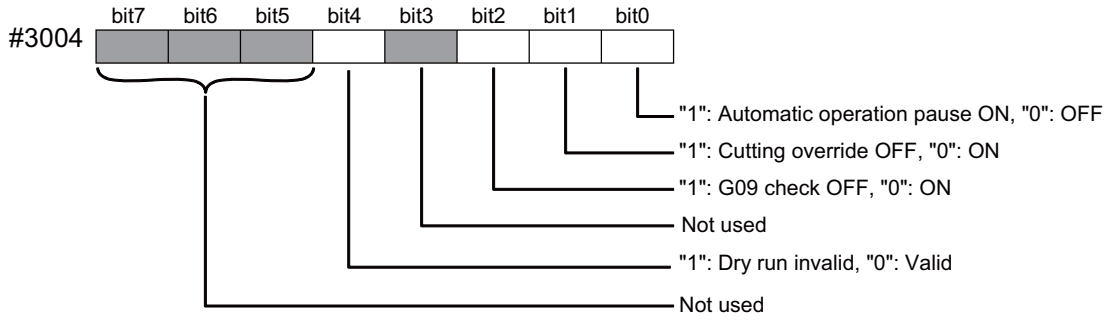
Part system synchronization	PLC sign is on	PLC signal is off
System variable is on	Function disabled	Function disabled
System variable is off	Function disabled	Function enabled

Dry run disable operates in the same manner.

13.4.4 System variable



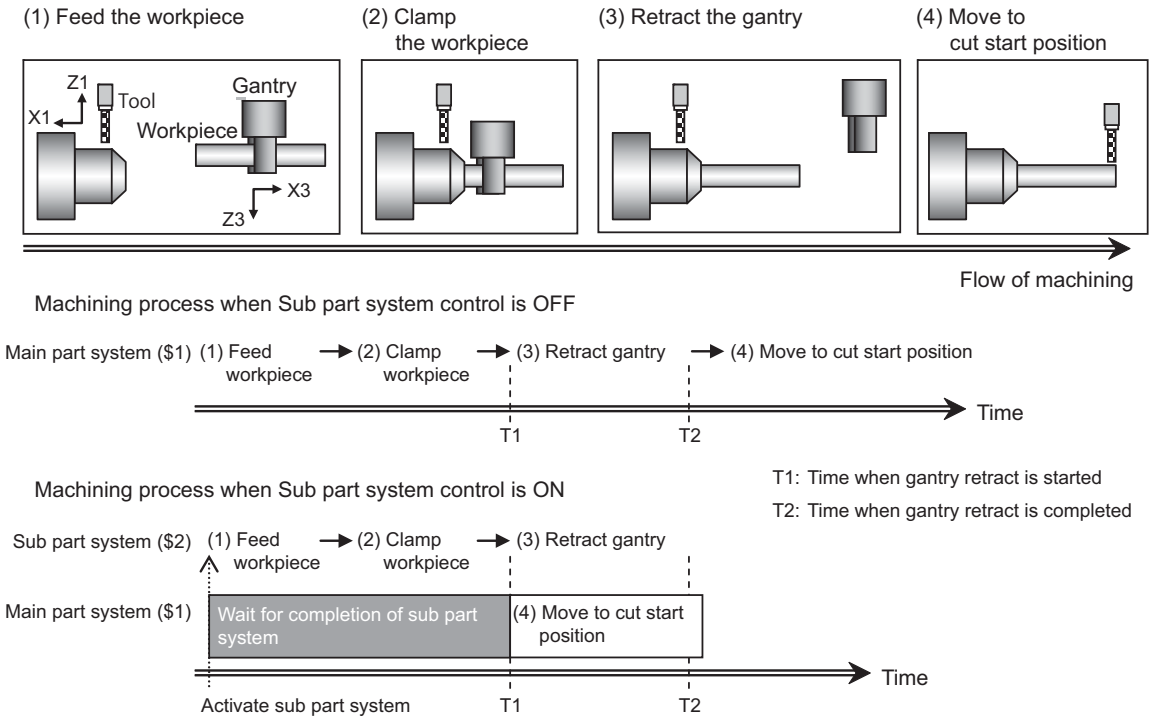
NOTE: #3003 is set to "0" after reset.



NOTE: #3004 is set to "0" after reset.

13.5 Sub Part System control I

This function activates and operates any non-operating part system (sub part system) in the multi-part system.
Sub part system control I can be used in the same manner as calling subprogram in a non-operating part system. An auxiliary axis machining program can be controlled in the sub part system by commanding Sub part system control I (G122) from the main part system.
In the usage example below, the tool positioning starts to the machining start point at the same time (time T1) as the start of gantry retract by using Sub part system control I (G122) in the flow from feeding the workpiece to moving to cut start position in order to reduce the cycle time.
Select whether main part system or sub part system for each part system in Sub part system control I. When using a part system as sub part system, by setting the operation mode to "Sub part system I operation mode" with the PLC signal and commanding Sub part system control I (G122) from an operating part system, it is possible to activate the part system in the sub part system I operation mode as sub part system.

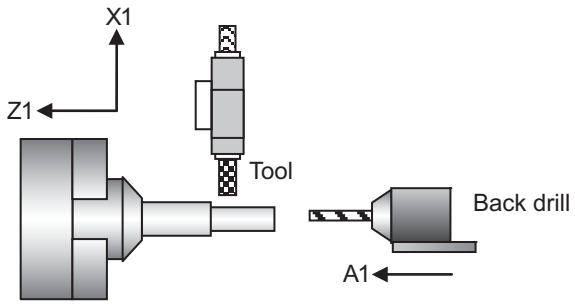


[Related signals]
(1) Sub part system control: Sub part system control I mode ON (SBSMO:XC0E)
(2) Sub part system control: Sub part system processing (SBS:XC4E)
(3) Sub part system control: Calling sub part system (SBSCL:R617)
(4) Sub part system control: Waiting for sub part system completion (SBSWT:R618)
(5) Sub part system control: Caller of sub part system(SBSSY:R619)
(6) Sub part system control: Sub part system control I mode (SBSM:YC0E)
(7) Timing synchronization ignore (YCD0)

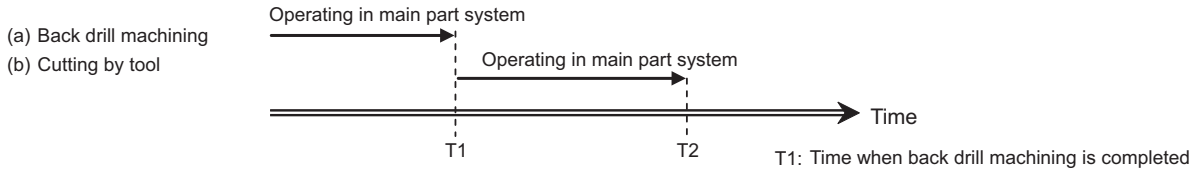
13.6 Sub Part System Control II

This function activates and operates any non-operating part system (sub part system) in the multi-part system. Using sub part systems enables parallel operation between an operating program in main part system and a program called with Sub part system control II (G144).
Sub part systems does not have any controllable axes soon after the activation. When an axis is needed to be controlled in sub part system, command the arbitrary axis exchange control (G140) to give sub part system authorization to control the axis.

In the machine configuration below, when performing the back drill machining (machining (a)) and the cutting by tool (machining (b)), machining (a) and (b) are operated in order only with main part system, however machining (a) and (b) can be operated simultaneously by using the sub part system in addition to the main part system, resulting in a shorter cycle time. In the usage example below, T2 (time when machining (b) is completed) is shorter.

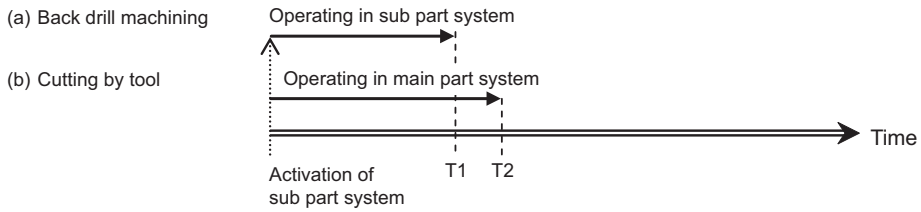


Machining process when Sub part system control is OFF



T1: Time when back drill machining is completed
T2: Time when cutting by the tool is completed

Machining process when Sub part system control is ON



[Related signals]
(1) Sub part system control: Sub part system processing (SBS:XC4E)
(2) Sub part system control: Sub part system control II identification No. (SBSID:R616)
(3) Sub part system control: Calling sub part system (SBSCL:R617)
(4) Sub part system control: Waiting for sub part system completion (SBSWT:R618)
(5) Sub part system control: Caller of sub part system(SBSSY:R619)
(6) Timing synchronization ignore (YCD0)

14

External PLC link

14.1 CC-Link

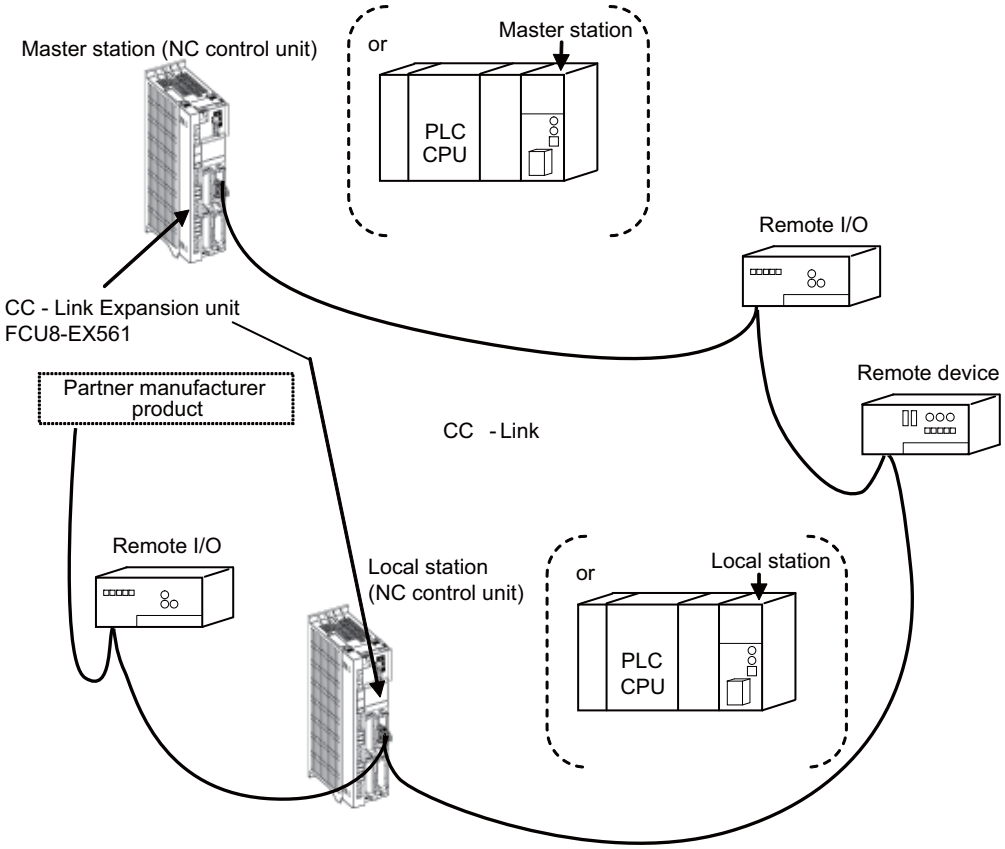
NC control unit can be connected to the PLC network to serve as the master (Ver.2 mode)/local (Ver.1 mode, Ver.2 mode) station of the MELSEC CC-Link.
CC-Link is the abbreviation of Control & Communication Link. For CC-Link, refer to the following documents.
"CC-Link System Master/Local Module User's Manual" (SH-080394E) issued by Mitsubishi Electric Corp.

In order to use CC-Link, it is necessary to install the CC-Link master/local module in the NC control unit. If not installed, it cannot be connected to the PLC network, and the screen for the CC-Link related parameters will not be displayed.
Even if the CC-Link master/local module is installed but the cable is not connected, the alarm "Z68 CC-Link unconnected" will occur. For names of each section of the communication module and how to set the module, refer to "CC-Link (Master/Local) Specifications Manual" (BNP-C3072-089).
If the NC is a local station, it is dealt as an intelligent device station.

[Outline of CC-Link]

(1) Distributing and installing each module to the equipments such as conveyor line and mechanical device and so on can simplify the wiring of the whole system.
(2) The ON/OFF data and numerical data such as input/output treated by each module can be communicated easily and at high speed.
(3) The simple distributed system can be established by connecting several PLC CPUs or NCs.
(4) Connecting the device equipments made by the partner maker can flexibly support various systems.

Outline Drawing (M800W Series)



Abbreviations and terms related to CC-Link are as follows.

Abbreviations and terms	Description
Master station	Station that controls the remote and local stations. One master station is required for each system.
Local station	Station having a CPU and the ability to communicate with the master and other local stations.
Remote I/O station	Remote station that handles bit information only.
Remote device station	Remote station that handles bit information and word information data.
Remote station	Generic term for remote I/O station and remote device station. Controlled by the master station.
Standby master station	Station to backup the data link control instead of the master station when an error occurs to the master station.
Intelligent device station	Station that can perform transient transmission. (Including local stations)
Slave station	Generic term for remote I/O station, remote device station, local station, intelligent device station and standby master station.
SB	Link special relay (for CC-Link) Bit unit information that indicates the module operating status and data link status of the master station/local station. Represented as SB for the sake of convenience.
SW	Link special relay (for CC-Link) 16-bit unit information that indicates the module operating status and data link status of the master station/local station. Represented as SW for the sake of convenience.
RX	Remote input (for CC-Link) Information entered in bit units from the remote station to the master station. Represented as RX for the sake of convenience.
RY	Remote output (for CC-Link) Information output in bit units from the remote station to the master station. Represented as RY for the sake of convenience.
RWw	Remote register (Write area for CC-Link) Information output in 16-bit units from the master station to the remote device station. Represented as RWw for the sake of convenience.
RWr	Remote register (Read area for CC-Link) Information entered in 16-bit units from the master station to the remote device station. Represented as RWr for the sake of convenience.

14.1.1 Performance Specifications

M8 Series is compliant with CC-Link Ver.1.10, Ver.2.00.

Item		CC-Link master/local module					
			Ver.1.10	Ver.2.00			
Maximum number of link points per system (Note 1)		Remote I/O (RX, RY)	2048 points each	8192 points each			
		Remote register (RWw) (master station -> slave station)	256 points	2048 points			
		Remote register (RWr) (slave station -> master station)	256 points	2048 points			
Extended cyclic setting			-	Single	Double	Quadruple	Octuple
Number of link points per 1 slave station (Note 2) (Note 3)	Occupies 1 station	Remote I/O (RX, RY)	32 points each	32 points each	32 points each	64 points each	128 points each
		Remote register (RWw) (master station -> slave station)	4 words	4 words	8 words	16 words	32 words
		Remote register (RWr) (slave station -> master station)	4 words	4 words	8 words	16 words	32 words
	Occupies 2 stations	Remote I/O (RX, RY)	64 points each	64 points each	96 points each	192 points each	384 points each
		Remote register (RWw) (master station -> slave station)	8 words	8 words	16 words	32 words	64 words
		Remote register (RWr) (slave station -> master station)	8 words	8 words	16 words	32 words	64 words
	Occupies 3 stations	Remote I/O (RX, RY)	96 points each	96 points each	160 points each	320 points each	640 points each
		Remote register (RWw) (master station -> slave station)	12 words	12 words	24 words	48 words	96 words
		Remote register (RWr) (slave station -> master station)	12 words	12 words	24 words	48 words	96 words
	Occupies 4 stations	Remote I/O (RX, RY)	128 points each	128 points each	224 points each	448 points each	896 points each
		Remote register (RWw) (master station -> slave station)	16 words	16 words	32 words	64 words	128 words
		Remote register (RWr) (slave station -> master station)	16 words	16 words	32 words	64 words	128 words

(Note 1) If the points which can be reserved as the device for the CC-Link in the NC side (RX, RY) does not satisfy 8192 points, the number of points which can be reserved is the max. number of link points per one system. The remote register (RWw, RWr) is also in the same manner.

(Note 2) The final station of the local stations has 30 points.
(Ex.) If 4 stations are occupied, the number of link points=32 × 3 + 30 = 126 points

(Note 3) The number of link points per slave station can be calculated from the number of occupied stations and cyclic setting as follows.

Version	Cyclic setting	Expression
Ver.1.10	-	RX/RY Number of occupied stations×4×8 (Point) RWr/RWw Number of occupied stations×4 (Word)
Ver.2.00	1 time	
	2 times or more	RX/RY (Number of occupied stations×4-2)×Cyclic setting×8 (Point) RWr/RWw Number of occupied stations×4×Cyclic setting (Word)

(Note 4) Refer to "CC-Link Specifications Manual" (BNP-C3072-089) on parameter setting.

Item	CC-Link master/local module	
The number of occupied stations (Local stations)	1 to 4 stations (Select by parameter)	
Transmission speed	Can select from 156kbps / 625kbps / 2.5Mbps / 5Mbps / 10Mbps (Select by parameter)	
Communication method	Polling method	
Synchronous method	Frame synchronization method	
Encoding method	NRZI method	
Transmission path	Bus (conforming to EIA RS485)	
Transmission format	Conforms to HDLC	
Error control system	CRC($X^{16} + X^{12} + X^5 + 1$)	
Maximum number of connected stations	Ver. 1.10	64 modules Note that the following conditions must be satisfied. Condition 1: (1×a)+(2×b)+(3×c)+(4×d) ≤ 64 a: Number of modules occupying 1 station b: Number of modules occupying 2 stations c: Number of modules occupying 3 stations d: Number of modules occupying 4 stations Condition 2: (16×A)+(54×B)+(88×C) ≤ 2304 A: Number of remote I/O stations ≤ 64 B: Number of remote device stations ≤ 42 C: Number of local stations, standby master stations, intelligent device stations ≤ 26
	Ver. 2.00	64 modules Note that the following conditions must be satisfied. Condition 1: (a+a2+a4+a8)+(b+b2+b4+b8)×2+(c+c2+c4+c8)×3+(d+d2+d4+d8)× 4 ≤ 64 (a×32+a2×32+a4×64+a8×128)+(b×64+b2×96+b4×192+b8×384)+(c ×96+c2×160+c4×320+c8×640)+(d×128+d2×224+d4×448+d8×896) ≤ 8192 (a×4+a2×8+a4×16+a8×32)+(b×8+b2×16+b4×32+b8×64)+(c×12+c2 ×24+c4×48+c8×96)+(d×16+d2×32+d4×64+d8×128) ≤ 2048 a : Number of modules that occupy 1 station which are set to "Single". b : Number of modules that occupy 2 stations which are set to "Single". c : Number of modules that occupy 3 stations which are set to "Single". d : Number of modules that occupy 4 stations which are set to "Single". a2: Number of modules that occupy 1 station which are set to "Double". b2: Number of modules that occupy 2 stations which are set to "Double". c2: Number of modules that occupy 3 stations which are set to "Double". d2: Number of modules that occupy 4 stations which are set to "Double". a4: Number of modules that occupy 1 station which are set to "Quadruple". b4: Number of modules that occupy 2 stations which are set to "Quadruple". c4: Number of modules that occupy 3 stations which are set to "Quadruple". d4: Number of modules that occupy 4 stations which are set to "Quadruple". a8: Number of modules that occupy 1 station which are set to "Octuple". b8: Number of modules that occupy 2 stations which are set to "Octuple". c8: Number of modules that occupy 3 stations which are set to "Octuple". d8: Number of modules that occupy 4 stations which are set to "Octuple". Condition 2: {(16×A)+(54×B)+(88×C)} ≤ 2304 A: Number of remote I/O stations ≤ 64 B: Number of remote device stations ≤ 42 C: Number of local stations, standby master stations, intelligent device stations ≤ 26
	(Note) For checking the number of modules to connect, the check sheet can be downloaded from CC-Link Partner Assorciation's website. Check it in advance. URL http://www.cc-link.org/	
Remote station No.	1 to 64	

Item	CC-Link master/local module
Maximum overall cable distance and station to station cable length	Version 1.10 compatible CC-Link dedicated cable (terminal resistor of 110Ω used) Transmission speed Maximum overall cable distance 156 kbps 1200 m 625 kbps 900 m 2.5 Mbps 400 m 5 Mbps 160 m 10 Mbps 100 m Station to station cable length is 20 cm or longer regardless of the transmission speed. (Note) When CC-Link Ver.1.00 compliant cables are mixed, the cable length between stations and the maximum total length of the cable should follow the specifications for CC-Link Ver.1.00.
Connection cable	Version 1.10 compatible CC-Link dedicated cable (3-core twisted pair cable with shield) This can be used with the cables made by different manufacturers as long as they are Ver.1.10 compliant cables.
RAS function (Note)	- Automatic return function - Slave station cut-off function - Error detection by the link special relay/register

(Note) "RAS" is short for "Reliability", "Availability" and "Serviceability".

14.1.2 Usable Functions

Of all the CC-Link functions, the following functions can be used with the NC.

(○: Available ×: Not available −: Not relevant)

	Function item		MELSEC		NC control unit	
			Master station	Local station	Master station (Note 1)	Local station
Method	Ver.1.10		○	○	○	○
	Ver.2.00		○	○	○	○
Master function	Communication between master station and remote I/O station		○	-	○	-
	Communication between master station and remote device station		○	-	○	-
	Communication between master station and local station		○	○	○	○
	Remote net Ver.1 mode		○	-	○	-
	Remote net Ver.2 mode		○	-	○	-
	Remote net additional mode		○	-	×	-
	Remote I/O net mode		○	-	×	-
	Block guarantee of cyclic data per station		○	○	×	×
	32-bit data guarantee of cyclic data		○	○	×	×
	Setting the number of points for remote I/O station		○	-	○	-
	Reserved station function		○	-	○	-
	Error cancel station setting function		○	-	○	-
	Data link stop/restart		○	○	○	○
	Automatic refresh function		○	○	○	○
	Scan synchronization function	Synchronous mode	○	-	○	-
		Asynchronous mode	○	○	-	-
Setting & display function	LED diagnosis status		16-point display		16-point display	
	Station number setting		Module front panel switches		Parameters	
	Baud rate setting				Parameters	
	Mode setting switch					
	Condition setting				H/W switch (SW1)	
RAS function	Automatic return function		○	○	○	○
	Slave station cut-off function		○	-	○	-
	Data link status setting when the master station CPU has an error		○	○	○	○
	Setting the status of input data from a data link faulty station		○	○	○	○
	Slave station refresh/compulsory clear setting in case of PLC CPU STOP		○	-	○	-
	Other station data link status (SB/SW)		○	○	○	○
	Monitor diagnosis		○	○	×	×
	Standby master function		○	-	○	-
	Master station duplication error cancel function		○	-	×	-
	Temporary error cancel station designation function		○	-	○	-
Diagnosis function	Line test		○	-	(Note 4)	-
	Hardware test		○	○	○	○

	Function item	MELSEC		NC control unit	
		Master station	Local station	Master station (Note 1)	Local station
Exclusive instruction	RIRD instruction / RIWT instruction	○	○	○	○
	RDMSG instruction	○	○	×	×

(Note 1) When installing two FCU8-EX561, these cannot be used as master stations at a time.
(Note 2) Refer to "CC-Link Specifications Manual" (BNP-C3072-089) on parameter setting.
(Note 3) When connecting NC with GX Developer as a slave station, set it as the intelligent device station.
(Note 4) Available only for the test with the H/W switch.

14.1.2.1 Machine Input/Output Signal Allocation By CC-Link

Input/output device allocation when HN571 is mounted is as shown below.

	RIO only			With CC-Link communication			
	RIO1	RIO2	RIO3	RIO1	RIO2	RIO3	CC-Link communication
Input	X00 : XFF	X100 : X1FF	X200 : X2FF	X00 : XFF	X100 : X1FF	X200 : X2FF	X0 : X5FF
Output	Y00 : YFF	Y100 : Y1FF	Y200 : Y2FF	Y00 : YFF	Y100 : Y1FF	Y200 : Y2FF	Y0 : Y5FF

(Note) When using CC-Link communication, do not duplicate the devices used by actual RIO.

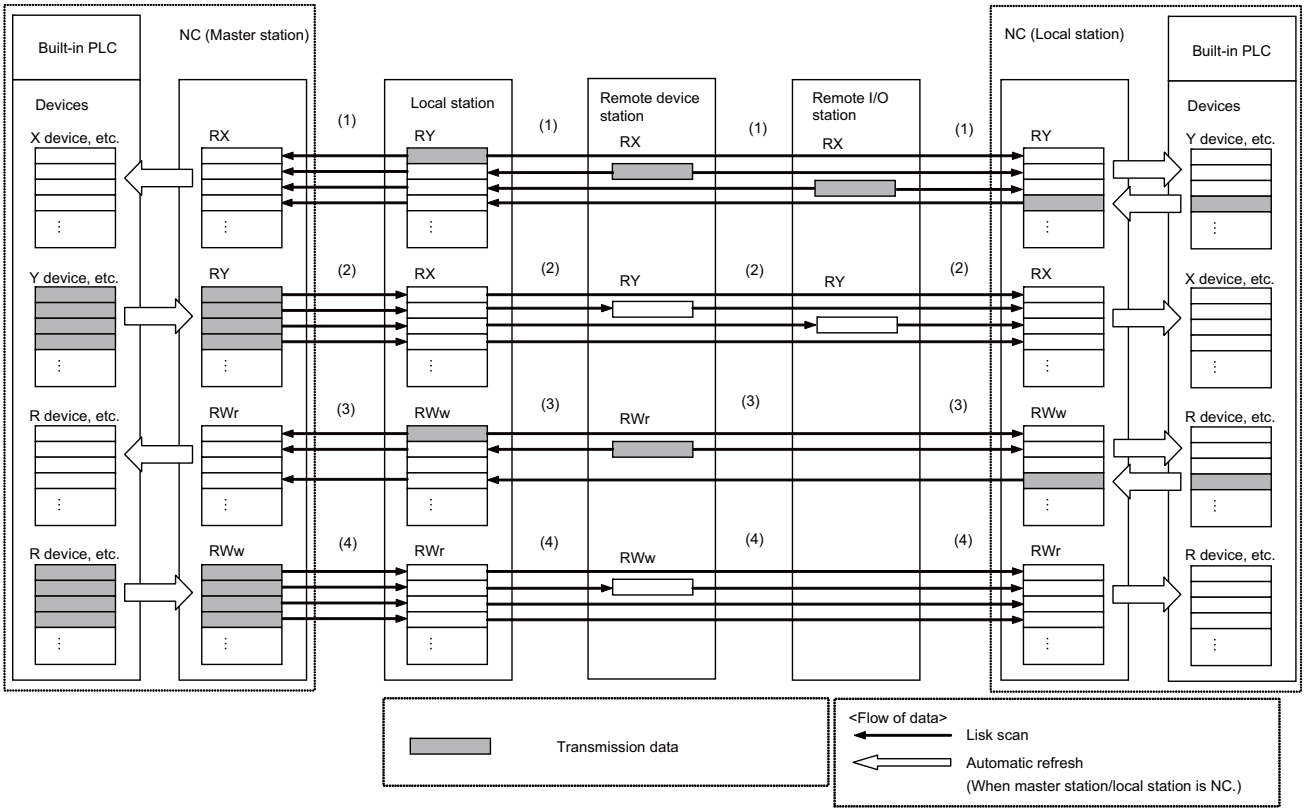
14.1.2.2 File Register By CC-Link

Device	Description
R8300 to R9799 R18300 to R19799 R28300 to R29799	User backup area
R9800 to R9899 R19800 to R19899 R29800 to R29899	User work area

14.1.3 Communication Data

14.1.3.1 Communication Data Flow

The flow of data communicated by the CC-Link's link scan is as follows.
(The master station and local station of MELSEC CPU can be also mixed.)



(1) By executing a link scan, data in the remote I/O station, and remote device station's remote input (RX) and local station's remote output (RY) are transmitted to the master station's remote input (RX) and the local station's remote output (RY).

(2) By executing a link scan, data in the master station's remote output (RY) is transmitted to the remote I/O station and remote device station's remote output (RY) and the local station's remote input (RX).

(3) By executing a link scan, data in the remote device station's remote register (RWr) and the local station's remote register (RWw) is transmitted to the master station's remote register (RWr) and the local station's remote register (RWw).

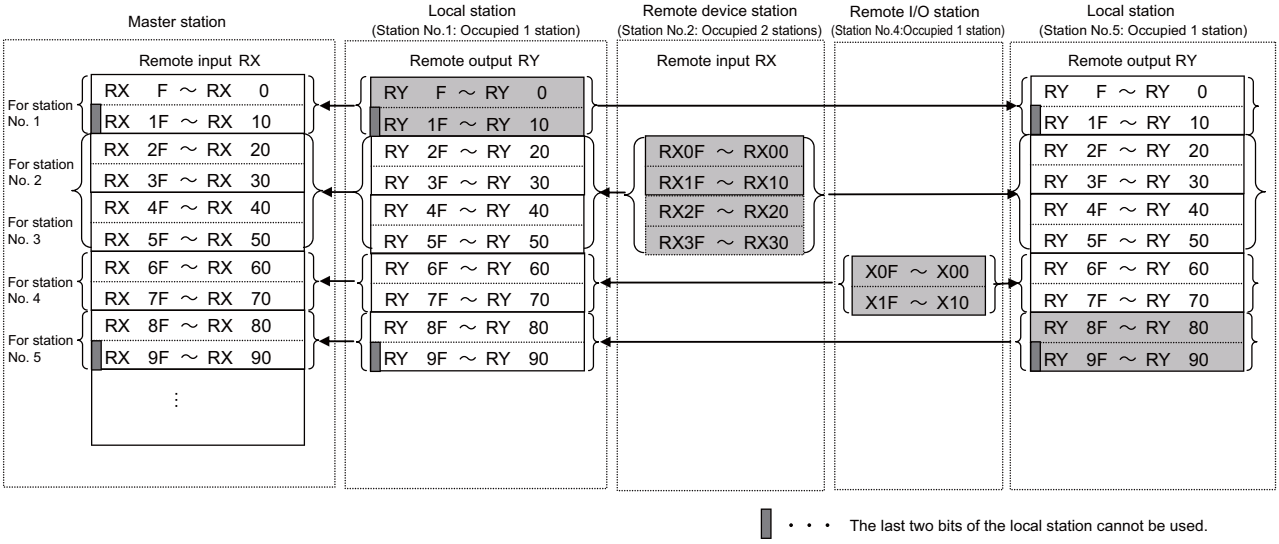
(4) By executing a link scan, data in the master station's remote register (RWw) is transmitted to the remote device station's remote register (RWw) and the local station's remote register (RWr).

14.1.3.2 Register Allocation

Allocation of remote input, remote output, remote register by protocol version is as follows.

Ver.1 mode

(1) Ver.1 remote input and remote output

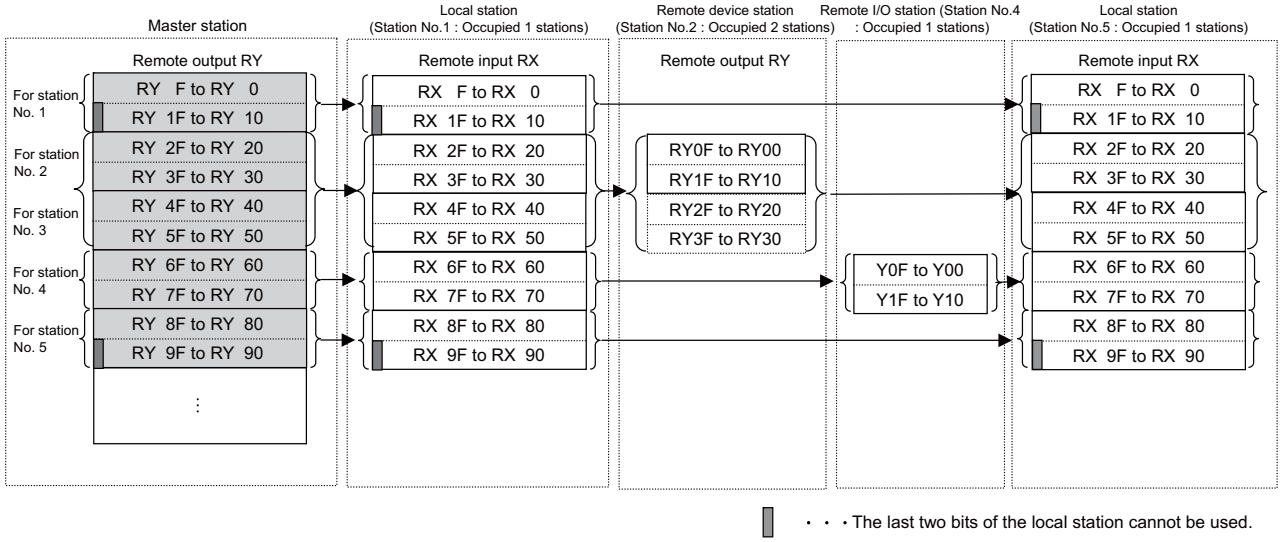


[Ver.1 RX/RY]

Master station <- Local station/Remote device station/Remote I/O station

(a) Master station
- The input status from the local station (RY), remote device station and remote I/O station (RX) is stored.
- Two words are used per station.

(b) Local station
- Data to be sent to the master station is stored in the remote output (RY) of the address corresponding to the host station number.
- The input status from the remote device station, remote I/O station (RX) and other remote local stations is stored.
- Two words are used per station.



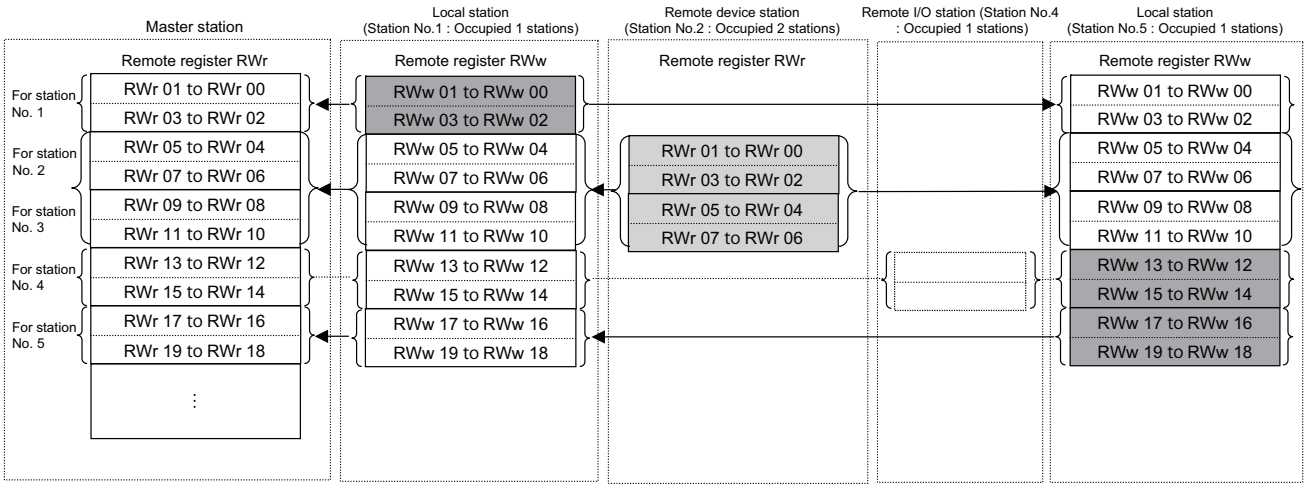
[Ver.1 RX/RY]

Master station -> Local station/Remote device station/Remote I/O station

(a) Master station
- The output status to the local station (RY), remote device station and remote I/O station (RX) is stored.
- Two words are used per station.

(a) Local station
- The data received from the remote device station, remote I/O station (RY), and master station (RY) is stored.
- Two words are used per station.

(2) Ver.1 remote register

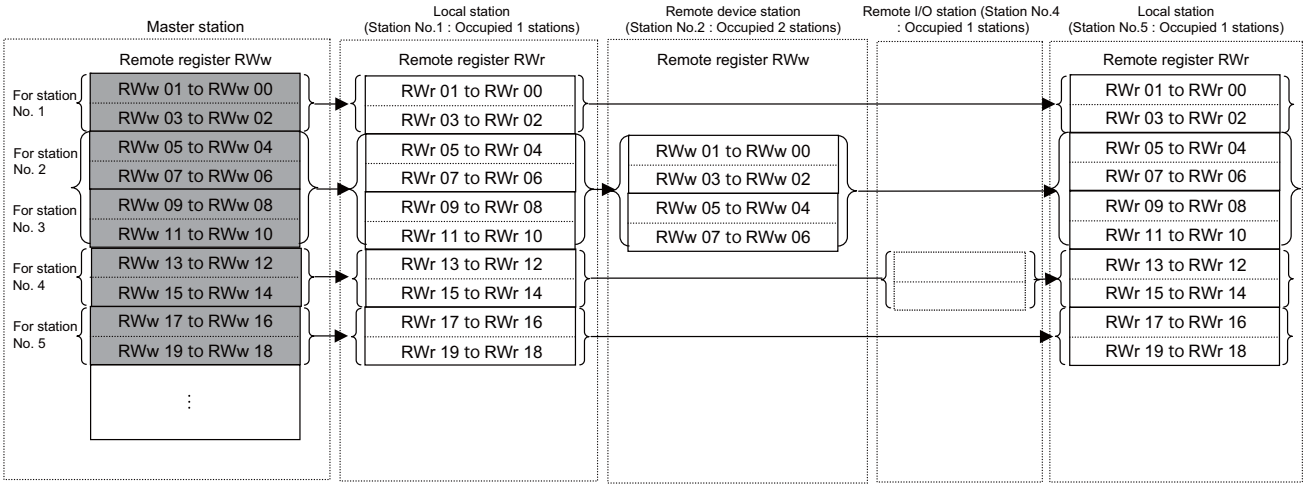


[Ver.1 RWr/RWw]

Master station <- Local station/Remote device station

(a) Master station
- The input status from the local station (RWw) and remote device station (RWr) is stored.
- Four words are used per station.
- Area for the remote I/O station is also secured.

(b) Local station
- Data to be sent to the master station is stored in the remote output (RWw) of the address corresponding to the host station number.
- The input status from the remote device station (RWr) and other local stations is stored.
- Four words are used per station.
- Area for the remote I/O station is also secured.



[Ver.1 RWr/RWw]

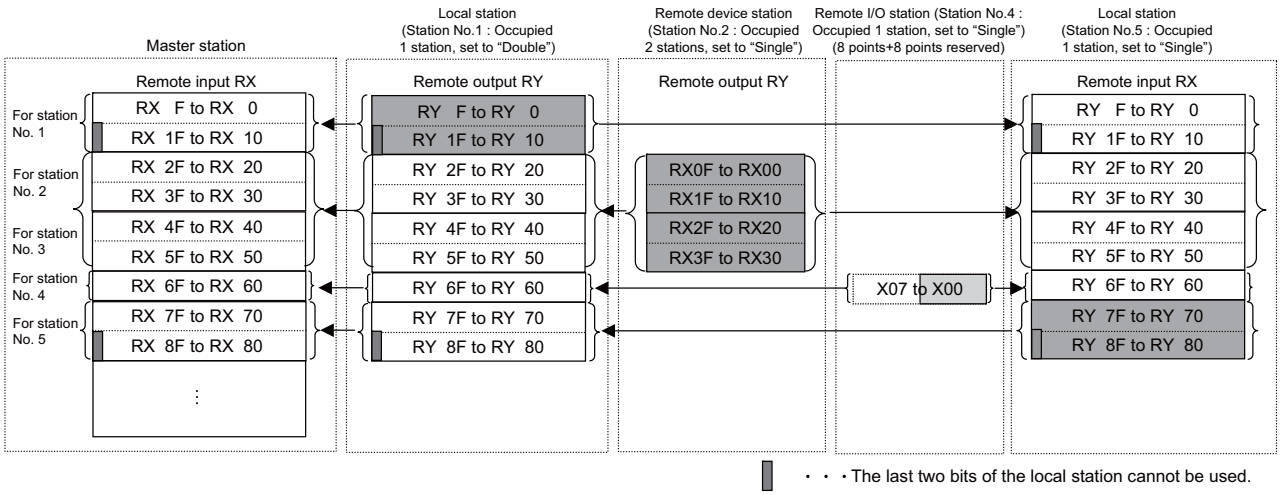
Master station -> Local station/Remote device station

(a) Master station
- The output status to the remote device station (RWw) and all local stations (RWr) is stored.
- Four words are used per station.
- Area for the remote I/O station is also secured.

(b) Local station
- The data received from the remote device station (RWw) and master station (RWw) is stored.
- Four words are used per station.
- Area for the remote I/O station is also secured.

Ver.2 mode

(1) Ver.2 remote input and remote output



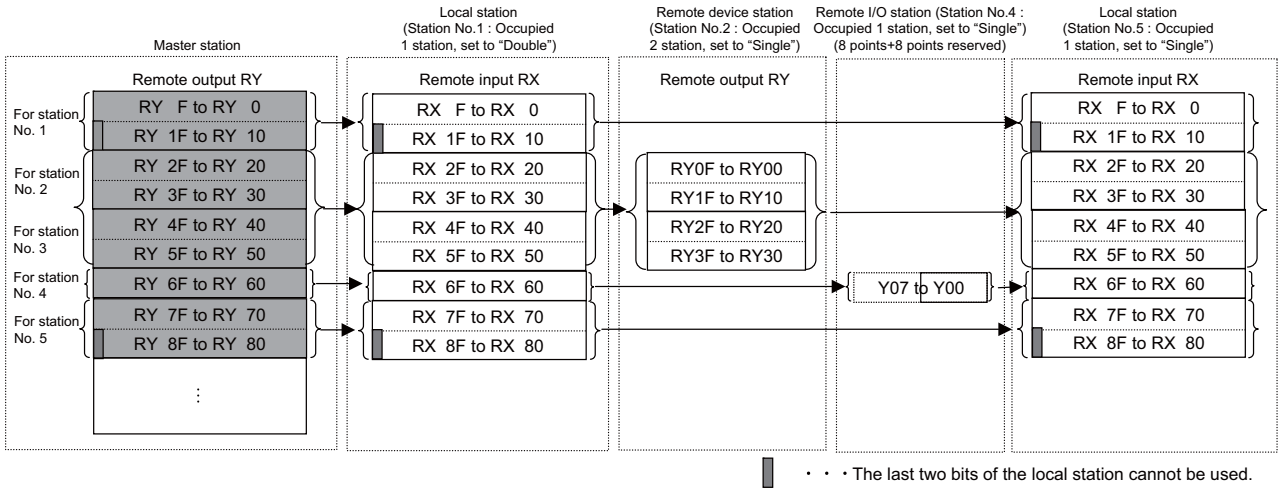
[Ver.2 RX/RY]

Master station <- Local station/Remote device station/Remote I/O station

(a) Master station
- The input status from the local station (RY), remote device station and remote I/O station (RX) is stored.
- The number of used points changes depending on the number of occupied stations and the extended cyclic setting. (Refer to "Performance Specification".)
- For remote I/O station, the number of used points can be set to 8, 16 points, or 32 points with parameter.

(b) Local station
- Data to be sent to the master station is stored in the remote output (RY) of the address corresponding to the host station number.
- The input status from the remote device station, remote I/O station (RX) and other remote local stations is stored.
- The input status from the remote device station, remote I/O station (RX), and other local stations is stored. (Refer to "Performance Specification".)
- For remote I/O station, the number of used points can be set to 8, 16 points, or 32 points with parameter of the master station.

(Note) Refer to "CC-Link Specifications Manual" (BNP-C3072-089) on parameter setting.



[Ver.2 RX/RY]

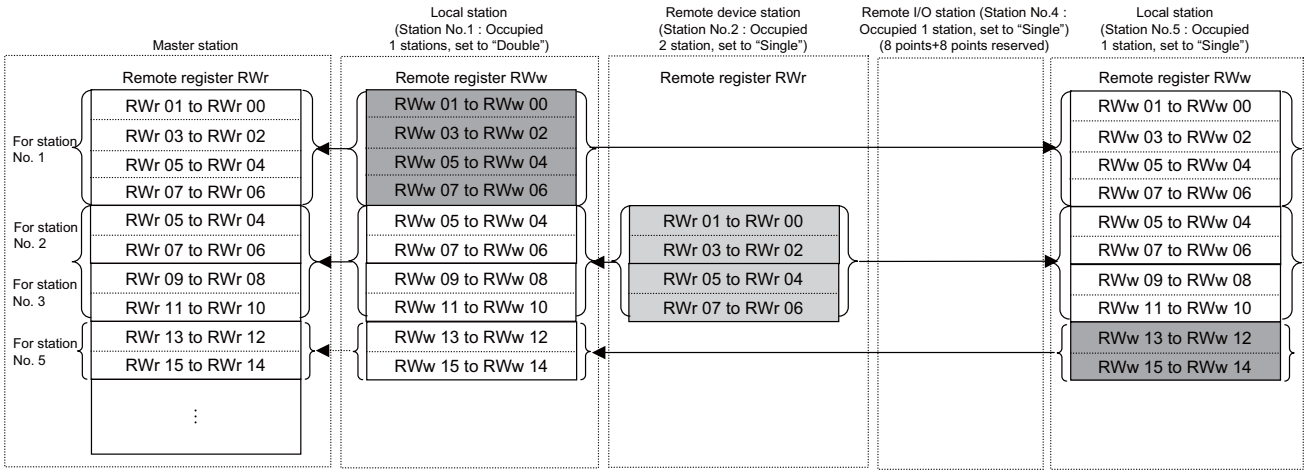
Master station -> Local station/Remote device station/Remote I/O station

(a) Master station
- The output status to the local station (RY), remote device station and remote I/O station (RX) is stored.
- The number of used points changes depending on the number of occupied stations and the extended cyclic setting. (Refer to "Performance Specification".)
- For remote I/O station, the number of used points can be set to 8, 16 points, or 32 points with parameter.

(a) Local station
- The data received from the remote device station, remote I/O station, and master station (RY) is stored.
- The number of used points changes depending on the number of occupied stations and the extended cyclic setting. (Refer to "Performance Specification".)
- For remote I/O station, the number of used points can be set to 8, 16 points, or 32 points with parameter of the master station.

(Note) Refer to "CC-Link Specifications Manual" (BNP-C3072-089) on parameter setting.

(2) Ver.2 remote register

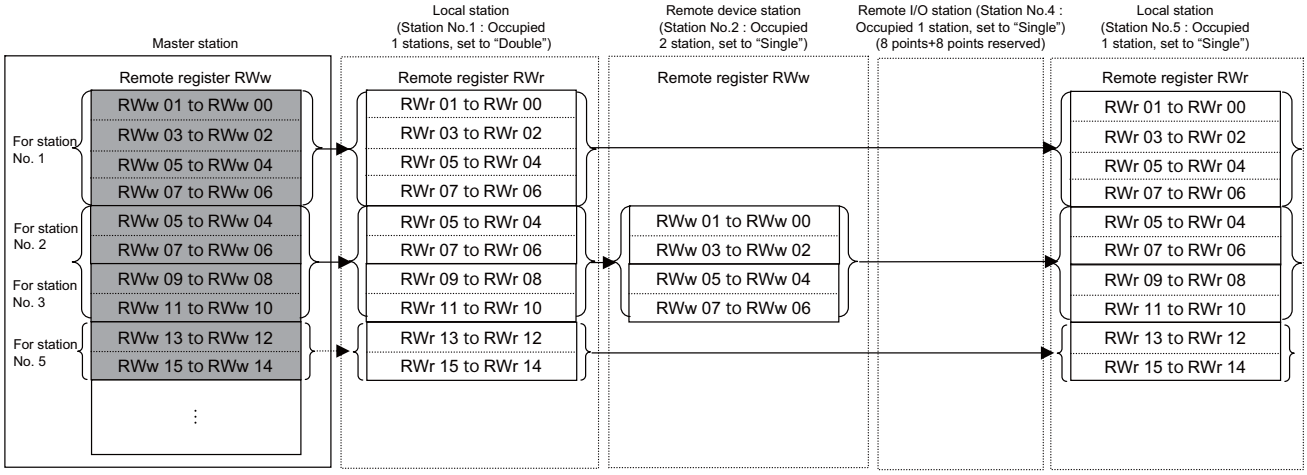


[Ver.2 RWr/RWw]

Master station <- Local station/Remote device station

(a) Master station
- The input status from the local station (RWw) and remote device station (RWr) is stored.
- The number of used points changes depending on the number of occupied stations and the extended cyclic setting. (Refer to "Performance Specification")
- Area for the remote I/O station is also secured.

(b) Local station
- Data to be sent to the master station is stored in the remote register (RWw) of the address corresponding to the host station number.
- The input status from the remote device station (RWw) and other local stations is stored.
- Four words are used per station.
- Area for the remote I/O station is also secured.



[Ver.2 RX/RY]

Master station -> Local station/Remote device station

(a) Master station
- The output status to the remote device station (RWw) and all local stations (RWr) is stored.
- The number of used points changes depending on the number of occupied stations and the extended cyclic setting. (Refer to "Performance Specification")
- Area for the remote I/O station is also secured.

(b) Local station
- The data received from the remote device station (RWw) and master station (RWw) is stored.
- Four words are used per station.
- Area for the remote I/O station is also secured.

14.1.3.3 Automatic Refresh

Data transfer between the CC-Link master/local module and the NC built-in PLC device is performed automatically. Set the destination device to automatically refresh in the following parameters.
Parameter #24014+40(n-1) "RX dev name" to #24025+40(n-1) "SW dev No."
(n=Slot No.)
The devices possible to set as destination devices in the automatic refresh are as follows.

Device name	Device range	RX,RY,SB	RWr,RWw,SW
X	X0 to X5FF (Do not duplicate the devices used by actual I/O)	RX only	×
Y	Y0 to Y5FF (Do not duplicate the devices used by actual I/O)	RY only	×
M	M0 to M61439	○	○
L	L0 to L1023	○	○
B	B0 to BDFFF	○	○
D	D0 to D4095	○	○
R	(User backup area) R8300 to R9799, R18300 to R19799, R28300 to R29799 (User work area) R9800 to R9899, R19800 to R19899, R29800 to R29899	○	○
ZR	ZR0 to ZR13311 (note2)	○	○
W	W0 to W2FFF	○	○
SB	SB0 to SB3FF	SB only	×
SW	SW0 to SW3FF	×	SW only

(Note 1) When using the multi-project function, the devices M, L, B, D, W, SB, and SW are assigned as the first project device.

(Note 2) Since ZR device is used for interface or parameter interface, etc. between PLC and CNC, be aware when setting it as a forwarding destination to refresh.

14.1.3.4 Occupied Number of Stations of the System and Settable Range of the Device

The device range allocated for CC-Link remote I/O (RX, RY) and remote register (RWw, RWr) varies depending on the number of occupied stations (actual number of link points) set per system. In order to operate the NC and CC-Link normally, calculate the device range in the expressions in the blow table, and confirm that the settable range is not exceeded.

RX,RY,SB	RWr,RWw,SW	Settable device name	Settable device range
RX only	-	X	Min.: X0 Max.: X5FF - Actual number of link points
RY only	-	Y	Min.: Y0 Max.: Y5FF - Actual number of link points
○	○	M	Min.: M0 Max.: M61439 - Actual number of link points
○	○	L	Min.: L0 Max.: L1023 - Actual number of link points
○	○	B	Min.: B0 Max.: BDFFF - Actual number of link points
○	○	D	Min.: D0 Max.: D4095 - Actual number of link points
○	○	R	Area 1: Min.: R8300 Max.: R9799 - Actual number of link points Area 2: Min.: R9800 Max.: R9899 - Actual number of link points Area 3: Min.: R18300 Max.: R19799 - Actual number of link points Area 4: Min.: R19800 Max.: R19899 - Actual number of link points Area 5: Min.: R28300 Max.: R29799 - Actual number of link points Area 6: Min.: R29800 Max.: R29899 - Actual number of link points
○	○	ZR	Min.: ZR0 Max.: ZR13311 - Actual number of link points (Note 4)
○	○	W	Min.: W0 Max.: W2FFF - Actual number of link points

(Note 1) NC or PLC ladder does not operate normally when the device area secured for CC-Link is duplicated with the actual machine input/output signal used by the NC or machine side or when it is outside the range indicated above.
When the NC does not start normally, reduce the number of connections or set the station No. to a smaller one so that the actual number of link points is reduced and the device area falls in the range indicated in the table above. Then, restart the NC and set the CC-Link parameters again.

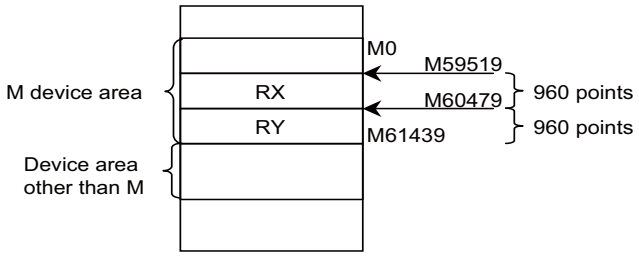
(Note 2) When using the multi-project function, the devices M, L, B, D, W, SB and SW are assigned as the first project device.

(Note 3) When changing CC-Link system configuration, always confirm that the parameters of all the NCs connected with CC-Link is within the range.

(Ex.) Setting range when the occupied number of stations is 30 per one CC-Link system:

(1) Actual number of remote input/output points (Actual number of link points): Occupied number of stations(30)*32=960 points

(2) Setting range of RX and RY when they are set (in the order of RX, and then RY) with M devices: RY device: M61439–Actual number of link points (960)= to M60479
RX device: M60479 – Actual number of link points (960)= to M59519
(with securing 960 points from the head of RY)



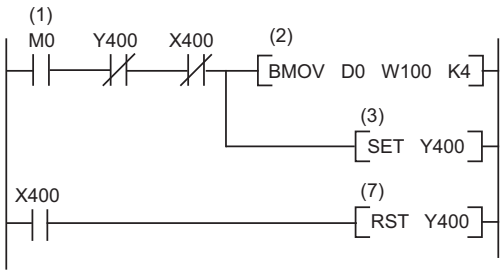
* Make sure not to overlap with the device area other than M.

(Note 4) Since ZR device is used for interface or parameter interface, etc. between PLC and CNC, be aware when setting it as a forwarding destination to refresh.

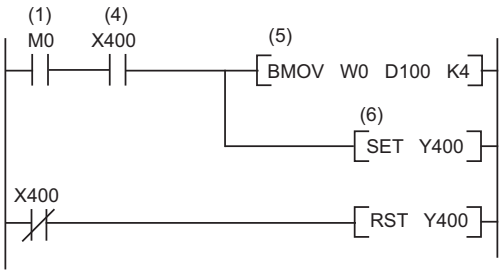
14.1.3.5 Data Guarantee of Cyclic Data at the Time of Communication between Master and Local Stations

Cyclic data may be separated into new data and old data, depending on the auto refresh timing.
When the data guarantee of cyclic data (RWr/RWw) per station is necessary, it is guaranteed by applying an interlock in the remote input/output (RX/RY).
As illustrated below, apply an interlock in the remote input/output (RX/RY).

Transmitting station (Master station)



Receiving station (Local station)



(1) The send/receive command (M0) turns ON.
(2) Data of D0 to D3 are stored in W100 to W103 (RWw0 to Rww3).
(3) Upon completion of storage in W100 to W103, Y400 (RY0) for handshake turns ON.
(4) By cyclic transmission, remote output (RY) data are sent following the remote register (RWw) data, and then the receiving station's X400 (RX0) is turned ON.
(5) Data of W0 to W3 (RWr0 to RWr3) are stored in D100 to D103.
(6) Upon completion of storage in D100 to D103, Y 400 (RY0) for handshake turns ON.
(7) When the data reach the receiving station, Y400 is turned OFF.

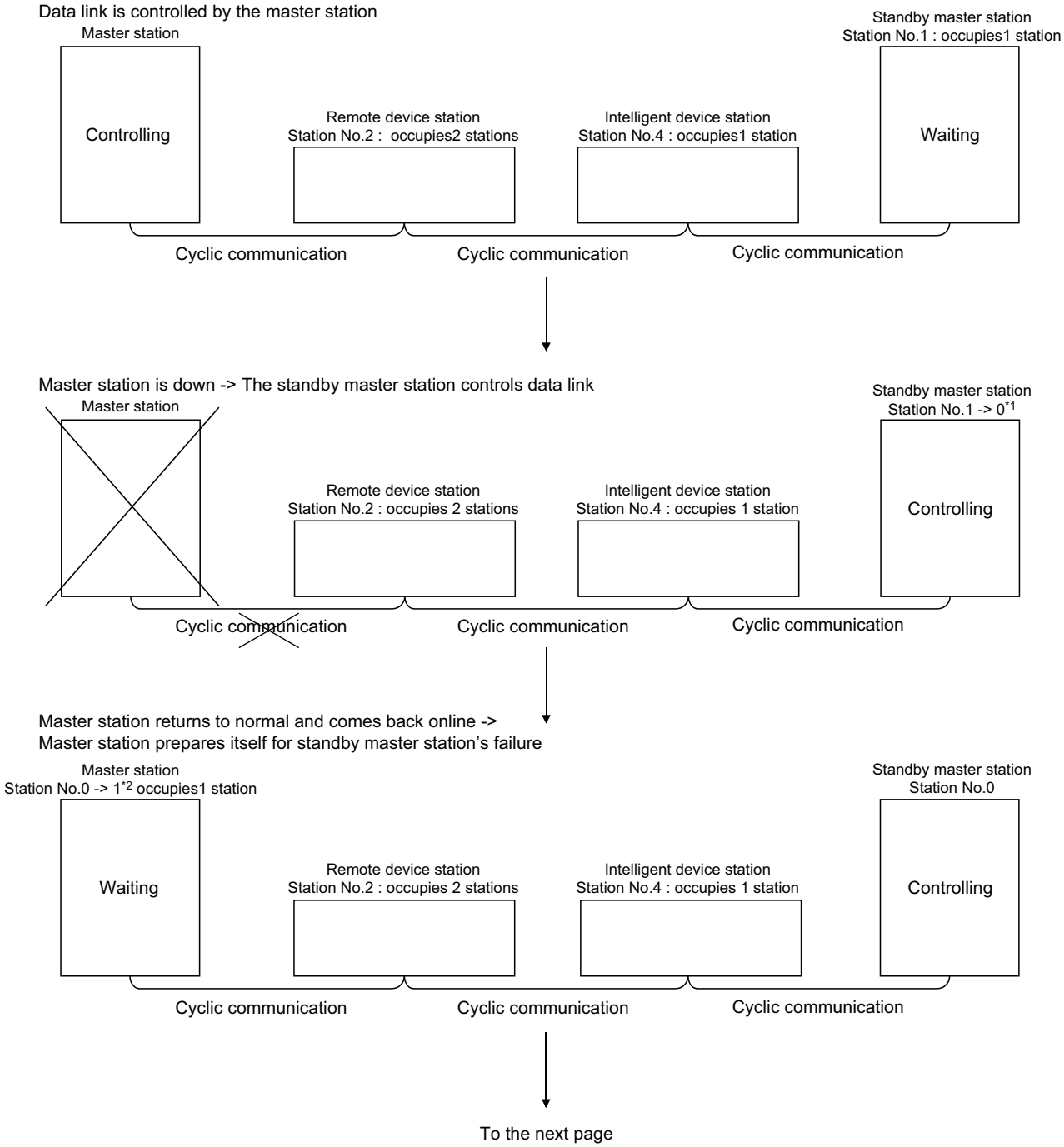
14.1.3.6 Communication Error Invalid Time

When the power supply of the CNC is turned ON, communication error may occur during link establishment with the other stations.
To prevent this communication error occurrence, specify a period of time (from the power supply ON of the CNC till startup of the CNC is completed) during which the control does not detect a Fieldbus communication error.
Set the parameter "#1332 F-bus init delay" (Field bus communication error invalid time) or "#1490 F-bus init delay 2" (Field bus communication error invalid time 2). (0.0 to 6000.0 seconds in 0.1-second increments)

14.1.4 Standby Master Function

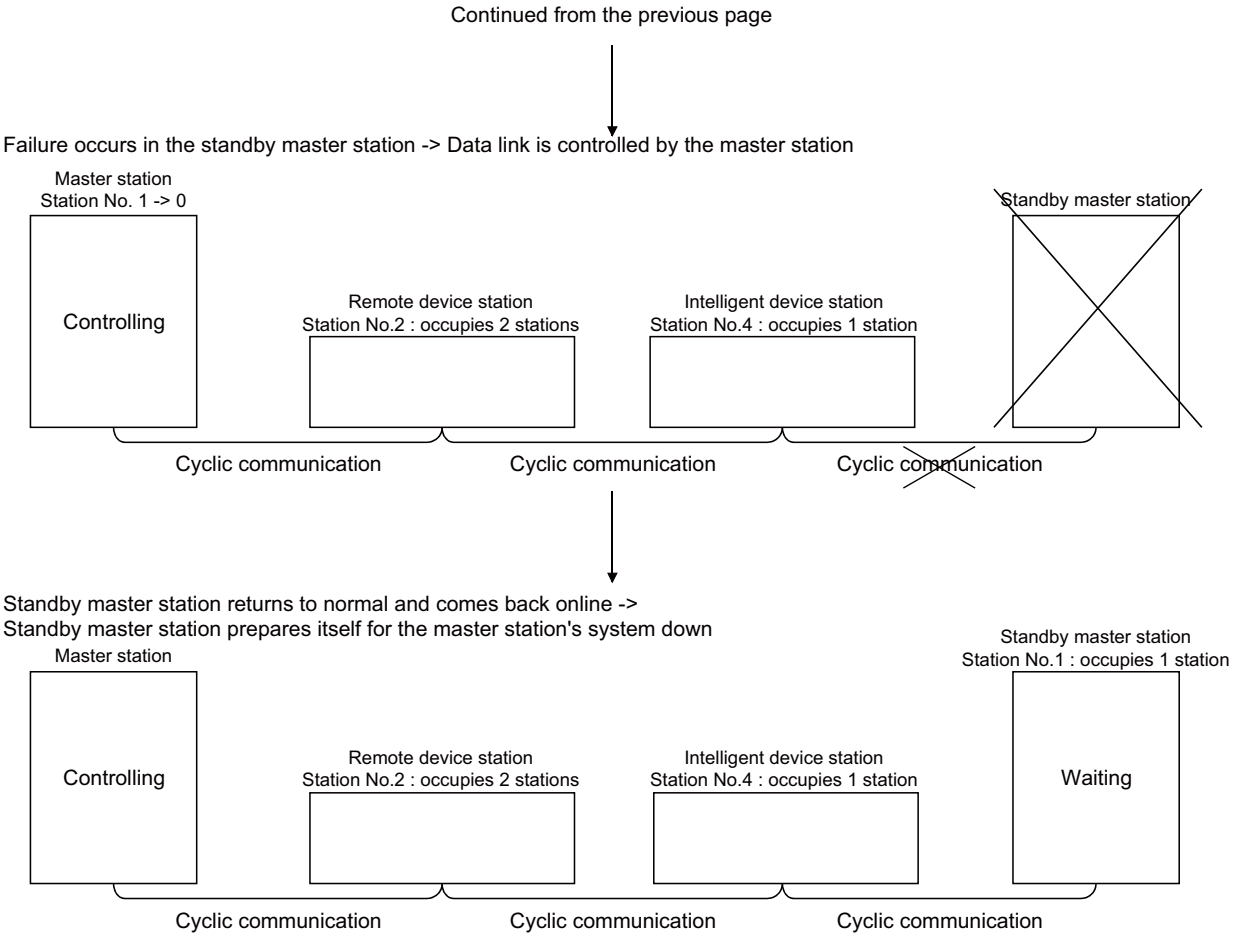
This function enables the data link to continue working by switching to a standby master station (backup station for the master station) if a malfunction occurs in the master station.
The master station can return to online even during data link controlled by the standby master station, and prepares itself for standby master station's system down. (Master station duplex function)
NC can function both as a master and standby master station.

Controlling : controls data link in CC-Link system
Waiting : stands by for failure of the station controlling data link CC-Link system



To the next page

*1 When data link control is transferred to standby master station at the master station's system down, the station No. of the standby master station is changed to "0".
*2 When master station comes back online as a standby master station, the master station's No. changes to the one set in the network parameter "Standby master station No.".



14.1.4.1 How to Set

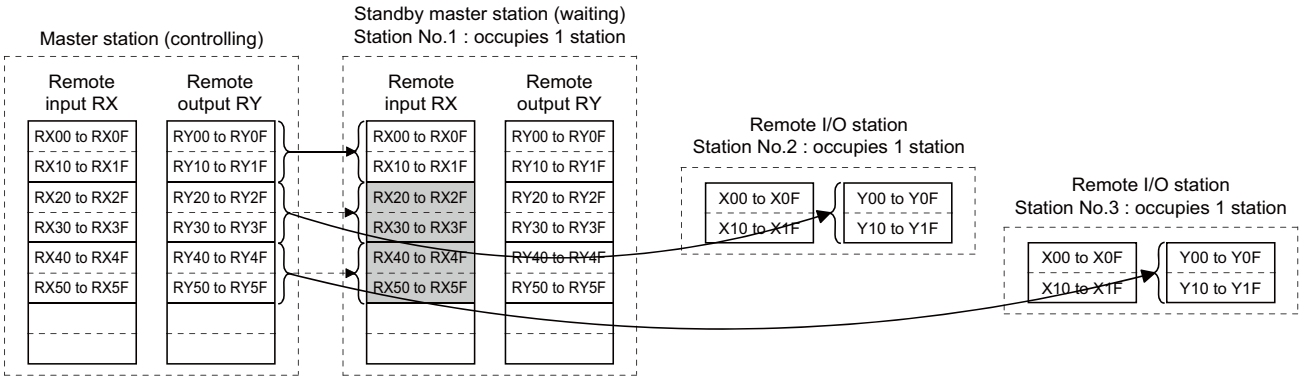
To enable this function, set the parameter #24010+40(n-1) (n=slot No.) "Standby master station".
When NC is master station, set the station No. of standby master station.
When NC is standby master station, set this parameter to "1".
When NC is neither master nor standby master station, set "0".

14.1.4.2 Overview of Link Data Transmission When Standby Master Function is in Use

Below is the outline of how link data are transmitted when standby master function is in use.

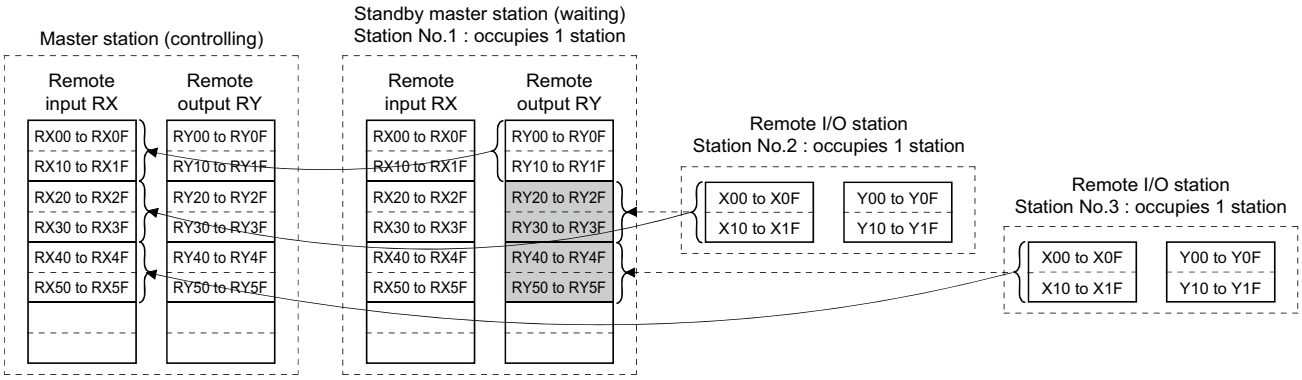
(1) When master station controls data link:

(a) Master station



Data sent from the master station to the remote input RX and remote register RWr in the standby master station (shown by the shaded areas in the above diagram) are used as output data when the master station becomes faulty; these data should be saved in another device using the sequence program.
When the master station becomes faulty, the saved data are transferred to the remote output RY and remote register RWw in the standby master station using the sequence program.

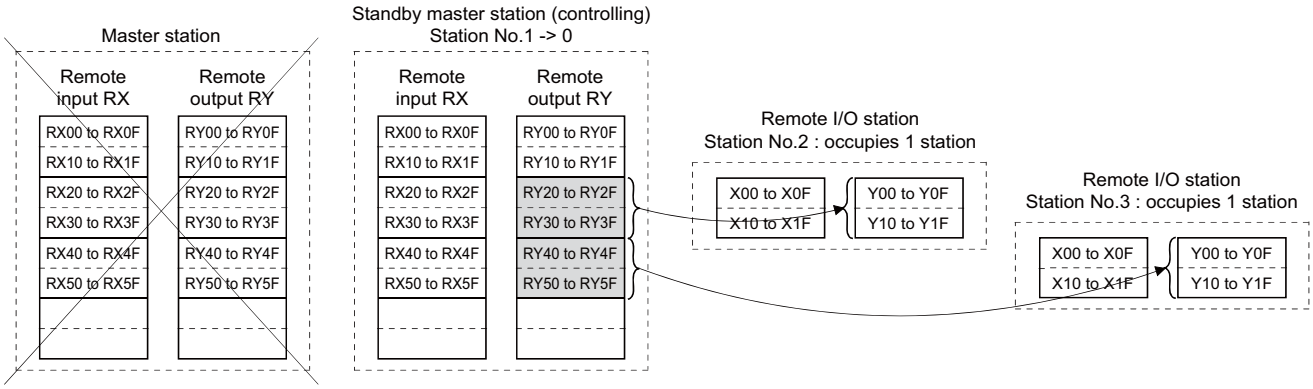
(b) Master station input



Data sent to the remote output RY and remote register RWw in the standby master station are used as input data by the standby master station when local stations are operating; thus these data don't need to be saved in another device.

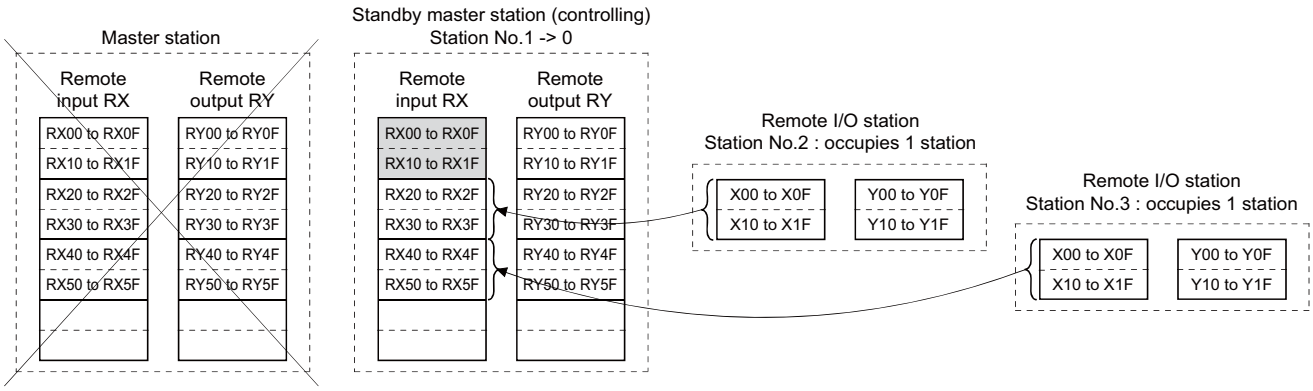
(2) When master station is faulty --> Standby master station controls data link

(a) Standby master station output



Data sent to the remote output RY and remote register RWw in the standby master station by the sequence program are then transmitted to other stations as output data.
When NC is master station, and a mounted module other than NC has failure,
the alarm "Z67 CC-Link communication error B9FF" will occur.c

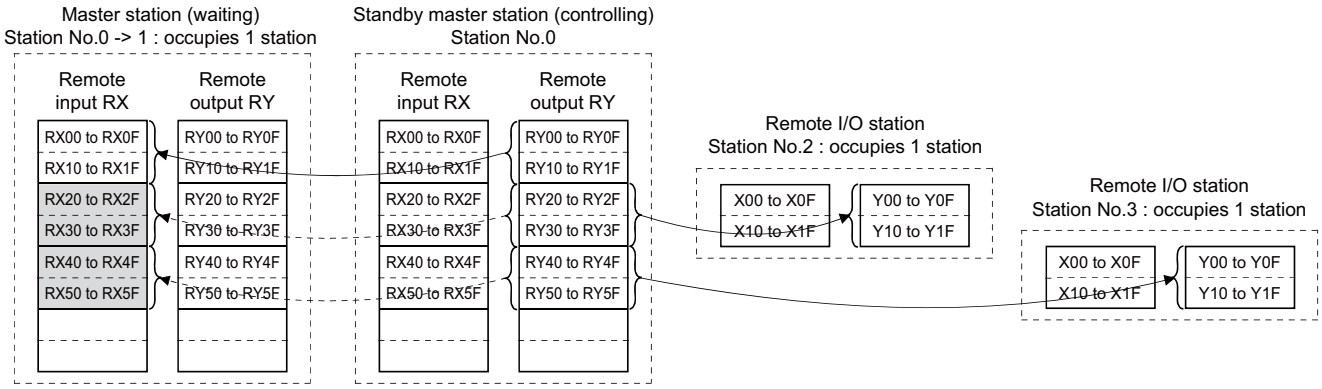
(b) Standby master station input



Data in the standby master station's shaded areas are either input or retained in accordance with the parameter "Setting of data link faulty station".
(When NC is standby master station, the said parameter is #24003+40(n-1) (n=slot No.) "set of faulty sta.")

(3) Master station's recovery --> Standby master station controls data link

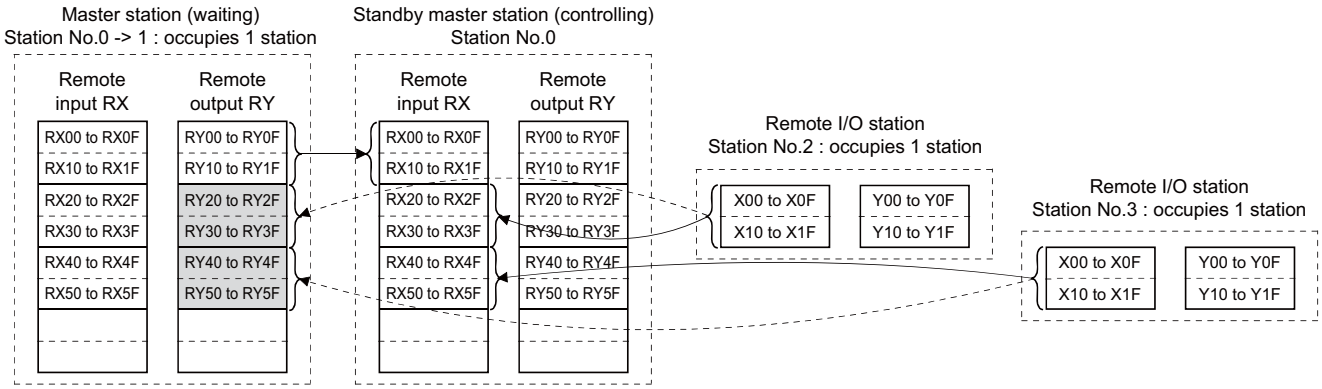
(a) Standby master station output



Data sent from the standby master station to the remote input RX and remote register RWr in the master station (shown by the shaded areas in the above diagram) are used as the output data in case of the standby master station's failure.

In the event that the standby master station becomes inoperable, the saved data are then transferred to the master station's remote output RY and remote register RWw using the sequence program.

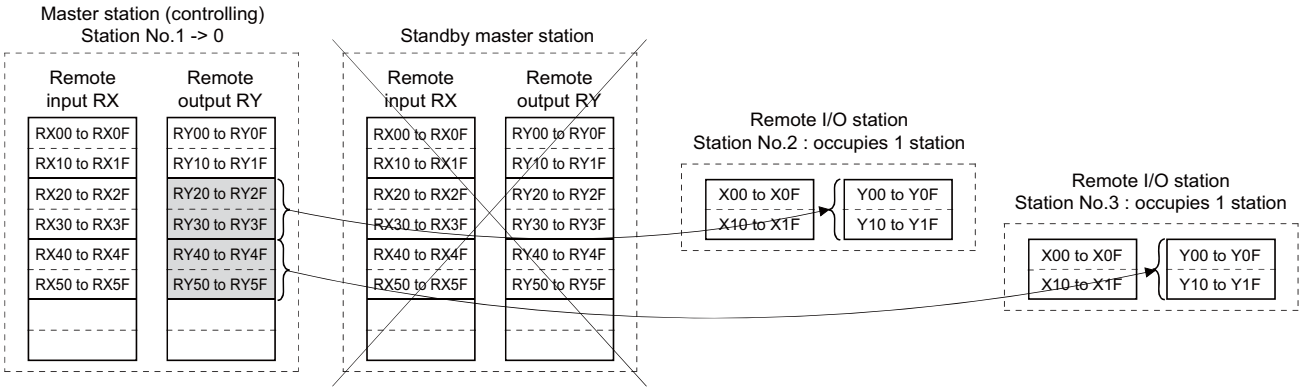
(b) Standby master station input



Data sent to the master station's remote output RY and remote register RWw are used by the master station as input information to operate the local stations. Thus, there is no need to save these data in another device.

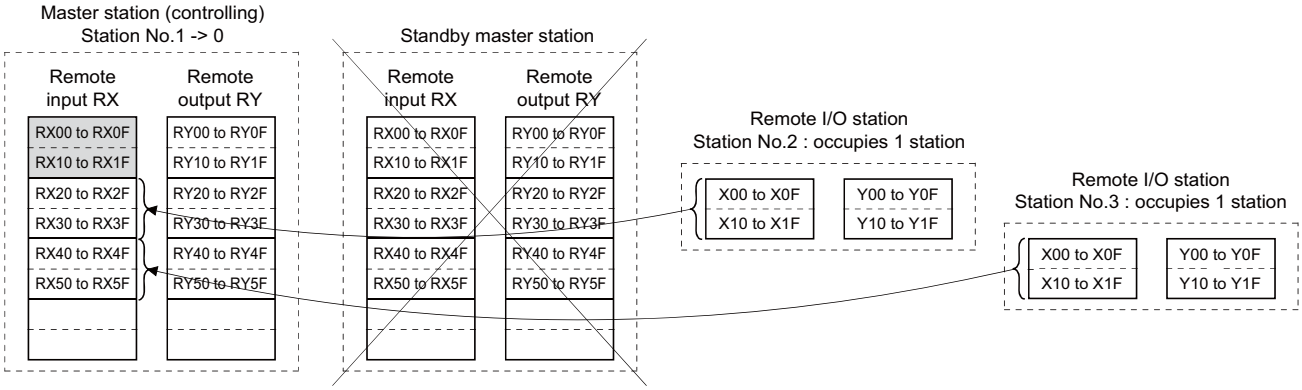
(4) Standby master station becomes faulty --> Master station controls data link:

(a) Master station output



Data sent to the master station's remote output RY and remote register RWw using the sequence program are transmitted to the other station as output information.

(b) Master station input



The information in the master station's shaded areas is either input or held in accordance with the setting of the network parameter "Setting of data link faulty station".
(If NC is master station, the said parameter is #24003+40(n-1) (n=slot No.) "set of faulty sta.")

14.1.4.3 Points to Note When Using Standby Master Function

(1) Only one standby master station resides in a single data link system.

(2) The total number of stations is 64, including standby master station.

(3) If a master station error is detected in the initial state (before parameter communication starts), switching to the standby master station won't be carried out.

(4) The data link control is automatically transferred to the standby master station in the event of the master station's failure, but refreshing cyclic data won't be instructed.
Thus, give this instruction using the sequence program. For the instruction timing, see "ON/OFF Timings of Link Special Relays (SB) Relating to Standby Master Function".
After instructing this, the information before the master station failure is output to each station.

(5) When the data link is being controlled by the standby master station, the master station's parameters cannot be updated.

(6) The error (error code: B39A) occurs at the standby master station if there is a difference between the standby master station's station number setting and the number set with the master station's parameter "Standby master station No.".
If this error has occurred, change the master station's parameter setting, or change the station No. setting switch of the standby master station, and then reset the standby master station.
(Note) If master station or standby master station is NC,the said parameter is
#24001+40(n-1) (n=slot No.) "station No." , and
#24010+40(n-1) (n=slot No.) "stanby master sta."

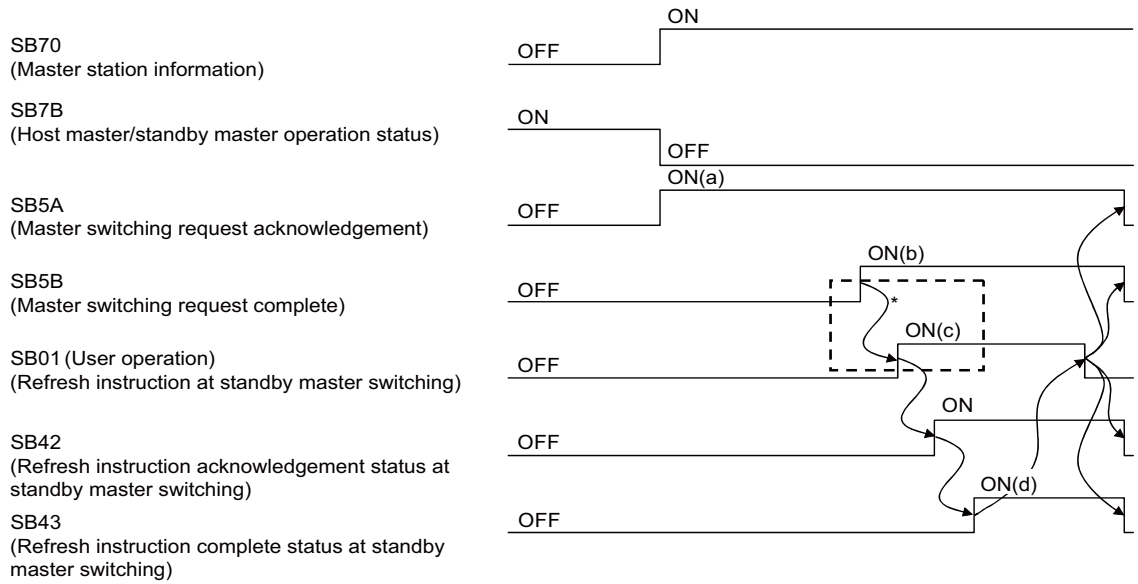
(7) If you detach the master station's terminal block and then attach it again without turning OFF the power while the master station is controlling data link, both the master and standby master stations operate as master stations, which will result in an error (error code: BBC5). ("ERR." LED flashes)

(8) When the data link control is transferred to the standby master station at the master station's failure, the "ERR." LED of the standby master station flashes.
(This is because the station No. of the standby master station will change from the one set with a parameter to zero and the standby master station becomes absent. Data link itself is normally performed.)
To avoid this, set the standby master station to be an error cancel station.
(When NC is master station, the parameter to change is #24126+15(n-1) (n=n-th connected station) "reserved station".)
But, if you set the station to be an error cancel station, other errors can't be detected. Thus, be careful.

(9) Among the data sent from (the station operating as) the master station to (the station operating as) the standby master station, the point number and range of devices that will be saved by the sequence program may differ according to the system used.
In the case of the example in "Overview of Link Data Transmission When Standby Master Function is in Use" (1), the above-mentioned devices are in the shaded areas between RX20 and RX5F.

14.1.4.4 ON/OFF Timings of Link Special Relays (SB) Relating to Standby Master Function

The following shows the ON/OF timings of the link special relays (SB) relating to the standby master function.



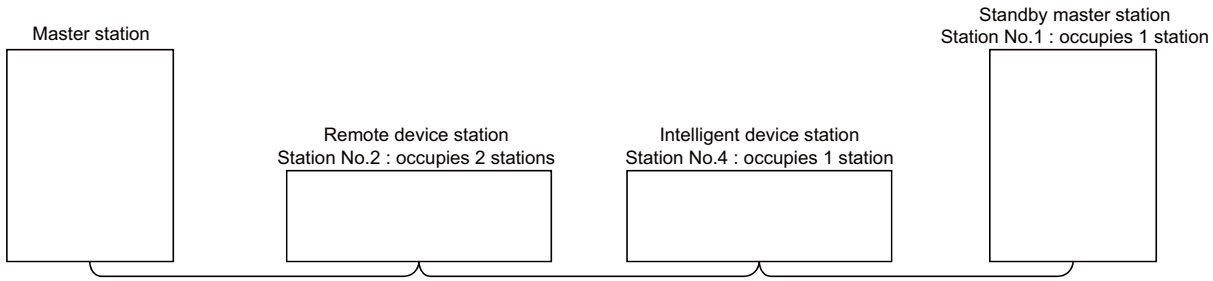
* When SB5B is turned ON, the sequence program switches RX to RY and RWr to RWw.
In addition, SB01 is turned ON by the sequence program. (Enclosed with dotted lines)

(a) to (d) in the diagram correspond to those in the program example in "Program Example When Using Standby Master (Master Station Duplex) Function" (4).

14.1.4.5 Program Example When Using Standby Master (Master Station Duplex) Function

A program when using the standby master function (master station duplex function) is generated under the following conditions.

(1) System configuration



(2) Master station's parameter setting (in the case of the slot No.1)

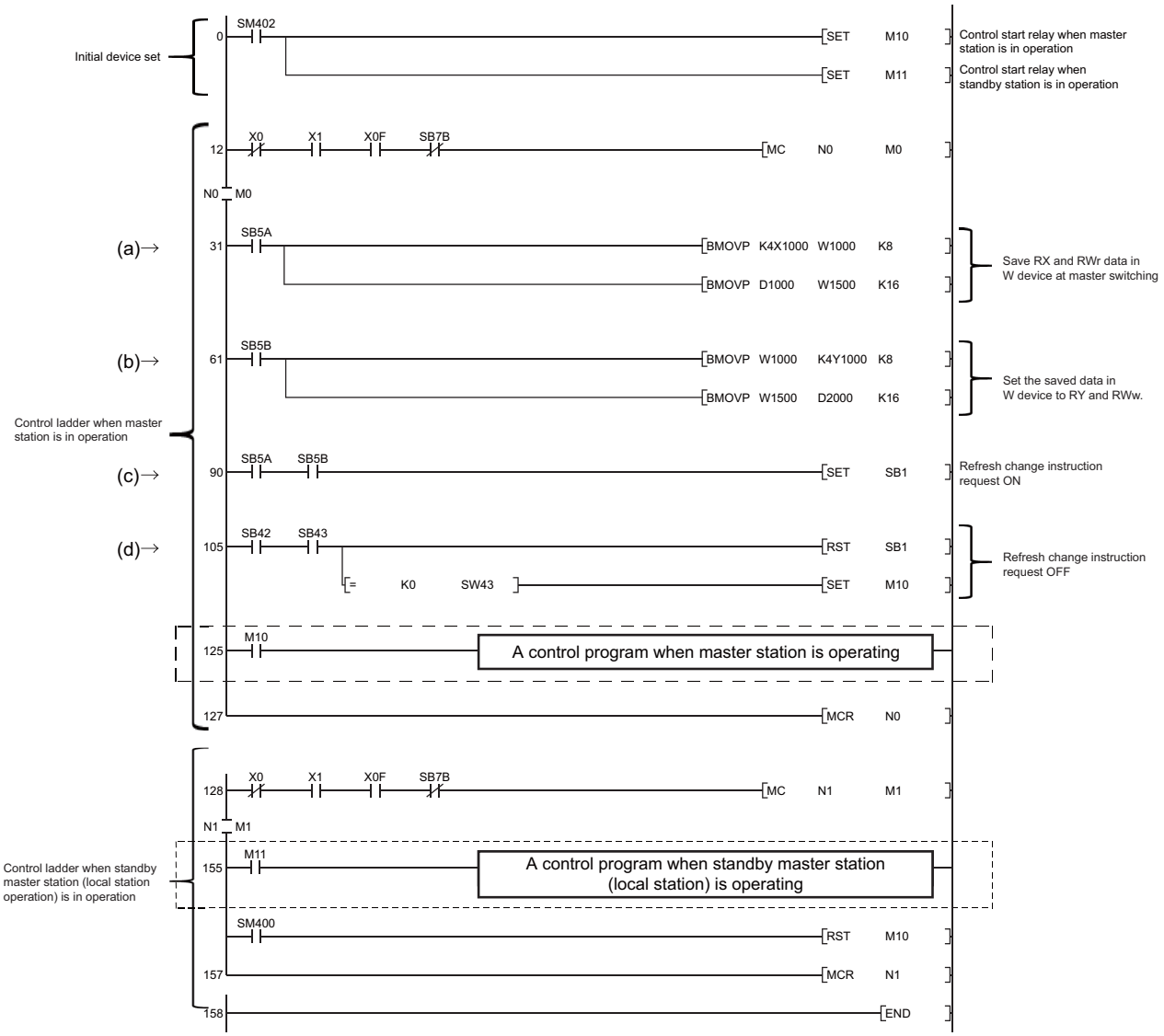
#24001 station No. 0
#24010 stanby master sta. 1
#24014 RX dev name X
#24015 RX dev No. 1000
#24016 RY dev name Y
#24017 RX dev No. 1000
#24018 RWr dev name W
#24019 RWr dev No. 0
#24020 RWw dev name W
#24021 RWw dev No. 100
#24022 SB dev name SB
#24023 SB dev No. 0
#24024 SW dev name SW
#24025 SW dev No. 0

(3) Standby station's parameter setting (in the case of the slot No.1)

#24001 station No. 1
#24010 stanby master sta. 1
#24014 RX dev name X
#24015 RX dev No. 1000
#24016 RY dev name Y
#24017 RX dev No. 1000
#24018 RWr dev name W
#24019 RWr dev No. 0
#24020 RWw dev name W
#24021 RWw dev No. 100
#24022 SB dev name SB
#24023 SB dev No. 0
#24024 SW dev name SW
#24025 SW dev No. 0

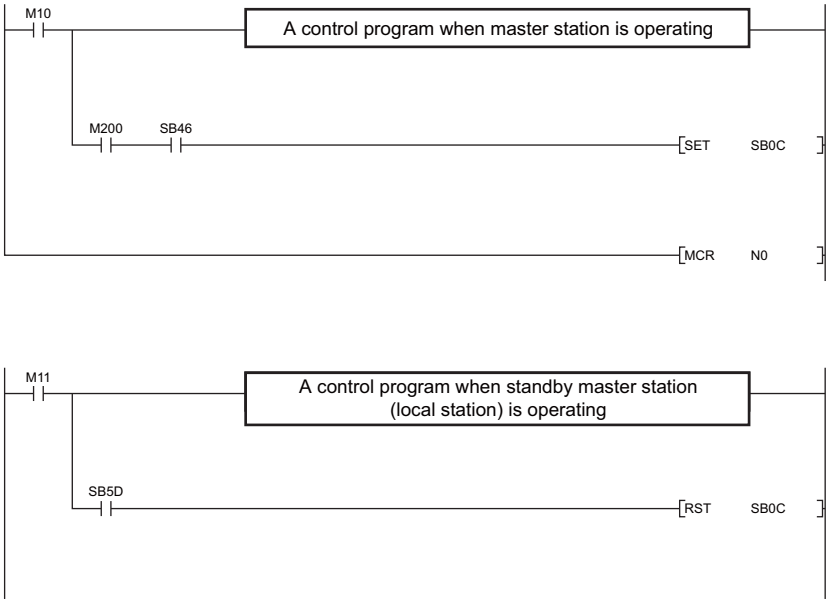
(4) Program example when using standby master function (master station duplex function)

(a) to (d) on the left correspond to those of the timing chart in "ON/OFF Timings of Link Special Relays (SB) Relating to Standby Master Function".



(5) When data link control is compulsorily transferred from standby master station to master station

The parts enclosed with broken or dotted lines in the program example (4) need to be changed to as shown below.



M10	Control start relay when master station is in operation
M11	Control start relay when standby station is in operation
M200	Forced master switching request
SB0C	Forced master switching
SB46	Forced master switching executable status
SB5D	Forced master switching completion signal

14.1.5 Transient Function

Transient function enables data to be written and read with an arbitrary station when needed, without constantly transmitting data. To enable this function, the counterpart station should also support the transient function.
This function follows RIRD/RIWT instructions.
This function is available at the PC's medium speed. Do not use this at the PC's high speed.
Including when two or more projects are set by the multi-project function, two or more instructions cannot be executed at a time through the entire program. Thus, give the second instruction after completing the first instruction.
When using the multi-project function, the target device of host station by the transient instruction from the other station is assigned to the first project's devices.

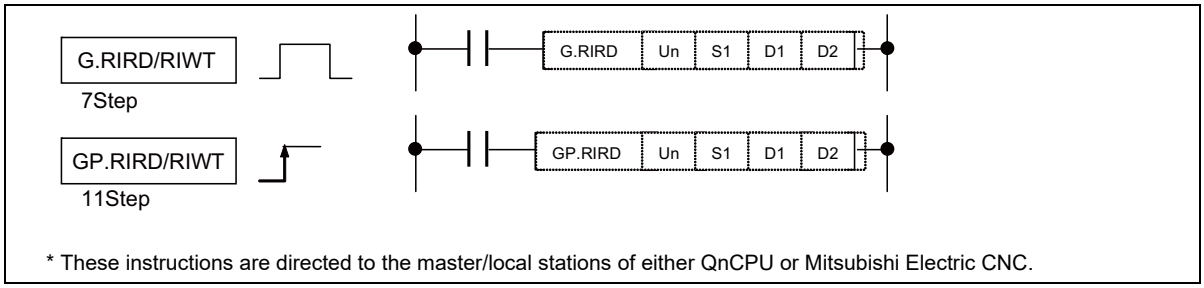
Transient Instruction (RIRD/RIWT) format

Compatible instruction mode	**Available instructions: G.RIRD, G.RIWT**

	Data to set	Available devices																					Digit	Index
		Bit devices										Word devices									Constant		Pointer		
		X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R	ZR	W	SW	Z	SD	K	H	P		
	S											○	○	○	○	○	○	○		○					
	D1											○	○	○	○	○	○	○		○					
	D2	○	○	○	○	○	○	○		○															

Extension instruction mode	**Available instructions: G.RIRD, GP.RIRD, G.RIWT, GP.RIWT**

	Data to set	Available devices																					Digit	Index
		Bit devices										Word devices									Constant		Pointer		
		X	Y	M	L	F	B	SB	T	SM	V	T	C	D	R	ZR	W	SW	Z	SD	K	H	P		
	S											○	○	○	○	○	○	○		○					
	D1											○	○	○	○	○	○	○		○					
	D2	○	○	○	○	○	○	○		○															



* These instructions are directed to the master/local stations of either QnCPU or Mitsubishi Electric CNC.

(1) Data to set

RIRD instruction

Data to set	Description
Un	Start I/O number of the host station
S1	Start number of the host station's device in which control data is stored.
D1	Start number of the device where data to read is stored.
D2	Device that is turned ON for one scan upon completion of reading. At an abnormal completion, (D2)+1 device also turns ON.

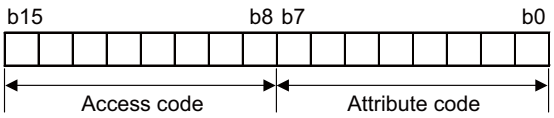
RIRD instruction

Data to set	Description
Un	Start I/O number of the host station
S1	Start number of the host station's device in which control data is stored.
D1	Start number of the device where data to write is stored.
D2	Device that is turned ON for one scan upon completion of writing. At an abnormal completion, (D2)+1 device also turns ON.

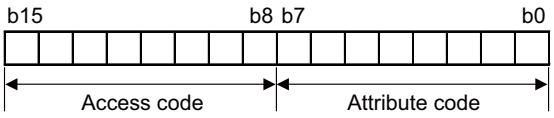
* For the Un value, specify U1 for channel 1 and U2 for channel 2.

(2) Control data

RIRD instruction

Device	Item	Data to set	Setting range	Set by (*1)
(S1)+ 0	Completion status	Stores the status when the instruction is complete. 0 : No error (normal completion) Other than 0 : Error code	-	System
(S1)+ 1	Station number	Specify the station numbers of the local and intelligent device stations.	0 to 64	User
(S1)+ 2	Access code Attribute code		See (3).	User
(S1)+ 3	Device number	Specify the device start number.	(*2)	User
(S1)+ 4	Number of points to read	Specify the read data count (in word units).	1 to 480 (*3) 1 to 32 (*4)	User

RIRW instruction

Device	Item	Data to set	Setting range	Set by (*1)
(S1)+ 0	Completion status	Stores the status when the instruction is complete. 0 : No error (normal completion) Other than 0 : Error code	-	System
(S1)+ 1	Station number	Specify the station numbers of the local and intelligent device stations.	0 to 64	User
(S1)+ 2	Access code Attribute code		See (3).	User
(S1)+ 3	Device number	Specify the device start number.	(*2)	User
(S1)+ 4	Number of points to write	Specify the number of data to write (in word units).	1 to 480(*3) 1 to 10(*4)	User

(*1) User: means the data set by a user before executing the exclusive instruction.
System: NC stores the execution result of the exclusive instruction.

(*2) See the manuals of the local or intelligent device station where reading is performed.

(*3) The maximum number of data to be read.
Specify the value within the receive buffer area setting range which has been set by the parameter.

(*4) To read the PLC CPU's devices when the counterpart CPU is other than QCPU (Q mode), QCPU (A mode) and QnACPU/AnUCPU, the setting range shall be 1 to 32 words.

(3) Access code/Attribute code

Device memory in the CPU

Device meaning	Name	Device type		Unit	Access code	Attribute code
		Bit	Word			
Input relay	X	○		Hexadecimal	01H	05H
Output relay	Y	○		Hexadecimal	02H	
Internal relay	M	○		Decimal	03H	
Latch relay	L	○		Decimal	83H	
Link relay	B	○		Hexadecimal	23H	
Timer (contact)	T	○		Decimal	09H	
Timer (coil)	T	○		Decimal	0AH	
Timer (present value)	T		○	Decimal	0CH	
Retentive timer (contact)	ST	○		Decimal	89H	
Retentive timer (coil)	ST	○		Decimal	8AH	
Retentive timer (present value)	ST		○	Decimal	8CH	
Counter (contact)	C	○		Decimal	11H	
Counter (coil)	C	○		Decimal	12H	
Counter (present value)	C		○	Decimal	14H	
Data register	D		○	Decimal	04H	
Link register	W		○	Hexadecimal	24H	
File register	R		○	Decimal	84H	
Link special relay	SB	○		Hexadecimal	63H	
Link special register	SW		○	Hexadecimal	64H	
Special relay	SM	○		Decimal	43H	
Special register	SD		○	Decimal	44H	

(Note) Devices other than shown above cannot be accessed.

When accessing a bit device, specify the address with 0 or a multiple of 16.

(4) Error code

Error code	Error description
2111	When the Un value is outside the specified range. When CC-Link module is not mounted on the expansion module specified by Un
2112	When the module specified by Un is not an intelligent function module. When the module specified by Un is not a special function module.
4002	When an attempt was made to execute an unsupported instruction.
4003	When the number of devices in the instruction is incorrect.
4004	When the instruction contains the device which cannot be used.
4100	When the instruction contains the data that cannot be used.
4101	When the number of data set to be used exceeds the allowable range. When the storage data or constants of the device specified by the instruction exceeds the allowable range.
F110	Time out
	When the other transient process instruction is being executed (in a busy state).

(5) Points to note

If you want to execute the next transient instruction after checking the completion device (D2), give the next transient instruction during the falling edge of the completion device (D2).

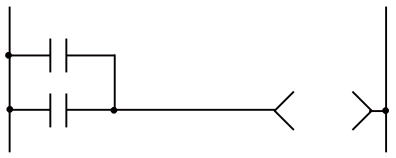
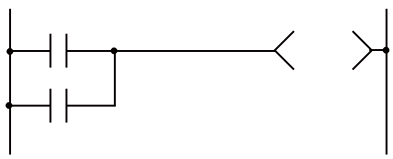
If the next transient instruction is given during the rising edge, the control data's completion status ((S1)+0) will be F114 (Error completion).

15

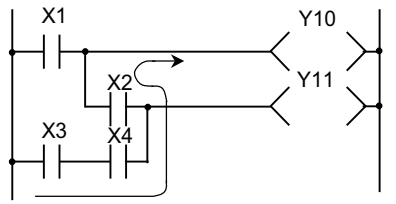
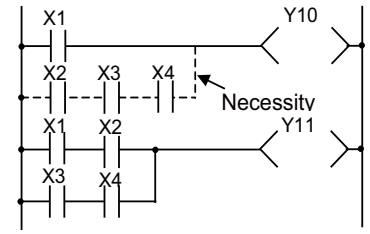
Appx.1: Example of Faulty Circuit

Wrong configurations of circuits are shown below. Correct the circuitry, if any.

(1) Circuit containing OR

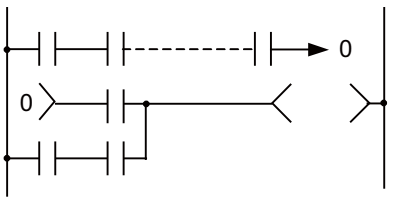
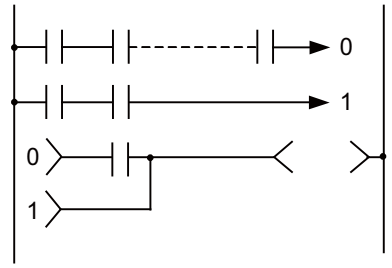
Faulty circuit producing errors	Correct circuit
	

(2) Rounding circuit

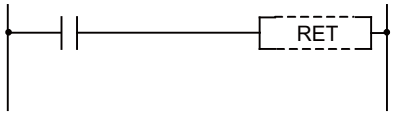
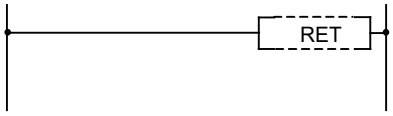
Faulty circuit producing errors	Correct circuit
	

Whether or not the Y10 condition includes X3, X4 and X2 is unknown

(3) Modification of loopback circuit

Faulty circuit producing errors	Correct circuit
	

(4) Presence of a contact before RET, FEND, or MCR circuit

Faulty circuit producing errors	Correct circuit
	

Revision History

Date of revision	Manual No.	Revision details
Apr. 2015	IB(NA)1501271-A	First edition created.
Sep. 2015	IB(NA)1501271-B	The descriptions were revised corresponding to S/W version A4 of Mitsubishi Electric CNC M800/M80 series. The following chapters were added. - 10.9 Spindle Oscillation - Appendix 2 List of PLC window data (Moved from 11.21 PLC Window) The explanations were added to the following chapters. - 10.4 Turret Gear Change Control - 10.6 Spindle Position Control (Spindle/C Axis Control) - 11.2 Thread Recutting - 11.4 High-speed Simple Program Check - 11.12 Operator Message Display - 11.15 Constant Torque Control - 12.1 Arbitrary Axis Exchange Control - 12.3 Single Block between Part Systems - 12.4 Synchronization between Part Systems OFF - 12.5 Sub Part System Control I - 12.6 Sub Part System Control II The following chapters were deleted. (Because the explanations were overlapped with Programming Manual (Lathe System) and Programming Manual (Machining Center System).) - 10.9 Multiple Spindle Synchronization Set Control - 11.7 Dwell/Miscellaneous Function Time Override - 11.9 Torque Limitation Skip Other mistakes were corrected.
Mar. 2016	IB(NA)1501271-C	The descriptions were revised corresponding to S/W version B2 of Mitsubishi Electric CNC M800/M80 series. The following chapters were added. - 4.8 PLS/PLF Instruction Behavior in the State from PLC STOP to RUN - 8.3.4 Changing Processing Cycle of the High-speed Ladder by the Parameter - 10.4 Spindle-mode Servo Motor Control - 10.5 Spindle-mode Rotary Axis Control - 10.12 Multiple Spindle Synchronization Set Control - 11.3 Manual Speed Clamp - 11.12 Machine Group-based Alarm Stop - 11.13 Diagnosis Data Output - 11.19 Real-Time Tuning 1 (Speed Gain) - 11.20 Real-Time Tuning 2 (Rapid Traverse Time Constant) - 11.26 Returning to the Previous Machining Program before the External Search - 11.28 MES Interface Library - 11.29 Power Consumption Computation - 11.30 EcoMonitorLight Connection Other mistakes were corrected.
Nov. 2016	IB(NA)1501271-D	The descriptions were revised corresponding to S/W version C1 of Mitsubishi Electric CNC M800/M80 series. The following chapters were added. - 11.7 Coordinate Rotation by Parameter - 11.9 Automatic Error Detection - 11.14 Interference Check III - 11.21 Simple Inclined Surface Machining Command - 11.23 Applying the Rotary Axis Configuration Parameter - 11.33 Buzzer Sound Control (Continue to the next page)

Date of revision	Manual No.	Revision details
		(Continued from the previous page) The following chapters were revised. - Introduction - Precautions for Safety - 2.2 Multi-project Function - 2.7 User PLC Data Area Configuration and Size - 10.6 Turret Gear Change Control - 10.9 Spindle Synchronization Control II - 10.10 Guide Bushing Spindle Synchronization - 11.12 Tool Life Management (Lathe System) - 11.17 Alarm Message Display - 11.18 Operator Message Display - 11.19 PLC Switches - 11.22 3-Dimensional Manual Feed - 11.30 PLC Window - 11.32 Direct Screen Selection Other mistakes were corrected.
Mar. 2017	IB(NA)1501271-E	The descriptions were revised corresponding to S/W version C3 of Mitsubishi Electric CNC M800/M80 series. The following chapters were added. - 10.4 Selecting Z Phase Detection Method - 11.1 Program Format Switch The following chapters were revised. - 11.22 Simple Inclined Surface Machining Command - 11.30 PLC Axis Indexing Other mistakes were corrected.
Dec. 2017	IB(NA)1501271-F	The descriptions were revised corresponding to S/W version C7 of Mitsubishi Electric CNC M800/M80 series. The following chapters were added. - 10.5 Proximity Switch Method Orientation - 11.21 GOT Connection - 11.32 NC Axis/PLC Axis Switchover The following chapters were deleted. - 11.31 PLC Window - Appendix 2:List of PLC Window Data Other mistakes were corrected.
Apr. 2018	IB(NA)1501271-G	The descriptions were revised corresponding to the specifications of Mitsubishi Electric CNC E80 series. The descriptions were revised corresponding to S/W version D1 of Mitsubishi Electric CNC M800/M80 series. The following chapters were revised. - 11.12 Tool Life Management (Machining Center System) - 11.13 Tool Life Management (Lathe System) Other mistakes were corrected.
Apr. 2019	IB(NA)1501271-H	The descriptions were revised corresponding to S/W version E0 of Mitsubishi Electric CNC M800/M80/E80 series. The following chapters were revised. - 2.2 Multi-project Function - 2.7 User PLC Data Area Configuration and Size - 3.2 List of Devices - 5.5 Master Control Instruction - 10.7 Spindle-mode Rotary Axis Control - 10.9 Multiple-spindle Control II - 10.10 Spindle Position Control (Spindle/C Axis Control) (Continue to the next page)

Date of revision	Manual No.	Revision details
		(Continued from the previous page) - 10.11 Spindle Synchronization Control II - 11.3 Thread Recutting - 11.6 High-speed Simple Program Check - 11.12 Tool Life Management (Machining Center System) - 11.13 Tool Life Management (Lathe System) - 11.24 3-Dimensional Manual Feed - 11.25 Applying the Rotary Axis Configuration Parameter - 11.30 PLC Axis Control - 11.34 Direct Screen Selection - 12.2 Control Axis Superimposition II Other mistakes were corrected.
Sep. 2019	IB(NA)1501271-J	The descriptions were revised corresponding to S/W version E1 of Mitsubishi Electric CNC M800/M80/E80 series. The following chapters were added. - 3 Input/Output Signals - 9.3.5 Initializing Remote I/O at PLC STOP - 12.5 Workpiece Coordinate System Shift - 12.8 Manual Numerical Value Command The following chapters were revised. - 11.14 Multiple Spindle Synchronization Set Control - 12.17 Interference Check III - 12.21 Operator Message Display - 12.22 PLC Switches - 13.1 Arbitrary Axis Exchange Control Other mistakes were corrected.
Jun. 2020	IB(NA)1501271-K	The descriptions were revised corresponding to S/W version F1 of Mitsubishi Electric CNC M800/M80/E80 series. The following chapters were added. - 11.10.6 Position Loop Gain Switch - 12.5 Reservation of Tool Wear Compensation (Lathe System) The following chapters were revised. - 12.36 External Search Other mistakes were corrected.
Aug. 2023	IB(NA)1501271-L	The descriptions were revised corresponding to S/W version FB of Mitsubishi Electric CNC M800/M80/E80 series. The following chapter was added. - 12.27.10.2 Multiple-Axis Synchronization Control - 12.32.1 Outline - 12.32.2 Explanation of Operation - 12.32.3 Precautions - 12.32.4 Timing Chart - 12.32.5 Usage Example - 12.40.6 Usage Example - 12.42 Tool Head Hot Swapping The following chapters was revised. - 5.1.2 Basic Instructions - 5.7 Operations when the OUT, SET/RST, or PLS/PLF Instruction of the Same Device is Used - 5.8 5.8 PLS/PLF Instruction Behavior in the State from PLC STOP to RUN - 7.2 Arithmetic Operation Instruction - 7.4 Data Transfer Instruction - 8.1.3 Explanation of Terminology - 8.1.8 Control Data Buffer Contents (Continue to the next page)

Date of revision	Manual No.	Revision details
		(Continued from the previous page) - 8.1.9 8.1.9 File Register (R Register) Assignment and Parameters - 8.1.10 Details of Each Instruction - 8.2.1 Instruction List - 11.10.5 Precautions - 11.12.4 Precautions and Restrictions - 12.26.2 How to apply tool axis rotation angle compensation amount (G174) - 12.32 Circular Feed in Manual Mode - 12.34.2.6 Operation Function: Reference Position Return - 12.36.5 Precautions - 12.40.1 Outline - 12.40.7 Precautions The chapter title was corrected. - 12.40.2 Power Consumption Computation Setting The following chapters were deleted. - 8.1.12 Examples of Tool Registration Screen - 8.1.13 Display of Spindle Tool and Standby Tool - 12.27.10.1 Relation with rotary axis angle designation (mechanical axis specification) Other mistakes were corrected.
Jan. 2024	IB(NA)1501271-M	The descriptions were revised corresponding to S/W version FC of Mitsubishi Electric CNC M800/M80/E80 series. The following chapter was added. - 14.1.3.6 Communication Error Invalid Time The following chapters were revised. - 7.5 Program Branch Instruction - 11.7.13 Precautions Other mistakes were corrected.
Jun. 2024	IB(NA)1501271-N	The descriptions were revised corresponding to S/W version FD of Mitsubishi Electric CNC M800/M80/E80 series. The following chapters were added. - 10.3.3 Relation with Other Functions - 12.33.11 Constant-Gradient Acceleration/Deceleration - 12.43 Brake Wear Diagnostics The following chapters were changed. - 10.2.1 Operation Sequence - 10.3 Miscellaneous Command High-Speed Output - 10.3.1.2 Operation Sequence Which Does Not Wait for a Finish Signal from the PLC During Miscellaneous Command Performance - 10.3.2.2 Operation Sequence Which Does Not Wait for a Finish Signal from the PLC During Miscellaneous Command Performance - 12.35.3 Relation with Other Functions - 13.4.1 Description of Operation Other mistakes were corrected.
Jan. 2025	IB(NA)1501271-P	The descriptions were revised corresponding to S/W version FG of Mitsubishi Electric CNC M800/M80/E80 series. The following chapters were changed. - 4.3.2 Independent Device Among Projects - 12.18.2 Instructions for Use - 12.43.2.1 Function Enabling Conditions - 12.43.2.2 Parameter setting method - 12.43.2.3 Operation Procedure, Operation Sequence - 12.43.4 Precautions Other mistakes were corrected.

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Notice

Every effort has been made to keep up with software and hardware revisions in the contents described in this manual. However, please understand that in some unavoidable cases simultaneous revision is not possible. Please contact your Mitsubishi Electric dealer with any questions or comments regarding the use of this product.

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MODEL	M800/M80/E80 Series
MODEL CODE	100-436
Manual No.	IB-1501271

IB(NA)1501271(ENG)-P(2501)MEE
Made in JAPAN

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