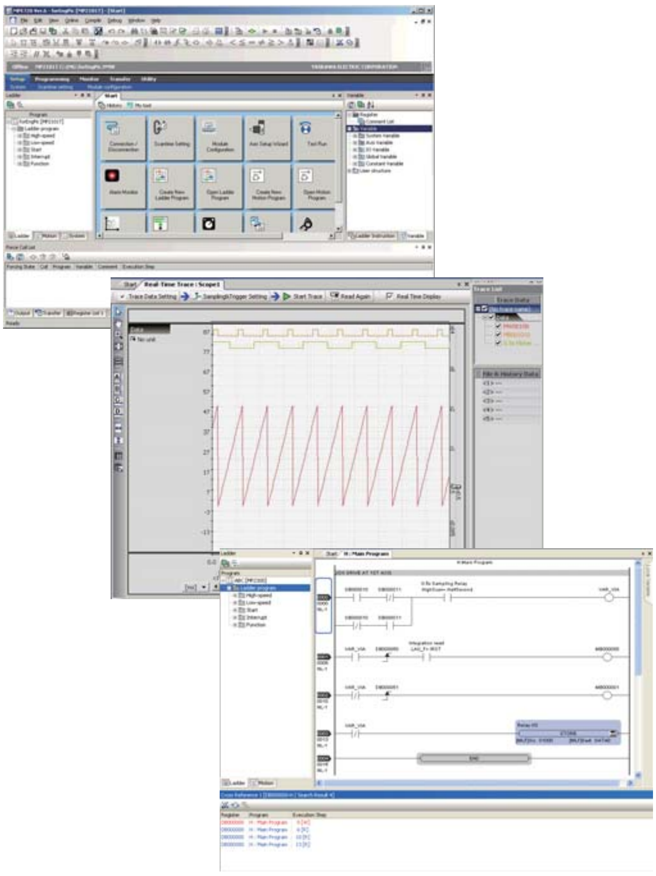
YASKAWA

Machine Controller MP2000 Series

USER'S MANUAL
LADDER PROGRAMMING



MANUAL NO. SIE-C887-1.2D

About this Manual

- This manual provides comprehensive information on ladder programming for MP2000-series Machine Controllers. It provides the following information on MP2000-series Machine Controllers.
  - Introduction to Ladder Programming
  - Specifications
  - Program Development Flow
  - Programming
  - Instructions
  - MPE720 Engineering Tool
  - Troubleshooting
- This manual provides information on MP2000-series Machine Controllers and MPE720 version 6. For information on the MP900-series Machine Controllers and MPE720 version 5, refer to the appropriate manuals for them.
- Read this manual carefully to ensure the proper use of the MP2000-series Machine Controllers. Keep this manual in a safe place so that it can be referred to whenever necessary.

Using this Manual

■ Intended Audience

This manual is intended for the following users.

- Those responsible for designing the MP2000-series Machine Controller system
- Those responsible for writing the MP2000-series Machine Controller ladder programs

■ MPE720 Engineering Tool Version Number

In this manual, the operation of the MPE720 is described using screen captures of MPE720 version 6.
For this reason, the screen captures and some descriptions may differ for MPE720 version 5.

■ Abbreviations

The following abbreviation is used in this manual.

- MP2000: A generic term for the MP2100, MP2100M, MP2101, MP2101M, MP2101T, MP2101TM, MP2200, MP2300, MP2300S, MP2310, MP2400, MP2500/M/B/MB, and MPU-01.

MP2000-series Manuals

- The MP2000 Series includes the MP2100, MP2100M, MP2101, MP2101M, MP2101T, MP2101TM, MP2200, MP2300, MP2300S, MP2310, MP2400, MPU-01, MP2500/M/B/MB, and MPU-01. There are many manuals available for one or more of these Machine Controllers. A list of the related manuals is provided on the following page. Refer to these manuals as required.

■ Related Manuals

The following manuals are related to the MP2000 Series. Refer to these manuals as required.

Manual Name	Manual Number	Description
Machine Controller MP210□/MP210□M User's Manual, Design and Maintenance	SIEP C880700 01	Describes the functions, specifications, setup procedures, and operating methods of the MP2100/MP2100M.
Machine Controller MP2200 User's Manual	SIEP C880700 14	Describes the functions, specifications, setup procedures, and operating methods of the MP2200.
Machine Controller MP2300 Basic Module User's Manual	SIEP C880700 03	Describes the functions, specifications, setup procedures, and operating methods of the MP2300.
Machine Controller MP2300S Basic Module User's Manual	SIEP C880732 00	Describes the functions, specifications, setup procedures, and operating methods of the MP2300S.
Machine Controller MP2310 Basic Module User's Manual	SIEP C880732 01	Describes the functions, specifications, setup procedures, and operating methods of the MP2310.
Machine Controller MP2400 User's Manual	SIEP C880742 00	Describes the functions, specifications, setup procedures, and operating methods of the MP2400.
Machine Controller MP2500/MP2500M/ MP2500D/MP2500MD User's Manual	SIEP C880752 00	Describes how to use the MP2500, MP2500M, MP2500D, and MP2500MD Machine Controllers.
Machine Controller MP2000 Series Built-in SVB/SVB-01 Motion Module User's Manual	SIEP C880700 33	Describes the SVB Module that is built into an MP2000-series Machine Controller and the SVB-1 Optional Module.
Machine Controller MP2000 Series SVC-01 Motion Module User's Manual	SIEP C880700 41	Describes the SVC-01 SVA Motion Module for MP2000-series Machine Controllers.
Machine Controller MP2000 Series SVA-01 Motion Module User's Manual	SIEP C880700 32	Describes the SVA-01 SVA Motion Module for MP2000-series Machine Controllers.
Machine Controller MP2000 Series Pulse Output Motion Module PO-01 User's Manual	SIEP C880700 28	Describes the PO-01 Pulse Output Motion Module for MP2000-series Machine Controllers.
Machine Controller MP2000 Series Communication Module User's Manual	SIEP C880700 04	Describes the Communications Modules that can be connected to MP2000-series Machine Controllers.
Machine Controller MP2000 Series 262IF-01 FL-net Communication Module User's Manual	SIEP C880700 36	Describes the 262IF-01 FL-net Communications Module for MP2000-series Machine Controllers.
Machine Controller MP2000 Series 263IF-01 EtherNet/IP Communication Module User's Manual	SIEP C880700 39	Describes the 263IF-01 EtherNet/IP Communications Module for MP2000-series Machine Controllers.
Machine Controller MP2000 Series I/O Module User's Manual	SIEP C880700 34	Describes the I/O Modules that can be connected to MP2000-series Machine Controllers.
Machine Controller MP2000 Series Analog Input/Analog Output Module AI-01/AO-01 User's Manual	SIEP C880700 26	Describes the AI-01 Analog Input Module and AO-01 Analog Output Module for MP2000-series Machine Controllers.
Machine Controller MP2000 Series Counter Module CNTR-01 User's Manual	SIEP C880700 27	Describes the CNTR-01 Counter Module for MP2000-series Machine Controllers.
Machine Controller MP2000 Series MPU-01 Multiple-CPU Module User's Manual	SIEP C880781 05	Describes the MPU-01 Multiple-CPU Module for MP2000-series Machine Controllers.
Machine Controller MP2000 Series User's Manual for Motion Programming	SIEP C880700 38	Describes the instructions that are used in motion programming for MP2000-series Machine Controllers.
Engineering Tool for MP2000 Series Machine Controller MPE720 Version 6 User's Manual	SIEP C880700 30	Describes how to install and operate the MPE720 version 6 Engineering Tool for MP2000-series Machine Controllers.
Machine Controller MP900/MP2000 Series MPE720 Software for Programming Device User's Manual	SIEP C880700 05	Describes how to install and operate the MPE720 programming device software for MP900/MP2000-series Machine Controllers.
Machine Controller MP2000 Series Embedded C-Language Programming Package Development Guide	SIEP C880700 25	Describes how to develop, design, and maintain embedded C-language application programs for MP2000-series Machine Controllers.
Machine Controller MP900/MP2000 Series New Ladder Editor User's Manual	SIEZ-C887-13.2	Describes the operating methods of the New Ladder Editor, which assists MP900/MP2000-series design and maintenance.

Manual Name	Manual Number	Description
Machine Controller MP900/MP2000 Series Distributed I/O Module User's Manual, MECHATROLINK System	SIE-C887-5.1	Describes MECHATROLINK distributed I/O for MP900/ MP2000-series Machine Controllers.
Machine Controller MP900/MP2000 Series User's Manual, For Linear Servomotors	SIEP C880700 06	Describes the connection methods, setting methods, and other information for Linear Servomotors.
AC Servo Drives Σ-V Series User's Manual, Setup, Rotational Motor	SIEP S800000 43	Describes the installation, wiring, connections, and trial operation of the Σ-V Series Servo Drives and Rotational Servomotors.
AC Servo Drives Σ-V Series User's Manual, Setup, Linear Motor	SIEP S800000 44	Describes the installation, wiring, connections, and trial operation of the Σ-V Series Servo Drives and Linear Servomotors.
AC Servo Drives Σ-V Series User's Manual, Design and Maintenance, Analog-voltage, Pulse-string Reference, Rotational Motor	SIEP S800000 45	Describes the design and maintenance of the Σ-V Series Analog Servo Drives and Rotational Servomotors.
AC Servo Drives Σ-V Series User's Manual, Design and Maintenance, Analog-voltage/ Pulse-string Reference, Linear Motor	SIEP S800000 47	Describes the design and maintenance of the Σ-V Series Analog Servo Drives and Linear Servomotors.
AC Servo Drives Σ-V Series User's Manual, Design and Maintenance, MECHATROLINK-II Communications Reference, Rotational Motor	SIEP S800000 46	Describes the design and maintenance of the Σ-V Series MECHATROLINK-II Communications-reference Servo Drives and Rotational Servomotors.
AC Servo Drives Σ-V Series User's Manual, Design and Maintenance, MECHATROLINK-II Communications Reference, Linear Motor	SIEP S800000 48	Describes the design and maintenance of the Σ-V Series MECHATROLINK-II Communications-reference Servo Drives and Linear Servomotors.
AC Servo Drives Σ-V Series User's Manual, MECHATROLINK-II Commands	SIEP S800000 54	Describes the MECHATROLINK-II communications commands of the Σ-V Series Servo Drives with MECHATROLINK-II communications references.
AC Servo Drives Σ-V Series User's Manual, Operation of Digital Operator	SIEPS 800000 55	Describes operating procedures of the Digital Operator for Σ-V Series Servo Drives.

Visual Aids

The following visual aids are used to indicate certain types of information for easier reference. Use these to help you understand the different types of information.

IMPORTANT

- Indicates information that must be remembered.
  Also indicates alarm displays and other minor precautions that will not result in machine damage.

INFO

- Indicates supplemental information and convenient information to remember.

◀ EXAMPLE ▶

- Indicates concrete examples.

TERMS

- Indicates definitions of difficult terms or terms that have not been previously explained in this manual.

Copyrights

- DeviceNet is a registered trademark of the ODVA (Open DeviceNet Venders Association).
- PROFIBUS is a trademark of the PROFIBUS User Organization.
- Ethernet is a registered trademark of the Xerox Corporation.
- MPLINK is a registered trademark of Yaskawa Electric Corporation.
- Microsoft, Windows, Windows NT, and Internet Explorer are trademarks or registered trademarks of the Microsoft Corporation.
- Pentium is a registered trademark of the Intel Corporation.
- MECHATROLINK is a trademark of the MECHATROLINK Members Association.
- Other product names and company names are the trademarks or registered trademarks of the respective company. "TM" and the ® mark do not appear with product or company names in this manual.

Safety Information

The following signal words and marks are used to indicate safety precautions in this manual. Information marked as shown below is important for safety. Always read this information and heed the precautions that are provided.

⚠ WARNING

Indicates precautions that, if not heeded, could possibly result in loss of life or serious injury.

⚠ CAUTION

Indicates precautions that, if not heeded, could result in relatively serious or minor injury, or property damage.

If not heeded, even precautions classified as cautions (⚠ CAUTION) can lead to serious results depending on circumstances.

PROHIBITED

Indicates prohibited actions. For example, indicates prohibition of open flame.

MANDATORY

Indicates mandatory actions. For example, indicates that grounding is required.

Safety Precautions

This section provides important precautions that must be observed in ladder programming. Before you start to program, carefully read all of this manual and all other provided manuals and make sure that you program the MP2000-series Machine Controller correctly. You must be completely familiar with the MP2000-series Machine Controllers, safety information, and all safety precautions before you attempt to use the Machine Controller.

■ Storage and Transportation

⚠ CAUTION

- If disinfectants or insecticides must be used to treat packing materials such as wooden frames, pallets, or plywood, the packing materials must be treated before the product is packaged, and methods other than fumigation must be used.
  Example: Heat treatment, where materials are kiln-dried to a core temperature of 56°C for 30 minutes or more.
  If the electronic products, which include stand-alone products and products installed in machines, are packed with fumigated wooden materials, the electrical components may be greatly damaged by the gases or fumes resulting from the fumigation process. In particular, disinfectants containing halogen, which includes chlorine, fluorine, bromine, or iodine can contribute to the erosion of the capacitors.

■ Other General Precautions

Observe the following general precautions to ensure safe application.

- The MP2000-series Machine Controllers were not designed or manufactured for use in devices or systems directly related to human life.
  Users who intend to use products that are described in this manual for special purposes such as devices or systems relating to transportation, medical, space aviation, atomic power control, or underwater use must contact Yaskawa Electric Corporation beforehand.
- The MP2000-series Machine Controllers have been manufactured under strict quality control guidelines. However, if an MP2000-series Machine Controller is to be installed in any location in which a failure of the MP2000-series Machine Controllers could involve a life and death situation or in a facility where failure may cause a serious accident, safety devices MUST be installed to minimize the likelihood of any serious accident.
- The products shown in illustrations in this manual are sometimes shown without covers or protective guards. Always replace the cover or protective guard as specified first, and then operate the products in accordance with the manual.
- The drawings that are presented in this manual are typical examples and may not match the product you received.
- If the manual must be ordered due to loss or damage, inform your nearest Yaskawa representative or one of the offices listed on the back of this manual.
- Contact your nearest Yaskawa representative or one of the offices listed on the back of this manual to order a new nameplate whenever a nameplate becomes worn or damaged.

Warranty

(1) Details of Warranty

■ Warranty Period

The warranty period for a product that was purchased (hereinafter called “delivered product”) is one year from the time of delivery to the location specified by the customer or 18 months from the time of shipment from the Yaskawa factory, whichever is sooner.

■ Warranty Scope

Yaskawa shall replace or repair a defective product free of charge if a defect attributable to Yaskawa occurs during the warranty period above. This warranty does not cover defects caused by the delivered product reaching the end of its service life and replacement of parts that require replacement or that have a limited service life.
This warranty does not cover failures that result from any of the following causes.

1. Improper handling, abuse, or use in unsuitable conditions or in environments not described in product catalogs or manuals, or in any separately agreed-upon specifications
2. Causes not attributable to the delivered product itself
3. Modifications or repairs not performed by Yaskawa
4. Abuse of the delivered product in a manner in which it was not originally intended
5. Causes that were not foreseeable with the scientific and technological understanding at the time of shipment from Yaskawa
6. Events for which Yaskawa is not responsible, such as natural or human-made disasters

(2) Limitations of Liability

1. Yaskawa shall in no event be responsible for any damage or loss of opportunity to the customer that arises due to failure of the delivered product.
2. Yaskawa shall not be responsible for any programs (including parameter settings) or the results of program execution of the programs provided by the user or by a third party for use with programmable Yaskawa products.
3. The information described in product catalogs or manuals is provided for the purpose of the customer purchasing the appropriate product for the intended application. The use thereof does not guarantee that there are no infringements of intellectual property rights or other proprietary rights of Yaskawa or third parties, nor does it construe a license.
4. Yaskawa shall not be responsible for any damage arising from infringements of intellectual property rights or other proprietary rights of third parties as a result of using the information described in catalogs or manuals.

(3) Suitability for Use

1. It is the customer's responsibility to confirm conformity with any standards, codes, or regulations that apply if the Yaskawa product is used in combination with any other products.
2. The customer must confirm that the Yaskawa product is suitable for the systems, machines, and equipment used by the customer.
3. Consult with Yaskawa to determine whether use in the following applications is acceptable. If use in the application is acceptable, use the product with extra allowance in ratings and specifications, and provide safety measures to minimize hazards in the event of failure.
   - Outdoor use, use involving potential chemical contamination or electrical interference, or use in conditions or environments not described in product catalogs or manuals
   - Nuclear energy control systems, combustion systems, railroad systems, aviation systems, vehicle systems, medical equipment, amusement machines, and installations subject to separate industry or government regulations
   - Systems, machines, and equipment that may present a risk to life or property
   - Systems that require a high degree of reliability, such as systems that supply gas, water, or electricity, or systems that operate continuously 24 hours a day
   - Other systems that require a similar high degree of safety
4. Never use the product for an application involving serious risk to life or property without first ensuring that the system is designed to secure the required level of safety with risk warnings and redundancy, and that the Yaskawa product is properly rated and installed.
5. The circuit examples and other application examples described in product catalogs and manuals are for reference. Check the functionality and safety of the actual devices and equipment to be used before using the product.
6. Read and understand all use prohibitions and precautions, and operate the Yaskawa product correctly to prevent accidental harm to third parties.

(4) Specifications Change

The names, specifications, appearance, and accessories of products in product catalogs and manuals may be changed at any time based on improvements and other reasons. The next editions of the revised catalogs or manuals will be published with updated code numbers. Consult with your Yaskawa representative to confirm the actual specifications before purchasing a product.

Contents

1

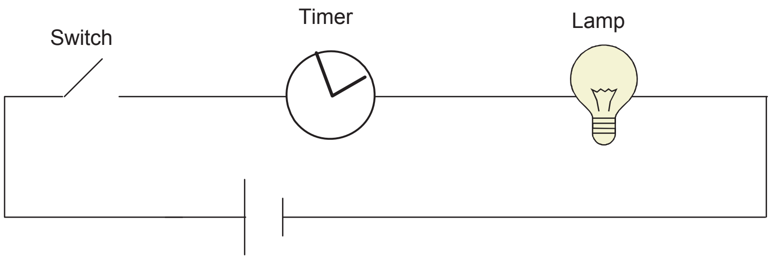
Introduction to Ladder Programming

This chapter gives an overview of ladder programming and describes its features.

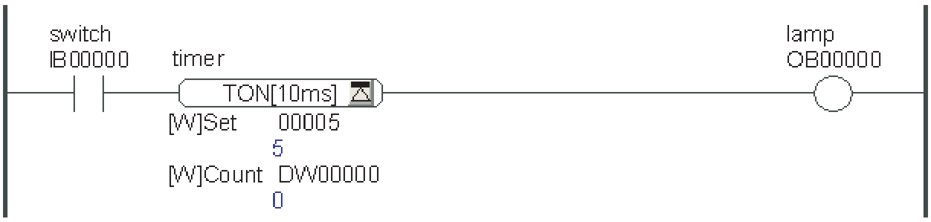
1.1 What Is a Ladder Program?

A ladder program uses ladder instructions and registers to symbolically represent electrical circuits that consist of switches, timers, lamps, and other devices.

Illustration of a Circuit



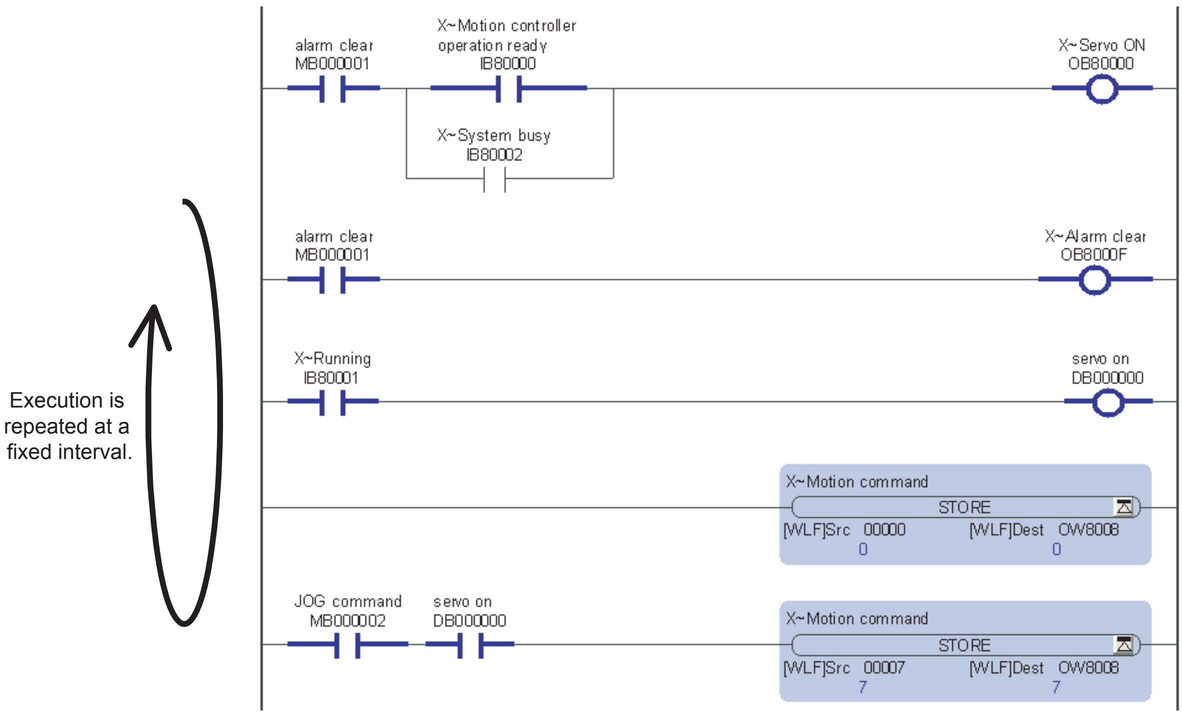
Ladder Program



Ladder programming allows you to easily program large, complex circuits.

Each of the ladder programs that you create is executed in a single scan and then executed repeatedly at fixed intervals.

Ladder Programming Example

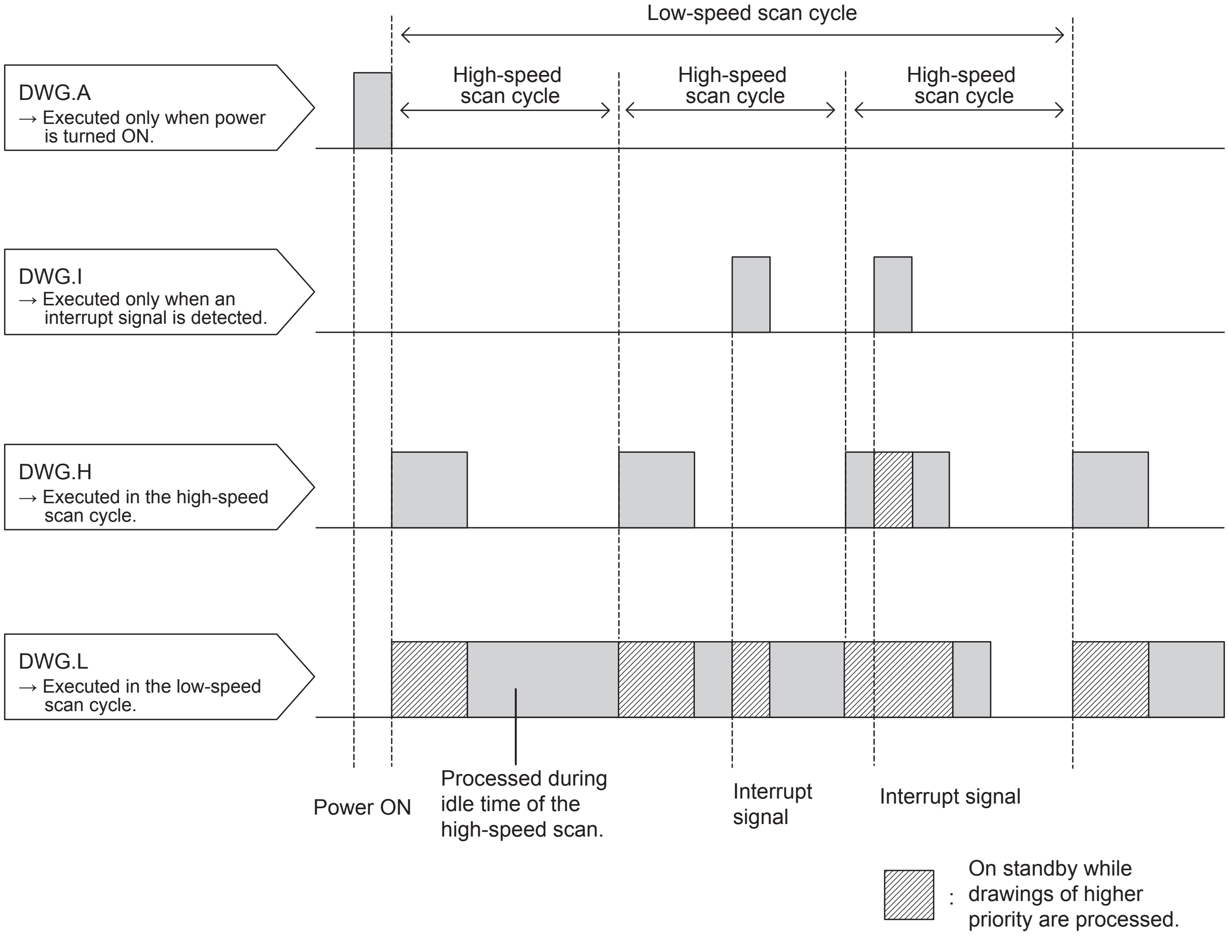


1.2 Features of Ladder Programming for MP2000-series Machine Controllers

This section describes the features of ladder programming.

1.2.1 Types of Ladder Drawings and Their Different Execution Timing

Ladder programs are managed in units of drawings (DWG). These are called ladder drawings.
In the MP2000-series Machine Controllers, ladder drawings are executed at various times, as illustrated in the following figure.
Processing can be executed at the appropriate time by programming it in the appropriate ladder drawing.



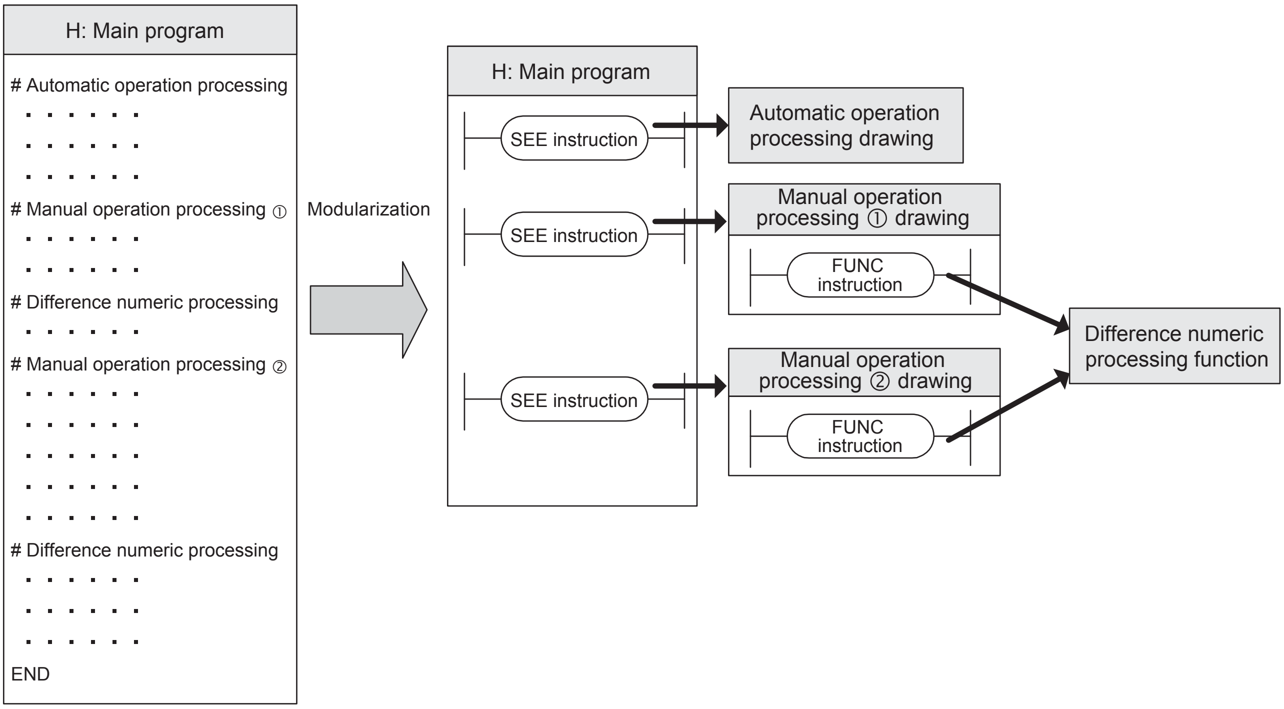
■ Drawing Execution Timing

Priority	Ladder Drawing	Execution Timing (Processing Example)
1 (High)	DWG.A	This drawing is executed only once when the power supply is turned ON (e.g., for data initialization).
2 (↑)	DWG.I	This drawing is executed when an interrupt signal is detected (e.g., for interrupt processing for external signals).
3 (↑)	DWG.H	This drawing is executed every high-speed scan cycle (e.g., for motion control).
4 (Low)	DWG.L	This drawing is executed every low-speed scan cycle (e.g., for touch panel display processing).

- The drawings with lower numbers have higher execution priority.

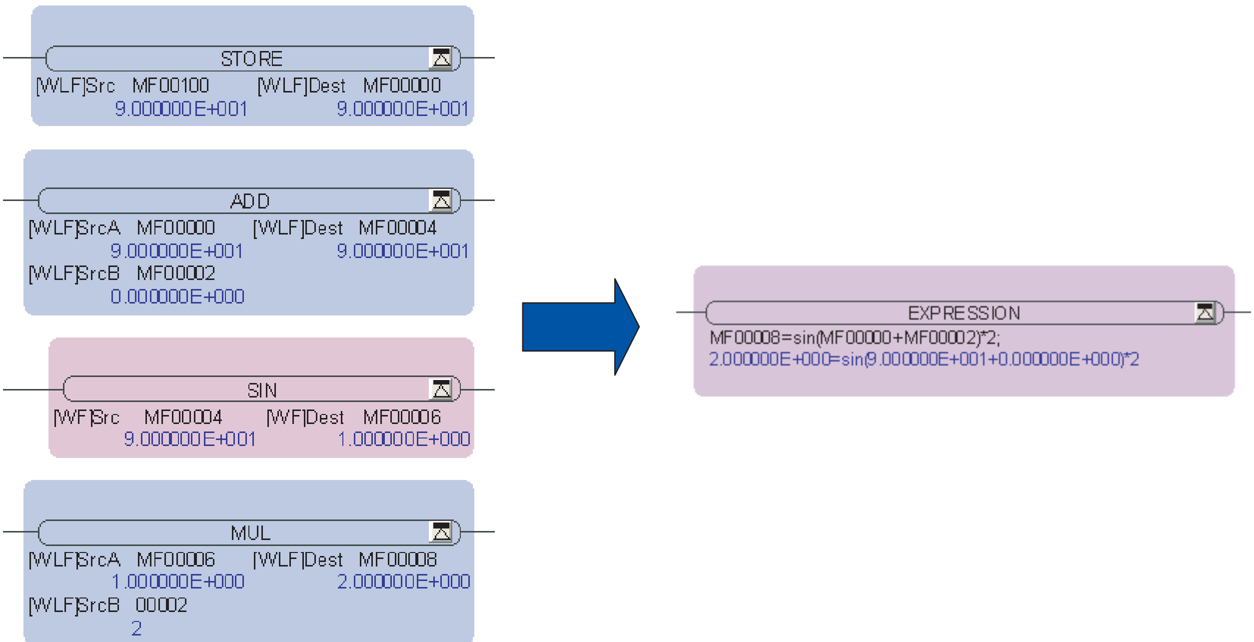
1.2.2 Program Modules

The main program can be separated into modular units to suit different processing requirements, such as child drawings, grandchild drawings, and functions, to make the program easier to read.



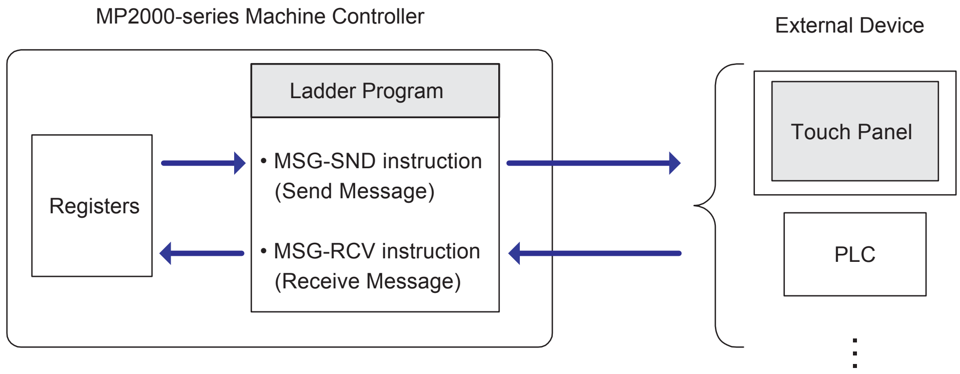
1.2.3 Programming Complicated Numeric Operations

Complicated calculations written over several lines can be written easily within a single EXPRESSION instruction. Variables, structures, and basic functions, such as those for sine and cosine calculations, can be programmed using familiar C-like expressions.
You can display the current value inside expressions in the same way as you can for other ladder language instructions.



1.2.4 Communications Control with External Devices

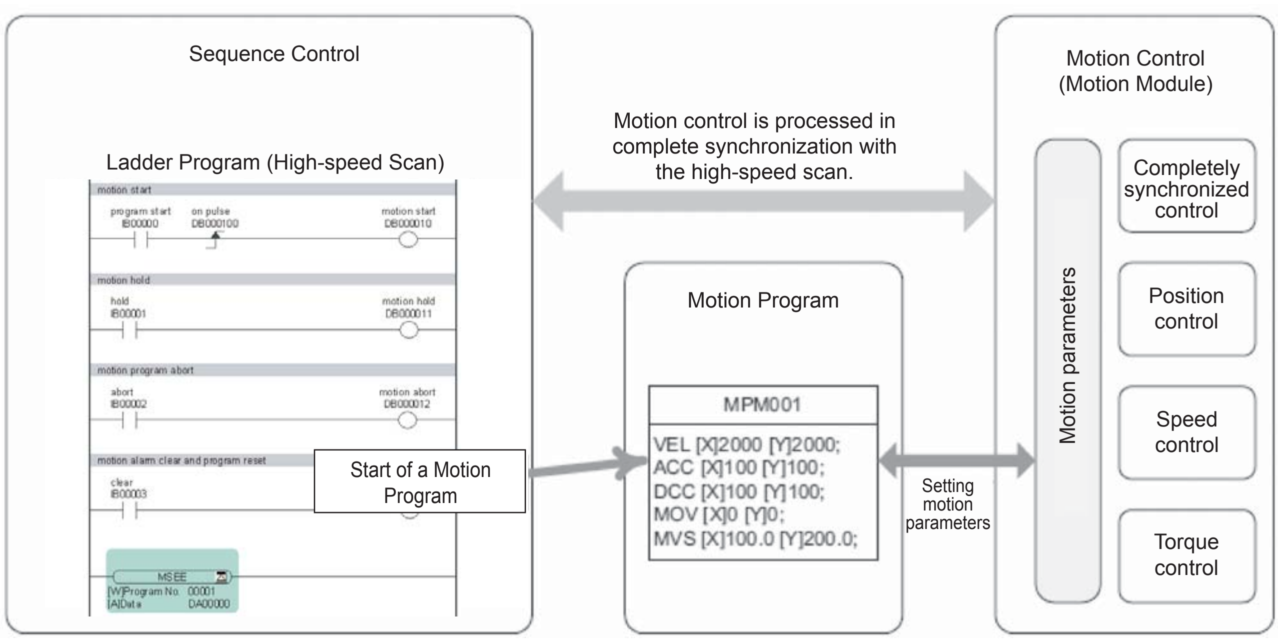
The MSG-SND and MSG-RCV ladder instructions support various protocols and can be used to control communications with many external devices, such as a touch panels or host PLCs. This allows external devices to access registers in the Machine Controller.



INFO Instead of using a ladder program, the Machine Controller can also communicate with external devices by using I/O message communications or automatic reception.
Refer to *Chapter 6 Ethernet Communications* in the *Machine Controller MP2310 Basic Module User's Manual* (Manual No.: SIEP C880732 01) for details.

1.2.5 Complete Synchronization with Motion Control

Ladder programs that are started in the high-speed scan are processed in complete synchronization with motion control processing. This allows you to call and process a motion program that performs complicated motion control synchronously with a ladder program.



2

Specifications for Ladder Programs

This chapter gives the specifications for ladder programs.

2.1 MP2000-series Machine Controller Specifications

2.1.1 Applicable Machine Controllers

You can use ladder programs with the following MP2000-series Machine Controllers.

- MP2100
- MP2100M
- MP2101
- MP2101M
- MP2101T
- MP2101TM
- MP2200 with CPU-01
- MP2200 with CPU-02
- MP2200 with CPU-03
- MP2200 with CPU-04
- MP2300
- MP2300S
- MP2310
- MP2500
- MP2500B
- MP2500M
- MP2500MB
- MPU-01

INFO

The MP2400 supports only motion programs and sequence programs.
You cannot use ladder programs with it.

2.1.2 Machine Controller Program Specifications

Machine Controller		MP2100 and MP2100M	MP2300	MP2300S	MP2200 with CPU-01	MP2310	MP2200 with CPU-02	MP2101, MP2101M, MP2101T, MP2101TM, MP2200 with CPU-03, MP2200 with CPU-04, and MPU-01
Program Capacity[*1]		5.5 MB			7.5 MB		11.5 MB	
Ladder Programs	Applicable Models	Applicable[*2]	NA	Applicable				
Ladder Programs	Startup Processing	64 drawings max. including parent drawings, operation error drawings, child drawings, and grandchild drawings						
Ladder Programs	Interrupt Processing	64 drawings max. including parent drawings, operation error drawings, child drawings, and grandchild drawings						
Ladder Programs	High-speed Scan Processing	200 drawings max. including parent drawings, operation error drawings, child drawings, and grandchild drawings						
Ladder Programs	Low-speed Scan Processing	500 drawings max. including parent drawings, operation error drawings, child drawings, and grandchild drawings						
Ladder Programs	User Functions	500 drawings max.						
Ladder Programs	Maximum Number of Steps	1,000 steps per drawing						
Motion Programs	Applicable Models	Applicable						
Motion Programs	Number of Programs	256 programs max. including motion programs and sequence programs						
Motion Programs	Number of Groups	8 groups (Up to 16 axes can be set in one group.)						
Motion Programs	Number of Tasks	16 tasks max. (This is the number of simultaneously executable motion programs.)						
Motion Programs	Number of Parallel Forks per Task	8 (4 main program forks × 2 subprogram forks)						
Sequence Programs	Applicable Models	NA	Applicable	Applicable	NA	Applicable	NA	Applicable
Sequence Programs	Number of Programs	256 programs max. including motion programs and sequence programs						
Sequence Programs	Number of Tasks	16 tasks max. (This is the number of simultaneously executable sequence programs.)						
Accessible Registers	M Registers	Applicable (65,535 words) These registers are backed up with a battery.[*3]						
Accessible Registers	S Registers	Applicable (8,192 words) These registers are backed up with a battery.[*3]						
Accessible Registers	I Registers	Applicable (32,768 words + motion monitor parameters)						
Accessible Registers	O Registers	Applicable (32,768 words + motion setting parameters)						
Accessible Registers	C Registers	Applicable (16,384 words)						
Accessible Registers	D Registers	Applicable (Can be specified to between 0 and 16,384 words.) These registers are unique to each drawing (DWG). They can be used within each drawing.						
Accessible Registers	# Registers	Applicable (Can be specified to between 0 and 16,384 words.) These are internal registers that are unique to each drawing (DWG). They can be referenced within each drawing.						
Capacity of Table Data Backed Up by a Battery		None				1 MB		3 MB

∗ 1. This is the total capacity for ladder programs and motion programs.
∗ 2. This is supported only for version 2.66 or higher.
∗ 3. The # registers can be used only when ladder programs are used.

Specifications for Ladder Programs

2

2.2 Engineering Tool Specifications

This section gives the specifications for programs for the Engineering Tool.

2.2.1 Applicable Engineering Tool

You can create ladder programs with the following Engineering Tool.

- MPE720 version 5 for all MP2000-series Machine Controllers except for the MP2400
- MPE720 version 6 for all MP2000-series Machine Controllers

INFO

In addition to the Engineering Tool, you can also use the following Support Tools to monitor Machine Controller information and transfer data.

- MPLOGGER (Control Information Monitoring Tool)
- MPLoader (Data Transfer Tool)
- MPLoadMaker (Automatic Transfer Data Creation Tool)

You can install the Engineering Tool and Support Tools in one PC to use them.

2.2.2 MPE720 Version 6 Engineering Tool Specifications

The following table shows the relationship between the Engineering Tool and the Machine Controller.

Machine Controller	MPE720 Version 6 (CPMC-MPE770)	Remarks
MP2100	Applicable	–
MP2100M	Applicable	–
MP2101	Applicable	Applicable with MPE720 version 6.24 or higher
MP2101M	Applicable	Applicable with MPE720 version 6.24 or higher
MP2101T	Applicable	Applicable with MPE720 version 6.24 or higher
MP2101TM	Applicable	Applicable with MPE720 version 6.24 or higher
MP2200 with CPU-01	Applicable	–
MP2200 with CPU-02	Applicable	–
MP2200 with CPU-03	Applicable	Applicable with MPE720 version 6.20 or higher
MP2200 with CPU-04	Applicable	Applicable with MPE720 version 6.22 or higher
MP2300	Applicable	–
MP2300S	Applicable	Applicable with MPE720 version 6.04 or higher
MP2310	Applicable	Applicable with MPE720 version 6.04 or higher
MPU-01	Applicable	Applicable with MPE720 version 6.23 or higher

The following table shows the relationship between the Engineering Tool and the programs.

Program	MPE720 Version 6 (CPMC-MPE770)	Remarks
Ladder Programs	Applicable	–
Motion Programs	Applicable	–
Sequence Programs	Applicable	–

2.3 Ladder Programming Instructions

The following table lists the ladder programming instructions.
Refer to the reference sections for details on individual instructions.

Type	Symbol	Function	Reference
Relay Circuit Instructions	NOC	NO Contact	5.2.1
	NCC	NC Contact	5.2.2
	TON[10 ms]	10-ms ON-Delay Timer	5.2.3
	TOFF[10 ms]	10-ms OFF-Delay Timer	5.2.4
	TON[1 s]	1-s ON-Delay Timer	5.2.5
	TOFF[1 s]	1-s OFF-Delay Timer	5.2.6
	ON-PLS	Rising-edge Pulses	5.2.7
	OFF-PLS	Falling-edge Pulses	5.2.8
	COIL	Coil	5.2.9
	S-COIL	Set Coil	5.2.10
	R-COIL	Reset Coil	5.2.11
Numeric Operation Instructions	STORE	Store	5.3.1
	ADD	Add	5.3.2
	ADDX	Extended Add	5.3.3
	SUB	Subtract	5.3.4
	SUBX	Extended Subtract	5.3.5
	MUL	Multiply	5.3.6
	DIV	Divide	5.3.7
	MOD	Integer Remainder	5.3.8
	REM	Real Remainder	5.3.9
	INC	Increment	5.3.10
	DEC	Decrement	5.3.11
	TMADD	Add Time	5.3.12
	TMSUB	Subtract Time	5.3.13
	SPEND	Spend Time	5.3.14
	INV	Invert Sign	5.3.15
	COM	One’s Complement	5.3.16
	ABS	Absolute Value	5.3.17
	BIN	Binary Conversion	5.3.18
	BCD	BCD Conversion	5.3.19
	PARITY	Parity Conversion	5.3.20
	ASCII	ASCII Conversion 1	5.3.21
	BINASC	ASCII Conversion 2	5.3.22
	ASCBIN	ASCII Conversion 3	5.3.23
Logic Operation Instructions	AND	Inclusive AND	5.4.1
	OR	Inclusive OR	5.4.2
	XOR	Exclusive OR	5.4.3
	<	Less Than	5.4.4
	≤	Less Than or Equal	5.4.5
	=	Equal	5.4.6
	≠	Not Equal	5.4.7
	≥	Greater Than or Equal	5.4.8
	>	Greater Than	5.4.9
	RCHK	Range Check	5.4.10

Type	Symbol	Function	Reference
Program Control Instructions	SEE	Call Sequence Subprogram	5.5.1
	MSEE	Call Motion Program	5.5.2
	FUNC	Call User Function	5.5.3
	INS	Direct Input String	5.5.4
	OUTS	Direct Output String	5.5.5
	XCALL	Call Extended Program	5.5.6
	WHILE END_WHILE	WHILE construct	5.5.7
	FOR END_FOR	FOR construct	5.5.8
	IF END_IF	IF construct	5.5.9
	IF ELSE END_IF	IF ELSE construct	5.5.10
	EXPRESSION	Expression	5.5.11
Basic Function Instructions	SQRT	Square Root	5.6.1
	SIN	Sine	5.6.2
	COS	Cosine	5.6.3
	TAN	Tangent	5.6.4
	ASIN	Arc Sine	5.6.5
	ACOS	Arc Cosine	5.6.6
	ATAN	Arc Tangent	5.6.7
	EXP	Exponential	5.6.8
	LN	Natural Logarithm	5.6.9
	LOG	Common Logarithm	5.6.10
Data Manipulation Instructions	ROTL	Bit Rotate Left	5.7.1
	ROTR	Bit Rotate Right	5.7.2
	MOVB	Move Bit	5.7.3
	MOVW	Move Word	5.7.4
	XCHG	Exchange	5.7.5
	SETW	Table Initialization	5.7.6
	BEXTD	Byte-to-word Expansion	5.7.7
	BPRESS	Word-to-byte Compression	5.7.8
	BSRCH	Binary Search	5.7.9
	SORT	Sort	5.7.10
	SHFTL	Bit Shift Left	5.7.11
	SHFTR	Bit Shift Right	5.7.12
	COPYW	Copy Word	5.7.13
	BSWAP	Byte Swap	5.7.14
DDC Instructions	DZA	Dead Zone A	5.8.1
	DZB	Dead Zone B	5.8.2
	LIMIT	Upper/Lower Limit	5.8.3
	PI	PI Control	5.8.4
	PD	PD Control	5.8.5
	PID	PID Control	5.8.6
	LAG	First Order Lag	5.8.7
	LLAG	Phase Lead Lag	5.8.8
	FGN	Function Generator	5.8.9
	IFGN	Inverse Function Generator	5.8.10
	LAU	Linear Accelerator/Decelerator 1	5.8.11
	SLAU	Linear Accelerator/Decelerator 2	5.8.12
	PWM	Pulse Width Modulation	5.8.13

Type	Symbol	Function	Reference
Table Manipulation Instructions	TBLBR	Read Table Block	5.9.1
	TBLBW	Write Table Block	5.9.2
	TBLSRL	Search Table Row	5.9.3
	TBLSRC	Search Table Column	5.9.4
	TBLCL	Clear Table Block	5.9.5
	TBLMV	Move Table Block	5.9.6
	QTBLR	Read Queue Table	5.9.7
	QTBLRI	Read Queue Table with Pointer Increment	5.9.7
	QTBLW	Write Queue Table	5.9.8
	QTBLWI	Write Queue Table with Pointer Increment	5.9.8
	QTBLCL	Clear Queue Table Pointer	5.9.9
Standard System Function Instructions	COUNTER	Counter	5.10.1
	FINFOUT	First-in First-out	5.10.2
	TRACE	Trace	5.10.3
	DTRC-RD	Read Data Trace	5.10.4
	ITRC-RD	Read Inverter Trace	5.10.5
	MSG-SND	Send Message	5.10.6
	MSG-RCV	Receive Message	5.10.7
	ICNS-WR	Write Inverter Parameters	5.10.8
	ICNS-RD	Read Inverter Parameters	5.10.9
	MLNK-SVW	Write SERVOPACK Parameters	5.10.10
	MOTREG-W	Write Motion Register	5.10.11
	MOTREG-R	Read Motion Register	5.10.12
C-language Control Instructions	C-FUNC	Call User C-language Function	5.11.1
	TSK-CTRL	Control User C-language Task	5.11.2

3

Ladder Program Development Flow

This chapter describes the development flow for ladder programs.

3.1 Ladder Program Design Procedures

This section describes the design procedures for ladder programs as outlined below.

① Preparation for Devices to Be Connected

Assemble and wire all devices to be connected.
Install MPE720 on a PC.

Refer to *3.1.1 Connecting the Hardware*.
Refer to *3.1.2 Installing MPE720 Version 6*.
Refer to *3.1.3 Communications Settings*.

② System Startup

Perform self configuration and start the system.

Refer to *3.1.4 System Startup*.

③ Creating a Project

Create a project before you start ladder program development.

Refer to *3.1.5 Creating a Project*.

④ Creating Ladder Programs

Enter the ladder programs in the Ladder Editor.

Refer to *3.1.6 Creating Ladder Programs*.

⑤ Transferring Ladder Programs

Transfer the ladder programs that you created to the MP2000-series Machine Controllers.

Refer to *3.1.7 Transferring Ladder Programs*.

⑥ Checking the Operation of the Ladder Programs

Check the operation of the ladder programs.

Refer to *3.1.8 Checking the Operation of the Ladder Programs*.

⑦ Saving the Ladder Programs to Flash Memory

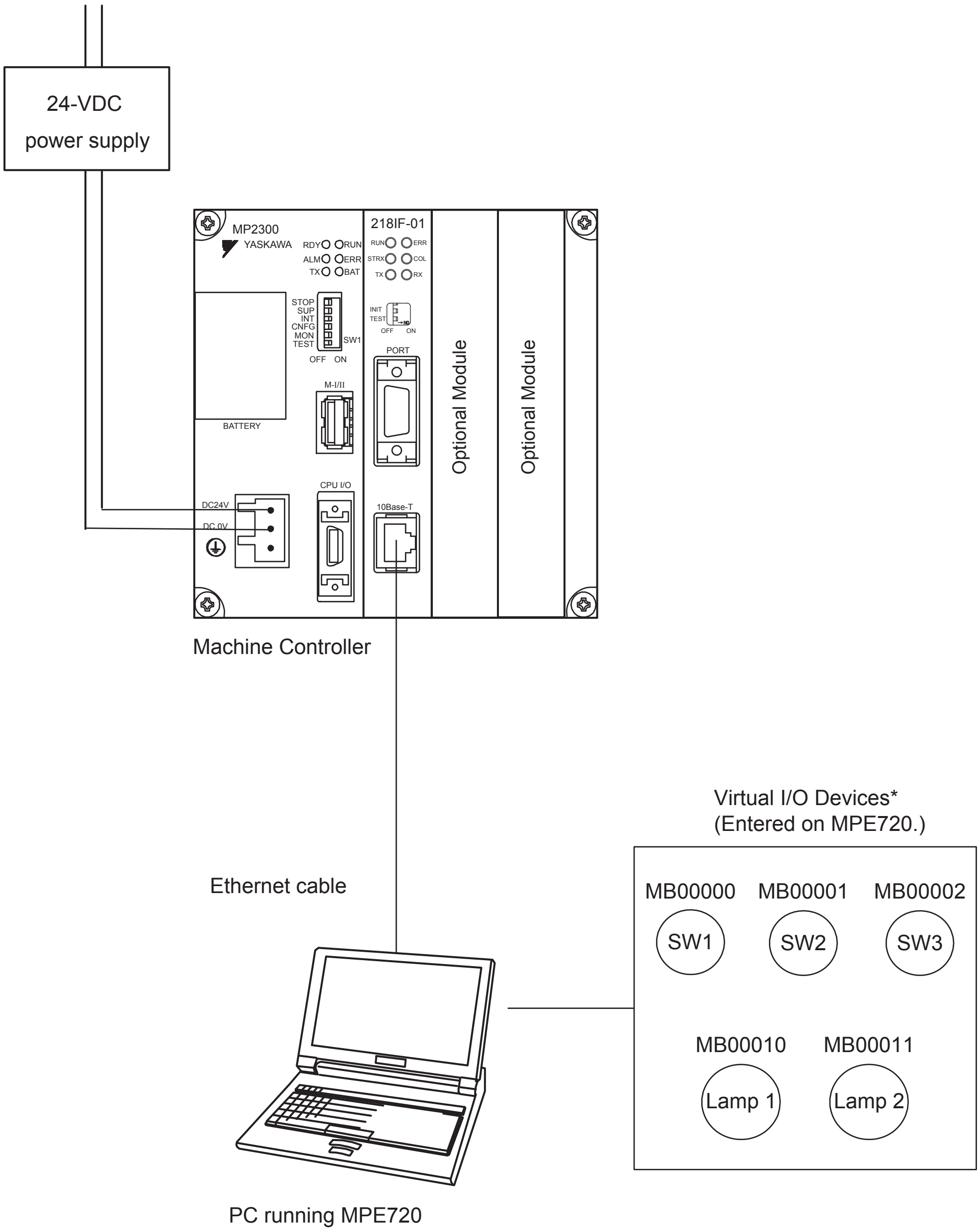
Save the debugged ladder programs to flash memory.

Refer to *3.1.9 Saving the Ladder Programs to Flash Memory*.

- The above flowchart is an example of the ladder program design process. Settings to interface the external devices must be completed to use programs on the actual system.

3.1.1 Connecting the Hardware

The flow of ladder program development that is described in this chapter is based on the following system configuration.



* In this chapter, M registers in the Machine Controller are used to simulate virtual I/O devices in the example system.
In practice, the input and output signals would be connected to I/O Modules on the Machine Controller, and the ladder program would be created using I and O registers.

3.1.2 Installing MPE720 Version 6

Install MPE720 version 6 on a PC.
Refer to the *Engineering Tool for MP2000 Series Machine Controller MPE720 Version 6 User's Manual* (SIEP C880700 30) for the installation procedure.

3.1.3 Communications Settings

After you install MPE720 version 6 on the PC, set up communications between the MP2000-series Machine Controller and the PC.
Refer to the *Engineering Tool for MP2000 Series Machine Controller MPE720 Version 6 User's Manual* (SIEP C880700 30) for the communications setup procedure.

3.1.4 System Startup

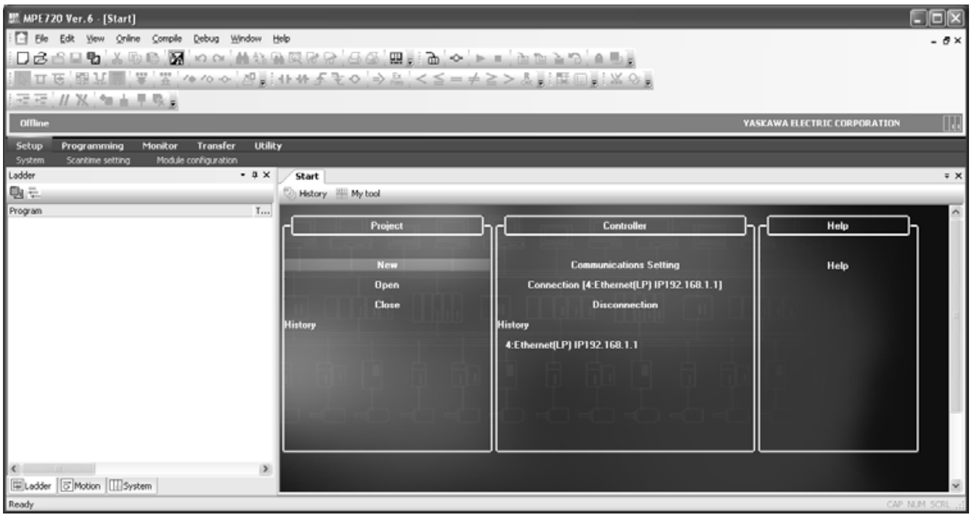
Set up the system by performing self configuration. Self configuration automatically recognizes the Modules that are installed in the MP2000-series Machine Controller and the devices that are connected through the MECHATROLINK connector. This allows you to quickly and easily set up the system. You can perform self configuration by using the DIP switch on the Machine Controller or by using the MPE720.
Refer to the user's manual for your Machine Controller for details on self configuration.

3.1.5 Creating a Project

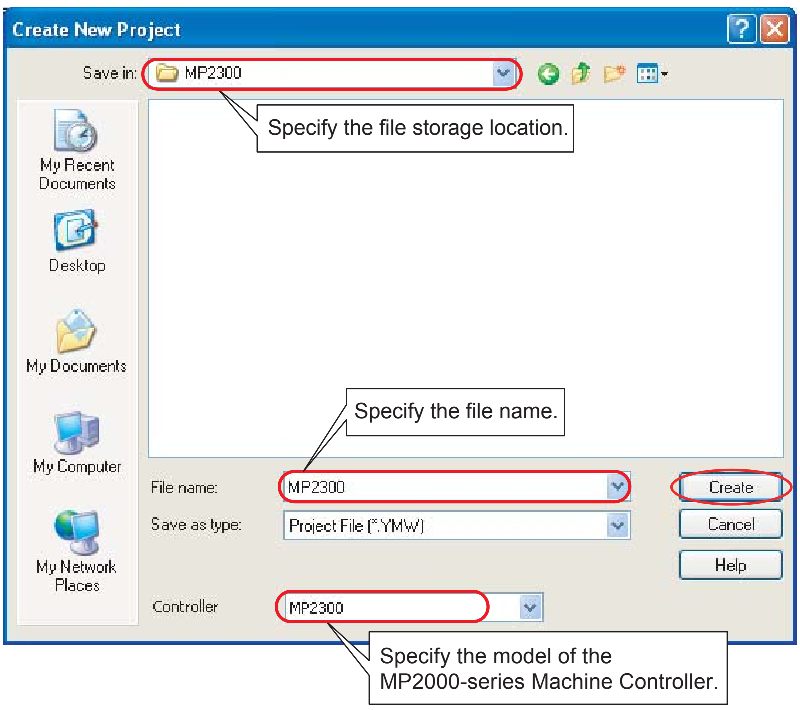
Use the following procedure to create a project.

1. Double-click the following icon on the PC desktop to start MPE720 version 6.

2. When MPE720 version 6 starts, select ***New*** on the Start Tab Page.



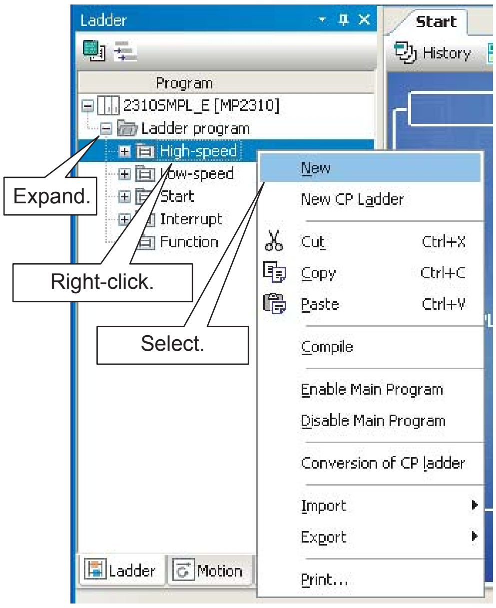
3. Specify the file name, file storage location, and Machine Controller model, and then click the **Create** Button.



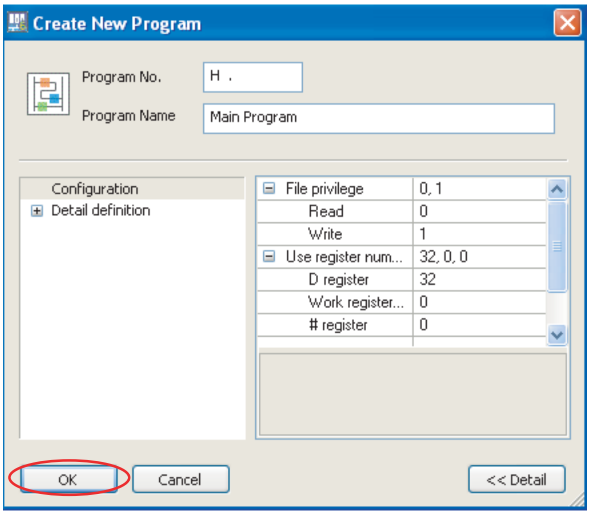
3.1.6 Creating Ladder Programs

Start the Ladder Editor and use the following procedure to create a ladder program.

1. In the pane on the left, expand the tree under **Ladder program**. Right-click **High-speed** and select ***New*** from the menu.



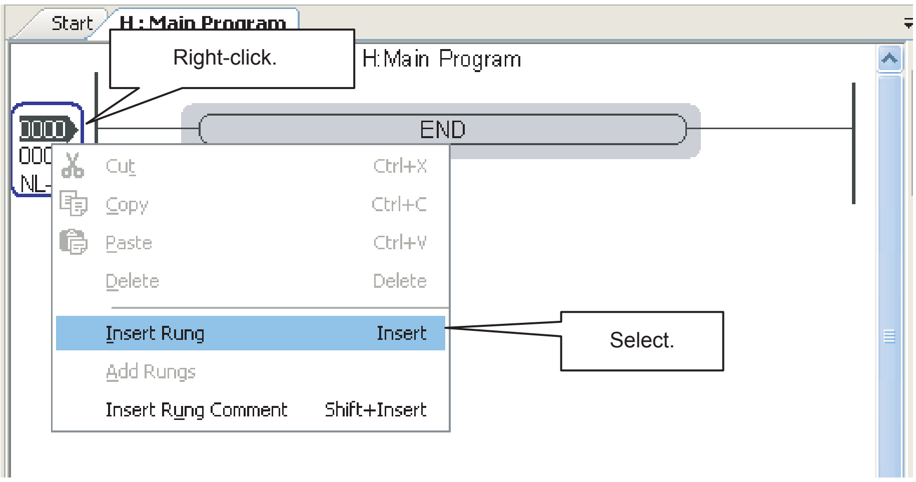
2. Click the **OK** Button.



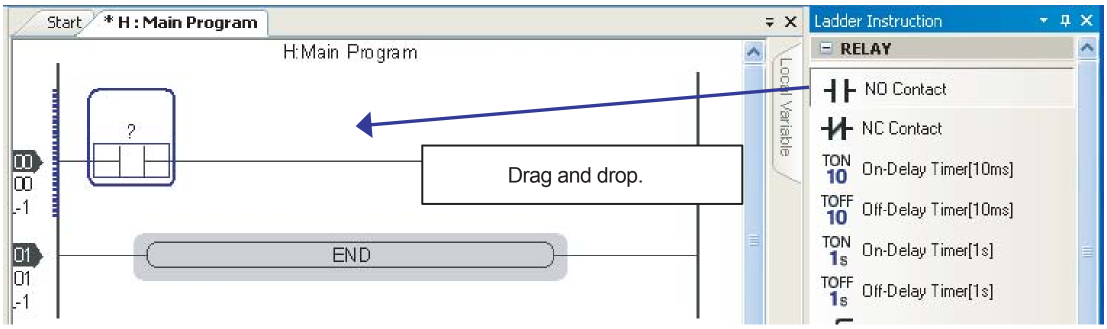
3. Create the ladder program in the Ladder Editor that you started.

Ladder programs are entered by inserting rungs, then instructions, and finally parameters for the instructions. The following example shows how to insert an NO Contact instruction.

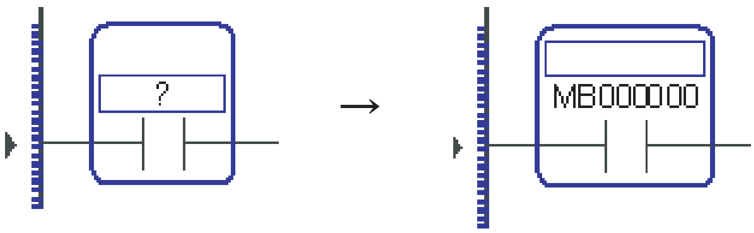
① Right-click the tab with the row number, and select ***Insert Rung***.



② Drag the instruction to insert (here, the NO Contact instruction under the relay instructions) from the Ladder Instructions Pane to the inserted rung.

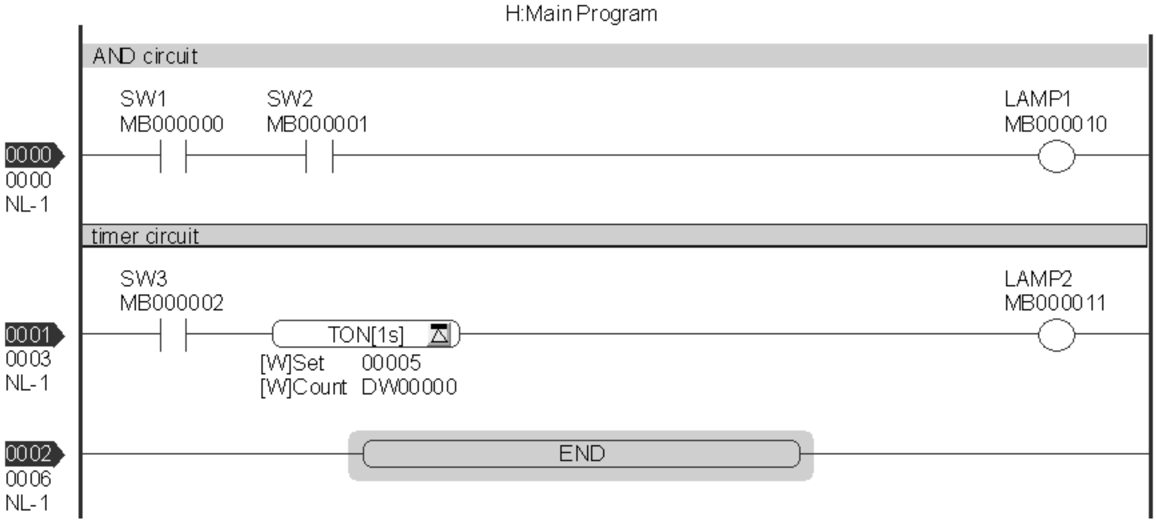


③ Click the portion of the instruction with a question mark and enter the parameter (MB00000) from the key-board.



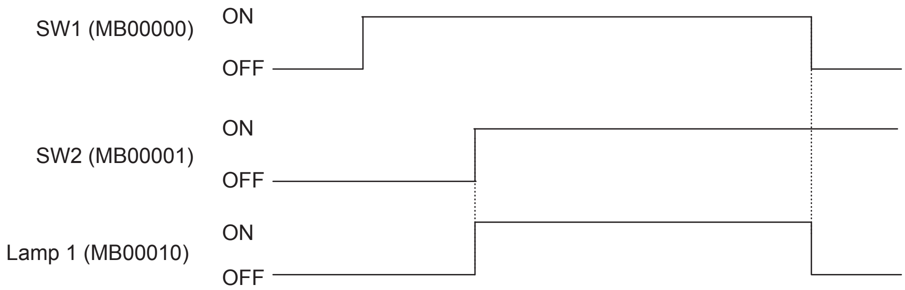
- The types and number of instruction parameters depend on the instruction. Refer to *Chapter 5 Instructions* for details on individual instructions.

④ Repeat steps 1 to 3 until you have created the entire ladder program. The following figures show examples of a ladder program and its timing chart.

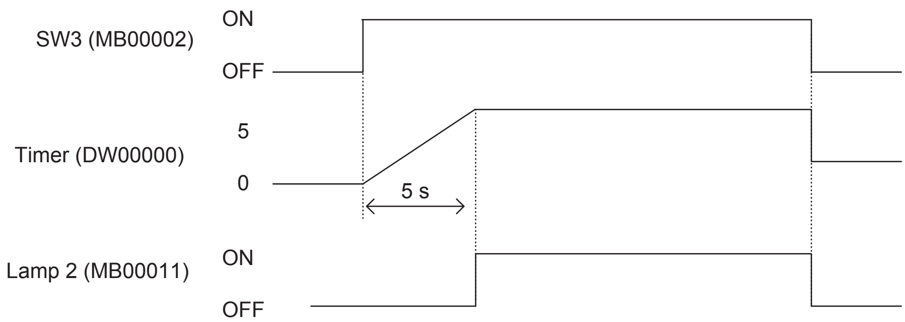


- The ladder program example that is shown above uses M registers for switches and lamps.
When you enter a ladder program for an actual system, use the appropriate I and O registers.

AND Circuit Operation



Timer Circuit Operation



4. While displaying the ladder program, select ***Compile - Compile*** from the menu bar to compile the program. When the compilation is finished, the ladder program will be saved automatically.

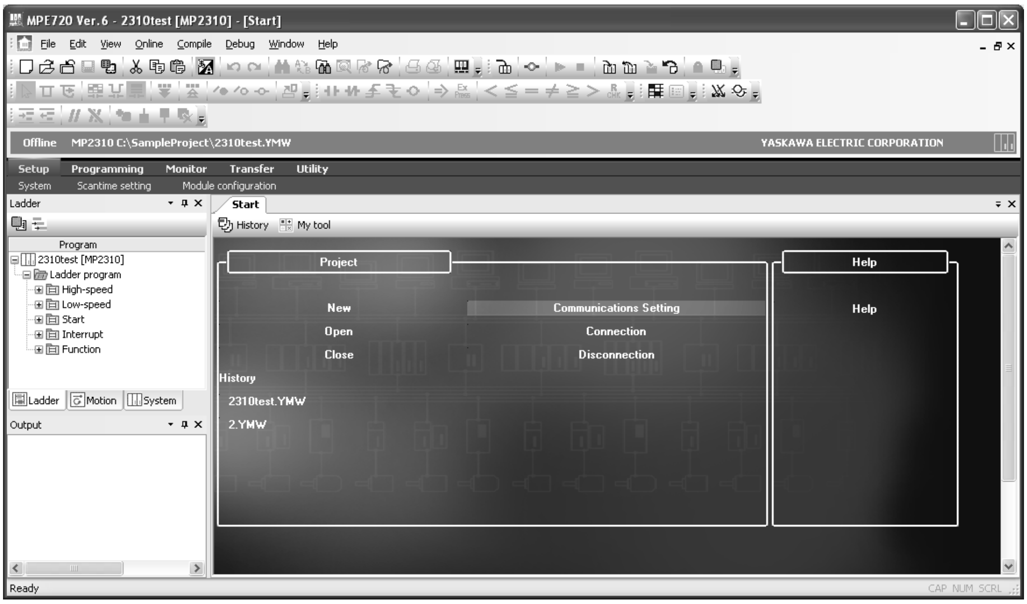
IMPORTANT

If an error is displayed in the Output Pane during compilation, the ladder program will not be saved.

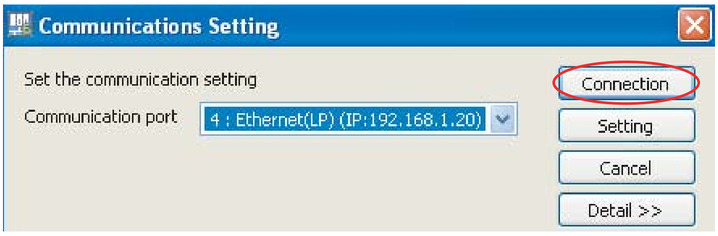
3.1.7 Transferring Ladder Programs

Use the following procedure to transfer the ladder program to the MP2000-series Machine Controller. This procedure is not necessary if you created the ladder program online.

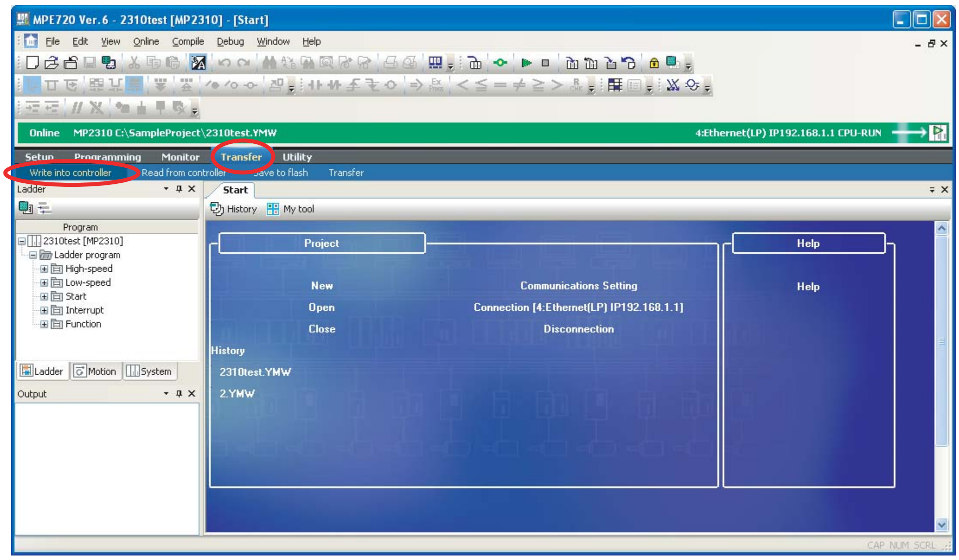
1. Select ***Communications Setting*** on the Start Tab Page.



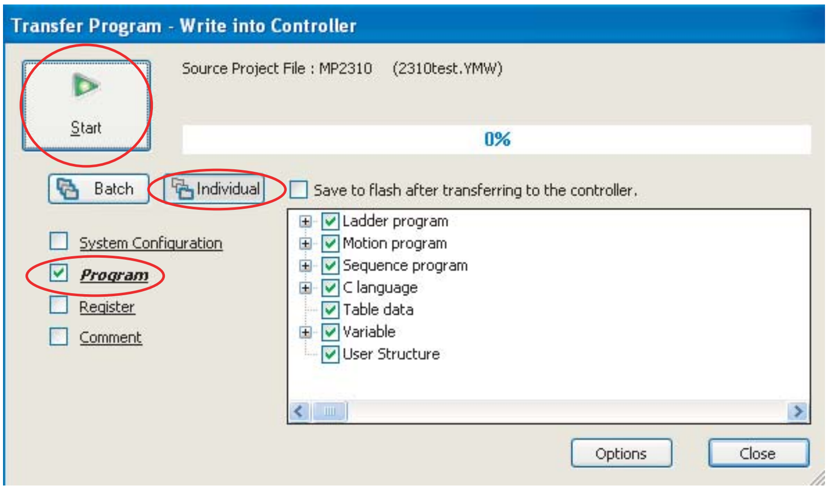
2. Select the desired communications port in the **Communications Setting** Box, and then click the **Connection** Button.



3. Wait for the MPE720 to go online, and then select ***Transfer*** – ***Write into controller***.



4. Click the **Individual** Button, then select the **Program** Check Box. Click the **Start** Button.



INFO

- When an individual transfer is selected, the same file in the Machine Controller will be overwritten with the selected project file data.
- When a batch transfer is selected, the RAM in the MP2000-series Machine Controller will be cleared before the transfer, and all project file data will be written in the RAM.

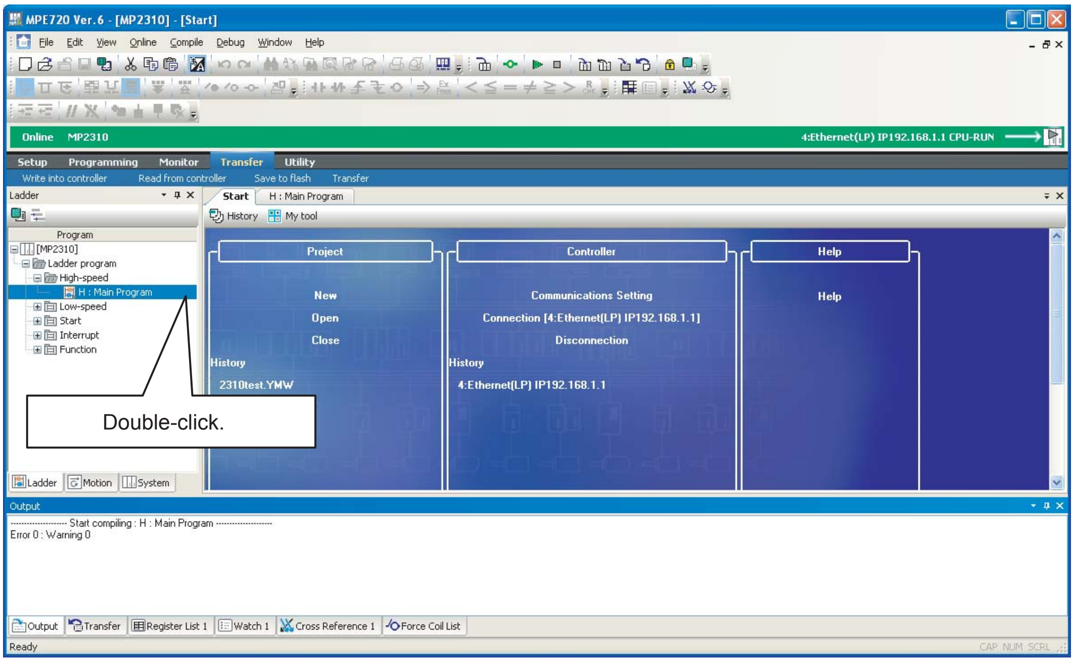
5. Click the **CPU STOP** Button. The transfer will start.

3.1.8 Checking the Operation of the Ladder Programs

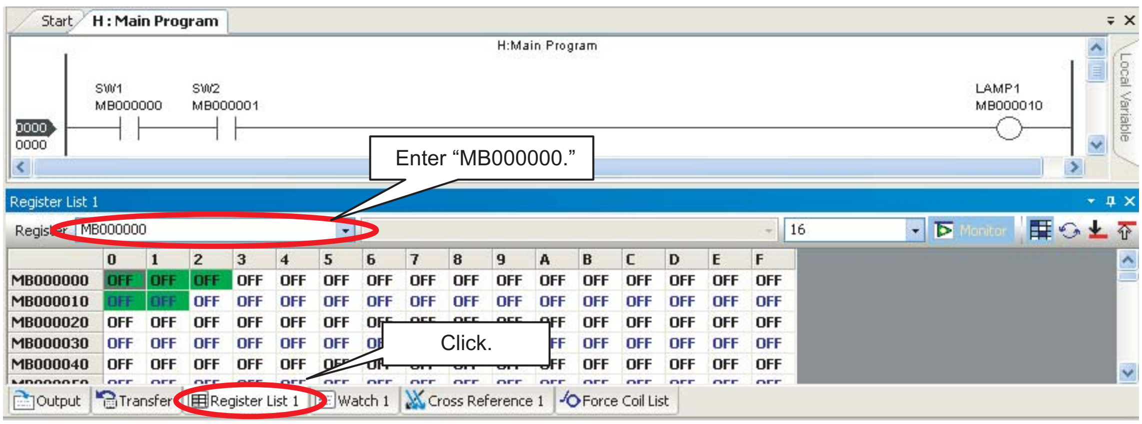
This section provides procedures to check the ladder program that was created in *3.1.6 Creating Ladder Programs*. Confirm that your program operates correctly by manipulating registers with the Register List, and by checking the runtime monitor in the Register List and Ladder Editor.

(1) Preparations for Checking Operation

1. Open the ladder program that was transferred.



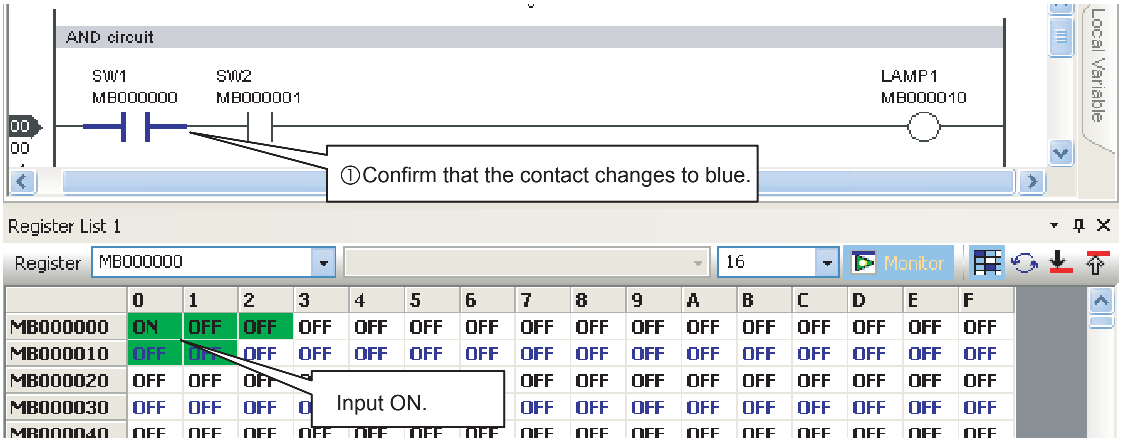
2. Click the **Register List 1** Tab, and then enter “MB000000” in the **Register** Box.
If the **Register List 1** Tab is not visible, select ***View*** – ***Register List*** – ***Register List 1*** from the menu bar. The tab will be displayed and the register list will be opened.



(2) Confirming the Operation of the 0000th Line (AND Circuit)

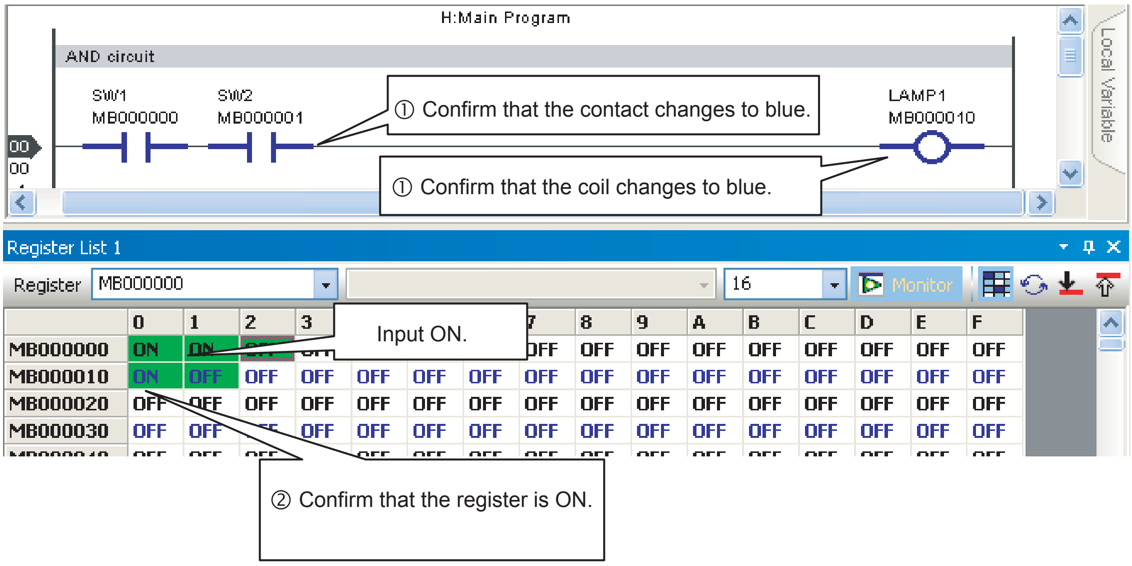
1. Set MB000000 to ON in the Register List. Confirm that the NO contact for MB000000 in the Ladder Editor changes to blue.

- When a coil or contact is highlighted in blue, it means that it is ON.



2. Set MB000001 to ON in the Register List. Confirm the following points.

- In the Ladder Editor, the NO contact for MB000001 and coil for MB000010 must be blue.
- In the Register List, MB000010 must be ON.

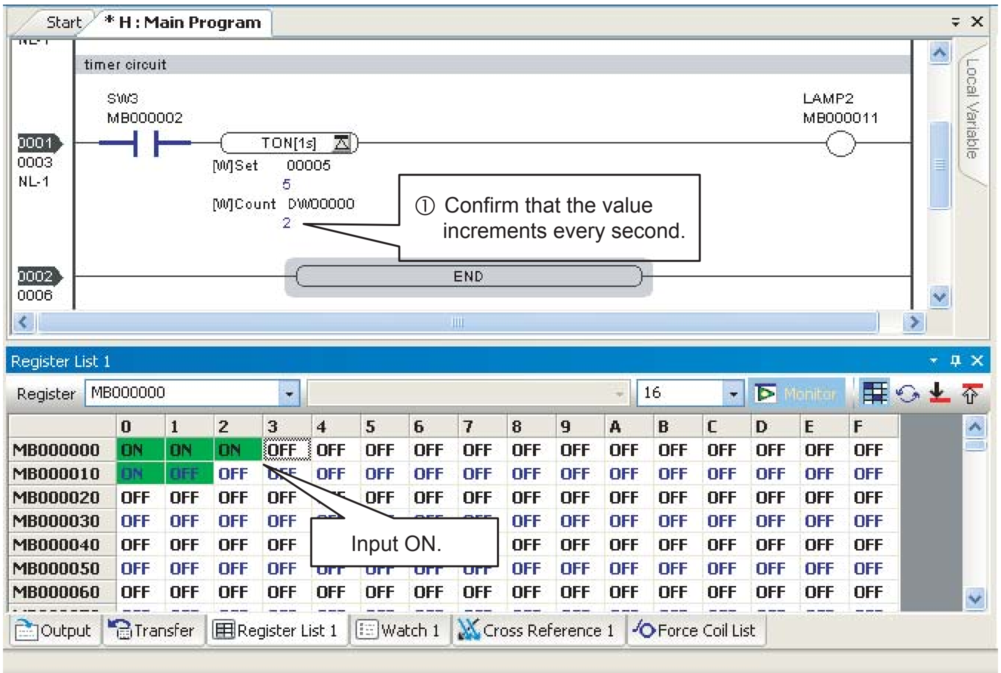


If no problems occur in the above procedure, then this concludes checking the operation of the 0000th line.

(3) Confirming the Operation of the 0001st Line (Timer Circuit)

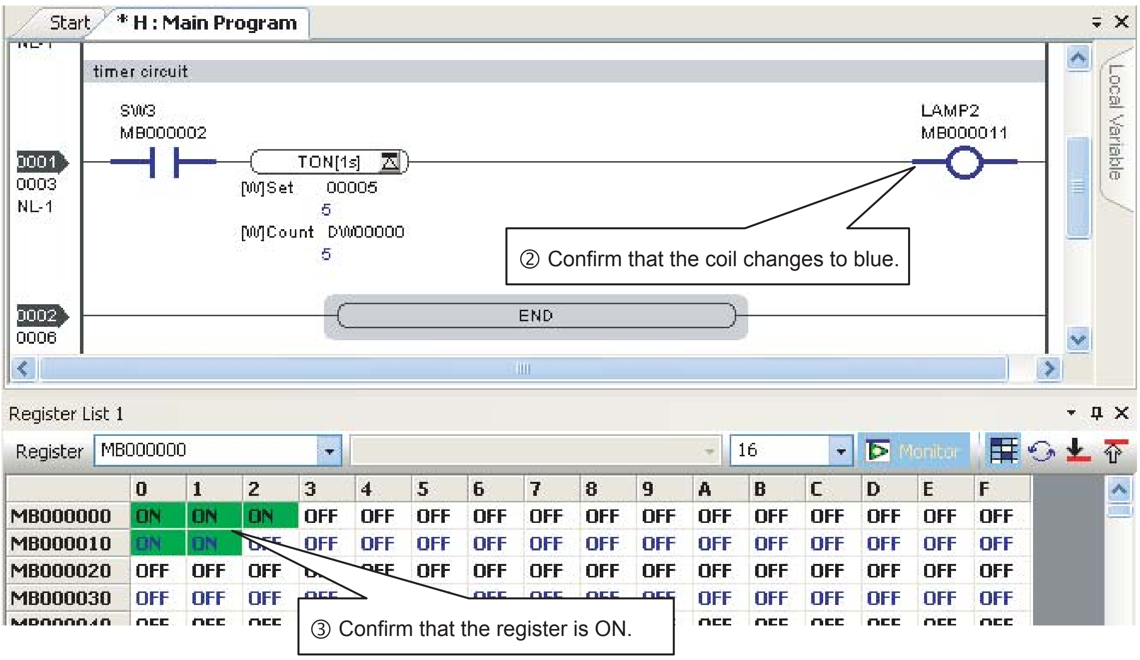
Set MB000002 to ON in the Register List. Confirm the following points.

① The DW00000 timer must increment every second.



② After five seconds, the coil for MB000011 must turn blue in the Ladder Editor.

③ In the Register List, MB000011 must be ON for step ②.

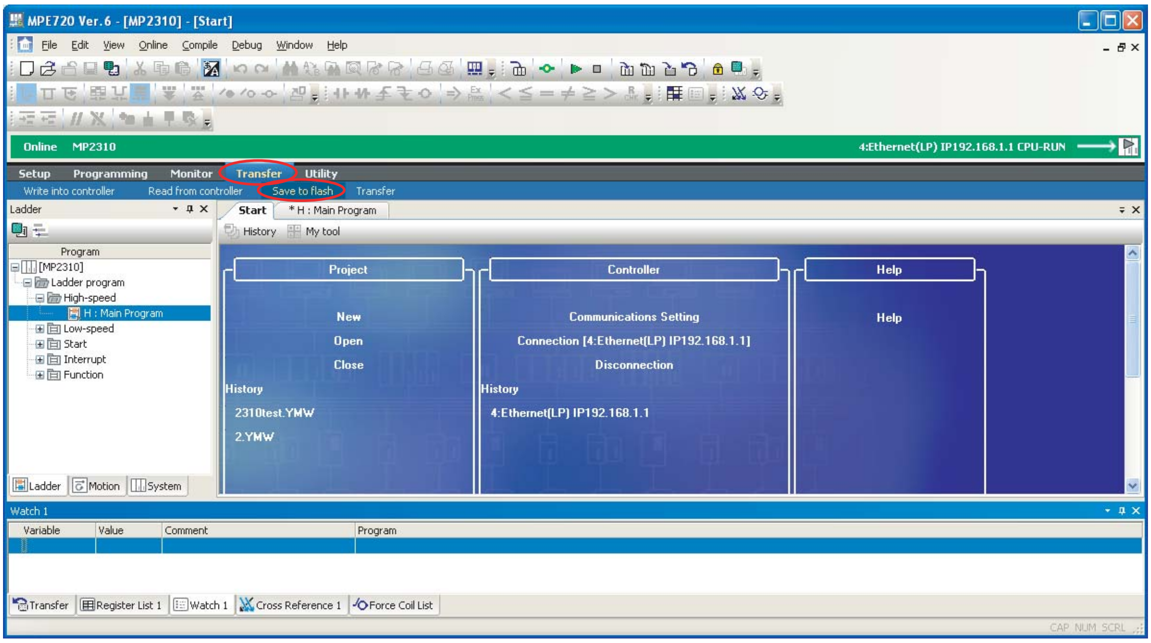


If no problems occur in the above procedure, then this concludes checking the operation of the 0001st line.

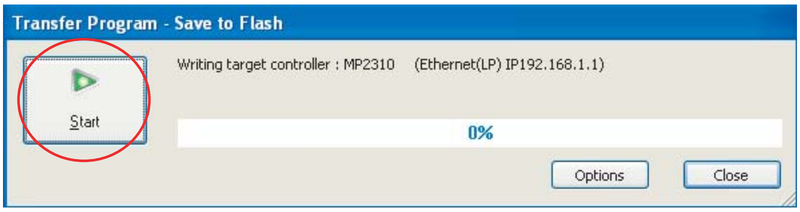
3.1.9 Saving the Ladder Programs to Flash Memory

Use the following procedure to save the data from the RAM in the MP2000-series Machine Controller to the flash memory in the MP2000-series Machine Controller.

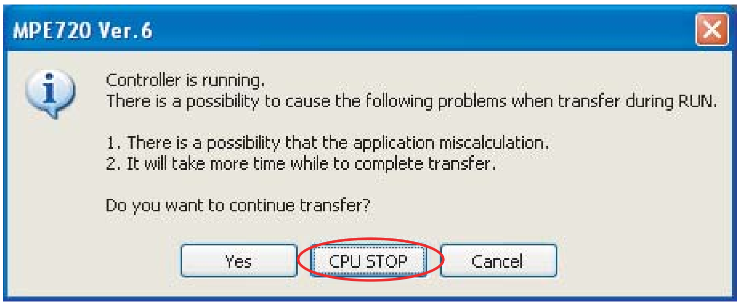
1. Select ***Transfer*** – ***Save to flash*** from the following window.



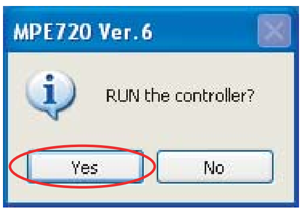
2. Click the **Start** Button.



3. Click the **CPU STOP** Button. The transfer will start.



4. Click the **Yes** Button in the following dialog box. The Machine Controller will switch to RUN Mode.



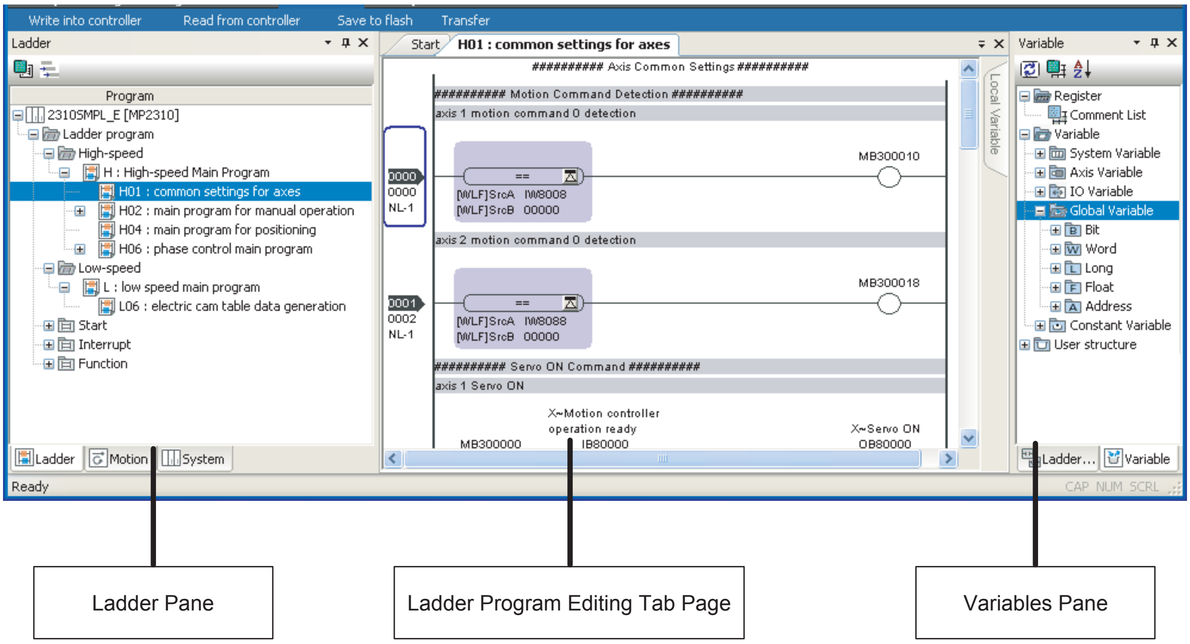
4

Programming

This chapter describes ladder programming methods and the elements that are necessary for ladder programming.

4.1 Ladder Program Editor

On the MPE720 version 6 Engineering Tool, the following panes are displayed to edit a ladder program. These panes are used to create and edit ladder programs.



■ Ladder Pane

Ladder programs are displayed by drawing.
Refer to *4.2 Ladder Drawings* for details on drawings.

■ Ladder Program Editing Tab Page

This tab page is used to edit ladder programs.

■ Variables Pane

This pane displays variables. Refer to *4.4 Registers (Variables)* for details on variables.
In addition to the panes and tab page that were just described, various other panes, tab pages, and tool bars also exist.
Refer to the *Engineering Tool for MP2000 Series Machine Controller MPE720 Version 6 User's Manual* (SIEP C880700 30) for details on MPE720 version 6.

4.2 Ladder Drawings

Ladder programs are managed as drawings (ladder drawings) that are identified by their drawing numbers (DWG numbers).
The ladder drawings form the basis of the ladder programs.

4.2.1 Types of Ladder Drawings

(1) Types and Priorities of Drawings

There are the following types of ladder drawings: parent drawings, child drawings, grandchild drawings, and operation error drawings.

- Parent Drawings
  These drawings are automatically executed by the system when the execution conditions that are listed in the following table are met.
- Child Drawings
  These drawings are executed when they are called from a parent drawing with a Call Program (SEE) instruction.
- Grandchild Drawings
  These drawings are executed when they are called from a child drawing with a Call Program (SEE) instruction.
- Operation Error Drawings
  These drawings are automatically executed by the system when an operation error occurs.

There are also five different types of drawings based on their role.
The following table gives the priority and parent drawing execution conditions for each type of drawing.

Priority*	Drawing Type	Role	Parent Drawing Execution Condition	Maximum Number of Drawings
1	DWG.A	Startup processing	Power ON (Processed once when the power supply is turned ON.)	64
2	DWG.I	Interrupt processing	External interrupt (Executed when a DI interrupt or counter match interrupt is received from an Optional Module.)	64
3	DWG.H	High-speed scan processing	Started at fixed intervals. (Executed every high-speed scan.)	200
4	DWG.L	Low-speed scan processing	Started at fixed intervals. (Executed every low-speed scan.)	500
–	Functions	User functions	Function call (Executed when called with a FUNC instruction from a drawing.)	500

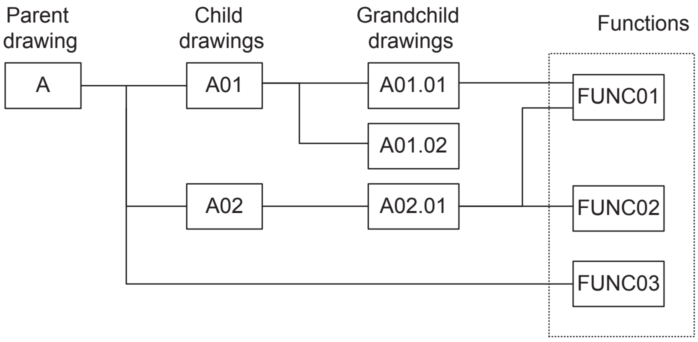
* Drawings with lower numbers have higher priority.

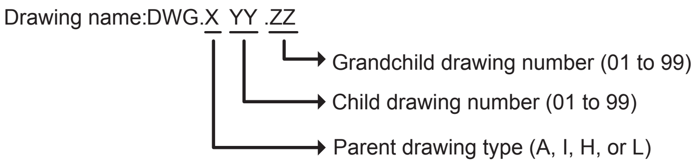
The breakdown of the number of drawings in each category is given in the following table.

Drawing	Number of Drawings			
	DWG.A	DWG.I	DWG.H	DWG.L
Parent drawings	1 drawing	1 drawing	1 drawing	1 drawing
Operation error drawings	1 drawing	1 drawing	1 drawing	1 drawing
Child drawings Grandchild drawings	Total of 62 drawings max.	Total of 62 drawings max.	Total of 198 drawings max.	Total of 498 drawings max.

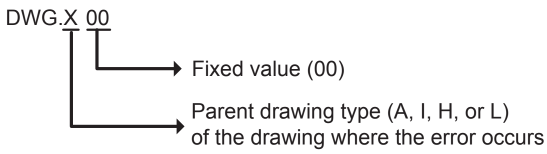
(2) Hierarchical Configuration of Drawings

Each process program is organized in a parent-child-grandchild hierarchy.
The parent drawing first must call a child drawing, and then the child drawing must call a grandchild drawing. This is called the hierarchical configuration of drawings.
A parent drawing cannot call a child drawing with a different drawing type. Similarly, a child drawing cannot call a grandchild drawing from a different drawing type. A parent drawing cannot call a grandchild drawing directly.
You can call functions from any drawing regardless of the drawing type or hierarchy.
The hierarchy of drawings is shown below using DWG.A drawings as an example.





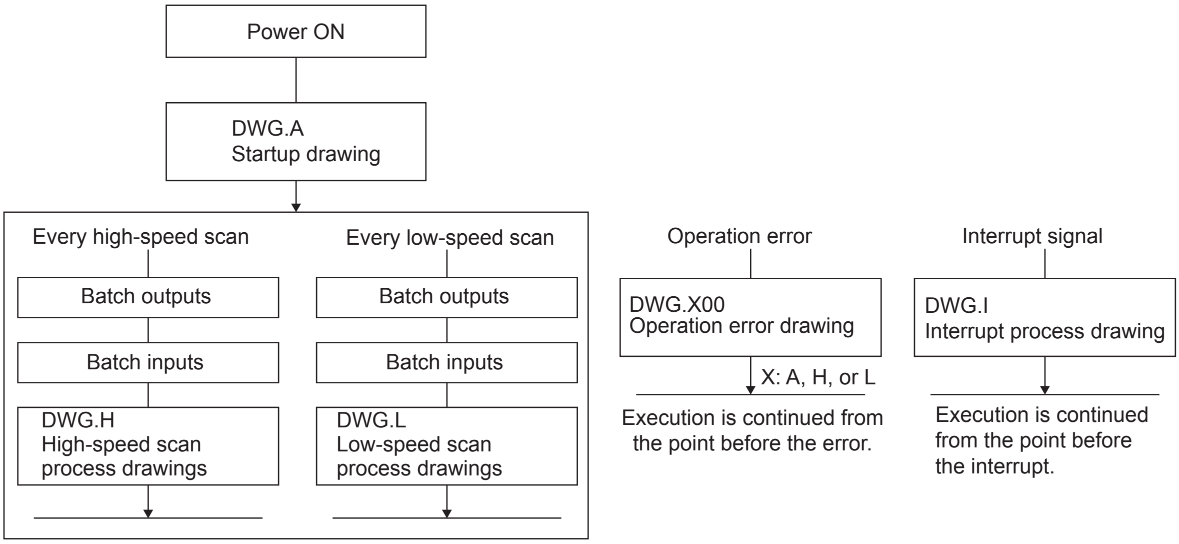
The following notation is used for operation error drawings.



4.2.2 Controlling the Execution of Drawings

(1) Controlling the Execution of Drawings

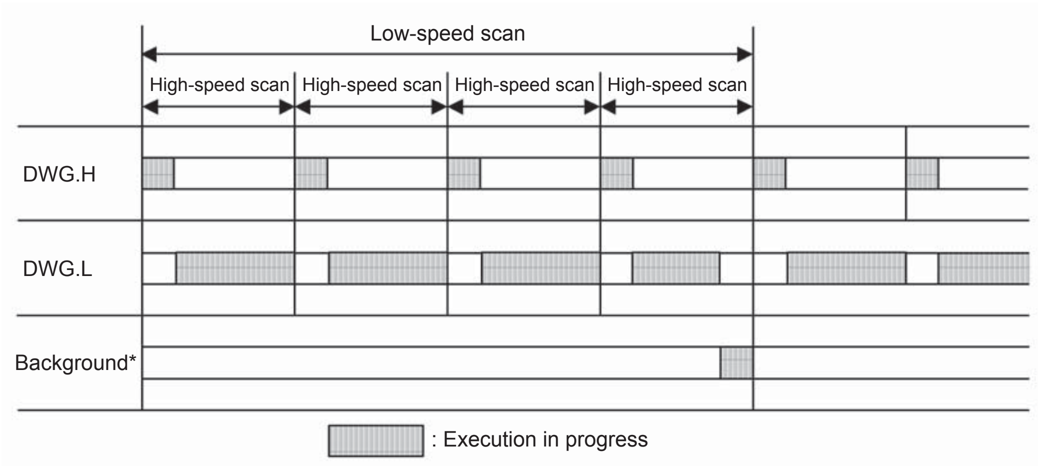
Drawings are executed based on their priorities, as shown in the following figure.



- The parent drawing of each drawing is automatically called and executed by the system.

(2) Scheduling the Execution of Scan Process Drawings

All scan process drawings are not executed at the same time. The following figure shows how execution time is allocated to them based on their priority levels.



* This time is used to execute internal system processing, such as self-diagnosis.

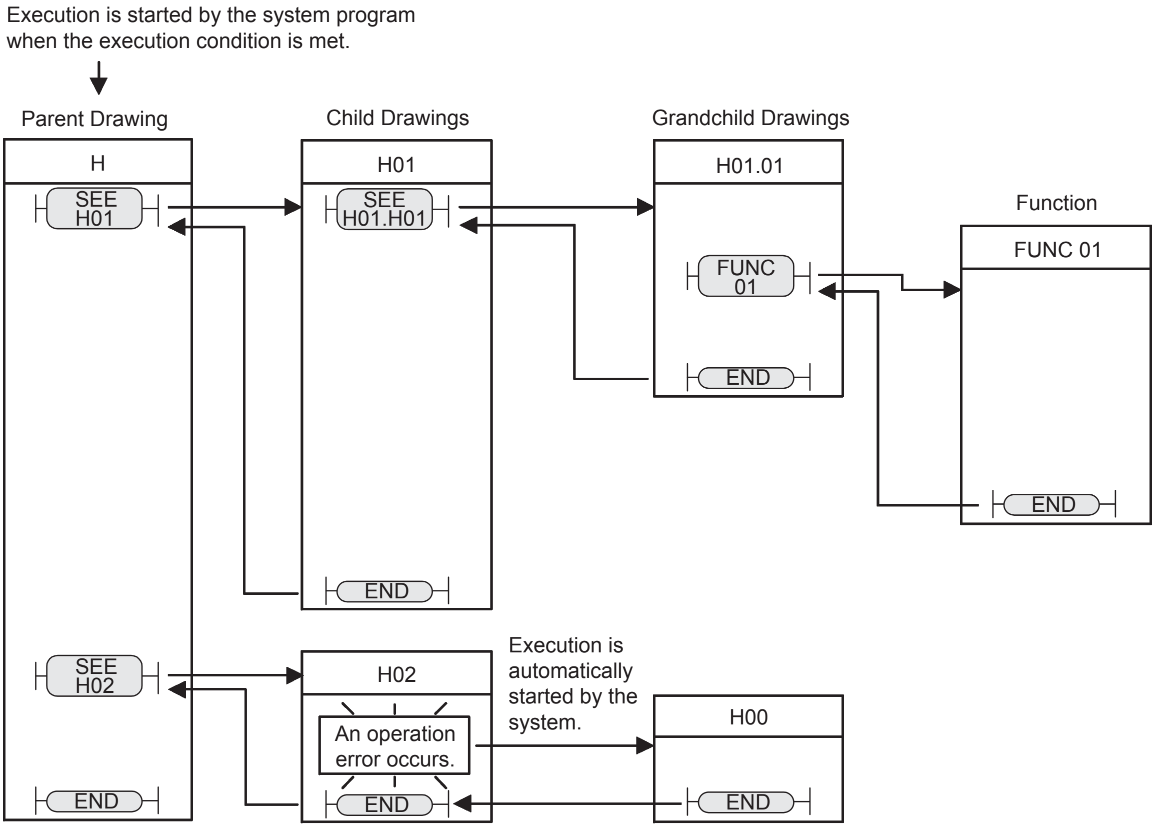
The low-speed scan is executed during the time that is not used by the high-speed scans. Set the time of the high-speed scan to approximately twice the total execution time of the high-speed drawings (DWG.H).

Programming

4

(3) Execution Processing of Drawings

The execution processing for drawings is executed by calling the drawings from the top to the bottom, following the hierarchy of the drawings. The hierarchy of drawings is shown below using DWG.A drawings as an example.



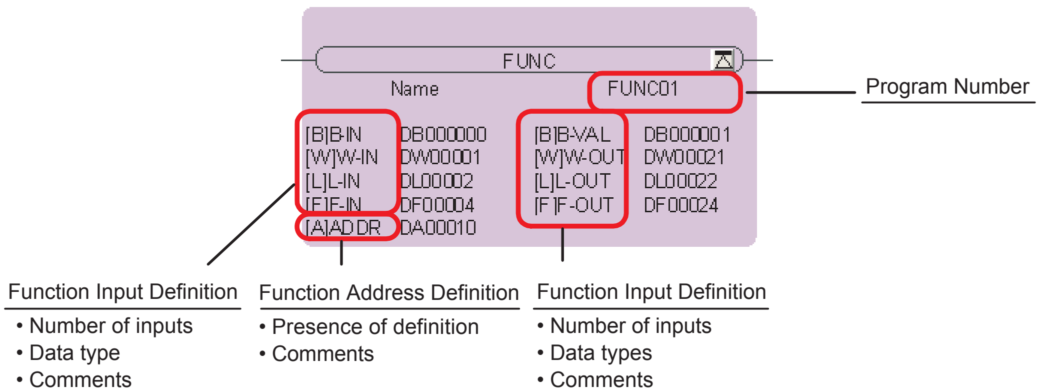
- The parent drawing is automatically called and executed by the system.
  Child drawings and grandchild drawings are executed by calling them from a parent drawing or a child drawing using the Call Program (SEE) instruction.
- You can call functions from any drawing. You can also call functions from other functions.
- If an operation error occurs, the operation error drawing for the drawing type will be started automatically.

4.3 User Functions

4.3.1 What Is a User Function?

(1) Overview of User Functions

A user function contains a function definition (program number and I/O definitions) and processing instructions that are defined by the user.
The following figure shows an example of a function definition.



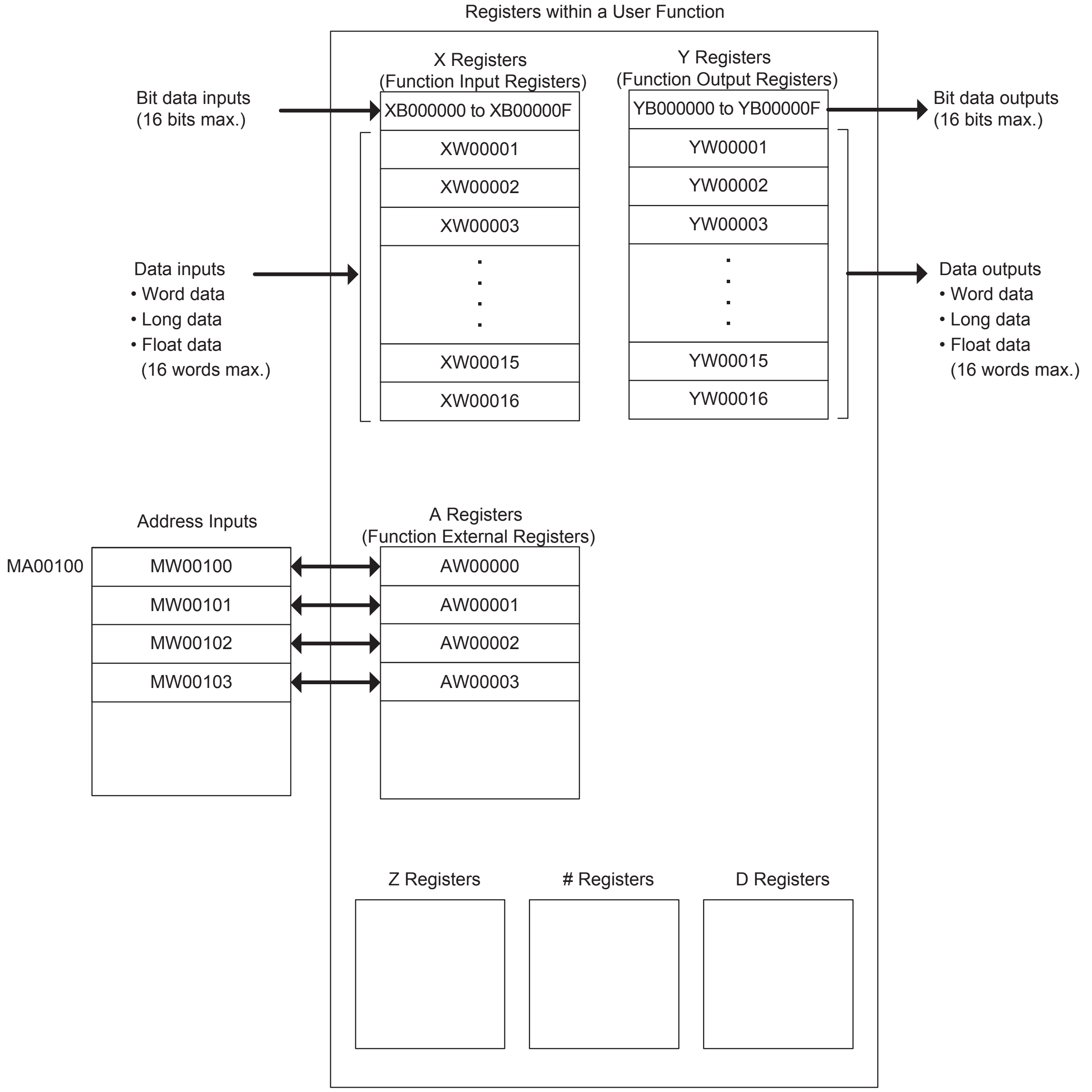
The processing to be performed by a function is created using a ladder program.
Functions are executed when they are called from a parent, child, or grandchild drawing with the FUNC instruction.
You can call a user function freely from any drawing. You can also simultaneously call the same function from different types or different levels of drawings. You can also call user functions from other user functions.
The use of functions provides the following advantages.

- Easy user program modularization
- Easy user programming and program maintenance

IMPORTANT

User functions can be called from any programs, any number of times.
When you call a user function, consider what values could be in the variables in each function, and perform initialization as needed.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

(2) Relationship between I/O Data for a Function and Registers in the Function



IMPORTANT

The X, Y, Z, and D registers are initialized to different values when a function is called.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

INFO

The S, M, I, O, and C registers can also be accessed from within a function.

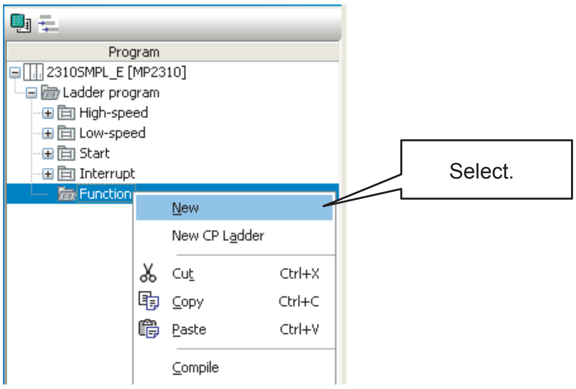
4.3.2 Creating User Functions

This section describes how to create a user function that has, as an example, the following specifications.

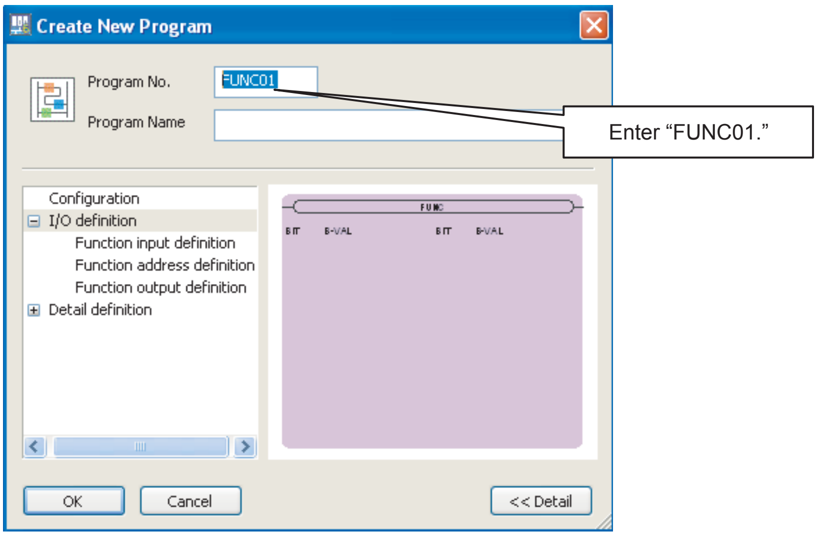
Function Definition Item	Name	Remarks
Program Number	FUNC01	
Function Input Value	IN	Integer data
Function Output Value 1	OUT1	Integer data
Function Output Value 2	OUT2	Integer data
Processing Details		
Multiply the function input value (IN) by 2 and output it to function output value 1 (OUT1). Multiply the function input value (IN) by 3 and output it to function output value 2 (OUT2).		

■ Procedure to Create a User Function

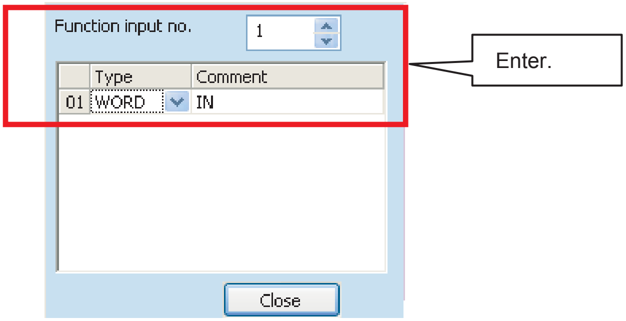
1. In the pane on the left, expand the tree under **Ladder program**. Right-click **Function** and select ***New*** from the menu.



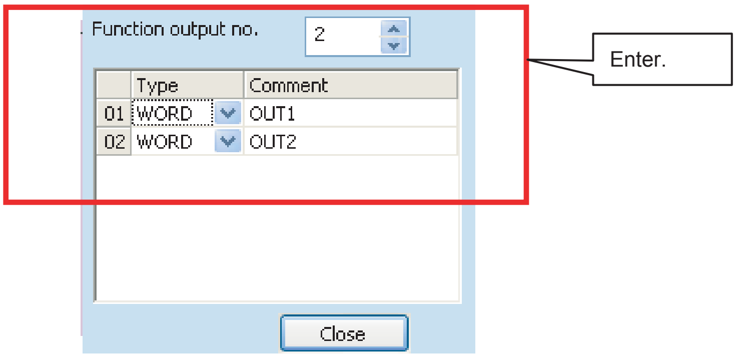
2. Enter “FUNC01” in the **Program No.** Box.



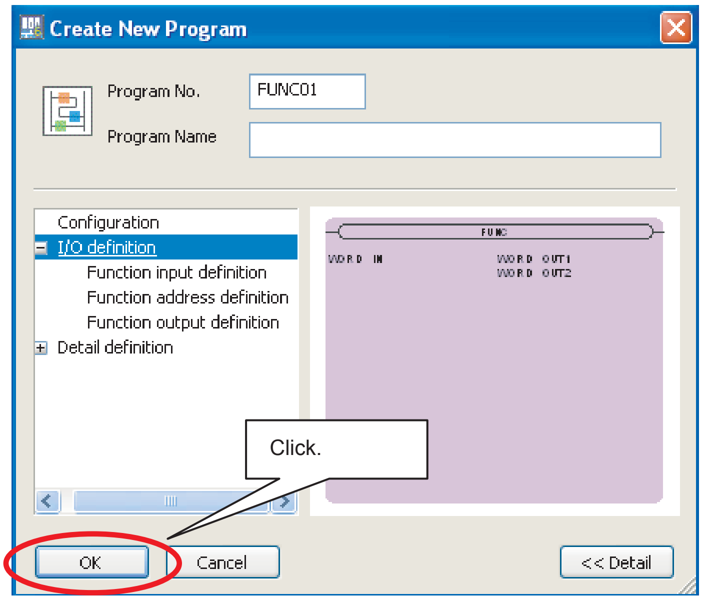
3. Select **Function input definition** under **I/O definition** and enter the following information.



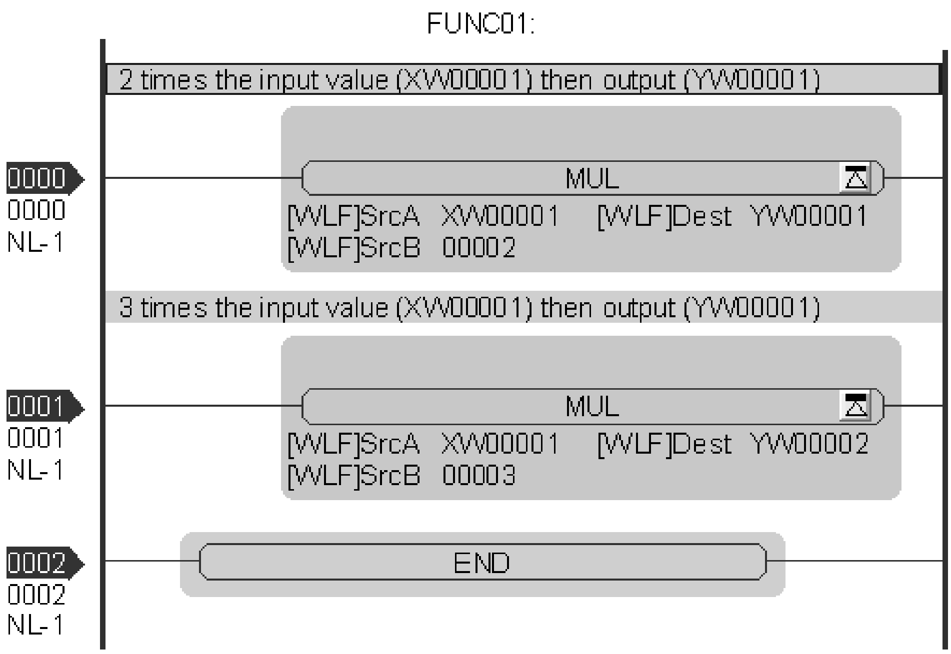
4. Select **Function output definition** under **I/O definition** and enter the following information.



5. Click the **OK** Button. This concludes setting the function definition.



6. Create the following ladder program in the drawing of the FUNC01 user function that was created in step 5.



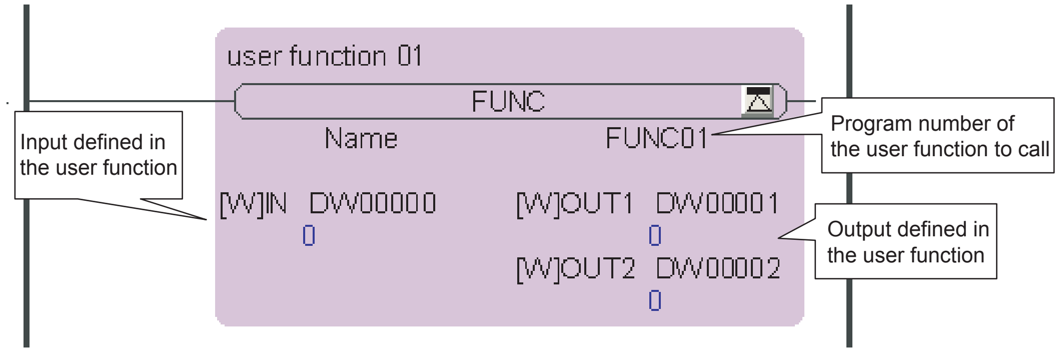
7. Compile the user function to conclude the creation of the user function.

4.3.3 Calling a User Function

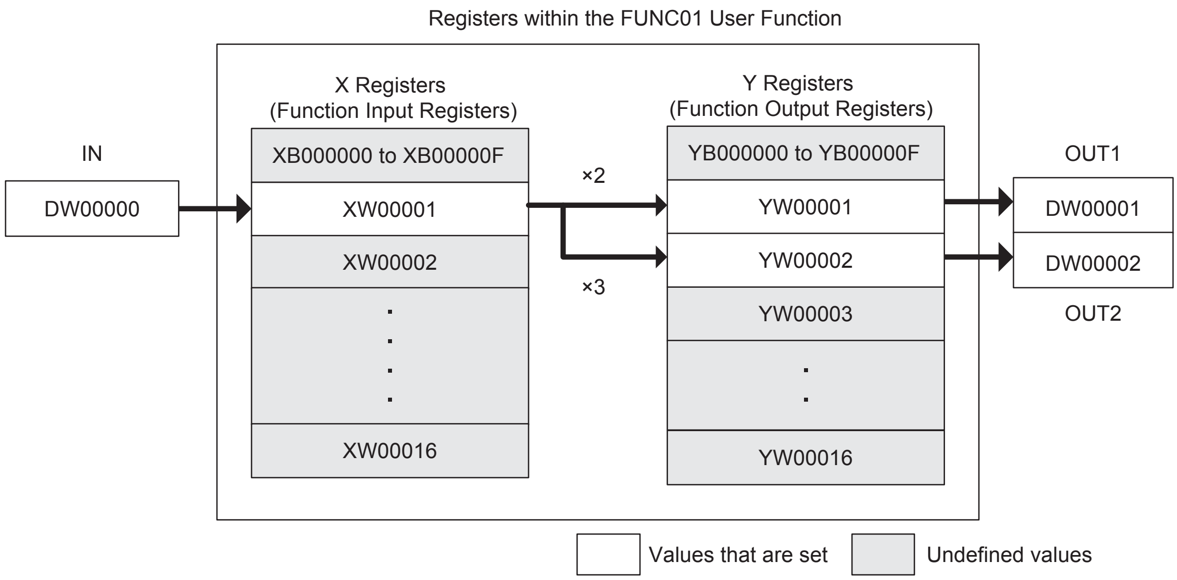
You can call a user function by using a FUNC instruction in the ladder drawing.
This section describes how to call the user function that was created in the previous section from the high-speed drawing (DWG.H).

■ Example for Calling the FUNC01 User Function from DWG.H

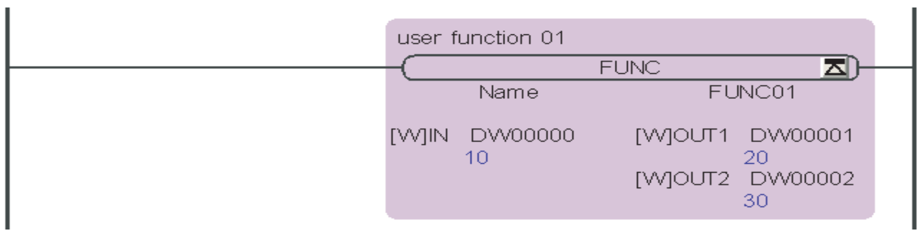
Program a FUNC instruction in DWG.H as shown below.



This diagram shows a conceptual image of what the programming shown above accomplishes.



In this example, when DW00000 in DWG.H is set to 10, DW00001 becomes 20 and DW00002 becomes 30, demonstrating that the user function was called correctly.



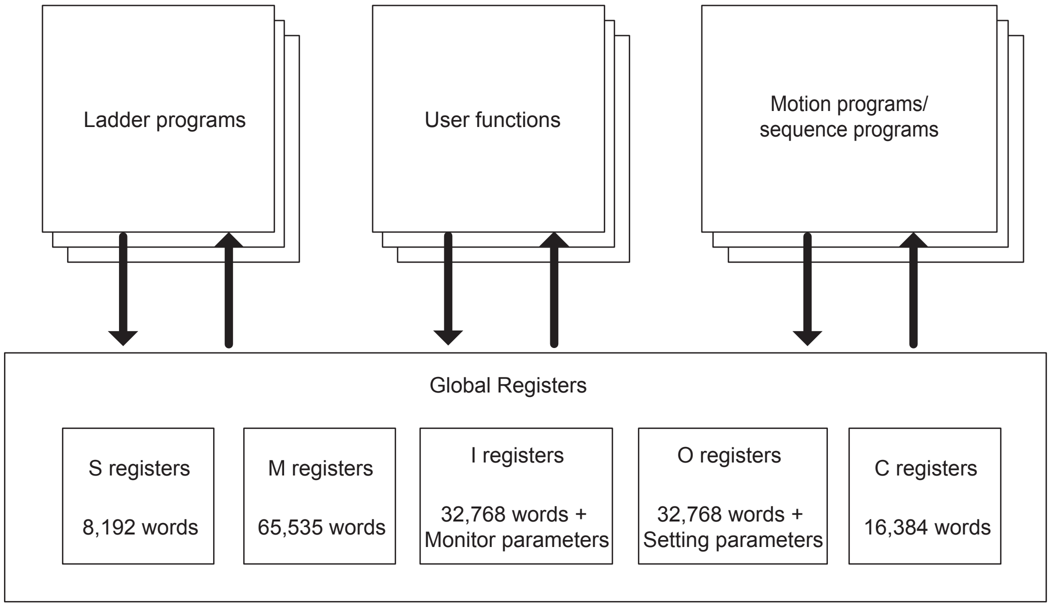
4.4 Registers (Variables)

4.4.1 What Are Registers?

Registers are areas that store data within the Machine Controller. Variables are registers with labels (variable names). There are two kinds of registers: global registers that are shared between all programs, and local registers that are used only by a specific program.

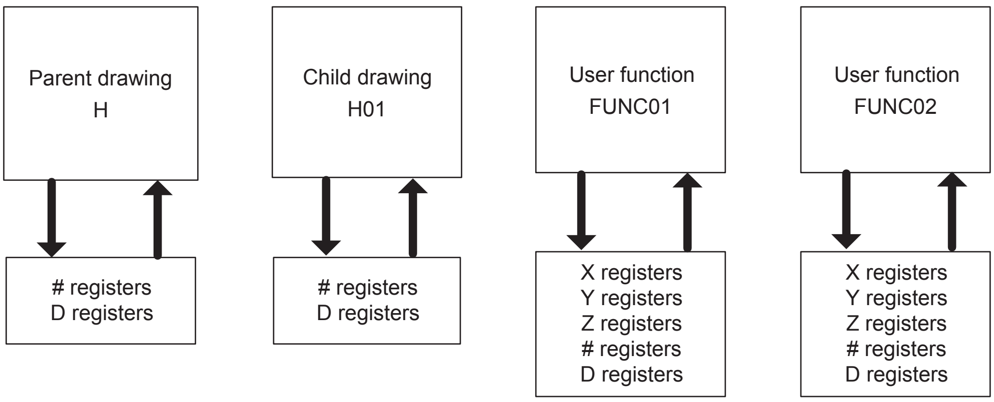
(1) Global Registers

Global registers are variables that are shared by ladder programs, user functions, motion programs, and sequence programs. Memory space for global registers is reserved by the system for each register type.



(2) Local Registers

Local registers can be used within a specific drawing. They cannot be used in other drawings.



Local Registers

4.4.2 Register Types

(1) Global Registers

Global registers are variables that are shared by ladder programs, user functions, motion programs, and sequence programs. In other words, the operation results of a ladder program can be used by other user functions, motion programs, or sequence programs.

Type	Name	Designation Method	Usable Range	Description
S	System registers (S registers)	SBnnnnnh, SWnnnnn, SLnnnnn, SFnnnnn, SAnnnnn	SW00000 to SW08191	These registers are prepared by the system. They report the status of the Machine Controller and other information. The system clears the registers from SW00000 to SW00049 to 0 at startup. They have a battery backup.
M	Data registers (M registers)	MBnnnnnh, MWnnnnn, MLnnnnn, MFnnnnn, MAnnnnn	MW00000 to MW65534	These registers are used as interfaces between programs. They have a battery backup.
I	Input registers (I registers)	IBhhhhh, IWhhhh, ILhhhh, IFhhhh	IW0000 to IW7FFF	These registers are used for input data.
			IW8000 to IWFFFF	These registers store the motion monitor parameters. These registers are used for Motion Modules.
O	Output registers (O registers)	OBhhhhh, OWhhhh, OLhhhh, OFhhhh	OW0000 to OW0FFF	These registers are used for output data.
			OW8000 to OWFFFF	These registers store the motion setting parameters. These registers are used for Motion Modules.
C	Constant registers (C registers)	CBnnnnnh, CWnnnnn, CLnnnnn, CFnnnnn, CAnnnnn	CW00000 to CW16383	These registers can be read in programs but they cannot be written. The values are set from the MPE720.

- n: decimal digit, h: hexadecimal digit

(2) Local Registers

Local registers are valid within only one specific program. The local registers in other programs cannot be accessed. You specify the usable range of local registers from the MPE720.

Type	Name	Designation Method	Description
#	# registers	#Bnnnnnh, #Wnnnn, #Lnnnnn, #Fnnnnn, #Annnnn	These registers can be read in programs but they cannot be written. The values are set from the MPE720.
D	D registers	DBnnnnnh, DWnnnn, DLnnnnn, DFnnnnn, DAnnnnn	These registers can be used for general purposes within a program. By default, 32 words are reserved for each program. The default values after startup depend on the setting of the **D Register Clear when Start** Option. For details, refer to ■ *Setting the D Register Clear When Start Option.*

- n: decimal digit, h: hexadecimal digit

■ Local Registers within a User Function

In addition to the # registers and D registers, there are local registers that can be used only within user functions.

Type	Name	Designation Method	Description
X	Function input registers	XBnnnnnh, XWnnnnn, XLnnnnn, XFnnnnn	These registers are used for inputs to functions. Bit inputs: XB000000 to XB00000F Integer inputs: XW00001 to XW00016 Double-length integers: XL00001 to XL00015 Real numbers: XF00001 to XF00015
Y	Function output registers	YBnnnnnh, YWnnnnn, YLnnnnn, YFnnnnn	These registers are used for outputs from functions. Bit outputs: YB000000 to YB00000F Integer outputs: YW00001 to YW00016 Double-length integers: YL00001 to YL00015 Real numbers: YF00001 to YF00015
Z	Function internal registers	ZBnnnnnh, ZWnnnnn, ZLnnnnn, ZFnnnnn	These are internal registers that are unique within each function. You can use them for internal processing in functions.
A	Function external registers	ABnnnnnh, AWnnnnn, ALnnnnn, AFnnnnn	These are external registers that use the address input values as the base addresses. When the address input value of an M or D register is provided by the source of the function call, then the registers of the source of the function call can be accessed from inside the function by using that address as the base.

- n: decimal digit, h: hexadecimal digit

IMPORTANT

User functions can be called from any programs, any number of times.

When you call a user function, consider what values could be in the local registers, and perform initialization as needed.

Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

(3) Precautions When Using Local Registers within a User Function

When you call a user function, consider what values should be in the local registers, and perform initialization as needed.

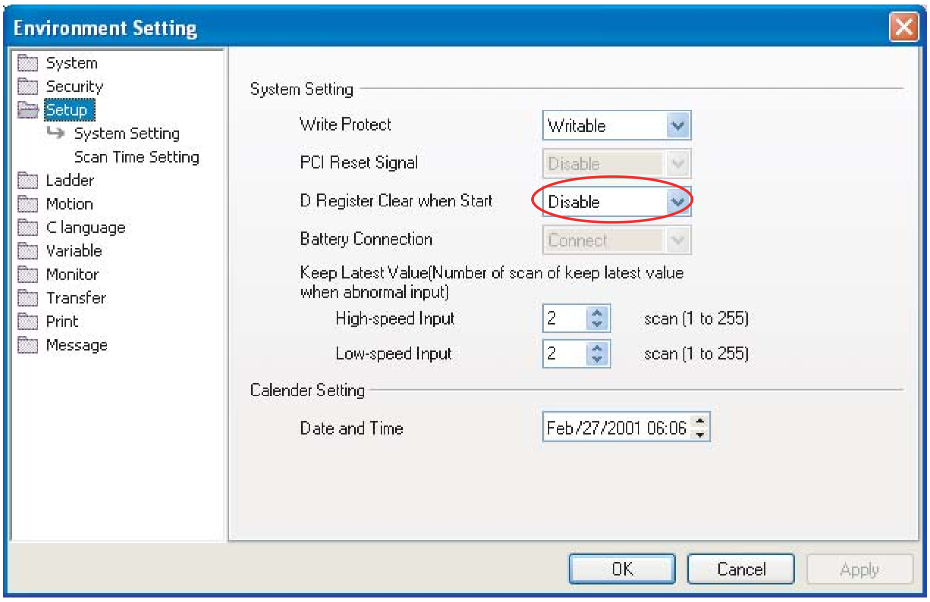
Name	Precaution
X registers (function input registers)	If input values are not set, the values will be uncertain. Do not use X registers that are outside of the range that is specified in the input definitions.
Y registers (function output registers)	If output values are not set, the values will be uncertain. Always set the values of the range of Y registers that is specified in the output definitions.
Z registers (function internal registers)	When the function is called, the previously set values will be lost and the values will be uncertain. These registers are not appropriate for instructions if the previous value must be retained. Use them only after initializing them within the function.
# registers	These are constant registers. Their values cannot be changed.
D registers	When the function is called, the previously set values are preserved. If a previous value is not necessary, initialize the value or use a Z register instead. D registers retain the data until the power is turned OFF. The default values after startup depend on the setting of the **D Register Clear when Start** Option. For details, refer to ■ *Setting the D Register Clear When Start Option.*

■ Setting the D Register Clear When Start Option

1. Select ***File*** – ***Environment Setting*** from the MPE720 Version 6 Window.

2. Select ***Setup*** – ***System Setting.***

3. Select **Enable** or **Disable** for the **D Register Clear when Start** Option.



Set Values
Disable: The initial values will be uncertain.
Enable: The initial values will be 0.

4.4.3 Data Types

(1) List of Data Types

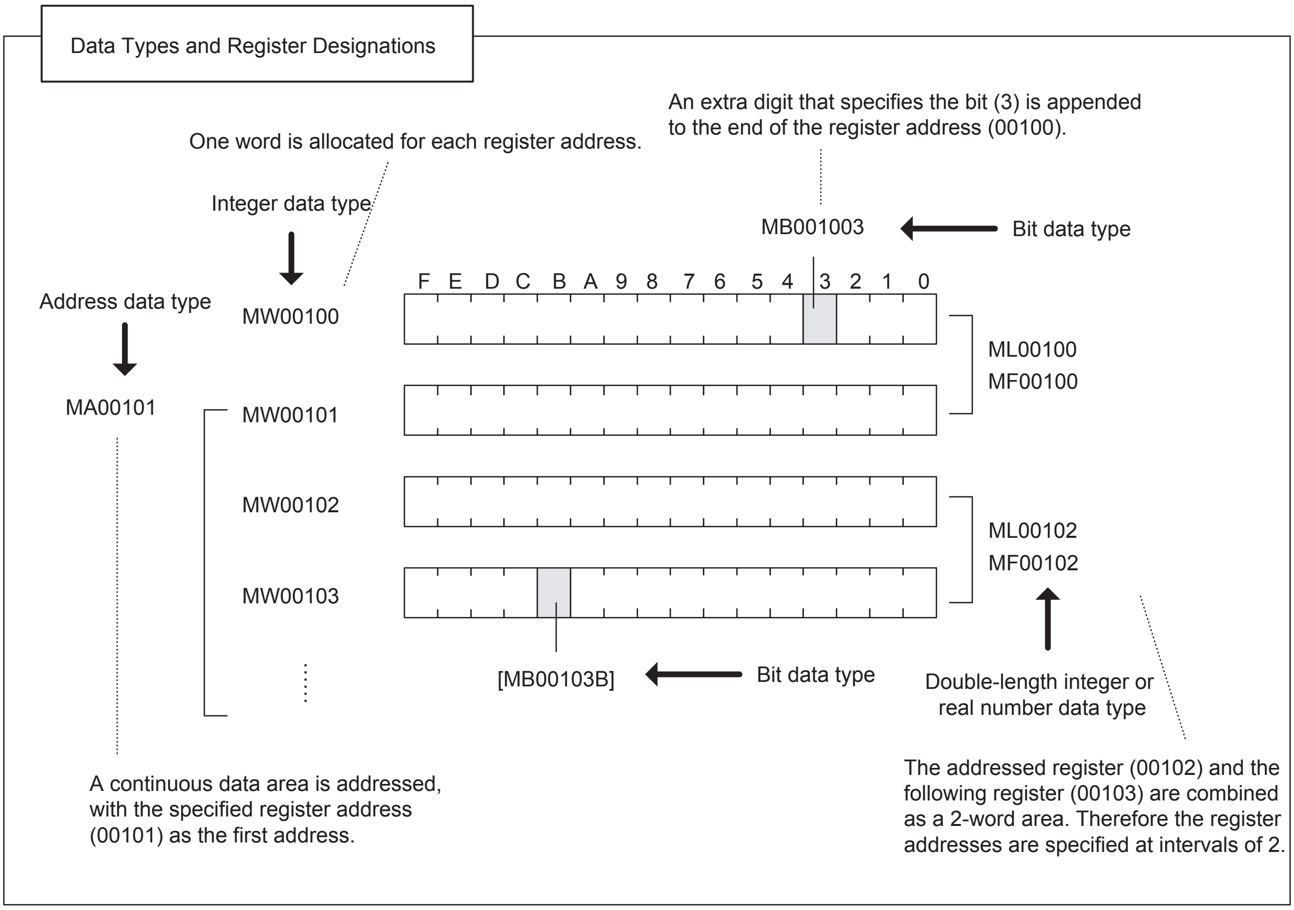
There are various data types that you can use depending on the purpose of the application: bit, integer, double-length integer, real number, and address.

Symbol	Data Type	Range of Values	Remarks
B	Bit	1 (ON) or 0 (OFF)	Used in relay circuits and to determine ON/OFF status.
W	Integer	-32,768 to 32,767 (8000 to 7FFF hex)	Used for numeric operations. The values in parentheses on the left are for logical operations.
L	Double-length integer	-2,147,483,648 to 2,147,483,647 (80000000 to 7FFFFFFF hex)	Used for numeric operations. The values in parentheses on the left are for logical operations.
F	Single-precision real number	±(1.175E-38 to 3.402E+38) or 0	Used for numeric operations.
A	Address	0 to 32,767	Used only as pointers for addressing.

IMPORTANT

The MP3000-series Machine Controllers do not have separate registers for each data type. As shown in the following figure, the same address will access the same register even if the data type is different.

For example, MB001003, a bit address, and the MW00100, an integer address, have different data types, but they both access the same register, MW00100.



(2) Precautions for Operations Using Different Data Types

If you perform an operation using different data types, the results will be different depending on the data type of the storage register, as described below.

[a] Storing Real Number Data in an Integer Register

MW00100 = MF00200: The real number data is converted to integer data and stored in the destination register.
(00001) (1.234)

- There may be rounding error due to storing a real number in an integer register.
  Whether numbers are rounded or truncated when converting a real number to an integer can be set in the properties of the drawing. (See below.)

MW00100 = MF00200 + MF00202:
(0124) (123.48) (0.02) The result of the operation may be different depending on the value of the variable.
(0123) (123.49) (0.01)

[b] Storing Real Number Data in a Double-length Integer Register

ML00100 = MF00200: The real number data is converted to integer data and stored in the destination register.
(65432) (65432.1)

[c] Storing Double-length Integer Data in an Integer Register

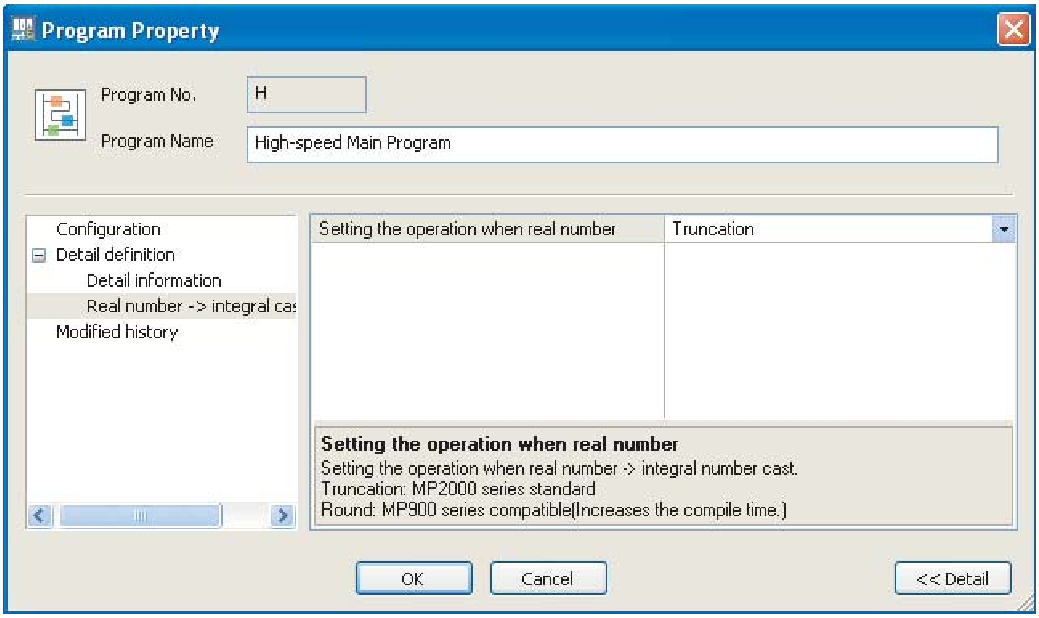
MW00100 = ML00200: The lower 16 bits of the double-length integer data are stored without change.
(-00001) (65535)

[d] Storing Integer Data in a Double-length Integer Register

ML00100 = MW00200: The integer data is converted to double-length integer data and stored in the destination register.
(0001234) (1234)

■ Setting for Real Number Casting

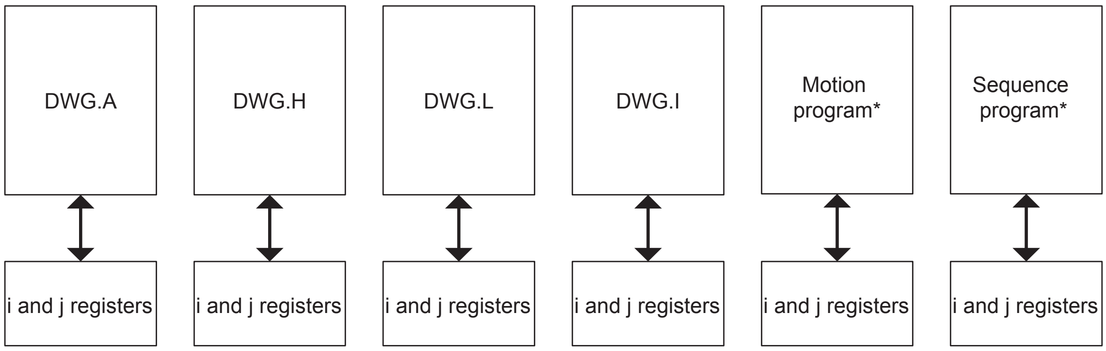
The casting method (truncating or rounding) can be set in the detailed definitions in the Program Property Dialog Box. The method to use for real number casting is set for each drawing.



4.4.4 Index Registers (i, j)

There are two index registers, i and j, that are used to modify relay and register addresses. The functions of i and j are identical.

There are index registers for each program type, as shown in the following figure.

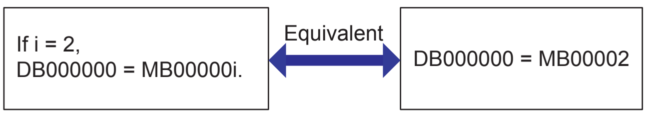


* Motion programs and sequence programs have separate i and j registers for each task.

- Functions reference the i and j registers that belong to the calling drawing.
  For example, a function called by DWG.H will reference the i and j registers for DWG.H.

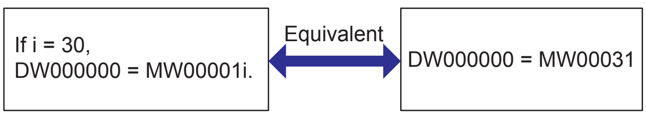
The operation for each register data type is described next.

[a] Attaching an Index to a Bit Register



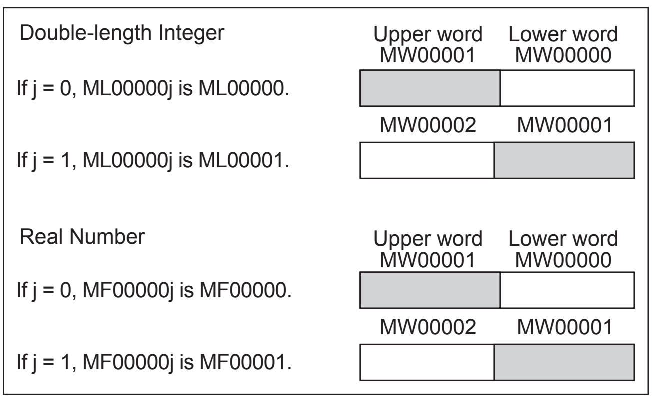
Using an index is the same as adding the value of i or j to the register address.
For example, if i = 2, MB00000i is the same as MB00002.

[b] Attaching an Index to an Integer Register



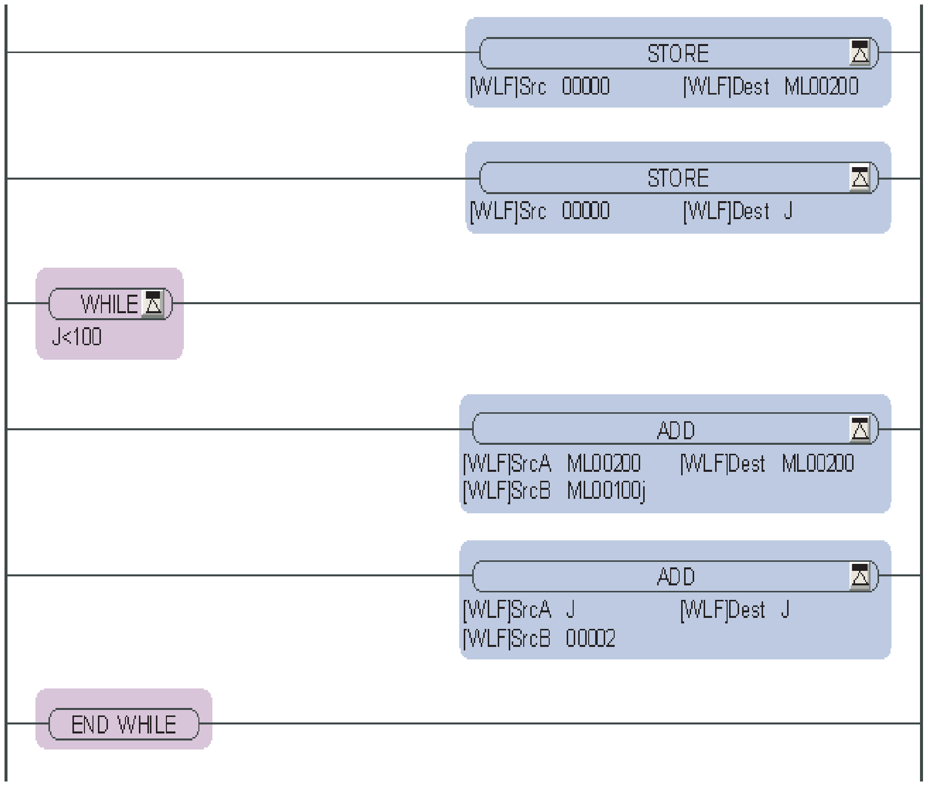
Using an index is the same as adding the value of i or j to the register address.
For example, if i = 30, MW00001i is the same as MW00031.

[c] Attaching an Index to a Double-length Integer or a Real Number Register



Using an index is the same as adding the value of i or j to the register address.
For example, if j = 1, ML00000j is the same as ML00001.
Similarly, if j = 1, MF00000j is the same as MF00001.
In the case of double-length integers and real numbers, the one-word area of the register address and the one-word area of the register address + 1 are used together. Be careful of overlapping areas when indexing double-length integer or real number register addresses. For example, when using ML00000j with both j = 0 and j = 1, the one-word area of MW00001 will overlap.

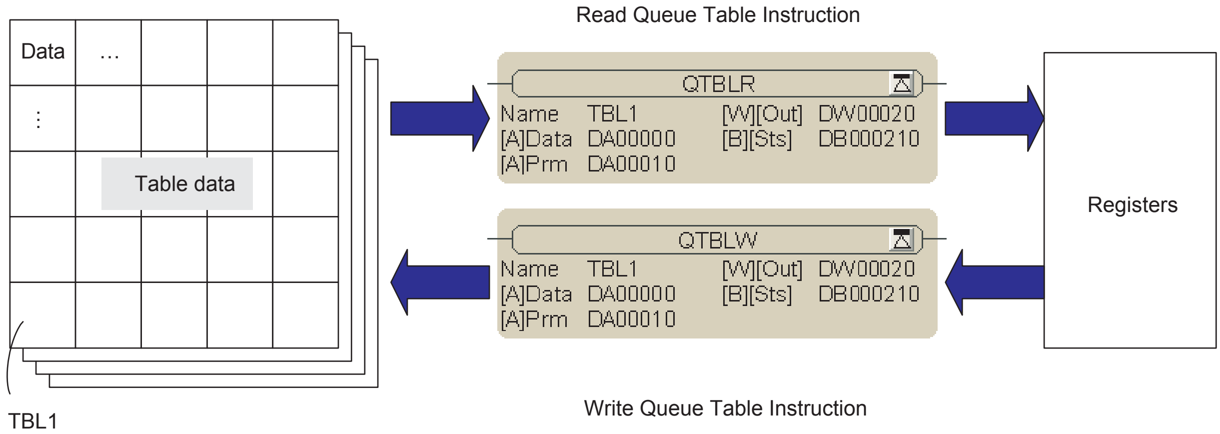
A programming example that uses indexed registers is shown below.
This example uses index j to find the total of the values in 50 registers from ML00100 to ML00198.



4.5 Table Data

4.5.1 What Is Table Data?

Table data is data that is managed in tabular form. The data is stored separately from the registers.
Data can be copied from a table to registers or from registers to a table by executing table data manipulation instructions in the ladder program. Tables can also be used to hold data when there is not a sufficient range of registers.



4.5.2 Creating Table Data

Use the following procedure to create table data. The table definition information and column attributes that are set for table data are listed in the following table.

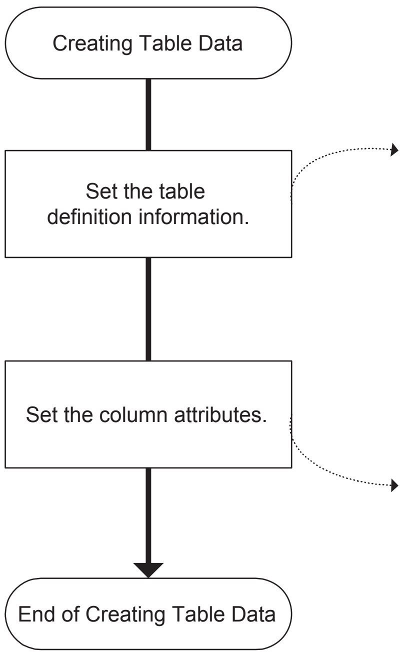


Table Definition Information	Description
Table Name	This is the name of the table.
Table Type	Select an array-type or record-type table.
Number of Columns	This is the number of columns in the table. (10,000 columns max.)
Number of Rows	This is the number of rows in the table. (10,000 rows max.)
Table Comment	This is a comment for the table.
Table Data Storage Location	Select normal or battery backup. Refer to *2.1.2 Machine Controller Program Specifications* for details on the maximum size of tables and which models have battery backup storage.

Column Attribute	Description
Column Name	This is the name of the column.
Data Type	The data type can be integer, double-length integer, real number, or text string.
Size	This is the length of the data type.
Display Type	The display type can be binary, decimal, hexadecimal, real number, or text string.
Column Comment	This is a comment for the column.

INFO

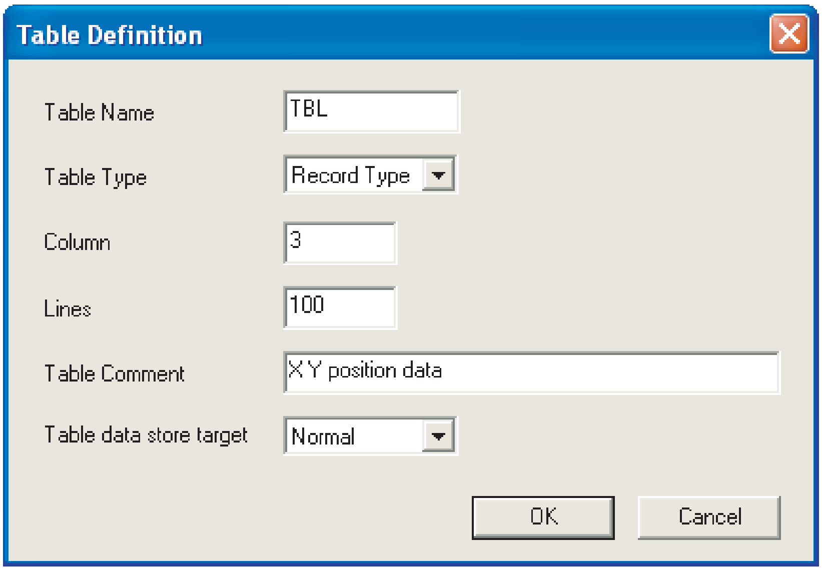
You can select one of the following table types when you create table data.
- Array type: Specifies a table where all columns have the same attributes.
- Record type: Specifies a table where each column has a different attribute.

You can select one of the following table data storage locations.
- Normal: Refer to *2.1.2 Machine Controller Program Specifications* for the maximum program size. The maximum size per table is 5 MB.
- Battery backup: Refer to *2.1.2 Machine Controller Program Specifications* for the maximum size of table data that can be backed up with the battery. The maximum size per table is 3 MB.

■ Procedure to Create Table Data

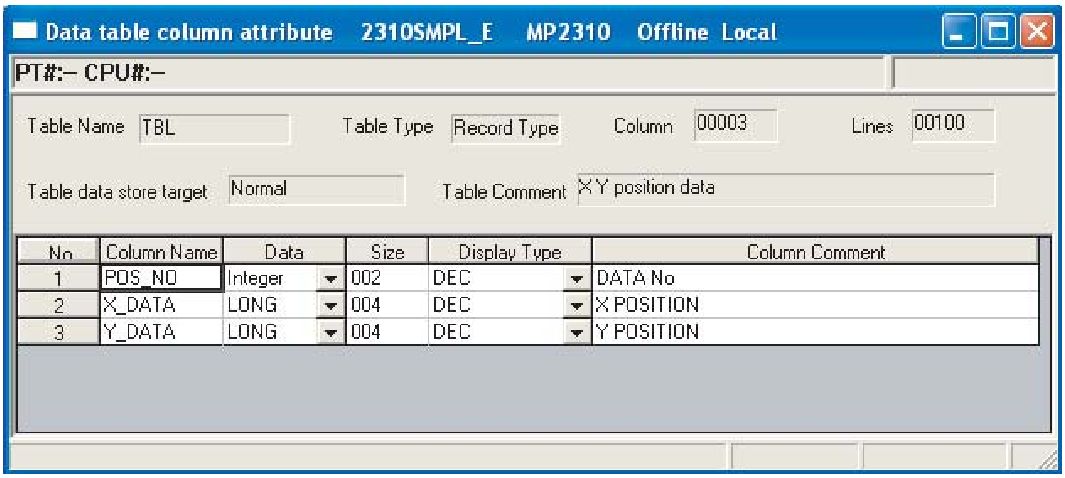
1. Select ***File - Open*** – ***Define Data Table*** – ***Data Table Map*** in the Module Configuration Definitions Window. The Table Data Store Target Dialog Box will be displayed.

2. Select ***File*** – ***Create New*** from the menu bar. The Table Definition Dialog Box will be displayed. Set the table definition information and click the **OK** Button.



3. The Data Table Column Attribute Dialog Box will be displayed. Set the table data column attributes, and then save them.

- If the table is set to an array-type table, set only one row of column attributes.



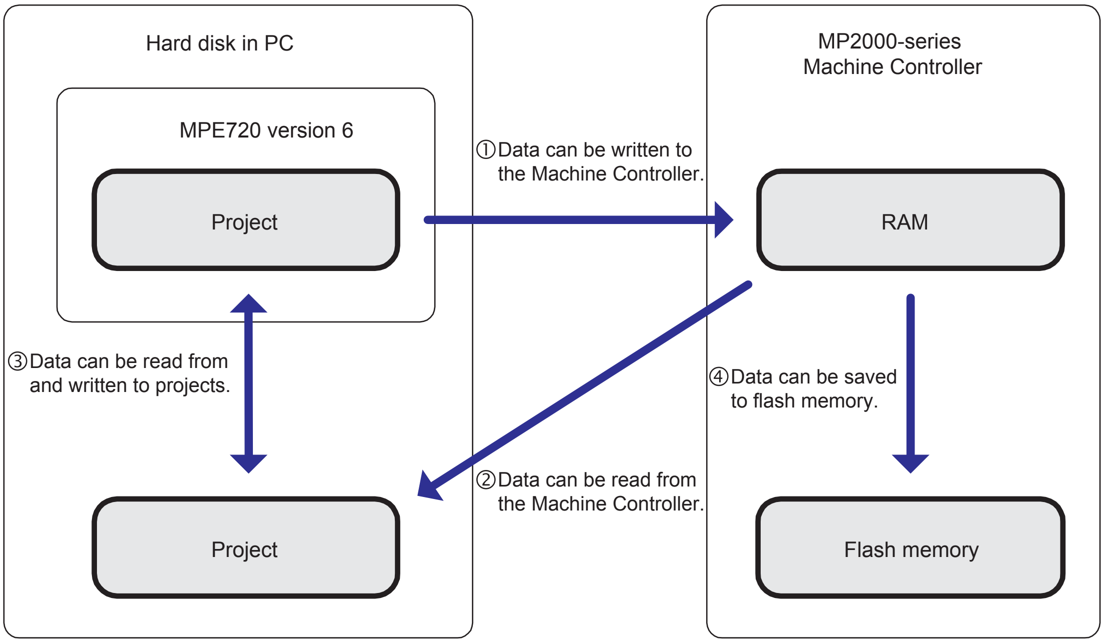
The Table Data Store Target Dialog Box that was displayed in step 1 will show the table that you created.
This concludes the creation of the data table.

INFO

When a table is created, the contents are initialized to 0.
Select the table that was created in the Table Data Store Target Dialog Box, and click the **Table Data** Button to read or write table data.
Use the table instructions to perform operations on the table data from a ladder program.

4.6 Transferring Data

You can perform one of the four operations that are shown in the following figure to transfer data.



① Writing Data to a Machine Controller

You can transfer the project data that was created offline to RAM in the Machine Controller.

② Reading Data from the Machine Controller.

You can transfer data from the Machine Controller to a project on the hard disk of the PC.

③ Reading Data from and Writing Data to Projects

You can transfer data between projects on the hard disk of the PC.

④ Saving Data to Flash Memory

You can transfer the data in RAM in the Machine Controller to flash memory.

IMPORTANT

Always save the data to flash memory after you transfer it to the MP2000-series Machine Controller. Failure to save the data to flash memory will result in losing the data that was transferred when the power is turned OFF and ON again, causing the Machine Controller to run on the data that was last saved in the flash memory.

4.7 Setting the High-speed/Low-speed Scan Times

(1) What Are the Scan Times?

With an MP2000-series Machine Controller, both the high-speed scan and low-speed scan can be set. The high-speed scan time is the cycle at which high-speed drawings are executed. The low-speed scan time is the cycle at which low-speed drawings are executed. The following table shows the possible set values and default values for each scan time.

Item	Possible Set Values	Default
High-speed Scan Time	0.5 to 32 ms (in 0.5-ms increments)	10.0 ms
Low-speed Scan Time	2.0 to 300.0 ms (in 0.5-ms increments)	200.0 ms

- The possible set values and default values depend on the model. Refer to the user's manual for the Module you are using for details.

(2) Scan Time Set Value Precautions

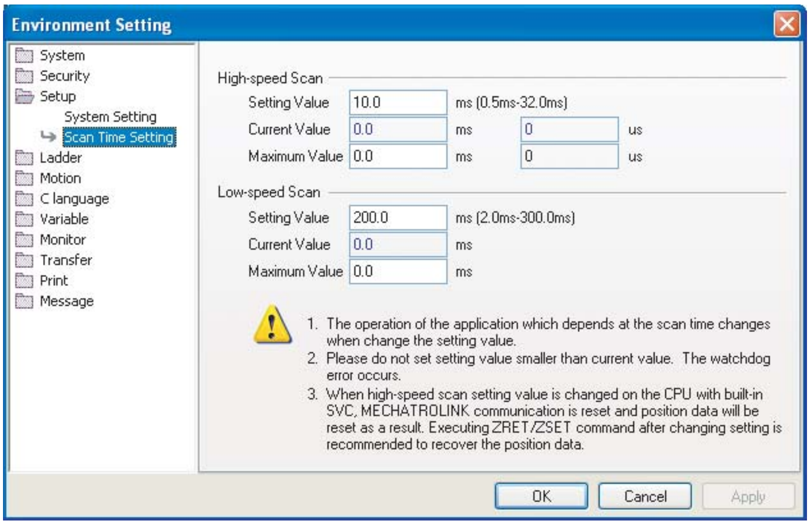
Observe the following precautions when setting the high-speed scan time and low-speed scan time.

- Set the scan set value so that it is 1.25 times greater than the maximum value.
  - If the scan set value is too close to the maximum value, the refresh rate of the MPE720 window will noticeably drop and can cause communications timeout errors to occur. If the maximum value exceeds the scan set value, a watchdog error may occur and cause the Machine Controller system to shut down.
- If you are using MECHATROLINK-II or MECHATROLINK-III, set values that are an integral multiple of the communications cycle. If you change the communications cycle, check the scan time set values.
- Do not change the scan set value while the Servo is ON. Never change the scan set values while an axis is in motion (i.e., while the motor is rotating). Doing so may cause the motor to rotate out of control.
- After changing or setting the scan times, make sure to save the data to flash memory.

(3) Checking and Setting the Scan Times

You can check the current and maximum values of the scan times and the set values of the scan times, and you can set the scan times in the following dialog box of MPE720 Version 6.0.

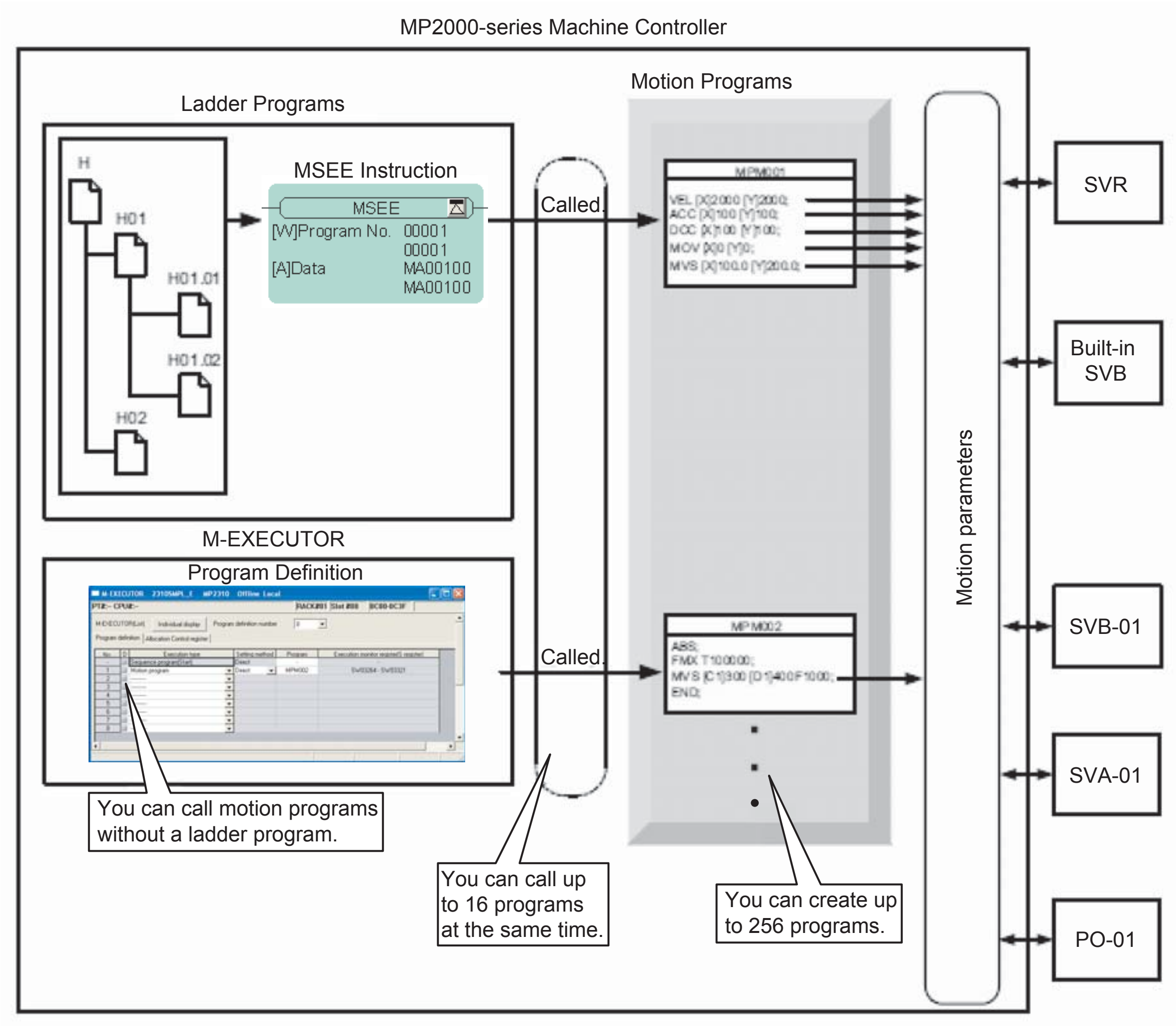
Select ***File – Environment Setting – Setup – Scan Time Setting.***



4.8 Advanced Programming

4.8.1 Motion Programs

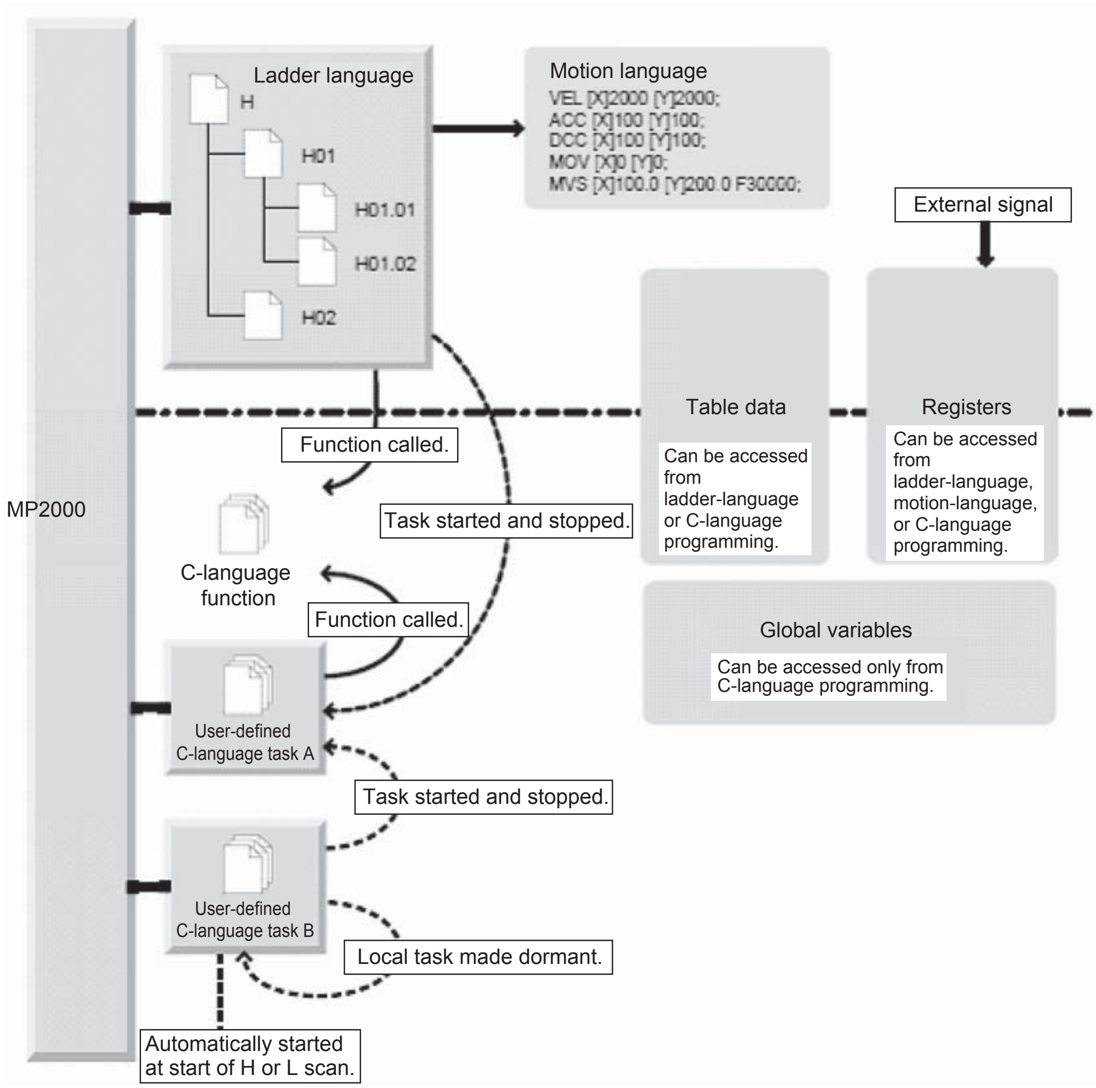
A motion program is written in a text-based motion language. In addition to basic motion control and operations, motion programs can also be used to easily program complex movements, such as linear interpolation and circular interpolation.
You can execute motion programs either by placing MSEE instructions in ladder programming in high-speed drawings, or by registering the motion programs in the Program Definition Tab Page for the M-EXECUTOR.



For details on motion programs, refer to the *Machine Controller MP2000 Series User's Manual for Motion Programming* (Manual No.: SIEP C880700 38).

4.8.2 C-language Programs

You can use the MP2000-series Machine Controller Embedded C-language Programming Package to use C-language functions and C-language tasks in addition to ladder programs and motion programs.
You can call C-language functions and start and stop C-language tasks from the ladder programs.
The following configuration is for using C-language programming.



For details on C-language programming, refer to the *Machine Controller MP2000 Series Embedded C-Language Programming Package Development Guide* (Manual No.: SIEP C880700 25).

4.8.3 Security

MPE720 version 6 has the following security features. You can use these security features for data protection by specifying access privileges for individual projects and program drawings.

■ User Administration (User Name and Password Setting)

You can register and change the name of the users who can open projects.
If the setting is performed while the Machine Controller is online, the setting will provide access privileges to the Machine Controller.

■ Project Password Setting

You can set a password for opening a project file.

■ Program Password Setting

You can set a password for opening ladder programs and motion programs. A password can be set for each program.

■ Online Security Setting

You can set a security key (i.e., a password) and privilege levels for reading data from a Machine Controller. This allows you to restrict the ability to read the program data from the Machine Controller or the ability to open the programs to users who have the specified level of privilege or a higher privilege.

Refer to the *Engineering Tool for MP2000 Series Machine Controller MPE720 Version 6 User's Manual* (SIEP C880700 30) for detailed setting procedures for security.

4.8.4 Tracing

MPE720 version 6 has three trace modes.

■ Realtime Tracing

You can monitor specified registers on a graph in real time.

■ Data Tracing

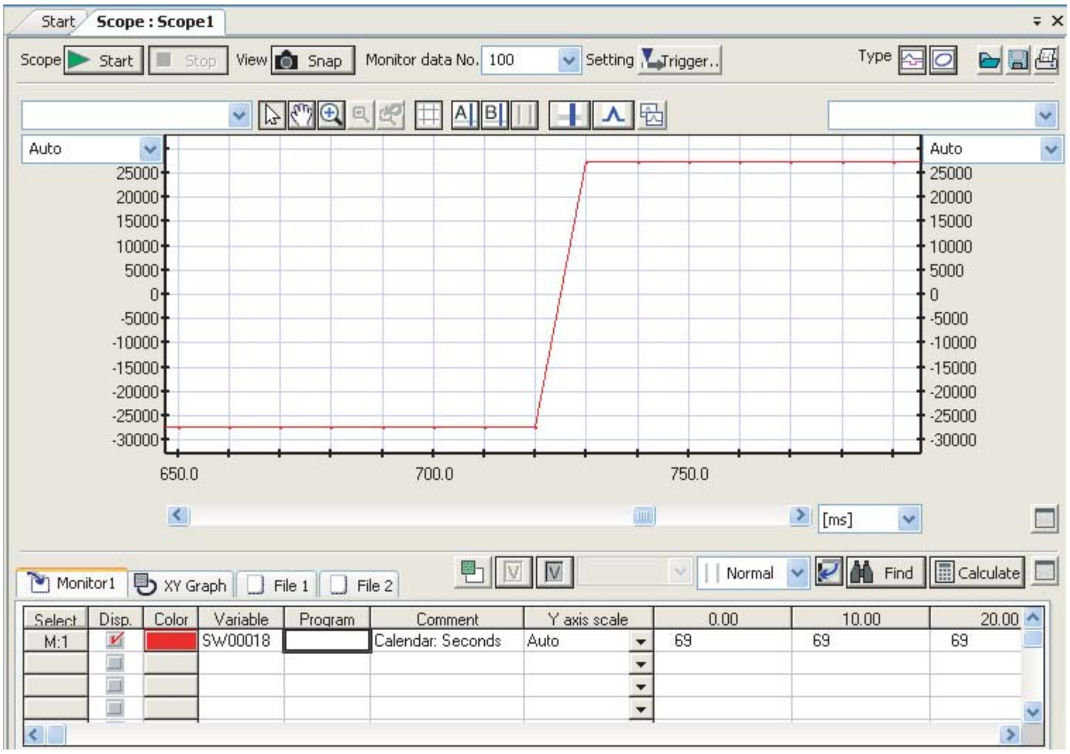
You can have the Machine Controller collect data for specified registers during a specified time period, and perform operations on that data and plot it on a graph.
This allows you to analyze register data that is acquired during specific time periods to debug ladder programs.

■ XY Tracing

This trace mode acquires the position data of the X axis and Y axis every scan, and displays the data in a 2-dimensional graph.

All three modes support exporting the trace data to CSV files.
Use tracing to check operation and to debug the ladder programs and motion programs.

Data Tracing Display Example



Refer to the *Engineering Tool for MP2000 Series Machine Controller MPE720 Version 6 User's Manual* (SIEP C880700 30) for detailed setting procedures for tracing.

5

Instructions

This chapter describes the ladder programming instructions in detail.

5.1 How to Read the Instructions

This chapter describes each instruction using the following format.

(1) Operation

The operation performed by the instruction is described.
Figures are used to show the operation performed by the instruction.

(2) Format

This area shows how the instruction appears in a ladder program.

Icon:

Shows the icon used in the MPE720.

Key entry:

Shows the shortcut key combination used in the Ladder Editor.

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
The name of the parameter that appears in the ladder programs is given.	×	○	○	○	×	○	○

×: This data type cannot be used.
○: All registers with this data type can be used.

(3) Programming Example

This section gives a ladder programming example that uses the instruction.

(4) Additional Information

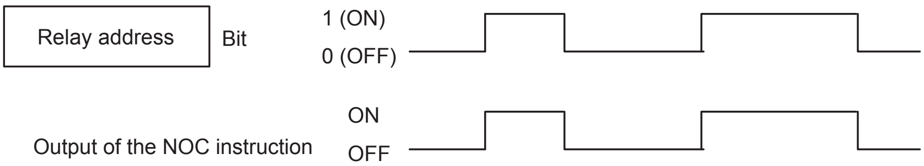
This section contains additional information about the instruction. It is omitted if there is no additional information that is required for the instruction.

5.2 Relay Circuit Instructions

5.2.1 NO Contact (NOC)

(1) Operation

The NOC instruction outputs ON whenever the bit with the specified relay address is 1 (ON).
The NOC instruction outputs OFF when the bit is 0 (OFF).



(2) Format

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Relay address	O	×	×	×	×	×	×

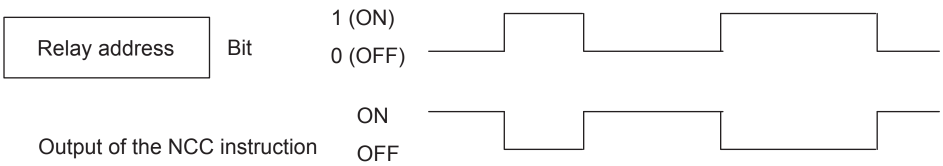
(3) Programming Example

The DB000001 output coil is ON whenever the DB000000 relay in the NOC instruction is ON.

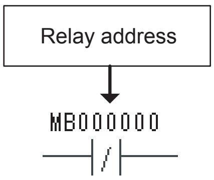
5.2.2 NC Contact (NCC)

(1) Operation

The NCC instruction outputs OFF whenever the bit with the specified relay address is 1 (ON).
The NCC instruction outputs ON when the bit is 0 (OFF).



(2) Format



Icon: 

Key entry:]/

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Relay address	O	×	×	×	×	×	×

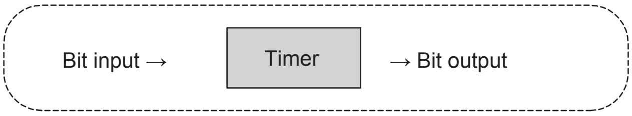
(3) Programming Example

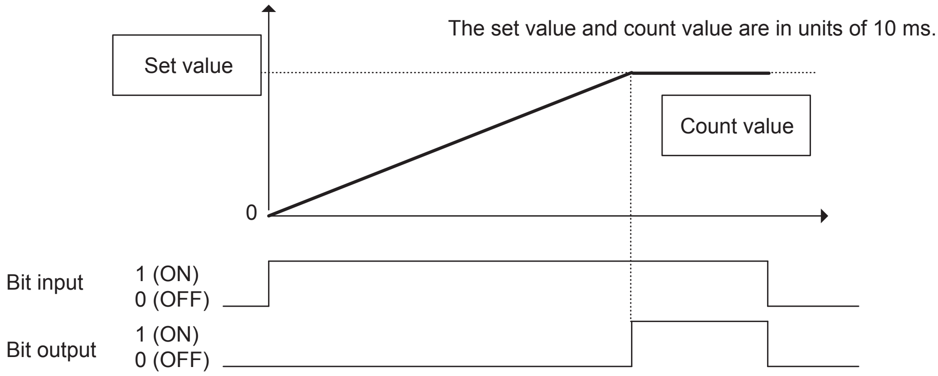
The DB000001 coil is ON whenever the DB000000 relay in the NCC instruction is OFF.

5.2.3 10-ms ON-Delay Timer (TON[10ms])

(1) Operation

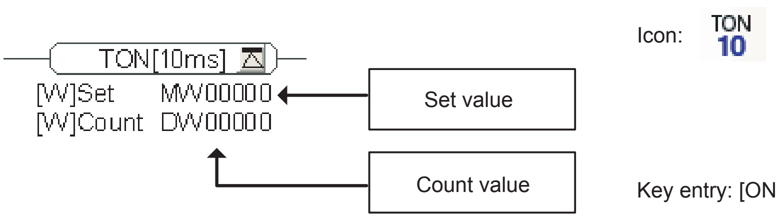
The timer counts the time whenever the timer bit input is 1 (ON). The bit output is set to 1 (ON) when the count value equals the set value.
If the bit input changes to 0 (OFF) during counting, the timer will stop counting. If the bit input changes to 1 (ON) again, the timer starts counting again from the beginning (i.e., from 0). The actual counted time (in units of 10 ms) is stored in the Count register.





- The counting error is 10 ms or less.

(2) Format

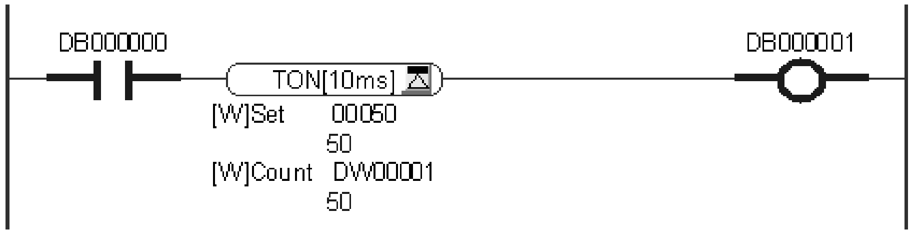


Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Set value (Set)	×	○	×	×	×	×	○
Count value (Count)	×	○*	×	×	×	×	×

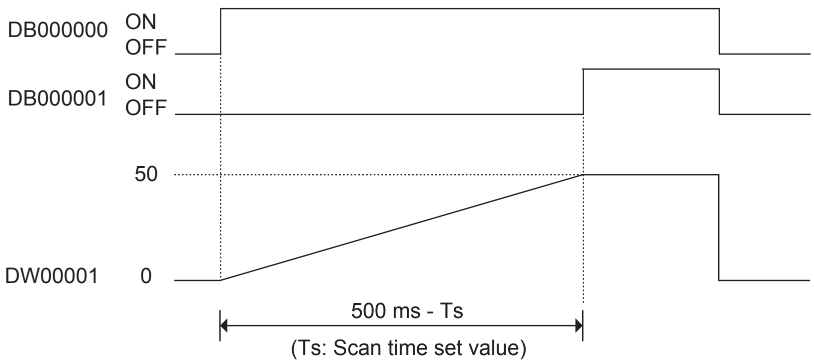
* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the set value of the TON instruction is 50, and the count value is stored in the DW00001 register.
The DB000001 coil will turn ON after the DB000000 relay stays ON for 500 ms.



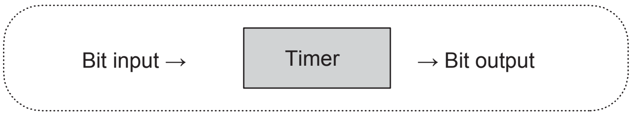
The timing chart is shown below.

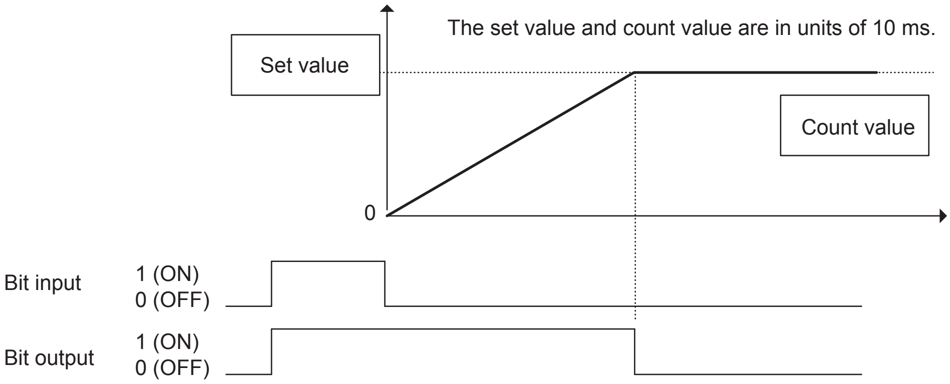


5.2.4 10-ms OFF-Delay Timer (TOFF[10ms])

(1) Operation

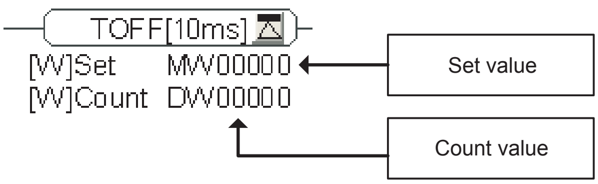
The timer counts the time whenever the timer bit input is 0 (OFF). The bit output is set to 0 (OFF) when the count value equals the set value.
If the bit input changes to 0 (OFF) during counting, the timer will stop counting. If the bit input changes to 1 (ON) again, the timer starts counting again from the beginning (i.e., from 0). The actual counted time (in units of 10 ms) is stored in the Count register.





- The counting error is 10 ms or less.

(2) Format



Icon: 

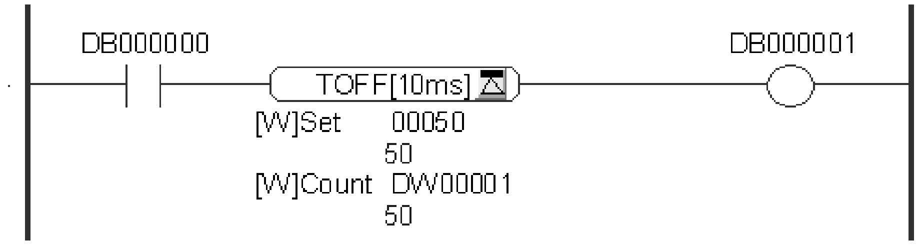
Key entry: [OFF

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Set value (Set)	×	○	×	×	×	×	○
Count value (Count)	×	○*	×	×	×	×	×

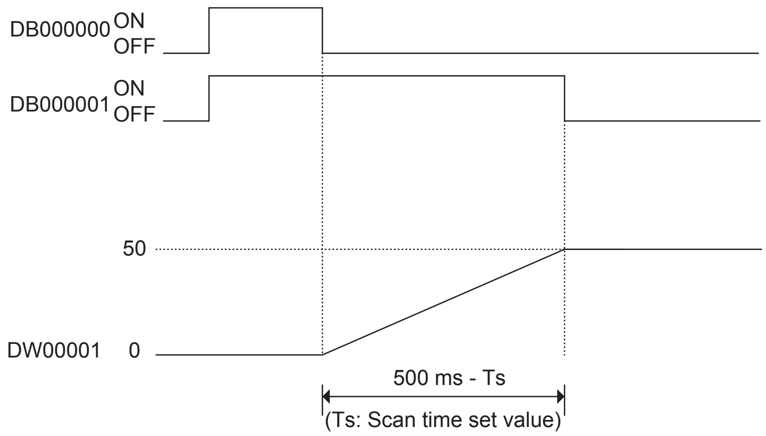
* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the set value of the TOFF instruction is 50, and the count value is stored in the DW00001 register.
The DB000001 coil will turn OFF after the DB000000 relay stays OFF for 500 ms.



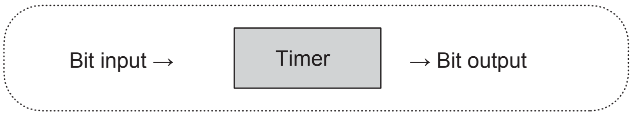
The timing chart is shown below.

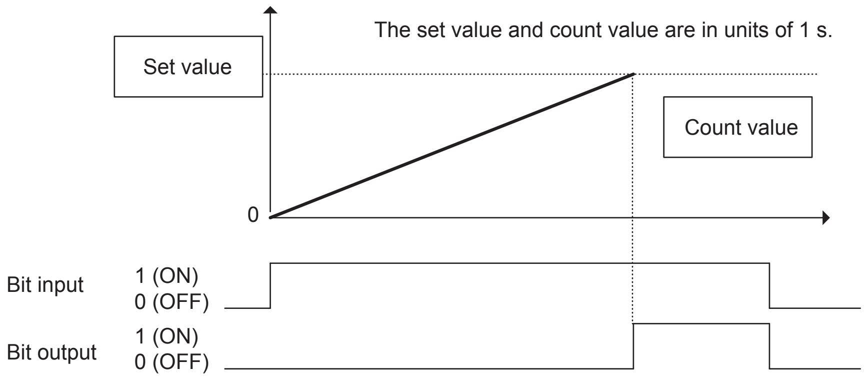


5.2.5 1-s ON-Delay Timer (TON[1s])

(1) Operation

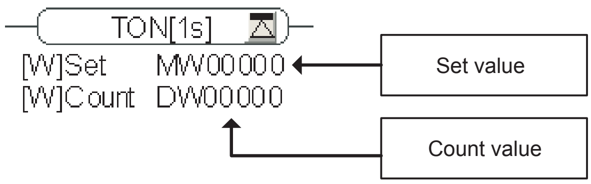
The timer counts the time whenever the timer bit input is 1 (ON). The bit output is set to 1 (ON) when the count value equals the set value.
If the bit input changes to 0 (OFF) during counting, the timer will stop counting. If the bit input changes to 1 (ON) again, the timer starts counting again from the beginning (i.e., from 0). The actual counted time (in units of 1 s) is stored in the Count register.





- The counting error is 1 s or less.

(2) Format



Icon: 

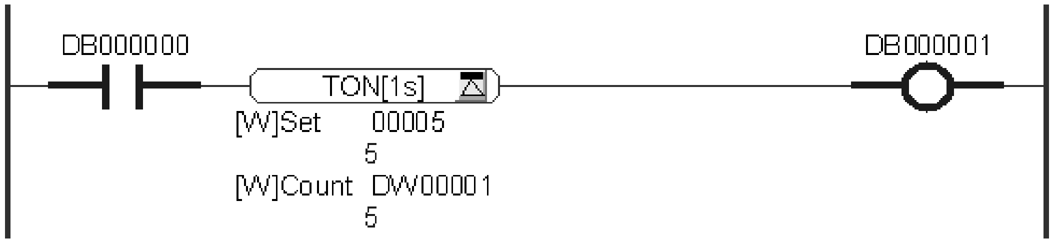
Key entry: [SON

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Set value (Set)	×	○	×	×	×	×	○
Count value (Count)	×	○*	×	×	×	×	×

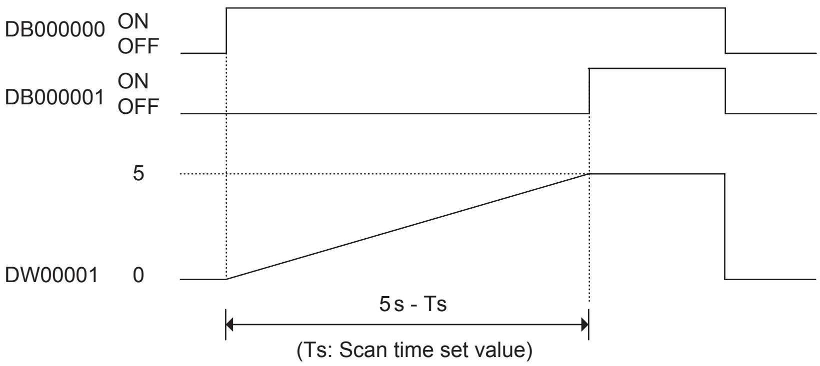
* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the set value of the TON instruction is 5, and the count value is stored in the DW00001 register.
The DB000001 coil will turn ON after the DB000000 relay stays ON for 5 s.



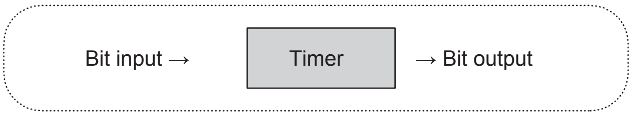
The timing chart is shown below.

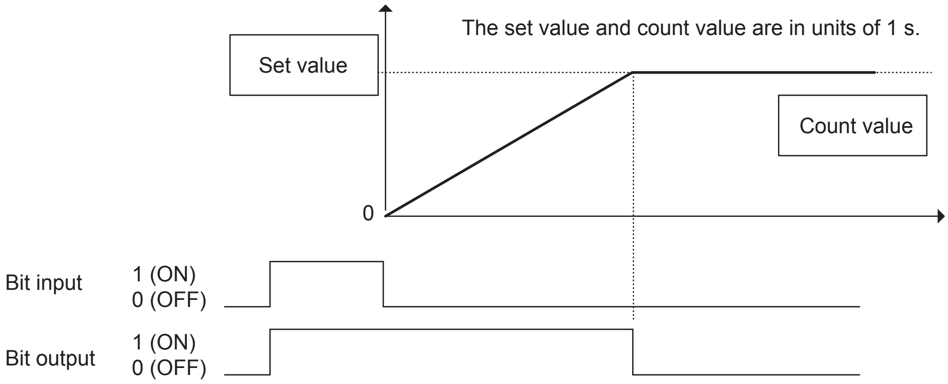


5.2.6 1-s OFF-Delay Timer (TOFF[1s])

(1) Operation

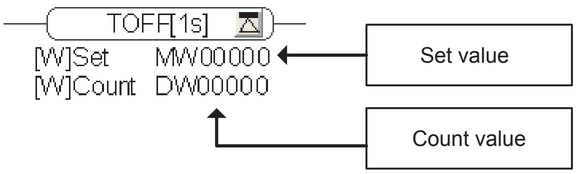
The timer counts the time whenever the timer bit input is 0 (OFF). The bit output is set to 1 (ON) when the count value equals the set value.
If the bit input changes to 0 (OFF) during counting, the timer will stop counting. If the bit input changes to 1 (ON) again, the timer starts counting again from the beginning (i.e., from 0). The actual counted time (in units of 1 s) is stored in the Count register.





- The counting error is 1 s or less.

(2) Format



Icon: 

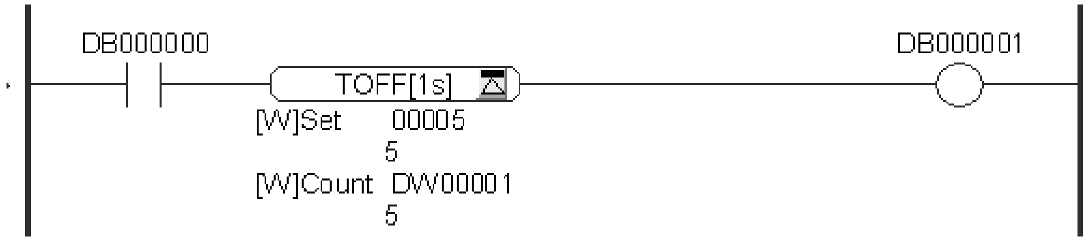
Key entry: [SOFF

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Set value (Set)	×	○	×	×	×	×	○
Count value (Count)	×	○*	×	×	×	×	×

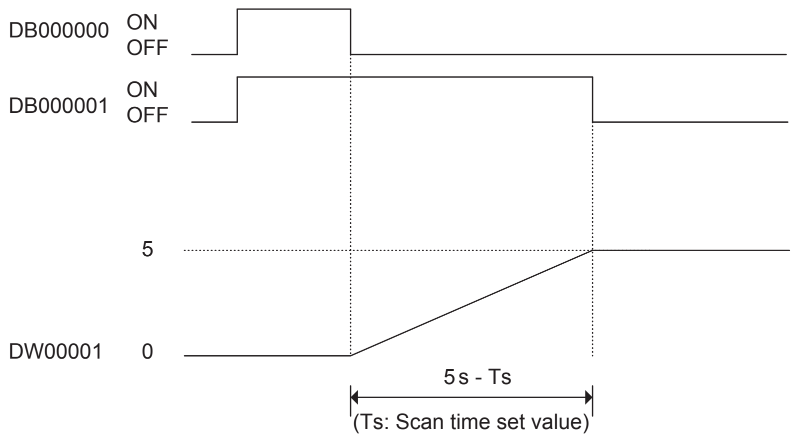
* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the set value of the TOFF instruction is 5, and the count value is stored in the DW00001 register.
The DB000001 coil will turn OFF after the DB000000 relay stays OFF for 5 s.



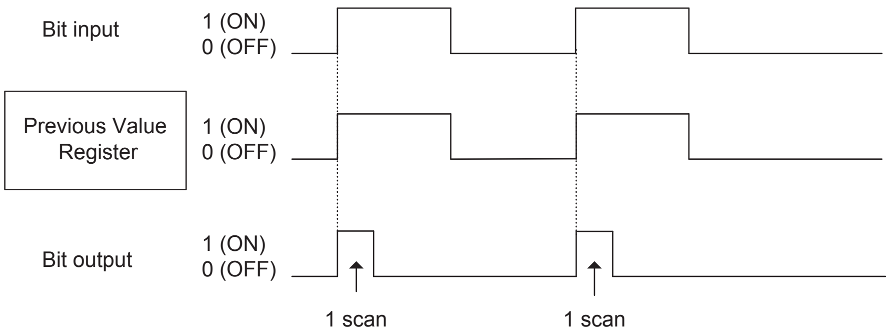
The timing chart is shown below.



5.2.7 Rising-edge Pulses (ON-PLS)

(1) Operation

The ON-PLS instruction sets the bit output to 1 (ON) for only one scan when the bit input changes from 0 (OFF) to 1 (ON). The previous value of the bit input is saved in the Previous Value Register of the ON-PLS instruction.

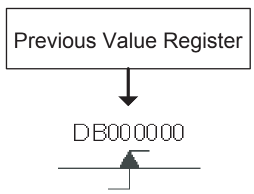


The following table shows the relationship between the bit input of the ON-PLS instruction, the Previous Value Register, and the bit output.

Bit Input	Previous Value Register	ON-PLS Instruction	Bit Output
0 (OFF)	0 (OFF)	→	0 (OFF)
0 (OFF)	1 (ON)	→	0 (OFF)
1 (ON)	0 (OFF)	→	1 (ON)
1 (ON)	1 (ON)	→	0 (OFF)

In the third row of the table, notice how the bit input changes from 0 (OFF) in the Previous Value Register to 1 (ON), causing the ON-PLS instruction to set the bit output to 1 (ON).

(2) Format



Icon: 

Key entry:]P

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Previous Value Register	O*	×	×	×	×	×	×

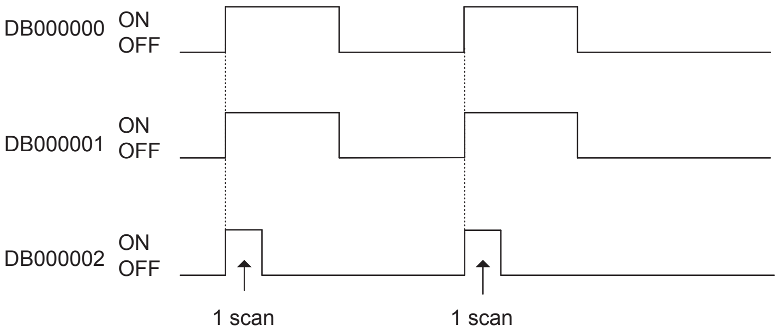
* C and # registers cannot be used.

- The Previous Value Register holds the previous value of the bit input. Do not use other instructions to set the value of this register.

(3) Programming Example

The DB000002 output coil turns ON for only one scan if the status of DB000001 changes when the DB000000 relay changes from OFF to ON.

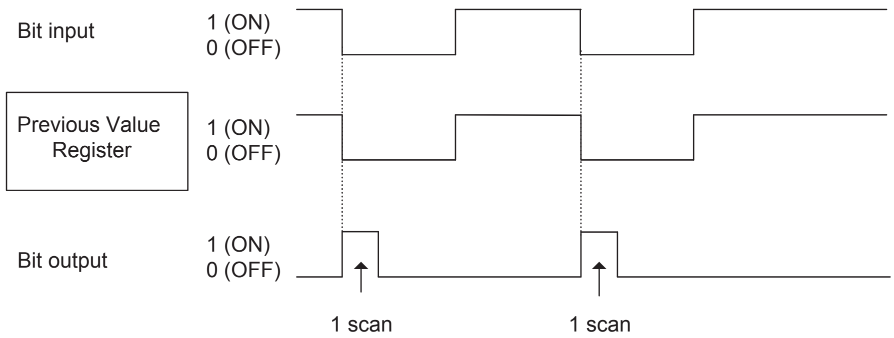
The timing chart is shown below.



5.2.8 Falling-edge Pulses (OFF-PLS)

(1) Operation

The OFF-PLS instruction sets the bit output to 1 (ON) for only one scan when the bit input changes from 1 (ON) to 0 (OFF). The previous value of the bit input is saved in the Previous Value Register of the OFF-PLS instruction.

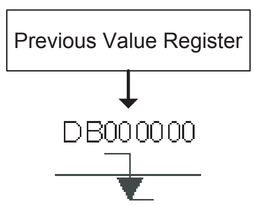


The following table shows the relationship between the bit input of the OFF-PLS instruction, the Previous Value Register, and the bit output.

Bit Input	Previous Value Register	OFF-PLS Instruction	Bit Output
0 (OFF)	0 (OFF)	→	0 (OFF)
0 (OFF)	1 (ON)	→	1 (ON)
1 (ON)	0 (OFF)	→	0 (OFF)
1 (ON)	1 (ON)	→	0 (OFF)

In the second row of the table, notice how the bit input changes from 1 (ON) in the Previous Value Register to 0 (OFF), causing the OFF-PLS instruction to set the bit output to 1 (ON).

(2) Format



Icon: 

Key entry:]N

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Previous Value Register	O*	×	×	×	×	×	×

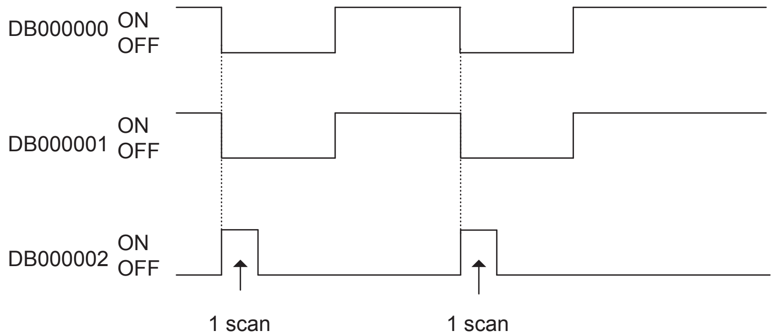
* C and # registers cannot be used.

- The Previous Value Register holds the previous value of the bit input. Do not use other instructions to set the value of this register.

(3) Programming Example

The DB000002 output coil turns ON for only one scan if the status of DB000001 changes when the DB000000 relay changes from ON to OFF.

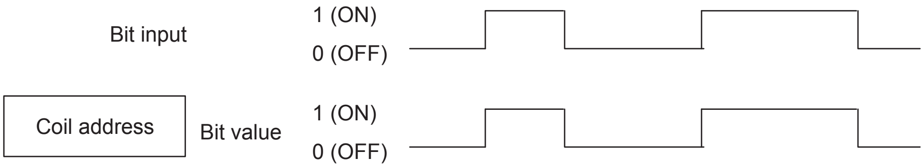
The timing chart is shown below.



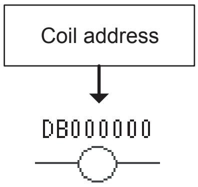
5.2.9 Coil (COIL)

(1) Operation

The COIL instruction sets the value of the bit at the coil address to 1 (ON) whenever the bit input is 1 (ON). The value of the bit at the coil address is set to 0 (OFF) whenever the bit input is 0 (OFF).



(2) Format



Icon: 

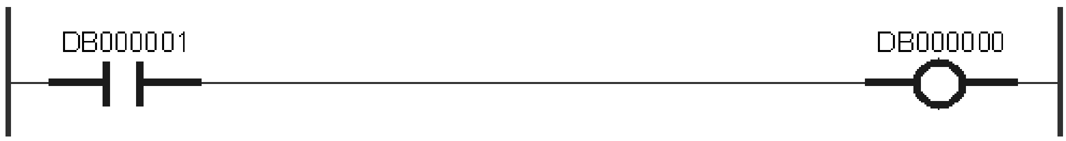
Key entry: @

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Coil address	○*	×	×	×	×	×	×

∗ C and # registers cannot be used.

(3) Programming Example

The DB000000 coil turns ON when the DB000001 relay turns ON.

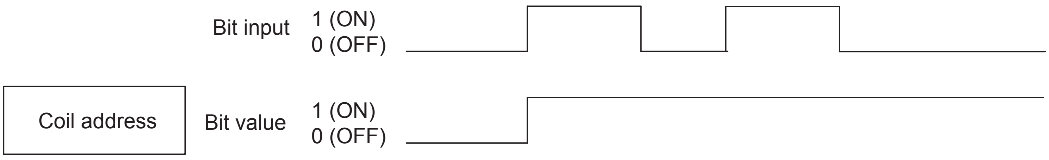


If there are no instructions on the left side, the DB000000 coil is OFF because there is no input.

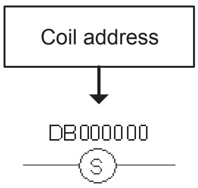
5.2.10 Set Coil (S-COIL)

(1) Operation

The S-COIL instruction sets the value of the bit at the coil address to 1 (ON) when the bit input is 1 (ON). The set coil stays in the ON state.



(2) Format



Icon: 

Key entry: @S

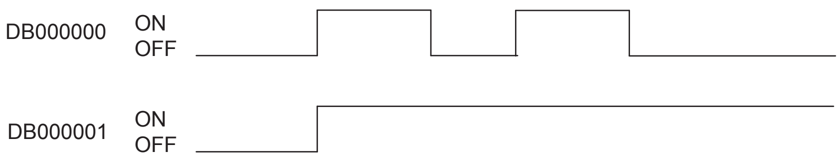
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Coil address	O*	×	×	×	×	×	×

* C and # registers cannot be used.

(3) Programming Example

The DB000001 set coil stays in the ON state when the DB000000 relay turns ON.

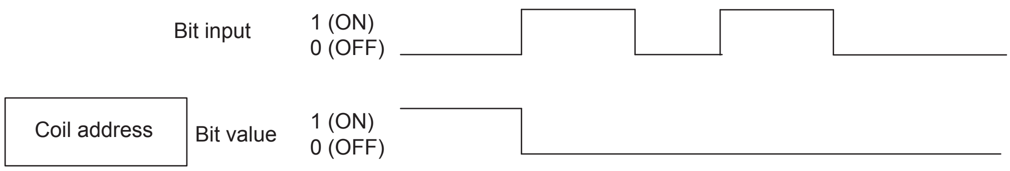
The timing chart is shown below.



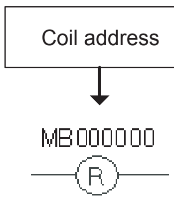
5.2.11 Reset Coil (R-COIL)

(1) Operation

The R-COIL instruction sets the bit at the reset coil address to 1 (ON) when the bit input is 1 (ON). The set coil is changed to OFF.



(2) Format



Icon: 

Key entry: @R

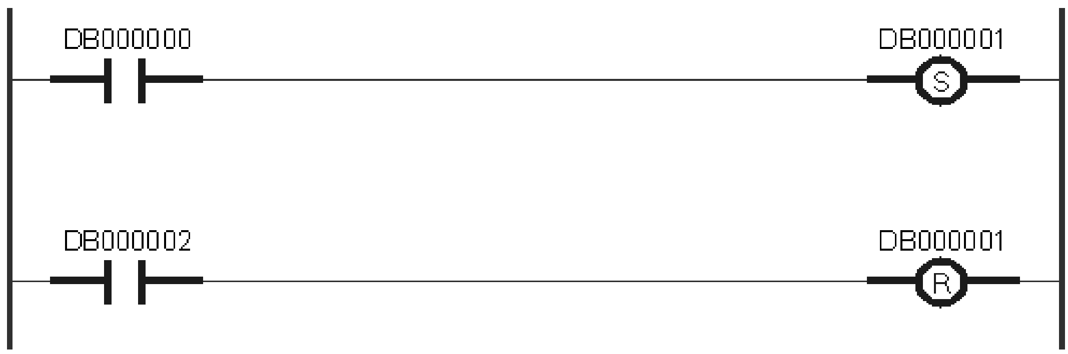
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Coil address	O*	×	×	×	×	×	×

* C and # registers cannot be used.

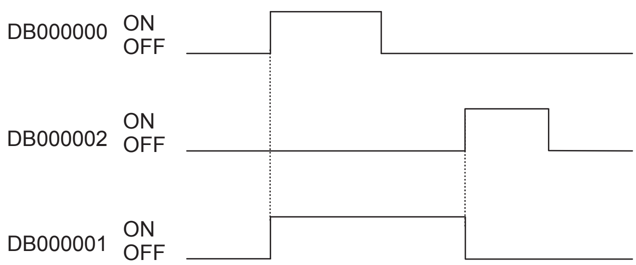
(3) Programming Example

In the following programming example, the reset coil is used to turn OFF the set coil that was turned ON in the first line.

The DB000001 reset coil in the second line turns ON if the DB000002 relay turns ON while the DB000001 set coil is ON, therefore turning OFF the DB000001 set coil.



The timing chart is shown below.



Instructions

5

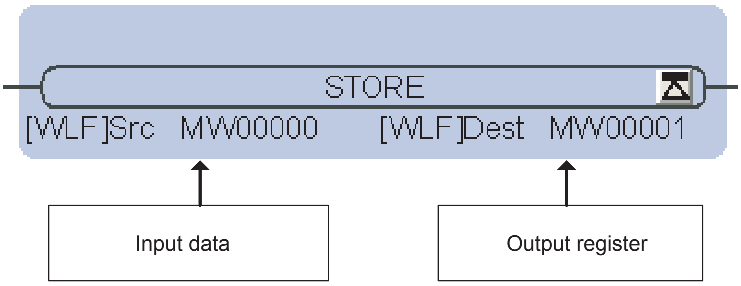
5.3 Numeric Operation Instructions

5.3.1 Store (STORE)

(1) Operation

The input data is stored in the output register.

(2) Format



Icon: 

Key entry: ;

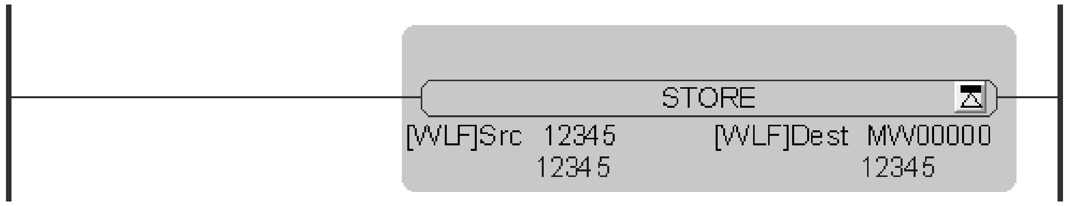
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	○	○	○	○	○
Output register (Dest)	×	○*	○*	○*	○*	○	×

* C and # registers cannot be used.

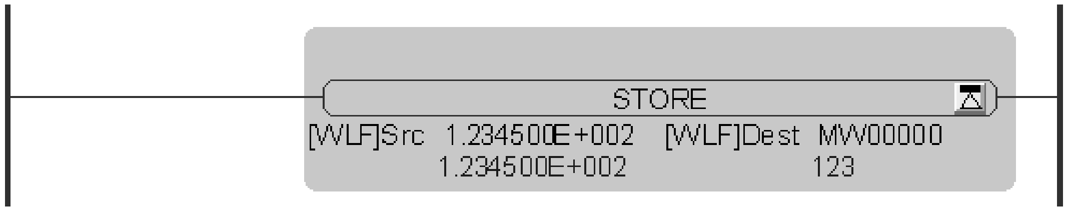
(3) Programming Examples

In the following programming examples, the input data is stored in the output register.

- Storing the Input Data, an Integer Value of 12345, in the MW00000 Output Register

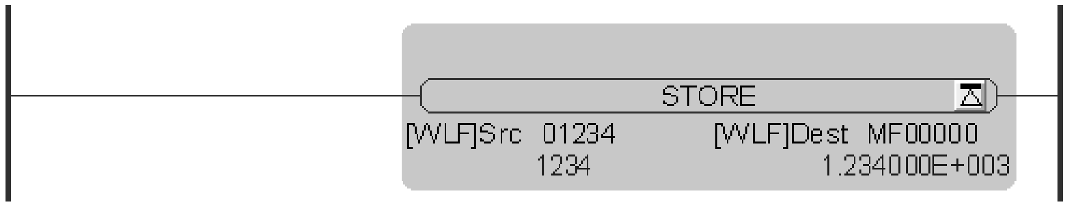


- Storing the Input Data, a Real Value of 123.45, in the MW00000 Output Register



- Storing the Double-length Integer 89ABCDEF Hex in the MW00000 Output Register
  The lower word of the double-length integer –12,817 (CDEF hex) is stored in MW00000.

- Storing the Input Data, an Integer Value of 1234, in the MF00000 Output Register



INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

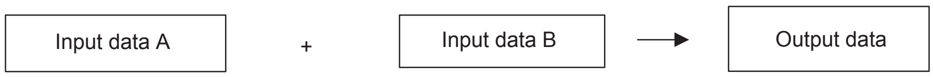
Instructions

5

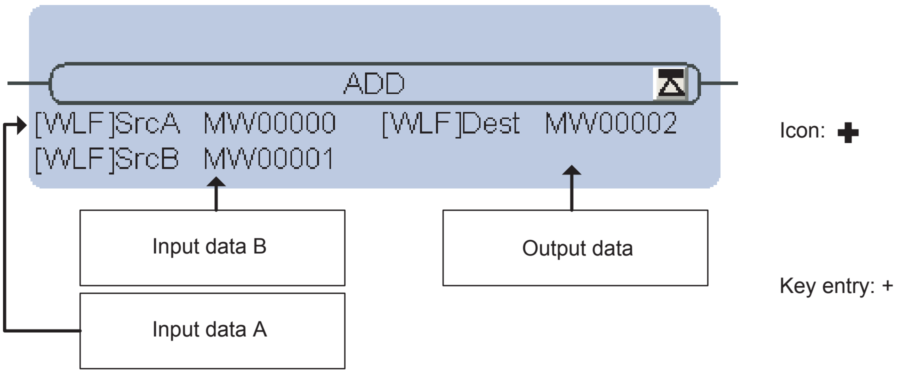
5.3.2 Add (ADD (+))

(1) Operation

Input data A and input data B are added and the result is stored in the output data.
An operation error occurs if the result produces an overflow or underflow.



(2) Format



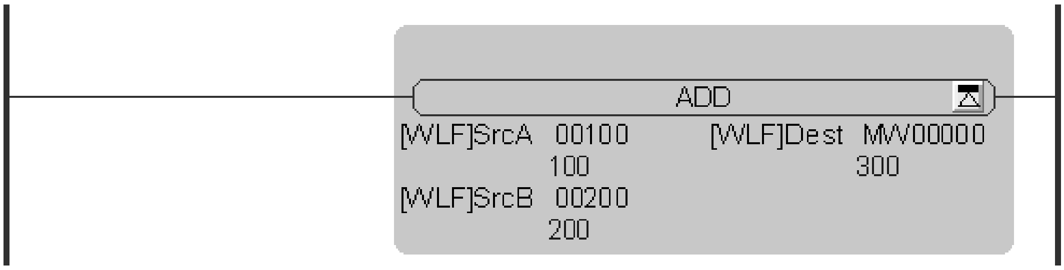
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○
Output data (Dest)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

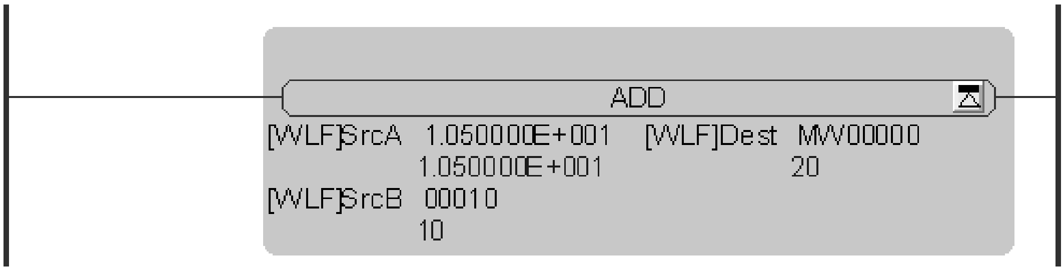
(3) Programming Examples

In the following programming examples, input data A and input data B are added and the result is stored in the output data.

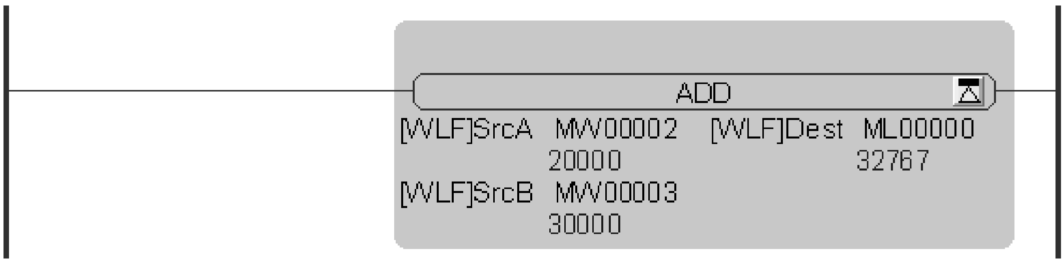
- Storing the Output Data in MW00000 When Input Data A Is 100 and Input Data B Is 200
  100 + 200 → MW00000 = 300



- Storing the Output Data in MW00000 When Input Data A Is 10.5 and Input Data B Is 10
  10.5 + 10 → MW00000 = 20 (when truncating below the decimal point is set)



- Storing the Output Data in ML00000 When Input Data A in MW00002 Is 20,000 and Input Data B in MW00003 Is 30,000
  MW00002 (20,000) + MW00003 (30,000) → ML00000 = 32,767*



* In the example given above, an overflow error occurs because both input data A and B are integers, which limits the result to a number within the range for integers.

(4) Additional Information

With integer operations, an overflow operation error occurs if the result exceeds 32,767 and an underflow operation error occurs if the result is less than -32,768.
With double-length integer operations, an overflow operation error occurs if the result exceeds 2,147,483,647 and an underflow operation error occurs if the result is less than -2,147,483,648.

INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.
Normally, addition and subtraction instructions (+, –, ++, and – –) involving double-length integers are performed as 32-bit operations.
However, these instructions are performed as 64-bit operations if they are used to correct the remainder produced by an immediately preceding MUL instruction (×) and are immediately followed by a DIV instruction (÷).

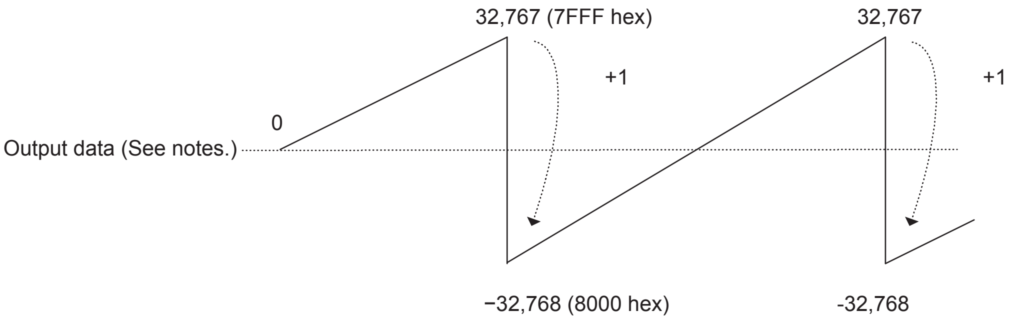
5.3.3 Extended Add (ADDX (++))

(1) Operation

Input data A and input data B are added and the result is stored in the output data.
Overflows are not treated as operation errors. Operation continues from the maximum value in the negative direction.
Underflows are not treated as operation errors. Operation continues from the maximum value in the positive direction.

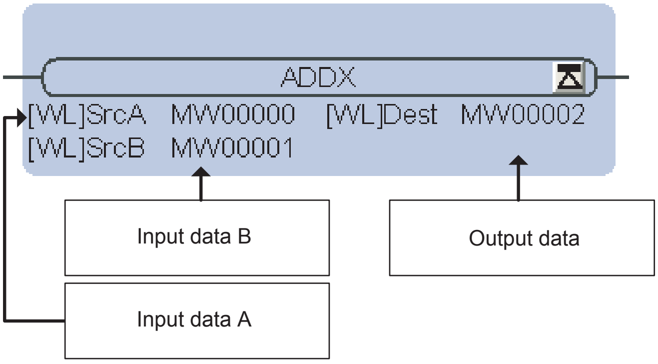
Input data A ++ (Extended Add) Input data B → Output data

■ Output Data Behavior



- In the example shown above, the output data is integer data. With double-length integers, adding 1 to 2,147,483,647 (7FFFFFFF hex) results in -2,147,483,648 (80000000 hex).
- Unlike operations for the ADD, SUB, or EXPRESSION instructions, overflows and underflows do not occur.

(2) Format



Icon: ✚✚

Key entry: ++

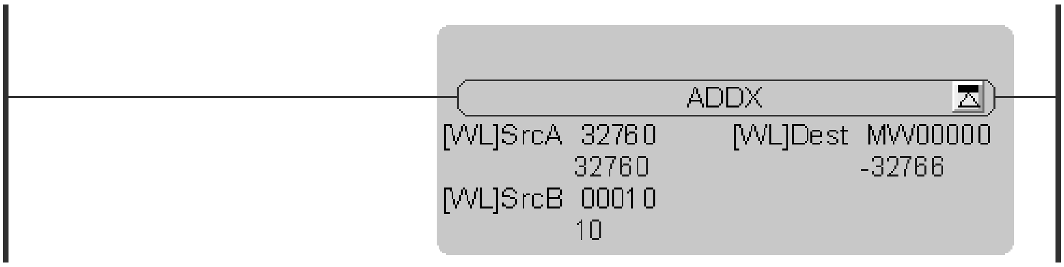
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	×	×	○	○
Input data B (SrcB)	×	○	○	×	×	○	○
Output data (Dest)	×	○*	○*	×	×	○	×

* C and # registers cannot be used.

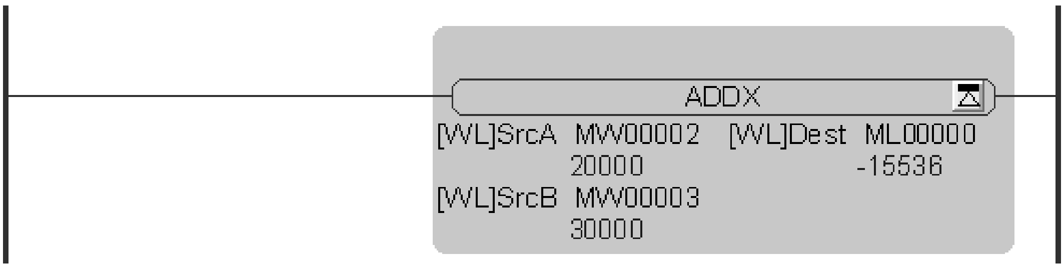
(3) Programming Examples

In the following programming examples, input data A and input data B are extended-added and the result is stored in the output data.

- Storing the Output Data in MW00000 When Input Data A Is 32,760 and Input Data B Is 10
  32,760 ++ 10 → MW00000 = -32,766

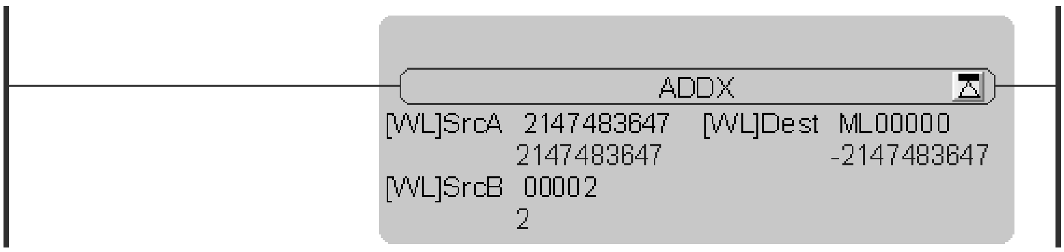


- Storing the Output Data in ML00000 When Input Data A in MW00002 Is 20,000 and Input Data B in MW00003 is 30,000
  20,000 ++ 30,000 → ML00000 = -15,536*

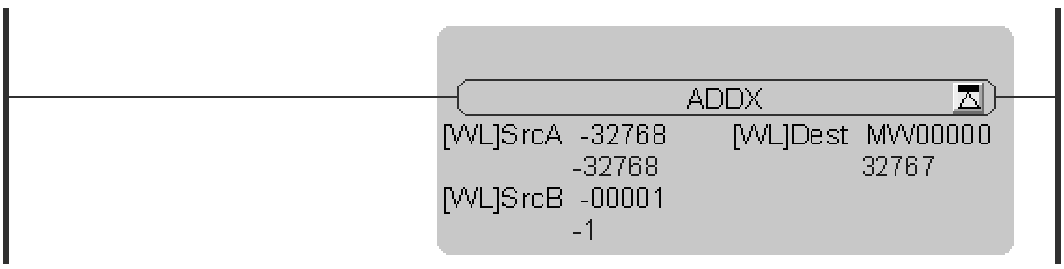


* In the example given above, ML00000 does not equal 50,000 because both input data A and B are integers, which limits the result to a number within the range for integers.

- Storing the Output Data in ML00000 When Input Data A Is 2,147,483,647 and Input Data B Is 2
  2,147,483,647 ++ 2 → ML00000 = -241,783,647



- Storing the Output Data in MW00000 When Input Data A Is -32,768 and Input Data B Is -1
  -32,768 ++ -1 → MW00000 = 32,767



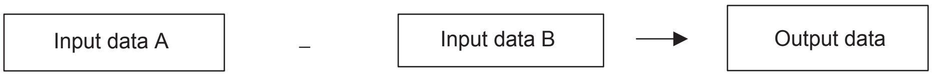
INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.
Normally, addition and subtraction instructions (+, –, ++, and – –) involving double-length integers are performed as 32-bit operations.
However, these instructions are performed as 64-bit operations if they are used to correct the remainder produced by an immediately preceding MUL instruction (×) and are immediately followed by a DIV instruction (÷).

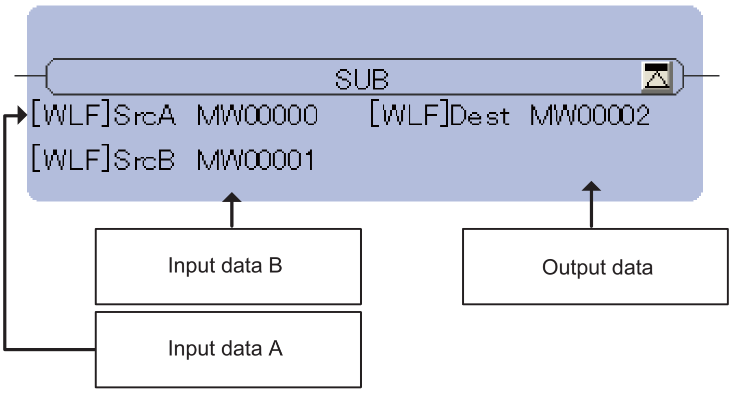
5.3.4 Subtract (SUB (–))

(1) Operation

Input data B is subtracted from input data A and the result is stored in the output data.
An operation error occurs if the result produces an overflow or underflow.



(2) Format



Icon:

Key entry: –

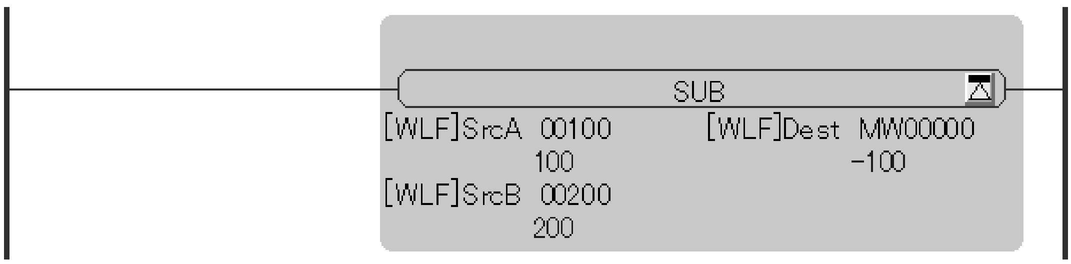
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○
Output data (Dest)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

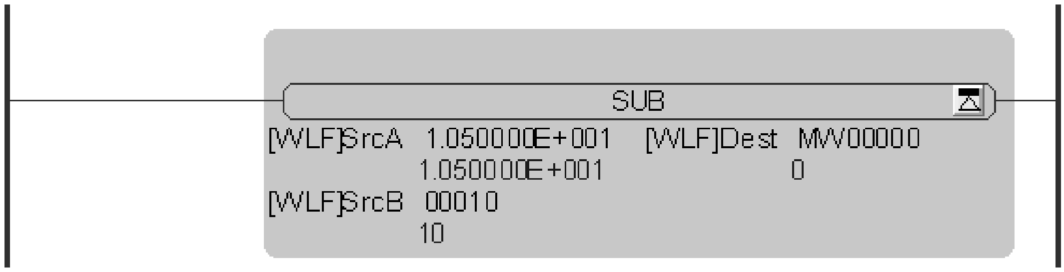
(3) Programming Examples

In the following programming examples, input data B is subtracted from input data A and the result is stored in the output data.

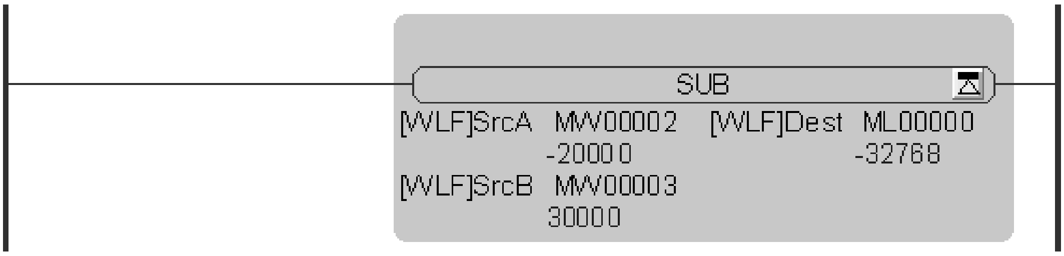
- Storing the Output Data in MW00000 When Input Data A Is 100 and Input Data B Is 200
  100 – 200 → MW00000 = -100



- Storing the Output Data in MW00000 When Input Data A Is 10.5 and Input Data B Is 10
  10.5 – 10 → MW00000 = 0 (when truncating below the decimal point is set)



- Storing the Output Data in ML00000 When Input Data A in MW00002 Is -20,000 and Input Data B in MW00003 Is 30,000
  -20,000 – 30,000 → ML00000 = -32,768*



* In the example given above, an underflow error occurs because both input data A and B are integers, which limits the result to a number within the range for integers.

(4) Additional Information

With integer operations, an overflow operation error occurs if the result exceeds 32,767 and an underflow operation error occurs if the result is less than -32,768.
With double-length integer operations, an overflow operation error occurs if the result exceeds 2,147,483,647 and an underflow operation error occurs if the result is less than -2,147,483,648.

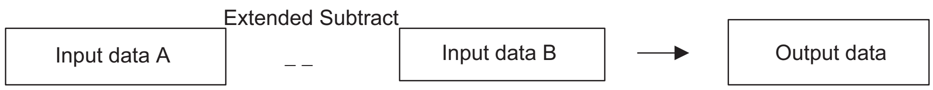
INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.
Normally, addition and subtraction instructions (+, –, ++, and – –) involving double-length integers are performed as 32-bit operations.
However, these instructions are performed as 64-bit operations if they are used to correct the remainder produced by an immediately preceding MUL instruction (×) and are immediately followed by a DIV instruction (÷).

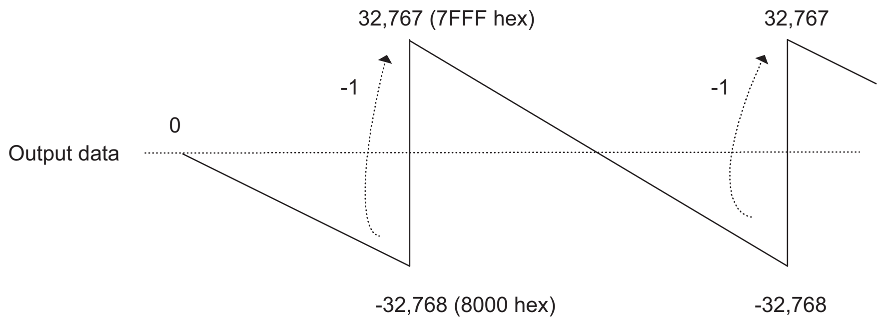
5.3.5 Extended Subtract (SUBX (– –))

(1) Operation

Input data B is subtracted from input data A and the result is stored in the output data.
Overflows are not treated as operation errors. Operation continues from the maximum value in the negative direction.
Underflows are not treated as operation errors. Operation continues from the maximum value in the positive direction.

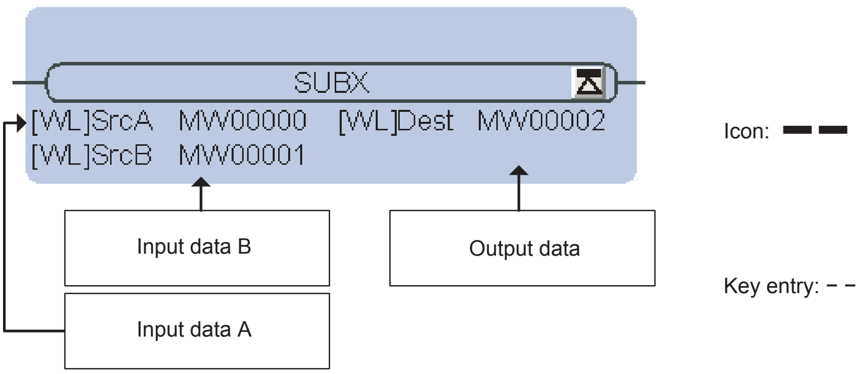


■ Output Data Behavior



- In the example shown above, the output data is integer data. With double-length integers, subtracting 1 from -2,147,483,647 (80000000 hex) results in 2,147,483,647(7FFFFFFF hex).
- Unlike operations for the ADD, SUB, or EXPRESSION instructions, overflows and underflows do not occur.

(2) Format



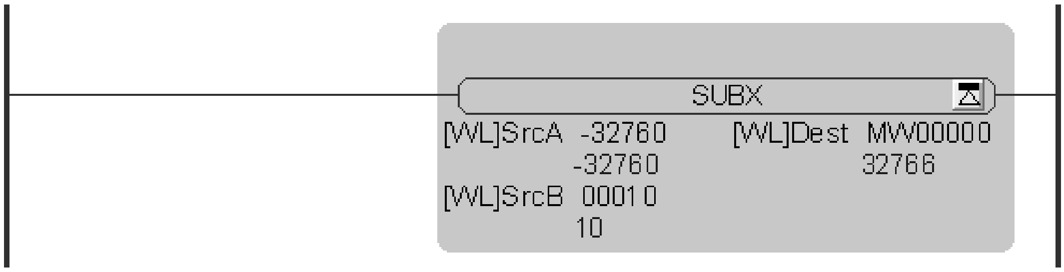
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	×	×	○	○
Input data B (SrcB)	×	○	○	×	×	○	○
Output data (Dest)	×	○*	○*	×	×	○	×

* C and # registers cannot be used.

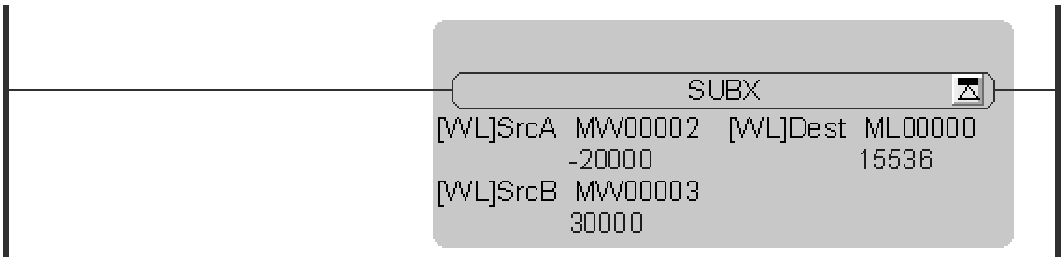
(3) Programming Examples

In the following programming examples, input data B is extended-subtracted from input data A and the result is stored in the output data.

- Storing the Output Data in MW00000 When Input Data A Is -32,760 and Input Data B Is 10
  -32,768 – – 10 → MW00000 = 32,766

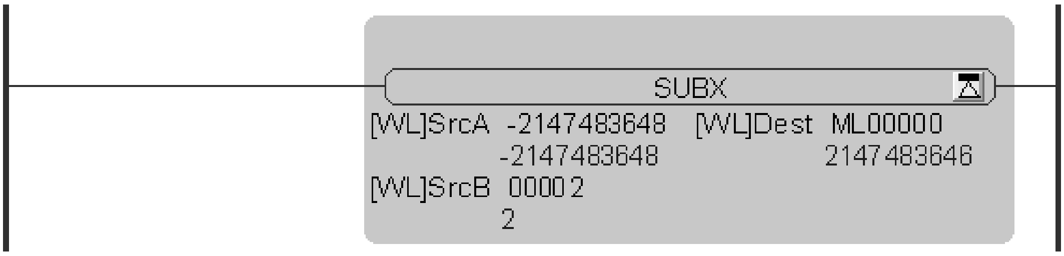


- Storing the Output Data in ML00000 When Input Data A in MW00002 Is -20,000 and Input Data B in MW00003 Is 30,000
  -20,000 – –30,000 → ML00000 = 15,536*

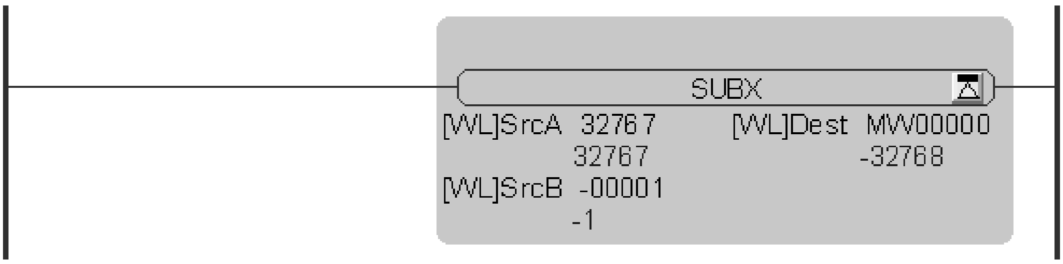


* In the example given above, ML00000 does not equal -50,000 because both input data A and B are integers, which limits the result to a number within the range for integers.

- Storing the Output Data in ML00000 When Input Data A Is -2,147,483,648 and Input Data B Is 2
  -2,147,483,648 – – 2 → ML00000 = 241,783,646



- Storing the Output Data in MW00000 When Input Data A Is 32,767 and Input Data B Is -1
  32,767 – – -1 → MW00000 = -32,768



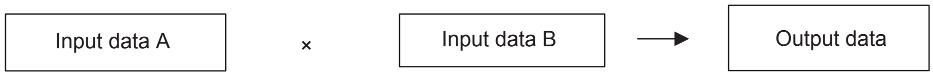
INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.
Normally, addition and subtraction instructions (+, –, ++, and – –) involving double-length integers are performed as 32-bit operations.
However, these instructions are performed as 64-bit operations if they are used to correct the remainder produced by an immediately preceding MUL instruction (×) and are immediately followed by a DIV instruction (÷).

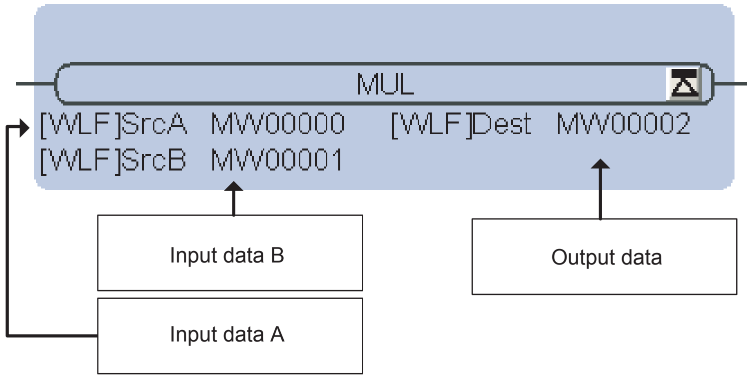
5.3.6 Multiply (MUL (x))

(1) Operation

Input data A and input data B are multiplied and the result is stored in the output data.



(2) Format



Icon: ✖

Key entry: *

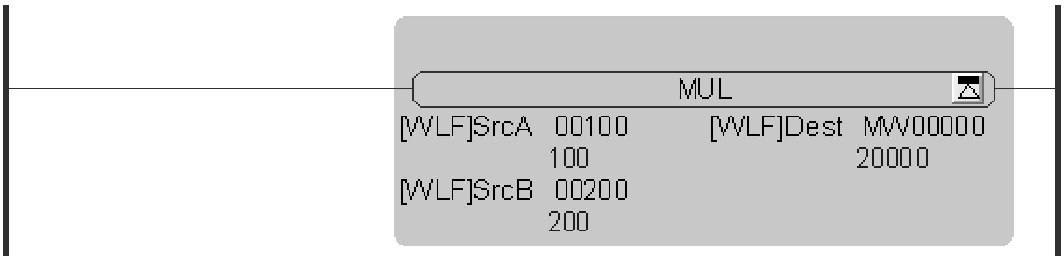
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○
Output data (Dest)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

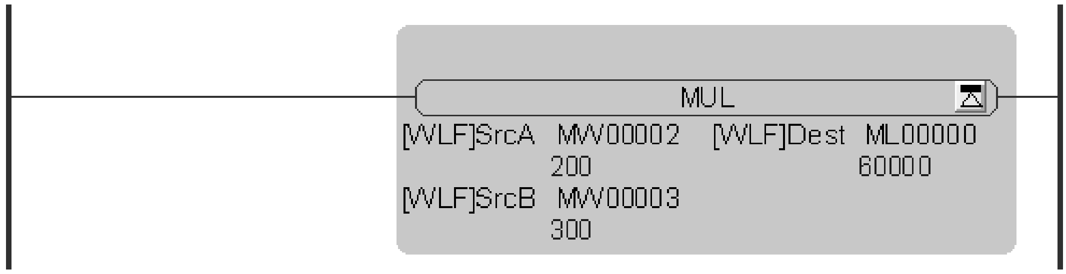
(3) Programming Examples

In the following programming examples, input data A and input data B are multiplied and the result is stored in the output data.

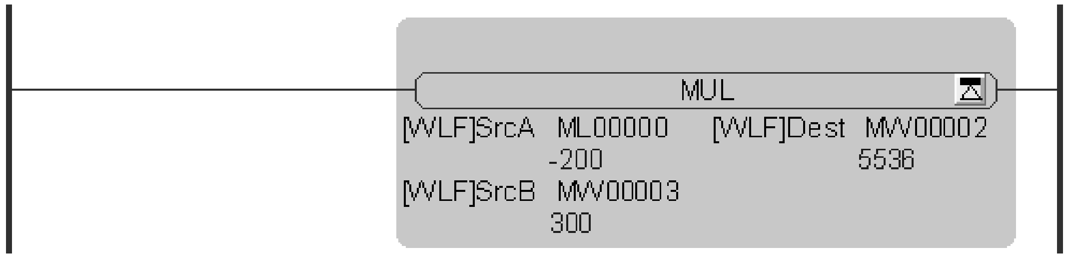
- Storing the Output Data in MW00000 When Input Data A Is 100 and Input Data B Is 200
  $100 \times 200 \rightarrow$ MW00000 = 20,000



- Storing the Output Data in ML00000 When Input Data A in MW00002 Is 200 and Input Data B in MW00003 Is 300
  200 × 300 → ML00000 = 60,000



- Storing the Output Data in MW00002 When Input Data A in ML00000 Is -200 and Input Data B in MW00003 Is 300
  -200 × 300 → MW00002 = 5,536*



* The input data contains a double-length integer, so this operation is performed as a double-length integer operation. However, the output data is integer data, so if the operation result exceeds the range for integers, the lower 16-bits of the original operation result is stored in the output data.

INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.
Normally, addition and subtraction instructions (+, –, ++, and – –) involving double-length integers are performed as 32-bit operations.
However, these instructions are performed as 64-bit operations if they are used to correct the remainder produced by an immediately preceding MUL instruction (×) and are immediately followed by a DIV instruction (÷).

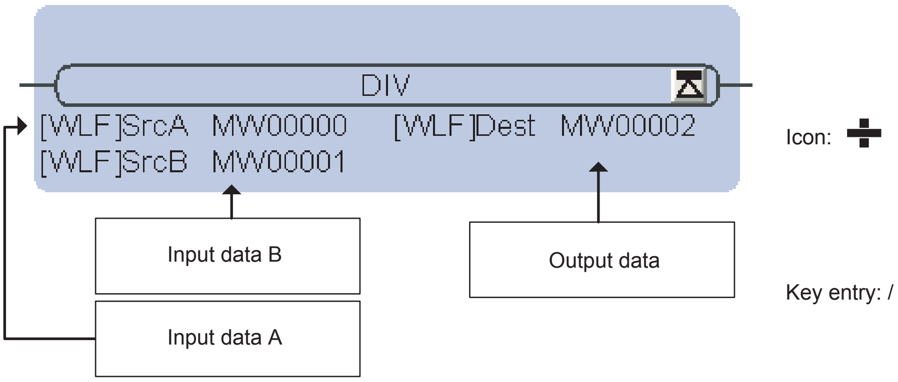
5.3.7 Divide (DIV (÷))

(1) Operation

Input data A is divided by input data B and the result is stored in the output data.

Input data A ÷ Input data B → Output data

(2) Format



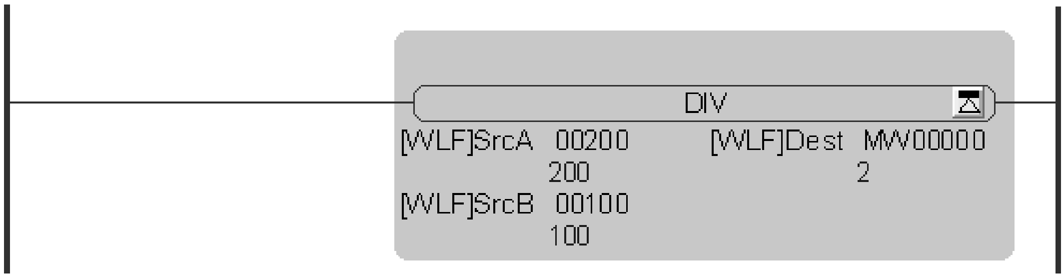
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○
Output data (Dest)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

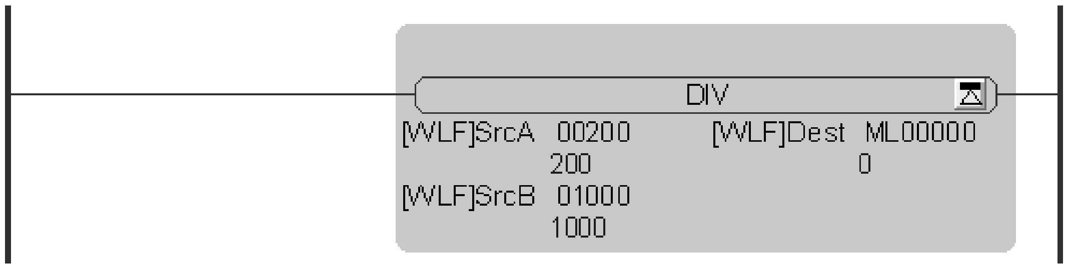
(3) Programming Examples

In the following programming examples, input data A is divided by input data B and the result is stored in the output data.

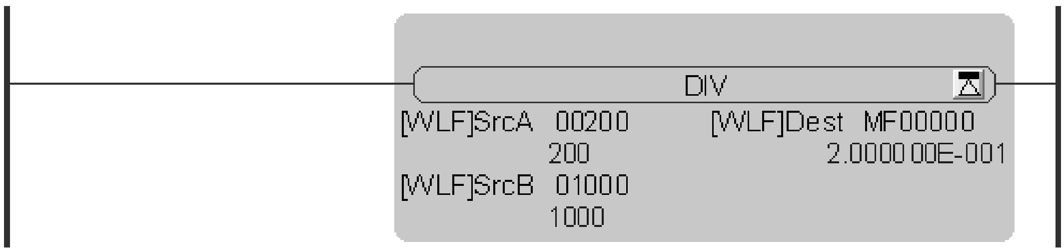
- Storing the Output Data in MW00000 When Input Data A Is 200 and Input Data B Is 100
  200 ÷ 100 → MW00000 = 2



- Storing the Output Data in ML00000 When Input Data A Is 200 and Input Data B Is 1,000
  200 ÷ 1,000 → ML00000 = 0



- Storing the Output Data in MF00000 When Input Data A Is 200 and Input Data B Is 1,000
  200 ÷ 1,000 → MF00000 = 0.2



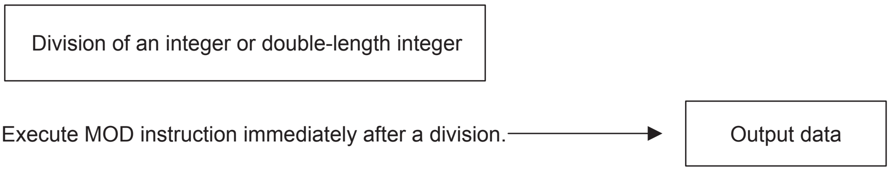
INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.
Normally, addition and subtraction instructions (+, –, ++, and – –) involving double-length integers are performed as 32-bit operations.
However, these instructions are performed as 64-bit operations if they are used to correct the remainder produced by an immediately preceding MUL instruction (×) and are immediately followed by a DIV instruction (÷).

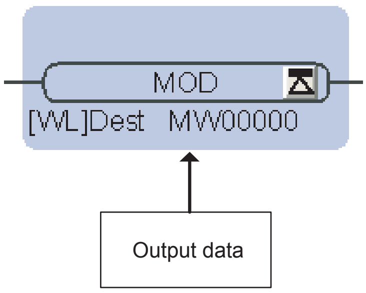
5.3.8 Integer Remainder (MOD)

(1) Operation

The remainder of the immediately preceding integer or double-length integer division is stored in the output data. The MOD instruction must be executed immediately after the DIV instruction. If the MOD instruction is executed at any other time, the operation result obtained before the next numeric operation instruction will be invalid.



(2) Format



Icon: 

Key entry: MOD

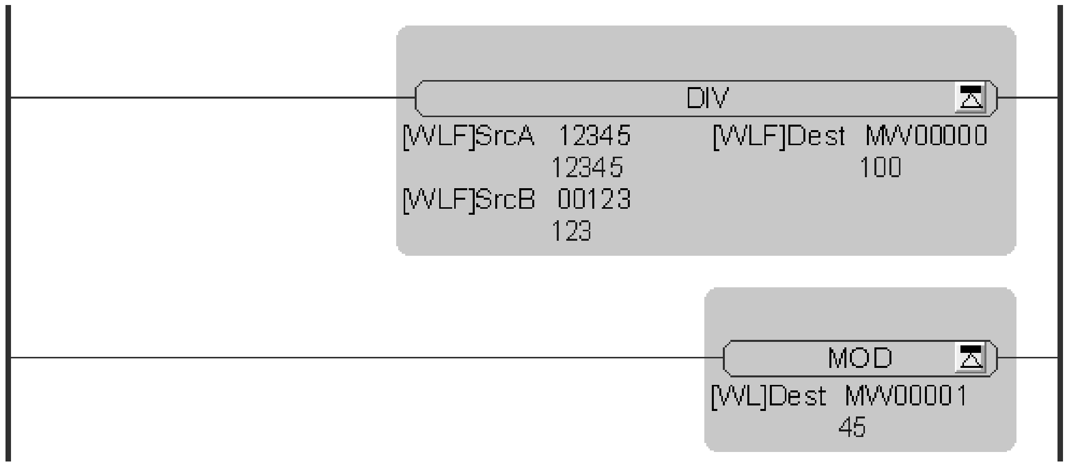
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Output data (Dest)	×	○*	○*	×	×	○	×

* C and # registers cannot be used.

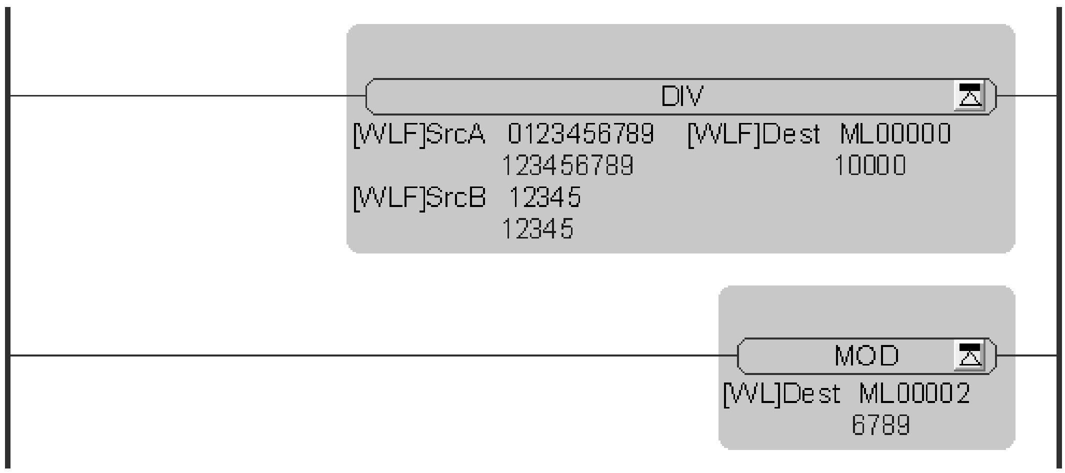
(3) Programming Examples

In the following programming examples, input data A is divided by input data B and the remainder is stored in the output data.

- If the Immediately Preceding Division Is as Follows: 12,345 ÷ 123 → MW00000 = 100
  And then the MOD instruction is executed immediately afterward → MW00001 = 45.



- If the Immediately Preceding Division Is as Follows: 123,456,789 ÷ 12,345 → ML00000 = 10,000
  And then the MOD instruction is executed immediately afterward → ML00002 = 6,789



INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

5.3.9 Real Remainder (REM)

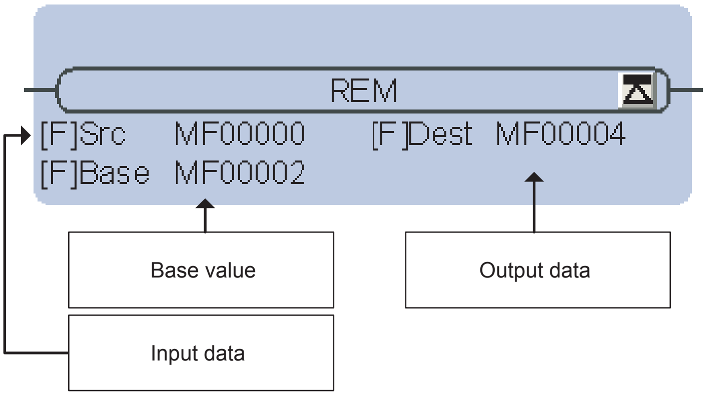
(1) Operation

The remainder from a real number division is stored in the output data. Here, the remainder refers to the remainder obtained by repeatedly subtracting the base value from the input data.
Specifically, the value obtained by subtracting the base value from the input data n number of times (input data - base value × n) is output when it becomes less than the base value.

■ Condition n

The output data is computed by using the first value of n that satisfies the following formula when the value of n is incremented from 0, 1, 2, 3, etc.
(Input data – Base value × n) < Base value

(2) Format



Icon: REM

Key entry: REM

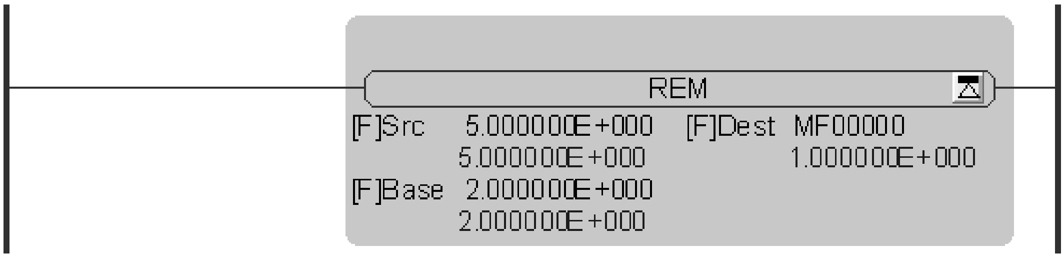
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	×	×	○	×	×	○
Base (Base)	×	×	×	○	×	×	○
Output data (Dest)	×	×	×	○*	×	○	×

* C and # registers cannot be used.

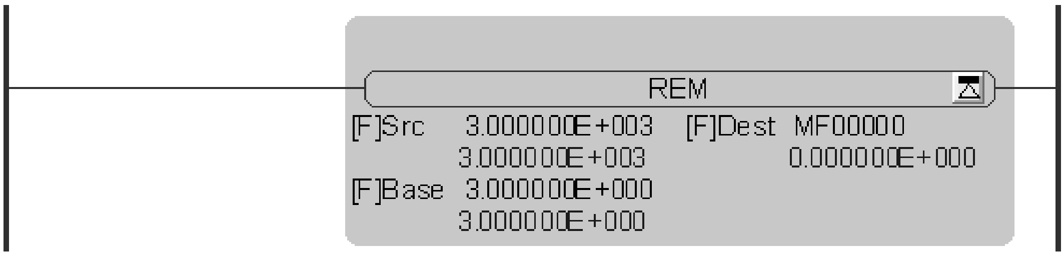
(3) Programming Examples

In the following programming examples, the base value is subtracted from the input data n times and the remainder is stored in the output data.

- Storing the Output Data in MF00000 When the Input Data Is 5.0 and the Base Value Is 2.0
  5.0 – 2.0 – 2.0 = 1.0 < Base (2.0) → MF00000 = 1.0



- Storing the Output Data in MF00000 When the Input Data Is 3000.0 and the Base Value Is 3.0
  3,000.0 – 3.0 – 3.0 ... = 0.0 < Base (3.0) → MF00000 = 0.0

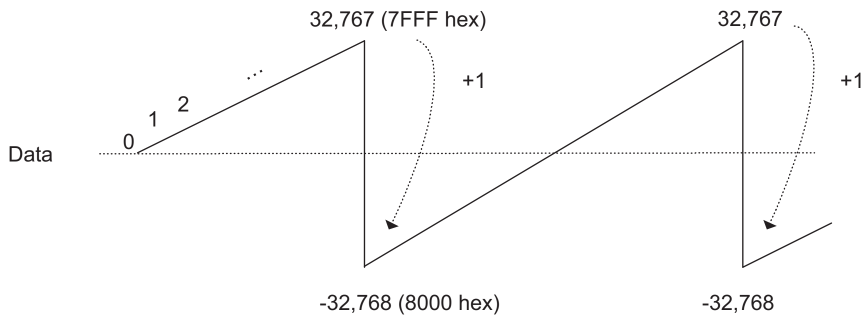


5.3.10 Increment (INC)

(1) Operation

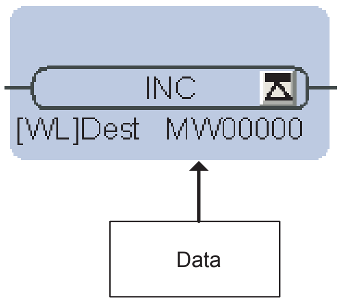
A value of 1 is added to the integer or double-length integer data. No overflow or underflow will occur for either an integer or double-length integer. This operation handles overflows and underflows in the same way as the ADDX instruction.

■ Output Data Behavior



- In the example shown above, the data is an integer. With double-length integers, adding 1 to 2,147,483,647 (7FFFFFFF hex) results in -2,147,483,648(80000000 hex).

(2) Format



Icon: **+1**

Key entry: INC

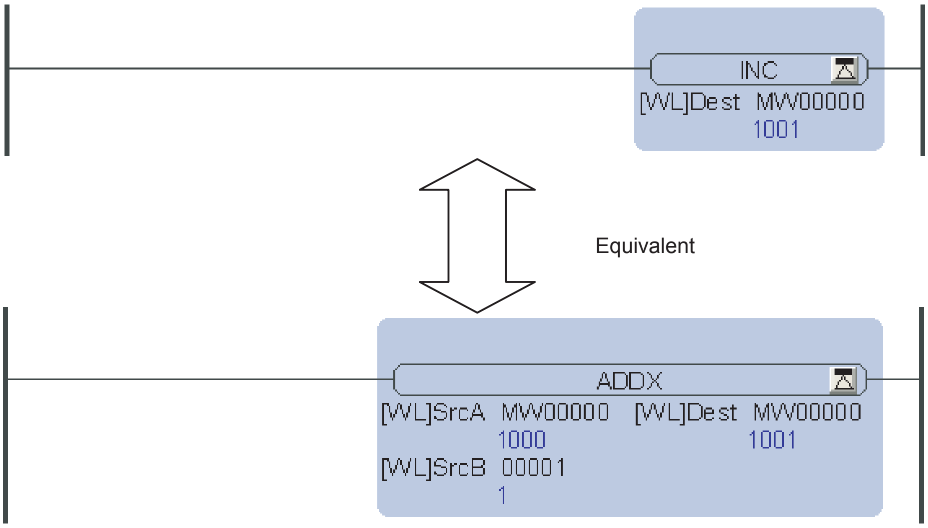
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Data (Dest)	×	○*	○*	×	×	○	×

* C and # registers cannot be used.

(3) Programming Examples

The following programming examples achieve the same result by using the INC instruction and by using the ADDX instruction.

The INC instruction is equivalent to adding 1 to the data 1,000 in MW00000 using the ADDX instruction.

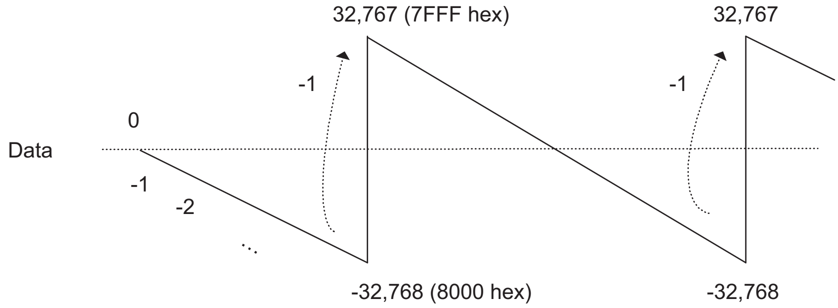


5.3.11 Decrement (DEC)

(1) Operation

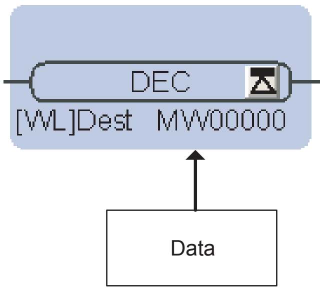
A value of 1 is subtracted from the integer or double-length integer data. No overflow or underflow will occur for either an integer or double-length integer. This operation handles overflows and underflows in the same way as the SUBX instruction.

■ Output Data Behavior



- In the example shown above, the data is an integer. With double-length integers, subtracting 1 from -2,147,483,648 (80000000 hex) results in 2,147,483,647(7FFFFFFF hex).

(2) Format



Icon: **-1**

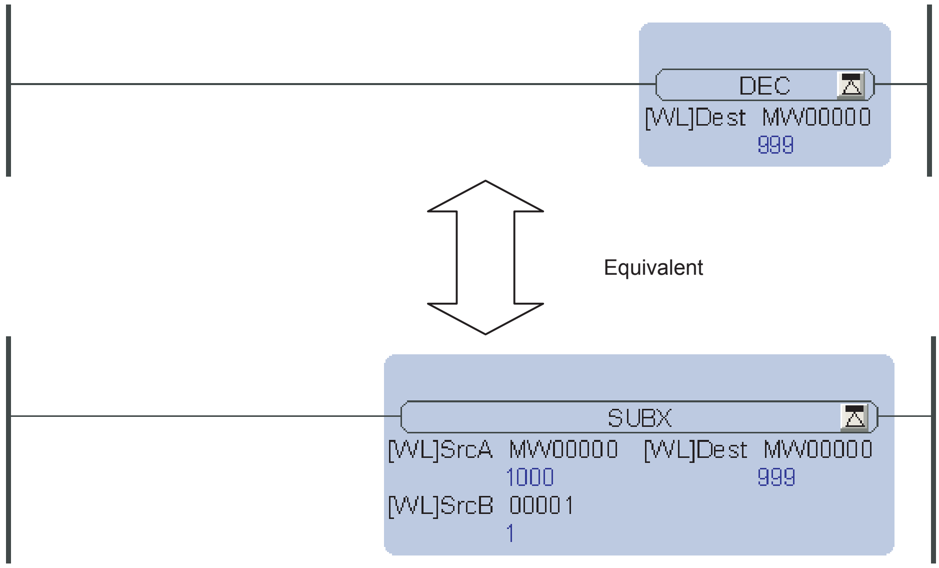
Key entry: DEC

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Data (Dest)	×	O*	O*	×	×	O	×

* C and # registers cannot be used.

(3) Programming Examples

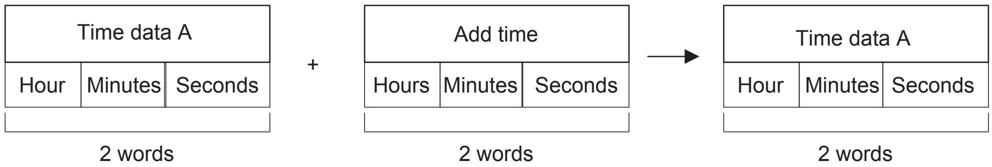
The following programming examples achieve the same result by using the DEC instruction and by using the SUBX instruction.
The DEC instruction is equivalent to subtracting 1 from the data 1,000 in MW00000 using the SUBX instruction.



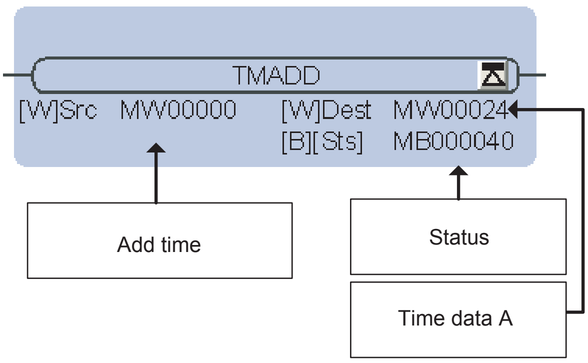
5.3.12 Add Time (TMADD)

(1) Operation

A duration (hours/minutes/seconds) is added to a time (hour/minutes/seconds). The add time is added to time data A and the result is stored in time data A. Time data is two words long.



(2) Format



Icon: 

Key entry: TMADD

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Add time (Src)	×	○*2	×	×	×	×	×
Time data A (Dest)	×	○*2	×	×	×	×	×
Status (Sts)*1	○*2	×	×	×	×	×	×

* 1. Optional.
* 2. C and # registers cannot be used.

The time data is formatted as shown below.

Offset	Contents	Data Range (BCD)
0	Hour/minutes	Upper byte (hour): 00 to 23 Lower byte (minutes): 00 to 59
1	Seconds	0000 to 0059

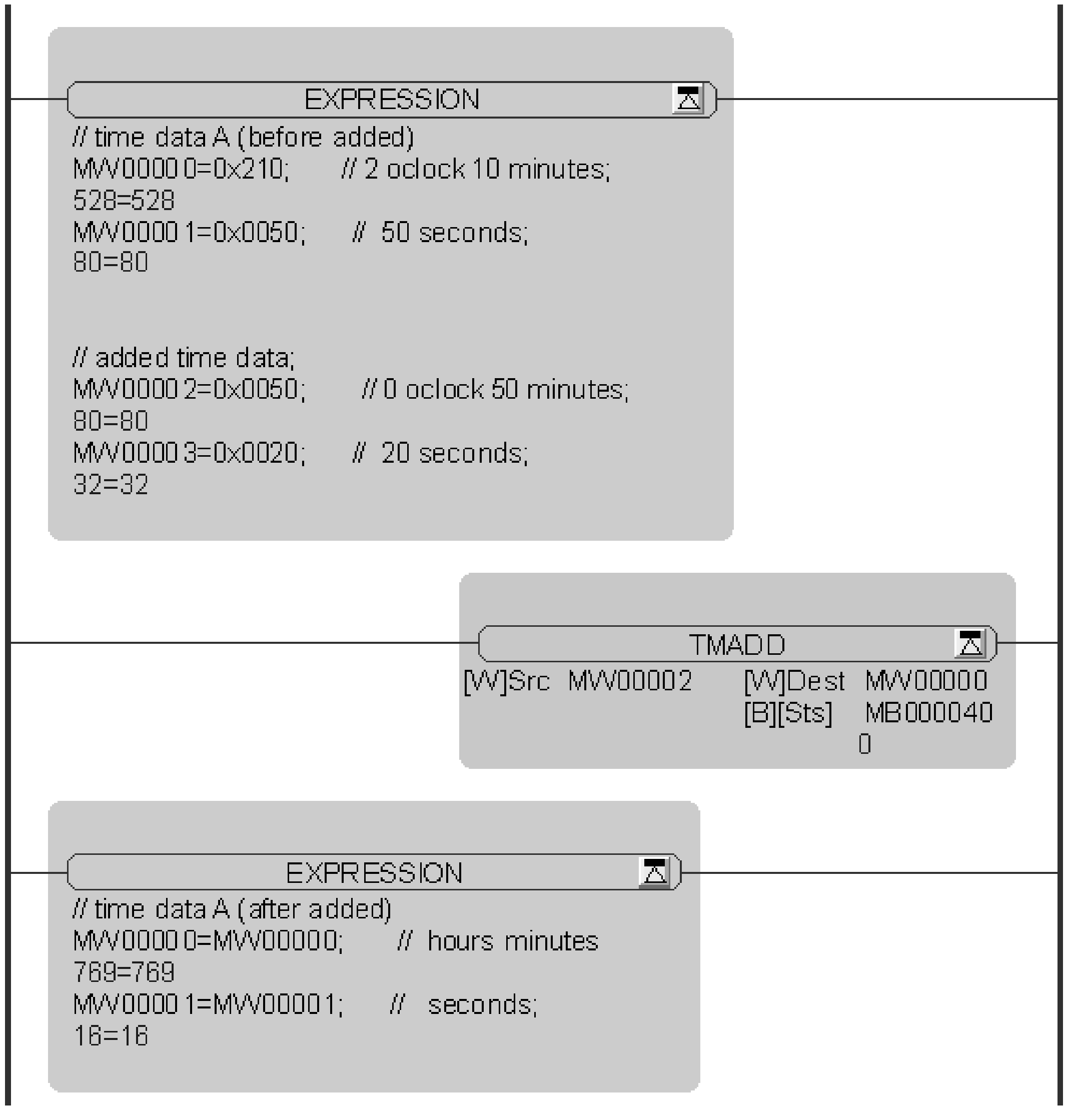
If the operation result exceeds any of the data ranges given above, time data A is not updated, the seconds data is set to 9,999, and the status bit is set to 1 (ON).
If the operation result is within the ranges, the status bit is set to 0 (OFF).

(3) Programming Example

The following table gives typical conditions for creating ladder programming that uses the TMADD instruction. The examples show time data A before instruction execution, and the add time.

Time	Time Data A before Execution of Instruction	Add Time
Hour/minutes	MW00000 = 0210 hex (2:10)	MW00002 = 0050 hex (0 hours 50 minutes)
Seconds	MW00001 = 0050 hex (50 seconds)	MW00003 = 0020 hex (20 seconds)

In the following programming example, the time data is added to the time under the above conditions and the resulting time data is stored.



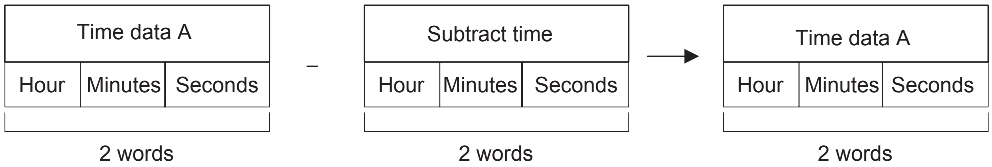
The result of adding the add time to the value of time data A before instruction execution is shown below.

Time	Time Data A after Execution of Instruction
Hour/minutes	MW00000 = 769 = 0301 hex (3:01)
Seconds	MW00001 = 16 = 0010 hex (10 seconds)

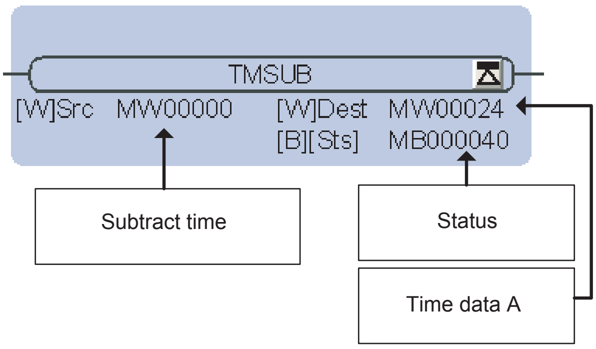
5.3.13 Subtract Time (TMSUB)

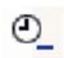
(1) Operation

A duration (hours/minutes/seconds) is subtracted from a time (hour/minutes/seconds). The subtract time is subtracted from time data A and the result is stored in time data A. Time data is two words long.



(2) Format



Icon: 

Key entry: TMSUB

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Subtract time (Src)	×	○*2	×	×	×	×	×
Time data A (Dest)	×	○*2	×	×	×	×	×
Status (Sts)*1	○*2	×	×	×	×	×	×

∗ 1. Optional.
∗ 2. C and # registers cannot be used.

The time data is formatted as shown below.

Offset	Contents	Data Range (BCD)
0	Hour/minutes	Upper byte (hour): 00 to 23 Lower byte (minutes): 00 to 59
1	Seconds	0000 to 0059

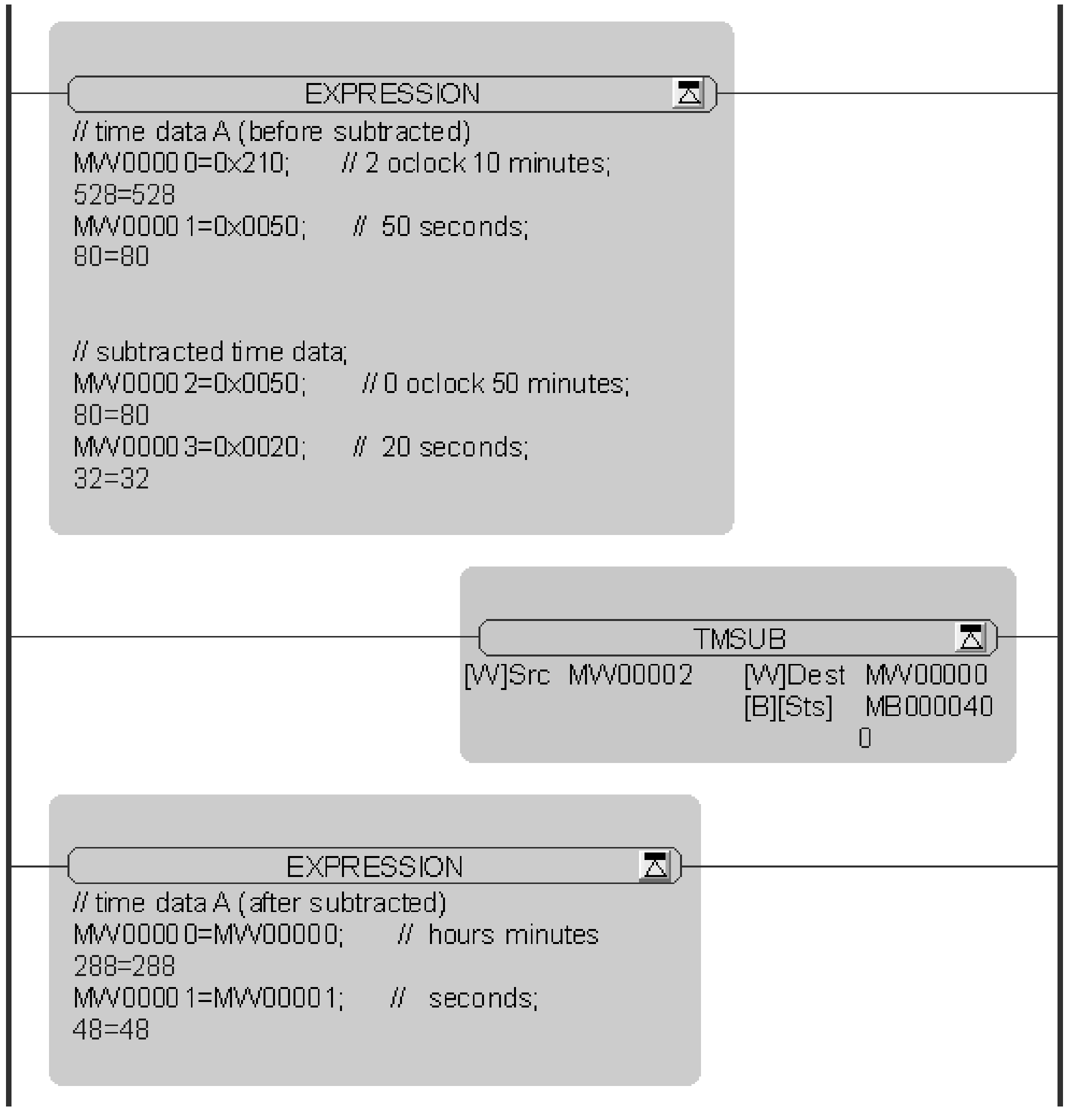
If the operation result exceeds any of the data ranges given above, time data A is not updated, the seconds data is set to 9,999, and the status bit is set to 1 (ON).
If the operation result is within the ranges, the status bit is set to 0 (OFF).

(3) Programming Example

The following table gives typical conditions for creating ladder programming that uses the TMSUB instruction. The examples show time data A before instruction execution, and the subtract time.

Time	Time Data A before Execution of Instruction	Subtract Time
Hour/minutes	MW00000 = 0210 hex (2:10)	MW00002 = 0050 hex (0 hours 50 minutes)
Seconds	MW00001 = 0050 hex (50 seconds)	MW00003 = 0020 hex (20 seconds)

In the following programming example, the subtract time is subtracted from the time under the above conditions and the resulting time data is stored.



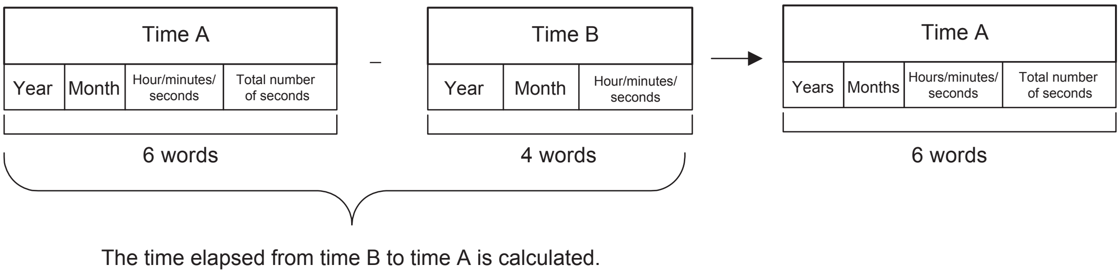
The result of subtracting the subtract time from the value of time data A before instruction execution is shown below.

Time	Time Data A after Execution of Instruction
Hour/minutes	MW00000 = 288 = 0120 hex (1:20)
Seconds	MW00001 = 48 = 0030 hex (30 seconds)

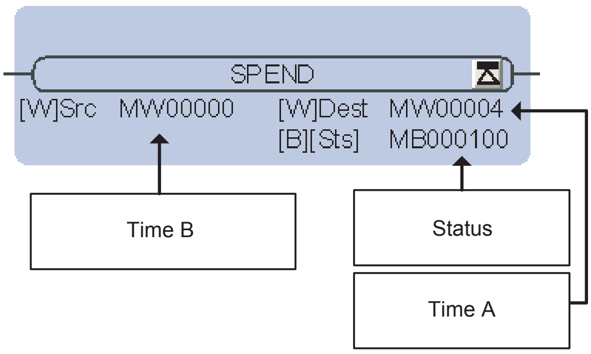
5.3.14 Spend Time (SPEND)

(1) Operation

The elapsed time is calculated by subtracting two data items (year/month/day/hour/minutes/seconds). The instruction subtracts time B from time A, which gives the time elapsed from time B to time A and the result is stored in time A. Time data is four words long.



(2) Format



Icon: 

Key entry: SPEND

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Time B (Src)	×	○[*2]	×	×	×	×	×
Time A (Dest)	×	○[*2]	×	×	×	×	×
Status (Sts)[*1]	○[*2]	×	×	×	×	×	×

∗ 1. Optional.
∗ 2. C and # registers cannot be used.

Time data B is formatted as shown below.

Offset	Contents	Data Range (BCD)	I/O
0	Year (BCD)	0000 to 0099	IN
1	Month/day (BCD)	Upper byte (month): 01 to 12 Lower byte (day): 01 to 31	IN
2	Hour/minutes (BCD)	Upper byte (hour): 00 to 23 Lower byte (minutes): 00 to 59	IN
3	Seconds (BCD)	0000 to 0059	IN

Time data A is formatted as shown below.

Offset	Contents	Data Range (BCD)	I/O
0	Year (BCD)	0000 to 0099	IN/OUT
1	Month/day (BCD)	Upper byte (month): 01 to 12 Lower byte (day): 01 to 31	IN/OUT
2	Hour/minutes (BCD)	Upper byte (hour): 00 to 23 Lower byte (minutes): 00 to 59	IN/OUT
3	Seconds (BCD)	0000 to 0059	IN/OUT
4	Total number of seconds	Operation result of years, months, days, hours, minutes, and seconds converted into seconds (double-length integer)	IN/OUT
5			

If the operation result exceeds any of the data ranges given above, time data A is not updated, the seconds data is set to 9,999, and the status bit is set to 1 (ON).
If the operation result is within the ranges, the status bit is set to 0 (OFF).

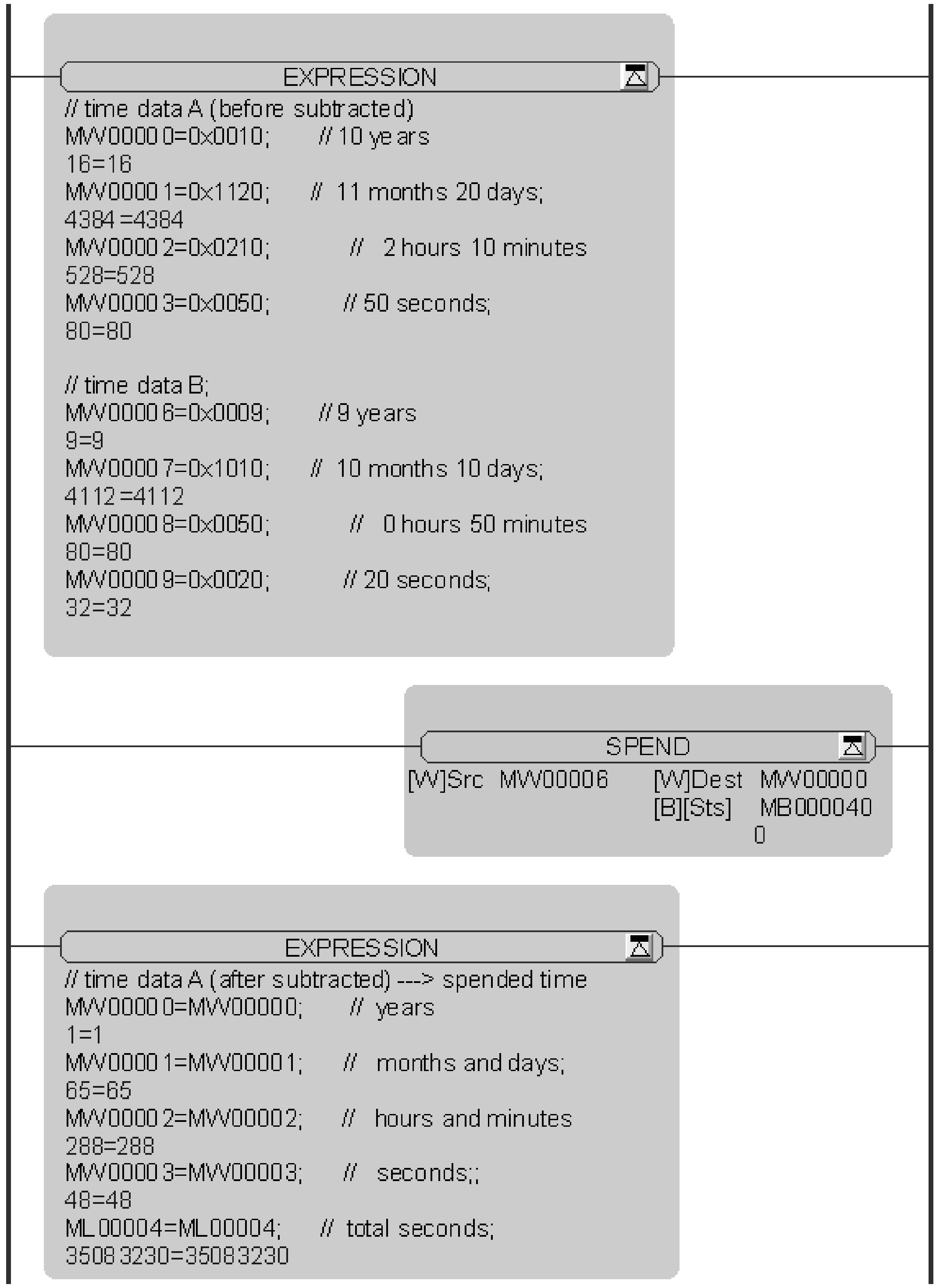
INFO

A year is calculated as 365 days. Leap years are not supported.
The number of months is not calculated. Only the number of days is calculated.

(3) Programming Example

The following table gives typical conditions for creating ladder programming that uses the SPEND instruction.
(The elapsed time between November 20, 2010, 02:10:50 and October 10, 2009, 00:50:20 is found.)

	Time A before Execution of Instruction	Time B
Year	MW00000 = 0010 hex (2010)	MW00006 = 0009 hex (2009)
Month/day	MW00001 = 1120 hex (November 20)	MW00007 = 1010 hex (October 10)
Hour/minutes	MW0002 = 0210 hex (2:10)	MW00008 = 0050 hex (0:50)
Seconds	MW00003 = 0050 hex (50 seconds)	MW00009 = 0020 hex (20 seconds)



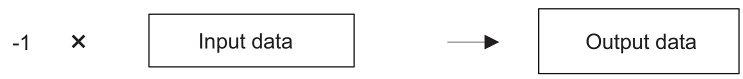
The execution result of this SPEND instruction example is shown below.

	Time A after Execution of Instruction
Years	MW00000 = 1 = 0001 hex (1 year)
Months/days	MW00001 = 65 = 0041 hex (0 months, 41 days)
Hours/minutes	MW00002 = 288 = 0120 hex (1 hour, 20 minutes)
Seconds	MW00003 = 48 = 0030 hex (30 seconds)
Total number of seconds	ML00004 = 35083230

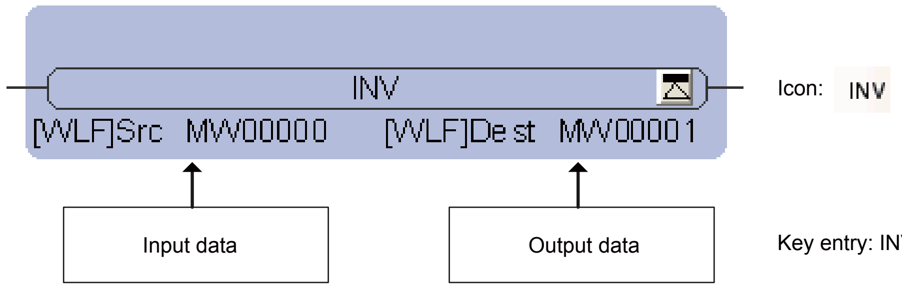
5.3.15 Invert Sign (INV)

(1) Operation

The sign of the input data is inverted and the result is stored in the output data.



(2) Format



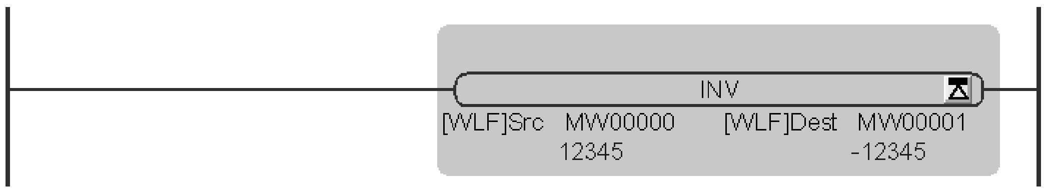
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	○	○	×	○	○
Output data (Dest)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the INV instruction inverts the sign of 12,345 in input data A in MW00000 and stores the result in the output data in ML00002.

-1 × MW00000 (12,345) → ML00002 = -12,345



INFO

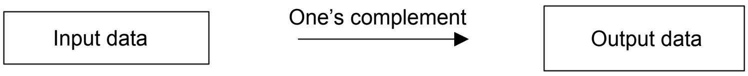
When performing operations with different data types, the result of the operation will depend on the data type of the output register.

Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

5.3.16 One's Complement (COM)

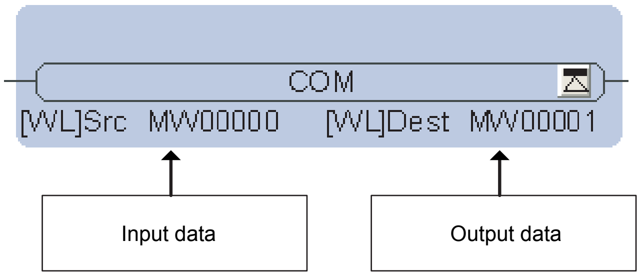
(1) Operation

The one's complement of the input data is stored in the output data.



- This instruction inverts the 0's and 1's in the binary representation of the input data and stores the result in the output data.

(2) Format



Icon: 

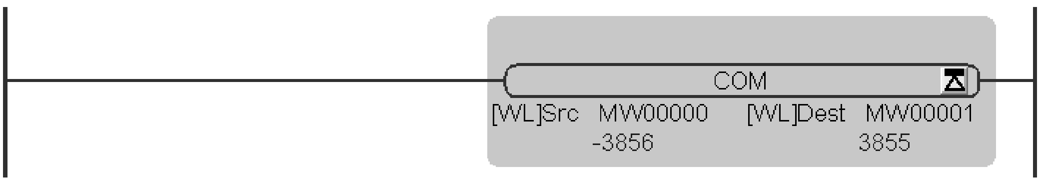
Key entry: COM

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	○	×	×	○	○
Output data (Dest)	×	○*	○*	×	×	○	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the one's complement of -3,856 (F0F0 hex) in the input data in MW00000 is stored in the output data in MW00001.
MW00000 = -3,856 (F0F0 hex) → MW00001 = 3,855 (0F0F hex)



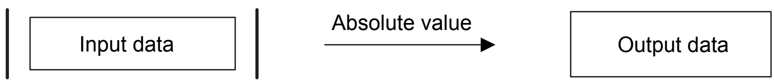
INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

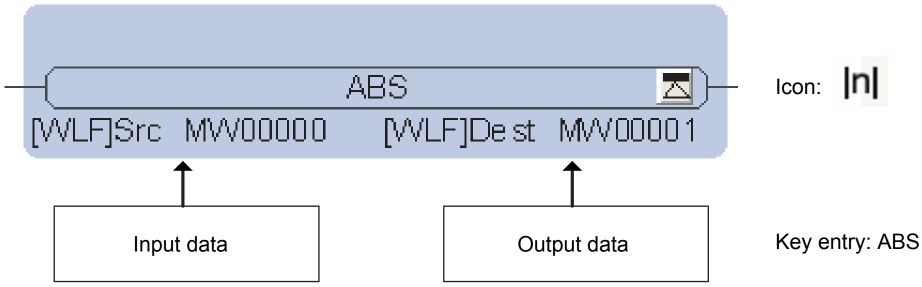
5.3.17 Absolute Value (ABS)

(1) Operation

The absolute value of the input data is stored in the output data.



(2) Format

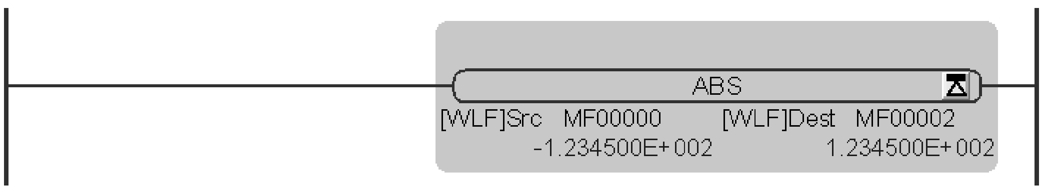


Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	○	○	×	○	○
Output data (Dest)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the absolute value of -123.45 in the input data in MF00000 is stored in the output data in MF00002.
| MF00000(-123.45) | → MF00002 = 123.45



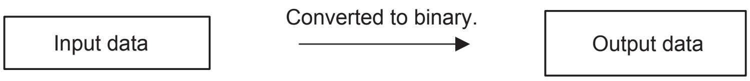
INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

5.3.18 Binary Conversion (BIN)

(1) Operation

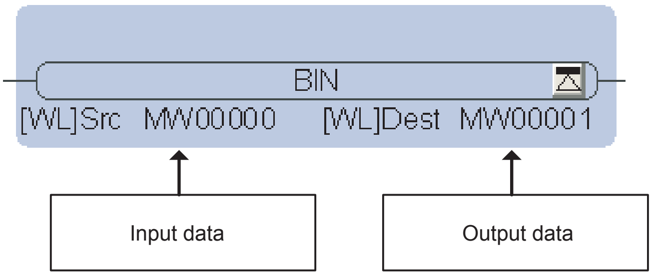
The value of the input data is converted from BCD data to binary data and stored in the output data.
If the input data is not BCD data, such as 123F hex, the result of the binary conversion will be incorrect.



The output data is computed as shown below when the input BCD data is abcd.

Output data = (a × 1,000) + (b × 100) + (c × 10) + d

(2) Format



Icon: 

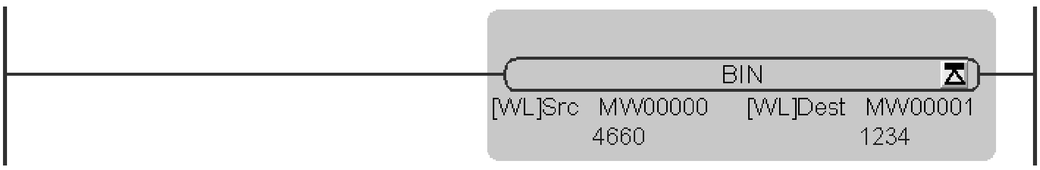
Key entry: BIN

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	○	×	×	○	○
Output data (Dest)	×	○*	○*	×	×	○	×

∗ C and # registers cannot be used.

(3) Programming Example

In the following programming example, the value 4,660 (1234 hex) in input data A in MW00000 is converted to binary and stored in the output data in MW00001.
MW00000 = 1234 hex: (1 × 1,000) + (2 × 100) + (3 × 10) + 4 → MW00001 = 1,234



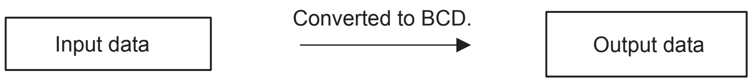
INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

5.3.19 BCD Conversion (BCD)

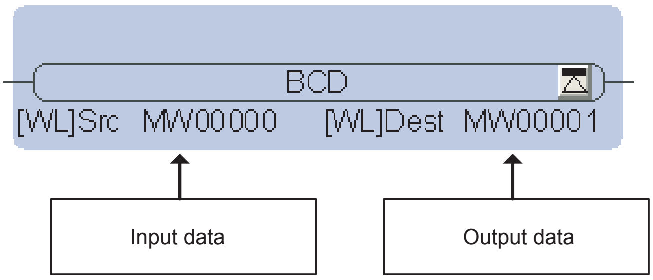
(1) Operation

The input data is converted from binary data to BCD data and stored in the output data.
If the input data is greater than 9,999, or a negative value, the result will be incorrect.



The output data is computed as shown below when the input decimal data is abcd.
Output data = (a × 49) + (b × 256) + (c × 16) + d

(2) Format



Icon: 

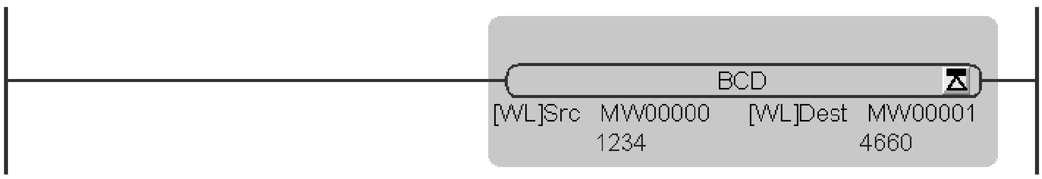
Key entry: BCD

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	○	×	×	○	○
Output data (Dest)	×	○*	○*	×	×	○	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the value 1,234 in input data A in MW00000 is converted to BCD and stored in the output data in MW00001.
MW00000 = 1,234: (1 × 4,096) + (2 × 256) + (3 × 16) + 4 → MW00001 = 4,660 (1234 hex)



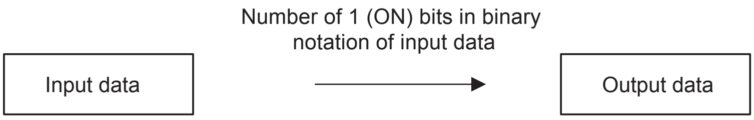
INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

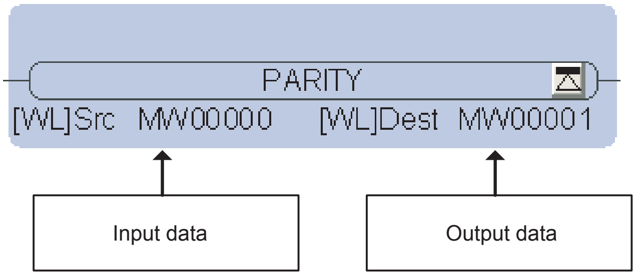
5.3.20 Parity Conversion (PARITY)

(1) Operation

The number of bits set to 1 (ON) in the input data is calculated in binary notation and stored in the output data.



(2) Format



Icon: 

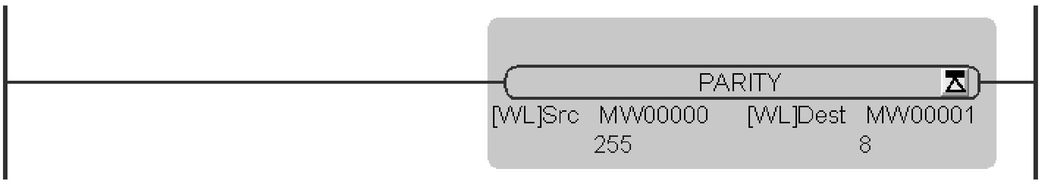
Key entry: PARITY

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	○	×	×	○	○
Output data (Dest)	×	○*	○*	×	×	○	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the number of bits set to 1 (ON) in 255 (00FF hex) in the input data A in MW00000 is stored in the output data in MW00001.
Number of 1 bits in MW00000 (0FF hex) = 8 → MW00001 = 8



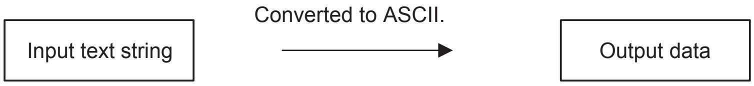
INFO

When performing operations with different data types, the result of the operation will depend on the data type of the output register.
Refer to *4.4.2 (3) Precautions When Using Local Registers within a User Function* for details.

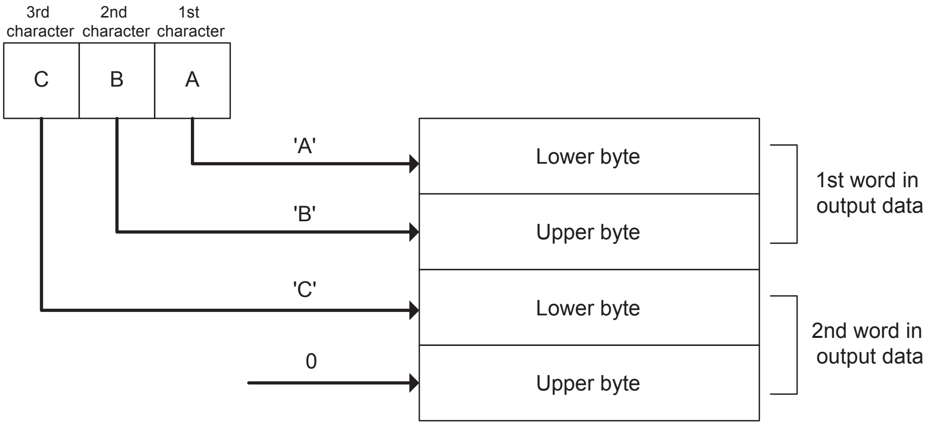
5.3.21 ASCII Conversion 1 (ASCII)

(1) Operation

The input text string is converted to ASCII and stored in the output data. The text string is case sensitive.
The input text string can contain up to 32 characters (16 words).

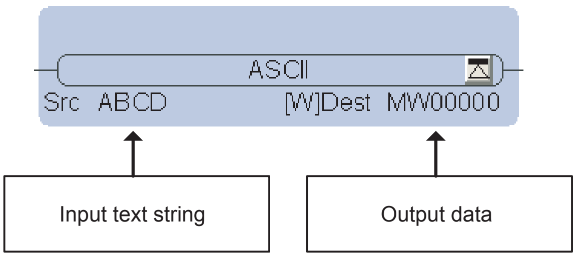


■ Storage Location of ASCII Values for Input Text String



- If the text string contains an odd number of characters, the upper byte of the last word is set to zeros.

(2) Format



Icon: 

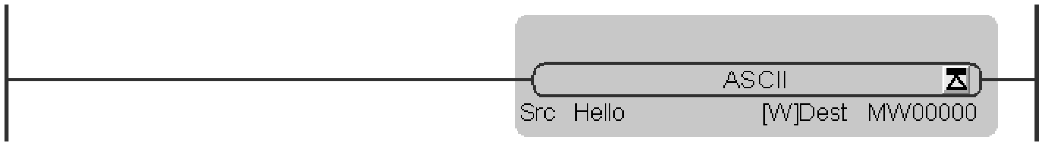
Key entry: ASCII

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input text string (Src)	×*1						
Output data (Dest)	×	○*2	×	×	×	×	×

∗ 1. ASCII text
∗ 2. C and # registers cannot be used.

(3) Programming Example

In the following programming example, the input string “Hello” is converted to ASCII and stored in the output data in MW00000.



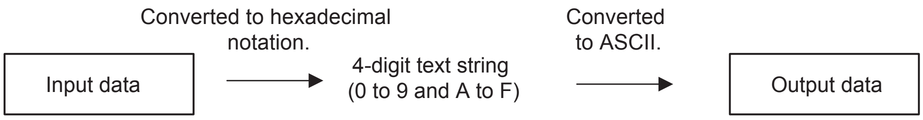
The ASCII values are stored as given in the following table.

Address	ASCII Value	Character
MW00000 (lower byte)	48 hex	H
MW00000 (upper byte)	65 hex	e
MW00001 (lower byte)	6C hex	l
MW00001 (upper byte)	6C hex	l
MW00002 (lower byte)	6F hex	o
MW00002 (upper byte)	0	-

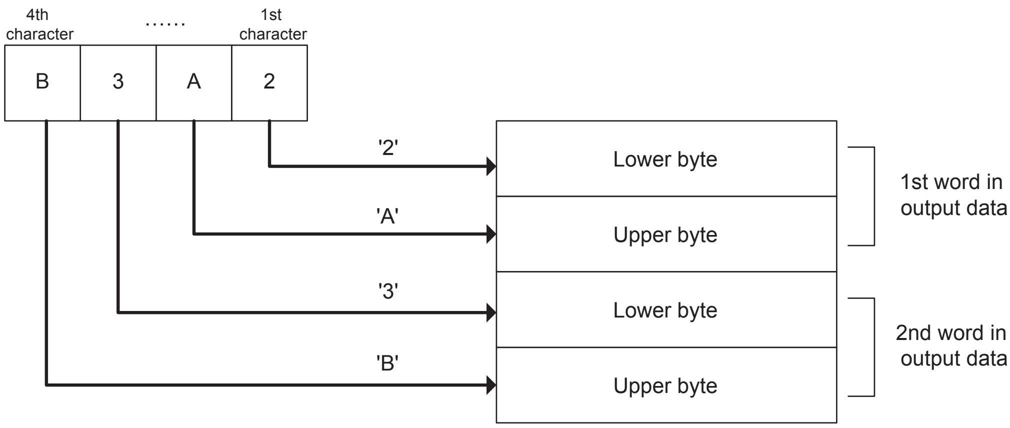
5.3.22 ASCII Conversion 2 (BINASC)

(1) Operation

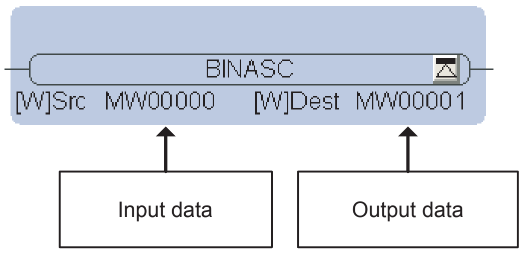
The 16-bit binary data stored in the 1-word input data is converted to four-digit hexadecimal ASCII and stored in the 2-word output data.



■ Storage Location of ASCII Values for Input Data of 10,811(2A3B hex)



(2) Format



Icon: 

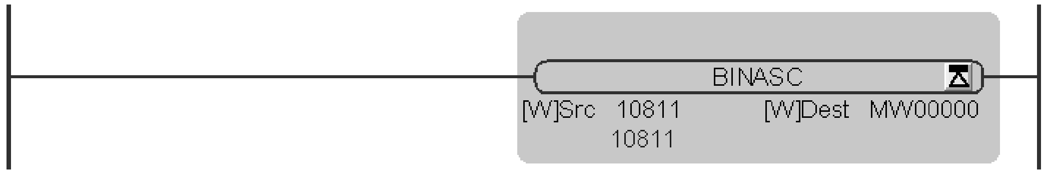
Key entry: BINASC

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	×	×	×	×	○
Output data (Dest)	×	○*	×	×	×	×	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, 10,811 (2A3B hex) in the input data is converted to ASCII and stored in the output data in MW00000.



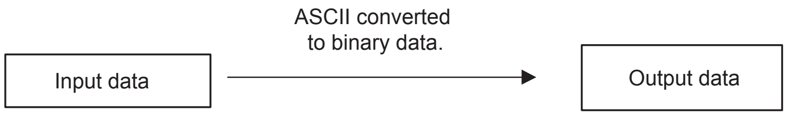
The ASCII values are stored as given in the following table.

Address	ASCII Value	Character
MW00000 (lower byte)	32 hex	2
MW00000 (upper byte)	41 hex	A
MW00001 (lower byte)	33 hex	3
MW00001 (upper byte)	42 hex	B

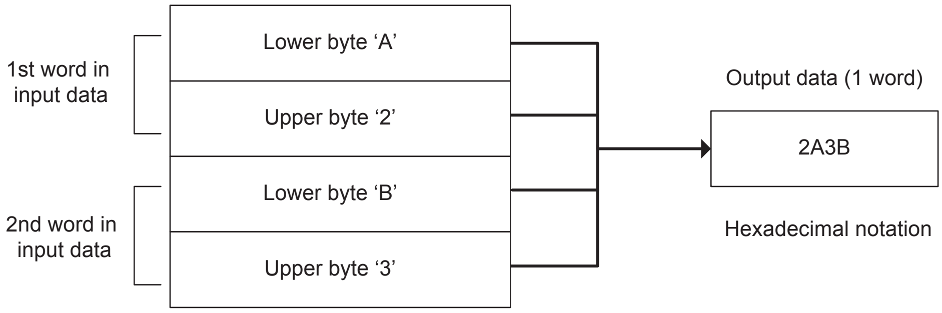
5.3.23 ASCII Conversion 3 (ASCBIN)

(1) Operation

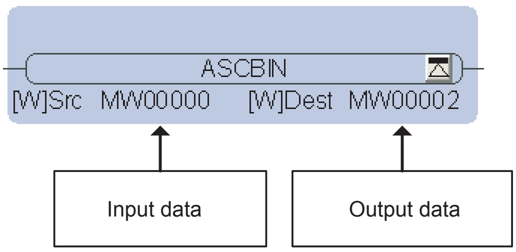
The value given in 4-digit hexadecimal ASCII and stored in the 2-word input data is converted to 16-bit binary data and stored in 1-word output data.



■ Output Data When First Word of Input Data Is 4132 Hex (‘2’ ‘A’) and Second Word Is 4232 Hex (‘3’ ‘B’)



(2) Format



Icon: 

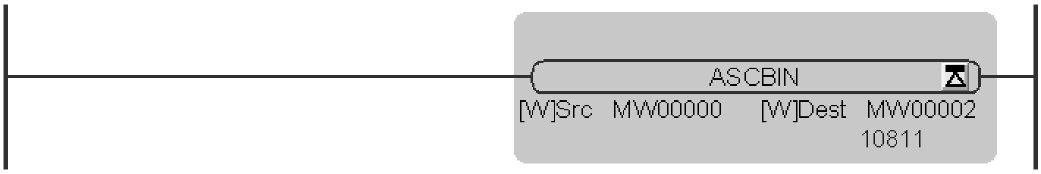
Key entry: ASCBIN

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	×	×	×	×	○
Output data (Dest)	×	○*	×	×	×	×	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the ASCBIN instruction is used to store the input data in MW00000 in the output data in MW00002.



The ASCII values are stored as given in the following table.

Address	ASCII Value	Character
MW00000 (lower byte)	32 hex	2
MW00000 (upper byte)	41 hex	A
MW00001 (lower byte)	33 hex	B
MW00001 (upper byte)	42 hex	3

The output data in MW00000 is set to 10,811 (2A3B hex).

5.4 Logic Operations and Comparison Instructions

5.4.1 Inclusive AND (AND)

(1) Operation

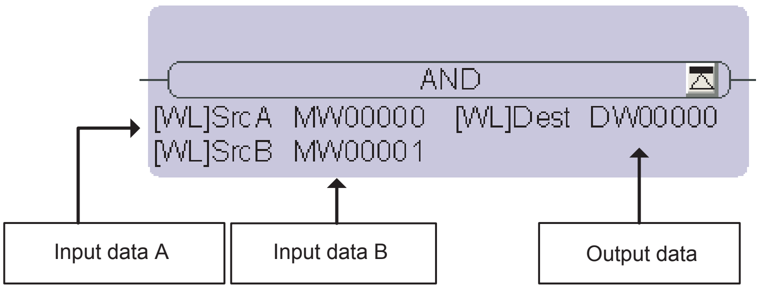
The AND instruction performs a logical AND operation on input data A and input data B and the result is stored in the output data.
This instruction can be used only with integer or double-length integer data.

Input data A | Inclusive AND (AND) | Input data B → Output data

Each bit in the input data is evaluated as shown in the following truth table.

Input data A	Input data B	Output data
0	0	0
0	1	0
1	0	0
1	1	1

(2) Format



Icon: 

Key entry: &

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○
Output data (Dest)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

Instructions

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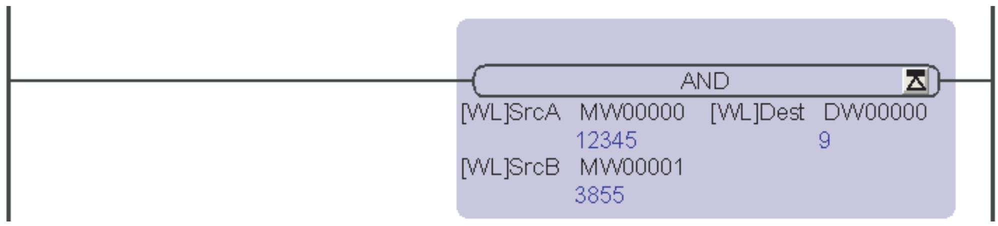
(3) Programming Example

In the following programming example, a logical AND is performed on 12,345 (3039 hex) in input data A in MW00000 and 3,855 (0F0F hex) in input data B in MW00001, and the result is stored in the output data in DW00000.

	Bit F			Bit C	Bit B			Bit 8	Bit 7			Bit 4	Bit 3			Bit 0
MW00000 : 12,345 (3039 hex)	0	0	1	1	0	0	0	0	0	0	1	1	1	0	0	1
MW00001 : 3,855 (0F0F hex)	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1

MW00000 & MW00001 → DW00000

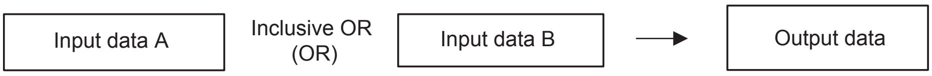
DW00000 : 9 (0009 hex)	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1



5.4.2 Inclusive OR (OR)

(1) Operation

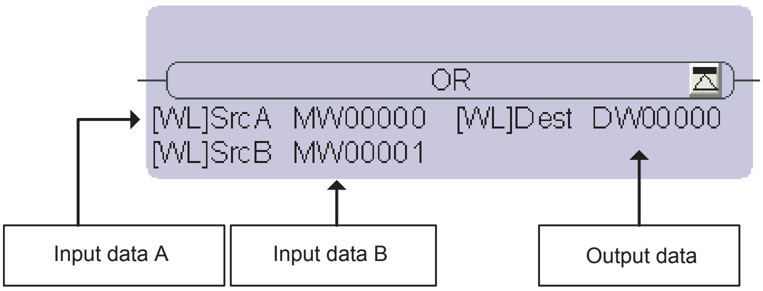
The OR instruction performs a logical OR operation on input data A and input data B and the result is stored in the output data.
This instruction can be used only with integer or double-length integer data.



Each bit in the input data is evaluated as shown in the following truth table.

Input data A	Input data B	Output data
0	0	0
0	1	1
1	0	1
1	1	1

(2) Format



Icon: 

Key entry: |

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○
Output data (Dest)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

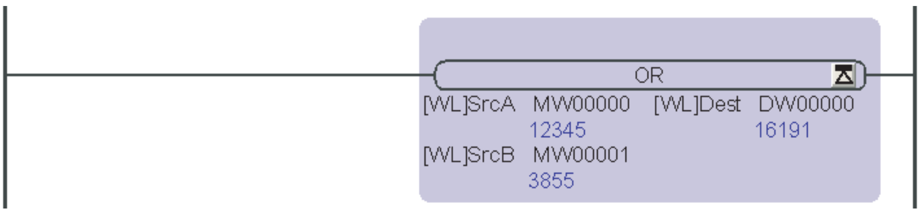
(3) Programming Example

In the following programming example, a logical OR is performed on 12,345 (3039 hex) in input data A in MW00000 and 3,855 (0F0F hex) in input data B in MW00001, and the result is stored in the output data in DW00000.

	Bit F			Bit C	Bit B			Bit 8	Bit 7			Bit 4	Bit 3			Bit 0
MW00000 : 12,345 (3039 hex)	0	0	1	1	0	0	0	0	0	0	1	1	1	0	0	1
MW00001 : 3,855 (0F0F hex)	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1

MW00000 | MW00001 → DW00000

DW00000 : 16,191 (3F3F hex)	0	0	1	1	1	1	1	1	0	0	1	1	1	1	1	1



5.4.3 Exclusive OR (XOR)

(1) Operation

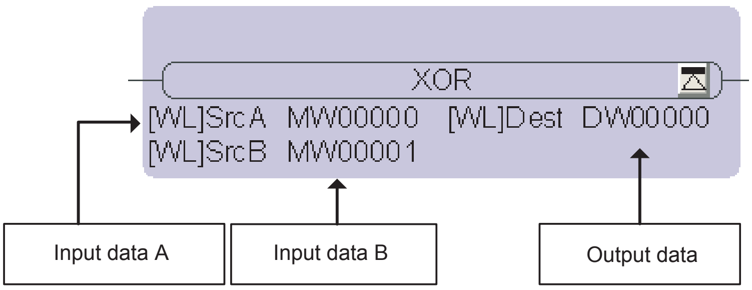
The XOR instruction performs an exclusive logical OR operation on input data A and input data B and the result is stored in the output data.
This instruction can be used only with integer or double-length integer data.

Input data A Exclusive OR (XOR) Input data B → Output data

Each bit in the input data is evaluated as shown in the following truth table.

Input data A	Input data B	Output data
0	0	0
0	1	1
1	0	1
1	1	0

(2) Format



Icon: 

Key entry: ^

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○
Output data (Dest)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

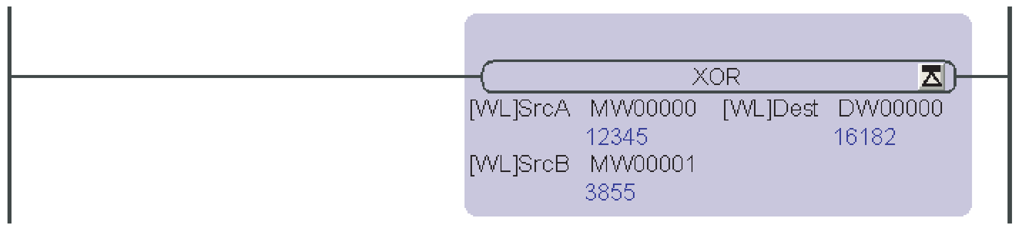
(3) Programming Example

In the following programming example, an exclusive logical OR is performed on 12,345 (3039 hex) in input data A in MW00000 and 3,855 (0F0F hex) in input data B in MW00001, and the result is stored in the output data in DW00000.

	Bit F			Bit C	Bit B			Bit 8	Bit 7			Bit 4	Bit 3			Bit 0
MW00000 : 12,345 (3039 hex)	0	0	1	1	0	0	0	0	0	0	1	1	1	0	0	1
MW00001 : 3,855 (0F0F hex)	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1

MW00000 ^ MW00001 → DW00000

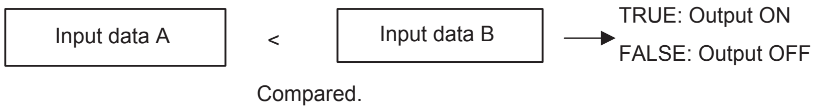
DW00000 : 16,182 (3F36 hex)	0	0	1	1	1	1	1	1	0	0	1	1	0	1	1	0



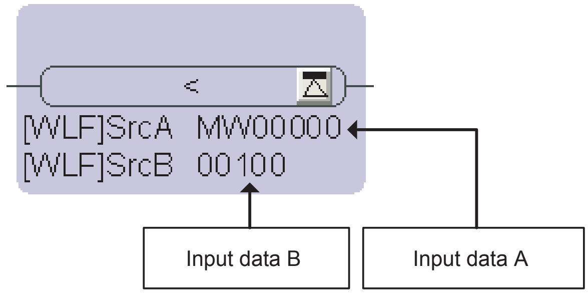
5.4.4 Less Than (<)

(1) Operation

Input data A and input data B are compared and the result is stored in the bit output.



(2) Format



Icon: 

Key entry: <

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○

(3) Programming Example

In the following programming example, the INC instruction on the right end of the line is executed because the comparison is true and turns the output ON; that is, input data A is less than input data B when input data A in MW00000 is 90 and input data B is 100.

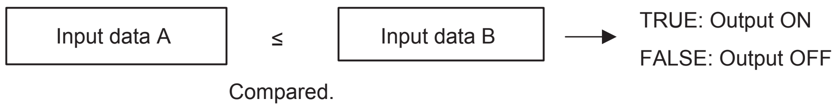
INFO

With real number data, the value displayed by the MPE720 may not match the execution result of the comparison instruction due to a slight precision error.

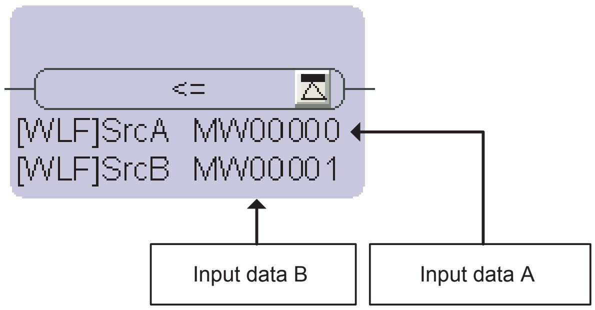
5.4.5 Less Than or Equal (≤)

(1) Operation

Input data A and input data B are compared and the result is stored in the bit output.



(2) Format



Icon: 

Key entry: <=

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○

(3) Programming Example

In the following programming example, the INC instruction on the right end of the line is not executed because the comparison is false and turns the output OFF; that is, input data A is not less than or equal to input data B when input data A in MW00000 is 101 and input data B is 100.

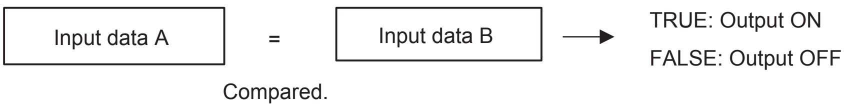
INFO

With real number data, the value displayed by the MPE720 may not match the execution result of the comparison instruction due to a slight precision error.

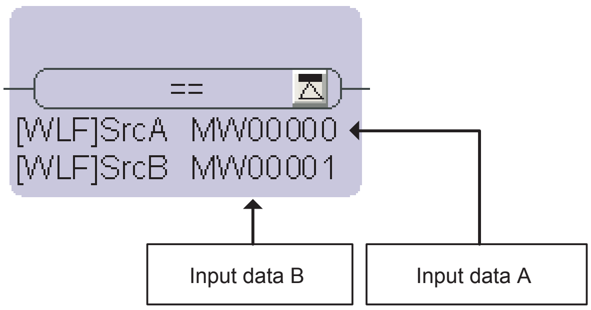
5.4.6 Equal (=)

(1) Operation

Input data A and input data B are compared and the result is stored in the bit output.



(2) Format



Icon: =

Key entry: =

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○

(3) Programming Example

In the following programming example, the INC instruction on the right end of the line is executed because the comparison is true and turns the output ON; that is, input data A is equal to input data B when input data A in MW00000 is 100 and input data B is 100.

INFO

With real number data, the value displayed by the MPE720 may not match the execution result of the comparison instruction due to a slight precision error.

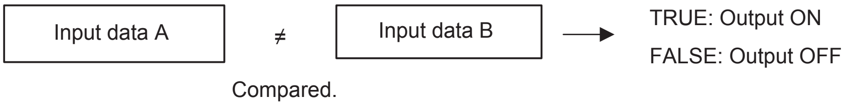
Instructions

5

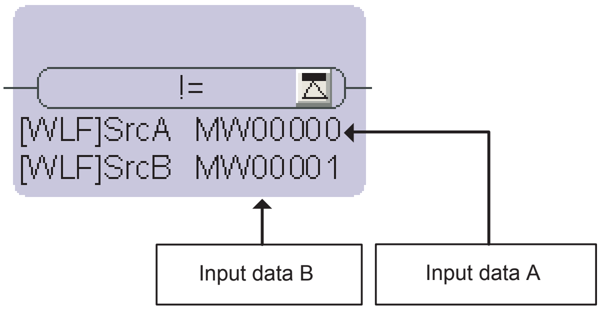
5.4.7 Not Equal (≠)

(1) Operation

Input data A and input data B are compared and the result is stored in the bit output.



(2) Format



Icon: 

Key entry: <>

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○

(3) Programming Example

In the following programming example, the INC instruction on the right end of the line is not executed because the comparison is false and turns the output OFF; that is, input data A is equal to input data B when input data A in MW00000 is 100 and input data B is 100.

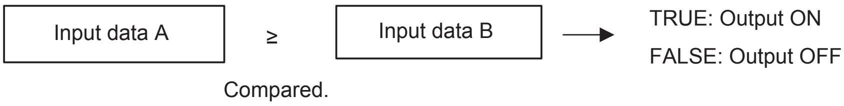
INFO

With real number data, the value displayed by the MPE720 may not match the execution result of the comparison instruction due to a slight precision error.

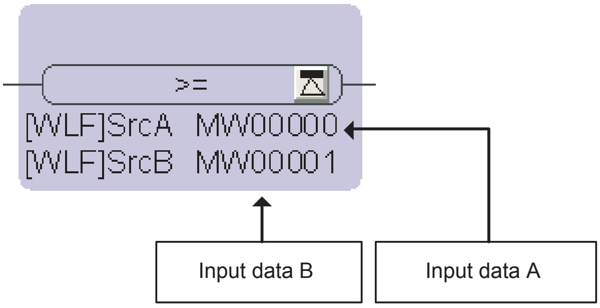
5.4.8 Greater Than or Equal (≥)

(1) Operation

Input data A and input data B are compared and the result is stored in the bit output.



(2) Format



Icon: 

Key entry: >=

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○

(3) Programming Example

In the following programming example, the INC instruction on the right end of the line is executed because the comparison is true and turns the output ON; that is, input data A is greater than or equal to input data B when input data A in MW00000 is 100 and input data B is 100.

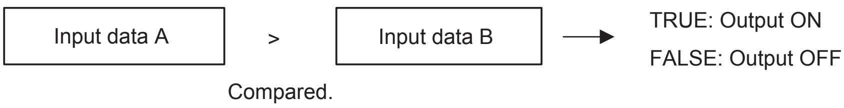
INFO

With real number data, the value displayed by the MPE720 may not match the execution result of the comparison instruction due to a slight precision error.

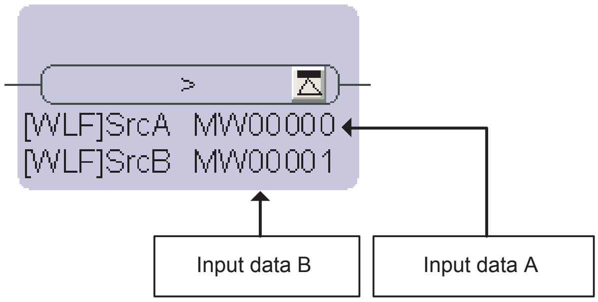
5.4.9 Greater Than (>)

(1) Operation

Input data A and input data B are compared and the result is stored in the bit output.



(2) Format



Icon: 

Key entry: >

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data A (SrcA)	×	○	○	○	×	○	○
Input data B (SrcB)	×	○	○	○	×	○	○

(3) Programming Example

In the following programming example, the INC instruction on the right end of the line is not executed because the comparison is false and turns the output OFF; that is, input data A is not greater than input data B when input data A in MW00000 is 100 and input data B is 100.

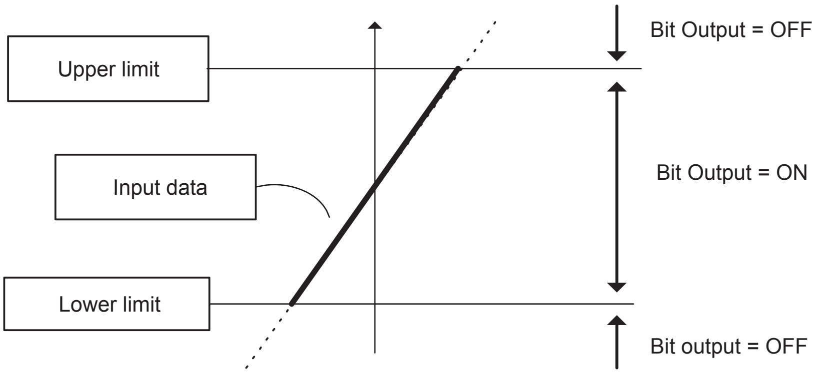
INFO

With real number data, the value displayed by the MPE720 may not match the execution result of the comparison instruction due to a slight precision error.

5.4.10 Range Check (RCHK)

(1) Operation

The RCHK instruction checks to see if the input data is between the upper limit and lower limit and the result is stored in the bit output.



[a] Bit Output = ON

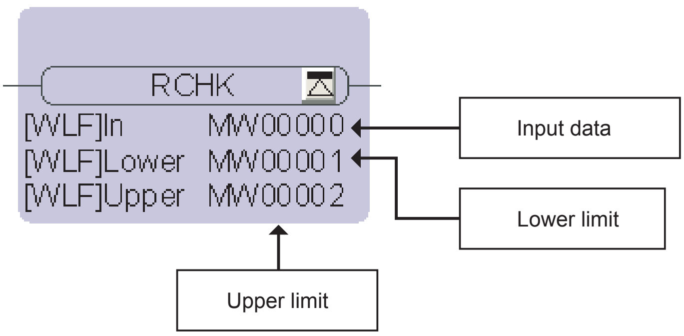
The bit output is turned ON if the value of the input data is within the range that is greater than or equal to the lower limit, and less than or equal to the upper limit.

Lower limit ≤ Input data ≤ Upper limit

[b] Bit Output = OFF

The bit output is turned OFF if the value of the input data is outside the range that is greater than or equal to the lower limit, and less than or equal to the upper limit.

(2) Format



Icon: 

Key entry: RCHK

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (In)	×	○	○	○	×	○	○
Lower limit (Lower)	×	○	○	○	×	○	○
Upper limit (Upper)	×	○	○	○	×	○	○

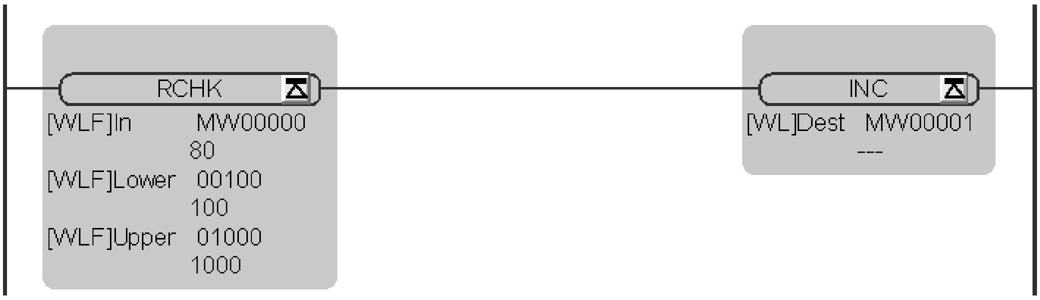
INFO

Always set the lower limit to a value that is less than or equal to the upper limit. If the lower limit is greater than the upper limit, the result will be invalid.

(3) Programming Examples

The following programming examples execute the RCHK instruction.

- When Input Data (MW00000) = 80, Lower Limit = 100, and Upper Limit = 1,000
  The INC instruction on the right end of the line is not executed because the input data is less than the lower limit and turns the bit output OFF.



- When Input Data (MW00000) = 500, Lower Limit = 100, and Upper Limit = 1,000
  The INC instruction on the right end of the line is executed because the value of the input data is within the range that is greater than or equal to the lower limit and less than or equal to the upper limit, which turns ON the bit output.

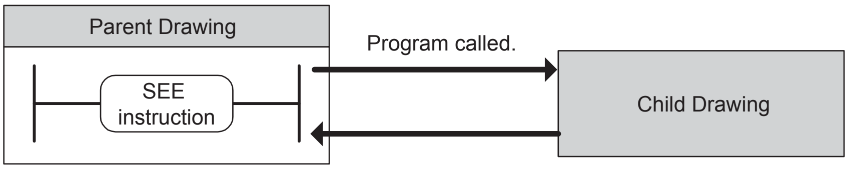
- When Input Data (MW00000) = 1,000, Lower Limit = 100, and Upper Limit = 1,000
  The INC instruction on the right end of the line is executed because the value of the input data is within the range that is greater than or equal to the lower limit and less than or equal to the upper limit, which turns ON the bit output.

5.5 Program Control Instructions

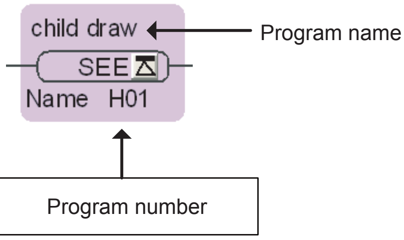
5.5.1 Call Sequence Program (SEE)

(1) Operation

The SEE instruction calls a child drawing from a parent drawing, or a grandchild drawing from a child drawing.



(2) Format



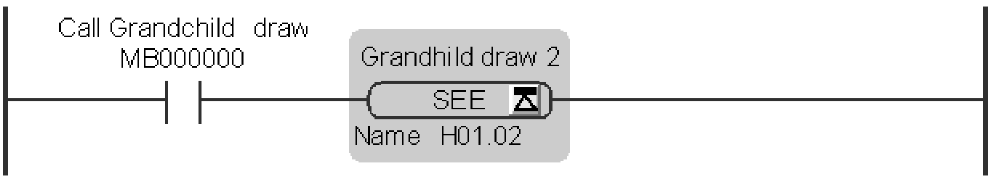
Icon: SEE

Key entry: SEE

Parameter Name	Applicable Data Types
Program number (Name)	Registers cannot be used. Specify the program number directly. The name of the specified program appears above the instruction.

(3) Programming Example

In the following programming example, the SEE instruction calls drawing H01.02 when the MB000000 relay is ON. Thereafter, the process is executed and execution resumes from the next step after the SEE instruction. The SEE instruction does not call drawing H01.02 if the MB000000 relay is OFF.



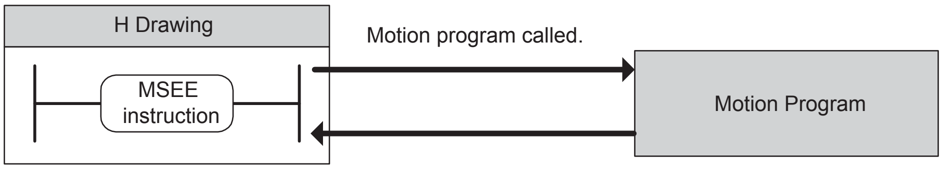
Instructions

5

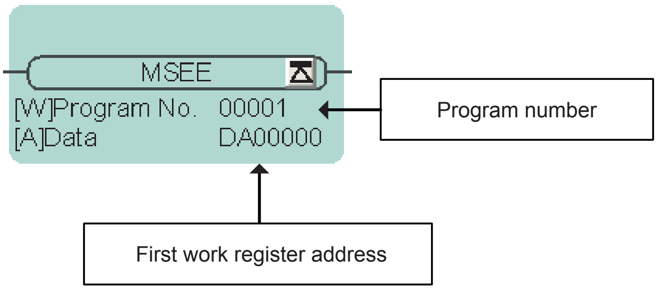
5.5.2 Call Motion Program (MSEE)

(1) Operation

The MSEE instruction calls the specified motion program.
Motion programs can be called only from H drawings.



(2) Format



Icon: 

Key entry: MSEE

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Program number (Program No.)	×	○*	×	×	×	×	○
First work register address (Data)	×	×	×	×	○*	×	×

* M or D register only.

■ Work Register Configuration

Address	Data Type	Name	Description	I/O
0	W	Status Flags	Motion program status flags	OUT
1	W	Control Signals	Motion program control signals	IN
2	W	Interpolation Override	The override is used when executing interpolation instructions. Range: 0 to 32,767 Unit: 1 = 0.01%	IN
3	W	System Work Number	This is the system work number that calls the motion program.	IN

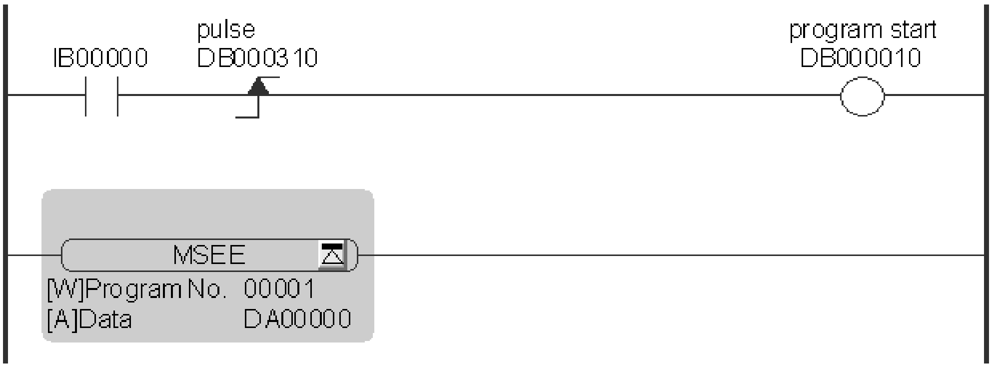
INFO

Specify the program number from 1 to 256.
For details on motion programs, refer to the *Machine Controller MP2000 Series User's Manual for Motion Programming* (Manual No.: SIEP C880700 38).

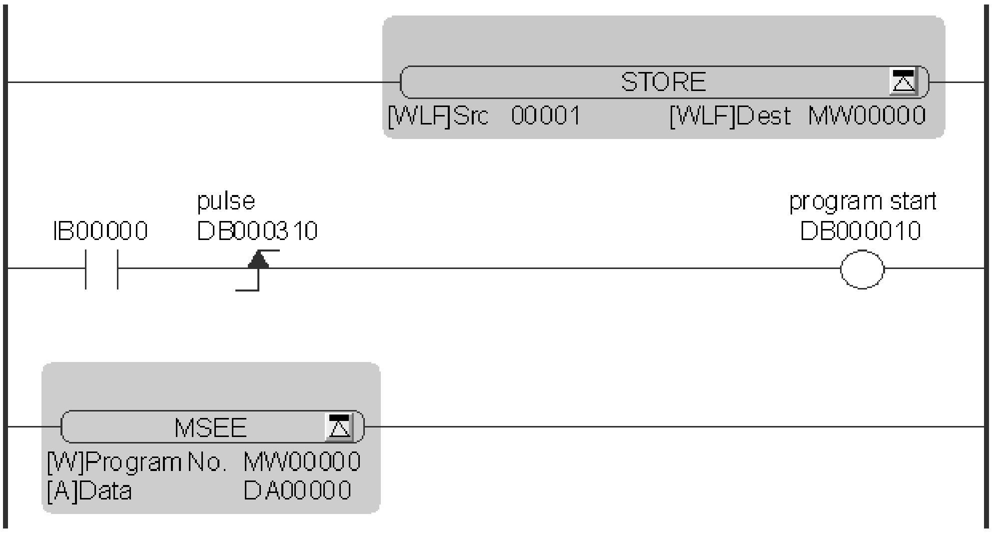
(3) Programming Examples

The following programming examples show how to execute the motion program MPM001 with program number 1. When the IB00000 relay turns ON, the Request for Start of Program Operation (DB000010) in the control signals turns ON and executes the MPM001 motion program.

- Direct Designation
  The program number is directly set to 1.



- Indirect Designation
  The program number is set in MW00000.



IMPORTANT

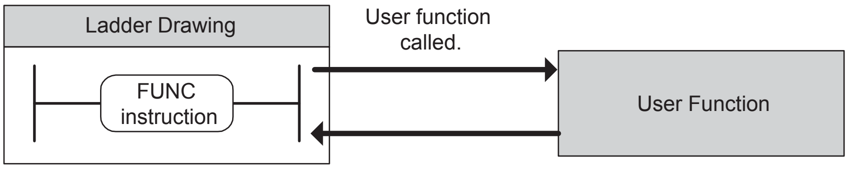
Continue execution of the MSEE instruction until execution of the motion program is completed.

When using indirect designation, do not change the register value until the execution of the motion program is completed.

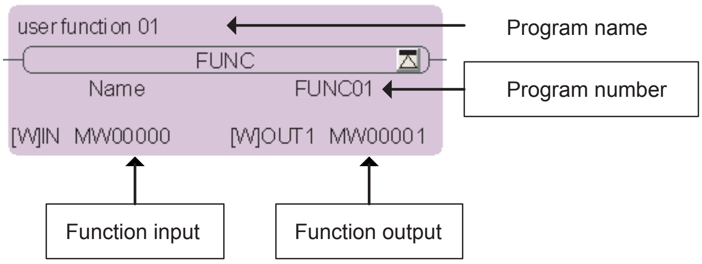
5.5.3 Call User Function (FUNC)

(1) Operation

The FUNC instruction calls a user function. The user function must be defined before it can be called.
Refer to *4.3 User Functions* for details on user functions.



(2) Format



Icon: FUNC

Key entry: FUNC

Parameter Name	Applicable Data Types
Program number (Name)	Registers cannot be used. Specify the program number directly. The name of the specified program appears above the instruction.
Function input	The register that is set in the function's input definition can be used.
Function output	The register that is set in the function's output definition can be used.

(3) Programming Example

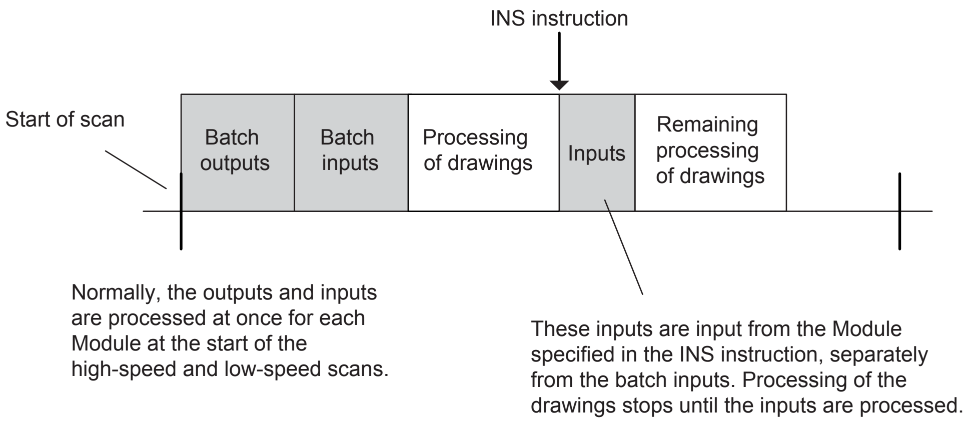
Refer to *4.3 User Functions* for programming examples for user functions.

5.5.4 Direct Input String (INS)

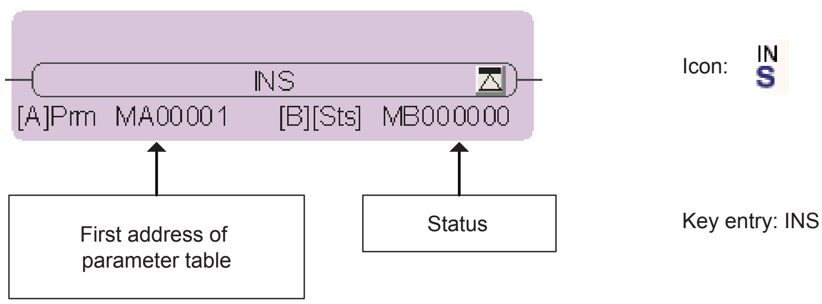
(1) Operation

The INS instruction is executed in user programs to input data independently from the I/O batch processing that is performed by the system at the start of the high-speed and low-speed scans. When the INS instruction is executed, the inputs from the specified Module are processed according to the settings in a parameter table. The next instruction is not executed until input processing is completed.
The following Modules can be specified.

- CPU Module (IO)
- LIO-01/02 Module (LIO)
- LIO-04/05 Module (LIO32)
- LIO-06 Module (MIXIO)
- AI-01 Module (AI)



(2) Format



Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First address of parameter table (Prm)	×	×	×	×	○*1	×	×
Status (Sts)*2	○*1	×	×	×	×	×	×

∗ 1. C and # registers cannot be used.
∗ 2. Optional.

■ Parameter Table Configuration

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RSSEL	Unit selection 1	Specify the Module to input from.	IN
1	W	MDSEL	Unit selection 2		IN
2	W	STS	Status	Each bit receives the input status for one word. 0: Normal, 1: Error	OUT
3	W	N	Number of words	Specify the number of continuous words.	IN
4	W	ID1	Input data 1	Receives the data that was input. Contains 0 if an error occurs.	OUT
:	:	:	:		:
N + 3	W	IDN	Input data N		OUT

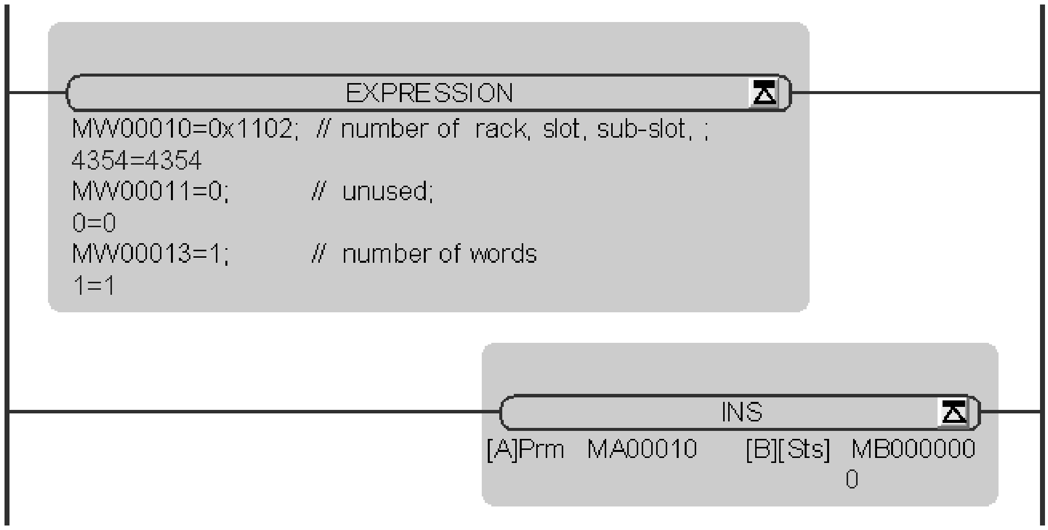
The following table gives details about the parameters in the MP2000-series Controller.

Parameter \ Module Name	CPU (IO)	LIO-01/02 (LIO)	LIO-04/05 (LIO32)	LIO-06 (MIXIO)	AI-01 (AI)
RSSEL	Specify the rack, slot, and subslot of the target Module. Hexadecimal notation: zxyy hex x: Rack number from 1 to 4 yy: Slot number from 0 to 9 z: Subslot number from 1 to maximum value (determined by Module specifications)				
MDSEL	0 (Not used.)	0 (Not used.)	Offset: 0 or 1	Channel number - 1: 0 or 1	Channel number - 1: 0 to 7
STS	Always 0.	Always 0.	Always 0.	Always 0.	*
N	1	1	1 or 2 – MDSEL	1 or 2 – MDSEL	1 to 8 – MDSEL

* If a channel for which the allocation has been deleted in the AI Module detailed definition is specified for the INS instruction, the applicable channel number is output for the bit. This is because it is not possible to read the data on channels for which allocations have been deleted.
The relation between bits and channels is shown below.
Bit 0: Channel 1
Bit 1: Channel 2
Bit 2: Channel 3
Bit 3: Channel 4
Bit 4: Channel 5
Bit 5: Channel 6
Bit 6: Channel 7
Bit 7: Channel 8

(3) Programming Example

When one word is input from the LIO at subslot number 1 on the LIO-01 Module mounted in rack 1 and slot 2, the input data of the LIO is stored in MW00014.



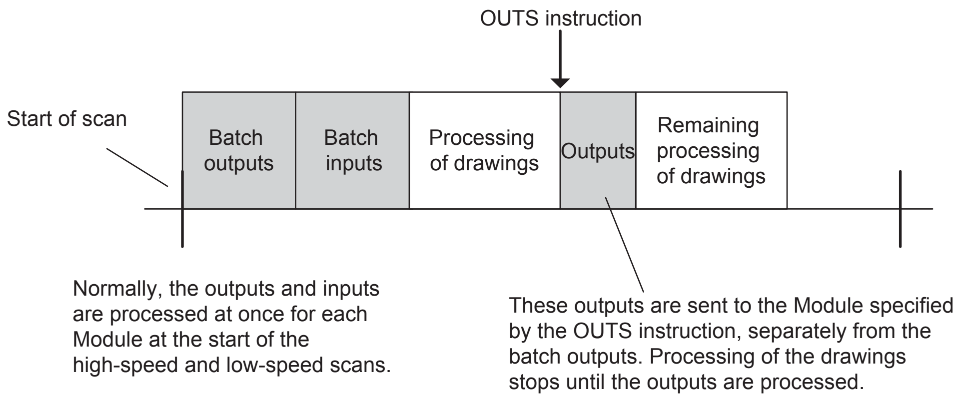
5.5.5 Direct Output String (OUTS)

(1) Operation

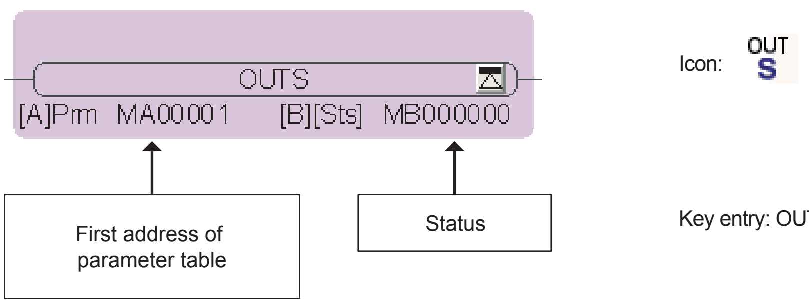
The OUTS instruction is executed in user programs to output data independently from the I/O batch processing that is performed by the system at the start of the high-speed and low-speed scans. When the OUTS instruction is executed, the outputs from the specified Module are processed according to the settings in the parameter table.

The following Modules can be specified.

- CPU Module (IO)
- LIO-01/02 (LIO)
- LIO-04/05 (LIO32)
- LIO-06 (MIXIO)
- DO-01 (DO)
- AO-01 (AO)



(2) Format



Key entry: OUTS

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First address of parameter table (Prm)	×	×	×	×	○*1	×	×
Status (Sts)*2	○*1	×	×	×	×	×	×

∗ 1. C and # registers cannot be used.
∗ 2. Optional.

■ Parameter Table Configuration

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RSSEL	Unit selection 1	Specify the Module to output to.	IN
1	W	MDSEL	Unit selection 2		IN
2	W	STS	Status	Each bit receives the input status for one word. 0: Normal, 1: Error	OUT
3	W	N	Number of words	Specify the number of output words (always 1).	IN
4	W	OD1	Output data 1	Specify the data to output.	OUT
:	:	:	:		:
N + 3	W	ODN	Output data N		OUT

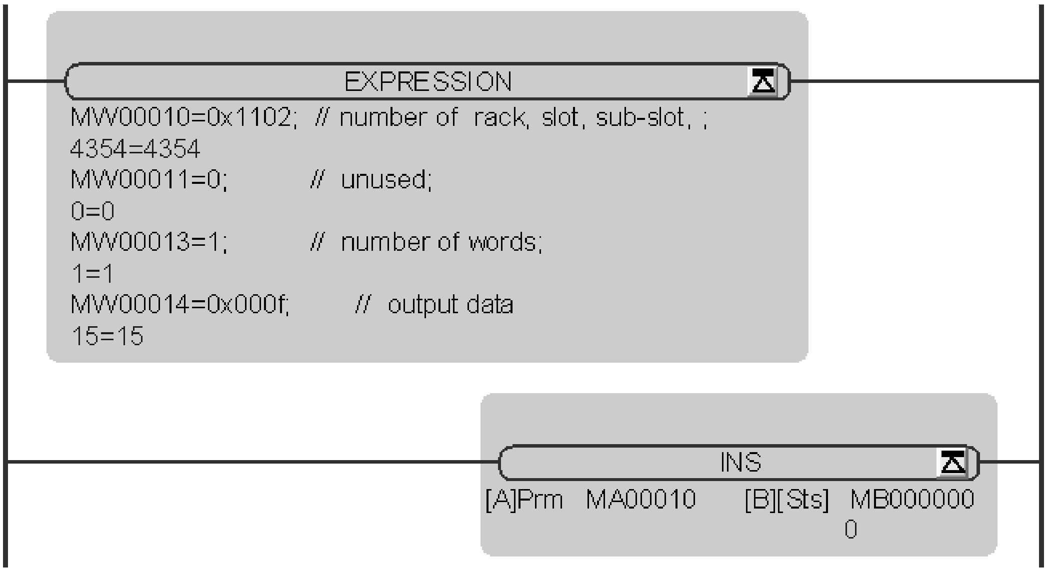
The following table gives details about the parameters in the MP2000-series Controller.

Parameter \ Module Name	CPU (IO)	LIO-01/02 (LIO)	LIO-04/05 (LIO32)	LIO-06 (MIXIO)	DO-01 (DO)	AO-01 (AO)
RSSEL	Specify the rack, slot, and subslot of the target Module. Hexadecimal notation: zxyy hex x: Rack number from 1 to 4 yy: Slot number from 0 to 9 z: Subslot number from 1 to maximum value (determined by Module specifications)					
MDSEL	0 (Not used.)	0 (Not used.)	Offset: 0 or 1	Offset: 0 or 1	Offset: 0 to 3	Channel number - 1: 0 to 3
STS	Always 0.	Always 0.	Always 0.	Always 0.	Always 0.	*
N	1	1	1 or 2 – MDSEL	1 or 2 – MDSEL	1 to 4 – MDSEL	1 to 4 – MDSEL

* If a channel for which the allocation has been deleted in the AO Module detailed definition is specified for the OUTS instruction, the applicable channel number is output for the bit. This is because it is not possible to read the data on channels for which allocations have been deleted.
The relation between bits and channels is shown below.
Bit 0: Channel 1
Bit 1: Channel 2
Bit 2: Channel 3
Bit 3: Channel 4

(3) Programming Example

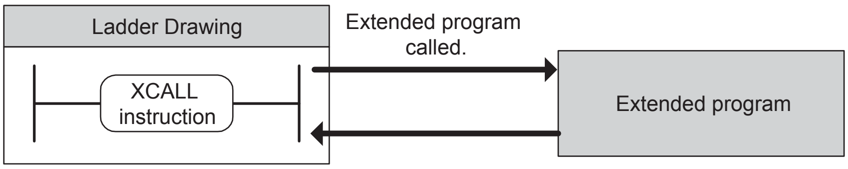
When one word is output to the LIO at subslot number 1 on the LIO-01 Module mounted in rack 1 and slot 2, the data in MW00014 is output to LIO.



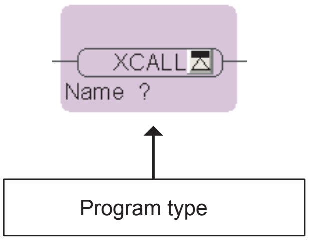
5.5.6 Call Extended Program (XCALL)

(1) Operation

An extended program (i.e., a table program, such as a constants table, an I/O conversion table, an interlock table, or a part composition table) is executed. The MPE720 converts the extended program into a ladder program. Converted ladder programs can be executed with the XCALL instruction.
Although more than one XCALL instruction can be used in a single drawing, the same extended program cannot be called more than once.



(2) Format



Icon: 

Key entry: XCALL

Parameter Name	Applicable Data Types
Program type (Name)	Registers cannot be used. Specify the following type. • MCTBL: Constants table • IOTBL: I/O conversion table* • ILKTBL: Interlock table* • ASMTBL: Part composition table*

* I/O conversion tables, interlock tables, and part composition tables are not supported by MPE720 version 6. Use MPE720 version 5 if you have created these types of tables.

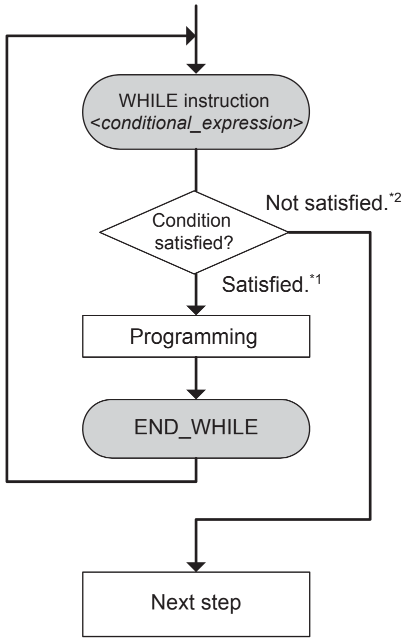
(3) Programming Example

This example shows how to call an MCTBL constants table.

5.5.7 WHILE Construct (WHILE, END_WHILE)

(1) Operation

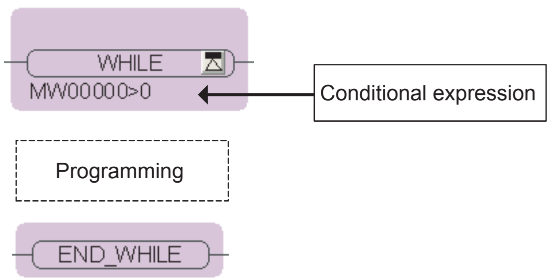
The programming between the WHILE and END_WHILE instructions are executed when the conditional expression for the WHILE instruction is satisfied. After the last line is executed, program execution returns to the WHILE instruction. Execution of the programming is repeated for as long as the conditional expression is satisfied.
If the conditional expression is not satisfied, program execution jumps to the next step following the END_WHILE instruction. None of the programming between the WHILE and END_WHILE instructions is executed.



* 1. The programming is executed and then execution returns to the WHILE instruction.
* 2. The programming is not executed and execution jumps to the next step.

(2) Format

Icon: 



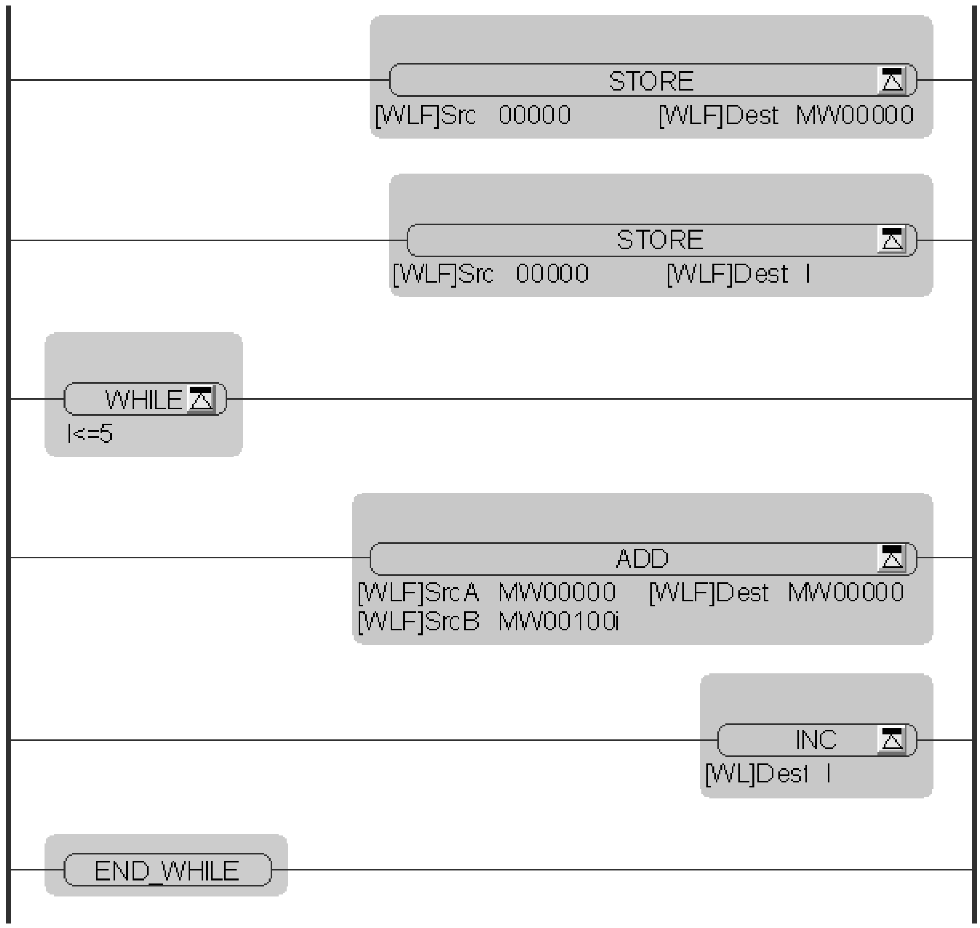
Key entry: WHILE, WEND

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Conditional expression	O*	O*	O*	O*	×	O*	O*

* Write with the format for an EXPRESSION instruction.
Refer to *Chapter D Format for EXPRESSION Instruction* for details on the format used to write the expression.

(3) Programming Example

In the following programming example, the registers from MW00100 to MW00105 are added together and stored in the MW00000 register.
The conditional expression is I ≤ 5, so the ADD instruction is executed while I is 0 to 5.
The conditional expression is no longer satisfied when I is 6, so program execution jumps to the next step following the END_WHILE instruction.



IMPORTANT

Execution of the programming is repeated for as long as the conditional expression for the WHILE instruction is satisfied.

If the conditional expression never becomes unsatisfied, or if it takes too much time to become unsatisfied, the Machine Controller system will shut down.

In the example given above, an endless loop would occur if the programming did not include the instruction that increments I.

(4) Additional Information

[a] Applicable Conditional Expressions

The conditional expression for a WHILE instruction must be written with the format for an EXPRESSION instruction to produce a Boolean (TRUE or FALSE) result. Numerical expressions that include substitution operators will not be recognized.

Expression Example	Notation	Remarks
MB000001 == true	OK	TRUE: 1 (ON)
MB000001 != false	OK	FALSE: 0 (OFF)
MW00002 < 100	OK	–
MF00002 < sin(60.0)	OK	–
MW00001 == 0x00FF OK	OK	Prefix hexadecimal values with 0x.
MB000001 = true	NG	–
MW00001 = MW00002	NG	–

* Refer to *Appendix D Format for EXPRESSION Instruction* for details on applicable instructions, operation order, and notation conventions.

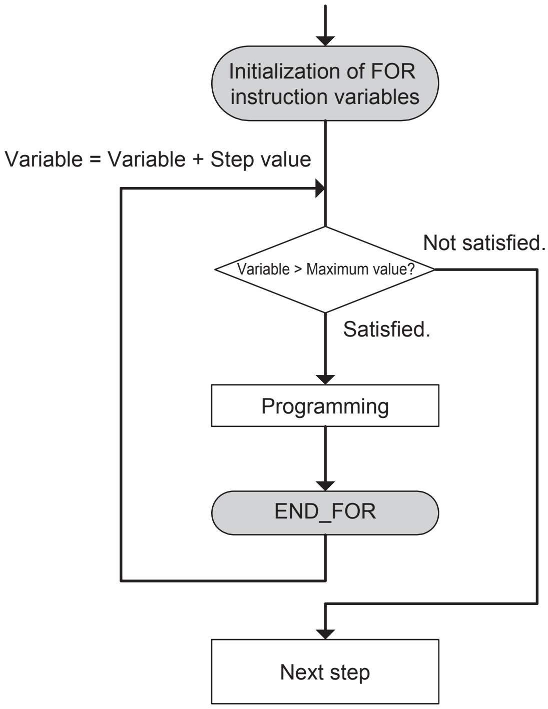
[b] Nesting Depth

The FOR, WHILE, and IF constructs can contain other constructs. This is called nesting. The maximum depth of a nested structure that uses FOR, WHILE, and IF statements is limited to 8 levels.
If an instruction is preceded by a contact, it is treated like an IF construct and is included in the number of nesting levels.

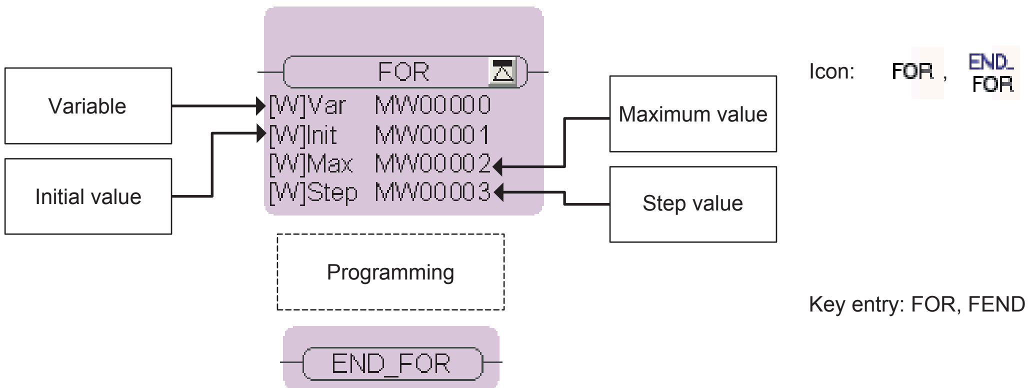
5.5.8 FOR Construct (FOR, END_FOR)

(1) Operation

The programming between the FOR and END_FOR instructions is repeatedly executed.
The initial value starts with the value in a register specified as the variable. This variable is incremented by the step value each time execution is repeated.
The conditional expression for the FOR instruction is no longer satisfied when the value of the variable exceeds the maximum value, so program execution jumps to the next step.



(2) Format



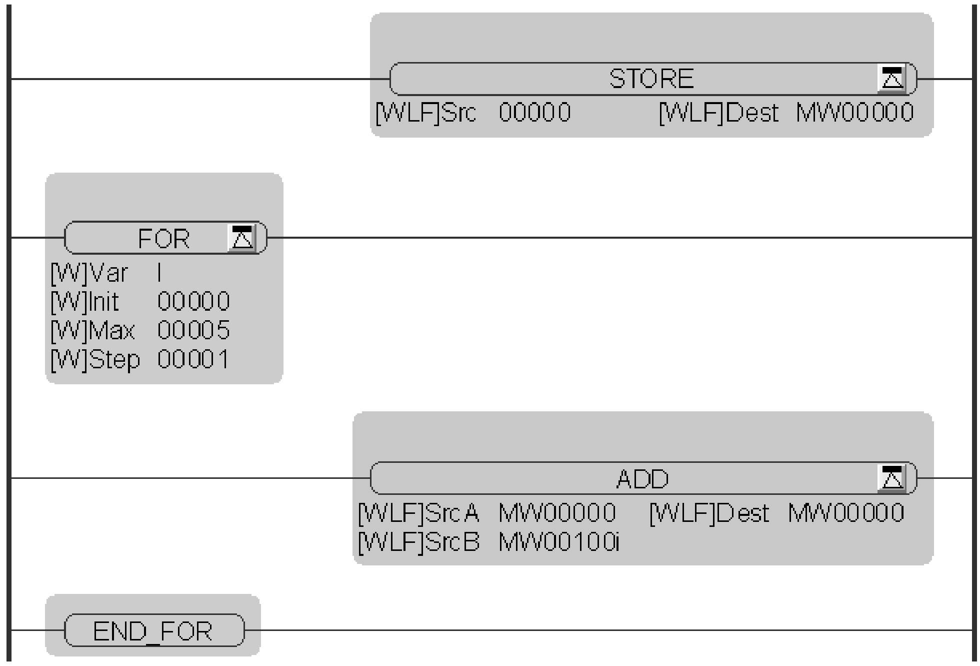
Key entry: FOR, FEND

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Variable (Var)	×	○*	×	×	×	○	×
Initial value (Init)	×	○	×	×	×	○	○
Maximum value (Max)	×	○	×	×	×	○	○
Step value (Step)	×	○	×	×	×	○	○

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the registers from MW00100 to MW00105 are added together and stored in the MW00000 register.
In this example, variable I is initialized to 0 by storing 0. Thereafter, the ADD instruction is executed until variable I exceeds the maximum value of 5. The conditional expression is no longer satisfied when I is 6, so program execution jumps to the next step following the END_FOR instruction.



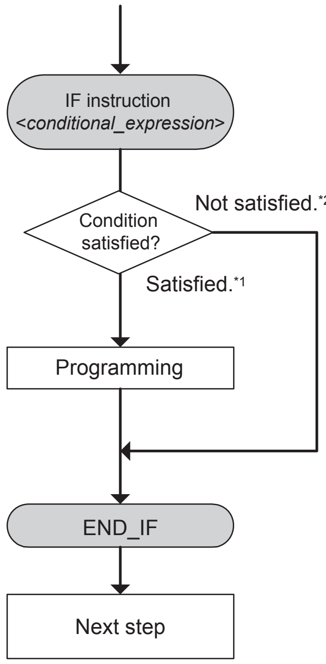
(4) Additional Information

The FOR, WHILE, and IF constructs can contain other constructs. This is called nesting. The maximum depth of a nested structure that uses FOR, WHILE, and IF statements is limited to 8 levels.
If an instruction is preceded by a contact, it is treated like an IF construct and is included in the number of nesting levels.

5.5.9 IF Construct (IF, END_IF)

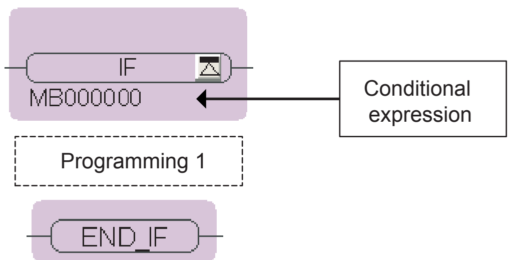
(1) Operation

Execution of the programming between the IF and END_IF instructions is repeated for as long as the conditional expression for the IF instruction is satisfied.
The programming is not executed if the conditional expression is not satisfied.



∗ 1. The programming is executed and execution jumps to the next step.
∗ 2. The programming is not executed and execution jumps to the next step.

(2) Format



Icon: 

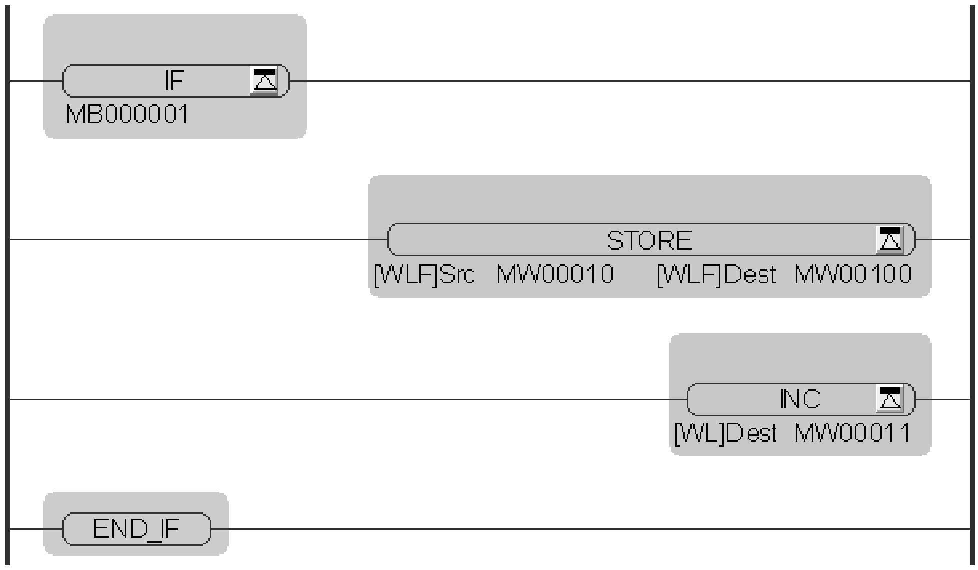
Key entry: IF, IEND

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Conditional expression	O*	O*	O*	O*	×	O*	O*

∗ Write with the format for an EXPRESSION instruction.
Refer to *Appendix D Format for EXPRESSION Instruction* for details on the format used to write the expression.

(3) Programming Example

When the conditional expression (MB000001) for the IF instruction turns ON, the value of MW00010 is set in MW01000 and MW00011 is incremented.



(4) Additional Information

[a] Applicable Conditional Expressions

The conditional expression for an IF instruction must be written with the format for an EXPRESSION instruction to produce a Boolean (TRUE or FALSE) result. Numerical expressions that include substitution operators will not be recognized.

Expression Example	Notation	Remarks
MB000001 == true	OK	TRUE: 1 (ON)
MB000001 != false	OK	FALSE: 0 (OFF)
MW00002 < 100	OK	–
MF00002 < sin(60.0)	OK	–
MW00001 == 0x00FF OK	OK	Prefix hexadecimal values with 0x.
MB000001 = true	NG	–
MW00001 = MW00002	NG	–

* Refer to *Appendix D Format for EXPRESSION Instruction* for details on applicable instructions, operation order, and notation conventions.

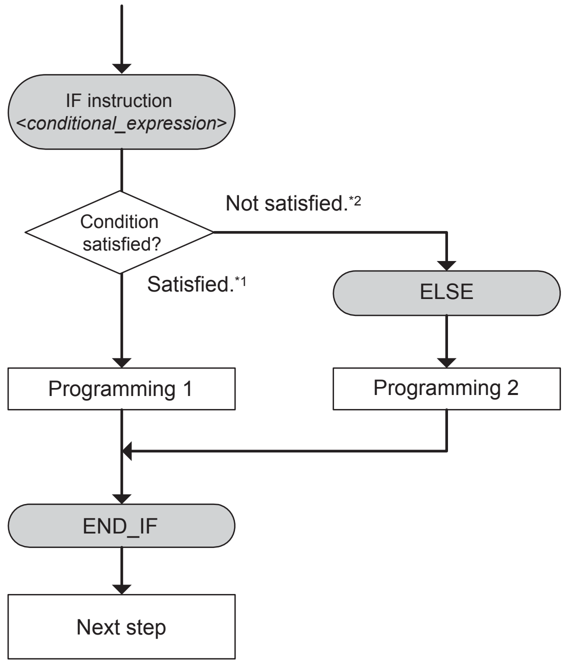
[b] Nesting Depth

The FOR, WHILE, and IF constructs can contain other constructs. This is called nesting. The maximum depth of a nested structure that uses FOR, WHILE, and IF statements is limited to 8 levels.
If an instruction is preceded by a contact, it is treated like an IF construct and is included in the number of nesting levels.

5.5.10 IF-ELSE Construct (IF, ELSE, END_IF)

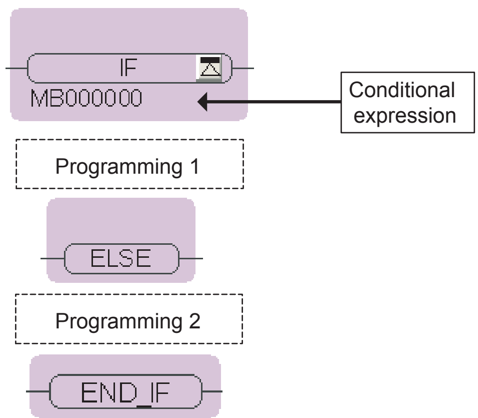
(1) Operation

When the conditional expression for the IF instruction is satisfied, only programming 1 is executed. Programming 2 is not executed.
If the conditional expression is not satisfied, only programming 2 is executed. Programming 1 is not executed.



∗ 1. Programming 1 is executed and execution jumps to the next step.
∗ 2. Programming 2 is executed and execution jumps to the next step.

(2) Format



Icon: 

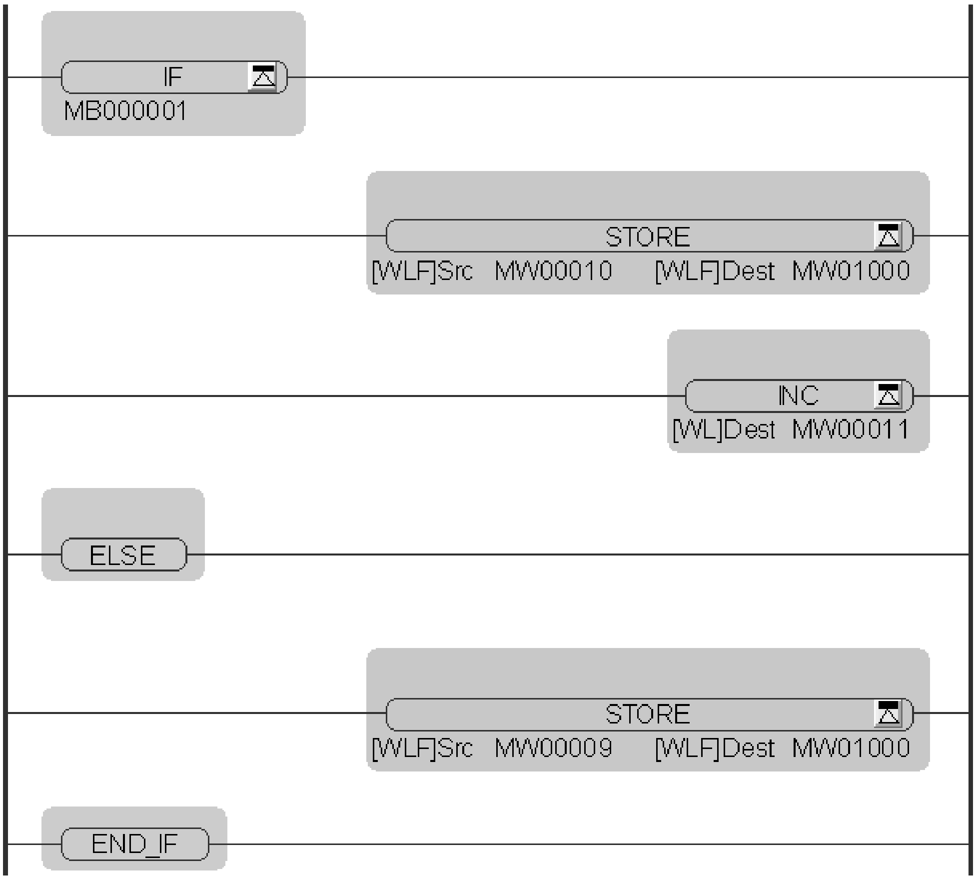
Key entry: IF, ELSE, IEND

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Conditional expression	○*	○*	○*	○*	×	○*	○*

∗ Write with the format for an EXPRESSION instruction.
Refer to *Appendix D Format for EXPRESSION Instruction* for details on the format used to write the expression.

(3) Programming Example

When the conditional expression (MB000001) for the IF instruction turns ON, the value of MW00010 is set in MW01000 and MW00011 is incremented. When the conditional expression (MB000001) for the IF instruction is OFF, the value of MW00009 is set in MW01000.



(4) Additional Information

The conditional expressions that can be used, and the nesting depth is the same as for IF constructs.

5.5.11 Expression (EXPRESSION)

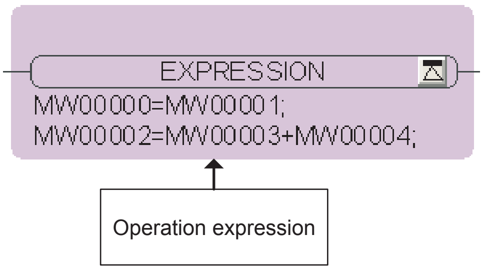
(1) Operation

You can use the following elements in an EXPRESSION instruction:

- A variable name or structure in place of a register, similar to C language.
- Basic functions, such as the SIN and COS functions.
- Arithmetic operators, logical operators, comparison operators, and substitution operators.
- Arrays.

EXPRESSION instruction
MW00000 = 10; MW00001 = DATA1; ML00002 = MW00000 + 100; MF00004 = sin(MF00006); MW00006 = 0x3FFF; ⋮

(2) Format



Icon: 

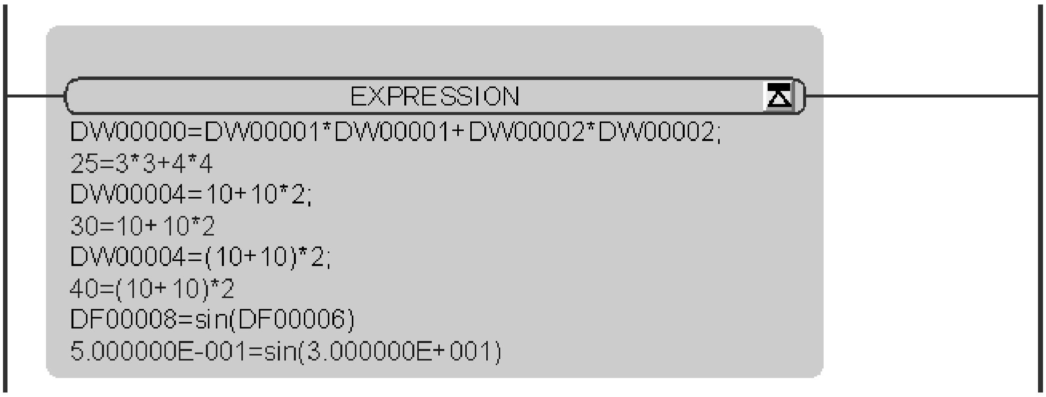
Key entry: EXPR

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Operation expression	○*	○*	○*	○*	×	○*	○*

* Write with the format for an EXPRESSION instruction.
Refer to *Appendix D Format for EXPRESSION Instruction* for details on the format used to write the expression.

(3) Programming Example

In the following programming example, multiple operations are programmed in a single EXPRESSION instruction.



(4) Additional Information

The EXPRESSION instruction can be programmed with numeric expressions in addition to expressions that return Boolean TRUE or FALSE values.

Expression Example	Notation	Remarks
MB000000 = true;	OK	TRUE: 1 (ON)
MW00000 = MW00001+10	OK	–
MW00000 = 0x00FF;	OK	Prefix hexadecimal values with 0x.
MB000000 == true;	NG	–
MW00001 > MW00000;	NG	–

- Refer to *Appendix D Format for EXPRESSION Instruction* for details on applicable instructions, operation order, and notation conventions.

5.6 Basic Function Instructions

5.6.1 Square Root (SQRT)

(1) Operation

The SQRT instruction calculates the square root of the integer or real number input data and stores the result in the output data.
Double-length integers cannot be used.

- If the input data is less than 0, the absolute value of the input data will be used to perform the operation and output the result.

[a] Integer SQRT: When the Input Data and Output Data Are Integer Data.

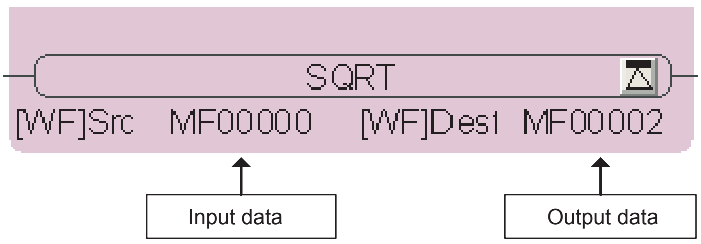
$$\sqrt{\boxed{\text{Input data}}} \times 128\sqrt{2} \longrightarrow \boxed{\text{Output data}}$$

- With an integer SQRT instruction, the result is calculated differently from the square root used in mathematics.

[b] Real Number SQRT: For Any Other Data Types

$$\sqrt{\boxed{\text{Input data}}} \longrightarrow \boxed{\text{Output data}}$$

(2) Format



Icon: 

Key entry: SQRT

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	×	○	×	○	○
Output data (Dest)	×	○*	×	○*	×	○	×

* C and # registers cannot be used.

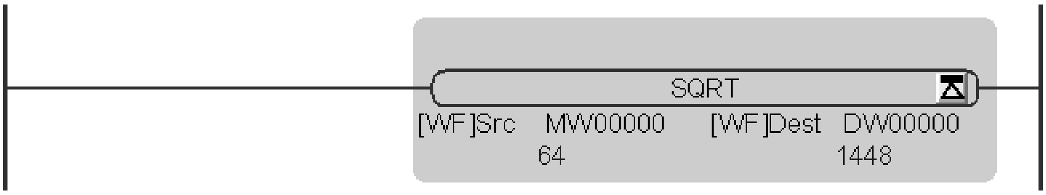
(3) Programming Examples

The following programming examples demonstrate the SQRT instruction using integer and real number input data.

- Integer SQRT

  The square root of 64, an integer in the input data in MW00000, is multiplied by 128 $\sqrt{2}$ and the result is stored in the output data in DW00000.

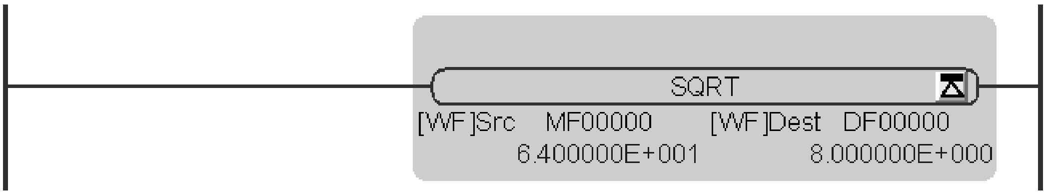
  $\sqrt{64} \times 128\sqrt{2} \rightarrow$ DW00000 = 1,448



- Real Number SQRT

  The square root of 64.0, a real number in the input data in MF00000, is calculated and the result is stored in the output data in DF00000.

  $\sqrt{64.0} \rightarrow$ DF00000 = 8.0



5.6.2 Sine (SIN)

(1) Operation

The SIN instruction calculates the sine of the integer or real number input data and stores the result in the output data. Double-length integers cannot be used.

[a] Integer Input Data and Output Data

SIN (Input data) × 10000 ⟶ Output data

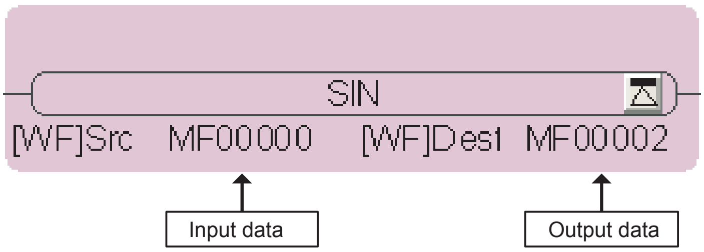
∗ 1. The input data is in degrees, where 1 = 0.01 degree.
∗ 2. The operation result is multiplied by 10,000 and stored in the output data.

[b] Real Number Input Data and Output Data

SIN (Input data) ⟶ Output data

- The input data is in degrees.

(2) Format



Icon: 

Key entry: SIN

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	○	×	○	×	○	○
Output data (Dest)	×	○*	×	○*	×	○	×

∗ C and # registers cannot be used.

[a] Integer

The input data is in degrees, where 1 = 0.01 degrees.
Therefore, the SIN function can operate on values between -327.78 and 327.67 degrees.
The output of the SIN function is multiplied by 10,000, so the output data will be output between -10,000 and 10,000.

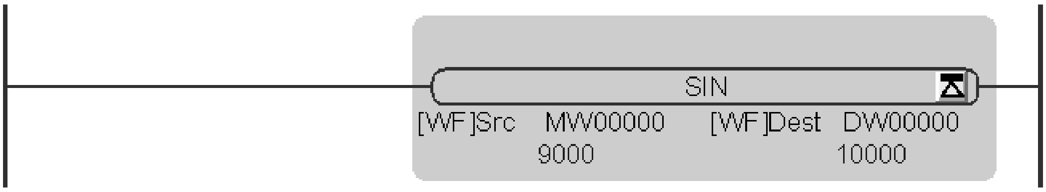
[b] Real Number

The input data is in degrees.

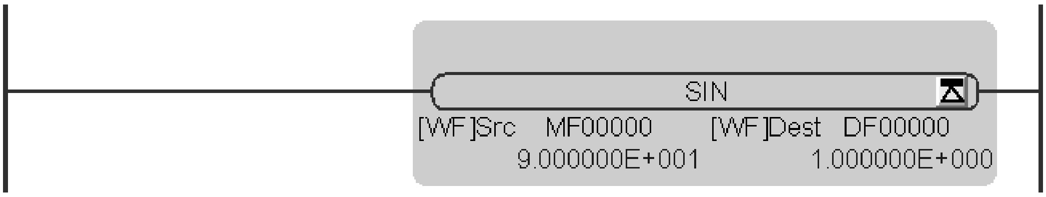
(3) Programming Examples

The following programming examples demonstrate the SIN instruction using integer and real number input data.

- Integer SIN
  The sine of 9,000, an integer in the input data in MW00000, is calculated and the result is stored in the output data in DW00000.
  SIN (90.00 deg) × 10,000 → DW00000 = 10,000



- Real Number SIN
  The sine of 90.0, a real number in the input data in MF00000, is calculated and the result is stored in the output data in DF00000.
  SIN (90.0 deg) → DF00000 = 1.0



5.6.3 Cosine (COS)

(1) Operation

The COS instruction calculates the cosine of the integer or real number input data and stores the result in the output data.
Double-length integers cannot be used.

[a] Integer Input Data and Output Data

COS (Input data) × 10000 → Output data

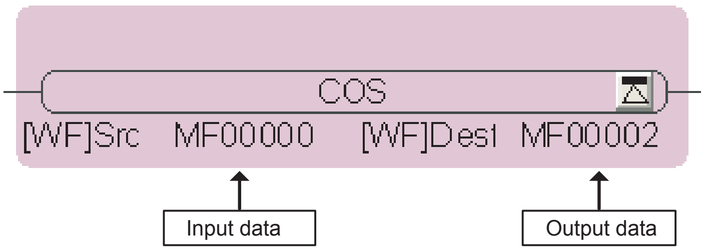
* 1. The input data is in degrees, where 1 = 0.01 degree.
* 2. The operation result is multiplied by 10,000 and stored in the output data.
* 3. The input data must be between -327.68 and 32.767 degrees. Any other number will not produce the correct result.

[b] Real Number Input Data and Output Data

COS (Input data) → Output data

- The input data is in degrees.

(2) Format



Icon: COS

Key entry: COS

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	O	×	O	×	O	O
Output data (Dest)	×	O*	×	O*	×	O	×

* C and # registers cannot be used.

[a] Integer

The input data is in degrees, where 1 = 0.01 degree.
Therefore, the COS function instruction can operate on values between -327.78 and 327.67 degrees.
The output of the COS function is multiplied by 10,000, so the data will be output between -10,000 and 10,000.

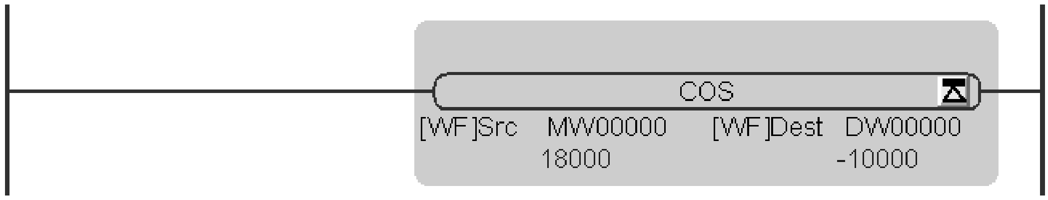
[b] Real Number

The input data is in degrees.

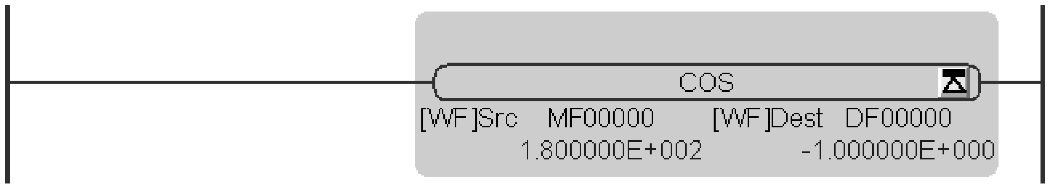
(3) Programming Examples

The following programming examples demonstrate the COS instruction using integer and real number input data.

- Integer COS
  The cosine of 18,000, an integer in the input data in MW00000, is calculated and the result is stored in the output data in DW00000.
  COS (180.00 deg) × 10,000 → DW00000 = -10,000



- Real Number COS
  The cosine of 180.0, a real number in the input data in MF00000, is calculated and the result is stored in the output data in DF00000.
  COS (180.0 deg) → DF00000 = -1.0



5.6.4 Tangent (TAN)

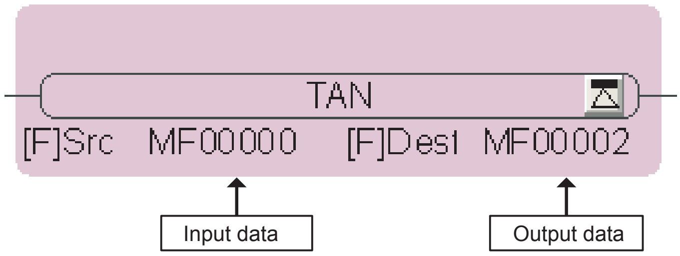
(1) Operation

The TAN instruction calculates the tangent of the real number input data and stores the result in the output data.

- The input data is in degrees.

TAN (Input data) ⟶ Output data

(2) Format



Icon: 

Key entry: TAN

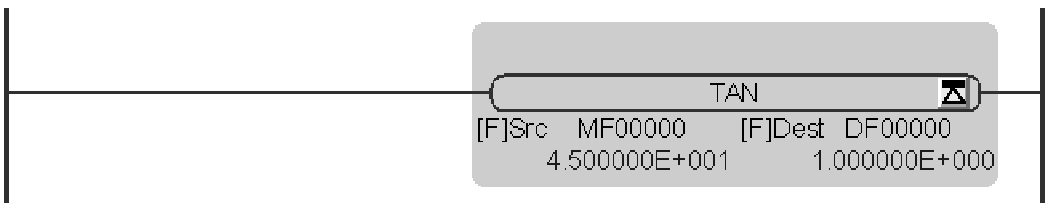
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	×	×	○	×	×	○
Output data (Dest)	×	×	×	○*	×	×	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the tangent of 45 in the input data in MW00000 is calculated and the result is stored in the output data in DF00000.

TAN (45.00 deg) → DF00000 = 1.0



5.6.5 Arc Sine (ASIN)

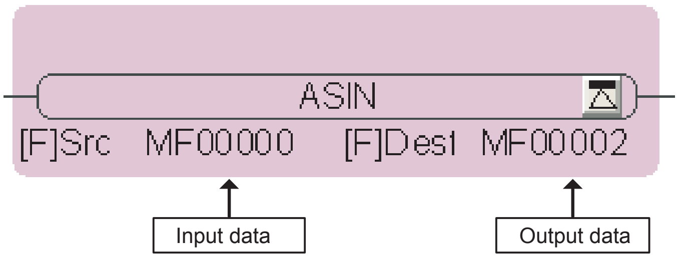
(1) Operation

The ASIN instruction calculates the arc sine of the real number input data and stores the result in the output data.

- The output data is in degrees.

SIN ($\boxed{\text{Input data}}$)$^{-1}$ $\longrightarrow$ $\boxed{\text{Output data}}$

(2) Format



Icon: 

Key entry: ASIN

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	×	×	○	×	×	○
Output data (Dest)	×	×	×	○*	×	×	×

* C and # registers cannot be used.

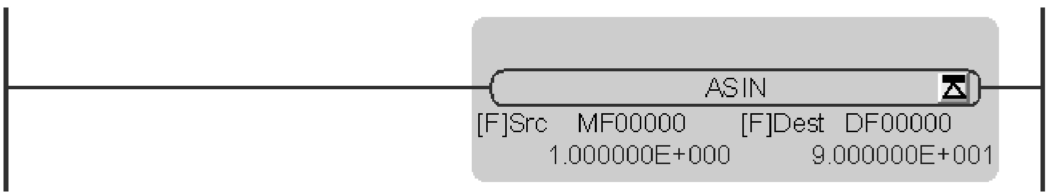
■ Input Data Range

Set the input data to a value between -1.0 and 1.0. The output is set to 0 if the input value is out of range.

(3) Programming Example

In the following programming example, the arc sine of 1.0 in the input data in MF00000 is calculated and the result is stored in the output data in DF00000.

SIN $(1.0)^{-1} \rightarrow$ DF00000 = 90.0 (degrees)



5.6.6 Arc Cosine (ACOS)

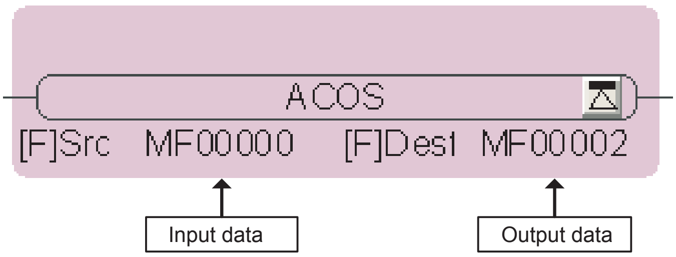
(1) Operation

The ACOS instruction calculates the arc cosine of the real number input data and stores the result in the output data.

- The output data is in degrees.

$$\mathrm{COS}\ (\ \boxed{\text{Input data}}\ )^{-1} \longrightarrow \boxed{\text{Output data}}$$

(2) Format



Icon: 

Key entry: ACOS

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	×	×	○	×	×	○
Output data (Dest)	×	×	×	○*	×	×	×

* C and # registers cannot be used.

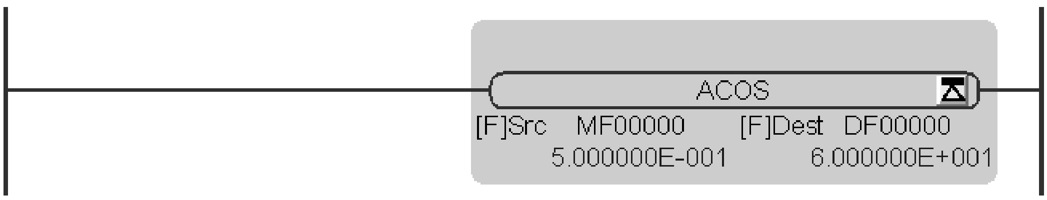
■ Input Data Range

Set the input data to a value between -1.0 and 1.0. The output is set to 0 if the input value is out of range.

(3) Programming Example

In the following programming example, the arc sine of 0.5 in the input data in MF00000 is calculated and the result is stored in the output data in DF00000.

$\mathrm{COS}\ (0.5)^{-1} \rightarrow$ DF00000 = 60.0 (degrees)



Instructions

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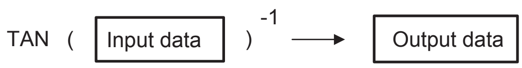
5.6.7 Arc Tangent (ATAN)

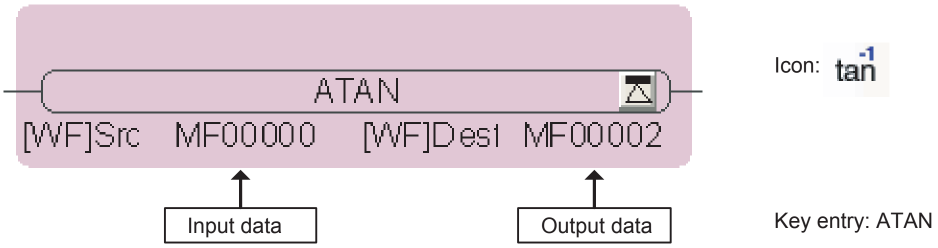
(1) Operation

The ATAN instruction calculates the arc tangent of the real number input data and stores the result in the output data.

- The output data is in degrees.



(2) Format



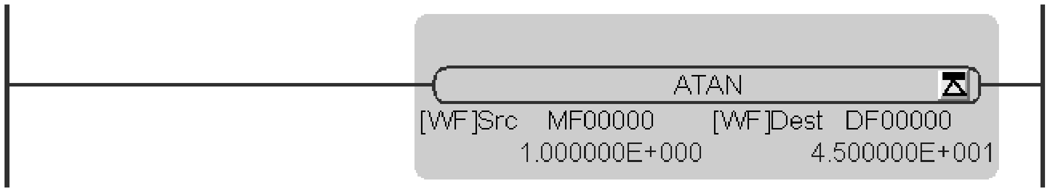
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	×	×	○	×	×	○
Output data (Dest)	×	×	×	○*	×	×	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the arc tangent of 1.0 in the input data in MF00000 is calculated and the result is stored in the output data in DF00000.

$TAN\ (1.0)^{-1} \rightarrow DF00000 = 45.0$ (degrees)

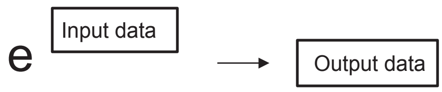


5.6.8 Exponential (EXP)

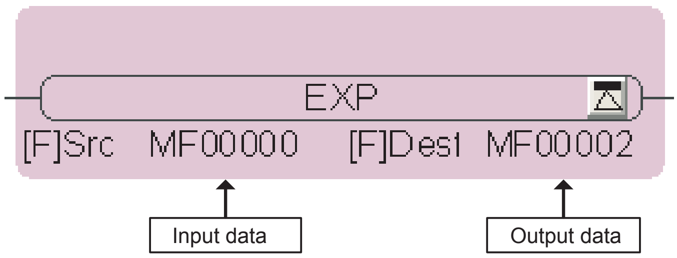
(1) Operation

The EXP instruction calculates the value obtained by raising base *e* of the natural logarithm to the real number input data and stores the result in the output data.

- "e" is the base of the natural logarithm.



(2) Format



Icon: 

Key entry: EXP

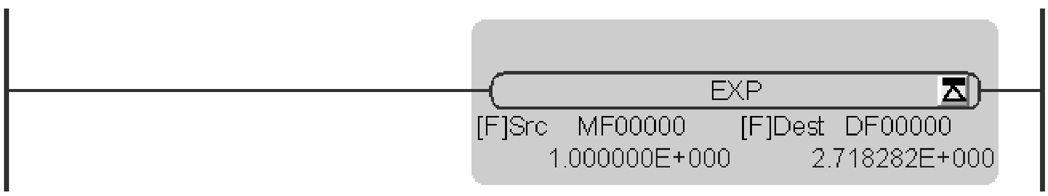
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	×	×	○	×	×	○
Output data (Dest)	×	×	×	○*	×	×	×

* C and # registers cannot be used.

(3) Programming Example

The following programming example calculates base *e* of the natural logarithm raised to 1.0 in the input data in MF00000, and stores the result in the output data in DF00000.

$e^{1.0} \rightarrow$ DF00000 = 2.718282



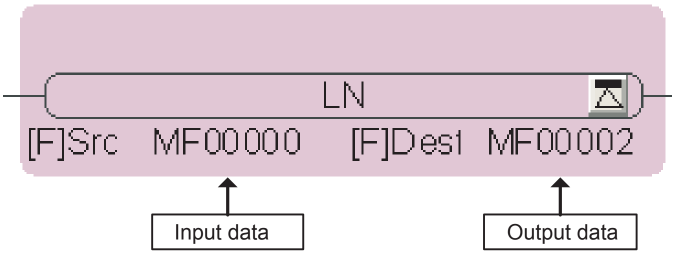
INFO: If the operation result overflows, the output data will be set to the maximum value 3.402E+38 and an operation error will not occur.

5.6.9 Natural Logarithm (LN)

(1) Operation

The LN instruction calculates the natural logarithm of X ($\log_e$ X), when input data X is a real number and stores the result in the output data.

(2) Format



Icon: ln

Key entry: LN

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	×	×	○	×	×	○
Output data (Dest)	×	×	×	○*	×	×	×

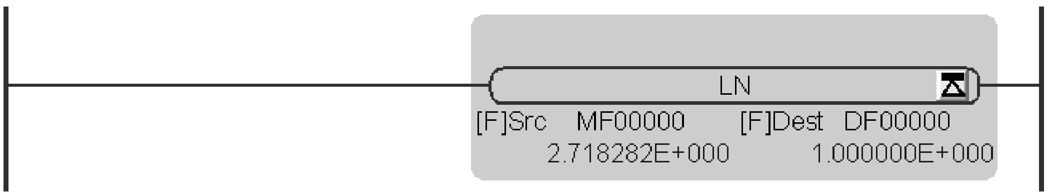
* C and # registers cannot be used.

■ When Input Data Is Less Than or Equal to 0

If the input data is less than 0, the absolute value of the input data will be used to perform the operation and output the result.
The output data is set to -∞ if the input value is 0.

(3) Programming Example

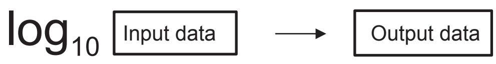
The following programming example calculates the natural logarithm when the input data is 2.718282 (≈ e) in MF00000, and stores the result in the output data in DF00000.
$\text{Log}_e\ 2.718282 \approx \log_e e \rightarrow$ DF00000 = 1.0



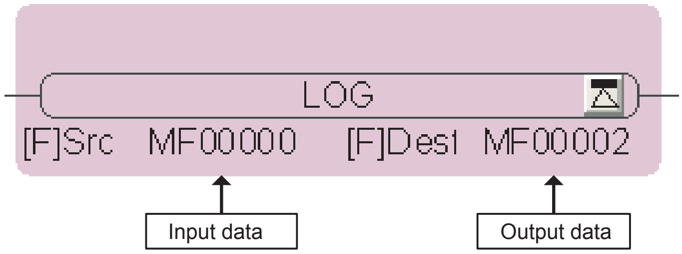
5.6.10 Common Logarithm (LOG)

(1) Operation

The LOG instruction calculates the common logarithm of X ($\log_{10}$ X), when input data X is a real number and stores the result in the output data.



(2) Format



Icon: 

Key entry: LOG

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input data (Src)	×	×	×	○	×	×	○
Output data (Dest)	×	×	×	○*	×	×	×

* C and # registers cannot be used.

■ When Input Data Is Less Than or Equal to 0

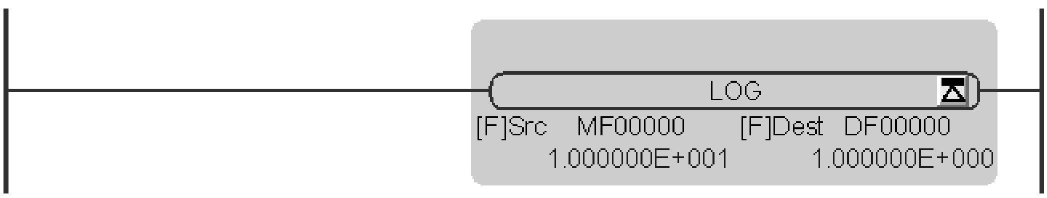
If the input data is less than 0, the absolute value of the input data will be used to perform the operation and output the result.

The output data is set to -∞ if the input value is 0.

(3) Programming Example

The following programming example calculates the common logarithm when the input data is 10.0 in MF00000, and stores the result in the output data in DF00000.

$\log_{10} 10.0 \rightarrow$ DF00000 = 1.0



Instructions

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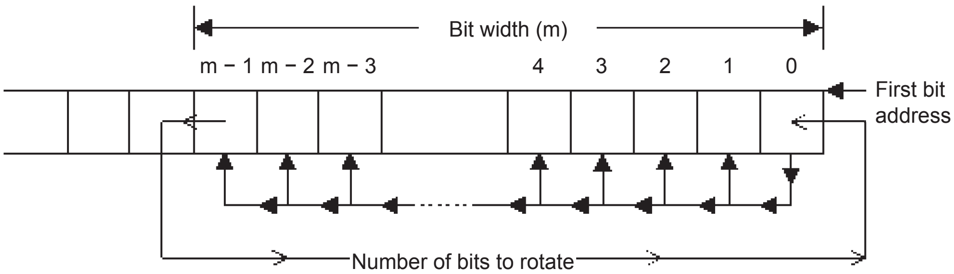
5.7 Data Shift Instructions

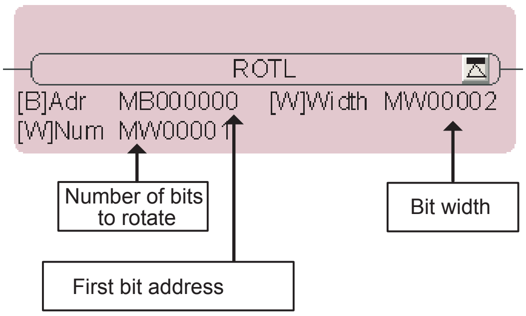
5.7.1 Bit Rotate Left (ROTL)

(1) Operation

The ROTL instruction rotates the data specified by the first bit address and bit width to the left by the specified number of bits.



(2) Format



Icon:

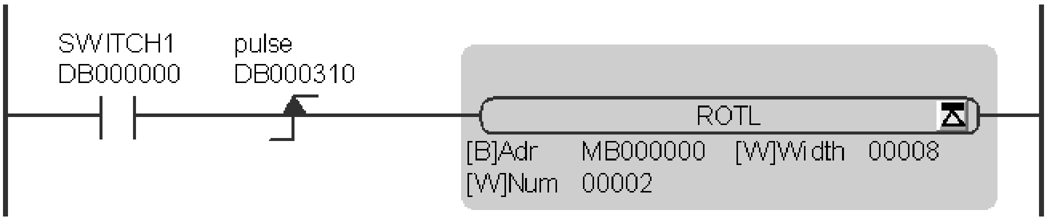
Key entry: ROTL

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First bit address (Adr)	○*	×	×	×	×	×	×
Number of bits to rotate (Num)	×	○	×	×	×	○	○
Bit width (Width)	×	○	×	×	×	○	○

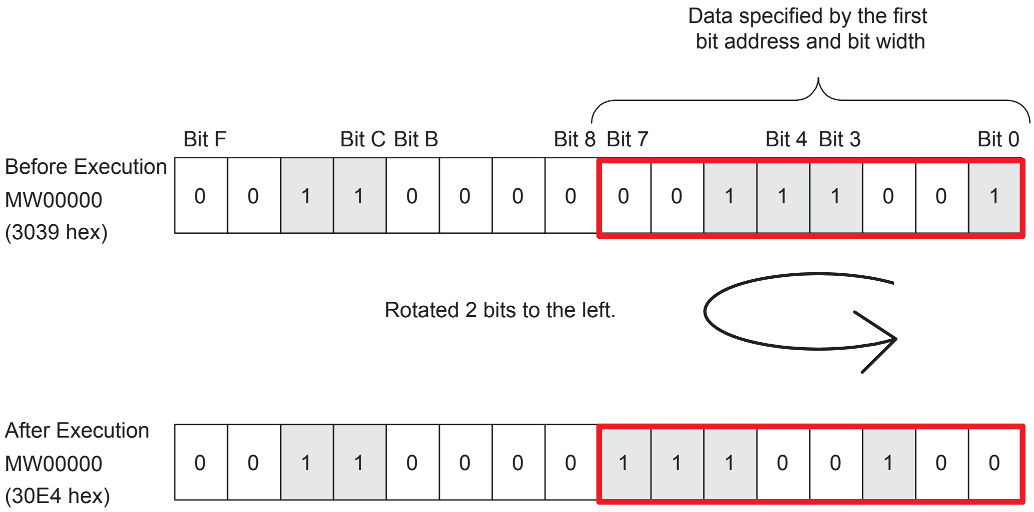
* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the data specified as 8 bits wide from the first bit address at MB000000 is rotated two bits to the left.
The ROTL instruction is executed when switch 1 (DB000000) turns ON.



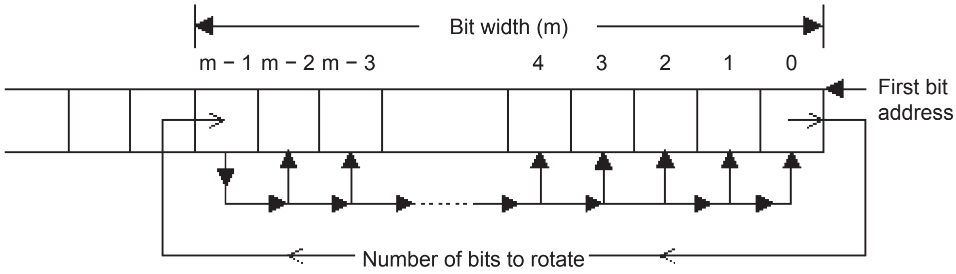
The following figure shows the operation when MW00000 is 12,345 (3039 hex).



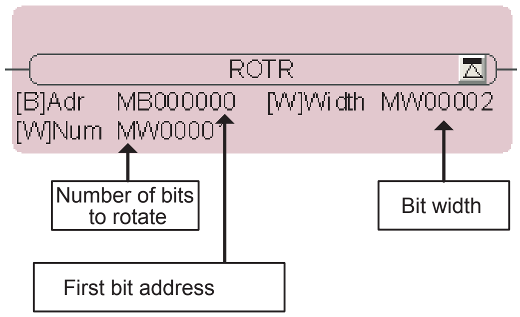
5.7.2 Bit Rotate Right (ROTR)

(1) Operation

The ROTR instruction rotates the data specified by the first bit address and bit width to the right by the specified number of bits.



(2) Format



Icon: 

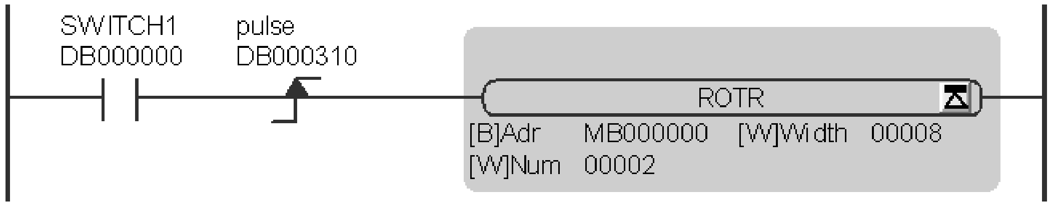
Key entry: ROTR

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First bit address (Adr)	○*	×	×	×	×	×	×
Number of bits to rotate (Num)	×	○	×	×	×	○	○
Bit width (Width)	×	○	×	×	×	○	○

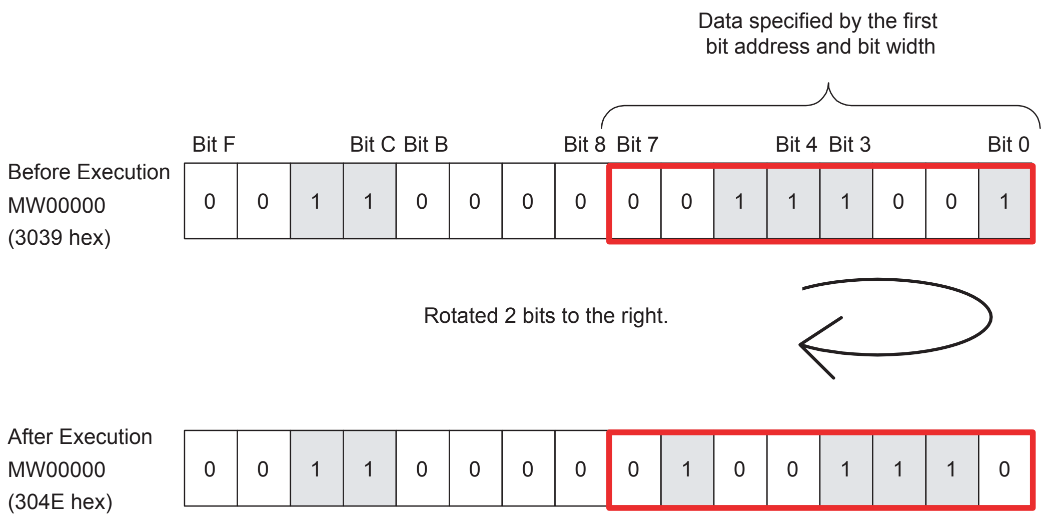
∗ C and # registers cannot be used.

(3) Programming Example

In the following programming example, the data specified as 8 bits wide from the first bit address at MB000000 is rotated two bits to the right.
The ROTR instruction is executed when switch 1 (DB000000) turns ON.



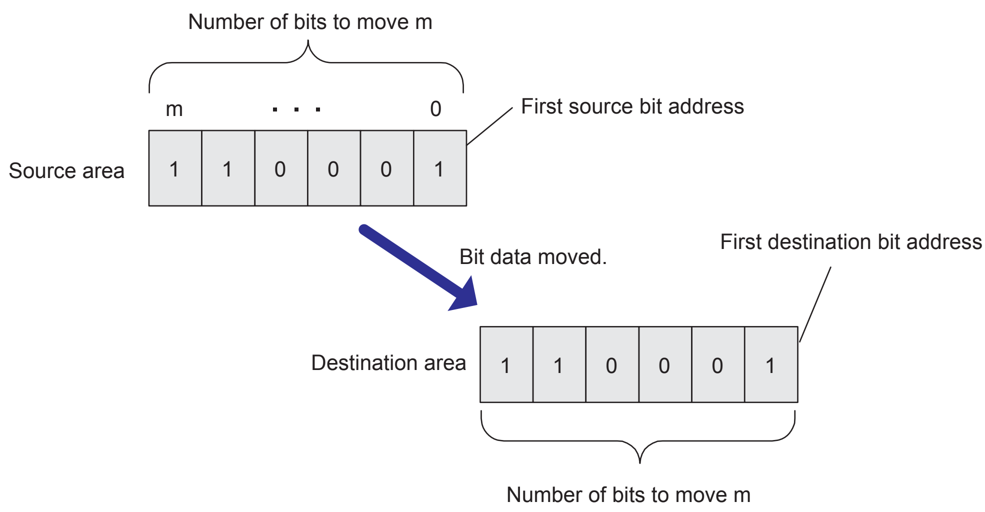
The following figure shows the operation when MW00000 is 12,345 (3039 hex).



5.7.3 Move Bit (MOVB)

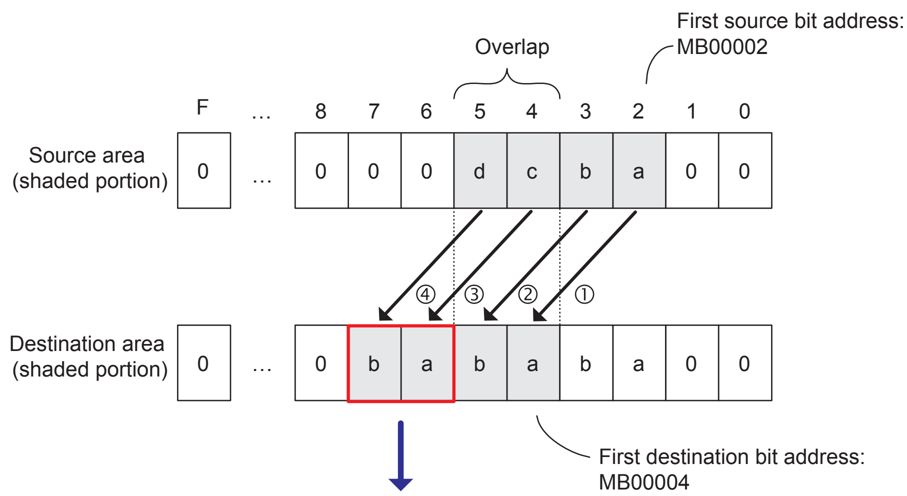
(1) Operation

The MOVB instruction moves the designated number of bits of data from the area that starts with the first source bit address to the area that starts with the first destination bit address.



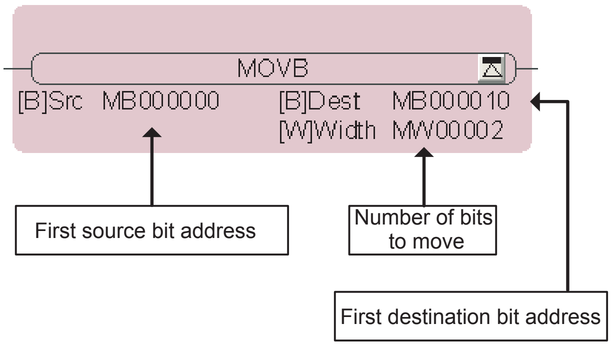
- The bits are moved one bit at a time from the lowest relay address.
  If the source area and destination area overlap, the source data that is actually moved may not be the data that was in the source area before the instruction was executed.

■ Example Where the Source Area and Destination Area Overlap



Bit status is moved in the following order: ① to ④. This means that the status of bits 2 and 3 are moved to bits 4 and 5 (① and ②) and then the status of bits 4 and 5 are moved (③ and ④).

(2) Format



Icon: 

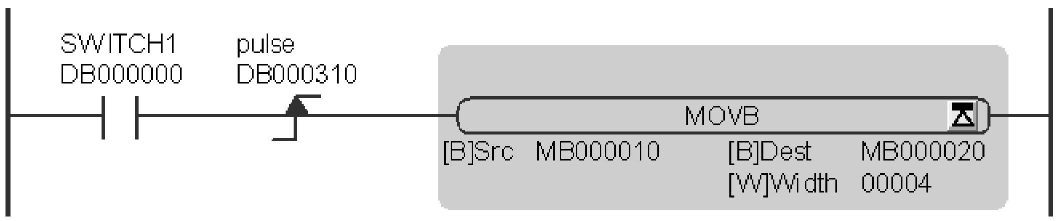
Key entry: MOVB

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First source bit address (Src)	○	×	×	×	×	×	×
First destination bit address (Dest)	○*	×	×	×	×	×	×
Number of bits to move	×	○	×	×	×	○	○

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, four bits of data are moved from the area that starts with the first source bit address at MB000010 to the area that starts with the first destination bit address at MB000020.
The MOVB instruction is executed when switch 1 (DB000000) turns ON.



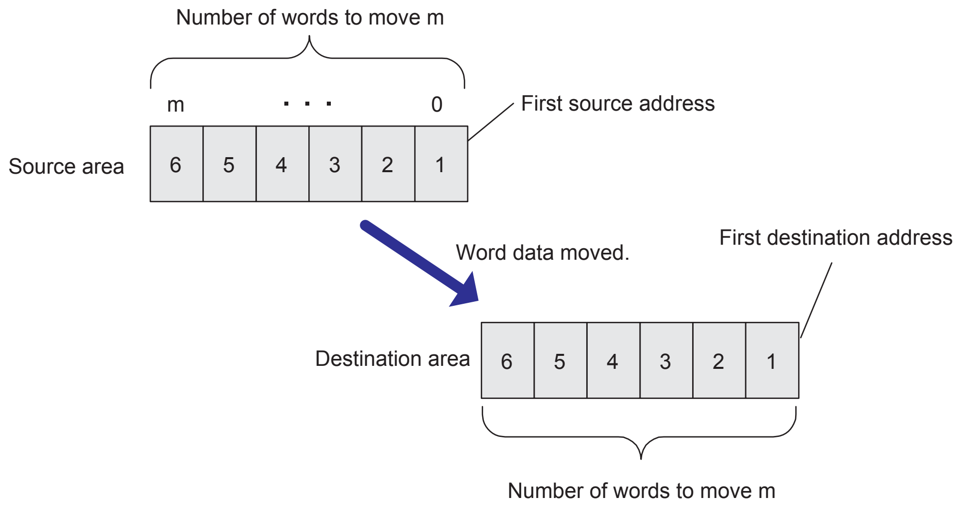
The following table illustrates how the data in the source area is moved to the destination area.

Source area			Destination area		
Register	Data		Register	Data before Execution of Instruction	Data after Execution of Instruction
MB000010	0	⇒	MB000020	0	0
MB000011	1		MB000021	0	1
MB000012	1		MB000022	0	1
MB000013	1		MB000023	0	1

5.7.4 Move Word (MOVW)

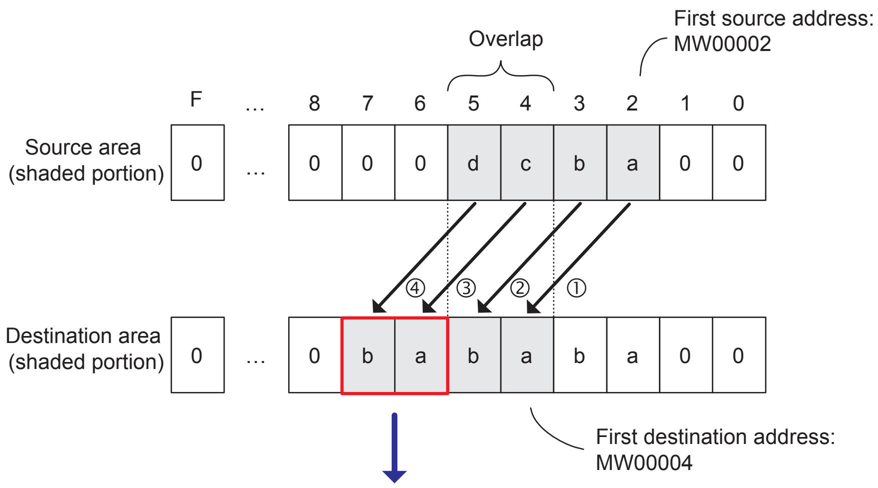
(1) Operation

The MOVW instruction moves the specified number of words from the area that starts with the first source address to the area that starts with the first destination address.



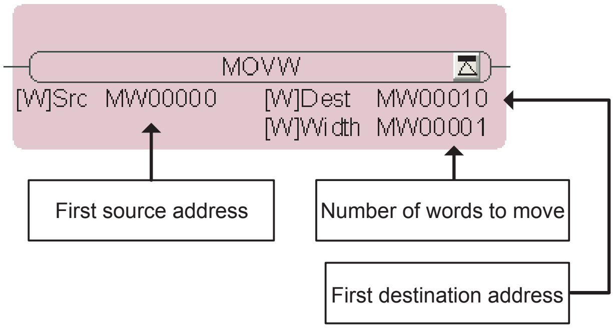
- The words are moved one at a time from the lowest register address.
  If the source area and destination area overlap, the source data that is actually moved may not be the data that was in the source area before the instruction was executed.

■ Example Where the Source Area and Destination Area Overlap



Word contents are moved in the following order: ① to ④. This means that the contents of MW00002 and MW00003 are moved to MW00004 and MW00005 (① and ②) and then the contents of MW00004 and MW00005 are moved (③ and ④).

(2) Format



Icon: 

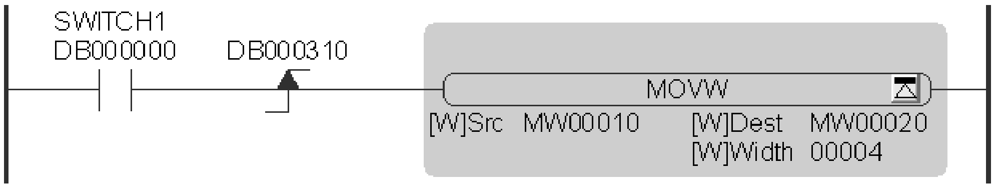
Key entry: MOVW

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First source address (Src)	×	○	×	×	×	×	×
First destination address (Dest)	×	○*	×	×	×	×	×
Number of words to move (Width)	×	○	×	×	×	○	○

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, four words of data from the area that starts with the first source address at MW00010 are moved to the area that starts with the first destination address at MW00020.
The MOVW instruction is executed when switch 1 (DB000000) turns ON.



The following table illustrates how the data in the source area is moved to the destination area.

Source area	
Register	Data
MW00010	10
MW00011	20
MW00012	30
MW00013	40

⇒

Destination area		
Register	Data before Execution of Instruction	Data after Execution of Instruction
MW00020	0	10
MW00021	0	20
MW00022	0	30
MW00023	0	40

Instructions

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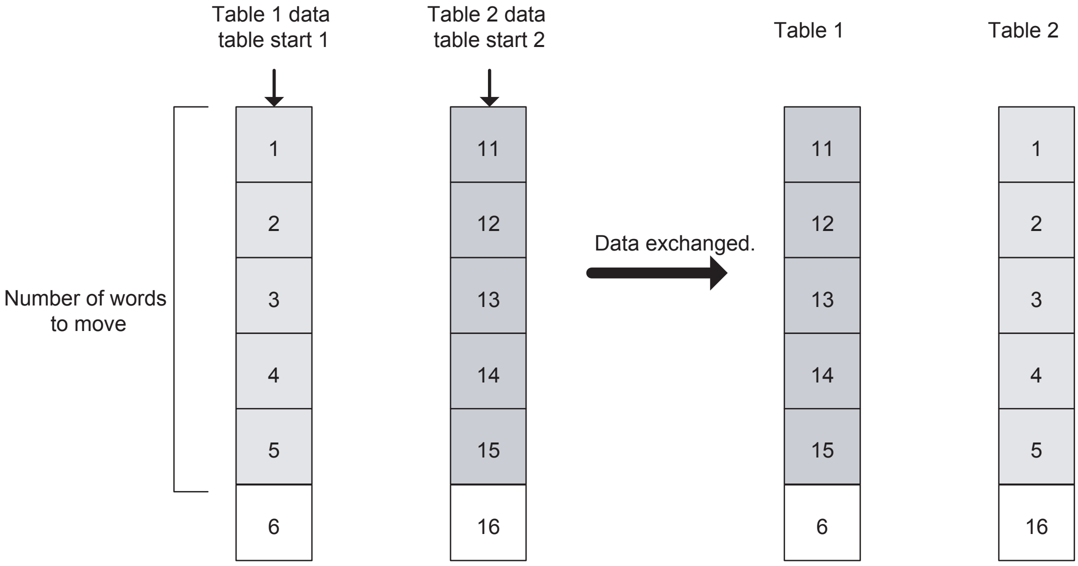
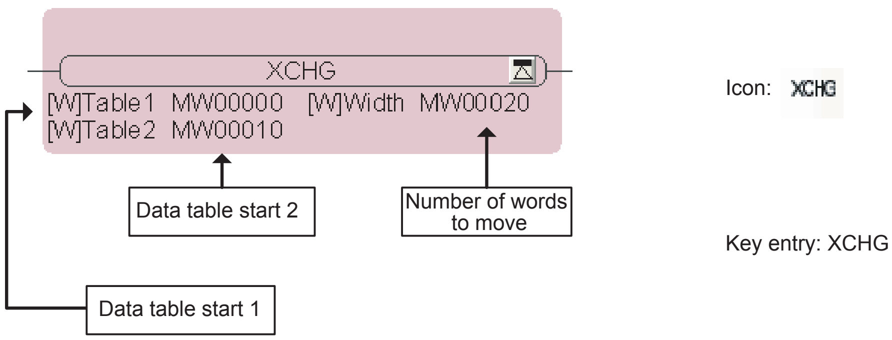
5.7.5 Exchange (XCHG)

(1) Operation

The XCHG instruction exchanges the designated number of words to move between table 1 and table 2.
The data contents of table 1 and table 2 specified by data table start 1, data table start 2, and the number of words to move are exchanged.



(2) Format

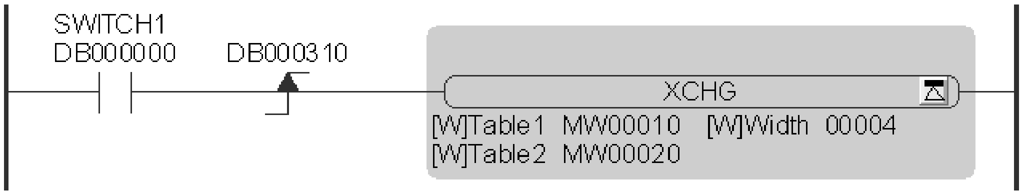


Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Data table start 1 (Table1)	×	○*	×	×	×	×	×
Data table start 2 (Table2)	×	○*	×	×	×	×	×
Number of words to move (Width)	×	○	×	×	×	○	○

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, four words of data are exchanged between table 1, which starts at MW00010, and table 2, which starts at MW00020.
The XCHG instruction is executed when switch 1 (DB000000) turns ON.



The following table illustrates how the data is exchanged between table 1 and table 2.

Table 1

Register	Data before Execution of Instruction	Data after Execution of Instruction
MW00010	10	123
MW00011	20	234
MW00012	30	345
MW00013	40	456

⇔

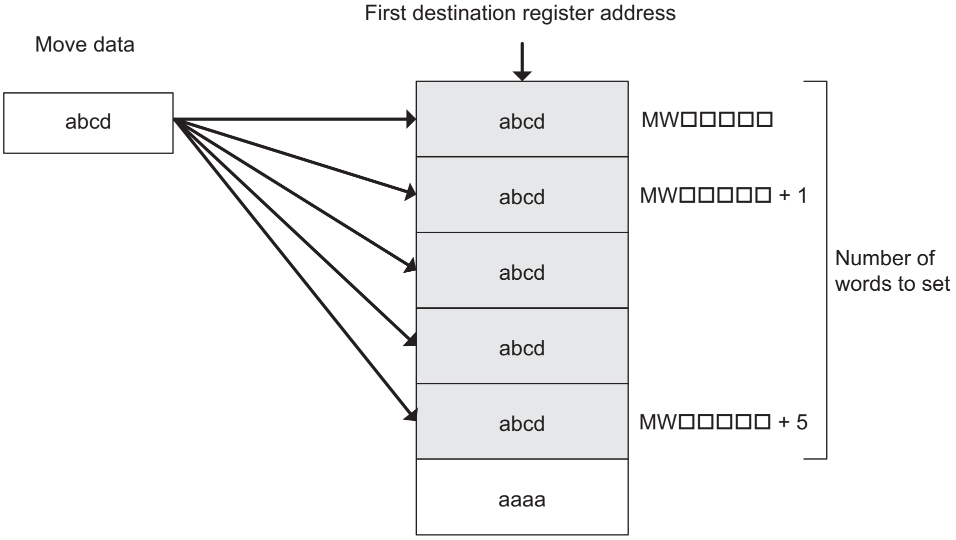
Table 2

Register	Data before Execution of Instruction	Data after Execution of Instruction
MW00020	123	10
MW00021	234	20
MW00022	345	30
MW00023	456	40

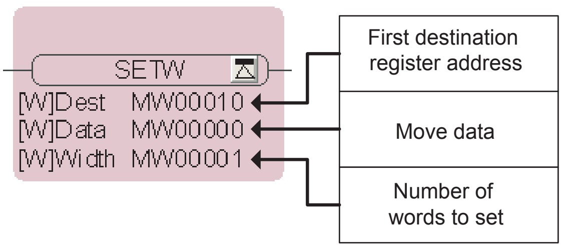
5.7.6 Table Initialization (SETW)

(1) Operation

The SETW instruction stores the data designated by the move data in all registers in the area that starts from the first destination register address for the number of words to set. The data is stored one word at a time from the lowest register address to the highest.
The data is stored in order from the lowest register address to the highest.



(2) Format



Icon: 

Key entry: SETW

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First destination register address (Dest)	×	○*	×	×	×	×	×
Move data (Data)	×	○	×	×	×	○	○
Number of words to set (Width)	×	○	×	×	×	○	○

∗ C and # registers cannot be used.

(3) Programming Example

In the following programming example, the area of 1,000 words from MW00000 is initialized to the move data (0) on the first scan of the high-speed scan after the power is turned ON.

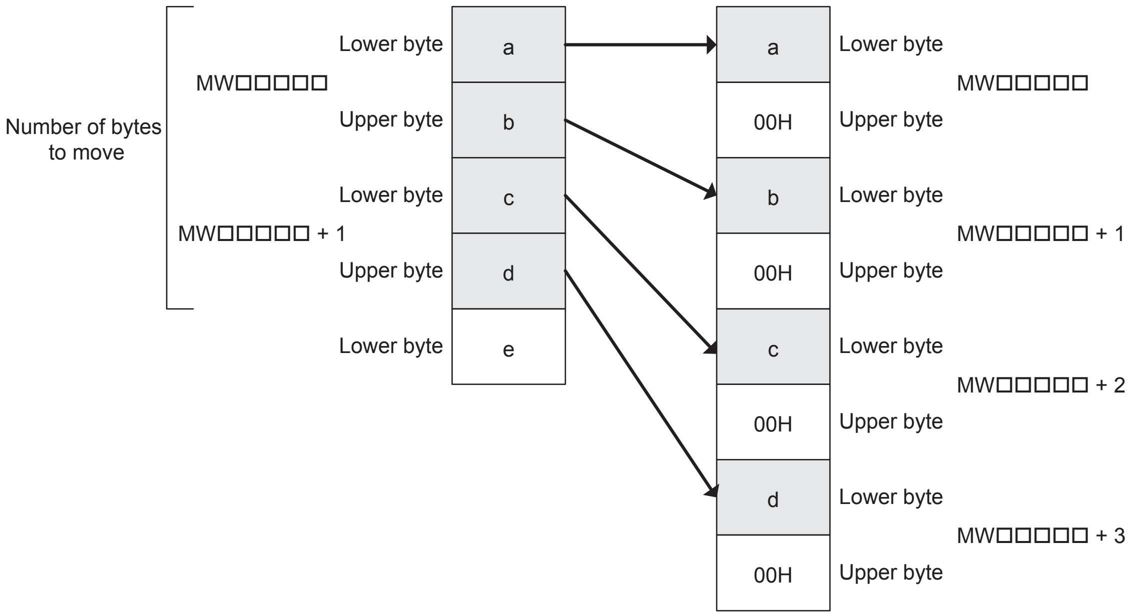
The following table illustrates how the registers are initialized to 0 after execution of the first scan of the high-speed scan when the power is turned ON.

Register	Data
MW00000	0
MW00001	0
:	:
MW00998	0
MW00999	0

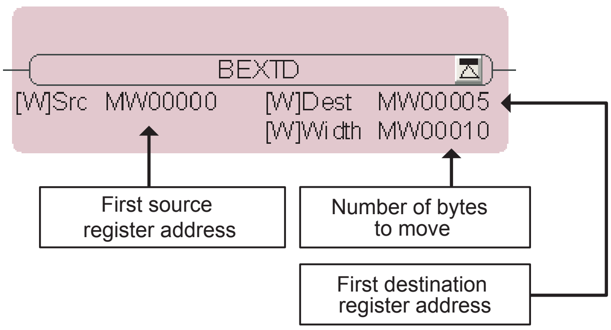
5.7.7 Byte-to-word Expansion (BEXTD)

(1) Operation

The BEXTD instruction expands the byte data from an area designated by the number of bytes to move from the first source register address into individual word data, one byte at a time, and moves the word data to the area that starts with the first destination register address. When the byte is expanded into a word, the upper byte of the word is set to 0.
The byte data from an area designated by the number of bytes to move from the first source register address is expanded into individual word data and moved to the area that starts with the first destination register address.



(2) Format



Icon: B EXTD

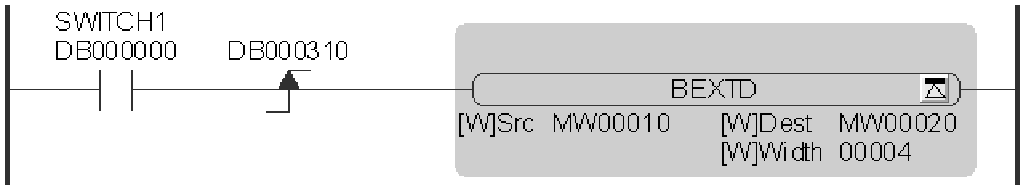
Key entry: BEXTD

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First source register address (Src)	×	○	×	×	×	×	×
First destination register address (Dest)	×	○*	×	×	×	×	×
Number of bytes to move (Width)	×	○	×	×	×	○	○

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, four bytes of data are expanded and moved from the area that starts with the first source register address at MW00010 to the area of words that starts with the first destination register address at MW00020.
The BEXTD instruction is executed when switch 1 (DB000000) turns ON.



The following table illustrates how the byte data in the source area is expanded and moved into word data in the destination area.

Source area		
Register		Data
MW00010	Lower byte	10 hex
	Upper byte	20 hex
MW00011	Lower byte	30 hex
	Upper byte	40 hex

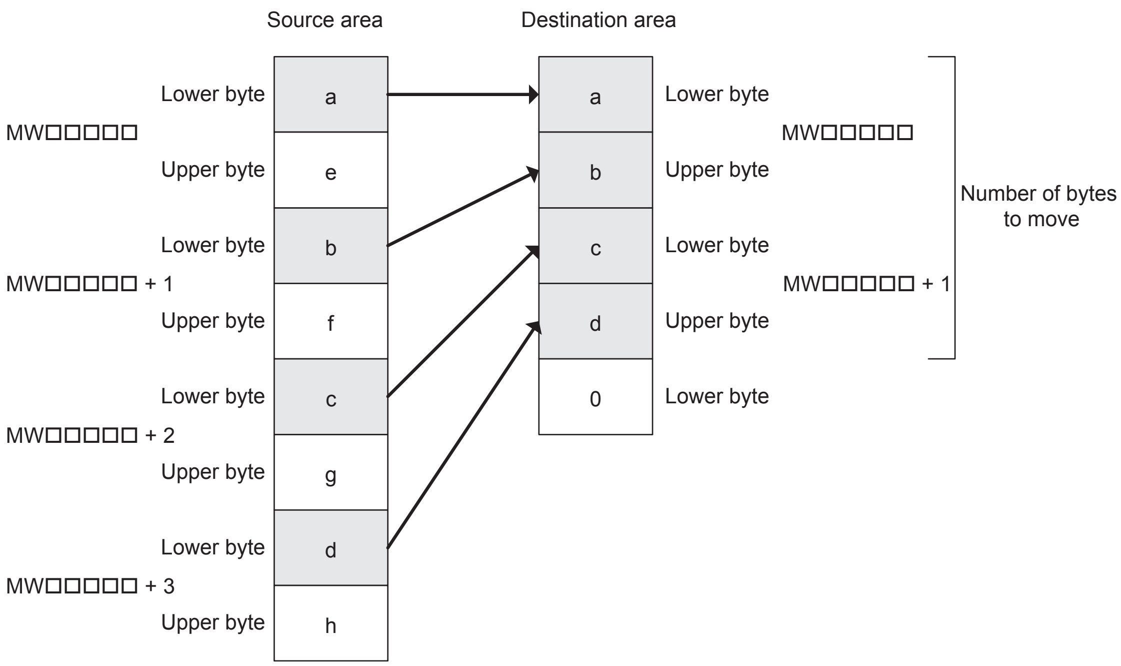
⇒

Destination area		
Register		Data
MW00020	Lower byte	10 hex
	Upper byte	00 hex
MW00021	Lower byte	20 hex
	Upper byte	00 hex
MW00022	Lower byte	30 hex
	Upper byte	00 hex
MW00023	Lower byte	40 hex
	Upper byte	00 hex

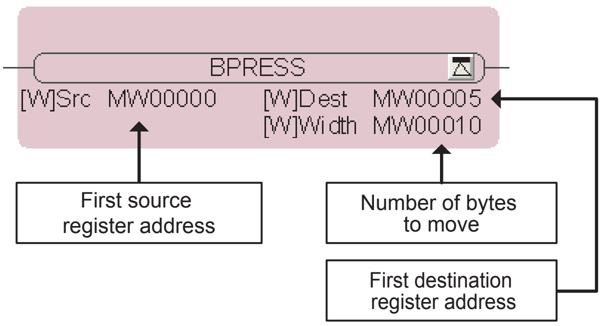
5.7.8 Word-to-byte Compression (BPRESS)

(1) Operation

The BPRESS instruction stores the lower bytes of word data for the designated number of bytes to move starting from the first source register address, in the area that starts from the first destination register address, one byte at a time. This instruction performs the opposite operation of the BEXTD instruction.
The word data designated by the number of bytes to move is moved from the first source register address to the area that starts with the first destination register address.
The upper byte is discarded.



(2) Format



Icon: 

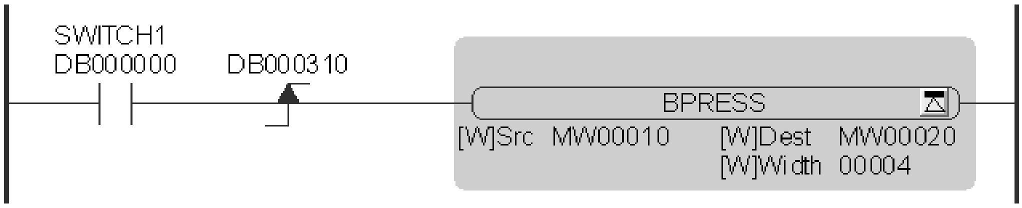
Key entry: BPRESS

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First source register address (Src)	×	○	×	×	×	×	×
First destination register address (Dest)	×	○*	×	×	×	×	×
Number of bytes to move (Width)	×	○	×	×	×	○	○

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the lower bytes of data are moved from the area of four words that starts with the first source register address at MW00010 to the area of four bytes that starts with the first destination register address at MW00020.
The BPRESS instruction is executed when switch 1 (DB000000) turns ON.



The following table illustrates how the word data in the source area is compressed and moved into byte data in the destination area.

Source area		
Register		Data
MW00010	Lower byte	12 hex
	Upper byte	23 hex
MW00011	Lower byte	34 hex
	Upper byte	45 hex
MW00012	Lower byte	56 hex
	Upper byte	67 hex
MW00013	Lower byte	78 hex
	Upper byte	89 hex

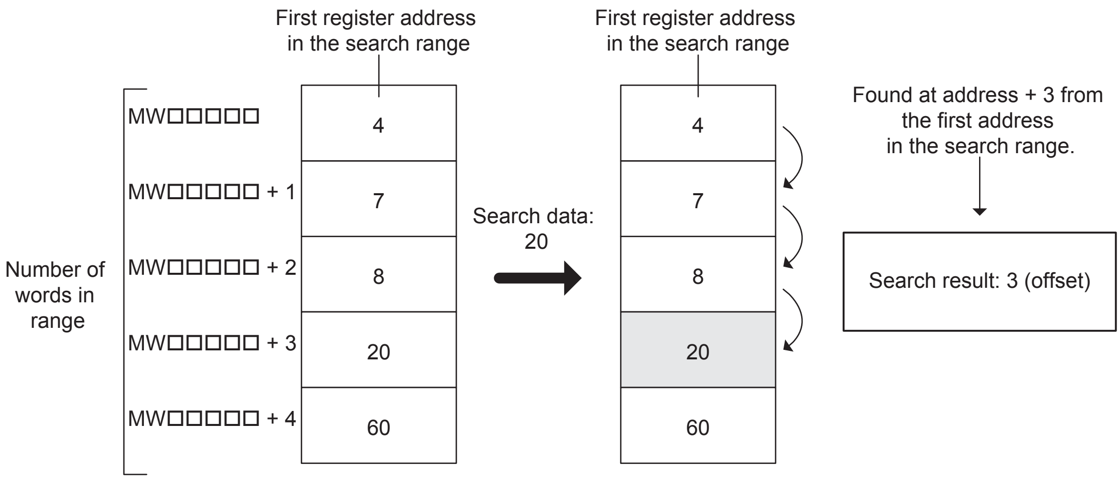
⇒

Destination area		
Register		Data
MW00020	Lower byte	12 hex
	Upper byte	34 hex
MW00021	Lower byte	56 hex
	Upper byte	78 hex

5.7.9 Binary Search (BSRCH)

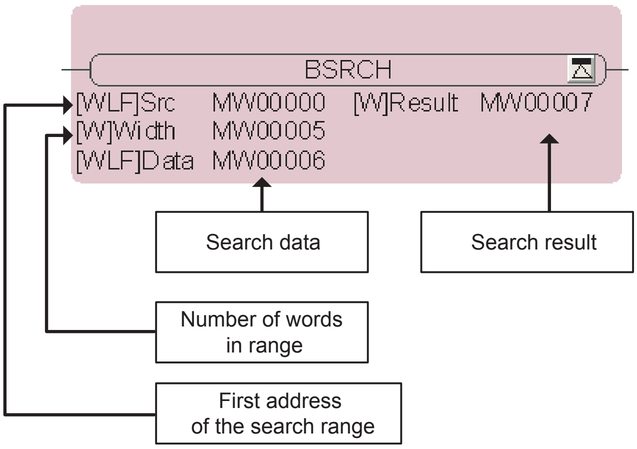
(1) Operation

The BSRCH instruction searches for the search data using a binary search method in the area designated by the number of words from the first address in the search range. The search result is output as the offset word number of the data that matches the search data from the first register in the search range.



* 1. Always sort the search area in ascending order before executing the BSRCH instruction.
* 2. The conceptual diagram shown here is for integers. The instruction operates in the same way for double-length integers and real numbers.
* 3. If the search data is not found, the instruction sets the search result to -1.

(2) Format



Icon:

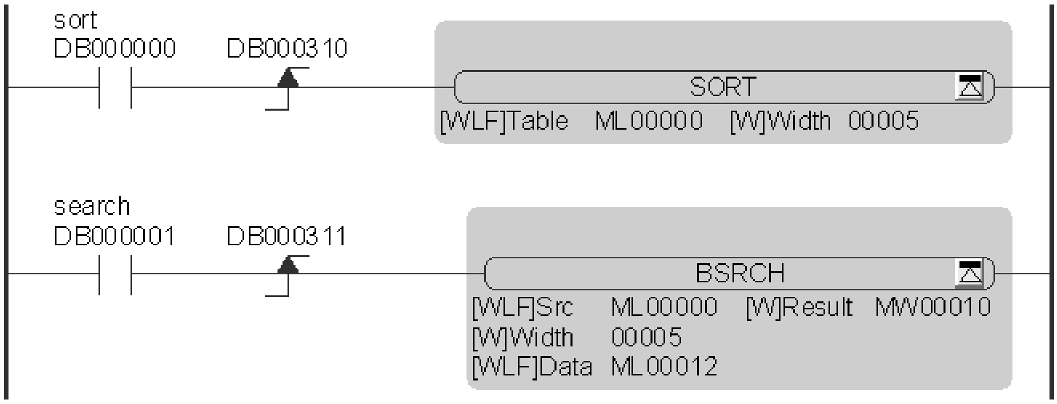
Key entry: BSRCH

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First address of search range (Src)	×	○	○	○	×	×	×
Number of words in range (Width)	×	○	×	×	×	○	○
Search data (Data)	×	○	○	○	×	○	○
Search result (Result)	×	○*	×	×	×	×	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the data from ML00000 to ML00008 is sorted when the sort command (DB000000) turns ON.
Then, if the search command (DB000001) turns ON, the search data in ML00012 is searched for in the sorted data area.



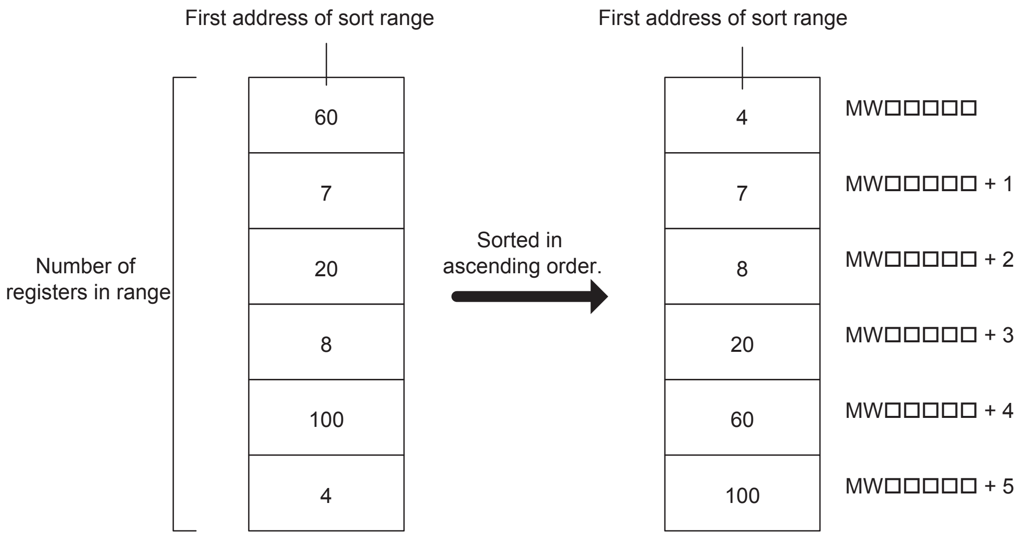
The following table shows how the sort is processed when the first line is executed. Here, the data from ML00000 to ML00008 is as listed below, and the search data in ML00012 is 70. When the second line is executed, the search result in MW00010 is set to 4 as the result of finding 70.

Register	Data before Execution of 1st Line	Data after Execution of 1st Line	Execution Result of 2nd Line
ML00000	100	15	ML00004 = 70, so MW00010 = 4
ML00002	30	30	
ML00004	90	70	
ML00006	15	90	
ML00008	70	100	

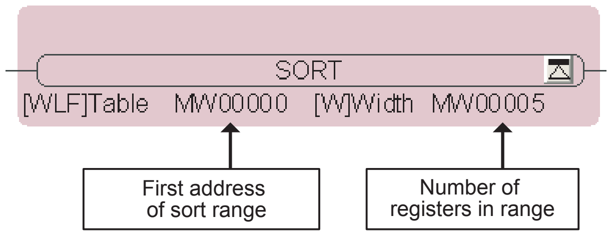
5.7.10 Sort (SORT)

(1) Operation

The SORT instruction sorts the data in the range of registers from the first address of the sort range in ascending order. The following diagram describes the operation using integers as an example. The sort is performed in the same way for double-length integers and real numbers.



(2) Format



Icon: 

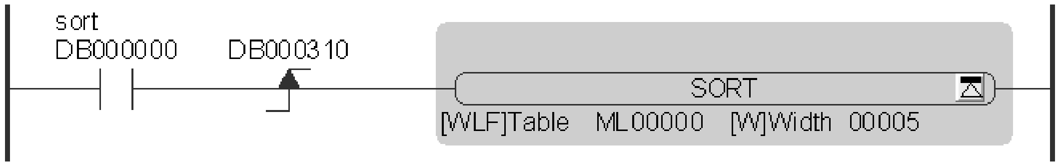
Key entry: SORT

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First address of sort range (Table)	×	○*	○*	○*	×	×	×
Number of registers in range (Width)	×	○	×	×	×	○	○

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the data from ML00000 to ML00008 is sorted in ascending order when the sort command (DB000000) turns ON.



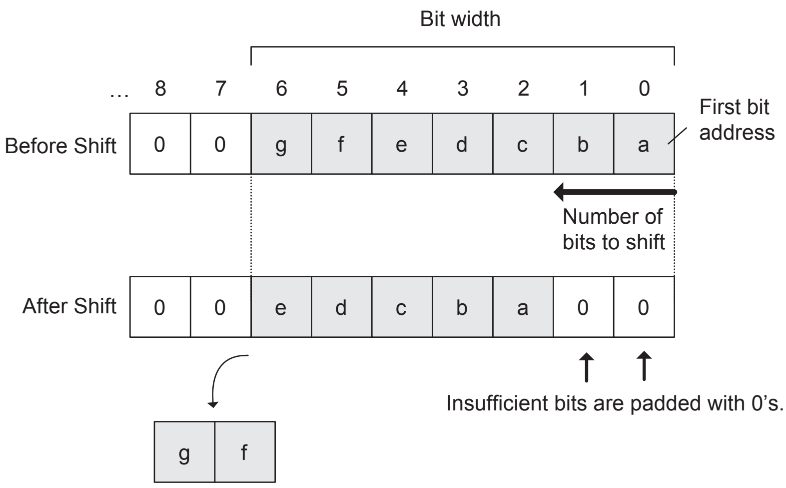
The following table shows how the data from ML00000 to ML00008 is sorted when the SORT instruction is executed.

Register	Data before Execution of Instruction	Data after Execution of Instruction
ML00000	100	15
ML00002	30	30
ML00004	90	70
ML00006	15	90
ML00008	70	100

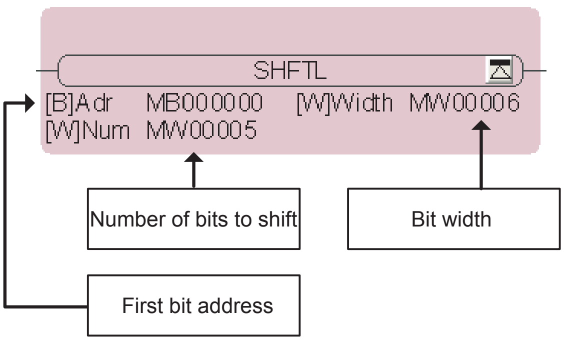
5.7.11 Bit Shift Left (SHFTL)

(1) Operation

The SHFTL instruction shifts the bits specified by the first bit address and bit width to the left by the specified number of bits to shift.
Data that overflows from the bit width is discarded and insufficient bits are padded with 0's.



(2) Format



Icon: 

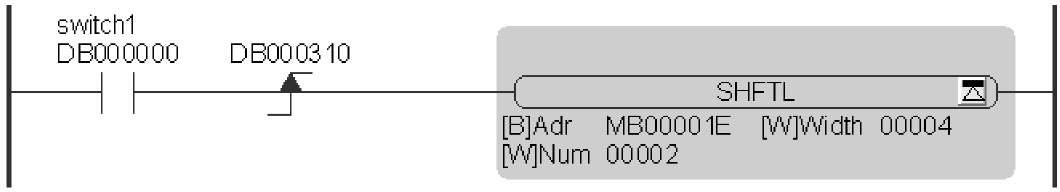
Key entry: SHFTL

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First bit address (Adr)	○*	×	×	×	×	×	×
Number of bits to shift (Num)	×	○	×	×	×	○	○
Bit width (Width)	×	○	×	×	×	○	○

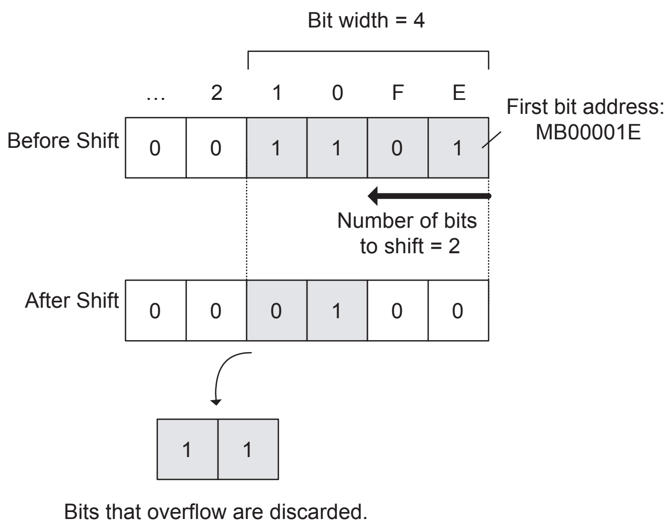
＊ C and # registers cannot be used.

(3) Programming Example

In the following programming example, four bits from the first bit address at MB00001E are shifted two bits to the left when switch 1 (DB000000) turns ON.



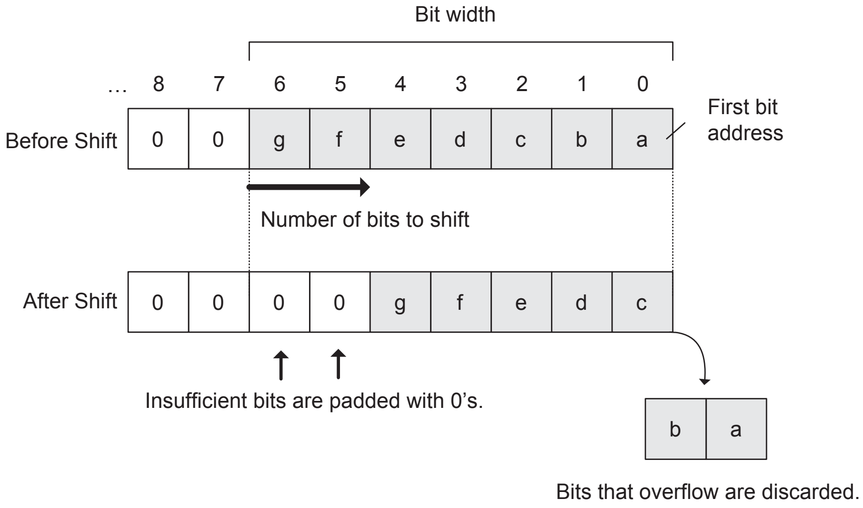
The following figure illustrates the result when the above instructions are executed.



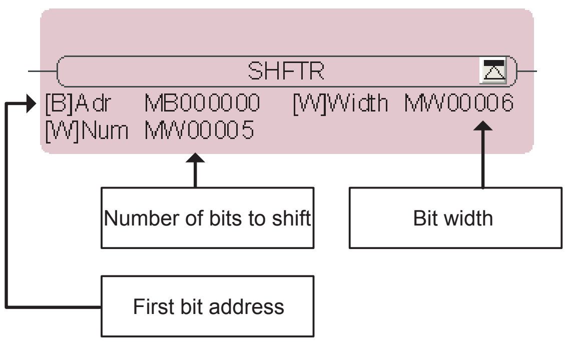
5.7.12 Bit Shift Right (SHFTR)

(1) Operation

The SHFTR instruction shifts the bits specified by the first bit address and bit width to the right by the specified number of bits to shift.
Data that overflows from the bit width is discarded and insufficient bits are padded with 0's.



(2) Format



Icon: 

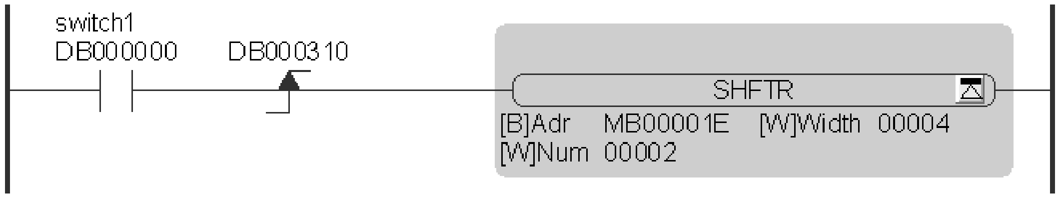
Key entry: SHFTR

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First bit address (Adr)	○*	×	×	×	×	×	×
Number of bits to shift (Num)	×	○	×	×	×	○	○
Bit width (Width)	×	○	×	×	×	○	○

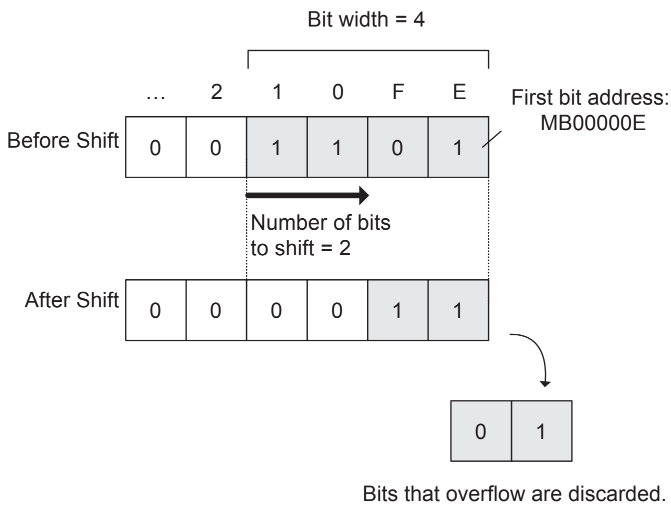
* C and # registers cannot be used.

(3) Programming Example

In the following programming example, four bits from the first bit address at MB00001E are shifted two bits to the right when switch 1 (DB000000) turns ON.



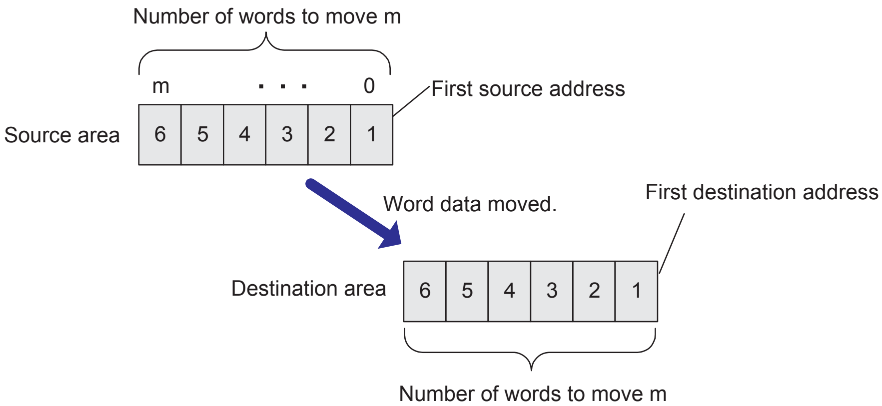
The following figure illustrates the result when the above instructions are executed.



5.7.13 Copy Word (COPYW)

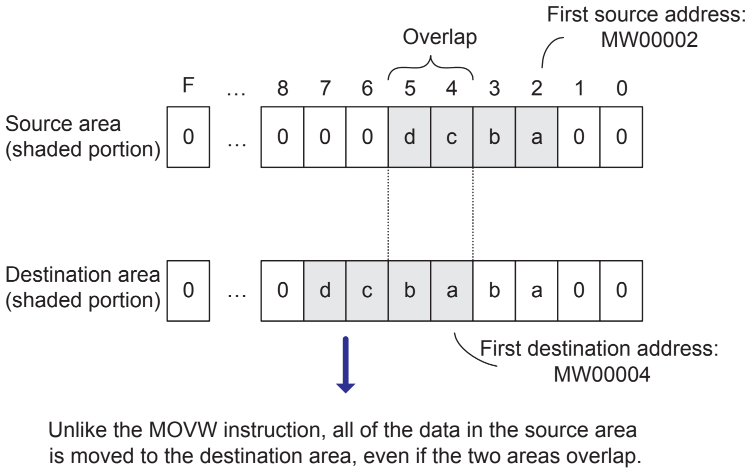
(1) Operation

The COPY instruction copies the specified number of words to move from the area that starts with the first source address to the area that starts with the first destination address.
The data is copied as a block from the source to the destination. Unlike the MOVW instruction, the data is copied to the destination as is, even if the source and destination overlap.

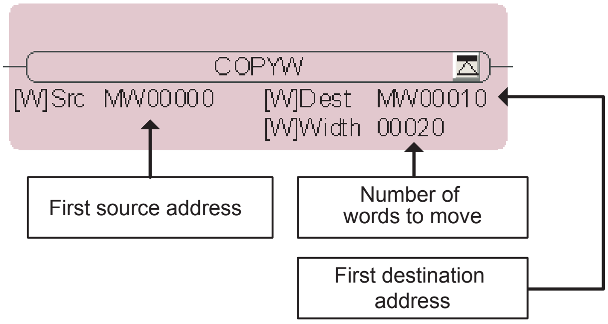


- This instruction differs from the MOVW instruction by the way it handles overlap between the source and destination areas.

■ Example Where the Source Area and Destination Area Overlap



(2) Format



Icon: 

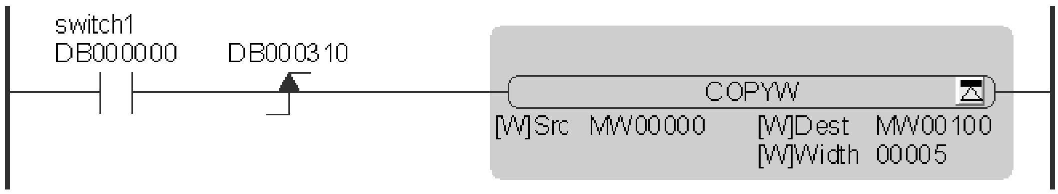
Key entry: COPYW

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First source address (Src)	×	○	×	×	×	×	×
First destination address (Dest)	×	○*	×	×	×	×	×
Number of words to move (Width)	×	○	×	×	×	○	○

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, five words of data are copied from the area that starts with the first source address at MW00000 to the area that starts with the first destination address at MW00100 when switch 1 (DB000000) turns ON.



The following figure illustrates the result when the above instructions are executed.

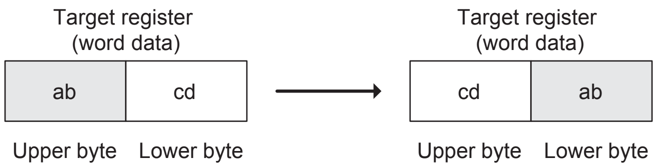
Register	Data
MW00000	1
MW00001	2
MW00002	3
MW00003	4
MW00004	5

Register	Data before Execution of Instruction	Data after Execution of Instruction
MW00100	123	1
MW00101	234	2
MW00102	345	3
MW00103	456	4
MW00104	567	5

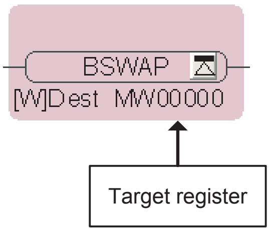
5.7.14 Byte Swap (BSWAP)

(1) Operation

The BSWAP instruction swaps the upper byte and lower byte of the target register.



(2) Format



Icon: 

Key entry: BSWAP

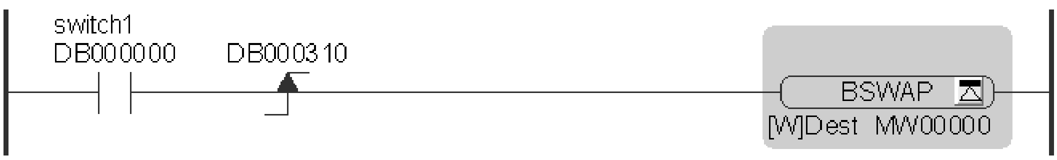
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Target register (Dest)	×	○*	×	×	×	×	×

* C and # registers cannot be used.

(3) Programming Example

In the following programming example, the upper byte and lower byte of MW00000 are swapped when switch 1 (DB000000) turns ON.

- If MW00000 is 00FF hex, MW00000 will be FF00 hex after execution of the BSWAP instruction.

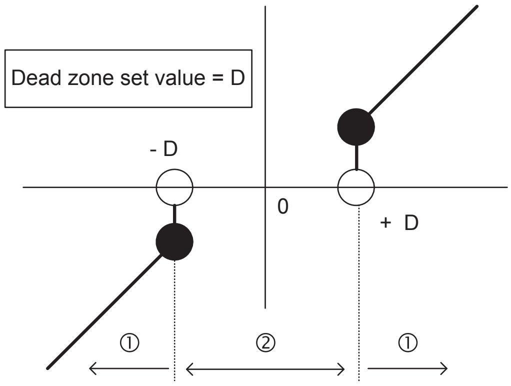


5.8 DDC Instructions

5.8.1 Dead Zone A (DZA)

(1) Operation

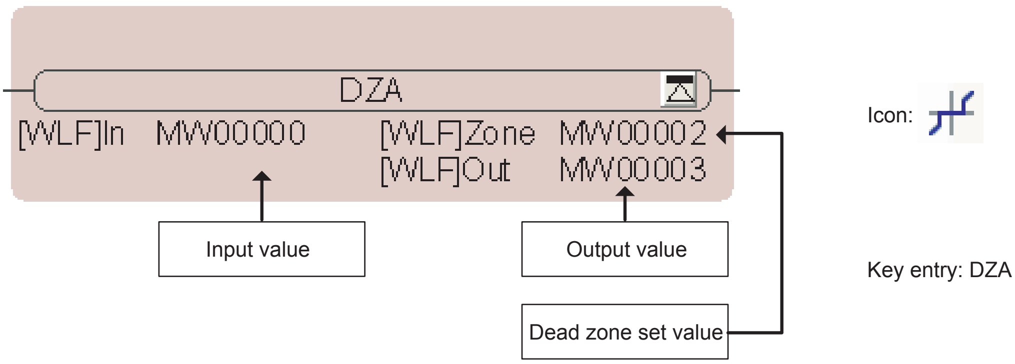
The DZA instruction calculates the output value by comparing the input value against a predefined dead zone.
As shown in the following figure, if the absolute value of the input value is greater than or equal to the absolute value of D, the input value is outside of the dead zone, so it becomes the output value.
If the absolute value of the input value is less than the absolute value of D, the input value is inside of the dead zone, so the output is set to 0.



① If | Input value | ≥ | D |
Output value = Input value

② If | Input value | < | D |
Output value = 0

(2) Format



Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value (In)	×	○	○	○	×	○	○
Dead zone set value (Zone)	×	○	○	○	×	○	○
Output value (Out)	×	○*	○*	○*	×	○	×

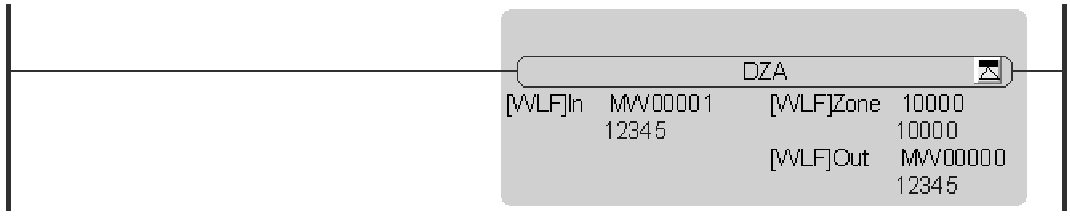
* C and # registers cannot be used.

Instructions
5

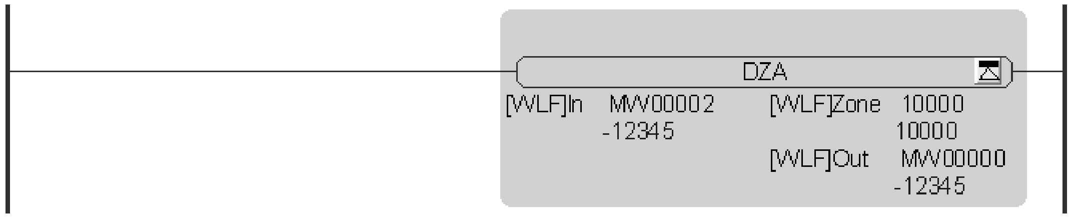
(3) Programming Examples

In the following programming examples, the dead zone set value is set to 10,000 and the output value is stored in MW00000.
The output values are calculated with respect to the input values in MW00001 to MW00003 as shown below.

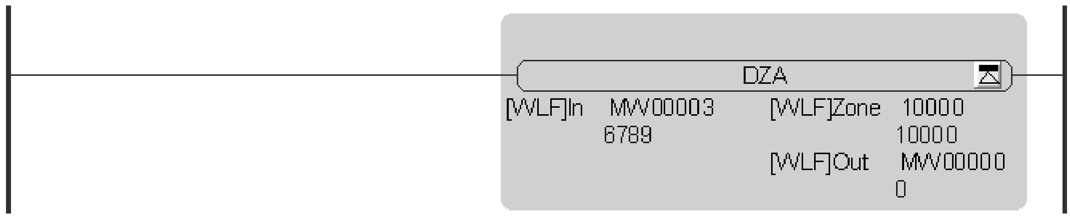
- Outside of the Dead Zone
  | MW00001 (12,345) | ≥ | 10,000 |, so MW00000 is 12,345.



| MW00002 (-12,345) | ≥ | 10,000 |, so MW00000 is -12,345.



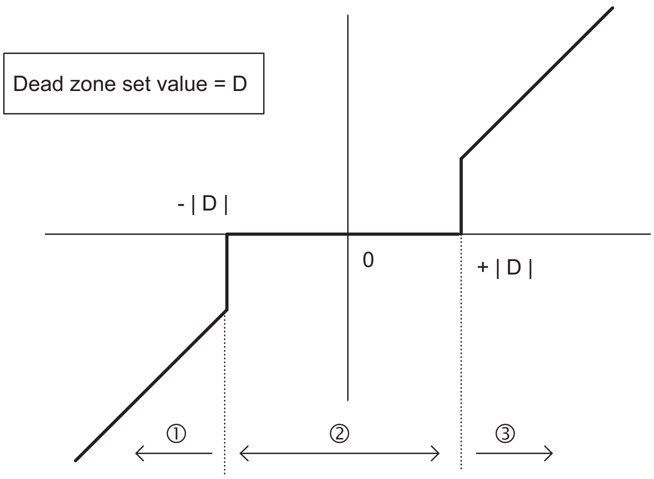
- Inside of the Dead Zone
  | MW00003 (6,789) | < | 10,000 |, so MW00000 is 0.



5.8.2 Dead Zone B (DZB)

(1) Operation

The DZB instruction calculates the output value by comparing the input value against a predefined dead zone.
As shown in the following figure, if the absolute value of the input value is less than the absolute value of D, the input value is inside of the dead zone, so the output is set to 0.
Unlike the DZA instruction, when the input value is outside of the dead zone, the sign of the input value determines whether the output value is obtained by adding the absolute value of D to or subtracting it from the input value.

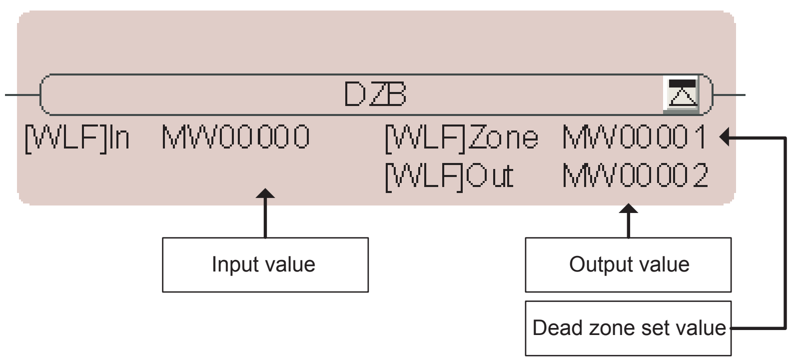


① If Input value < 0 and | Input value | ≥ | D |
Output value = Input value + | D |

② If | Input value | < | D |
Output value = 0

③ If Input value > 0 and | Input value | ≥ | D |
Output value = Input value – | D |

(2) Format



Icon: 

Key entry: DZB

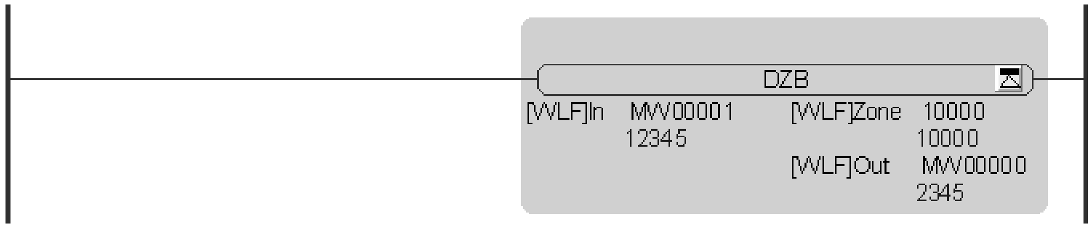
Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value (In)	×	○	○	○	×	○	○
Dead zone set value (Zone)	×	○	○	○	×	○	○
Output value (Out)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

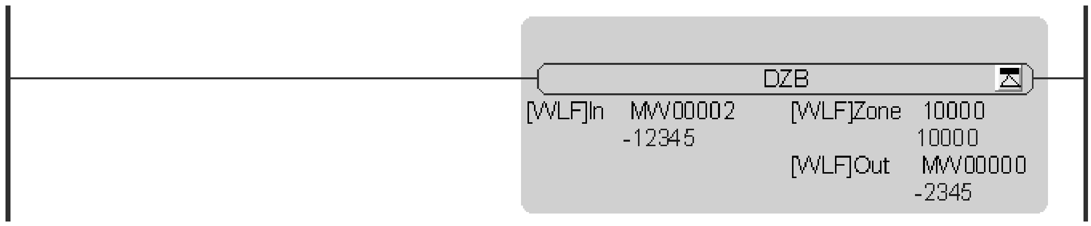
(3) Programming Examples

In the following programming examples, the dead zone set value is set to 10,000 and the output value is stored in MW00000.
The output values are calculated with respect to the input values in MW00001 to MW00003 as shown below.

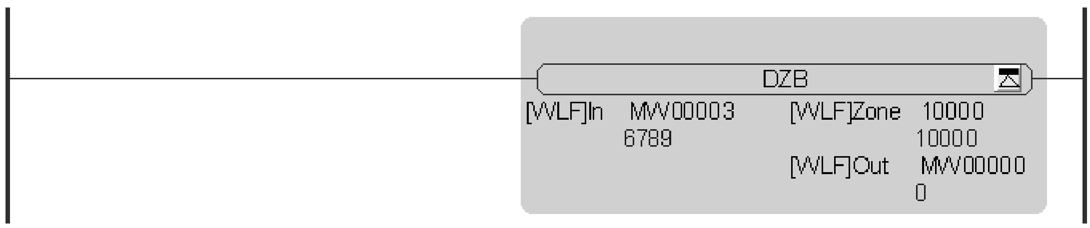
- Outside of the Dead Zone
  Because MW00001 (12,345) > 0 and | MW00001 (12,345) | ≥ | 10,000 |, so MW00000 = 12,345 – | 10,000 | = 2,345.



MW00002 (-12,345) < 0, | MW00002 (-12,345) | ≥ | 10,000 |, so MW00000 = -12,345 + | 10,000 | = -2,345.



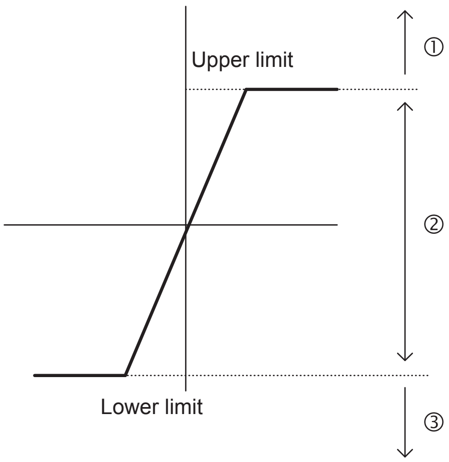
- Inside of the Dead Zone
  | MW00003 (6,789) | < | 10,000 |, so MW00000 is 0.



5.8.3 Upper/Lower Limit (LIMIT)

(1) Operation

The LIMIT instruction controls the output value so that it does not exceed the specified upper and lower limits for the input value.
As shown in the following figure, if the input value is within the upper and lower limits, the input value is output unaltered.
The upper limit is output when the input value is greater than upper limit. The lower limit is output when the input value is less than the lower limit.

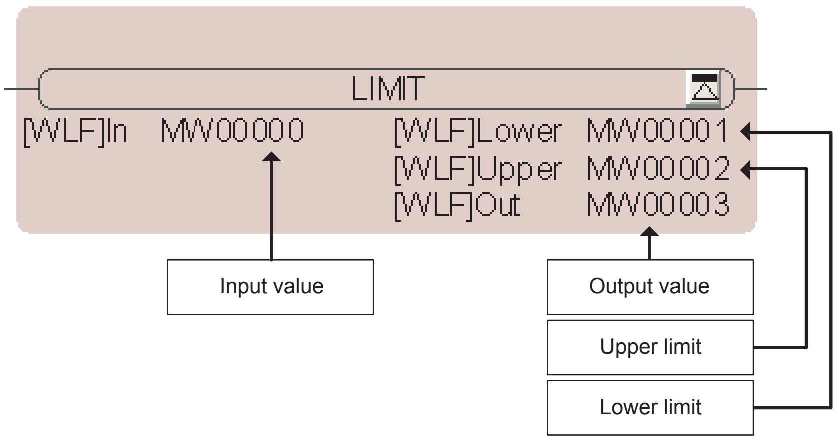


① If Input value > Upper limit
Output value = Upper limit

② If Lower limit ≤ Input value ≤ Upper value
Output value = Input value

③ Input value < Lower limit
Output value = Lower limit

(2) Format



Icon: 

Key entry: LIMIT

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value (In)	×	○	○	○	×	○	○
Lower limit (Lower)	×	○	○	○	×	○	○
Upper limit (Upper)	×	○	○	○	×	○	○
Output value (Out)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

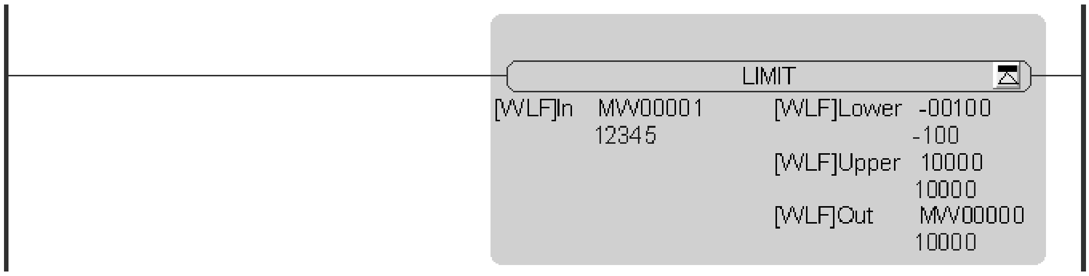
INFO

Always set the lower limit to a value that is less than or equal to the upper limit.

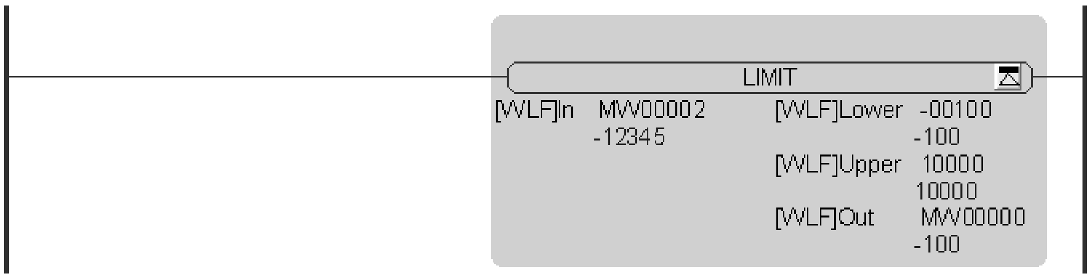
(3) Programming Examples

In the following programming examples, the operation results are stored as the output value (MW00000) when the lower limit is -100 and the upper limit is 10,000.
The output values are calculated with respect to the input values in MW00001 to MW00003 as shown below.

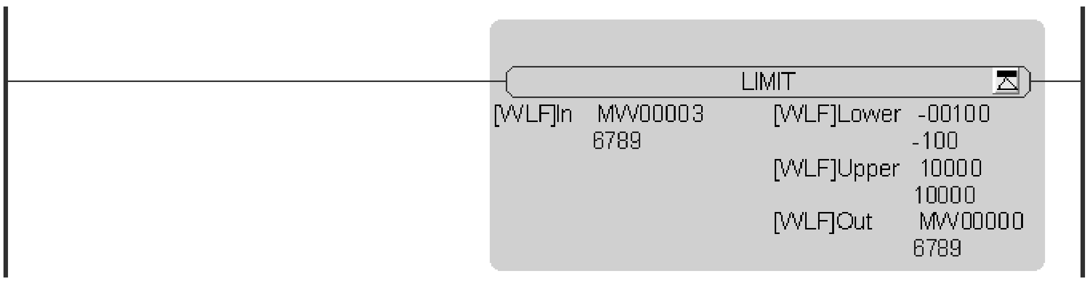
- The Input Value Is Outside of the Upper and Lower Limits
  Because MW00001 (12,345) is greater than the upper limit (10,000), MW00000 becomes the upper limit (10,000).



Because MW00002 (-12,345) is less than the lower limit (-100), MW00000 becomes the lower limit (-100).



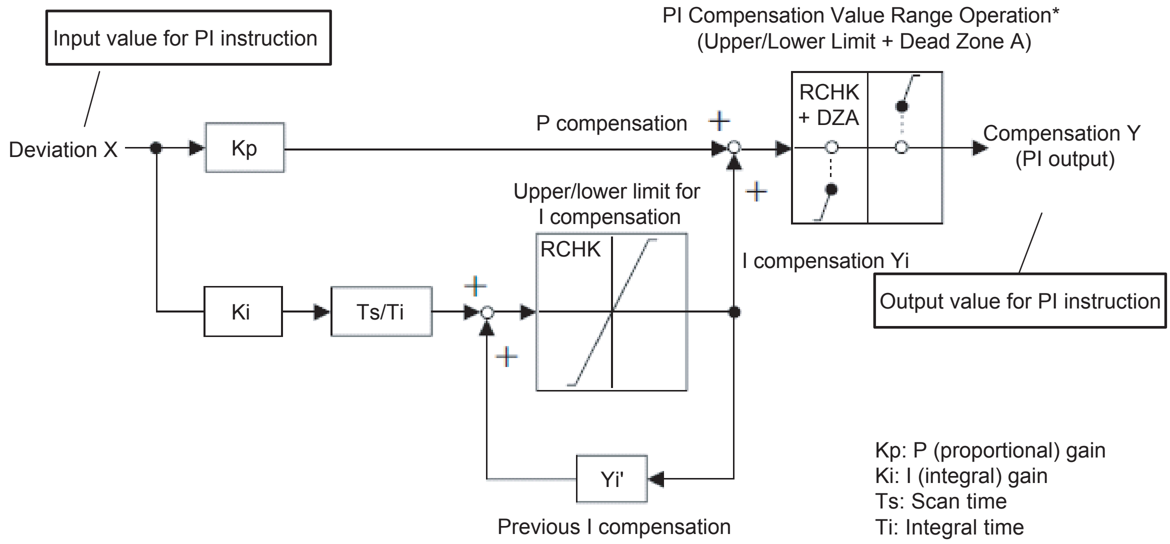
- The Input Value Is Within the Upper and Lower Limits
  Because the lower limit (-100) is less than MW00003 (6,789), which is less than the upper limit (10,000), MW00000 becomes 6,789.



5.8.4 PI Control (PI)

(1) Operation

When deviation X is input, the PI instruction performs P and I operations and a range operation based on predefined parameters in a parameter table, and outputs the result as compensation Y.
When the reset integration bit in the parameter table is closed (turned ON), the PI compensation is calculated using an I compensation value of 0.
The input value to the PI instruction can be an integer or a real number. Double-length integers cannot be used.
The structure of the parameter table is different for integers and real numbers.

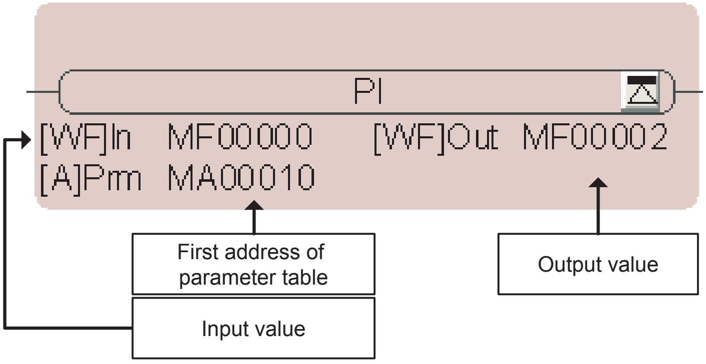


* The range operation for the PI compensation is processed as follows if the P + I compensation crosses the PI upper or lower limit (UL or LL), or the PI dead zone (DB):
- If the P compensation and I compensation have the same sign (divergence) → The previous value is retained for the I compensation value.
- If the P compensation and I compensation have different signs (convergence to 0) → The I compensation value is updated to a new value.

The operation of the PI instruction can be expressed by the following formula, where X (s) is the input value and Y (s) is the output value.

$$\frac{Y(s)}{X(s)} = Kp + Ki \times \frac{1}{Ti \times s}$$

(2) Format



Icon: PI

Key entry: PI

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value (In)	×	○	×	○	×	○	○
First address of parameter table (Prm)	×	×	×	×	○*	○	○
Output value (Out)	×	○*	×	○*	×	○	×

* C and # registers cannot be used.

[a] Parameter Table Configuration for PI Instruction with Integers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	Kp	P gain	Gain for the P compensation (A gain of 1 is equivalent to 100.)	IN
2	W	Ki	Integral adjustment gain	Gain for the input to the integration circuit (A gain of 1 is equivalent to 100.)	IN
3	W	Ti	Integral time	Integral time (ms)	IN
4	W	IUL	Upper integration limit	Upper limit for the I compensation	IN
5	W	ILL	Lower integration limit	Lower limit for the I compensation	IN
6	W	UL	PI upper limit	Upper limit for the P + I compensation	IN
7	W	LL	PI lower limit	Lower limit for the P + I compensation	IN
8	W	DB	PI output dead zone	Dead zone width for the P + I compensation	IN
9	W	Y	PI output	PI compensation output (output to Out)	OUT
10	W	Yi	I compensation	I compensation storage	OUT
11	W	IREM	I remainder	I remainder storage	OUT

* The relay input and output bits are assigned as given below. (Close = Bit change to 1 (ON), Open = Bit change to 0 (OFF))

Bit	Symbol	Name	Specification	I/O
0	IRST	Reset integration bit	This input is closed to reset the integration operation.	IN
1 to 7	–	(Reserved.)	Spare input relays	IN
8 to F	–	(Reserved.)	Spare output relays	OUT

[b] Parameter Table Configuration for PI Instruction with Real Numbers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	–	(Reserved.)	Spare register	–
2	F	Kp	P gain	Gain for the P compensation	IN
4	F	Ki	Integral adjustment gain	Gain for the input to the integral circuit	IN
6	F	Ti	Integral time	Integral time (s)	IN
8	F	IUL	Upper integration limit	Upper limit for the I compensation	IN
10	F	ILL	Lower integration limit	Lower limit for the I compensation	IN
12	F	UL	PI upper limit	Upper limit for the P + I compensation	IN
14	F	LL	PI lower limit	Lower limit for the P + I compensation	IN
16	F	DB	PI output dead zone	Dead zone width for the P + I compensation	IN
18	F	Y	PI output	PI compensation output (output to Out)	OUT
20	F	Yi	I compensation	I compensation storage	OUT

* The relay input and output bit assignments are the same as for integers.

[c] Internal Operation of the Instruction

The deviation X input is used to calculate the output value (PI compensation) as shown below.
In the formula shown below, Yi’ is the previous I compensation of Yi and Ts is the scan time set value.

- When IRST (reset integration) is closed, the PI compensation is calculated with the I compensation set to 0.

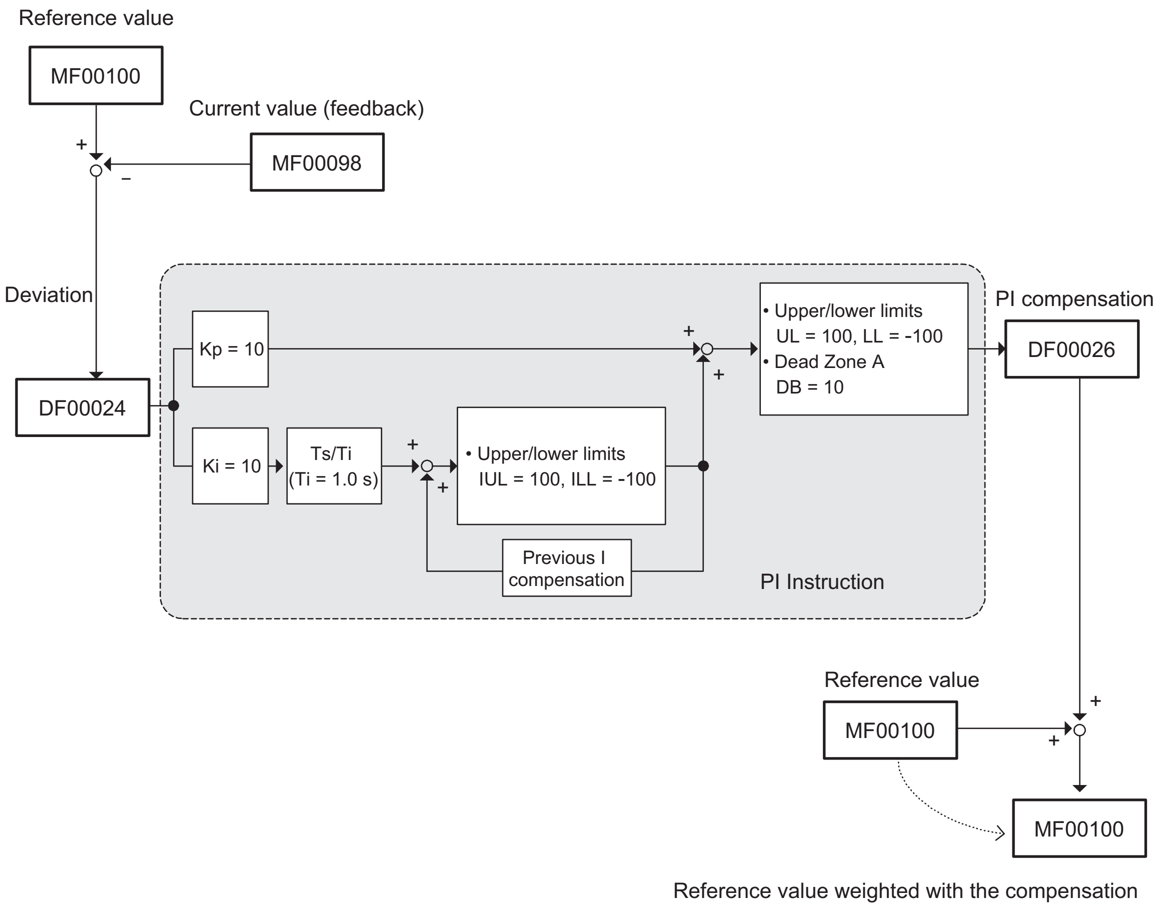
P compensation = Upper/lower limit (UL or LL) of ($Kp \times X$)

Yi (I compensation) = Upper/lower limit (IUL or ILL) of $\{ (Ki \times X + IREM) / \frac{Ti}{Ts} + Yi' \}$

Y (PI compensation) = P compensation + Upper/lower limit (UL or LL) and Dead zone A (Width DB) of the I compensation

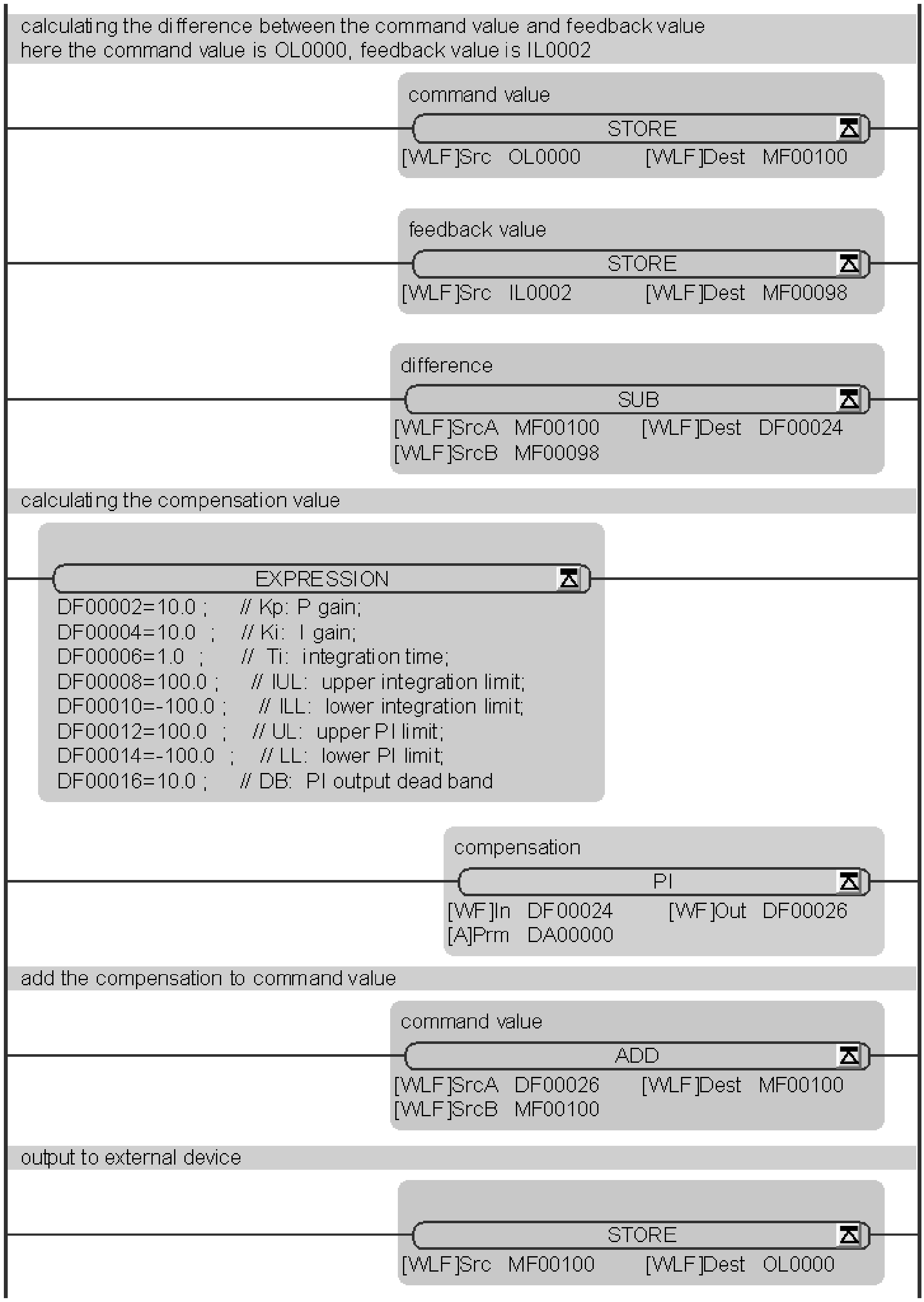
(3) Programming Example

This programming example calculates the reference value in MF00100 weighted with the PI compensation.
The deviation in DF00024 is obtained from the reference value in MF00100 and the current value in MF00098 and it is used as the input to the PI instruction.
The reference value to output is obtained by adding the original reference value in MF00100 to the PI compensation output in DF00026.
The following block diagram illustrates the programming example.



The programming example is shown below.

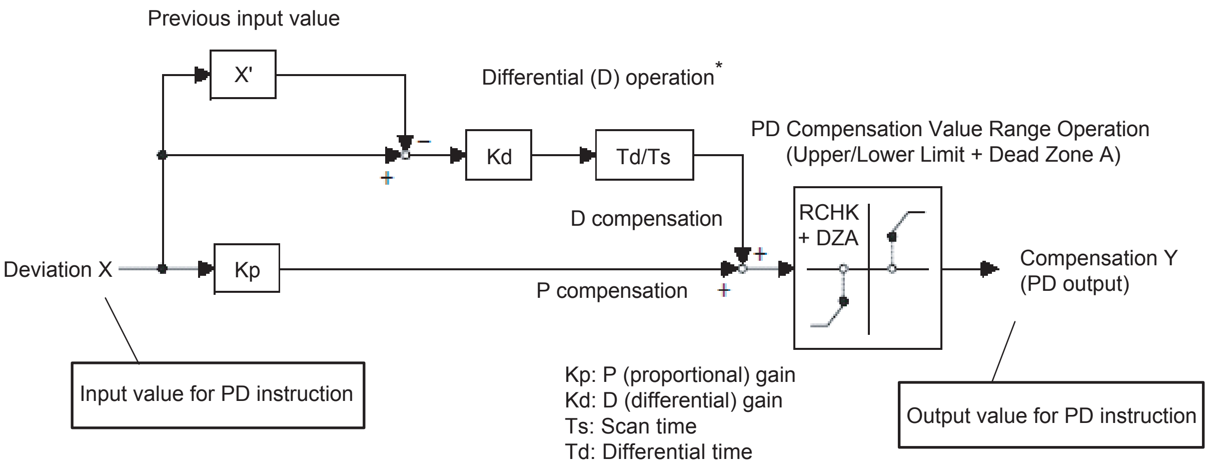
- The OL00000 (reference value) and IL00002 (feedback value) registers are assigned to external devices.



5.8.5 PD Control (PD)

(1) Operation

When deviation X is input, the PD instruction performs P and D operations and a range operation based on predefined parameters in a parameter table, and outputs the result as compensation Y.
The input value to the PD instruction can be an integer or a real number. Double-length integers cannot be used.
The structure of the parameter table is different for integers and real numbers.



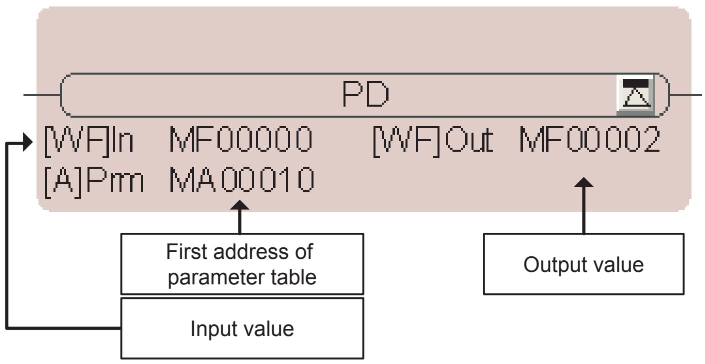
* The differential time (Td) changes based on the relationship between the change in the deviation input (X – X') and the previous deviation input (X') as follows:

- If the change in the deviation input (X – X') and the previous deviation input (X') have the same sign (divergence)
  → Td = Td1 (differential time for divergence)
- If the change in the deviation input (X – X') and the previous deviation input (X') have different signs (convergence)
  → Td = Td2 (differential time for convergence)

The operation of the PD instruction can be expressed by the following formula, where X (s) is the input value and Y (s) is the output value.

$$\frac{Y(s)}{X(s)} = Kp + Kd \times Td \times S$$

(2) Format



Icon: PD

Key entry: PD

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value (In)	×	○	×	○	×	○	○
First address of parameter table (Prm)	×	×	×	×	○*	○	○
Output value (Out)	×	○*	×	○*	×	○	×

* C and # registers cannot be used.

[a] Parameter Table Configuration for PD Instruction with Integers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	Kp	P gain	Gain for the P compensation (A gain of 1 is equivalent to 100.)	IN
2	W	Kd	D gain	Gain for the input to the differential circuit (A gain of 1 is equivalent to 100.)	IN
3	W	Td1	Differential time for divergence	Differential time used when the input diverges (ms)	IN
4	W	Td2	Differential time for convergence	Differential time used when the input converges (ms)	IN
5	W	UL	PD upper limit	Upper limit for the P + D compensation	IN
6	W	LL	PD lower limit	Lower limit for the P + D compensation	IN
7	W	DB	PD output dead zone	Dead zone width for the P + D compensation	IN
8	W	Y	PD output	PD compensation output (output to Out)	OUT
9	W	X	Input value storage	Storage of current input value	OUT

* The relay input and output bits are assigned as given below.

Bit	Symbol	Name	Specification	I/O
0 to 7	–	(Reserved.)	Spare input relays	IN
8 to F	–	(Reserved.)	Spare output relays	OUT

[b] Parameter Table Configuration for PD Instruction with Real Numbers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	–	(Reserved.)	Spare register	–
2	F	Kp	P gain	Gain for the P compensation	IN
4	F	Kd	D gain	Gain for the input to the differential circuit	IN
6	F	Td1	Differential time for divergence	Differential time used when the input diverges (s)	IN
8	F	Td2	Differential time for convergence	Differential time used when the input converges (s)	IN
10	F	UL	PD upper limit	Upper limit for the P + D compensation	IN
12	F	LL	PD lower limit	Lower limit for the P + D compensation	IN
14	F	DB	PD output dead zone	Dead zone width for the P + D compensation	IN
16	F	Y	PD output	PD compensation output (output to Out)	OUT
18	F	X	Input value storage	Storage of current input value	OUT

* The relay input and output bit assignments are the same as for integers.

[c] Internal Operation of the Instruction

The deviation X input is used to calculate the PD compensation output as shown below.
In the formula shown below, X’ is the previous input value of X, Ts is the scan time set value, and Td* is the differential time.

* The differential time (Td) is Td1 when X – X’ and X’ have the same sign, and Td2 when X – X’ and X’ have different signs.

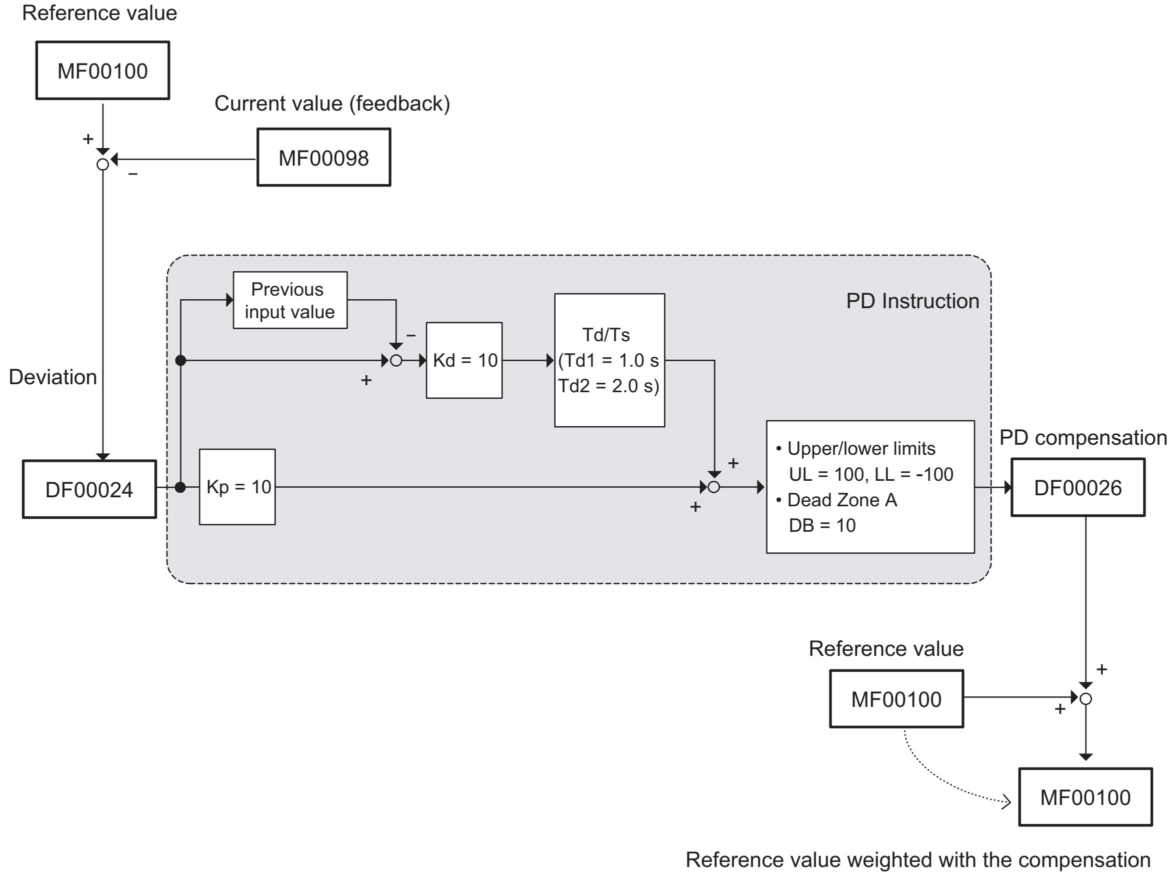
P compensation = Upper/lower limit (UL or LL) of $(Kp \times X)$

D compensation = $Kd \times (X - X') \times$ Upper/lower limit (IUL or ILL) of $\frac{Td}{Ts}$

PD compensation = Upper/lower limit (UL or LL) of (P compensation + D compensation) and Dead zone A (Width DB)

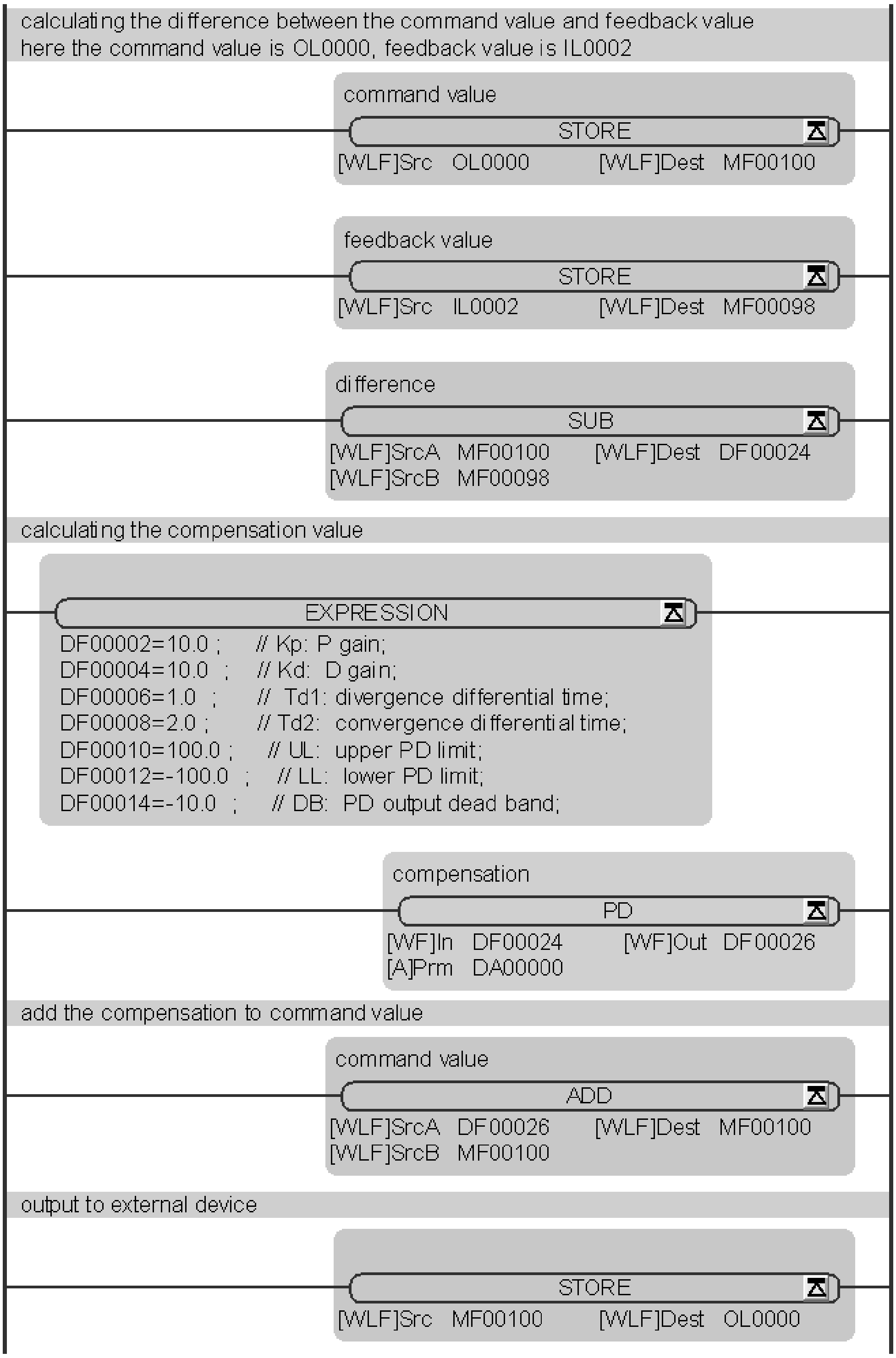
(3) Programming Example

This programming example calculates the reference value in MF00100 weighted with the PD compensation.
The deviation in DF00024 is obtained from the reference value in MF00100 and the current value in MF00098 and it is used as the input to the PD instruction.
The reference value to output is obtained by adding the original reference value in MF00100 to the PD compensation output in DF000026.
The following block diagram illustrates the programming example.



The programming example is shown below.

- The OL00000 (reference value) and IL00002 (feedback value) registers are assigned to external devices.



(4) Additional Information

[a] Transfer Functions

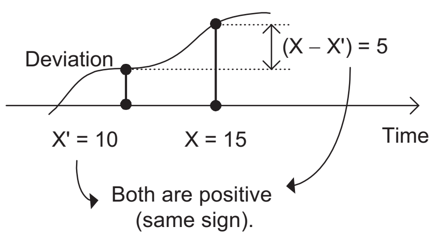
The transfer function of the P and D operations can be expressed by the formula shown below.
In this formula, X (s) is the input value and Y (s) is the output value.

$$\frac{Y(s)}{X(s)} = Kp + Kd \times Td \times S$$

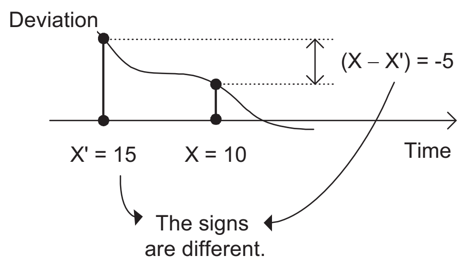
[b] Divergence and Convergence

The following figure shows the relation between the current deviation X and previous deviation X’ on the divergence and convergence sides.

• Example of a Diverging Deviation



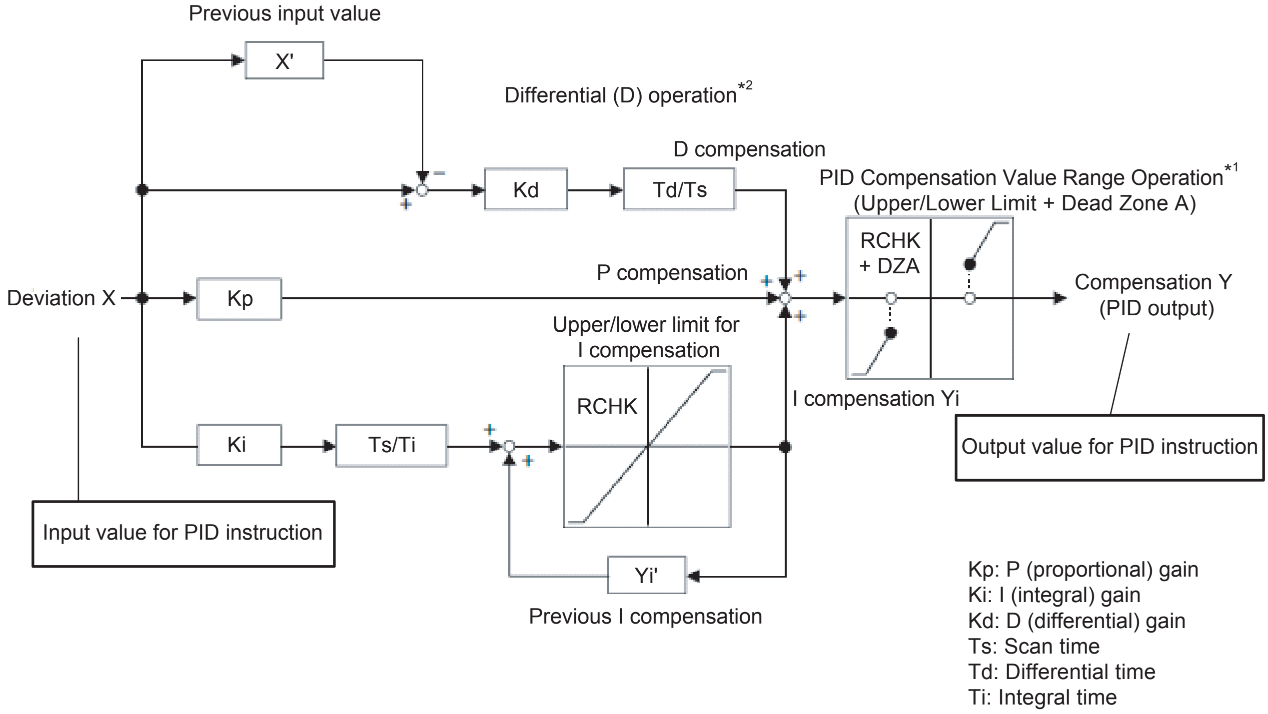
• Example of a Converging Deviation



5.8.6 PID Control (PID)

(1) Operation

When deviation X is input, the PID instruction performs P, I, and D operations and a range operation based on predefined parameters in a parameter table, and outputs the result as compensation Y.
When the reset integration bit in the parameter table is closed (turned ON), the PI compensation is calculated using an I compensation value of 0.
The input value to the PID instruction can be an integer or a real number. Double-length integers cannot be used.
The structure of the parameter table is different for integers and real numbers.



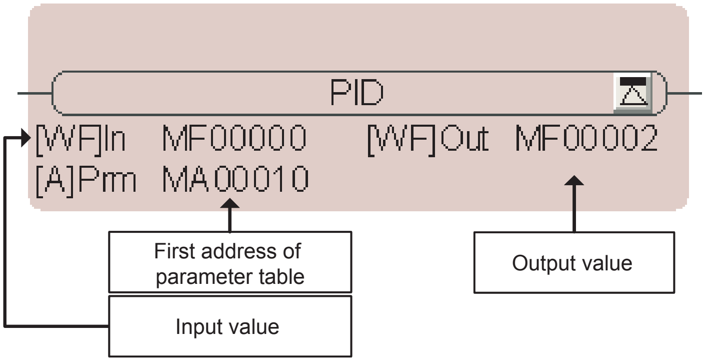
* 1. If the P + I + D compensation crosses the UL or LL (PID upper or lower limit), or DB (PI dead zone), the following processing is performed,
- If the P compensation and I compensation have the same sign (divergence) → The previous value is retained for the I compensation value.
- If the P compensation and I compensation have different signs (convergence to 0) → The I compensation value is updated to a new value.

* 2. The differential time (Td) changes based on the relationship between the change in the deviation input (X – X') and the previous deviation input (X') as follows:
- If the change in the deviation input (X – X') and the previous deviation input (X') have the same sign (divergence)
→ Td = Td1 (differential time for divergence)
- If the change in the deviation input (X – X') and the previous deviation input (X') have different signs (convergence)
→ Td = Td2 (differential time for convergence)

The operation of the PID instruction can be expressed by the following formula, where X (s) is the input value and Y (s) is the output value.

$$\frac{Y(s)}{X(s)} = Kp + Ki \times \frac{1}{Ti \times s} + Kd \times Td \times S$$

(2) Format



Icon: PID

Key entry: PID

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value (In)	×	○	×	○	×	○	○
First address of parameter table (Prm)	×	×	×	×	○*	○	○
Output value (Out)	×	○*	×	○*	×	○	×

* C and # registers cannot be used.

[a] Parameter Table Configuration for PID Instruction with Integers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	Kp	P gain	Gain for the P compensation (A gain of 1 is equivalent to 100.)	IN
2	W	Ki	I gain	Gain for the input to the integration circuit (A gain of 1 is equivalent to 100.)	IN
3	W	Kd	D gain	Gain for the input to the differential circuit (A gain of 1 is equivalent to 100.)	IN
4	W	Ti	Integral time	Integral time (ms)	IN
5	W	Td1	Differential time for divergence	Differential time used when the input diverges (ms)	IN
6	W	Td2	Differential time for convergence	Differential time used when the input converges (ms)	IN
7	W	IUL	Upper integration limit	Upper limit for the I compensation	IN
8	W	ILL	Lower integration limit	Lower limit for the I compensation	IN
9	W	UL	PID upper limit	Upper limit for the P + I compensation	IN
10	W	LL	PID lower limit	Lower limit for the P + I compensation	IN
11	W	DB	PID output dead zone	Dead zone width for the P + I compensation	IN
12	W	Y	PID output	PI compensation output (output to Out)	OUT
13	W	Yi	I compensation	I compensation storage	OUT
14	W	IREM	I remainder	I remainder storage	OUT
15	W	X	Input value storage	Storage of current input value	OUT

* The relay input and output bits are assigned as given below. (Close = Bit change to 1 (ON), Open = Bit change to 0 (OFF))

Bit	Symbol	Name	Specification	I/O
0	IRST	Reset integration bit	This input is closed to reset the integration operation.	IN
1 to 7	–	(Reserved.)	Spare input relays	IN
8 to F	–	(Reserved.)	Spare output relays	OUT

[b] Parameter Table Configuration for PID Instruction with Real Numbers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	–	(Reserved.)	Spare register	IN
2	F	Kp	P gain	Gain for the P compensation	IN
4	F	Ki	I gain	Gain for the input to the integral circuit	IN
6	F	Kd	D gain	Gain for the input to the differential circuit	IN
8	F	Ti	Integral time	Integral time (s)	IN
10	F	Td1	Differential time for divergence	Differential time used when the input diverges (s)	IN
12	F	Td2	Differential time for convergence	Differential time used when the input converges (s)	IN
14	F	IUL	Upper integration limit	Upper limit for the I compensation	IN
16	F	ILL	Lower integration limit	Lower limit for the I compensation	IN
18	F	UL	PID upper limit	Upper limit for the P + I + D compensation	IN
20	F	LL	PID lower limit	Lower limit for the P + I + D compensation	IN
22	F	DB	PID output dead zone	Dead zone width for the P + I + D compensation	IN
24	F	Y	PID output	PID compensation output (output to Out)	OUT
26	F	Yi	I compensation	I compensation storage	OUT
28	F	X	Input value storage	Storage of current input value	OUT

* The relay input and output bit assignments are the same as for integers.

[c] Internal Operation of the Instruction

The deviation X input is used to calculate the PID compensation output as shown below.
In the formula shown below, X' is the previous input value of X, Y' is the previous I compensation, Ts is the scan time set value, and Td* is the differential time.

* The differential time (Td) is Td1 when X – X' and X' have the same sign, and Td2 when X – X' and X' have different signs.

- When IRST (reset integration) is closed, the PID compensation is calculated with the I compensation set to 0.

P compensation = Upper/lower limit (UL or LL) of (Kp × X)

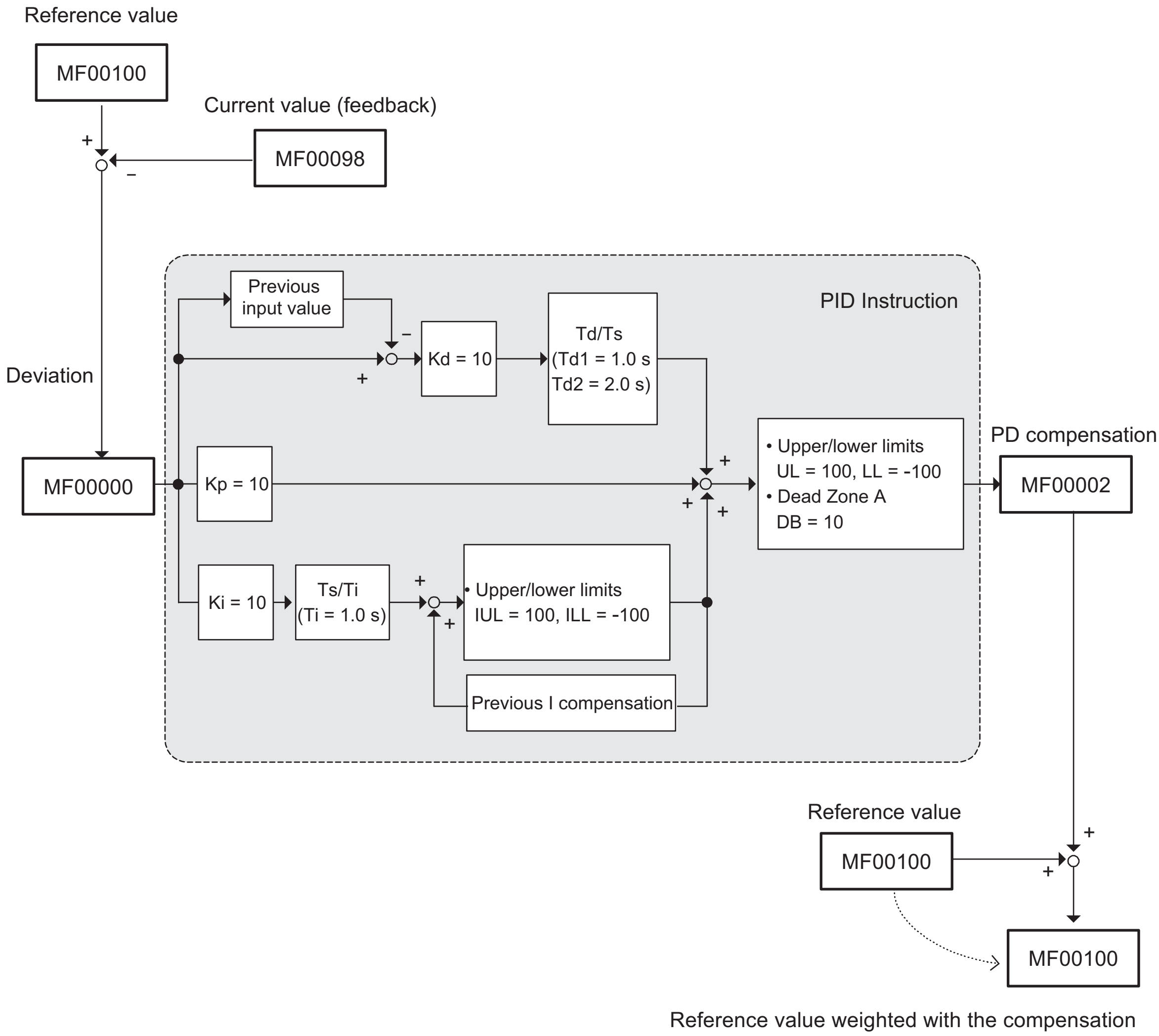
Yi (I compensation) = Upper/lower limit (IUL or ILL) of $\{ (\mathrm{Ki} \times \mathrm{X} + \mathrm{IREM}) / \frac{\mathrm{Ti}}{\mathrm{Ts}} + \mathrm{Yi'}\}$

D compensation = Kd × (X – X') × Upper/lower limit (IUL or ILL) of $\frac{\mathrm{Td}}{\mathrm{Ts}}$

Y (PID compensation) = Upper/lower limits (UL or LL) of P + I + D compensation values and dead zone A (Width DB)

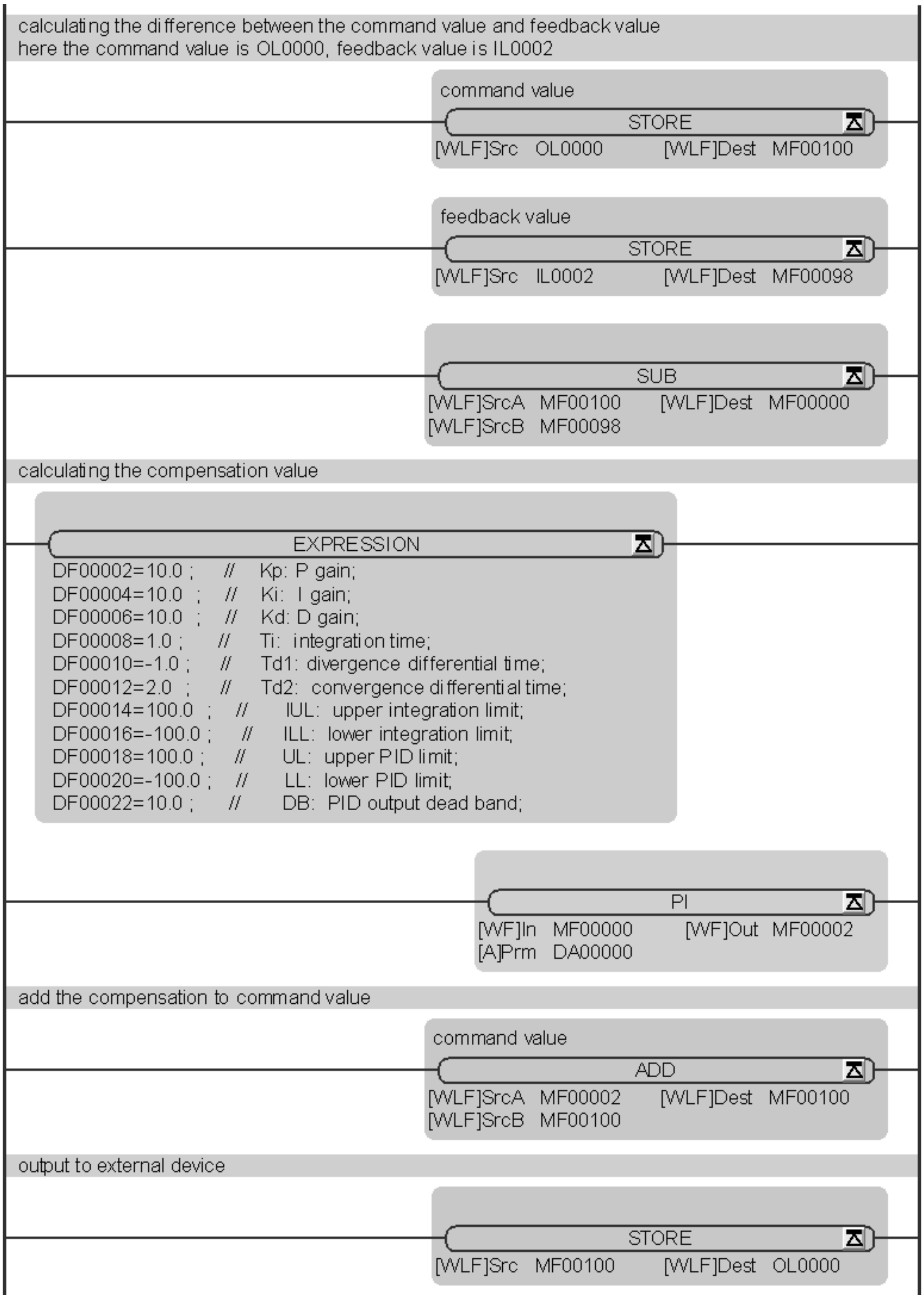
(3) Programming Example

This programming example calculates the reference value in MF00100 weighted with the PID compensation.
The deviation in MF00000 is obtained from the reference value in MF00100 and the current value in MF00098 and it is used as the input to the PID instruction.
The reference value to output is obtained by adding the original reference value in MF00100 to the PID compensation output in MF00002.
The following block diagram illustrates the programming example.



The programming example is shown below.

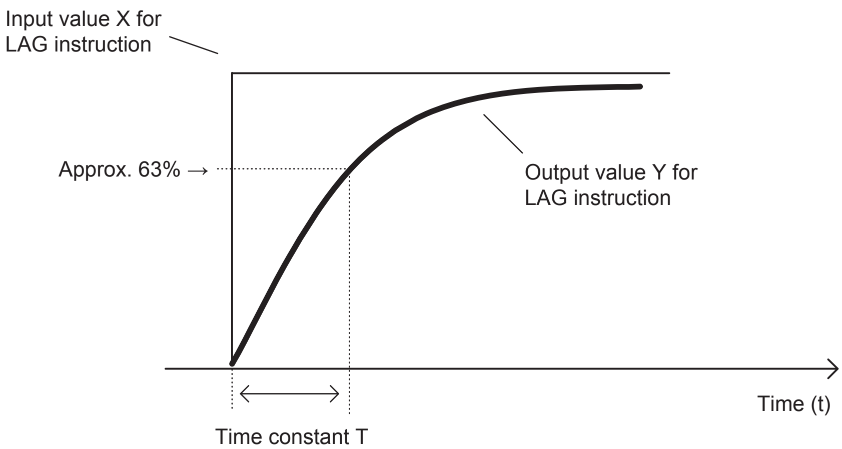
- The OL00000 (reference value) and IL00002 (feedback value) registers are assigned to external devices.



5.8.7 First-order Lag (LAG)

(1) Operation

The LAG instruction calculates the first-order lag according to predefined parameters in a parameter table.
The input value to the LAG instruction can be an integer or a real number. Double-length integers cannot be used.
The structure of the parameter table is different for integers and real numbers.



The LAG operation in the figure shown above can be expressed by the formula shown below.

$$\frac{Y(s)}{X(s)} = \frac{1}{1 + T \times s}$$

Therefore,

$$T \times \frac{dY}{dt} + Y = X$$

The following operation is performed internally by the LAG instruction, where dt = Ts and dY = Y – Y'.
In the formula shown below, Y' is the previous output value, Ts is the scan time set value,* and REM is the remainder.

* The unit for Ts is the same as the unit for T.

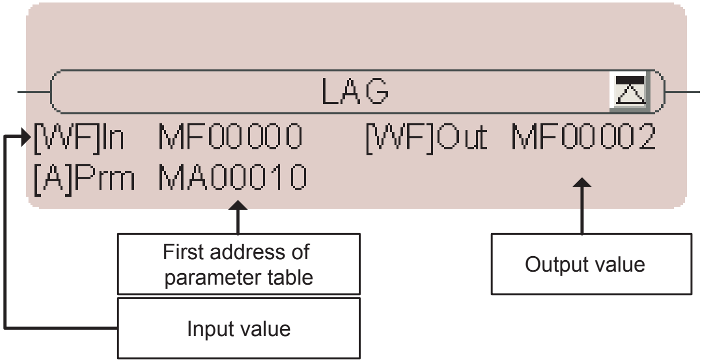
$$Y = \frac{T \times Y' + Ts \times X + REM}{T + Ts}$$

- When IRST (LAG reset) is closed, Y outputs 0 and REM outputs 0.
- The symbols in the figure correspond to those in the parameter table.

Instructions

5

(2) Format



Icon: LAG

Key entry: LAG

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value (In)	×	○	×	○	×	○	○
First address of parameter table (Prm)	×	×	×	×	○*	○	○
Output value (Out)	×	○*	×	○*	×	○	×

* C and # registers cannot be used.

[a] Parameter Table Configuration for LAG Instruction with Integers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	T	First-order lag time constant	First-order lag time constant (ms)	IN
2	W	Y	LAG output	LAG output (output to Out)	OUT
3	W	REM	Remainder	Remainder storage	OUT

* The relay input and output bits are assigned as given below. (Close = Bit change to 1 (ON), Open = Bit change to 0 (OFF))

Bit	Symbol	Name	Specification	I/O
0	IRST	LAG reset bit	This input is closed to reset the LAG operation.	IN
1 to 7	–	(Reserved.)	Spare input relays	IN
8 to F	–	(Reserved.)	Spare output relays	OUT

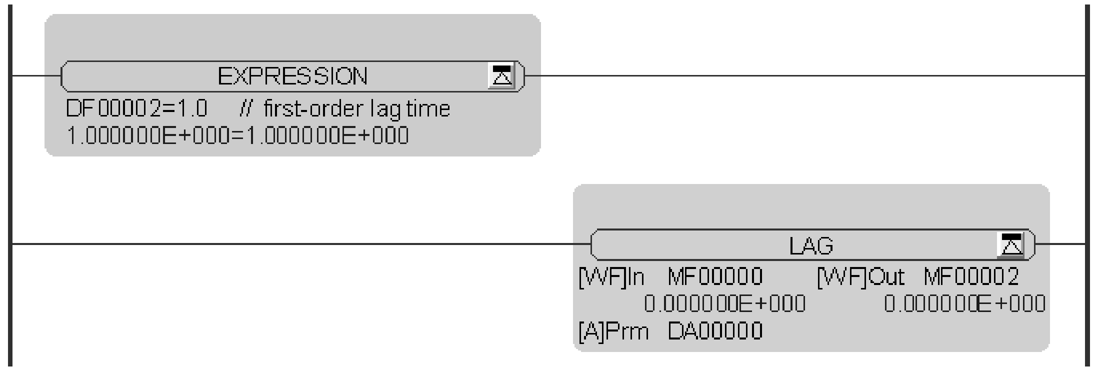
[b] Parameter Table Configuration for LAG Instruction with Real Numbers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	–	(Reserved.)	Spare register	–
2	F	T	First-order lag time constant	First-order lag time constant (s)	IN
4	F	Y	LAG output	LAG output (output to Out)	OUT

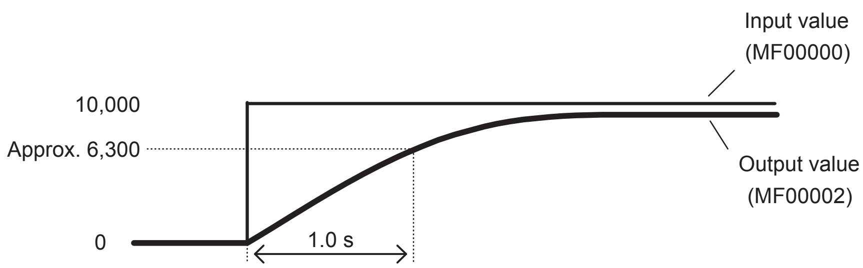
* The relay input and output bit assignments are the same as for integers.

(3) Programming Example

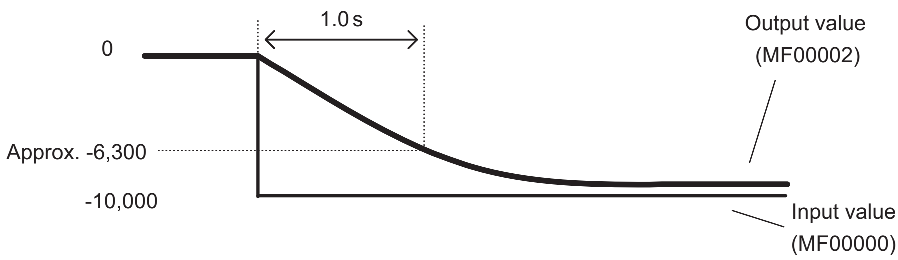
In the following programming example, the LAG instruction is executed where MF00000 is the input value in the parameter table, MF00002 is the output value, and the first-order lag time constant is set to 1.0.



MF00002 changes as shown below when the input value (MF00000) changes from 0 to 10,000.



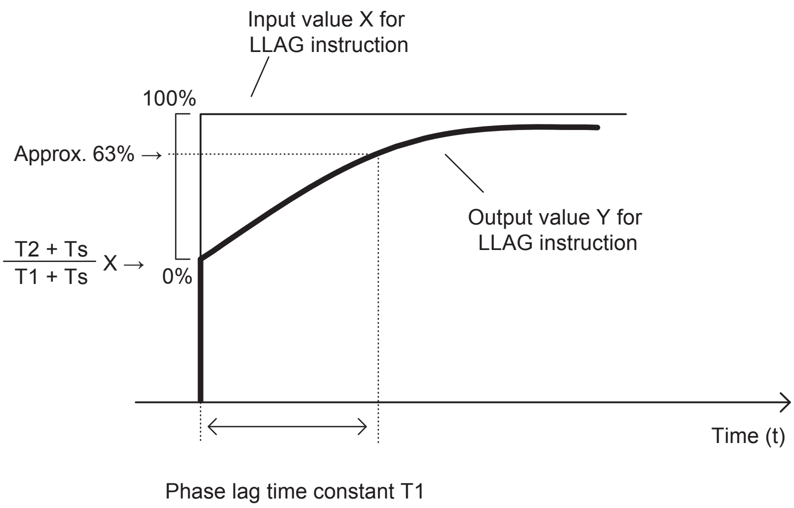
MF00002 changes as shown below when the input value (MF00000) changes from 0 to -10,000.



5.8.8 Phase Lead Lag (LLAG)

(1) Operation

The LLAG instruction calculates the phase lead and lag according to predefined parameters in a parameter table. The input value to the LLAG instruction can be an integer or real number. Double-length integers cannot be used.
The structure of the parameter table is different for integers and real numbers.



The LLAG operation in the figure shown above can be expressed by the formula shown below.

$$\frac{Y(s)}{X(s)} = \frac{1 + T2 \times s}{1 + T1 \times s}$$

Therefore,

$$T1 \times \frac{dY}{dt} + Y = T2 \times \frac{dX}{dt} + X$$

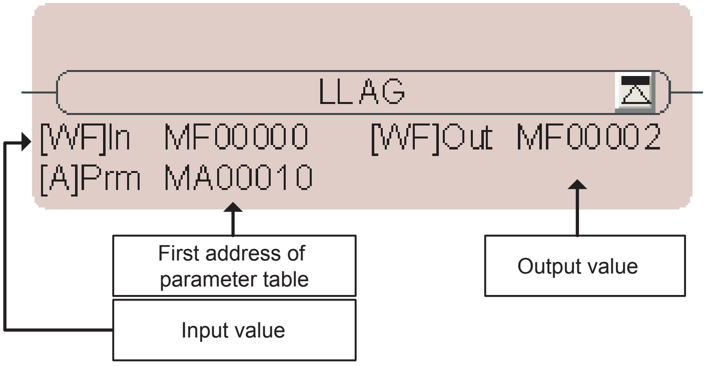
The following operation is performed internally by the LLAG instruction, where dt = Ts, dY = Y – Y’, and dX = X – X’.
In the formula shown below, Y’ is the previous output value, X’ is the previous input value, Ts is the scan time set value*, and REM is the remainder.

* The unit for Ts is the same as the unit for T1.

$$Y = \frac{T1 \times Y' + (T2 + Ts) \times X - T2 \times X' + REM}{T1 + Ts}$$

- When IRST (LLAG reset) is closed, Y outputs 0, REM outputs 0, and X outputs 0.

(2) Format



Icon 

Key entry: LLAG

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value (In)	×	○	×	○	×	○	○
First address of parameter table (Prm)	×	×	×	×	○*	○	○
Output value (Out)	×	○*	×	○*	×	○	×

* C and # registers cannot be used.

[a] Parameter Table Configuration for LLAG Instruction with Integers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	T2	Phase lead time constant	Phase lead time constant (ms)	IN
2	W	T1	Phase lag time constant	Phase lag time constant (ms)	IN
3	W	Y	LLAG output	LLAG output (output to Out)	OUT
4	W	REM	Remainder	Remainder storage	OUT
5	W	X	Input value storage	Input value storage	OUT

* The relay input and output bits are assigned as given below. (Close = Bit change to 1 (ON), Open = Bit change to 0 (OFF))

Bit	Symbol	Name	Specification	I/O
0	IRST	LLAG reset bit	This input is closed to reset the LLAG operation.	IN
1 to 7	–	(Reserved.)	Spare input relays	IN
8 to F	–	(Reserved.)	Spare output relays	OUT

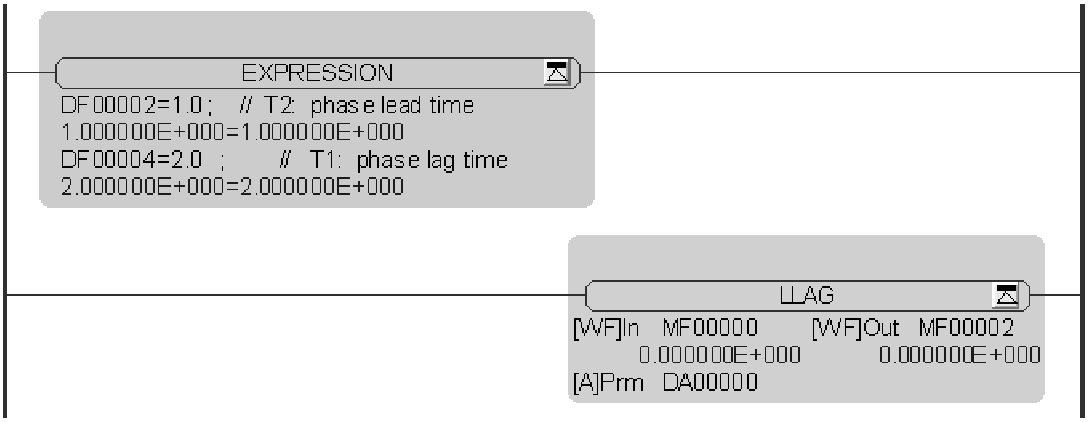
[b] Parameter Table Configuration for LLAG Instruction with Real Numbers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	–	(Reserved.)	Spare register	–
2	F	T2	Phase lead time constant	Phase lead time constant (s)	IN
4	F	T1	Phase lag time constant	Phase lag time constant (s)	IN
6	F	Y	LLAG output	LLAG output (output to Out)	OUT
8	F	X	Input value storage	Input value storage	OUT

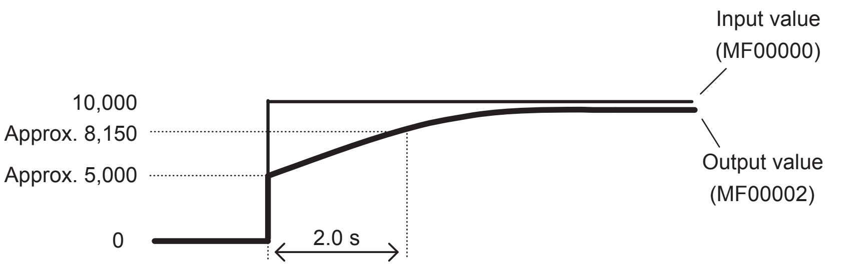
* The relay input and output bit assignments are the same as for integers.

(3) Programming Example

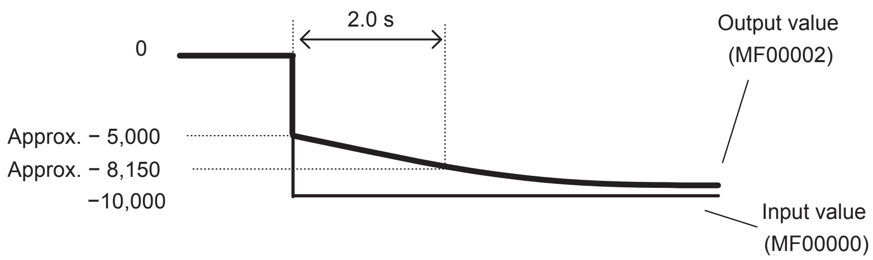
In the following programming example, the LLAG instruction is executed where MF00000 is the input value, MF00002 is the output value, the phase lead time constant is set to 1.0 seconds, and the phase lag time constant is set to 2.0 seconds.



MF00002 changes as shown below when the input value (MF00000) changes from 0 to 10,000.



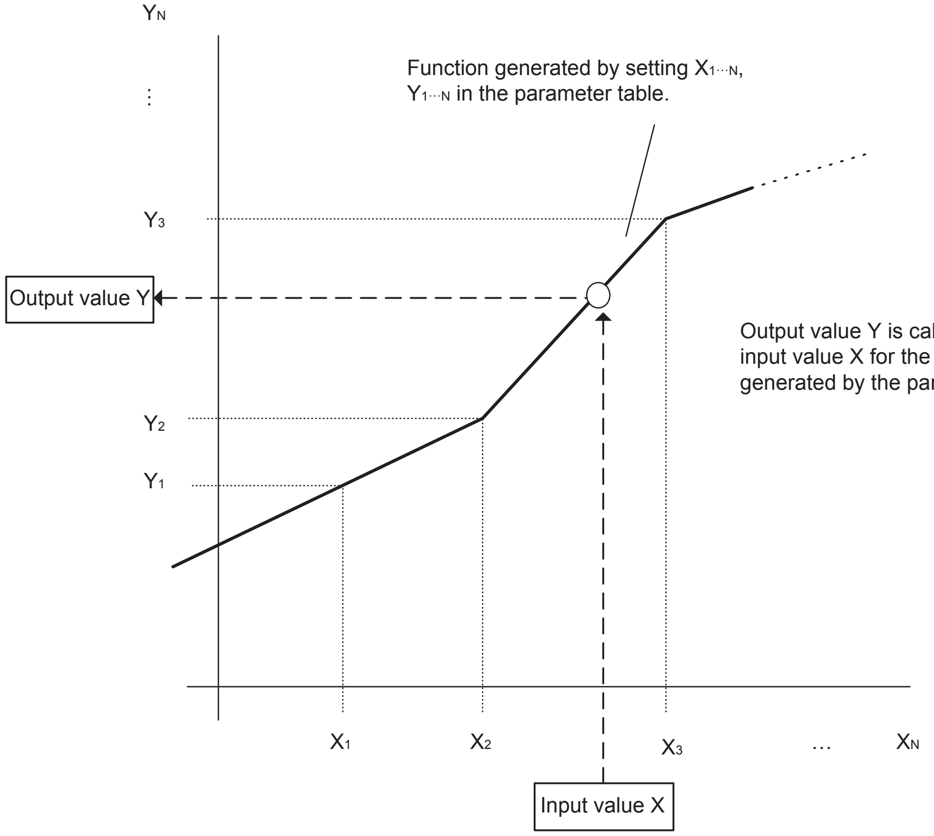
MF00002 changes as shown below when the input value (MF00000) changes from 0 to -10,000.



5.8.9 Function Generator (FGN)

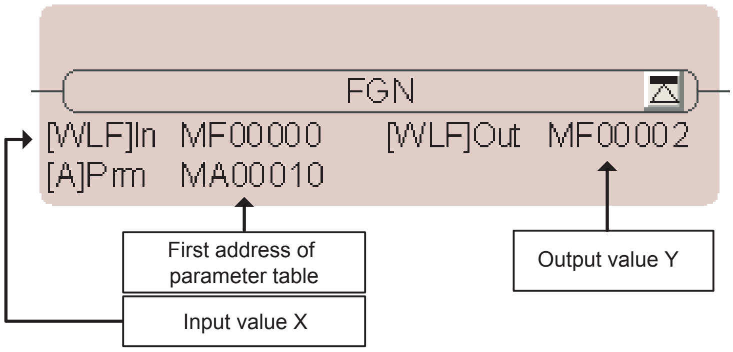
(1) Operation

The FGN instruction generates a function based on the parameters specified in the parameter table. It then uses the function to calculate output value Y based on the value of input X.
The FGN instruction will be for integers, double-length integers, or real numbers, depending on the data type of input value X. The structure of the parameter table changes accordingly.



- Create the parameter table so that $X_1 < X_2 < \ldots < X_N$.

(2) Format



Icon: FGN

Key entry: FGN

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value X (In)	×	○	○	○	×	○	○
First address of parameter table (Prm)	×	×	×	×	○	×	×
Output value Y (Out)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

[a] Parameter Table Configuration for FGN Instruction with Integers

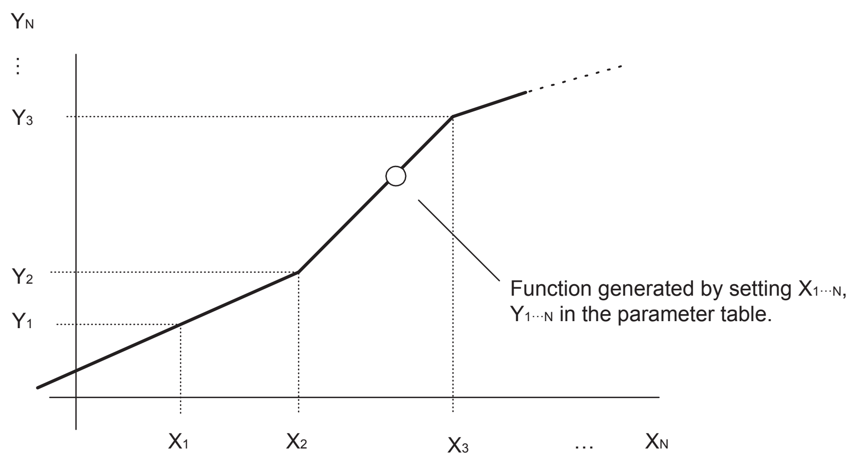
If input value X is an integer, the FGN instruction will be for integers.
Create the parameter table as shown below.

Address	Data Type	Symbol	Name
0	W	N	Number of pairs of X and Y
1	W	X_1	Data X_1
2	W	Y_1	Data Y_1
3	W	X_2	Data X_2
4	W	Y_2	Data Y_2
:	:	:	:
2N - 1	W	X_N	Data X_N
2N	W	Y_N	Data Y_N

[b] Parameter Table Configuration for FGN Instruction with Double-length Integers or Real Numbers

If input value X is a double-length integer, the FGN instruction will be for double-length integers. If input value X is a real number, the FGN instruction will be for real numbers.
Create the parameter table as shown below.

Address	Data Type	Symbol	Name
0	W	N	Number of pairs of X and Y
1	W	–	Reserved.
2	L/F	X_1	Data X_1
4	L/F	Y_1	Data Y_1
6	L/F	X_2	Data X_2
8	L/F	Y_2	Data Y_2
:	:	:	:
4N - 2	L/F	X_N	Data X_N
4N	L/F	Y_N	Data Y_N

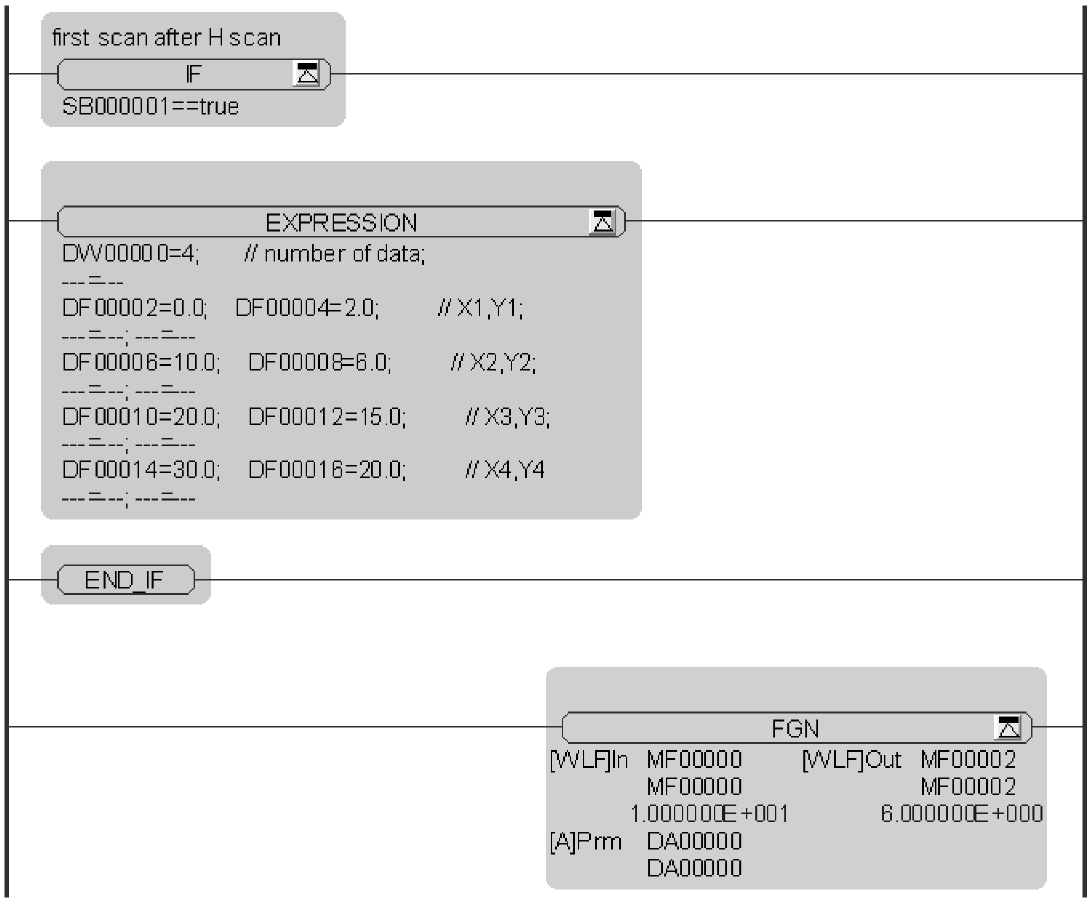


INFO For the FGN instruction, make sure to set the data so that $X_1 < X_2 < \cdots < X_N$, regardless of whether the parameter table is for integer data, double-length integer data, or real number data.

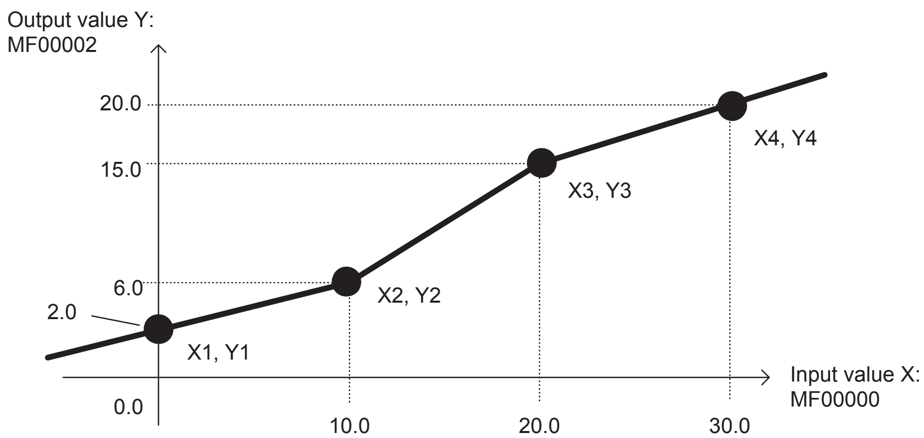
(3) Programming Example

In the following programming example, the function is generated using the FGN instruction for real numbers with the parameter table given below.

Number of Pairs	4
X1, Y1	0.0, 2.0
X2, Y2	10.0, 6.0
X3, Y3	20.0, 15.0
X4, Y4	30.0, 20.0



The following figure shows the relationship between input value X in MF00000 and output value Y in MF00002.



(4) Additional Information

The FGN instruction searches for the pair X_n and Y_n where $X_n \leq$ Input $X \leq X_n + 1$ to calculate output value Y.

$$\boxed{\text{Output value Y}} = Y_n + \frac{Y_{n+1} - Y_n}{X_{n+1} - X_n} \times (\boxed{\text{Input value X}} - X_n) \ (1 \leq n \leq N - 1)$$

If the pair X_n and Y_n, where $X_n \leq$ Input $X \leq X_{n+1}$, does not exist, the calculation is as follows:

- If Input value $X < X_1$,

$$\boxed{\text{Output value Y}} = Y_1 + \frac{Y_2 - Y_1}{X_2 - X_1} \times (\boxed{\text{Input value X}} - X_1)$$

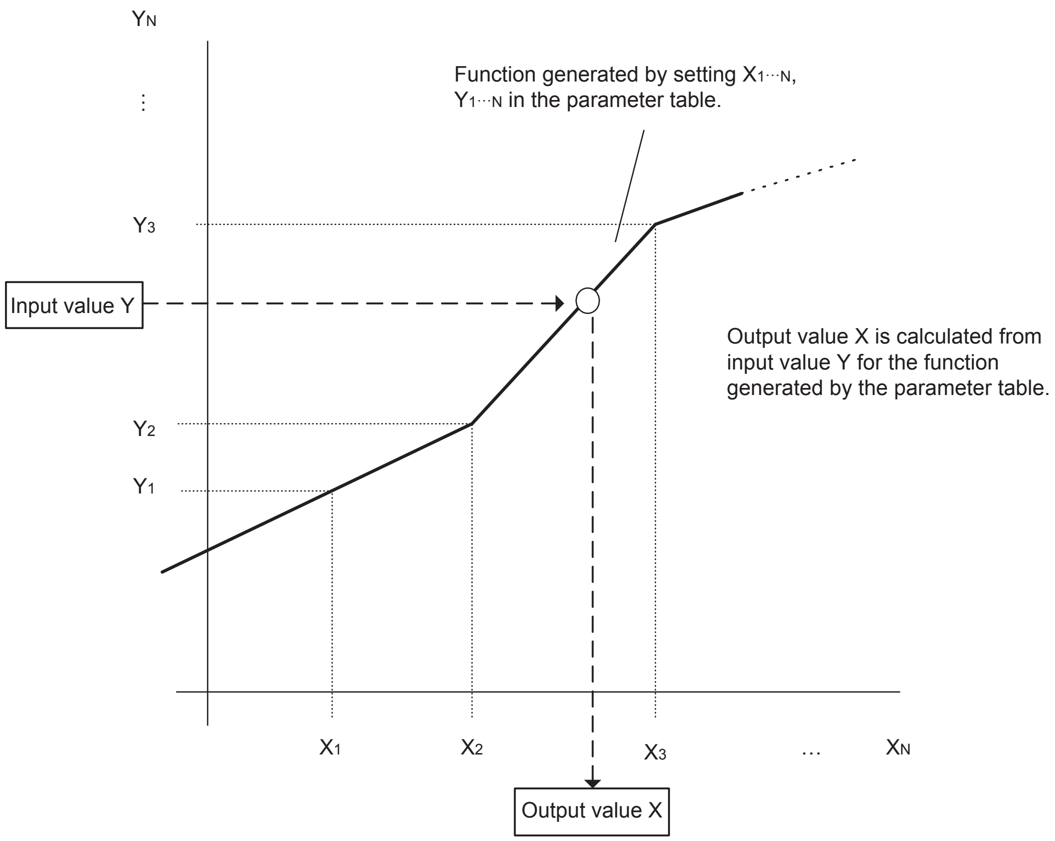
- If Input value $X > X_N$,

$$\boxed{\text{Output value Y}} = Y_N + \frac{Y_N - Y_{N-1}}{X_N - X_{N-1}} \times (\boxed{\text{Input value X}} - X_N)$$

5.8.10 Inverse Function Generator (IFGN)

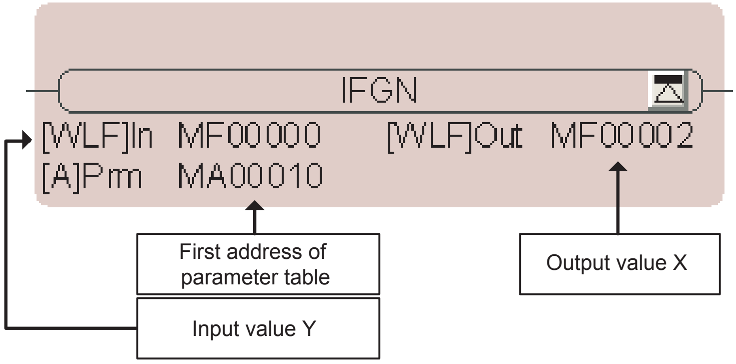
(1) Operation

The IFGN instruction generates a function based on the parameters specified in the parameter table in the same way as the FGN instruction.
It then uses the function to calculate output value X based on the value of input Y, i.e., the opposite direction from the FGN instruction.
The structure of the parameter table is the same as for the FGN instruction.



- Create the parameter table so that $Y_1 < Y_2 < ... < Y_N$.

(2) Format



Icon: 

Key entry: IFGN

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value Y (In)	×	○	○	○	×	○	○
First address of parameter table (Prm)	×	×	×	×	○	×	×
Output value X (Out)	×	○*	○*	○*	×	○	×

* C and # registers cannot be used.

[a] Parameter Table Configuration for IFGN Instruction with Integers

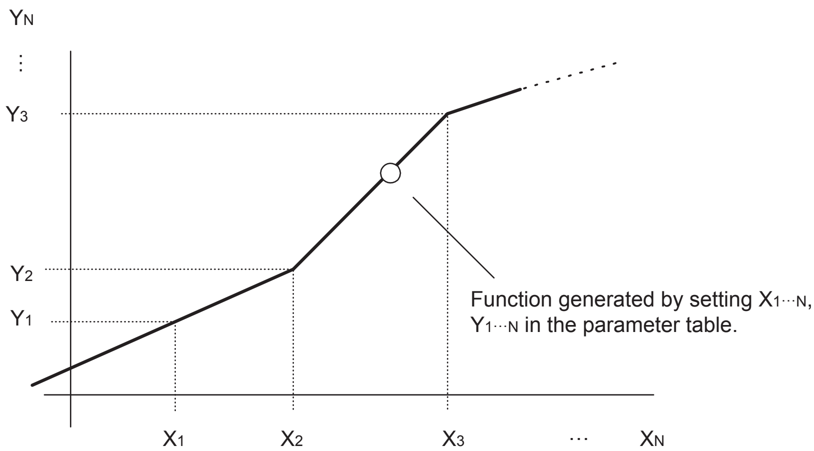
If input value Y is an integer, the IFGN instruction will be for integers.
Create the parameter table as shown below.

Address	Data Type	Symbol	Name
0	W	N	Number of pairs of X and Y
1	W	X_1	Data X_1
2	W	Y_1	Data Y_1
3	W	X_2	Data X_2
4	W	Y_2	Data Y_2
:	:	:	:
2N - 1	W	X_N	Data X_N
2N	W	Y_N	Data Y_N

[b] Parameter Table Configuration for IFGN Instruction with Double-length Integers or Real Numbers

If input value Y is a double-length integer, the IFGN instruction will be for double-length integers. If input value Y is a real number, the IFGN instruction will be for real numbers.
Create the parameter table as shown below.

Address	Data Type	Symbol	Name
0	W	N	Number of pairs of X and Y
1	W	–	Reserved.
2	L/F	X_1	Data X_1
4	L/F	Y_1	Data Y_1
6	L/F	X_2	Data X_2
8	L/F	Y_2	Data Y_2
:	:	:	:
4N - 2	L/F	X_N	Data X_N
4N	L/F	Y_N	Data Y_N

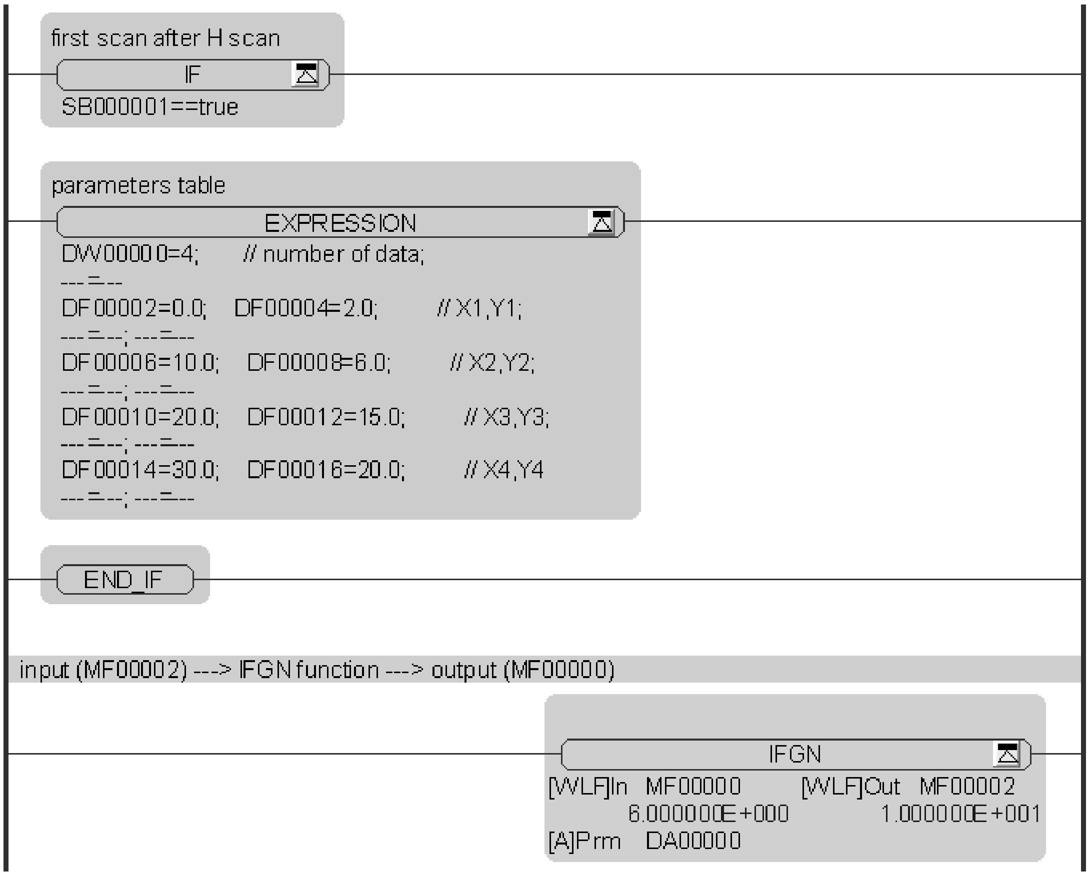


INFO For the IFGN instruction, make sure to set the data so that $Y_1 < Y_2 < \cdots < Y_N$, regardless of whether the parameter table is for integer data, double-length integer data, or real number data.

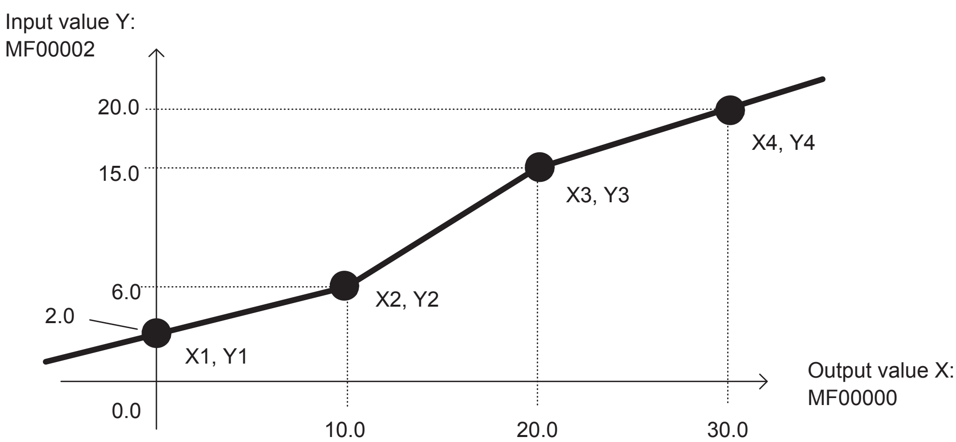
(3) Programming Example

In the following programming example, the function is generated using the IFGN instruction for real numbers with the parameter table given below.

Number of Pairs	4
X1, Y1	0.0, 2.0
X2, Y2	10.0, 6.0
X3, Y3	20.0, 15.0
X4, Y4	30.0, 20.0



The following figure shows the relationship between input value Y in MF00002 and output value X in MF00000.



(4) Additional Information

The IFGN instruction searches for the pair X_n and Y_n where $Y_n \leq$ Input Y $\leq Y_n + 1$ to calculate output value X.

$$\boxed{\text{Output value X}} = X_n + \frac{X_{n+1} - X_n}{Y_{n+1} - Y_n} \times (\boxed{\text{Input value Y}} - Y_n)\ (1 \leq n \leq N - 1)$$

If the pair X_n and Y_n, where $Y_n \leq$ Input Y $\leq Y_{n+1}$, does not exist, the calculation is as follows:

- If Input value Y < Y_1,

$$\boxed{\text{Output value X}} = X_1 + \frac{X_2 - X_1}{Y_2 - Y_1} \times (\boxed{\text{Input value Y}} - Y_1)$$

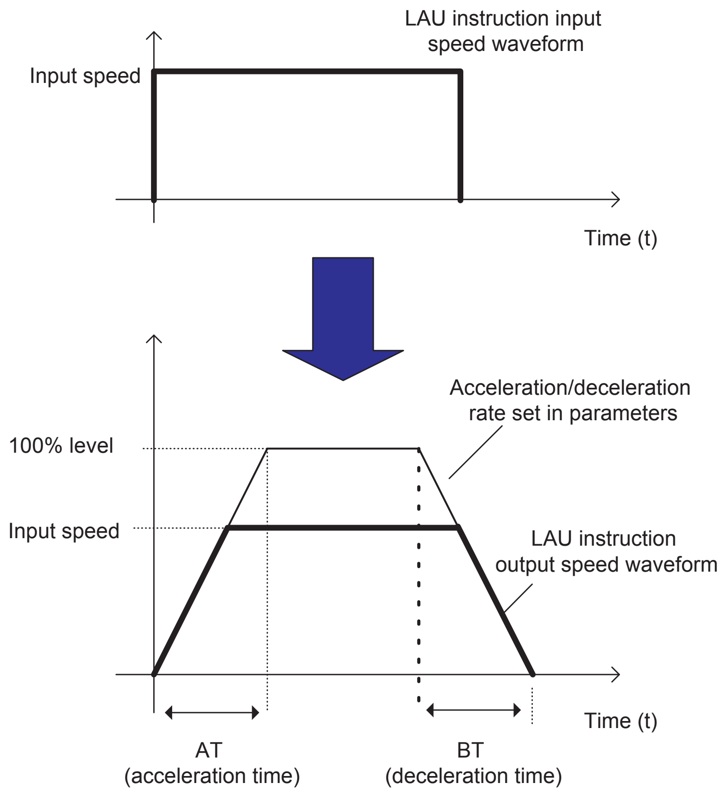
- If Input value Y > Y_N,

$$\boxed{\text{Output value X}} = X_N + \frac{X_N - X_{N-1}}{Y_N - Y_{N-1}} \times (\boxed{\text{Input value Y}} - Y_N)$$

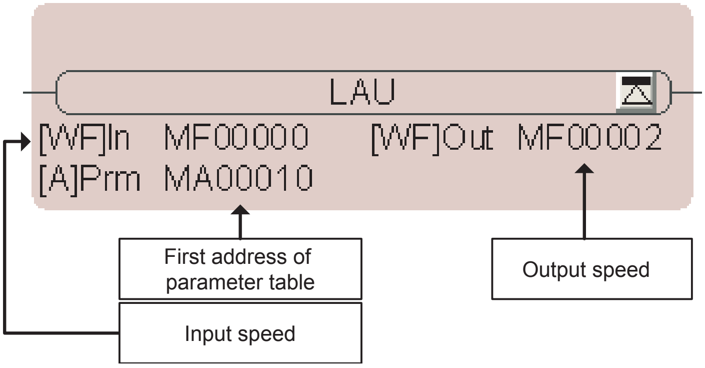
5.8.11 Linear Accelerator/Decelerator 1 (LAU)

(1) Operation

The LAU instruction outputs the speed that results from applying a constant acceleration or deceleration rate to the input speed. The acceleration or deceleration rate is applied according to predefined parameters in a parameter table. The input value to the LAU instruction can be an integer or a real number. Double-length integers cannot be used. The structure of the parameter table is different for integers and real numbers.



(2) Format



Icon: 

Key entry: LAU

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input speed (In)	×	○	×	○	×	○	○
First address of parameter table (Prm)	×	×	×	×	○	×	×
Output speed (Out)	×	○*	×	○*	×	○	×

* C and # registers cannot be used.

[a] Parameter Table Configuration for LAU Instruction with Integers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	LV	100% level of input	Scale for 100% input	IN
2	W	AT	Acceleration time	Time to accelerate from 0% to 100% (0.1 s)	IN
3	W	BT	Deceleration time	Time to decelerate from 100% to 0% (0.1 s)	IN
4	W	QT	Quick stop time	Time to make a quick stop from 100% to 0% (0.1 s)	IN
5	W	V	Current speed	LAU output (output to Out)	OUT
6	W	DVDT	Current acceleration/ deceleration rate	Scaling with the normal acceleration rate set to 5,000	OUT
7	W	–	(Reserved.)	Spare register	–
8	W	VIM	Previous speed reference	For storage of the previous speed reference input value	OUT
9	W	DVDTK	DVDT coefficient	Scaling factor for DVDT (Current Acceleration Rate)	IN
10	L	REM	Remainder	Remainder of the acceleration/deceleration rate	OUT

* The relay input and output bits are assigned as given below. (Close = Bit change to 1 (ON), Open = Bit change to 0 (OFF))

Bit	Symbol	Name	Specification	I/O
0	RN	Line running	This input is closed to run the line.	IN
1	QS	Quick stop	This input is opened to execute a quick stop.	IN
2	DVDTF	Skip execution of DVDT operation	This input is closed to skip execution of the DVDT operation.	IN
3	DVDTS	DVDT operation selection	Selects the method for calculating DVDT	IN
4 to 7	–	(Reserved.)	Spare input relays	IN
8	ARY	Accelerating	This output is closed during acceleration.	OUT
9	BRY	Decelerating	This output is closed during deceleration.	OUT
A	LSP	Zero speed	This output is closed during zero speed.	OUT
B	EQU	Equal	This output is closed when the input speed equals the output speed.	OUT
C to F	–	(Reserved.)	Spare output relays	OUT

- If QS (quick stop) is opened, QT (quick stop time) is used as the acceleration/deceleration time.

[b] Parameter Table Configuration for LAU Instruction with Real Numbers

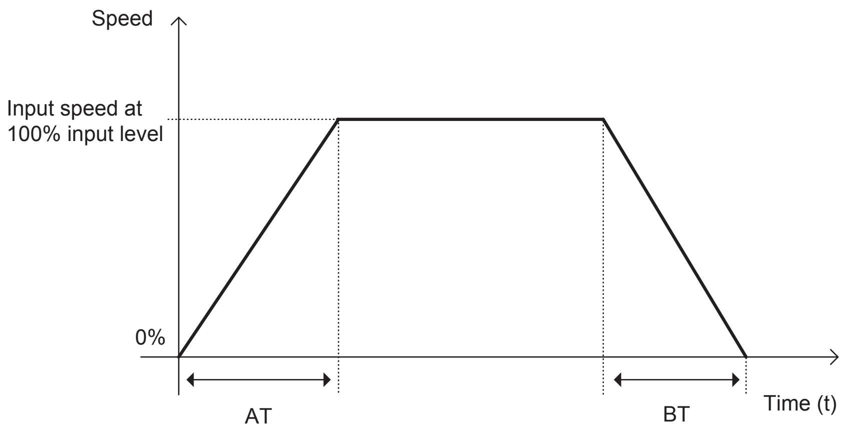
Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	–	(Reserved.)	Spare register	–
2	F	LV	100% level of input	Scale for 100% input	IN
4	F	AT	Acceleration time	Time to accelerate from 0% to 100% (s)	IN
6	F	BT	Deceleration time	Time to decelerate from 100% to 0% (s)	IN
8	F	QT	Quick stop time	Time to make a quick stop from 100% to 0% (s)	IN
10	F	V	Current speed	LAU output (output to Out)	OUT
12	F	DVDT	Current acceleration/ deceleration rate	The current acceleration or deceleration rate is output.	OUT

* The relay input and output bits are assigned as given below. (Close = Bit change to 1 (ON), Open = Bit change to 0 (OFF))

Bit	Symbol	Name	Specification	I/O
0	RN	Line running	This input is closed to run the line.	IN
1	QS	Quick stop	This input is opened to execute a quick stop.	IN
2 to 7	–	(Reserved.)	Spare input relays	IN
8	ARY	Accelerating	This output is closed during acceleration.	OUT
9	BRY	Decelerating	This output is closed during deceleration.	OUT
A	LSP	Zero speed	This output is closed during zero speed.	OUT
B	EQU	Equal	This output is closed when the input speed equals the output speed.	OUT
C to F	–	(Reserved.)	Spare output relays	OUT

- If QS (quick stop) is opened, QT (quick stop time) is used as the acceleration/deceleration time.

Output Speed Waveform When Input Speed Is at the 100% Input Level (LV)



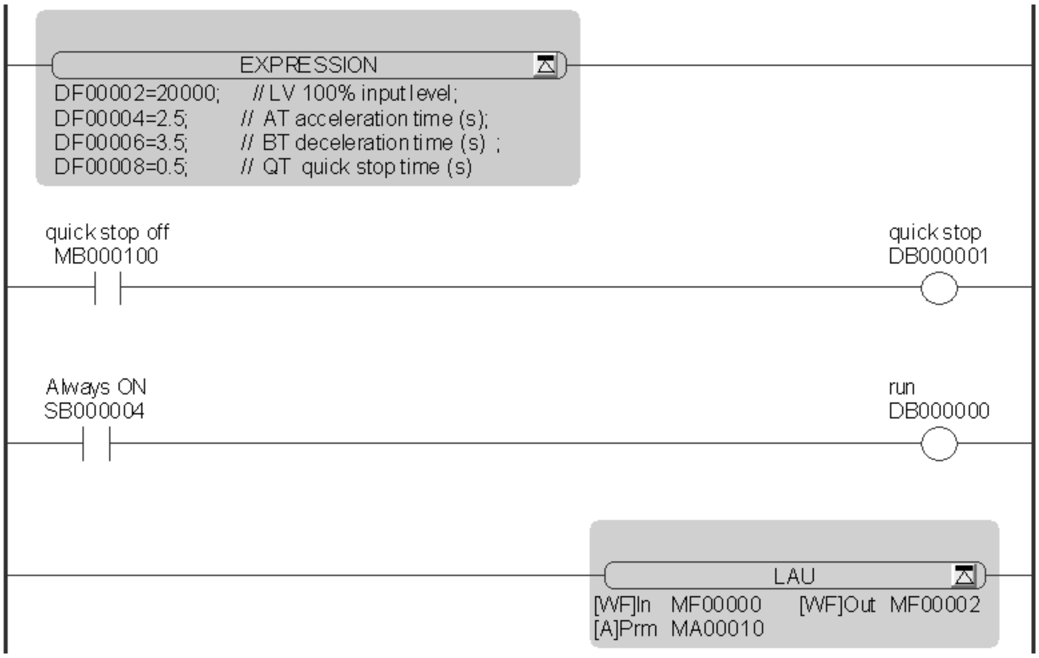
The acceleration time (AT) is the time from the 0% speed to the 100% speed. The deceleration time (BT) is the time from the 100% speed to the 0% speed. The 100% speed is set as the 100% level of input. The setting of this parameter determines the acceleration/deceleration rate. When the input speed is applied, operation is performed at the acceleration/deceleration rate.
Therefore, the ratio between the set value for LV (input at 100% level) and the input speed determines the actual acceleration/deceleration time.
Refer to *(4) Additional Information* for details on the processing that is performed internally by the LAU instruction.

INFO
When QS (quick stop) opens (OFF), the acceleration/deceleration time is set to the QT (quick stop time).
To execute a quick stop, open (OFF) QS (quick stop) and set the input speed to 0 at the same time.

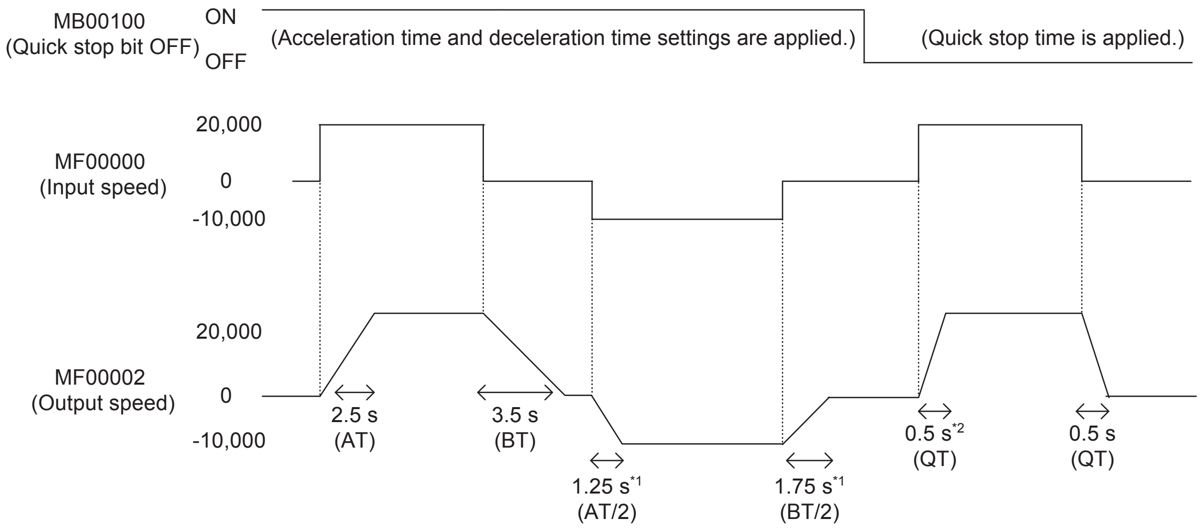
(3) Programming Example

In the following programming example, the LAU instruction for real numbers is executed with the specified acceleration and deceleration rates where MF00000 is the input speed and MF00002 is the output speed.
The following parameters are set with an EXPRESSION instruction to create the acceleration or deceleration rate.

- 100% level of acceleration/deceleration rate input = 20,000
- Acceleration time = 2.5 s
- Deceleration time = 3.5 s
- Quick stop time = 0.5 s



The following figure shows how each register operates.



∗ 1. The acceleration time is applied when moving away from 0, and the deceleration time is applied when moving toward 0.
∗ 2. The quick stop time is also applied as the acceleration time.

(4) Additional Information

This information applies when the LAU instruction is used for integer or real number data.

[a] LAU Instruction with Integers

The LAU instruction for integers calculates the speed output value during acceleration, deceleration, and quick stops, and the current acceleration or deceleration rates using the formula shown below based on predefined parameters.
In this formula, V is the speed output value, V' is the previous speed output value, VI is the input value for the speed reference, and Ts is the scan time set value.

■ Speed Output Value during Acceleration

The speed output value during acceleration is calculated as follows:

If VI > V' (V' ≥ 0), then V = V' + ADV.
If VI < V' (V' ≤ 0), then V = V' − ADV.

$$\text{ADV (acceleration rate)} = \frac{\text{LV} \times \text{Ts (0.1 ms)} + \text{REM}}{\text{AT (0.1 s)} \times 1{,}000}$$

■ Speed Output Value during Deceleration

The speed output value during deceleration is calculated as follows:

If VI > V' (V' < 0), then V = V' + BDV.
If VI < V' (V' > 0), then V = V' − BDV.

$$\text{BDV (deceleration rate)} = \frac{\text{LV} \times \text{Ts (0.1 ms)} + \text{REM}}{\text{BT (0.1 s)} \times 1{,}000}$$

■ Speed Output Value during a Quick Stop

The speed output value during a quick stop is calculated as follows:

If QS = OFF (VI > V', V' < 0), then V = V' + QDV.
If QS = OFF (VI < V', V' > 0), then V = V' − QDV.

$$\text{QDV (Quick Stop Rate)} = \frac{\text{LV} \times \text{Ts (0.1 ms)} + \text{REM}}{\text{QT (0.1 s)} \times 1{,}000}$$

■ Current Acceleration/Deceleration Rate

If DVDTF is ON, DVDT (current acceleration/deceleration rate) will be calculated according to the setting of DVDTS (DVDT operation selection) using one of the following formulas. If DVDTF is OFF, DVDT is set to 0.

$$\text{If DVDTS = ON, DVDT} = \frac{(\text{V} - \text{V'}) \times 5{,}000}{\text{ADV}}$$

$$\text{If DVDTS = ON, DVDT} = (\text{V} - \text{V'}) \times \text{DVDTK}$$

INFO

ARY (accelerating) turns ON when V' ≥ 0 and ADV > 0, or when V' ≤ 0 and ADV < 0.
BRY (decelerating) turns ON at the following times:
- When V' < 0 and BDV > 0, or when V' > 0 and BDV < 0
- When V' < 0 and QDV > 0, or when V' > 0 and QDV < 0

LSP (zero speed) turns ON when V equals 0. EQU (equal) turns ON when VI equals V.
If RN (line running) is opened (OFF), the outputs for V, DVDT, and REM are set to 0.

[b] LAU Instruction for Real Numbers

The LAU instruction for real numbers calculates the speed output value during acceleration, deceleration, and quick stops, and the current acceleration or deceleration rates using the formula shown below based on predefined parameters.
In this formula, V is the speed output value, V' is the previous speed output value, VI is the input value for the speed reference, and Ts is the scan time set value.

■ Speed Output Value during Acceleration

The speed output value during acceleration is calculated as follows:

If VI > V' (V' ≥ 0), then V = V' + ADV.
If VI < V' (V' ≤ 0), then V = V' − ADV.

$$\text{ADV (acceleration rate)} = \frac{\text{LV} \times \text{Ts (0.1 ms)}}{\text{AT (s)} \times 10{,}000}$$

■ Speed Output Value during Deceleration

The speed output value during deceleration is calculated as follows:

If VI < V' (V' > 0), then V = V' + BDV.
If VI > V' (V' < 0), then V = V' − BDV.

$$\text{BDV (deceleration rate)} = \frac{-\text{LV} \times \text{Ts (0.1 ms)}}{\text{BT (s)} \times 10{,}000}$$

■ Speed Output Value during a Quick Stop

The speed output value during a quick stop is calculated as follows:

If QS = OFF (VI < V', V' > 0), then V = V' + QDV.
If QS = OFF (VI > V', V' < 0), then V = V' − QDV.

$$\text{QDV (Quick Stop Rate)} = \frac{-\text{LV} \times \text{Ts (0.1 ms)}}{\text{QT (s)} \times 10{,}000}$$

■ Current Acceleration/Deceleration Rate

The DVDT (current acceleration/deceleration rate) is calculated as follows after V (speed output) has been calculated:
DVDT = V - V'

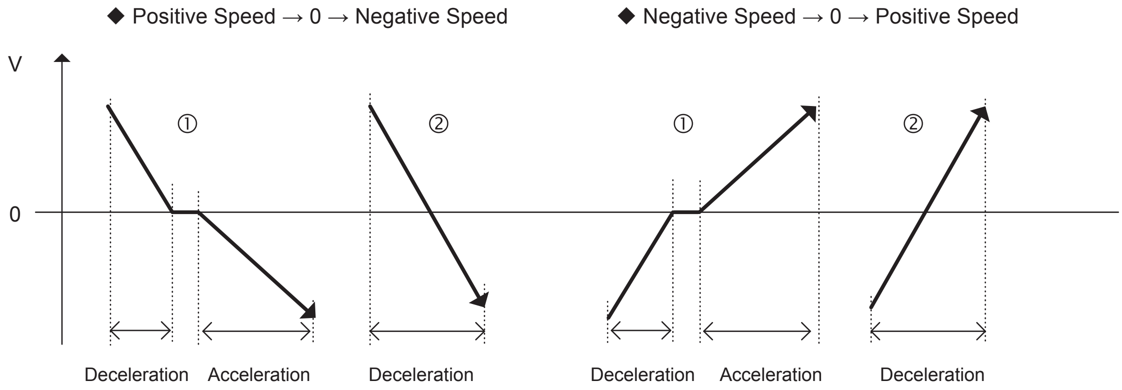
INFO

ARY (accelerating) turns ON when V' ≥ 0 and ADV > 0, or when V' ≤ 0 and ADV < 0.
BRY (decelerating) turns ON at the following times:
- When V' < 0 and BDV > 0, or when V' > 0 and BDV < 0
- When V' < 0 and QDV > 0, or when V' > 0 and QDV < 0

LSP (zero speed) turns ON when V equals 0. EQR (equal) turns ON when VI equals V.
ARY (accelerating) turns ON when V ≠ V' and DVDT and V have the same sign and BRY (decelerating) turns ON when V ≠ V' and DVDT and V do not have the same sign.
If RN (line running) is opened (OFF), the outputs for V and DVDT are set to 0.

[c] Precaution When Input Speed Changes Across a Speed of 0

If a reference is input that causes the speed to cross a speed of 0, the output changes as shown by ② in the following figure.



① If operation stops at a speed of 0, operation will proceed according to the set deceleration and acceleration times.

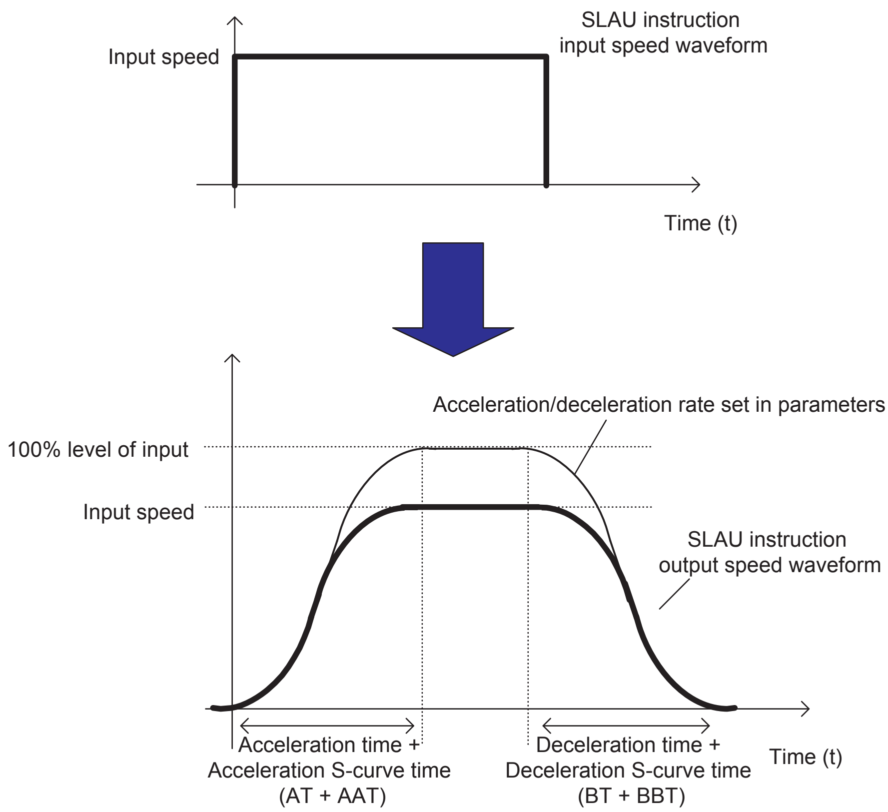
② If the speed reference crosses the point where speed equals 0, operation is controlled by the deceleration time so that the speed does not fluctuate.

5.8.12 Linear Accelerator/Decelerator 2 (SLAU)

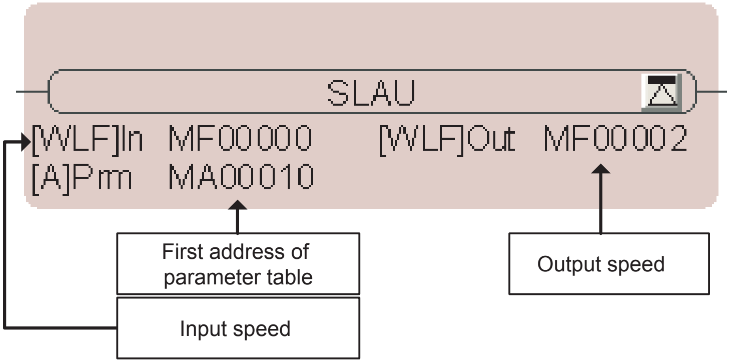
(1) Operation

The SLAU instruction outputs the speed that results from applying a variable acceleration or deceleration rate to the input speed. Operation for the acceleration or deceleration rate is performed in an S curve according to predefined parameters in a parameter table.
The input value to the SLAU instruction can be an integer or a real number.
The structure of the parameter table depends on the data type.

- Double-length integers can be used only for CPU software version 2.30 or higher. For earlier versions, the lower 16 bits of the double-length integer are used in the calculations as an integer.



(2) Format



Icon: 

Key entry: SLAU

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input speed (In)	×	○	○*1	○	×	○	×
First address of parameter table (Prm)	×	×	×	×	○*2	○	○
Output speed (Out)	×	○*2	○*1, 2	○*2	×	○	×

* 1. This data type can be used only for version 2.30 or higher. For earlier versions, the lower 16 bits of the double-length integer are used in the calculations as an integer.

* 2. C and # registers cannot be used.

[a] Parameter Table Configuration for SLAU Instruction with Integers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	LV	100% level of input	Scale for 100% input	IN
2	W	AT	Acceleration time	Time to accelerate from 0% to 100% (0.1 s)	IN
3	W	BT	Deceleration time	Time to decelerate from 100% to 0% (0.1 s)	IN
4	W	QT	Quick stop time	Time to make a quick stop from 100% to 0% (0.1 s)	IN
5	W	AAT	Acceleration S-curve time	Acceleration S-curve region time (0.01 to 32.00 s)	IN
6	W	BBT	Deceleration S-curve time	Deceleration S-curve region time (0.01 to 32.00 s)	IN
7	W	V	Current speed	SLAU output (output to Out)	OUT
8	W	DVDT1	Current acceleration/ deceleration rate 1	Scaling with the normal acceleration rate set to 5,000	OUT
9	W	–	(Reserved.)	Spare register	–
10	W	ABMD	Speed increase when holding	Amount of speed change until the speed stabilizes after the hold command is executed	OUT
11	W	REM1	Remainder	Remainder of the acceleration/deceleration rate	OUT
12	W	–	(Reserved.)	Spare register	–
13	W	VIM	Previous speed reference	For storage of the previous speed reference input value	OUT
14	L	DVDT2	Current acceleration/ deceleration rate 2	1,000 times the actual acceleration/deceleration	OUT
16	L	DVDT3	Current acceleration/ deceleration rate 3	Current acceleration/deceleration rate (= DVDT2/ 1,000)	OUT
18	L	REM2	Remainder	Remainder of the S-curve region acceleration/deceleration rate	OUT
20	W	REM3	Remainder	Remainder of the current speed	OUT
21	W	DVDTK	DVDT1 coefficient	Scaling factor for DVDT (Current acceleration rate 1) (-32,768 to 32,767)	OUT

* The relay input and output bits are assigned as follows. (Close = Bit change to 1 (ON), Open = Bit change to 0 (OFF))

Bit	Symbol	Name	Specification	I/O
0	RN	Line running	This input is closed to run the line.	IN
1	QS	Quick stop	This input is opened to execute a quick stop.	IN
2	DVDTF	Skip execution of DVDT1 operation	This input is closed to skip execution of the DVDT operation.	IN
3	DVDTS	DVDT1 operation selection	Selects the method for calculating DVDT	IN
4 to 7	–	(Reserved.)	Spare input relays	IN
8	ARY	Accelerating	This output is closed during acceleration.	OUT
9	BRY	Decelerating	This output is closed during deceleration.	OUT
A	LSP	Zero speed	This output is closed during zero speed.	OUT
B	EQU	Equal	This output is closed when the input speed equals the output speed.	OUT
C	–	(Reserved.)	Spare output relay	OUT
D	CCF	Work relay	System internal work relay	OUT
E	BBF	Work relay	System internal work relay	OUT
F	AAF	Work relay	System internal work relay	OUT

- If QS (quick stop) is opened, QT (quick stop time) is used as the acceleration/deceleration time.

[b] Parameter Table Configuration for SLAU Instruction with Double-length Integers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*1	IN/OUT
1	W	–	(Reserved.)	–	–
2	L	LV	100% level of input	Scale for 100% of input value	IN
4	L	AT	Acceleration time	Time to accelerate from 0% to 100% (0.1 s)	IN
6	L	BT	Deceleration time	Time to decelerate from 100% to 0% (0.1 s)	IN
8	L	QT	Quick stop time	Time to make a quick stop from 100% to 0% (0.1 s)	IN
10	L	AAT	Acceleration S-curve time	Acceleration S-curve region time (0.01 s)	IN
12	L	BBT	Deceleration S-curve time	Deceleration S-curve region time (0.01 s)	IN
14	L	V	Current speed	SLAU output (also the output to the A register)	OUT
16	L	DVDT	Current acceleration/ deceleration rate	The current acceleration or deceleration rate is output. (The output is truncated below the decimal point.)*2	OUT
18	L	ABMD	Speed increase when holding	Amount of speed change until the speed stabilizes after the hold command is executed	OUT
20	D	V_D	Current speed	SLAU output for system use (double-precision real number)	IN/OUT
24	D	DVDT_D	Current acceleration/ deceleration rate	Current acceleration or deceleration rate for system use (double-precision real number)	IN/OUT

* 1. D is a double-length real number expressed in four words. The MPE720 cannot display this value as a real number.
* 2. The relay input and output bits are assigned as given below. (Close = Bit change to 1 (ON), Open = Bit change to 0 (OFF))

Bit	Symbol	Name	Specification	I/O
0	RN	Line running	This input is closed to run the line.	IN
1	QS	Quick stop	This input is opened to execute a quick stop.	IN
2	DVDTF	Acceleration/deceleration rate flag	When the input is closed, DVDT (current acceleration/ deceleration rate) is multiplied by 1,000 and then output.	IN
3 to 7	–	(Reserved.)	Spare input relays	IN
8	ARY	Accelerating	This output is closed during acceleration.	OUT
9	BRY	Decelerating	This output is closed during deceleration.	OUT
A	LSP	Zero speed	This output is closed during zero speed.	OUT
B	EQU	Equal	This output is closed when the input value equals the output value.	OUT
C to F	–	Work relays	System internal work relays	IN/OUT

- If QS (quick stop) is opened, QT (quick stop time) is used as the acceleration/deceleration time.

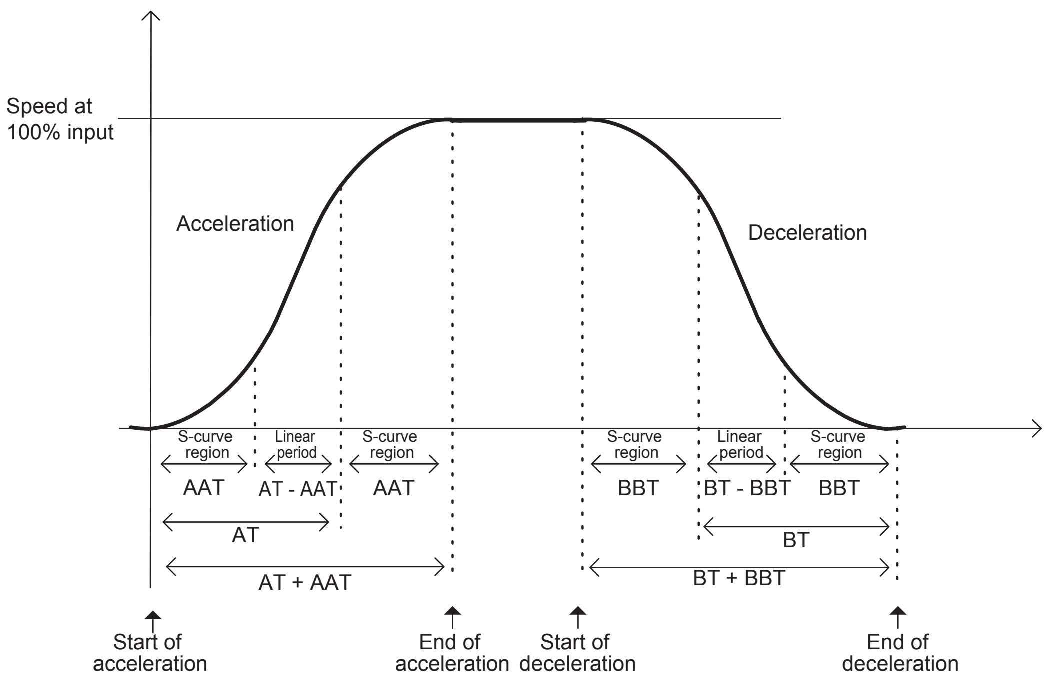
[c] Parameter Table Configuration for SLAU Instruction with Real Numbers

Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	–	(Reserved.)	Spare register	–
2	F	LV	100% level of input	Scale for 100% input	IN
4	F	AT	Acceleration time	Time to accelerate from 0% to 100% (s)	IN
6	F	BT	Deceleration time	Time to decelerate from 100% to 0% (s)	IN
8	F	QT	Quick stop time	Time to make a quick stop from 100% to 0% (s)	IN
10	F	AAT	Acceleration S-curve time	Acceleration S-curve region time (s)	IN
12	F	BBT	Deceleration S-curve time	Deceleration S-curve region time (s)	IN
14	F	V	Current speed	SLAU output (output to Out)	OUT
16	F	DVDT1	Current acceleration/ deceleration rate 1	The actual acceleration or deceleration rate is output.	OUT
18	F	ABMD	Speed increase when holding	Amount of speed change until the speed stabilizes after the hold command is executed	OUT

* The relay input and output bits are assigned as given below. (Close = Bit change to 1 (ON), Open = Bit change to 0 (OFF))

Bit	Symbol	Name	Specification	I/O
0	RN	Line running	This input is closed to run the line.	IN
1	QS	Quick stop	This input is opened to execute a quick stop.	IN
2 to 7	–	(Reserved.)	Spare input relays	IN
8	ARY	Accelerating	This output is closed during acceleration.	OUT
9	BRY	Decelerating	This output is closed during deceleration.	OUT
A	LSP	Zero speed	This output is closed during zero speed.	OUT
B	EQU	Equal	This output is closed when the input speed equals the output speed.	OUT
C to F	–	(Reserved.)	Spare output relays	OUT

- If QS (quick stop) is opened, QT (quick stop time) is used as the acceleration/deceleration time.



Refer to *(4) Additional Information* for details on the processing that is performed internally by the LAU instruction.

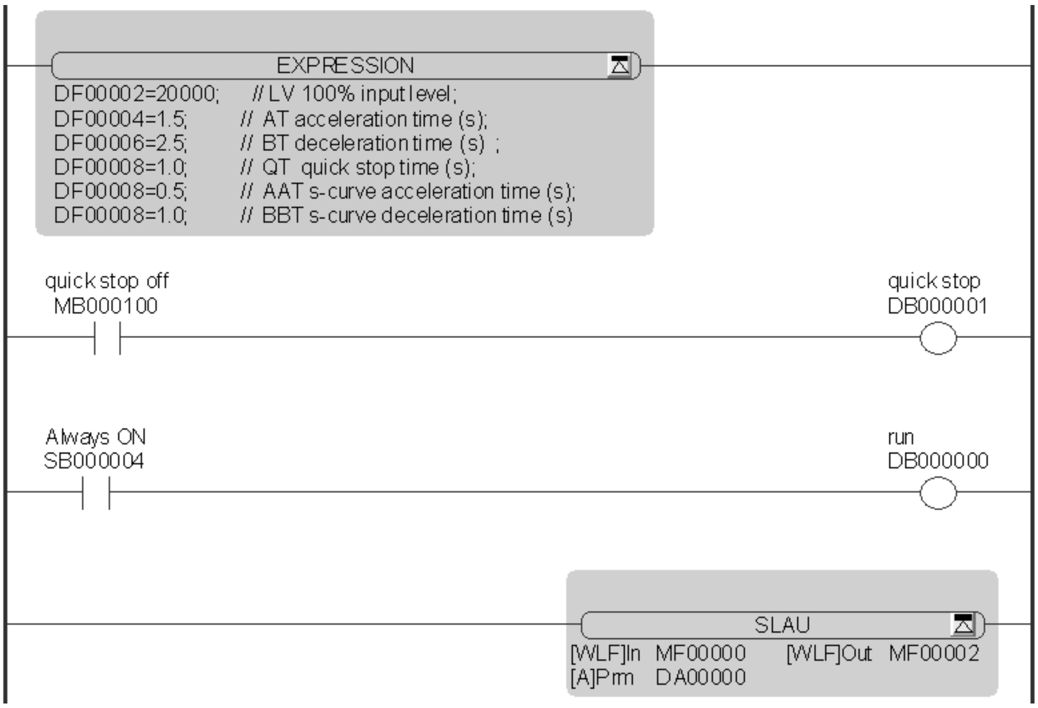
INFO

When QS (quick stop) opens (OFF), the output decelerates at the quick stop time and the output speed is set to 0.
It is not necessary to set the input speed to 0 in the same way as for the LAU instruction.
For a quick stop, the speed is decelerated linearly without applying the S-curve.
Set the parameters so that AT or BT (linear acceleration or deceleration time) is greater than or equal to AAT or BBT (S-curve acceleration or deceleration time).

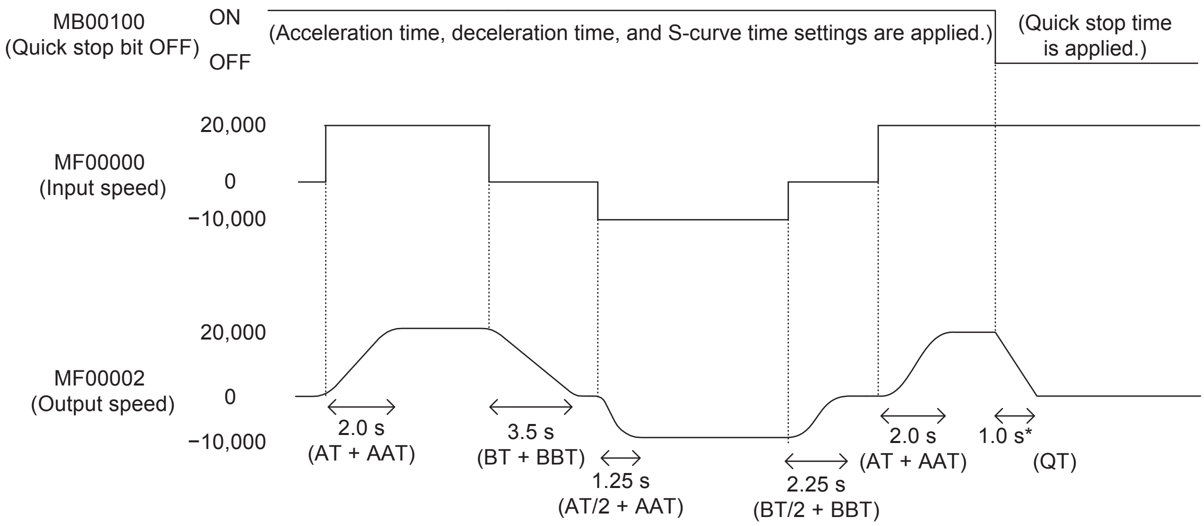
(3) Programming Example

In the following programming example, the SLAU instruction for real numbers is executed with the specified acceleration and deceleration rates where MF00000 is the input speed and MF00002 is the output speed.
The following parameters are set with an EXPRESSION instruction to create the acceleration or deceleration rate.

- Speed when input level of acceleration or deceleration rate is 100% = 20,000
- Acceleration time = 1.5 s
- Deceleration time = 2.5 s
- Quick stop time = 0.5 s
- Acceleration S-curve time = 0.5 s
- Deceleration S-curve time = 1.0 s



The following figure shows how each register operates.



* If the quick stop bit is turned OFF, the speed is decelerated to a stop using the quick stop time, regardless of the S-curve time and input speed.

(4) Additional Information

The following operations are performed internally by the SLAU instruction.

[a] Operation of the SLAU Instruction for Integers

The SLAU instruction for integers calculates the speed output value during acceleration, deceleration, quick stops, S-curve acceleration, S-curve deceleration, and the current acceleration or deceleration rates using the formulas shown below based on predefined parameters.
In this formula, V is the speed output value, V’ is the previous speed output value, VI is the input value for the speed reference, and Ts is the scan time set value.

■ Speed Output Value during Acceleration

The speed output value during acceleration is calculated as follows:

If VI > V' (V' ≥ 0) outside an S-curve region (ADVS > ADV), then V = V' + ADV.
If VI < V' (V' ≤ 0) outside an S-curve region (ADVS > ADV), then V = V' − ADV.

$$\text{ADV (acceleration rate)} = \frac{\text{LV} \times \text{Ts (0.1 ms)} + \text{REM1}}{\text{AT (0.1 s)} \times 1{,}000}$$

■ Speed Output Value during Deceleration

The speed output value during deceleration is calculated as follows:

If VI > V' (V'< 0) outside an S-curve region (BDVS > BDV), then V = V' + BDV.
If VI < V' (V'> 0) outside an S-curve region (BDVS > BDV), then V = V' − BDV.

$$\text{BDV (deceleration rate)} = \frac{\text{LV} \times \text{Ts (0.1 ms)} + \text{REM1}}{\text{BT (0.1 s)} \times 1{,}000}$$

Speed Output Value during a Quick Stop

The speed output value during a quick stop is calculated as follows:

If QS = OFF (VI > V', V' < 0), then V = V' + QDV.
If QS = OFF (VI < V', V' > 0), then V = V' − QDV.

$$\text{QDV (Quick Stop Rate)} = \frac{\text{LV} \times \text{Ts (0.1 ms)} + \text{REM1}}{\text{QT (0.1 s)} \times 1{,}000}$$

- For a quick stop, the speed is decelerated linearly without applying the S-curve.

Speed Output Value during S-Curve Acceleration

The speed output value during S-curve acceleration is calculated as follows:

If VI > V' (V' ≥ 0) inside an S-curve region (ADVS < ADV), then V = V' + ADVS.
If VI < V' (V' ≤ 0) inside an S-curve region (ADVS < ADV), then V = V' − ADVS.

ADVS (S-curve region acceleration rate) = ADVS' ± AADVS

$$\text{AADVS} = \frac{\text{ADV} \times \text{Ts (0.1 ms)} + \text{REM2}}{\text{AAT (0.01 s)} \times 100}$$

Speed Output Value during S-Curve Deceleration

The speed output value during S-curve deceleration is calculated as follows:

If VI > V' (V'< 0) inside an S-curve region (BDVS < BDV), then V = V' + BDVS.
If VI < V' (V'> 0) inside an S-curve region (BDVS < BDV), then V = V' − BDVS.

BDVS (S-curve region deceleration rate) = BDVS' ± BBDVS

$$\text{BBDVS} = \frac{\text{BDV} \times \text{Ts (0.1 ms)} + \text{REM2}}{\text{BBT (0.01 s)} \times 100}$$

Current Acceleration/Deceleration Rate

If DVDTF (skip execution of DVDT1 operation) is ON, DVDT1 (current acceleration/deceleration rate 1) will be calculated according to the setting of DVDTS (DVDT1 operation selection) using one of the following formulas. If DVDTF is OFF, DVDT1 is set to 0.

$$\text{If DVDTS is ON, DVDT1} = \frac{(\text{V} - \text{V}') \times 5{,}000}{\text{ADV}}$$

If DVDTS is OFF, DVDT1 = (V – V') × DVDTK

The value for DVDT2 (current acceleration/deceleration rate 2) is calculated as follows:

During acceleration:	Inside the S-curve region: DVDT2 = ±ADVS
	Outside the S-curve region: DVDT2 = ±ADV
During deceleration:	Inside the S-curve region: DVDT2 = ±BDVS
	Outside the S-curve region: DVDT2 = ±BDV
During a quick stop:	DVDT = ±QDV

The result of ABMD (speed increase upon holding) is output after the following operation is performed.

$$\text{ABMD} = \frac{\text{DVDT2}' \times \text{DVDT2}'}{2 \times \text{AADVS (BBDVS)}}$$

DVDT2': Previous value of DVDT2 (current acceleration/deceleration rate 2)

INFO

ARY (accelerating) turns ON at the following times:
- When V’ ≥ 0 and ADV > 0, or when V’ ≤ 0 and ADV < 0
- If V’ ≥ 0 and ADVS > 0 inside an S-curve region, or if V’ ≤ 0 and ADVS < 0 inside an S-curve region

BRY (decelerating) turns ON at the following times:
- When V’ < 0 and BDV > 0, or when V’ > 0 and BDV < 0
- When V’ < 0 and QDV > 0, or when V’ > 0 and QDV < 0
- When V’ < 0 and BDVS > 0 inside an S-curve region, or if V’ > 0 and BDVS < 0 inside an S-curve region

LSP (zero speed) turns ON when V equals 0. EQU (equal) turns ON when VI equals V.
If RN (line running) is opened (OFF), the outputs for V, DVDT1, DVDT2, DVDT3, REM1, REM2, and REM3 are set to 0.

[b] Operation of the SLAU Instruction for Double-length Integers or Real Numbers

The SLAU instruction for double-length integers or real numbers calculates the speed output value during acceleration, deceleration, quick stops, S-curve acceleration, S-curve deceleration, and the current acceleration or deceleration rates using the formulas shown below.
In this formula, V is the speed output value, V’ is the previous speed output value, VI is the input value for the speed reference, Ts is the scan time set value, ADVS’ is the previous ADVS value, and BDVS’ is the previous BDVS value.

■ Speed Output Value during Acceleration

The speed output value during acceleration is calculated as follows:

If VI > V' (V' ≥ 0) outside an S-curve region (ADVS > ADV), then V = V' + ADV.
If VI < V' (V' ≤ 0) outside an S-curve region (ADVS > ADV), then V = V' − ADV.

$$\text{ADV (acceleration rate)} = \frac{\text{LV} \times \text{Ts (0.1 ms)}}{\text{AT (s)} \times 10{,}000}$$

■ Speed Output Value during Deceleration

The speed output value during deceleration is calculated as follows:

If VI > V' (V'< 0) outside an S-curve region (BDVS > BDV), then V = V' + BDV.
If VI < V' (V'> 0) outside an S-curve region (BDVS > BDV), then V = V' − BDV.

$$\text{BDV (deceleration rate)} = \frac{-\text{LV} \times \text{Ts (0.1 ms)}}{\text{BT(s)} \times 10{,}000}$$

■ Speed Output Value during a Quick Stop

The speed output value during a quick stop is calculated as follows:

If QS = OFF (VI > V', V' < 0), then V = V' + QDV.
If QS = OFF (VI < V', V' > 0), then V = V' − QDV.

$$\text{QDV (Quick Stop Rate)} = \frac{-\text{LV} \times \text{Ts (0.1 ms)}}{\text{QT (s)} \times 10{,}000}$$

- For a quick stop, the speed is decelerated linearly without applying the S-curve.

■ Speed Output Value during S-Curve Acceleration

The speed output value during S-curve acceleration is calculated as follows:

If VI > V' (V' ≥ 0) inside an S-curve region (ADVS < ADV), then V = V' + ADVS.
If VI < V' (V' ≤ 0) inside an S-curve region (ADVS < ADV), then V = V' − ADVS.

ADVS (S-curve region acceleration rate) = ADVS' ± AADVS

$$\text{AADVS} = \frac{\text{ADV} \times \text{Ts (0.1 ms)}}{\text{AAT (s)} \times 10{,}000}$$

■ Speed Output Value during S-Curve Deceleration

The speed output value during S-curve deceleration is calculated as follows:

If VI > V' (V'< 0) inside an S-curve region (BDVS < BDV), then V = V' + BDVS.
If VI < V' (V'> 0) inside an S-curve region (BDVS < BDV), then V = V' − BDVS.

BDVS (S-curve region deceleration rate) = BDVS' ± BBDVS

$$\text{BBDVS} = \frac{\text{BDV} \times \text{Ts (0.1 ms)}}{\text{BBT (s)} \times 10{,}000}$$

■ Current Acceleration/Deceleration Rate

The value of DVDT (current acceleration/deceleration rate 1) is output after the following operation is performed:

During acceleration:	Inside the S-curve region: DVDT = ADVS
	Outside the S-curve region: DVDT = ADV
During deceleration:	Inside the S-curve region: DVDT = BDVS
	Outside the S-curve region: DVDT = BDV
During a quick stop:	DVDT = QDV

The result of ABMD (speed increase upon holding) is output after the following operation is performed.

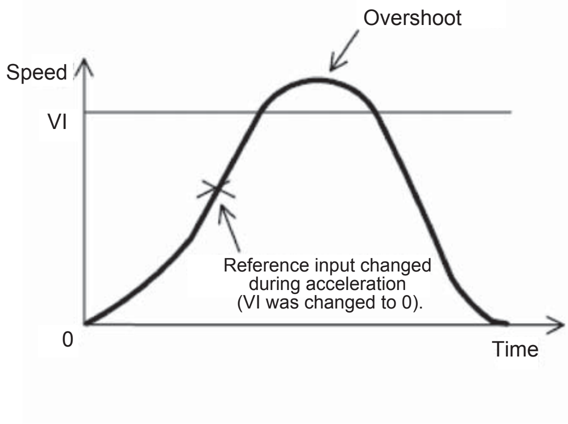
$$\text{ABMD} = \frac{\text{DVDT} \times \text{DVDT}}{2 \times \text{AADVS (BBDVS)}}$$

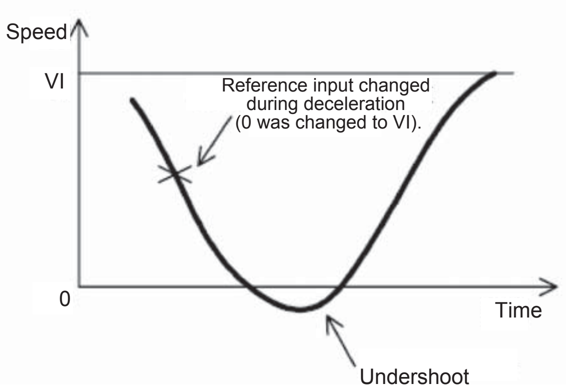
INFO

LSP (zero speed) turns ON when V equals 0. EQU (equal) turns ON when VI equals V.
If RN (line running) is opened (OFF), the outputs for V, DVDT, and AVMD are set to 0.

[c] Precautions in Using the SLAU Instruction for Integers

Do not change the input value before the input speed (VI) is reached (i.e., during acceleration or deceleration). Otherwise, overshooting or undershooting may occur as shown in the following figures.



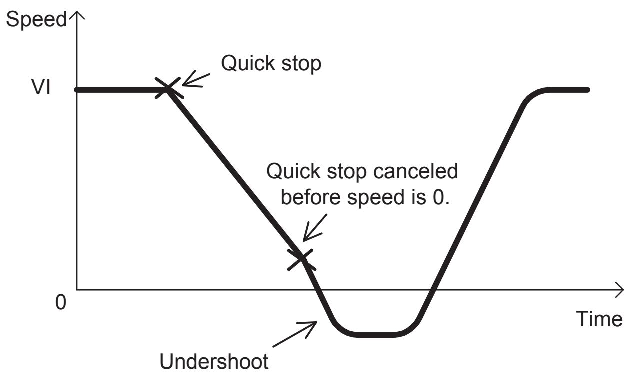


If VI (input value) must be changed while accelerating or decelerating, take one of the following measures in your application program.

- Use the SLAU instruction for real numbers.
- Use the SLAU instruction for integers together with the LIMIT instruction. Specifically, use the output value of the SLAU instruction for integers as the input value to the LIMIT instruction to prevent overshooting or undershooting.

[d] Precaution When Canceling a Quick Stop While Decelerating during a Quick Stop

When decelerating for a quick stop, do not cancel the quick stop before the output speed reaches 0. Otherwise, undershooting may occur while approaching the input speed.



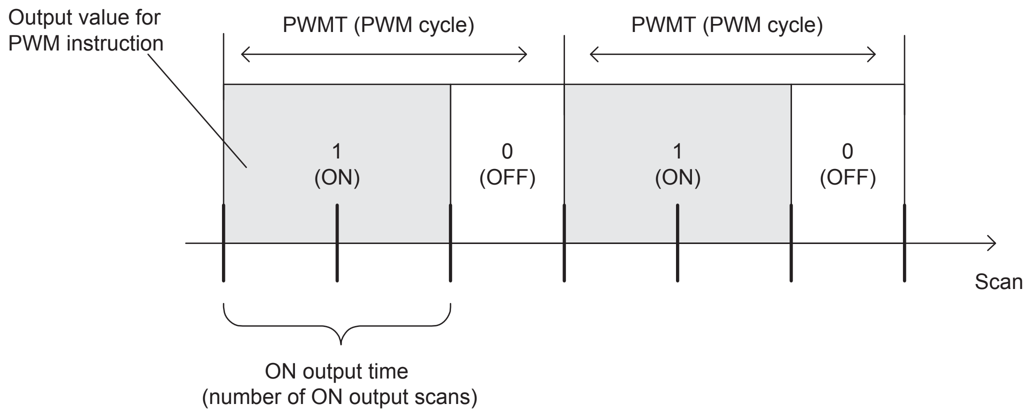
If you must reset the quick stop before the output speed reaches 0 and undershooting is a problem, take one of the following measures in your application program.

- Do not cancel the quick stop before the output speed reaches 0.
- Use the LIMIT instruction on the output speed to prevent undershooting when the quick stop is canceled.

5.8.13 Pulse Width Modulation (PWM)

(1) Operation

The PWM instruction converts the input value (from -100.00% to 100.00%) using pulse-width modulation and outputs the result to the output value and parameter table. The input value and output value must be integers. Double-length integers and real numbers cannot be used.



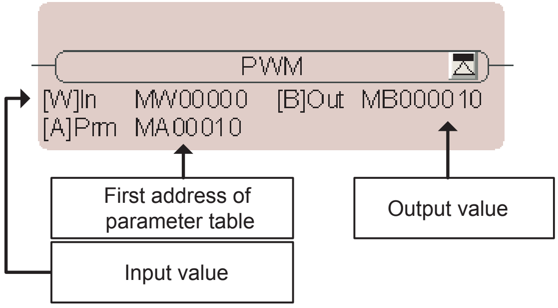
The ON output time and number of ON output scans of the PWM instruction can be calculated with the following formula.
X is the input value, PWMT is the PWM cycle (ms), and Ts is the scan time set value (ms).

$$\text{ON output time} = \frac{\text{PWMT (X + 10,000)}}{20{,}000}$$

$$\text{Number of ON output scans} = \frac{\text{PWMT (X + 10,000)}}{\text{Ts} \times 20{,}000}$$

- The relation between the input value and the PWM output ON ratio is as follows:
  - Input value 100.00% → 100% ON (ON output time = PWMT)
  - Input value 0.00% → 50% ON (ON output time = PWMT/2)
  - Input value -100.00% → 0% ON (ON output time = 0)
- After turning ON the power supply, close PWMRST (PWM reset) to clear all internal calculations before using the PWM instruction. When the PWM reset bit is closed, all internal calculations are reset and then the PMW operation starts execution from that point.

(2) Format



Icon: PWM

Key entry: PWM

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Input value (In)	×	○	×	×	×	○	○
First address of parameter table (Prm)	×	×	×	×	○*	○	○
Output value (Out)	○*	×	×	×	×	○	×

* C and # registers cannot be used.

[a] Ranges of Input and Output Values

The input value must be between -10,000 and 10,000 in units of 0.01%.
If the input exceeds this range, processing is performed for the upper limit (10,000) and the lower limit (-10,000).
The output value is set to 1 when the PWM output is ON, or to 0 when the PWM output is OFF.

[b] Parameter Table Configuration

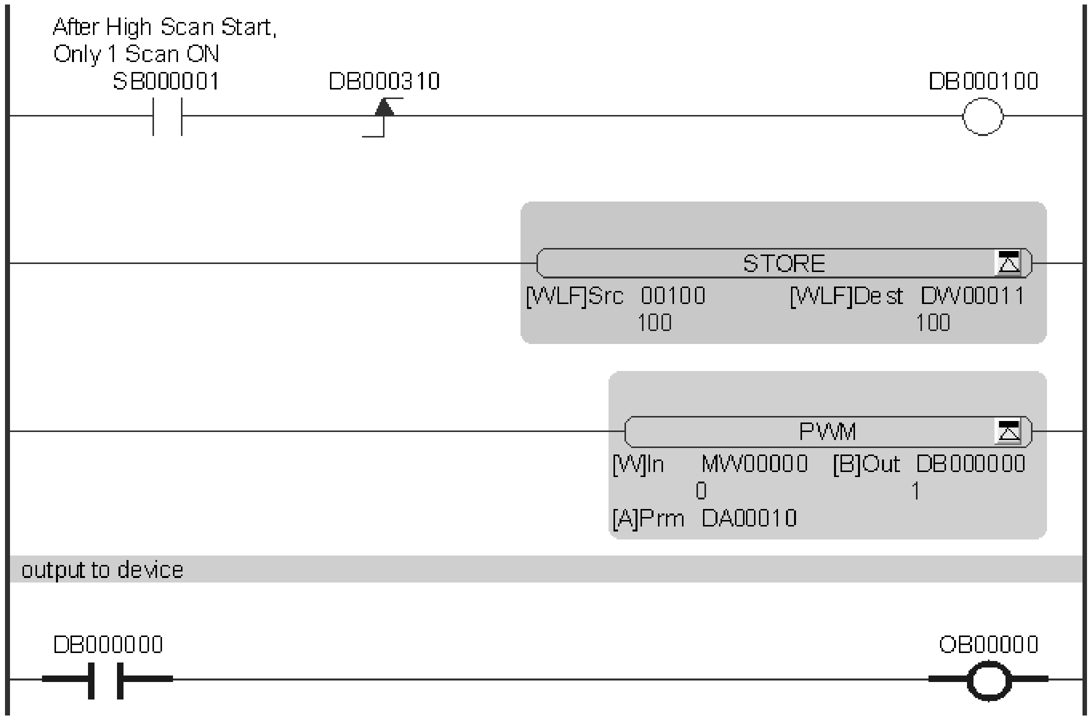
Address	Data Type	Symbol	Name	Specification	I/O
0	W	RLY	Relay I/O	Relay inputs and relay outputs*	IN/OUT
1	W	RWMT	PWM cycle	PWM cycle (1 ms) Range: 1 to 32,767 ms	IN
2	W	ONCNT	ON output setting timer	ON output setting timer (1 ms)	OUT
3	W	CVON	ON output counting timer	ON output counting timer (1 ms)	OUT
4	W	CVONREM	ON output counting timer remainder	ON output counting timer remainder (0.1 ms)	OUT
5	W	OFFCNT	OFF output setting timer	OFF output setting timer (1 ms)	OUT
6	W	CVOFF	OFF output counting timer	OFF output counting timer (1 ms)	OUT
7	W	CVOFFREM	OFF output counting timer remainder	OFF output counting timer remainder (0.1 ms)	OUT

* The relay input and output bits are assigned as given below. (Close = Bit change to 1 (ON), Open = Bit change to 0 (OFF))

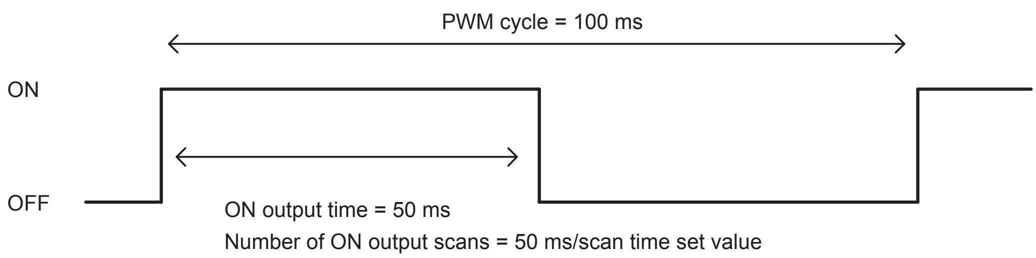
Bit	Symbol	Name	Specification	I/O
0	PWMRST	PWM reset bit	This input is closed to reset the PWM operation.	IN
2 to 7	–	(Reserved.)	Spare input relays	IN
8	PWMOUT	PWM output	PWM output (The output value is set to 1 when the output is ON, or to 0 when the output is OFF.)	OUT
9 to F	–	(Reserved.)	Spare output relays	OUT

(3) Programming Example

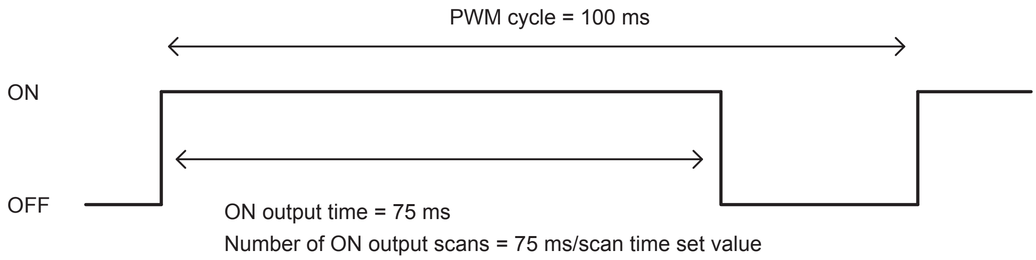
In the following programming example, the PWM output for the input value in MW00000 is stored in OB000000 where the PWM cycle is 100 ms.



This figure shows the output of OB000000 when MW00000 is 0 (0%: ON output time is 1/2 of the PWM cycle).



This figure shows the output of OB000000 when MW00000 is 7,500 (75%: ON output time is 3/4 of the PWM cycle).

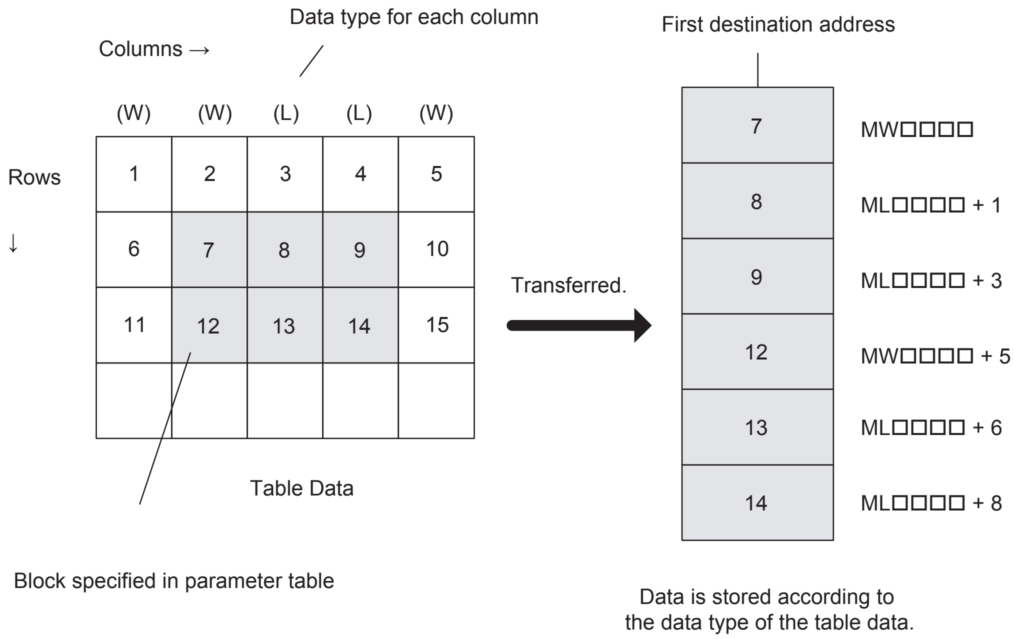


5.9 Table Manipulation Instructions

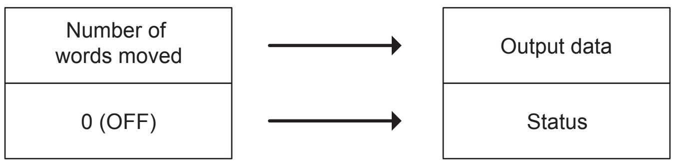
5.9.1 Read Table Block (TBLBR)

(1) Operation

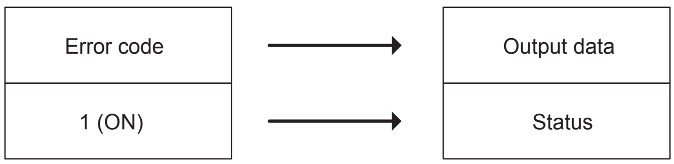
The TBLBR instruction moves the block of the table data that is specified by the table name, row number, and column number to a continuous area that starts at the first destination address. The data is stored in the destination area according to the data type of the elements that were read.
If an error occurs when accessing the table, such as data that is outside of the valid range or not enough data length at the destination, an error is output and no data is read. The contents in the destination area will remain unchanged.
If the instruction ends normally, the number of words that were moved is output, and the Status bit is turned OFF. If an error occurs, an error code is output and the Status bit is turned ON.



[a] If the Move Succeeds



[b] If the Move Fails

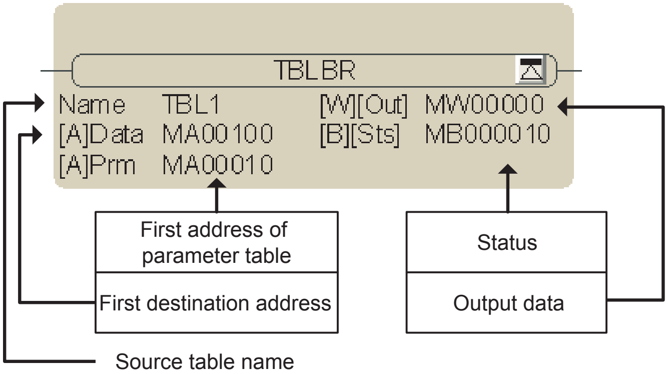


- If the move fails, the destination area will retain the contents from before the instruction was executed.

Instructions

5

(2) Format



Icon: 

Key entry: TBLBR

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First destination address (Data)	×	×	×	×	○*2	×	×
First address of parameter table (Prm)	×	×	×	×	○	×	×
Output data (Out)*1	×	○*2	×	×	×	○	×
Status (Sts)*1	○*2	×	×	×	×	×	×

∗ 1. Optional.
∗ 2. C and # registers cannot be used.

[a] Parameter Table Configuration

Address	Data Type	Symbol	Name	Specification	I/O
0	L	ROW1	First row number of table elements	First row number of table elements to move (1 to 65,535)	IN
2	L	COL1	First column number of table elements	First column number of table elements to move (1 to 32,767)	IN
4	W	RLEN	Number of row elements	Number of row elements (1 to 32,767)	IN
5	W	CLEN	Number of column elements	Number of column elements (1 to 32,767)	IN

[b] Error Codes

Error Code	Error Name	Meaning
0001 hex	Table undefined	The target table is undefined.
0002 hex	Outside range of row numbers	The row number of the table element is outside the target table.
0003 hex	Outside range of column numbers	The column number of the table element is outside the target table.
0004 hex	Incorrect number of elements	The number of target elements is invalid.
0005 hex	Insufficient storage area	The storage area is insufficient.
0006 hex	Insufficient element type	The data type specified for the element is wrong.
0007 hex	Queue buffer error	An attempt was made to read from an empty queue buffer or to write to a full queue buffer by advancing the pointer.
0008 hex	Queue table error	The specified table is not a queue table.
0009 hex	System error	An unexpected error was detected in the system during instruction execution.

- The error codes apply to all table manipulation instructions.

(3) Programming Example

In the following programming example, the specified block in record table data TBL1 is moved to an area that starts at MW00100 when switch 1 (DB000000) turns ON.

The parameter table is set as shown in the following table.

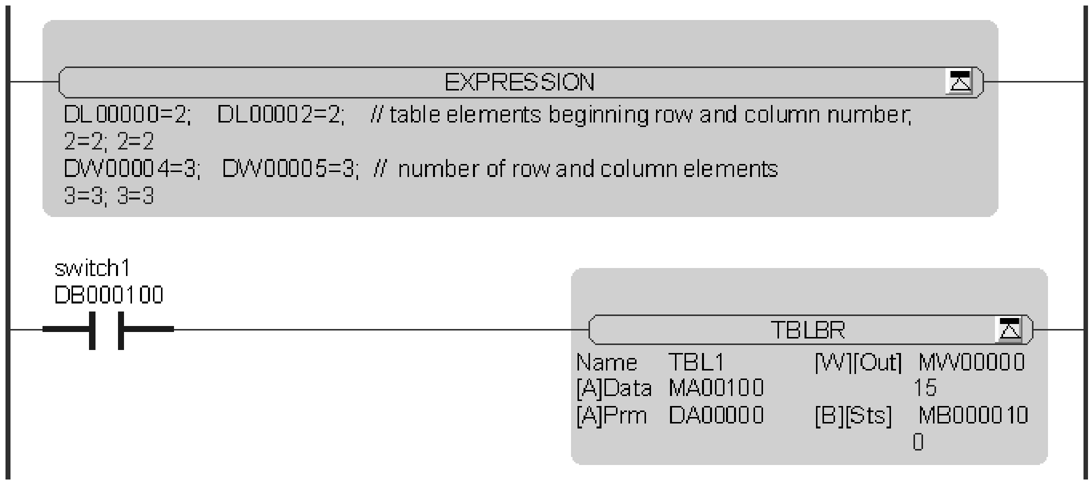
Register	Data	Remarks
DL00000	2	First row number of table elements
DL00002	2	First column number of table elements
DW00004	3	Number of row elements
DW00005	3	Number of column elements

The contents of table data TBL1 are given below.

Row \ Column	1 (W)	2 (W)	3 (L)	4 (L)	5 (F)
1	1000	1001	10000	10001	1.1
2	2000	2002	20000	20002	1.2
3	3000	3003	30000	30003	1.3
4	4000	4004	40000	40004	1.4
5	5000	5005	50000	50005	1.5

Block to move

- The column data types are given in parentheses.



After the instruction is executed, the data is moved to an area that starts from MW00100 as shown below.
The number of words that was moved is set to 15 in MW00000 (output data), and MB000010 (status) is set to 0 (move successful).

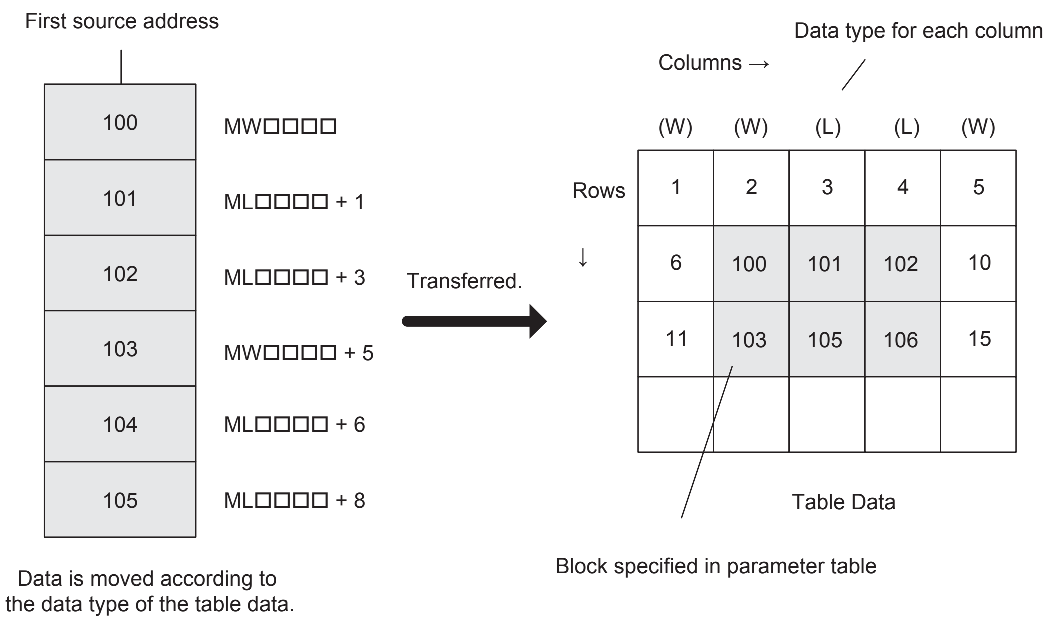
Register	Data	Register	Data	Register	Data
MW00100	2002	ML00101	20000	ML00103	20002
MW00105	3003	ML00106	30000	ML00108	30003
MW00110	4004	ML00111	40000	ML00113	40004

- The registers are assigned as shown in the above table.

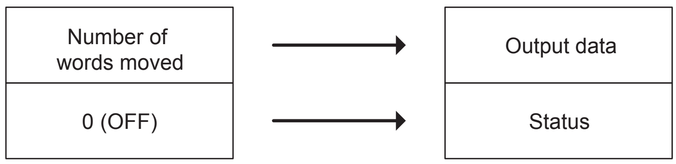
5.9.2 Write Table Block (TBLBW)

(1) Operation

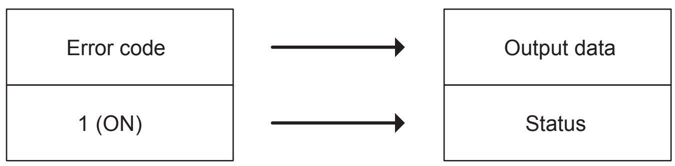
The TBLBW instruction moves the data from a continuous area that starts at the first source address to a block of the table data that is specified by the table name, row number, and column number. The data is stored under the assumption that the data type of the source area and each element in the table data are the same.
If an error occurs when accessing the table, such as data that is outside of the valid range or not enough data length at the source, an error is output and no data is written. The contents in the destination area will remain unchanged.
If the instruction ends normally, the number of words that were moved is output, and the Status bit is turned OFF. If an error occurs, an error code is output and the Status bit is turned ON.



[a] If the Move Succeeds

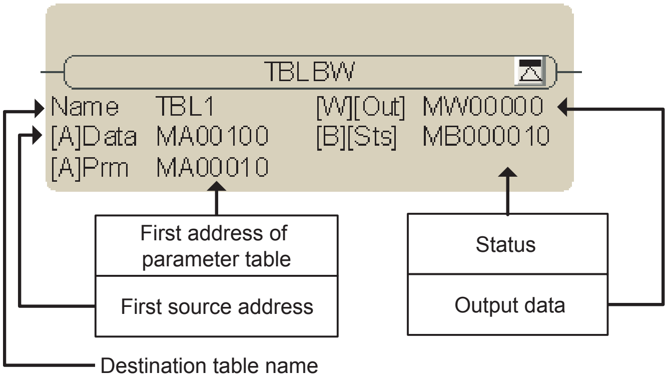


[b] If the Move Fails



- If the move fails, the destination area will retain the contents from before the instruction was executed.

(2) Format



Icon: 

Key entry: TBLBW

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First source address (Data)	×	×	×	×	○*2	×	×
First address of parameter table (Prm)	×	×	×	×	○	×	×
Output data (Out)*1	×	○*2	×	×	×	○	×
Status (Sts)*1	○*2	×	×	×	×	×	×

* 1. Optional.
* 2. C and # registers cannot be used.

[a] Parameter Table Configuration

Address	Data Type	Symbol	Name	Specification	I/O
0	L	ROW1	First row number of table elements	First row number of table elements to move (1 to 65,535)	IN
2	L	COL1	First column number of table elements	First column number of table elements to move (1 to 32,767)	IN
4	W	RLEN	Number of row elements	Number of row elements (1 to 32,767)	IN
5	W	CLEN	Number of column elements	Number of column elements (1 to 32,767)	IN

[b] Error Codes

Error Code	Error Name	Meaning
0001 hex	Table undefined	The target table is undefined.
0002 hex	Outside range of row numbers	The row number of the table element is outside the target table.
0003 hex	Outside range of column numbers	The column number of the table element is outside the target table.
0004 hex	Incorrect number of elements	The number of target elements is invalid.
0005 hex	Insufficient storage area	The storage area is insufficient.
0006 hex	Insufficient element type	The data type specified for the element is wrong.
0007 hex	Queue buffer error	An attempt was made to read from an empty queue buffer, or to write to a full queue buffer by advancing the pointer.
0008 hex	Queue table error	The specified table is not a queue table.
0009 hex	System error	An unexpected error was detected in the system during instruction execution.

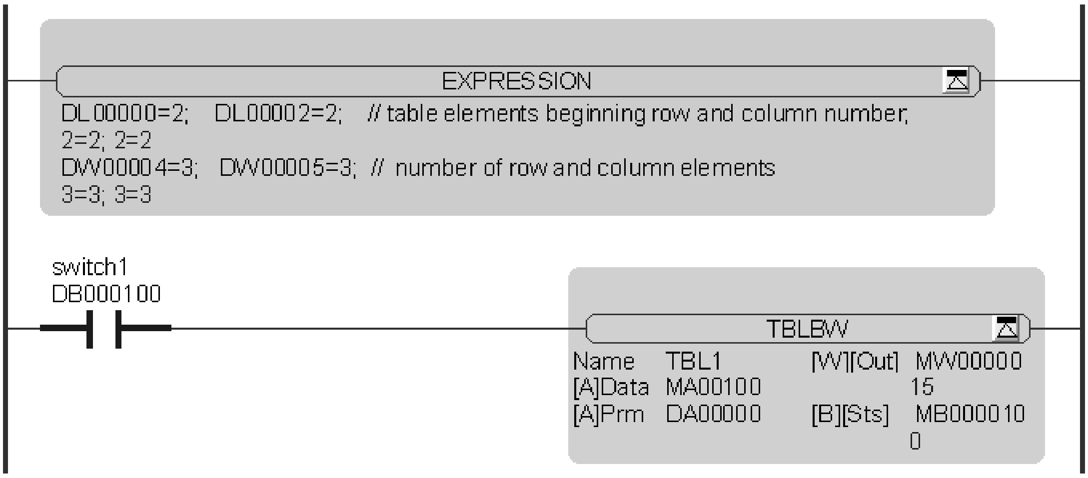
- The error codes apply to all table manipulation instructions.

(3) Programming Example

In the following programming example, an area of data that starts at MW00100 is moved to a specified block in record table data TBL1 when switch 1 (DB00000) turns ON.

The parameter table is set as shown in the following table.

Register	Data	Remarks
DL00000	2	First row number of table elements
DL00002	2	First column number of table elements
DW00004	3	Number of row elements
DW00005	3	Number of column elements



The data that is written is given below.

Register	Data	Register	Data	Register	Data
MW00100	1	ML00101	2	ML00103	3
MW00105	4	ML00106	5	ML00108	6
MW00110	7	ML00111	8	ML00113	9

The following table shows the contents of table data TBL1 after the instruction is executed.
The number of words that were moved is set to 15 in MW00000, and MB000010 (status) is set to 0 (move successful).

Row \ Column	1 (W)	2 (W)	3 (L)	4 (L)	5 (F)
1					
2		1	2	3	
3		4	5	6	
4		7	8	9	
5					

Area that is written

- The column data types are given in parentheses.

5.9.3 Search for Table Row (TBLSRL)

(1) Operation

The TBLSRL instruction searches for the search data in column elements of the table data that is specified by the table name, row numbers, and column number. The search result is output as the row number of the data that matches the search data. The type of the data to be searched is automatically determined by the data type of the specified column elements.

If the instruction ends normally and the search data is found, the search result in the input parameter table is set to 1, the output data is set to the row number, and the status is turned OFF. If the search data is not found, the search result and output data are set to 0. If an error occurs, an error code is set in the output data and the status is turned ON.

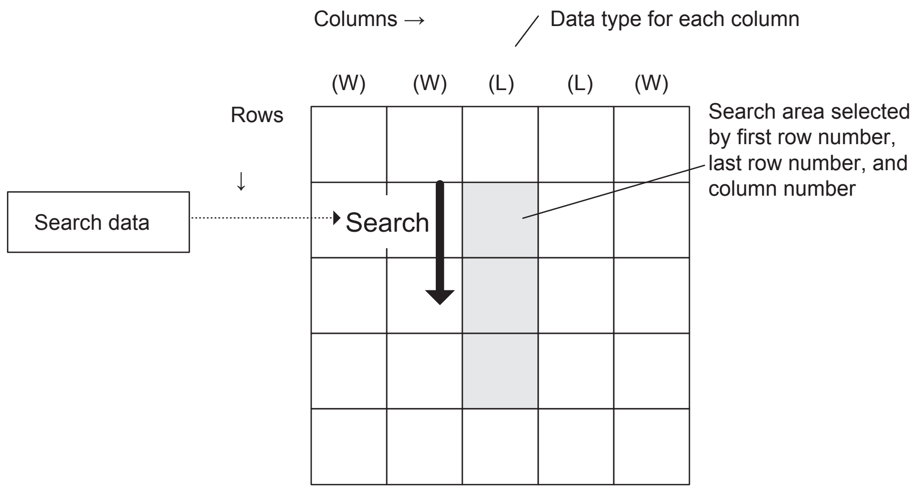


Table Data

[a] Search Data Found

Row number	→	Output data
0 (OFF)	→	Status
1: Matching row exists	→	Search result for parameters

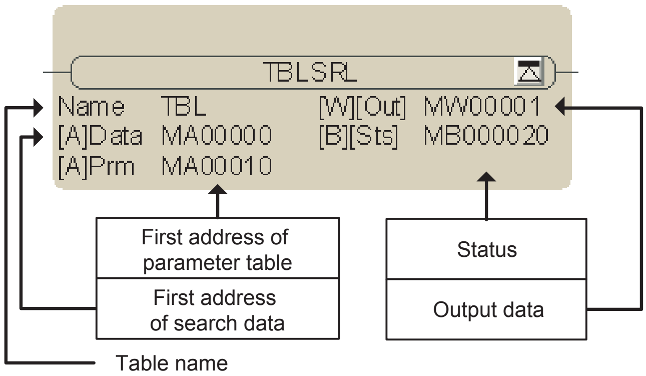
[b] Search Data Not Found

0	→	Output data
0 (OFF)	→	Status
0: No matching row	→	Search result for parameters

[c] Search Error

Error code	→	Output data
1 (ON)	→	Status

(2) Format



Icon: 

Key entry: TBLSRL

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First address of search data (Data)	×	×	×	×	○	×	×
First address of parameter table (Prm)	×	×	×	×	○	×	×
Output data (Out)*1	×	○*2	×	×	×	○	×
Status (Sts)*1	○*2	×	×	×	×	×	×

* 1. Optional.
* 2. C and # registers cannot be used.

[a] Parameter Table Configuration

Address	Data Type	Symbol	Name	Specification	I/O
0	L	ROW1	First row number of table elements	First row number of table elements to search (1 to 65,535)	IN
2	L	ROW2	Last row number of table elements	Last row number of table elements to search (1 to 65,535)	IN
4	L	COLUMN	Column number of table elements	Column number of table elements to search (1 to 32,767)	IN
6	W	FIND	Search result	Search result 0: No matching row 1: Matching row exists	OUT

[b] Error Codes

Error Code	Error Name	Meaning
0001 hex	Table undefined	The target table is undefined.
0002 hex	Outside range of row numbers	The row number of the table element is outside the target table.
0003 hex	Outside range of column numbers	The column number of the table element is outside the target table.
0004 hex	Incorrect number of elements	The number of target elements is invalid.
0005 hex	Insufficient storage area	The storage area is insufficient.
0006 hex	Insufficient element type	The data type specified for the element is wrong.
0007 hex	Queue buffer error	An attempt was made to read from an empty queue buffer, or to write to a full queue buffer by advancing the pointer.
0008 hex	Queue table error	The specified table is not a queue table.
0009 hex	System error	An unexpected error was detected in the system during instruction execution.

(3) Programming Example

In the following programming example, a search is made for search data 32 in MW00000 in part of a column of array table data TBL1.

The parameter table is set as shown in the following table.

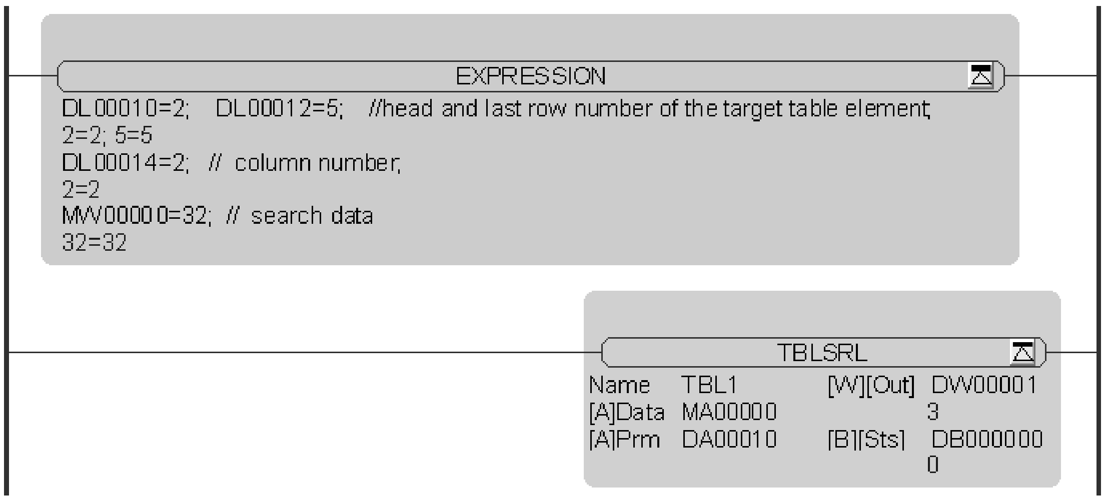
Register	Data	Remarks
DL00010	2	First row number of table elements
DL00012	5	Last row number of table elements
DL00014	2	Column number of table elements

The contents of table data TBL1 are given below. (Table elements are integer data.)

Row \ Column	1	2	3	4	5
1	11	12	13	14	15
2	21	22	23	24	25
3	31	32	33	34	35
4	41	42	43	44	45
5	51	52	53	54	55

Area to search

A match for 32 (MW00000) was found in row number 3 in the search area, so DW00001 is set to 3.



Instructions

5

5.9.4 Search for Table Column (TBLSRC)

(1) Operation

The TBLSRC instruction searches for the search data in row elements of the table data that is specified by the table name, column numbers, and row number. The search result is output as the column number of the data that matches the search data. The type of the data to be searched is automatically determined by the data types of the specified row elements.

If the instruction ends normally and the search data is found, the search result in the input parameter table is set to 1, the output data is set to the column number, and the status is turned OFF. If the search data is not found, the search result and output data are set to 0. If an error occurs, an error code is set in the output data and the status is turned ON.

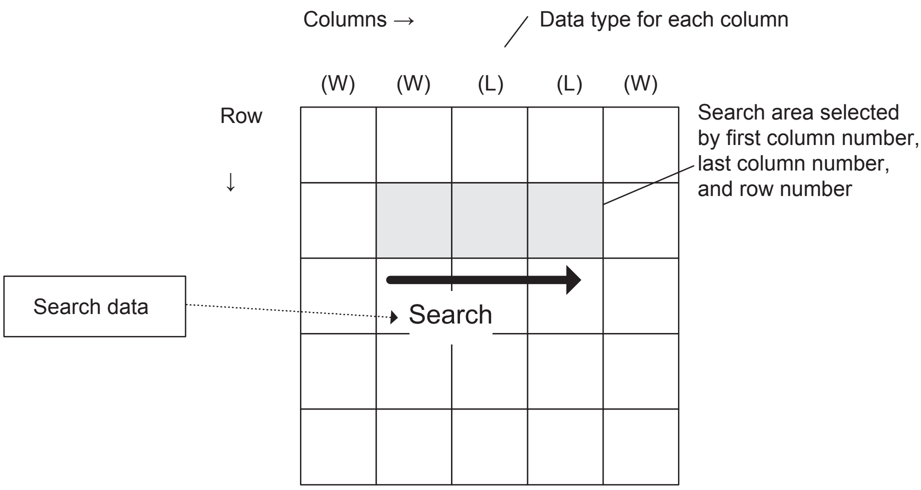
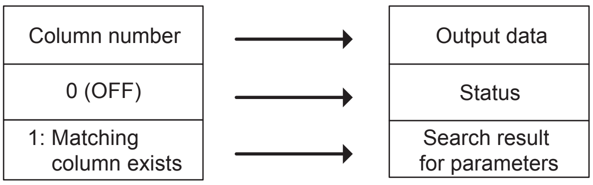
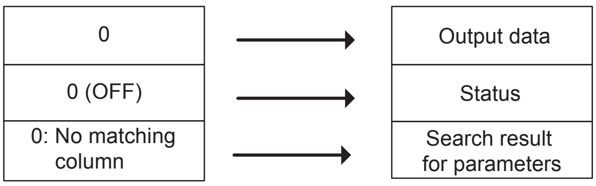


Table Data

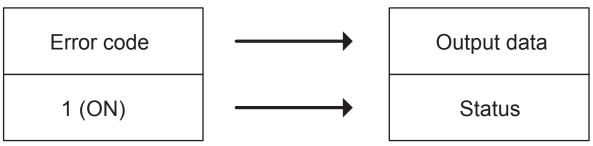
[a] Search Data Found



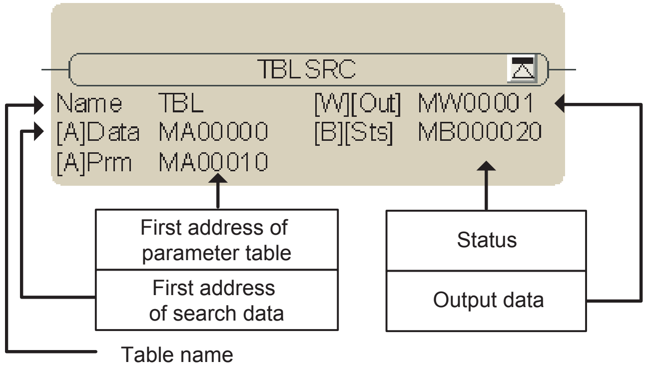
[b] Search Data Not Found



[c] Search Error



(2) Format



Icon: 

Key entry: TBLSRC

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First address of search data (Data)	×	×	×	×	○	×	×
First address of parameter table (Prm)	×	×	×	×	○	×	×
Output data (Out)*1	×	○*2	×	×	×	○	×
Status (Sts)*1	○*2	×	×	×	×	×	×

* 1. Optional.
* 2. C and # registers cannot be used.

[a] Parameter Table Configuration

Address	Data Type	Symbol	Name	Specification	I/O
0	L	ROW1	Row number of table elements	Row number of table elements to search (1 to 65,535)	IN
2	L	COLUMN1	First column number of table elements	First column number of table elements to search (1 to 32,767)	IN
4	L	COLUMN2	Last column number of table elements	Last column number of table elements to search (1 to 32,767)	IN
6	W	FIND	Search result	Search result 0: No matching column 1: Matching column exists	OUT

[b] Error Codes

Error Code	Error Name	Meaning
0001 hex	Table undefined	The target table is undefined.
0002 hex	Outside range of row numbers	The row number of the table element is outside the target table.
0003 hex	Outside range of column numbers	The column number of the table element is outside the target table.
0004 hex	Incorrect number of elements	The number of target elements is invalid.
0005 hex	Insufficient storage area	The storage area is insufficient.
0006 hex	Unexpected element type	The data type specified for the element is wrong.
0007 hex	Queue buffer error	An attempt was made to read from an empty queue buffer, or to write to a full queue buffer by advancing the pointer.
0008 hex	Queue table error	The specified table is not a queue table.
0009 hex	System error	An unexpected error was detected in the system during instruction execution.

(3) Programming Example

In the following programming example, a search is made for search data 34 in MW00000 in part of a row of array table data TBL1.

The parameter table is set as shown in the following table.

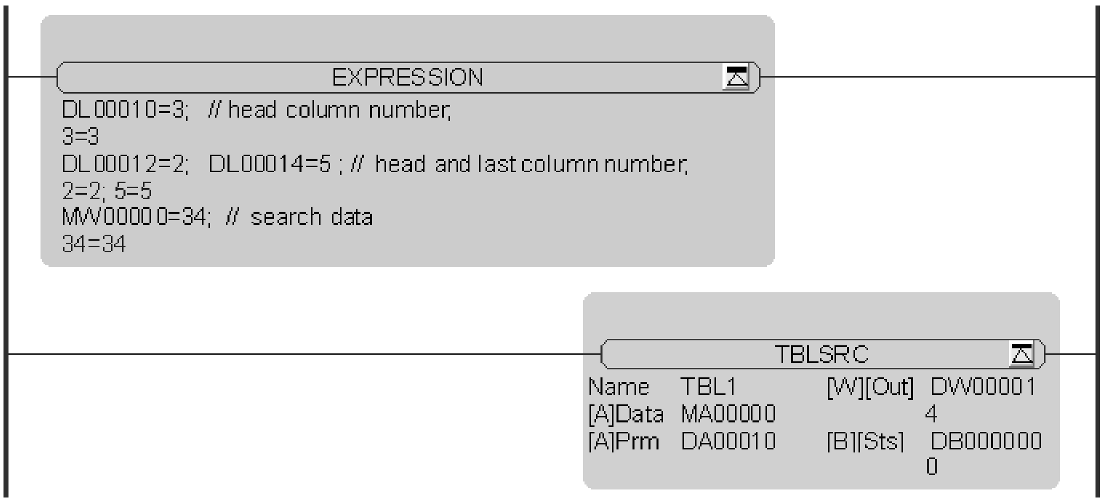
Register	Data	Remarks
DL00010	3	Row number of table elements
DL00012	2	First column number of table elements
DL00014	5	Last column number of table elements

The contents of table data TBL1 are given below. (Table elements are integer data.)

Row \ Column	1	2	3	4	5
1	11	12	13	14	15
2	21	22	23	24	25
3	31	32	33	34	35
4	41	42	43	44	45
5	51	52	53	54	55

Area to search

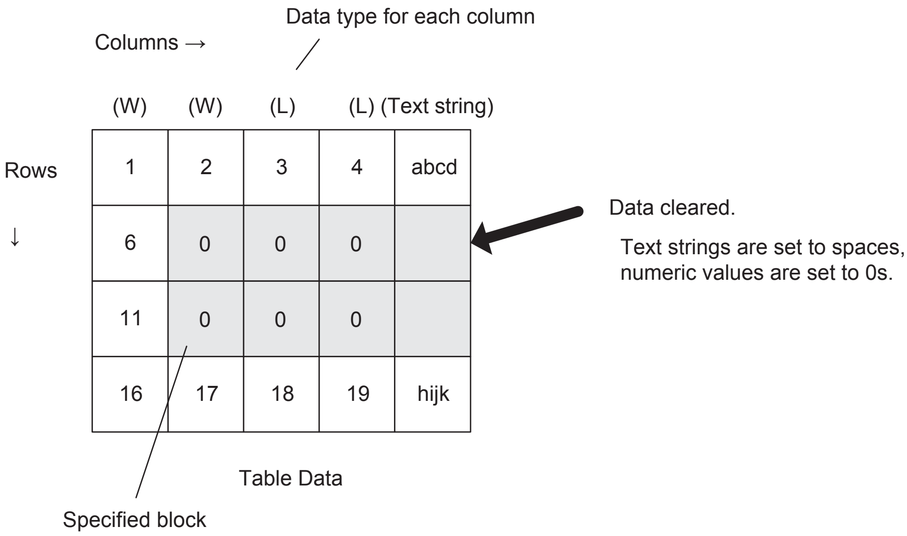
A match for 34 (MW00000) was found in column number 4 in the search area, so DW00001 is set to 4.



5.9.5 Clear Table Block (TBLCL)

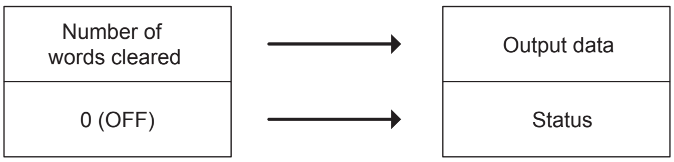
(1) Operation

The TBLCL instruction clears the block of data in the table data that is specified by the table name, row numbers, and column numbers. The elements are filled with spaces if the data type is for text strings, and 0s if the data type is for numeric values.
If both the first row number and the first column number of the table element are 0, the entire table will be cleared.
If an error occurs when accessing the table, such as data that is outside of the valid range or not enough data length at the destination, an error is output and no data is written.
If the instruction ends normally, the number of words that were cleared is output and the status is turned OFF. If an error occurs, an error code is set in the output data and the status is turned ON.

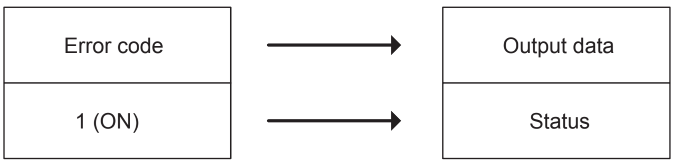


- If the first row number and column number of the table element are both 0, the entire table is cleared.

[a] If the Clear Succeeds

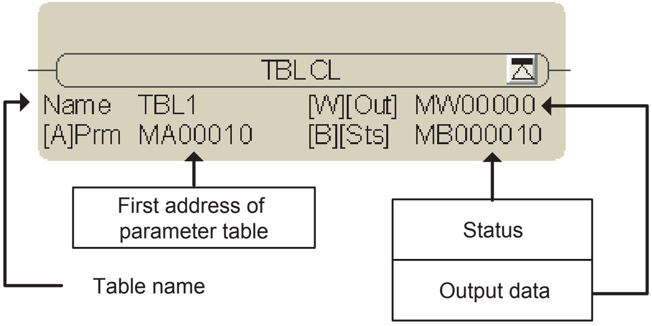


[b] If the Clear Fails



- If the clear fails, the table data will retain the contents from before the instruction was executed.

(2) Format



Icon: TBL CL

Key entry: TBLCL

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First address of parameter table (Prm)	×	×	×	×	○	×	×
Output data (Out)*1	×	○*2	×	×	×	○	×
Status (Sts)*1	○*2	×	×	×	×	×	×

＊1. Optional.
＊2. C and # registers cannot be used.

[a] Parameter Table Configuration

Address	Data Type	Symbol	Name	Specification	I/O
0	L	ROW	First row number of table elements	First row number of table elements to clear (1 to 65,535)	IN
2	L	COL	First column number of table elements	First column number of table elements to clear (1 to 32,767)	IN
4	W	RLEN	Number of row elements	Number of row elements (1 to 32,767)	IN
5	W	CLEN	Number of column elements	Number of column elements (1 to 32,767)	IN

[b] Error Codes

Error Code	Error Name	Meaning
0001 hex	Table undefined	The target table is undefined.
0002 hex	Outside range of row numbers	The row number of the table element is outside the target table.
0003 hex	Outside range of column numbers	The column number of the table element is outside the target table.
0004 hex	Incorrect number of elements	The number of target elements is invalid.
0005 hex	Insufficient storage area	The storage area is insufficient.
0006 hex	Insufficient element type	The data type specified for the element is wrong.
0007 hex	Queue buffer error	An attempt was made to read from an empty queue buffer, or to write to a full queue buffer by advancing the pointer.
0008 hex	Queue table error	The specified table is not a queue table.
0009 hex	System error	An unexpected error was detected in the system during instruction execution.

(3) Programming Example

In the following programming example, the specified block is cleared from record table data TBL1 when switch 1 (DB000100) turns ON.
The parameter table is set as shown in the following table.

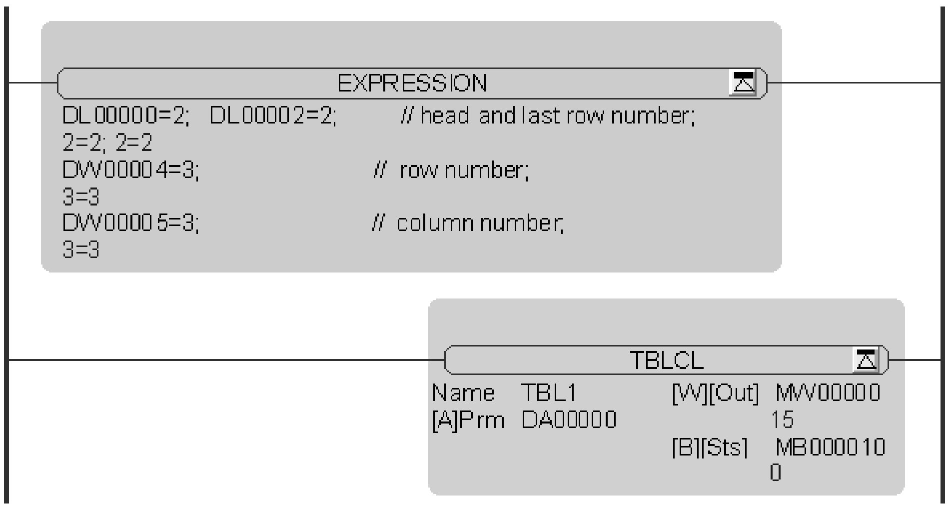
Register	Data	Remarks
DL00000	2	First row number of table elements
DL00002	2	First column number of table elements
DW00004	3	Number of row elements
DW00005	3	Number of column elements

The contents of table data TBL1 are given below.

Row \ Column	1 (W)	2 (W)	3 (L)	4 (Text string)	5 (F)
1	1000	1001	10000	ABCD	1.1
2	2000	2002	20000	BCDE	1.2
3	3000	3003	30000	CDEF	1.3
4	4000	4004	40000	DEFG	1.4
5	5000	5005	50000	EFGH	1.5

Area to clear

- The column data types are given in parentheses.



The data is cleared after the instruction is executed as shown below.

Row \ Column	1 (W)	2 (W)	3 (L)	4 (Text string)	5 (F)
1	1000	1001	10000	ABCD	1.1
2	2000	0	0		1.2
3	3000	0	0		1.3
4	4000	0	0		1.4
5	5000	5005	50000	EFGH	1.5

Area that was cleared

- The column data types are given in parentheses.

5.9.6 Move Table Block (TBLMV)

(1) Operation

The TBLMV instruction moves a block of data in the table data that is specified by the table name, row number, and column number to a different table block. The block can be moved between different tables or within the same table. If the data type of the column elements in the source and destination do not match, an error is output and no data is moved.
If the instruction ends normally, the number of words that were moved is output, and the Status bit is turned OFF. If an error occurs, an error code is output and the Status bit is turned ON.

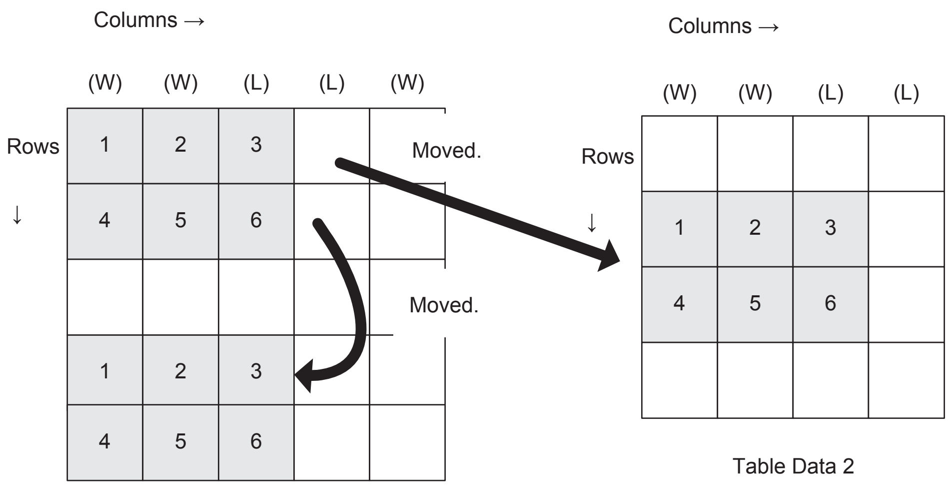
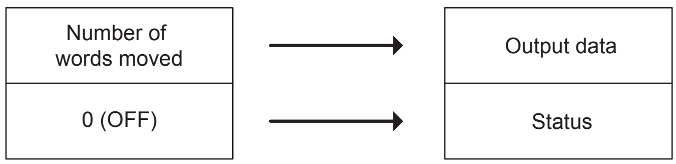


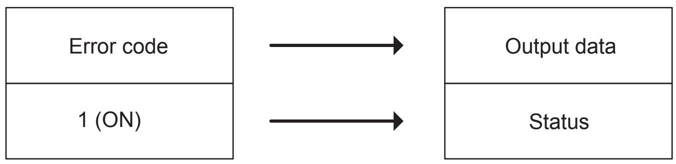
Table Data 1

Table Data 2

[a] If the Move Succeeds

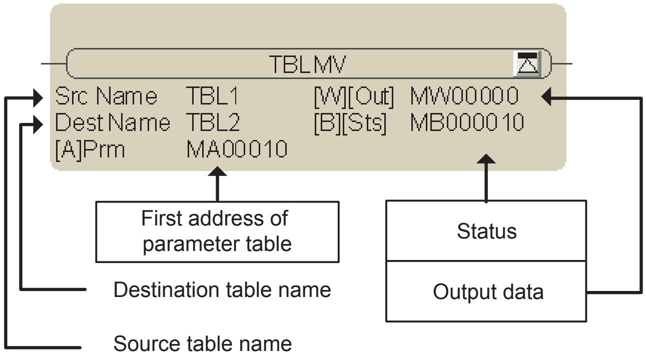


[b] If the Move Fails



- If the move fails, the table data will retain the contents from before the instruction was executed.

(2) Format



Icon: 

Key entry: TBLMV

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First address of parameter table (Prm)	×	×	×	×	○	×	×
Output data (Out)*1	×	○*2	×	×	×	○	×
Status (Sts)*1	○*2	×	×	×	×	×	×

* 1. Optional.
* 2. C and # registers cannot be used.

[a] Parameter Table Configuration

Address	Data Type	Symbol	Name	Specification	I/O
0	L	ROW1	First row number of table elements	First row number of table elements at source to move (1 to 65,535)	IN
2	L	COLUMN1	First column number of table elements	First column number of table elements at source to move (1 to 32,767)	IN
4	W	RLEN	Number of row elements	Number of row elements (1 to 32,767)	IN
5	W	CLEN	Number of column elements	Number of column elements (1 to 32,767)	IN
6	L	ROW2	First row number of table elements	First row number of table elements at destination (1 to 65,535)	IN
8	L	COLUMN2	First column number of table elements	First column number of table elements at destination (1 to 32,767)	IN

[b] Error Codes

Error Code	Error Name	Meaning
0001 hex	Table undefined	The target table is undefined.
0002 hex	Outside range of row numbers	The row number of the table element is outside the target table.
0003 hex	Outside range of column numbers	The column number of the table element is outside the target table.
0004 hex	Incorrect number of elements	The number of target elements is invalid.
0005 hex	Insufficient storage area	The storage area is insufficient.
0006 hex	Insufficient element type	The data type specified for the element is wrong.
0007 hex	Queue buffer error	An attempt was made to read from an empty queue buffer, or to write to a full queue buffer by advancing the pointer.
0008 hex	Queue table error	The specified table is not a queue table.
0009 hex	System error	An unexpected error was detected in the system during instruction execution.

(3) Programming Example

In the following programming example, the specified block in record table data TBL1 is moved to the specified block in table data TBL2 when switch 1 (DB000100) turns ON.

The contents of table data TBL1 are given below.

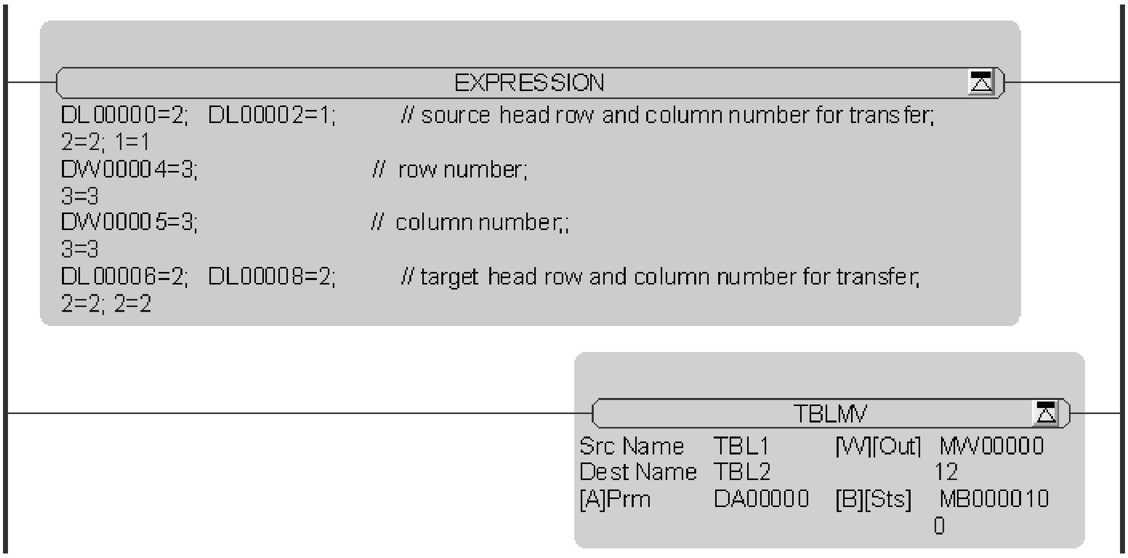
Row \ Column	1 (W)	2 (W)	3 (L)
1	1000	1001	10000
2	2000	2002	20000
3	3000	3003	30000
4	4000	4004	40000
5	5000	5005	50000

Block to move

- The column data types are given in parentheses.

The parameter table is set as shown in the following table.

Register	Data	Remarks
DL00000	2	First row number at source
DL00002	1	First column number at source
DW00004	3	Number of row elements
DW00005	3	Number of column elements
DL00006	2	First row number at destination
DL00008	2	First column number at destination



This table shows the contents of table data TBL2 after the instruction is executed.

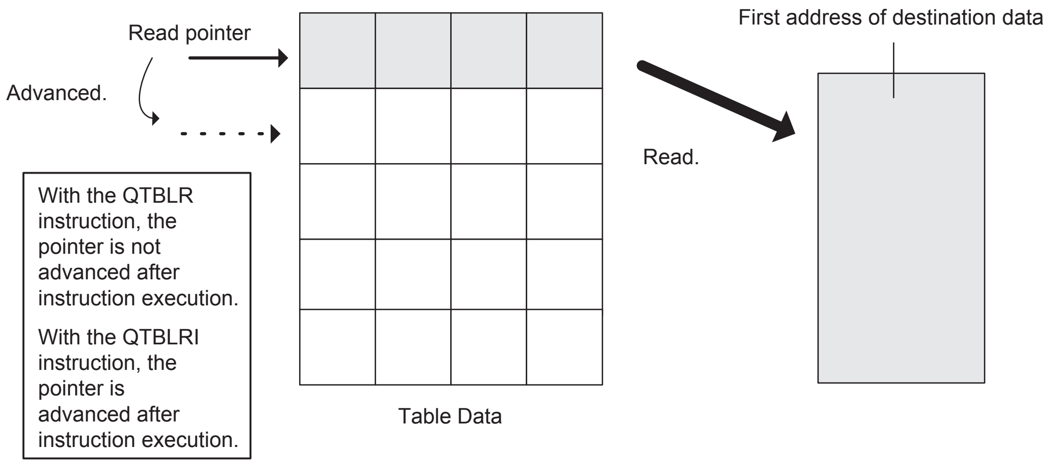
Row \ Column	1 (W)	2 (W)	3 (W)	4 (L)	5 (L)
1					
2		2000	2002	20000	
3		3000	3003	30000	
4		4000	4004	40000	
5					

Block that was moved

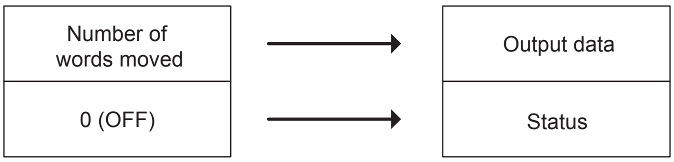
5.9.7 Read Queue Table (QTBLR and QTBLRI)

(1) Operation

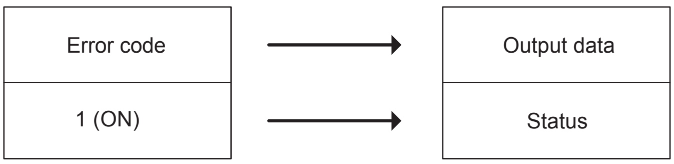
Column elements of the table data that are specified by the table name, row number, and column number are continuously read and stored in a continuous area that starts at a specified register. The data types of the elements that are read are automatically determined by the table that is specified. The data types of the destination registers are ignored and the data is stored according to the data types in the table without any conversion.
The QTBLR instruction does not change the queue table read pointer. The QTBLRI instruction advances the queue table read pointer by one row.
If an error occurs when accessing the table, such as a table name error, an out of range row number, or an empty queue buffer, an error is output, no data is read, and the pointer is not advanced.
The contents of the destination registers will be retained.
If the instruction ends normally, the number of words that were moved is output, and the Status bit is turned OFF. If an error occurs, an error code is output and the Status bit is turned ON.



[a] If the Read Succeeds

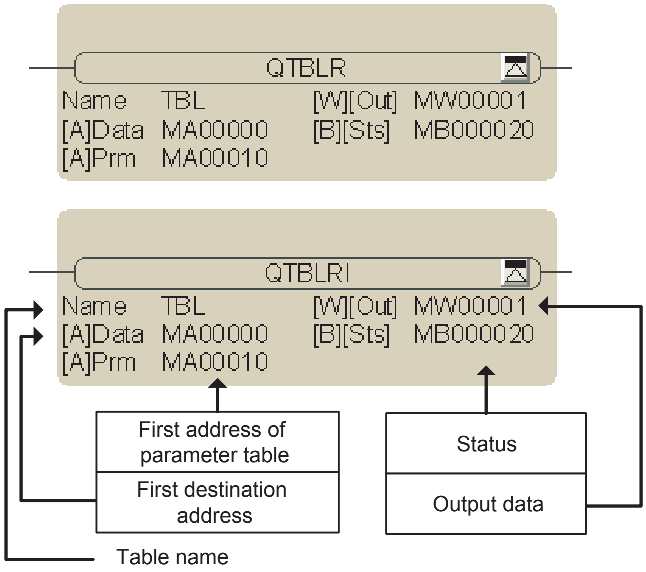


[b] If the Read Fails



- If the read fails, the data at the destination will retain the contents from before the instruction was executed.

(2) Format



Icon: 

Key entry: QTBLR, QTBLRI

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First destination address (Data)	×	×	×	×	○	×	×
First address of parameter table (Prm)	×	×	×	×	○*2	×	×
Output data (Out)*1	×	○*2	×	×	×	○	×
Status (Sts)*1	○*2	×	×	×	×	×	×

∗ 1. Optional.
∗ 2. C and # registers cannot be used.

[a] Parameter Table Configuration

Address	Data Type	Symbol	Name	Specification	I/O
0	L	ROW	Relative row number of table elements	Relative row number of table elements at source to move (1 to 65,535)	IN
2	L	COLUMN	First column number of table elements	First column number of table elements at source to move (1 to 32,767)	IN
4	W	CLEN	Number of column elements	Number of column elements to move (1 to 32,767)	IN
5	W	Reserved.			
6	L	RPTR	Read pointer	Read pointer of the queue after execution	OUT
8	L	WPTR	Write pointer	Write pointer of the queue after execution	OUT

[b] Error Codes

Error Code	Error Name	Meaning
0001 hex	Table undefined	The target table is undefined.
0002 hex	Outside range of row numbers	The row number of the table element is outside the target table.
0003 hex	Outside range of column numbers	The column number of the table element is outside the target table.
0004 hex	Incorrect number of elements	The number of target elements is invalid.
0005 hex	Insufficient storage area	The storage area is insufficient.
0006 hex	Insufficient element type	The data type specified for the element is wrong.
0007 hex	Queue buffer error	An attempt was made to read from an empty queue buffer, or to write to a full queue buffer by advancing the pointer.
0008 hex	Queue table error	The specified table is not a queue table.
0009 hex	System error	An unexpected error was detected in the system during instruction execution.

[c] Setting the Relative Row Numbers of Table Elements

Relative Row Number	Row That Is Read	Remarks
0	Read pointer row	The pointer is advanced only for the QTBLRI instruction.
1	Read pointer row	Pointer is not advanced.
2	Read pointer row – 1	Pointer is not advanced.
3	Read pointer row – 2	Pointer is not advanced.
:	:	
n	Read pointer row – (n – 1)	Pointer is not advanced.

(3) Programming Example

In the following programming example, the specified column elements in array table data TBL1 are read and stored in MW00010 to MW00012 when switch 2 (DB000002) turns ON.
Before switch 2 is turned ON, the table data is set as shown below by turning ON switch 1 three times while changing the contents of MW00000 to MW00002. (Refer to information on the Write Queue Table instruction.)

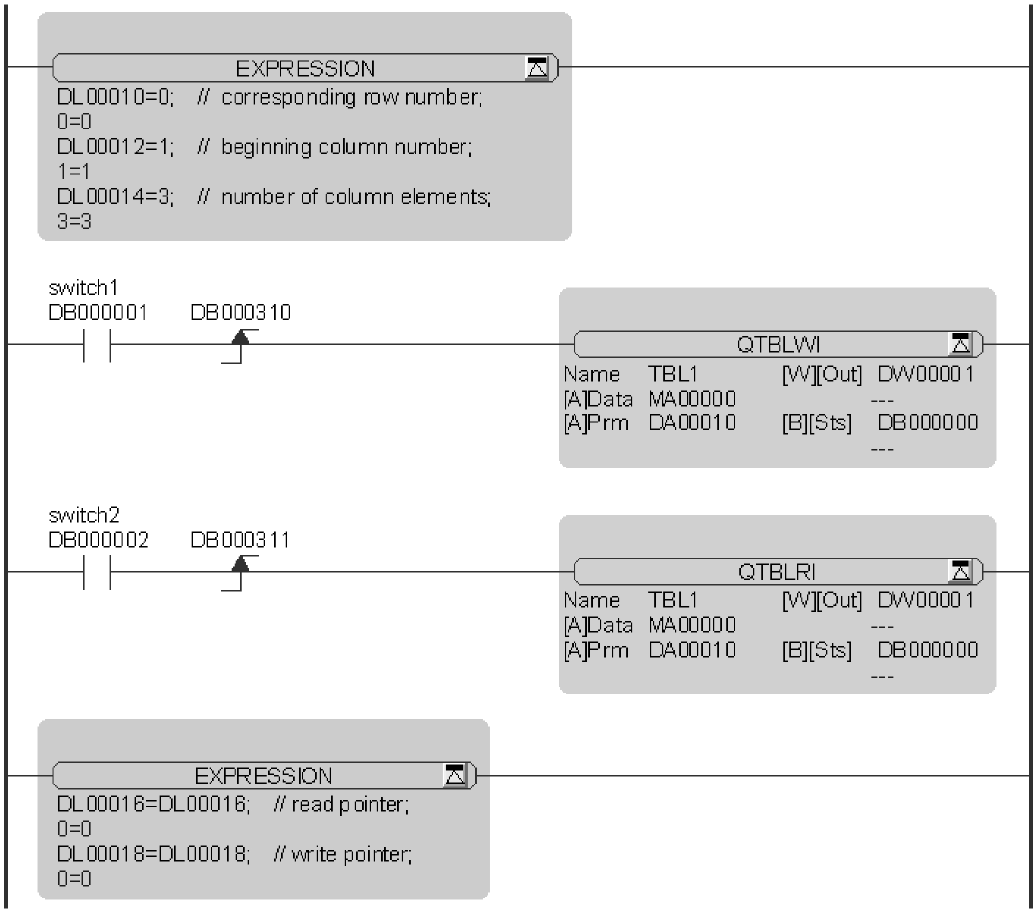
The contents of table data TBL1 are given below.

Row \ Column	1 (W)	2 (W)	3 (W)
1	11	12	13
2	21	22	23
3	31	32	33

- The column data types are given in parentheses.

The parameter table is set as shown in the following table.

Register	Data	Remarks
DL00010	0	Relative row number
DL00012	1	First column number
DW00014	3	Number of row elements



Here, switch 2 (DB000002) is turned ON three times. The data that is read changes each time from the first time to the third time, as shown below.

Register	1st Data	2nd Data	3rd Data
MW00010	11	21	31
MW00011	12	22	32
MW00012	13	23	33

The read pointer is advanced each time the instruction is executed starting at the first row on the first pass, the second row on the second pass, and so on, therefore resulting in the table shown above.

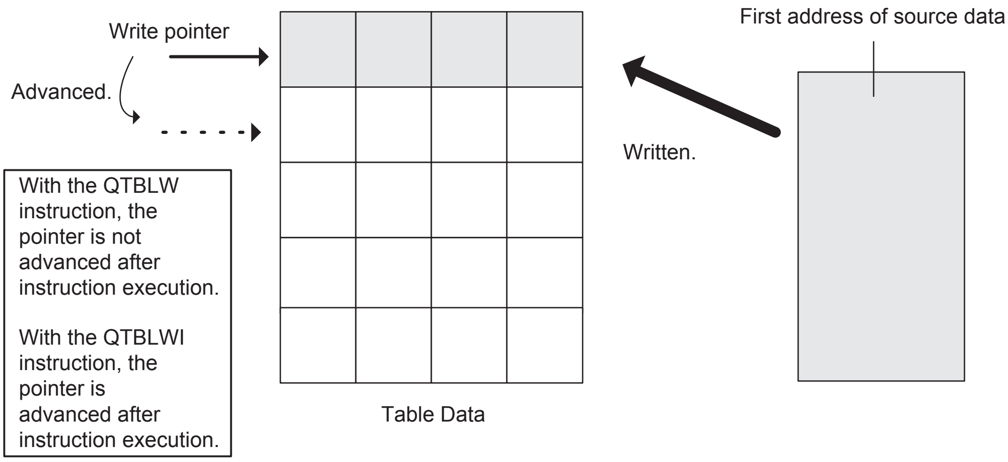
INFO

When the power supply is turned ON, values of the read pointer and write pointer are undefined. Always execute the QTBLCL instruction before using the QTBLR, QTBLRI, QTBLW, or QTBLWI instruction.
An operation error may occur if the QTBLR, QTBLRI, QTBLW, or QTBLWI instruction is executed without first executing the QTBLCL instruction.

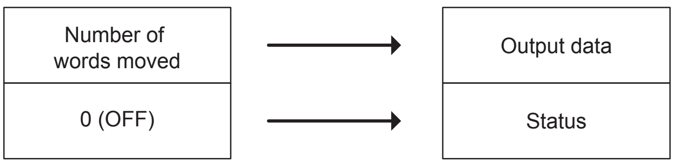
5.9.8 Write Queue Table (QTBLW and QTBLWI)

(1) Operation

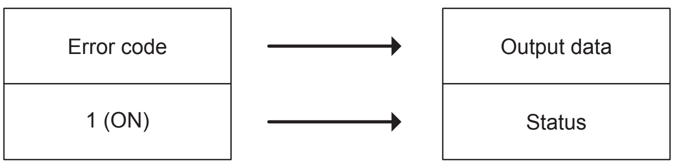
Data in a continuous area that starts at a specified register is continuously written to columns in a specified table. The instruction is processed under the assumption that the data type of the source and destination are the same.
The QTBLW instruction does not change the queue table write pointer. The QTBLWI instruction advances the queue table write pointer by one row.
If an error occurs when accessing the table, such as a table name error, an out of range row number, or a full queue buffer, an error is output, no data is written, and the pointer is not advanced.
The contents of the destination registers will be retained.
If the instruction ends normally, the number of words that were moved is output, and the Status bit is turned OFF. If an error occurs, an error code is output and the Status bit is turned ON.



[a] If the Write Succeeds

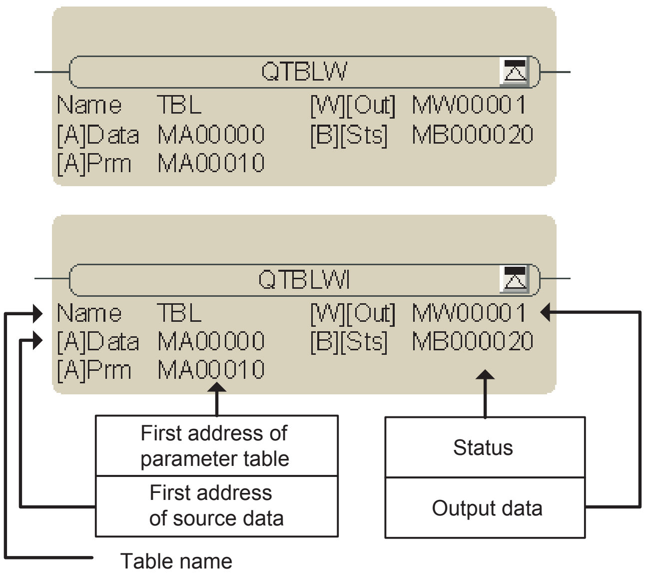


[b] If the Write Fails



- If the write fails, the table data will retain the contents from before the instruction was executed.

(2) Format



Icon: 

Key entry: QTBLW, QTBLWI

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
First address of source data (Data)	×	×	×	×	○	×	×
First address of parameter table (Prm)	×	×	×	×	○ *2	×	×
Output data (Out) *1	×	○ *2	×	×	×	○	×
Status (Sts) *1	○ *2	×	×	×	×	×	×

∗ 1. Optional.
∗ 2. C and # registers cannot be used.

[a] Parameter Table Configuration

Address	Data Type	Symbol	Name	Specification	I/O
0	L	ROW	Relative row number of table elements	Relative row number of table elements at destination (1 to 65,535)	IN
2	L	COLUMN	First column number of table elements	First column number of table elements at destination (1 to 32,767)	IN
4	W	CLEN	Number of column elements	Number of column elements to move (1 to 32,767)	IN
5	W	Reserved.			
6	L	RPTR	Read pointer	Read pointer of the queue after execution	OUT
8	L	WPTR	Write pointer	Write pointer of the queue after execution	OUT

[b] Error Codes

Error Code	Error Name	Meaning
0001 hex	Table undefined	The target table is undefined.
0002 hex	Outside range of row numbers	The row number of the table element is outside the target table.
0003 hex	Outside range of column numbers	The column number of the table element is outside the target table.
0004 hex	Incorrect number of elements	The number of target elements is invalid.
0005 hex	Insufficient storage area	The storage area is insufficient.
0006 hex	Insufficient element type	The data type specified for the element is wrong.
0007 hex	Queue buffer error	An attempt was made to read from an empty queue buffer, or to write to a full queue buffer by advancing the pointer.
0008 hex	Queue table error	The specified table is not a queue table.
0009 hex	System error	An unexpected error was detected in the system during instruction execution.

[c] Setting the Relative Row Number of Table Elements

Relative Row Number	Row That Is Read	Remarks
0	Write pointer row	The pointer is advanced only for the QTBLWI instruction.
1	Write pointer row	Pointer is not advanced.
2	Write pointer row – 1	Pointer is not advanced.
3	Write pointer row – 2	Pointer is not advanced.
:	:	
n	Write pointer row – (n – 1)	Pointer is not advanced.

(3) Programming Example

In the following programming example, the data from MW00000 to MW00002 is written to the specified column elements in array table data TBL1 when switch 1 (DB000001) turns ON.

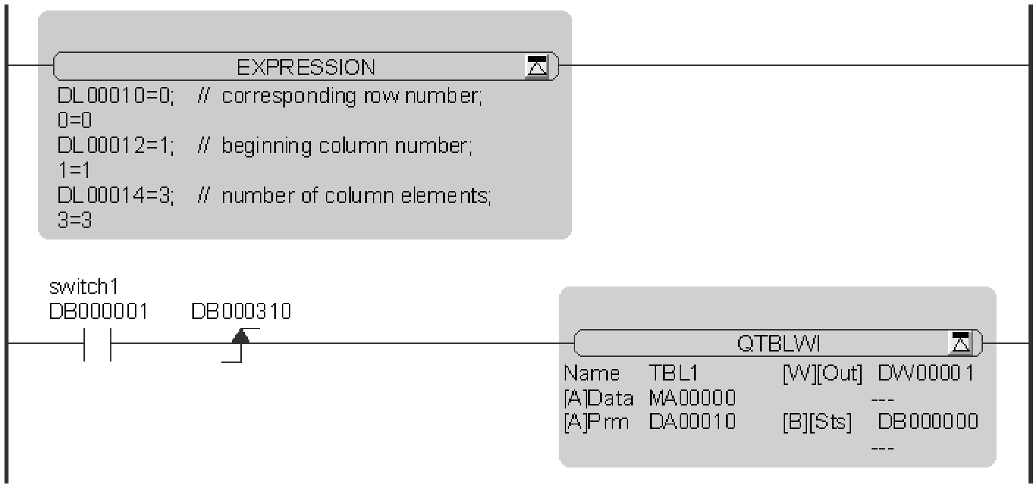
Initialize table data TBL1 before executing this type of programming.

Row \ Column	1 (W)	2 (W)	3 (W)
1	0	0	0
2	0	0	0
3	0	0	0

- The column data types are given in parentheses.

The parameter table is set as shown in the following table.

Register	Data	Remarks
DL00010	0	Relative row number
DL00012	1	First column number
DW00014	3	Number of row elements



After changing the contents of MW00000 to MW00002 as shown in the following table, turn ON the switch 1 (DB000001) three times.

Register	1st Data	2nd Data	3rd Data
MW00000	11	21	31
MW00001	12	22	32
MW00002	13	23	33

The write pointer is advanced each time the instruction is executed starting at the first row on the first pass, the second row on the second pass, and so on. After three executions, TBL1 will be set with data as shown below.

Row \ Column	1 (W)	2 (W)	3 (W)
1	11	12	13
2	21	22	23
3	31	32	33

Written on first pass
Written on second pass
Written on third pass

INFO

When the power is turned ON, values of the read pointer and write pointer are undefined. Always execute the QTBLCL instruction before using the QTBLR, QTBLRI, QTBLW, or QTBLWI instruction.
An operation error may occur if the QTBLR, QTBLRI, QTBLW, or QTBLWI instruction is executed without first executing the QTBLCL instruction.

5.9.9 Clear Queue Table Pointers (QTBLCL)

(1) Operation

The QTBLCL instruction returns the queue read and queue write pointers to their initial values (first row) for the table data that is specified by the table name.
If the instruction ends normally, the output data is set to 0 and the status is turned OFF. If an error occurs, an error code is set in the output data and the status is turned ON.

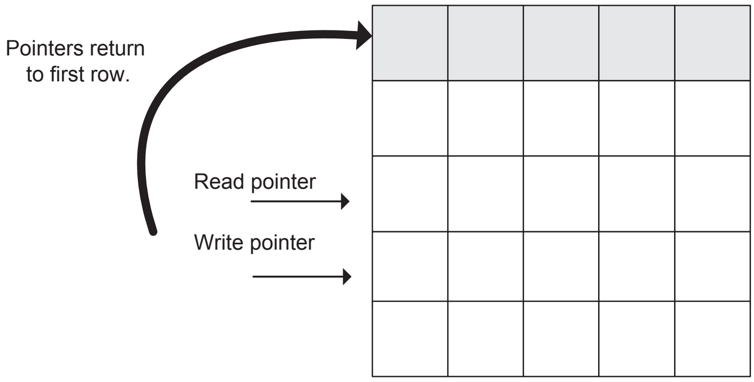
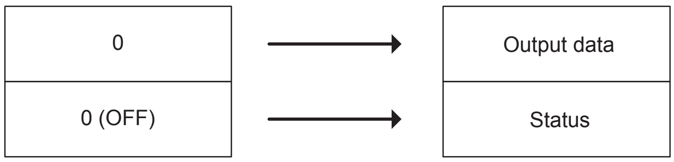
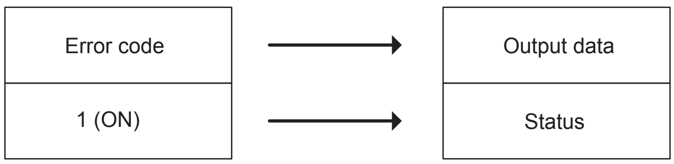


Table Data

[a] If the Queue Clear Succeeds

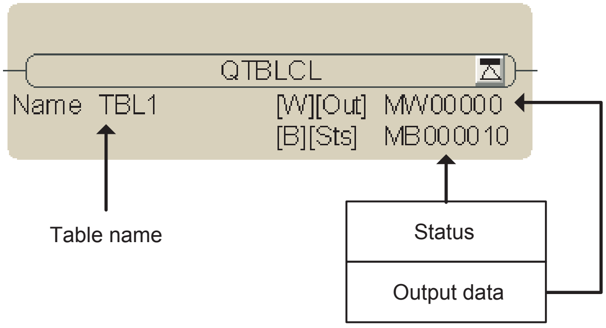


[b] If the Queue Clear Fails



- If the clear fails, the queues will retain the contents from before the instruction was executed.

(2) Format



Icon: 

Key entry: QTBLCL

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Output data (Out)*1	×	○*2	×	×	×	○	×
Status (Sts))*1	○*2	×	×	×	×	×	×

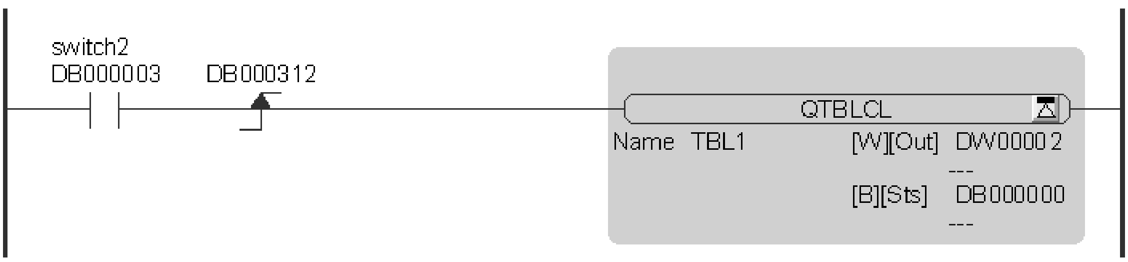
* 1. Optional.
* 2. C and # registers cannot be used.

■ Error Codes

Error Code	Error Name	Meaning
0001 hex	Table undefined	The target table is undefined.
0002 hex	Outside range of row numbers	The row number of the table element is outside the target table.
0003 hex	Outside range of column numbers	The column number of the table element is outside the target table.
0004 hex	Incorrect number of elements	The number of target elements is invalid.
0005 hex	Insufficient storage area	The storage area is insufficient.
0006 hex	Insufficient element type	The data type specified for the element is wrong.
0007 hex	Queue buffer error	An attempt was made to read from an empty queue buffer, or to write to a full queue buffer by advancing the pointer.
0008 hex	Queue table error	The specified table is not a queue table.
0009 hex	System error	An unexpected error was detected in the system during instruction execution.

(3) Programming Example

In the following programming example, the queue pointers for the specified queue table are initialized when switch 2 (DB000003) turns ON.



INFO

When the power is turned ON, values of the read pointer and write pointer are undefined. Always execute the QTBLCL instruction before using the QTBLR, QTBLRI, QTBLW, or QTBLWI instruction.
An operation error may occur if the QTBLR, QTBLRI, QTBLW, or QTBLWI instruction is executed without first executing the QTBLCL instruction.

5.10 System Function Instructions

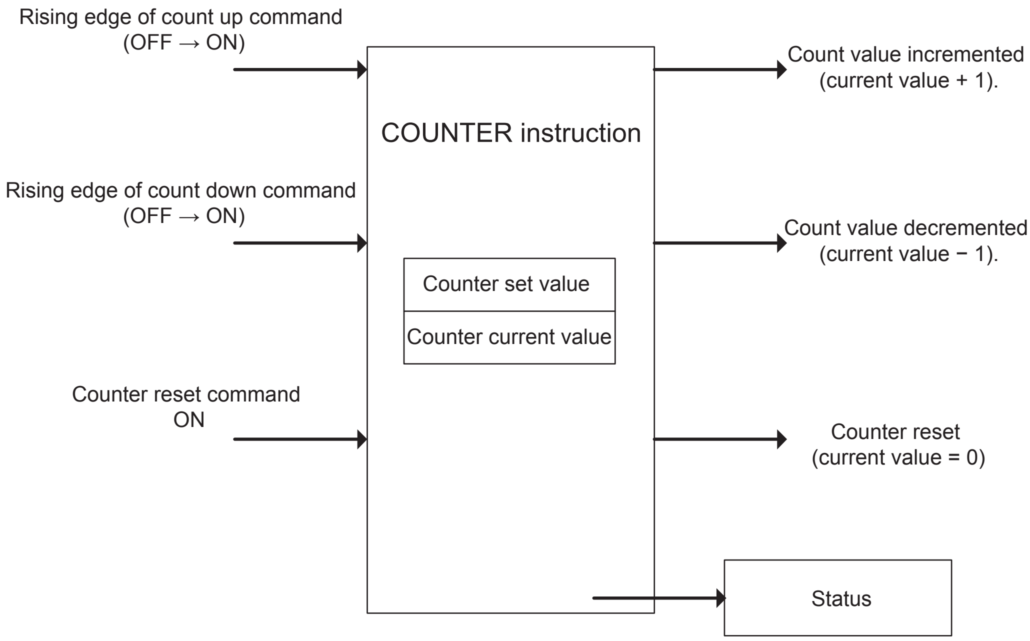
5.10.1 Counter (COUNTER)

(1) Operation

When the count up or count down command changes from OFF to ON, the current value is incremented or decremented.

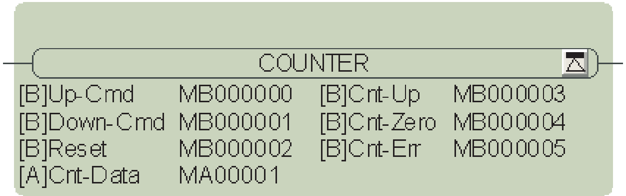
When the counter reset command turns ON, the current value of the counter is set to 0. The current value of the counter is compared against the set value and the result is output.

If a counter error occurs (i.e., if the current value is greater than the set value), the current value will neither be incremented nor decremented.



Three status are output as shown below.
- Count matched (current value = set value).
- Count is zero (current value = 0).
- Counter error
  (current value > set value or current value < 0).

(2) Format



Icon: 

Key entry: COUNTER

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Count up command (Up-Cmd)	○	×	×	×	×	×	×
Count down command (Down-Cmd)	○	×	×	×	×	×	×
Counter reset command (Reset)	○	×	×	×	×	×	×
First address of counter processing data area (Cnt-Data)	×	×	×	×	○*1	×	×
Count up (Cnt-Up)	○*2	×	×	×	×	×	×
Zero count (Cnt-Zero)	○*2	×	×	×	×	×	×
Count error (Cnt-Err)	○*2	×	×	×	×	×	×

∗ 1. M or D register only.
∗ 2. C and # registers cannot be used.

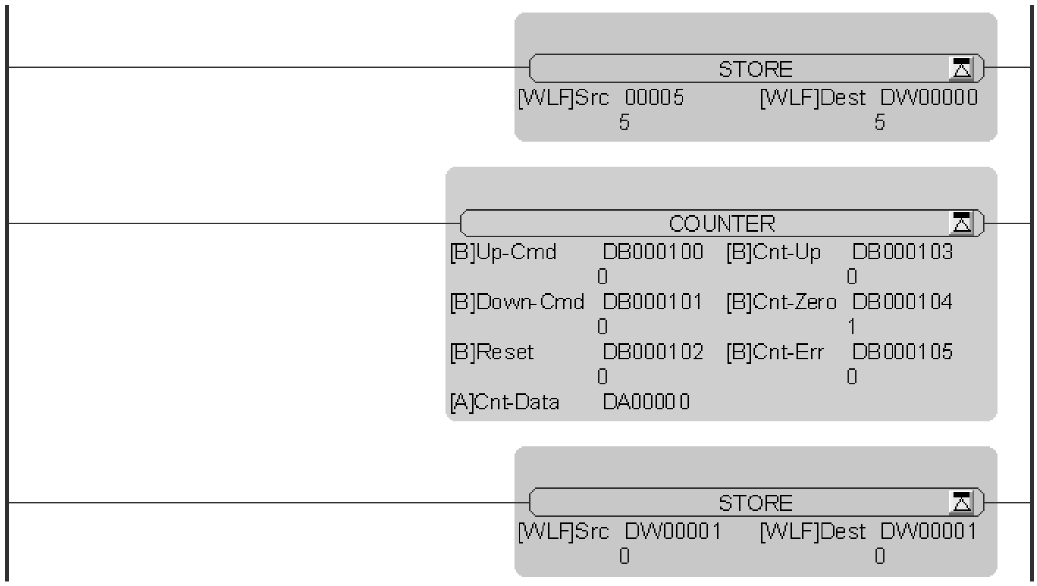
The parameters are described in the following table.

Parameter Name	Description	I/O
Count up command (Up-Cmd)	The count value is incremented when this command changes from OFF to ON.*	IN
Count down command (Down-Cmd)	The count value is decremented when this command changes from OFF to ON.*	IN
Counter reset command (Reset)	The current value is reset to 0 when this command turns ON.	IN
First address of counter processing data area (Cnt-Data)	+0 word: Set value	IN
	+1 word: Current value	OUT
	+2 word: Work flags	OUT
Count up (Cnt-Up)	Turns ON when the current value equals the set value.	OUT
Zero count (Cnt-Zero)	Turns ON when the current value equals 0.	OUT
Count error (Cnt-Err)	Turns ON when the current value is greater than the set value. Also turns ON when the current value is less than 0.	OUT

∗ If the count up command and count down command change from OFF to ON at the same time, the current value stays the same.

(3) Programming Example

In the following programming example, the first line sets the counter set value to 5, and the third line monitors the counter current value in DW00001.
When DB000100 changes from OFF to ON, DW00001 is incremented, and when DB000101 changes from OFF to ON, DW00001 is decremented.



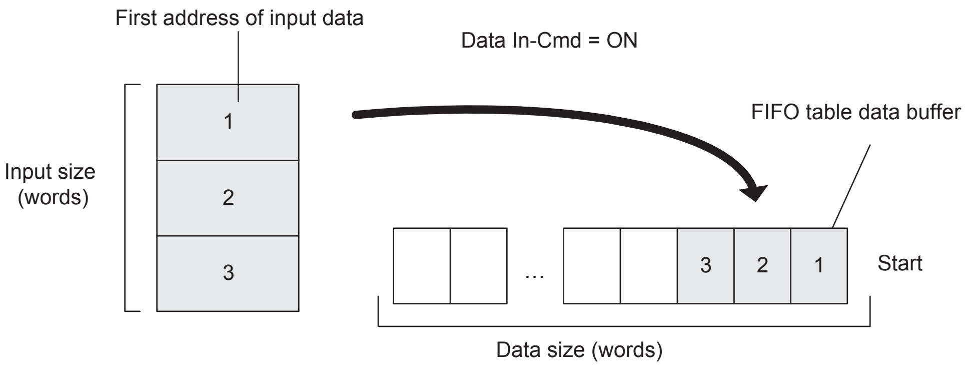
5.10.2 First-in First-out (FINFOUT)

(1) Operation

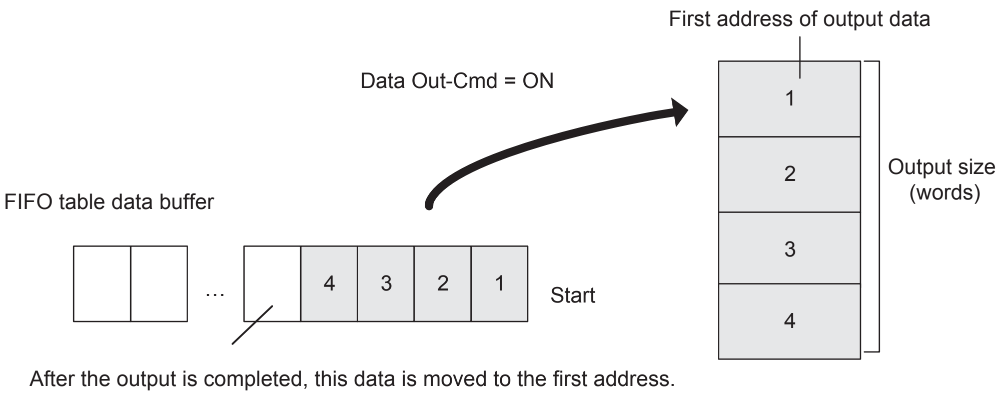
The FINFOUT instruction calls a first-in first-out block data transfer function. The FIFO data table consists of a 4-word header and a data buffer. Always set the three words with the data size, input size, and output size before you execute this instruction.

- When the Data Input Command (In-Cmd) turns ON, the specified number of data items from the specified input data area are stored sequentially in the data area of the FIFO table.
- When the Data Output Command (Out-Cmd) turns ON, the specified number of data items are moved from the first address in the data area of the FIFO table to the specified output data area.
- When the Reset Command (Reset) turns ON, the number of stored words is set to 0 and Tbl-Emp (FIFO table empty) turns ON.
- If the data empty size is less than the input size or if the data size is less than the output size, Tbl-Err (FIFO table error) turns ON.

[a] If the Data Input Command (In-Cmd) Is ON



[b] If the Data Option Command (Out-Cmd) Is ON

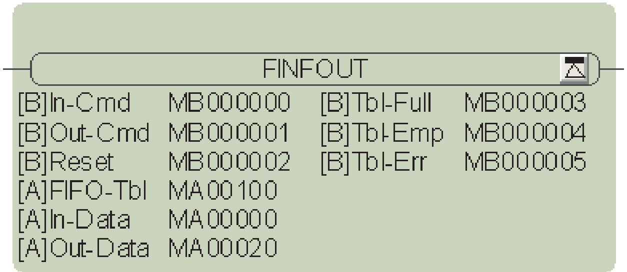


[c] If the Reset Command (Reset) Is ON

The number of words stored in the FIFO table is set to 0.

- The contents of the table buffer are retained and not cleared to 0.

(2) Format



Icon: 

Key entry: FINFOUT

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Data input command (In-Cmd)	○	×	×	×	×	×	×
Data output command (Out-Cmd)	○	×	×	×	×	×	×
Reset command (Reset)	○	×	×	×	×	×	×
First address of FIFO table (FIFO-Tbl)	×	×	×	×	○*1	×	×
First address of input data (In-Data)	×	×	×	×	○*1	×	×
First address of output data (Out-Data)	×	×	×	×	○*1	×	×
FIFO table full (Tbl-Full)	○*2	×	×	×	×	×	×
FIFO table empty (Tbl-Emp)	○*2	×	×	×	×	×	×
FIFO table error (Tbl-Err)	○*2	×	×	×	×	×	×

* 1. M or D register only.
* 2. C and # registers cannot be used.

Instructions

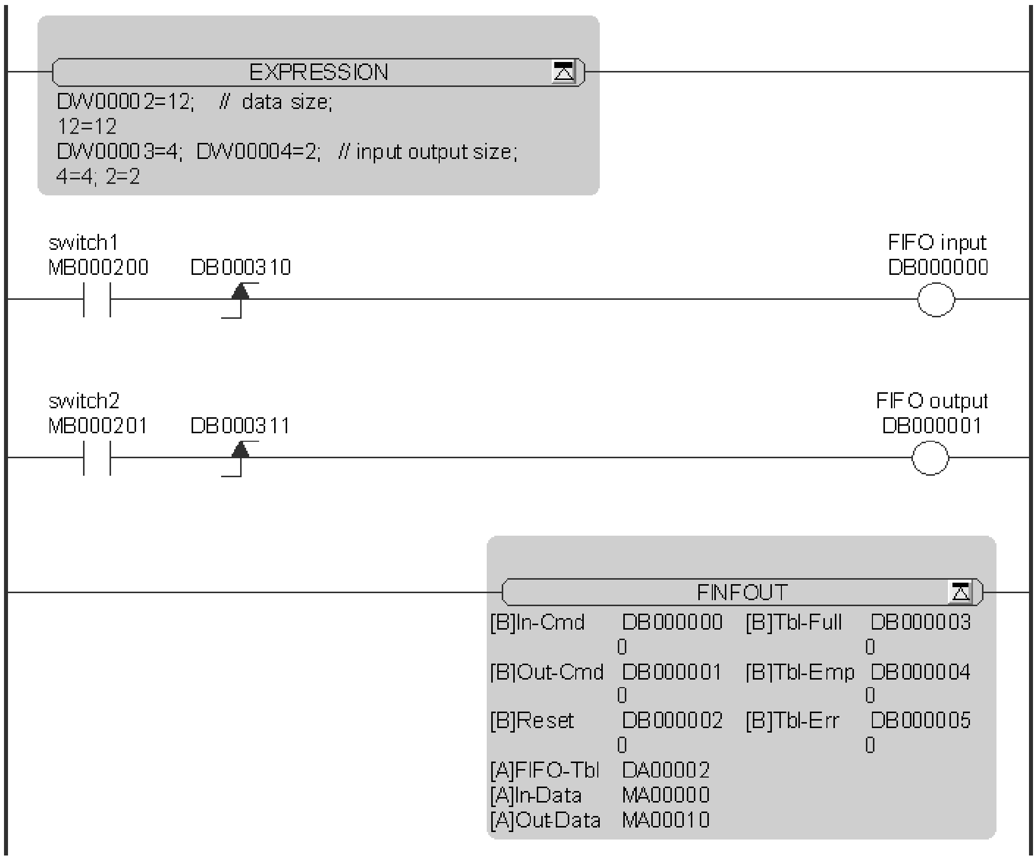
5

The parameters are described in the following table.

Parameter Name	Description	I/O
Data input command (In-Cmd)	Data is stored in the FIFO table when this command turns ON.	IN
Data output command (Out-Cmd)	Data is transferred out of the FIFO table when this command turns ON.	IN
Reset command (Reset)	The number of words to store is set to 0 when this command turns ON.	IN
First address of FIFO table (FIFO-Tbl)	+0 word: Data size	IN
	+1 word: Input size	IN
	+2 word: Output size	IN
	+3 word: Data storage size	OUT
	+4 word and on: Data	OUT
First address of input data (In-Data)	First address of input data	IN
First address of output data (Out-Data)	First address of output data	IN
FIFO table full (Tbl-Full)	Turns ON when the FIFO table is full.	OUT
FIFO table empty (Tbl-Emp)	Turns ON when the FIFO table is empty.	OUT
FIFO table error (Tbl-Err)	Turns ON when the FIFO table has an error.	OUT

(3) Programming Example

In the following programming example, a FIFO table is created with a data size of 12 words, input size of 4 words, and an output size of 2 words, and then the FINFOUT instruction is executed.



The data from MW00000 to MW00003 is stored in the FIFO table buffer when switch 1 turns ON.
The data storage size in DW00005 is set to 4.

Register	Data
MW00000	123
MW00001	234
MW00002	345
MW00003	456

FIFO Table Data Buffer	Data
DW00006	123
DW00007	234
DW00008	345
DW00009	456
DW00010	0
:	:
DW00017	0

Stored area

Next, when switch 2 turns ON, two words of data from the first address in the FIFO table buffer are output to the area from MW0010 to MW0011. The data storage size in DW00005 is set to 2.

FIFO Table Data Buffer	Data
DW00006	123 → 345
DW00007	234 → 456

Register	Data
MW00010	123
MW00011	234
MW00012	0

Stored area

The output data is moved out and the remaining data is moved forward.

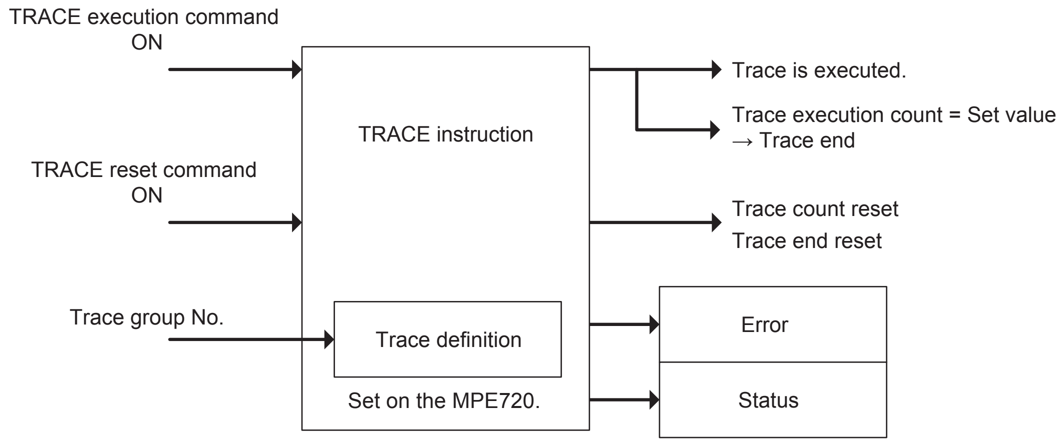
5.10.3 Trace (TRACE)

(1) Operation

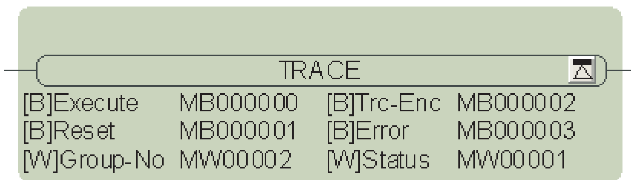
The TRACE instruction performs trace execution control of the trace data that is specified by the trace group number (1 to 4).

- The trace definition is set in the Data Trace Definitions in the MPE720. Refer to the *Engineering Tool for MP2000 Series Machine Controller MPE720 Version 6 User's Manual* (SIEP C880700 30) for details.

- The trace is executed if Execute (trace execution command) is ON.
- The trace counter is reset when Reset (trace reset command) turns ON. This also resets Trc-End (trace end).
- Trc-End (trace end) turns ON when the specified number of traces have been executed.



(2) Format



Icon: 

Key entry: TRACE

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Trace execution command (Execute)	○	×	×	×	×	×	×
Trace reset command (Reset)	○	×	×	×	×	×	×
Trace group No. (Group-No)	×	○	×	×	×	○	○
Trace end (Trc-End)	○*	×	×	×	×	×	×
Error	○*	×	×	×	×	×	×
Status	×	○*	×	×	×	○	×

* C and # registers cannot be used.

The parameters are described in the following table.

Parameter Name	Description	I/O
Trace execution command (Execute)	Trace execution begins when this command turns ON.	IN
Trace reset command (Reset)	Trace execution is reset when this command turns ON.	IN
Trace group No. (Group-No)	Trace group No. specification (1 to 4)	IN
Trace end (Trc-End)	Turns ON when the trace ends.	OUT
Error	Turns ON when an error occurs.	OUT
Status	Trace execution status	OUT

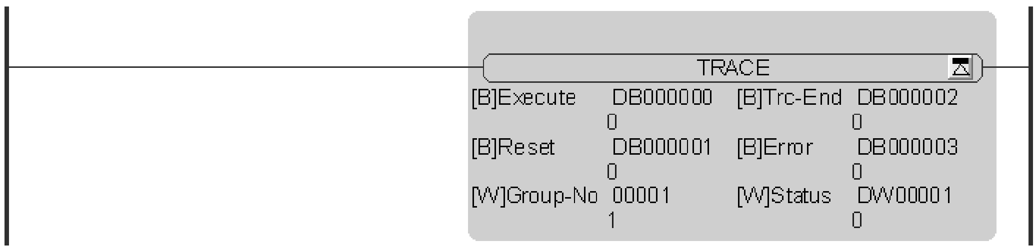
The status configuration is shown below.

Bit	Name	Remarks
0	Trace data full	Turns ON after once going through the data trace memory of the specified group.
1 to 7	Reserved for system.	–
8	No trace definition	The function will not be executed.
9	Group No. error	The function will not be executed.
10 to 12	Reserved for system.	–
13	Execution timing error	The function will not be executed.
14	Reserved for system.	–
15	Reserved for system.	–

(3) Programming Example

In the following programming example, the definition for trace group number 1 is used to execute a trace. The trace starts when DB000000 turns ON.

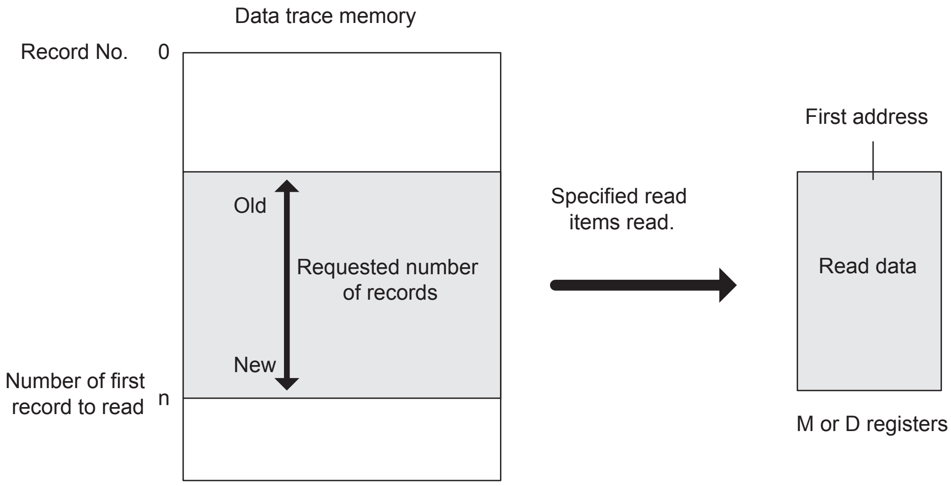
- Set the data trace definition for trace group number 1 on the MPE720 in advance. Make sure to set the sampling condition to *Program*.



5.10.4 Read Data Trace (DTRC-RD)

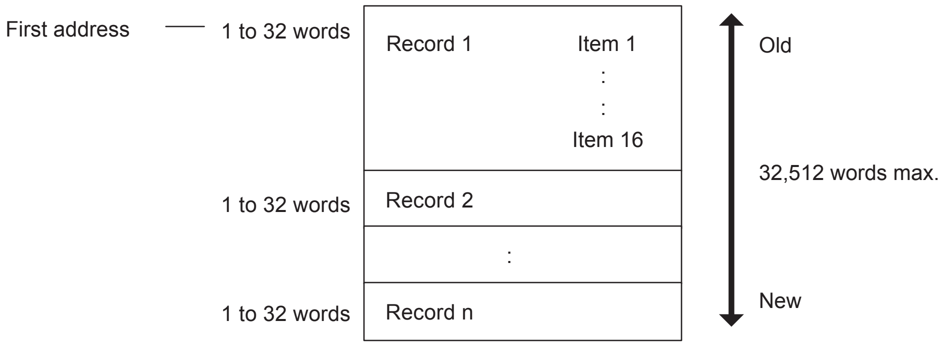
(1) Operation

The DTRC-RD instruction reads trace data in the Machine Controller and stores it in registers. The data in the trace memory can be read by specifying the first record number and the number of records. You can designate and read only the required items in a record.

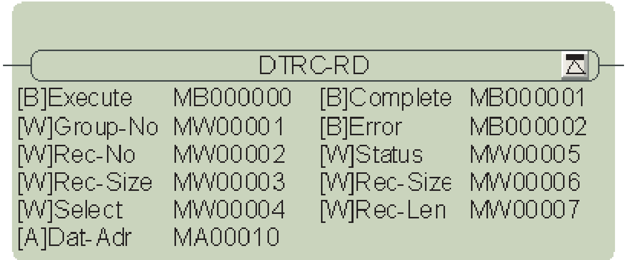


■ Structure of Read Data

The length of a record can be from 1 to 32 words, depending on the selected data items. The maximum number of records can be from 1,015 to 32,511 depending on the record length.



(2) Format



Icon: 

Key entry: DTRCRD

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Trace read execution command (Execute)	○	×	×	×	×	×	×
Trace group No. (Group-No)	×	○	×	×	×	×	×
Record No. (Rec-No)	×	○	×	×	×	×	×
Number of records (Rec-Size)	×	○	×	×	×	×	×
Item selection (Select)	×	○	×	×	×	×	×
First address (Dat-Adr)	×	×	×	×	○*1	×	×
Trace completed (Complete)	○*2	×	×	×	×	×	×
Error	○*2	×	×	×	×	×	×
Status	×	○*2	×	×	×	×	×
Number of records read (Rec-Size)	×	○*2	×	×	×	×	×
Length of 1 read record (Rec-Len)	×	○*2	×	×	×	×	×

* 1. M or D register only.
* 2. C and # registers cannot be used.

The parameters are described in the following table.

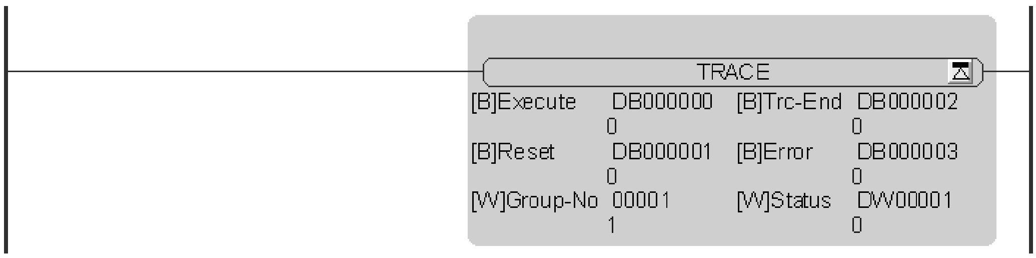
Parameter Name	Description	I/O
Trace read execution command (Execute)	Data trace read execution command	IN
Trace group No. (Group-No)	Data trace group No. (1 to 4).	IN
Record No. (Rec-No)	Number of first record to read (0 to maximum records – 1)	IN
Number of records (Rec-Size)	Requested number of records to read (0 to maximum records – 1)	IN
Item selection (Select)	Items to read (0001 to FFFF hex) Bits 0 to F correspond to data specifiers 1 to 16 in the trace definition.	IN
First address (Dat-Adr)	Number of first register to read (MA, DA)	IN
Trace completed (Complete)	Turns ON when the trace read ends.	OUT
Error	Turns ON when an error occurs.	OUT
Status	Data trace read execution status	OUT
Number of records read (Rec-Size)	Number of records that were read	OUT
Length of 1 read record (Rec-Len)	Length of 1 read record (words)	OUT

The status configuration is shown below.

Bit	Name	Remarks
0 to 7	Reserved for system.	–
8	No trace definition	The function will not be executed.
9	Group No. error	The function will not be executed.
10	Specified record No. error	The function will not be executed.
11	Specified number of records error	The function will not be executed.
12	Data storage error	The function will not be executed.
13	Reserved for system.	–
14	Reserved for system.	–
15	Address input error	The function will not be executed.

(3) Programming Example

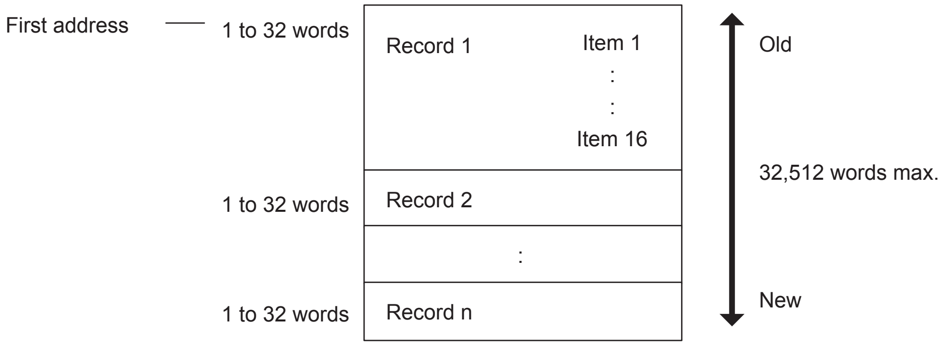
In the following programming example, a data trace is executed for group definition number 1.
The trace is executed when DB000000 turns ON.



(4) Additional Information

[a] Structure of Read Data

The read data is structured as shown in the following figure.



[b] Record Lengths

A record consists of the selected data items.
The record length (number of words in a single record) is determined by the selected registers and the number of data items.

- Number of words for 1 record = Bn × 1 word + Wn × 1 word + Ln × 2 words + Fn × 2 words
  Bn: Number of selected bit registers
  Wn: Number of selected integer registers
  Ln: Number of selected double-length integer registers
  Fn: Number of selected real number registers
  The maximum total is 16 registers.
- Maximum record length = 32 words (with 16 double-length integers or real number registers)
- Minimum record length = 1 word (with 1 record for each bit or integer register)

[c] Number of Records

The number of records that can be specified depends on the record length as shown below.

- Number of records with the maximum record length: 0 to 1,015
- Number of records with the minimum record length: 0 to 32,511

(Upper limit: 32,521 divided by the record length - 1)

[d] Latest Record Number

The most recent record number for each trace group is stored in the system registers as shown below.

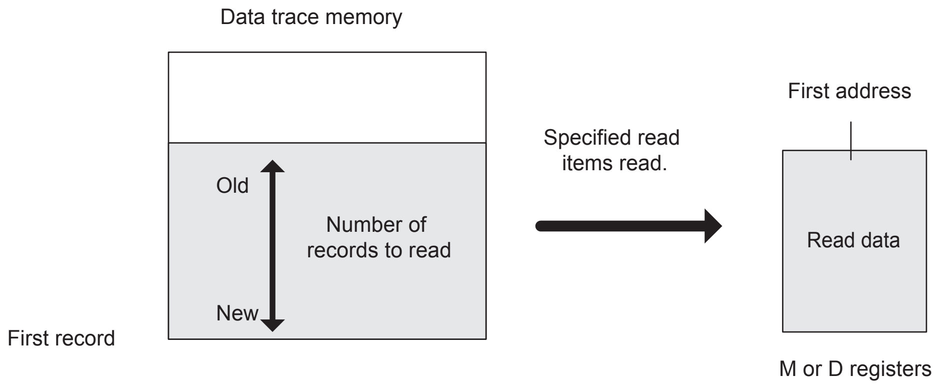
System Register Address	Description
SW00100	Latest record number in group 1.
SW00101	Latest record number in group 2.
SW00102	Latest record number in group 3.
SW00103	Latest record number in group 4.
SW00104	–
SW00105	–
SW00106	–
SW00107	–

5.10.5 Read Inverter Trace (ITRC-RD)

(1) Operation

The ITRC-RD instruction reads trace data in the Inverter and stores it in registers. You can specify the required records and read them from the trace buffer. You can designate and read only the required items in each record.

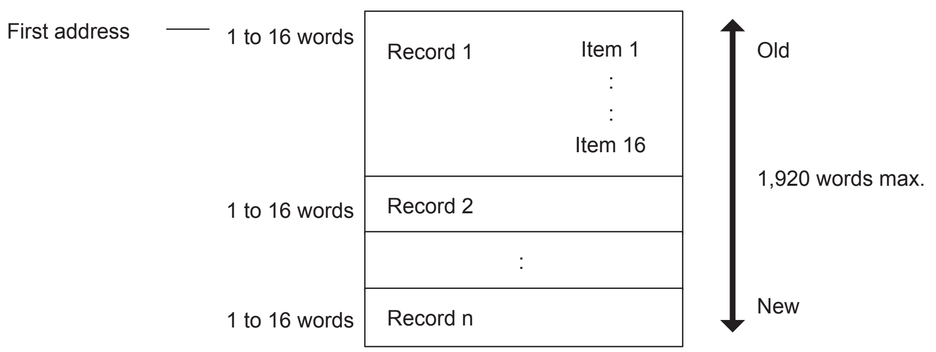
Applicable Inverters:
This instruction is applicable to Inverters that are connected to the MP930, SVB-01, or 215IF.



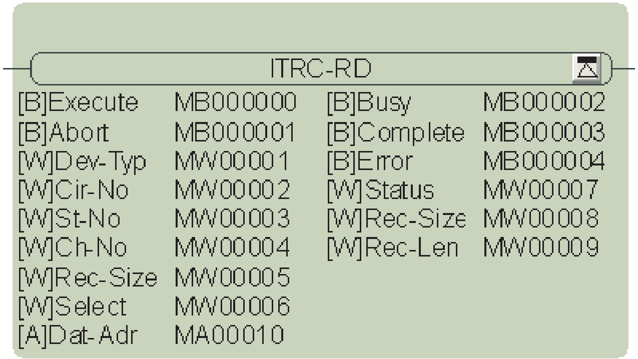
■ Structure of Read Data

The length of a record can be from 1 to 16 words, depending on the selected data items.
The maximum number of records is 120.

- Records are always read from the first record.



(2) Format



Icon: 

Key entry: ITRC-RD

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Trace read execution command (Execute)	○	×	×	×	×	×	×
Trace read abort command (Abort)	○	×	×	×	×	×	×
Communications device type (Dev-Typ)	×	○	×	×	×	○	○
Circuit number (Cir-No)	×	○	×	×	×	○	○
Slave station number (St-No)	×	○	×	×	×	○	○
Communications buffer channel number (Ch-No)	×	○	×	×	×	○	○
Number of records (Rec-Size)	×	○	×	×	×	○	○
Item selection (Select)	×	○	×	×	×	○	○
First address (Dat-Adr)	×	×	×	×	○*1	×	×
Busy	○*2	×	×	×	×	×	×
Complete	○*2	×	×	×	×	×	×
Error	○*2	×	×	×	×	×	×
Status	×	○*2	×	×	×	○	×
Number of records read (Rec-Size)	×	○*2	×	×	×	○	×
Read record length (Rec-Len)	×	○*2	×	×	×	○	×

* 1. M or D register only.
* 2. C and # registers cannot be used.

The parameters are described in the following table.

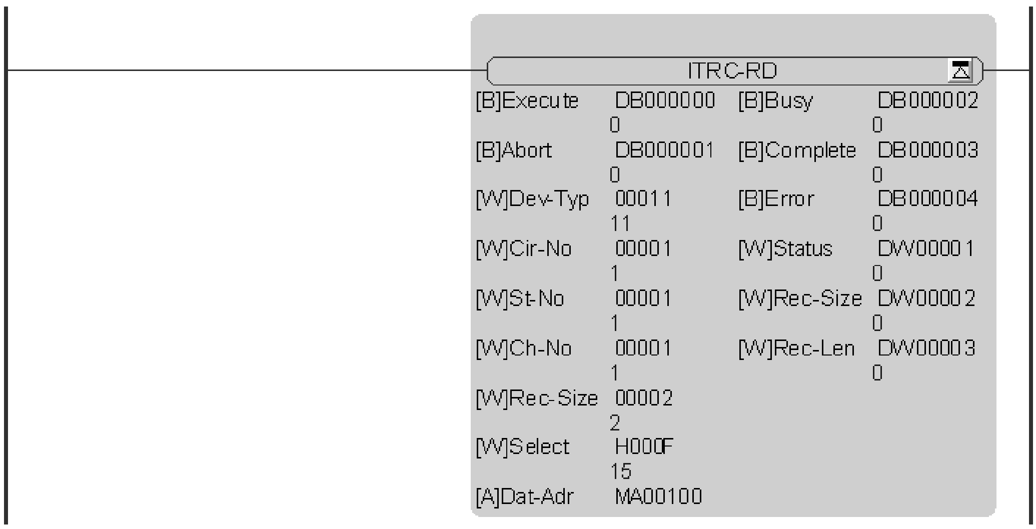
Parameter Name	Description	I/O
Trace read execution command (Execute)	Reading begins when this command turns ON.	IN
Trace read abort command (Abort)	Reading is aborted when this command turns ON.	IN
Communications device type (Dev-Typ)	215IF = 1, MP930 = 4, and SVB-01 = 10	IN
Circuit number (Cir-No)	215IF = 1 or 2, MP930 = 1, and SVB-01 = 1 to 16	IN
Slave station number (St-No)	215IF = 1 to 64, MP930 = 1 to 14, and SVB-01 = 1 to 14	IN
Communications buffer channel number (Ch-No)	215IF = 1 to 3, MP930 = 1, and SVB-01 = 1 to 8	IN
Number of records (Rec-Size)	Number of records to read (1 to 64)	IN
Item selection (Select)	Items to read (0001 to FFFF hex) Bits 0 to F corresponds to trace data items 1 to 26.	IN
First address (Dat-Adr)	First register address to read at source (MA, DA)	IN
Busy	Turns ON while reading Inverter trace data is in progress.	OUT
Complete	Turns ON when reading Inverter trace data is completed.	OUT
Error	Turns ON when an error occurs.	OUT
Status	Inverter trace data read execution status	OUT
Number of records read (Rec-Size)	Number of records that were read	OUT
Read record length (Rec-Len)	Length of records that were read	OUT

The status configuration is shown below.

Bit	Name	Remarks
0 to 8	Reserved for system.	–
9	Communications parameter error	The function will not be executed.
10	Reserved for system.	–
11	Specified number of records error	The function will not be executed.
12	Data storage error	The function will not be executed.
13	Communications error	The function will not be executed.
14	Reserved for system.	–
15	Address input error	The function will not be executed.

(3) Programming Example

In the following programming example, trace data is read from an Inverter.
Two records of trace data are read from the Inverter that is connected to station 1 of the SVB–01 on circuit 1. The data is stored in the area that starts with MW00100.

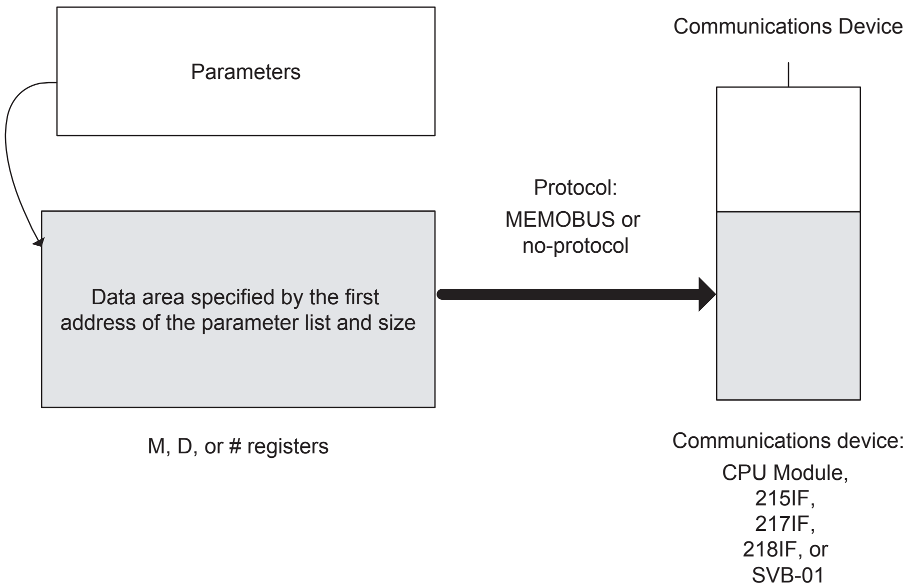


5.10.6 Send Message (MSG-SND)

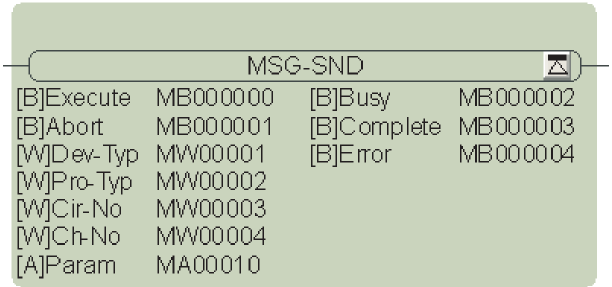
(1) Operation

The MSG-SND instruction sends a message to a remote station of the specified communications device type on the specified circuit.
This instruction supports the following communications devices and protocols.

Communications devices: CPU Module, 215IF, 217IF, 218IF, and SVB-01
Protocol: MEMOBUS communications or no-protocol



(2) Format



Icon: 

Key entry: MSG-SND

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Send execution command (Execute)	○	×	×	×	×	×	×
Send abort command (Abort)	○	×	×	×	×	×	×
Communications device type (Dev-Typ)	×	○	×	×	×	○	○
Communications protocol (Pro-Typ)	×	○	×	×	×	○	○
Circuit number (Cir-No)	×	○	×	×	×	○	○
Communications buffer channel number (Ch-No)	×	○	×	×	×	○	○
First address of parameter list (Param)	×	×	×	×	○*1	×	×
Busy	○*2	×	×	×	×	×	×
Complete	○*2	×	×	×	×	×	×
Error	○*2	×	×	×	×	×	×

∗ 1. M or D register only.
∗ 2. C and # registers cannot be used.

The parameters are described in the following table.

Parameter Name	Description	I/O
Send execution command (Execute)	The message is sent when this command turns ON.	IN
Send abort command (Abort)	Sending the message is aborted when this command turns ON.	IN
Communications device type (Dev-Typ)	CPU Module = 8, 215IF = 1, 217IF = 5, 218IF = 6, 218IF-02 = 16, and SVB-01 = 10	IN
Communications protocol (Pro-Typ)	MEMOBUS = 1, No-protocol = 2	
Circuit number (Cir-No)	CPU Module = 1 or 2, 215IF = 1 to 8, 217IF = 1 to 24, 218IF(-02) = 1 to 8, and SVB-01 = 1 to 16	IN
Communications buffer channel number (Ch-No)	CPU Module = 1 or 2, 215IF = 1 to 13, 217IF = 1, 218IF(-02) = 1 to 10, and SVB-01 = 1 to 8	IN
First address of parameter list (Param)	First address of parameter list (MA, DA, or #A)	IN
Busy	Turns ON while sending the message is in progress.	OUT
Complete	Turns ON when sending the message is completed.	OUT
Error	Turns ON when an error occurs.	OUT

[a] Parameter Details

This section describes the parameters in detail. The parameter number corresponds to the word offset from the first address of the parameter list.

For example, if the first address of the parameter list is MA00100, set the value in MW00110 to set PARAM10.

Parameter No.	IN/OUT	Description	
		MEMOBUS	No-protocol
PARAM00	OUT	Processing result	Processing result
PARAM01	OUT	Status	Status
PARAM02	IN	Remote station number	Remote station number
PARAM03	SYS	Reserved for system.	Reserved for system.
PARAM04	IN	Function code	–
PARAM05	IN	Data address	Data address
PARAM06	IN	Data size	Data size
PARAM07	IN	Remote CPU number	Remote CPU number
PARAM08	IN	Coil offset	–
PARAM09	IN	Input relay offset	–
PARAM10	IN	Input register offset	–
PARAM11	IN	Hold register offset	Register offset
PARAM12	SYS	Reserved for system.	Reserved for system.
PARAM13	SYS	Reserved for system.	Reserved for system.
PARAM14	SYS	Reserved for system.	Reserved for system.
PARAM15	SYS	Reserved for system.	Reserved for system.
PARAM16	SYS	Reserved for system.	Reserved for system.

■ Processing Result (PARAM00)

This parameter outputs the result of processing to the upper byte. The lower byte is used for system analysis.

- 00□□ hex: Processing (Busy)
- 10□□ hex: Processing completed (Complete)
- 8□□□ hex: Error

  The following errors can occur.

  - 81□□ hex: Function code error

    An attempt was made to send an unused function code. Or an unused function code was received.
  - 82□□ hex: Address setting error

    The data address, coil offset, input relay offset, input register offset, or hold register offset is outside of the valid range.
  - 83□□ hex: Data size error

    The size of the send or receive data was set outside of the valid range.
  - 84□□ hex: Circuit number setting error

    The set circuit number is outside of the valid range.
  - 85□□ hex: Channel number setting error

    The set channel number is outside of the valid range.
  - 86□□ hex: Station address error

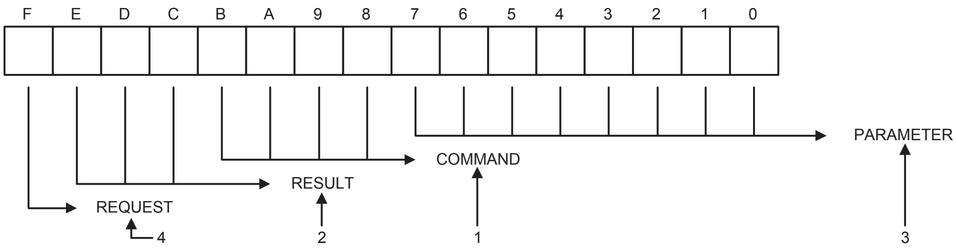
    The set station number is outside of the valid range.
  - 88□□ hex: Communications section error

    The communications section returned an error response.
  - 89□□ hex: Device selection error

    A device that cannot be used was selected.

■ Status (PARAM01)

The status of the communications section is output to this parameter.
The bit assignments are shown in the following figure.



1. COMMAND

The abbreviations and meanings of the commands are given in the following table.

Code	Abbreviation	Meaning
1	U_SEND	Sends a general-purpose message.
2	U_REC	Receives a general-purpose message.
3	ABORT	Aborts operation.
8	M_SEND	Sends a MEMOBUS command and ends when a response is received.
9	M_REC	Receives a MEMOBUS command and returns a response.
C	MR_SEND	Sends a MEMOBUS response.

2. RESULT

The abbreviations and meanings of the results are listed in the following table.

Code	Abbreviation	Meaning
0	–	Execution is in progress.
1	SEND_OK	The send was completed normally.
2	REC_OK	The reception was completed normally.
3	ABORT_OK	Aborting was completed.
4	FMT_NG	A parameter format error occurred.
5	SEQ_NG or INIT_NG	A command sequence error occurred or a token was not received. There is no connection to a communications system.
6	RESET_NG or O_RING_NG	A reset status exists. Out of ring: A token was not received within the token monitoring time.
7	REC_NG	A data reception error occurred. (An error was detected in a low-level program.)

3. PARAMETER

If the RESULT is 4 (FMT_NG), one of the following error codes is given. Otherwise, the remote station address is given.

Code	Error
00	No error
01	Station address out of range
02	MEMOBUS response monitoring time error
03	Number of retries setting error
04	Cyclic area setting error
05	Message signal CPU number error
06	Message signal register address error
07	Message signal number of words error

4. REQUEST

1 = Request
2 = Reception completed notification

■ Remote Station Number (PARAM02)/Serial

1 to 254: The message is sent to the station with the specified device address.

■ Function Code (PARAM04)

Set the MEMOBUS function code to send.
The function codes are listed in the following table.

Function Code		Setting
00 hex	Not used.	×
01 hex	Read Coil Status	○
02 hex	Read Input Relay Status	○
03 hex	Read Hold Register Contents	○
04 hex	Read Input Register Contents	○
05 hex	Change Single Coil Status	○
06 hex	Write Single Hold Register	○
07 hex	Not used.	×
08 hex	Loopback Test	○
09 hex	Expanded Read Hold Register Contents	○
0A hex	Expanded Read Input Register Contents	○
0B hex	Expanded Write Hold Register	○
0C hex	Not used.	×
0D hex	Expanded Read Nonconsecutive Hold Registers	○
0E hex	Expanded Write Nonconsecutive Hold Registers	○
0F hex	Change Multiple Coil Status	○
10 hex	Write Multiple Hold Registers	○
11 hex to 20 hex	Not used.	×
21 hex to 3F hex	Reserved for system.	×
40 hex to 4F hex	Reserved for system.	×
50 hex and higher	Not used.	×

- ○: Can be set, ×: Cannot be set.
- When the target device is operating as the master, only MW and MB data can be read and written. When the target device is operating as a slave, MB, MW, IB, and IW data can be read and written for coils, hold registers, input relays, and input registers, respectively.

■ Data Addresses

The range of addresses that can be set for each function code are given in the following table.

Function Code		Setting
00 hex	Not used.	Not valid.
01 hex	Read Coil Status	0 to 65,535 (0 to FFFF hex)*
02 hex	Read Input Relay Status	0 to 65,535 (0 to FFFF hex)*
03 hex	Read Hold Register Contents	0 to 32,767 (0 to 7FFF hex)
04 hex	Read Input Register Contents	0 to 32,767 (0 to 7FFF hex)
05 hex	Change Single Coil Status	0 to 65,535 (0 to FFFF hex)*
06 hex	Write Single Hold Register	0 to 32,767 (0 to 7FFF hex)
07 hex	Not used.	Not valid.
08 hex	Loopback Test	Not valid.
09 hex	Expanded Read Hold Register Contents	0 to 32,767 (0 to 7FFF hex)
0A hex	Expanded Read Input Register Contents	0 to 32,767 (0 to 7FFF hex)
0B hex	Expanded Write Hold Register	0 to 32,767 (0 to 7FFF hex)
0C hex	Not used.	Not valid.
0D hex	Expanded Read Nonconsecutive Hold Registers	0 to 32,767 (0 to 7FFF hex)
0E hex	Expanded Write Nonconsecutive Hold Registers	0 to 32,767 (0 to 7FFF hex)
0F hex	Change Multiple Coil Status	0 to 65,535 (0 to FFFF hex)*
10 hex	Write Multiple Hold Registers	0 to 32,767 (0 to 7FFF hex)

* Requests to read or write relays or coils: Set the first bit address of the data.
Requests to read or write consecutive registers: Set the first word address of the data.
Requests to read or write nonconsecutive registers: Set the first word address of the address table.

[b] Data Size (PARAM06)

Set the data size (number of bits or number of words) for the read or write request. The setting range depends on the function code.
The setting ranges for serial data sizes are listed in the following table.

Function Code		Data Size Setting Range	
		215IF or 218IF	CPU Module, 217IF, or SVB-01
00 hex	Not used.	Not valid.	
01 hex	Read Coil Status	1 to 2,000 (1 to 07D0 hex) bits	
02 hex	Read Input Relay Status	1 to 2,000 (1 to 07D0 hex) bits	
03 hex	Read Hold Register Contents	1 to 125 (1 to 007D hex) words	
04 hex	Read Input Register Contents	1 to 125 (1 to 007D hex) words	
05 hex	Change Single Coil Status	Not valid.	
06 hex	Write Single Hold Register	Not valid.	
07 hex	Not used.	Not valid.	
08 hex	Loopback Test	Not valid.	
09 hex	Expanded Read Hold Register Contents	1 to 508 (1 to 01FC hex) words	1 to 252 (1 to 00FC hex) words
0A hex	Expanded Read Input Register Contents	1 to 508 (1 to 01FC hex) words	1 to 252 (1 to 00FC hex) words
0C hex	Not used.	Not valid.	
0D hex	Expanded Read Nonconsecutive Hold Registers	1 to 508 (1 to 01FC hex) words	1 to 252 (1 to 00FC hex) words
0E hex	Expanded Write Nonconsecutive Hold Registers	1 to 254 (1 to 01FE hex) words	1 to 126 (1 to 007E hex) words
0F hex	Change Multiple Coil Status	1 to 800 (1 to 0320 hex) bits	
10 hex	Write Multiple Hold Registers	1 to 100 (1 to 0064 hex) words	

■ Remote CPU Number (PARAM07)

Specify the remote CPU number. If the remote device is an MP2000-series Machine Controller, set the number to 1. If the remote device is any other Yaskawa Controller that consists of more than one CPU Module, set the CPU number of the send destination.
In all other cases, set the number to 0.

■ Coil Offset (PARAM08)

Set the offset to the word address of the coil. This setting is valid for function codes 01, 05, and 0F hex.

■ Input Relay Offset (PARAM09)

Set the offset to the word address of the input relay. This setting is valid for function code 02 hex.

■ Input Register Offset (PARAM10)

Set the offset to the word address of the input register. This setting is valid for function codes 04 and 0A hex.

■ Hold Register Offset (PARAM11)

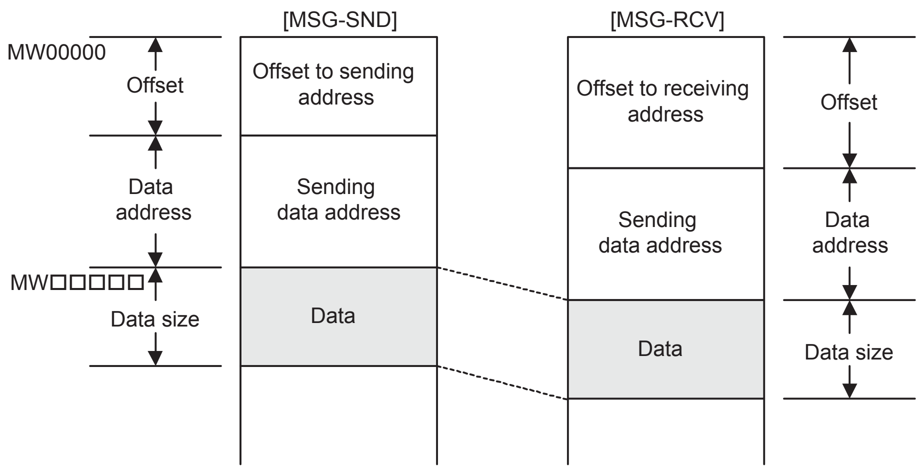
Set the offset to the word address of the hold register. This setting is valid for function codes 03, 06, 09, 0B, 0D, 0E, and 10 hex.

■ Reserved for System (PARAM12)

The channel number that is currently in use is held in this parameter. Set this parameter to 0000 hex from a user program in the first scan after the power supply is turned ON. Do not change the value of the parameter after that. It is used by the system.

■ Relationship between Data Addresses, Sizes, and Offsets

The following figure shows the relationship between the data addresses, sizes, and offsets.



■ No-protocol Communications

It is not necessary to set PARAM04, PARAM09, and PARAM10. Only MW registers can be sent. PARAM11 is the offset to the word address of the MW registers.

[c] Inputs

■ Execute (Send Execution Command)

The message is sent when this command turns ON.

■ Abort (Send Abort Command)

This command aborts sending the message. It takes priority over Execute (Send Execution Command).

■ Dev-Typ (Communications Device Type)

Specify the communications device type.
CPU Module = 8, 215IF = 1, 217IF = 5, 218IF = 6, 218IF-02 = 16, and SVB-01 = 11

■ Pro-Typ (Communications Protocol)

Specify the communications protocol. For no-protocol communications, a response is not received from the remote device.
MEMOBUS: Set this input to 1.
No-protocol: Set this input to 2.

■ Cir-No (Circuit Number)

Specify the circuit number.
CPU Module = 1 or 2, 215IF = 1 to 8, 217IF = 1 to 24, 218IF = 1 to 8, and SVB-01 = 1 to 16

■ Ch-No (Channel Number)

Specify the channel number of the communications section. Do not set the same channel number more than once for the same circuit.
CPU Module = 1, 215IF = 1 to 13, 217IF = 1, 218IF = 1 to 10, and SVB-01 = 1 to 8

■ PARAM (First Address of Parameter List)

Set the first address of the parameter list. For details on this parameter, refer to *[a] Parameter Details* earlier in this section.

[d] Output

■ Busy (Processing)

This item indicates that processing is in progress. Keep Execute ON while Busy is ON.

■ Complete (Processing Completed)

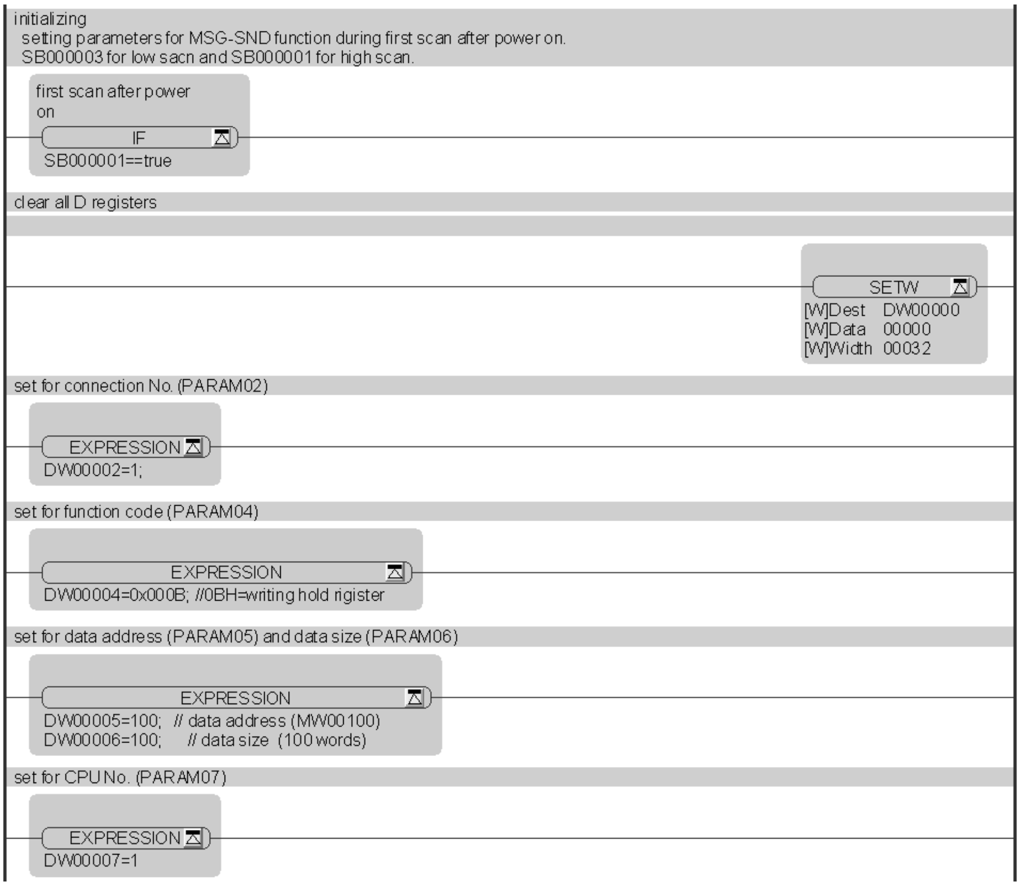
This item turns ON for only one scan when processing is completed normally.

■ Error

This item turns ON for only one scan when an error occurs. For the causes of the error, refer to information on PARAM00 and PARAM01 in *[a] Parameter Details* earlier in this section.

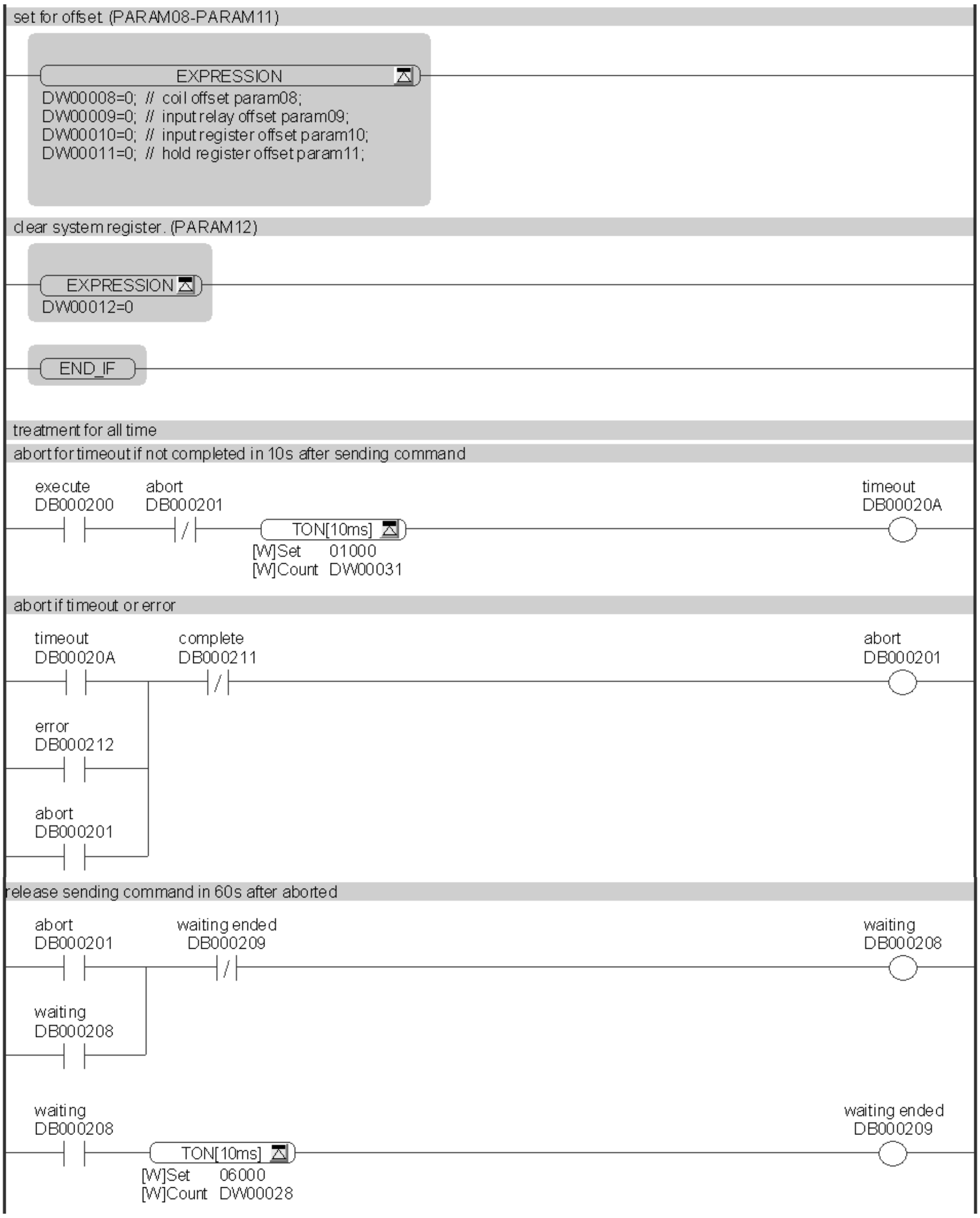
(3) Programming Example

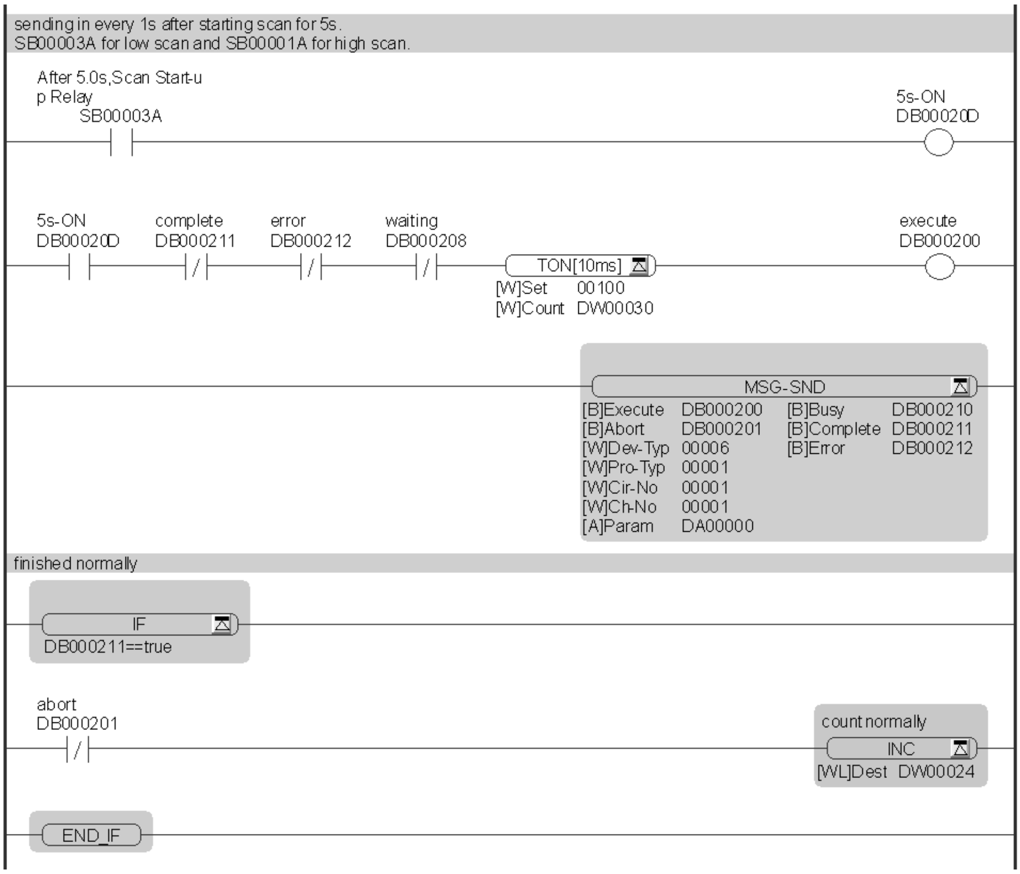
In the following programming example, sending data is started according to the set parameters 6.0 seconds after the power supply is turned ON.

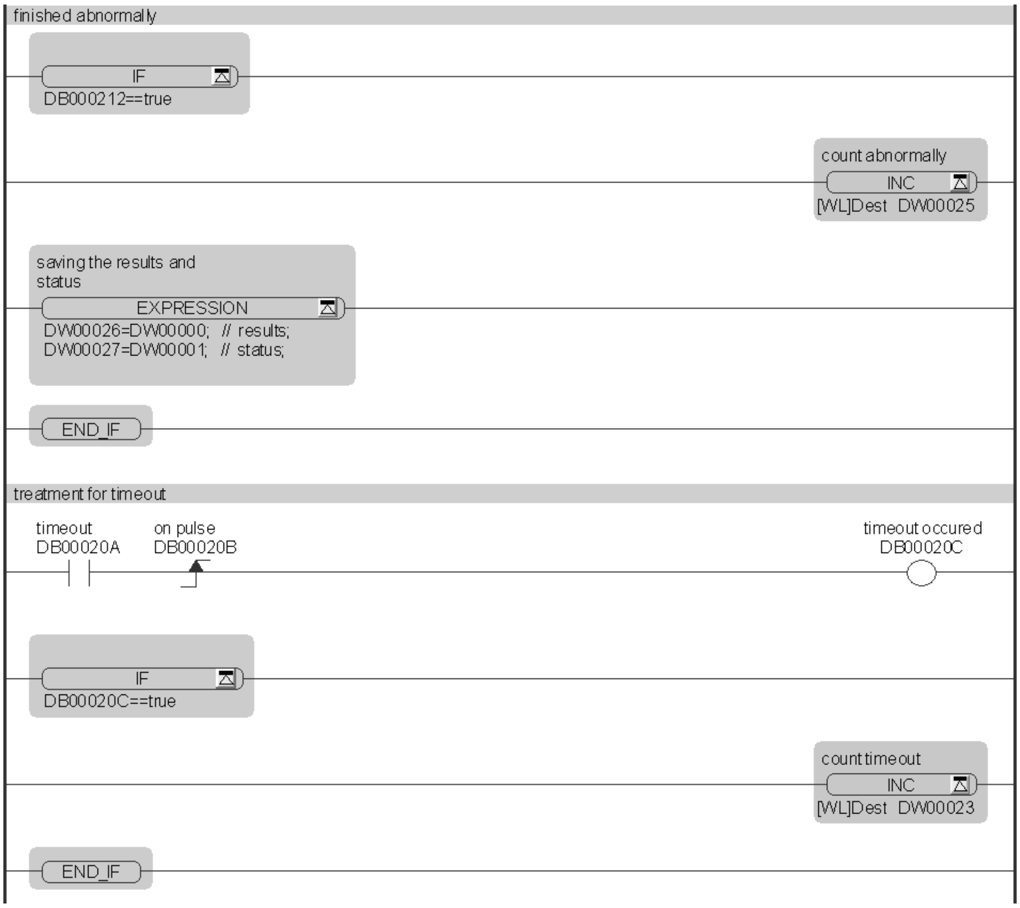


Instructions

5


set for offset (PARAM08-PARAM11)
EXPRESSION
DW00008=0; // coil offset param08;
DW00009=0; // input relay offset param09;
DW00010=0; // input register offset param10;
DW00011=0; // hold register offset param11;
clear system register. (PARAM12)
EXPRESSION
DW00012=0
END_IF
treatment for all time
abort for timeout if not completed in 10s after sending command
execute
DB000200
abort
DB000201
TON[10ms]
[W]Set 01000
[W]Count DW00031
timeout
DB00020A
abort if timeout or error
timeout
DB00020A
complete
DB000211
abort
DB000201
error
DB000212
abort
DB000201
release sending command in 60s after aborted
abort
DB000201
waiting ended
DB000209
waiting
DB000208
waiting
DB000208
waiting
DB000208
TON[10ms]
[W]Set 06000
[W]Count DW00028
waiting ended
DB000209


sending in every 1s after starting scan for 5s.
SB00003A for low scan and SB00001A for high scan.
After 5.0s,Scan Start-u p Relay
SB00003A
5s-ON
DB00020D
5s-ON
DB00020D
complete
DB000211
error
DB000212
waiting
DB000208
TON[10ms]
[W]Set 00100
[W]Count DW00030
execute
DB000200
MSG-SND
[B]Execute DB000200
[B]Abort DB000201
[W]Dev-Typ 00006
[W]Pro-Typ 00001
[W]Cir-No 00001
[W]Ch-No 00001
[A]Param DA00000
[B]Busy DB000210
[B]Complete DB000211
[B]Error DB000212
finished normally
IF
DB000211==true
abort
DB000201
count normally
INC
[WL]Dest DW00024
END_IF



INFO

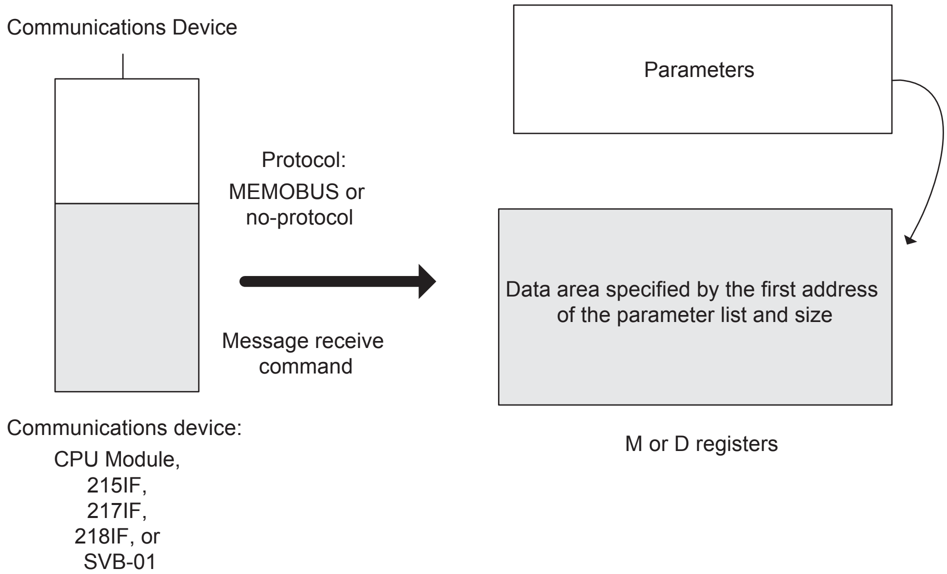
Refer to *Chapter 6 Built-in Ethernet Communications* in the *Machine Controller MP2300S Basic Module User's Manual* (Manual No.: SIEP C880732 00) for application examples of message functions.

5.10.7 Receive Message (MSG-RCV)

(1) Operation

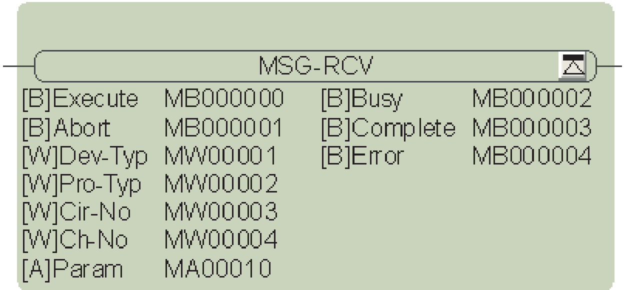
A message is received from a remote station on the specified circuit of the communications device type.
Keep the message receive command ON until the Complete bit turns ON.
This instruction supports the following communications devices and protocols.

Communications devices: CPU Module, 215IF, 217IF, 218IF, and SVB-01
Protocol: MEMOBUS communications or no-protocol



- The Complete bit changes to 1 (ON) when the message reception is completed.
  Until then, keep the receive message command ON.

(2) Format



Icon: 

Key entry: MSG-RCV

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Receive execution command (Execute)	○	×	×	×	×	×	×
Receive abort command (Abort)	○	×	×	×	×	×	×
Communications device type (Dev-Typ)	×	○	×	×	×	○	○
Communications protocol (Pro-Typ)	×	○	×	×	×	○	○
Circuit number (Cir-No)	×	○	×	×	×	○	○
Communications buffer channel number (Ch-No)	×	○	×	×	×	○	○
First address of parameter list (Param)	×	×	×	×	○*1	×	×
Busy	○*2	×	×	×	×	×	×
Complete	○*2	×	×	×	×	×	×
Error	○*2	×	×	×	×	×	×

∗ 1. M or D register only.
∗ 2. C and # registers cannot be used.

The parameters are described in the following table.

Parameter Name	Description	I/O
Receive execution command (Execute)	The message is received when this command turns ON.	IN
Receive abort command (Abort)	Receiving the message is aborted when this command turns ON.	IN
Communications device type (Dev-Typ)	CPU Module = 8, 215IF = 1, 217IF = 5, 218IF = 6, 218IF-02 = 16, and SVB-01 = 10	IN
Communications protocol (Pro-Typ)	MEMOBUS = 1, No-protocol = 2	–
Circuit number (Cir-No)	CPU Module = 1 or 2, 215IF = 1 to 8, 217IF = 1 to 24, 218IF(-02) = 1 to 8, and SVB-01 = 1 to 16	IN
Communications buffer channel number (Ch-No)	CPU Module = 1 or 2, 215IF = 1 to 13, 217IF = 1, 218IF(-02) = 1 to 10, and SVB-01 = 1 to 8	IN
First address of parameter list (Param)	First address of parameter list (MA, DA, or #A)	IN
Busy	Turns ON while receiving the message is in progress.	OUT
Complete	Turns ON when receiving the message is completed.	OUT
Error	Turns ON when an error occurs.	OUT

[a] Parameter Details

This section describes the parameters in detail. The parameter number corresponds to the word offset from the first address of the parameter list.

For example, if the first address of the parameter list is MA00100, set the value in MW00110 to set PARAM10.

Parameter No.	IN/OUT	Description	
		MEMOBUS	No-protocol
PARAM00	OUT	Processing result	Processing result
PARAM01	OUT	Status	Status
PARAM02	OUT	Remote station number	Remote station number
PARAM03	SYS	Reserved for system.	Reserved for system.
PARAM04	OUT	Function code	–
PARAM05	OUT	Data address	Data address
PARAM06	OUT	Data size	Data size
PARAM07	OUT	Remote CPU number	Remote CPU number
PARAM08	IN	Coil offset	–
PARAM09	IN	Input relay offset	–
PARAM10	IN	Input register offset	–
PARAM11	IN	Hold register offset	Register offset
PARAM12	IN	Writing range low	Register offset
PARAM13	IN	Writing range high	Register offset
PARAM14	SYS	Reserved for system.	Reserved for system.
PARAM15	SYS	Reserved for system.	Reserved for system.
PARAM16	SYS	Reserved for system.	Reserved for system.

■ Processing Result (PARAM00)

This parameter outputs the result of processing to the upper byte. The lower byte is used for system analysis.

- 00□□ hex: Processing (Busy)
- 10□□ hex: Processing completed (Complete)
- 8□□□ hex: Error

  The following errors can occur.

  - 81□□ hex: Function code error
    An unused function code was received.
  - 82□□ hex: Address setting error
    The data address, coil offset, input relay offset, input register offset, or hold register offset is set outside of the valid range.
  - 83□□ hex: Data size error
    The size of the send or receive data was outside of the valid range.
  - 84□□ hex: Circuit number setting error
    The set circuit number is outside of the valid range.
  - 85□□ hex: Channel number setting error
    The set channel number is outside of the valid range.
  - 86□□ hex: Station address error
    The set station number is outside of the valid range.
  - 88□□ hex: Communications section error
    The communications section returned an error response.
  - 89□□ hex: Device selection error
    A device that cannot be used was selected.

■ Status (PARAM01)

The status of the communications section is output to this parameter. For details, refer to information on the Status parameter (PARAM01) in *5.10.6 Send Message (MSG-SND)*.

■ Remote Station Number (PARAM02)

The station number of the source is output to this parameter.

■ Function Code (PARAM04)

The MEMOBUS function code that was received is output to this parameter.
The MEMOBUS function codes are listed in the following table.

Function Code		Setting
00 hex	Not used.	×
01 hex	Read Coil Status	○
02 hex	Read Input Relay Status	○
03 hex	Read Hold Register Contents	○
04 hex	Read Input Register Contents	○
05 hex	Change Single Coil Status	○
06 hex	Write Single Hold Register	○
07 hex	Not used.	×
08 hex	Loopback Test	○
09 hex	Expanded Read Hold Register Contents	○
0A hex	Expanded Read Input Register Contents	○
0B hex	Expanded Write Hold Register	○
0C hex	Not used.	×
0D hex	Expanded Read Nonconsecutive Hold Registers	○
0E hex	Expanded Write Nonconsecutive Hold Registers	○
0F hex	Change Multiple Coil Status	○
10 hex	Write Multiple Hold Registers	○
11 hex to 20 hex	Not used.	×
21 hex to 3F hex	Reserved for system.	×
40 hex to 4F hex	Reserved for system.	×
50 hex and higher	Not used.	×

- When the target device is operating as a slave, MB, MW, IB, and IW data can be read and written for coils, hold registers, input relays, and input registers, respectively.

■ Data Address (PARAM05)

The data address that was requested by the sending node is output to this parameter

■ Data Size (PARAM06)

The data size (number of bits or number of words) in the read or write request is output to this parameter.

■ Remote CPU Number (PARAM07)

If the remote device is an MP2000-series Machine Controller, 1 is output to this parameter.
If the remote device is any other Yaskawa Controller that consists of more than one CPU Module, the CPU number is output to this parameter.
In all other cases, 0 is output to this parameter.

■ Coil Offset (PARAM08)

Set the offset to the word address of the coil.
This setting is valid for function codes 01, 05, and 0F hex.

■ Input Relay Offset (PARAM09)

Set the offset to the word address of the input relay.
This setting is valid for function code 02 hex.

■ Input Register Offset (PARAM10)

Set the offset to the word address of the input register.
This setting is valid for function codes 04 and 0A hex.

■ Hold Register Offset (PARAM11)

Set the offset to the word address of the hold register.
This setting is valid for function codes 03, 06, 09, 0B, 0D, 0E, and 10 hex.

■ Writing Range Low (PARAM12) and Writing Range High (PARAM13)

Set the range for which to enable writing for write requests. Any write request that is not within this range will cause an error. This setting is valid for function codes 0B, 0E, 0F, and 10 hex.
$0 \leq$ Write range low $\leq$ Write range high $\leq$ Highest MW address

■ Reserved for System (PARAM14)

The channel number that is currently in use is held in this parameter. Set this parameter to 0000 hex from a user program in the first scan after the power supply is turned ON. Do not change the value of the parameter after that. It is used by the system.

■ No-protocol Communications

It is not necessary to set PARAM04, PARAM08, PARAM09, PARAM10, and PARAM11.
PARAM12 is also used for the offset to the MW word address at the write destination.

[b] Inputs

■ Execute (Receive Execution Command)

The message is received when this command turns ON.
Keep the Execute bit ON until the Complete or Error bit turns ON.

■ Abort (Receive Abort Command)

This command aborts receiving the message. It takes priority over Execute (Receive Execution Command).

■ Dev-Typ (Communications Device Type)

Specify the communications device type.
CPU Module = 8, 215IF = 1, 217IF = 5, 218IF = 6, 218IF-02 = 16, and SVB-01 = 11

■ Pro-Typ (Communications Protocol)

Specify the communications protocol. For no-protocol communications, a response is not sent to the remote station.
MEMOBUS: Set this input to 1.
No-protocol: Set this input to 2.

■ Cir-No (Circuit Number)

Specify the circuit number.
CPU Module = 1 or 2, 215IF = 1 to 8, 217IF = 1 to 24, 218IF = 1 to 8, and SVB-01 = 1 to 16

■ Ch-No (Channel Number)

Specify the channel number of the communications section. Do not set the same channel number more than once for the same circuit.
CPU Module = 1, 215IF = 1 to 13, 217IF = 1, 218IF = 1 to 10, and SVB-01 = 1 to 8

■ PARAM (First Address of Parameter List)

Set the first address of the parameter list. For details on this parameter, refer to *[a] Parameter Details* earlier in this section.

[c] Outputs

■ Busy (Processing)

This item indicates that processing is in progress. Keep Execute ON while Busy is ON.

■ Complete (Processing Completed)

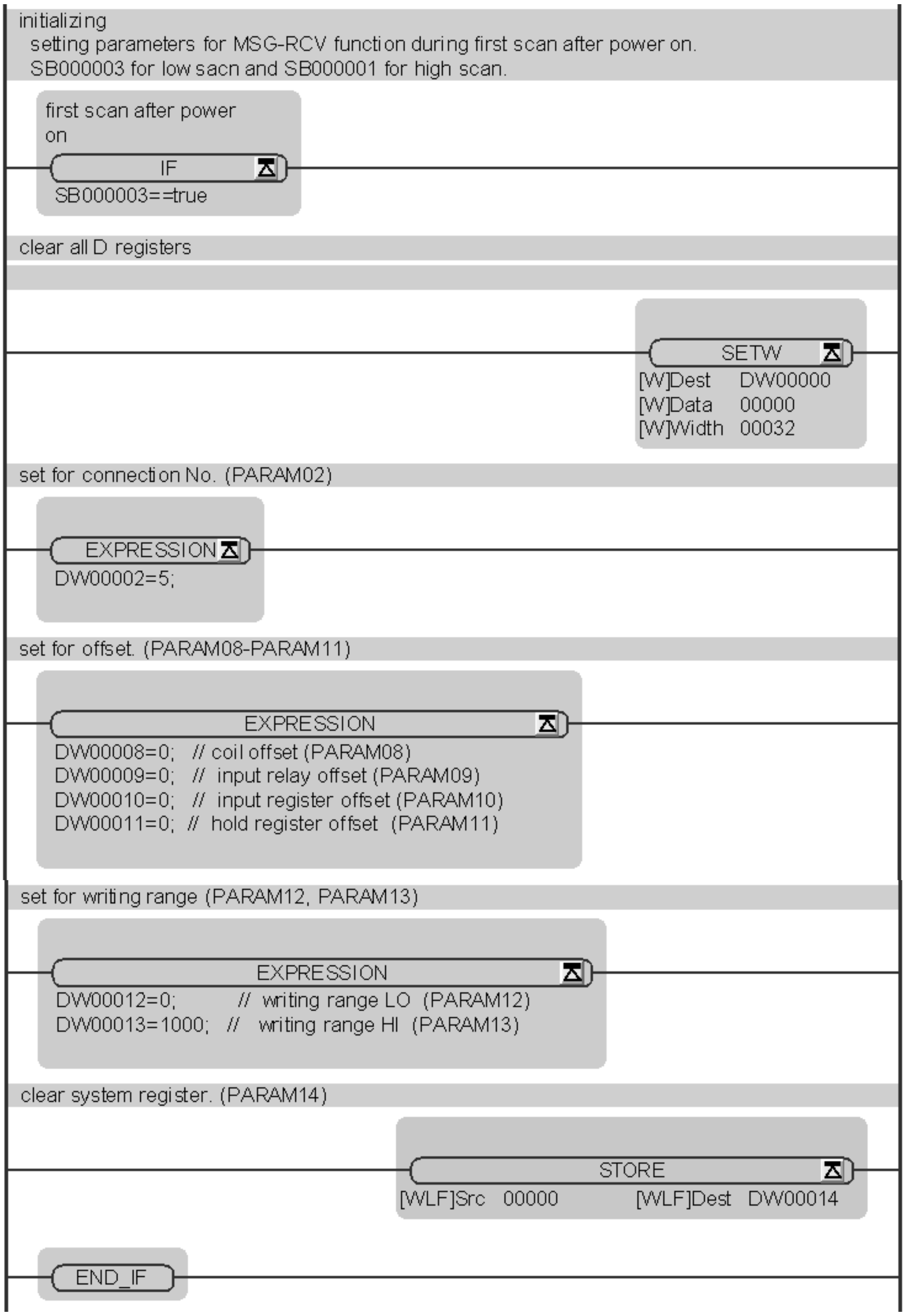
This item turns ON for only one scan when processing is completed normally.

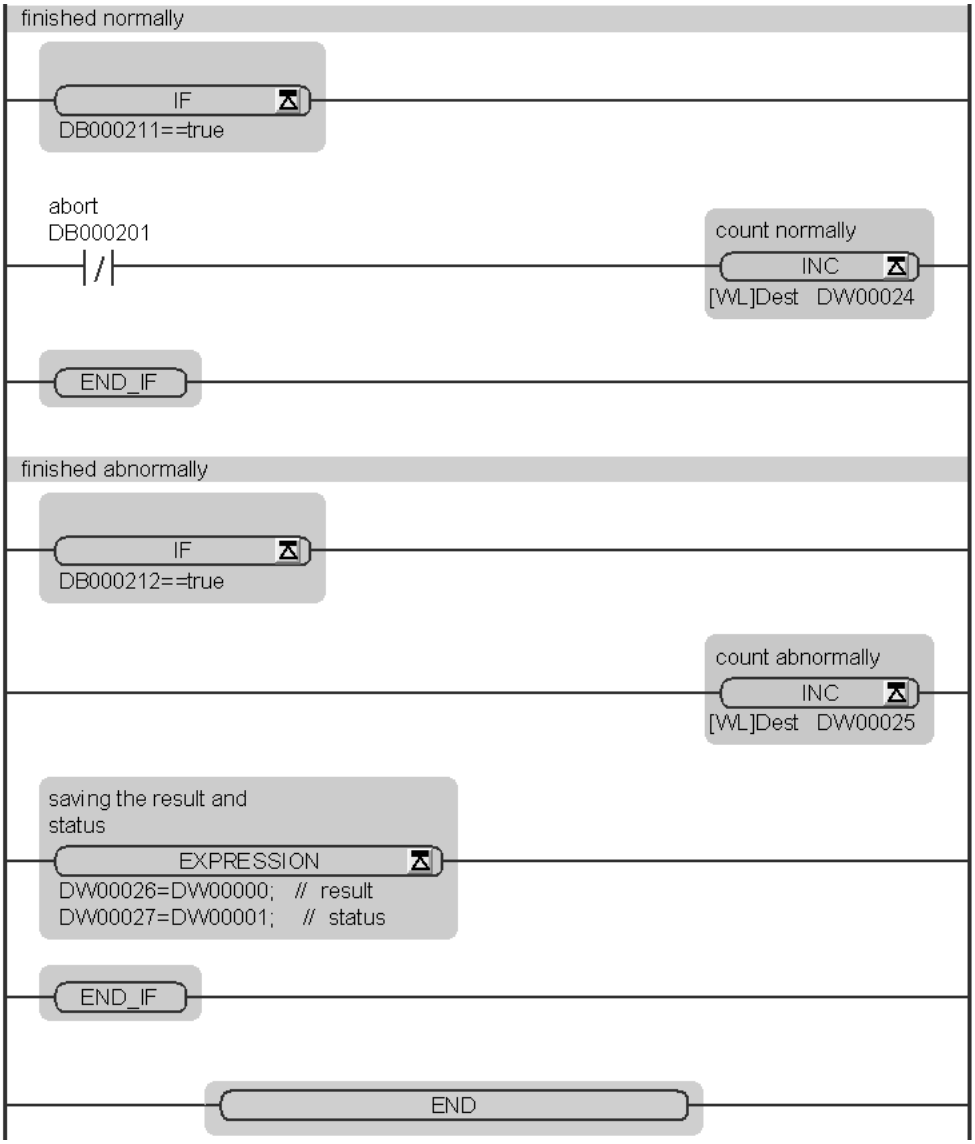
■ Error

This item turns ON for only one scan when an error occurs.
For the causes of the error, refer to information on PARAM00 and PARAM01 in *[a] Parameter Details* earlier in this section.

(3) Programming Example

In the following programming example, message reception continues with the parameters that are set after the power supply is turned ON.





INFO

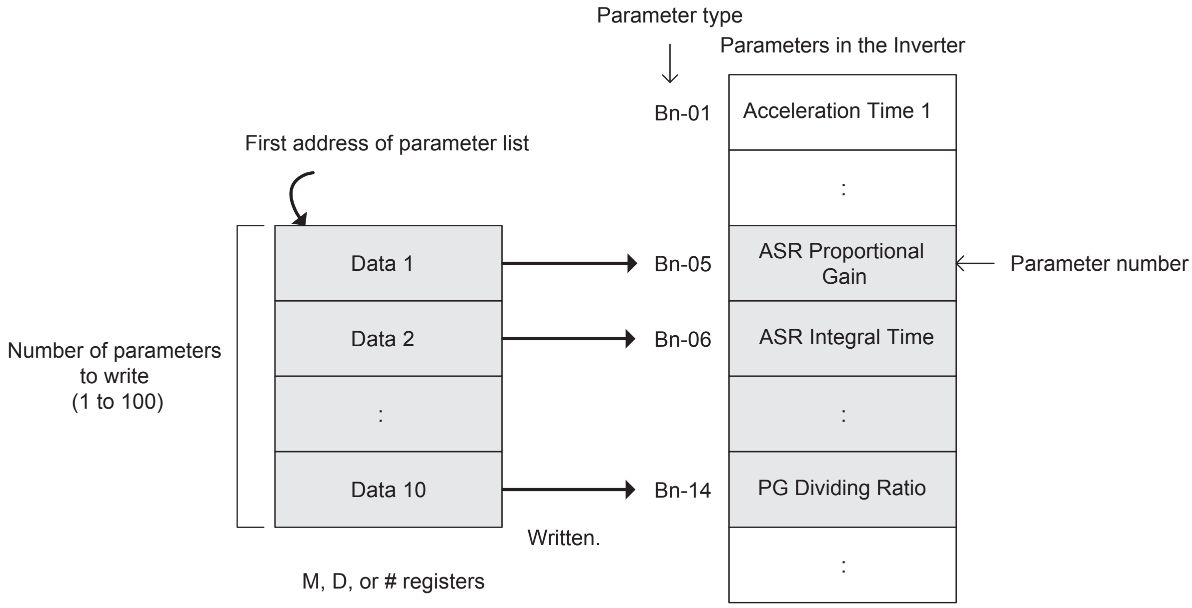
Refer to *Chapter 6 Built-in Ethernet Communications* in the *Machine Controller MP2300S Basic Module User's Manual* (Manual No.: SIEP C880732 00) for application examples of message functions.

5.10.8 Write Inverter Parameter (ICNS-WR)

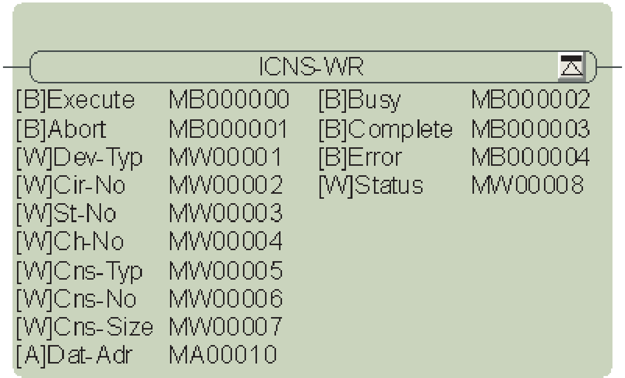
(1) Operation

The ICNS-WR instruction writes data to parameters in an Inverter. You can specify the types and range of the parameters in the Inverter.

Applicable Inverters:
This instruction is applicable to Inverters that are connected to the MP930, SVB-01, or 215IF.



(2) Format



Icon: 

Key entry: ICNS-WR

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Write command (Execute)	○	×	×	×	×	×	×
Write processing abort command (Abort)	○	×	×	×	×	×	×
Communications device type (Dev-Typ)	×	○	×	×	×	○	○
Circuit number (Cir-No)	×	○	×	×	×	○	○
Slave station number (St-No)	×	○	×	×	×	○	○
Communications buffer channel number (Ch-No)	×	○	×	×	×	○	○
Parameter type (Cns-Typ)	×	○	×	×	×	○	○
Parameter number (Cns-No)	×	○	×	×	×	○	○
Number of parameters to write (Cns-Size)	×	○	×	×	×	○	○
First address (Dat-Adr)	×	×	×	×	○*1	×	×
Writing (Busy)	○*2	×	×	×	×	×	×
Write completed (Complete)	○*2	×	×	×	×	×	×
Error	○*2	×	×	×	×	×	×
Write execution status (Status)	×	○*2	×	×	×	○	×

∗ 1. M or D register only.
∗ 2. C and # registers cannot be used.

The parameters are described in the following table.

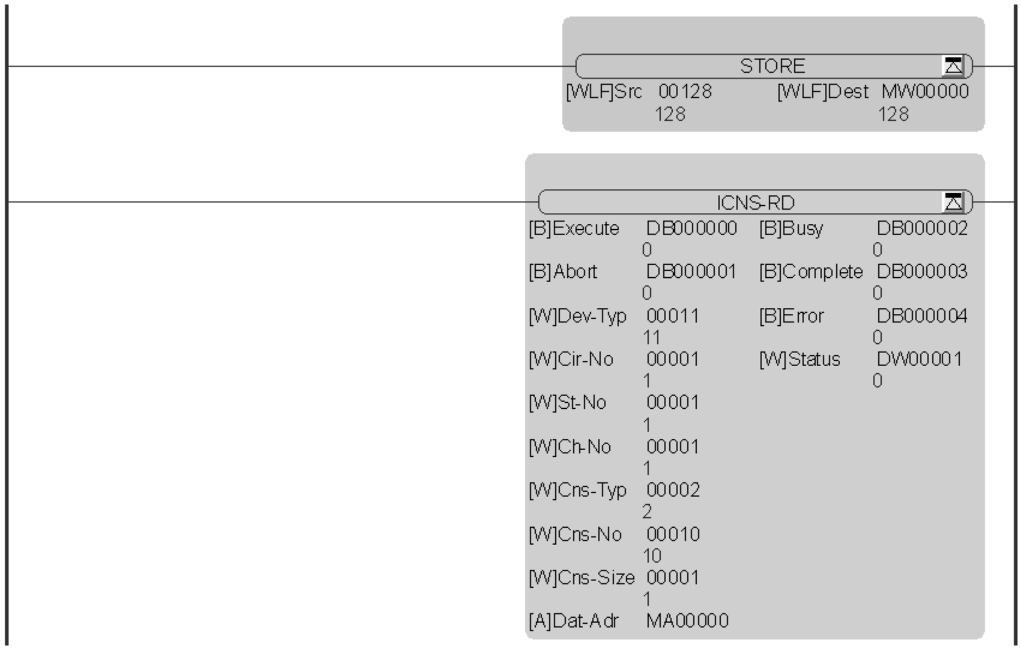
Parameter Name	Description	I/O
Write command (Execute)	Writing the Inverter parameters begins when this command turns ON.	IN
Write processing abort command (Abort)	The write process is aborted when this command turns ON.	IN
Communications device type (Dev-Typ)	215IF = 1, MP930 = 4, and SVB-01 = 10	IN
Circuit number (Cir-No)	215IF = 1 or 2, MP930 = 1, and SVB-01 = 1 to 16	IN
Slave station number (St-No)	215IF = 1 to 64, MP930 = 1 to 14, and SVB-01 = 1 to 14	IN
Communications buffer channel number (Ch-No)	215IF = 1 to 3, MP930 = 1, and SVB-01 = 1 to 8	IN
Parameter type (Cns-Typ)	Inverter parameter type: 0 = Direct specification of reference number, 1 = An, 2 = Bn, 3 = Cn, 4 = Dn, 5 = En, 6 = Fn, 7 = Hn, 8 = Ln, 9 = On, and 10 = Tn	IN
Parameter number (Cns-No)	Inverter parameter number (1 to 99) The upper limit depends on the model of the Inverter. If the parameter type (Cns-Typ) is set to 0, specify the reference number.	IN
Number of parameters to write (Cns-Size)	Number of parameters to write to the Inverter (1 to 100)	IN
First address (Dat-Adr)	The first register address of the parameters (MA, DA, or #A).	IN
Writing (Busy)	Turns ON while writing parameters to the Inverter is in progress.	OUT
Write completed (Complete)	Turns ON when writing parameters to the Inverter is completed.	OUT
Error	Turns ON when an error occurs.	OUT
Write execution status (Status)	Inverter parameter write execution status	OUT

The status configuration is shown below.

Bit	Name	Remarks
0 to 7	Reserved for system.	The error code is given here when an Inverter response error is received. 01 hex: Function code error 02 hex: Reference number error 03 hex: Error in the number of data items written 21 hex: Error in the upper or lower limit of the write data 22 hex: Write error (during operation or under-voltage)
8	Execution sequence error	The function will not be executed.
9	Communications parameter error	The function will not be executed.
10	Specified type error	–
11	Specified number error	The function will not be executed.
12	Specified data error	The function will not be executed.
13	Communications error	The function will not be executed.
14	Inverter response error	The function will not be executed.
15	Address input error	The function will not be executed.

(3) Programming Example

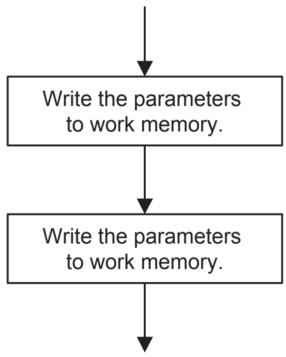
In the following programming example, the data in MW00000 is written to parameter Bn-10 in the Inverter that is connected as station 1 to the SVB-01 on circuit 1.
When DB000000 turns ON, the parameter is written to the Inverter.
After execution, you must check the Complete bit (DB000003) to make sure that it has turned ON, and then write the data to parameter storage memory in the Inverter (EEPROM). (Refer to *(4) Additional Information*.)



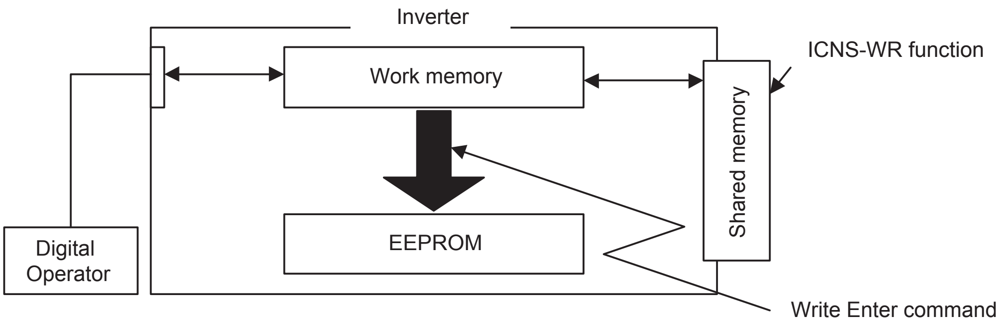
(4) Additional Information

[a] Writing Parameters to EEPROM

The procedure to write parameters to the parameter storage memory in the Inverter (EEPROM) is given in the following figure.



The parameters are first written to work memory in the Inverter with the ICNS-WR system function. To write those parameters to EEPROM, you must use the Write Enter command that is shown in the following figure.



[b] Executing the Write Enter Command

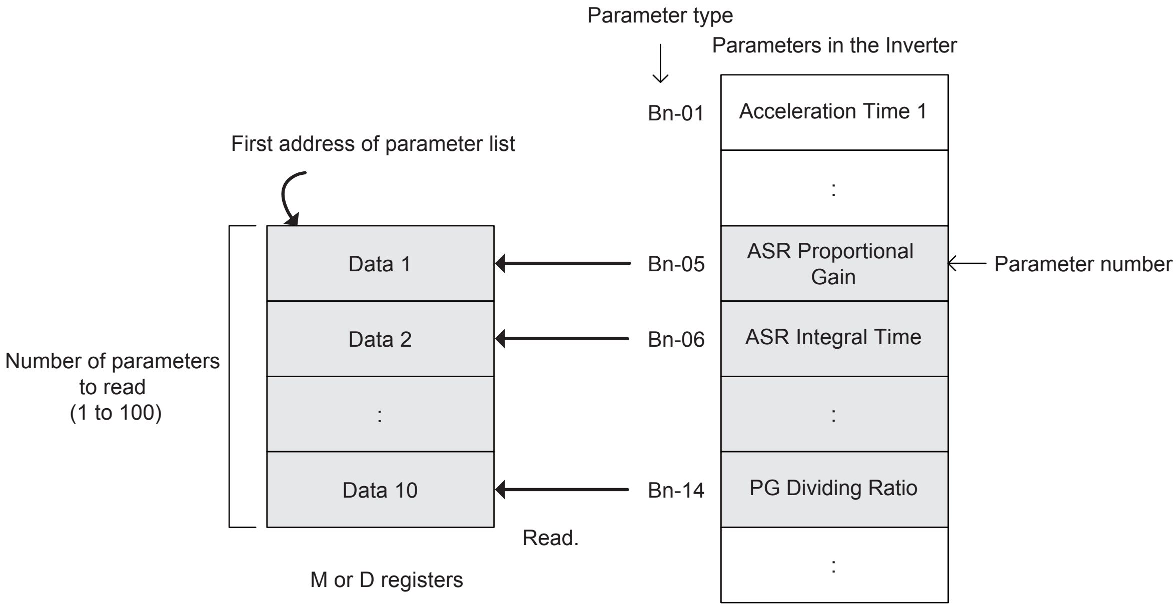
To execute the Write Enter command, use the ICNS-WR function to write data of 0 to the reference “FEED”.

5.10.9 Read Inverter Parameter (ICNS-RD)

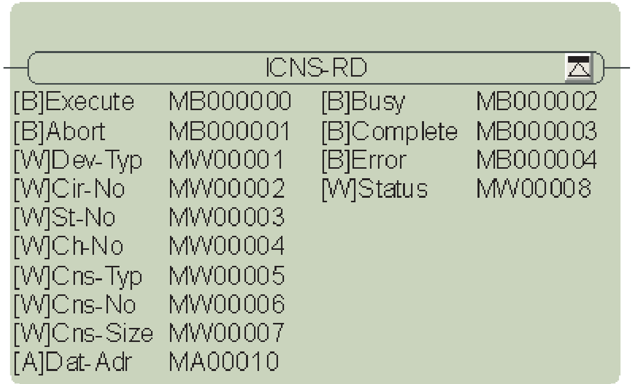
(1) Operation

The ICNS-RD instruction reads parameters from an Inverter. You can specify the types and range of the parameters in the Inverter.

Applicable Inverters:
This instruction is applicable to Inverters that are connected to the MP930, SVB-01, or 215IF.



(2) Format



Icon: 

Key entry: ICNS-RD

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Read command (Execute)	○	×	×	×	×	×	×
Read processing abort command (Abort)	○	×	×	×	×	×	×
Communications device type (Dev-Typ)	×	○	×	×	×	○	○
Circuit number (Cir-No)	×	○	×	×	×	○	○
Slave station number (St-No)	×	○	×	×	×	○	○
Communications buffer channel number (Ch-No)	×	○	×	×	×	○	○
Parameter type (Cns-Typ)	×	○	×	×	×	○	○
Parameter number (Cns-No)	×	○	×	×	×	○	○
Number of parameters to read (Cns-Size)	×	○	×	×	×	○	○
First address (Dat-Adr)	×	×	×	×	○[*1]	×	×
Reading (Busy)	○[*2]	×	×	×	×	×	×
Read completed (Complete)	○[*2]	×	×	×	×	×	×
Error	○[*2]	×	×	×	×	×	×
Read execution status (Status)	×	○[*2]	×	×	×	○	×

∗ 1. M or D register only.
∗ 2. C and # registers cannot be used.

The parameters are described in the following table.

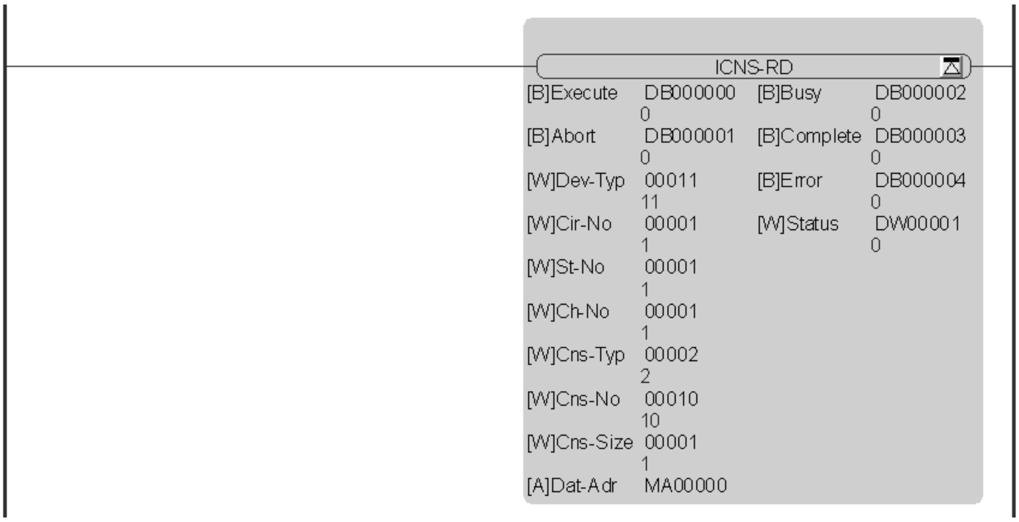
Parameter Name	Description	I/O
Read command (Execute)	Reading the Inverter parameters begins when this command turns ON.	IN
Read processing abort command (Abort)	The read process is aborted when this command turns ON.	IN
Communications device type (Dev-Typ)	215IF = 1, MP930 = 4, and SVB-01 = 10	IN
Circuit number (Cir-No)	215IF = 1 or 2, MP930 = 1, and SVB-01 = 1 to 16	IN
Slave station number (St-No)	215IF = 1 to 64, MP930 = 1 to 14, and SVB-01 = 1 to 14	IN
Communications buffer channel number (Ch-No)	215IF = 1 to 3, MP930 = 1, and SVB-01 = 1 to 8	IN
Parameter type (Cns-Typ)	Inverter parameter type: 0 = Direct specification of reference number, 1 = An, 2 = Bn, 3 = Cn, 4 = Dn, 5 = En, 6 = Fn, 7 = Hn, 8 = Ln, 9 = On, and 10 = Tn	IN
Parameter number (Cns-No)	Inverter parameter number (1 to 99) The upper limit depends on the model of the Inverter. If the parameter type (Cns-Typ) is set to 0, specify the reference number.	IN
Number of parameters to read (Cns-Size)	Number of parameters to read from the Inverter (1 to 100)	IN
First address (Dat-Adr)	The first register address of the parameters (MA, DA, or #A).	IN
Reading (Busy)	Turns ON while reading parameters from the Inverter is in progress.	OUT
Read completed (Complete)	Turns ON while reading parameters from the Inverter is completed.	OUT
Error	Turns ON when an error occurs.	OUT
Read execution status (Status)	Inverter parameter read execution status	OUT

The status configuration is shown below.

Bit	Name	Remarks
0 to 7	Reserved for system.	The error code is given here when an Inverter response error is received. 01 hex: Function code error 02 hex: Reference number error
8	Execution sequence error	The function will not be executed.
9	Communications parameter error	The function will not be executed.
10	Specified type error	–
11	Specified number error	The function will not be executed.
12	Specified data error	The function will not be executed.
13	Communications error	The function will not be executed.
14	Inverter response error	The function will not be executed.
15	Address input error	The function will not be executed.

(3) Programming Example

In the following programming example, parameter Bn-10 in the Inverter that is connected as station 1 to the SVB-01 on circuit 1 is read and the data is stored in MW00000.
When DB000000 turns ON, the parameter is read from the Inverter.



Instructions

5

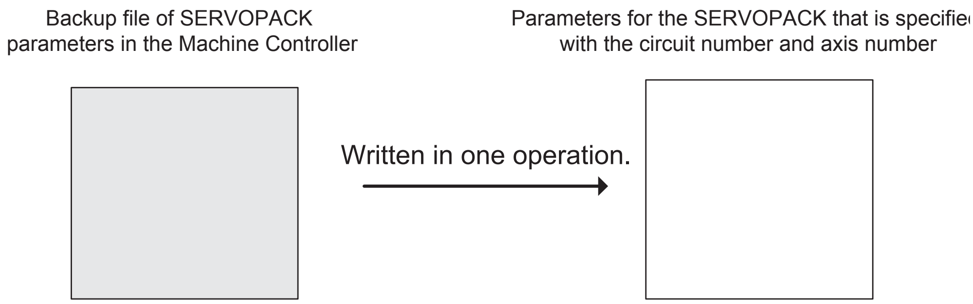
5.10.10 Write SERVOPACK Parameter (MLNK-SVW)

(1) Operation

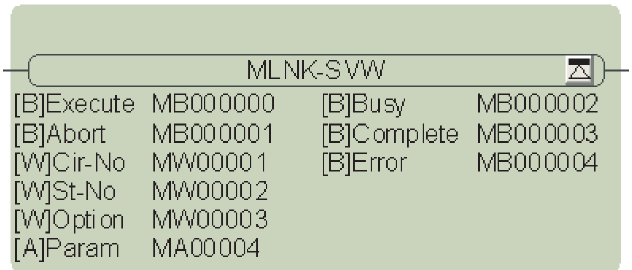
The MLNK-SVW instruction writes all the parameters that are saved in the Machine Controller as a SERVOPACK parameter backup file to the SERVOPACK that is specified with the circuit number and axis number.
This instruction can be used to write SERVOPACK parameters using only a ladder program (i.e., without the use of MPE720 or other tools) when a SERVOPACK is replaced.

IMPORTANT

An MP2000-series Machine Controller with software version 2.81 or higher is required to execute the MLNK-SVW instruction for a SERVOPACK connected to an SVC Module.



(2) Format



Icon: 

Key entry: MLNK-SVW

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Write command (Execute)	○	×	×	×	×	×	×
Write processing abort command (Abort)	○	×	×	×	×	×	×
Circuit number (Cir-No)	×	○	×	×	×	×	×
Axis number (St-No)	×	○	×	×	×	×	×
Option settings (Option)	×	○	×	×	×	×	×
First address (Param)	×	×	×	×	○*1	×	×
Writing (Busy)	○*2	×	×	×	×	×	×
Write completed (Complete)	○*2	×	×	×	×	×	×
Error	○*2	×	×	×	×	×	×

* 1. M or D register only.
* 2. C and # registers cannot be used.

The parameters are described in the following table.

Parameter Name	Description	I/O
Write command (Execute)	Writing the SERVOPACK parameters begins when this command turns ON.	IN
Write processing abort command (Abort)	The write process is aborted when this command turns ON.	IN
Circuit number (Cir-No)	Destination circuit number (1 to 16)	IN
Axis number (St-No)	Destination axis number (1 to 16)	IN
Option settings (Option)	Command Option Bit Settings Bit E: ID Check Enable/Disable; 0: Enable, 1: Disable Bit F: Version Check Enable/Disable; 0: Enable, 1: Disable The other bits are not used. Any settings in the other bits are ignored.	IN
First address (Param)	First address of function workspace	IN
Writing (Busy)	Turns ON while writing the parameters is in progress.	OUT
Write completed (Complete)	Turns ON for one scan only after the parameters are written.	OUT
Error	Turns ON for one scan only when an error occurs. (The error details are output to PARAM00 and PARAM01.)	OUT

The option settings are described in the following table.

Bit	Description
0 to D	Not used. (Settings will be ignored.)
E	ID Check Enable/Disable (0: Enable, 1: Disable) This option allows you to disable detecting inconsistencies between the ID information in the source file and the ID information where the data is written. Use this option when writing to a stepping motor drive. If this bit is set to 1 (disable), the model information is not checked. This can result in writing parameters for the wrong model, which can cause problems. Take sufficient caution when you disable the check. An inconsistent ID information error will also occur if a SERVOPACK parameters file that was edited or saved offline is used. If that occurs, also disable the ID check.
F	Version Check Enable/Disable (0: Enable, 1: Disable) If the version of the source SERVOPACK (communications interface) is not the same as the version at the write destination, an inconsistent version error will occur. SERVOPACK parameters and setting ranges are sometimes different for different versions as the result of changes to specifications. Confirm that no problems will occur before you disable the version check. This will allow you to write the parameters. An inconsistent version error will also occur if a SERVOPACK parameters file that was edited or saved offline is used. If that occurs, also disable the version check.

[a] Details on Function Workspace

This section provides details on the function workspace. The parameter number corresponds to the word offset from the first address.
For example, if the first address is MA00100, set the value in MW00105 to set PARAM05.

Parameter No.	IN/OUT	Description
PARAM00	OUT	Processing result
PARAM01	OUT	Error code
PARAM02	OUT	Copy of Cir-No
PARAM03	OUT	Copy of St-No
PARAM04	SYS	For system use #1
PARAM05	SYS	For system use #2
PARAM06	SYS	For system use #3

■ Processing Result (PARAM00)

- 0000 hex: Processing (Busy)
- 1000 hex: Processing completed (Complete)
- 8□□□ hex: Error

The following errors can occur.

- 8100 hex: Reserved.
- 8200 hex: Address setting error
  The set data address is outside of the valid range.
- 8300 hex: Reserved.
- 8400 hex: Circuit number setting error
  The set circuit number is outside of the valid range.
- 8500 hex: Reserved.
- 8600 hex: Axis number setting error
  The set axis number is outside of the valid range.
- 8700 hex: Reserved.
- 8800 hex: Communications interface task error
  An error was returned from the communications interface task.
- 8900 hex: Reserved.
- 8A00 hex: Function execution duplication error
  More than one MLNK-SVW function was executed at the same time.

■ Error Code (PARAM01)

This parameter outputs the error code from the communications interface task. This parameter is valid only when the processing result (PARAM00) is 8800 hex.

- 0000 hex: Reserved.
- 0001 hex: No SERVOPACK parameter backup file
- 0002 hex: Backup file error
- 0003 hex: Inconsistent ID information
- 0004 hex: Inconsistent version
- 0005 hex: Module error
- 0006 hex: SERVOPACK controller command duplication error
- 0007 hex: Communications error
- 0008 hex: Undefined command
- 0009 hex: Invalid parameter
- 000A hex: Internal system error

■ Copy of Cir-No (PARAM02)

This is a copy of the Cir-No input data.

■ Copy of St-No (PARAM03)

This is a copy of the St-No input data.

■ For System Use #1 (PARAM04)

This parameter is used by the system. Set this parameter to 0000 hex from a user program in the first scan after the power supply is turned ON. Do not modify this parameter at any other time.

■ For System Use #2 (PARAM05)

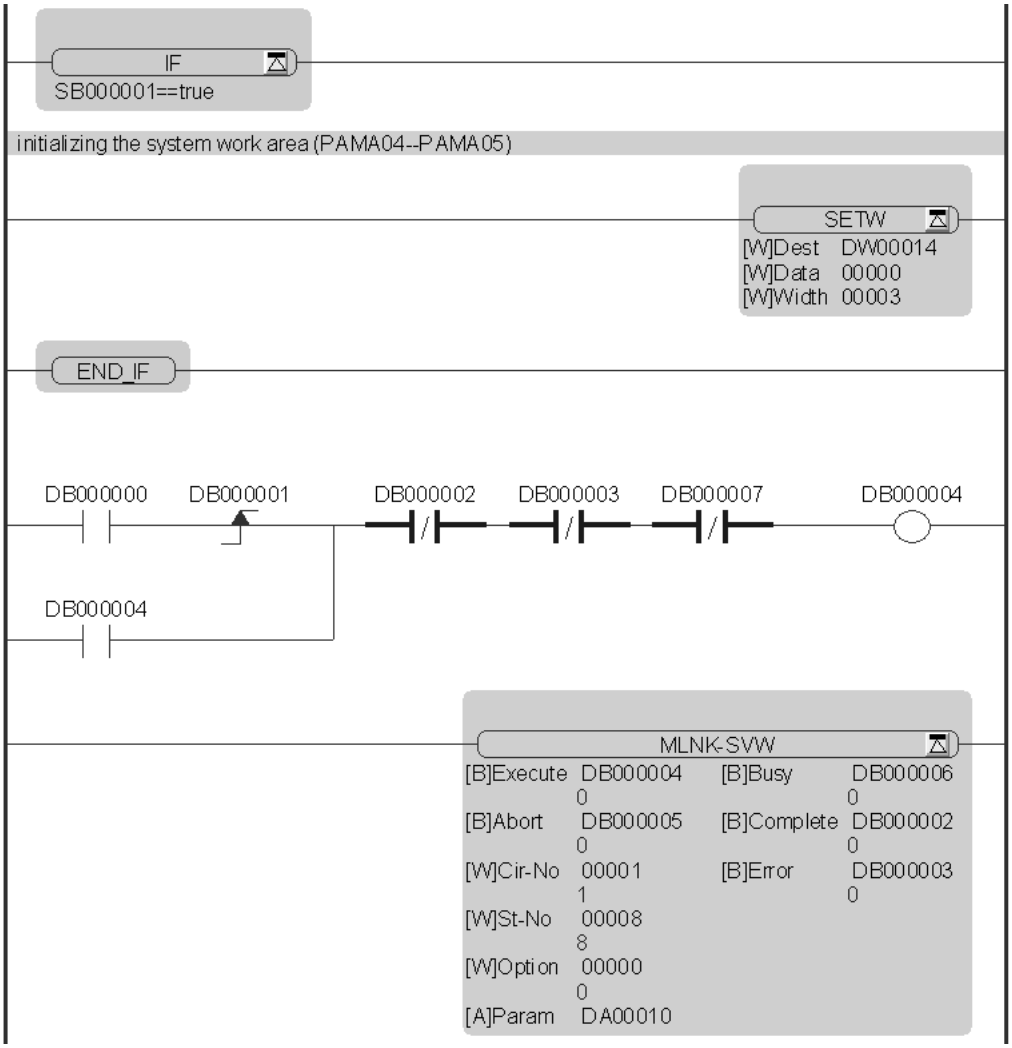
This parameter is used by the system. Set this parameter to 0000 hex from a user program in the first scan after the power supply is turned ON. Do not modify this parameter at any other time.

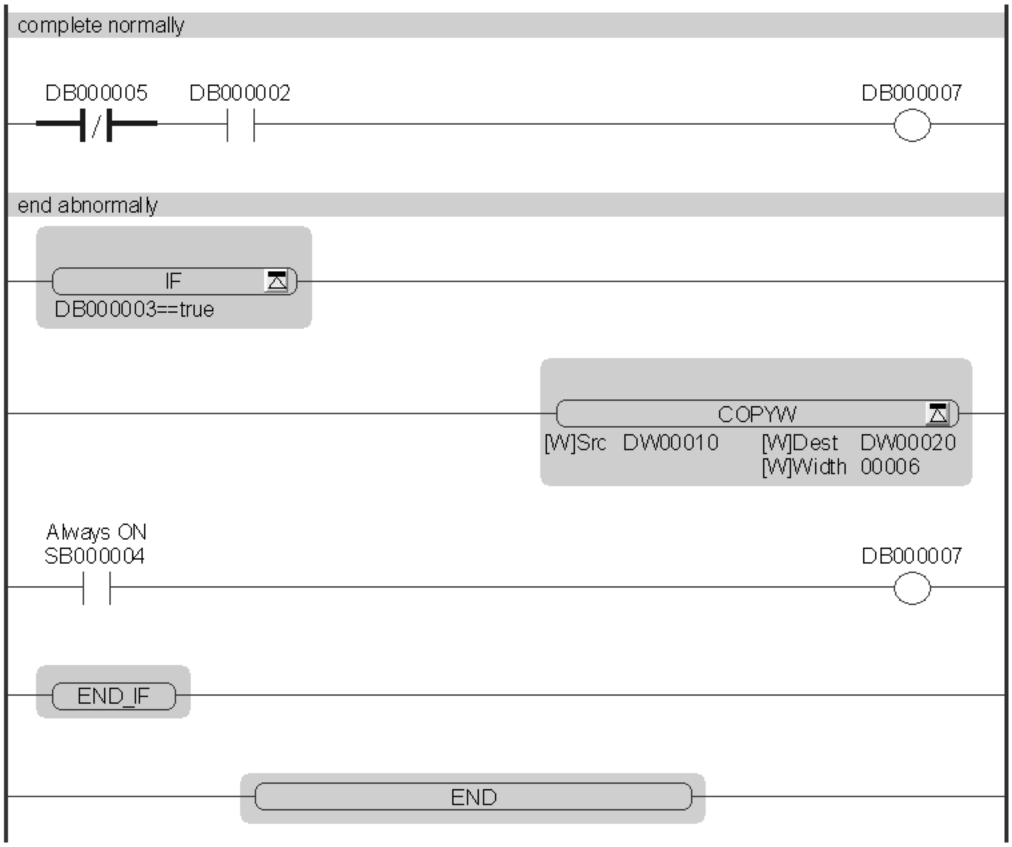
■ For System Use #3 (PARAM06)

This parameter is used by the system. Set this parameter to 0000 hex from a user program in the first scan after the power supply is turned ON. Do not modify this parameter at any other time.

(3) Programming Example

In the following programming example, the parameters are written to the SERVOPACK.
If a backup file of the SERVOPACK parameters exists in the Machine Controller, the SERVOPACK parameters are written once to the specified SERVOPACK when DB000000 turns ON. The specified SERVOPACK is the one that is defined in the Module configuration definition with a MECHATROLINK circuit number of 1 and defined in the MECHATROLINK detailed definition with ST#8.

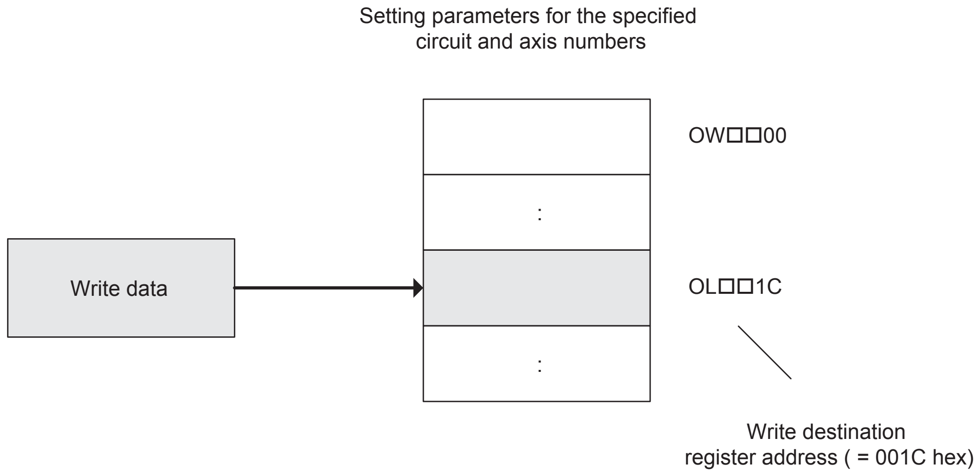



complete normally
DB000005
DB000002
DB000007
end abnormally
IF
DB000003==true
COPYW
[W]Src DW00010
[W]Dest DW00020
[W]Width 00006
Always ON
SB000004
DB000007
END_IF
END

5.10.11 Write Motion Register (MOTREG-W)

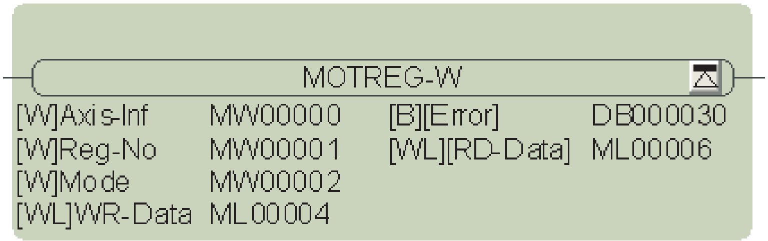
(1) Operation

The MOTREG-W instruction calls a function that accesses a specified motion register.
The data is written to the motion register by specifying the circuit number, axis number, and register address. This instruction is used with setting parameters.



- This function is useful to store the same setting parameter for multiple axes with different circuit and axis numbers.
  To store data with the STORE or EXPRESSION instructions, you need to consider an offset to address the circuit and the axis numbers.

(2) Format



Icon: 

Key entry: MOTREG-W

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Axis information (Axis-Inf)	×	○	×	×	×	×	×
Register address (Reg-No)	×	○	×	×	×	×	×
Mode	×	○	×	×	×	×	×
Write data (WR-Data)	×	○	○	×	×	×	×
Error	○*	×	×	×	×	×	×
Read data (RD-Data)	×	○*	○*	×	×	×	×

* C and # registers cannot be used. These parameters may be omitted.

The parameters are described in the following table.

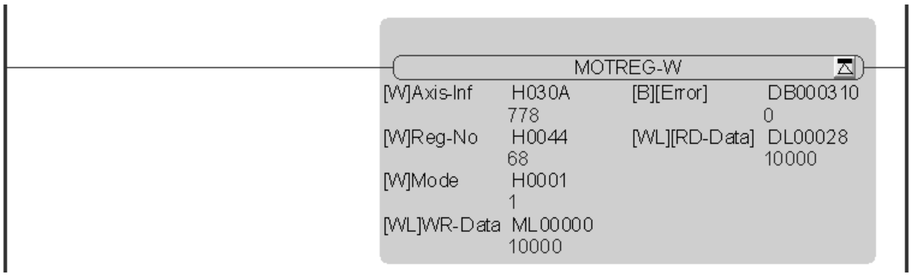
Parameter Name	Description	I/O
Axis information (Axis-Inf)	Circuit number and axis number Upper byte: Circuit number (01 to 10 hex) Lower byte: Axis number (01 to 10 hex)	IN
Register address (Reg-No)	Integer register: 0000 to 007F hex Double-length integer register: 0000 to 007E hex	IN
Mode	Access type and access size Upper byte: Access type 0: Write WR-Data to specified register. 1: Write inclusive OR of specified register and WR-Data to specified register. 2: Write AND of specified register and WR-Data to specified register. Others: Write WR-Data to specified register. Lower byte: Access size 0: Integer data 1: Double-length integer data Others: Integer data	IN
Write data (WR-Data)	If the access size for Mode is an integer and the input data type is a double-length integer, only the lower word will be used.	IN
Error	Error cause (Turns ON when an error occurs.) The register cannot be written to or read from because the circuit number, axis number, or register address is outside of the valid range, or because the Module does not exist. When an error occurs, RD-Data is set to 0.	OUT
Read data (RD-Data)	This is the data that is read after writing is completed. If integer data is specified, the data is output with the sign.	OUT

(3) Programming Example

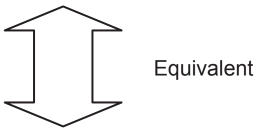
In the following programming example, the value in ML00000 is written to the Step Travel Distance parameter in OW□□44 for axis number 10 on circuit number 3.
Set the following items.

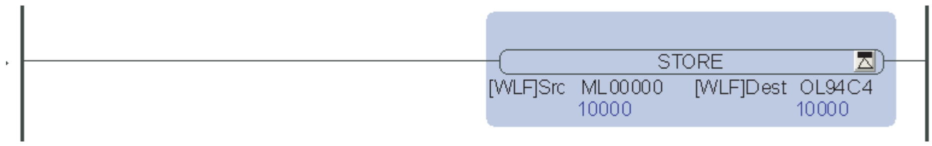
- Axis-Inf = 030A hex (circuit 3, axis 10)
- Register address = 0044 hex
- Mode = 0001 hex (double-length Integer)

For simplicity, this example omits the error and data reading processes.



The same result can be achieved by directly specifying the register address and storing data with the STORE instruction.

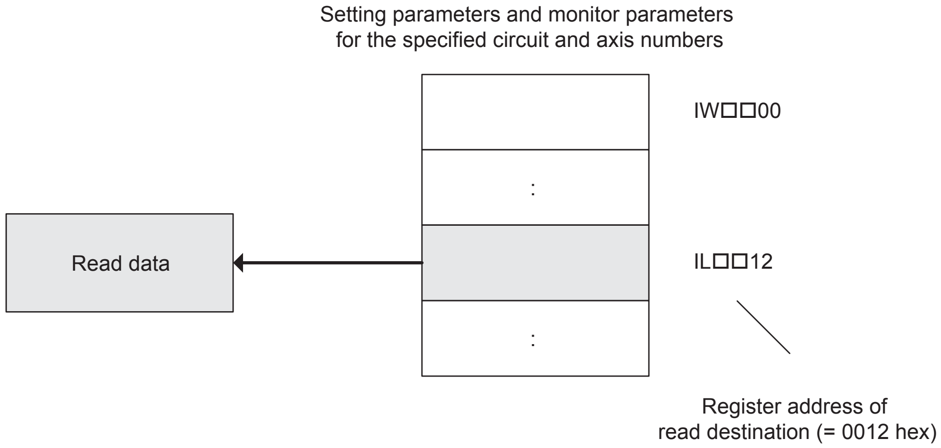




5.10.12 Read Motion Register (MOTREG-R)

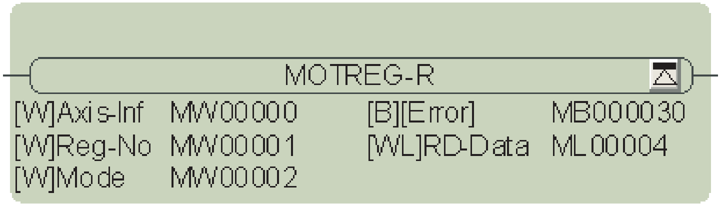
(1) Operation

The MOTREG-R instruction calls a function that accesses a specified motion register.
The value is read from the motion register by specifying the circuit number, axis number, and register address.
This instruction is used with setting parameters and monitor parameters.



- This instruction is useful to read the same parameter for multiple axes with different circuit and axis numbers. To read data with the STORE or EXPRESSION instructions, you need to consider an offset to address the circuit and the axis numbers.

(2) Format



Icon: 

Key entry: MOTREG-R

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Axis information (Axis-Inf)	×	○	×	×	×	×	×
Register address (Reg-No)	×	○	×	×	×	×	×
Mode	×	○	×	×	×	×	×
Write data (WR-Data)	×	○	○	×	×	×	×
Error	○*	×	×	×	×	×	×
Read data (RD-Data)	×	○*	○*	×	×	×	×

* C and # registers cannot be used. These parameters may be omitted.

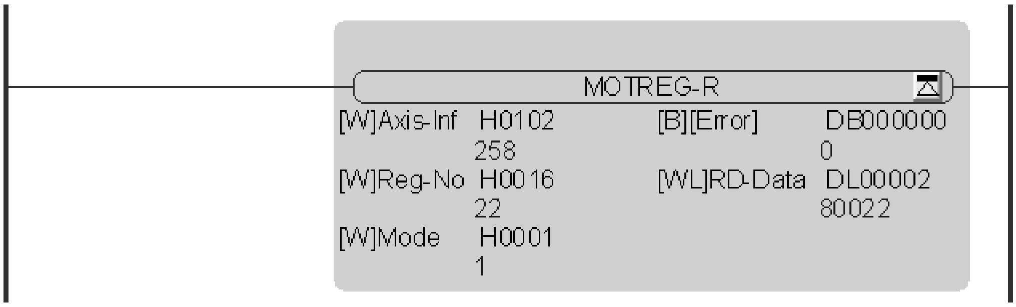
The parameters are described in the following table.

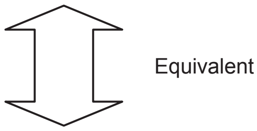
Parameter Name	Description	I/O
Axis information (Axis-Inf)	Circuit number and axis number Upper byte: Circuit number (01 to 10 hex) Lower byte: Axis number (01 to 10 hex)	IN
Register address (Reg-No)	Integer register: 0000 to 007F hex Double-length integer register: 0000 to 007E hex	IN
Mode	Register type and access size Upper byte: Register type 0: I register (monitor parameter) 1: O register (setting parameter) Others: I register Lower byte: Access size 0: Integer data 1: Double-length integer data Others: Integer data	IN
Error	Error cause (Turns ON when an error occurs.) The register cannot be written to or read from because the circuit number, axis number, or register address is outside of the valid range, or because the Module does not exist. When an error occurs, RD-Data is set to 0.	OUT
Read data (RD-Data)	If integer data is specified, the data is output with the sign.	OUT

(3) Programming Example

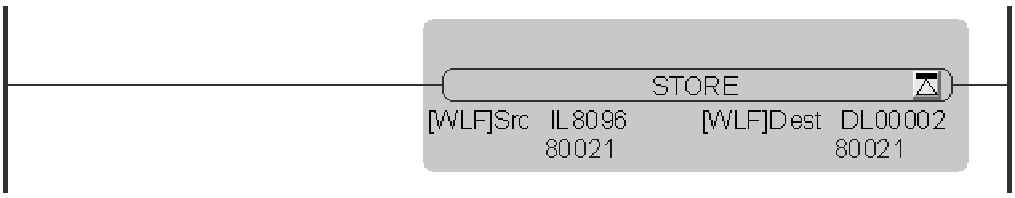
In the following programming example, the Machine Coordinate System Feedback Position in IL8096 for axis number 2 on circuit number 1 is read.
Set the following items to read the feedback position and store it in DL00002.

- Axis-Inf = 0102 hex (circuit 1, axis 2)
- Register address = 0016 hex
- Mode = 0001 hex (monitor parameter, double-length integer)





The same result can be achieved by directly specifying the register address and storing data in DL00002 with the STORE instruction.

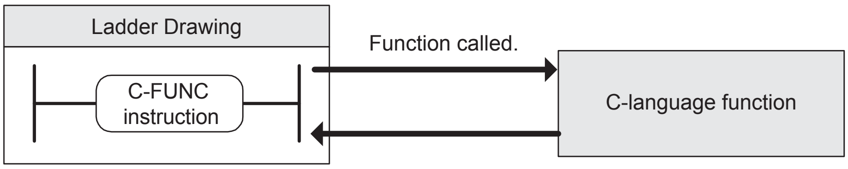


5.11 C-language Control Instructions

5.11.1 Call C-language Function (C-FUNC)

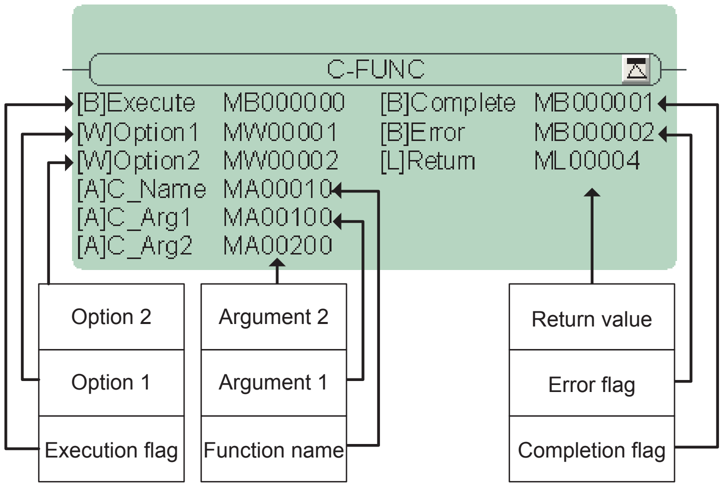
(1) Operation

This instruction calls a C-language function from a ladder drawing.



- For details on C-language functions, refer to the *Machine Controller MP2000 Series Embedded C-Language Programming Package Development Guide* (Manual No.: SIEP C880700 25).

(2) Format



Icon: C-FUNC

Key entry: C-FUNC

Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Execution flag (Execute)	○	×	×	×	×	×	×
Option 1 (Option1)	×	○	×	×	×	○	○
Option 2 (Option2)	×	○	×	×	×	○	○
Function name (C_Name)	×	×	×	×	○	×	×
Argument 1 (C_Arg1)	×	×	×	×	○*3	×	×
Argument 2 (C_Arg2)	×	×	×	×	○*3	×	×
Completion flag*1 (Complete)	○*2	×	×	×	×	×	×
Error flag*1 (Error)	○*2	×	×	×	×	×	×
Return value (Return)	×	×	○	×	×	×	×

∗ 1. Optional.
∗ 2. C and # registers cannot be used.
∗ 3. M or D register only.

Instructions

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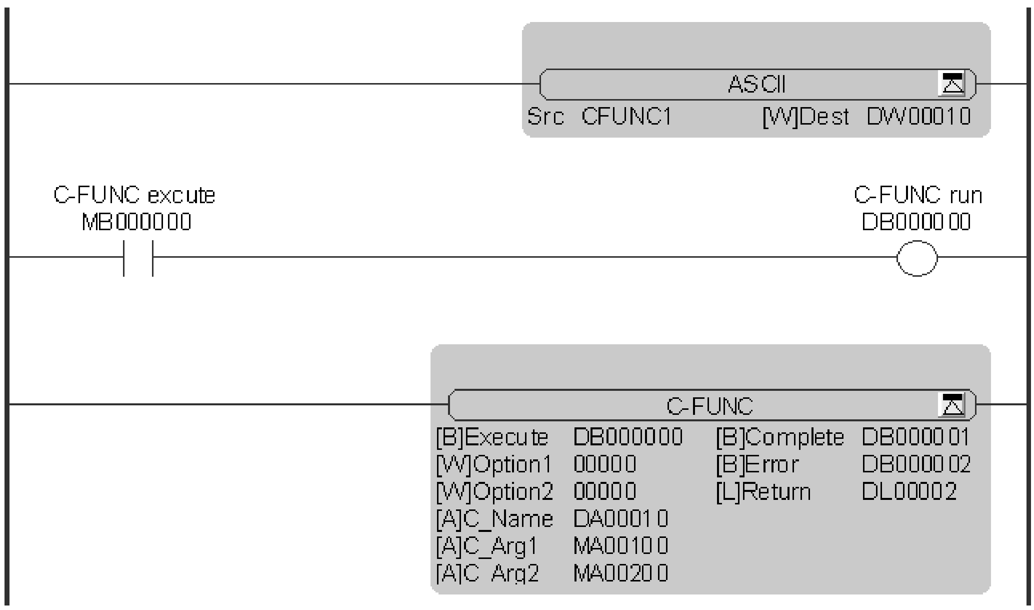
The parameters are described in the following table.

Parameter Name	Description	I/O
Execution flag (Execute)	The C-FUNC function is executed when this command turns ON.	IN
Option 1 (Option1)	Option specification 1 (for future use)	IN
Option 2 (Option2)	Option specification 2 (for future use)	IN
Function name (C_Name)	Specify the first register address to pass to argument 1 of the user C-language function.	IN
Argument 1 (C_Arg1)	Specify the first register address to pass to argument 1 of the user C-language function.	IN
Argument 2 (C_Arg2)	Specify the first register address to pass to argument 2 of the user C-language function.	IN
Completion flag (Complete)	Turns ON when execution of the C-FUNC function is completed.	OUT
Error flag (Error)	Turns ON when one of the following errors occurs. • Register limit exceeded for C_Name, C_Arg.1, or C_Arg.2.* The sizes of C_Arg.1 and C_Arg.2 are not considered. • The function specified by C_Name does not exist.	OUT
Return value (Return)	Stores the value that is returned by the user C-language function.	OUT

* This error is detected even when Execute is OFF.

(3) Programming Example

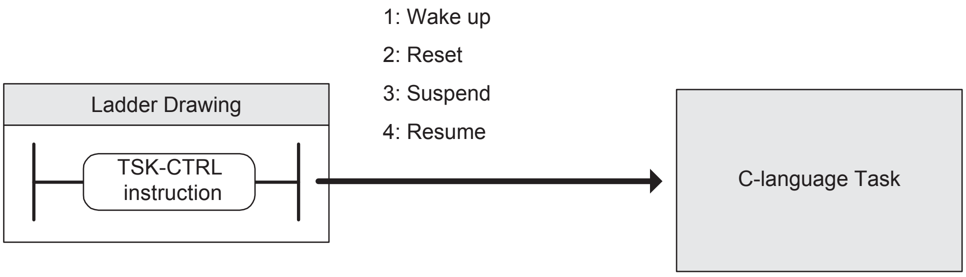
In the following programming example, the CFUNC1 C-language function is executed.
First the CFUNC1 C-language function is loaded into the Controller.
Next, when the C-FUNC execution command (MB000000) turns ON, the CFUNC1 C-language function is executed by the C-FUNC instruction.
The MA00100 and MA00200 addresses are passed to the C-language function as the arguments and the return value from the function is set in DL00002. Options 1 and 2 are not used, so 0 is set for them.



5.11.2 C-language Task Control (TSK-CTRL)

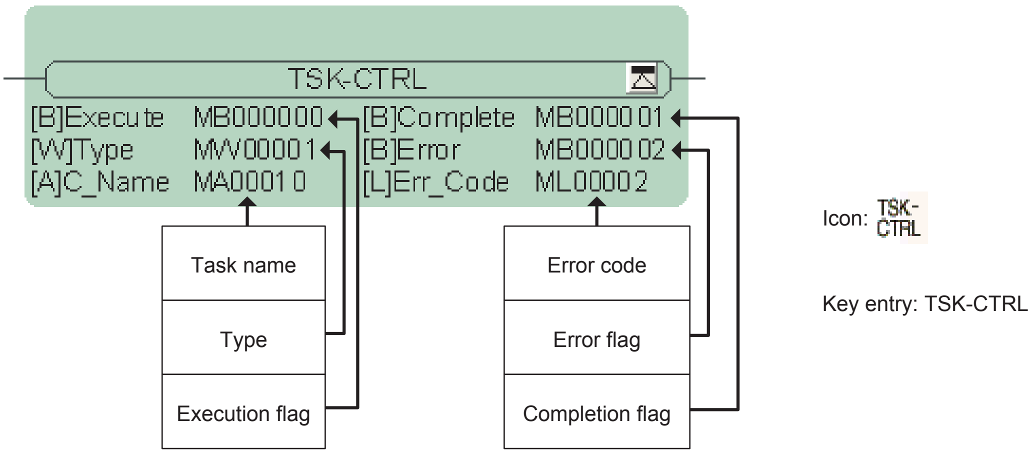
(1) Operation

This instruction controls a C-language task from a ladder drawing. The task can be woken up, reset, suspended, or resumed.



- For details on C-language functions, refer to the *Machine Controller MP2000 Series Embedded C-Language Programming Package Development Guide* (Manual No.: SIEP C880700 25).

(2) Format



Parameter Name	Applicable Data Types						
	B	W	L	F	A	Index	Constant
Execution flag (Execute)	○	×	×	×	×	×	×
Type (Type)	×	○	×	×	×	○	×
Task name (C_Name)	×	×	×	×	○	×	×
Completion flag (Complete)	○*	×	×	×	×	×	×
Error flag (Error)	○*	×	×	×	×	×	×
Error code (Err_code)	×	×	○*	×	×	×	×

* C and # registers cannot be used.

The parameters are described in the following table.

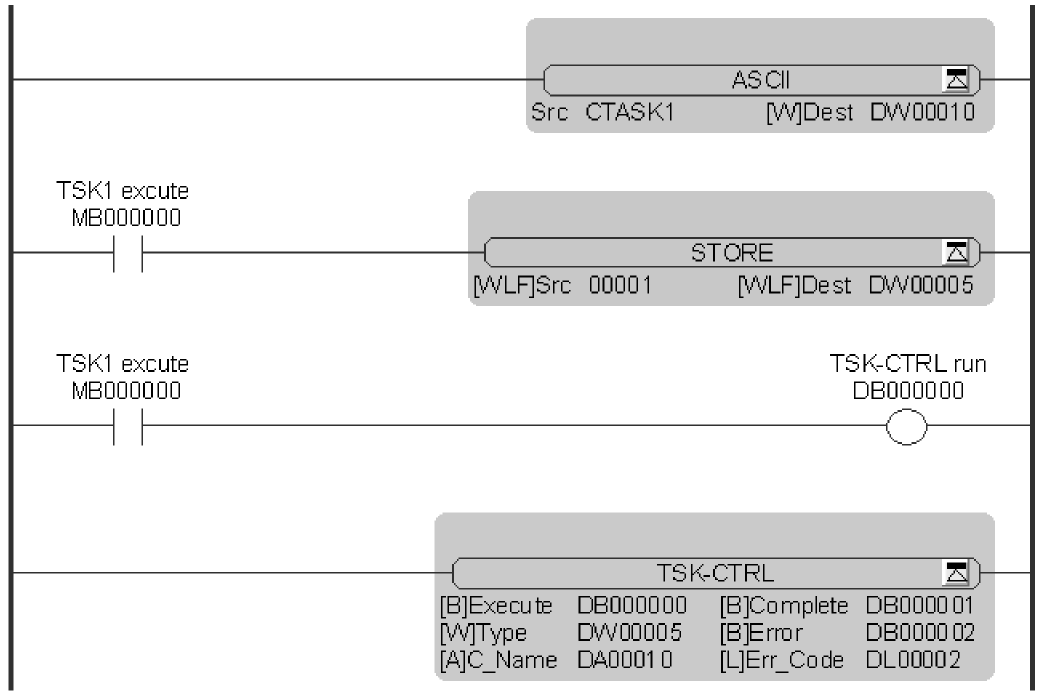
Parameter Name	Description	I/O
Execution flag (Execute)	The TSK-CTRL instruction is executed when this command turns ON.	IN
Type (Type)	1: Wake up A task that is in WAIT state is woken up. 2: Reset A task is ended, deleted, generated again, and started. The task then executes itself and goes into WAIT state. 3: Suspend The task is suspended and placed in SUSPEND state. 4: Resume A task in SUSPEND state is changed to READY state.	IN
Task name (C_Name)	Specify the first register address of the registers in which the task name of the user C-language task is stored.	IN
Completion flag (Complete)	Turns ON when execution of the TSK-CTRL instruction is completed.	OUT
Error flag (Error)	Turns ON when an error occurs. (The error is given in Err_code.)	OUT
Error code (Err_code)	Error Codes 0☐00000000 No error 0☐00000091 Type setting error • The value of Type is outside of the valid range. • Type was set to Wake up when the state was not WAIT or WAIT-SUSPEND. • Type was set to Suspend when the state was not WAIT or READY. 0☐00000094 The task specified by C_Name does not exist. 0☐00000096 Register upper/lower limit exceeded for C_Name.*1 0☐FFFFFFDD Error detected by µITRON: Illegal ID number*2 0☐FFFFFFCC Error detected by µITRON: Task not registered*2 0☐FFFFFFC1 Error detected by µITRON: Illegal object state • The task is in DORMANT state. • Resume was specified when the task was not in SUSPEND state. 0☐FFFFFFBB Error detected by µITRON: Context error • The task could not be executed in a non-task context. 0☐FFFFFFB7 Error detected by µITRON: Queuing overflow*2	OUT

∗ 1. Execute is not treated as a rising edge, but as a level. This allows cyclic execution in the high scan level and low scan level tasks.

∗ 2. The errors that are detected by µITRON normally do not occur because of system management.

(3) Programming Example

In the following programming example, the CTASK1 C-language task is executed.
First the CTASK1 C-language task is loaded into the Controller.
Next, when the TSK1 execute command (MB000000) turns ON, the CTASK1 C-language task is executed by the TSK-CTRL instruction.



6

Features of the MPE720 Engineering Tool

This chapter describes the key features of the MPE720 Engineering Tool for ladder programming. Refer to the *Engineering Tool for MP2000 Series Machine Controller MPE720 Version 6 User's Manual* (SIEP C880700 30) for details on these features, information on other features, and operating procedures.

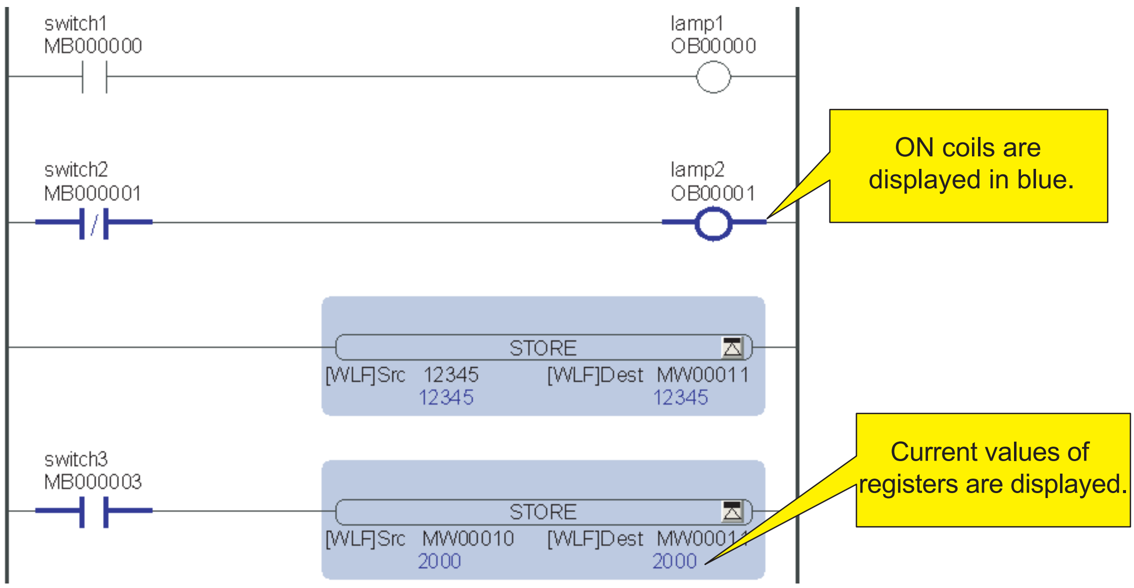
This chapter describes the following ladder programming and debugging features of MPE720 version 6.

- Ladder program runtime monitoring
- Searching/replacing
- Cross references
- Multiple coils
- Forcing coils ON and OFF
- Viewing called programs
- Register lists
- Tuning panel
- Enabling and disabling ladder programs
- Compiling for MPE720 version 5

MPE720 version 6 provides many other features. Refer to the *Engineering Tool for MP2000 Series Machine Controller MPE720 Version 6 User's Manual* (SIEP C880700 30) for details on these features and information on other features.

6.1 Ladder Program Runtime Monitoring

You can monitor the execution status of each instruction. Using runtime monitoring requires a connection to the Machine Controller.
Instructions where the relay output is ON are displayed in blue.
The current values of the parameter registers of the instructions that are being executed are also displayed.

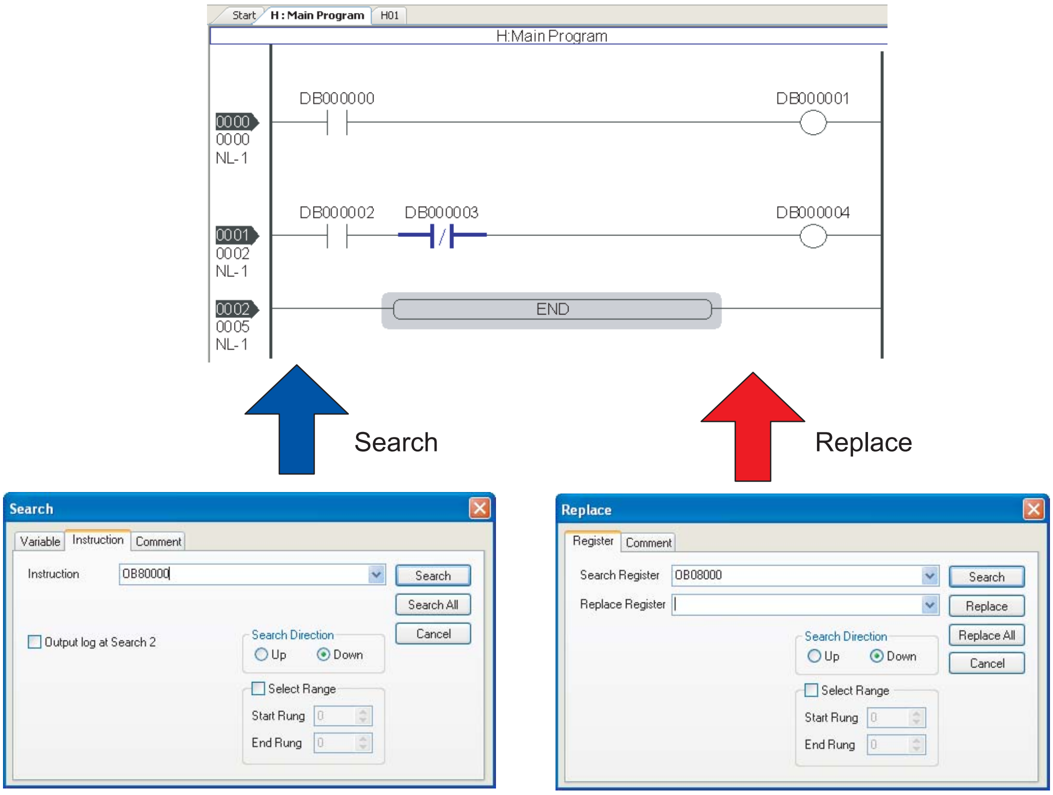


6.2 Searching/Replacing

Two different search/replace operations are provided.

- Searching and Replacing in Programs
  You can search for and replace variables, instructions, and comments in the currently active ladder drawing.

- Searching and Replacing in Project Files
  You can search for and replace variables in all ladder drawings in a project file.
  You can use this operation only when the MPE720 is not connected to the Machine Controller.



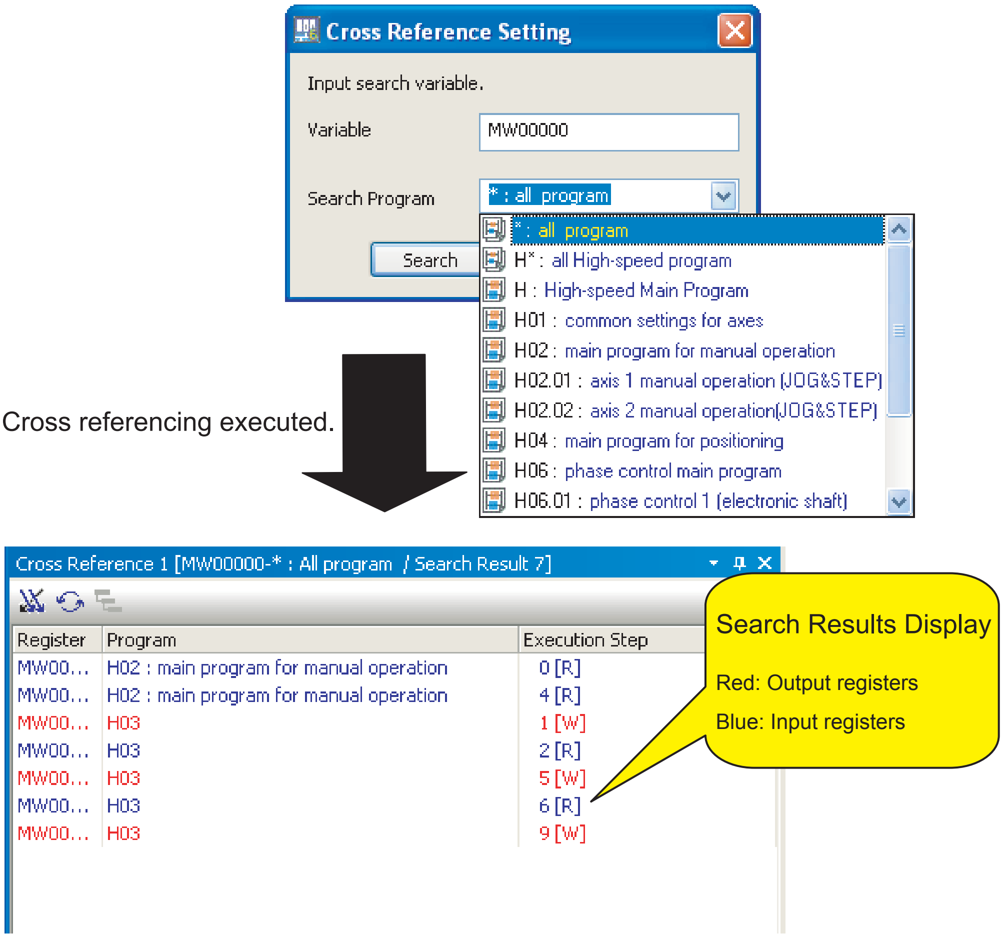
Search Dialog Box

Replace Dialog Box

You can search for and replace variables, comments, and other items.

6.3 Cross References

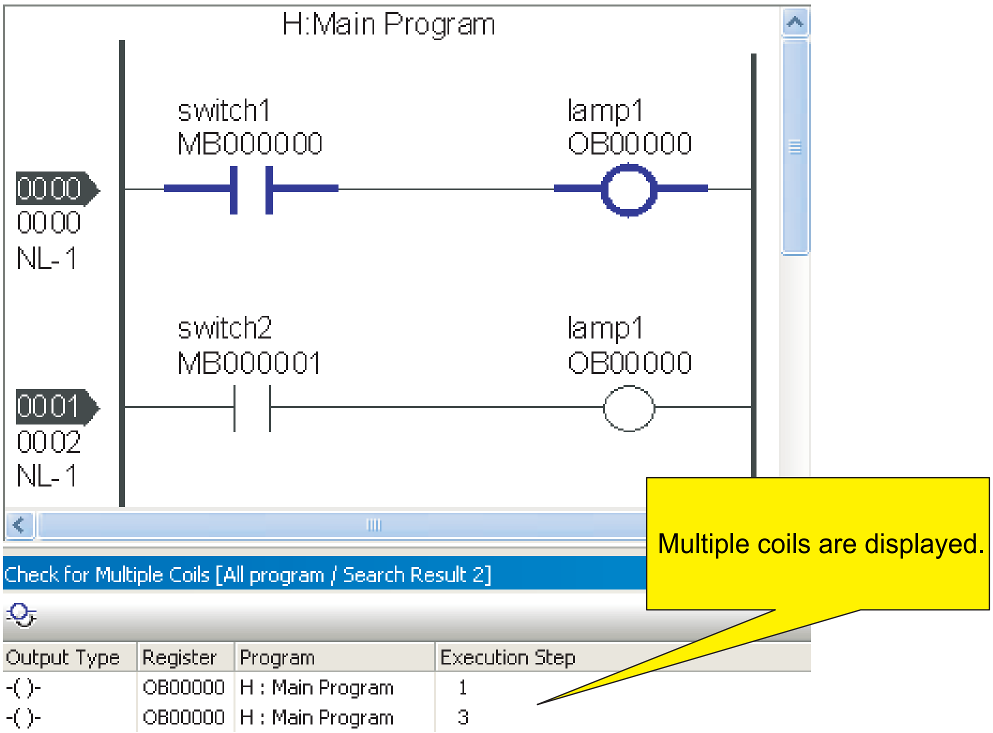
Cross referencing allows you to check whether a register is used in a program, and where it is used.
The search results indicate output registers in red, input registers in blue.



If the value of a register is different from its set value, it means that the value of the register may have been overwritten somewhere in the program. In this case, you can search for the registers using cross references. Check the registers displayed in red to locate the instructions that are overwriting them.

6.4 Checking for Multiple Coils

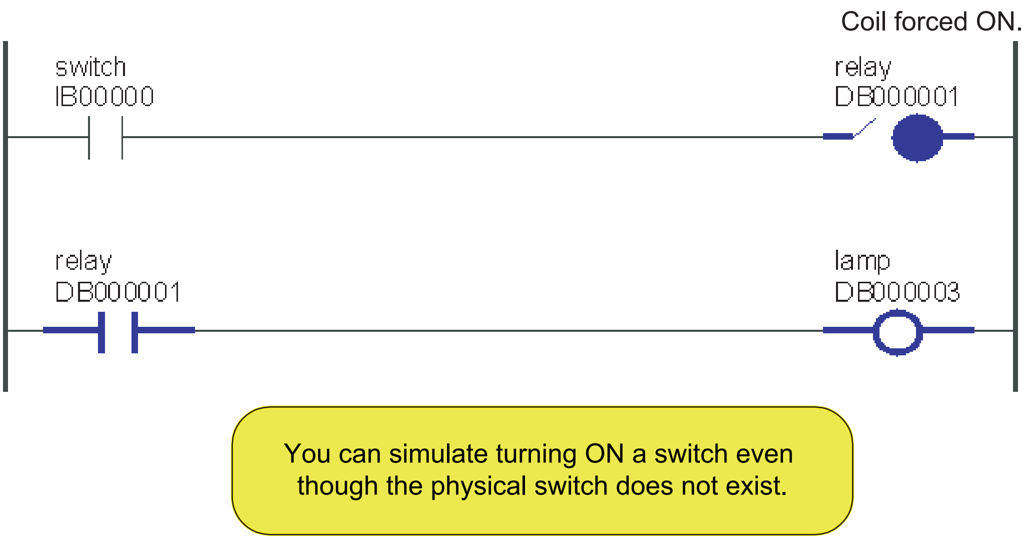
You can check for multiple coils (different coils that use the same register) in an entire ladder program, and display the search results.



6.5 Forcing Coils ON and OFF

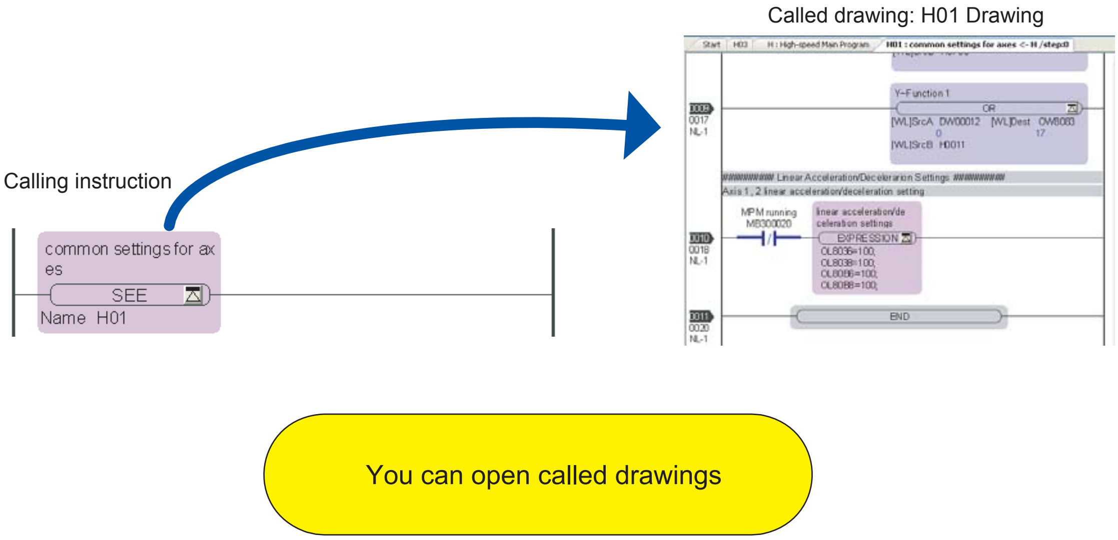
You can force a specified coil ON or OFF from the Ladder Editor.
The coil will output ON or OFF regardless of the output of the instruction to the left of the coil.

In the following example, you can simulate turning ON the switch (IB00000) by forcing the DB000001 relay ON even though the physical switch does not exist.



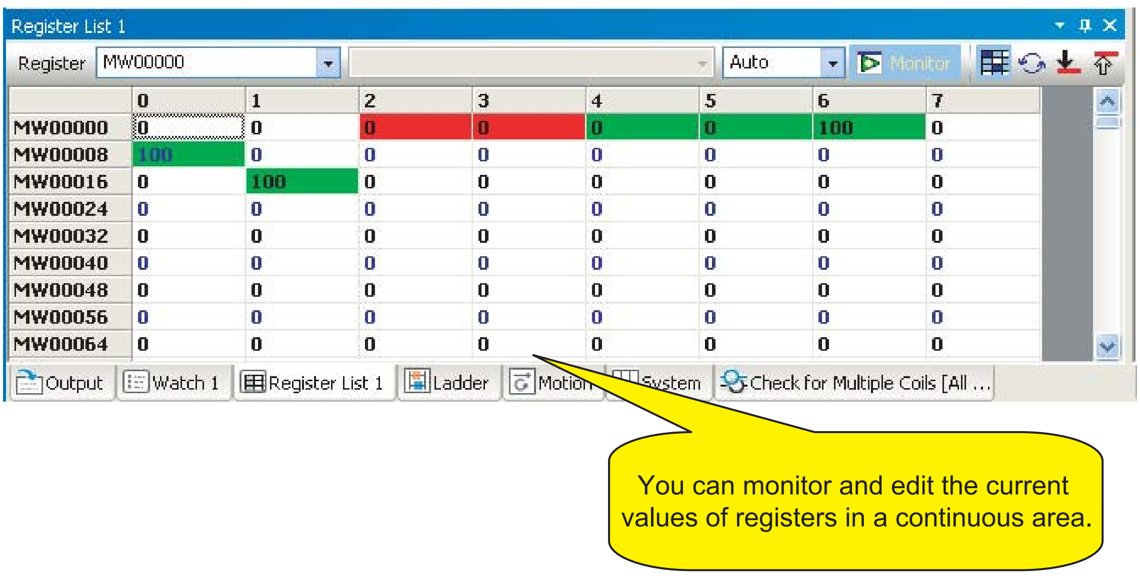
6.6 Viewing Called Programs

You can open a drawing that is called with an SEE instruction or an FUNC instruction.



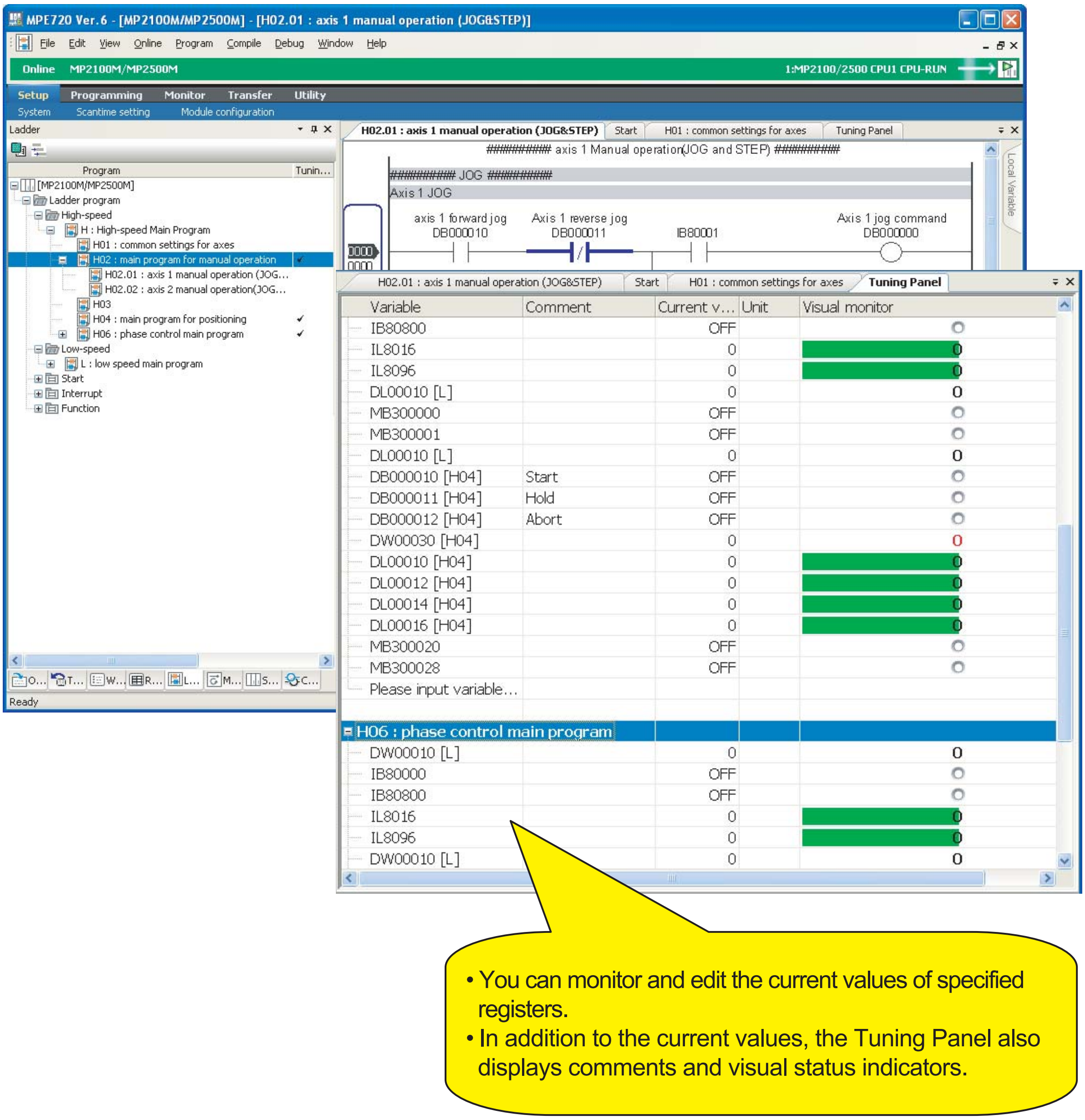
6.7 Register Lists

You can monitor and edit the current values of the registers in a continuous area on a register list. Realtime monitoring and editing are possible if the Machine Controller is connected.
Also, if you turn ON display of the register map, registers that are used in the ladder program are displayed with a green background, and registers that are used for more than one data type are displayed with a red background.



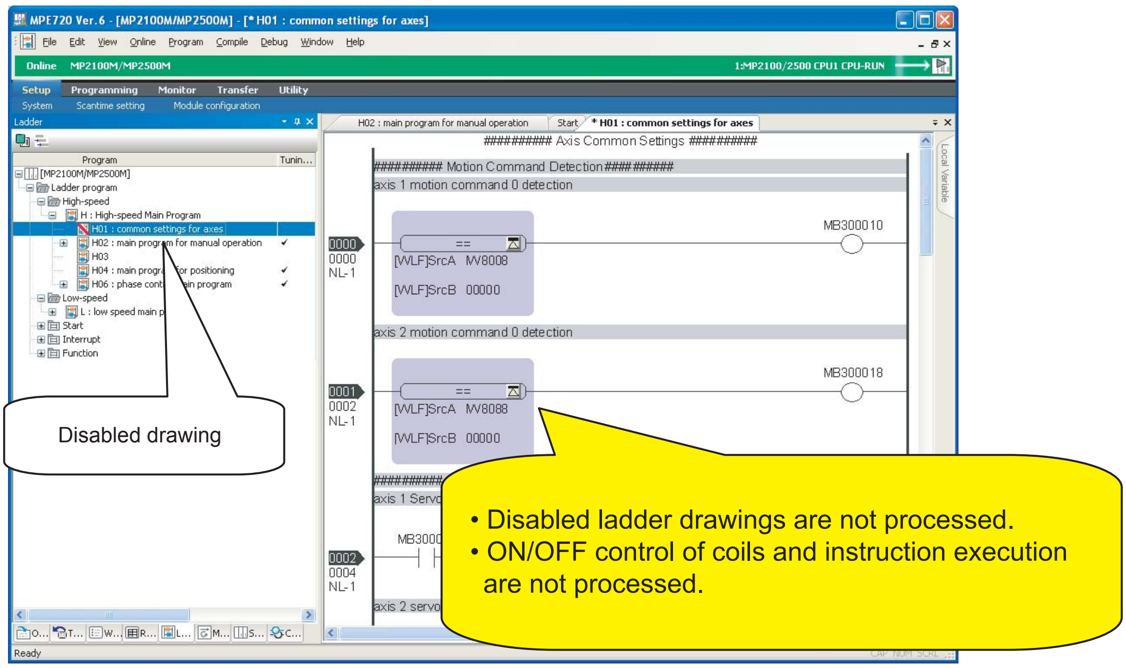
6.8 Tuning Panel

The Tuning Panel allows you to display and edit the current values of pre-registered variables.
You can use the Tuning Panel to control and check the operation of your application.
You can adjust the **Visual monitor** Column to display data according to specific conditions.

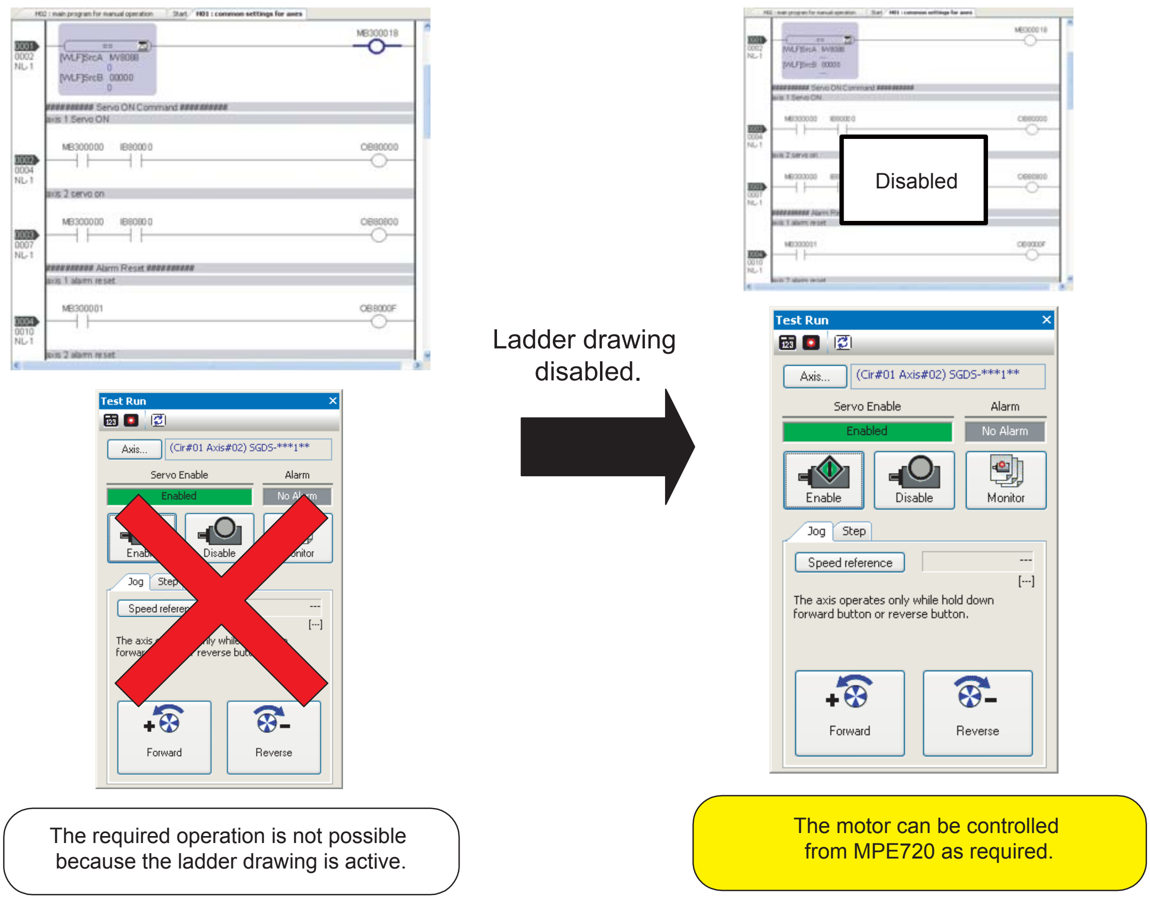


6.9 Enabling and Disabling Ladder Programs

You can enable and disable individual drawings in ladder programs.



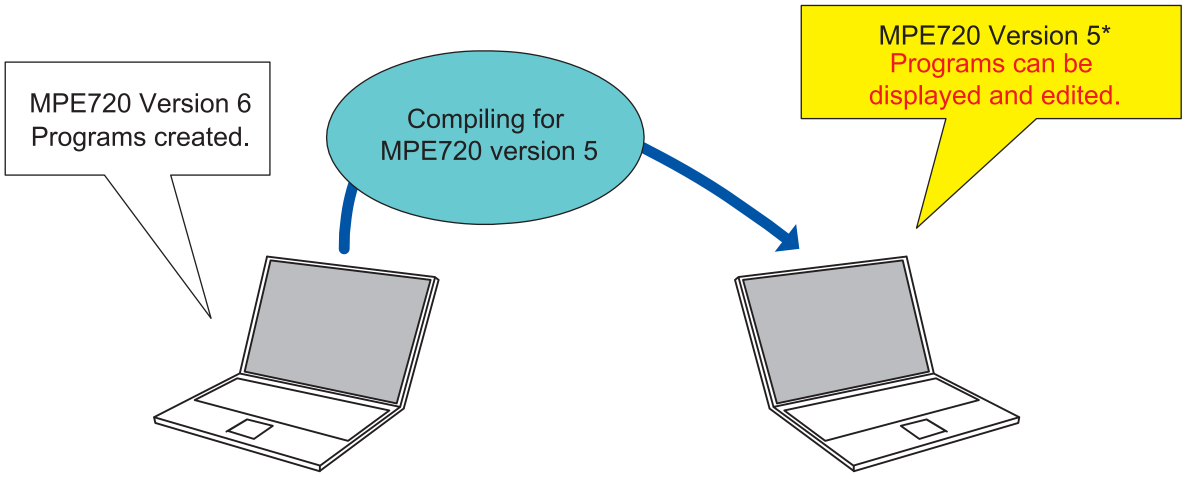
This feature is used to temporarily disable ladder drawings that contain processing to turn ON the power supply to servomotors or jog processing for servomotors. This allows you to check the operation of individual servomotors with the test run operation of the MPE720 or the Module configuration definition.



6.10 Compiling for MPE720 Version 5

Compiling for MPE720 version 5 allows you to display and edit ladder programs on MPE720 version 5 (version 5.34 or higher) even when you compile them on MPE720 version 6.

However, compiling errors will occur if notation that is supported only on MPE720 version 6 is used.
If you do not compile for MPE720 version5, you will not be able to display and edit the ladder programs that you create on MPE720 version 6 on MPE720 version 5.



* MPE720 version 5.34 or higher is required to display and edit programs that were compiled for MPE720 version 5 on MPE720 version 6.

7

Troubleshooting

This chapter describes troubleshooting.

7.1 Basic Flow of Troubleshooting

When a problem occurs, it is important to quickly find the cause of the problem and get the system running again as quickly as possible. The basic troubleshooting flow is illustrated below.

Step 1	Visually confirm the following items.
• Machine movement • Power supply • I/O device status • Wiring status • Indicator status (LED indicators on each Module) • Switch settings (e.g., DIP switches) • Parameter settings and program contents	

↓

Step 2	Monitor the system to see if the problem changes in response to the following operations.
• Switching the Controller to STOP status • Resetting alarms • Turning the power supply OFF and ON again	

↓

Step 3	Determine the location of the cause from the results of steps 1 and 2.
• Controller or external? • Sequence control or motion control? • Software or hardware?	

7.2 Indicator Status

The pattern of the indicators on the MP2000-series Machine Controller shows the operating status. The following table gives the indicator lighting patterns and corresponding corrective actions.

Class	Indicator Status					Meaning	Corrective Action
	RDY	RUN	ALM	ERR	BAT		
Normal	Not lit.	Not lit.	Lit.	Lit.	Not lit.	Hardware has been reset.	Normally, the CPU Unit will start within 10 seconds. If more than 10 seconds is required, there is an error in a user program or a hardware failure.
	Not lit.	Not lit.	Not lit.	Not lit.	Not lit.	The Machine Controller is being initialized.	
	Not lit.	Lit.	Not lit.	Not lit.	Not lit.	Drawing A is being executed.	
	Lit.	Not lit.	Not lit.	Not lit.	Not lit.	The user program is stopped. (The Machine Controller is in Offline Stopped Mode.)	This status is entered at the following times. It does not represent an error. • The stop operation was performed from the MPE720. • The STOP switch was turned ON.
	Lit.	Lit.	Not lit.	Not lit.	Not lit.	The user programs are being executed normally.	Normal operation is in progress.
Error	Not lit.	Not lit.	Not lit.	Lit.	Not lit.	A serious failure, watchdog timer error, or Module synchronization error has occurred.	A hardware failure, watchdog timer error, or Module synchronization error has occurred. Refer to *7.3 Problem Classifications.*
	Not lit.	Not lit.	Not lit.	Flashing.	Not lit.	A software error occurred. Number of Flashes 3: Read address error exception 3: Write address error exception 5: FPU exception 6: General illegal instruction exception 7: Slot illegal instruction exception 8: General FPU suppression exception 9: Slot FPU suppression exception 10: TLB multibit exception 11: LTB reading error exception 12: LTB writing error exception 13: LTB read protection violation exception 14: LTB write protection violation exception 15: Initial page write exception	A system error occurred. Refer to *7.4.5 System Errors.*
	Not lit.	Not lit.	Flash ing.	Flashing.	Not lit.	A hardware error occurred. Number of Flashes 2: RAM diagnostic error 3: ROM diagnostic error 4: CPU Function Module diagnostic error 5: FPU Function Module diagnostic error	A hardware failure has occurred. Replace the Module.
Alarm	–	–	–	–	Lit.	Battery alarm	Replace the Battery.
	Lit.	Lit.	Lit.	Not lit.	Not lit.	An operation error occurred. An I/O error occurred.	• Operation Errors Refer to *7.4.1 Operation Errors.* • I/O Errors Refer to *7.4.2 I/O Errors.*

7.3 Problem Classifications

7.3.1 Overview

The following table gives the problems that can occur on an MP2000-series Machine Controller and the indicator lighting patterns.

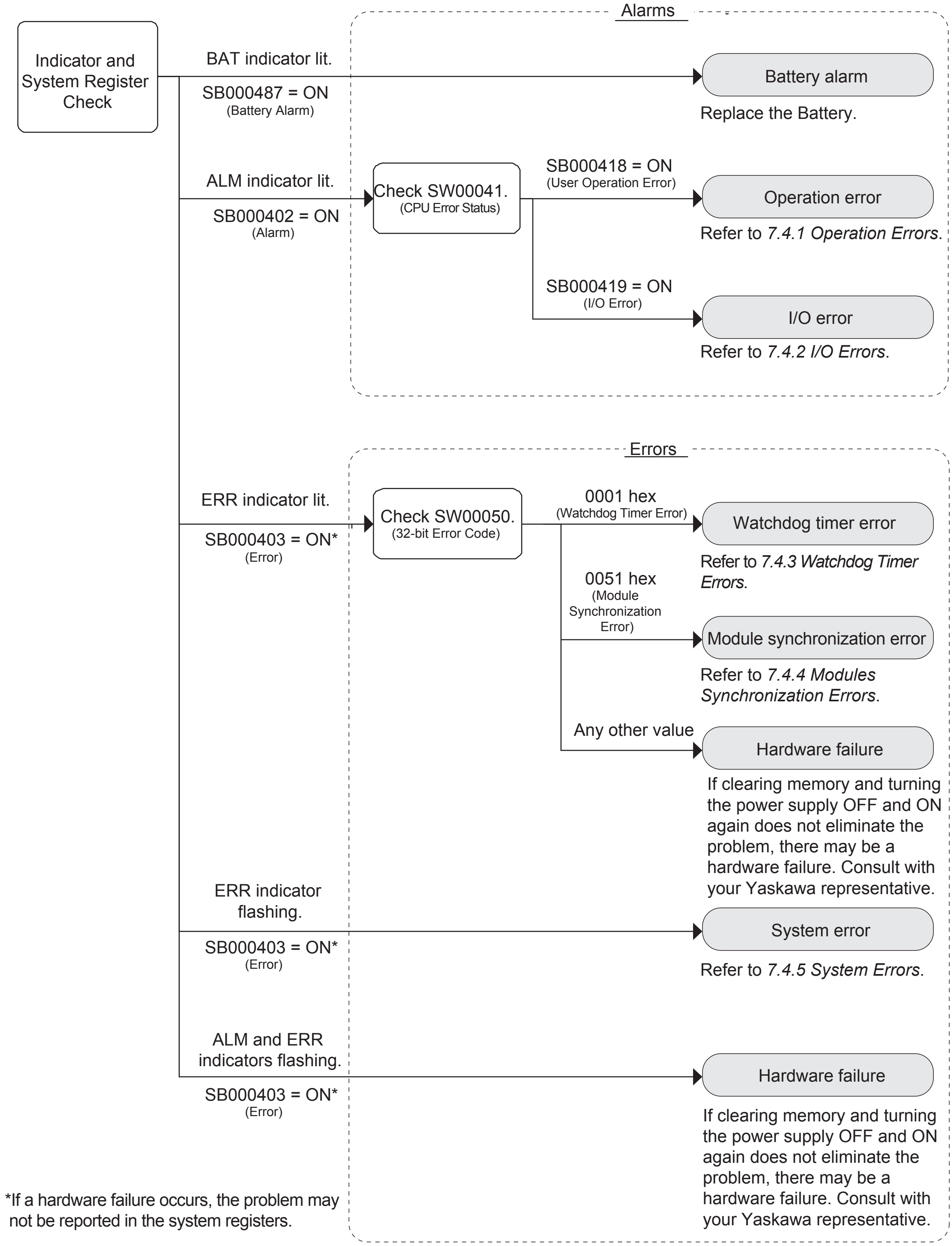
Classification	Problem	Indicators		
		ALM	ERR	BAT
Alarm	Battery alarm	Not lit.	Not lit.	Lit.
	Operation error	Lit.	Not lit.	Not lit.
	I/O error	Lit.	Not lit.	Not lit.
	Motion program alarm*1	Not lit.	Not lit.	Not lit.
	Axis alarm/warning *2	Not lit.	Not lit.	Not lit.
Error	Watchdog timer error	Not lit.	Lit.	Not lit.
	Module synchronization error	Not lit.	Lit.	Not lit.
	System error	Not lit.	Flashing.	Not lit.
	Hardware failure	Not lit.	Lit.	Not lit.
		Flashing.	Flashing.	Not lit.

∗ 1. If a motion program alarm occurs, refer to *Chapter 10 Troubleshooting* in the *Machine Controller MP2000 Series User's Manual for Motion Programming* (Manual No.: SIEP C880700 38) and clear the alarm.

∗ 2. If an axis alarm/warning occurs, refer to the user's manual for your Motion Module and clear the alarm.

7.3.2 Error Checking Flowchart for MP2000-series Machine Controllers

Use the following flowchart to troubleshoot problems based on the indicators and system registers.



Troubleshooting

7

7.4 Detailed Troubleshooting

7.4.1 Operation Errors

Operation errors can be caused by the following problems.

- An illegal operation was performed in a ladder program.
- An illegal operation was performed in a motion program.
- An illegal operation was performed in a sequence program.

If an operation error occurs, use the following procedure to isolate the error.

1. Check the contents of SW00080 to SW00089 to identify the type of drawing and error.

Information on operation errors is stored in the following system registers according to the type of drawing in which the error occurred. Information on errors in motion programs is stored in the system registers for DWG.H.

<table>
<tr><th>Drawing Type</th><th>Error</th><th>Register Address</th><th>Description</th></tr>
<tr><td rowspan="2">DWG.A</td><td>Error Count</td><td>SW00080</td><td rowspan="8">• Error Count
Gives the number of errors that have occurred.

• Error Code
Bit 15 ····· 12 | Bit 11 ···· 0
Index error | Error code
Refer to A.9 Interrupt Status for information on error codes.</td></tr>
<tr><td>Error Code</td><td>SW00081</td></tr>
<tr><td rowspan="2">DWG.I</td><td>Error Count</td><td>SW00082</td></tr>
<tr><td>Error Code</td><td>SW00083</td></tr>
<tr><td rowspan="2">DWG.H</td><td>Error Count</td><td>SW00084</td></tr>
<tr><td>Error Code</td><td>SW00085</td></tr>
<tr><td rowspan="2">DWG.L</td><td>Error Count</td><td>SW00088</td></tr>
<tr><td>Error Code</td><td>SW00089</td></tr>
</table>

■ Example: When SW00085 Contains a Value Other Than 0000 Hex

You can tell that an operation error occurred in high-speed scan processing. If the value in SW00084 is continuously incremented, it means that the instruction that is causing the operation error is being executed continuously.

2. Check the contents of SW00122, SW00138, SW00154, and SW00186 to identify the drawing number.

<table>
<tr><th>Name</th><th>Register Address</th><th>Description</th></tr>
<tr><td>DWG.A Error Drawing No.</td><td>SW00122</td><td rowspan="4">Parent drawing: FFFF hex
Child drawing: xx00 hex (xx hex: Child drawing number)
Grandchild drawing: xxyy hex (yy hex: Grandchild drawing number)
Function: 8000 hex
Motion program/sequence program: F0xx hex (xx hex: Program number)</td></tr>
<tr><td>DWG.I Error Drawing No.</td><td>SW00138</td></tr>
<tr><td>DWG.H Error Drawing No.</td><td>SW00154</td></tr>
<tr><td>DWG.L Error Drawing No.</td><td>SW00186</td></tr>
</table>

3. Identify the instruction that caused the error in the drawing.

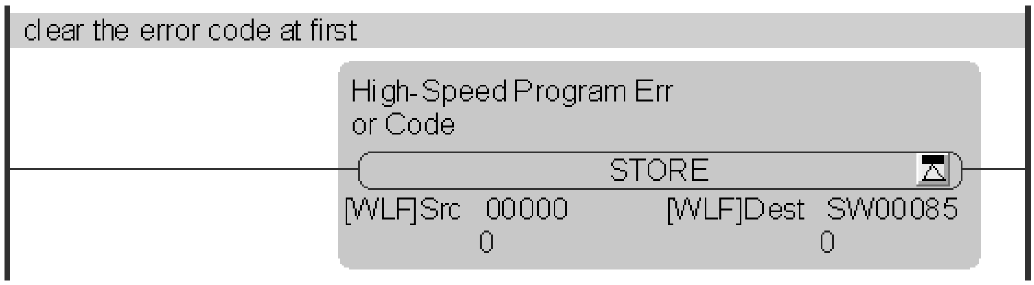
The method to identify operation errors is different for integer operations and real number operations. To identify operation errors for integer operations, refer to ■ *Troubleshooting Method 1.*
To identify operation errors for real number operations, refer to ■ *Troubleshooting Method 2.*

■ Troubleshooting Method 1

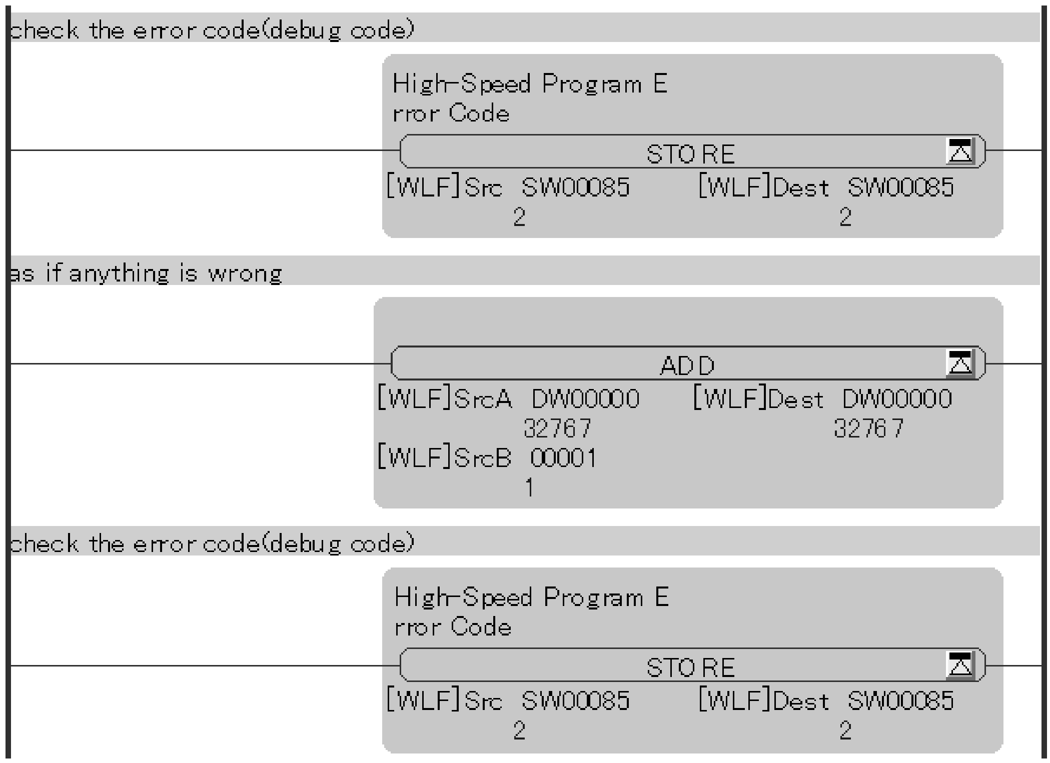
You can use the following procedure to troubleshoot operation errors that occur in DWG.H (0002 hex: Integer operation overflow).

1. Identify the error drawing number with the SW00154 system register and open that drawing.

2. Add the following code to the beginning of the drawing.



3. Add debugging code before and after the instruction that you think is causing the error.



4. Check the contents of the register address in the debugging code.
If it changes from 0 (no error) to 2 (integer operation overflow), an integer operation overflow has occurred.

5. Repeat steps 3 and 4, above, to isolate the instruction that is causing the error.

INFO

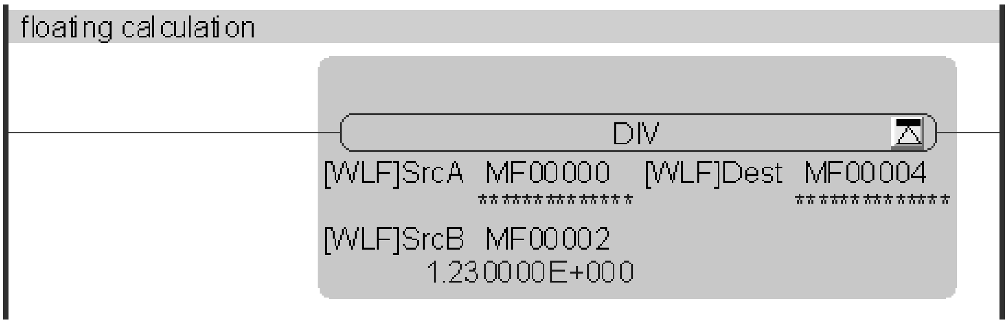
You can use the above debugging method only with an integer or double-length integer operation.
You cannot use the above debugging method with real number operations.

■ Troubleshooting Method 2

You can use the following procedure to troubleshoot operation errors that occur in DWG.H (0030 hex: Invalid real number operation (not a number)).

1. Identify the error drawing number with the SW00154 system register and open that drawing.

2. Check the value of the real number operation with the online monitor.



In this example, MF000000 in the DIV instruction is "************".
"************" indicates an illegal value for a real number (not a number). If you use that value in a real number operation, the system will generate an operation error (0030 hex: Invalid real number operation (not a number)).

INFO

Operation errors can be caused by the following problems.
- A value is not set in a register (undefined data).
- A bit, integer, or double-length integer operation was performed for a register that uses the same address.

To perform real number operations, you must set real number values.

3. Repeat step 2, above, to isolate the register that is causing the error.

7.4.2 I/O Errors

An I/O error can occur in the following cases.

- Option Module allocations or Module detail definitions were set in the Module Configuration.
- A cable was disconnected or a Module failed while the system was operating.

If an I/O error occurs, you can check the following system registers to check the I/O error.

Name	Register Address	Description
I/O Error Count	SW00200	Number of I/O errors that have occurred (total of SW00201 and SW00203).
Input Error Count	SW00201	Number of input errors that have occurred
Output Error Count	SW00203	Number of output errors that have occurred

You can also use the following system registers to find the address of the I/O register (IW□□□□/OW□□□□) for which the I/O error occurred.

■ Example: When an I/O Error Was Detected for an I/O Device Assigned to IW1234

A value of 1234 hex will be stored in SW00202.

Name	Register Address	Meaning
Input Error Address	SW00202	The latest input error address (register address in IW□□□□)
Output Error Address	SW00204	The latest output error address (register address in OW□□□□)

After you find the I/O register address, identify the slot of the Module and then find the I/O status from the following system registers.
For details on I/O status, refer to *2.5.5 System I/O Error Status* in the *Machine Controller MP2000 Troubleshooting Manual* (Manual No.: SIJP C880700 40 (Japanese version)).

Name	Register Address	Meaning
Input Error Address	SW00208 to SW00215	CPU Function Module
	SW00216 to SW00223	Reserved for system.
	SW00224 to SW00231	Error status of Rack 1, Slot 1
	SW00232 to SW00239	Error status of Rack 1, Slot 2
	SW00240 to SW00247	Error status of Rack 1, Slot 3
	SW00248 to SW00255	Error status of Rack 1, Slot 4
	...	...
	SW00496 to SW00503	Error status of Rack 4, Slot 9

7.4.3 Watchdog Timer Errors

Watchdog timer errors can be caused by the following problems.

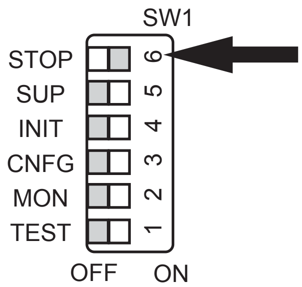
- An infinite loop occurs in a user program.
- The scan time is exceeded by a user program.
- A Motion Module*1 fails.
- A watchdog timer error occurs in an MPU-01 Module.*2

* 1. Motion Modules: PO-01, SVA-01, SVB-01, SVC-01, and MPU-01

* 2. If a watchdog error occurs when you are using an MPU-01 Module, refer to *Chapter 6 Troubleshooting* in the *Machine Controller MP2000 Series MPU-01 Multiple-CPU Module User's Manual* (Manual No.: SIEP C880781 05).

If a watchdog timer error occurs, it is important to determine if the cause of the error is in the CPU Module or in a Motion Module.

To determine where the cause of the error was, stop the programs in the CPU Module and then restart the CPU Module to see if the problem changes.



Turn ON the STOP switch on the front panel of the CPU Unit and then turn the power supply OFF and ON again to start the CPU Module without executing the ladder programs in the CPU Module.

If a watchdog timer does not occur when the programs in the CPU Module are stopped, it is very likely that the cause of the error is in the CPU Module. Check the programs to see if there are any infinite loops.

If this does not solve the problem, then there is a chance that the Motion Module is faulty. Consult with your Yaskawa representative.

7.4.4 Module Synchronization Errors

Module synchronization errors can be caused by the following problems.

- A Motion Module*1 fails.
- A watchdog timer error occurs in an MPU-01 Module.*2

* 1. Motion Modules: PO-01, SVA-01, SVB-01, SVC-01, and MPU-01

* 2. If a Module synchronization error occurs when you are using an MPU-01 Module, refer to *Chapter 6 Trouble-shooting* in the *Machine Controller MP2000 Series MPU-01 Multiple-CPU Module User's Manual* (Manual No.: SIEP C880781 05).

If a Module synchronization error occurs (i.e., if SW00050 = 0051 hex), the slot where the Module synchronization error was detected is reported in the system registers given in the following table.

Register Address	Description
SW00076	Slot where Module synchronization error was detected* xxyy hex: xx: Rack number (01 to 04), yy: Slot number (01 to 09)

* Module synchronization errors are reported for CPU Modules with a system software version of 2.75 or higher. For version 2.74 or lower, it is reported as a watchdog timer error.

If a Module synchronization error occurs, consult with your Yaskawa representative.

7.4.5 System Errors

System errors can be caused by the following problems.

- Illegal processing was performed in a user program.
- A problem occurred in the installation environment.
- A hardware failure occurred.

If you are using embedded C-language programs, a system error that results in the system going down can be caused by illegal pointer access or an illegal operation on floating-point data. The causes of system errors are given in the following table.

Number of Flashes of ERR Indicator	Error	Cause	Corrective Action
3 times	Read address error exception	Long word (32-bit) or word (16-bit) data was read from an incorrect address.*	Check for the types of illegal processing given on the left and correct any problems.
4 times	Write address error exception		
5 times	FPU exception	An illegal operation was performed for floating-point data (not a number, division by 0, overflow, etc.)	

* For details, refer to *Chapter 10 Precautions* in the *Machine Controller MP2000 Series Embedded C-Language Programming Package Development Guide* (Manual No.: SIEP C880700 25).

If you are not using embedded C-language programs or if you are using embedded C-language programs and none of the above illegal programming problems exist, the cause may be a hardware error.
Hardware errors can be caused by the installation environment or by failures in the hardware itself.

If there are no problems in the installation environment and the error recurs regardless of corrective actions, the hardware itself may have failed. Consult with your Yaskawa representative.

Appendix A

System Registers

This appendix describes the registers that are provided by the system of the Machine Controller.

System registers are provided by the MP2000-series Machine Controller system. They can be used to read system error information, the current operating status, and other information.

	Contents
SW00000	System Service Registers
SW00030	System Status
SW00050	System Error Status
SW00080	Overview of User Operation Error Status
SW00090	System Service Execution Status
SW00110	Detailed User Operation Error Status
SW00190	Alarm Counter and Alarm Clear
SW00200	System I/O Error Status
SW00504	Reserved for system.
SW00652	CF Card-related System Registers (MP2200-series CPU-02 and CPU-03 only)
SW00698	Interrupt Status
SW00800	Module Information
SW01312	Reserved for system.
SW01411	MPU-01 Module System Status
SW02048	Reserved for system.
SW03200	Motion Program Information
SW05200 to SW08191	Reserved for system.

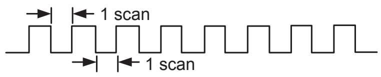
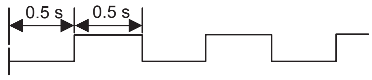
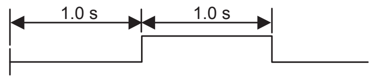
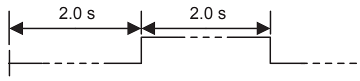
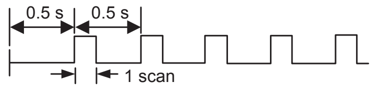
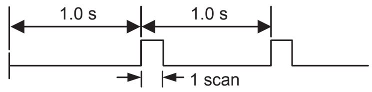
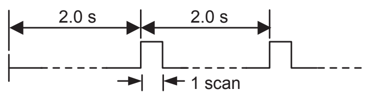
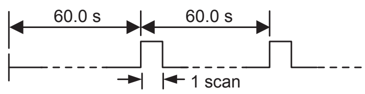
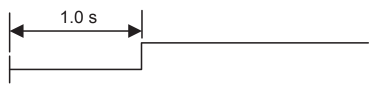
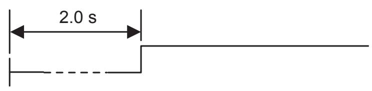
A.1 System Service Registers

(1) Common to All Drawings

Name	Register Address	Remarks
Reserved for system.	SB000000	Not used.
High-speed Scan	SB000001	ON for only the first scan after the high-speed scan starts.
Low-speed Scan	SB000003	ON for only the first scan after low-speed scan starts.
Always ON	SB000004	Always ON (1).
Reserved for system.	SB000005 and SB000006	Not used.
High-speed Scan in Progress	SB000007	ON (1) during execution of the high-speed scan.
Reserved for system.	SB000008 to SB00000F	Not used.

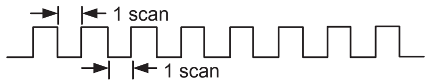
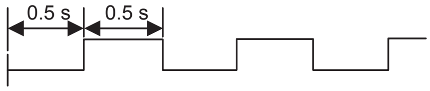
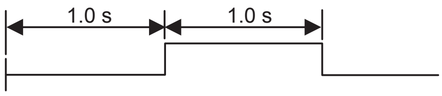
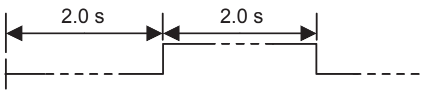
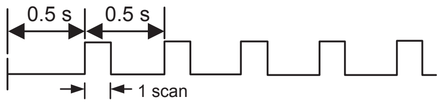
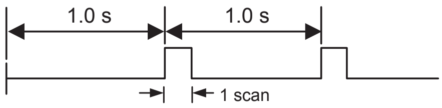
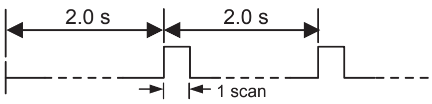
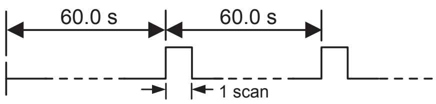
(2) Exclusive to DWG.H Only

Operation starts when the high-speed scan starts.

Name	Register Address	Remarks
1-scan Flicker Relay	SB000010	
0.5-s Flicker Relay	SB000011	
1.0-s Flicker Relay	SB000012	
2.0-s Flicker Relay	SB000013	
0.5-s Sampling Relay	SB000014	
1.0-s Sampling Relay	SB000015	
2.0-s Sampling Relay	SB000016	
60.0-s Sampling Relay	SB000017	
1.0 s After Start of Scan Relay	SB000018	
2.0 s After Start of Scan Relay	SB000019	
5.0 s After Start of Scan Relay	SB00001A	

(3) Exclusive to DWG.L Only

Operation starts when the low-speed scan starts.

Name	Register Address	Remarks
1-scan Flicker Relay	SB000030	
0.5-s Flicker Relay	SB000031	
1.0-s Flicker Relay	SB000032	
2.0-s Flicker Relay	SB000033	
0.5-s Sampling Relay	SB000034	
1.0-s Sampling Relay	SB000035	
2.0-s Sampling Relay	SB000036	
60.0-s Sampling Relay	SB000037	
1.0 s After Start of Scan Relay	SB000038	
2.0 s After Start of Scan Relay	SB000039	
5.0 s After Start of Scan Relay	SB00003A	

(4) Scan Execution Status and Calendar

Name	Register Address	Remarks
High-speed Scan Set Value	SW00004	This is the set value of the high-speed scan (0.1 ms).
High-speed Scan Current Value	SW00005	This is the current value of the high-speed scan (0.1 ms).
High-speed Scan Maximum Value	SW00006	This is the maximum value of the high-speed scan (0.1 ms).
High-speed Scan Set Value 2	SW00007	This is the set value of the high-speed scan (1 μs).
High-speed Scan Current Value 2	SW00008	This is the current value of the high-speed scan (1 μs).
High-speed Scan Maximum Value 2	SW00009	This is the maximum value of the high-speed scan (1 μs).
Low-speed Scan Set Value	SW00010	This is the set value of the low-speed scan (0.1 ms).
Low-speed Scan Current Value	SW00011	This is the current value of the low-speed scan (0.1 ms)
Low-speed Scan Maximum Value	SW00012	This is the maximum value of the low-speed scan (0.1 ms)
Reserved for system.	SW00013	Not used.
Current Scan Time	SW00014	This is the current value of the scan that is currently being executed (0.1 ms).
Calendar: Year	SW00015	1999: 0099 (BCD) (last two digits only)
Calendar: Month Day	SW00016	December 31: 1231 (BCD)
Calendar: Hours and Minutes	SW00017	23: 59: 2359 (BCD)
Calendar: Seconds	SW00018	59 s: 59 (BCD)
Calendar: Week	SW00019	0: Sunday, 1: Monday, 2: Tuesday, 3: Wednesday, 4: Thursday, 5: Friday, 6: Saturday

(5) System Program Software Numbers and Remaining Program Memory Capacity

Name	Register Address	Remarks
System Program Software Version	SW00020	S□□□□ (□□□□ is replaced with the BCD value.)
System Number	SW00021 to SW00025	Not used.
Remaining Program Memory Capacity	SL00026	Bytes
Total Memory Capacity	SL00028	Bytes

A.2 System Status

The system operating status and errors are stored in registers SW00040 to SW00048. You can check the system status to determine whether the cause of the error is hardware or software related.

Name	Register Address	Contents		
Reserved for system.	SW00030 to SW00039	–		
CPU Status	SW00040	SB000400	READY	0: Error, 1: Ready
		SB000401	RUN	0: Stopped, 1: Running
		SB000402	ALARM	0: Normal, 1: Alarm
		SB000403	ERROR	0: Normal, 1: Error
		SB000404	Reserved for system.	–
		SB000405	Reserved for system.	–
		SB000406	FLASH	1: Flash operation
		SB000407	WEN	0: Writing disabled, 1: Writing enabled
		SB000408 to SB00040D	Reserved for system.	–
		SB00040E	Operation Stop Request	0: RUN selected, 1: STOP selected
		SB00040F	Run Switch Status at Power ON	0: STOP, 1: RUN
CPU Error Status	SW00041	SB000410	Serious Failure	1: WDGE, undefined instruction Refer to SW00050 for details.
		SB000411	Reserved for system.	–
		SB000412	Reserved for system.	–
		SB000413	Exception Error	–
		SB000414 to SB000417	Reserved for system.	–
		SB000418	User Operation Error	1: User operation error
		SB000419	I/O Error	1: I/O error
		SB00041A to SB00041F	Reserved for system.	–
H Scan Exceeded Counter	SW00044	–	–	–
L Scan Exceeded Counter	SW00046	–	–	–
Reserved for system.	SW00047		Reserved for system.	–
Hardware Configuration Status	SW00048	SB000480	TEST	DIP switch status 0: ON, 1: OFF
		SB000481	MON	
		SB000482	CNFG	
		SB000483	INIT	
		SB000484	SUP	
		SB000485	STOP	
		SB000486		
		SB000487	Battery Alarm	–
		SB000488 to SB00048F	Reserved for system.	–
Reserved for system.	SW00049	SB000490 to SB00049F	Reserved for system.	–

A.3 System Error Status

Details on the system errors are stored in registers SW00050 to SW00079.

<table>
<tr><th>Name</th><th>Register Address</th><th colspan="2">Contents</th></tr>
<tr><td rowspan="16">32-bit Error Code</td><td rowspan="15">SW00050</td><td>0001 hex</td><td>Watchdog timer error</td></tr>
<tr><td>0041 hex</td><td>ROM diagnostic error</td></tr>
<tr><td>0042 hex</td><td>RAM diagnostic error</td></tr>
<tr><td>0043 hex</td><td>CPU diagnostic error</td></tr>
<tr><td>0044 hex</td><td>FPU diagnostic error</td></tr>
<tr><td>0050 hex</td><td>EXIO error</td></tr>
<tr><td>0051 hex</td><td>Module synchronization error*1</td></tr>
<tr><td>00E0 hex</td><td>Read address exception error</td></tr>
<tr><td>0100 hex</td><td>Write address exception error</td></tr>
<tr><td>0120 hex</td><td>FPU exception error</td></tr>
<tr><td>0180 hex</td><td>General illegal instruction exception error</td></tr>
<tr><td>01A0 hex</td><td>Slot illegal instruction exception error</td></tr>
<tr><td>01E0 hex</td><td>User break after instruction execution</td></tr>
<tr><td>0800 hex</td><td>General FPU suppression exception error</td></tr>
<tr><td>0820 hex</td><td>Slot FPU suppression exception error</td></tr>
<tr><td>SW00051</td><td colspan="2">For system error analysis</td></tr>
<tr><td rowspan="2">32-bit Error Address</td><td>SW00052</td><td colspan="2" rowspan="2">For system error analysis</td></tr>
<tr><td>SW00053</td></tr>
<tr><td>Error Task</td><td>SW00054</td><td colspan="2">0000 hex: System, 0001 hex: DWG.A, 0002 hex: DWG.I,
0003 hex: DWG.H, 0005 hex: DWG.L</td></tr>
<tr><td>Program Type</td><td>SW00055</td><td colspan="2">0000 hex: System, 0001 hex: DWG.A, 0002 hex: DWG.I,
0003 hex: DWG.H, 0005 hex: DWG.L, 0008 hex: Function,
000F hex: Motion program/sequence program</td></tr>
<tr><td>Error Drawing No.</td><td>SW00056</td><td colspan="2">Ladder program parent drawing: FFFF hex
Ladder program function: 8000 hex
Ladder program child drawing: xx00 hex (xx hex: Child drawing number)
Ladder program grandchild drawing: xxyy hex (yy hex: Grandchild drawing number)
Motion program/sequence program: F0xx hex (xx hex: Program number)</td></tr>
<tr><td rowspan="2">Calling Drawing Type</td><td rowspan="2">SW00057</td><td colspan="2">Type of the calling drawing in which the error occurred</td></tr>
<tr><td colspan="2">0001 hex: DWG.A, 0002 hex: DWG.I, 0003 hex: DWG.H,
005 hex: DWG.L, 8000 hex: Ladder program function,
000F hex: Motion program/sequence program,
0010 hex: Reserved for system, 0011 hex: Reserved for system.</td></tr>
<tr><td rowspan="2">Calling Drawing No.</td><td rowspan="2">SW00058</td><td colspan="2">Number of the calling drawing in which the error occurred</td></tr>
<tr><td>Parent drawing:
FFFF hex
Function: 0100 hex</td><td>Child drawing: xx00 hex
(xx hex: Child drawing number)
Grandchild drawing: xxyy hex
(yy hex: Grandchild drawing number)</td></tr>
<tr><td>Calling Drawing Step No.</td><td>SW00059</td><td colspan="2">Step number in the calling drawing in which the error occurred
This number is set to 0 if the error occurred in the parent drawing.</td></tr>
</table>

Name	Register Address	Contents
Error Data	SW00060 and SW00061	Reserved for system.
	SW00062 to SW00065	Name of task that caused the error
	SW00066 and SW00067	Reserved for system.
	SW00068	Year when error occurred
	SW00069	Month when error occurred
	SW00070	Day of week when error occurred
	SW00071	Day when error occurred
	SW00072	Hour when error occurred
	SW00073	Minutes when error occurred
	SW00074	Seconds when error occurred
	SW00075	Milliseconds when error occurred (Not used.)
	SW00076	Slot where module synchronization error was detected*2 xxyy hex: xx: Rack number (01 to 04), yy: Slot number (01 to 09)
	SW00078 and SW00079	Reserved for system.

* 1. This error is reported for CPU Modules with a system software version of 2.75 or higher. For version 2.74 or lower, it is reported as a watchdog timer error (0001 hex).
* 2. This error is reported for CPU Modules with a system software version of 2.75 or higher.

A.4 Overview of User Operation Error Status

Details are given in registers SW00080 to SW00089 when a user operation error occurs in a program.

<table>
<tr><th colspan="2">Name</th><th>Register Address</th><th>Contents</th></tr>
<tr><td rowspan="2">DWG.A</td><td>Error Count</td><td>SW00080</td><td rowspan="8">• Error Count
Gives the number of errors that have occurred.

• Error Code
Bit 15 • • • • • 12 Bit 11 • • • • • 0
| Index error | Error Code |

Refer to (1) User Operation Error Code -1 or (2) User Operation Error Code -2 for information on error codes.</td></tr>
<tr><td>Error Code</td><td>SW00081</td></tr>
<tr><td rowspan="2">DWG.I</td><td>Error Count</td><td>SW00082</td></tr>
<tr><td>Error Code</td><td>SW00083</td></tr>
<tr><td rowspan="2">DWG.H</td><td>Error Count</td><td>SW00084</td></tr>
<tr><td>Error Code</td><td>SW00085</td></tr>
<tr><td rowspan="2">DWG.L</td><td>Error Count</td><td>SW00088</td></tr>
<tr><td>Error Code</td><td>SW00089</td></tr>
</table>

(1) User Operation Error Code -1

<table>
<tr><th></th><th>Error Code</th><th colspan="3">Error Description</th><th colspan="2">System Default</th></tr>
<tr><td rowspan="6">Integer Operations</td><td>0001 hex</td><td colspan="3">Integer operation underflow</td><td colspan="2">-32,768</td></tr>
<tr><td>0002 hex</td><td colspan="3">Integer operation overflow</td><td colspan="2">32,767</td></tr>
<tr><td>0003 hex</td><td colspan="3">Integer operation division error</td><td colspan="2">The A register stays the same.</td></tr>
<tr><td>0009 hex</td><td colspan="3">Double-length integer operation underflow</td><td colspan="2">-2,147,483,648</td></tr>
<tr><td>000A hex</td><td colspan="3">Double-length integer operation overflow</td><td colspan="2">2,147,483,647</td></tr>
<tr><td>000B hex</td><td colspan="3">Double-length integer operation division error</td><td colspan="2">The A register stays the same.</td></tr>
<tr><td rowspan="21">Real Number Operations</td><td>0010 hex</td><td colspan="3">Non-numerical integer storage error</td><td colspan="2">Data is not stored. [00000]</td></tr>
<tr><td>0011 hex</td><td colspan="3">Integer storage underflow</td><td colspan="2">Data is not stored. [-32,768]</td></tr>
<tr><td>0012 hex</td><td colspan="3">Integer storage overflow</td><td colspan="2">Data is not stored. [+ 32,767]</td></tr>
<tr><td>0021 hex</td><td colspan="3">Real number storage underflow</td><td colspan="2">Data is not stored. [-1.0E + 38]</td></tr>
<tr><td>0022 hex</td><td colspan="3">Real number storage overflow</td><td colspan="2">Data is not stored. [1.0E + 38]</td></tr>
<tr><td>0023 hex</td><td colspan="3">Real number operation division by zero error</td><td colspan="2">Data is not stored. [F register stays the same.]</td></tr>
<tr><td>0030 hex</td><td colspan="3">Invalid real number operation (not a number)</td><td colspan="2">Data is not stored.</td></tr>
<tr><td>0031 hex</td><td colspan="3">Real number operation exponent underflow</td><td colspan="2">0.0</td></tr>
<tr><td>0032 hex</td><td colspan="3">Real number operation exponent overflow</td><td colspan="2">Maximum Value</td></tr>
<tr><td>0033 hex</td><td colspan="3">Real number operation division error (0/0)</td><td colspan="2">Operation is not executed.</td></tr>
<tr><td>0034 hex</td><td colspan="3">Real number storage exponent underflow</td><td colspan="2">A value of 0.0 is stored.</td></tr>
<tr><td>0035 hex</td><td colspan="3">Real number operation stack error</td><td colspan="2">–</td></tr>
<tr><td rowspan="9">0040 to 0059 hex</td><td colspan="3">Real number operation error in standard system function</td><td colspan="2">Operation is aborted and output is set to 0.0.</td></tr>
<tr><td rowspan="8"></td><td>0040 hex: SQRT</td><td>0041 hex: SIN</td><td>0042 hex: COS</td><td>0043 hex: TAN</td></tr>
<tr><td>0044 hex: ASIN</td><td>0045 hex: ACOS</td><td>0046 hex: ATAN</td><td>0047 hex: EXP</td></tr>
<tr><td>0048 hex: LN</td><td>0049 hex: LOG</td><td>004A hex: DZA</td><td>004B hex: DZB</td></tr>
<tr><td>004C hex: LIM</td><td>004D hex: PI</td><td>004E hex: PD</td><td>004F hex: PID</td></tr>
<tr><td>0050 hex: LAG</td><td>0051 hex: LLAG</td><td>0052 hex: FGN</td><td>0053 hex: IFGN</td></tr>
<tr><td>0054 hex: LAU</td><td>0055 hex: SLAU</td><td>0056 hex: REM</td><td>0057 hex: RCHK</td></tr>
<tr><td>0058 hex: BSRCH</td><td>0059 hex: SORT</td><td></td><td></td></tr>
<tr><td colspan="4">For an index error, 1000, 2000, or 3000 hex is added.</td></tr>
</table>

(2) User Operation Error Code -2

	Error Code	Error Description	System Default
Integer and Real Number Operations	1000 hex	Index error in drawing	Re-executed as if i and j were set to 0. (Both i and j registers stay the same.)
	2000 hex	Index error in function	Re-executed as if i and j were set to 0. (Both i and j registers stay the same.)
	3000 hex	Index error in motion program or sequence program	Re-executed as if i and j were set to 0. (Both i and j registers stay the same.)
Integer Operations	□060 to □0C9 hex (□ = 1, 2, or 3)	Index error in integer system function	Operation is aborted and output is set to input.

□06D hex: PI	□06E hex: PD	□06F hex: PID	□070 hex: LAG
□071 hex: LLAG	□072 hex: FGN	□073 hex: IFGN	□074 hex: LAU
□075 hex: SLAU	□076 hex: FGN	□077 hex: IFGN	□08E hex: INS
□08F hex: OUTS	□090 hex: ROTL	□091 hex: ROTR	□092 hex: MOVB
□093 hex: MOVW	□094 hex: SETW	□095 hex: XCHG	□096 hex: LIMIT
□097 hex: LIMIT	□098 hex: DZA	□099 hex: DZA	□09A hex: DZB
□09B hex: DZB	□09C hex: PWM	□09E hex: SHFTL	□09F hex: SHFTR
□0A0 hex: BEXTEND	□0A1 hex: BPRESS	□0A2 hex: SORT	□0A4 hex: SORT
□0A6 hex: RCHK	□0A7 hex: RCHK	□0A8 hex: COPYW	□0A9 hex: ASCII
□0AA hex: BINASC	□0AB hex: ASCBIN	□0AC hex: BSRC H	□0AD hex: BSRC H
□0AE hex: TIMEADD	□0AF hex: TIMSUB	□0B1 hex: SPEND	□0C0 hex: TBLBR
□0C1 hex: TBLBW	□0C2 hex: TBLSRL	□0C3 hex: TBLSRC	□0C4 hex: TBLCL
□0C5 hex: TBLMW	□0C6 hex: QTBLR	□0C7 hex: QTBLRI	□0C8 hex: QTBLW
□0C9 hex: QTBLWI			

A.5 System Service Execution Status

The execution status of system services is stored in registers SW00090 to SW00103.

Name	Register Address	Remarks
Reserved for system.	SW00090	–
Reserved for system.	SW00091	
Reserved for system.	SW00092	
Reserved for system.	SW00093	
Reserved for system.	SW00094 to SW00097	–
Data Trace Definition Existence	SW00098	Bits 0 to 3: Groups 1 to 4 Defined: 1, Not defined: 0
Data Trace Execution Status	SW00099	Bits 0 to 3: Groups 1 to 4 Trace stopped: 1, Trace in progress: 0

Latest Record Numbers in Data Trace

Name	Register Address	Remarks
Data Trace Group 1	SW00100	Latest record number
Data Trace Group 2	SW00101	Latest record number
Data Trace Group 3	SW00102	Latest record number
Data Trace Group 4	SW00103	Latest record number

A.6 Detailed User Operation Error Status

Detailed information is given in registers SW00110 to SW00189 when a user operation error occurs in a program.

Name	Register Address				Contents
	DWG.A	DWG.I	DWG.H	DWG.L	
Error Count	SW00110	SW00126	SW00142	SW00174	• Error Counts and Error Codes Same as in *Appendix A.4 Overview of User Operation Error Status.* • Error Drawing No. Parent drawing: FFFF hex Child drawing: xx00 hex (xx hex: Child drawing number) Grandchild drawing: xxyy hex (yy hex: Grandchild drawing number) Function: 8000 hex Motion program/sequence program: F0xx hex (xx hex: Program number) • Calling Drawing No. Number of the calling drawing in which the operation error occurred • Calling Drawing Step No. Step number in the calling drawing in which the operation error occurred This number is set to 0 if the error occurred in the parent drawing.
Error Code	SW00111	SW00127	SW00143	SW00175	
Reserved for system.	SW00112 to SW00121	SW00128 to SW00137	SW00144 to SW00153	SW00176 to SW00185	
Error Drawing No.	SW00122	SW00138	SW00154	SW00186	
Calling Drawing No.	SW00123	SW00139	SW00155	SW00187	
Calling Drawing Step No.	SW00124	SW00140	SW00156	SW00188	
Reserved for system.	SW00125	SW00141	SW00157	SW00189	

A.7 System I/O Error Status

Details on the system I/O errors are stored in registers SW00200 to SW00503.

Name	Register Address	Contents
I/O Error Count	SW00200	Number of I/O error occurrences
Input Error Count	SW00201	Number of input error occurrences
Input Error Address	SW00202	The latest input error address (register address in IW□□□□)
Output Error Count	SW00203	Output error count
Output Error Address	SW00204	The latest output error address (register address in OW□□□□)
Reserved for system.	SW00205	Not used.
	SW00206	
	SW00207	
I/O Error Status	SW00208 to SW00215	Error status for CPU Module
	SW00216 to SW00223	Reserved for system.
	SW00224 to SW00231	Error status of Rack 1, Slot 1
	SW00232 to SW00239	Error status of Rack 1, Slot 2
	SW00240 to SW00247	Error status of Rack 1, Slot 3
	SW00248 to SW00255	Error status of Rack 1, Slot 4
	…	…
	SW00496 to SW00503	Error status of Rack 4, Slot 9

A.8 CF Card-related System Registers (MP2200-series CPU-02 and CPU-03 only)

The status of the CF Card is reported in registers SW00652 to SW00659.
These registers can be used only when a CF card is supported (the MP2200 with the CPU-02 or CPU-03).
For all other models, they are reserved for the system.

Name	Register Address		Contents
Total capacity of CF card	SL00652		Unit: Bytes
Card status	SW00654	SB006540	0: CF card not mounted, 1: CF card mounted
		SB006541	0: Not supplying power, 1: Supplying power
		SB006542	0: Cannot detect a CF card, 3: CF card detected
		SB006543	0: Not accessing CF card, 1: Accessing CF card
		SB006544	0: –, 1: Checking FAT file system
		SB006545 to SB00654F	Reserved for system.
FAT type	SW00655	0001 hex	FAT12
		0002 hex	FAT16
		0003 hex	FAT32
Reserved for system.	SW00656		–
Reserved for system.	SW00657		–
Batch load and batch save	SW00658	SB006580	Batch load in progress
		SB006581	CF card reading error
		SB006582	Load file model mismatch error
		SB006583	Load file write error
		SB006584	Save to flash memory error
		SB006585	Folder for batch loading does not exist.
		SB006586	Loading error due to program write protection
		SB006587	Reserved for system.
		SB006588	Batch save in progress
		SB006589	CF card writing error
		SB00658A	Save file read error
		SB00658B	Security error
		SB00658C to SB00658F	Reserved for system.
Reserved for system.	SW00659		–

A.9 Interrupt Status

A.9.1 Interrupt Status List

Name	Register Address	Remarks
Interrupt information	SW00698	Interrupt detection count
	SW00699	Number of interrupting methods
	SW00700 SW00701 SW00702	Interrupting module 1
	SW00703 SW00704 SW00705	Interrupting module 2
	: :	
	SW00787 SW00788 SW00789	Interrupting module 30

A.9.2 Details on Interrupting Module

	F 8	7 0	(Bit numbers)
SW00□□ + 0	Rack	Slot	mmss hex
SW00□□ + 1	Interrupt Type		
SW00□□ + 2	Hardware Interrupt Cause Register Values		

(1) Rack

mm = 01 to 04
The rack number where the Module in which the interrupt occurred is mounted is reported.

(2) Slot

ss = 01 to 09
The slot number where the Module in which the interrupt occurred is mounted is reported.

(3) Interrupt Type

1: DI interrupt for CPU IO (MP2100, MP2100M, MP2101, MP2101M, MP2101T, MP2101TM, or MP2300)
2: DI interrupt for LIO-01, LIO-02, LIO-04, or LIO-05
3: Counter interrupt for LIO-01, LIO-02, LIO-06, or CNTR-01

(4) Hardware Interrupt Cause Register Values

For the hardware interrupt cause register values, refer to *2.5.6 Interrupt Status* in the *Machine Controller MP2000 Troubleshooting Manual* (Manual No.: SIJP C880700 40 (Japanese version)).

A.10 Module Information

The Module information is reported as shown in this section.

- The contents of the registers depends on the model. Refer to the manuals for your Machine Controller.

(1) CPU Function Module

Name	Register Address	Remarks
CPU Unit Information	SW00800	CPU Module ID
	SW00801	Hardware version (BCD)
	SW00802	Software version (BCD)
	SW00803	Number of sub-slots (hex)
	SW00804	Function Module 1 ID (hex)
	SW00805	Function Module 1 Status
	SW00806	Function Module 2 ID (hex)
	SW00807	Function Module 2 Status
	SW00808	Function Module 3 ID (hex)
	SW00809	Function Module 3 Status
	SW00810	Function Module 4 ID (hex)
	SW00811	Function Module 4 Status
	SW00812	Function Module 5 ID (hex)
	SW00813	Function Module 5 Status
	SW00814	Function Module 6 ID (hex)
	SW00815	Function Module 6 Status
Option Module Information	SW00816 to SW01095	Option Module Information (Depends on the CPU model and mounted Option Modules.)

(2) Option Modules

Name	Register Address	Remarks
Module Information	SW00□□□ + 0	Option Module ID
	SW00□□□ + 1	Hardware version (BCD)
	SW00□□□ + 2	Software version (BCD)
	SW00□□□ + 3	Number of sub-slots (hex)
	SW00□□□ + 4	Function Module 1 ID (hex)
	SW00□□□ + 5	Function Module 1 Status
	SW00□□□ + 6	Function Module 2 ID (hex)
	SW00□□□ + 7	Function Module 2 Status

(3) Function Module Status Details

Value	Text Displayed in MPE720 Module Configuration Definition	Status
0	None	There is no Module Definition and the Module is not mounted.
1	Empty	There is a Function Module Definition, but the Module is not mounted.
2	Operating (Driving)	The Module is operating normally.
3	Standby (Reserved for system.)	The Module is on standby.
4	Failure	An error was detected in the Module.
5	× Module name	The mounted Module does not match the definition.
6	Waiting for initialization	The Module is mounted, but there is no Detailed Function Module Definition.
7	Driving stop	Local I/O is stopped.
8 or higher	–	Reserved for system.

A.11 MPU-01 System Status

Name	Register Address	Remarks
MPU-01 #1 Status	SW01411	Status of MPU-01 Module circuit number 1
MPU-01 #1 Error Status	SW01412	Error status of MPU-01 Module circuit number 1
MPU-01 #2 Status	SW01413	Status of MPU-01 Module circuit number 2
MPU-01 #2 Error Status	SW01414	Error status of MPU-01 Module circuit number 2
MPU-01 #3 Status	SW01415	Status of MPU-01 Module circuit number 3
MPU-01 #3 Error Status	SW01416	Error Status of MPU-01 Module circuit number 3
MPU-01 #4 Status	SW01417	Status of MPU-01 Module circuit number 4
MPU-01 #4 Error Status	SW01418	Error Status of MPU-01 Module circuit number 4
MPU-01 #5 Status	SW01419	Status of MPU-01 Module circuit number 5
MPU-01 #5 Error Status	SW01420	Error Status of MPU-01 Module circuit number 5
MPU-01 #6 Status	SW01421	Status of MPU-01 Module circuit number 6
MPU-01 #6 Error Status	SW01422	Error Status of MPU-01 Module circuit number 6
MPU-01 #7 Status	SW01423	Status of MPU-01 Module circuit number 7
MPU-01 #7 Error Status	SW01424	Error Status of MPU-01 Module circuit number 7
MPU-01 #8 Status	SW01425	Status of MPU-01 Module circuit number 8
MPU-01 #8 Error Status	SW01426	Error Status of MPU-01 Module circuit number 8
MPU-01 #9 Status	SW01427	Status of MPU-01 Module circuit number 9
MPU-01 #9 Error Status	SW01428	Error Status of MPU-01 Module circuit number 9
MPU-01 #10 Status	SW01429	Status of MPU-01 Module circuit number 10
MPU-01 #10 Error Status	SW01430	Error Status of MPU-01 Module circuit number 10
MPU-01 #11 Status	SW01431	Status of MPU-01 Module circuit number 11
MPU-01 #11 Error Status	SW01432	Error status of MPU-01 Module circuit number 11
MPU-01 #12 Status	SW01433	Status of MPU-01 Module circuit number 12
MPU-01 #12 Error Status	SW01434	Error status of MPU-01 Module circuit number 12
MPU-01 #13 Status	SW01435	Status of MPU-01 Module circuit number 13
MPU-01 #13 Error Status	SW01436	Error status of MPU-01 Module circuit number 13
MPU-01 #14 Status	SW01437	Status of MPU-01 Module circuit number 14
MPU-01 #14 Error Status	SW01438	Error status of MPU-01 Module circuit number 14
MPU-01 #15 Status	SW01439	Status of MPU-01 Module circuit number 15
MPU-01 #15 Error Status	SW01440	Error status of MPU-01 Module circuit number 15
MPU-01 #16 Status	SW01441	Status of MPU-01 Module circuit number 16
MPU-01 #16 Error Status	SW01442	Error status of MPU-01 Module circuit number 16

A.12 Motion Program Information

(1) System Work Numbers 1 to 8

System Work Number		System Work 1	System Work 2	System Work 3	System Work 4	System Work 5	System Work 6	System Work 7	System Work 8
Executing Main Program No.		SW03200	SW03201	SW03202	SW03203	SW03204	SW03205	SW03206	SW03207
Status		SW03264	SW03322	SW03380	SW03438	SW03496	SW03554	SW03612	SW03670
Control Signals		SW03265	SW03323	SW03381	SW03439	SW03497	SW03555	SW03613	SW03671
Fork 0	Program Number	SW03266	SW03324	SW03382	SW03440	SW03498	SW03556	SW03614	SW03672
	Block Number	SW03267	SW03325	SW03383	SW03441	SW03499	SW03557	SW03615	SW03673
	Alarm Code	SW03268	SW03326	SW03384	SW03442	SW03500	SW03558	SW03616	SW03674
Fork 1	Program Number	SW03269	SW03327	SW03385	SW03443	SW03501	SW03559	SW03617	SW03675
	Block Number	SW03270	SW03328	SW03386	SW03444	SW03502	SW03560	SW03618	SW03676
	Alarm Code	SW03271	SW03329	SW03387	SW03445	SW03503	SW03561	SW03619	SW03677
Fork 2	Program Number	SW03272	SW03330	SW03388	SW03446	SW03504	SW03562	SW03620	SW03678
	Block Number	SW03273	SW03331	SW03389	SW03447	SW03505	SW03563	SW03621	SW03679
	Alarm Code	SW03274	SW03332	SW03390	SW03448	SW03506	SW03564	SW03622	SW03680
Fork 3	Program Number	SW03275	SW03333	SW03391	SW03449	SW03507	SW03565	SW03623	SW03681
	Block Number	SW03276	SW03334	SW03392	SW03450	SW03508	SW03566	SW03624	SW03682
	Alarm Code	SW03277	SW03335	SW03393	SW03451	SW03509	SW03567	SW03625	SW03683
Fork 4	Program Number	SW03278	SW03336	SW03394	SW03452	SW03510	SW03568	SW03626	SW03684
	Block Number	SW03279	SW03337	SW03395	SW03453	SW03511	SW03569	SW03627	SW03685
	Alarm Code	SW03280	SW03338	SW03396	SW03454	SW03512	SW03570	SW03628	SW03686
Fork 5	Program Number	SW03281	SW03339	SW03397	SW03455	SW03513	SW03571	SW03629	SW03687
	Block Number	SW03282	SW03340	SW03398	SW03456	SW03514	SW03572	SW03630	SW03688
	Alarm Code	SW03283	SW03341	SW03399	SW03457	SW03515	SW03573	SW03631	SW03689
Fork 6	Program Number	SW03284	SW03342	SW03400	SW03458	SW03516	SW03574	SW03632	SW03690
	Block Number	SW03285	SW03343	SW03401	SW03459	SW03517	SW03575	SW03633	SW03691
	Alarm Code	SW03286	SW03344	SW03402	SW03460	SW03518	SW03576	SW03634	SW03692
Fork 7	Program Number	SW03287	SW03345	SW03403	SW03461	SW03519	SW03577	SW03635	SW03693
	Block Number	SW03288	SW03346	SW03404	SW03462	SW03520	SW03578	SW03636	SW03694
	Alarm Code	SW03289	SW03347	SW03405	SW03463	SW03521	SW03579	SW03637	SW03695
Logical Axis 1 Program Current Position		SL03290	SL03348	SL03406	SL03464	SL03522	SL03580	SL03638	SL03696
Logical Axis 2 Program Current Position		SL03292	SL03350	SL03408	SL03466	SL03524	SL03582	SL03640	SL03698
Logical Axis 3 Program Current Position		SL03294	SL03352	SL03410	SL03468	SL03526	SL03584	SL03642	SL03700
Logical Axis 4 Program Current Position		SL03296	SL03354	SL03412	SL03470	SL03528	SL03586	SL03644	SL03702
Logical Axis 5 Program Current Position		SL03298	SL03356	SL03414	SL03472	SL03530	SL03588	SL03646	SL03704
Logical Axis 6 Program Current Position		SL03300	SL03358	SL03416	SL03474	SL03532	SL03590	SL03648	SL03706
Logical Axis 7 Program Current Position		SL03302	SL03360	SL03418	SL03476	SL03534	SL03592	SL03650	SL03708
Logical Axis 8 Program Current Position		SL03304	SL03362	SL03420	SL03478	SL03536	SL03594	SL03652	SL03710
Logical Axis 9 Program Current Position		SL03306	SL03364	SL03422	SL03480	SL03538	SL03596	SL03654	SL03712
Logical Axis 10 Program Current Position		SL03308	SL03366	SL03424	SL03482	SL03540	SL03598	SL03656	SL03714
Logical Axis 11 Program Current Position		SL03310	SL03368	SL03426	SL03484	SL03542	SL03600	SL03658	SL03716
Logical Axis 12 Program Current Position		SL03312	SL03370	SL03428	SL03486	SL03544	SL03602	SL03660	SL03718
Logical Axis 13 Program Current Position		SL03314	SL03372	SL03430	SL03488	SL03546	SL03604	SL03662	SL03720
Logical Axis 14 Program Current Position		SL03316	SL03374	SL03432	SL03490	SL03548	SL03606	SL03664	SL03722
Logical Axis 15 Program Current Position		SL03318	SL03376	SL03434	SL03492	SL03550	SL03608	SL03666	SL03724
Logical Axis 16 Program Current Position		SL03320	SL03378	SL03436	SL03494	SL03552	SL03610	SL03668	SL03726

(2) System Work Numbers 9 to 16

System Work Number		System Work 9	System Work 10	System Work 11	System Work 12	System Work 13	System Work 14	System Work 15	System Work 16
Executing Main Program No.		SW03208	SW03209	SW03210	SW03211	SW03212	SW03213	SW03214	SW03215
Status		SW03728	SW03786	SW03844	SW03902	SW03960	SW04018	SW04076	SW04134
Control Signals		SW03729	SW03787	SW03845	SW03903	SW03961	SW04019	SW04077	SW04135
Fork 0	Program Number	SW03730	SW03788	SW03846	SW03904	SW03962	SW04020	SW04078	SW04136
	Block Number	SW03731	SW03789	SW03847	SW03905	SW03963	SW04021	SW04079	SW04137
	Alarm Code	SW03732	SW03790	SW03848	SW03906	SW03964	SW04022	SW04080	SW04138
Fork 1	Program Number	SW03733	SW03791	SW03849	SW03907	SW03965	SW04023	SW04081	SW04139
	Block Number	SW03734	SW03792	SW03850	SW03908	SW03966	SW04024	SW04082	SW04140
	Alarm Code	SW03735	SW03793	SW03851	SW03909	SW03967	SW04025	SW04083	SW04141
Fork 2	Program Number	SW03736	SW03794	SW03852	SW03910	SW03968	SW04026	SW04084	SW04142
	Block Number	SW03737	SW03795	SW03853	SW03911	SW03969	SW04027	SW04085	SW04143
	Alarm Code	SW03738	SW03796	SW03854	SW03912	SW03970	SW04028	SW04086	SW04144
Fork 3	Program Number	SW03739	SW03797	SW03855	SW03913	SW03971	SW04029	SW04087	SW04145
	Block Number	SW03740	SW03798	SW03856	SW03914	SW03972	SW04030	SW04088	SW04146
	Alarm Code	SW03741	SW03799	SW03857	SW03915	SW03973	SW04031	SW04089	SW04147
Fork 4	Program Number	SW03742	SW03800	SW03858	SW03916	SW03974	SW04032	SW04090	SW04148
	Block Number	SW03743	SW03801	SW03859	SW03917	SW03975	SW04033	SW04091	SW04149
	Alarm Code	SW03744	SW03802	SW03860	SW03918	SW03976	SW04034	SW04092	SW04150
Fork 5	Program Number	SW03745	SW03803	SW03861	SW03919	SW03977	SW04035	SW04093	SW04151
	Block Number	SW03746	SW03804	SW03862	SW03920	SW03978	SW04036	SW04094	SW04152
	Alarm Code	SW03747	SW03805	SW03863	SW03921	SW03979	SW04037	SW04095	SW04153
Fork 6	Program Number	SW03748	SW03806	SW03864	SW03922	SW03980	SW04038	SW04096	SW04154
	Block Number	SW03749	SW03807	SW03865	SW03923	SW03981	SW04039	SW04097	SW04155
	Alarm Code	SW03750	SW03808	SW03866	SW03924	SW03982	SW04040	SW04098	SW04156
Fork 7	Program Number	SW03751	SW03809	SW03867	SW03925	SW03983	SW04041	SW04099	SW04157
	Block Number	SW03752	SW03810	SW03868	SW03926	SW03984	SW04042	SW04100	SW04158
	Alarm Code	SW03753	SW03811	SW03869	SW03927	SW03985	SW04043	SW04101	SW04159
Logical Axis 1 Program Current Position		SL03754	SL03812	SL03870	SL03928	SL03986	SL04044	SL04102	SL04160
Logical Axis 2 Program Current Position		SL03756	SL03814	SL03872	SL03930	SL03988	SL04046	SL04104	SL04162
Logical Axis 3 Program Current Position		SL03758	SL03816	SL03874	SL03932	SL03990	SL04048	SL04106	SL04164
Logical Axis 4 Program Current Position		SL03760	SL03818	SL03876	SL03934	SL03992	SL04050	SL04108	SL04166
Logical Axis 5 Program Current Position		SL03762	SL03820	SL03878	SL03936	SL03994	SL04052	SL04110	SL04168
Logical Axis 6 Program Current Position		SL03764	SL03822	SL03880	SL03938	SL03996	SL04054	SL04112	SL04170
Logical Axis 7 Program Current Position		SL03766	SL03824	SL03882	SL03940	SL03998	SL04056	SL04114	SL04172
Logical Axis 8 Program Current Position		SL03768	SL03826	SL03884	SL03942	SL04000	SL04058	SL04116	SL04174
Logical Axis 9 Program Current Position		SL03770	SL03828	SL03886	SL03944	SL04002	SL04060	SL04118	SL04176
Logical Axis 10 Program Current Position		SL03772	SL03830	SL03888	SL03946	SL04004	SL04062	SL04120	SL04178
Logical Axis 11 Program Current Position		SL03774	SL03832	SL03890	SL03948	SL04006	SL04064	SL04122	SL04180
Logical Axis 12 Program Current Position		SL03776	SL03834	SL03892	SL03950	SL04008	SL04066	SL04124	SL04182
Logical Axis 13 Program Current Position		SL03778	SL03836	SL03894	SL03952	SL04010	SL04068	SL04126	SL04184
Logical Axis 14 Program Current Position		SL03780	SL03838	SL03896	SL03954	SL04012	SL04070	SL04128	SL04186
Logical Axis 15 Program Current Position		SL03782	SL03840	SL03898	SL03956	SL04014	SL04072	SL04130	SL04188
Logical Axis 16 Program Current Position		SL03784	SL03842	SL03900	SL03958	SL04016	SL04074	SL04132	SL04190

Appendix B

CP (Previous) Ladder Instructions and New Ladder Instructions

This appendix describes some CP (previous) ladder instructions and new ladder instructions.

B.1 Correspondence between CP (Previous) Ladder Instructions and New Ladder Instructions

Changing from CP ladder programs to new ladder programs involves changes to some instructions and the addition of new instructions.

This section tells you what to do in new ladder programs for instructions that can be used only in CP ladder programs.

It also provides a list of instructions that can be used only in new ladder instructions.

(1) Handling Instructions Supported Only by CP (Previous) Ladder Programs in New Ladder Programs

Instruction Name	Function Outline	Procedure in New Ladder Programs
Instructions in [ ] Brackets	Instructions in [ ] brackets are executed only when the value of the B register is ON.	Use the IF instruction.
IFON instruction	Processing up to the IEND instruction is executed only when the value of the B register is ON.	
IFOFF instruction	Processing up to the IEND instruction is executed only when the value of the B register is OFF.	
Call User Function instruction	A user function is called.	Use the FUNC instruction.
Function Input instruction	The input data is stored in the function input register.	
Function Output instruction	The data in the function output register is stored in the specified register.	
Comment instruction	Text with double quotation marks (“ ”) is treated as a comment.	Use rung comments.
Integer Replacement instruction	Data is replaced in an A register and the integer operation is started.	Use the STORE instruction.
Real Number Replacement instruction	Data is replaced in an F register and the real number operation is started.	
Store instruction	The contents of the A or F register is stored in the specified register.	

(2) Instructions That You Can Use Only in New Ladder Programs

Instruction Name	Function Outline
IF instruction	The programming between the IF and END_IF instructions is executed while the conditional expression for the IF instruction is satisfied.
FUNC instruction	A user function is called.
STORE instruction	Integer, double-length integer, or real number data is stored in a register.
EXPRESSION instruction	A numeric expression is written.
MLINK-SVW instruction	The specified SERVOPACK parameter is written.
MOTREG-W instruction	The specified motion register is written.
MOTREG-R instruction	The specified motion register is read.

B.2 Converting CP (Previous) Ladder Programs to New Ladder Programs

You can use the CP ladder program conversion function on MPE720 version 6 to convert CP ladder programs to new ladder programs. When converting a program, DWG properties and comments in the program will be converted at the same time.

You must be offline to convert CP ladder programs. (You cannot convert CP ladder programs while connected to the Machine Controller.) Refer to *3.6 Converting CP Ladder Programs to Ordinary Ladder Programs* in the *Engineering Tool for MP2000 Series Machine Controller MPE720 Version 6 User's Manual* (SIEP C880700 30) on converting CP ladder programs.

■ Procedure to Convert CP Ladder Programs

1. Select a program folder (High-speed, Low-speed, Start, Interrupt, or Function) or select a program that contains programs of the lower hierarchical levels. Then, right-click the selected folder or program and select ***Conversion of CP ladder*** from the pop-up menu.

When the selected program contains programs of lower hierarchical levels, the following message will appear asking for confirmation.

Conversion: Click this button to convert the current program and all lower level programs to new ladder programs.

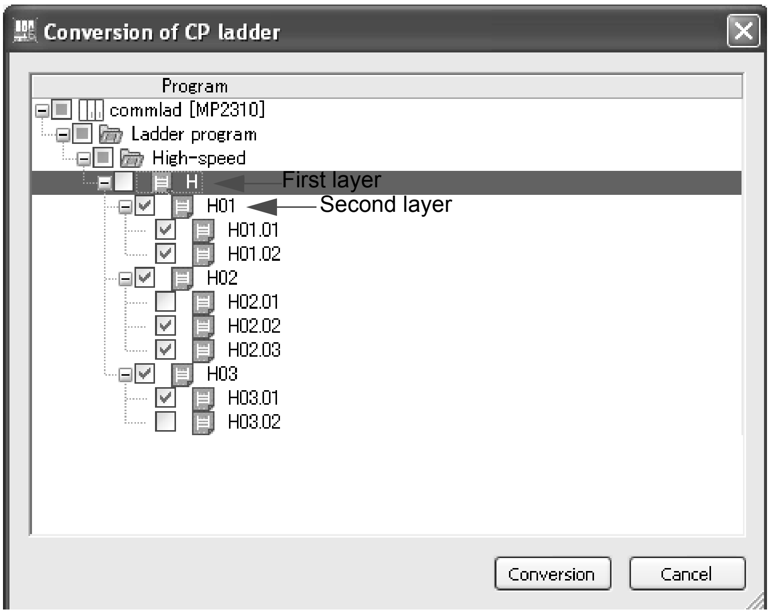
Select: Click this button to display the **Conversion of CP ladder** Dialog Box. See step 2 for details on setting.

Cancel: Click this button to cancel program conversion.

2. Click **Select.**

The **Conversion of CP ladder** Dialog Box will appear.
The check box of the CP ladder program specified in step 1 or the check boxes of the CP ladder programs that are displayed under the ladder program specified in step 1 will be selected.
When a program from the second hierarchical level is specified in step 1, the check box of the programs of first hierarchical level will also be selected.

- After deselecting the check boxes of the CP ladder programs not to be converted in step 3, the check boxes of the project file, ladder program folder, High-speed, Low-speed, Start, Interrupt, or Function folder to which non-selected CP ladder programs belong will be shaded. This is because some of CP ladder programs in the file or folder are selected and the rest are not selected.



3. Clear the check boxes of CP ladder programs not to be converted.

- New Ladder programs are shaded, and cannot be selected.

4. Click ***Conversion***. All the selected CP ladder programs will be converted to new ladder programs.

If you click the **Cancel** Button, the CP ladder program conversion will be cancelled.

An error code (0xAxxxxxxx) and an error name may be displayed in the Output Subwindow in accordance with the changed program.
Select the error code (0xAxxxxxxx) and press the **F1** Key. ***Error Generating Information*** will appear.
Check the error causes and take corrective action.

Appendix C

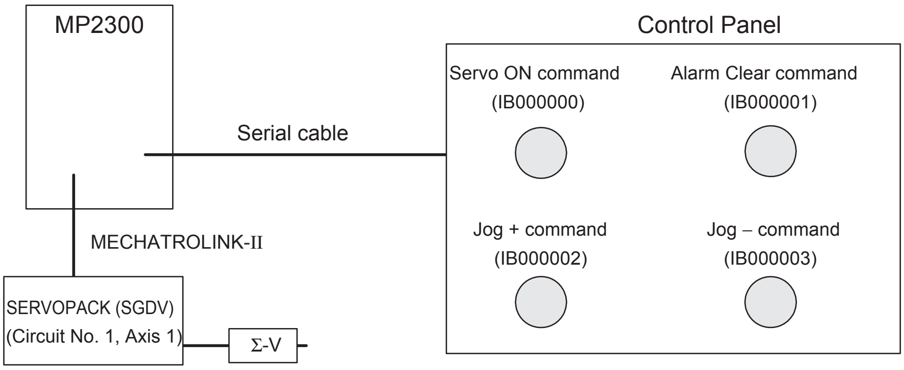
Sample Programming

This appendix describes ladder programming examples that perform test runs.

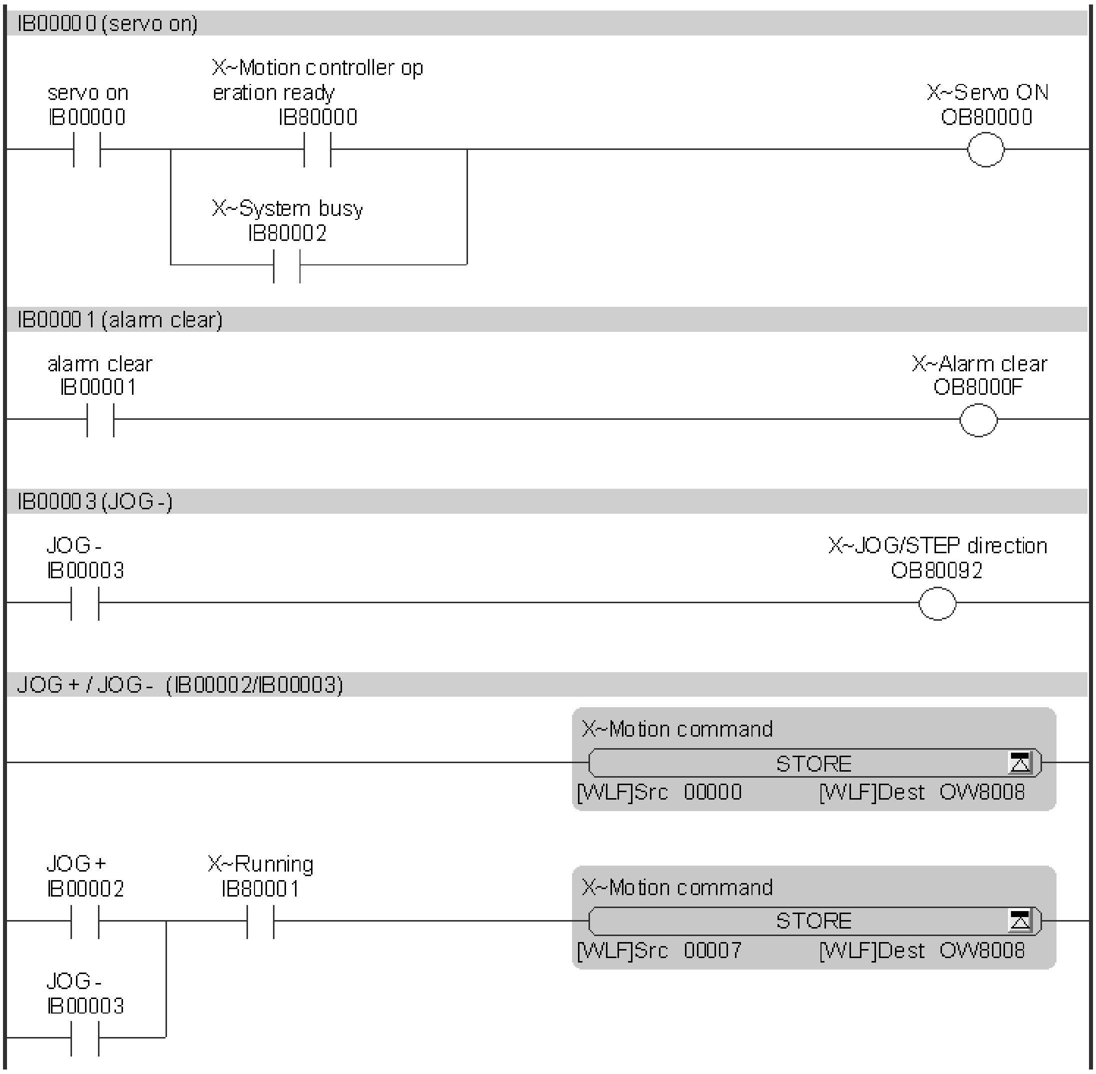
C.1 Jogging from the Control Panel

The following configuration and ladder programming example illustrate how to control a motor from switches on a control panel when the motor and control panel are connected to the MP2300.

■ Configuration Example



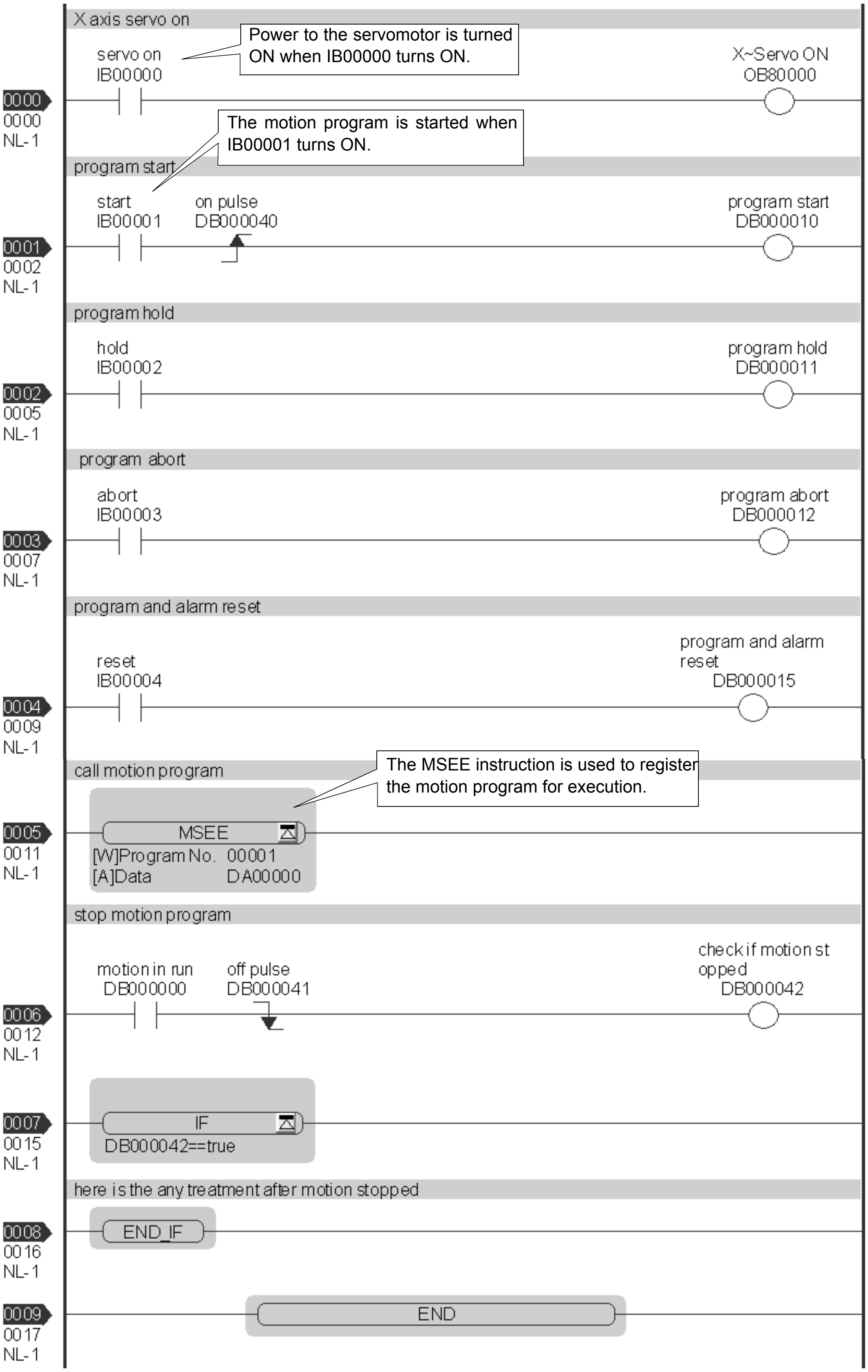
■ Ladder Programming Example



C.2 Motion Program Control

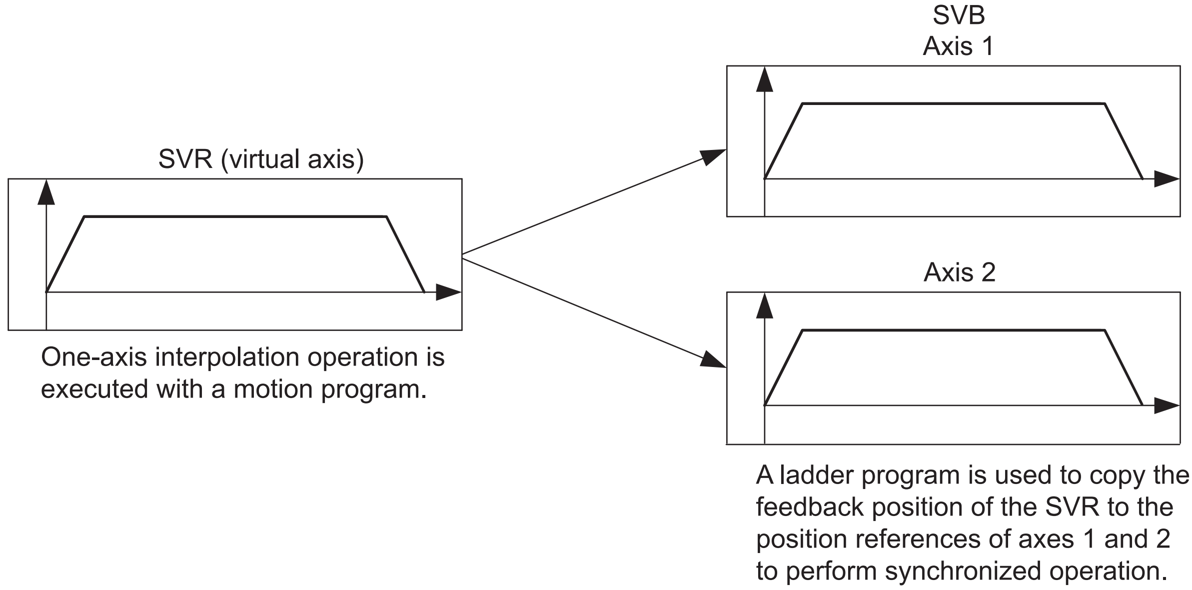
The following ladder programming example demonstrates how to control execution of a motion program.

■ Ladder Programming Example



C.3 Simple Synchronized Operation of Two Axes with a Virtual Axis

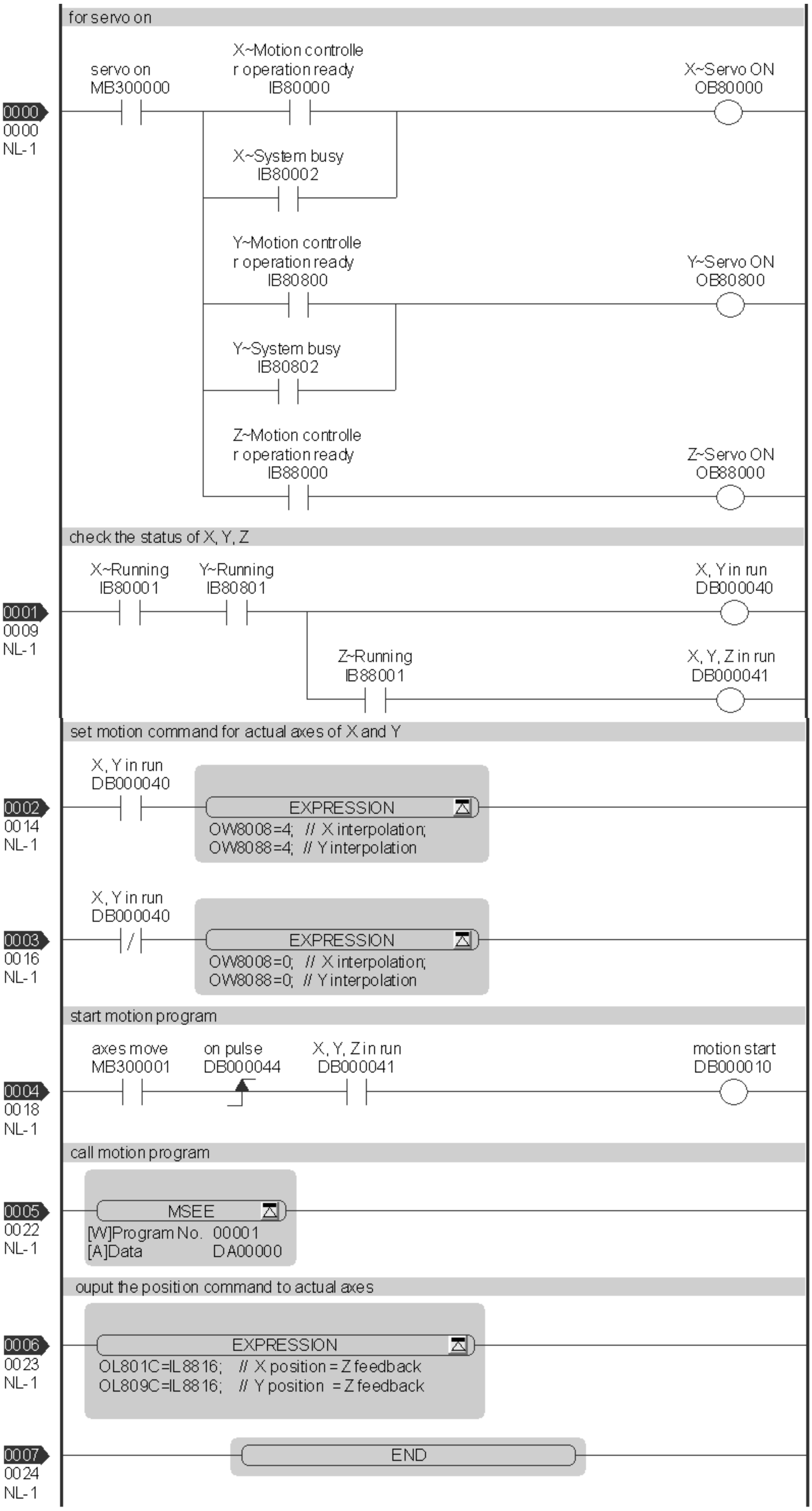
With the following sample programs, a motion program moves an SVR (virtual axis) and a ladder program distributes the feedback position of the SVR to two physical axes to perform synchronized operation with two axes.



■ Motion Programming Example

```
FMX T10000K;                  "Set maximum interpolation speed K = 1,000.
INC;                          "Incremental Mode
IAC T500;                     "Interpolation acceleration time = 500 ms
IDC T500;                     "Interpolation deceleration time = 500 ms
MVS [SVR] 1000K F10000K;      "Interpolation for travel distance of 1,000,000
END;
```

■ Ladder Programming Example

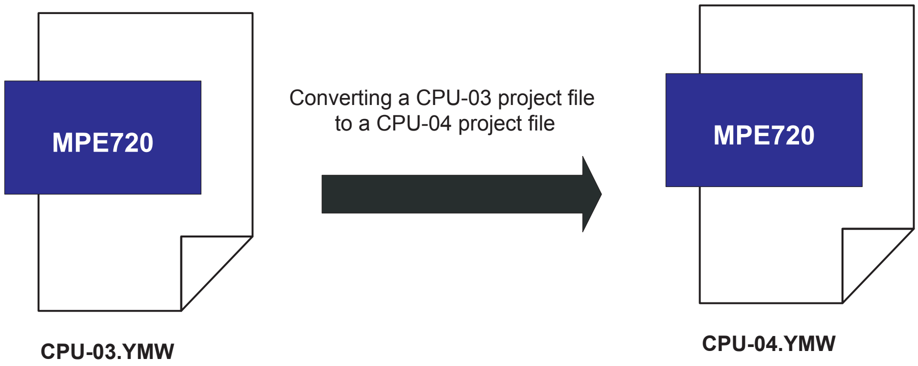


Sample Programming

AppC

C.4 Transferring Project Files to Different Models

Use the following procedure to transfer a project file to a different model.
This example shows how to convert a CPU-03 project file to a CPU-04 project file.



■ Procedure

1. Create a new project file for the CPU-04.
2. Select ***Online - Transfer - Read from Project.***
3. Select the CPU-03 project file and transfer it to the CPU-04 project.
4. Manually set the Module configuration definitions.

INFO

The Module configuration definition will be lost when you transfer a project file to a different model.
Set the Module configuration definitions and parameters manually.
You cannot use the axis data copy function for Module configuration definitions between different project files.

Appendix D

Format for EXPRESSION Instruction

This appendix describes the format for the EXPRESSION instruction.

D.1 Elements That You Can Use in Numeric Expressions

Numeric expressions can include operators, operands (constants and variables), and functions.
This section describes each of these elements.

(1) Operators

[a] Types of Operators and Usable Operators

The following table gives the types of operators and usable operators.

Type	Usable Operators	
Arithmetic and Logic Operators	+	Add
	−	Subtract
	*	Multiply
	/	Divide
	%	Remainder
	&	Bit-wise AND
	|	Bit-wise OR
Logic Operators (Usable only with bit data)	&&	Inclusive AND
	||	Inclusive OR
	!	Logical NOT
Comparison Operators	==	Equal to right-side value
	!=	Unequal to right-side value
	>	Greater than right-side value
	>=	Greater than or equal to right-side value
	<	Less than right-side value
	<=	Less than or equal to right-side value
Substitution Operator	=	Substitutes left-side value with right-side value
Reserved Words	true	TRUE for a logical expression
	false	FALSE for a logical expression

[b] Order of Evaluation

Operators are evaluated according to their processing priority and the order in which operands are grouped, as listed below.

Priority*	Operators	Description	Grouping Order
High	[] ()	Expression	Left to right
↑	– !	Unary	Right to left
	* / %	Multiplication, division, and remainder	Left to right
	+ –	Addition and subtraction	
	< > <= >=	Relational	
	== !=	Equivalence	
	&	Bit-wise AND	
↓	|	Bit-wise OR	
	&&	Inclusive AND	
Low	||	Inclusive OR	

- Operators on the same line have the same processing priority and are evaluated according to their grouping order.

(2) Operands

[a] Constants

Integers or real numbers may be used as a constant.

- An integer may be any number that can be expressed within the range of a 32-bit integer.
  (-2,147,483,648 to 2,147,483,647)
- A real number may be any number that can be expressed within the range of 32-bit floating point data.
  ± (1.175494351e–38F to 3.402823466e+38F)

INFO

Hexadecimal numbers must be expressed using the 0x□□□□ notation when used in the EXPRESSION, IF, or WHILE instruction.

The H□□□□ notation will result in an error.

Example: H012F ... NG 0x012F ... OK

The H□□□□ notation must be used for all other instructions, such as the STORE instruction.

[b] Variables

The EXPRESSION instruction allows you to assign arbitrary variable names that are allowed in C language to registers in the Machine Controller.
Although the C language does not have Boolean variables, bit registers in the Machine Controller are treated as Boolean variables. Boolean variables are either TRUE or FALSE and can be used only in logical expressions.

■ Limitations on Variable Names

The following limitations apply to variable names.

- Variable names must start with a non-numeric character.
- For ASCII characters, only alphabetic characters, underscores, and numbers may be used.
- The following variable names cannot be used because they are already used as function names.

◀ EXAMPLE ▶

Abc	OK
Get_input()	OK
1ab	NG
Sin	NG

(3) Instructions That You Can Use with EXPRESSION Instructions

Instruction	Description	Example	Reserved Word
+	Add	MW00001 = MW00002 + MW00003	√
–	Subtract	MW00001 = MW00002 – MW00003	√
*	Multiply	MW00001 = MW00002 × MW00003	√
/	Divide	MW00001 = MW00002 / MW00003	√
%	Remainder	MW00001 = MW00002 % MW00003	√
&	Bit-wise AND	MW00001 = MW00002 & 4096	√
|	Bit-wise OR	MW00001 = MW00002 | 4096	√
&&	Inclusive AND	MB000010 = MB000011 && MB000012	√
||	Inclusive OR	MB000010 = MB000011 || MB000012	√
!	Logical NOT	MB000010 = !MB000011	√
==	Equal to right-side value	MB000010 = MB000011 == true	√
>=	Right-side value is less than or equal to left-side value	MB000010 = MW00020 >= MW00021	√
>	Right-side value is less than left-side value	MB000010 = MW00020 > MW00021	√
<	Right-side value is greater than left-side value	MB000010 = MW00020 < MW00021	√
<=	Right-side value is greater than or equal to left-side value	MB000010 = MW00020 <= MW00021	√
=	Substitute left-side value with right-side value	MW00001 = MW00002	√
true	TRUE	MB000010 = MB000011 == true	√
false	FALSE	MB000010 = MB000011 == false	√
sin()	SIN	MW00001 = sin(MW00002)	√
cos()	COS	MF00002 = cos(MF00004)	√
atan()	ARCTAN	MW00001 = atan(MF00002)	√
tan()	TAN	MW00001 = tan(MW00002)	√
()	Parentheses	MW00001 = (MW00002 + MW00003) / MW00004	√
asin()	ARCSIN	MW00001 = asin(MW00002)	√
acos()	ARCCOS	MW00001 = acos(MW00002)	√
sqrt()	AQRT	MW00001 = sqrt(MW00002)	√
abs()	ABS	MW00001 = abs(MW00002)	√
exp()	EXP	MW00001 = exp(MW00002)	√
log()	LOG natural logarithm	MW00001 = log(MW00002)	√
log10()	LOG10 common logarithm	MW00001 = log10(MW00002)	√

D.2 National Limitations

Several limitations apply when combining operands and operators to form numeric expressions. An expression is not recognized as a numeric expression unless it meets these conditions.
This section describes these limitations.

D.2.1 Arithmetic Operators

These operators can be used with integer and real number operands. The unary minus operator can be used only once. Bit operations can be performed only on integer data. Bit operands cannot be used for arithmetic operations. No automatic data type conversion is performed even if the calculation result exceeds the range of the assigned register. Therefore, the user must assign the appropriate data type to the variable.

◀ EXAMPLE ▶

MW00001 = MW00002 + MW00003	OK
MW00001 = MW00002 / 345	OK
MF00002 = (MW00004 + MF00002) / (ML00018 + MW00008)	OK
MW00001 = MW00002 & 4096	OK
MB000010 = MB000011 - MB000012	NG
MW00001 = MB000011 * MW00001	NG

D.2.2 Comparison Operators

These operators can be used with integer and real number operands. The left side must be a bit data register. To use an integer bit operand in a comparison operation with the == or != operator, compare it with TRUE or FALSE.

◀ EXAMPLE ▶

MB000010 = MW00002 != MW00003	OK
MB000010 = MF00002 < 99.99	OK
MB000010 = MW00002 >= MW00003	OK
MB000010 = MB000011 == true	OK
MB000010 = MB000011 != 0	NG
MB000010 = MB000011 == 1	NG

D.2.3 Logic Operators

These operators can be used with bit operands.

◀ EXAMPLE ▶

MB000010 = MB000011 && MB000012	OK
MB000010 = !MB000011	OK
MB000010 = (MW000020 >= 50) && MB000011	OK
MB000010 = MW00001 || MW00002	NG
MB000010 = !MW00001	NG

D.2.4 Substitution Operator

Real number and integer registers can be substituted with either real number or integer data, even if the data type differs on the right and left sides. When you substitute an integer with a real number, a round-off error will occur.
Bit registers can be substituted only with logical values, such as another bit register or a TRUE/FALSE. If you substitute a bit register with a non-logical value, that value will be compared against 0 or 0.0 and the TRUE or FALSE outcome will be converted to a code before it is substituted.
Bit data cannot be substituted into non-bit registers.

◀ EXAMPLE ▶

MW00001 = MW00002;	OK
MF00000 = MW00002 / 345;	OK
MB000010 = MB000010;	OK
MW00010 = MB0000101;	NG
MW00001 = true;	NG

D.2.5 Functions

The arguments and return values for functions depend on the specifications of the functions in the Machine Controller. Therefore, if the input for the sin(), cos(), and atan() functions is an integer or integer register, the output value will be returned as an integer. If the input is a real number or a real number register, the output value will be returned as a real number.
The argument for the tan() function is a real number so an integer register input will be treated as a real number.

◀ EXAMPLE ▶

MW00001 = sin(MW00002);	OK
MF00002 = cos(MF00000 × 3.14);	OK
MW00001 = -atan(MF00002);	OK

D.2.6 Others

■ Parentheses

You can group multiple expressions by enclosing them with parenthesis ( ).

◀ EXAMPLE ▶

MW00001 = -(MW00002 + 10) / (MW00003 – MW00005);	OK

■ Arrays

You can specify arrays by using square brackets [ ], just like with the C language.

◀ EXAMPLE ▶

MW00001 = MW00002[100];	OK
MW00001 = MW00002[MW00003];	OK
MB000010 = MB000020[0]:	OK

Appendix E

Precautions

This appendix provides precautions on ladder programs and motion parameters.

E.1 General Precautions

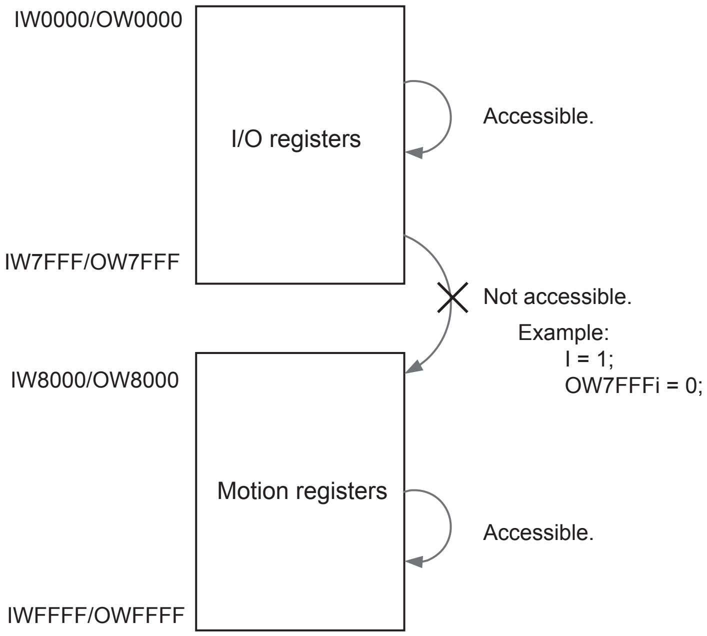
(1) Do Not Forget to Save The Data to Flash Memory When You Change or Transfer a Program

Do not forget to save the data to flash memory when you change or transfer a ladder program or motion program. If you do not, any changes that were made to the program will be lost when the power supply to the Machine Controller is turned OFF.

E.2 Precautions on Motion Parameters

(1) Do Not Use a Subscript to Reference a Motion Register from an I/O Register

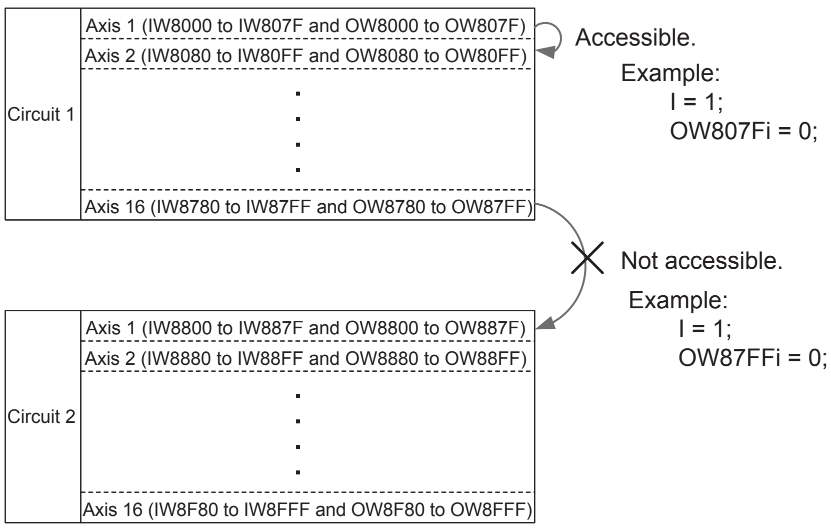
I/O registers and motion registers are not assigned to consecutive memory locations.
When using a subscript, make sure that you access registers within the range of I/O registers or within the range of motion registers.



(2) Do Not Use a Subscript to Reference a Motion Register in a Different Circuit

Motion registers on different circuits are not assigned to continuous memory location, just as is true for I/O registers and motion registers.
When using a subscript, access registers within the range of motion registers for each circuit.
If the circuit numbers are the same, it is possible to access motion registers for different axes.

Circuit No.	Axis 1	Axis 2	...	Axis 16
1	OW8000 to OW807F	OW8080 to OW80FF	...	OW8780 to OW87FF
2	OW8800 to OW887F	OW8880 to OW88FF	...	OW8F80 to OW8FFF
3	OW9000 to OW907F	OW9080 to OW90FF	...	OW9780 to OW97FF
4	OW9800 to OW987F	OW9880 to OW98FF	...	OW9F80 to OW9FFF
5	OWA000 to OWA07F	OWA080 to OWA0FF	...	OWA780 to OWA7FF
6	OWA800 to OWA87F	OWA880 to OWA8FF	...	OWAF80 to OWAFFF
7	OWB000 to OWB07F	OWB080 to OWB0FF	...	OWB780 to OWB7FF
8	OWB800 to OWB87F	OWB880 to OWB8FF	...	OWBF80 to OWBFFF
9	OWC000 to OWC07F	OWC080 to OWC0FF	...	OWC780 to OWC7FF
10	OWC800 to OWC87F	OWC880 to OWC8FF	...	OWCF80 to OWCFFF
11	OWD000 to OWD07F	OWD080 to OWD0FF	...	OWD780 to OWD7FF
12	OWD800 to OWD87F	OWD880 to OWD8FF	...	OWDF80 to OWDFFF
13	OWE000 to OWE07F	OWE080 to OWE0FF	...	OWE780 to OWE7FF
14	OWE800 to OWE87F	OWE880 to OWE8FF	...	OWEF80 to OWEFFF
15	OWF000 to OWF07F	OWF080 to OWF0FF	...	OWF780 to OWF7FF
16	OWF800 to OWF87F	OWF880 to OWF8FF	...	OWFF80 to OWFFFF



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Revision History

The revision dates and numbers of the revised manuals are given on the bottom of the back cover.

MANUAL NO. SIE-C887-1.2D

Published in Japan February 2014 98-7 14 -1

- WEB revision number
- Revision number
- Date of original publication
- Date of publication

Date of Publication	Rev. No.	WEB Rev. No.	Section	Revised Contents
February 2014	14	1	5.8.2 (1)	Revision: Formula for input value and output value related to dead zone
August 2013		0	All chapters	Completely revised.
			Back cover	Revision: Address
February 2013	13	0	Back cover	Revision: Address
February 2012	12	0	Back cover	Revision: Address
Jane 2011	11	0	Front cover	Revision: Format
			Back cover	Revision: Address, format
December 2009	10	0	–	Based on Japanese user’s manual, SI-C887-1.2E <17> published in October 2009.
			Preface	Revision: General precautions Addition: PL on fumigation and warranty
			1.3	Addition: Characteristics of registers in user functions
			2.3.2	Revision: Integer input for function input registers Addition: Notes on the use of registers (X, Y, Z, and D) in functions
			5.2	Revision: Definition of TRACE function
			Back cover	Revision: Address
October 2008	9	0	Back cover	Revision: Address
March 2007	8	0	–	Based on Japanese user’s manual, SI-C887-1.2D <14> published in July 2006.
			Back cover	Revision: Address
April 2006	7	0	–	Based on Japanese user’s manual, SI-C887-1.2D <13> published in February 2006.
			3.3.1	Revision: RSSEL, MDSEL, and STS designations
August 2005	6	0	Back cover	Revision: Address
March 2005	5	0	All chapters	Completely revised.
			Back cover	Revision: Address
June 2003	4	0	Back cover	Revision: Address
December 2002	3	0	Back cover	Revision: Address
February 2001	2	0	All chapters	Completely revised.
October 1998	1	0	All chapters	Partly revised.
July 1998	–	–	–	First edition

Machine Controller MP2000 Series

USER'S MANUAL
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MANUAL NO. SIE-C887-1.2D

Published in Japan February 2014 98-7 ⟨14⟩-1
13-6-9