FT9Y-B1382

IDEC

FT1A Series SmartAXIS

Ladder Programming Manual

Automation Organizer WindLDR

IDEC CORPORATION

SAFETY PRECAUTIONS

- Read the SmartAXIS Pro/Lite User's Manual to make sure of correct operation before starting installation, wiring, operation, maintenance, and inspection of the SmartAXIS.
- All SmartAXIS modules are manufactured under IDEC's rigorous quality control system, but users must add a backup or failsafe provision to the control system when using the SmartAXIS in applications where heavy damage or personal injury may be caused in case the SmartAXIS should fail.
- In this user's manual, safety precautions are categorized in order of importance to Warning and Caution:

⚠ Warning **Warning notices are used to emphasize that improper operation may cause severe personal injury or death.**

- The SmartAXIS is not designed for use in medical equipment, nuclear power, railways, aviation, passenger vehicle equipment, or similar applications requiring a high degree of reliability and safety. The SmartAXIS cannot be used for such applications.
- When using the SmartAXIS in applications not described above that require a high degree of reliability in terms of functionality and precision, appropriate measures such as failsafe mechanisms and redundant mechanisms must be taken for a system containing the SmartAXIS.
- Emergency stop and interlocking circuits must be configured outside the SmartAXIS.
- If relays or transistors in the SmartAXIS output circuits should fail, outputs may remain in the on or off state. For output signals which may cause serious accidents, configure monitor circuits outside the SmartAXIS.
- The SmartAXIS self-diagnostic function may detect internal circuit or program errors, stop programs, and turn outputs off. Configure circuits so that the system containing the SmartAXIS is not jeopardized when outputs turn off.
- Turn off power to the SmartAXIS before installation, removal, wiring, maintenance, and inspection of the SmartAXIS. Failure to turn power off may cause electrical shocks or fire hazard.
- Special expertise is required to install, wire, program, and operate the SmartAXIS. People without such expertise must not use the SmartAXIS.
- Install the SmartAXIS according to the instructions described in SmartAXIS Pro/Lite user's manual. Improper installation will result in falling, failure, or malfunction of the SmartAXIS.

⚠ Caution **Caution notices are used where inattention might cause personal injury or damage to equipment.**

- The SmartAXIS is designed for installation in a cabinet. Do not install the SmartAXIS outside a cabinet.
- Install the SmartAXIS in environments described in SmartAXIS Pro/Lite user's manual. If the SmartAXIS is used in places where the SmartAXIS is subjected to high-temperature, high-humidity, condensation, corrosive gases, excessive vibrations, and excessive shocks, then electrical shocks, fire hazard, or malfunction will result.
- The environment for using the SmartAXIS is "Pollution degree 2." Use the SmartAXIS in environments of pollution degree 2 (according to IEC 60664-1).
- While moving or transporting prevent the SmartAXIS from falling, otherwise damage or malfunction of the SmartAXIS will result.
- Wiring must use lead sizes that are appropriate for the applied voltage and current. Terminal screws must be tightened with the prescribed tightening torque.
- Prevent metal fragments and pieces of wire from dropping inside the SmartAXIS housing. Put a cover on the SmartAXIS modules during installation and wiring. Ingress of such fragments and chips may cause fire hazard, damage, or malfunction.
- Use a power supply of the rated value. Use of the wrong power supply may cause fire hazard.
- Use an IEC 60127-approved fuse on the power line outside the SmartAXIS. This is required when equipment containing the SmartAXIS is designed for use in Europe.
- Use an IEC 60127-approved fuse on the output circuit. This is required when equipment containing the SmartAXIS is designed for use in Europe.
- Use an EU-approved circuit breaker. This is required when equipment containing the SmartAXIS is destined for Europe.
- Make sure of safety before starting and stopping the SmartAXIS or when operating the SmartAXIS to force outputs on or off. Incorrect operation of the SmartAXIS may cause machine damage or accidents.
- Do not connect the ground wire directly to the SmartAXIS. Connect a protective ground to the cabinet containing the SmartAXIS using an M4 or larger screw. This is required when equipment containing the SmartAXIS is designed for use in Europe.
- Do not disassemble, repair, or modify the SmartAXIS modules.
- The SmartAXIS contains electronic parts and batteries. When disposing of the SmartAXIS, do so in accordance with national and local regulations.

ABOUT THIS MANUAL

This user's manual describes basic and advanced instructions and the usage of software for SmartAXIS ladder programming.

Chapter 1: Operation Basics

General information about simple operating procedures from creating a user program using WindLDR on a computer to monitoring the SmartAXIS operation.

Chapter 2: Ladder Program Monitoring on the SmartAXIS

Monitoring the ladder program in the SmartAXIS.

Chapter 3: Device Addresses

Device addresses available for the SmartAXIS to program basic and advanced instructions. Special internal relays and special data registers are also described.

Chapter 4: Instructions Reference

List of all basic and advanced instructions and general rules of using advanced instructions, terms, data types, and formats used for advanced instructions.

Chapter 5: Basic Instructions

Programming of the basic instructions, available devices, and sample programs.

Chapter 6 through Chapter 26:

Detailed descriptions for advanced instructions.

Appendix

Additional information about execution times and byte sizes for instructions.

Index

Alphabetical listing of key words.

Publication history

March 2013 First Edition

Trademarks

SmartAXIS is a trademark of IDEC Corporation.

RELATED MANUALS

The following manuals related to the SmartAXIS are available. Refer to them in conjunction with this manual.

Type No.	Manual Name	Description
FT9Y-B1378	SmartAXIS Pro/Lite User's Manual	Describes product specifications, installation and wiring instructions, instructions for basic programming operations and special functions, device and instruction lists, communication functions, and troubleshooting procedures for the SmartAXIS Pro/ Lite series.
FT9Y-B1382	SmartAXIS Ladder Programming Manual (this manual)	Describes basic operations for ladder programming, instructions for editing and monitoring ladders on the SmartAXIS, available devices and instruction lists, and details of each instruction.
FT9Y-B1390	SmartAXIS Touch User's Manual	Describes product specifications, installation and wiring instructions, instructions for setting basic programming actions and special functions, device and instruction lists, communication functions, and troubleshooting procedures for the Touch series.
WindLDR Help		Describes usage instructions for WindLDR, programming software for the SmartAXIS Pro/Lite series.
WindO/I-NV3 Help		Describes programming for the SmartAXIS Touch series, and usage instructions for the WindO/I-NV3 configuration software.

NAMES AND ABBREVIATIONS USED IN THIS MANUAL

Model Names

Name Used in this Manual	Description (Detailed Type No.)
SmartAXIS	FT1A programmable logic controllers.
SmartAXIS Lite	Modules without LCD. (FT1A-B12RA, FT1A-B12RC, FT1A-B24RA, FT1A-B24RC, FT1A-B40RKA, FT1A-B40RSA, FT1A-B40RC, FT1A-B48KA, FT1A-B48SA, FT1A-B48KC, FT1A-B48SC)
SmartAXIS Pro	Modules with LCD. (FT1A-H12RA, FT1A-H12RC, FT1A-H24RA, FT1A-H24RC, FT1A-H40RKA, FT1A-H40RSA, FT1A-H40RC, FT1A-H48KA, FT1A-H48SA, FT1A-H48KC, FT1A-H48SC)
SmartAXIS Touch	Modules that extend the functionality of display. (FT1A-M12RA-W, FT1A-M12RA-B, FT1A-M12RA-S, FT1A-C12RA-W, FT1A-C12RA-B, FT1A-C12RA-S)
12-I/O type	SmartAXIS Pro and Lite models with 12 I/O points. (FT1A-B12RA, FT1A-B12RC, FT1A-H12RA, FT1A-H12RC)
24-I/O type	SmartAXIS Pro and Lite models with 24 I/O points. (FT1A-B24RA, FT1A-B24RC, FT1A-H24RA, FT1A-H24RC)
40-I/O type	SmartAXIS Pro and Lite models with 40 I/O points. (FT1A-B40RKA, FT1A-B40RSA, FT1A-B40RC, FT1A-H40RKA, FT1A-H40RSA, FT1A-H40RC)
48-I/O type	SmartAXIS Pro and Lite models with 48 I/O points. (FT1A-B48KA, FT1A-B48SA, FT1A-B48KC, FT1A-B48SC, FT1A-H48KA, FT1A-H48SA, FT1A-H48KC, FT1A-H48SC)
AC power type	SmartAXIS Pro and Lite models with an AC power supply. (FT1A-B12RC, FT1A-H12RC, FT1A-B24RC, FT1A-H24RC, FT1A-B40RC, FT1A-H40RC, FT1A-B48KC, FT1A-B48SC, FT1A-H48KC, FT1A-H48SC)
DC power type	SmartAXIS Pro and Lite models with a DC power supply. (FT1A-B12RA, FT1A-H12RA, FT1A-B24RA, FT1A-H24RA, FT1A-B40RKA, FT1A-H40RKA, FT1A-B40RSA, FT1A-H40RSA, FT1A-B48KA, FT1A-B48SA, FT1A-H48KA, FT1A-H48SA)

TABLE OF CONTENTS

1: OPERATION BASICS

Introduction

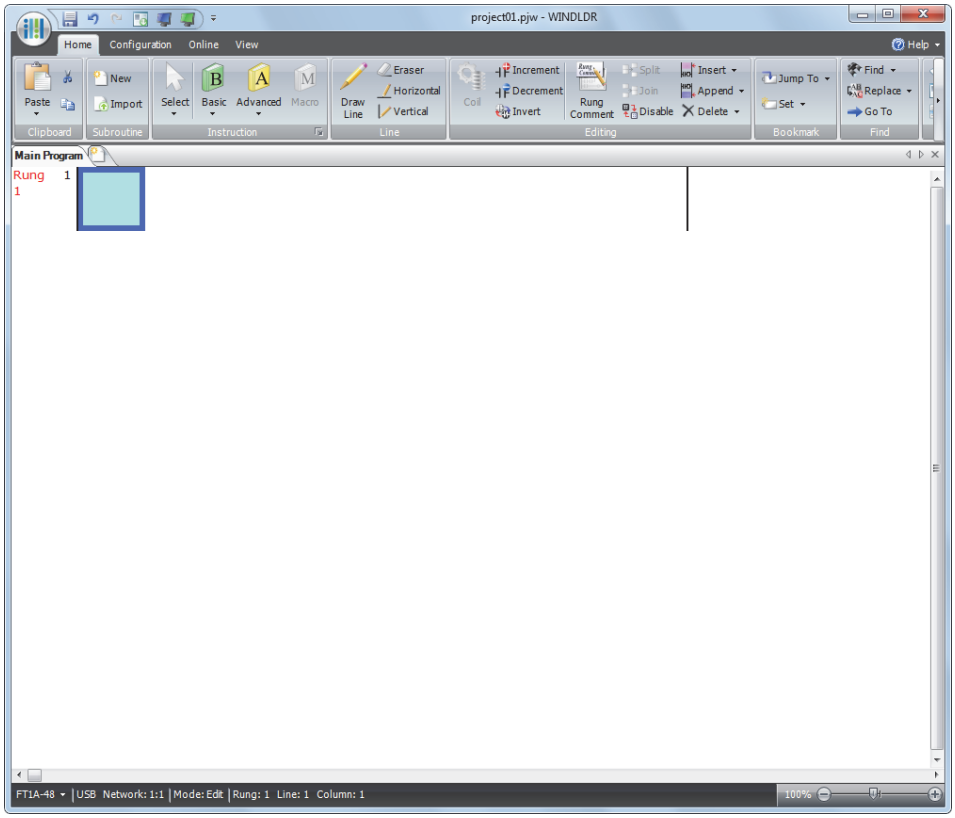
This chapter describes basic procedures for operating WindLDR, software required for programming and maintenance of the SmartAXIS Pro/Lite series.

Note: SmartAXIS Touch series use WindO/I-NV3 for programming. See the SmartAXIS Touch User's Manual for instructions for programming and basic operation of WindO/I-NV3 with the Touch series.

Start WindLDR

From the Start menu of Windows, select **Programs** > **Automation Organizer** > **WindLDR** > **WindLDR**.

WindLDR starts and a blank ladder editing screen appears with menus and tool bars shown on top of the screen.

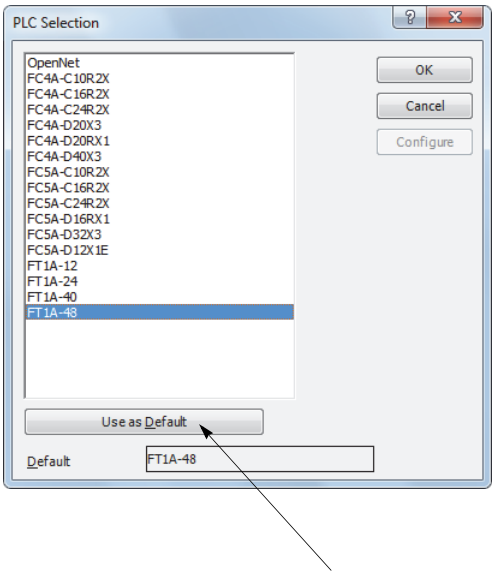


PLC Selection

Before programming a user program in WindLDR, select a PLC type.

1. Select **Configuration** from the WindLDR menu bar, then select **PLC Type**.

The PLC Selection dialog box appears.



If the Use as Default button is pressed, then the same PLC will be selected as default when WindLDR is started next time.

PLC Selection Option	SmartAXIS Type No.
FT1A-12	FT1A-H12RA FT1A-B12RA FT1A-H12RC FT1A-B12RC
FT1A-24	FT1A-H24RA FT1A-B24RA FT1A-H24RC FT1A-B24RC
FT1A-40	FT1A-H40RKA FT1A-H40RSA FT1A-B40RKA FT1A-B40RSA FT1A-H40RC FT1A-B40RC
FT1A-48	FT1A-H48KA FT1A-H48SA FT1A-B48KA FT1A-B48SA FT1A-H48KC FT1A-H48SC FT1A-B48KC FT1A-B48SC

2. Select a PLC type in the selection box.
3. Click **OK**.

Create Ladder Program

This section describes the procedure for creating a simple ladder program in WindLDR.

Note: See "Instructions Reference" on page 4-1 for details on basic and advanced instructions.

Sample User Program

Create a sample program using WindLDR that performs the following operation:

When only input I0 is turned on, output Q0 is turned on.
When only input I1 is turned on, output Q1 is turned on.
When both inputs I0 and I1 are turned on, output Q2 flashes in 1-sec increments.

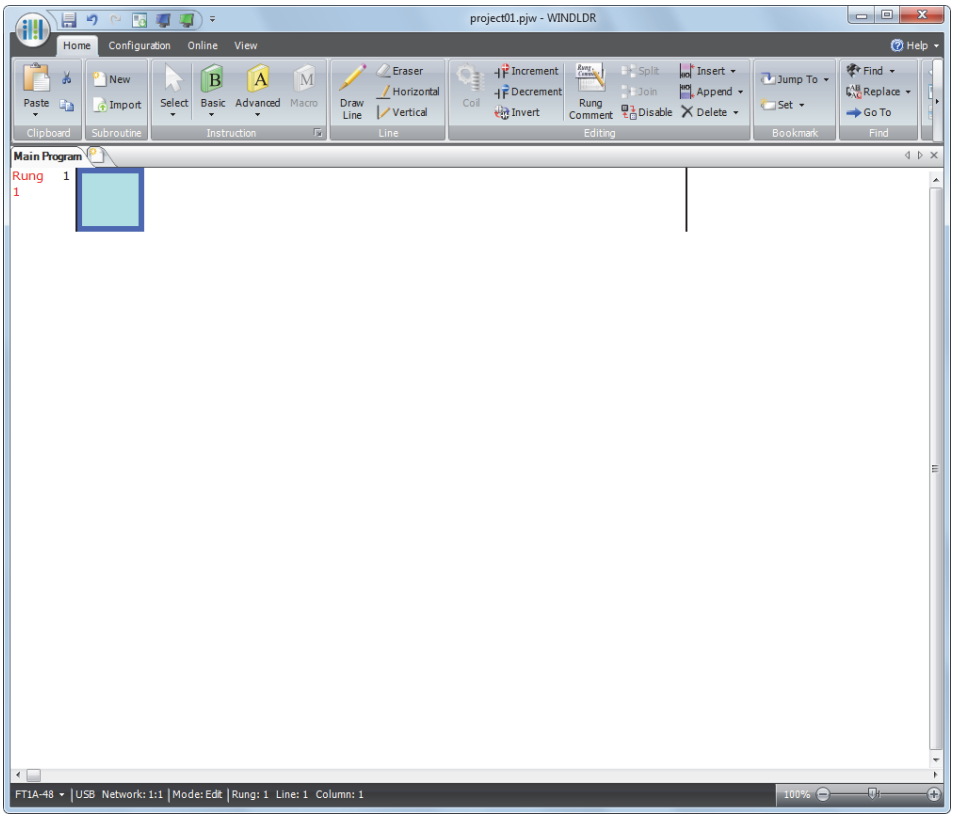
Rung No.	Input I0	Input I1	Output Operation
1	ON	OFF	Output Q0 is turned ON.
2	OFF	ON	Output Q1 is turned ON.
3	ON	ON	Output Q2 flashes in 1-sec increments.

Note: One collection of a group of instructions that control output or advanced instructions is called a rung. WindLDR manages programs in rung units. Function descriptions can be configured as rung comments for individual rungs.

Start WindLDR

From the Start menu of Windows, select **Programs** > **Automation Organizer** > **WindLDR** > **WindLDR**.

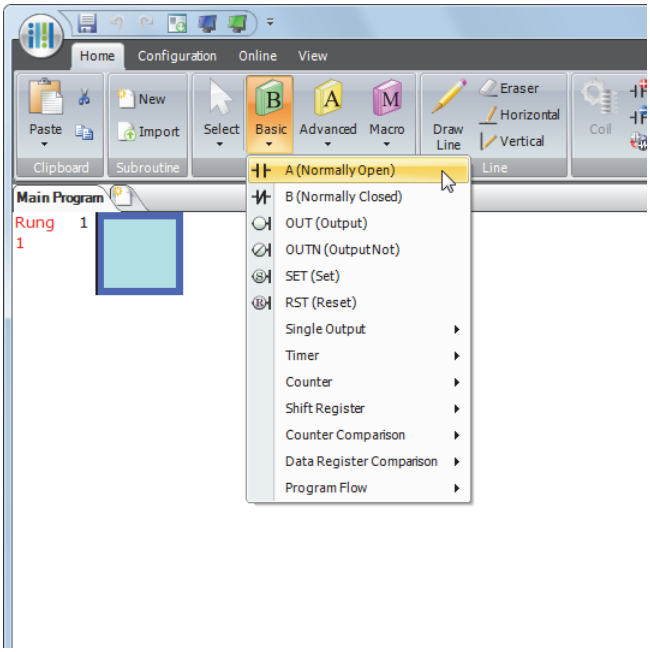
WindLDR starts and a blank ladder editing screen appears with menus and tool bars shown on top of the screen.



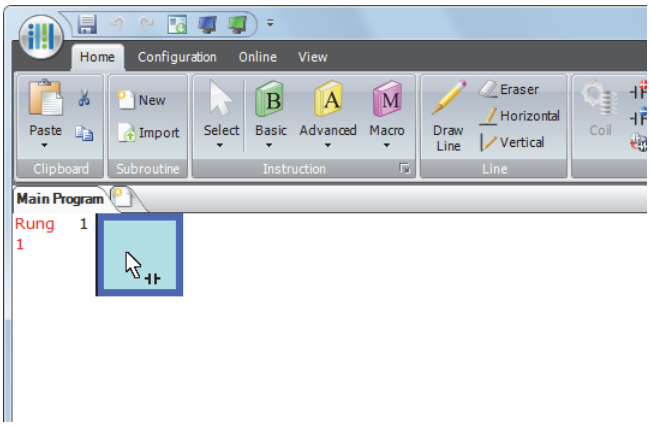
Edit User Program Rung by Rung

Start the user program with the LOD instruction by inserting a NO contact of input I0.

1. From the WindLDR menu bar, select **Home** > **Basic** > **A (Normally Open)**.



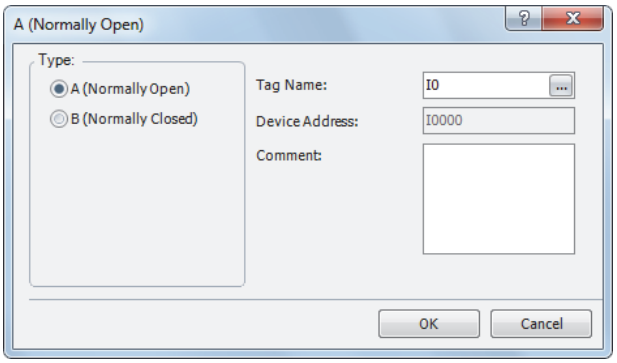
2. Move the mouse pointer to the first column of the first line where you want to insert a NO contact, and click the left mouse button.



Note: Another method to insert a NO (or NC) contact is to move the mouse pointer where you want to insert the contact, and type A (or B).

The Normally Open dialog box appears.

3. Enter **I0** in the Tag Name field, and click **OK**.



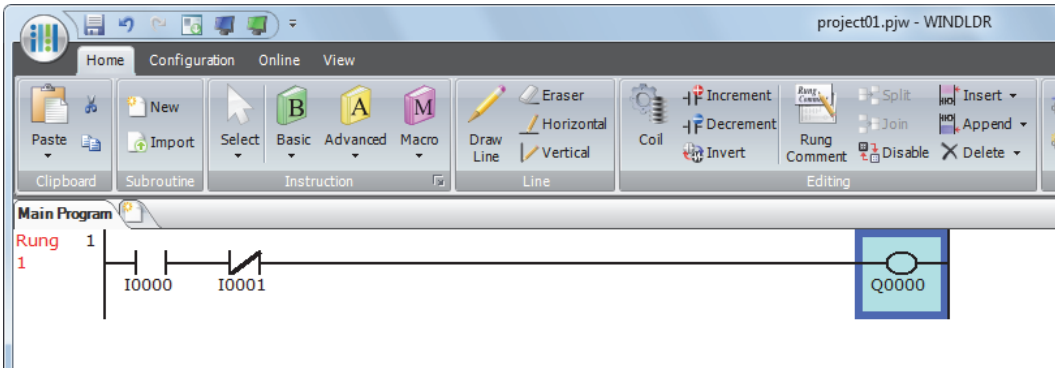
A NO contact of input I0 is programmed in the first column of the first ladder line.
Next, program the ANDN instruction by inserting a NC contact of input I1.

4. From the WindLDR menu bar, select **Home** > **Basic** > **B (Normally Closed)**.
5. Move the mouse pointer to the second column of the first ladder line where you want to insert a NC contact, and click the left mouse button.
The Normally Closed dialog box appears.
6. Enter **I1** in the Tag Name field, and click **OK**.
A NC contact of input I1 is programmed in the second column of the first ladder line.
At the end of the first ladder line, program the OUT instruction by inserting a NO coil of output Q0.
7. From the WindLDR menu bar, select **Home** > **Basic** > **OUT (Output)**.
8. Move the mouse pointer to the third column of the first ladder line where you want to insert an output coil, and click the left mouse button.

Note: Another method to insert an instruction (either basic or advanced) is to type the instruction symbol, OUT, where you want to insert the instruction.

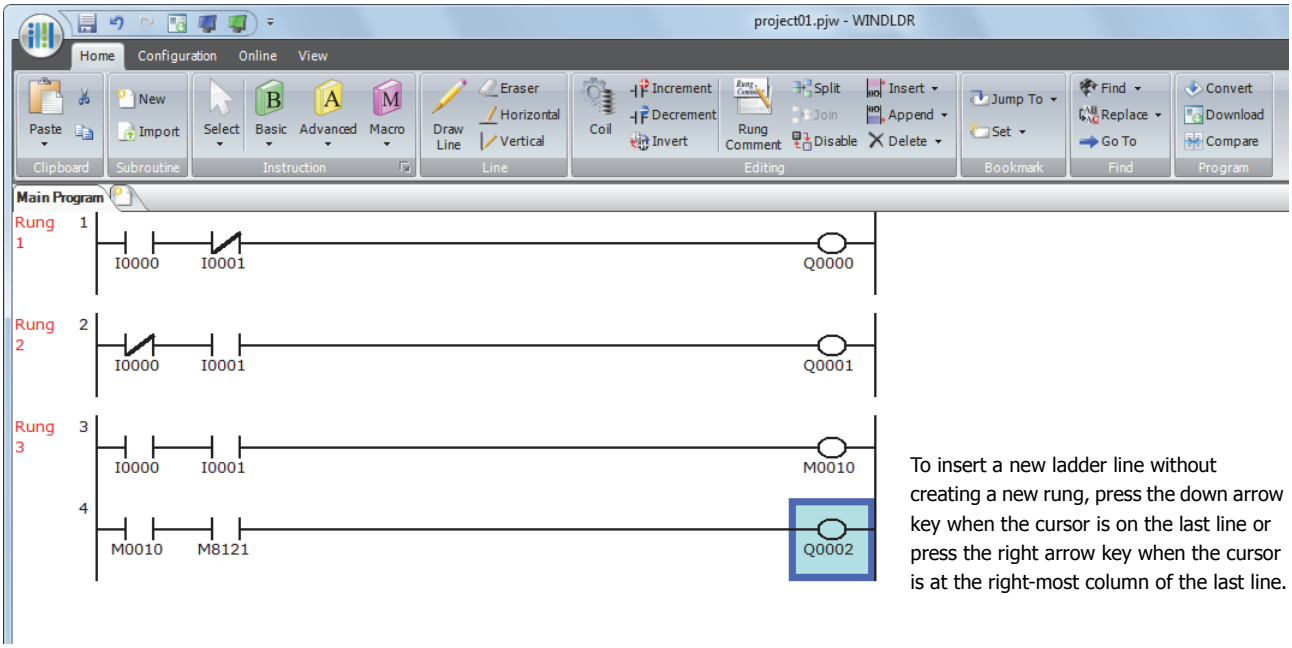
The Output dialog box appears.

9. Enter **Q0** in the Tag Name field, and click **OK**.
A NO output coil of output Q0 is programmed in the right-most column of the first ladder line. This completes programming for rung 1.



Continue programming for rungs 2 and 3 by repeating similar procedures.
A new rung is inserted by pressing the **Enter** key while the cursor is on the preceding rung. A new rung can also be inserted by selecting **Home** > **Append** > **Append a Rung**.

When completed, the ladder program looks like below.



To insert a new ladder line without creating a new rung, press the down arrow key when the cursor is on the last line or press the right arrow key when the cursor is at the right-most column of the last line.

The ladder program can be checked to see if it it contains any user program syntax error.

10. From the menu bar, select **Home** > **Convert (above Program)**.
When the instruction symbols are connected correctly, conversion is completed successfully. If any error is found, the errors are listed on the screen. Then, make corrections as necessary.

Now, save the file with a new name.

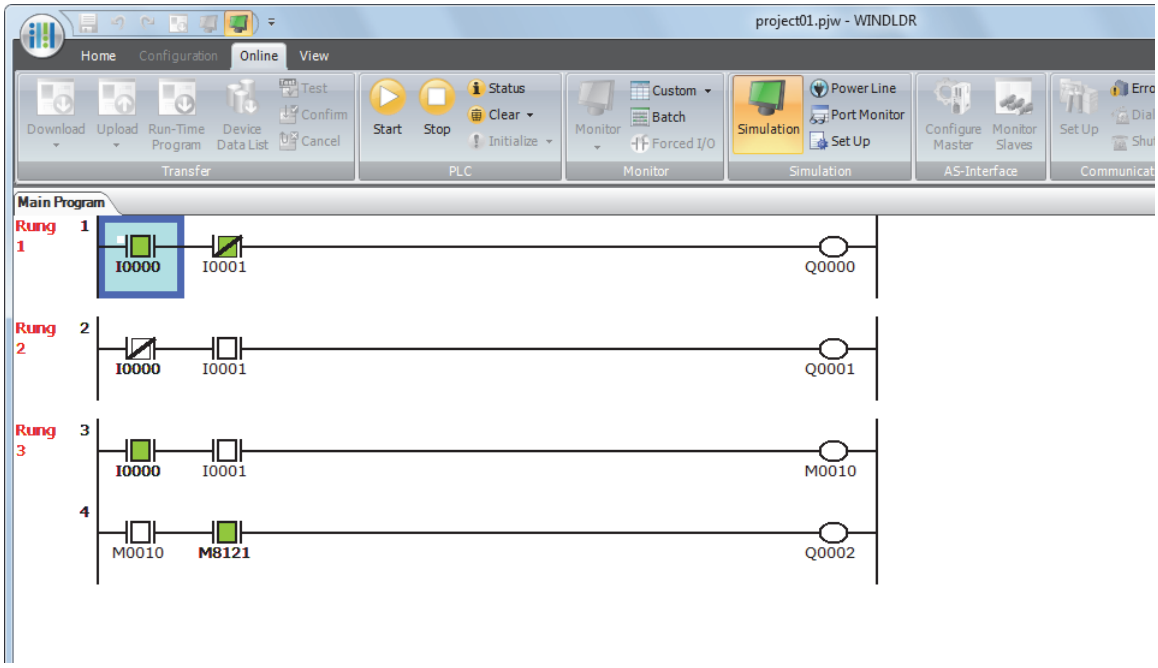
Save Project

1. Select the WindLDR application button at the upper-left corner of the WindLDR screen, followed by **Save**, and type **TEST01** in the File Name field. Change the Folder or Drive as necessary.

Simulate Operation

Before downloading the user program, you can simulate the operation on the WindLDR screen without connecting the SmartAXIS.

From the WindLDR menu bar, select **Online** > **Simulation**. The Simulation screen appears.



To change an input status, place the mouse pointer on the input and right-click the mouse. In the pop-up menu, select Set or Reset to set or reset the input.

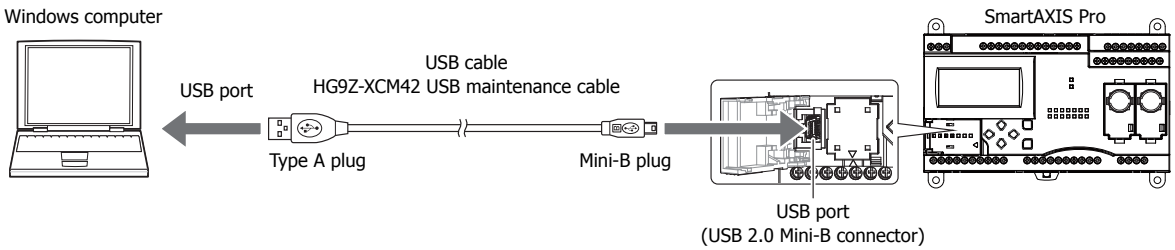
To quit simulation, from the WindLDR menu bar, select **Online** > **Simulation**.

Download Program

You can download the user program from WindLDR running on a computer to the SmartAXIS.

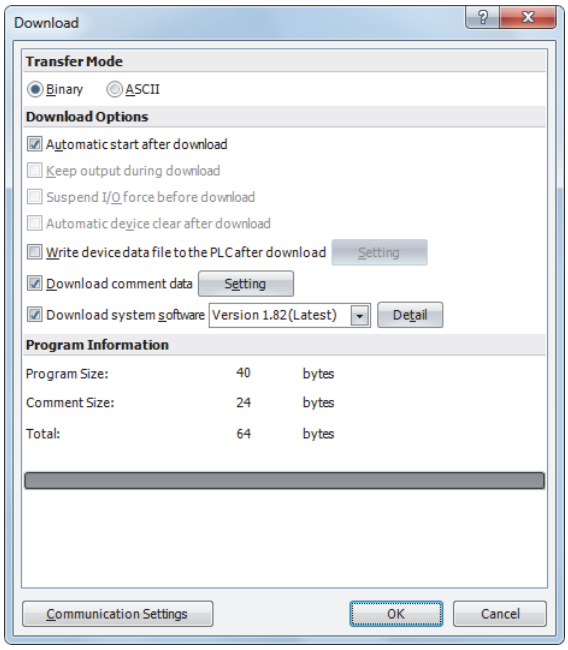
User programs can be downloaded to the SmartAXIS from WindLDR using USB or Ethernet. This section describes the procedure from configuring communication settings to downloading a user program to the SmartAXIS via USB.

To use USB, the SmartAXIS USB port must be connected to a computer using a USB cable.



Note: In order for WindLDR to communicate with the SmartAXIS via USB, a dedicated USB driver must be installed on the computer. See the "Appendix" of the SmartAXIS Pro/Lite User's Manual for driver installation procedure.

1. From the WindLDR menu bar, select **Online** > **Set Up**.
2. The Communication Settings dialog box appears. Click the **USB** tab and then click **OK**.
   The communication method is now set to USB. Next, download a user program.
3. From the WindLDR menu bar, select **Online** > **Download**. The Download dialog box appears, then click **OK**. The user program is downloaded to the SmartAXIS.



Note: The Download dialog box can also be opened by selecting **Home** > **Download**.

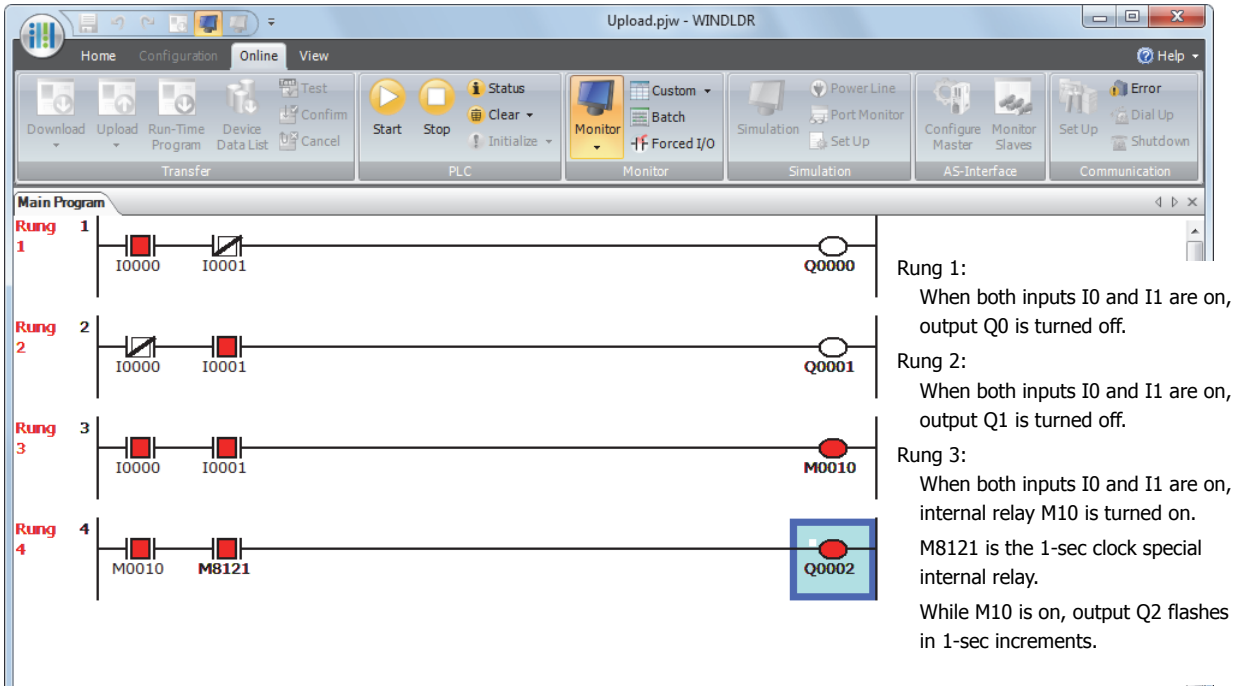
Note: When downloading a user program, all values and selections in the Function Area Settings are also downloaded to the SmartAXIS. For details on function settings, see Chapter 5 "Special Functions" in the SmartAXIS Pro/Lite User's Manual.

Monitor Operation

Another powerful function of WindLDR is to monitor the PLC operation on the computer. The input and output status of the sample program can be monitored in the ladder diagram.

From the WindLDR menu bar, select **Online** > **Monitor** > **Monitor**.

When both inputs I0 and I1 are on, the ladder diagram on the monitor screen looks as follows:



Rung 1:

When both inputs I0 and I1 are on, output Q0 is turned off.

Rung 2:

When both inputs I0 and I1 are on, output Q1 is turned off.

Rung 3:

When both inputs I0 and I1 are on, internal relay M10 is turned on.

M8121 is the 1-sec clock special internal relay.

While M10 is on, output Q2 flashes in 1-sec increments.

Quit WindLDR

When you have completed monitoring, you can quit WindLDR either directly from the monitor screen or from the editing screen. In both cases, from the WindLDR application button, click **Exit WindLDR**.

2: LADDER PROGRAM MONITORING ON THE SMARTAXIS

Introduction

SmartAXIS Pro and Touch are equipped with an LCD and capable of monitoring the ladder program in the SmartAXIS. This chapter describes how to use the ladder program monitoring.

Notes

- For other SmartAXIS Pro functions, refer to the "SmartAXIS Pro/Lite User's Manual".
- For other SmartAXIS Touch functions, refer to the "SmartAXIS Touch User's Manual".

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Basic Operations

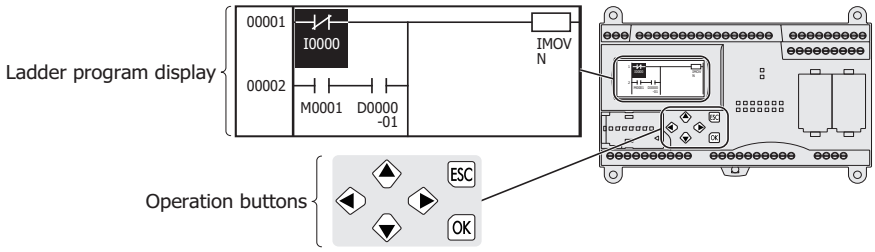
LCD and Operation Buttons

SmartAXIS Pro

Five symbols horizontally and two symbols vertically are displayed in the ladder program display screen.

The operation buttons are laid out on SmartAXIS Pro as shown in the diagram on the right.

A total of six buttons, ◀ (left), ▲ (up), ▼ (down), ▶ (right), ESC (ESC), and OK (OK), are available to use.

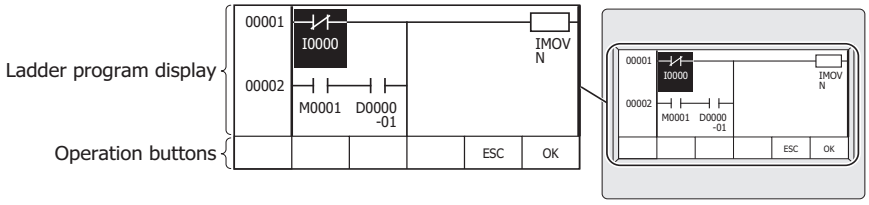


For the SmartAXIS Touch

Five symbols horizontally and two symbols vertically are displayed in the ladder program display screen.

The operation buttons are laid out on the LCD display screen.

A total of six buttons, ◀ (left), ▲ (up), ▼ (down), ▶ (right), ESC (ESC), and OK (OK), are available to use.



Note: The LCD resolution (number of pixels) differs between the SmartAXIS Pro and the SmartAXIS Touch, but the content of the ladder program display screen is the same, excluding the display area for the SmartAXIS Touch operation buttons. This chapter describes the operations using the LCD display on the SmartAXIS Pro. When using the SmartAXIS Touch, read this manual taking into consideration that the operation button display area is omitted.

Button Operations

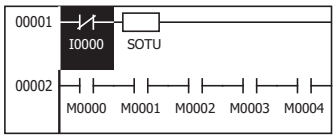
The button operations differ when the button is pressed and released and when the button is pressed and held.

Press/Hold	Operation
Press	The button is pressed for 0.1 seconds or more and less than 2 seconds and then released.
Press and hold	The button is pressed for 2 seconds or more and then released.

Notes

- This chapter describes the button operations for the ladder program monitoring.
- For details on SmartAXIS Pro button operations, refer to the "SmartAXIS Pro/Lite User's Manual".
- For details on SmartAXIS Touch button operations, refer to the "SmartAXIS Touch User's Manual".

List of Button Operations on the Ladder Program Display Screen



Button	Press/Hold	Basic operation
OK/OK	Press	When the cursor is on a NO contact or a NC contact, this toggles the state of that contact. When the cursor is not on a NO contact or a NC contact, nothing happens.
	Press and hold	Displays the details screen (a screen that displays the details of the instruction at the cursor position).
ESC/ESC	Press	Ends the ladder program monitoring.
	Press and hold	Nothing happens.
◈/↑	Press	Moves the cursor up one line. When the cursor is on the top line of a rung, nothing happens.
	Press and hold	Repeats the press operation.
◈/↓	Press	Moves the cursor down one line. When the cursor is at the last line of the ladder program, nothing happens.
	Press and hold	Repeats the press operation.
◈/→	Press	Moves the cursor to the right. When the cursor is at the right edge of a line, nothing happens.
	Press and hold	Repeats the press operation.
◈/←	Press	Moves the cursor to the left. When the cursor is at the left edge of a line, nothing happens.
	Press and hold	Repeats the press operation.

List of Button Operations when an Item is Selected

Details screen

```
OPCODE: MOV  (W)
S1 -: D0000 = 1234
D1 R: D0123 = 1234
REP : 03/99
```

Button	Press/Hold	Basic operation
OK/OK	Press	Nothing happens.
	Press and hold	
ESC/ESC	Press	Returns to the ladder program display screen.
	Press and hold	Ends the ladder program monitor.
◈/→	Press	With the repeat designation ('R' is displayed), this button displays the device with 1 added to the currently displayed device number. This operates until the repeat count displayed in REP matches the repeatable range. If there is no repeat designation ('-' is displayed), nothing happens.
	Press and hold	Repeats the press operation.
◈/←	Press	With the repeat designation ('R' is displayed), this button displays the device with 1 subtracted from the currently displayed device number. This operates until the repeat count displayed in REP is "01". If there is no repeat designation ('-' is displayed), nothing happens.
	Press and hold	Repeats the press operation.
◈/↑	Press	If there is a displayed item above the current screen, the screen moves up once.
	Press and hold	Repeats the press operation.
◈/↓	Press	If there is a displayed item below the current screen, the screen moves down once.
	Press and hold	Repeats the press operation.

Ladder Program Monitor

This function displays the ladder program on the LCD along with execution states. This enables you to visually understand the states of the ladder program.

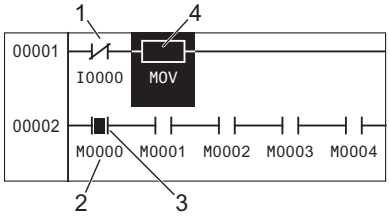
Displayed Contents

Display example

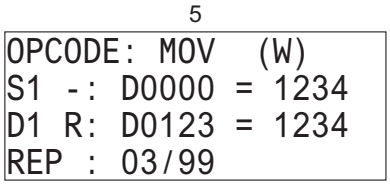
Note: The LCD resolution (number of pixels) differs between the SmartAXIS Pro and the SmartAXIS Touch, but the content of the ladder program display screen is the same, excluding the display area for the SmartAXIS Touch operation buttons. This chapter describes the operations using the LCD display on the SmartAXIS Pro. When using the SmartAXIS Touch, read this manual taking into consideration that the operation Button display area is omitted.

Five symbols horizontally and two symbols vertically are displayed in the ladder program display screen.
For the symbol of each instruction, see "Instructions Reference" on page 4-1.

Ladder program display screen



Details screen



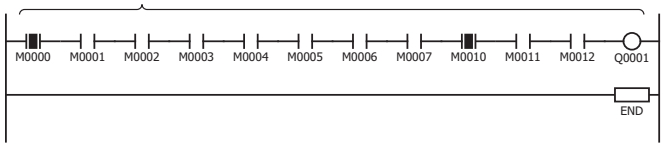
Explanation of displayed content

1. Shows the cursor. The content at the cursor position is displayed inverted.
2. Devices are shown as "device symbol (one character)" + "address (four digits)" (+ "bit position (two digits)").
   For devices, see "Device Addresses" on page 3-1.
3. If the instruction results (output) is on, it is displayed inverted.
4. Instructions except for LOD, LODN, OUT, OUTN, SET, RST, AND, ANDN, OR, and ORN are displayed as ⊣□⊢ with the instruction name displayed in a maximum of five characters under the box. MCS, MCR, JMP, END, LABEL, LJMP, LCAL, and LRET instructions are displayed in one line on the screen.
5. When the OK/OK (OK) button is pressed, the details of the instruction at the cursor position are displayed. A maximum of four lines are displayed.
   Press the ESC/ESC (ESC) button to return to the original screen.

Details of the following instructions can be displayed in the Details screen: LOD, LODN, OUT, OUTN, SET, RST, AND, ANDN, OR, ORN, TML, TIM, TMH, TMS, TMLO, TIMO, TMHO, TMSO, CNT, CDP, CUD, CNTD, CDPD, CUDD, SFR, SFRN, CC=, CC>=, DC=, DC>= (basic instructions), MOV, MOVN, IMOV, IMOVN, IBMV, IBMVN (move instructions), ADD, SUB, MUL, DIV, INC, DEC, ROOT, SUM (binary arithmetic instructions).
However, programs with a number of columns that exceeds 11 cannot be displayed. Arithmetic operation instructions are all counted as one column. Programs with blocks (circuits) of instructions that start with LOD, LODN, CC=, CC≥, DC=, DC≥, LC=, LC<>, LC<, LC>, LC<=, LC>= instructions and end with OUT, OUTN, SET, RST, and arithmetic instructions exceeding four lines cannot be displayed.

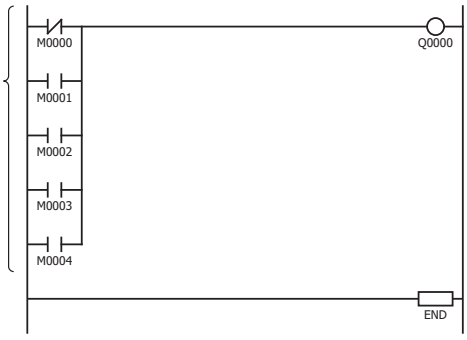
Ladder logic program that cannot be monitored example 1

12 or more columns of instructions laid out



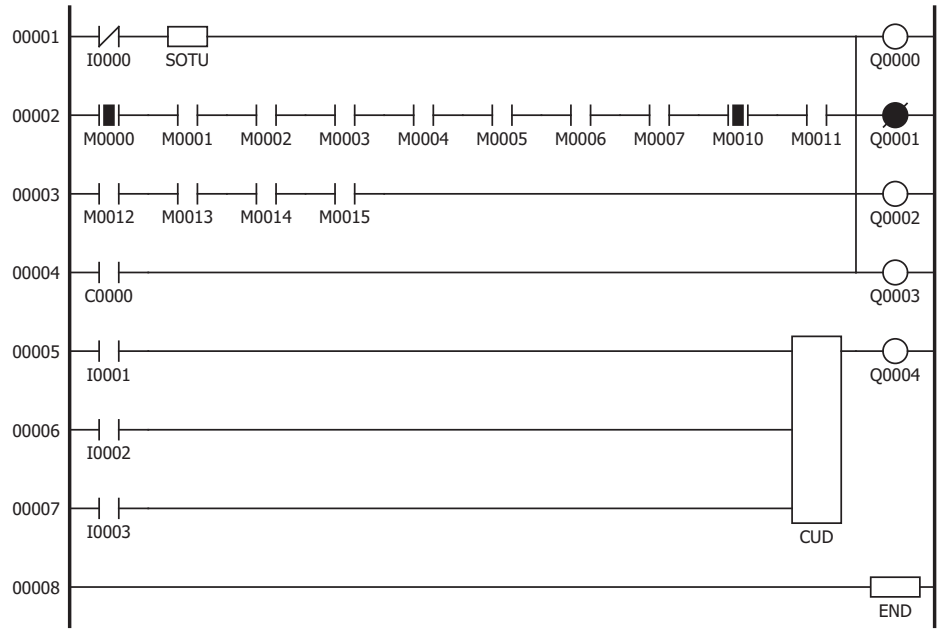
Ladder logic program that cannot be monitored example 2

Blocks (circuits) of instructions that start with LOD, LODN, CC=, CC≥, DC=, DC≥, LC=, LC<>, LC<, LC>, LC<=, LC>= instructions and end with OUT, OUTN, SET, RST, and arithmetic instructions that exceed 4 lines



Using the Ladder Program Monitor

This section describes how to monitor the following ladder program.



Note: The LCD resolution (number of pixels) differs between the SmartAXIS Pro and the SmartAXIS Touch, but the content of the ladder program display screen is the same, excluding the display area for the SmartAXIS Touch operation buttons. This chapter describes the operations using the LCD display on the SmartAXIS Pro. When using the SmartAXIS Touch, read this manual taking into consideration that the operation button display area is omitted.

Starting the Ladder Program Monitoring

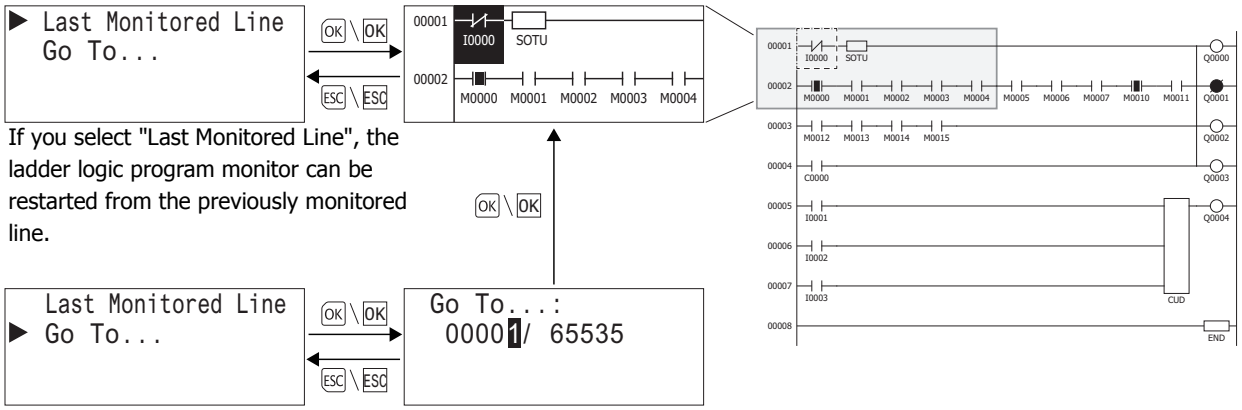
The way to start the ladder program monitor differs between the SmartAXIS Pro and the SmartAXIS Touch.

For the SmartAXIS Pro, see Chapter 6 "HMI Function" - "Monitoring the Program" in the SmartAXIS Pro/Lite User's Manual, and start the ladder program monitoring.

For the SmartAXIS Touch, see Chapter 24 "Monitor Functions" - "2.3 Ladder Program Monitor" - "Ladder Monitor" in the SmartAXIS Touch User's Manual and start the ladder program monitoring.

When the ladder program monitor is started, the ladder line selection screen is displayed. When the ladder line is specified, the ladder program including the specified line is displayed.

Ladder line selection screen



If you select "Go To..." and specify a ladder logic program monitor line, the ladder logic program is displayed with the specified line at the beginning.

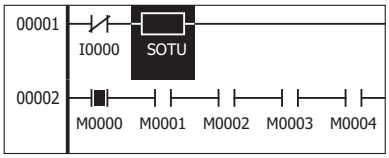
Notes:

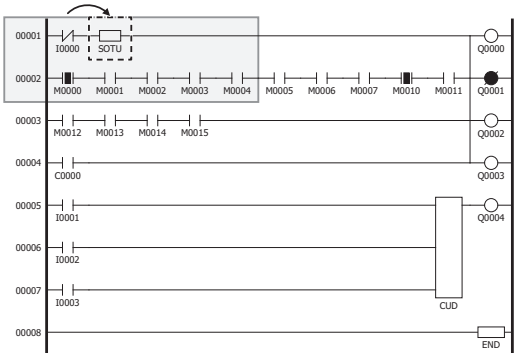
The previously monitored line default setting is the 1st line.

- The previously monitored line is reset to the default setting at the times listed below.
- The SmartAXIS Pro power is turned on again.
- A user program is downloading to the SmartAXIS Pro.

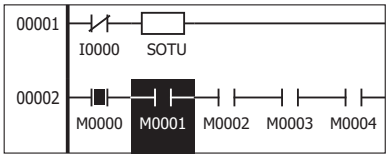
Moving the Cursor

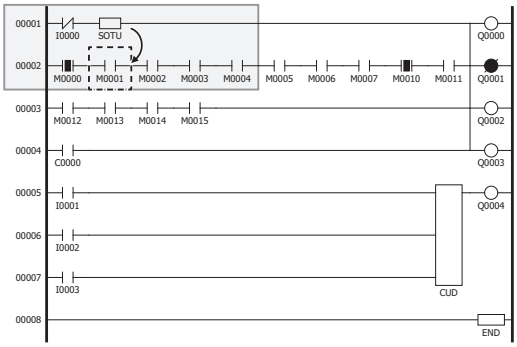
1. Press the ◈/→ (right) button once.
The cursor moves column to the right.



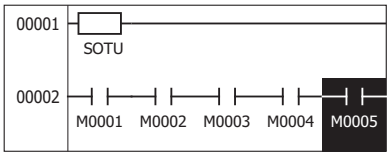


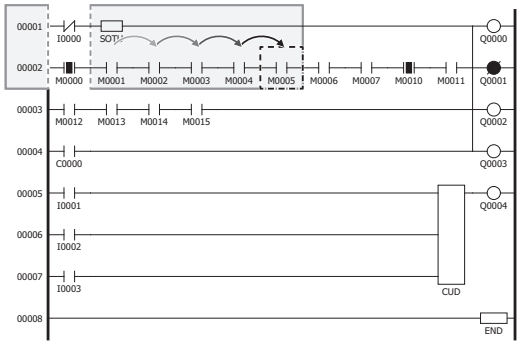
2. Press the ◈/↓ (down) button once.
The cursor moves one line down.



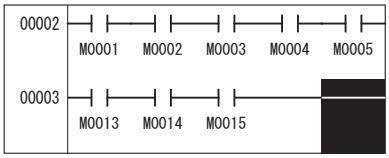


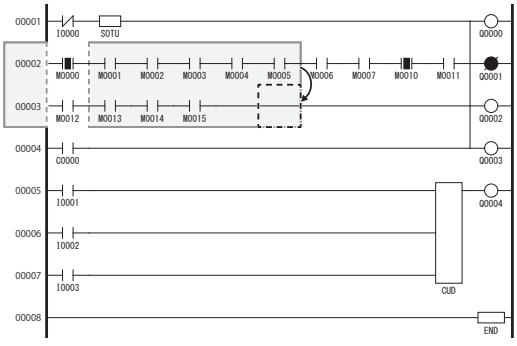
3. Press the ◈/→ (right) button four times.
The ladder program display screen moves right one instruction.



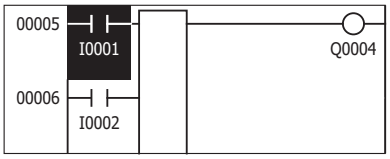


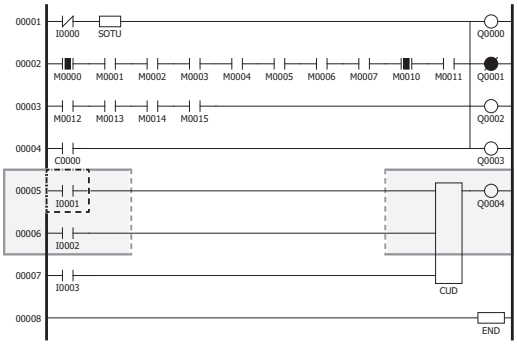
4. Press the ◈/↓ (down) button once.
The ladder program display screen moves down one line.



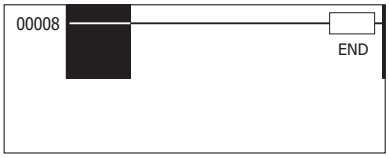


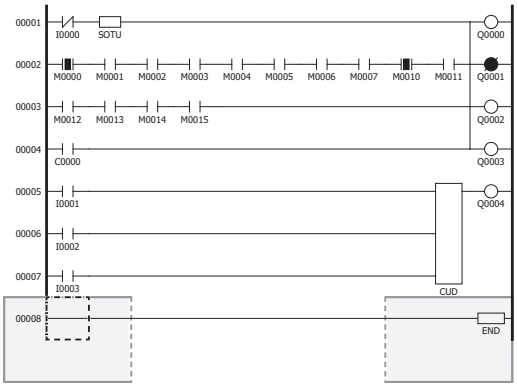
5. Press the ◈/↓ (down) button twice.
The cursor moves to the start of the next rung. The ladder program display screen changes as shown below.





6. Press the ◈/↓ (down) button three times.
The cursor moves to the rung containing the END instruction.

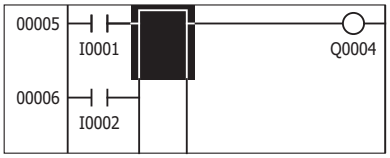


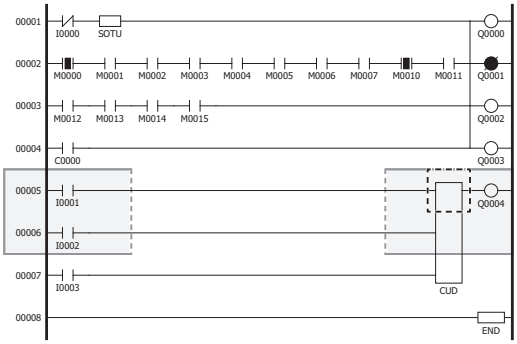


Displaying Detailed Device Information

This section describes the steps to monitor the detailed information of the CUD instruction.

1. In the state of step 5 on the previous page, press the ◈/→ (right) button once.
The cursor moves to the CUD instruction.

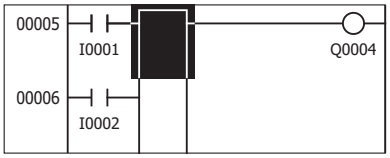


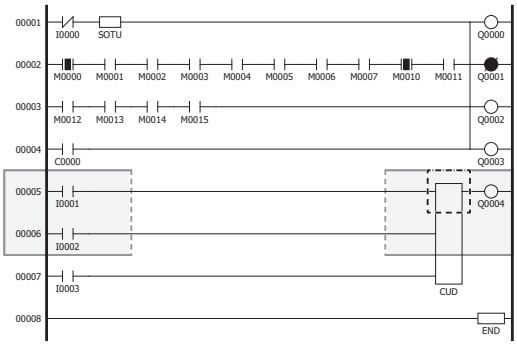


2. With the cursor at the position of the CUD instruction, press the OK/OK (OK) button.
The details screen is displayed.

```
OPCODE: CUD   (W)
C    : C 000 = ON
PRE  : #     =    5
CUR  : CC000 =    0
```

3. After you check the details, press the ESC/ESC (ESC) button.
Returns to the ladder program display screen.





Note: Monitoring ladder program of FT1A Touch using WindLDR

You can monitor ladder programs and change device values of FT1A Touch using WindLDR. There is a limitation when you use bit devices out of the control devices as 16-/32-bit data and change its device values.

When you monitor bit devices, such as internal relays or shift registers, you can monitor values of those bit devices starting from any addresses. However, when you change values of those devices, device addresses must be 16-bit aligned. For example, you can change 16-/32-bit values of internal relays starting with M0000, M0020, or M1180, but values of internal relays starting with M0007, M0037, or M1181 cannot be changed.

When unaligned bit devices are entered in the Custom Monitor dialog box of WindLDR to monitor 16-/32-bit values, monitored values are shown in grayed cell and you cannot change values of those devices.

3: DEVICE ADDRESSES

Introduction

This chapter describes device addresses available for the SmartAXIS Pro/Lite to program basic and advanced instructions. Special internal relays and special data registers are also described. For details on the device addresses of SmartAXIS Touch, see Chapter 27 "Internal Devices" in the SmartAXIS Touch User's Manual.

The SmartAXIS is programmed using devices such as inputs, outputs, remote inputs, remote outputs, internal relays, timers, counters, shift registers, and data registers.

Inputs (I) are relays to receive input signals through the input terminals.
Remote inputs (I) are relays to receive input signals from external devices connected to the remote I/O slaves.
Outputs (Q) are relays to send the processed results of the user program to the output terminals.
Remote outputs (O) are relays to send output signals to external devices connected to the remote I/O slaves.
Internal relays (M) are relays used in the CPU and cannot be output to the output terminals.
Special internal relays (M) are internal relays dedicated to specific functions.
Timers (T) are relays used in the user program, available as 1-sec, 100-ms, 10-ms, and 1-ms timers.
Counters (C) are relays used in the user program, available as adding counters and reversible counters.
Shift registers (R) are registers to shift the data bits according to pulse inputs.
Data registers (D) are registers used to store numerical data.

Special data registers (D) are dedicated to special functions.

Device Addresses

Available I/O numbers depend on the SmartAXIS type.

Device	FT1A-12		FT1A-24		FT1A-40		FT1A-48		FT1A-Touch	
	Device Address	Points	Device Address	Points	Device Address	Points	Device Address	Points	Device Address	Points
Input (I)*1	I0 - I7	8	I0 - I7 I10 - I17	16	I0 - I7 I10 - I17 I20 - I27	24	I0 - I7 I10 - I17 I20 - I27 I30 - I35	30	I0 - I7	8
Remote Input (I)*1	—	—	I40 - I75 I80 - I115 I120 - I155	90	I40 - I75 I80 - I115 I120 - I155	90	I40 - I75 I80 - I115 I120 - I155	90	—	—
Output (Q)*1	Q0 - Q3	4	Q0 - Q7	8	Q0 - Q7 Q10 - Q17	16	Q0 - Q7 Q10 - Q17 Q20, Q21	18	Q0 - Q3	4
Remote Output (Q)*1	—	—	Q40 - Q61 Q80 - Q101 Q120 - Q141	54	Q40 - Q61 Q80 - Q101 Q120 - Q141	54	Q40 - Q61 Q80 - Q101 Q120 - Q141	54	—	—
Internal Relay (M)*1	M0 - M317	256	M0 - M1277	1024	M0 - M1277	1024	M0 - M1277	1024	M0 - M1277	1024
Special Internal Relay (M)*1	M8000 - M8177	144	M8000 - M8177	144	M8000 - M8177	144	M8000 - M8177	144	M8000 - M8177	144
Shift Register (R)	R0 - R127	128	R0 - R127	128	R0 - R127	128	R0 - R127	128	R0 - R127	128
Timer (T)	T0 - T99	100	T0 - T199	200	T0 - T199	200	T0 - T199	200	T0 - T199	200
Counter (C)	C0 - C99	100	C0 - C199	200	C0 - C199	200	C0 - C199	200	C0 - C199	200
Data Register (D)	D0 - D399	400	D0 - D1999*2	2000	D0 - D1999*2	2000	D0 - D1999*2	2000	D0 - D1999	2000
Special Data Register (D)	D8000 - D8199	200	D8000 - D8199	200	D8000 - D8199	200	D8000 - D8199	200	D8000 - D8199	200

Notes:

*1 The least significant digit of input, output, internal relay, and special internal relay device address is an octal number (0 through 7). Upper digits are decimal numbers.

*2 Out of data registers D0 through D1999, D1000 through D1999 cannot be designated as "keep" types. Retained in STOP→RUN, but zeroed out when the power is turned on.

Special Internal Relays

Special internal relays M8000 through M8177 are used for controlling the CPU operation and communication and for indicating CPU status. All special internal relays cannot be used as destinations of advanced instructions.

Internal relays M300 through M335 are used to read input device status of the IOREF (I/O refresh) instruction.

Note: Do not change the status of reserved special internal relays, otherwise the SmartAXIS may not operate correctly.

Special Internal Relay Device Addresses

Device Address	Description		CPU Stopped	Power OFF	Read/Write
M8000	Start Control		Maintained	Maintained	Read/Write
M8001	1-sec Clock Reset		Cleared	Cleared	Write
M8002	All Outputs OFF		Cleared	Cleared	Write
M8003	Carry (Cy) or Borrow (Bw)		Cleared	Cleared	Read
M8004	User Program Execution Error		Cleared	Cleared	Read
M8005	Remote I/O Slave 1 Communication Error		Operating	Cleared	Read
M8006	Remote I/O Slave 2 Communication Error		Operating	Cleared	Read
M8007	Remote I/O Slave 3 Communication Error		Operating	Cleared	Read
M8010	In Daylight Saving Time Period (System version 1.10 or later)		Operating	Cleared	Read
M8011-M8012	— Reserved —		—	—	—
M8013	Calendar/Clock Data Write/Adjust Error Flag		Operating	Cleared	Read
M8014	Calendar/Clock Data Read Error Flag		Operating	Cleared	Read
M8015	— Reserved —		—	—	—
M8016	Calendar Data Write Flag		Operating	Cleared	Write
M8017	Clock Data Write Flag		Operating	Cleared	Write
M8020	Calendar/Clock Data Write Flag		Operating	Cleared	Write
M8021	Clock Data Adjust Flag		Operating	Cleared	Write
M8022	User Communication Receive Instruction Cancel Flag (Port 2)		Cleared	Cleared	Write
M8023	User Communication Receive Instruction Cancel Flag (Port 3)		Cleared	Cleared	Write
M8024	BMOV/WSFT Executing Flag		Maintained	Maintained	Read
M8025	Maintain Outputs While CPU Stopped		Maintained	Cleared	Read/Write
M8026	SD Memory Card Status		Maintained	Cleared	Read
M8027	SD Memory Card Writing Flag		Maintained	Cleared	Read
M8030	High-speed Counter (Group 1/I0)	Comparison Output Reset	Cleared	Cleared	Read/Write
M8031		Gate Input	Maintained	Cleared	Read/Write
M8032		Reset Input	Maintained	Cleared	Read/Write
M8033		Reset Status	Maintained	Cleared	Read
M8034		Comparison ON Status	Maintained	Cleared	Read
M8035		Overflow	Maintained	Cleared	Read
M8036		Underflow	Maintained	Cleared	Read
M8037		Count Direction	Maintained	Cleared	Read
M8040	High-speed Counter (Group 2/I2)	Comparison Output Reset	Cleared	Cleared	Read/Write
M8041		Gate Input	Maintained	Cleared	Read/Write
M8042		Reset Input	Maintained	Cleared	Read/Write
M8043		Comparison ON Status	Maintained	Cleared	Read
M8044		Overflow	Maintained	Cleared	Read
M8045	High-speed Counter (Group 3/I3)	Comparison Output Reset	Cleared	Cleared	Read/Write
M8046		Gate Input	Maintained	Cleared	Read/Write
M8047		Reset Input	Maintained	Cleared	Read/Write
M8050		Reset Status	Maintained	Cleared	Read
M8051		Comparison ON Status	Maintained	Cleared	Read
M8052		Overflow	Maintained	Cleared	Read
M8053		Underflow	Maintained	Cleared	Read
M8054		Count Direction	Maintained	Cleared	Read

Device Address	Description		CPU Stopped	Power OFF	Read/Write
M8055	High-speed Counter (Group 4/I5)	Comparison Output Reset	Cleared	Cleared	Read/Write
M8056		Gate Input	Maintained	Cleared	Read/Write
M8057		Reset Input	Maintained	Cleared	Read/Write
M8060		Comparison ON Status	Maintained	Cleared	Read
M8061		Overflow	Maintained	Cleared	Read
M8062-M8067	— Reserved —		—	—	—
M8070	Interrupt Input I0 Status	(ON: Allowed, OFF: Prohibited)	Cleared	Cleared	Read
M8071	Interrupt Input I2 Status		Cleared	Cleared	Read
M8072	Interrupt Input I3 Status		Cleared	Cleared	Read
M8073	Interrupt Input I5 Status		Cleared	Cleared	Read
M8074	Interrupt Input I6 Status		Cleared	Cleared	Read
M8075	Interrupt Input I7 Status		Cleared	Cleared	Read
M8076	SD Memory Card Access Stop Flag		Operating	Cleared	Write
M8077	— Reserved —		—	—	—
M8080	Interrupt Input I0 Edge	(ON: Rising, OFF: Falling)	Cleared	Cleared	Read
M8081	Interrupt Input I2 Edge		Cleared	Cleared	Read
M8082	Interrupt Input I3 Edge		Cleared	Cleared	Read
M8083	Interrupt Input I5 Edge		Cleared	Cleared	Read
M8084	Interrupt Input I6 Edge		Cleared	Cleared	Read
M8085	Interrupt Input I7 Edge		Cleared	Cleared	Read
M8086 M8087	— Reserved —		—	—	—
M8090	Catch Input ON/OFF Status	Group 1/I0	Maintained	Cleared	Read
M8091		Group 2/I2	Maintained	Cleared	Read
M8092		Group 3/I3	Maintained	Cleared	Read
M8093		Group 4/I5	Maintained	Cleared	Read
M8094		Group 5/I6	Maintained	Cleared	Read
M8095		Group 6/I7	Maintained	Cleared	Read
M8096 M8097	— Reserved —		—	—	—
M8100	User Communication Receive Instruction Cancel Flag	Connection 1	Cleared	Cleared	Write
M8101		Connection 2	Cleared	Cleared	Write
M8102		Connection 3	Cleared	Cleared	Write
M8103-M8107	— Reserved —		—	—	—
M8110	Connection Status	Connection 1 (ON: Connected, OFF: Not Connected)	Operating	Cleared	Read
M8111		Connection 2 (ON: Connected, OFF: Not Connected)	Operating	Cleared	Read
M8112		Connection 3 (ON: Connected, OFF: Not Connected)	Operating	Cleared	Read
M8113-M8117	— Reserved —		—	—	—
M8120	Initialize Pulse		Cleared	Cleared	Read
M8121	1-sec Clock		Operating	Cleared	Read
M8122	100-ms Clock		Operating	Cleared	Read
M8123	10-ms Clock		Operating	Cleared	Read
M8124	Timer/Counter Preset Value Changed		Maintained	Maintained	Read
M8125	In-operation Output		Cleared	Cleared	Read
M8126 M8127	— Reserved —		—	—	—
M8130	Disconnect User Communication Connection	Connection 1	Maintained	Cleared	Read/Write
M8131		Connection 2	Maintained	Cleared	Read/Write
M8132		Connection 3	Maintained	Cleared	Read/Write
M8133-M8143	— Reserved —		—	—	—

Device Address	Description		CPU Stopped	Power OFF	Read/Write
M8144	Timer Interrupt Status (ON: Allowed, OFF: Prohibited)		Cleared	Cleared	Read
M8145-M8147	— Reserved —		—	—	—
M8150	Comparison Result 1		Maintained	Cleared	Read
M8151	Comparison Result 2		Maintained	Cleared	Read
M8152	Comparison Result 3		Maintained	Cleared	Read
M8153-M8157	— Reserved —		—	—	—
M8160	Key Input Status	ESC Key + Up Key	Cleared	Cleared	Read
M8161		ESC Key + Down Key	Cleared	Cleared	Read
M8162		ESC Key + Left Key	Cleared	Cleared	Read
M8163		ESC Key + Right Key	Cleared	Cleared	Read
M8164 M8165	— Reserved —		—	—	—
M8166	High-speed Counter (Group5/I6)	Comparison Output Reset	Cleared	Cleared	Read/Write
M8167		Gate Input	Maintained	Cleared	Read/Write
M8170		Reset Input	Maintained	Cleared	Read/Write
M8171		Comparison ON Status	Maintained	Cleared	Read
M8172		Overflow	Maintained	Cleared	Read
M8173	High-speed Counter (Group 6/I7)	Comparison Output Reset	Cleared	Cleared	Read/Write
M8174		Gate Input	Maintained	Cleared	Read/Write
M8175		Reset Input	Maintained	Cleared	Read/Write
M8176		Comparison ON Status	Maintained	Cleared	Read
M8177		Overflow	Maintained	Cleared	Read

M8000 Start Control

M8000 is used to control the operation of the CPU. The CPU stops operation when M8000 is turned off while the CPU is running. M8000 can be turned on or off using the WindLDR Online menu. When a stop or reset input is designated, M8000 must remain on to control the CPU operation using the stop or reset input.

M8000 maintains its status when the CPU is powered down. When the data to be maintained during power failure is broken after the CPU has been off for a period longer than the battery backup duration, the CPU restarts operation or not as selected in **Configuration** > **Run/Stop Control** > **Run/Stop Selection at Memory Backup Error**. For details on SmartAXIS Pro/Lite start control, see Chapter 4 "Operation Basics" – "Start/Stop Operation" in the SmartAXIS Pro/Lite User's Manual.

M8001 1-sec Clock Reset

While M8001 is on, M8121 (1-sec clock) is turned off.

M8002 All Outputs OFF

When M8002 is turned on, all outputs and remote outputs go off until M8002 is turned off. Self-maintained circuits using outputs also go off and are not restored when M8002 is turned off.

M8003 Carry (Cy) and Borrow (Bw)

When a carry or borrow results from executing an addition or subtraction instruction, M8003 turns on. M8003 is also used for the bit shift and rotate instructions. For the causes of carry (CY) and borrow (BW), see "Carry and Borrow" on page 4-13.

M8004 User Program Execution Error

When an error occurs while executing a user program, M8004 turns on. The cause of the user program execution error can be checked using **Online** > **Monitor** > **Monitor,** then **Online** > **Status** > **Error Status** > **Details**.

For a list of Pro/Lite user program execution errors, see Chapter 13 "Troubleshooting" – "User Program Execution Errors" in the SmartAXIS Pro/Lite User's Manual.

M8005 Remote I/O Slave 1 Communication Error

When an error occurs during communication with remote I/O slave 1, M8005 turns on. When the error is cleared, M8005 turns off.

M8006 Remote I/O Slave 2 Communication Error

When an error occurs during communication with remote I/O slave 2, M8006 turns on. When the error is cleared, M8006 turns off.

M8007 Remote I/O Slave 3 Communication Error

When an error occurs during communication with remote I/O slave 3, M8007 turns on. When the error is cleared, M8007 turns off.

M8010 In Daylight Saving Time Period

When the daylight saving time is enabled, M8010 is turned on while in the daylight saving time period. When the daylight saving tiem is disabled, M8010 is always off.

M8013 Calendar/Clock Data Write/Adjust Error Flag

When an error occurs while calendar/clock data is written or clock data is adjusted, M8013 turns on. If calendar/clock data is written or clock data is adjusted successfully, M8013 turns off.

M8014 Calendar/Clock Data Read Error Flag

When an error occurs while calendar/clock data is read from the internal clock to the special data registers (D8008 to D8014), M8014 turns on. If calendar/clock data is read successfully, M8014 turns off.

M8016 Calendar Data Write Flag

When M8016 is turned on, data in data registers D8015 through D8018 (calendar new data) are set to the internal clock.

M8017 Clock Data Write Flag

When M8017 is turned on, data in data registers D8019 through D8021 (clock new data) are set to the internal clock.

M8020 Calendar/Clock Data Write Flag

When M8020 is turned on, data in data registers D8015 through D8021 (calendar/clock new data) are set to the internal clock.

M8021 Clock Data Adjust Flag

When M8021 is turned on, the clock is adjusted with respect to seconds. If *seconds* are between 0 and 29 for current time, adjustment for *seconds* will be set to 0 and minutes remain the same. If *seconds* are between 30 and 59 for current time, adjustment for *seconds* will be set to 0 and *minutes* are incremented by one.

M8022 User Communication Receive Instruction Cancel Flag (Port 2)

When M8022 is turned on, all RXD2 instructions ready for receiving user communication through port 2 are disabled.

M8023 User Communication Receive Instruction Cancel Flag (Port 3)

When M8023 is turned on, all RXD3 instructions ready for receiving user communication through port 3 are disabled.

M8024 BMOV/WSFT Executing Flag

While the BMOV or WSFT is executed, M8024 turns on. When completed, M8024 turns off. If the CPU is powered down while executing BMOV or WSFT, M8024 remains on when the CPU is powered up again.

M8025 Maintain Outputs While CPU Stopped

Outputs are normally turned off when the CPU is stopped. M8025 is used to maintain the output statuses when the CPU is stopped. When the CPU is stopped with M8025 turned on, the output ON/OFF statuses are maintained. When the CPU restarts, M8025 is turned off automatically.

M8026 SD Memory Card Status

When an SD memory card is inserted into the SmartAXIS, M8026 turns on. When an SD memory card is not inserted, M8026 turns off.

M8027 SD Memory Card Writing Flag

While logging data is written to the SD memory card, M8027 turns on. When writing logging data is finished, M8027 turns off.

M8030-M8061 Special Internal Relays for High-speed Counter

Special internal relays used for the high-speed counter.

For details on the Pro/Lite high-speed counter, see Chapter 5 “Special Functions” – “High-Speed Counter” in the SmartAXIS Pro/Lite User's Manual. For details on the Touch high-speed counter, see Chapter 3 “Project” – “4 Special Functions” – “High-Speed Counter” in the SmartAXIS Touch User's Manual.

M8070-M8075 Interrupt Input Status

Turns on when the corresponding user interrupt is allowed. When interrupt inputs are disabled, these internal relays are turned off.

M8070=Interrupt input I0 status, M8071=Interrupt input I2 status, M8072=Interrupt input I3 status

M8073=Interrupt input I5 status, M8074=Interrupt input I6 status, M8075=Interrupt input I7 status

M8076 SD Memory Card Access Stop Flag

Access to the SD memory card stops when M8076 is turned from off to on.

M8080-M8085 Interrupt Input Edge (ON: Rising, OFF: Falling)

This flag indicates whether the interrupt input is triggered with a rising edge or falling edge.

M8090-M8095 Catch Input ON/OFF Status

When a rising or falling input edge is detected during a scan, the input statuses of catch inputs Group 1/I0 through Group 6/I7 at the moment are set to M8090 through M8095, respectively, without regard to the scan status. Only one edge is detected in one scan. For the catch input function, see Chapter 5 "Special Functions" - "Catch Input" in the SmartAXIS Pro/Lite User's Manual.

M8100-M8102 User Communication Receive Instruction Cancel Flag

When M8100, M8101, or M8102 is turned on, all ERXD instructions ready for receiving user communication through connection 1, connection 2, or connection 3 are disabled, respectively.

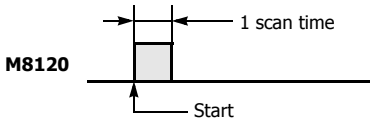
M8110-M8112 Connection Status

When SmartAXIS and a network device are connected via the maintenance communication server, user communication server/client, or Modbus TCP server/client, the connection status turns on. When no network devices are connected, the connection status turns off.

These relays are always off for the 12-I/O type (SmartAXIS without Ethernet port).

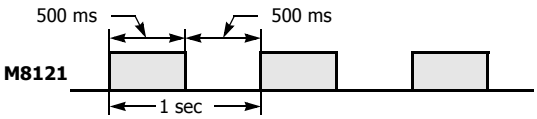
M8120 Initialize Pulse

When the CPU starts operation, M8120 turns on for a period of one scan.



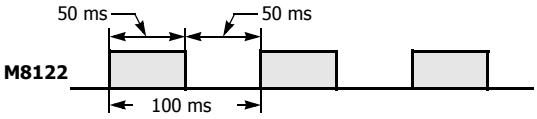
M8121 1-sec Clock

While M8001 (1-sec clock reset) is off, M8121 generates clock pulses in 1-sec increments, with a duty ratio of 1:1 (500 ms on and 500 ms off).



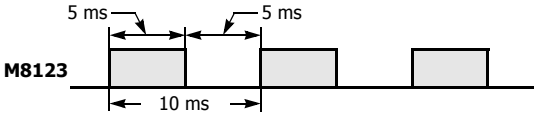
M8122 100-ms Clock

M8122 always generates clock pulses in 100-ms increments, whether M8001 is on or off, with a duty ratio of 1:1 (50 ms on and 50 ms off).



M8123 10-ms Clock

M8123 always generates clock pulses in 10-ms increments, whether M8001 is on or off, with a duty ratio of 1:1 (5 ms on and 5 ms off).



M8124 Timer/Counter Preset Value Changed

When timer or counter preset values are changed in the CPU module RAM, M8124 turns on. When a user program is downloaded to the CPU from WindLDR or when the changed timer/counter preset value is cleared, M8124 turns off.
When a timer or counter is designated as a destination of an advanced instruction, the timer/counter preset value is also changed.

M8125 In-operation Output

M8125 remains on while the CPU is running.

M8130-M8132 Disconnect User Communication Connection

When SmartAXIS is connected to a remote host with the user communication client and a special internal relay corresponding to the connection is turned from off to on, the connection is disconnected. Special internal relays M8130 through M8132 are allocated to connections 1 through 3, respectively.
These relays are enabled only when user communication client is used. These relays have no effect for the user communication server. Nothing happens for the 12-I/O type (SmartAXIS without Ethernet port) when these relays are turned on.

M8144 Timer Interrupt Status

When timer interrupt is enabled, M8144 is turned on. When disabled, M8144 is turned off.

M8150 Comparison Result 1

When the CMP= instruction is used, M8150 is turned on when the value of device designated by S1 is greater than that of device designated by S2 (S1 > S2). See "Special Internal Relays M8150, M8151, and M8152 in CMP=" on page 7-2.
When the ICMP>= instruction is used, M8150 is turned on when the value of device designated by S2 is greater than that of device designated by S1 (S2 < S1). See "Special Internal Relays M8150, M8151, and M8152 in ICMP>=" on page 7-6.

M8151 Comparison Result 2

When the CMP= instruction is used, M8151 is turned on when the value of device designated by S1 is equal to that of device designated by S2 (S1 = S2). See "Special Internal Relays M8150, M8151, and M8152 in CMP=" on page 7-2.
When the ICMP>= instruction is used, M8151 is turned on when the value of device designated by S3 is greater than that of device designated by S2 (S3 > S2). See "Special Internal Relays M8150, M8151, and M8152 in ICMP>=" on page 7-6.

M8152 Comparison Result 3

When the CMP= instruction is used, M8152 is turned on when the value of device designated by S1 is less than that of device designated by S2 (S1 < S2). See "Special Internal Relays M8150, M8151, and M8152 in CMP=" on page 7-2.
When the ICMP>= instruction is used, M8152 is turned on when the value of device designated by S2 is less than that of device designated by S1 and greater than that of device designated by S3 (S1 > S2 > S3). See "Special Internal Relays M8150, M8151, and M8152 in ICMP>=" on page 7-6.

M8160-M8163 Button Input Status

When the ESC and direction buttons on the SmartAXIS Pro are simultaneously pressed, the corresponding special internal relays M8160 through M8163 turn on. When no buttons are pressed, M8160 through M8163 turn off.

M8166-M8177 Special Internal Relays for High-speed Counter

Special internal relays used for the high-speed counter.
For details on the Pro/Lite high-speed counter, see Chapter 5 "Special Functions" – "High-Speed Counter" in the SmartAXIS Pro/Lite User's Manual. For details on the Touch high-speed counter, see Chapter 3 "Project" – "4 Special Functions" – "High-Speed Counter" in the SmartAXIS Touch User's Manual.

Special Data Registers

Note: Do not change the data in any of the reserved special data registers, otherwise the SmartAXIS may not operate correctly.

Special Data Register Device Addresses

Device Address	Description		Updated	See Page
D8000	Quantity of Inputs		When I/O initialized	3-11
D8001	Quantity of Outputs		When I/O initialized	3-11
D8002	SmartAXIS Type Information		Power-up	3-11
D8003	Memory Cartridge Information		Power-up	3-11
D8004	— Reserved —		—	—
D8005	General Error Code		When error occurred	3-11
D8006	User Program Execution Error Code		When error occurred	3-11
D8007	— Reserved —		—	—
D8008	Calendar/Clock Current Data (Read only)	Year	Every 500 ms	3-11
D8009		Month	Every 500 ms	3-11
D8010		Day	Every 500 ms	3-11
D8011		Day of Week	Every 500 ms	3-11
D8012		Hour	Every 500 ms	3-11
D8013		Minute	Every 500 ms	3-11
D8014		Second	Every 500 ms	3-11
D8015	Calendar/Clock New Data (Write only)	Year	—	3-11
D8016		Month	—	3-11
D8017		Day	—	3-11
D8018		Day of Week	—	3-11
D8019		Hour	—	3-11
D8020		Minute	—	3-11
D8021		Second	—	3-11
D8022	Scan Time Data	Constant Scan Time Preset Value (1 to 1,000 ms)	—	3-11
D8023		Scan Time Current Value (ms)	Every scan	3-11
D8024		Scan Time Maximum Value (ms)	At occurrence	3-11
D8025		Scan Time Minimum Value (ms)	At occurrence	3-11
D8026	Communication Mode Information (Port 2 and Port 3)		Every scan	3-11
D8027	Port 2 Slave Number		Every scan	3-12
D8028	Port 3 Slave Number		Every scan	3-12
D8029	System Software Version		Power-up	3-12
D8030	Communication Adapter Information		Power-up	3-12
D8031	Optional Cartridge Information		Power-up	3-12
D8032	Interrupt Input Jump Destination Label No. (I0)		—	3-12
D8033	Interrupt Input Jump Destination Label No. (I2)		—	3-12
D8034	Interrupt Input Jump Destination Label No. (I3)		—	3-12
D8035	Interrupt Input Jump Destination Label No. (I5)		—	3-12
D8036	Timer Interrupt Jump Destination Label No.		—	3-12
D8037	Interrupt Input Jump Destination Label No. (I6)		—	3-12
D8038	Interrupt Input Jump Destination Label No. (I7)		—	3-12
D8039	SD Memory Card Capacity (Megabytes)		Every 1 sec	3-12
D8040	Analog Input Value (AI0)		Every scan	3-13
D8041	Analog Input Value (AI1)		Every scan	3-13
D8042	Analog Input Value (AI2)		Every scan	3-13
D8043	Analog Input Value (AI3)		Every scan	3-13
D8044	Analog Input Value (AI4)		Every scan	3-13
D8045	Analog Input Value (AI5)		Every scan	3-13
D8046	Analog Input Value (AI6)		Every scan	3-13
D8047	Analog Input Value (AI7)		Every scan	3-13
D8048-D8049	— Reserved —		—	—

Device Address	Description			Updated	See Page
D8050	High-speed Counter (Group 1/I0)	High Word	Current Value / Frequency Measurement Value (I0)	Every scan	3-13
D8051		Low Word			
D8052		High Word	Preset Value	—	3-13
D8053		Low Word			
D8054		High Word	Reset Value	—	3-13
D8055		Low Word			
D8056	High-speed Counter (Group 2/I2)	High Word	Current Value / Frequency Measurement Value (I2)	Every scan	3-13
D8057		Low Word			
D8058		High Word	Preset Value	—	3-13
D8059		Low Word			
D8060		High Word	Reset Value	—	3-13
D8061		Low Word			
D8062	High-speed Counter (Group 3/I3)	High Word	Current Value / Frequency Measurement Value (I3)	Every scan	3-13
D8063		Low Word			
D8064		High Word	Preset Value	—	3-13
D8065		Low Word			
D8066		High Word	Reset Value	—	3-13
D8067		Low Word			
D8068	High-speed Counter (Group 4/I5)	High Word	Current Value / Frequency Measurement Value (I5)	Every scan	3-13
D8069		Low Word			
D8070		High Word	Preset Value	—	3-13
D8071		Low Word			
D8072		High Word	Reset Value	—	3-13
D8073		Low Word			
D8074	Backlight ON Time			Every scan	3-13
D8075-D8076	— Reserved —			—	—
D8077	Out of Analog Input Range Status			—	3-13
D8078	MAC Address (Read only)			Every 1 sec	3-13
D8079					
D8080					
D8081					
D8082					
D8083					
D8084	IP Address (Current Data) Read only			Every 1 sec	3-13
D8085					
D8086					
D8087					
D8088	Subnet Mask (Current Data) Read only			Every 1 sec	3-13
D8089					
D8090					
D8091					
D8092	Default Gateway (Current Data) Read only			Every 1 sec	3-13
D8093					
D8094					
D8095					
D8096-D8103	— Reserved —			—	—
D8104	RS232C Control Signal Status (Ports 2 and 3)			Every scan	3-13
D8105	RS232C DSR Input Control Signal Option (Ports 2 and 3)			When sending/ receiving data	3-14
D8106	RS232C DTR Output Control Signal Option (Ports 2 and 3)			When sending/ receiving data	3-14
D8107-D8109	— Reserved —			—	—
D8110	Connection 1 Connected IP Address			Every 1 sec	3-14
D8111					
D8112					
D8113					

Device Address	Description			Updated	See Page
D8114	Connection 2 Connected IP Address			Every 1 sec	3-14
D8115					
D8116					
D8117					
D8118	Connection 3 Connected IP Address			Every 1 sec	3-14
D8119					
D8120					
D8121					
D8122-D8129	— Reserved —			—	—
D8130	Connection 1 Connected Port Number			Every 1 sec	3-14
D8131	Connection 2 Connected Port Number			Every 1 sec	3-14
D8132	Connection 3 Connected Port Number			Every 1 sec	3-14
D8133	— Reserved —			—	—
D8134	High-speed Counter (Group 5/I6)	High Word	Current Value / Frequency Measurement Value (I6)	Every scan	3-13
D8135		Low Word			
D8136		High Word	Preset Value	—	3-13
D8137		Low Word			
D8138		High Word	Reset Value	—	3-13
D8139		Low Word			
D8140	High-speed Counter (Group 6/I7)	High Word	Current Value / Frequency Measurement Value (I7)	Every scan	3-13
D8141		Low Word			
D8142		High Word	Preset Value	—	3-13
D8143		Low Word			
D8144		High Word	Reset Value	—	3-13
D8145		Low Word			
D8146	— Reserved —			——	—
D8147					
D8148	Remote I/O Slave 1	Communication Error Status		When error occurred	3-14
D8149		Analog Input (AI10)		Every scan	3-14
D8150		Analog Input (AI11)		Every scan	3-14
D8151		Analog Input (AI12)		Every scan	3-14
D8152		Analog Input (AI13)		Every scan	3-14
D8153		Analog Input (AI14)		Every scan	3-14
D8154		Analog Input (AI15)		Every scan	3-14
D8155		Analog Input (AI16)		Every scan	3-14
D8156		Analog Input (AI17)		Every scan	3-14
D8157	Remote I/O Slave 2	Communication Error Status		When error occurred	3-14
D8158		Analog Input (AI20)		Every scan	3-14
D8159		Analog Input (AI21)		Every scan	3-14
D8160		Analog Input (AI22)		Every scan	3-14
D8161		Analog Input (AI23)		Every scan	3-14
D8162		Analog Input (AI24)		Every scan	3-14
D8163		Analog Input (AI25)		Every scan	3-14
D8164		Analog Input (AI26)		Every scan	3-14
D8165		Analog Input (AI27)		Every scan	3-14
D8166	Remote I/O Slave 3	Communication Error Status		When error occurred	3-14
D8167		Analog Input (AI30)		Every scan	3-14
D8168		Analog Input (AI31)		Every scan	3-14
D8169		Analog Input (AI32)		Every scan	3-14
D8170		Analog Input (AI33)		Every scan	3-14
D8171		Analog Input (AI34)		Every scan	3-14
D8172		Analog Input (AI35)		Every scan	3-14
D8173		Analog Input (AI36)		Every scan	3-14
D8174		Analog Input (AI37)		Every scan	3-14
D8175-D8199	— Reserved —			—	—

D8000 Quantity of Inputs

The total of input points provided on the SmartAXIS is stored to D8000.

D8001 Quantity of Outputs

The total of output points provided on the SmartAXIS is stored to D8001.

D8002 SmartAXIS Type Information

Information about the SmartAXIS type is stored to D8002.

- **0:** SmartAXIS Pro/Lite 12-I/O type
- **1:** SmartAXIS Pro/Lite 24-I/O type
- **2:** SmartAXIS Pro/Lite 40-I/O type
- **3:** SmartAXIS Pro/Lite 48-I/O type
- **4:** SmartAXIS Touch

D8003 Memory Cartridge Information

When an optional memory cartridge is installed on the SmartAXIS cartridge connector, information about the user program stored on the memory cartridge is stored to D8003.

- **0:** SmartAXIS Pro/Lite 12-I/O type
- **1:** SmartAXIS Pro/Lite 24-I/O type
- **2:** SmartAXIS Pro/Lite 40-I/O type
- **3:** SmartAXIS Pro/Lite 48-I/O type
- **255:** The memory cartridge does not store any user program.

D8005 General Error Code

SmartAXIS general error information is stored to D8005. When a general error occurs, the bit corresponding to the error occurred turns on.

The general error and user program execution error can be cleared by writing "1" to the most significant bit of D8005 using a user program.

For details on Pro/Lite general error codes, see Chapter 13 "Troubleshooting" in the SmartAXIS Pro/Lite User's Manual. For details on Touch general error codes, see Chapter 30 "Troubleshooting" - "3 Troubleshooting" in the SmartAXIS Touch User's Manual.

D8006 User Program Execution Error Code

SmartAXIS user program execution error information is stored to D8006. When a user program execution error occurs, the error code corresponding to the error occurred is stored to D8006.

For details on Pro/Lite user program execution error codes, see Chapter 13 "Troubleshooting" in the SmartAXIS Pro/Lite User's Manual. For details on Touch user program execution error codes, see Chapter 30 "Troubleshooting" - "3 Troubleshooting" in the SmartAXIS Touch User's Manual.

D8008-D8021 Calendar/Clock Data

D8008 through D8021 are used for reading calendar/clock data from the internal clock and for writing calendar/clock data to the internal clock.

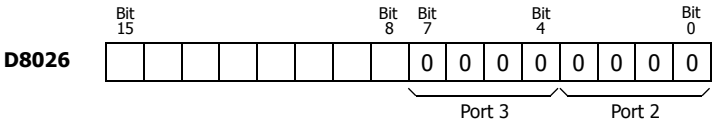
D8022-D8025 Scan Time Data

D8022 through D8025 are special data registers for checking the scan time and configuring the constant scan time.

For details on the SmartAXIS Pro/Lite scan time, see Chapter 5 "Special Functions" – "Constant Scan Time" in the SmartAXIS Pro/Lite User's Manual.

D8026 Communication Mode Information (Port 2 and Port 3)

Communication mode information of port 2 and port 3 is stored to D8026.



- **0:** Maintenance Communication
- **1:** User Communication
- **2:** Modbus RTU Master
- **3:** Modbus RTU Slave

D8027-D8028 Slave Number

The slave number is stored to D8027 and D8028 when the communication mode for port 2 and 3 is maintenance communication or Modbus RTU slave.

The slave number can be specified with either a constant or a data register in the function area settings. When data register is specified, the slave number can be changed by storing the slave number in D8027 and D8028.

D8027: Port 2 Slave Number

D8028: Port 3 Slave Number

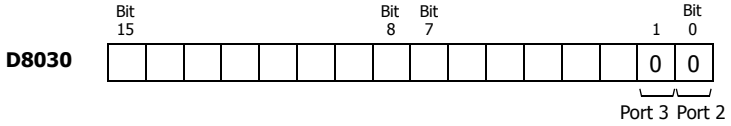
For SmartAXIS Pro/Lite maintenance communication, see Chapter 9 "Maintenance Communication" - "Maintenance Communication via Serial Communication" in the SmartAXIS Pro/Lite User's Manual. For Modbus RTU slaves, see Chapter 11 "Modbus Communication" - "Modbus Communication via RS-232C/RS-485" in the SmartAXIS Pro/Lite User's Manual. For SmartAXIS Touch maintenance communication and Modbus RTU slaves, see Chapter 13 "Troubleshooting" - "Reading Error Data" in the SmartAXIS Pro/Lite User's Manual.

D8029 System Software Version

The PLC system software version number is stored to D8029. This value is indicated in the PLC status dialog box called from the WindLDR menu bar. Select **Online** > **Monitor** > **Monitor**, then select **Online** > **Status**. See Chapter 13 "Troubleshooting" - "Reading Error Data" in the SmartAXIS Pro/Lite User's Manual.

D8030 Communication Adapter Information

Information about the communication adapters installed on the port 2 and port 3 connectors is stored to D8030.

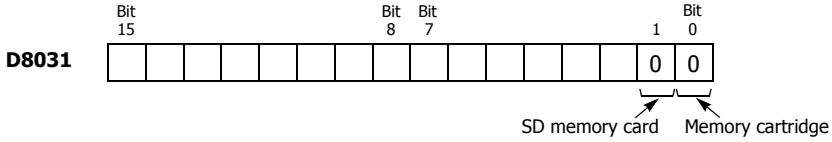


0: RS232C communication adapter is installed

1: RS485 communication adapter is installed or no communication adapter is installed

D8031 Optional Cartridge Information

Information about the optional cartridge installed on the SmartAXIS is stored to D8031.



0: No optional cartridge is installed

1: Memory cartridge is installed

2: SD memory card is installed

3: Memory cartridge and SD memory card are installed

D8032-D8035, D8037, D8038 Interrupt Input Jump Destination Label No.

Jump destination label numbers for interrupt inputs are stored in these special data registers. To use interrupt inputs, store the label number that corresponds to the special data register allocated to the interrupt input.

D8032=I0, D8033=I2, D8034=I3, D8035=I5, D8037=I6, D8038=I7

For details on SmartAXIS Pro/Lite interrupt inputs, see Chapter 5 "Special Functions" – "Interrupt Inputs" in the SmartAXIS Pro/Lite User's Manual. For details on SmartAXIS Touch interrupt inputs, see Chapter 3 "Project" – "4 Special Functions" – "Interrupt Input" in the SmartAXIS Touch User's Manual.

D8036 Timer Interrupt Jump Destination Label No.

The jump destination label number when the timer interrupt occurs is stored in D8036. To use the timer interrupt, store the corresponding label number.

For details on the SmartAXIS Pro/Lite timer interrupt, see Chapter 5 "Special Functions" – "Timer Interrupt" in the SmartAXIS Pro/Lite User's Manual. For details on the SmartAXIS Touch timer interrupt, see Chapter 3 "Project" – "4 Special Functions" – "Timer Interrupt" in the SmartAXIS Touch User's Manual.

D8039 SD Memory Card Capacity

The capacity of the inserted SD or SDHC (maximum size 32 GB) memory card in megabytes is stored to D8039.

D8040-D8047 Analog Input Value

The analog input values (0 to 10 VDC) to the analog input terminals are converted to digital values (0 to 1000) and stored to the corresponding special data registers.

D8040=AI0, D8041=AI1, D8042=AI2, D8043=AI3, D8044=AI4, D8045=AI5, D8046=AI6, D8047=AI7

D8050-D8073, D8134-D8145 High-speed Counter

These special data registers are used with the high-speed counter function and the frequency measurement function.

For details on the SmartAXIS Pro/Lite high-speed counter, see Chapter 5 "Special Functions" – "High-Speed Counter" in the SmartAXIS Pro/Lite User's Manual. For details on the SmartAXIS Touch high-speed counter, see Chapter 3 "Project" – "4 Special Functions" – "High-Speed Counter" in the SmartAXIS Touch User's Manual.

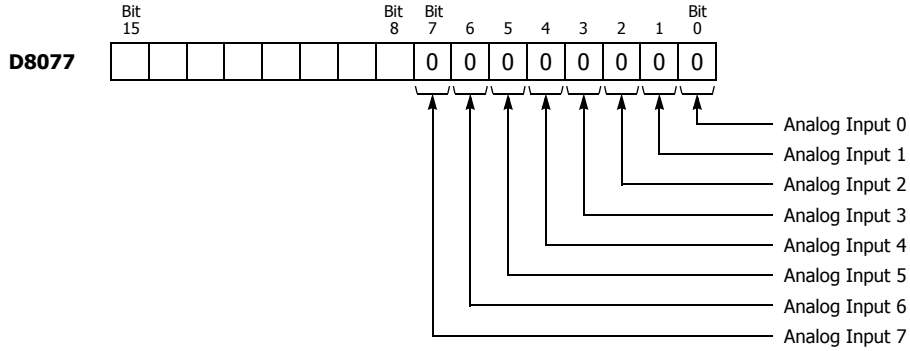
D8074 Backlight ON Time

The backlight ON time is stored. The backlight ON time can be configured by changing the value in D8074 between 1 to 65535 seconds. When D8074 is 0, the backlight is always ON. The backlight ON time can also be changed with the HMI function. For details, see Chapter 5 "Special Functions" - "Changing Backlight ON Time" in the SmartAXIS Touch User's Manual.

D8077 Out of Analog Input Range Status

When an analog input value is 11V or higher, the corresponding D8077 bit turns on. When an analog input value is lower than 11V, the corresponding D8077 bit turns off.

The assignment of each analog input is as follows.



D8078-D8083 MAC Address (Read only)

MAC address of the SmartAXIS is stored to the special data registers in hexadecimal as shown below.

Example) MAC address: AA-BB-CC-DD-EE-FF

D8078=AAh, D8079=BBh, D8080=CCh, D8081=DDh, D8082=EEh, D8083=FFh

D8084-D8087 IP Address (Current Data) Read only

IP address of the SmartAXIS is stored to the special data registers as shown below.

Example) IP address: aaa.bbb.ccc.ddd

D8084=aaa, D8085=bbb, D8086=ccc, D8087=ddd

D8088-D8091 Subnet Mask (Current Data) Read only

Subnet mask of the SmartAXIS is stored to the special data registers as shown below.

Example) Subnet mask: aaa.bbb.ccc.ddd

D8088=aaa, D8089=bbb, D8090=ccc, D8091=ddd

D8092-D8095 Default Gateway (Current Data) Read only

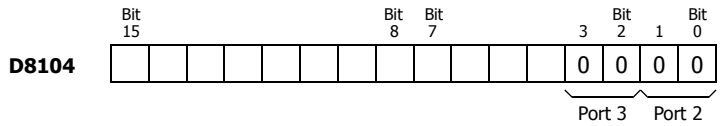
Default gateway of the SmartAXIS is stored to the special data registers as shown below.

Example) Default gateway: aaa.bbb.ccc.ddd

D8092=aaa, D8093=bbb, D8094=ccc, D8095=ddd

D8104 RS232C Control Signal Status (Port 2 and Port 3)

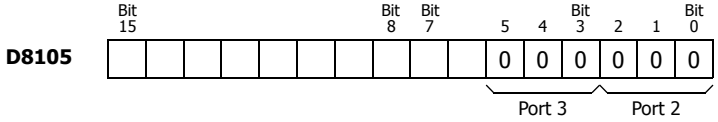
RS232C control signal status of port 2 and port 3 is stored to D8104.



00: Both DSR and DTR are off
01: DSR is off, DTR is on
10: DSR is on, DTR is off
11: Both DSR and DTR are on

D8105 RS232C DSR Input Control Signal Option (Port 2 and Port 3)

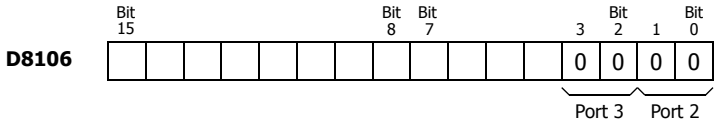
Special data register D8105 is used to control data flow between the SmartAXIS RS232C port 2 and port 3 and the remote terminal depending on the DSR (data set ready) signal sent from the remote terminal.



000: DSR is not used for data flow control
001: When DSR is on, SmartAXIS can transmit and receive data
010: When DSR is off, SmartAXIS can transmit and receive data
011: When DSR is on, SmartAXIS can transmit data (busy control)
100: When DSR is off, SmartAXIS can transmit data
Others: Same as 000

D8106 RS232C DTR Output Control Signal Option (Port 2 and Port 3)

Special data register D8106 is used to control the DTR (data terminal ready) signal to indicate the SmartAXIS operating status or transmitting/receiving status.



00: DTR is on (off while SmartAXIS is stopped)
01: DTR is off
10: DTR is on while SmartAXIS can receive data (auto switching)
11: Same as 00

D8110-D8121 Connection (1 through 3) Connected IP Address

The IP address of the remote host accessing the connection 1 through 3 is stored in special data registers.

Example) Connection 1 Connected IP Address: aaa.bbb.ccc.ddd

D8110=aaa, D8111=bbb, D8112=ccc, D8113=ddd

D8130-D8132 Connection Connected Port Number

When connections are established with other network devices, the port numbers of the connected network devices are stored in these special data registers.

D8130 : Connection 1 Connected Port Number

D8131 : Connection 2 Connected Port Number

D8132 : Connection 3 Connected Port Number

D8148, D8157, D8166 Remote I/O Communication Error Status

When a communication error occurs between the remote I/O communication slave and master, the details of the communication error are stored in these special data registers.

D8148 : Remote I/O Slave 1 Communication Error Status

D8157 : Remote I/O Slave 2 Communication Error Status

D8166 : Remote I/O Slave 3 Communication Error Status

D8149-D8156, D8158-D8165, D8167-D8174 Remote I/O Analog Input Values

The analog input values (0 to 10 VDC) to the remote I/O analog inputs are converted to digital values (0 to 1000) and stored in the special data registers allocated to each remote I/O slave.

- D8149=AI10, D8150=AI11, D8151=AI12, D8152=AI13, D8153=AI14, D8154=AI15, D8155=AI16, D8156=AI17
- D8158=AI20, D8159=AI21, D8160=AI22, D8161=AI23, D8162=AI24, D8163=AI25, D8164=AI26, D8165=AI27
- D8167=AI30, D8168=AI31, D8169=AI32, D8170=AI33, D8171=AI34, D8172=AI35, D8173=AI36, D8174=AI37

4: INSTRUCTIONS REFERENCE

Introduction

SmartAXIS instructions are divided into Basic Instructions, which perform sequencing, and Advanced Instructions, which perform moves, comparisons, Boolean computations, binary arithmetic operations, bit shifts, and other operations.

Basic Instruction List

Symbol	Name	Function	See Page
AND	And	Series connection of NO contact	5-4
AND LOD	And Load	Series connection of circuit blocks	5-5
ANDN	And Not	Series connection of NC contact	5-4
BPP	Bit Pop	Restores the result of bit logical operation which was saved temporarily	5-6
BPS	Bit Push	Saves the result of bit logical operation temporarily	5-6
BRD	Bit Read	Reads the result of bit logical operation which was saved temporarily	5-6
CC=	Counter Comparison (=)	Equal to comparison of counter current value	5-18
CC≥	Counter Comparison (≥)	Greater than or equal to comparison of counter current value	5-18
CDP	Dual Pulse Reversible Counter	Dual pulse reversible counter (0 to 65,535)	5-11
CDPD	Double-word Dual Pulse Reversible Counter	Double-word dual pulse reversible counter (0 to 4,294,967,295)	5-14
CNT	Adding Counter	Adding counter (0 to 65,535)	5-11
CNTD	Double-word Adding Counter	Double-word adding counter (0 to 4,294,967,295)	5-14
CUD	Up/Down Selection Reversible Counter	Up/down selection reversible counter (0 to 65,535)	5-11
CUDD	Double-word Up/Down Selection Reversible Counter	Double-word up/down selection reversible counter (0 to 4,294,967,295)	5-14
DC=	Data Register Comparison (=)	Equal to comparison of data register value	5-20
DC≥	Data Register Comparison (≥)	Greater than or equal to comparison of data register value	5-20
END	End	Ends a program	5-30
JEND	Jump End	Ends a jump instruction	5-29
JMP	Jump	Jumps a designated program area	5-29
LOD	Load	Stores intermediate results and reads contact status	5-1
LODN	Load Not	Stores intermediate results and reads inverted contact status	5-1
MCR	Master Control Reset	Ends a master control	5-27
MCS	Master Control Set	Starts a master control	5-27
OR	Or	Parallel connection of NO contact	5-4
OR LOD	Or Load	Parallel connection of circuit blocks	5-5
ORN	Or Not	Parallel connection of NC contact	5-4
OUT	Output	Outputs the result of bit logical operation	5-1
OUTN	Output Not	Outputs the inverted result of bit logical operation	5-1
RST	Reset	Resets output, internal relay, or shift register bit	5-3
SET	Set	Sets output, internal relay, or shift register bit	5-3
SFR	Shift Register	Forward shift register	5-22
SFRN	Shift Register Not	Reverse shift register	5-22
SOTD	Single Output Down	Falling-edge differentiation output	5-26
SOTU	Single Output Up	Rising-edge differentiation output	5-26
TIM	100-ms Timer	Subtracting 100-ms timer (0 to 6553.5 sec)	5-7
TIMO	100-ms Off-delay Timer	Subtracting 100-ms off-delay timer (0 to 6553.5 sec)	5-10
TMH	10-ms Timer	Subtracting 10-ms timer (0 to 655.35 sec)	5-7

Symbol	Name	Function	See Page
TMHO	10-ms Off-delay Timer	Subtracting 10-ms off-delay timer (0 to 655.35 sec)	5-10
TML	1-sec Timer	Subtracting 1-sec timer (0 to 65535 sec)	5-7
TMLO	1-sec Off-delay Timer	Subtracting 1-sec off-delay timer (0 to 65535 sec)	5-10
TMS	1-ms Timer	Subtracting 1-ms timer (0 to 65.535 sec)	5-7
TMSO	1-ms Off-delay Timer	Subtracting 1-ms off-delay timer (0 to 65.535 sec)	5-10

Advanced Instruction List

Group	Symbol	Name	Valid Data Type					See Page
			W	I	D	L	F	
NOP	NOP	No Operation						4-14
Move	MOV	Move	X	X	X	X	X	6-1
	MOVN	Move Not	X	X	X	X		6-5
	IMOV	Indirect Move	X		X		X	6-6
	IMOVN	Indirect Move Not	X		X			6-8
	BMOV	Block Move	X					6-9
	IBMV	Indirect Bit Move	X					6-10
	IBMVN	Indirect Bit Move Not	X					6-12
	NSET	N Data Set	X	X	X	X	X	6-13
	NRS	N Data Repeat Set	X	X	X	X	X	6-14
	XCHG	Exchange	X		X			6-15
	TCCST	Timer/Counter Current Value Store	X		X			6-16
Data Comparison	CMP=	Compare Equal To	X	X	X	X	X	7-1
	CMP<>	Compare Unequal To	X	X	X	X	X	7-1
	CMP<	Compare Less Than	X	X	X	X	X	7-1
	CMP>	Compare Greater Than	X	X	X	X	X	7-1
	CMP<=	Compare Less Than or Equal To	X	X	X	X	X	7-1
	CMP>=	Compare Greater Than or Equal To	X	X	X	X	X	7-1
	ICMP>=	Interval Compare Greater Than or Equal To	X	X	X	X	X	7-6
	LC=	Load Compare Equal To	X	X	X	X	X	7-8
	LC<>	Load Compare Unequal To	X	X	X	X	X	7-8
	LC<	Load Compare Less Than	X	X	X	X	X	7-8
	LC>	Load Compare Greater Than	X	X	X	X	X	7-8
	LC<=	Load Compare Less Than or Equal To	X	X	X	X	X	7-8
	LC>=	Load Compare Greater Than or Equal To	X	X	X	X	X	7-8
Binary Arithmetic	ADD	Addition	X	X	X	X	X	8-1
	SUB	Subtraction	X	X	X	X	X	8-1
	MUL	Multiplication	X	X	X	X	X	8-1
	DIV	Division	X	X	X	X	X	8-1
	INC	Increment	X	X	X	X		8-13
	DEC	Decrement	X	X	X	X		8-13
	ROOT	Root	X		X		X	8-14
	SUM	Sum (ADD)	X	X	X	X	X	8-15
		Sum (XOR)	X					8-15
Boolean Computation	ANDW	AND Word	X		X			9-1
	ORW	OR Word	X		X			9-1
	XORW	Exclusive OR Word	X		X			9-1
Shift and Rotate	SFTL	Shift Left						10-1
	SFTR	Shift Right						10-3
	BCDLS	BCD Left Shift			X			10-5
	WSFT	Word Shift	X					10-7
	ROTL	Rotate Left	X		X			10-8
	ROTR	Rotate Right	X		X			10-10

Group	Symbol	Name	Valid Data Type					See Page
			W	I	D	L	F	
Data Conversion	HTOB	Hex to BCD	X		X			11-1
	BTOH	BCD to Hex	X		X			11-3
	HTOA	Hex to ASCII	X					11-5
	ATOH	ASCII to Hex	X					11-7
	BTOA	BCD to ASCII	X		X			11-9
	ATOB	ASCII to BCD	X		X			11-12
	ENCO	Encode						11-15
	DECO	Decode						11-16
	BCNT	Bit Count						11-17
	ALT	Alternate Output						11-18
	CVDT	Convert Data Type	X	X	X	X	X	11-19
	DTDV	Data Divide	X					11-21
	DTCB	Data Combine	X					11-22
	SWAP	Data Swap	X		X			11-23
Week Programmer	WEEK	Weekly Timer						12-1
	YEAR	Yearly Timer						12-11
Interface	MSG	Message						13-1
User Communication	TXD2	Transmit 2						25-1
	TXD3	Transmit 3						25-1
	RXD2	Receive 2						25-7
	RXD3	Receive 3						25-7
Program Branching	LABEL	Label						14-1
	LJMP	Label Jump						14-1
	LCAL	Label Call						14-3
	LRET	Label Return						14-3
	DJNZ	Decrement Jump Non-zero						14-5
	DI	Disable Interrupt						16-1
	EI	Enable Interrupt						16-1
	IOREF	I/O Refresh						15-1
	HSCRF	High-speed Counter Refresh						15-3
Coordinate Conversion	XYFS	XY Format Set	X	X				17-1
	CVXTY	Convert X to Y	X	X				17-2
	CVYTX	Convert Y to X	X	X				17-3
	AVRG	Average	X	X	X	X	X	18-1
Pulse	PULS1	Pulse Output 1						19-1
	PULS2	Pulse Output 2						19-1
	PULS3	Pulse Output 3						19-1
	PULS4	Pulse Output 4						19-1
	PWM1	Pulse Width Modulation 1						19-8
	PWM2	Pulse Width Modulation 2						19-8
	PWM3	Pulse Width Modulation 3						19-8
	PWM4	Pulse Width Modulation 4						19-8
	RAMP1	Ramp Pulse Output 1						19-15
	RAMP2	Ramp Pulse Output 2						19-15
	ZRN1	Zero Return 1						19-26
	ZRN2	Zero Return 2						19-26
	ARAMP1	Advanced Ramp 1						19-32
	ARAMP2	Advanced Ramp 2						19-32
Dual / Teaching Timer	DTML	1-sec Dual Timer						20-1
	DTIM	100-ms Dual Timer						20-1
	DTMH	10-ms Dual Timer						20-1
	DTMS	1-ms Dual Timer						20-1
	TTIM	Teaching Timer						20-3

Group	Symbol	Name	Valid Data Type					See Page
			W	I	D	L	F	
Trigonometric Function	RAD	Degree to Radian					X	21-1
	DEG	Radian to Degree					X	21-2
	SIN	Sine					X	21-3
	COS	Cosine					X	21-4
	TAN	Tangent					X	21-5
	ASIN	Arc Sine					X	21-6
	ACOS	Arc Cosine					X	21-7
	ATAN	Arc Tangent					X	21-8
Logarithm / Power	LOGE	Natural Logarithm					X	22-1
	LOG10	Common Logarithm					X	22-2
	EXP	Exponent					X	22-3
	POW	Power					X	22-4
File Data Processing	FIFOF	FIFO Format	X					23-1
	FIEX	First-In Execute	X					23-3
	FOEX	First-Out Execute	X					23-3
	NDSRC	N Data Search	X	X	X	X	X	23-5
Clock	TADD	Time Addition						24-1
	TSUB	Time Subtraction						24-5
	HTOS	HMS to Sec						24-9
	STOH	Sec to HMS						24-10
	HOUR	Hour Meter						24-11
Ethernet Instructions	ETXD	Transmit over Ethernet						25-21
	ERXD	Receive over Ethernet						25-21
Data Logging	DLOG	Data Logging						26-1
	TRACE	Data Trace						26-8

Advanced Instruction Applicable SmartAXIS

Applicable advanced instructions depend on the SmartAXIS type as listed in the table below.

Group	Symbol	FT1A-12		FT1A-24		FT1A-40		FT1A-48		FT1A-Touch
		AC	DC	AC	DC	AC	DC	AC	DC	
NOP	NOP	X	X	X	X	X	X	X	X	X
Move	MOV	X	X	X	X	X	X	X	X	X
	MOVN	X	X	X	X	X	X	X	X	X
	IMOV	X	X	X	X	X	X	X	X	X
	IMOVN	X	X	X	X	X	X	X	X	X
	BMOV	X	X	X	X	X	X	X	X	X
	IBMV	X	X	X	X	X	X	X	X	X
	IBMVN	X	X	X	X	X	X	X	X	X
	NSET	X	X	X	X	X	X	X	X	X
	NRS	X	X	X	X	X	X	X	X	X
	XCHG	X	X	X	X	X	X	X	X	X
	TCCST	X	X	X	X	X	X	X	X	X
Data Comparison	CMP=	X	X	X	X	X	X	X	X	X
	CMP<>	X	X	X	X	X	X	X	X	X
	CMP<	X	X	X	X	X	X	X	X	X
	CMP>	X	X	X	X	X	X	X	X	X
	CMP<=	X	X	X	X	X	X	X	X	X
	CMP>=	X	X	X	X	X	X	X	X	X
	ICMP>=	X	X	X	X	X	X	X	X	X
	LC=	X	X	X	X	X	X	X	X	X
	LC<>	X	X	X	X	X	X	X	X	X
	LC<	X	X	X	X	X	X	X	X	X
	LC>	X	X	X	X	X	X	X	X	X
	LC<=	X	X	X	X	X	X	X	X	X
	LC>=	X	X	X	X	X	X	X	X	X
Binary Arithmetic	ADD	X	X	X	X	X	X	X	X	X
	SUB	X	X	X	X	X	X	X	X	X
	MUL	X	X	X	X	X	X	X	X	X
	DIV	X	X	X	X	X	X	X	X	X
	INC	X	X	X	X	X	X	X	X	X
	DEC	X	X	X	X	X	X	X	X	X
	ROOT	X	X	X	X	X	X	X	X	X
	SUM	X	X	X	X	X	X	X	X	X
Boolean Computation	ANDW	X	X	X	X	X	X	X	X	X
	ORW	X	X	X	X	X	X	X	X	X
	XORW	X	X	X	X	X	X	X	X	X
Shift and Rotate	SFTL	X	X	X	X	X	X	X	X	X
	SFTR	X	X	X	X	X	X	X	X	X
	BCDLS	X	X	X	X	X	X	X	X	X
	WSFT	X	X	X	X	X	X	X	X	X
	ROTL	X	X	X	X	X	X	X	X	X
	ROTR	X	X	X	X	X	X	X	X	X

Group	Symbol	FT1A-12		FT1A-24		FT1A-40		FT1A-48		FT1A-Touch
		AC	DC	AC	DC	AC	DC	AC	DC	
Data Conversion	HTOB	X	X	X	X	X	X	X	X	X
	BTOH	X	X	X	X	X	X	X	X	X
	HTOA	X	X	X	X	X	X	X	X	X
	ATOH	X	X	X	X	X	X	X	X	X
	BTOA	X	X	X	X	X	X	X	X	X
	ATOB	X	X	X	X	X	X	X	X	X
	ENCO	X	X	X	X	X	X	X	X	X
	DECO	X	X	X	X	X	X	X	X	X
	BCNT	X	X	X	X	X	X	X	X	X
	ALT	X	X	X	X	X	X	X	X	X
	CVDT	X	X	X	X	X	X	X	X	X
	DTDV	X	X	X	X	X	X	X	X	X
	DTCB	X	X	X	X	X	X	X	X	X
	SWAP	X	X	X	X	X	X	X	X	X
Week Programmer	WEEK	X	X	X	X	X	X	X	X	X
	YEAR	X	X	X	X	X	X	X	X	X
Display	MSG	X (Note)	X (Note)	X (Note)	X (Note)	X (Note)	X (Note)	X (Note)	X (Note)	–
User Communication	TXD2	X	X	X	X	X	X	X	X	X
	TXD3	–	–	–	–	X	X	X	X	X
	RXD2	–	–	X	X	X	X	X	X	X
	RXD3	–	–	–	–	X	X	X	X	X
Program Branching	LABEL	X	X	X	X	X	X	X	X	X
	LJMP	X	X	X	X	X	X	X	X	X
	LCAL	X	X	X	X	X	X	X	X	X
	LRET	X	X	X	X	X	X	X	X	X
	DJNZ	X	X	X	X	X	X	X	X	X
	DI	X	X	X	X	X	X	X	X	X
	EI	X	X	X	X	X	X	X	X	X
	IOREF	X	X	X	X	X	X	X	X	X
	HSCRF	–	X	–	X	–	X	–	X	X
Coordinate Conversion	XYFS	X	X	X	X	X	X	X	X	X
	CVXTY	X	X	X	X	X	X	X	X	X
	CVYTX	X	X	X	X	X	X	X	X	X
	AVRG	X	X	X	X	X	X	X	X	X

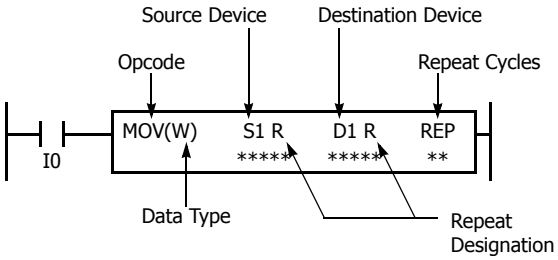
Note: MSG instructions can be used with Pro series only.

Group	Symbol	FT1A-12		FT1A-24		FT1A-40		FT1A-48		FT1A-Touch
		AC	DC	AC	DC	AC	DC	AC	DC	
Pulse	PULS1	–	–	–	–	–	X	X	X	–
	PULS2	–	–	–	–	–	X	X	X	–
	PULS3	–	–	–	–	–	X (Note1)	X	X	–
	PULS4	–	–	–	–	–	X (Note1)	X	X	–
	PWM1	–	–	–	–	–	X	X	X	–
	PWM2	–	–	–	–	–	X	X	X	–
	PWM3	–	–	–	–	–	X (Note1)	X	X	–
	PWM4	–	–	–	–	–	X (Note1)	X	X	–
	RAMP1	–	–	–	–	–	X	X	X	–
	RAMP2	–	–	–	–	–	X (Note2)	X (Note2)	X (Note2)	–
	ZRN1	–	–	–	–	–	X	X	X	–
	ZRN2	–	–	–	–	–	X	X	X	–
	ARAMP1	–	–	–	–	–	X	X	X	–
	ARAMP2	–	–	–	–	–	X (Note2)	X (Note2)	X (Note2)	–
Dual / Teaching Timer	DTML	X	X	X	X	X	X	X	X	X
	DTIM	X	X	X	X	X	X	X	X	X
	DTMH	X	X	X	X	X	X	X	X	X
	DTMS	X	X	X	X	X	X	X	X	X
	TTIM	X	X	X	X	X	X	X	X	X
Trigonometric Function	RAD	X	X	X	X	X	X	X	X	X
	DEG	X	X	X	X	X	X	X	X	X
	SIN	X	X	X	X	X	X	X	X	X
	COS	X	X	X	X	X	X	X	X	X
	TAN	X	X	X	X	X	X	X	X	X
	ASIN	X	X	X	X	X	X	X	X	X
	ACOS	X	X	X	X	X	X	X	X	X
	ATAN	X	X	X	X	X	X	X	X	X
Logarithm / Power	LOGE	X	X	X	X	X	X	X	X	X
	LOG10	X	X	X	X	X	X	X	X	X
	EXP	X	X	X	X	X	X	X	X	X
	POW	X	X	X	X	X	X	X	X	X
File Data Processing	FIFOF	X	X	X	X	X	X	X	X	X
	FIEX	X	X	X	X	X	X	X	X	X
	FOEX	X	X	X	X	X	X	X	X	X
	NDSRC	X	X	X	X	X	X	X	X	X
Clock	TADD	X	X	X	X	X	X	X	X	X
	TSUB	X	X	X	X	X	X	X	X	X
	HTOS	X	X	X	X	X	X	X	X	X
	STOH	X	X	X	X	X	X	X	X	X
	HOUR	X	X	X	X	X	X	X	X	X
Ethernet Instructions	ETXD	–	–	X	X	X	X	X	X	–
	ERXD	–	–	X	X	X	X	X	X	–
Data Logging	DLOG	–	–	–	–	X	X	X	X	–
	TRACE	–	–	–	–	X	X	X	X	–

Note1: When using RAMP1 in single-pulse output mode, PULS3 and PWM3 cannot be used. When using RAMP2 in single-pulse output mode, PULS4 and PWM4 cannot be used.

Note2: When using RAMP1 and ARAMP1 in dual-pulse output mode, RAMP2 and ARAMP2 cannot be used.

Structure of an Advanced Instruction



Repeat Designation

Specifies whether repeat is used for the device or not.

Repeat Cycles

Specifies the quantity of repeat cycles: 1 through 99.

Opcode

The opcode is a symbol used to identify the advanced instruction.

Data Type

Specifies word (W), integer (I), double word (D), long (L), or float (F) data.

Source Device

The source device specifies the 16- or 32-bit data to be processed by the advanced instruction. Some advanced instructions require two source devices.

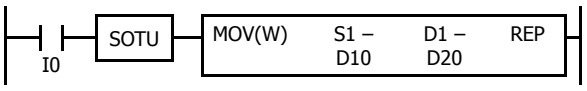
Destination Device

The destination device specifies the 16- or 32-bit data to store the result of the advanced instruction. Some advanced instructions require two destination devices.

Input Condition for Advanced Instructions

Almost all advanced instructions must be preceded by a contact, except NOP (no operation), LABEL (label), and LRET (label return) instructions. The input condition can be programmed using a bit device such as input, output, internal relay, or shift register. Timer and counter can also be used as an input condition to turn on the contact when the timer times out or the counter counts out.

While the input condition is on, the advanced instruction is executed in each scan. To execute the advanced instruction only at the rising or falling edge of the input, use the SOTU or SOTD instruction.



While the input condition is off, the advanced instruction is not executed and device statuses are held.

Source and Destination Devices

The source and destination devices specify 16- or 32-bit data, depending on the selected data type. When a bit device such as input, output, internal relay, or shift register is designated as a source or destination device, 16 or 32 points starting with the designated number are processed as source or destination data. When a word device such as timer or counter is designated as a source device, the current value is read as source data. When a timer or counter is designated as a destination device, the result of the advanced instruction is set to the preset value for the timer or counter. When a data register is designated as a source or destination device, the data is read from or written to the designated data register.

Using Timer or Counter as Source Device

Since all timer instructions—TML (1-sec timer), TIM (100-ms timer), TMH (10-ms timer), and TMS (1-ms timer)—subtract from the preset value, the current value is decremented from the preset value and indicates the remaining time. As described above, when a timer is designated as a source device of an advanced instruction, the current value, or the remaining time, of the timer is read as source data. Adding counters CNT start counting at 0, and the current value is incremented up to the preset value. Reversible counters CDP and CUD start counting at the preset value and the current value is incremented or decremented from the preset value. When any counter is designated as a source device of an advanced instruction, the current value is read as source data.

Using Timer or Counter as Destination Device

As described above, when a timer or counter is designated as a destination device of an advanced instruction, the result of the advanced instruction is set to the preset value of the timer or counter. Timer and counter preset values can be 0 through 65535.

When a timer or counter preset value is designated using a data register, the timer or counter cannot be designated as a destination of an advanced instruction. When executing such an advanced instruction, a user program execution error will result. For details of user program execution error, see Chapter 13 "Troubleshooting" - "User Program Execution Error" in the SmartAXIS Pro/Lite User's Manual.

Note: When a user program execution error occurs, the result is not set to the destination.

Data Types for Advanced Instructions

When using move, data comparison, binary arithmetic, Boolean computation, bit shift/rotate, data conversion, and coordinate conversion instructions, data types can be selected from word (W), integer (I), double word (D), long (L), or float (F). For other advanced instructions, the data is processed in units of 16-bit word.

Data Type	Symbol	Bits	Quantity of Data Registers Used	Range of Decimal Values
Word (Unsigned 16 bits)	**W**	16 bits	1	0 to 65,535
Integer (Signed 15 bits)	**I**	16 bits	1	–32,768 to 32,767
Double Word (Unsigned 32 bits)	**D**	32 bits	2	0 to 4,294,967,295
Long (Signed 31 bits)	**L**	32 bits	2	–2,147,483,648 to 2,147,483,647
Float (Floating point)	**F**	32 bits	2	-3.402823×10^{38} to 3.402823×10^{38}

Decimal Values and Hexadecimal Storage (Word, Integer, Double, and Long Data)

The following table shows hexadecimal equivalents which are stored in the CPU, as a result of addition and subtraction of the decimal values shown:

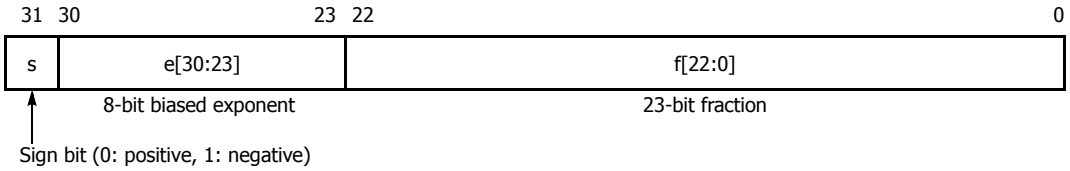
Data Type	Result of Addition	Hexadecimal Storage	Result of Subtraction	Hexadecimal Storage
			65535	FFFF
	0	0000	0	0000
Word	65535	FFFF	–1	(BW) FFFF
	131071	(CY) FFFF	–65535	(BW) 0001
			–65536	(BW) 0000
	65534	(CY) 7FFE	65534	(BW) 7FFE
	32768	(CY) 0000	32768	(BW) 0000
	32767	7FFF	32767	7FFF
	0	0000	0	0000
Integer	–1	FFFF	–1	FFFF
	–32767	8001	–32767	8001
	–32768	8000	–32768	8000
	–32769	(CY) FFFF	–32769	(BW) FFFF
	–65535	(CY) 8001	–65535	(BW) 8001
			4294967295	FFFFFFFF
	0	00000000	0	00000000
Double Word	4294967295	FFFFFFFF	–1	(BW) FFFFFFFF
	8589934591	(CY) FFFFFFFF	–4294967295	(BW) 00000001
			–4294967296	(BW) 00000000
	4294967294	(CY) 7FFFFFFE	4294967294	(BW) 7FFFFFFE
	2147483648	(CY) 00000000	2147483648	(BW) 00000000
	2147483647	7FFFFFFF	2147483647	7FFFFFFF
	0	00000000	0	00000000
Long	–1	FFFFFFFF	–1	FFFFFFFF
	–2147483647	80000001	–2147483647	80000001
	–2147483648	80000000	–2147483648	80000000
	–2147483649	(CY) FFFFFFFF	–2147483649	(BW) FFFFFFFF
	–4294967295	(CY) 80000001	–4294967295	(BW) 80000001

Floating-Point Data Format

The SmartAXIS can specify floating-point data (F) for advanced instructions. Like double word (D) and long integer (L) data, floating-point data also uses two consecutive data registers to execute advanced instructions. The SmartAXIS supports the floating-point data based on the single storage format of the IEEE (The Institute of Electrical and Electronics Engineers) Standard 754.

Single Storage Format

The IEEE single storage format consists of three fields: a 23-bit fraction, f; an 8-bit biased exponent, e; and 1-bit sign, s. These fields are stored contiguously in one 32-bit word, as shown in the figure below. Bits 0:22 contain the 23-bit fraction, f, with bit 0 being the least significant bit of the fraction and bit 22 being the most significant; bits 23:30 contain the 8-bit biased exponent, e, with bit 23 being the least significant bit of the biased exponent and bit 30 being the most significant; and the highest-order bit 31 contains the sign bit, s.



Single Storage Format

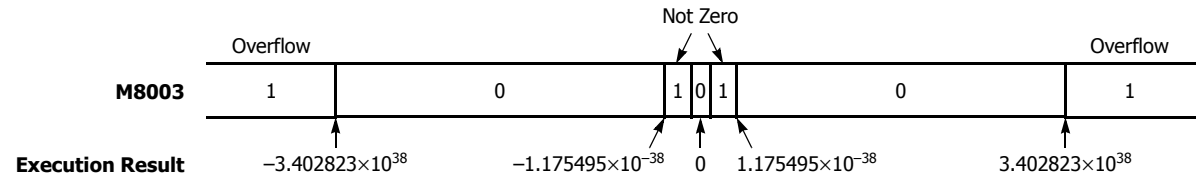
The table below shows the correspondence between the values of the three constituent fields s, e, and f and the value represented by the single storage format bit pattern. When any value out of the bit pattern is entered to the advanced instruction or when execution of advanced instructions, such as division by zero, has produced any value out of the bit pattern, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS.

Value	Exponent field e	Fraction field f	Representation in WindLDR
±0	e=0	f=0	0.0
Denormal numbers	e=0	f≠0	-1.175495E-38 to 1.175495E-38
Normal numbers	0<e<255	Arbitrary	-3.402823E+38 to -1.175495E-38 1.175495E-38 to 3.402823E+38
±∞ (± infinities)	e=255	f=0	INF
NaNs (Not a number values)		f≠0	NAN

Carry and Borrow in Floating-Point Data Processing

When advanced instructions involving floating-point data are executed, special internal relay M8003 (carry and borrow) is updated.

M8003	Execution Result	Value
1	≠ 0	Overflow (exceeds the range between -3.402823×10^{38} and 3.402823×10^{38})
1	0	Not zero (within the range between -1.175495×10^{-38} and 1.175495×10^{-38})
0	0	Zero



32-bit Data Storage

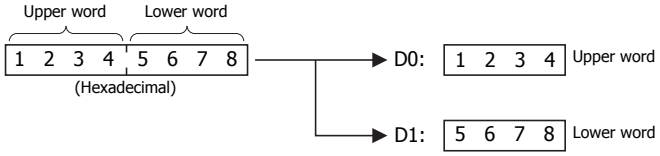
When double-word (D) or long (L) data is selected, the data is stored in consecutive devices in the following manner according to the 32-bit data storage setting configured in **Function Area Settings** under **Device Settings**.

For applicable devices and instructions, see Chapter 5 "Special Functions" – "32-bit Data Storage Setting" in the SmartAXIS Pro/ Lite User's Manual.

Word devices: The data storage when **From Upper Word** is selected under **Device Settings**

When D0 is specified as the source or destination device, the upper word is stored in D0 and the lower word is stored in D1.

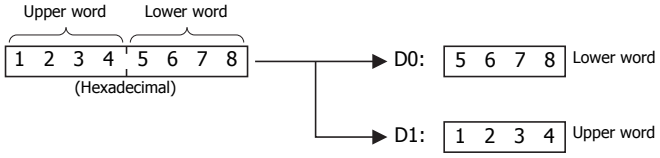
Double word data (constant)



The data storage when **From Lower Word** is selected under **Device Settings**

When D0 is specified as the source or destination device, the lower word is stored in D0 and the upper word is stored in D1.

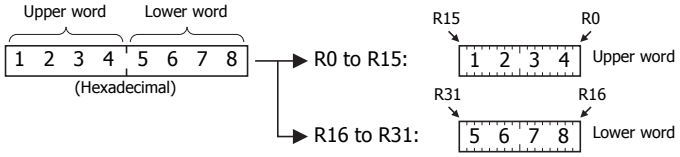
Double word data (constant)



Bit devices: The data storage when **From Upper Word** is selected under **Device Settings**

When R0 is specified as the source or destination device, the upper word is stored in R0 to R15 and the lower word is stored in R16 to R31.

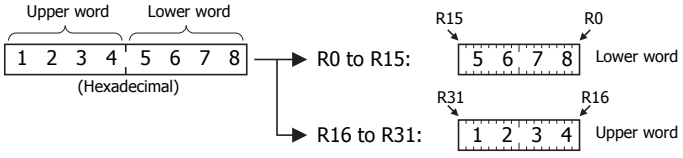
Double word data (constant)



The data storage when **From Lower Word** is selected under **Device Settings**

When R0 is specified as the source or destination device, the lower word is stored in R0-R15 and the upper word is stored in R16-R31.

Double word data (constant)



User Program Execution Errors

When an advanced instruction is executed, a user program execution error occurs when any of the following conditions are met.

- the result of the adavnced instruction is invalid
- source or destination device that is indirectly specified in the advanced instruction exceeds the valid device range
- the advanced instruction does not operate correctly

For example, the data in the source device does not comply with the normal floating-point format when the data type is Float (F).

When a user program execution error occurs, special internal relay M8004 turns on and the corresponding error code is stored in special data register D8006. For details about the error codes, see Chapter 13 "Troubleshooting" – "User Program Execution Error" in the SmartAXIS Pro/Lite User's Manual.

When a user program execution error occurs, instructions operate as follows:

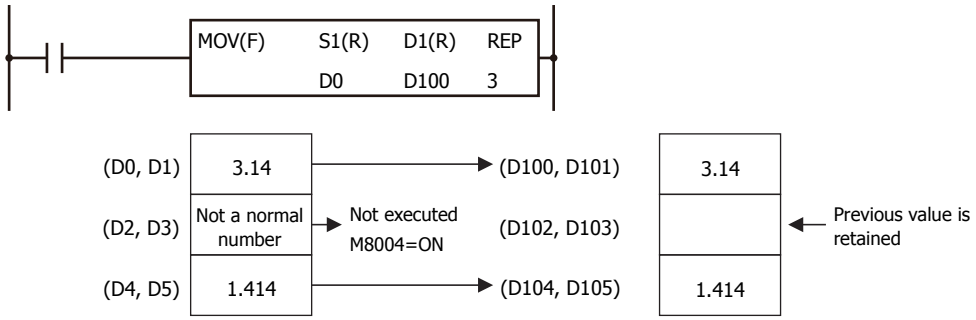
- When the source data is invalid, the execution of the advanced instruction is canceled and the data in the destination device is not changed.
- When the execution result is invalid, a value is stored in the destination device.
  For details on stored values, see the descriptions of relevant instructions.
- If a user program execution error occurred during a repeat operation, the operation is canceled and the next repeat operation is executed. M8004 is retained even when no further user program execution errors occur during subsequent repeat operations.

Example: User program execution error during a repeat operation

When the source data does not comply with the normal floating-point format.

When the second repeat operation is executed, special internal relay M8004 turns on because the source data is not a normal number in floating-point format.

The second repeat operation is canceled and the third repeat operation is executed.



Carry and Borrow

When the result of an operation exceeds the valid device range, a carry (CY) or borrow (BW) occurs.

Carrying and borrowing occur in the following conditions according to the data type:

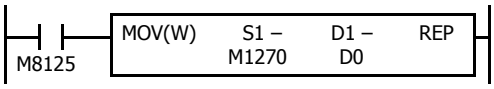
Data Type	Status
Word	Exceeds range between 0 and 65,535
Integer	Exceeds range between -32,768 and 32,767
Double Word	Exceeds range between 0 and 4,294,967,295
Long	Exceeds range between -2,147,483,648 and 2,147,483,647
Float	If an overflow or underflow occurs For details on overflow and underflow, see "Carry and Borrow in Floating-Point Data Processing" on page 4-11.

When a carry or borrow occurs, special internal relay M8003 (carry and borrow) turns on.

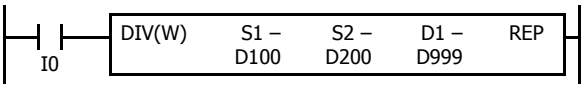
For example, when D0 has a value of FFFF (hex) and +1 is added using an INC instruction, the result is 10000 (hex), but when the data type is Word (W), 0000 (hex) is stored in D0 and 1 is stored in M8003.

Discontinuity of Device Areas

Each device area is discrete and does not continue, for example, from input to output or from output to internal relay. In addition, special internal relays M8000 through M8177 are in a separate area from internal relays M0 through M1277. Data registers D0 through D999, non-retentive data registers D1000 through D1999, and special data registers D8000 through D8199 are in separate areas and do not continue with each other.

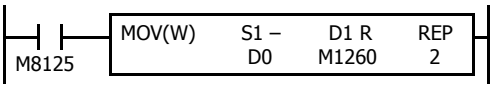


The internal relay ends at M1277. Since the MOV (move) instruction reads 16 internal relays, the last internal relay exceeds the valid range, resulting in a user program syntax error.



This program results in a user program syntax error. The destination of the DIV (division) instruction requires two data registers D999 and D1000. Since D1000 exceeds the valid range, a user program syntax error occurs.

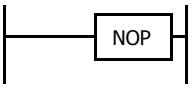
Advanced instructions execute operation only on the available devices in the valid area. If a user program syntax error is found during programming, WindLDR rejects the program instruction and shows an error message.



The MOV (move) instruction sets data of data register D0 to 16 internal relays M1260 through M1277 in the first repeat cycle. The destination of the second cycle is the next 16 internal relays M1280 through M1297, which are invalid, resulting in a user program syntax error.

For details about repeat operations of each advanced instruction, see the following chapters.

NOP (No Operation)



No operation is executed by the NOP instruction.

The NOP instruction may serve as a place holder. It can also be used to add a delay to the CPU scan time, in order to simulate communication with a machine or application, for debugging purposes.

The NOP instruction does not require an input and device.

Details of the other advanced instructions are described in the following chapters.

5: BASIC INSTRUCTIONS

Introduction

This chapter describes programming of the basic instructions, available devices, and sample programs.

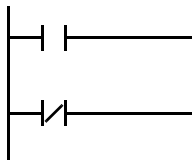
All basic instructions are available on all SmartAXIS.

LOD (Load) and LODN (Load Not)

The LOD instruction starts the logical operation with a NO (normally open) contact. The LODN instruction starts the logical operation with a NC (normally closed) contact.

A total of eight LOD and/or LODN instructions can be programmed consecutively.

Ladder Diagram



Valid Devices

Instruction	I	Q	M	T	C	R	D
LOD LODN	0-35 40-75 80-115 120-155	0-21 40-61 80-101 120-141	0-1277 8000-8177	0-199	0-199	0-127	0.0-1999.15 8000.0-8199.15

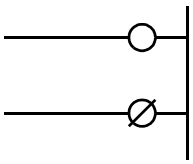
The valid device range depends on the SmartAXIS type. For details, see "Device Addresses" on page 3-1.

Data registers can be used as bit devices with the data register number and the bit position separated by a period.

OUT (Output) and OUTN (Output Not)

The OUT instruction outputs the result of bit logical operation to the specified device. The OUTN instruction outputs the inverted result of bit logical operation to the specified device.

Ladder Diagram



Valid Devices

Instruction	I	Q	M	T	C	R	D
OUT OUTN	—	0-21 40-61 80-101 120-141	0-1277 8000-8177	—	—	—	0.0-1999.15 8000.0-8199.15

The valid device range depends on the SmartAXIS type. For details, see "Device Addresses" on page 3-1.

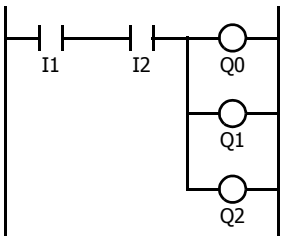
Data registers can be used as bit devices with the data register number and the bit position separated by a period.

Note: For restrictions on ladder programming of OUT and OUTN instructions, see "Restriction on Ladder Programming" on page 5-31.

Multiple OUT and OUTN

There is no limit to the number of OUT and OUTN instructions that can be programmed into one rung.

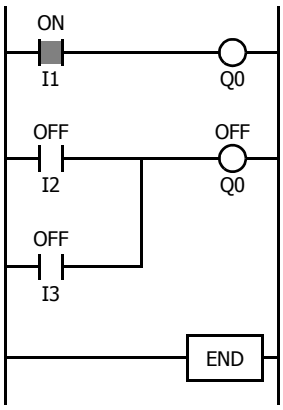
Ladder Diagram



Programming multiple outputs of the same output number is not recommended. However, if doing so, it is good practice to separate the outputs with the JMP/JEND set of instructions, or the MCS/MCR set of instructions. These instructions are detailed later in this chapter.

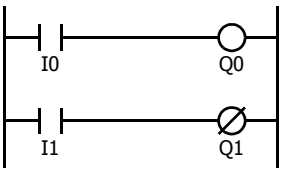
When the same output number is programmed more than once within one scan, the output nearest to the END instruction is given priority for outputting. In the example on the right, output Q0 is off.

Ladder Diagram



Examples: LOD (Load), OUT (Output), and NOT

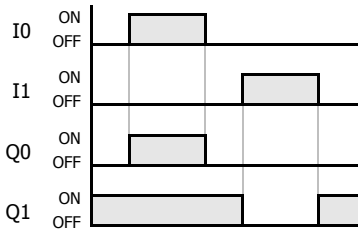
Ladder Diagram



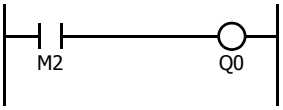
Program List

Instruction	Data
LOD	I0
OUT	Q0
LOD	I1
OUTN	Q1

Timing Chart



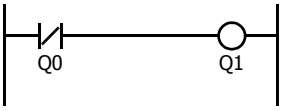
Ladder Diagram



Program List

Instruction	Data
LOD	M2
OUT	Q0

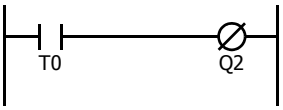
Ladder Diagram



Program List

Instruction	Data
LODN	Q0
OUT	Q1

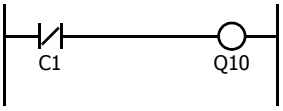
Ladder Diagram



Program List

Instruction	Data
LOD	T0
OUTN	Q2

Ladder Diagram



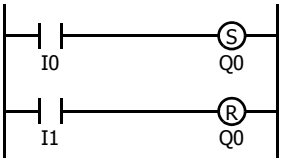
Program List

Instruction	Data
LODN	C1
OUT	Q10

SET and RST (Reset)

The SET and RST (reset) instructions are used to set (on) or reset (off) outputs, internal relays, and shift register bits. The same output can be set and reset many times within a program. SET and RST instructions operate in every scan while the input is on.

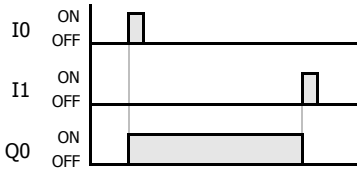
Ladder Diagram



Program List

Instruction	Data
LOD	I0
SET	Q0
LOD	I1
RST	Q0

Timing Chart



Valid Devices

Instruction	I	Q	M	T	C	R	D
SET RST	—	0-21 40-61 80-101 120-141	0-1277 8000-8177	—	—	0-127	0.0-1999.15 8000.0-8199.15

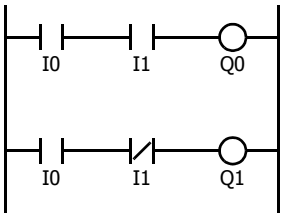
The valid device range depends on the SmartAXIS type. For details, see "Device Addresses" on page 3-1.

Note: For restrictions on ladder programming of SET and RST instructions, see "Restriction on Ladder Programming" on page 5-31.

AND and ANDN (And Not)

The AND instruction is used for programming a NO contact in a series. The ANDN instruction is used for programming a NC contact in a series. The AND or ANDN instruction is entered after the first set of contacts.

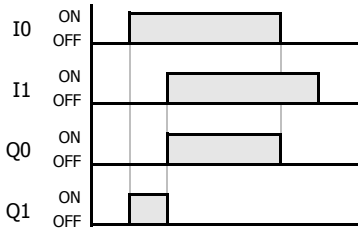
Ladder Diagram



Program List

Instruction	Data
LOD	I0
AND	I1
OUT	Q0
LOD	I0
ANDN	I1
OUT	Q1

Timing Chart



When both inputs I0 and I1 are on, output Q0 is on. When either input I0 or I1 is off, output Q0 is off.
When input I0 is on and input I1 is off, output Q1 is on. When either input I0 is off or input I1 is on, output Q1 is off.

Valid Devices

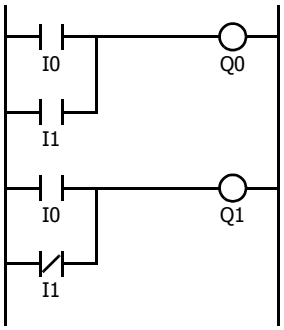
Instruction	I	Q	M	T	C	R	D
	0-35	0-21					
AND	40-75	40-61	0-1277	0-199	0-199	0-127	0.0-1999.15
ANDN	80-115	80-101	8000-8177				8000.0-8199.15
	120-155	120-141					

The valid device range depends on the SmartAXIS type. For details, see "Device Addresses" on page 3-1.
Data registers can be used as bit devices with the data register number and the bit position separated by a period.

OR and ORN (Or Not)

The OR instruction is used for programming a NO contact in parallel. The ORN instruction is used for programming a NC contact in parallel. The OR or ORN instruction is entered after the first set of contacts.

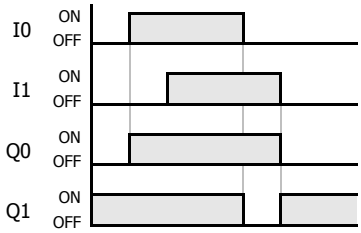
Ladder Diagram



Program List

Instruction	Data
LOD	I0
OR	I1
OUT	Q0
LOD	I0
ORN	I1
OUT	Q1

Timing Chart



When either input I0 or I1 is on, output Q0 is on. When both inputs I0 and I1 are off, output Q0 is off.
When either input I0 is on or input I1 is off, output Q1 is on. When input I0 is off and input I1 is on, output Q1 is off.

Valid Devices

Instruction	I	Q	M	T	C	R	D
	0-35	0-21					
OR	40-75	40-61	0-1277	0-199	0-199	0-127	0.0-1999.15
ORN	80-115	80-101	8000-8177				8000.0-8199.15
	120-155	120-141					

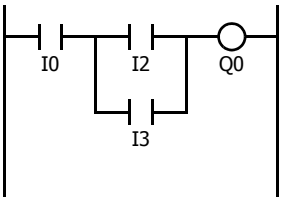
The valid device range depends on the SmartAXIS type. For details, see "Device Addresses" on page 3-1.
Data registers can be used as bit devices with the data register number and the bit position separated by a period.

AND LOD (Load)

The AND LOD instruction is used to connect, in a series, two or more circuits starting with the LOD instruction. The AND LOD instruction is the equivalent of a "node" on a ladder diagram.

When using WindLDR, the user does not need to program the AND LOD instruction. The circuit in the ladder diagram shown below is converted into AND LOD when the ladder diagram is compiled.

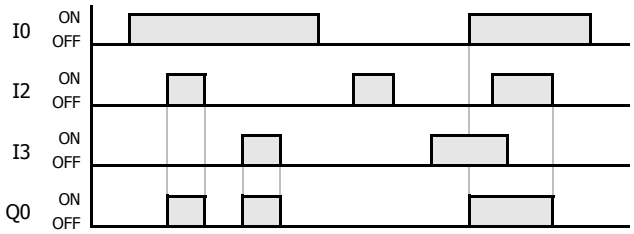
Ladder Diagram



Program List

Instruction	Data
LOD	I0
LOD	I2
OR	I3
ANDLOD	
OUT	Q0

Timing Chart



When input I0 is on and either input I2 or I3 is on, output Q0 is on.

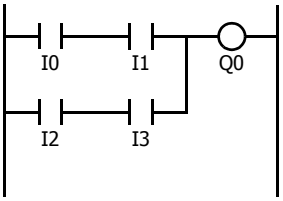
When input I0 is off or both inputs I2 and I3 are off, output Q0 is off.

OR LOD (Load)

The OR LOD instruction is used to connect, in parallel, two or more circuits starting with the LOD instruction. The OR LOD instruction is the equivalent of a "node" on a ladder diagram.

When using WindLDR, the user does not need to program the OR LOD instruction. The circuit in the ladder diagram shown below is converted into OR LOD when the ladder diagram is compiled.

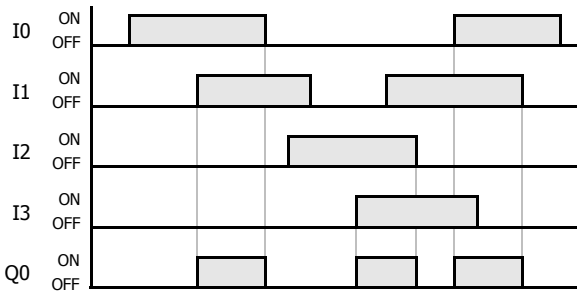
Ladder Diagram



Program List

Instruction	Data
LOD	I0
AND	I1
LOD	I2
AND	I3
ORLOD	
OUT	Q0

Timing Chart



When both inputs I0 and I1 are on or both inputs I2 and I3 are on, output Q0 is on.

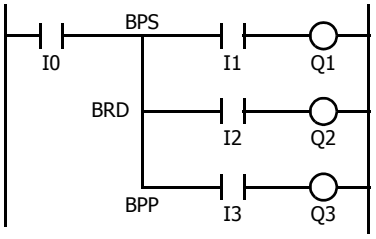
When either input I0 or I1 is off and either input I2 or I3 is off, output Q0 is off.

BPS (Bit Push), BRD (Bit Read), and BPP (Bit Pop)

The BPS (bit push) instruction is used to temporarily save the result of bit logical operation.
The BRD (bit read) instruction is used to read the result of the temporarily saved bit logical operation.
The BPP (bit pop) instruction is used to restore the result of the temporarily saved bit logical operation.

When using WindLDR, the user does not need to program the BPS, BRD, and BPP instructions. The circuit in the ladder diagram shown below is converted into BPS, BRD, and BPP when the ladder diagram is compiled.

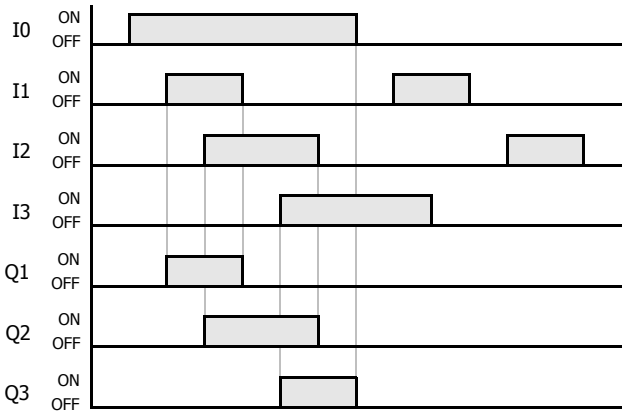
Ladder Diagram



Program List

Instruction	Data
LOD	I0
BPS	
AND	I1
OUT	Q1
BRD	
AND	I2
OUT	Q2
BPP	
AND	I3
OUT	Q3

Timing Chart



When both inputs I0 and I1 are on, output Q1 is turned on.

When both inputs I0 and I2 are on, output Q2 is turned on.

When both inputs I0 and I3 are on, output Q3 is turned on.

TML, TIM, TMH, and TMS (Timer)

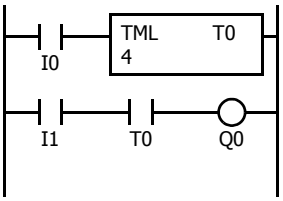
Four types of on-delay timers are available; 1-sec timer TML, 100-ms timer TIM, 10-ms timer TMH, and 1-ms timer TMS. A total of 100 (FT1A-12) or 200 (other SmartAXIS) on- and off-delay timers can be programmed in a user program. Each timer must be allocated to a unique number T0 through T199.

Timer	Device Address	Range	Increments	Preset Value	
TML (1-sec timer)	T0 to T199	0 to 65535 sec	1 sec	Constant:	0 to 65535
TIM (100-ms timer)	T0 to T199	0 to 6553.5 sec	100 ms	Data registers:	D0 to D1999
TMH (10-ms timer)	T0 to T199	0 to 655.35 sec	10 ms		
TMS (1-ms timer)	T0 to T199	0 to 65.535 sec	1 ms		

The valid device range depends on the SmartAXIS type. For details, see "Device Addresses" on page 3-1.
The preset value can be 0 through 65535 and designated using a decimal constant or data register.

TML (1-sec Timer)

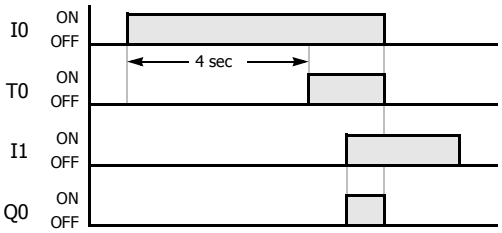
Ladder Diagram (TML)



Program List

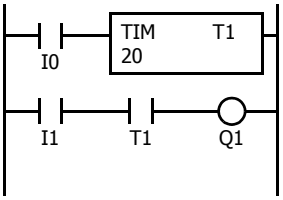
Instruction	Data
LOD	I0
TML	T0
	4
LOD	I1
AND	T0
OUT	Q0

Timing Chart



TIM (100-ms Timer)

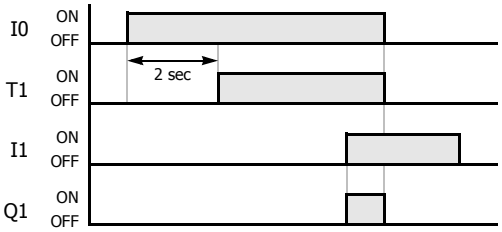
Ladder Diagram (TIM)



Program List

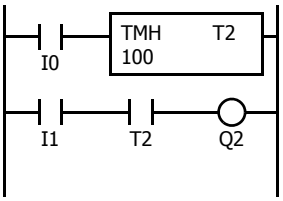
Instruction	Data
LOD	I0
TIM	T1
	20
LOD	I1
AND	T1
OUT	Q1

Timing Chart



TMH (10-ms Timer)

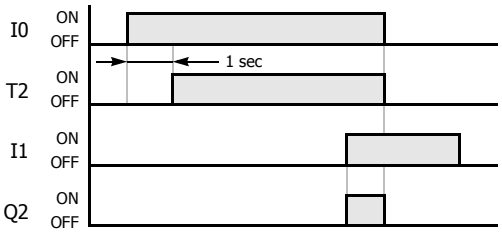
Ladder Diagram (TMH)



Program List

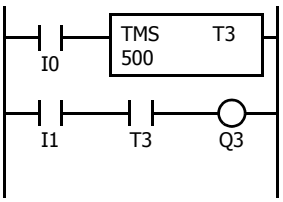
Instruction	Data
LOD	I0
TMH	T2
	100
LOD	I1
AND	T2
OUT	Q2

Timing Chart



TMS (1-ms Timer)

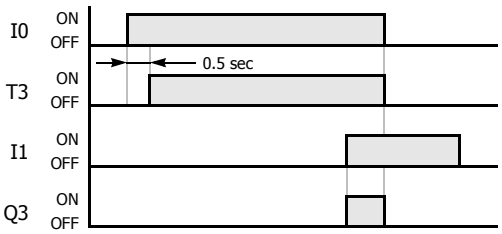
Ladder Diagram (TMS)



Program List

Instruction	Data
LOD	I0
TMS	T3
	500
LOD	I1
AND	T3
OUT	Q3

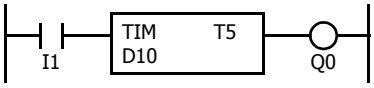
Timing Chart



Timer Circuit

The preset value 0 through 65535 can be designated using a data register D0 through D999 or D1000 through D1999; then the data of the data register becomes the preset value. Directly after the TML, TIM, TMH, or TMS instruction, the OUT, OUTN, SET, RST, TML, TIM, TMH, TMS, TMLO, TIMO, TMHO, or TMSO instruction can be programmed.

Ladder Diagram



Program List

Instruction	Data
LOD	I1
TIM	T5
	D10
OUT	Q0

Note: For restrictions on ladder programming of timer instructions, see "Restriction on Ladder Programming" on page 5-31.

- Countdown from the preset value is initiated when the operation result directly before the timer input is on.
- The timer output turns on when the current value (timed value) reaches 0.
- The current value returns to the preset value when the timer input is off.
- Timer preset and current values can be changed using WindLDR without downloading the entire program to the CPU again. From the WindLDR menu bar, select **Online** > **Monitor > Monitor**, then **Online** > **Custom** > **New Custom Monitor**.
- If a timer preset value is changed during countdown, the timer remains unchanged for that cycle. The change will be reflected in the next time cycle.
- If a timer preset value is changed to 0, then the timer stops operation, and the timer output is turned on immediately.
- If a current value is changed during countdown, the change becomes effective immediately.
- For data movement when changing, confirming, and clearing preset values, see "Changing, Confirming, and Clearing Preset Values for Timers and Counters" on page 5-17. Preset values can also be changed and confirmed using the LCD screen and pushbuttons.
- WindLDR ladder diagrams show TP (timer preset value) and TC (timer current value) in advanced instruction devices.
- The timer instructions (TML, TIM, TMH, TMS) and off-delay timer instructions (TMLO, TIMO, TMHO, TMSO) cannot be used in an interrupt program.
- If used, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For details about the user program execution errors, see "User Program Execution Errors" on page 4-13.

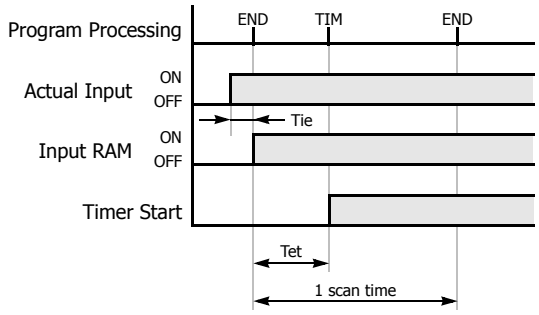
Timer Accuracy

Timer accuracy due to software configuration depends on three factors: timer input error, timer counting error, and timeout output error. These errors are not constant but vary with the user program and other causes.

Timer Input Error

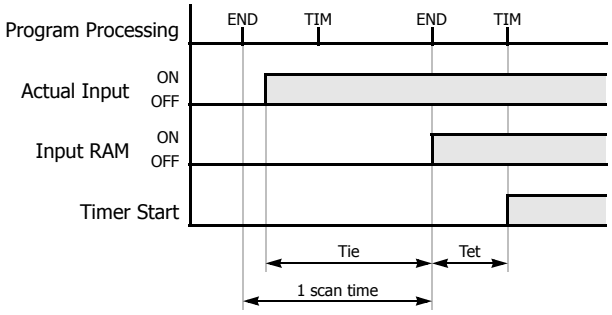
The input status is read at the END processing and stored to the input RAM. So, an error occurs depending on the timing when the timer input turns on in a scan cycle. The same error occurs on normal input and catch input. The timer input error shown below does not include input delay caused by the hardware.

Minimum Error



When the input turns on immediately before END processing, Tie is almost 0. Then the timer input error is only Tet (behind error) and is at its minimum.

Maximum Error



When the input turns on immediately after END processing, Tie is almost equal to one scan time. Then the timer input error is Tie + Tet = one scan time + Tet (behind error) and is at its maximum.

Tie: Time from input turning on to END processing
Tet: Time from END processing to the timer instruction execution

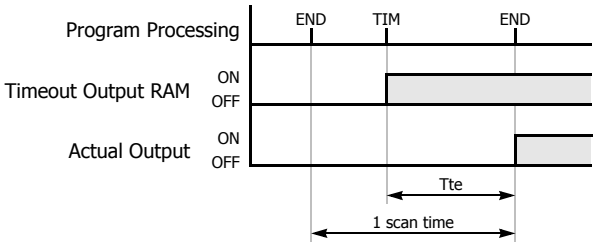
Timer Counting Error

Every timer instruction operation is individually based on asynchronous 16-bit reference timers. Therefore, an error can occur depending on the status of the asynchronous 16-bit timer when the timer instruction is executed. Use of a TMS (1-ms timer) is recommended to reduce advance errors.

Error		TML (1-sec timer)	TIM (100-ms timer)	TMH (10-ms timer)	TMS (1-ms timer)
Maximum	Advance error	1000 ms	100 ms	10 ms	1 ms
	Behind error	1 scan time	1 scan time	1 scan time	1 scan time

Timeout Output Error

The output RAM status is set to the actual output when the END instruction is processed. When timeout output turns from off to on, an error occurs depending on the position where the timer instruction is programmed in the user program. The timeout output error shown below does not include output delay caused by the hardware.



Timeout output error is equal to Tte (behind error) and can be between 0 and one scan time.

0 < Tte < 1 scan time

Tte: Time from the timer instruction execution to the END processing

Error Maximum and Minimum

Error		Timer Input Error	Timer Counting Error	Timeout Output Error	Total Error
Minimum	Advance error	0 (Note)	0	0 (Note)	0
	Behind error	Tet	0	Tte	0
Maximum	Advance error	0 (Note)	Increment	0 (Note)	Increment – (Tet + Tte)
	Behind error	1 scan time + Tet (1 scan time)	1 scan time	Tte (1 scan time)	2 scan times + (Tet + Tte)

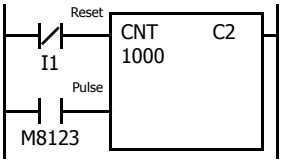
Notes: Advance error does not occur at the timer input and timeout output.
Tet + Tte = 1 scan time
Increment is 1 sec (TML), 100 ms (TIM), 10 ms (TMH), or 1 ms (TMS).
The maximum advance error is: Increment – 1 scan time
The maximum behind error is: 3 scan times

The timer input error and timeout output error shown above do not include the input response time (behind error) and output response time (behind error) caused by hardware.

Power Failure Memory Protection

Timers TML, TIM, TMH, and TMS do not have power failure protection. To provide a timer with this protection use a counter instruction and special internal relay M8121 (1-sec clock), M8122 (100-ms clock), or M8123 (10-ms clock).

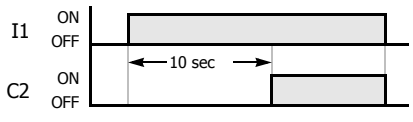
Ladder Diagram (10-sec Timer)



Program List

Instruction	Data
LODN	I1
LOD	M8123
CNT	C2
	1000

Timing Chart



Note: Designate counter C2 used in this program as a keep type counter. See Chapter 5 "Special Functions" - "Keep Designation for Internal Relays, Shift Registers, Counters, and Data Registers" in the SmartAXIS Pro/Lite User's Manual.

TMLO, TIMO, TMHO, and TMSO (Off-Delay Timer)

Four types of on-delay off-delay timers are available; 1-sec off-delay timer TMLO, 100-ms off-delay timer TIMO, 10-ms off-delay timer TMHO, and 1-ms off-delay timer TMSO. A total of 100 (FT1A-12) or 200 (other SmartAXIS) on- and off-delay timers can be programmed in a user program. Each timer must be allocated to a unique number T0 through T199.

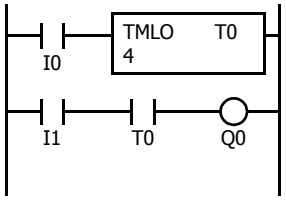
Timer	Device Address	Range	Increments	Preset Value	
TMLO (1-sec off-delay timer)	T0 to T199	0 to 65535 sec	1 sec	Constant:	0 to 65535
TIMO (100-ms off-delay timer)	T0 to T199	0 to 6553.5 sec	100 ms	Data registers:	D0 to D1999
TMHO (10-ms off-delay timer)	T0 to T199	0 to 655.35 sec	10 ms		
TMSO (1-ms off-delay timer)	T0 to T199	0 to 65.535 sec	1 ms		

The valid device range depends on the SmartAXIS type. For details, see "Device Addresses" on page 3-1.

The preset value can be 0 through 65535 and designated using a constant or a data register.

TMLO (1-sec Off-delay Timer)

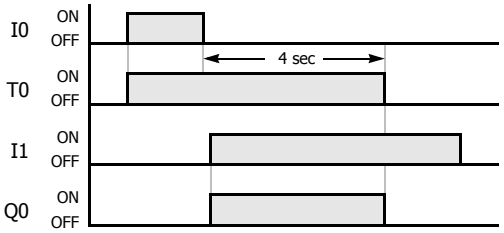
Ladder Diagram (TMLO)



Program List

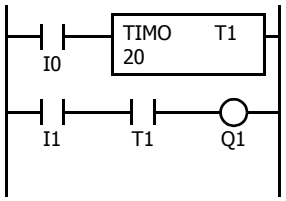
Instruction	Data
LOD	I0
TMLO	T0
	4
LOD	I1
AND	T0
OUT	Q0

Timing Chart



TIMO (100-ms Off-delay Timer)

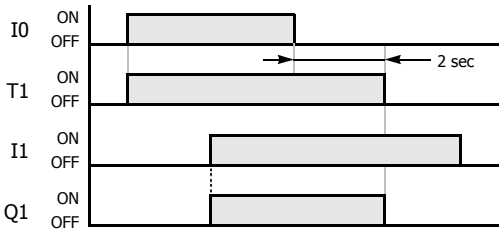
Ladder Diagram (TIMO)



Program List

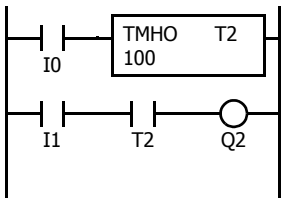
Instruction	Data
LOD	I0
TIMO	T1
	20
LOD	I1
AND	T1
OUT	Q1

Timing Chart



TMHO (10-ms Off-delay Timer)

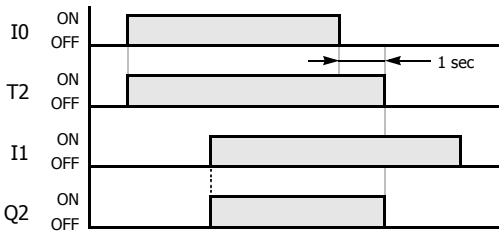
Ladder Diagram (TMHO)



Program List

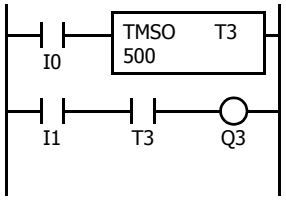
Instruction	Data
LOD	I0
TMHO	T2
	100
LOD	I1
AND	T2
OUT	Q2

Timing Chart



TMSO (1-ms Off-delay Timer)

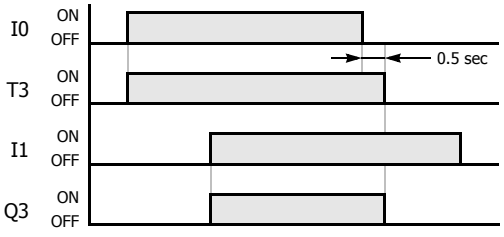
Ladder Diagram (TMSO)



Program List

Instruction	Data
LOD	I0
TMSO	T3
	500
LOD	I1
AND	T3
OUT	Q3

Timing Chart



CNT, CDP, and CUD (Counter)

Three types of counters are available; adding (up) counter CNT, dual-pulse reversible counter CDP, and up/down selection reversible counter CUD. A total of 100 (FT1A-12) or 200 (other SmartAXIS) counters can be programmed in a user program. Each counter must be allocated to a unique number C0 through C199.

Counter	Device Address	Preset Value	
CNT (adding counter)	C0 to C199	Constant:	0 to 65535
CDP (dual-pulse reversible counter)	C0 to C199	Data registers:	D0 to D1999
CUD (up/down selection reversible counter)	C0 to C199		

The valid device range depends on the SmartAXIS type. For details, see "Device Addresses" on page 3-1.

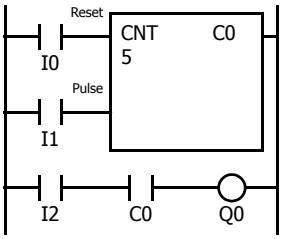
The preset value can be 0 through 65535 and designated using a decimal constant or data register.

CNT (Adding Counter)

When counter instructions are programmed, two addresses are required. The circuit for an adding (UP) counter must be programmed in the following order: reset input, pulse input, the CNT instruction, and a counter number C0 through C199, followed by a counter preset value from 0 to 65535.

The preset value can be designated using a decimal constant or a data register. When a data register is used, the data of the data register becomes the preset value.

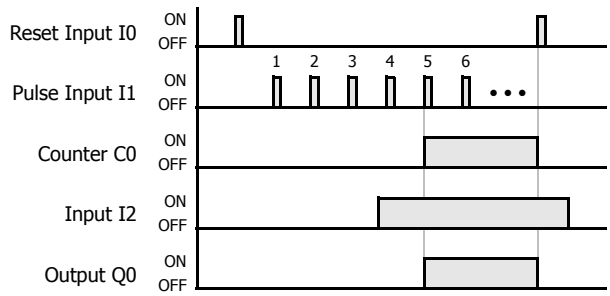
Ladder Diagram



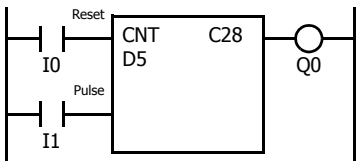
Program List

Instruction	Data
LOD	I0
LOD	I1
CNT	C0
	5
LOD	I2
AND	C0
OUT	Q0

Timing Chart



- The preset value 0 through 65535 can be designated using a data register D0 through D1999; then the data of the data register becomes the preset value.
- Directly after the CNT instruction, the OUT, OUTN, SET, RST, TML, TIM, TMH, or TMS instruction can be programmed.

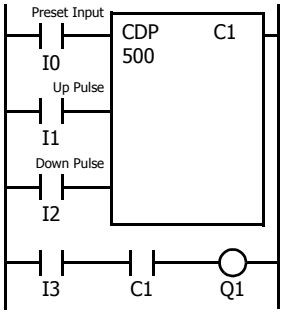


- A single counter number cannot be programmed more than once.
- While the reset input is off, the counter counts the leading edges of pulse inputs and compares them with the preset value.
- When the current value reaches the preset value, the counter turns output on. The output stays on until the reset input is turned on.
- When the reset input changes from off to on, the current value is reset.
- When the reset input is on, all pulse inputs are ignored.
- The reset input must be turned off before counting may begin.
- When power is off, the counter's current value is held, and can also be designated as "clear" type counters using Function Area Settings (see Chapter 5 "Special Functions" - "Keep Designation for Internal Relays, Shift Registers, Counters, and Data Registers" in the SmartAXIS Pro/Lite User's Manual.).
- Counter preset and current values can be changed using WindLDR without downloading the entire program to the CPU again. From the WindLDR menu bar, select **Online** > **Monitor** > **Monitor**, then **Online** > **Custom** > **New Custom Monitor**. Change the current value while the counter reset input is off.
- When the preset or current value is changed during counter operation, the change becomes effective immediately.
- When power is off, the preset values that were changed are cleared and the original preset values are loaded.
- For data movement when changing, confirming, and clearing preset values, see "Changing, Confirming, and Clearing Preset Values for Timers and Counters" on page 5-17. Preset values can also be changed and confirmed using the LCD screen and pushbuttons.
- WindLDR ladder diagrams show CP (counter preset value) and CC (counter current value) in advanced instruction devices.
- The CNT instruction cannot be used in an interrupt program. If used, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For details about the user program execution errors, see "User Program Execution Errors" on page 4-13.

CDP (Dual-Pulse Reversible Counter)

The dual-pulse reversible counter CDP has up and down pulse inputs, so the three inputs are required. The circuit for a dual-pulse reversible counter must be programmed in the following order: preset input, up-pulse input, down-pulse input, the CDP instruction, and a counter number C0 through C199, followed by a counter preset value from 0 to 65535.
The preset value can be designated using a decimal constant or a data register. When a data register is used, the data of the data register becomes the preset value.

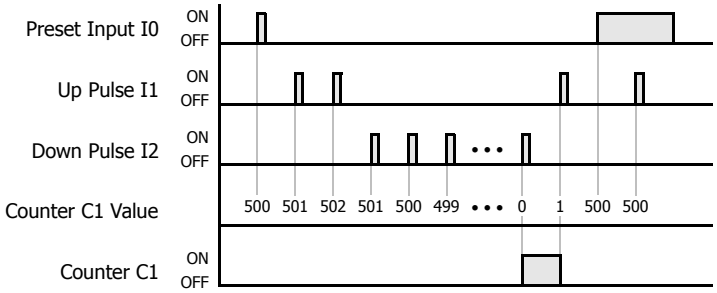
Ladder Diagram



Program List

Instruction	Data
LOD	I0
LOD	I1
LOD	I2
CDP	C1
	500
LOD	I3
AND	C1
OUT	Q1

Timing Chart



- A single counter number cannot be programmed more than once.
- The preset input must be turned on initially so that the current value returns to the preset value.
- The preset input must be turned off before counting may begin.
- When the up pulse and down pulses are on simultaneously, no pulse is counted.
- The counter output is on only when the current value is 0.
- After the current value reaches 0 (counting down), it changes to 65535 on the next count down.
- After the current value reaches 65535 (counting up), it changes to 0 on the next up count.
- When power is off, the counter's current value is held, and can also be designated as "clear" type counters using the Function Area Settings (see Chapter 5 "Special Functions" - "Keep Designation for Internal Relays, Shift Registers, Counters, and Data Registers" in the SmartAXIS Pro/Lite User's Manual.).
- Counter preset and current values can be changed using WindLDR without downloading the entire program to the CPU again. From the WindLDR menu bar, select **Online** > **Monitor** > **Monitor**, then **Online** > **Custom** > **New Custom Monitor**. Change the current value while the counter preset input is off.
- When the preset or current value is changed during counter operation, the change becomes effective immediately.
- When power is off, the changed preset values are cleared and the original preset values are loaded.
- For data movement when changing, confirming, and clearing preset values, see "Changing, Confirming, and Clearing Preset Values for Timers and Counters" on page 5-17. Preset values can also be changed and confirmed using the LCD screen and pushbuttons.
- WindLDR ladder diagrams show CP (counter preset value) and CC (counter current value) in advanced instruction devices. The CDP instruction cannot be used in an interrupt program.
- If used, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For details about the user program execution errors, see "User Program Execution Errors" on page 4-13.

Note: For restrictions on ladder programming of counter instructions, see "Restriction on Ladder Programming" on page 5-31.

Counter Operation after Count out

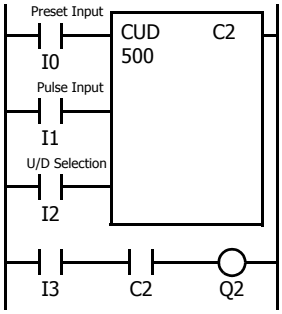
Condition	Counter Output
When the counter has counted out, either the current value or preset value is changed.	The counter maintains the counted out status.
Before the counter has counted out, the current value is changed to a larger value than the preset.	The counter output is turned on.
The preset value is changed to 0.	The counter output is turned on without regard to the current value.
When the reset input is on, the preset value is changed to 0.	The counter output is not turned on.

CUD (Up/Down Selection Reversible Counter)

The up/down selection reversible counter CUD has a selection input to switch the up/down gate, so the three inputs are required. The circuit for an up/down selection reversible counter must be programmed in the following order: preset input, pulse input, up/down selection input, the CUD instruction, and a counter number C0 through C199, followed by a counter preset value from 0 to 65535.

The preset value can be designated using a decimal constant or a data register. When a data register is used, the data of the data register becomes the preset value.

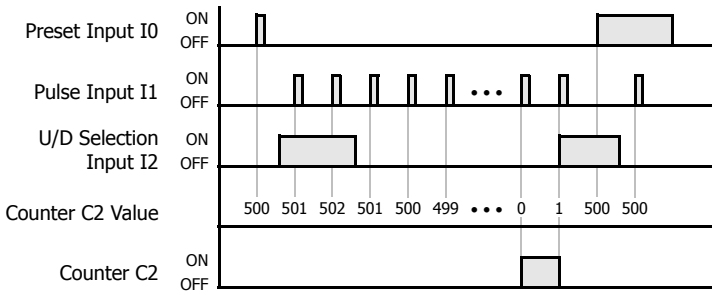
Ladder Diagram



Program List

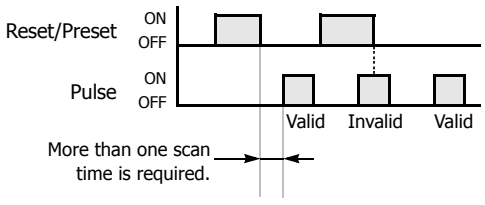
Instruction	Data
LOD	I0
LOD	I1
LOD	I2
CUD	C2
	500
LOD	I3
AND	C2
OUT	Q2

Timing Chart



Valid Pulse Inputs

The reset or preset input has priority over the pulse input. One scan after the reset or preset input has changed from on to off, and the counter starts counting the pulse inputs as they change from off to on.



- A single counter number cannot be programmed more than once.
- The preset input must be turned on initially so that the current value returns to the preset value.
- The preset input must be turned off before counting may begin.
- The up mode is selected when the up/down selection input is on.
- The down mode is selected when the up/down selection input is off.
- The counter output is on only when the current value is 0.
- After the current value reaches 0 (counting down), it changes to 65535 on the next count down.
- After the current value reaches 65535 (counting up), it changes to 0 on the next count up.
- When power is off, the counter's current value is held, and can also be designated as "clear" type counters using the Function Area Settings (see Chapter 5 "Special Functions" - "Keep Designation for Internal Relays, Shift Registers, Counters, and Data Registers" in the SmartAXIS Pro/Lite User's Manual.).
- Counter preset and current values can be changed using WindLDR without downloading the entire program to the CPU again. From the WindLDR menu bar, select **Online** > **Monitor** > **Monitor**, then **Online** > **Custom** > **New Custom Monitor**. Change the current value while the counter preset input is off.
- When the preset or current value is changed during counter operation, the change becomes effective immediately.
- When power is off, the changed preset values are cleared and the original preset values are loaded.
- For data movement when changing, confirming, and clearing preset values, see "Changing, Confirming, and Clearing Preset Values for Timers and Counters" on page 5-17. Preset values can also be changed and confirmed using the LCD screen and pushbuttons.
- WindLDR ladder diagrams show CP (counter preset value) and CC (counter current value) in advanced instruction devices. The CUD instruction cannot be used in an interrupt program.
- If used, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For details about the user program execution errors, see "User Program Execution Errors" on page 4-13.

Note: For restrictions on ladder programming of counter instructions, see "Restriction on Ladder Programming" on page 5-31.

CNTD, CDPD, and CUDD (Double-Word Counter)

Three types of double-word counters are available; adding (up) counter CNTD, dual-pulse reversible counter CDPD, and up/down selection reversible counter CUDD. A total of 50 (FT1A-12) or 100 (other SmartAXIS) double-word counters can be programmed in a user program. Each double-word counter uses 2 consecutive devices starting with the allocated device, which can be C0 through C198. Once used in a user program, counters cannot be used in any other counter instructions.

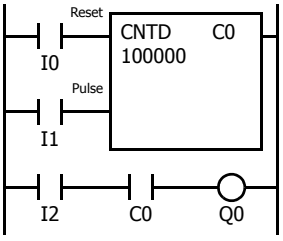
Counter	Device Address	Preset Value	
CNTD (double-word adding counter)	C0 to C198	Constant:	0 to 4,294,967,295
CDPD (double-word dual-pulse reversible counter)	C0 to C198	Data registers:	D0 to D998 D1000 to D1998
CUDD (double-word up/down selection reversible counter)	C0 to C198		

The valid device range depends on the SmartAXIS type. For details, see "Device Addresses" on page 3-1.
The preset value can be 0 through 4,294,967,295 and designated using a constant or a data register. If a data register is designated as the preset value, two consecutive data registers are used.

CNTD (Double-Word Adding Counter)

When double-word adding counter instructions are programmed, two addresses are required. The circuit for a double-word adding (UP) counter must be programmed in the following order: reset input, pulse input, the CNTD instruction, and a counter number C0 through C198, followed by a counter preset value from 0 to 4,294,967,295.
The preset value can be designated using a constant or a data register. When a data register is used, the double-word data of two consecutive data registers becomes the preset value. For 32-bit data storage setting, see Chapter 5 "Special Functions" - "32-bit Data Storage Setting" in the SmartAXIS Pro/Lite User's Manual.

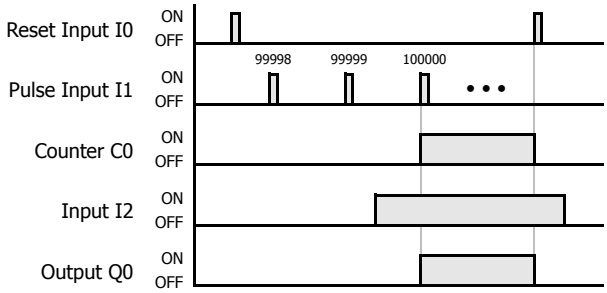
Ladder Diagram



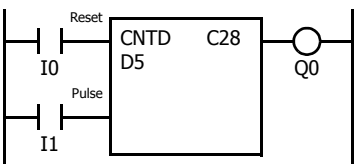
Program List

Instruction	Data
LOD	I0
LOD	I1
CNTD	C0
	100000
LOD	I2
AND	C0
OUT	Q0

Timing Chart



- The preset value 0 through 4,294,967,295 can be designated using a data register D0 through D1998; then the data of the data registers becomes the preset value.
- Directly after the CNTD instruction, the OUT, OUTN, SET, RST, TML, TIM, TMH, TMS, TMLO, TIMO, TMHO, or TMSO instruction can be programmed.



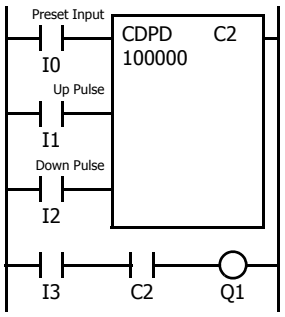
- Double-word counter instructions use two consecutive counters, and counters cannot be used more than once in a user program.
- While the reset input is off, the counter counts the leading edges of pulse inputs and compares them with the preset value.
- When the current value reaches the preset value, the counter turns output on. The output stays on until the reset input is turned on.
- When the reset input changes from off to on, the current value is reset.
- When the reset input is on, all pulse inputs are ignored.
- The reset input must be turned off before counting may begin.
- When power is off, the counter's current value is held, and can also be designated as "clear" type counters using Function Area Settings (see Chapter 5 "Special Functions" - "Keep Designation for Internal Relays, Shift Registers, Counters, and Data Registers" in the SmartAXIS Pro/Lite User's Manual.).
- Counter preset and current values can be changed using WindLDR without downloading the entire program to the CPU again. From the WindLDR menu bar, select **Online** > **Monitor** > **Monitor**, then **Online** > **Custom** > **New Custom Monitor**. To change a counter preset value, select DEC(D) in the pull-down list box.
- When the preset or current value is changed during counter operation, the change becomes effective immediately.
- When power is off, the changed preset values are cleared and the original preset values are loaded.
- For data movement when changing, confirming, and clearing preset values, see "Changing, Confirming, and Clearing Preset Values for Timers and Counters" on page 5-17.
- WindLDR ladder diagrams show CP (counter preset value) and CC (counter current value) in advanced instruction devices.
- The CNTD instruction cannot be used in an interrupt program.
- If used, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For details about the user program execution errors, see "User Program Execution Errors" on page 4-13.

CDPD (Double-Word Dual-Pulse Reversible Counter)

The double-word dual-pulse reversible counter CDPD has up and down pulse inputs, so the three inputs are required. The circuit for a double-word dual-pulse reversible counter must be programmed in the following order: preset input, up-pulse input, down-pulse input, the CDPD instruction, and a counter number C0 through C198, followed by a counter preset value from 0 to 4,294,967,295.

The preset value can be designated using a constant or a data register. When a data register is used, the double-word data of two consecutive data registers becomes the preset value. For 32-bit data storage setting, see Chapter 5 "Special Functions" - "32-bit Data Storage Setting" in the SmartAXIS Pro/Lite User's Manual.

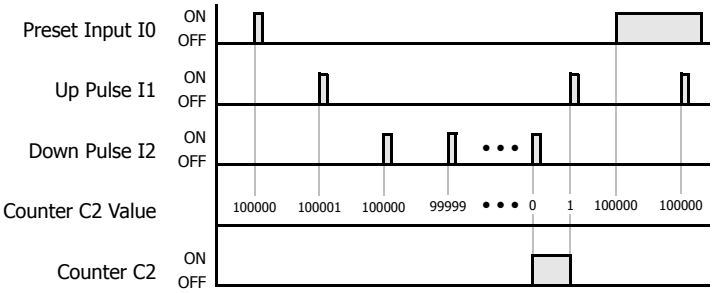
Ladder Diagram



Program List

Instruction	Data
LOD	I0
LOD	I1
LOD	I2
CDPD	C2
	100000
LOD	I3
AND	C2
OUT	Q1

Timing Chart



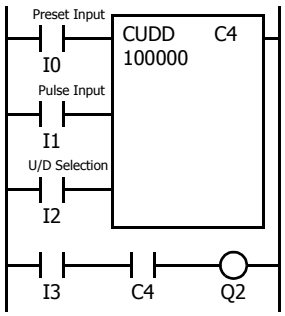
- Double-word counter instructions use two consecutive counters, and counters cannot be used more than once in a user program.
- The preset input must be turned on initially so that the current value returns to the preset value.
- The preset input must be turned off before counting may begin.
- When the up and down pulses are on simultaneously, no pulse is counted.
- The counter output is on only when the current value is 0.
- After the current value reaches 0 (counting down), it changes to 4,294,967,295 on the next count down.
- After the current value reaches 4,294,967,295 (counting up), it changes to 0 on the next count up.
- When power is off, the counter's current value is held, and can also be designated as "clear" type counters using the Function Area Settings (see Chapter 5 "Special Functions" - "Keep Designation for Internal Relays, Shift Registers, Counters, and Data Registers" in the SmartAXIS Pro/Lite User's Manual.).
- Counter preset and current values can be changed using WindLDR without downloading the entire program to the CPU again. From the WindLDR menu bar, select **Online** > **Monitor** > **Monitor**, then **Online** > **Custom** > **New Custom Monitor**. To change a counter preset value, select DEC(D) in the pull-down list box.
- When the preset or current value is changed during counter operation, the change becomes effective immediately.
- When power is off, the changed preset values are cleared and the original preset values are loaded.
- For data movement when changing, confirming, and clearing preset values, see "Changing, Confirming, and Clearing Preset Values for Timers and Counters" on page 5-17.
- WindLDR ladder diagrams show CP (counter preset value) and CC (counter current value) in advanced instruction devices. The CNPD instruction cannot be used in an interrupt program.
- If used, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For details about the user program execution errors, see "User Program Execution Errors" on page 4-13.

CUDD (Double-Word Up/Down Selection Reversible Counter)

The double-word up/down selection reversible counter CUDD has a selection input to switch the up/down gate, so the three inputs are required. The circuit for a double-word up/down selection reversible counter must be programmed in the following order: preset input, pulse input, up/down selection input, the CUDD instruction, and a counter number C0 through C198, followed by a counter preset value from 0 to 4,294,967,295.

The preset value can be designated using a constant or a data register. When a data register is used, the double-word data of two consecutive data registers becomes the preset value. For 32-bit data storage setting, see Chapter 5 "Special Functions" - "32-bit Data Storage Setting" in the SmartAXIS Pro/Lite User's Manual.

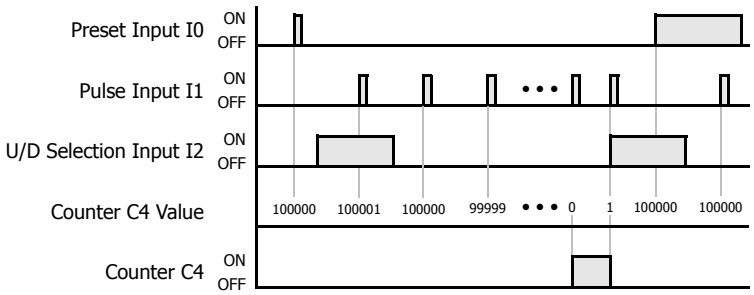
Ladder Diagram



Program List

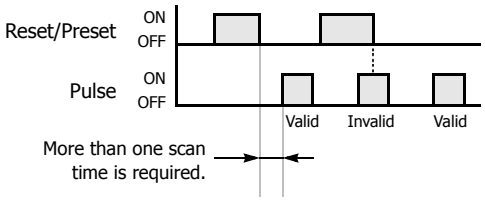
Instruction	Data
LOD	I0
LOD	I1
LOD	I2
CUDD	C4
	100000
LOD	I3
AND	C4
OUT	Q2

Timing Chart



Valid Pulse Inputs

The reset or preset input has priority over the pulse input. One scan after the reset or preset input has changed from on to off, the counter starts counting the pulse inputs as they change from off to on.



- Double-word counter instructions use two consecutive counters, and counters cannot be used more than once in a user program.
- The preset input must be turned on initially so that the current value returns to the preset value.
- The preset input must be turned off before counting may begin.
- The up mode is selected when the up/down selection input is on.
- The down mode is selected when the up/down selection input is off.
- The counter output is on only when the current value is 0.
- After the current value reaches 0 (counting down), it changes to 4,294,967,295 on the next count down.
- After the current value reaches 4,294,967,295 (counting up), it changes to 0 on the next count up.
- When power is off, the counter's current value is held, and can also be designated as "clear" type counters using the Function Area Settings (see Chapter 5 "Special Functions" - "Keep Designation for Internal Relays, Shift Registers, Counters, and Data Registers" in the SmartAXIS Pro/Lite User's Manual.).
- Counter preset and current values can be changed using WindLDR without downloading the entire program to the CPU again. From the WindLDR menu bar, select **Online** > **Monitor** > **Monitor**, then **Online** > **Custom** > **New Custom Monitor**. To change a counter preset value, select DEC(D) in the pull-down list box.
- When the preset or current value is changed during counter operation, the change becomes effective immediately.
- When power is off, the changed preset values are cleared and the original preset values are loaded.
- For data movement when changing, confirming, and clearing preset values, see "Changing, Confirming, and Clearing Preset Values for Timers and Counters" on page 5-17.
- WindLDR ladder diagrams show CP (counter preset value) and CC (counter current value) in advanced instruction devices. The CUDD instruction cannot be used in an interrupt program.
- If used, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For details about the user program execution errors, see "User Program Execution Errors" on page 4-13.

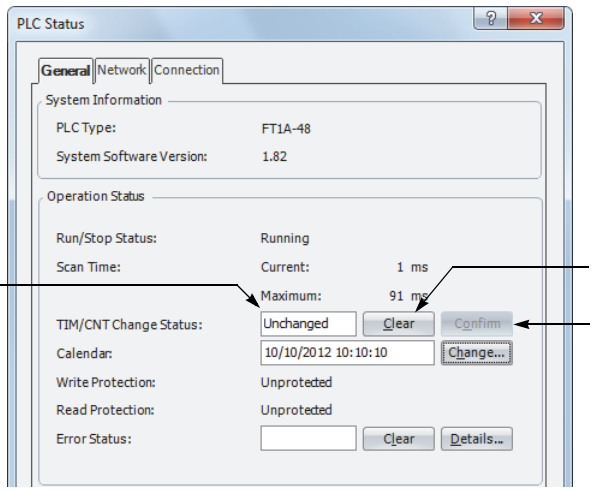
Changing, Confirming, and Clearing Preset Values for Timers and Counters

Preset values for timers and counters can be changed by selecting **Online** > **Monitor** > **Monitor**, followed by **Online** > **Custom** > **New Custom Monitor** on WindLDR for transferring a new value to the SmartAXIS RAM as described on preceding pages. After changing the preset values temporarily, the changes can be written to the user program in the SmartAXIS ROM or cleared from the RAM.

When the power is off, the temporarily changed preset values in the RAM are cleared and the original preset values are loaded. Confirm the changed preset values to store them in the ROM. The timer/counter preset values can be confirmed only when SmartAXIS is stopped.

To access the PLC Status dialog box from the WindLDR menu bar, select **Online** > **Monitor** > **Monitor**, then **Online** > **Status**.

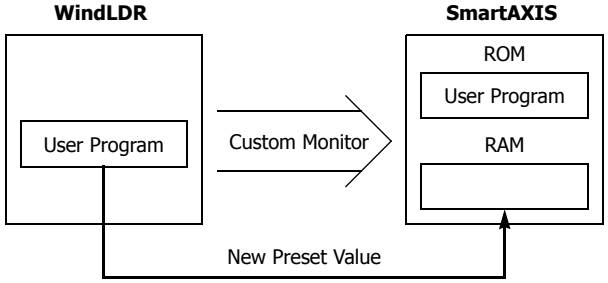
After pressing the Clear or Confirm button, the display changes to "Unchanged."



Data movement when changing a timer/counter preset value

When changing a timer/counter preset value using Custom Monitor on WindLDR, the new preset value is written to the SmartAXIS RAM. The user program and preset values in the ROM are not changed.

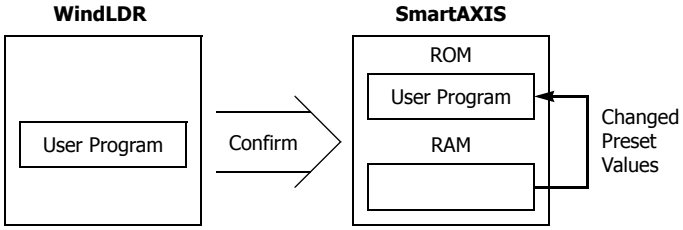
Note: The LCD screen and pushbuttons can also be used to change preset values and confirm changed preset values.



Data movement when confirming changed preset values

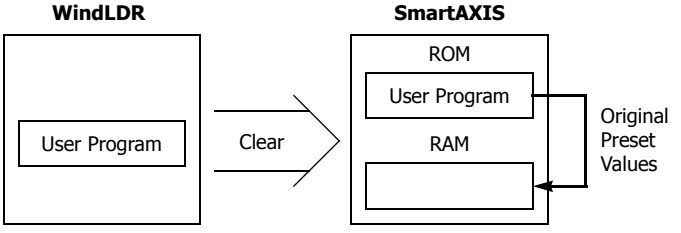
When the Confirm button is pressed before pressing the Clear button, the changed timer/counter preset values in the SmartAXIS RAM are written to the ROM.

When uploading the user program after confirming, the user program with changed preset values is uploaded from the SmartAXIS ROM to WindLDR.



Data movement when clearing changed preset values to restore original values

Changing preset values for timers and counters in the SmartAXIS RAM does not automatically update preset values in the user memory, ROM. This is useful for restoring original preset values. When the Clear button is pressed before pressing the Confirm button, the changed timer/counter preset values are cleared from the RAM and the original preset values are loaded from the ROM to the RAM.



CC= and CC>= (Counter Comparison)

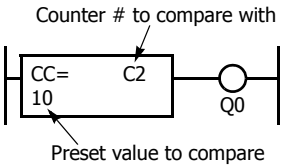
The CC= instruction is an equivalent comparison instruction for counter current values. This instruction will constantly compare current values to the value that has been programmed in. When the counter value equals the given value, the desired output will be initiated.

The CC>= instruction is an equal to or greater than comparison instruction for counter current values. This instruction will constantly compare current values to the value that has been programmed in. When the counter value is equal to or greater than the given value, the desired output will be initiated.

When a counter comparison instruction is programmed, two addresses are required. The circuit for a counter comparison instruction must be programmed in the following order: the CC= or CC>= instruction; a counter number C0 through C199, followed by a preset value to compare from 0 to 65535.

The preset value can be designated using a decimal constant or a data register D0 through D1999. When a data register is used, the data of the data register becomes the preset value.

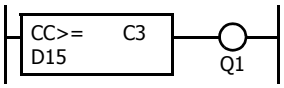
Ladder Diagram (CC=)



Program List

Instruction	Data
CC=	C2
	10
OUT	Q0

Ladder Diagram (CC>=)

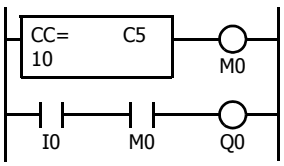


Program List

Instruction	Data
CC>=	C3
	D15
OUT	Q1

- The CC= and CC>= instructions can be used repeatedly for different preset values.
- The comparison instructions only compare the current value. The status of the counter does not affect this function.
- The comparison instructions also serve as an implicit LOD instruction.
- The comparison instructions can be used with internal relays, which are ANDed or ORed at a separate program address.
- Like the LOD instruction, the comparison instructions can be followed by the AND and OR instructions.

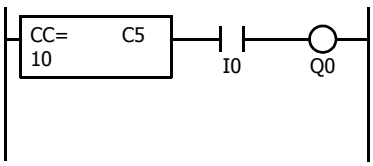
Ladder Diagram



Program List

Instruction	Data
CC=	C5
	10
OUT	M0
LOD	I0
AND	M0
OUT	Q0

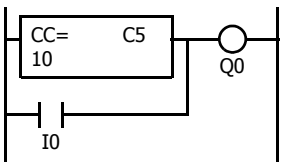
Ladder Diagram



Program List

Instruction	Data
CC=	C5
	10
AND	I0
OUT	Q0

Ladder Diagram

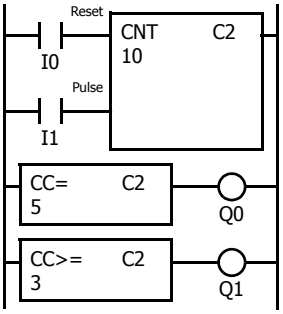


Program List

Instruction	Data
CC=	C5
	10
OR	I0
OUT	Q0

Examples: CC= and CC>= (Counter Comparison)

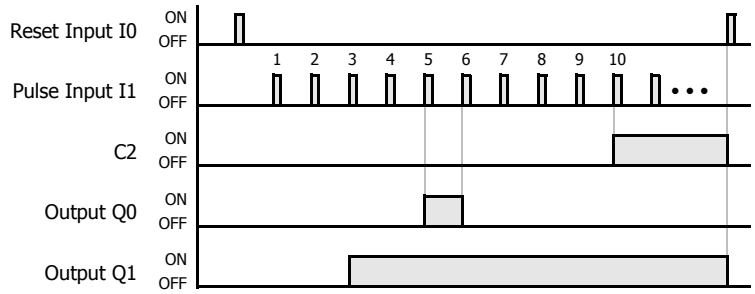
Ladder Diagram 1



Program List

Instruction	Data
LOD	I0
LOD	I1
CNT	C2
	10
CC=	C2
	5
OUT	Q0
CC³	C2
	3
OUT	Q1

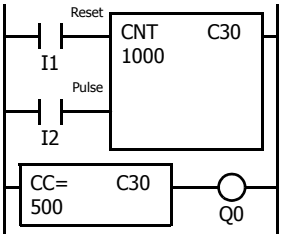
Timing Chart



Output Q0 is on when counter C2 current value is 5.

Output Q1 is turned on when counter C2 current value reaches 3 and remains on until counter C2 is reset.

Ladder Diagram 2



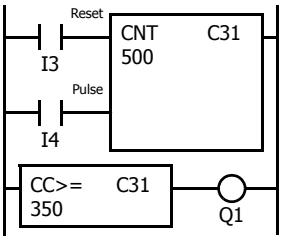
Program List

Instruction	Data
LOD	I1
LOD	I2
CNT	C30
	1000
CC=	C30
	500
OUT	Q0

Timing Chart

Output Q0 is on when counter C30 current value is 500.

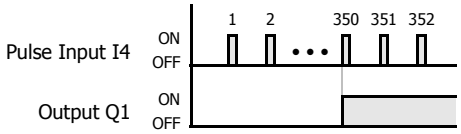
Ladder Diagram 3



Program List

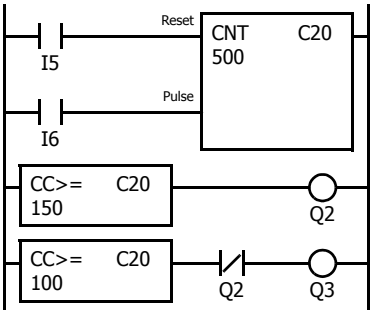
Instruction	Data
LOD	I3
LOD	I4
CNT	C31
	500
CC>=	C31
	350
OUT	Q1

Timing Chart



Output Q1 is turned on when counter C31 current value reaches 350 and remains on until counter C31 is reset.

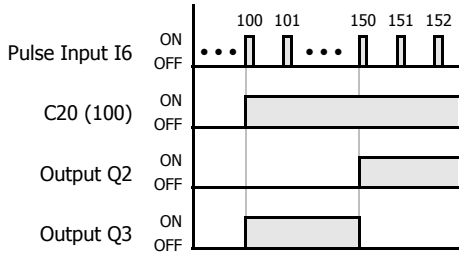
Ladder Diagram 4



Program List

Instruction	Data
LOD	I5
LOD	I6
CNT	C20
	500
CC>=	C20
	150
OUT	Q2
CC>=	C20
	100
ANDN	Q2
OUT	Q3

Timing Chart



Output Q3 is on when counter C20 current value is between 100 and 149.

DC= and DC>= (Data Register Comparison)

The DC= instruction is an equivalent comparison instruction for data register values. This instruction will constantly compare data register values to the value that has been programmed in. When the data register value equals the given value, the desired output will be initiated.

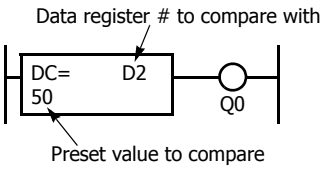
The DC>= instruction is an equal to or greater than comparison instruction for data register values. This instruction will constantly compare data register values to the value that has been programmed in. When the data register value is equal to or greater than the given value, the desired output will be initiated.

When a data register comparison instruction is programmed, two addresses are required. The circuit for a data register comparison instruction must be programmed in the following order: the DC= or DC>= instruction, a data register number D0 through D1999 followed by a preset value to compare from 0 to 65535.

The preset value can be designated using a decimal constant or a data register D0 through D1999. When a data register is used, the data of the data register becomes the preset value.

For LC (Load Compare) instructions, see "LC= (Load Compare Equal To)" on page 7-8.

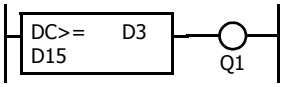
Ladder Diagram (DC=)



Program List

Instruction	Data
DC=	D2
	50
OUT	Q0

Ladder Diagram (DC>=)

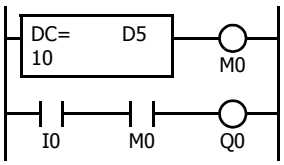


Program List

Instruction	Data
DC>=	D3
	D15
OUT	Q1

- The DC= and DC>= instructions can be repeated for different preset values.
- The comparison instructions also serve as an implicit LOD instruction.
- The comparison instructions can be used with internal relays, which are ANDed or ORed at a separate program address.
- Like the LOD instruction, the comparison instructions can be followed by the AND and OR instructions.

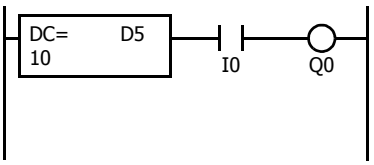
Ladder Diagram



Program List

Instruction	Data
DC=	D5
	10
OUT	M0
LOD	I0
AND	M0
OUT	Q0

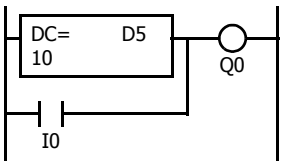
Ladder Diagram



Program List

Instruction	Data
DC=	D5
	10
AND	I0
OUT	Q0

Ladder Diagram

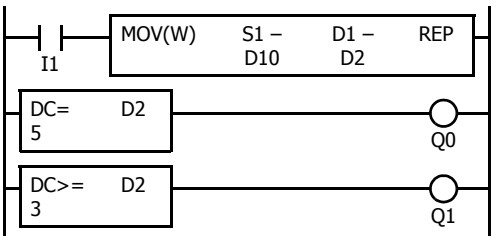


Program List

Instruction	Data
DC=	D5
	10
OR	I0
OUT	Q0

Examples: DC= and DC>= (Data Register Comparison)

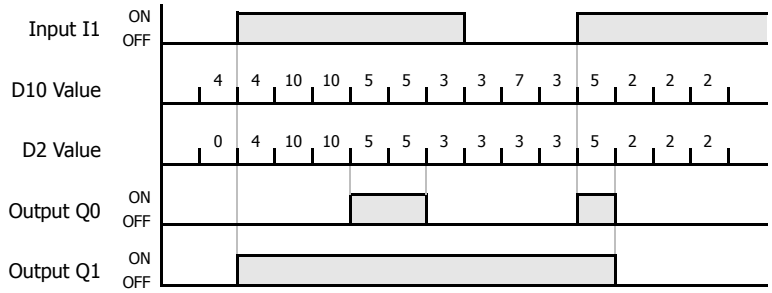
Ladder Diagram 1



Program List

Instruction	Data
LOD	I1
MOV(W)	
	D10 –
	D2 –
DC=	D2
	5
OUT	Q0
DC³	D2
	3
OUT	Q1

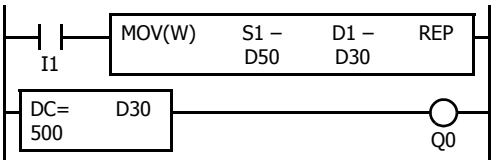
Timing Chart



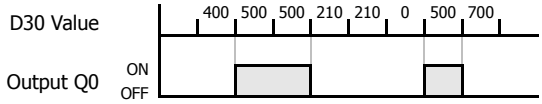
Output Q0 is on when data register D2 value is 5.

Output Q1 is on when data register D2 value is 3 or more.

Ladder Diagram 2

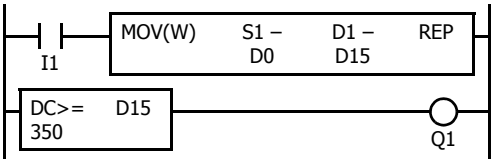


Timing Chart

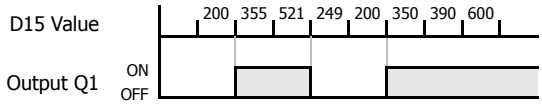


Output Q0 is on when data register D30 value is 500.

Ladder Diagram 3

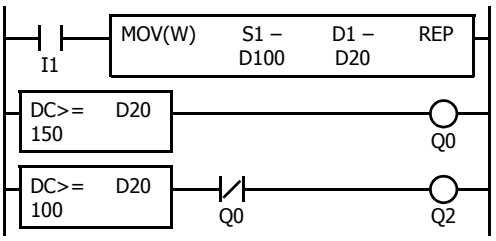


Timing Chart

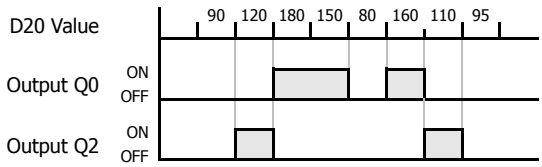


Output Q1 is on when data register D15 value is 350 or more.

Ladder Diagram 4



Timing Chart



Output Q2 is on while data register D20 value is between 149 and 100.

SFR and SFRN (Forward and Reverse Shift Register)

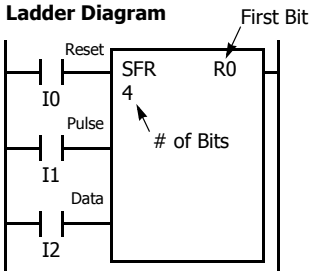
SmartAXIS have a shift register consisting of 128 bits which are allocated to R0 through R127. Any number of available bits can be selected to form a train of bits which store on or off status. The on/off data of constituent bits is shifted in the forward direction (forward shift register) or in the reverse direction (reverse shift register) when a pulse input is turned on.

Forward Shift Register (SFR)

When SFR instructions are programmed, two addresses are always required. The SFR instruction is entered, followed by a shift register number selected from appropriate device addresses. The shift register number corresponds to the first, or head bit. The number of bits is the second required address after the SFR instruction.

The SFR instruction requires three inputs. The forward shift register circuit must be programmed in the following order: reset input, pulse input, data input, and the SFR instruction, followed by the first bit and the number of bits.

Ladder Diagram

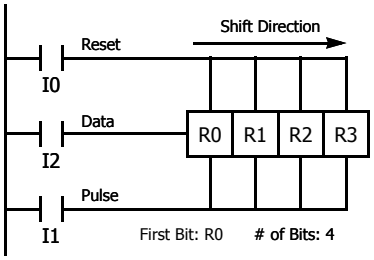


First Bit	R0 to R127
# of Bits	1 to 128

Program List

Instruction	Data
LOD	I0
LOD	I1
LOD	I2
SFR	R0
	4

Structural Diagram



Reset Input

The reset input will cause the value of each bit of the shift register to return to zero. Initialize pulse special internal relay, M8120, may be used to initialize the shift register at start-up.

Pulse Input

The pulse input triggers the data to shift. The shift is in the forward direction for a forward shift register and in reverse for a reverse shift register. A data shift will occur upon the leading edge of a pulse; that is, when the pulse *turns on*. If the pulse has been on and stays on, no data shift will occur.

Data Input

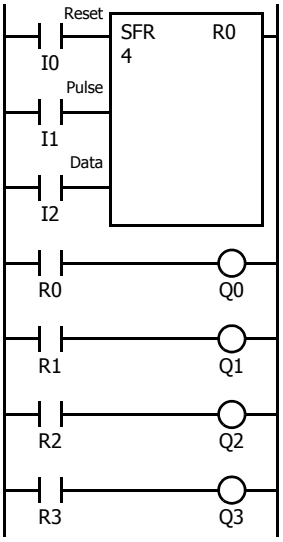
The data input is the information which is shifted into the first bit when a forward data shift occurs, or into the last bit when a reverse data shift occurs.

Note: When power is turned off, the statuses of all shift register bits are normally cleared. It is also possible to maintain the statuses of shift register bits by using the Function Area Settings as required. See Chapter 5 "Special Functions" - "Keep Designation for Internal Relays, Shift Registers, Counters, and Data Registers" in the SmartAXIS Pro/Lite User's Manual.

Note: The SFR instruction cannot be used in an interrupt program. If used, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For details about the user program execution errors, see "User Program Execution Errors" on page 4-13.

Note: For restrictions on ladder programming of shift register instructions, see "Restriction on Ladder Programming" on page 5-31.

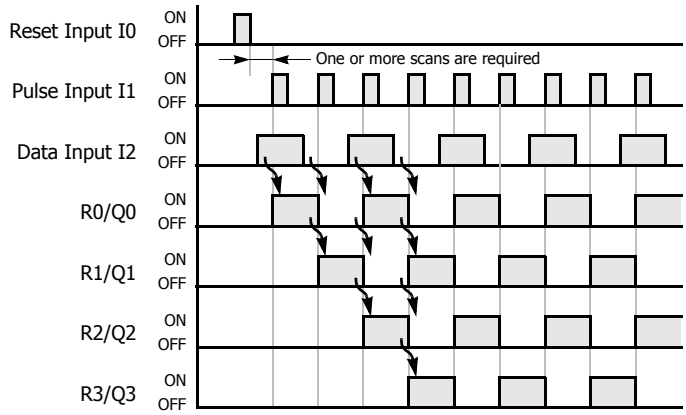
Ladder Diagram



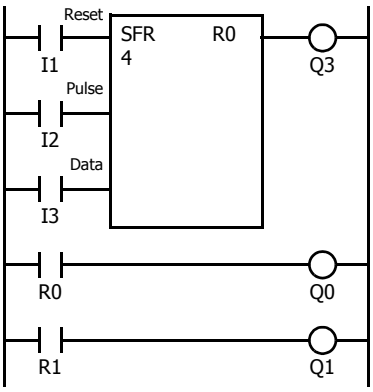
Program List

Instruction	Data
LOD	I0
LOD	I1
LOD	I2
SFR	R0
	4
LOD	R0
OUT	Q0
LOD	R1
OUT	Q1
LOD	R2
OUT	Q2
LOD	R3
OUT	Q3

Timing Chart



Ladder Diagram

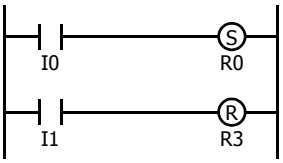


Program List

Instruction	Data
LOD	I1
LOD	I2
LOD	I3
SFR	R0
	4
OUT	Q3
LOD	R0
OUT	Q0
LOD	R1
OUT	Q1

- The last bit status output can be programmed directly after the SFR instruction. In this example, the status of bit R3 is read to output Q3.
- Each bit can be loaded using the LOD R# instruction.

Setting and Resetting Shift Register Bits



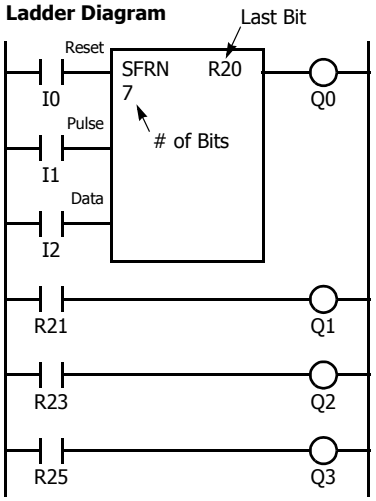
- Any shift register bit can be turned on using the SET instruction.
- Any shift register bit can be turned off using the RST instruction.
- The SET or RST instruction is actuated by any input condition.

Reverse Shift Register (SFRN)

For reverse shifting, use the SFRN instruction. When SFRN instructions are programmed, two addresses are always required. The SFRN instructions are entered, followed by a shift register number selected from appropriate device addresses. The shift register number corresponds to the lowest bit number in a string. The number of bits is the second required address after the SFRN instructions.

The SFRN instruction requires three inputs. The reverse shift register circuit must be programmed in the following order: reset input, pulse input, data input, and the SFRN instruction, followed by the last bit and the number of bits.

Ladder Diagram



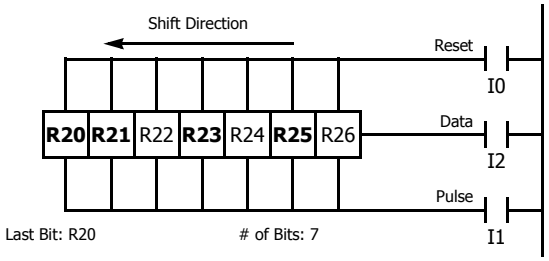
Last Bit	R0 to R127
# of Bits	1 to 128

Program List

Instruction	Data
LOD	I0
LOD	I1
LOD	I2
SFRN	R20
	7
OUT	Q0
LOD	R21
OUT	Q1
LOD	R23
OUT	Q2
LOD	R25
OUT	Q3

- The last bit status output can be programmed directly after the SFRN instruction. In this example, the status of bit R20 is read to output Q0.
- Each bit can be loaded using the LOD R# instructions.
- For details of reset, pulse, and data inputs, see "Forward Shift Register (SFR)" on page 5-22.

Structural Diagram



Note: Output is initiated only for those bits highlighted in bold print.

Note: When power is turned off, the statuses of all shift register bits are normally cleared. It is also possible to maintain the statuses of shift register bits by using the Function Area Settings as required. See Chapter 5 "Special Functions" - "Keep Designation for Internal Relays, Shift Registers, Counters, and Data Registers" in the SmartAXIS Pro/Lite User's Manual.

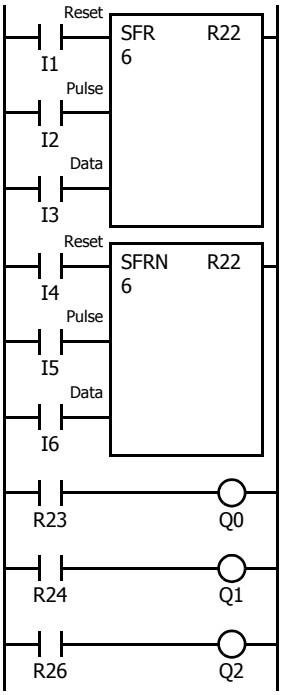
Note: The SFRN instruction cannot be used in an interrupt program. If used, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For details about the user program execution errors, see "User Program Execution Errors" on page 4-13.

Note: For restrictions on ladder programming of shift register instructions, see "Restriction on Ladder Programming" on page 5-31.

Bidirectional Shift Register

A bidirectional shift register can be created by first programming the SFR instruction as detailed in the Forward Shift Register section on page 5-22. Next, the SFRN instruction is programed as detailed in the Reverse Shift Register section on page 5-24.

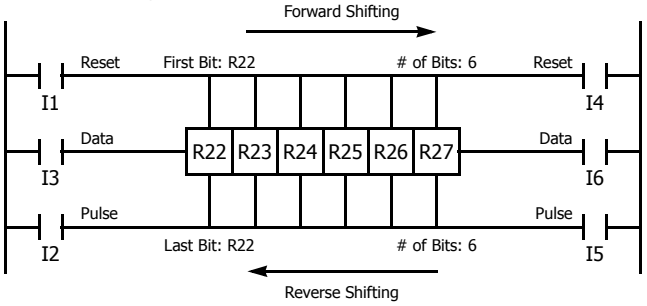
Ladder Diagram



Program List

Instruction	Data
LOD	I1
LOD	I2
LOD	I3
SFR	R22
	6
LOD	I4
LOD	I5
LOD	I6
SFRN	R22
	6
LOD	R23
OUT	Q0
LOD	R24
OUT	Q1
LOD	R26
OUT	Q2

Structural Diagram



Note: Output is initiated only for those bits highlighted in bold print.

SOTU and SOTD (Single Output Up and Down)

The SOTU instruction "looks for" the transition of a given input from off to on. The SOTD instruction looks for the transition of a given input from on to off. When this transition occurs, the desired output will turn on for the length of one scan. The SOTU or SOTD instruction converts an input signal to a "one-shot" pulse signal.

A total of 1024 SOTU and SOTD instructions can be used in a user program.

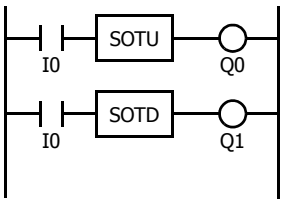
If operation is started while the given input is already on, the SOTU output will not turn on. The transition from off to on is what triggers the SOTU instruction.

The SOTU or SOTD instructions cannot be used in an interrupt program.

If used, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For details about the user program execution errors, see "User Program Execution Errors" on page 4-13.

When a CPU relay is defined as the SOTU or SOTD output, it may not operate if the scan time is not compatible with relay requirements.

Ladder Diagram

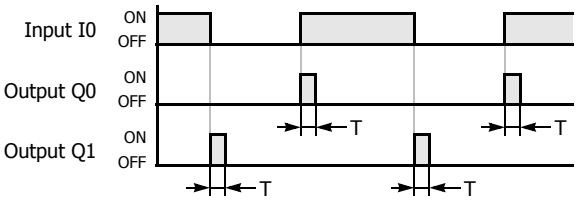


Program List

Instruction	Data
LOD	I0
SOTU	
OUT	Q0
LOD	I0
SOTD	
OUT	Q1

Note: For restrictions on ladder programming of SOTU and SOTD instructions, see "Restriction on Ladder Programming" on page 5-31.

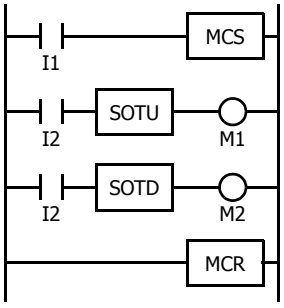
Timing Chart



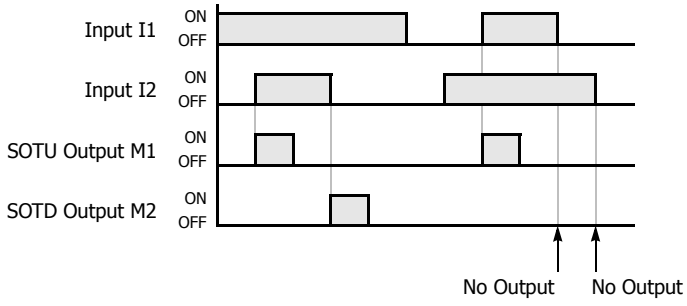
Note: "T" equals one scan time (one-shot pulse).

There is a special case when the SOTU and SOTD instructions are used between the MCS and MCR instructions (see "MCS and MCR (Master Control Set and Reset)" on page 5-27). If input I2 to the SOTU instruction turns on while input I1 to the MCS instruction is on, then the SOTU output turns on. If input I2 to the SOTD instruction turns off while input I1 is on, then the SOTD output turns on. If input I1 turns on while input I2 is on, then the SOTU output turns on. However, if input I1 turns off while input I2 is on, then the SOTD output does not turn on as shown below.

Ladder Diagram



Timing Chart



MCS and MCR (Master Control Set and Reset)

The MCS (master control set) instruction is usually used in combination with the MCR (master control reset) instruction. The MCS instruction can also be used with the END instruction, instead of the MCR instruction.

When the input preceding the MCS instruction is off, the MCS is executed so that all inputs to the portion between the MCS and the MCR are forced off. When the input preceding the MCS instruction is on, the MCS is not executed so that the program following it is executed according to the actual input statuses.

When the input condition to the MCS instruction is off and the MCS is executed, other instructions between the MCS and MCR are executed as follows:

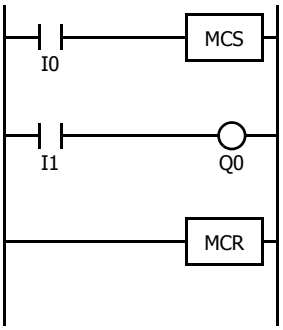
Instruction	Status
SOTU	Rising edges (ON pulses) are not detected.
SOTD	Falling edges (OFF pulses) are not detected.
OUT	All are turned off.
OUTN	All are turned on.
SET and RST	All are held in current status.
TML, TIM, TMH, and TMS	Current values are reset to zero. Timeout statuses are turned off.
CNT, CDP, and CUD	Current values are held. Pulse inputs are turned off. Countout statuses are turned off.
SFR and SFRN	Shift register bit statuses are held. Pulse inputs are turned off. The output from the last bit is turned off.

Input conditions cannot be set for the MCR instruction.

More than one MCS instruction can be used with one MCR instruction.

Corresponding MCS/MCR instructions cannot be nested within another pair of corresponding MCS/MCR instructions.

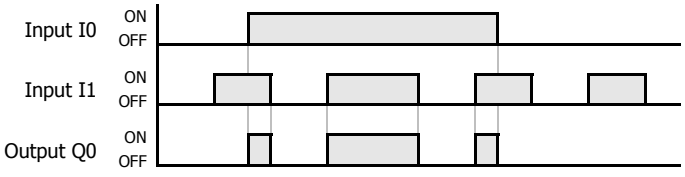
Ladder Diagram



Program List

Instruction	Data
LOD	I0
MCS	
LOD	I1
OUT	Q0
MCR	

Timing Chart

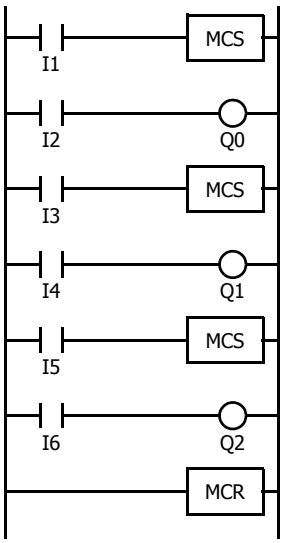


When input I0 is off, MCS is executed so that the subsequent input is forced off.

When input I0 is on, MCS is not executed so that the following program is executed according to the actual input statuses.

Multiple Usage of MCS instructions

Ladder Diagram



Program List

Instruction	Data
LOD	I1
MCS	
LOD	I2
OUT	Q0
LOD	I3
MCS	
LOD	I4
OUT	Q1
LOD	I5
MCS	
LOD	I6
OUT	Q2
MCR	

This master control circuit will give priority to I1, I3, and I5, in that order.

When input I1 is off, the first MCS is executed so that subsequent inputs I2 through I6 are forced off.

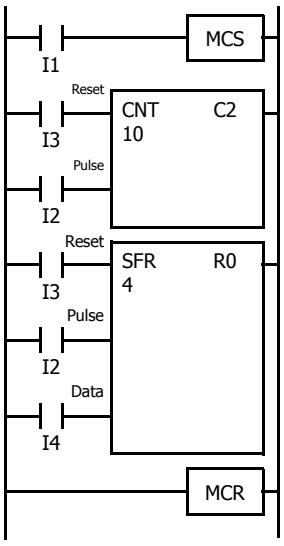
When input I1 is on, the first MCS is not executed so that the following program is executed according to the actual input statuses of I2 through I6.

When I1 is on and I3 is off, the second MCS is executed so that subsequent inputs I4 through I6 are forced off.

When both I1 and I3 are on, the first and second MCSs are not executed so that the following program is executed according to the actual input statuses of I4 through I6.

Counter and Shift Register in Master Control Circuit

Ladder Diagram

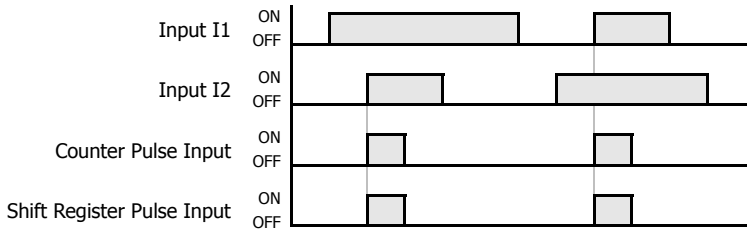


When input I1 is on, the MCS is not executed so that the counter and shift register are executed according to the actual status of subsequent inputs I2 through I4.

When input I1 is off, the MCS is executed so that subsequent inputs I2 through I4 are forced off.

When input I1 is turned on while input I2 is on, the counter and shift register pulse inputs are turned on as shown below.

Timing Chart



JMP (Jump) and JEND (Jump End)

The JMP (jump) instruction is usually used in combination with the JEND (jump end) instruction. At the end of a program, the JMP instruction can also be used with the END instruction, instead of the JEND instruction.

These instructions are used to proceed through the portion of the program between the JMP and the JEND *without* processing. This is similar to the MCS/MCR instructions, except that the portion of the program between the MCS and MCR instruction *is* executed.

When the operation result immediately before the JMP instruction is on, the JMP is valid and the program is *not* executed. When the operation result immediately before the JMP instruction is off, the JMP is invalid and the program is executed.

When the input condition to the JMP instruction is on and the JMP is executed, other instructions between the JMP and JEND are executed as follows:

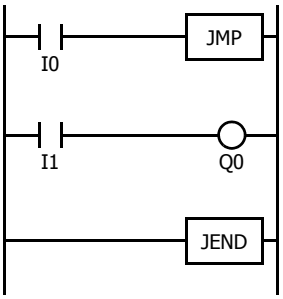
Instruction	Status
SOTU	Rising edges (ON pulses) are not detected.
SOTD	Falling edges (OFF pulses) are not detected.
OUT and OUTN	All are held in current status.
SET and RST	All are held in current status.
TML, TIM, TMH, and TMS	Current values are held. Timeout statuses are held.
CNT, CDP, and CUD	Current values are held. Pulse inputs are turned off. Countout statuses are held.
SFR and SFRN	Shift register bit statuses are held. Pulse inputs are turned off. The output from the last bit is held.

Input conditions cannot be set for the JEND instruction.

More than one JMP instruction can be used with one JEND instruction.

Corresponding JMP/JEND instructions cannot be nested within another pair of corresponding JMP/JEND instructions.

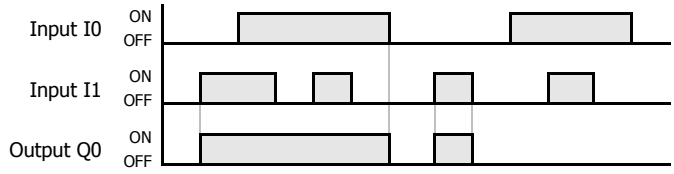
Ladder Diagram



Program List

Instruction	Data
LOD	I0
JMP	
LOD	I1
OUT	Q0
JEND	

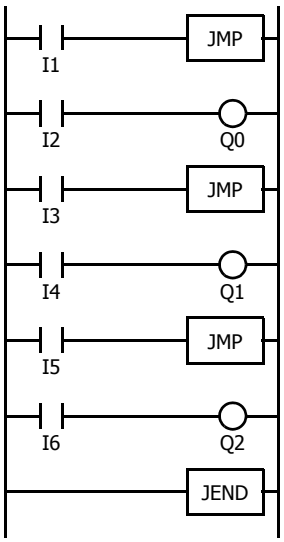
Timing Chart



When input I0 is on, JMP is executed so that the subsequent output status is held.

When input I0 is off, JMP is not executed so that the following program is executed according to the actual input statuses.

Ladder Diagram



Program List

Instruction	Data
LOD	I1
JMP	
LOD	I2
OUT	Q0
LOD	I3
JMP	
LOD	I4
OUT	Q1
LOD	I5
JMP	
LOD	I6
OUT	Q2
JEND	

This jump circuit will give priority to I1, I3, and I5, in that order.

When input I1 is on, the first JMP is executed so that subsequent output statuses of Q0 through Q2 are held.

When input I1 is off, the first JMP is not executed so that the following program is executed according to the actual input statuses of I2 through I6.

When I1 is off and I3 is on, the second JMP is executed so that subsequent output statuses of Q1 and Q2 are held.

When both I1 and I3 are off, the first and second JMPs are not executed so that the following program is executed according to the actual input statuses of I4 through I6.

END

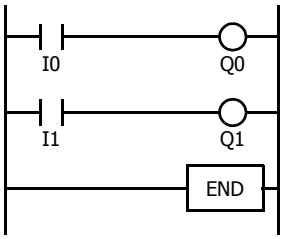
The END instruction is always required at the end of a program; however, it is not necessary to program the END instruction after the last programmed instruction. WindLDR automatically appends the END instruction at the end of a program.

A *scan* is the execution of all instructions from address zero to the END instruction. The time required for this execution is referred to as one *scan time*. The scan time varies with respect to program length, which corresponds to the address where the END instruction is found.

During the scan time, program instructions are processed sequentially. This is why the output instruction closest to the END instruction has priority over a previous instruction for the same output. No output is initiated until all logic within a scan is processed.

Output occurs simultaneously, and this is the first part of the END instruction execution. The second part of the END instruction execution is to monitor all inputs, also done simultaneously. Then program instructions are ready to be processed sequentially once again.

Ladder Diagram

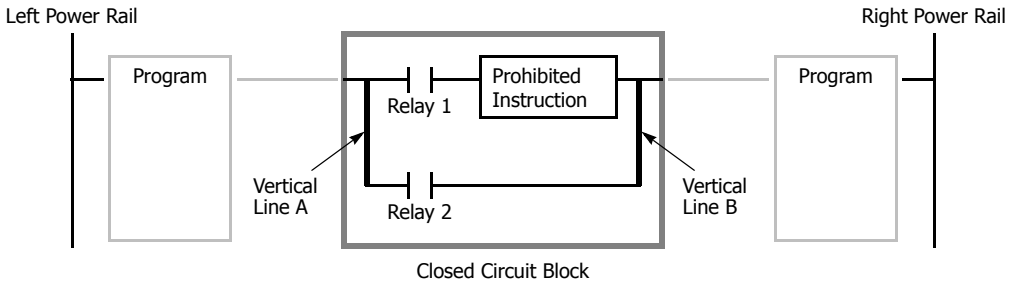


Program List

Instruction	Data
LOD	I0
OUT	Q0
LOD	I1
OUT	Q1
END	

Restriction on Ladder Programming

Due to the structure of WindLDR, the following ladder diagram cannot be programmed — a closed circuit block is formed by vertical lines, except for right and left power rails, and the closed circuit block contains one or more prohibited instructions shown in the table below.

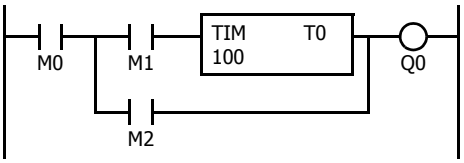


Prohibited Instructions	OUT, OUTN, SET, RST, TML, TIM, TMH, TMS, TMLO, TIMO, TMHO, TMSO, CNT, CDP, CUD, CNTD, CDPD, CUDD, SFR, SFRN, SOTU, SOTD
Error Detection	When converting the ladder program, an error message is shown, such as "TIM follows an invalid device." Conversion fails to create mnemonics and the program is not downloaded to the SmartAXIS.

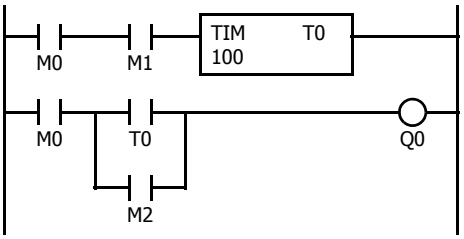
Modifying Prohibited Ladder Programs

Intended operation can be performed by modifying the prohibited ladder program as shown in the examples below:

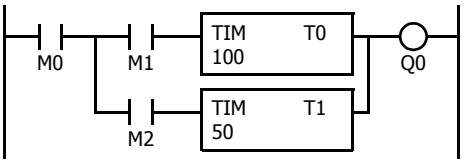
Prohibited Ladder Program 1



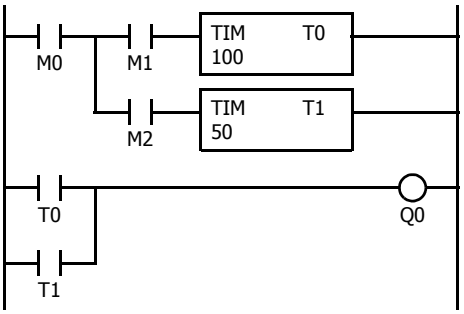
Modified Ladder Program 1



Prohibited Ladder Program 2



Modified Ladder Program 2



6: MOVE INSTRUCTIONS

Introduction

Data can be moved using the MOV (move), MOVN (move not), IMOV (indirect move), or IMOVN (indirect move not) instruction. The moved data is 16- or 32-bit data, and the repeat operation can also be used to increase the quantity of data moved. In the MOV or MOVN instruction, the source and destination device are designated by S1 and D1 directly. In the IMOV or IMOVN instruction, the source and destination device are determined by the offset values designated by S2 and D2 added to source device S1 and destination device D1.

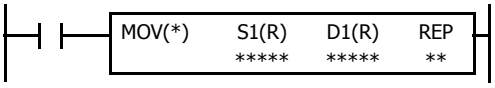
The BMOV (block move) instruction is useful to move consecutive blocks of timer, counter, and data register values.

The IBMV (indirect bit move) and IBMVN (indirect bit move not) instructions move one bit of data from a source device to a destination device. Both devices are determined by adding an offset to the device.

NSET (N data set) and NRS (N data repeat set) instructions can be used to set values to a group of devices. The XCHG (exchange) instruction is used to swap word or double-word data between two devices. The current timer or counter values can be changed using the TCCST (timer/counter current value store) instruction.

Since the move instructions are executed in each scan while input is on, a pulse input from a SOTU or SOTD instruction should be used.

MOV (Move)



S1 → D1
When input is on, 16- or 32-bit data from device assigned by S1 is moved to device assigned by D1.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	First device address to move	X	X	X	X	X	X	X	X	1-99
D1 (Destination 1)	First device address to move to	—	X	▲	X	X	X	X	—	1-99

For valid device address ranges, see "Device Addresses" on page 3-1.

▲ Internal relays M0 through M1277 can be designated as D1. Special internal relays cannot be designated as D1.
Both internal relays M0 through M1277 and special internal relays M8000 through M8177 can be designated as source devices.

When T (timer) or C (counter) is used as S1, the timer/counter current value (TC or CC) is displayed. When T (timer) or C (counter) is used as D1, the data is written in as a preset value (TP or CP) which can be 0 through 65535.

When F (float) data is selected, only data register and constant can be designated as S1, and only data register can be designated as D1.

When F (float) data is selected and S1 does not comply with the normal floating-point format, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

Valid Data Types

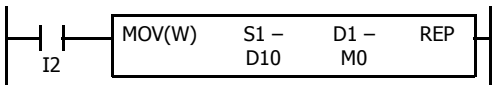
W (word)	X
I (integer)	X
D (double word)	X
L (long)	X
F (float)	X

When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source or destination, 16 points (word or integer data) or 32 points (double-word or long data) are used. When repeat is assigned for a bit device, the quantity of device bits increases in 16- or 32-point increments.

When a word device such as T (timer), C (counter), or D (data register) is assigned as the source or destination, 1 point (word or integer data) or 2 points (double-word, long, or float data) are used. When repeat is assigned for a word device, the quantity of device words increases in 1- or 2-point increments.

Examples: MOV

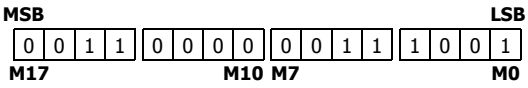
Data Type: Word



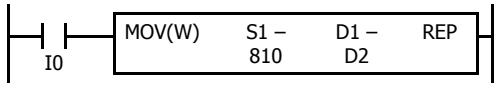
D10 → M0
When input I2 is on, data in data register D10 assigned by source device S1 is moved to 16 internal relays starting with M0 assigned by destination device D1.

D10 [12345] → M0 through M7, M10 through M17

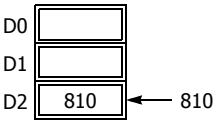
Data in the source data register is converted into 16-bit binary data, and the ON/OFF statuses of the 16 bits are moved to internal relays M0 through M7 and M10 through M17. M0 is the LSB (least significant bit). M17 is the MSB (most significant bit).



Data Type: Word

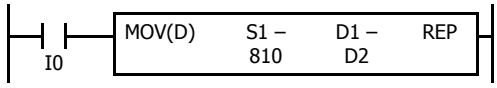


810 → D2
When input I0 is on, constant 810 assigned by source device S1 is moved to data register D2 assigned by destination device D1.

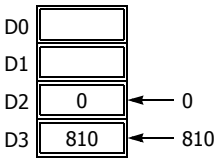


Data move operation for integer data is the same as for word data.

Data Type: Double Word

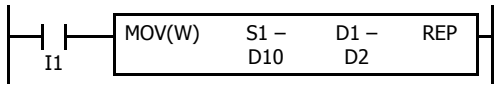


810 → D2·D3
When input I0 is on, constant 810 assigned by source device S1 is moved to data registers D2 and D3 assigned by destination device D1.

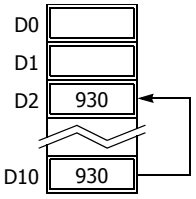


Data move operation for the long data type is the same as for the double-word data type.

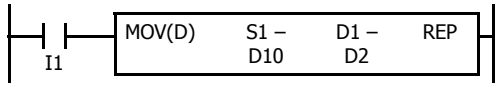
Data Type: Word



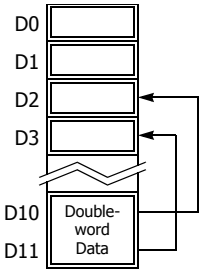
D10 → D2
When input I1 is on, data in data register D10 assigned by source device S1 is moved to data register D2 assigned by destination device D1.



Data Type: Double Word



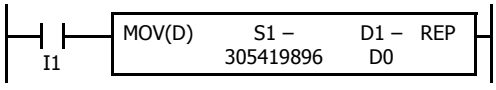
D10·D11 → D2·D3
When input I1 is on, data in data registers D10 and D11 assigned by source device S1 is moved to data registers D2 and D3 assigned by destination device D1.

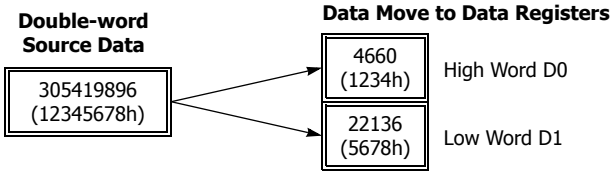


Double-word Data Move in Data Registers

When a data register, timer, or counter is selected as a double-word device, the upper-word data is loaded from or stored to the first device selected. The lower-word data is loaded from or stored to the subsequent device.

Double-word Destination Device: Data Register



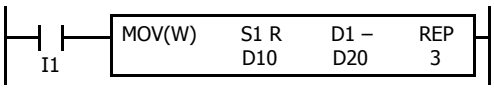


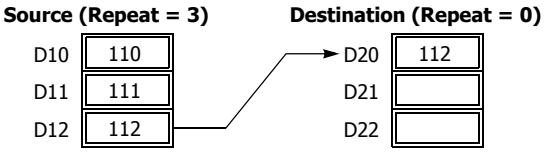
Repeat Operation in the Move Instructions

Repeat Source Device

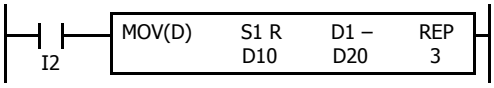
When the S1 (source) is set to repeat, as many devices as the repeat cycles, starting with the device designated by S1, are moved to the destination. As a result, only the last of the source devices is moved to the destination.

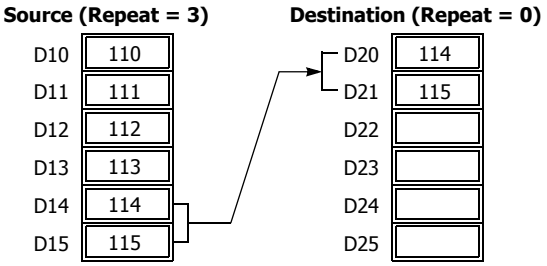
- **Data Type: Word**





- **Data Type: Double Word**

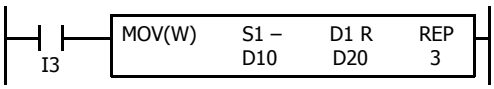


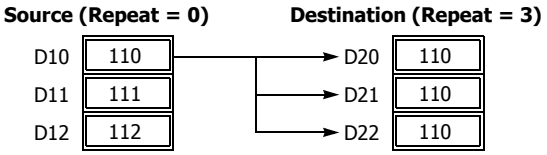


Repeat Destination Device

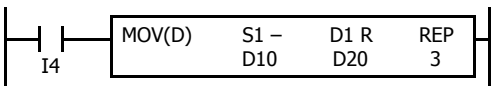
When the D1 (destination) is designated to repeat, the source device designated by S1 is moved to all destination devices as many times as the repeat cycles, starting with the destination designated by D1.

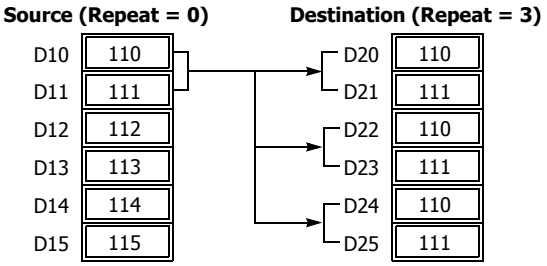
- **Data Type: Word**





- **Data Type: Double Word**



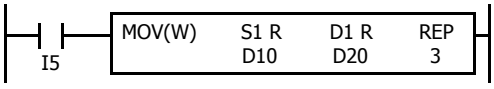


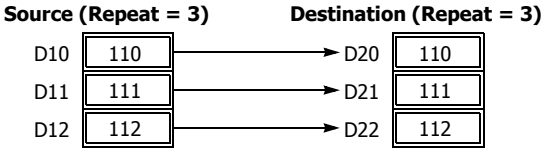
Repeat Source and Destination Devices

When both S1 (source) and D1 (destination) are set to repeat, as many devices as the repeat cycles, starting with the device designated by S1, are moved to the same quantity of devices starting with the device designated by D1.

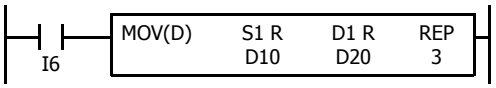
Note: The BMOV (block move) instruction has the same effect as the MOV instruction with both the source and destination designated to repeat.

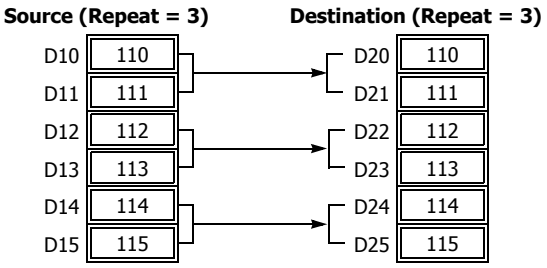
- **Data Type: Word**





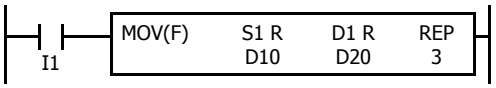
- **Data Type: Double Word**

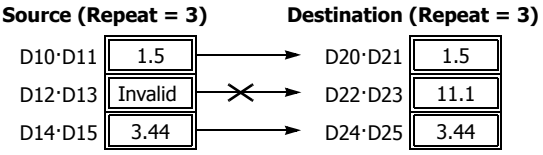




- **Data Type: Float**

When the source data does not comply with the normal floating-point format in any repeat operation, a user program execution error occurs, and the source data is not moved to the destination.

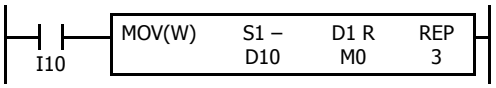


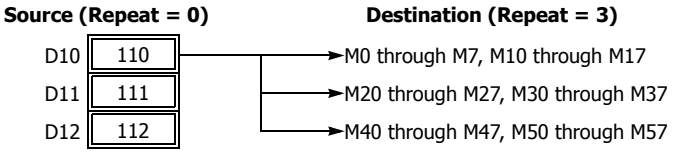


Repeat Bit Devices

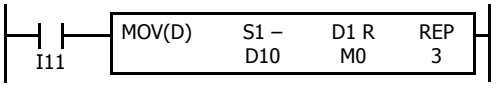
The MOV (move) instruction moves 16-bit data (word or integer data) or 32-bit data (double-word or integer data). When a bit device such as input, output, internal relay, or shift register is designated as the source or destination device, 16 or 32 bits starting with the one designated by S1 or D1 are the target data. If a repeat operation is designated for a bit device, the target data increases in 16- or 32-bit increments, depending on the selected data type.

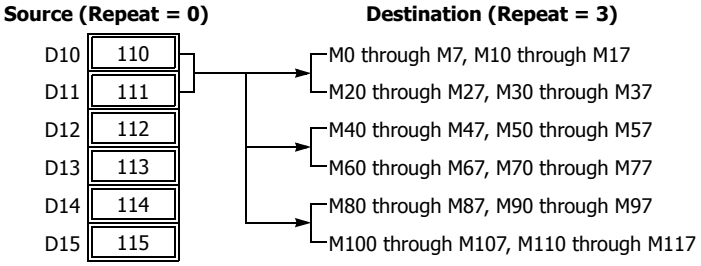
- **Data Type: Word**





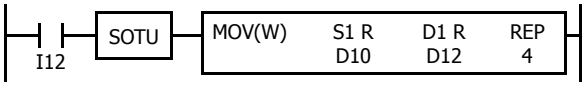
- **Data Type: Double Word**



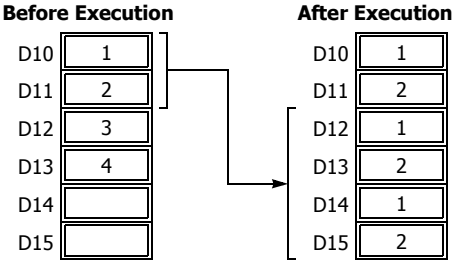


Overlapped Devices by Repeat

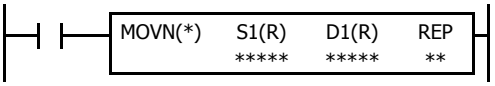
If the repeat operation is set for both the source and destination and if a portion of the source and destination areas overlap each other, then the source data in the overlapped area also changes.



Source: D10 through D13 (Repeat = 4)
Destination: D12 through D15 (Repeat = 4)



MOVN (Move Not)



S1 NOT → D1
When input is on, 16- or 32-bit data from device assigned by S1 is inverted bit by bit and moved to device assigned by D1.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	First device address to move	X	X	X	X	X	X	X	X	1-99
D1 (Destination 1)	First device address to move to	—	X	▲	X	X	X	X	—	1-99

For valid device address ranges, see "Device Addresses" on page 3-1.

▲ Internal relays M0 through M1277 can be designated as D1. Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as S1, the timer/counter current value (TC or CC) is displayed. When T (timer) or C (counter) is used as D1, the data is written in as a preset value (TP or CP) which can be 0 through 65535.

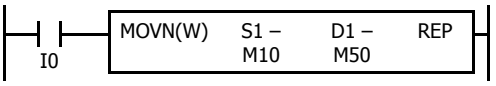
Valid Data Types

W (word)	X
I (integer)	X
D (double word)	X
L (long)	X
F (float)	—

When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source or destination, 16 points (word or integer data) or 32 points (double-word or long data) are used. When repeat is set for a bit device, the quantity of device bits increases in 16- or 32-point increments.

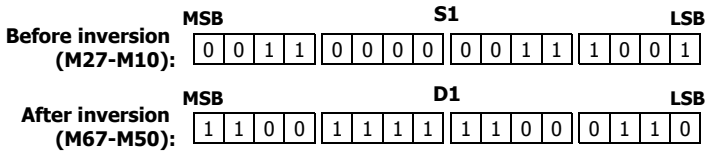
When a word device such as T (timer), C (counter), or D (data register) is assigned as the source or destination, 1 point (word or integer data) or 2 points (double-word or long data) are used. When repeat is set for a word device, the quantity of device words increases in 1- or 2-point increments.

Examples: MOVN

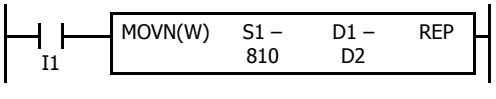


M10 NOT → M50
When input I0 is on, the 16 internal relays, starting with M10 assigned by source device S1, are inverted bit by bit and moved to 16 internal relays starting with M50 assigned by destination device D1.

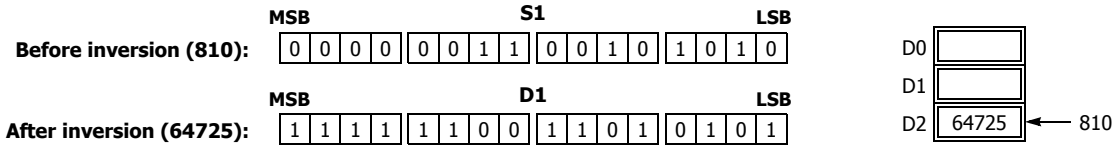
M10 through M17, M20 through M27 NOT → M50 through M57, M60 through M67

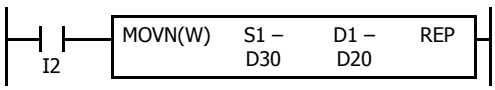


The ON/OFF statuses of the 16 internal relays M10 through M17 and M20 through M27 are inverted and moved to 16 internal relays M50 through M57 and M60 through M67. M50 is the LSB (least significant bit), and M67 is the MSB (most significant bit).

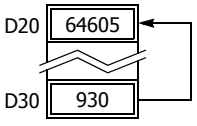


810 NOT → D2
When input I1 is on, decimal constant 810 assigned by source device S1 is converted into 16-bit binary data, and the ON/OFF statuses of the 16 bits are inverted and moved to data register D2 assigned by destination device D1.

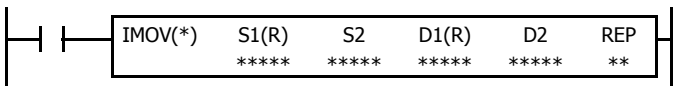




D30 NOT → D20
When input I2 is on, the data in data register D30, assigned by S1, is inverted bit by bit and moved to data register D20 assigned by D1.



IMOV (Indirect Move)



S1 + S2 → D1 + D2

When input is on, the values contained in devices assigned by S1 and S2 are added together to determine the data source. The 16- or 32-bit data is then moved to the destination, which is determined by the sum of values contained in devices assigned by D1 and D2.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	Base address to move from	X	X	X	X	X	X	X	—	1-99
S2 (Source 2)	Offset for S1	X	X	X	X	X	X	X	—	—
D1 (Destination 1)	Base address to move to	—	X	▲	X	X	X	X	—	1-99
D2 (Destination 2)	Offset for D1	X	X	X	X	X	X	X	—	—

For valid device address ranges, see "Device Addresses" on page 3-1.

▲ Internal relays M0 through M1277 can be designated as D1. Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as S1, S2, or D2, the device data is the timer/counter current value (TC or CC). When T (timer) or C (counter) is used as D1, the device data is the timer/counter preset value (TP or CP) which can be 0 through 65535.

When F (float) data is selected, only data register can be designated as S1 or D1.

When F (float) data is selected and S1 does not comply with the normal floating-point format, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS.

Source device S2 or destination device D2 does not have to be assigned. If S2 or D2 is not assigned, the source or destination device is determined by S1 or D1 without offset.

Make sure that the source data determined by S1 + S2 and the destination data determined by D1 + D2 are within the valid device range. If the derived source or destination device exceeds the valid device range, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

Valid Data Types

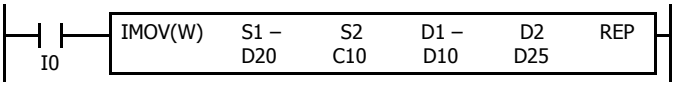
W (word)	X
I (integer)	—
D (double word)	X
L (long)	—
F (float)	X

When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source or destination, 16 points (word data) or 32 points (double-word data) are used. When repeat is assigned for a bit device, the quantity of device bits increases in 16- or 32-point increments.

When a word device such as T (timer), C (counter), or D (data register) is assigned as the source or destination, 1 point (word data) or 2 points (double-word or float data) are used. When repeat is assigned for a word device, the quantity of device words increases in 1- or 2-point increments.

Example: IMOV

- **Data Type: Word**



D20 + C10 → D10 + D25

Source device S1 and destination device D1 determine the type of device. Source device S2 and destination device D2 are the offset values to determine the source and destination devices.

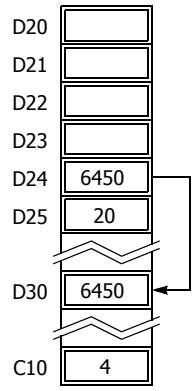
If the current value of counter C10 assigned by source device S2 is 4, the source data is determined by adding the offset value to data register D20 assigned by source device S1:

D(20 + 4) = D24

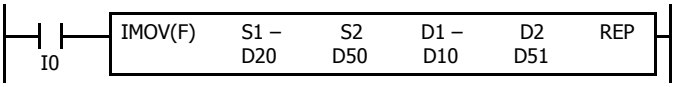
If data register D25 contains a value of 20, the destination is determined by adding the offset value to data register D10 assigned by destination device D1:

D(10 + 20) = D30

As a result, when input I0 is on, the data in data register D24 is moved to data register D30.



- **Data Type: Float**

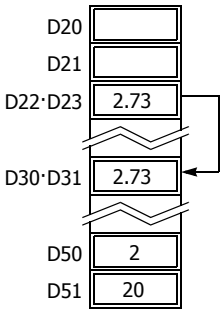


D20 + D50 → D10 + D51

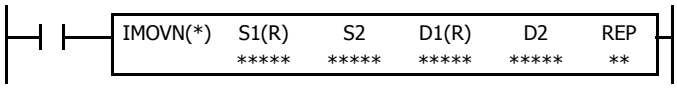
If data register D50 contains a value of 2, the source data is determined by adding the offset value to data register D20 assigned by source device S1: D(20 + 2) = D22

If data register D51 contains a value of 20, the destination is determined by adding the offset value to data register D10 assigned by destination device D1: D(10 + 20) = D30

As a result, when input I0 is on, the data in data registers D22·D23 is moved to data registers D30·D31.



IMOVN (Indirect Move Not)



S1 + S2 NOT → D1 + D2

When input is on, the values contained in devices assigned by S1 and S2 are added together to determine the data source. The 16- or 32-bit data is then inverted and moved to the destination, which is determined by the sum of values contained in devices assigned by D1 and D2.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	Base address to move from	X	X	X	X	X	X	X	—	1-99
S2 (Source 2)	Offset for S1	X	X	X	X	X	X	X	—	—
D1 (Destination 1)	Base address to move to	—	X	▲	X	X	X	X	—	1-99
D2 (Destination 2)	Offset for D1	X	X	X	X	X	X	X	—	—

For valid device address ranges, see "Device Addresses" on page 3-1.

▲ Internal relays M0 through M1277 can be designated as D1. Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as S1, S2, or D2, the device data is the timer/counter current value (TC or CC). When T (timer) or C (counter) is used as D1, the device data is the timer/counter preset value (TP or CP), 0 through 65535.

Source device S2 or destination device D2 does not have to be assigned. If S2 or D2 is not assigned, the source or destination device is determined by S1 or D1 without offset.

Make sure that the source data determined by S1 + S2 and the destination data determined by D1 + D2 are within the valid device range. If the derived source or destination device exceeds the valid device range, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

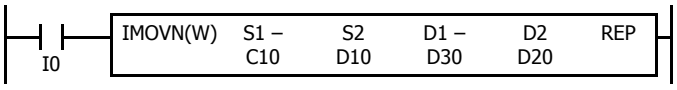
Valid Data Types

W (word)	X
I (integer)	—
D (double word)	X
L (long)	—
F (float)	—

When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source or destination, 16 points (word data) or 32 points (double-word data) are used. When repeat is set for a bit device, the quantity of device bits increases in 16- or 32-point increments.

When a word device such as T (timer), C (counter), or D (data register) is assigned as the source or destination, 1 point (word data) or 2 points (double-word data) are used. When repeat is assigned for a word device, the quantity of device words increases in 1- or 2-point increments.

Example: IMOVN



C10 + D10 NOT → D30 + D20

Source device S1 and destination device D1 determine the type of device. Source device S2 and destination device D2 are the offset values used to determine the source and destination devices.

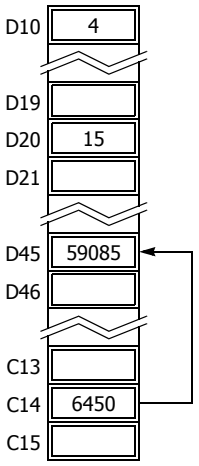
If the data of data register D10 assigned by source device S2 is 4, then the source data is determined by adding the offset value to counter C10 assigned by source device S1:

C(10 + 4) = C14

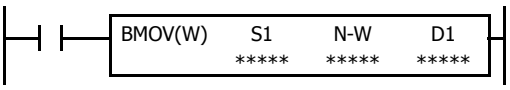
If data register D20 assigned by destination device D2 contains a value of 15, then the destination is determined by adding the offset value to data register D30 assigned by destination device D1:

D(30 + 15) = D45

As a result, when input I0 is on, the current value of counter C14 is inverted and moved to data register D45.

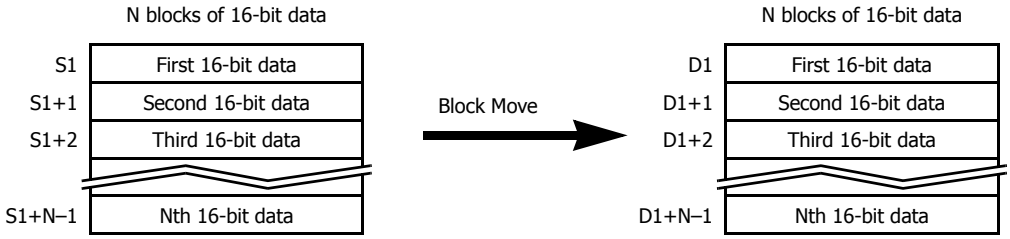


BMOV (Block Move)



S1, S1+1, S1+2, ... , S1+N–1 → D1, D1+1, D1+2, ... , D1+N–1

When input is on, N blocks of 16-bit word data starting with device assigned by S1 are moved to N blocks of destinations, starting with device assigned by D1. N-W specifies the quantity of blocks to move.



Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	First device address to move	X	X	X	X	X	X	X	—	—
N-W (N words)	Quantity of blocks to move	X	X	X	X	X	X	X	X	—
D1 (Destination 1)	First device address to move to	—	X	▲	X	X	X	X	—	—

For valid device address ranges, see "Device Addresses" on page 3-1.

▲ Internal relays M0 through M1277 can be designated as D1. Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as S1 or N-W, the timer/counter current value (TC or CC) is displayed. When T (timer) or C (counter) is used as D1, the data is written in as a preset value (TP or CP) which can be 0 through 65535.

Make sure that the last source data determined by S1+N–1 and the last destination data determined by D1+N–1 are within the valid device range. If the derived source or destination device exceeds the valid device range, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

Valid Data Types

W (word)	X
I (integer)	—
D (double word)	—
L (long)	—
F (float)	—

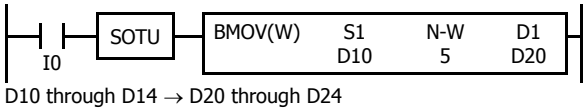
When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source, N-W, or destination, 16 points (word data) are used.

When a word device such as T (timer), C (counter), or D (data register) is assigned as the source, N-W, or destination, 1 point (word data) is used.

Special Internal Relay M8024: BMOV/WSFT Executing Flag

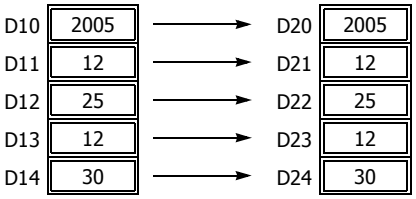
While the BMOV or WSFT is executed, M8024 turns on. When completed, M8024 turns off. If the CPU is powered down while executing BMOV or WSFT, M8024 remains on when the CPU is powered up again.

Example: BMOV

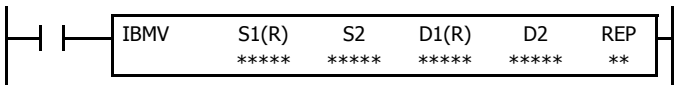


D10 through D14 → D20 through D24

When input I0 is turned on, data of 5 data registers, starting with D10 assigned by source device S1, is moved to 5 data registers starting with D20 assigned by destination device D1.



IBMV (Indirect Bit Move)



S1 + S2 → D1 + D2

When input is on, the values contained in devices assigned by S1 and S2 are added together to determine the source of data. The 1-bit data is then moved to the destination, which is determined by the sum of values contained in devices assigned by D1 and D2.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	Base address to move from	X	X	X	X	—	—	X	0 or 1	1-99
S2 (Source 2)	Offset for S1	X	X	X	X	X	X	X	0-65535	—
D1 (Destination 1)	Base address to move to	—	X	▲	X	—	—	X	—	1-99
D2 (Destination 2)	Offset for D1	X	X	X	X	X	X	X	0-65535	—

For valid device address ranges, see "Device Addresses" on page 3-1.

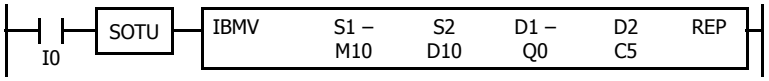
▲ Internal relays M0 through M1277 can be designated as D1. Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as S2 or D2, the timer/counter current value (TC or CC) is displayed.

Make sure that the last source data determined by S1+S2 and the last destination data determined by D1+D2 are within the valid device range. If the derived source or destination device exceeds the valid device range, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

Source device S2 or destination device D2 does not have to be assigned. If S2 or D2 is not assigned, the source or destination device is determined by S1 or D1 without offset.

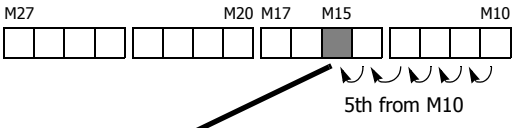
Examples: IBMV



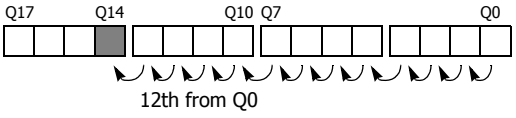
M10 + D10 → Q0 + C5

Source device S1 and destination device D1 determine the type of device. Source device S2 and destination device D2 are the offset values to determine the source and destination devices.

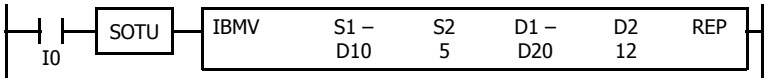
If the value of data register D10 assigned by source device S2 is 5, the source data is determined by adding the offset value to internal relay M10 assigned by source device S1.



If the current value of counter C5 assigned by destination device D2 is 12, the destination is determined by adding the offset value to output Q0 assigned by destination device D1.



As a result, when input I0 is on, the ON/OFF status of internal relay M15 is moved to output Q14.

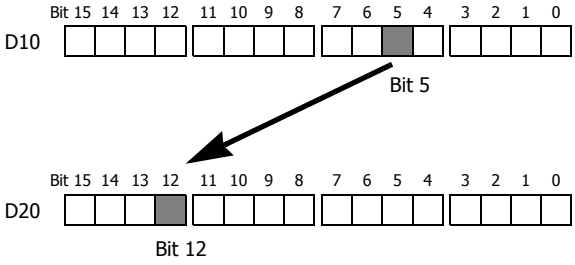


D10 + 5 → D20 + 12

Since source device S1 is a data register and the value of source device S2 is 5, the source data is bit 5 of data register D10 assigned by source device S1.

Since destination device D1 is a data register and the value of source device D2 is 12, the destination is bit 12 of data register D20 assigned by destination device D1.

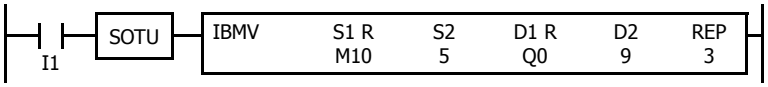
As a result, when input I0 is on, the ON/OFF status of data register D10 bit 5 is moved to data register D20 bit 12.



Repeat Operation in the Indirect Bit Move Instructions

Repeat Bit Devices (Source and Destination)

If a repeat operation is set for bit devices such as input, output, internal relay, or shift register, as many bit devices as the repeat cycles are moved.

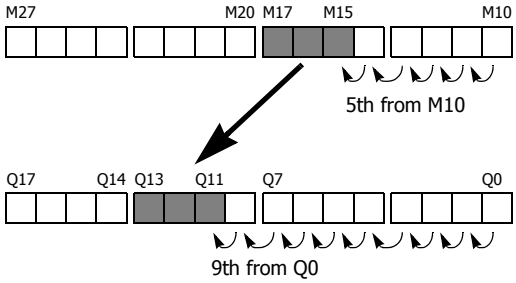


M10 + 5 → Q0 + 9
Repeat = 3

Since source device S1 is internal relay M10 and the value of source device S2 is 5, the source data is 3 internal relays starting with M15.

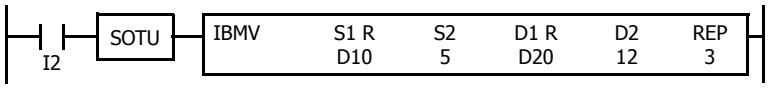
Since destination device D1 is output Q0 and the value of destination device D2 is 9, the destination is 3 outputs starting with Q11.

As a result, when input I1 is on, the ON/OFF statuses of internal relays M15 through M17 are moved to outputs Q11 through Q13.



Repeat Word Devices (Source and Destination)

If a repeat operation is for word devices such as data register, as many bit devices as the repeat cycles in the designated data register are moved.

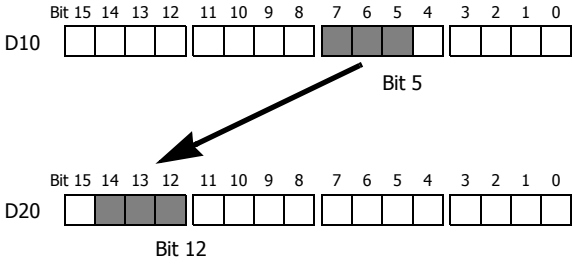


D10 + 5 → D20 + 12
Repeat = 3

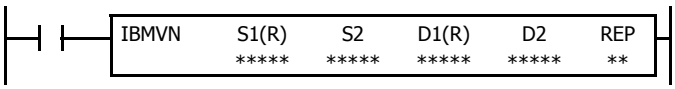
Since source device S1 is data register D10 and the value of source device S2 is 5, the source data is 3 bits starting with bit 5 of data register D10.

Since destination device D1 is data register D20 and the value of destination device D2 is 12, the destination is 3 bits starting with bit 12 of data register D20.

As a result, when input I2 is on, the ON/OFF statuses of data register D10 bits 5 through 7 are moved to data register D20 bits 12 through 14.



IBMVN (Indirect Bit Move Not)



S1 + S2 NOT → D1 + D2

When input is on, the values contained in devices assigned by S1 and S2 are together added to determine the data source. The 1-bit data is then inverted and moved to the destination, which is determined by the sum of values contained in devices assigned by D1 and D2.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	Base address to move from	X	X	X	X	—	—	X	0 or 1	1-99
S2 (Source 2)	Offset for S1	X	X	X	X	X	X	X	0-65535	—
D1 (Destination 1)	Base address to move to	—	X	▲	X	—	—	X	—	1-99
D2 (Destination 2)	Offset for D1	X	X	X	X	X	X	X	0-65535	—

For valid device address ranges, see "Device Addresses" on page 3-1.

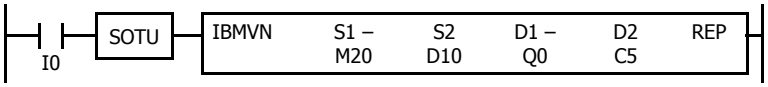
▲ Internal relays M0 through M1277 can be designated as D1. Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as S2 or D2, the timer/counter current (TC or CC) value is displayed.

Make sure that the last source data determined by S1+S2 and the last destination data determined by D1+D2 are within the valid device range. If the derived source or destination device exceeds the valid device range, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

Source device S2 or destination device D2 does not have to be used. If S2 or D2 are not used, the source or destination device is determined by S1 or D1 without offset.

Examples: IBMVN

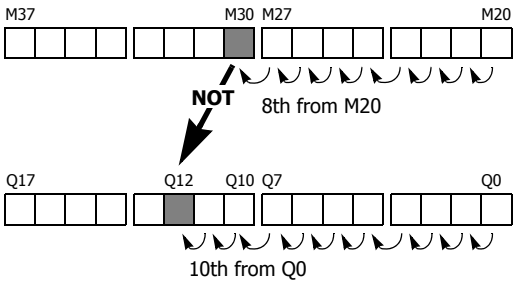


M20 + D10 NOT → Q0 + C5

Source device S1 and destination device D1 determine the type of device. Source device S2 and destination device D2 are the offset values used to determine the source and destination devices.

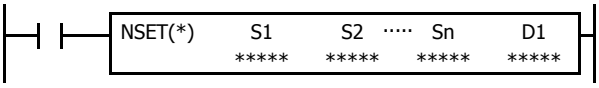
If the value of data register D10 assigned by source device S2 is 8, the source data is determined by adding the offset value to internal relay M20 assigned by source device S1.

If the current value of counter C5 assigned by destination device D2 is 10, the destination is determined by adding the offset value to output Q0 assigned by destination device D1.



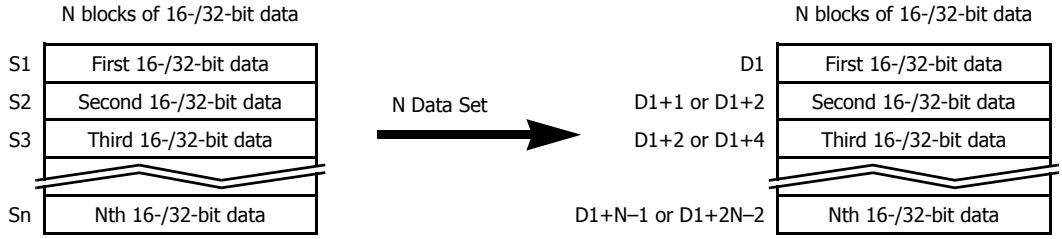
As a result, when input I0 is on, the ON/OFF status of internal relay M30 is inverted and moved to output Q12.

NSET (N Data Set)



S1, S2, S3, ... , Sn → D1, D2, D3, ... , Dn

When input is on, N blocks of 16- or 32-bit data in devices assigned by S1, S2, S3, ... , Sn are moved to N blocks of destinations, starting with device assigned by D1.



Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	First device address to move	X	X	X	X	X	X	X	X	—
D1 (Destination 1)	First device address to move to	—	X	▲	X	X	X	X	—	—

For valid device address ranges, see "Device Addresses" on page 3-1.

▲ Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as S1, the timer/counter current value (TC or CC) is displayed. When T (timer) or C (counter) is used as D1, the data is written in as a preset value (TP or CP).

When F (float) data is selected, only data register and constant can be designated as S1, and only data register can be designated as D1.

When F (float) data is selected and S1 does not comply with the normal floating-point format, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS.

Make sure that the last destination data determined by D1+N-1 (word or integer data) or D1+2N-2 (double-word, long, or float data) is within the valid device range. If the derived destination device exceeds the valid device range, a user program execution error will result, turning on special internal relay M8004 and ERROR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

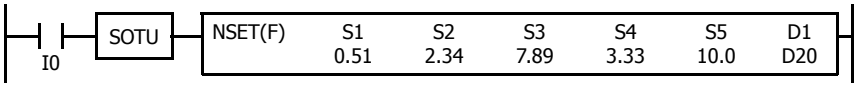
Valid Data Types

W (word)	X
I (integer)	X
D (double word)	X
L (long)	X
F (float)	X

When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source or destination, 16 points (word or integer data) or 32 points (double-word or long data) are used.

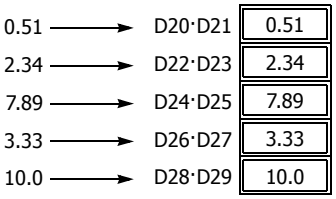
When a word device such as T (timer), C (counter), or D (data register) is assigned as the source or destination, 1 point (word or integer data) or 2 points (double-word, long, or float data) are used.

Example: NSET(F)

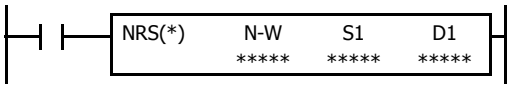


Five constants 0.51, 2.34, 7.89, 3.33, and 10.0 → D20 through D29

When input I0 is turned on, 5 constants assigned by source devices S1 through S5 are moved to 10 data registers starting with D20 assigned by destination device D1.

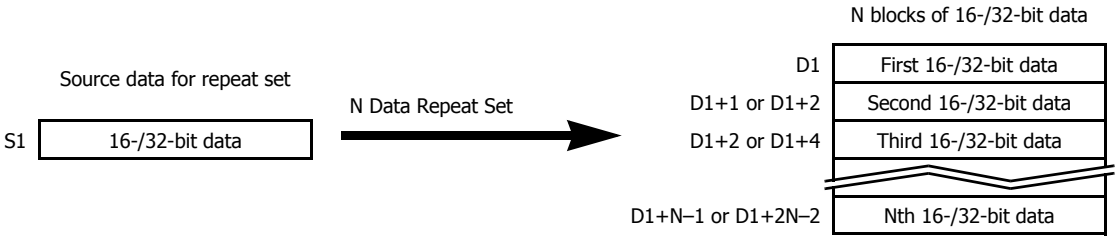


NRS (N Data Repeat Set)



S1 → D1, D2, D3, ... , Dn–1

When input is on, 16- or 32-bit data assigned by S1 is set to N blocks of destinations, starting with device assigned by D1.



Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
N-W (N blocks)	Quantity of blocks to move	X	X	X	X	X	X	X	X	—
S1 (Source 1)	First device address to move	X	X	X	X	X	X	X	X	—
D1 (Destination 1)	First device address to move to	—	X	▲	X	X	X	X	—	—

For valid device address ranges, see "Device Addresses" on page 3-1.

For the N-W, 1 word (16 bits) is always used without regard to the data type.

▲ Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as N-W or S1, the timer/counter current value (TC or CC) is displayed. When T (timer) or C (counter) is used as D1, the data is written in as a preset value (TP or CP).

When F (float) data is selected, only data register and constant can be designated as S1, and only data register can be designated as D1.

When F (float) data is selected and S1 does not comply with the normal floating-point format, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS.

Make sure that the last destination data determined by D1+N-1 (word or integer data) or D1+2N-2 (double-word, long, or float data) is within the valid device range. If the derived destination device exceeds the valid device range, a user program execution error will result, turning on special internal relay M8004 and ERROR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

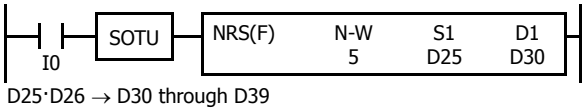
Valid Data Types

W (word)	X
I (integer)	X
D (double word)	X
L (long)	X
F (float)	X

When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source or destination, 16 points (word or integer data) or 32 points (double-word or long data) are used.

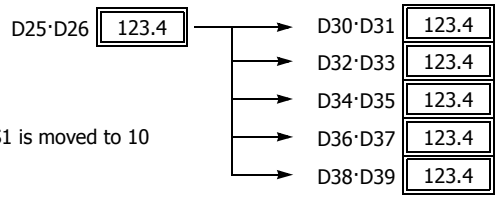
When a word device such as T (timer), C (counter), or D (data register) is assigned as the source or destination, 1 point (word or integer data) or 2 points (double-word, long, or float data) are used.

Example: NRS(F)

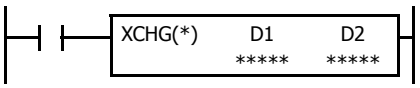


D25·D26 → D30 through D39

When input I0 is turned on, data of data registers D25·D26 assigned by source device S1 is moved to 10 data registers starting with D30 assigned by destination device D1.



XCHG (Exchange)



Word data: D1 ↔ D2
Double-word data: D1·D1+1 → D2, D2+1

When input is on, the 16- or 32-bit data in devices assigned by D1 and D2 are exchanged with each other.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
D1 (Destination 1)	First device address to exchange	—	X	▲	X	—	—	X	—	—
D2 (Destination 2)	First device address to exchange	—	X	▲	X	—	—	X	—	—

For valid device address ranges, see "Device Addresses" on page 3-1.

▲ Internal relays M0 through M1277 can be designated as D1 or D2. Special internal relays cannot be designated as D1 or D2.

Valid Data Types

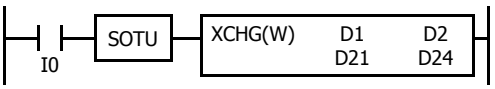
W (word)	X
I (integer)	—
D (double word)	X
L (long)	—
F (float)	—

When a bit device such as Q (output), M (internal relay), or R (shift register) is assigned as the destination, 16 points (word data) or 32 points (double-word data) are used.

When a word device such as D (data register) is assigned as the destination, 1 point (word data) or 2 points (double-word data) are used.

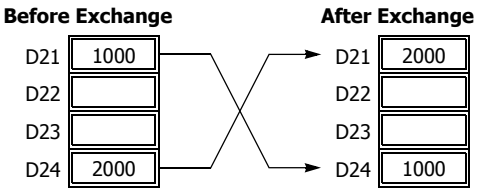
Examples: XCHG

- **Data Type: Word**

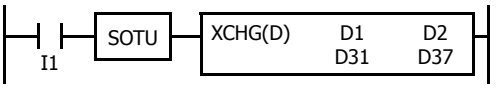


D21 ↔ D24

When input I0 is turned on, data of data registers D21 and D24 assigned by devices D1 and D2 are exchanged with each other.

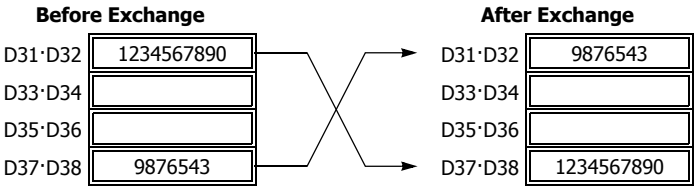


- **Data Type: Double Word**

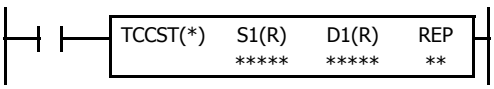


D31·D32 ↔ D37·D38

When input I1 is turned on, data of data registers D31·D32 and D37·D38 assigned by devices D1 and D2 are exchanged with each other.



TCCST (Timer/Counter Current Value Store)



S1 → D1
When input is on, 16- or 32-bit data assigned by S1 is displayed and stored to the current value of device assigned by D1.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	First device address to move	X	X	X	X	X	X	X	X	1-99
D1 (Destination 1)	First device address to move to	—	—	—	—	X	X	—	—	1-99

For valid device address ranges, see "Device Addresses" on page 3-1.

When T (timer) or C (counter) is used as S1, the timer/counter current value (TC or CC) is displayed. T (timer) or C (counter) is used as D1, and the data is written in as a current value (TP or CP).

Since the TCCST instruction is executed in each scan while input is on, a pulse input from a SOTU or SOTD instruction should be used.

Valid Data Types

W (word)	X
I (integer)	—
D (double word)	X
L (long)	—
F (float)	—

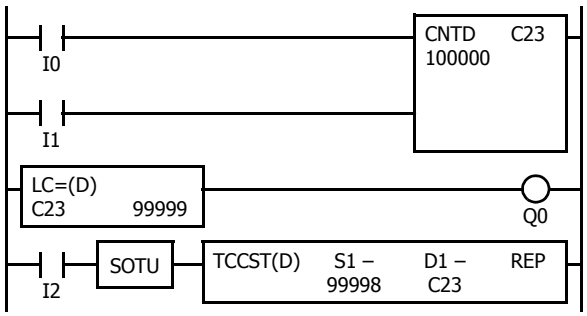
When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source, 16 points (word data) or 32 points (double-word data) are used. When repeat is assigned for a bit device, the quantity of device bits increases in 16- or 32-point increments.

When a word device such as T (timer), C (counter), or D (data register) is assigned as the source or destination, 1 point (word data) or 2 points (double-word data) are used. When repeat is assigned for a word device, the quantity of device words increases in 1- or 2-point increments.

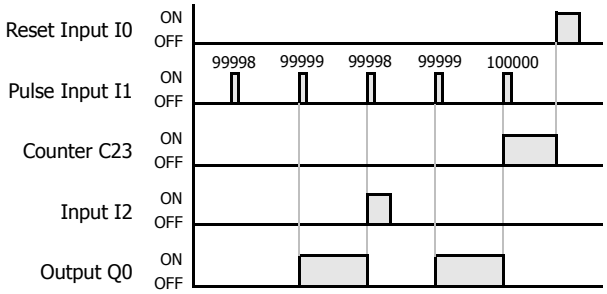
Example: TCCST

When input I2 is turned on, 99998 is written to the current value of counter C23.

Ladder Diagram



Timing Chart



7: DATA COMPARISON INSTRUCTIONS

Introduction

Data can be compared using data comparison instructions, such as equal to, unequal to, less than, greater than, less than or equal to, and greater than or equal to. When the comparison result is true, an output or internal relay is turned on. The repeat operation can also be used to compare more than one set of data.

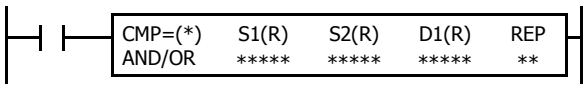
When the repeat operation is enabled, repeated comparison results of CMP instructions can be selected from AND or OR operation, and the result is outputted to an output or internal relay.

Three values can also be compared using the ICMP>= instruction.

Load comparison instructions load comparison results so that the following instructions can be initiated.

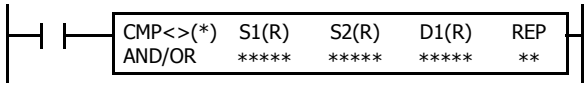
Since the data comparison instructions are executed in each scan while input is on, a pulse input from a SOTU or SOTD instruction should be used.

CMP= (Compare Equal To)



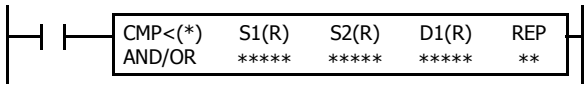
Data type W or I: S1 = S2 → D1 on
Data type D, L, or F: S1·S1+1 = S2·S2+1 → D1 on
When input is on, 16- or 32-bit data assigned by source devices S1 and S2 are compared. When S1 data is equal to S2 data, destination device D1 is turned on. When the condition is not met, D1 is turned off.

CMP<> (Compare Unequal To)



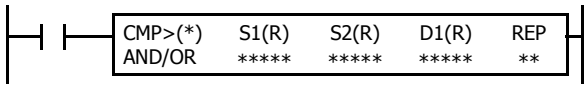
Data type W or I: S1≠ S2 → D1 on
Data type D, L, or F: S1·S1+1 ≠ S2·S2+1 → D1 on
When input is on, 16- or 32-bit data assigned by source devices S1 and S2 are compared. When S1 data is not equal to S2 data, destination device D1 is turned on. When the condition is not met, D1 is turned off.

CMP< (Compare Less Than)



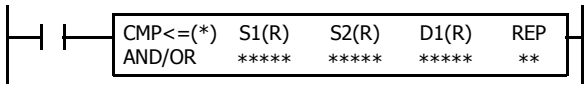
Data type W or I: S1 < S2 → D1 on
Data type D, L, or F: S1·S1+1 < S2·S2+1 → D1 on
When input is on, 16- or 32-bit data assigned by source devices S1 and S2 are compared. When S1 data is less than S2 data, destination device D1 is turned on. When the condition is not met, D1 is turned off.

CMP> (Compare Greater Than)



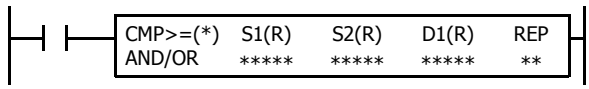
Data type W or I: S1 > S2 → D1 on
Data type D, L, or F: S1·S1+1 > S2·S2+1 → D1 on
When input is on, 16- or 32-bit data assigned by source devices S1 and S2 are compared. When S1 data is greater than S2 data, destination device D1 is turned on. When the condition is not met, D1 is turned off.

CMP<= (Compare Less Than or Equal To)



Data type W or I: S1 ≤ S2 → D1 on
Data type D, L, or F: S1·S1+1 ≤ S2·S2+1 → D1 on
When input is on, 16- or 32-bit data assigned by source devices S1 and S2 are compared. When S1 data is less than or equal to S2 data, destination device D1 is turned on. When the condition is not met, D1 is turned off.

CMP>= (Compare Greater Than or Equal To)



Data type W or I: S1 ≥ S2 → D1 on
Data type D, L, or F: S1·S1+1 ≥ S2·S2+1 → D1 on
When input is on, 16- or 32-bit data assigned by source devices S1 and S2 are compared. When S1 data is greater than or equal to S2 data, destination device D1 is turned on. When the condition is not met, D1 is turned off.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
Repeat Result	Logical AND or OR operation	—	—	—	—	—	—	—	—	—
S1 (Source 1)	Data to compare	X	X	X	X	X	X	X	X	1-99
S2 (Source 2)	Data to compare	X	X	X	X	X	X	X	X	1-99
D1 (Destination 1)	Comparison output	—	X	▲	—	—	—	—	—	1-99

For valid device address ranges, see "Device Addresses" on page 3-1.

When only S1 and/or S2 is repeated, the logical operation type can be selected from AND or OR.

▲ Internal relays M0 through M1277 can be designated as D1. Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as S1 or S2, the timer/counter current value (TC or CC) is displayed.

When F (float) data is selected, only data register and constant can be designated as S1 and S2.

When F (float) data is selected and S1 or S2 does not comply with the normal floating-point format, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

Valid Data Types

W (word)	X
I (integer)	X
D (double word)	X
L (long)	X
F (float)	X

When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source, 16 points (word or integer data) or 32 points (double-word or long data) are used. When repeat is assigned for a bit device, the quantity of device bits increases in 16- or 32-point increments.

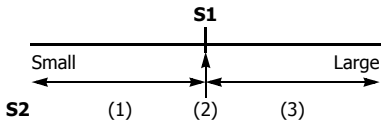
When a word device such as T (timer), C (counter), or D (data register) is assigned as the source, 1 point (word or integer data) or 2 points (double-word, long, or float data) are used. When repeat is assigned for a word device, the quantity of device words increases in 1- or 2-point increments.

When an output or internal relay is assigned as the destination, only 1 point is used regardless of the selected data type. When repeat is assigned for the destination, outputs or internal relays as many as the repeat cycles are used.

Special Internal Relays M8150, M8151, and M8152 in CMP=

Three special internal relays are available to indicate the comparison result of the CMP= instruction. Depending on the result, one of the three special internal relays turns on.

When S1 > S2, M8150 turns on.
When S1 = S2, M8151 turns on.
When S1 < S2, M8152 turns on.



S2 Value	M8150	M8151	M8152	D1 Status
(1) S1 > S2	**ON**	OFF	OFF	OFF
(2) S1 = S2	OFF	**ON**	OFF	**ON**
(3) S1 < S2	OFF	OFF	**ON**	OFF

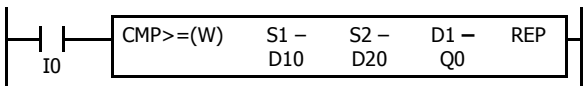
When repeat is designated, the comparison result of the last repeat cycle turns on one of the three special internal relays.

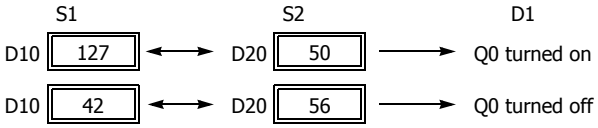
When more than one CMP = or ICMP>= instruction is used, M8150, M8151, or M8152 indicates the result of the instruction that was executed last.

Examples: CMP>=

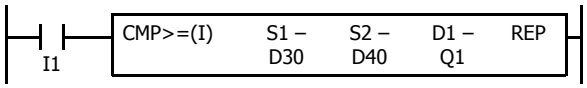
The following examples are described using the CMP≥ instruction. Data comparison operation for all other data comparison instructions is the same for the CMP≥ instruction.

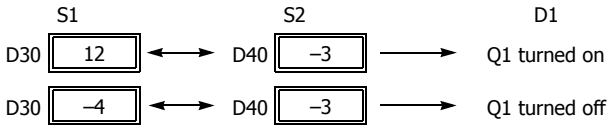
- **Data Type: Word**



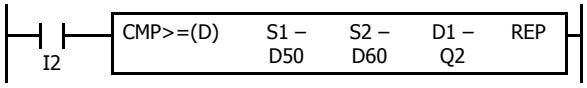


- **Data Type: Integer**

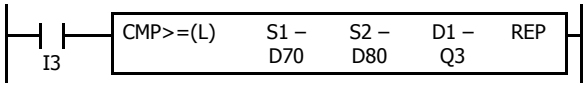


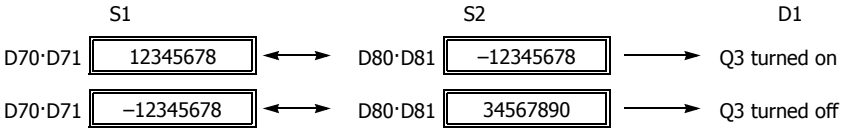


- **Data Type: Double Word**

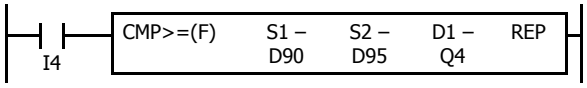


- **Data Type: Long**





- **Data Type: Float**



Repeat Operation in the Data Comparison Instructions

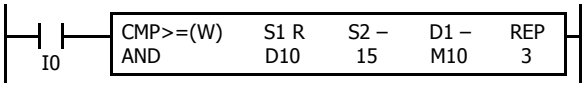
The following examples use the CMP≥ instruction of word and double word data. Repeat operation for all other data comparison instructions and other data types is the same as the following examples.

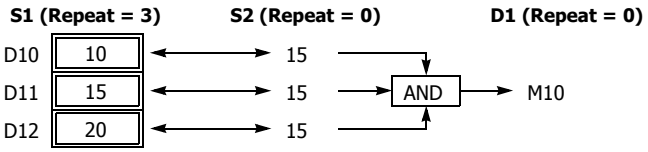
When the repeat operation is enabled, repeated comparison results of CMP instructions can be selected from AND or OR operation, and the result is output to an output or internal relay.

Repeat One Source Device

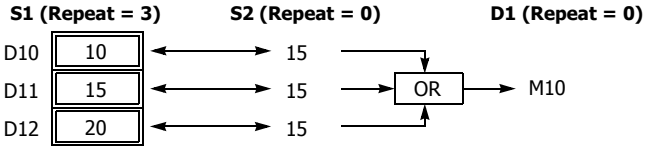
When only S1 (source) is designated to repeat, source devices (as many as the repeat cycles, starting with the device designated by S1) are compared with the device designated by S2. The comparison results are ANDed or ORed and set to the destination device designated by D1.

- **Data Type: Word (Repeat Logical Operation AND)**

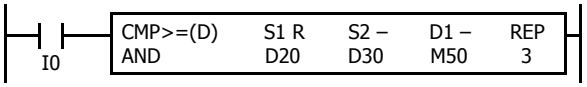


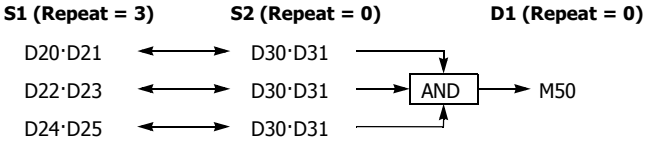


- **Data Type: Word (Repeat Logical Operation OR)**



- **Data Type: Double Word (Repeat Logical Operation AND)**

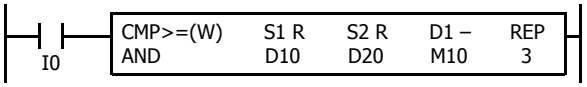


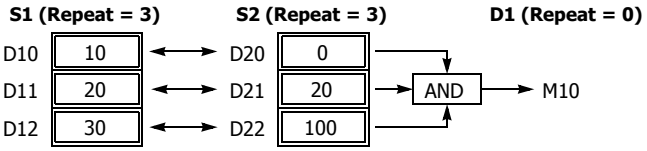


Repeat Two Source Devices

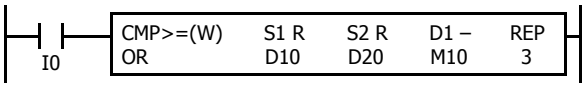
When S1 (source) and S2 (source) are designated to repeat, source devices (as many as the repeat cycles, starting with the devices designated by S1 and S2) are compared with each other. The comparison results are ANDed or ORed and set to the destination device designated by D1.

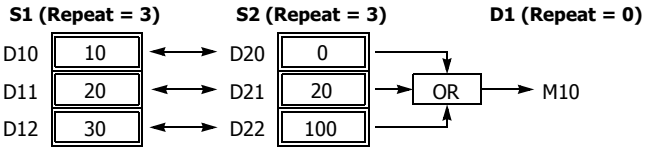
- **Data Type: Word (Repeat Logical Operation AND)**



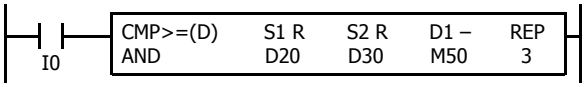


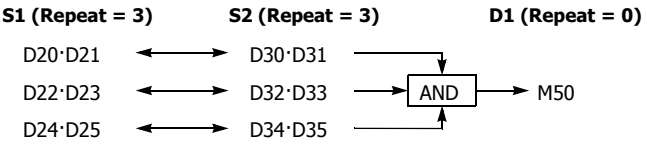
- **Data Type: Word (Repeat Logical Operation OR)**





- **Data Type: Double Word (Repeat Logical Operation AND)**

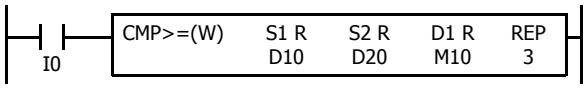


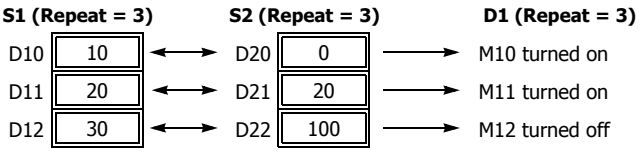


Repeat Source and Destination Devices

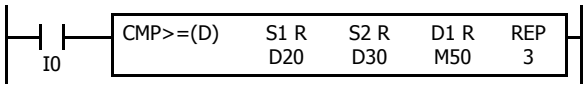
When S1, S2 (source), and D1 (destination) are designated to repeat, source devices (as many as the repeat cycles, starting with the devices designated by S1 and S2) are compared with each other. The comparison results are set to destination devices (as many as the repeat cycles, starting with the device designated by D1).

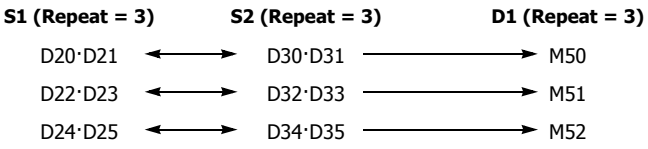
- **Data Type: Word**





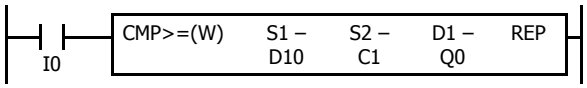
- **Data Type: Double Word**

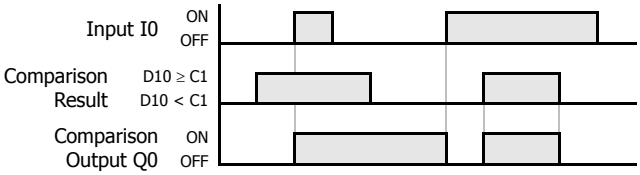




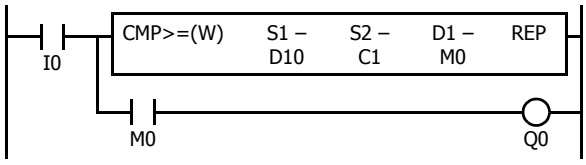
Comparison Output Status

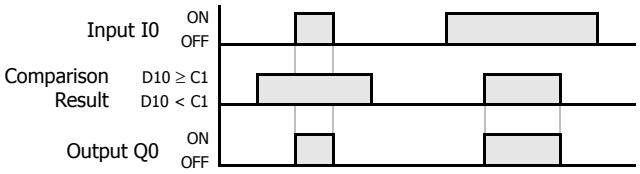
The comparison output is usually maintained while the input to the data comparison instruction is off. If the comparison output is on, the on status is maintained when the input is turned off as demonstrated by this program.



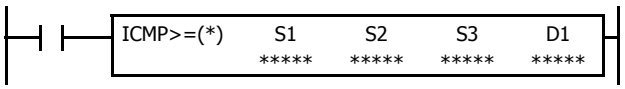


This program turns the output off when the input is off.





ICMP>= (Interval Compare Greater Than or Equal To)



Data type W or I: S1 ≥ S2 ≥ S3 → D1 on
Data type D, L, F: S1·S1+1 ≥ S2·S2+1 ≥ S3·S3+1 → D1 on
When input is on, the 16- or 32-bit data assigned by S1, S2, and S3 are compared. When the condition is met, destination device D1 is turned on. When the condition is not met, D1 is turned off.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	Data to compare	X	X	X	X	X	X	X	X	—
S2 (Source 2)	Data to compare	X	X	X	X	X	X	X	X	—
S3 (Source 3)	Data to compare	X	X	X	X	X	X	X	X	—
D1 (Destination 1)	Comparison output	—	X	▲	—	—	—	—	—	—

For the valid device address range, see "Device Addresses" on page 3-1.

▲ Internal relays M0 through M1277 can be designated as D1. Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as S1, S2, or S3, the timer/counter current value (TC or CC) is displayed.

When F (float) data is selected, only data register and constant can be designated as S1, S2, and S3.

When F (float) data is selected and S1, S2, or S3 does not comply with the normal floating-point format, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS.

When the data of S1 is smaller than that of S3 (S1 < S3), a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

W (word)	X
I (integer)	X
D (double word)	X
L (long)	X
F (float)	X

When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source, 16 points (word or integer data) or 32 points (double-word or long data) are used.

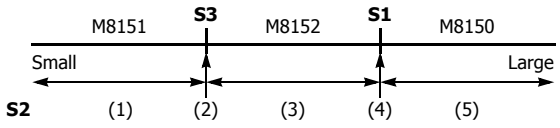
When a word device such as T (timer), C (counter), or D (data register) is assigned as the source, 1 point (word or integer data) or 2 points (double-word, long, or float data) are used.

The destination uses only one output or internal relay regardless of the selected data type.

Special Internal Relays M8150, M8151, and M8152 in ICMP>=

Three special internal relays are available to indicate the comparison result of the ICMP>= instruction. Depending on the result, one of the three special internal relays turns on. S1 must always be greater than or equal to S3 (S1 ≥ S3).

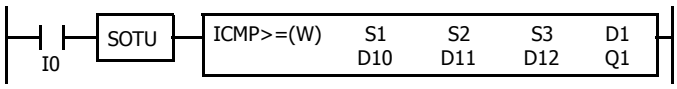
When S2 > S1, M8150 turns on.
When S2 < S3, M8151 turns on.
When S1 > S2 > S3, M8152 turns on.



S2 Value	M8150	M8151	M8152	D1 Status
(1) S2 < S3	OFF	**ON**	OFF	OFF
(2) S2 = S3	OFF	OFF	OFF	**ON**
(3) S3 < S2 < S1	OFF	OFF	**ON**	**ON**
(4) S2 = S1	OFF	OFF	OFF	**ON**
(5) S2 > S1	**ON**	OFF	OFF	OFF

When more than one ICMP>= or CMP= instruction is used, M8150, M8151, or M8152 indicates the result of the instruction that was executed last.

Example: ICMP>=



$D10 \geq D11 \geq D12 \rightarrow$ Q1 goes on

When input I0 is turned on, data of data registers D10, D11, and D12 assigned by source devices S1, S2, and S3 are compared. When the condition is met, internal relay Q1 assigned by destination device D1 is turned on. When the condition is not met, Q1 is turned off.

S1		S2		S3		D1	M8150	M8151	M8152	M8004
D10	17	> D11	15	= D12	15	→ Q1 goes on	OFF	OFF	OFF	OFF
D10	15	< D11	18	< D12	19	→ Q1 goes off	ON	ON	OFF	ON

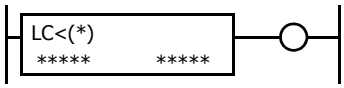
LC= (Load Compare Equal To)

Data type W or I: S1 = S2
Data type D, L, or F: S1·S1+1 = S2·S2+1
This instruction constantly compares 16- or 32- bit data assigned by S1 and S2. When S1 data is equal to S2 data, the output to the following instructions is turned on. When the condition is not met, the output is turned off.

LC<> (Load Compare Unequal To)

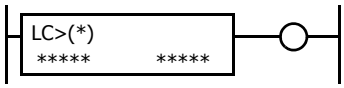
Data type W or I: S1 ≠ S2
Data type D, L, or F: S1·S1+1 ≠ S2·S2+1
This instruction constantly compares 16- or 32- bit data assigned by S1 and S2. When S1 data is not equal to S2 data, the output to the following instructions is turned on. When the condition is not met, the output is turned off.

LC< (Load Compare Less Than)



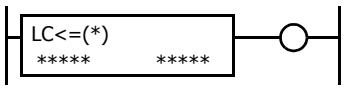
Data type W or I: S1 < S2
Data type D, L, or F: S1·S1+1 < S2·S2+1
This instruction constantly compares 16- or 32- bit data assigned by S1 and S2. When S1 data is less than S2 data, the output to the following instructions is turned on. When the condition is not met, the output is turned off.

LC> (Load Compare Greater Than)



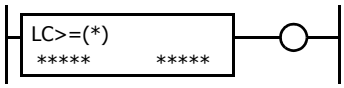
Data type W or I: S1 > S2
Data type D, L, or F: S1·S1+1 > S2·S2+1
This instruction constantly compares 16- or 32- bit data assigned by S1 and S2. When S1 data is greater than S2 data, the output to the following instructions is turned on. When the condition is not met, the output is turned off.

LC<= (Load Compare Less Than or Equal To)



Data type W or I: S1 ≤ S2
Data type D, L, or F: S1·S1+1 ≤ S2·S2+1
This instruction constantly compares 16- or 32- bit data assigned by S1 and S2. When S1 data is less than or equal to S2 data, the output to the following instructions is turned on. When the condition is not met, the output is turned off.

LC>= (Load Compare Greater Than or Equal To)



Data type W or I: S1 ≥ S2
Data type D, L, or F: S1·S1+1 ≥ S2·S2+1
This instruction constantly compares 16- or 32- bit data assigned by S1 and S2. When S1 data is greater than or equal to S2 data, the output to the following instructions is turned on. When the condition is not met, the output is turned off.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	Data to compare	X	X	X	X	X	X	X	X	—
S2 (Source 2)	Data to compare	X	X	X	X	X	X	X	X	—

For valid device address ranges, see "Device Addresses" on page 3-1.

When T (timer) or C (counter) is used, the timer/counter current value (TC or CC) is displayed.

When F (float) data is selected, only data register and constant can be designated.

When F (float) data is selected and S1 or S2 does not comply with the normal floating-point format, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS. The output to the following instructions is turned off. For user program execution errors, see "User Program Execution Errors" on page 4-13.

Valid Data Types

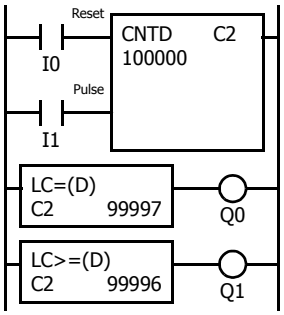
W (word)	X
I (integer)	X
D (double word)	X
L (long)	X
F (float)	X

When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned, 16 points (word or integer data) or 32 points (double-word or long data) are used.

When a word device such as T (timer), C (counter), or D (data register) is assigned, 1 point (word or integer data) or 2 points (double-word, long, or float data) are used.

Examples: LC

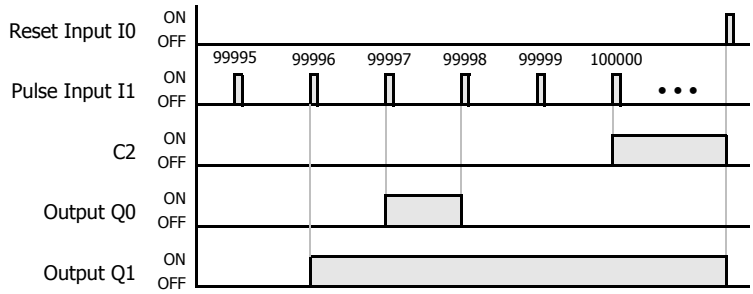
Ladder Diagram 1



Program List

Instruction	Data
LOD	I0
LOD	I1
CNTD	C2
	100000
LC=(D)	C2
	99997
OUT	Q0
LC>=(D)	C2
	99996
OUT	Q1

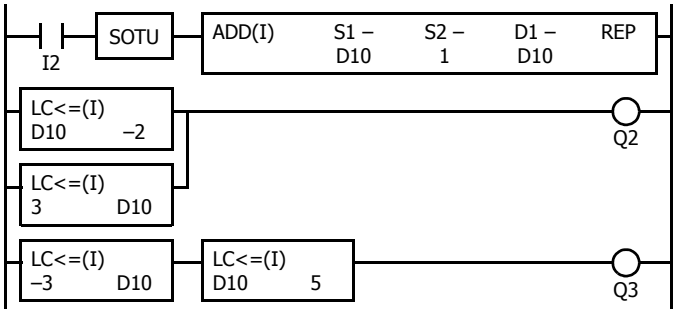
Timing Chart



Output Q0 is on when counter C2 current value is 99997.

Output Q1 is turned on when counter C2 current value reaches 99996 and remains on until counter C2 is reset.

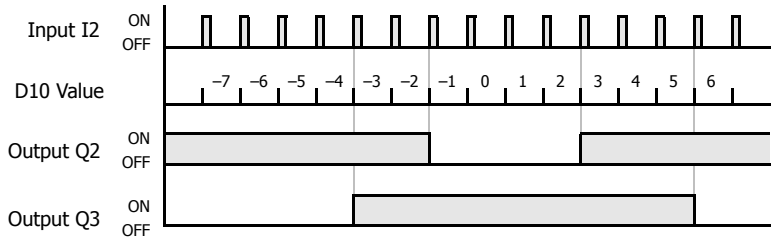
Ladder Diagram 2



Program List

Instruction	Data
LOD	I2
SOTU	
ADD(I)	D10
	1
	D10
LC<=(I)	D10
	–2
LC<=(I)	3
	D10
ORLOD	
OUT	Q2
LC<=(I)	–3
	D10
LC<=(I)	D10
	5
ANDLOD	
OUT	Q3

Timing Chart



Output Q2 is on when data register D10 is less than or equal to –2 and greater than or equal to 3.

Output Q3 is on while data register D10 is between –3 and 5.

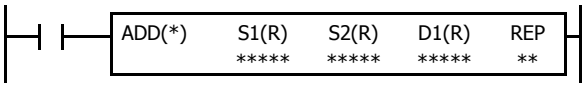
8: BINARY ARITHMETIC INSTRUCTIONS

Introduction

The binary arithmetic instructions make it possible for the user to program computations using addition, subtraction, multiplication, and division. For addition and subtraction devices, internal relay M8003 is used to carry or to borrow.

The ROOT instruction can be used to calculate the square root of the value stored in one or two data registers.

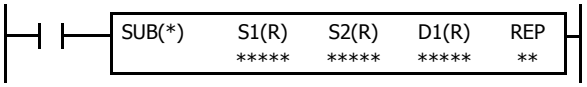
ADD (Addition)



Data type W or I: S1 + S2 → D1, CY
Data type D, L, or F: S1·S1+1 + S2·S2+1 → D1·D1+1, CY

When input is on, 16- or 32-bit data assigned by source devices S1 and S2 are added together. The result is set to destination device D1 and internal relay M8003 (carry or borrow).

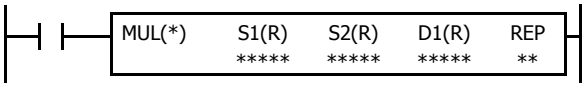
SUB (Subtraction)



Data type W or I: S1 – S2 → D1, BW
Data type D, L, or F: S1·S1+1 – S2·S2+1 → D1·D1+1, BW

When input is on, 16- or 32-bit data assigned by source device S2 is subtracted from 16- or 32-bit data assigned by source device S1. The result is set to destination device D1 and internal relay M8003 (carry or borrow).

MUL (Multiplication)

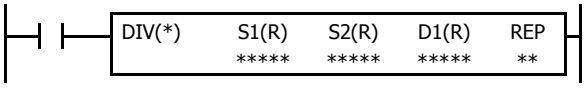


Data type W or I: S1 × S2 → D1·D1+1
Data type D, L, or F: S1·S1+1 × S2·S2+1 → D1·D1+1

When input is on, 16- or 32-bit data assigned by source device S1 is multiplied by 16- or 32-bit data assigned by source device S2. The result is set to destination device D1.

When the result exceeds the valid range for data types D or L, the ERR LED and special internal relay M8004 (user program execution error) are turned on.

DIV (Division)



Data type W or I: S1 ÷ S2 → D1 (quotient), D1+1 (remainder)
Data type D or L:
S1·S1+1 ÷ S2·S2+1 → D1·D1+1 (quotient), D1+2·D1+3 (remainder)
Data type F:
S1·S1+1 ÷ S2·S2+1 → D1·D1+1 (quotient)

When input is on, 16- or 32-bit data assigned by source device S1 is divided by 16- or 32-bit data assigned by source device S2. The quotient is set to 16- or 32-bit destination device D1, and the remainder is set to the next 16- or 32-bit data. Data type F does not generate a remainder.

When S2 is 0 (dividing by 0), the ERR LED and special internal relay M8004 (user program execution error) are turned on.

A user program execution error also occurs in the following division operations.

Data type I: –32768 ÷ (–1)
Data type L: –2147483648 ÷ (–1)

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	Data for calculation	X	X	X	X	X	X	X	X	1-99
S2 (Source 2)	Data for calculation	X	X	X	X	X	X	X	X	1-99
D1 (Destination 1)	Destination to store results	—	X	▲	X	X	X	X	—	1-99

For valid device address ranges, see "Device Addresses" on page 3-1.

▲ Internal relays M0 through M1277 can be designated as D1. Special internal relays cannot be designated as D1.

When T (timer) or C (counter) is used as S1 or S2, the timer/counter current value (TC or CC) is displayed. When T (timer) or C (counter) is used as D1, the data is written in as a preset value (TP or CP) which can be 0 through 65535.

When F (float) data is selected, only data register and constant can be designated as S1 and S2.

When F (float) data is selected and S1 or S2 does not comply with the normal floating-point format, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

Since the binary arithmetic instructions are executed in each scan while input is on, a pulse input from a SOTU or SOTD instruction should be used.

Valid Data Types

W (word)	X
I (integer)	X
D (double word)	X
L (long)	X
F (float)	X

When a bit device such as I (input), Q (output), M (internal relay), or R (shift register) is assigned as the source, 16 points (word or integer data) or 32 points (double-word, long, or float data) are used. When repeat is assigned for a bit device, the quantity of device bits increases in 16- or 32-point increments.

When a word device such as T (timer), C (counter), or D (data register) is assigned as the source, 1 point (word or integer data) or 2 points (double-word, long, or float data) are used. When repeat is assigned for a word device, the quantity of device words increases in 1- or 2-point increments.

Using Carry or Borrow Signals

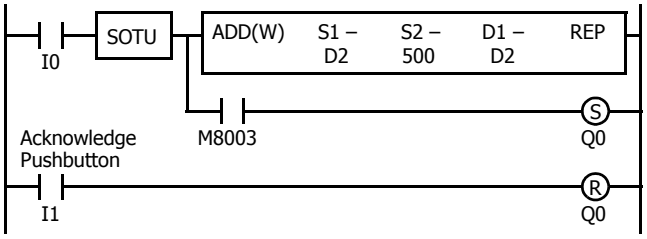
When the D1 (destination) data exceeds the valid data range as a result of any binary arithmetic operation, a carry or borrow occurs, and special internal relay M8003 is turned on.

Data Type	Carry/borrow occurs when D1 exceeds the range between
W (word)	0 and 65,535
I (integer)	–32,768 and 32,767
D (double word)	0 and 4,294,967,295
L (long)	–2,147,483,648 and 2,147,483,647
F (float)	-3.402823×10^{38} and -1.175495×10^{-38} 1.175495×10^{-38} and 3.402823×10^{38}

Examples: ADD

- **Data Type: Word**

This example demonstrates the use of a carry signal from special internal relay M8003 to set an alarm signal.

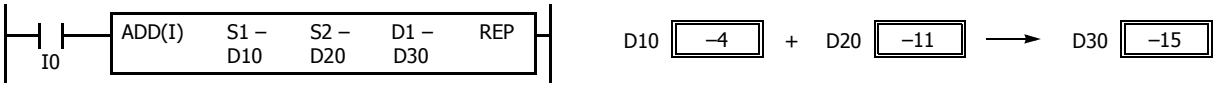


D2 + 500 → D2

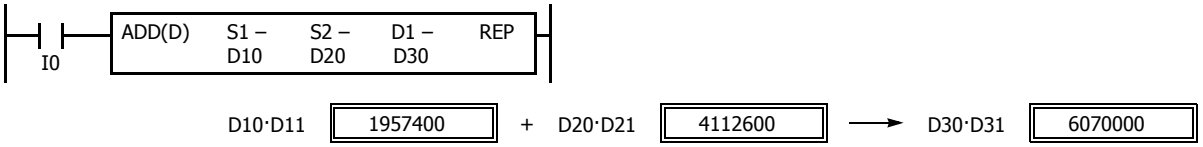
When a carry occurs, output Q0 is assigned as a warning indicator.

When the acknowledge pushbutton (input I1) is pressed, the warning indicator is reset.

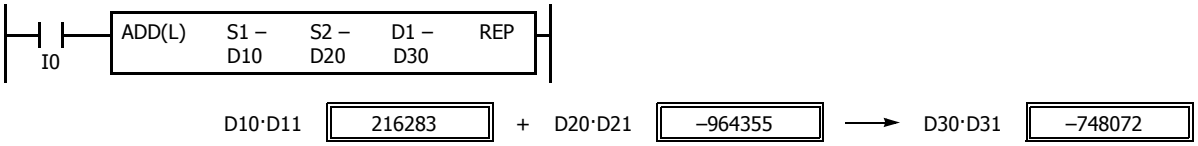
- **Data Type: Integer**



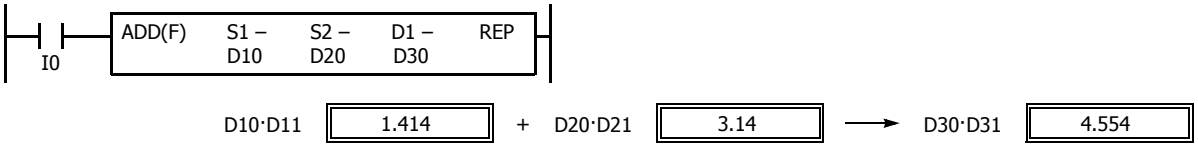
- **Data Type: Double Word**



- **Data Type: Long**



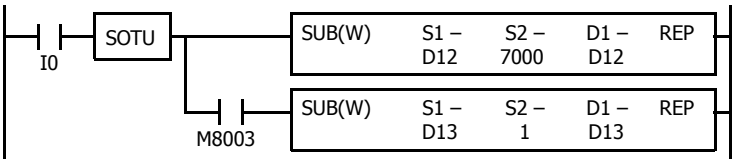
- **Data Type: Float**



Example: SUB

- **Data Type: Word**

The following example demonstrates the use of special internal relay M8003 to process a borrow.



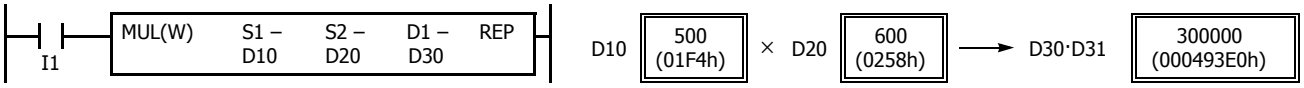
D12 – 7000 → D12

Borrow is processed so that the number of times a borrow occurs is subtracted from D13.

When a borrow occurs, D13 is decremented by one.

Examples: MUL

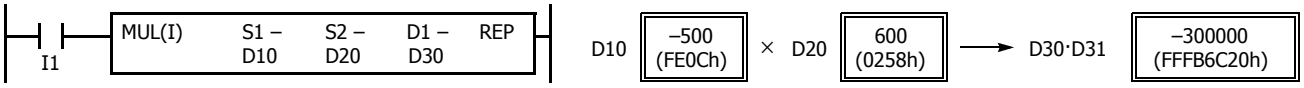
- **Data Type: Word**



When input I1 is on, data of D10 is multiplied by data of D20, and the result is set to D30 and D31.

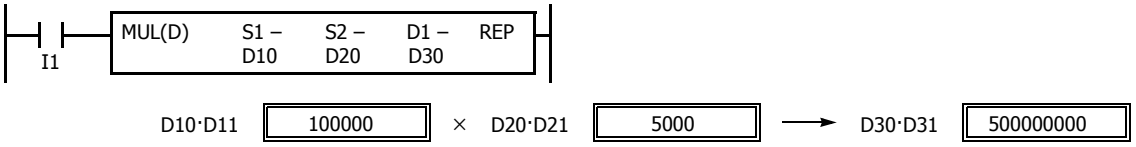
D30	4 (0004h)
D31	37856 (93E0h)

- **Data Type: Integer**



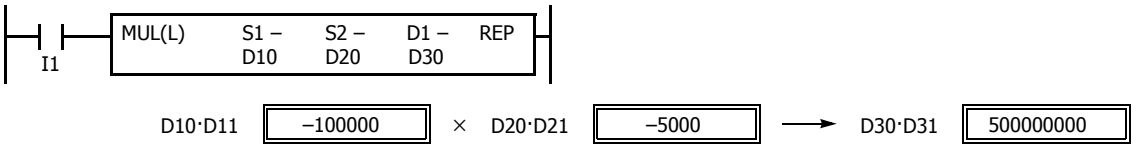
D30	65531 (FFFBh)
D31	27680 (6C20h)

- **Data Type: Double Word**



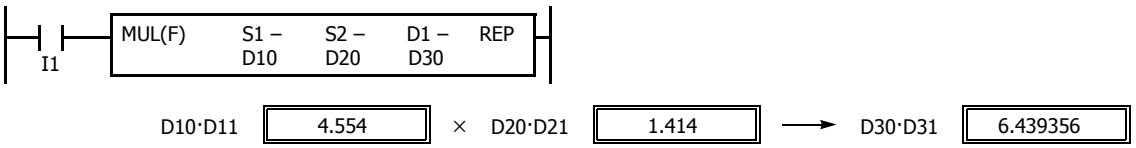
Note: In multiplication of double word data, the lower 32-bit data of the result is set to destination device D1·D1+1.

- **Data Type: Long**



Note: In multiplication of long data, the lower 32-bit data of the result is set to destination device D1·D1+1.

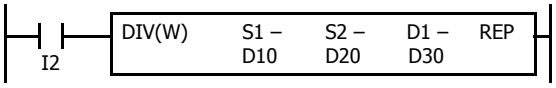
- **Data Type: Float**

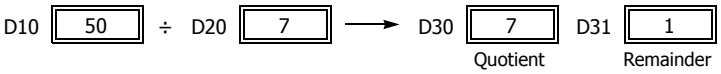


Note: Since the destination uses two word devices in the multiplication operation, data register D999 or D1999 cannot be used as destination device D1. When using a bit device such as internal relay for destination, 32 internal relays are required; so internal relay M1241 or a larger number cannot be used as destination device D1.

Examples: DIV

- **Data Type: Word**

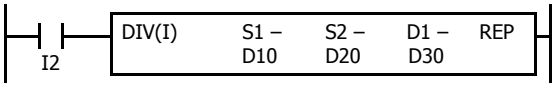


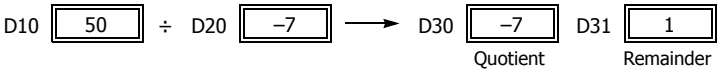


When input I2 is on, D10 data is divided by D20 data. The quotient is set to D30, and the remainder is set to D31.

Note: Since the destination uses two word devices in the division operation of word data, data register D999 or D1999 cannot be used as destination device D1. When using a bit device, such as internal relay for destination, 32 internal relays are required; so M1241 or a larger number cannot be used as destination device D1.

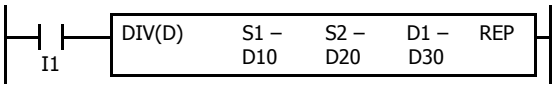
- **Data Type: Integer**

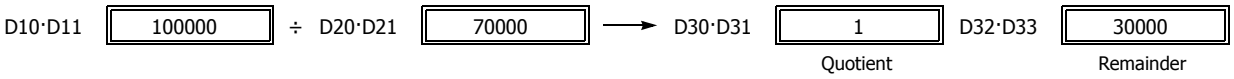




Note: Since the destination uses two word devices in the division operation of integer data, data register D999 or D1999 cannot be used as destination device D1. When using a bit device, such as internal relay for destination, 32 internal relays are required; so M1241 or a larger number cannot be used as destination device D1.

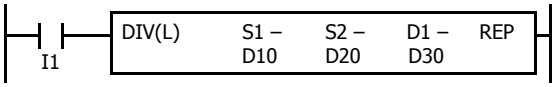
- **Data Type: Double Word**

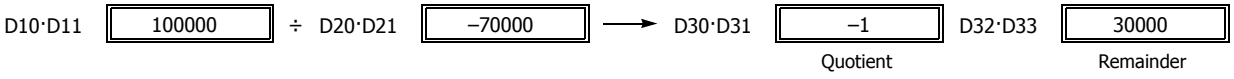




Note: Since the destination uses four word devices in the division operation of double-word data, data registers D997 through D999 or D1997 through D1999 cannot be used as destination device D1. When using a bit device such as internal relay for destination, 64 internal relays are required; so M1201 or a larger number cannot be used as destination device D1.

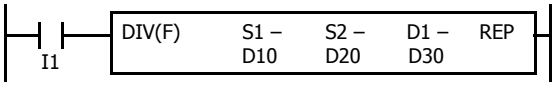
- **Data Type: Long**

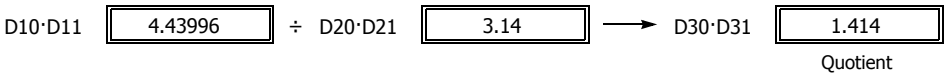




Note: Since the destination uses four word devices in the division operation of long data, data registers D997 through D999 or D1997 through D1999 cannot be used as destination device D1. When using a bit device, such as internal relay for destination, 64 internal relays are required; so M1201 or a larger number cannot be used as destination device D1.

- **Data Type: Float**





Note: Since the destination uses two word devices in the division operation of float data, data register D999 or D1999 cannot be used as destination device D1.

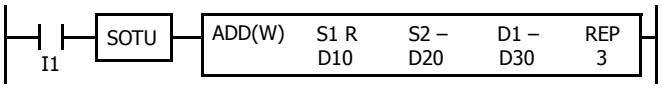
Repeat Operation in the ADD and SUB Instructions

Source devices S1 and S2 and destination device D1 can be assigned to repeat individually or in combination. When destination device D1 is not set to repeat, the final result is set to destination device D1. When repeat is assigned, as many consecutive devices as the repeat cycles, starting with the designated device, are used. Since the repeat operation works similarly on the ADD (addition) and SUB (subtraction) instructions, the following examples are described using the ADD instruction.

Repeat One Source Device

- **Data Type: Word and Integer**

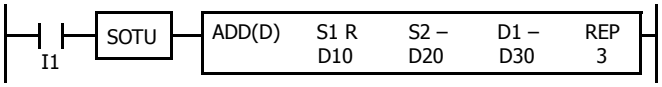
When only S1 (source) is assigned to repeat, the final result is set to destination device D1.



S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 0)
D10	10	+ D20	25	→ D30 (35)
D11	15	+ D20	25	→ D30 (40)
D12	20	+ D20	25	→ D30 45

- **Data Type: Double Word, Long, and Float**

When only S1 (source) is assigned to repeat, the final result is set to destination device D1·D1+1.

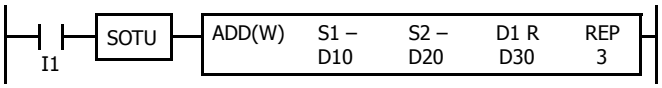


S1 (Repeat = 3)		S2 (Repeat = 0)	D1 (Repeat = 0)
D10·D11	+	D20·D21	→ (D30·D31)
D12·D13	+	D20·D21	→ (D30·D31)
D14·D15	+	D20·D21	→ D30·D31

Repeat Destination Device Only

- **Data Type: Word and Integer**

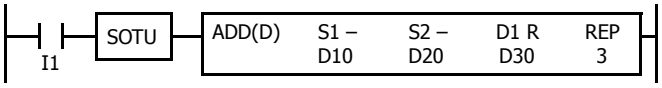
When only D1 (destination) is assigned to repeat, the same result is set to 3 devices starting with D1.



S1 (Repeat = 0)		S2 (Repeat = 0)		D1 (Repeat = 3)
D10	10	+ D20	25	→ D30 35
D10	10	+ D20	25	→ D31 35
D10	10	+ D20	25	→ D32 35

- **Data Type: Double Word, Long, and Float**

When only D1 (destination) is assigned to repeat, the same result is set to 3 devices starting with D1·D1+1.

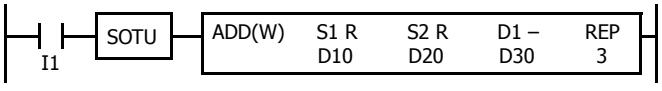


S1 (Repeat = 0)		S2 (Repeat = 0)	D1 (Repeat = 3)
D10·D11	+	D20·D21	→ D30·D31
D10·D11	+	D20·D21	→ D32·D33
D10·D11	+	D20·D21	→ D34·D35

Repeat Two Source Devices

- **Data Type: Word and Integer**

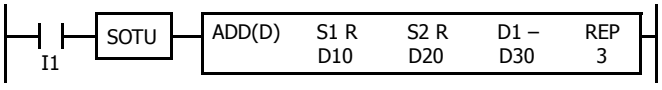
When S1 and S2 (source) are assigned to repeat, the final result is set to destination device D1.



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 0)
D10	10	+ D20	25	→ D30 (35)
D11	15	+ D21	35	→ D30 (50)
D12	20	+ D22	45	→ D30 65

- **Data Type: Double Word, Long, and Float**

When S1 and S2 (source) are assigned to repeat, the final result is set to destination device D1·D1+1.

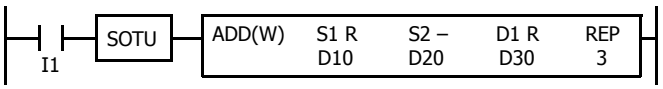


S1 (Repeat = 3)		S2 (Repeat = 3)	D1 (Repeat = 0)
D10·D11	+	D20·D21	→ (D30·D31)
D12·D13	+	D22·D23	→ (D30·D31)
D14·D15	+	D24·D25	→ D30·D31

Repeat Source and Destination Devices

- **Data Type: Word and Integer**

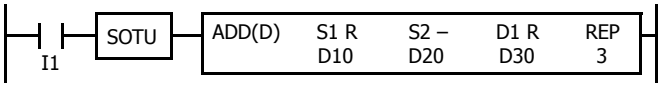
When S1 (source) and D1 (destination) are assigned to repeat, different results are set to 3 devices starting with D1.



S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 3)
D10 10	+	D20 25	→	D30 35
D11 15	+	D20 25	→	D31 40
D12 20	+	D20 25	→	D32 45

- **Data Type: Double Word, Long, and Float**

When S1 (source) and D1 (destination) are assigned to repeat, different results are set to 3 devices starting with D1·D1+1.

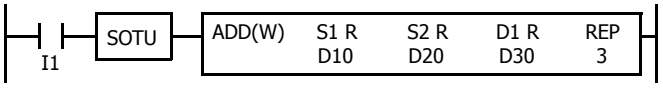


S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 3)
D10·D11	+	D20·D21	→	D30·D31
D12·D13	+	D20·D21	→	D32·D33
D14·D15	+	D20·D21	→	D34·D35

Repeat All Source and Destination Devices

- **Data Type: Word and Integer**

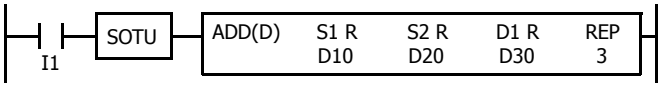
When all devices are assigned to repeat, different results are set to 3 devices starting with D1.



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 3)
D10 10	+	D20 25	→	D30 35
D11 15	+	D21 35	→	D31 50
D12 20	+	D22 45	→	D32 65

- **Data Type: Double Word, Long, and Float**

When all devices are assigned to repeat, different results are set to 3 devices starting with D1·D1+1.



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 3)
D10·D11	+	D20·D21	→	D30·D31
D12·D13	+	D22·D23	→	D32·D33
D14·D15	+	D24·D25	→	D34·D35

Note: Special internal relay M8003 (carry/borrow) is turned on when a carry or borrow occurs in the last repeat operation. When a user program execution error occurs in any repeat operation, special internal relay M8004 (user program execution error) and the ERR LED are turned on and maintained while operations for other instructions continues.

Repeat Operation in the MUL Instruction

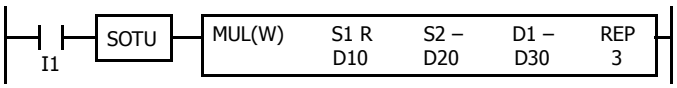
Since the MUL (multiplication) instruction uses two destination devices, the result is stored to destination devices as described below. Source devices S1 and S2 and destination device D1 can be designated to repeat individually or in combination. When destination device D1 is not assigned to repeat, the final result is set to destination device D1 and D1+1. When repeat is designated, consecutive devices as many as the repeat cycles starting with the designated device are used.

Since the repeat operation works similarly on word and integer data, the following examples are described using word data.

Repeat One Source Device

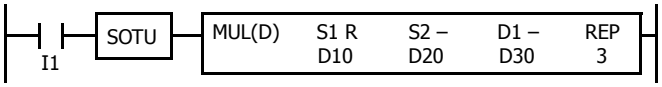
When only S1 (source) is assigned to repeat, the final result is set to destination device D1·D1+1.

- **Data Type: Word and Integer**



S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 0)
D10	×	D20	→	(D30·D31)
D11	×	D20	→	(D30·D31)
D12	×	D20	→	D30·D31

- **Data Type: Double Word, Long, and Float**

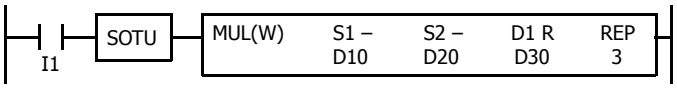


S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 0)
D10·D11	×	D20·D21	→	(D30·D31)
D12·D13	×	D20·D21	→	(D30·D31)
D14·D15	×	D20·D21	→	D30·D31

Repeat Destination Device Only

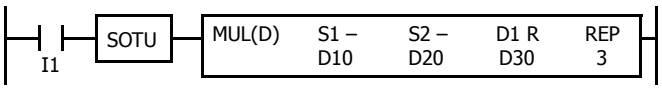
When only D1 (destination) is assigned to repeat, the same result is set to 3 devices starting with D1·D1+1.

- **Data Type: Word and Integer**



S1 (Repeat = 0)		S2 (Repeat = 0)		D1 (Repeat = 3)
D10	×	D20	→	D30·D31
D10	×	D20	→	D32·D33
D10	×	D20	→	D34·D35

- **Data Type: Double Word, Long, and Float**

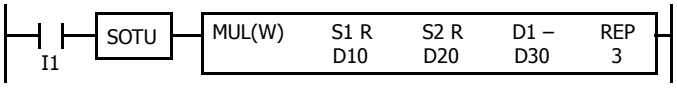


S1 (Repeat = 0)		S2 (Repeat = 0)		D1 (Repeat = 3)
D10·D11	×	D20·D21	→	D30·D31
D10·D11	×	D20·D21	→	D32·D33
D10·D11	×	D20·D21	→	D34·D35

Repeat Two Source Devices

When S1 and S2 (source) are assigned to repeat, the final result is set to destination device D1·D1+1.

- **Data Type: Word and Integer**



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 0)
D10	×	D20	→	(D30·D31)
D11	×	D21	→	(D30·D31)
D12	×	D22	→	D30·D31

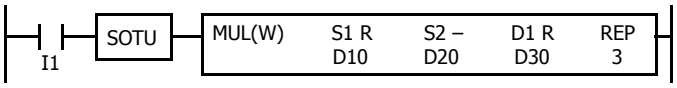
- **Data Type: Double Word, Long, and Float**

S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 0)
D10·D11	×	D20·D21	→	(D30·D31)
D12·D13	×	D22·D23	→	(D30·D31)
D14·D15	×	D24·D25	→	D30·D31

Repeat Source and Destination Devices

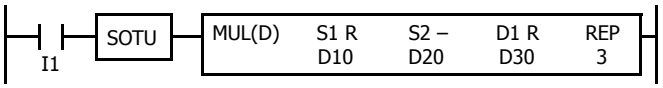
When S1 (source) and D1 (destination) are assigned to repeat, different results are set to 3 devices starting with D1·D1+1.

- **Data Type: Word and Integer**



S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 3)
D10	×	D20	→	D30·D31
D11	×	D20	→	D32·D33
D12	×	D20	→	D34·D35

- **Data Type: Double Word, Long, and Float**

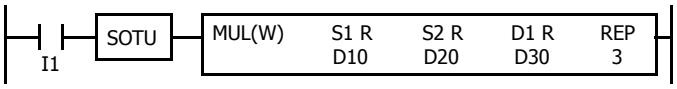


S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 3)
D10·D11	×	D20·D21	→	D30·D31
D12·D13	×	D20·D21	→	D32·D33
D14·D15	×	D20·D21	→	D34·D35

Repeat All Source and Destination Devices

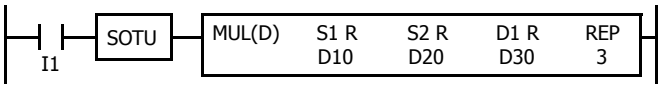
When all devices are assigned to repeat, different results are set to 3 devices starting with D1·D1+1.

- **Data Type: Word and Integer**



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 3)
D10	×	D20	→	D30·D31
D11	×	D21	→	D32·D33
D12	×	D22	→	D34·D35

- **Data Type: Double Word, Long, and Float**



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 3)
D10·D11	×	D20·D21	→	D30·D31
D12·D13	×	D22·D23	→	D32·D33
D14·D15	×	D24·D25	→	D34·D35

Repeat Operation in the DIV Instruction

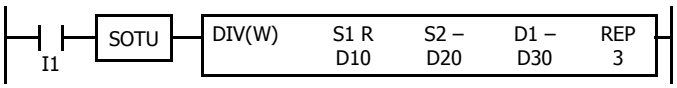
Since the DIV (division) instruction (except float data) uses two destination devices, the quotient and remainder are stored as described below. Source devices S1 and S2 and destination device D1 can be assigned to repeat individually or in combination. When destination device D1 is not assigned to repeat, the final result is set to destination device D1 (quotient) and D1+1 (remainder). When repeat is assigned, assigned as many consecutive devices as the repeat cycles starting with the designated device are used.

Division instructions in float data do not generate remainders and use two consecutive data registers to store quotients. When repeat is assigned for destination of float data, as many consecutive data registers as the repeat cycles are used.

Repeat One Source Device

- **Data Type: Word and Integer**

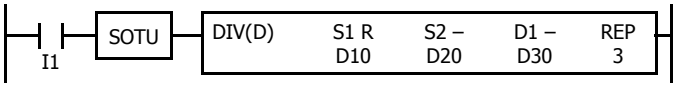
When only S1 (source) is assigned to repeat, the final result is set to destination devices D1 and D1+1.



S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 0)	
D10	÷	D20	→	(D30)	(D31)
D11	÷	D20	→	(D30)	(D31)
D12	÷	D20	→	D30	D31
				Quotient	Remainder

- **Data Type: Double Word and Long**

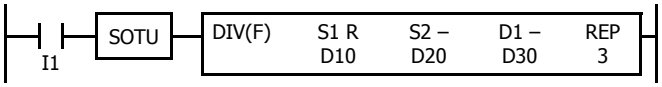
When only S1 (source) is assigned to repeat, the final result is set to destination devices D1·D1+1 and D1+2·D1+3.



S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 0)	
D10·D11	÷	D20·D21	→	(D30·D31)	(D32·D33)
D12·D13	÷	D20·D21	→	(D30·D31)	(D32·D33)
D14·D15	÷	D20·D21	→	D30·D31	D32·D33
				Quotient	Remainder

- **Data Type: Float**

When only S1 (source) is assigned to repeat, the final result is set to destination devices D1·D1+1.

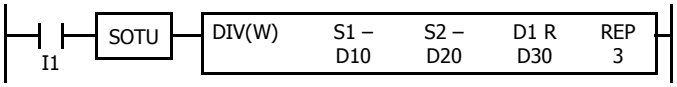


S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 0)
D10·D11	÷	D20·D21	→	(D30·D31)
D12·D13	÷	D20·D21	→	(D30·D31)
D14·D15	÷	D20·D21	→	D30·D31
				Quotient

Repeat Destination Device Only

- **Data Type: Word and Integer**

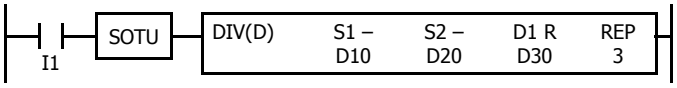
When only D1 (destination) is assigned to repeat, the same result is set to 6 devices starting with D1.



S1 (Repeat = 0)		S2 (Repeat = 0)		D1 (Repeat = 3)	
D10	÷	D20	→	D30	D33
D10	÷	D20	→	D31	D34
D10	÷	D20	→	D32	D35
				Quotient	Remainder

- **Data Type: Double Word and Long**

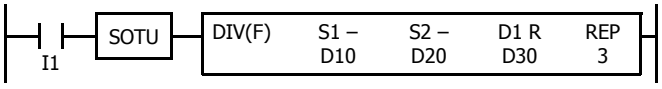
When only D1 (destination) is assigned to repeat, the same result is set to 6 devices starting with D1·D1+1.



S1 (Repeat = 0)		S2 (Repeat = 0)		D1 (Repeat = 3)	
D10·D11	÷	D20·D21	→	D30·D31	D36·D37
D10·D11	÷	D20·D21	→	D32·D33	D38·D39
D10·D11	÷	D20·D21	→	D34·D35	D40·D41
				Quotient	Remainder

- **Data Type: Float**

When only D1 (destination) is assigned to repeat, the same result is set to 3 devices starting with D1·D1+1.

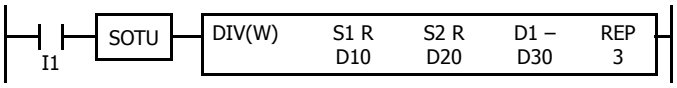


S1 (Repeat = 0)		S2 (Repeat = 0)		D1 (Repeat = 3)
D10·D11	÷	D20·D21	→	D30·D31
D10·D11	÷	D20·D21	→	D32·D33
D10·D11	÷	D20·D21	→	D34·D35
				Quotient

Repeat Two Source Devices

- **Data Type: Word and Integer**

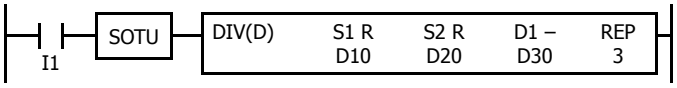
When S1 and S2 (source) are assigned to repeat, the final result is set to destination devices D1 and D1+1.



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 0)	
D10	÷	D20	→	(D30)	(D31)
D11	÷	D21	→	(D30)	(D31)
D12	÷	D22	→	D30	D31
				Quotient	Remainder

- **Data Type: Double Word and Long**

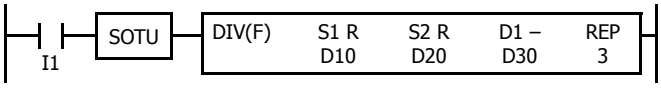
When S1 and S2 (source) are assigned to repeat, the final result is set to destination devices D1·D1+1 and D1+2·D1+3.



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 0)	
D10·D11	÷	D20·D21	→	(D30·D31)	(D32·D33)
D12·D13	÷	D22·D23	→	(D30·D31)	(D32·D33)
D14·D15	÷	D24·D25	→	D30·D31	D32·D33
				Quotient	Remainder

- **Data Type: Float**

When S1 and S2 (source) are assigned to repeat, the final result is set to destination devices D1·D1+1.

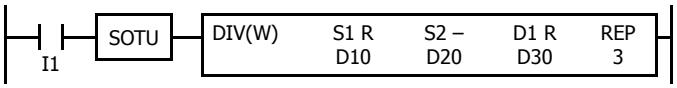


S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 0)
D10·D11	÷	D20·D21	→	(D30·D31)
D12·D13	÷	D22·D23	→	(D30·D31)
D14·D15	÷	D24·D25	→	D30·D31
				Quotient

Repeat Source and Destination Devices

- **Data Type: Word and Integer**

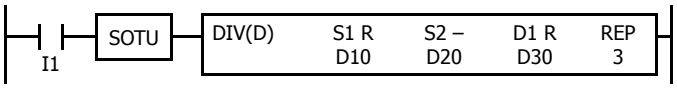
When S1 (source) and D1 (destination) are assigned to repeat, different results are set to 6 devices starting with D1.



S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 3)	
D10	÷	D20	→	D30	D33
D11	÷	D20	→	D31	D34
D12	÷	D20	→	D32	D35
				Quotient	Remainder

- **Data Type: Double Word and Long**

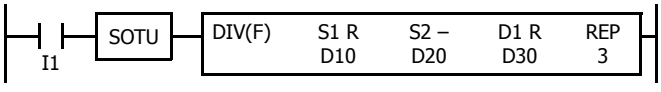
When S1 (source) and D1 (destination) are assigned to repeat, different results are set to 6 devices starting with D1·D1+1.



S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 3)	
D10·D11	÷	D20·D21	→	D30·D31	D36·D37
D12·D13	÷	D20·D21	→	D32·D33	D38·D39
D14·D15	÷	D20·D21	→	D34·D35	D40·D41
				Quotient	Remainder

- **Data Type: Float**

When S1 (source) and D1 (destination) are assigned to repeat, different results are set to 3 devices starting with D1·D1+1.

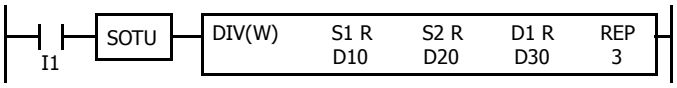


S1 (Repeat = 3)		S2 (Repeat = 0)		D1 (Repeat = 3)
D10·D11	÷	D20·D21	→	D30·D31
D12·D13	÷	D20·D21	→	D32·D33
D14·D15	÷	D20·D21	→	D34·D35
				Quotient

Repeat All Source and Destination Devices

- **Data Type: Word and Integer**

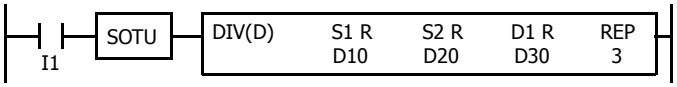
When all devices are assigned to repeat, different results are set to 6 devices starting with D1.



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 3)	
D10	÷	D20	→	D30	D33
D11	÷	D21	→	D31	D34
D12	÷	D22	→	D32	D35
				Quotient	Remainder

- **Data Type: Double Word and Long**

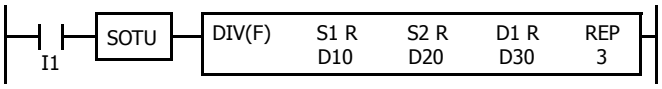
When all devices are assigned to repeat, different results are set to 6 devices starting with D1·D1+1.



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 3)	
D10·D11	÷	D20·D21	→	D30·D31	D36·D37
D12·D13	÷	D22·D23	→	D32·D33	D38·D39
D14·D15	÷	D24·D25	→	D34·D35	D40·D41
				Quotient	Remainder

- **Data Type: Float**

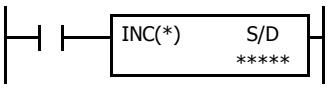
When all devices are assigned to repeat, different results are set to 3 devices starting with D1·D1+1.



S1 (Repeat = 3)		S2 (Repeat = 3)		D1 (Repeat = 3)
D10·D11	÷	D20·D21	→	D30·D31
D12·D13	÷	D22·D23	→	D32·D33
D14·D15	÷	D24·D25	→	D34·D35
				Quotient

Note: When a user program execution error occurs in any repeat operation, special internal relay M8004 (user program execution error) and the ERR LED are turned on and maintained while operations for other instructions continues.

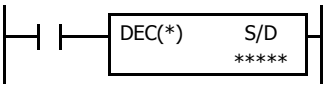
INC (Increment)



Data type W or I: S/D + 1 → S/D
Data type D or L: S/D·S/D+1 + 1 → S/D·S/D+1

When input is on, one is added to the 16- or 32-bit data assigned by device S/D and the result is stored to the same device.

DEC (Decrement)



Data type W or I: S/D – 1 → S/D
Data type D or L: S/D·S/D+1 – 1 → S/D·S/D+1

When input is on, one is subtracted from the 16- or 32-bit data assigned by device S/D and the result is stored to the same device.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S/D (Source/Destination)	Device to increment data	—	—	—	—	—	—	X	—	—

For valid device address ranges, see "Device Addresses" on page 3-1.

Since the INC and DEC instructions are executed in each scan while input is on, a pulse input from a SOTU or SOTD instruction should be used.

Valid Data Types

W (word)	X
I (integer)	X
D (double word)	X
L (long)	X
F (float)	—

When a word device such as D (data register) is assigned as the source/destination, 1 point (word or integer data) or 2 points (double-word or long data) are used.

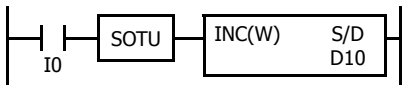
Increment beyond Limits

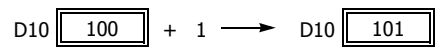
When the S/D value is at its maximum and is incremented by one, the value returns to 0, turning on the carry (M8003).

Decrement beyond Limits

When the S/D value is at its minimum and is decremented by one, the value returns to its maximum value (word or double-word data) or to –1 (integer or long data), turning on the internal relay M8003 (carry or borrow).

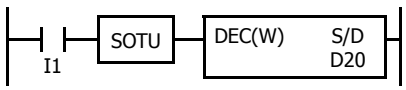
Example: INC

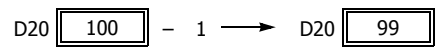




When input I0 is turned on, the data of D10 is incremented by one.
If SOTU is not programmed, the data of D10 is incremented in each scan.

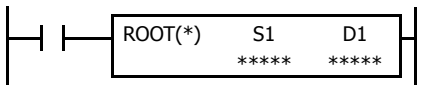
Example: DEC





When input I1 is turned on, the data of D20 is decremented by one.
If SOTU is not programmed, the data of D20 is decremented in each scan.

ROOT (Root)



Data type W:

$\sqrt{S1} \rightarrow D1$

When input is on, the square root of the device assigned by S1 is extracted and stored to the destination assigned by D1.

The square root is calculated to two decimals, omitting the figures below the second place of decimals, and multiplied by 100.

Data type D:

$\sqrt{S1 \cdot S1+1} \rightarrow D1 \cdot D1+1$

When input is on, the square root of the device assigned by S1·S1+1 is extracted and is stored to the destination assigned by D1·D1+1.

The square root is calculated to two decimals, omitting the figures below the second place of decimals, and multiplied by 100.

Data type F:

$\sqrt{S1 \cdot S1+1} \rightarrow D1 \cdot D1+1$

When input is on, the square root of the device assigned by S1·S1+1 is extracted and is stored to the destination assigned by D1·D1+1.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	Binary data	—	—	—	—	—	—	X	X	—
D1 (Destination 1)	Destination to store results	—	—	—	—	—	—	X	—	—

For valid device address ranges, see "Device Addresses" on page 3-1.

When F (float) data is selected and source device S1 contains a negative value, a user program execution error will result, turning on special internal relay M8004 and the ERR LED on the SmartAXIS.

When F (float) data is selected and S1 does not comply with the normal floating-point format, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS.

When a user program execution error occurs, the execution of the instruction is canceled. The value of D1 is left unchanged and the next instruction is executed. For user program execution errors, see "User Program Execution Errors" on page 4-13.

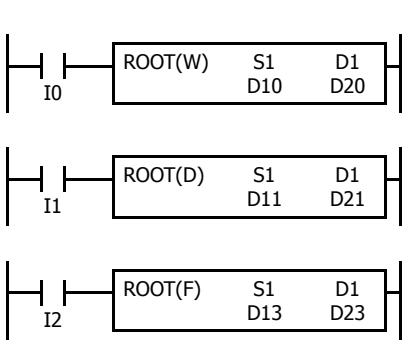
Since the ROOT instruction is executed in each scan while input is on, a pulse input from a SOTU or SOTD instruction should be used.

Valid Data Types

W (word)	X
I (integer)	—
D (double word)	X
L (long)	—
F (float)	X

When a word device such as D (data register) is assigned as the source or destination, 1 point (word data) or 2 points (double-word or float data) are used.

Examples: ROOT



Before Execution **After Execution**

D10 [55] → D20 [741] $\sqrt{55} = 7.4161$

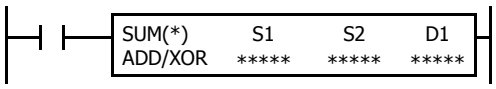
D11·D12 [4294967295] → D21·D22 [6553599]

$\sqrt{4294967295} = 65535.99999$

D13·D14 [20.738916] → D23·D24 [4.554]

$\sqrt{20.738916} = 4.554$

SUM (Sum)



Calculates the total of assigned data, depending on the calculation option.

ADD:
When input is on, N blocks of 16- or 32-bit data starting at device assigned by S1 are added together and the result is stored to the device assigned by D1. S2 specifies the quantity of data blocks.

XOR:
When input is on, N blocks of 16-bit data starting at the device assigned by S1 are XORed and the result is stored to the device assigned by D1. S2 specifies the quantity of data blocks.

Applicable SmartAXIS

FT1A-12	FT1A-24	FT1A-40	FT1A-48	FT1A-Touch
X	X	X	X	X

Valid Devices

Device	Function	I	Q	M	R	T	C	D	Constant	Repeat
S1 (Source 1)	First device address to calculate	—	—	—	—	X	X	X	—	—
S2 (Source 2)	Quantity of data blocks	—	—	—	—	—	—	X	X	—
D1 (Destination 1)	Destination to store results	—	—	—	—	—	—	X	—	—

For valid device address ranges, see "Device Addresses" on page 3-1.

When T (timer) or C (counter) is used as S1, the timer/counter current value (TC or CC) is displayed.

When F (float) data is selected, only a data register can be designated as S1.

For source S2, 1 word is always used without regard to the data type.

When F (float) data is selected and S1 does not comply with the normal floating-point format, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS.

When S2 is 0 or exceeds the correct value range for the selected device, a user program execution error will result, turning on special internal relay M8004 and ERR LED on the SmartAXIS. For user program execution errors, see "User Program Execution Errors" on page 4-13.

Valid Data Types

Calculation	ADD	XOR
W (word)	X	X
I (integer)	X	—
D (double word)	X	—
L (long)	X	—
F (float)	X	—

When ADD is selected, all data types can be used.

When XOR is selected, only W (word) data can be used.

When a word device such as T (timer), C (counter), or D (data register) is assigned as the source or destination, 1 point (word or integer data) or 2 points (double-word, long, or float data) are used.

Quantity of Source and Destination Devices

Depending on the ADD or XOR operation for W (word) and I (integer) data, the destination uses a different quantity of devices.

Operation	W (word), I (integer)		D (double word), L (long), F (float)	
ADD	S1, S2:	1 word device	S1, D1:	2 word devices
	D1:	2 word devices	S2:	1 word device
XOR	S1, S2, D1:	1 word device	—	

Carry and Borrow

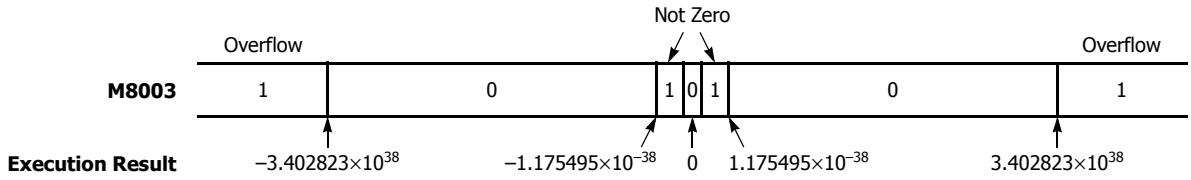
In advanced instructions involving D (double word), L (long), or F (floating point) data, special internal relay M8003 (carry and borrow) is turned on when the execution of the instruction results in the following value.

Data Type	M8003	Execution Result
D (double word)	1	Exceeds the range between 0 to 4,294,967,295
L (long)	1	Exceeds the range between –2,147,483,648 to 2,147,483,647
F (float)	1	See the figure below.

Carry and Borrow in Floating-Point Data Processing

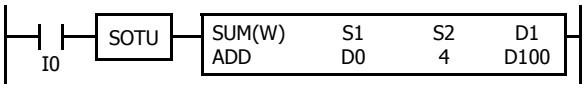
When advanced instructions involving floating-point data are executed, special internal relay M8003 (carry and borrow) is updated.

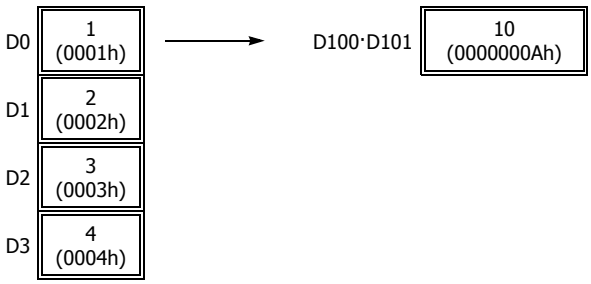
M8003	Execution Result	Value
1	≠ **0**	Overflow (exceeds the range between -3.402823×10^{38} and 3.402823×10^{38})
1	**0**	Not zero (within the range between -1.175495×10^{-38} and 1.175495×10^{-38})
0	**0**	Zero

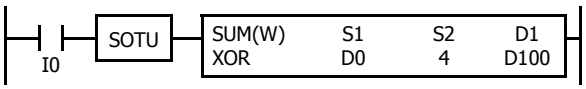


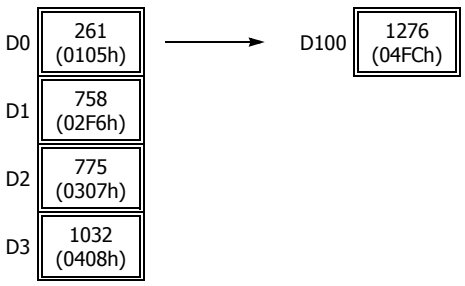
Examples: SUM

- **Data Type: Word**





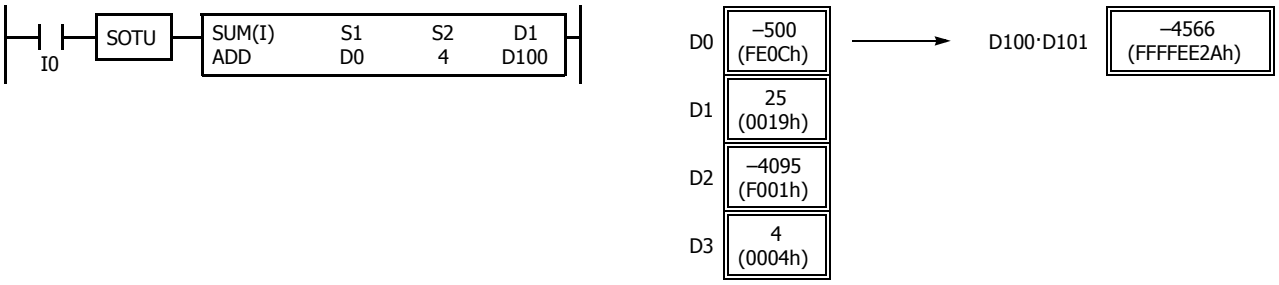




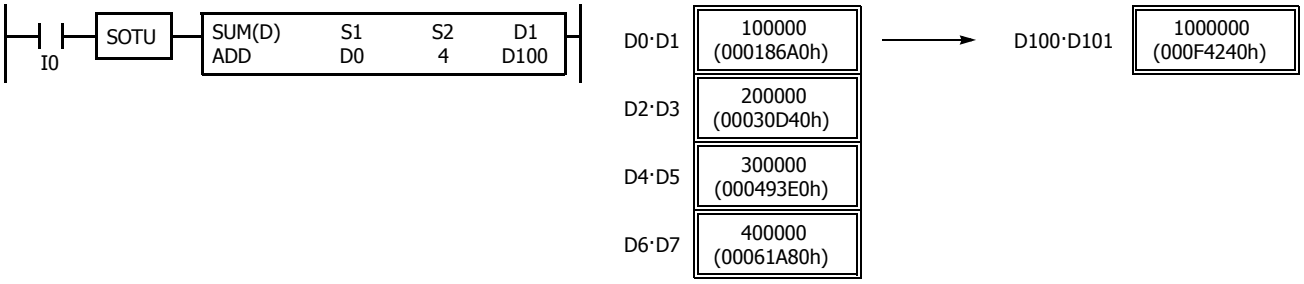
XOR Operation

	D0	(0105h)	0000 0001 0000 0101
	D1	(02F6h)	0000 0010 1111 0110
	D2	(0307h)	0000 0011 0000 0111
XOR	D3	(0408h)	0000 0100 0000 1000
	D100	(04FCh)	0000 0100 1111 1100

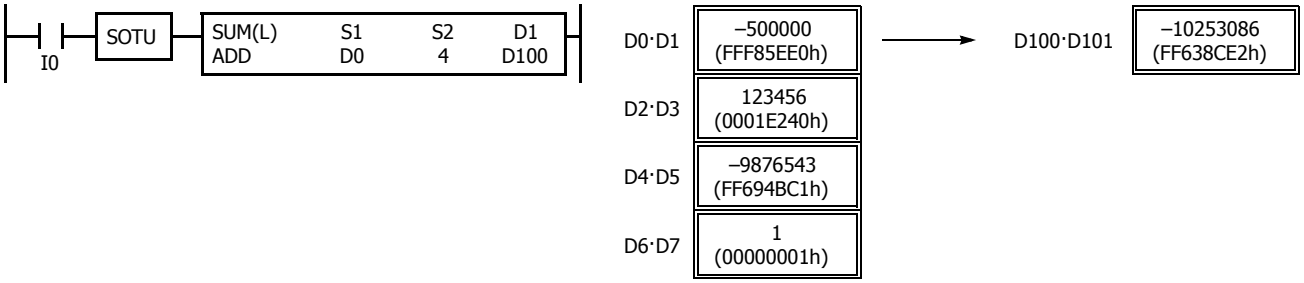
- **Data Type: Integer**



- **Data Type: Double Word**



- **Data Type: Long**



- **Data Type: Float**