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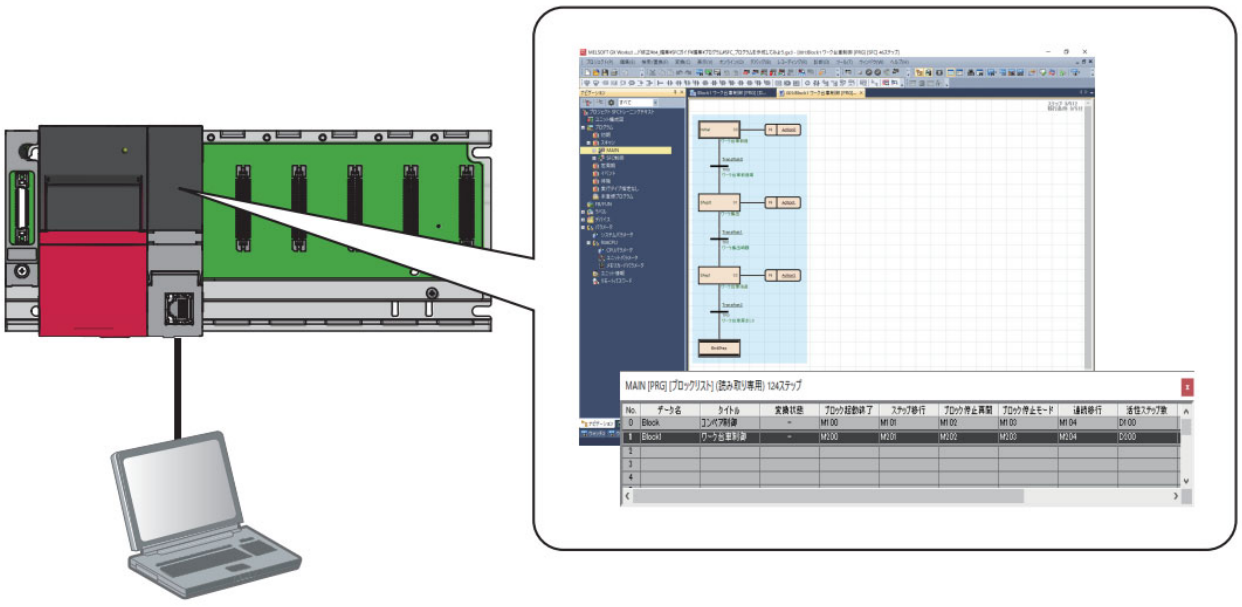
Programmable Controller

MELSEC iQ-R series

MELSEC iQ-R Series SFC Programming Guide

This document is a guidebook for the MELSEC iQ-R series SFC programming.
Shows the specifications and configuration of the SFC program, a simple program creation example, and the monitoring method.



Contents

1 Overview

1.1 Overview

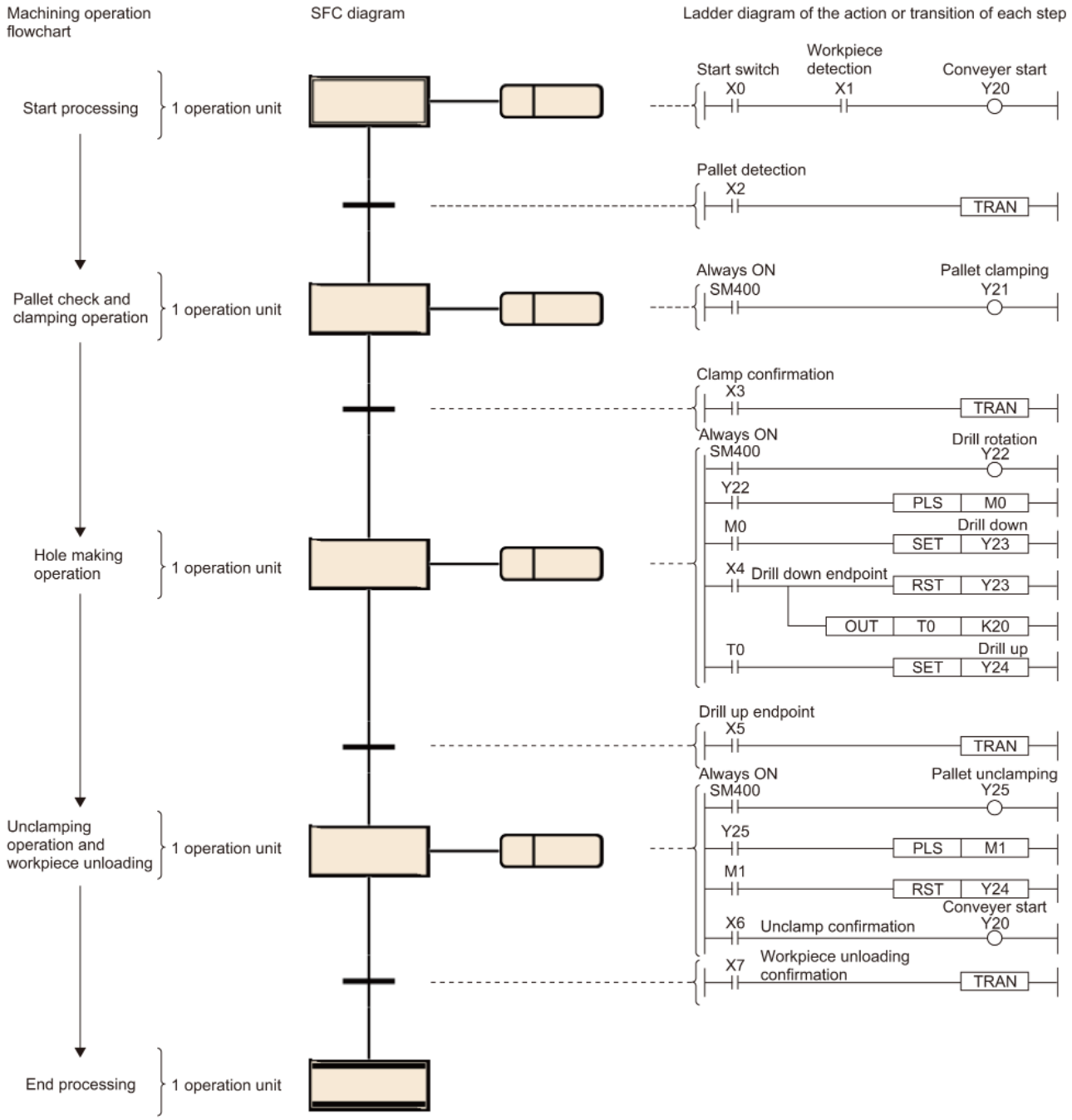
This document describes the specifications, functions, instructions, programming, and monitoring methods for programming using the SFC programming language.

SFC stands for Sequential Function Chart, which is a graphical programming language that represents each process in a series of control operations as a single step and enables the execution order and execution conditions of programs to be clearly expressed. This makes the program easy to understand visually and structurally. It also makes it easier to understand the correspondence between the processing flow and program control, which reduces the load on debugging and maintenance.

1.2 What is an SFC Program?

The SFC program consists of steps that represent units of operations in a series of machine operations.

In each step, the actual detailed control is programmed.



An SFC program starts at an initial step, executes an action of the next step in due order every time the relevant transition becomes TRUE, and ends a series of operations at an end step.

Operation of the SFC program

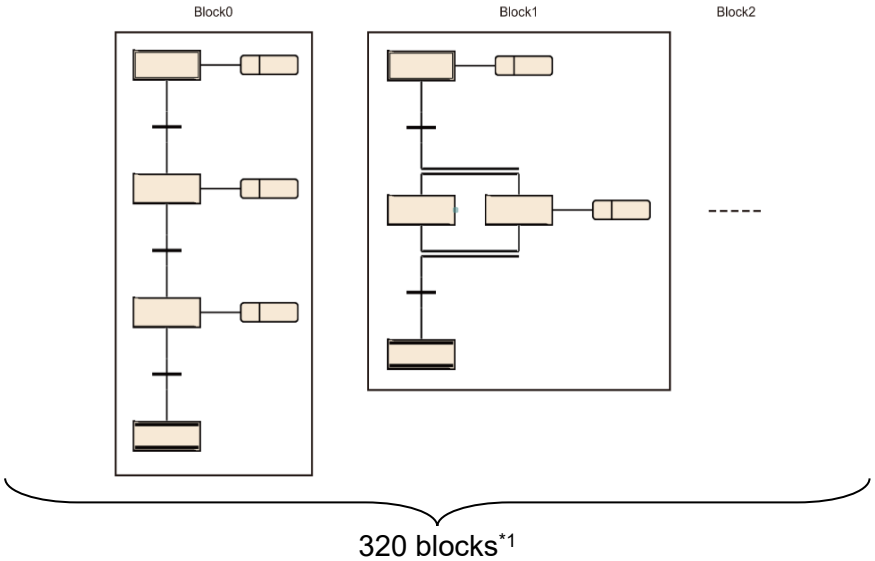
1. When starting a block, the initial step (1) is activated first and then the action (2) is executed. After execution of the action (2), the program checks whether the next transition (3) has become TRUE.
2. The program executes only the action (2) until the transition (3) becomes TRUE. When the transition (3) becomes TRUE, the program ends the action (2), deactivates the initial step (1), and activates the next normal step (4).
3. After execution of the action of the normal step (4), the program checks whether the next transition has become TRUE. If the next transition does not become TRUE, the program repeats the execution of the action of the normal step (4).
4. When the transition becomes TRUE, the program ends the action, deactivates the step (4), and activates the next step (5).
5. Every time the transition becomes TRUE, the program activates the next step and ends the block when it finally activates the end step (6).

1.3 What are blocks in SFC programs?

In the SFC program, a set of steps from the initial step to the end step is expressed as a block, and up to 320 blocks*1 from Block0 to Block319 can be created.

One block is programmed for each process (Processing, assembly, inspection, etc.), product (For product A processing, product B processing, etc.), and control unit such as automatic/manual operation.

Multiple blocks are created, and the actual machine is controlled by starting specific blocks according to the purpose and application, or by interrupting or terminating processing.



*1 For R00CPU, R01CPU, and R02CPU, the maximum number of blocks is 128.

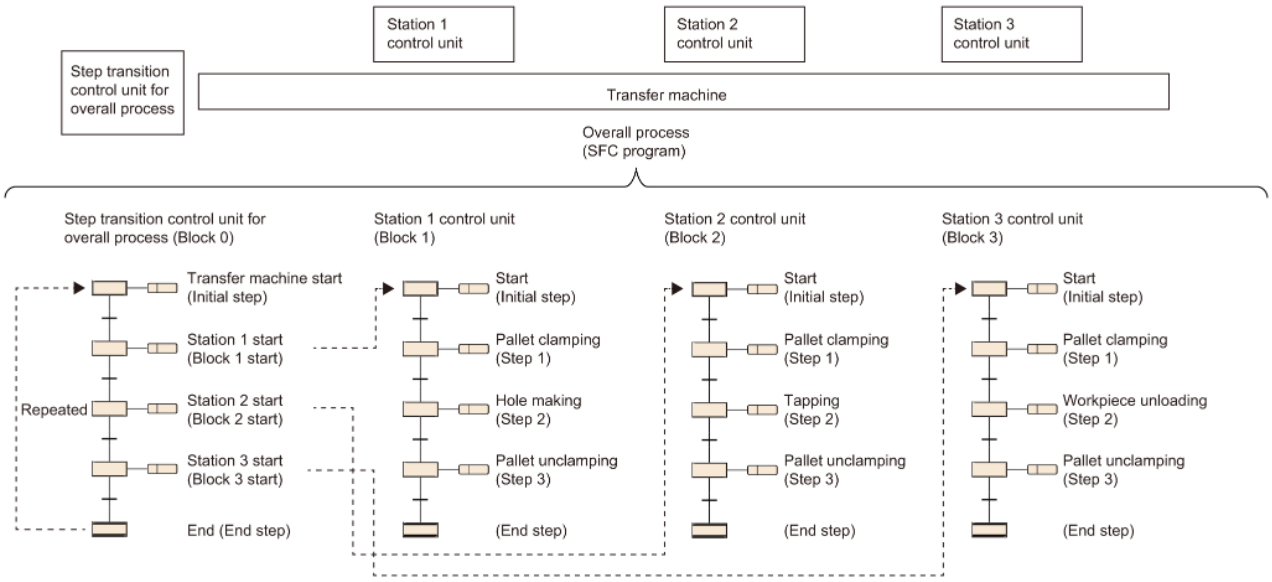
1.4 SFC Features

1. Easy system design and maintenance

The entire equipment, the mechanical equipment of each station, and the actual control of each machine can be associated with each block and each step of the SFC program on a one-to-one basis.

Therefore, even with little experience with sequence programs, you can pursue work such as system design and maintenance to a considerable depth.

In addition, since the control contents of each block and each step are easy to understand, it can be easily deciphered even by a program designed by another person compared to a sequence program.

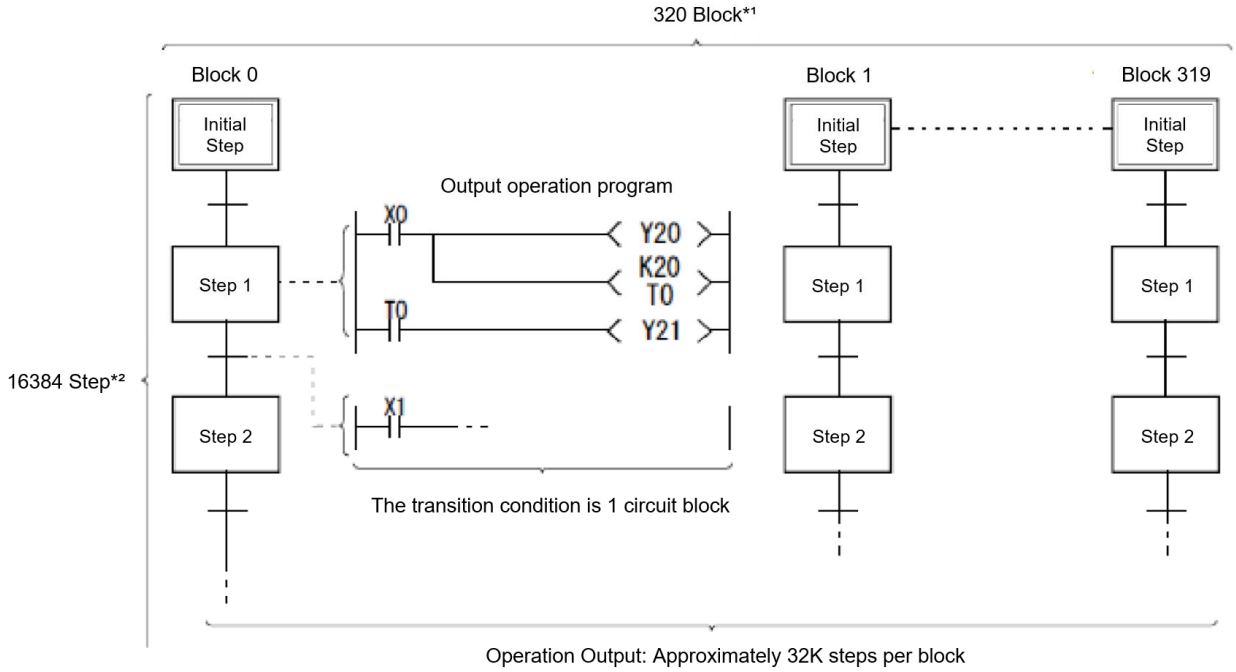


2. Easily divide and edit blocks and steps according to the control object

- You can create up to 320 blocks*1 for the entire SFC program.
- You can create up to 16384 steps*2 for the entire SFC program, and up to 512 steps in 1 block.
- The operation output can be created up to approximately 32K sequence steps in 1 block. (There are no constraints per step.)
- You can create only one circuit block for each transition condition.

By dividing the blocks and steps as follows, you can reduce the tact time and facilitate debugging and trial operation.

- To successfully divide a block by an operation unit of a machine.
- To successfully divide steps in a block.



*1 For R00CPU, R01CPU, and R02CPU, the maximum number of blocks is 128.

*2 For R00CPU, R01CPU, and R02CPU, the maximum number of steps is 1024 for all blocks and 128 for 1 block.

3. Rich step attributes make program design easy

Each step can have various step attributes. SFC programs can be designed easily by using attributes according to control or by using them in combination.

For details, see 2.5 Steps.

4. Easy-to-read display with comments

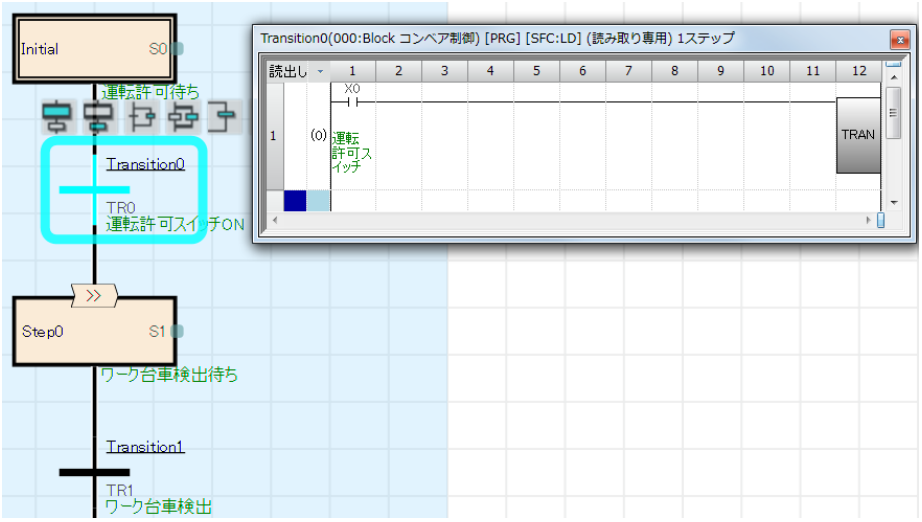
You can enter comments from "Device Comment Editor" in the "Step Properties" and "Transition Condition Properties" windows.

By displaying comments, you can make the SFC program easier to understand.

5. Floating Zoom side-by-side with SFC diagram and compare

Double-click a transition condition or behavior output to display Zoom.

By double-clicking this tab, you can float Zoom and compare it to the SFC diagram to see the transition conditions and behavior output program.



6. Automatic scroll function makes it easy to check where mechanical trouble occurs.

When a step that is not visible on the screen is activated during monitoring, the system automatically scrolls to display the activated step on the screen again. This monitoring function enables you to search for trouble spots even if you are not familiar with sequence programs.

7. Multiple ways to control the same functionality for different purposes

You can control the start, end, pause, and resume of each block, the start of a step (active), and the end of a step (inactive) in several ways.

- How to Start a Block
  This table describes how to start a block.

Items	Startup Method	Remarks
Automatic startup with CPU parameters (Block0 only)	If you set "Start condition setting" to "Automatically start Block0" in the SFC settings of the CPU parameters, Block0 starts automatically when the SFC program starts, and processing starts from the initial step.	Set this option when Block0 is used as a management block, preprocessing block, or always-on monitoring block.
Starting with the block start step	For each block in the SFC program, use the block start step [BC or BS] to start another block.	This is useful when the order of control is clear.
Start by SFC control instruction	Starts the block specified by the SFC control instruction from the operation output of the SFC program or from another sequence program. •To execute the command from the initial step of the specified block, use the SET [BL☐] command (block start). •To execute the command from the specified step of the specified block, use the SET [S☐/BL☐\S☐] command (step start).	This is useful for starting error recovery processing blocks or executing interrupt processing when an error is detected.
Booting by information device for SFC	The specified block is started by turning on "block start end bit" set for each block as an SFC information device.	It can be started from an external device, so it is useful for debugging and trial operation in block units.
Launching with engineering tools	Activates the specified block by turning on the SFC block device.	This is useful for debugging and trial operation.

- How to End a Block
  Describes how to end a block.

Items	Exit Method	Remarks
End by End Step	Executing an end step in a block terminates the processing of the block and makes it inactive.	Useful when stopping operation by automatic operation cycle stop.
Termination by SFC control instruction	Terminates the block specified by the RST [BL☐] instruction (block start) from the operation output of the SFC program or from another sequence program and deactivates the block. (The block is also terminated when all the active steps in the specified block are deactivated by the RST [BL☐\S☐] command (step termination).)	This is useful for stopping processing regardless of the operating status, such as emergency stop.
Termination by information device for SFC	Terminates the specified block by turning off "block start end bit" set for each block as an SFC information device.	It can also be terminated from an external device, so it is useful for debugging and trial operation in block units.
Exit with Engineering Tools	Terminates the specified block by turning off the SFC block device.	This is useful for debugging and trial operation.

- How to Stop a Block

  Describes how to stop a specified block while an SFC program is running.

Items	Stopping Method	Remarks
Stop by SFC control command	Temporarily stops execution of the block specified by the PAUSE [BL☐] command (block stop) from the operation output of the SFC program or from another sequence program.	This is useful for temporarily stopping the machine and manually repairing the abnormal area when an error is detected.
Stopping by information device for SFC	The specified block is stopped by turning on "block stop restart bit" set for each block as an SFC information device.	Since it can be stopped from an external device, it is useful for debugging and control while checking during trial operation.

The operation at block stop/restart depends on the combination of the SM325 (output mode setting at block stop), setting of the block stop mode bit of the SFC information device, and HOLD/non-HOLD of steps.

- How to Resume a Block

  Describes how to resume processing of blocks that were paused while the SFC program was running.

Items	Resume Method	Remarks
Resume by SFC control instruction	Resumes the block specified by the RSTART [BL☐] command (block restart) from the operation output of the SFC program other than the stopped block or from another sequence program.	This is useful for returning to automatic operation after manual control is completed during a pause.
Resume by Information Device for SFC	Resumes the specified block by turning off "block stop restart bit" set for each block as an SFC information device.	It can be started from an external device, so it is useful for debugging and trial operation in block units.

The operation at block stop/restart depends on the combination of the SM325 (output mode setting at block stop), setting of the block stop mode bit of the SFC information device, and HOLD/non-HOLD of steps.

- Method for starting (activating) step

  Describes how to activate a step.

Items	Startup Method	Remarks
Start with transition condition satisfied	When the previous transition condition is satisfied, the next step starts automatically.	-
Start by SFC control instruction	Starts the step specified by the SET [S□/BL□\S□] command (step start) from the operation output of the SFC program or from another sequence program.	-
launching with engineering tools	•The specified step is started by turning on the step relay. •Activates the step selected from the menu Debug > SFC Step Control.	This is useful for debugging and trial operation.

- Step End (deactivate) Method

  Describes how to end (deactivate) a step.

Items	Exit Method	Remarks
Termination due to establishment of transition conditions	The system terminates automatically when the next transition condition of the step is satisfied.	-
Exit with reset step [R]	When the reset step [R] is activated, the step specified for the attribute specification destination ends.	This is useful when you want to end the HOLD step [SC, SE, ST], for example, when the SFC program selection branch moves to the error processing step.
termination by SFC control instruction	Terminates the step specified by the RST [S□/BL□\S□] command (step termination) from the operation output of the SFC program or from another sequence program.	If all steps of the specified block are disabled by the RST command, the block is also terminated.
Exit with Engineering Tools	•Terminates the specified step by turning off the step relay. •Deactivates the step selected from the menu Debug > SFC Step Control.	This is useful for debugging and trial operation.

1.5 What control is suitable for SFC programming?

Since the SFC program can program the operation control of the machine as it is, it is suitable for the control with clear flow to some extent.

1. Example of Programmable Control in an SFC Program
    - Transportation control of automatic warehouse, transfer equipment, etc.
    - Assembly line
    - Semiconductor manufacturing equipment such as polishing, cleaning, and inspection
    - Batch processing of chemicals and pulp

2. Examples of Controls Difficult to Program in SFC Programs
    - Control such that signals enter at random, as in a transformer machine
    - Controls that require constant monitoring, such as emergency stop signals and interrupt signals*.

    *By using SFC control instructions and SFC information devices in program files other than SFC, it is possible to support control that requires constant monitoring.

3. Programming of manual circuits

    By programming manual circuits and individual operation circuits with the SFC program, you can easily understand what kind of work is being done at that time.

    By combining SFC control instructions and block information to stop, clear, and forcibly start blocks, manual circuits and individual operation circuits can be programmed with SFC programs.

2 SFC Program Basics

2.1 Overall Program Configuration and SFC Program

2.1.1 Performance specifications for the SFC program

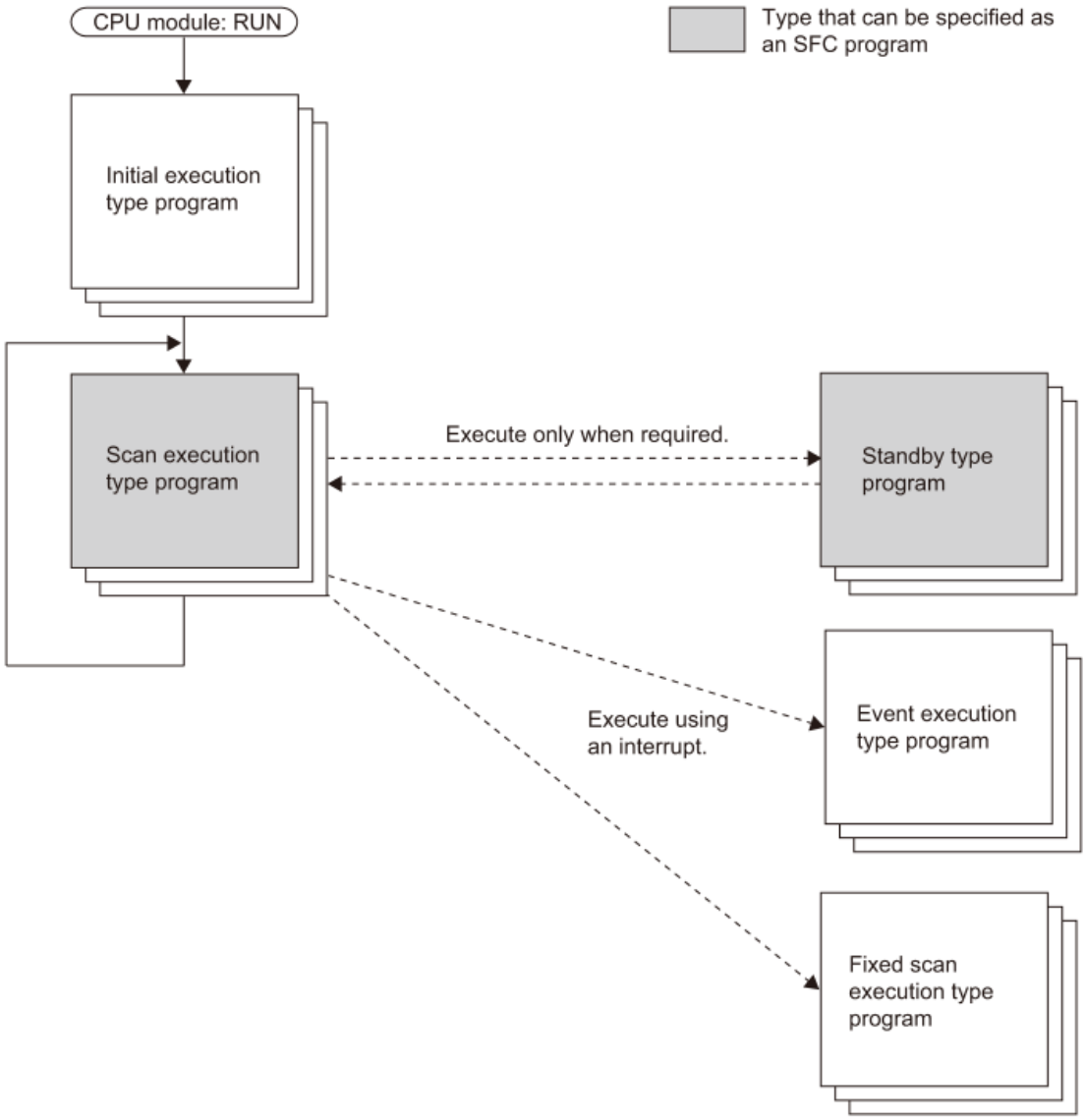
Indicates the performance specifications for the SFC function.

Item		Specifications
Number of device points (SFC)	Step relay (S)	R00CPU, R01CPU, R02CPU: 8192 points maximum CPU modules other than the above: 16384 points maximum
	SFC block device (BL)	R00CPU, R01CPU, R02CPU: 128 points CPU modules other than the above: 320 points
	SFC transition device (TR)	0 point
Number of executable SFC programs		1
Number of blocks		R00CPU, R01CPU, R02CPU: 128 blocks maximum CPU modules other than the above: 320 blocks maximum
Number of SFC steps		R00CPU, R01CPU, R02CPU: 1024 steps maximum for all blocks in total, 128 steps for one block alone CPU modules other than the above: 16384 steps maximum for all blocks in total, 512 steps for one block alone
Step No.		R00CPU, R01CPU, R02CPU: 0 to 127 per block CPU modules other than the above: 0 to 511 per block
Number of branches		32 branches maximum
Number of simultaneously active steps		R00CPU, R01CPU, R02CPU: 1024 steps maximum for all blocks in total, 128 steps for one block alone CPU modules other than the above: 1280 steps maximum for all blocks in total, 256 steps for one block alone
Number of initial steps		32 steps maximum per block
Number of actions		4 actions maximum per step
Number of sequential steps	Action	About 32K sequential steps per block (No restriction on the number per SFC step)
	Transition	Only one per ladder block
Number of online change (SFC block) target blocks		1 *1

2.1.2 Processing the entire program

Possible Execution Types

Describes whether the execution type of the SFC program can be specified.



Execution Type	Specification enable/disable	Remarks
Initial execution type program	×	—
Scan execution type program	○	Only one SFC program can be executed.
Standby type program	○	By specifying an SFC program by using the PSCAN(P) instruction, the execution type can be changed to the scan execution type.
Event execution type program	×	—
Fixed scan execution type program	×	—

Precautions

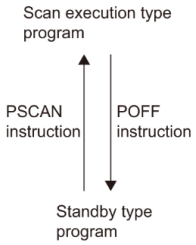
When no scan execution type SFC program exists (only standby type program), do not execute an SFC control instruction and monitoring for an SFC program.

Changing the Execution Type by Instruction

The execution type of a program can be changed by using a program control instruction.

Instruction symbol	Specification enable/disable	Remarks
PSCAN(P)	○ *1	Changes the execution type of the specified SFC program to the scan execution type. If this instruction is executed with another SFC program specified while an scan execution type SFC program already exists, an error occurs.
PSTOP(P)	×	If this instruction is executed for an SFC program, an error results.
POFF(P)	○ *1	Executes end processing of all blocks in the next scan and changes the execution type of the specified SFC program to the standby type in the following scan.

*1 An SFC program cannot be specified in the Process CPU (redundant mode).



■ **Precautions**

- Do not execute the PSCAN(P) instruction when a file is read/written from/to the CPU module or the data logging function is used. If executed, the scan time may extend several hundred milliseconds.
- When the SFC program start mode is set to the resume start, if a new SFC program (a different SFC program from the one most recently run) is run by using the PSCAN (P) instruction, the new SFC program is run by the initial start. In this case, "SFC program continuous start not possible" (event code: 0430) is saved in the event history.

2.2 Device List

Indicates the transition conditions for the SFC program and the devices that can be used in the operation output.

Classification	Category	Device name	Symbol	Range	Parameter Setting Range	Notation
User Devices	Bit	Input	X	12K Point *5	Cannot change	16 digits
	Bit	Output	Y	12K Point *5		16 digits
	Bit	Internal Relay	M	12K Point *5	Modifiable	10 digits
	Bit	Link Relay	B	8K Point		16 digits
	Bit	Annunciator	F	2K Point		10 digits
	Bit	Link Special Relay	SB	2K Point		16 digits
	Bit	Edge Relay	V	2K Point		10 digits
	Bit	Step Relay*3	S	0 Point		10 digits
	Bits/Word	Timer	T	1K Point *5		10 digits
	Bits/Word	Retentive Timer	ST	0 Point		10 digits
	Bit/Double Word	Long Timer	LT	1K Point *5		10 digits
	Bit/Double Word	Long Retentiive Timer	LST	0 Point		10 digits
	Bits/Word	Counter	C	512 Items*5		10 digits
	Bit/Double Word	Long Counter	LC	512 Items*5		10 digits
	Word	Data Register	D	18K Point*5		10 digits
	Word	Link Register	W	8K Point		16 digits
	Word	Link Special Register	SW	2K Point		16 digits
	Bit	Latch Relay	L	8K Point		10 digits
System Devices	Bit	Function Input	FX	16 Point	Cannot change	16 digits
	Bit	Function Output	FY	16 Point		16 digits
	Word	Function Register	FD	5 items x 4 words		10 digits
	Bit	Special Relay	SM	4K Point		10 digits
	Word	Special Register	SD	4K Point		10 digits
Link Direct Device	Bit	Link Input	Jn\X	Up to 160 K Point*1*6	Cannot change	16 digits
	Bit	Link Output	Jn\Y	Up to 160 K Point*1*6		16 digits
	Bit	Link Relay	Jn\B	Up to 640 K Point*1*6		16 digits
	Bit	Link Special Relay	Jn\SB	Up to 5120 Point*1*6		16 digits
	Word	Link Register	Jn\W	Up to 2560 K Point*1*6		16 digits
	Word	Link Special Register	Jn\SW	Up to 5120 Point*1*6		16 digits
Module Access Device	Word	Module Access Device	Un\G	Up to 268435456 Point*1	Cannot change	10 digits
CPU Buffer Memory Access Device	Word	CPU Buffer memory access device	U3En\G	Up to 268435456 Point*1	Cannot change	10 digits
			U3En\HG	Up to 12288 Point	Modifiable	10 digits
Index Register	Word	Index Register	Z	20 Point	Modifiable	10 digits
	Double Word	Long Index Register	LZ	2 Point	Modifiable	10 digits
File Register	Word	File Register	R/ZR	0 Point	Modifiable	10 digits
Refresh Data Register	Word	Refresh Data Register	RD	512 K Point	Modifiable	10 digits
Nesting	-	Nesting	N	15 Point	Cannot change	10 digits
Pointer	-	Pointer	P	8192 Items*2	Modifiable	10 digits
	-	Interrupt Pointer	I	1024 Point	Cannot change	10 digits
Other Devices	-	Network Number Designation Device	J	-	Cannot change	10 digits
	-	I/O No. Designated Device	U	-		16 digits
	-	SFC Block Device*3	BL	320 Items*5		10 digits
	-	SFC Transition Device*3*4	TR	0 Point		10 digits

*1 Maximum value that the CPU module can handle. Actual values vary by module.
*2 16384 points for R120CPU, R120ENCPU, R120CPU, and R120SFCPU.
*3 Can be collected on CPU module that can use the SFC feature.
*4 Can be used as a device comment in the SFC program.
*5: For R00 CPU, R01CPU, and R02CPU, the default points are as follows:

- Input (X), Output (Y), Internal Relay (M): 8K point
- Timer: 2K point
- Long Timer (LT), Long Counter (LC): 0 points
- Counter (C): 1K point
- Data register (D): 12K point
- SFC Block Device (BL): 128

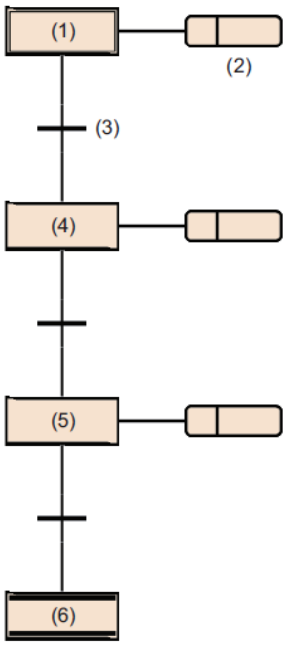
*6: The maximum number of points depends on the "Link Direct Device Settings" of the engineering tool. " If you use "Link Direct Device Configuration", check the version of the CPU module and engineering tool.

2.3 Configuring the SFC Program

The following describes the SFC diagrams, SFC control instructions, and SFC information devices used to configure SFC programs.

2.3.1 Basic Operation of SFC

The SFC program starts with the initial step, executes the next step each time the transition condition is satisfied, and ends the series of operations at the end step.



1. Initial Step
2. Operation Output
3. Transition Conditions
4. Normal Step
5. Normal Step
6. End Step

1. When the block starts, the initial step (1) is activated first, and the operation output (2) is executed. After the operation output (2) is executed, check whether the following transition condition (3) is satisfied.

2. Only action output (2) is executed until the transition condition (3) is satisfied. If the transition condition (3) is satisfied, the operation output (2) is terminated, the initial step (1) becomes inactive, and the next normal step (4) is activated.

3. After the operation output in step (4) is executed, check whether the following transition conditions have been satisfied. If the following transition conditions are not satisfied, repeat the execution of the action output in step (4).

4. If the transition condition is satisfied, the operation output ends, step (4) becomes inactive, and the next step (5) becomes active.

5. Each time the transition condition is satisfied, the next step is activated, and the block ends when the end step (6) is activated.

Point

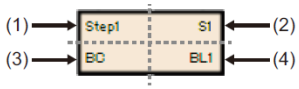
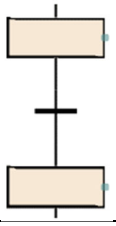
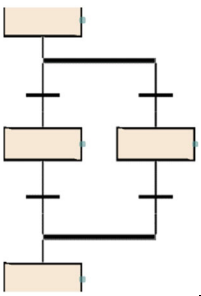
- You can create up to four operation outputs per step. If multiple action outputs are created, they are executed in order from the top.
- You can change the type of initial and normal steps by adding attributes.

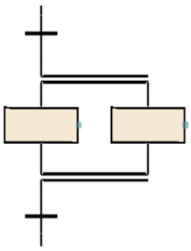
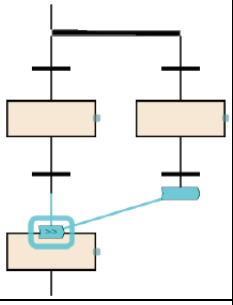
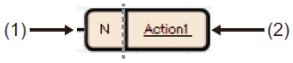
2.4 About SFC Elements

Indicates which elements are available in the SFC program.

For the number of blocks/elements that can be created, their behavior, and details about each element, see the following:

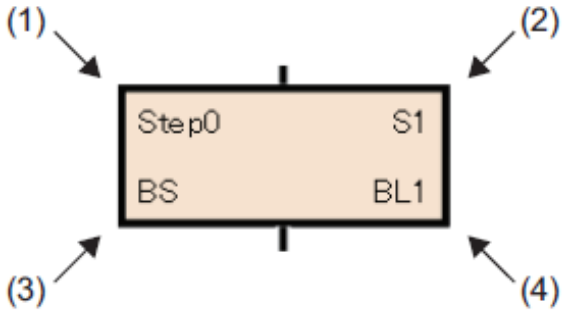
MELSEC iQ-R Programming Manual (Program Design Edition)

Items		Specifications
Step  (1) Step Name (2) Step No. (S☐) (3) Step Attributes (4) Step Attribute Specification Destination	Initial Step  	Indicates the beginning of a block, which is required for each block. If multiple processes are executed in parallel, you can create multiple initial steps. You can change the behavior of a step by specifying step attributes. For details, see the following: MELSEC iQ-R Programming Manual (Program Design Edition)
	Normal Step  	When the next transition condition of the step is satisfied, the activity shifts to the next step. You can change the behavior of a step by specifying step attributes. For details, see the following: MELSEC iQ-R Programming Manual (Program Design Edition)
	End Step  	Indicates the end of the block. Only the end step cannot be assigned a step number.
Transition Conditions  (1) Transition Condition Name (2) Transition Condition No. (TR☐)	Series Transition 	Move from the previous step to the next step.
	Selective Transition 	Refers to a branch that is displayed as a single line and selects one action.

	Parallel Transition  Jump and connection line can be switched.	Indicates a branch that is displayed as a double line and performs multiple processes in parallel.
	Jump Transition 	Jumps the execution to the specified step in the same SFC block.
Operation Output  (1) N: Qualifier (2) Operation Output Name		When the step is activated, the allocated operation output is executed. N indicates that the step is being executed while it is active. You cannot set anything other than N.

2.5 Steps

A step is the basic unit of a block.



(1) Step name

(2) Step No.

(3) Attribute

(4) Attribute specification destination

The following table shows the number of steps that can be used per block.

CPU module type	Maximum number of steps per block	Maximum number of blocks in all blocks
R00CPU, R01CPU, R02CPU	Up to 128 steps	Up to 1024 steps
CPU module other than the above	Up to 512 steps	Up to 16384 steps

Steps have the following characteristics:

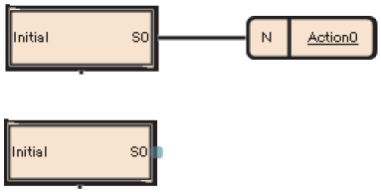
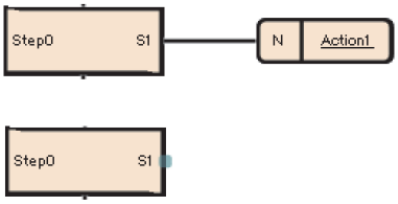
- When the step is activated, the associated operation output is executed.
- A step number is assigned to each step. Step No. is used to monitor execution steps or to forcibly start or stop an execution by using an SFC control instruction.
- The step name and step number are unique within each block.

Point

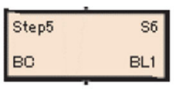
- You can change the step name, step number, attribute, and attribute specification destination from the step property window.
- Select a step and select [Edit]-> [Properties] from the menu to display the step properties screen.

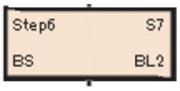
2.5.1 Step Type

Indicates the type of step.

Items		Contents
Initial Step		Indicates the beginning of the block. When a step is active, the next transition condition is always checked, and when the transition condition is satisfied, the activity shifts to the next step. Attributes of SC, SE, ST, and R can be added. You can choose not to create operation output.
Normal Step		The basic steps that make up a block. When a step is active, the next transition condition is always checked, and when the transition condition is satisfied, the activity shifts to the next step. Attributes of SC, SE, ST, R, BC, BS can be added. You can choose not to create operation output.
End Step		The step to end the block. You cannot create operation output.

Indicates the attributes of the step.

Items	Items		Contents
SC	Coil HOLD step [SC]		This is a step to hold the output of the coil which is turned on by the operation output even after the activation is transferred.
SE	operation HOLD step (no transition check) [SE]		This is the step of continuing to execute the operation output even after the activity has shifted. After the transition condition is satisfied and the next step becomes active, the transition condition is not checked.
ST	operation HOLD step (with Transition Check) [ST]		This is the step of continuing to execute the operation output even after the activity has shifted. After the transition condition is satisfied and the next step becomes active, the transition condition is checked repeatedly.
R	Reset Step [R]		Deactivates the specified step.
BC	Block Startup Step with Exit Check [BC]		This step activates the specified block. When the specified block becomes inactive and the transition condition is satisfied, the activity shifts to the next

			step. You cannot create operation output.
BS	Block Startup Step (No Exit Check) [BS]		This step activates the specified block. When the transition condition is satisfied, the activity shifts to the next step. You cannot create operation output.

Point

- You can change the step type by changing the "attribute" setting on the step property screen.
- For the reset step [R], block start step (with end check) [BC], and block start step (without end check) [BS], specify the step name or block number in "Attribute specification destination" on the property screen. increase.

2.5.2 Normal Step (no attributes)

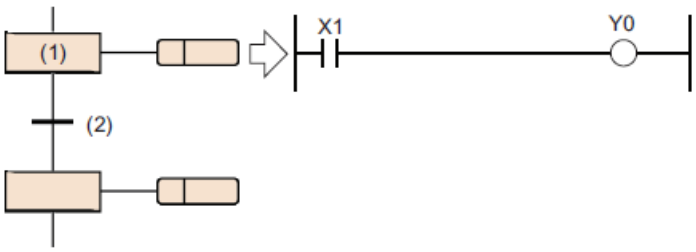
A normal step (with no attributes) is the basic step that constitutes a block. When a step is active, the next transition condition is always checked, and when the transition condition is satisfied, the activity shifts to the next step.

(1) Operation output of the step

The operation output status of each step differs depending on the instruction used.

- When using OUT instruction (except OUT C instruction)

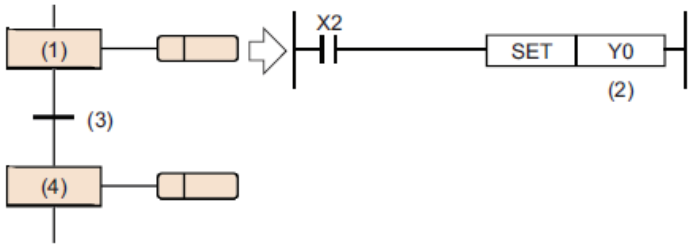
  When the activity shifts to the next step and the corresponding step becomes inactive, the output by the OUT command is automatically turned OFF. Similarly, the timer clears the current value and turns the contact OFF. However, output by OUT commands used in ST language selection statements or repeated statements is not automatically turned off.



If Y0 is turned ON by the OUT command in the operation output of step (1), Y0 is automatically turned OFF when the transition condition (2) is satisfied.

- Using SET, basic, and applied commands

  Even if the activity shifts to the next step and the corresponding step becomes inactive, data stored in the ON state or device/label is retained.
  To turn off the device/label in the ON state or clear the data stored in the device/label, use the RST command in another step.



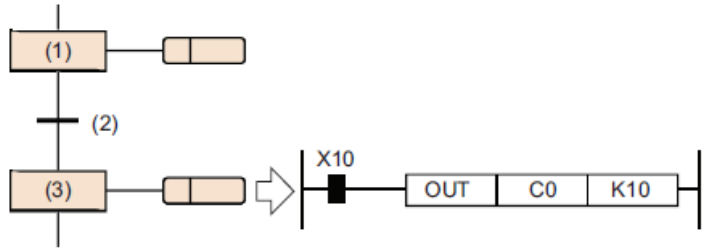
If Y0 is turned ON by the SET command in the operation output of step (1) (2), Y0 remains ON even if the transition condition (3) is satisfied and the operation proceeds to step (4).

- When using OUT C instruction

If the execution condition of the counter in the operation output is already ON and the transition condition is satisfied and the step is activated, the count is performed once.

If activation moves to the next step before executing the counter reset command, the current value of the counter and the ON state of the contact are retained even if the step becomes inactive.

To reset the counter, execute the RST command in another step.



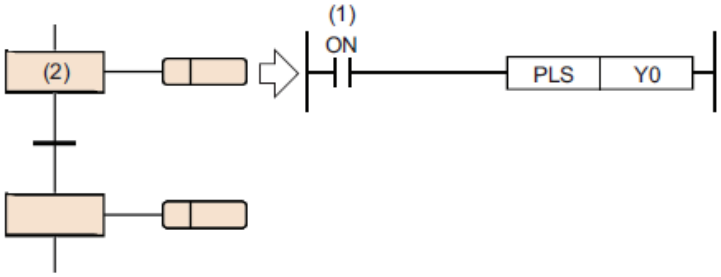
If step (1) is active and X10 is already ON, the counter C0 counts once when the transition condition (2) is satisfied, and the process proceeds to step (3).

C0 retains its value even if the transition condition is satisfied.

Reset the counters in a separate step.

- When using PLS and rise commands as the operation output

Even if the contact point of the execution condition is always ON, the command is executed every time the step changes from inactive to active.



Even if the execution condition contact is always ON (1), the PLS instruction is executed every time Step (2) becomes active.

The drop command is executed the same as the PLS command and the rise command.

Normal Step (no attributes)

- During step execution, always check the transition conditions described next to the applicable step, and when the transition conditions are satisfied, move the activity to the next step.
- Note the difference in operation when using counters when using SET, basic, and applied commands when using OUT commands
- When the interlock of the execution condition is ON, the PLS command and the rise command are executed every time the corresponding step becomes active.

2.5.3 Initial step

An initial step is a step that indicates the beginning of each block, and a maximum of 32 initial steps can be specified for each block.

Only selective joins are allowed when there are multiple initial steps. The initial step is executed in the same way as any other step.

The following attributes can be added to the initial step: SC (coil HOLD), SE (operation HOLD (no transition check)), ST (operation HOLD (transition check)), and R (reset).

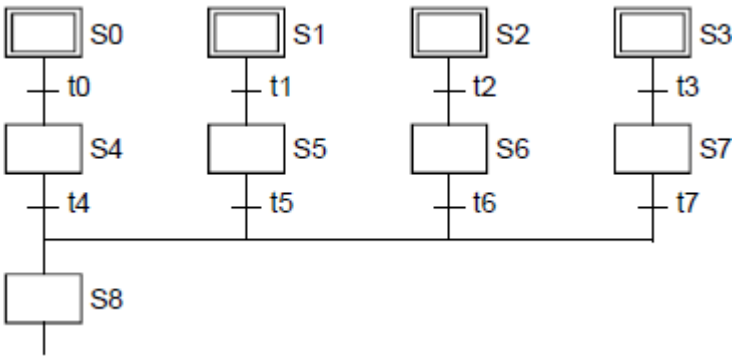
If you assign an attribute to an initial step, the action is the same as for steps other than the initial step, except that the action is automatically activated when the block starts.

(1) Active step at block activation

If the initial step consists of multiple steps, the activation steps for starting a block are as follows, depending on the activation method.

Operation of the active step	Startup Method
All the initial steps are activated	When starting by the block start step
	When starting by block start instruction of SFC control instruction
	Forced start is attempted by the block start end bit of the SFC information device.
	When Block0 starts due to the automatic start setting of Block0
Activate only the specified step	When any of the initial steps is specified by the step control instruction of the SFC control instruction

(2) Transition processing when multiple initial steps are activated



When blocks with multiple initial steps active are selectively combined, if any one of the transition conditions immediately before the combination is satisfied, the step immediately after the combination is activated.

In the above example program, step8 (S8) is activated when any of the transition conditions t4 to t7 is satisfied. If the step immediately after binding (S8 in the above example program) is activated and another transition condition immediately before binding (t4 to t7 in the above example program) is satisfied, the step immediately after binding is activated again.

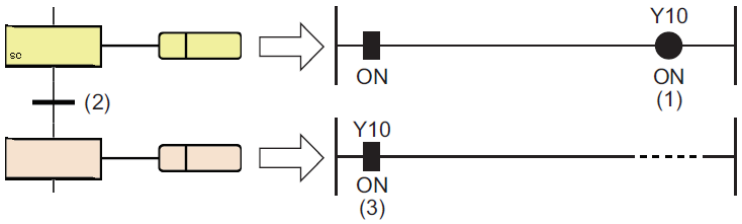
Initial Step

- Step to indicate the beginning of the block
- Up to 32 initial steps can be written per block
- By creating multiple initial steps, it is possible to easily describe the process of executing multiple processes and merging them.

2.5.4 Coil HOLD Step [SC]

A step that holds the outputs of a coil that has been turned on by the action even after the active state transitions.

After the transition condition is satisfied and the process moves to the next step, no calculation is performed in the operation output. Therefore, the coil output state does not change even if the input condition in the operation output changes. This is useful when you want to keep the output until the block ends, for example, when you want to output a hydraulic motor or a passage confirmation signal.



Y10 (1), which is turned ON by the OUT command, remains ON (3) even if the transition condition (2) is satisfied.

(1) Timing of coil output OFF

Below indicates the timing when the coil output that is held ON turns OFF in the coil HOLD step [SC] after the transition:

a) You performed a block end step. (Except when SM327 is ON)
b) The block is forcibly terminated by the RST instruction (block termination) of the SFC control instruction.
c) When the step is reset by the RST instruction (step end) of the SFC control instruction.
d) When the device specified in the block start end bit of the information device for SFC is reset.
e) When the reset step [R] set to reset the coil HOLD step [SC] is activated.
f) SM321 (start/stop of SFC program) is turned OFF.
g) The coil is reset programmatically.
h) When the stop output mode is OFF, and a stop command is executed.
i) S999 is specified for the reset step [R] in the block.

(2) Operation at block stop/restart

The following describes the processing performed when a block is stopped. The operation at block stop/restart depends on the combination of the SM325 (output mode setting at block stop), setting of the stop mode bit of the SFC information device, and HOLD/non-HOLD of steps.

<table>
<tr><td rowspan="2">Setting the Output Mode at Block Stop</td><td rowspan="2">Setting the Blocking Stop Mode Bit</td><td colspan="2">Operation</td></tr>
<tr><td>Active steps other than HOLD (Including SC, SE, and ST for which transition conditions have not been met)</td><td>HOLD Step
Coil HOLD step [SC]</td></tr>
<tr><td rowspan="2">SM325 = OFF (Coil Output OFF)</td><td>OFF or not set (stop immediately)</td><td>Immediately after a stop request is received, the coil output of the operation output is turned off and stopped. The state remains active.</td><td rowspan="2">Immediately after a stop request is made, the coil output of the operation output is turned off, and it becomes inactive.</td></tr>
<tr><td>ON (Stop after transition)</td><td>After the transition is completed, the process terminates the step, and at the same time, the transition destination step becomes active and stops before the operation output is executed.</td></tr>
<tr><td rowspan="2">SM325 = ON (Keep Coil Output)</td><td>OFF or not set (stop immediately)</td><td>Immediately after a stop request is made, the motor stops while maintaining the coil output of the operation output. The state remains active.</td><td rowspan="2">Immediately after a stop request is made, the motor stops while maintaining the coil output of the operation output. The state remains active.</td></tr>
<tr><td>ON (Stop after transition)</td><td>The operation is the same as usual until the transition is completed. After the transition is completed, the process terminates the step, and at the same time, the transition destination step becomes active and stops before the operation output is executed.</td></tr>
<tr><td colspan="2">Resume</td><td>Normal operation returns.</td><td>When the coil output is OFF: it is inactivated and cannot be restarted.
When HOLD coil output: Resumes while HOLD.</td></tr>
</table>

(3) Precautions when specifying the coil HOLD step

Note the following when specifying the coil HOLD step:

- Normally, the PLS and PLF commands are turned ON for only one scan of the designated device and then turned OFF. However, if the designated device is turned ON at the same time as the transition of the coil HOLD step [SC] is completed, the PLS and PLF commands remain ON.
  In this case, if the coil output of the coil HOLD step [SC] is turned OFF, or if the step is activated again, it is turned OFF.
- If the transition condition is satisfied in the coil HOLD step [SC], if the step is stopped with the setting for HOLD the SM325 (output mode at block stop), or if the coil output is only held but no operation is being performed, the operation of each instruction at the time of resuming the operation is in the non-execution state, and the operation depends on the execution condition before the non-execution.
- Count is not performed even if the count input condition is turned ON/OFF after the next step.
- When the timer coil is ON and the transition condition is satisfied and the step shifts, the timer stops measurement and retains the current value.

Coil holding step

- Even if the transition condition is satisfied, the coil output turned on by the OUT command is retained.
- After the transition condition is satisfied, the circuit is not operated and is not affected by ON/OFF state of the interlock condition.
- OFF the output held by the end step, SFC control command, SFC information device, etc.

2.5.5 Operation HOLD Step (no Transition Check) [SE]

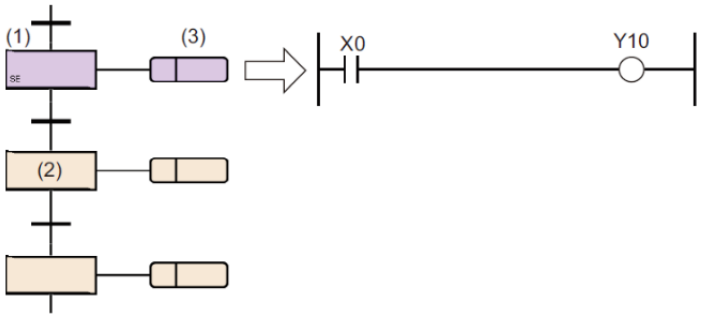
A step which continues the operation of the action even after the active state transitions.

After the transition becomes TRUE and the next step is activated, the transition is not checked.

When the transition condition is satisfied, the operation in the operation output continues even after the next step is completed. Therefore, the state of the coil changes when the input condition changes.

After the transition condition is satisfied and the next step becomes active, the system does not check the transition condition, and if the transition condition is satisfied again, the system does not move to the next step.

The operation HOLD step (no transition check) is useful when the corresponding block repeats the same operation while the cylinder is active, such as moving forward or backward.



If you move from step (1) to step (2), step (1) is being held.

During HOLD, the transition check is not performed, but the operation output (3) continues to be executed.

In this case, Y10 turns ON/OFF according to the ON/OFF state of X0.

(1) Timing of inactivation

Indicates when the operation HOLD step (no transition check) [SE] is deactivated.

a) You performed a block end step.
b) The block is forcibly terminated by the RST instruction (block termination) of the SFC control instruction.
c) When the step is reset by the RST instruction (step end) of the SFC control instruction.
d) When the device specified in the block start end bit of the information device for SFC is reset.
e) When the Reset Step [R] which is set to reset the operation HOLD step (no transition check) [SE] is activated.
f) SM321 (start/stop of SFC program) is turned OFF.
g) S999 is specified for the reset step [R] in the block.

(2) Operation at block stop/restart

The operation at block stop/restart depends on the combination of the SM325 (output mode setting at block stop), setting of the stop mode bit of the SFC information device, and HOLD/non-HOLD of steps.

<table>
<tr><td rowspan="2">Setting the Output Mode at Block Stop</td><td rowspan="2">Setting the Blocking Stop Mode Bit</td><td colspan="2">Operation</td></tr>
<tr><td>Active steps other than HOLD
(Including SC, SE, and ST for which transition conditions have not been met)</td><td>HOLD Step
operation HOLD step (no transition check) [SE]</td></tr>
<tr><td rowspan="2">SM325 = OFF (Coil Output OFF)</td><td>OFF or not set (stop immediately)</td><td>Immediately after a stop request is received, the coil output of the operation output is turned off and stopped. The state remains active.</td><td rowspan="2">Immediately after a stop request is received, the coil output of the operation output is turned off and stopped. The state remains active.</td></tr>
<tr><td>ON
(Stop after transition)</td><td>After the transition is completed, the process terminates the step, and at the same time, the transition destination step becomes active and stops before the operation output is executed.</td></tr>
<tr><td rowspan="2">SM325 = ON (Keep Coil Output)</td><td>OFF or not set (stop immediately)</td><td>Immediately after a stop request is made, the motor stops while maintaining the coil output of the operation output. The state remains active.</td><td rowspan="2">Immediately after a stop request is made, the motor stops while maintaining the coil output of the operation output. The state remains active.</td></tr>
<tr><td>ON
(Stop after transition)</td><td>The operation is the same as usual until the transition is completed. After the transition is completed, the process terminates the step, and at the same time, the transition destination step becomes active and stops before the operation output is executed.</td></tr>
<tr><td colspan="2">Resume</td><td>Normal operation returns.</td><td>To the operation output in the HOLD state
Restart execution.</td></tr>
</table>

Operation HOLD Step (No Transition Check)

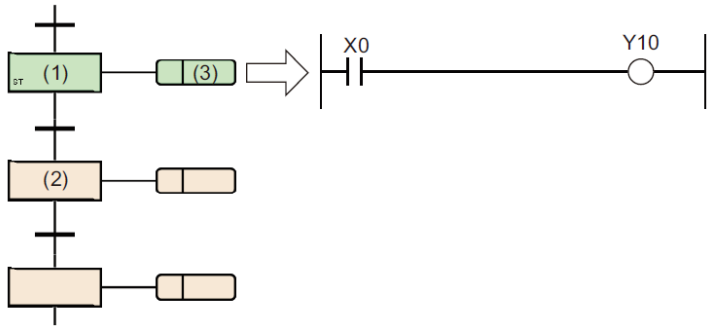
- If the transition condition is satisfied, the operation output of the step is continued.
- Once the transition condition is satisfied and the next step is activated, do not check the transition condition.
- OFF the output held by the end step, SFC control command, SFC information device, etc.
- When the operation output flag (SM325) is ON/OFF, the coil output is switched ON/OFF when the block is stopped.

2.5.6 Operation HOLD Step (with Transition Check) [ST]

The operation HOLD step (with the transition check) is a step that continues to execute the action output even after the activity shifts.

When the transition condition is satisfied, the operation in the operation output continues even after the next step is completed. Therefore, the state of the coil changes when the input condition changes.

After the transition condition is satisfied and the next step becomes active, the transition condition is checked repeatedly. When the transition condition is satisfied again, the next step is activated again and the operation in the operation output continues.

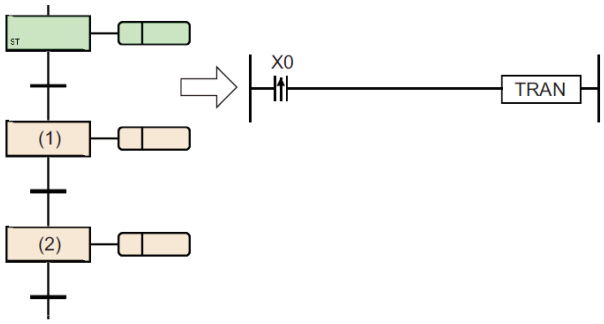


If you move from step (1) to step (2), step (1) is being held.

The operation output (3) continues to be executed even during the active step.

In this case, Y10 turns ON/OFF according to the ON/OFF state of X0.

A transition check is also performed, and the next step is activated when the transition condition is satisfied.



(1) Timing of inactivation

The timing at which the Operation HOLD Step (with transition check) becomes inactive is shown below.

a) You performed the end step for the block.
b) When the corresponding block is forcibly terminated by the SFC control instruction RST instruction (block termination).
c) When the step is reset by the SFC control command RST command (step end).
d) When the device specified as the block start-end device of the information device for SFC is reset.
e) When the reset step [R] which is set to reset the operation HOLD step (with transition check) [ST] is activated.
f) When SM321 (start/stop of SFC program) is turned OFF
g) S999 is specified for the reset step [R] in the block.

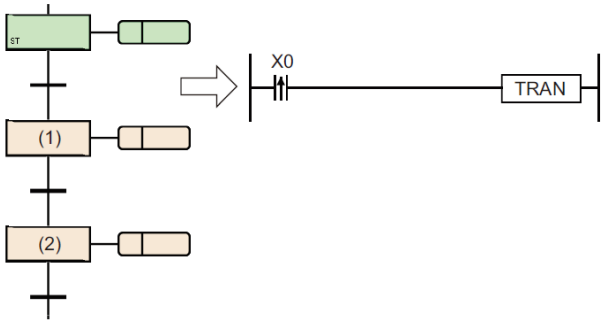
(2) Operation at block stop/restart

The operation at block stop/restart depends on the combination of the SM325 (output mode setting at block stop), setting of the stop mode bit of the SFC information device, and HOLD/non-HOLD of steps.

Setting the Output Mode at Block Stop	Setting the Block Stop Mode Bit	Operation	
		Active steps other than HOLD (Including SC, SE, and ST for which transition conditions have not been met)	HOLD Step operation HOLD step (no transition check) [SE]
SM325 = OFF (Coil Output OFF)	OFF or not set (stop immediately)	Immediately after a stop request is received, the coil output of the operation output is turned off and stopped. The state remains active.	Immediately after a stop request is received, the coil output of the operation output is turned off and stopped. The state remains active.
	ON (Stop after transition)	After the transition is completed, the process terminates the step, and at the same time, the transition destination step becomes active and stops before the operation output is executed.	
SM325 = ON (Keep Coil Output)	OFF or not set (stop immediately)	Immediately after a stop request is made, the motor stops while maintaining the coil output of the operation output. The state remains active.	Immediately after a stop request is made, the motor stops while maintaining the coil output of the operation output. The state remains active.
	ON (Stop after transition)	The operation is the same as usual until the transition is completed. After the transition is completed, the process terminates the step, and at the same time, the transition destination step becomes active and stops before the operation output is executed.	
Resume		Normal operation returns.	Resumes the operation output in the retained state, and also checks the transition conditions.

(3) Cautionary Notes

- In the operation HOLD step (with transition check) [ST], the next step of each scan is started while the next transition condition is satisfied. To prevent transition every time a scan is performed, use a startup execution command such as a PLS command as a transition condition.



By using the transition condition as the condition for starting the rise pulse operation, step (1) is started only for one scan at the time X0 turns ON.

Even if you move from step (1) to step (2) and step (1) becomes inactive, step (1) does not start unless X0 turns OFF → ON again.

- If the SM328 (clear processing mode upon arrival of END step) is ON, make sure that the transition condition immediately after the operation HOLD step (with transition check) [ST] is not always satisfied. The block cannot be terminated because the next step is always in the active state of not HOLD.

Operation HOLD Step (With Transition Check)

- If the transition condition is satisfied, the operation output of the step is continued.
- Check transition conditions immediately after step
- Transition conditions use instructions for startup execution, such as PLS instructions
- OFF the output held by the end step, SFC control command, SFC information device, etc.
- When the operation output flag (SM325) is ON/OFF, the coil output at block stop is switched to ON hold/OFF.

2.5.7 Reset Step [R]

- The reset step [R] deactivates the specified step in the local block before executing the scan operation outputs every time. This is the same as a normal step (no attribute) except that the specified step is reset.
- If the specified step No. is S999, all the HOLD steps [SC, SE, ST] held in the local block are deactivated. In this case, only the HOLD step [SC, SE, ST] that is being held can be deactivated. If the operation HOLD step [SE, ST] is not held, it is not disabled.
- The local step No. cannot be specified as the specified step No.

Reset Step

- Step of deactivating holding step*

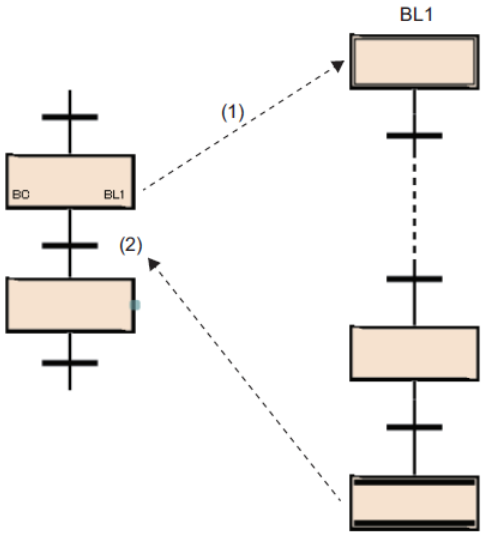
  *Holding step: a step in which the step attribute is set to coil holding step [SC], operation holding step (no transition check) [SE], operation holding step (transition check) [ST], and the transition condition is satisfied, and the step is held.

2.5.8 Block Startup Steps (With Exit Check) [BC]

The block start step (with completion check) activates the specified block.

When the specified block becomes inactive and the transition condition is satisfied, the activity shifts to the next step.

The block start step (with end check) can be used to subdivide blocks. This is useful, for example, when a machining process is set as a separate block on a machining line, and when machining is completed, the process returns to the starting source and moves to the next process.



Block start step (with end check) When [BC] is activated, block (BL1) is started (1).

No processing is performed until execution of the startup block (BL1) ends and the system becomes inactive, and the transition condition (2) is not checked.

When block (BL1) finishes executing and becomes inactive, only the transition condition (2) is checked, and when the transition condition (2) is satisfied, the process proceeds to the next step.

(1) Simultaneous block startup

When a block is started at the same time or when a block that has already been started is started, the operation settings for dual block start are used.

For details, see 3.4.1 Operation setting for block dual start.

Only one block can be specified. To start multiple blocks at the same time, use a parallel branch and use multiple block start steps.

(2) Cautionary Notes

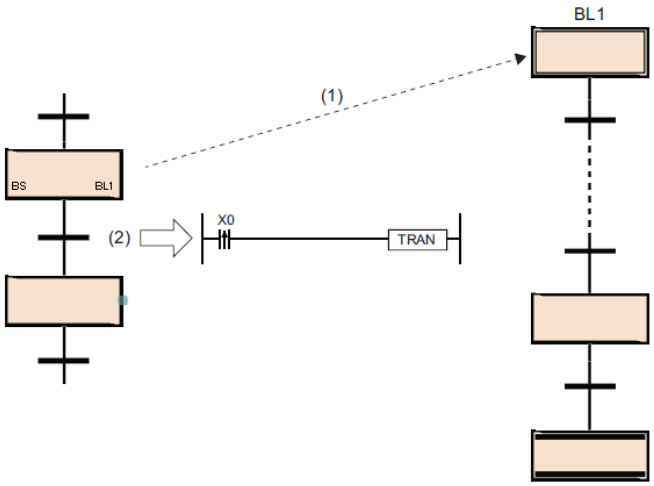
- Action output cannot be created for block start step (with end check) [BC].
- Block start step (with end check) [BC] cannot be created immediately before parallel join. Use the block start step (no end check) [BS] to create a parallel join immediately before joining it.

Block start step (with exit check)

- Step of activating the specified block
- Start checking the transition conditions after the startup block becomes inactive.
- Identical blocks cannot be started at the same time
- Parallel branching allows multiple blocks to be started simultaneously
- Cannot be created immediately before joining parallel joins

2.5.9 Block Startup Step (No Exit Check) [BS]

The block start step (no end check) activates the specified block.
When the transition condition is satisfied, the activity shifts to the next step.
This block start step (no end check) can be used for asynchronous processing.



After the block (BL1) is started by the block start step (no end check) [BS], only the transition condition (2) is checked, and if the condition is satisfied, the process proceeds to the next step without waiting for the start block (BL1) to finish.

(1) Simultaneous block startup

When a block is started at the same time or when a block that has already been started is started, the operation settings for dual block start are used.

For details, see 3.4.1 Operation setting for block dual start.

Only one block can be specified. To start multiple blocks at the same time, use a parallel branch and use multiple block start steps.

(2) Cautionary Notes

- Action output cannot be created for block start step (no end check) [BS].
- You can create a block start step (no end check) immediately before a parallel join.

Block start step (with exit check)

- Step of activating the specified block
- After starting the specified block, only the transition condition is checked.
- Identical blocks cannot be started at the same time
- Parallel branching allows multiple blocks to be started simultaneously
- Can be created just before joining parallel joins

2.5.10 End step

The end step is to terminate the block.

- When the activity shifts to the end step and there is no active step other than the HOLD step in the block, all the HOLD steps [SC, SE, ST] in the block are deactivated and the block is terminated.
- If an active step other than the one being held exists in the block, the following processing is performed according to the status of SM328 (clear processing mode upon arrival of END step).

Status of the SM328	Contents
OFF (default)	Performs clearing processing. Kills all active steps remaining in the block and terminates the block.
ON	Does not perform clearing processing. Continues execution of the block without terminating the block.

- When clearing processing is executed, all coil output by OUT command is turned off. However, for the coil output of the HOLD step [SC, SE, ST], the following processing is performed according to the status of SM327 (output when the END step is executed).

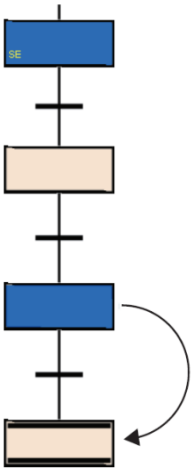
Status of the SM327	Contents
OFF (default)	Turns OFF all output of the HOLD step [SC, SE, ST].
ON	Retains all output of the HOLD step [SC, SE, ST]. The setting of the SM327 is valid only for the HOLD step [SC, SE, ST] that is being held. The output of all the hold steps [SC, SE, ST] whose transition conditions have not been satisfied and are not held are turned OFF. Even when the SM327 is ON, the step is inactive. However, in the case of forced termination by a block termination command, the coil output of all steps is turned off.

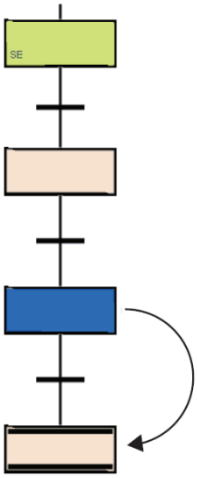
- Indicates how to start the block again after the block ends.

<table>
<tr><th colspan="2">Items</th><th>Contents</th></tr>
<tr><td rowspan="2">Block0</td><td>For Block0 in the SFC setting of the parameter
Set the start condition to "start automatically"</td><td>The initial step is automatically reactivated and repeated processing is executed.</td></tr>
<tr><td>For Block0 in the SFC setting of the parameter
Set the start condition to "Do not start automatically"</td><td rowspan="2">Restart the specified block when a start request is made in the following way:
• Activate the block activation step in another block.
• Execute the SET command (block start) of the SFC control command.
• Turn ON the block start end bit of the SFC information device.</td></tr>
<tr><td colspan="2">non-Block0</td></tr>
</table>

(1) Cautionary Notes

- Operation output cannot be created at the end step.
- The setting of SM327 (output when the END step is executed) takes effect only when the activity shifts to the end step. In case of forced termination by RST command (block termination), the coil output of all steps is turned OFF.
- If only the HOLD step [SC, SE, ST] remains when the activity shifts to the end step, the HOLD step [SC, SE, ST] becomes inactive even if the SM328 (clear processing mode when the END step arrives) is ON. If you do not want to turn off the coil output of the HOLD step [SC, SE, ST], turn on the SM327. The operation relationship between the SM328 and the HOLD step [SC, SE, ST] is shown below.

<table>
<tr><th>When the normal active step remains or the HOLD step [SC, SE, ST] where the transition has not been established remains (non-HOLD)</th><th>Remaining active steps during HOLD</th></tr>
<tr><td> 

If the SM328 is OFF, it is cleared and the block is terminated.
If the SM328 is ON, processing continues without clearing.</td><td> 

Clears and terminates the block regardless of the SM328 setting.</td></tr>
</table>

- If the SM328 is ON, processing returns to the original block when the block started by the block start step no longer contains a non-HOLD active step.
- Make sure that the transition condition after the operation HOLD step (with transition check) [ST] is not always satisfied. If the transition condition immediately after the operation HOLD step (with transition check) [ST] is always satisfied, the next step is always in the active state, and blocks cannot be terminated when the SM328 is turned on.

End Step

- When there is no active step other than the holding step in the block, all the holding steps [SC, SE, ST] in the block are deactivated and the block is terminated.
- By using SM327 (output during END step), coil output during holding step is maintained.
- Regarding block restart, Block0 can be automatically started after the end step is executed, but Block1~319 must be started programmatically.

2.5.11 Instructions that cannot be used for operation output

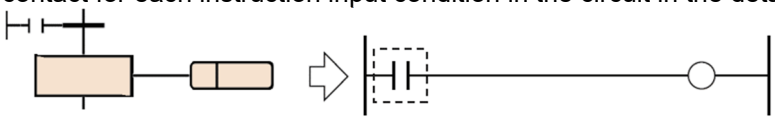
Some instructions cannot be used in the operation output. The following instructions cannot be used:

Classification	Instruction
Master control instruction	MC *1
	MCR *1
Termination instruction	FEND
	END
Program branch instruction	CJ *1
	SCJ *1
	JMP *1
	GOEND
Program execution control instruction	IRET
Structured instruction	BREAK *1
	RET
Transition condition dummy output	TRAN

*1 Available in function/function blocks in operation output.

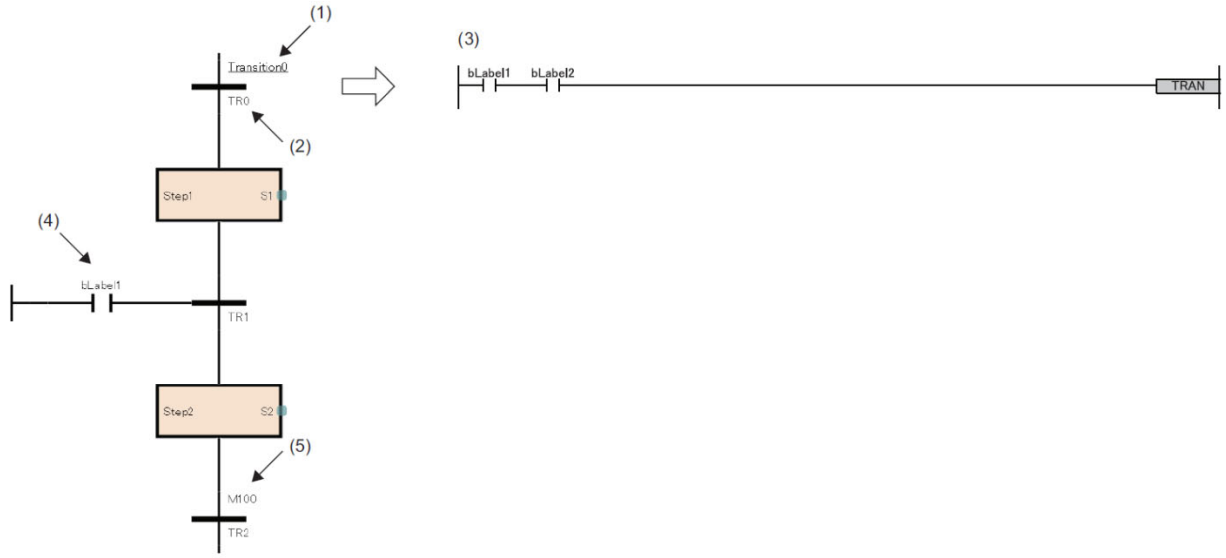
Point

Be sure to create a contact for each instruction input condition in the circuit in the detailed representation.



2.6 Transition Conditions

The transition condition is the basic unit for constructing a block, and when the condition is satisfied, the activity shifts to the next step.

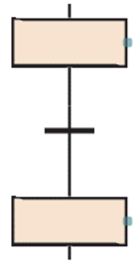
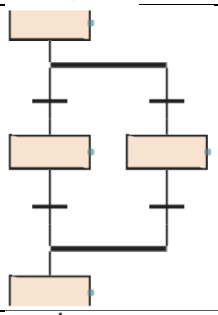
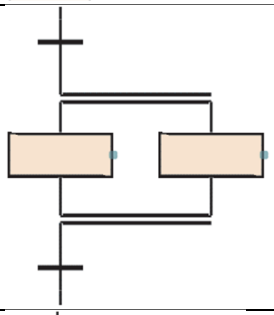
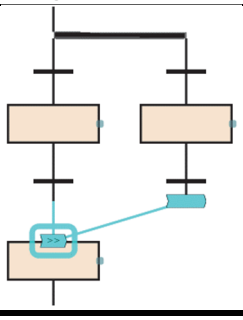


a) Transition Condition Name
b) Transition Condition No.
c) Detailed representation of transition conditions
d) Direct representation of transition conditions
e) Transition Criteria Labels/Devices

Detailed expressions for transition conditions can be created in ladder, ST, and FBD/LD languages. For ladder language, you can switch between detailed expressions and MELSAP-L (Instruction format).

2.6.1 Types of Transition Conditions

The types of transition conditions are as follows:

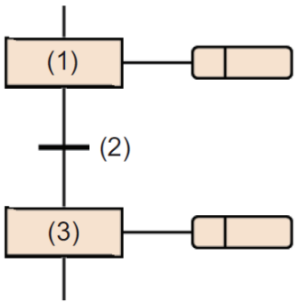
Items		Contents
Series Sequence		When the transition becomes TRUE, the active state transitions from the preceding step to the subsequent step.
Selective Sequence (Divergence/ Convergence)		Divergence: A step branches to multiple transitions, and only the step in the line where the transition becomes TRUE first is activated. Convergence: The next step is activated when the transition immediately before convergence, which is in the line where the transition becomes TRUE first, becomes TRUE.
Simultaneous Sequence (Divergence/ Convergence)		Divergence: All the steps branched from one step are activated simultaneously. Convergence: When all the steps immediately before convergence are activated and the common transition becomes TRUE, the active state transitions to the next step.
Jump Sequence		When the transition becomes TRUE, the active state transitions to the specified step in the same block.

Point

For the operation of transition to the step, which is already activated, refer to the following. 3.4.1 Operation setting at block dual start.

2.6.2 Series Sequence

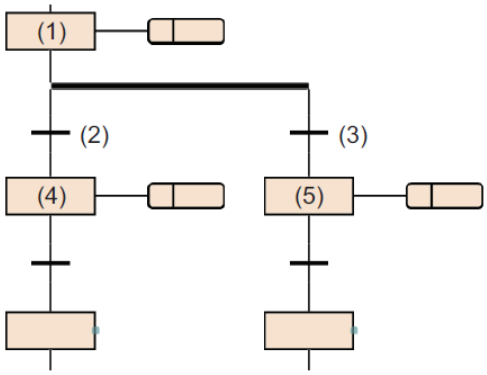
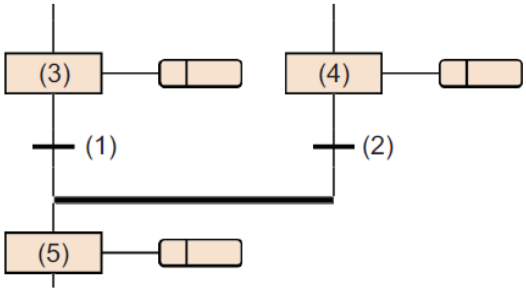
When the transition becomes TRUE, the active state transitions from the preceding step to the subsequent step.



When the transition (2) becomes TRUE while the step (1) is active, the step (1) is deactivated, and the step (3) is activated.

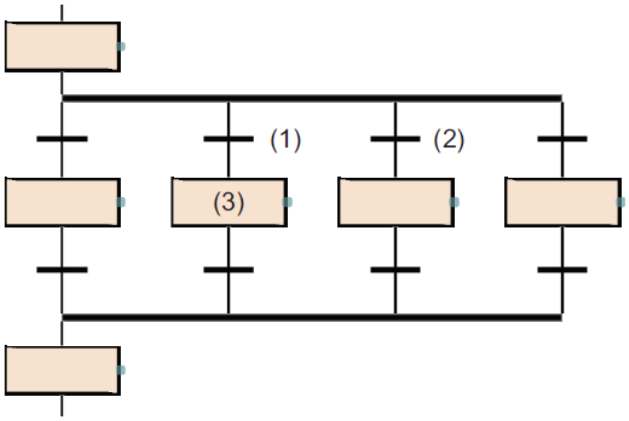
2.6.3 Selective Sequence (Divergence/ Convergence)

A step branches to multiple transitions, and only the step in the line where the transition becomes TRUE first is activated. The next step is activated when the transition immediately before convergence, which is in the line where the transition becomes TRUE first, becomes TRUE.

Items	Contents	
Divergence		When the step (1) is active, the step (4) or (5) is activated depending on which of the transition (2) and transition (3) becomes TRUE first. The step (1) becomes inactive. However, if it is a HOLD step [SC, SE, ST], the step holds the coil output or action according to its attribute. ・If multiple transitions become TRUE simultaneously, the condition to the left will take precedence. ・Subsequent processing will proceed from step to step in the selected column until another convergence occurs.
Convergence		When the transition (1) or transition (2) on the activated branch becomes TRUE, the step (5) is activated. The activated step (3) or step (4) becomes inactive. However, if it is a HOLD step [SC, SE, ST], the step holds the coil output or action according to its attribute.

In selective transition, you can branch to a maximum of 32 transition conditions.

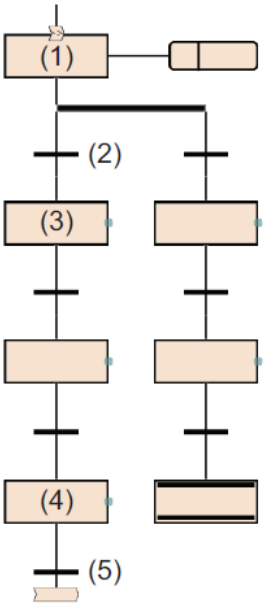
If multiple transition conditions are satisfied at the same time, the transition conditions on the left have priority.



If the transition conditions (1) and (2) are satisfied at the same time, the operation output of step (3) is executed.

You can also create SFC diagrams with different number of branches and joins for selection transition. However, you cannot create SFC diagrams of a combination of selective branches and parallel joins, or a combination of parallel branches and selective joins.

In selection transition, you can skip joins by jump transition and end steps.



If the transition condition (2) is satisfied during the operation output of step (1), steps (3) to (4) are executed in order. When the transition condition (5) is satisfied, the jump transitions to step (1).

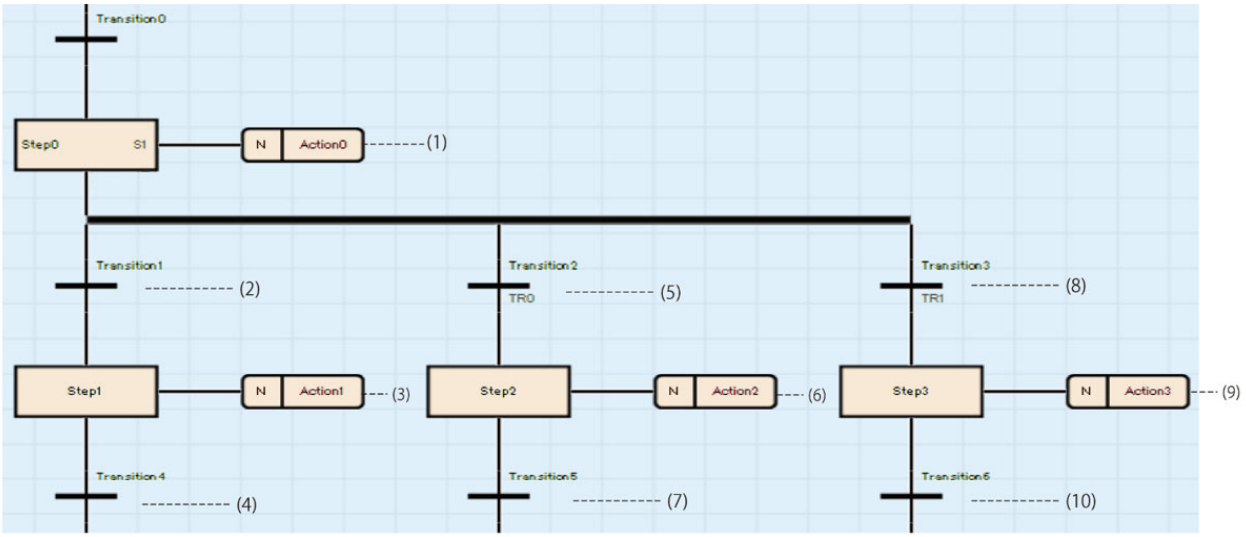
Point

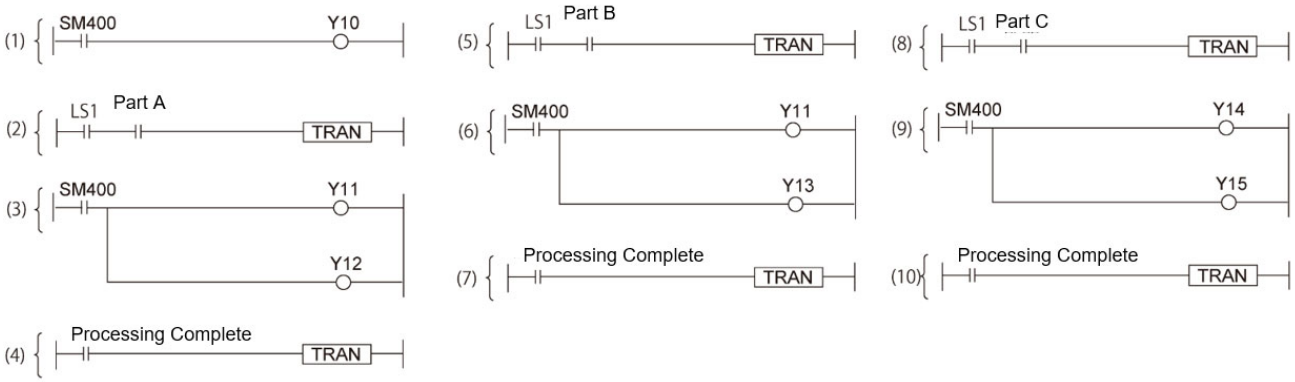
The above program can be created by changing the steps other than the left end of the selected branch to the end step and changing the end step at the left end of the selected branch to the jump transition.
For the operation method to change the step, refer to the following manual.
GX Works3 Operating Manual

(1) Actions appropriate for selective transition

Select transition is used when the previous operation is common, and you want to change the work from the middle of the process according to conditions.

For example, a conveyor can be used to transport multiple types of parts to a machining table, and the machining method is controlled differently depending on the type of parts delivered to the machining table.



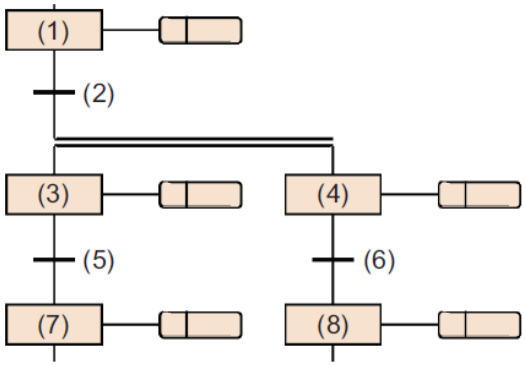
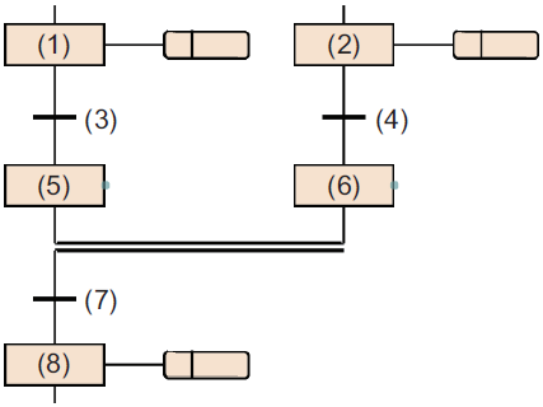


Selective transition

- Of multiple steps connected in parallel, only the step for which the transition condition is satisfied earliest is activated.
- Up to 32 steps can be selected.
- If multiple transition conditions for the selected step are satisfied at the same time, priority is given to the transition conditions on the left side.

2.6.4 Simultaneous Sequence (Divergence/ Convergence)

In parallel transition, activity moves from one step to all the multiple branched steps at the same time. If all the steps immediately before the connection are activated, the activation moves to the next step when the common transition conditions are satisfied.

Items	Contents	
Divergence		When the transition (2) becomes TRUE while the step (1) is active, both step (3) and step (4) are activated at the same time. The step (1) becomes inactive. However, if it is a HOLD step [SC, SE, ST], the step holds the coil output or action according to its attribute. Processing will proceed to step (7) when transition (5) becomes TRUE, and to step (8) when transition (6) becomes TRUE.
Convergence		When the transition (3) and transition (4) become TRUE while the step (1) and step (2) are active, the step (5) and step (6) are activated. After the step (5) and step (6) immediately before the convergence become active, the transition (7) is checked and then becomes TRUE, the step (8) is activated. The step (5) and step (6) become inactive. However, if it is a HOLD step [SC, SE, ST], the step holds the coil output or action according to its attribute.

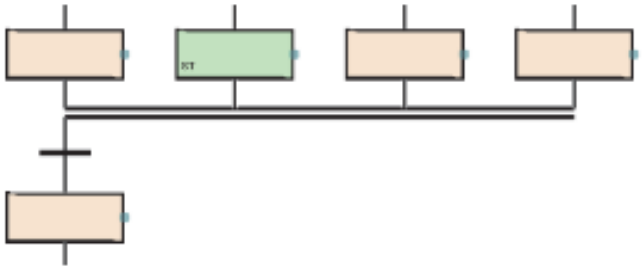
The simultaneous sequence allows transitions to up to 32 steps.

If another block is started by the simultaneous sequence, the START source block and START destination block will be executed simultaneously.

A simultaneous convergence is always performed after a simultaneous branch.

(1) Cautionary Notes

When the steps connected by a convergence include HOLD steps [SC, SE, ST] that hold operations, the operation is performed as follows.

Items	Contents
Coil HOLD step [SC]	Like the inactive step, it does not move to the next step.
Operation HOLD step (without transition check) [SE]	
Operation HOLD step (with transition check) [ST]	If the other connected steps are active, the process moves to the  next step.

In the simultaneous convergence, a block start step (with END check) [BC] cannot be created immediately before the convergence. Use a block start step (without END check) [BS].

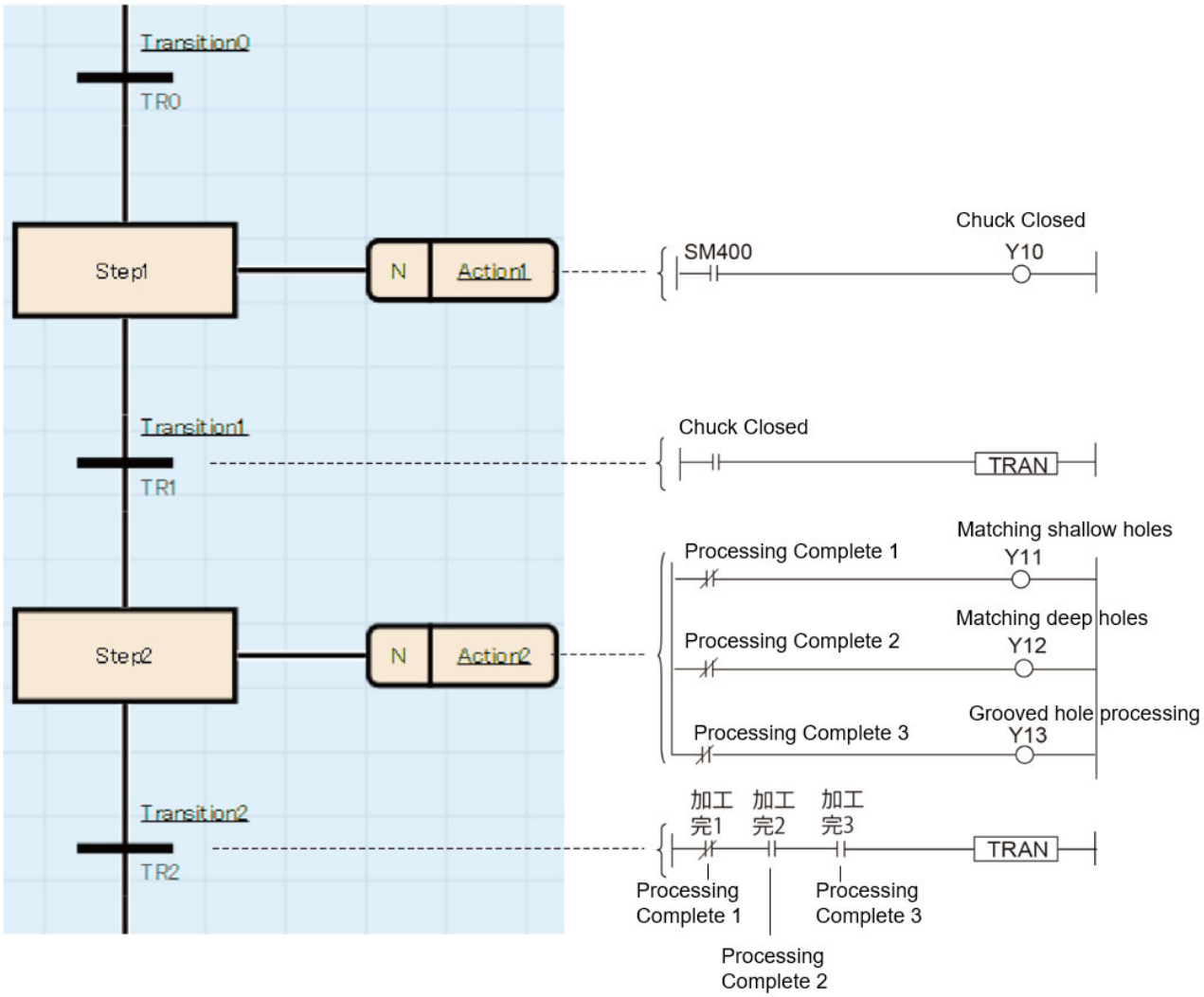
(2) Processing Suitable for Parallel Transition

Parallel transition is used to reduce the interlock condition when the previous transition condition is satisfied and multiple operations are started at the same time, and the termination conditions for each operation are different.

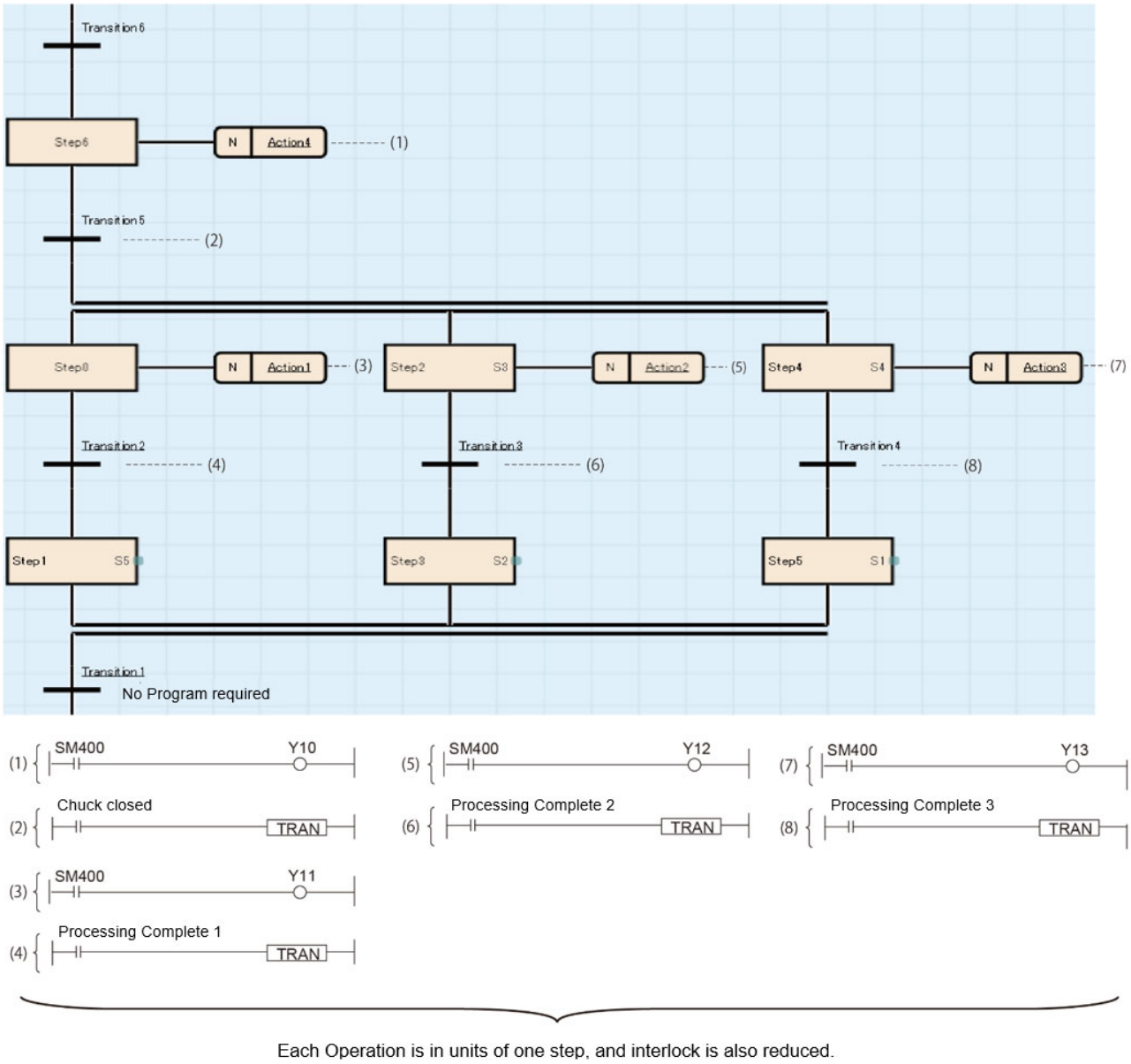
For example, a part is set on a machining table, and multiple drilling operations are performed on the same part.

By using parallel transition, you can create programs that are easier to see and reduce interlocks.

(a) Without parallel transition



(b) When using parallel transition



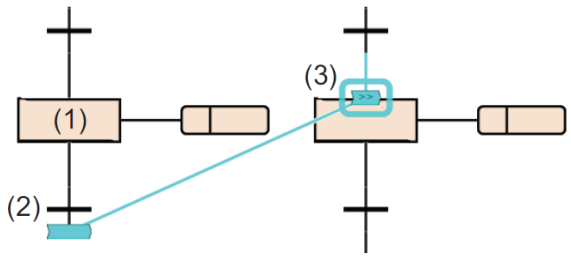
Each Operation is in units of one step, and interlock is also reduced.

Parallel Transition

- When the transition condition is satisfied, all steps connected in parallel are executed.
- Up to 32 simultaneous steps
- Need to align the number of branches and joins

2.6.5 Jump Sequence

When the transition becomes TRUE, the active state transitions to the specified step in the same block.

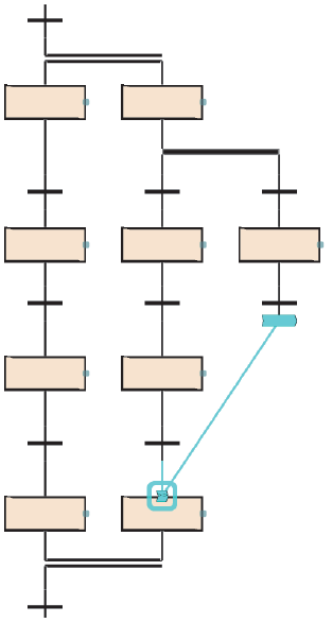


When the transition (2) becomes TRUE while the step (1) is active, the step (3) is activated.

There are no restrictions regarding the number of jump sequences.

A jump sequence in the simultaneous sequence is possible only in the same branch. A jump sequence to another branch within a simultaneous branch, a jump sequence for exiting from a simultaneous branch, or a jump sequence to a simultaneous branch from outside a simultaneous branch cannot be created.

Example of jump sequence that can be specified in the simultaneous branch



(1) Cautionary Notes

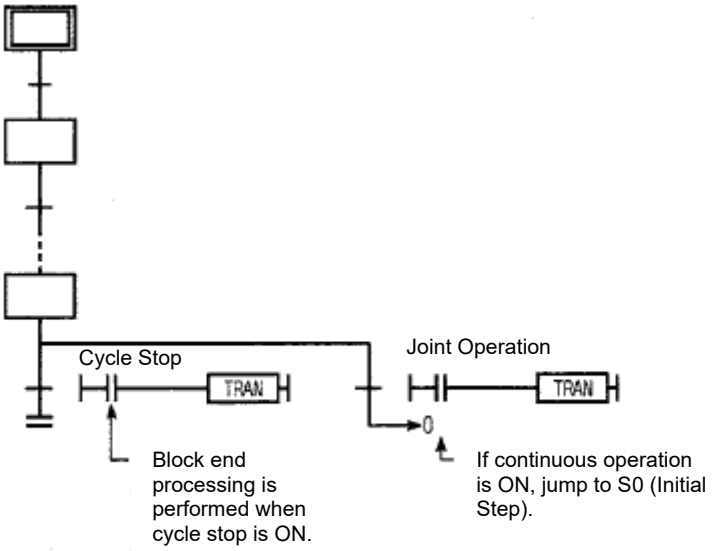
Under the following conditions, a step cannot be specified as the destination of jump sequence.

- When a step at the position escaping from a simultaneous sequence is specified
- When a step at the position entering a simultaneous sequence is specified
- When a step immediately before the preceding transition is specified
- When current step is specified

(2) Processes suitable for jump transitions

Jump transition is used to perform the same task repeatedly without restarting the system by performing block end processing each time.

For example, if the continuous operation command is ON when one cycle of work is completed, the initial step can be used again.



Jump Transition

- When the transition condition is satisfied, the activity shifts to the specified step in the same block.
- Jump transitions within parallel transitions can only be used within the same branch
- Jump transition to own step is prohibited

2.6.6 Instructions that can be used in transition conditions

The following table lists the instructions that can be used in transition programs. Classification instruction symbol

Classification	Instruction symbol
Contact instruction	LD, LDI, AND, ANI, OR, ORI
	LDP, LDF, ANDP, ANDF, ORP, ORF
	LDPI, LDFI, ANDPI, ANDFI, ORPI, ORFI*1
Association instruction	ANB, ORB
	INV
	MEP, MEF
	EGP, EGF*1
Comparison operation instruction	LD☐, LD☐_U, AND☐, AND☐_U, OR☐, OR☐_U
	LDD☐, LDD☐ _ U, ANDD☐, ANDD☐ _ U, ORD☐, ORD☐ _ U
Real number instruction	LDE☐, ANDE☐, ORE☐
	LDED☐, ANDED☐, ORED☐
Character string processing instruction	LD$☐, AND$☐, OR$☐
Creating a dummy transition condition	TRAN*2

*1 The EGP and EGF instructions cannot be used in a transition program created in ST or FBD/LD.

*2 The LDPI, LDFI, ANDPI, ANDFI, ORPI, ORFI, and TRAN instructions cannot be used in a transition program created in MELSAP-L (instruction format).

2.7 SFC control instruction

SFC control instructions are used to check a block or step operation status (active/inactive), or to execute a forced start, end, or others. If SFC control instructions are used, SFC programs can be controlled from the actions of sequence programs and SFC programs.

The following table lists the SFC control instructions.

Instruction name	Instruction symbol	Processing
Checking the status of a step	LD, LDI, AND, ANI, OR, ORI [S☐]*1	Checks whether the specified step is active.
	LD, LDI, AND, ANI, OR, ORI [BL☐ \S☐]	
Checking the status of a block	LD, LDI, AND, ANI, OR, ORI [BL☐]	Checks whether the specified step is active.
Batch-reading the status of steps	MOV (P) [K4S☐] *1	Batch-reads (in units of 16-bit binary data) the status (active or inactive) of steps in a specified block and stores the read data in a specified device.
	MOV (P) [BL☐\K4S☐]	
	DMOV (P) [K8S☐] *1	Batch-reads (in units of 32-bit binary data) the status (active or inactive) of steps in a specified block and stores the read data in a specified device.
	DMOV (P) [BL☐\K8S☐]	
	BMOV (P) [K4S☐] *1	Batch-reads (in units of the specified number of words starting from a specified step) the status (active or inactive) of steps in a specified block.
	BMOV (P) [BL☐\K4S☐]	
Starting a block	SET [BL☐]	Activates a specified block and executes a step sequence starting from an initial step.
Ending a block	RST [BL☐]	Deactivates a specified block.
Pausing a block	PAUSE [BL☐]	Temporarily stops a step sequence in a specified block.
Restarting a block	RSTART [BL☐]	Releases the temporary stop and restarts the sequence from the step where the sequence was stopped in the specified block.
Activating a step	SET [S☐] *1	Activates a specified step.
	SET [BL☐\S☐]	
Deactivating a step	RST [S☐] *1	Deactivates the specified step.
	RST [BL☐\S☐]	
Switching a block	BRSET	Specifies a target block No. of SFC control instruction.

*1 When using in a sequence program, Block0 is the target block. When using in a SFC program, current block is the target block.

For details on the SFC control instructions, refer to the following:

MELSEC iQ-R Programming Manual (CPU Module Instructions, Standard Functions/Function Blocks)

(1) Cautionary Notes

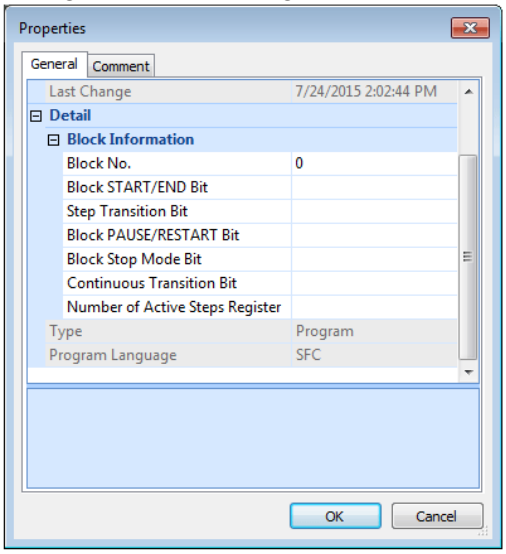
- Do not use the SFC control instructions in interrupt programs.
- Execute the SFC control instruction only when SM321 (SFC program start/stop) is on.
- Step relay can be used only with the following instructions.
    - Step activation check, batch reading of activated steps, step start, step end
- Step relay specifies the step in the running block. Therefore, to specify a step for a specific block, use BL\S.☐☐

2.8 Information Device for SFC

SFC information device is the device or label which operates the forced start/termination and pause/restart direction to a block, check of the status of transition and the number of active steps, or direction of continuous transition operation of a transition.

SFC information device is set every block.

[Navigation window] > [Program] > SFC program file > Properties of block to be set



The following shows the types of information devices for SFC and the devices that can be used.

Items	Contents	Available Data	
		Device	Data Type (Label)
Block START/END Bit	Sets the device or label to check whether the block is active. Setting the bit to ON can start the block and setting it to off can end the block.	Bit: Y, M, L, F, V, B Word: Bit specification of D, W, RD	Bool, Boolean array, INT bit specification, Word bit specification
Step Transition Bit	Sets the device or label to check whether the transition of the step being executed becomes TRUE. This bit turns on when the transition to the next step becomes TRUE after execution of the action of each step.		
Block PAUSE/RESTART Bit	Sets the device or label to pause or restart an active block. Setting the bit to on stops the block at the step-in execution and setting it to off restarts executing the block from the step where the block was stopped previously.		
Block Stop Mode Bit	Sets the device or label that decides the timing for stopping a block. Setting the bit to on stops the block after transition of each step and setting it to off stops all steps immediately.		
Continuous Transition Bit	Sets the device or label that decides the continuous transition action when the transition becomes TRUE. Setting the bit to on enables continuous transition and accordingly the action of the next step is executed in the same scan. Setting the bit to off disables continuous transition and accordingly one step is executed every scan.		
Number of Active Steps Register	Sets the device or label in which the number of currently active steps of a block is to be stored.	D, W, R, ZR, RD	INT, WORD

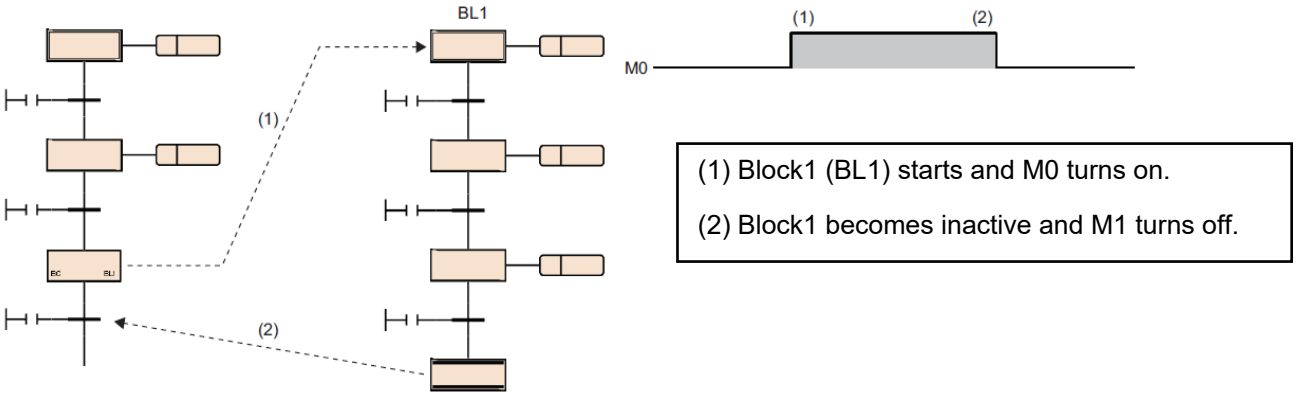
You can specify global or local labels as well as global or local devices for the SFC information device. You cannot use indirect specification, digit specification, or index qualification (Z, LZ).

2.8.1 Block START/END bit

This bit is a device or label to check whether the block is active.
Setting the bit to ON can start the block and setting it to off can end the block.
If a program to start a block is not available or because the START/END of a block can also be controlled from the engineering tool, this device or label can be used for debugging or test operation in units of block.

- When the set block starts, the block START/END bit is automatically turned on. While the set block is active, the block START/END bit stays on.
- When the set block becomes inactive, the block START/END bit is automatically turned off. While the set block is inactive, the block START/END bit stays off.

M0 is specified in the block START/END bit of Block1 (BL1).



(1) Block1 (BL1) starts and M0 turns on.

(2) Block1 becomes inactive and M1 turns off.

- When the block START/END bit is turned on while the set block is inactive, the block is started independently.
- When the block START/END bit is turned off while the set block is active, the block is ended.

The block START/END bit can also be turned on or off by the test operation of the engineering tool. (GX Works3 Operating Manual)

When the block START/END bit is turned off to make the set block inactive, processing will occur as follows:

- Execution of the set block is stopped, and the outputs of the step being executed are all turned off. However, the devices turned on by using the SET instruction will not be turned off.
- If another block has been started by a block start step in the set block, the set block ends but the start destination block will remain active and continue processing.

Selective transition

By changing the current value of BL☐ or BL☐\S☐ from watch window of the engineering tool, the status of a block (START/END) or a step (active/inactive) can be changed.
Also, the status of the specified step (active/inactive) is changed from the menu [Debug] > [Control SFC Steps]. (GX Works3 Operating Manual)

(1) Cautionary Notes

The following table shows the restart operation after the set block is deactivated.

<table>
<tr><td colspan="2">Set Block</td><td>Contents</td></tr>
<tr><td rowspan="3">Block0</td><td>When the start conditions setting of is "Auto-start Block0" in the SFC setting of the CPU parameter.</td><td>Operation is restarted from the initial step following end step processing.</td></tr>
<tr><td>When the start conditions setting of is "Do not auto-start Block0" in the SFC setting of the CPU parameter.</td><td rowspan="2">The block is deactivated after end step processing, and processing is restarted from the initial step when another start request occurs for that block.</td></tr>
<tr><td colspan="2">Other than Block0</td></tr>
</table>

When the SFC program ends, all block START/END bits that have been set in the SFC information devices are turned off. However, only when a resume start is enabled with the resume start setting, all blocks START/END bits are restored when the SFC program starts.

If the block to which the block start end bit is set is being written during the SFC inactive block RUN, start is ignored. Therefore, do not turn ON the block start end bit while writing during the SFC inactive block RUN.

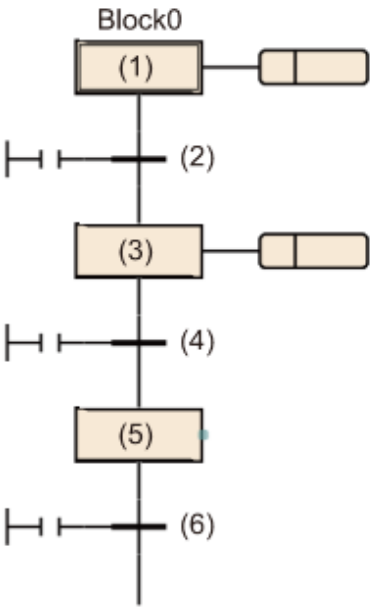
Block START/END bit

- Can be used as a device to check the active status of a specified block
- Can also be used to start and end specified blocks
    - By creating an SFC program by dividing blocks for each device and setting block start and end bits, it is possible to check and debug the operation on a per-device basis.

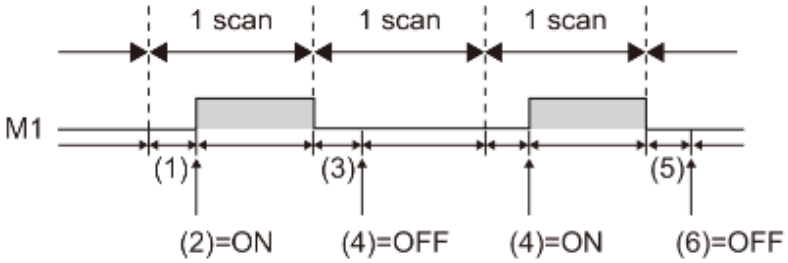
2.8.2 Step transition bit

This bit is a device or label to check whether the transition of the step being executed becomes TRUE.
This bit turns on when the transition to the next step becomes TRUE after execution of the action of each step.
A step transition bit which is on is automatically turned off when processing of the specified block is performed again.

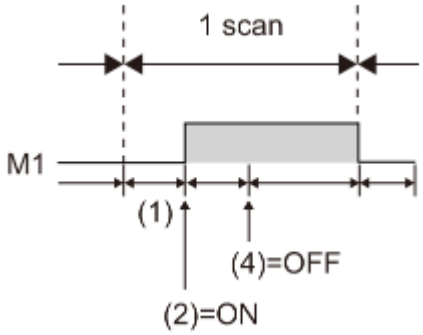
Example: M1 is specified in the step transition bit of Block0



If transition (2) becomes TRUE after execution of step (1), M1 is on during execution of another block.
M1 is turned off at the time of Block0 processing in the next scan.
If transition (4) does not become TRUE after execution of step (3), M1 stays off.
If transition (4) becomes TRUE, M1 is on during execution of another block.
If transition (6) does not become TRUE after execution of step (5), M1 stays off.



If the continuous transition bit is turned on and set to "Continuous transition", the step transition bit will remain on during the action of the next step after the transition becomes TRUE. It will also remain on following the execution of multiple steps, even if the transition becomes FALSE. In these cases, the step transition bit will be turned off when the specified block is executed in the next scan.



If transition (2) becomes TRUE after execution of step (1), M1 is turned on.
Even if transition (4) does not become TRUE, M1 stays on.
M1 is turned off at the time of Block0 processing in the next scan.

When multiple active steps exist in the block, the step transition bit turns on when one of the transitions becomes TRUE.

(1) Cautionary Notes

- When the end step is executed, the step transition bit of the block is turned on. The step transition bit remains on until the block is reactivated next.
- The step transition bit is not turned off when the SFC program starts or ends.

2.8.3 Block PAUSE/RESTART bit

This bit is a device or label to pause or restart an active block.

Setting the bit to on stops the block at the step-in execution and setting it to off restarts executing the block from the step where the block was stopped previously.

Settings	Contents
OFF → ON	When OFF → ON is selected, the specified block stops at the step being executed.
ON → OFF	When ON → OFF is selected, execution of the specified block resumes from the operation output of the stopped step. • The operation HOLD step (without transition check) [SE] or the operation HOLD step (with transition check) [ST] stopped in the operation HOLD state resumes execution in the operation HOLD state. • If the coil HOLD step [SC] is stopped by setting the coil output OFF (SM325 = OFF), it becomes inactive and cannot be resumed. When the tester is stopped with the coil output hold setting (SM325 = ON), the HOLD status is maintained even after the tester resumes operation to maintain the HOLD status.

- If another block has been started by a block start step, turning on the block PAUSE/RESTART bit stops the specified block, but the start destination block will remain active and continue processing. To stop the start destination block at the same time, the start destination's block PAUSE/RESTART bit must also be turned off.
- When the block PAUSE/RESTART bit specified in an inactive block is turned on, the block does not operate in inactive state and is put in the stopped state immediately when it becomes active.
- Even after the specified block is forcibly terminated, the state of the block PAUSE/RESTART bit remains held. If the block is forcibly terminated while it is stopped and the status of the block PAUSE/RESTART bit is not changed, the block is put in stopped state immediately after the restart.

Operation when the block is paused or restart depends on the combination of the SM325 (Output mode at block stop) status, block stop mode bit setting of the SFC information device, and step hold status.

(1) Cautionary Notes

The block PAUSE/RESTART bit is not turned off when the SFC program starts or ends.

Stop restart bit

- When the block stop restart bit is turned on, the corresponding block is paused.
- When the block stop restart bit is turned off, the pause of the corresponding block is released.
- Operation in conjunction with block stop instruction (PAUSE [BL☐]) and block resume instruction (RSTART [BL☐]) of SFC control instruction.

2.8.4 Block stop mode bit

This bit is a device or label that determines the timing for stopping a block.

Setting the bit to on stops the block after transition of each step and setting it to off stops all steps immediately.

Settings	Contents
OFF (immediate stop)	When a stop request is issued, the system immediately enters the stop status.
When ON (stop after transition)	After a stop request is received, the transition conditions for the step being executed are satisfied, and the process stops when it is migrated. The operation output of the step after transition is not executed. If there are multiple active steps in a block, the process stops sequentially, starting with the step for which the transition was completed. The held step stops immediately after the stop request is made, regardless of the setting of the block stop mode bit.

Operation when the block is paused or restart depends on the combination of the SM325 (Output mode at block stop) status, block stop mode bit setting of the SFC information device, and step hold status.

(1) Cautionary Notes

The block stop mode bit is not turned off when the SFC program starts or ends.

Mode bit at block stop

- When the block stop mode bit is OFF, a stop request is issued to the block.
  - Stop Block Now
- When the block stop mode bit is ON, a stop request is issued to the block.
  - When the transition condition of the step being executed is satisfied and the process is moved, the process stops.
- The holding step stops immediately after the stop request regardless of the setting of the block stop mode bit.

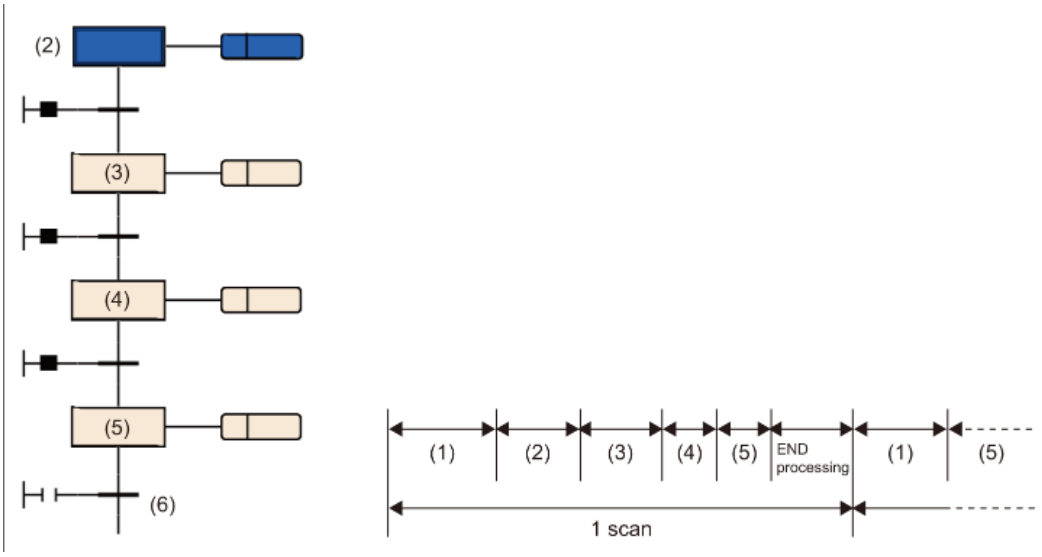
2.8.5 Continuous transition bit

This bit is a device or label that determines the continuous transition action when the transition becomes TRUE.

Setting the bit to on enables continuous transition and accordingly the action of the next step is executed in the same scan. Setting the bit to OFF disables continuous transition and accordingly one step is executed every scan.

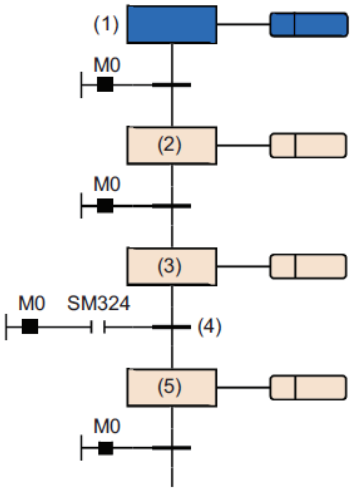
Settings	Contents
Off (no continuous transition)	When the transition becomes TRUE, the action of the transition destination step is executed in the next scan.
On (continuous transition)	When the transition becomes TRUE, the action of the transition destination step is executed within the same scan. When the transition of the steps become TRUE continuously, the actions are executed within the same scan until the transition becomes FALSE or reaches the end step.

Example: The continuous transition bit of an SFC information device is specified.



Scan	Contents
Scan 1	After execution of the sequence program (1), steps (2) to (5) of the SFC program are executed continuously.
Scan 2 and after	After execution of the sequence program (1), the action of step (2) is executed until the transition (6) becomes TRUE.

- When the continuous transition bit is set, a continuous transition is disabled while the set bit device is off and is enabled when the bit device is on, regardless of the on/off state of SM323 (All-blocks continuous transition status). When the continuous transition bit is not set, a continuous transition is disabled while SM323 is off and is enabled when it is on.
- SM324 (Continuous transition disable flag) is turned on automatically by the system at SFC program execution but is off during continuous transition. Use of SM324 under the AND condition in a transition disables a continuous transition.



When M0 is on, one scan causes continuous transitions from steps (1) to (3).
Since SM324 is added as the AND condition to the transition (4), the transition (4) after execution of step (3) does not become TRUE.
In the next scan, SM324 is turned on after step (3) and therefore a transition to step (5) occurs within the scan.

(1) Behavior with/without Continuous Transition

The SFC program transition conditions are "With Continuous Transition" and "Without Continuous Transition".

The setting with or without continuous transition depends on the setting of the continuous transition bit of the SFC information device and the SM323 (with or without full block continuous transition).

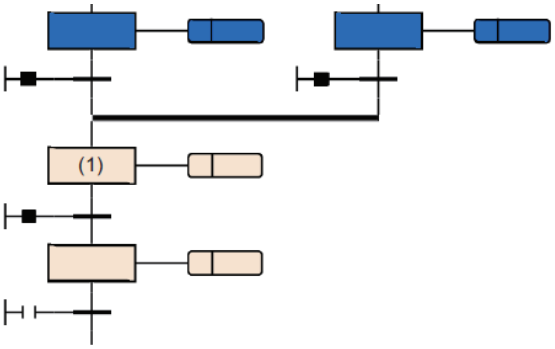
Continuous Transition bit	SM323	Contents	
No setting	OFF	No Continuous transition	When the transition condition is satisfied, the operation output of the transition destination step is executed for the next scan.
	ON	With Continuous Transition	When the transition condition is satisfied, the operation output of the transition destination step is executed within the same scan. If the transition conditions of the steps are satisfied continuously, the processes are executed in the same scan until the transition conditions fail or the end step is reached.
OFF	ON/OFF	No Continuous transition	When the transition condition is satisfied, the operation output of the transition destination step is executed for the next scan.
ON	ON/OFF	With Continuous Transition	When the transition condition is satisfied, the operation output of the transition destination step is executed within the same scan. If the transition conditions of the steps are satisfied continuously, the processes are executed in the same scan until the transition conditions fail or the end step is reached.

Point

- You can shorten the operating time by setting "With Continuous Transition". This eliminates the wait time between the completion of the transition condition and the execution of the operation output at the destination step.
- However, setting "With Continuous Transition" may slow down other block or sequence programs.

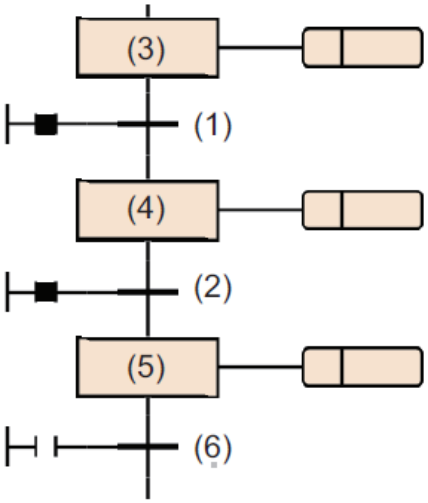
(2) Cautionary Notes

- If the continuous transition bit is turned on, execution of actions (from a transition becoming TRUE to destination step) takes priority over the other processing. This can shorten a takt time. In this case, however, the operations of the other blocks and sequence program may become slower.
- The continuous transition bit is not turned off when the SFC program starts or ends.
- When a jump transition or selective convergence causes the active state to transition from multiple steps to one step, the action of one step may be executed twice in a single scan.



When the setting is "Continuous transition", step (1) is executed twice in a single scan.

- If the transition after the step becomes TRUE with the setting of "Continuous transition", a step is started or ended within one scan. In this case, since the END processing has not been executed, the input/output refresh of coil output by using the OUT instruction in the action is not reflected and therefore other programs cannot detect ON of the coil. In the case of output (Y), for example, output (Y) is not output while END processing is unexecuted and other programs cannot detect output (Y) ON. Accordingly, ON of the step relay cannot be detected, either. To reflect the I/O refresh of the OUT instruction, create a program so that one step is executed in multiple scans.



When the transition (1) and (2) become TRUE, the following is executed in one scan.

- The action of step (3) is executed.
- As the transition (1) becomes TRUE, the action of step (3) is turned off.
- Step (3) becomes inactive, and step (4) becomes active.
- As continuous transitions are enabled, the action of step (4) is executed.
- As the transition (2) becomes TRUE, the action of step (4) is turned off.
- Step (4) becomes inactive, and step (5) becomes active.
- As continuous transitions are enabled, the action of step (5) is executed.
- As the transition (6) does not become TRUE, the action of step (5) is not turned off.

- When creating a program that uses a jump sequence for looping, eliminate continuous transitions or prevent all transitions in the loop from becoming TRUE during execution. If all transitions in the loop become TRUE during execution with continuous transitions enabled, an infinite loop occurs in a single scan.

2.8.6 Number of Active Steps Register

This register is a device or label in which the number of active steps of a block is to be stored. The number of active steps stored in the number of active steps register includes the following steps.

- Normal active step
- Coil HOLD step [SC] that holds the operation
- Operation HOLD step (with transition check) [ST] that holds the operation
- Operation HOLD step (without transition check) [SE] that holds the operation
- Steps that stop each operation

(1) Cautionary Notes

- When a block ends, the number of active steps register becomes 0.
- The register does not become 0 when the SFC program ends but becomes 0 when the program starts.

Number of Active Steps Register

- Stores the number of currently active steps in the block

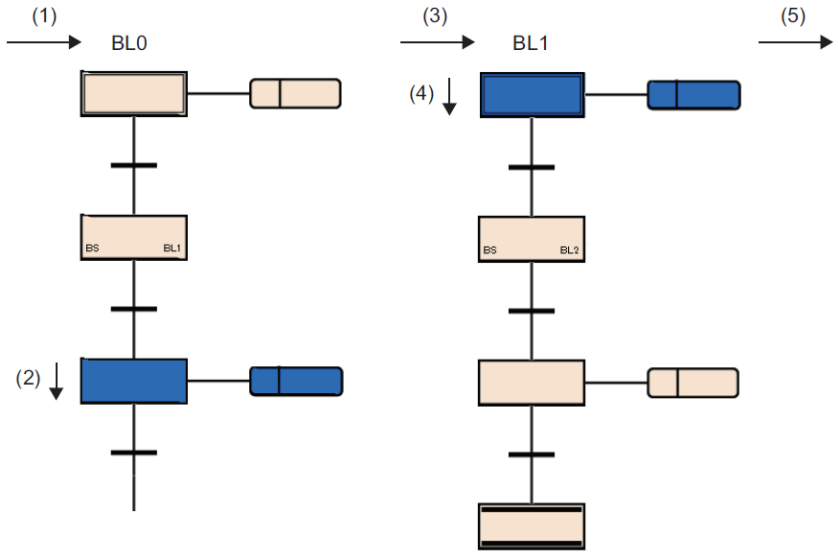
2.9 SFC Program Processing Order

2.9.1 Execution order of each Block

While the SFC program is running, the actions of each step are executed sequentially starting from the initial step of an active block.

An SFC program containing multiple blocks checks the state (active/inactive) of the blocks in ascending order of block numbers (Block0 → Block1 → Block2).
An active block executes the actions of active steps in the block.

An inactive block checks for existence of a start request. If a start request exists, the block is activated and the active steps in the block are executed.



In the following order:

(1) Begins processing Block0 (BL0).

(2) Perform the steps in Block0 (BL0).

(3) Performs processing for Block1 (BL1).

(4) Perform the initial step for Block1 (BL1).

(5) Processes the following blocks:

Only Block0 can be started automatically when the Block0 AutoStart is specified in the start condition setting of the SFC setting. With this setting, even when Block0 reaches the end step and becomes inactive, it is started again in the next scan.

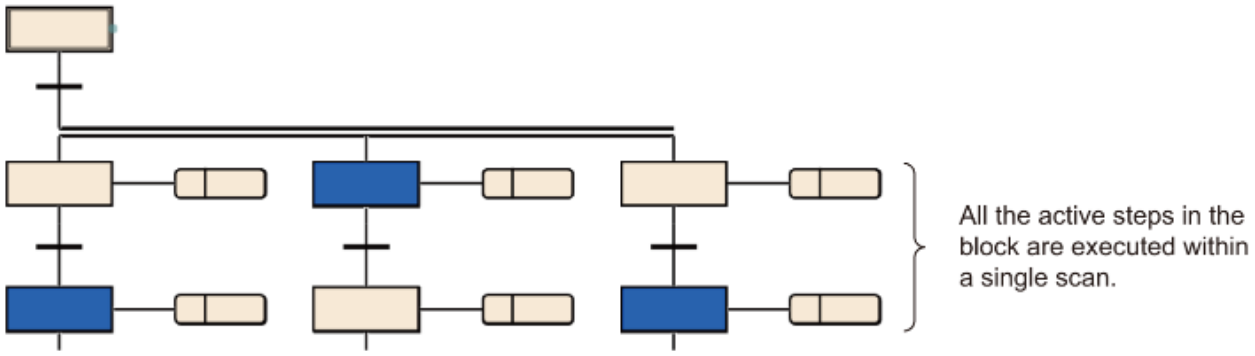
A request for END, PAUSE, RESTART of a block is processed immediately before execution processing in the block.

Execution order of each block

- Check the activity in order from the young number block to the old number block.
- Active block executes the operational output of the active step in the block.

2.9.2 Execution order of each Step

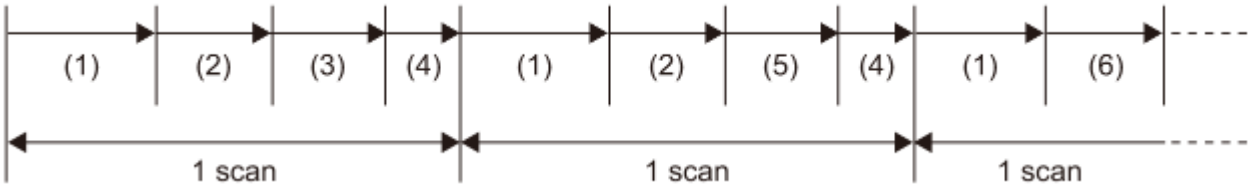
In the SFC program, the actions of all active steps are processed within one scan.



When the action of each step is finished, whether the transition to the next step becomes TRUE or not is checked.

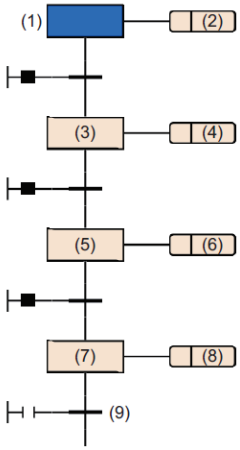
- When the transition has not become TRUE: The action of the same step is executed again in the next scan.
- When the transition has become TRUE: The outputs of the executed actions by using the OUT instruction are all turned off. When the next scan is executed, the action of the next step is executed. The step executed previously is deactivated and the action becomes inactive.

Even when the transition becomes TRUE, if coil HOLD step [SC] is set in the step attribute, the step is not deactivated but performs processing according to the attribute.



(1) Execution of sequence program
(2) Execution of action
(3) Checking the transition to the next step (FALSE)
(4) END processing
(5) Checking the transition to the next step (TRUE)
(6) The next action is executed.

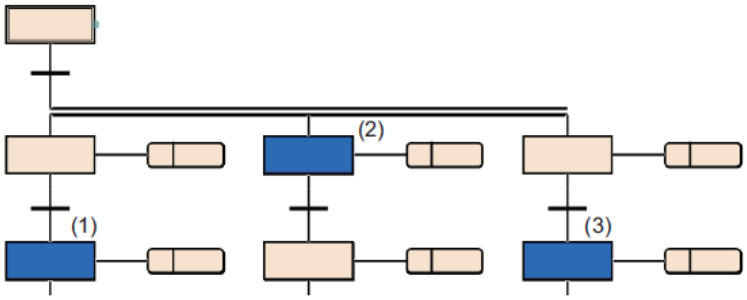
Example: The continuous transition bit of an SFC information device is not specified.



Scan	Contents
1st scan	Activate step (1) and execute operation output (2).
Second scan	Activate step (3) and execute operation output (4).
Third scan	Activate Step (5) and execute the operation output (6).
4th scan	Activate step (7) and execute operation output (8).
5th scan or later	Step (7) is activated, and the operation output (8) is executed until the transition condition (9) is satisfied.

(1) Cautionary Notes

- As a step for which the transition becomes TRUE at the first execution is deactivated in a single scan, the I/O refresh of coil output is not reflected and therefore other programs cannot detect that the coil output is on. To reflect the I/O refresh, create a program so that one step is executed in multiple scans.
- The actions of active steps in a block are executed simultaneously (within the same scan). For this reason, do not create SFC programs which depend on the execution sequence of actions.



The execution order of the operation output in (1), (2), and (3) is undefined.

Execution order of each Step

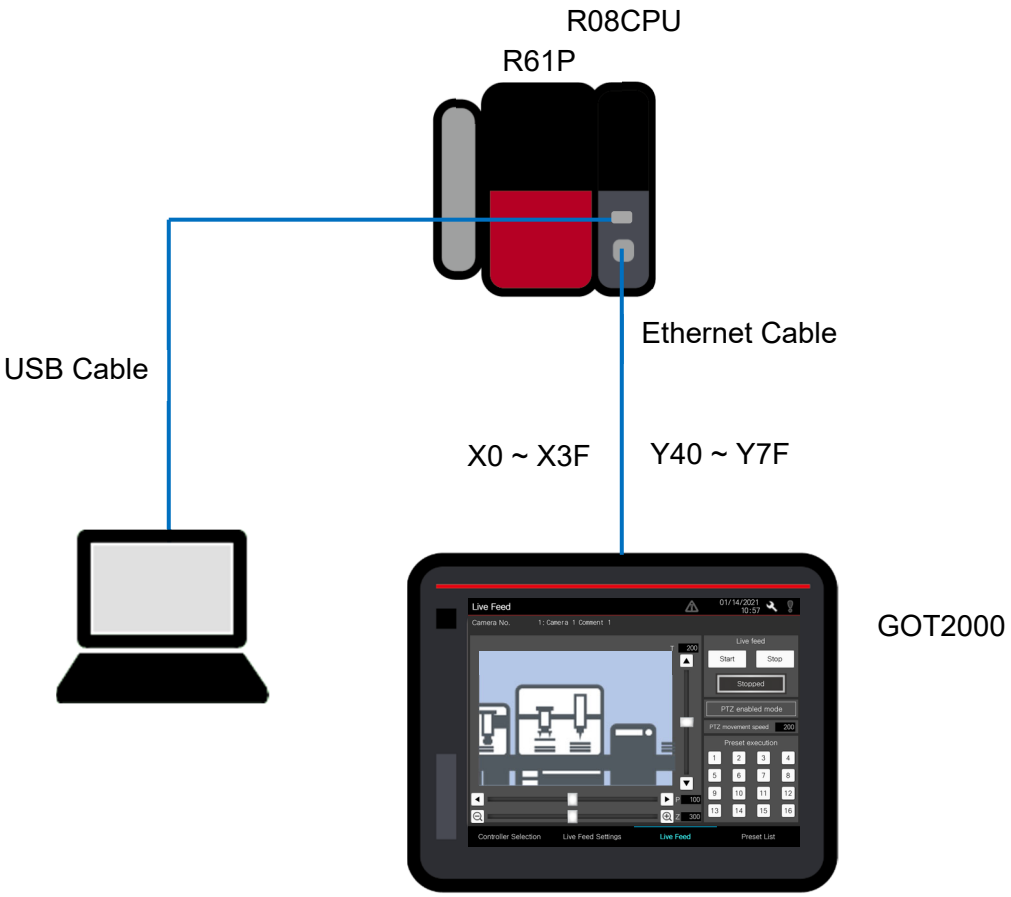
- Process the operation output of the active step and the status of the transition condition to the next step

3 Create an SFC Program

In this chapter, you will create a simple SFC program to understand the basic operations.

3.1 Target system configuration

Here is an example system configuration for illustration purposes:



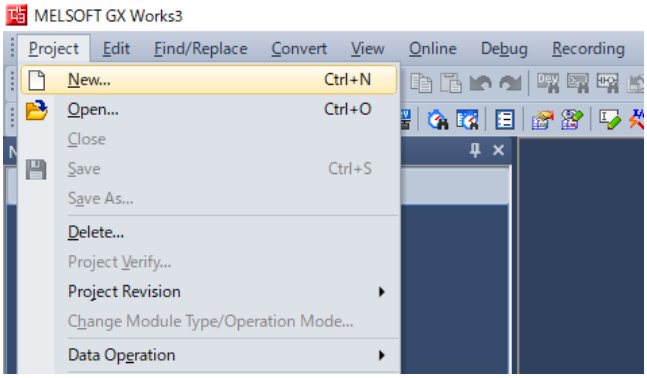
3.2 Creating Programs

This is explained from the screen after starting GX Works3.

3.2.1 New Project

[Procedure]

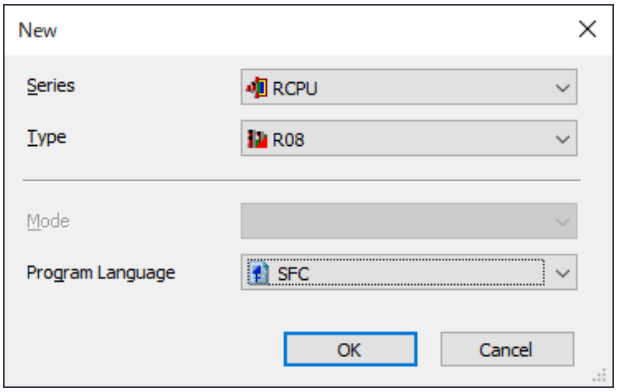
Select Project > New (Alternatively, click Ctrl+N)



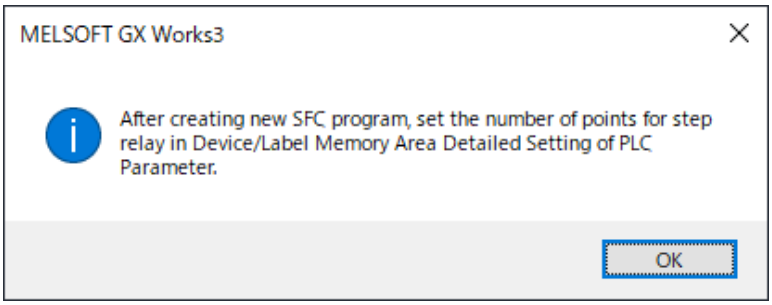
After the above operation, the following dialog box appears. Specify the Series, Model (Type), and Programming Language to be used.

[Settings]

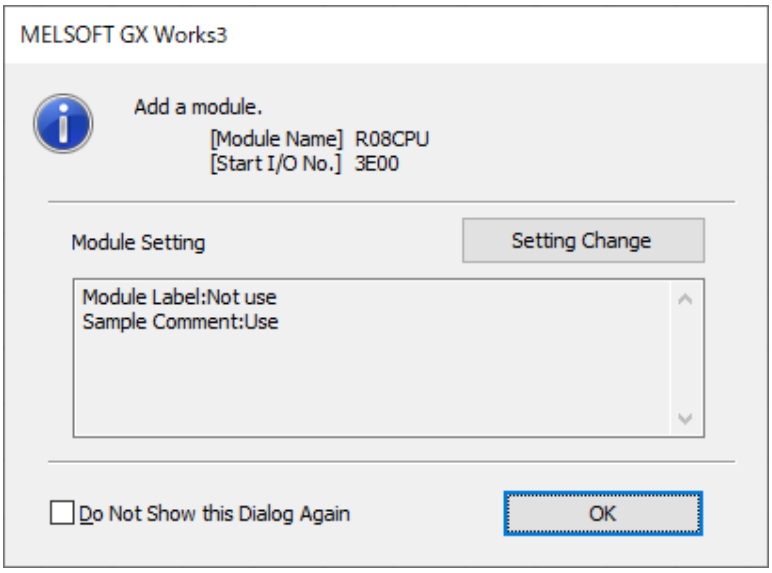
- Series: RCPU
- Type: R08CPU
- Programming Language: SFC



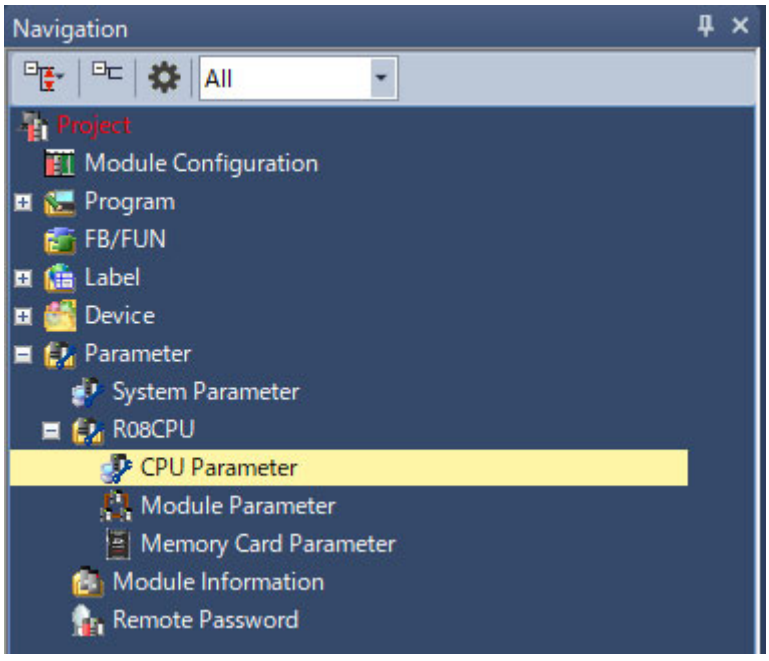
When the following dialog box appears, click the OK button.



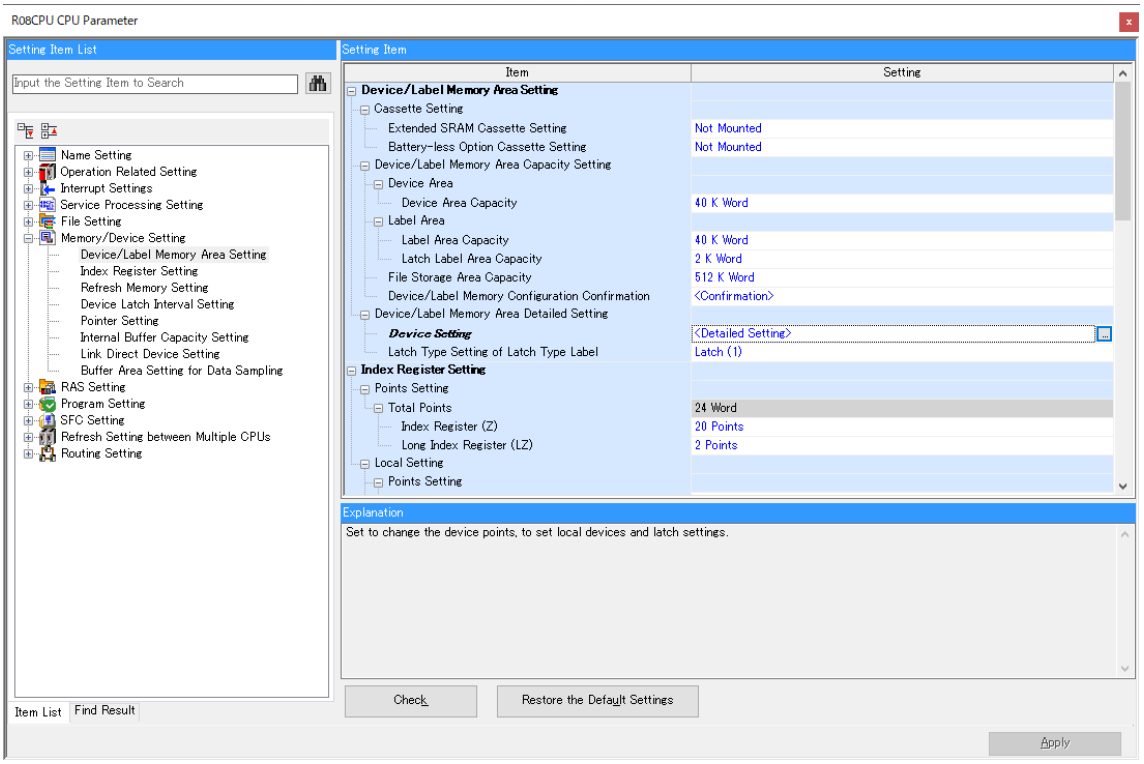
Click the [OK] button in the following dialog box.



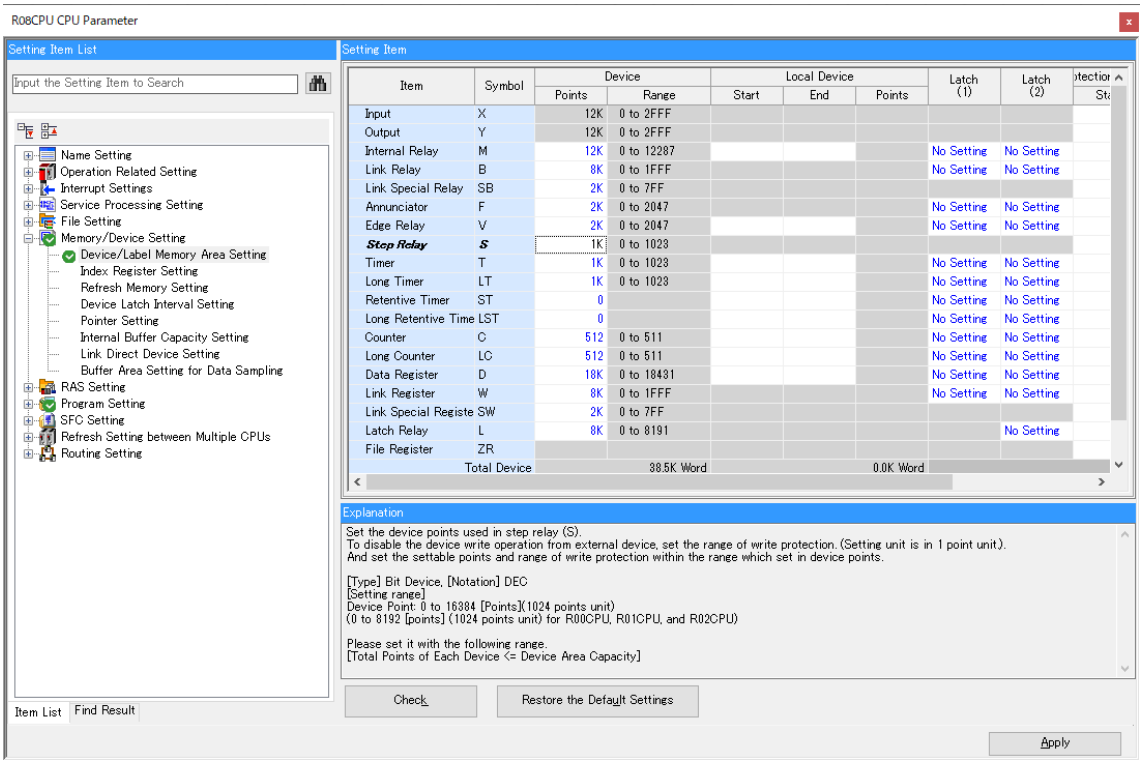
From the Project view in the navigation window, double-click "Parameters" → "R08CPU" → "CPU Parameters".



Double-click "Memory/Device Settings" in "CPU Parameters" → "Device/Label Memory Area Settings" → "Device Settings".



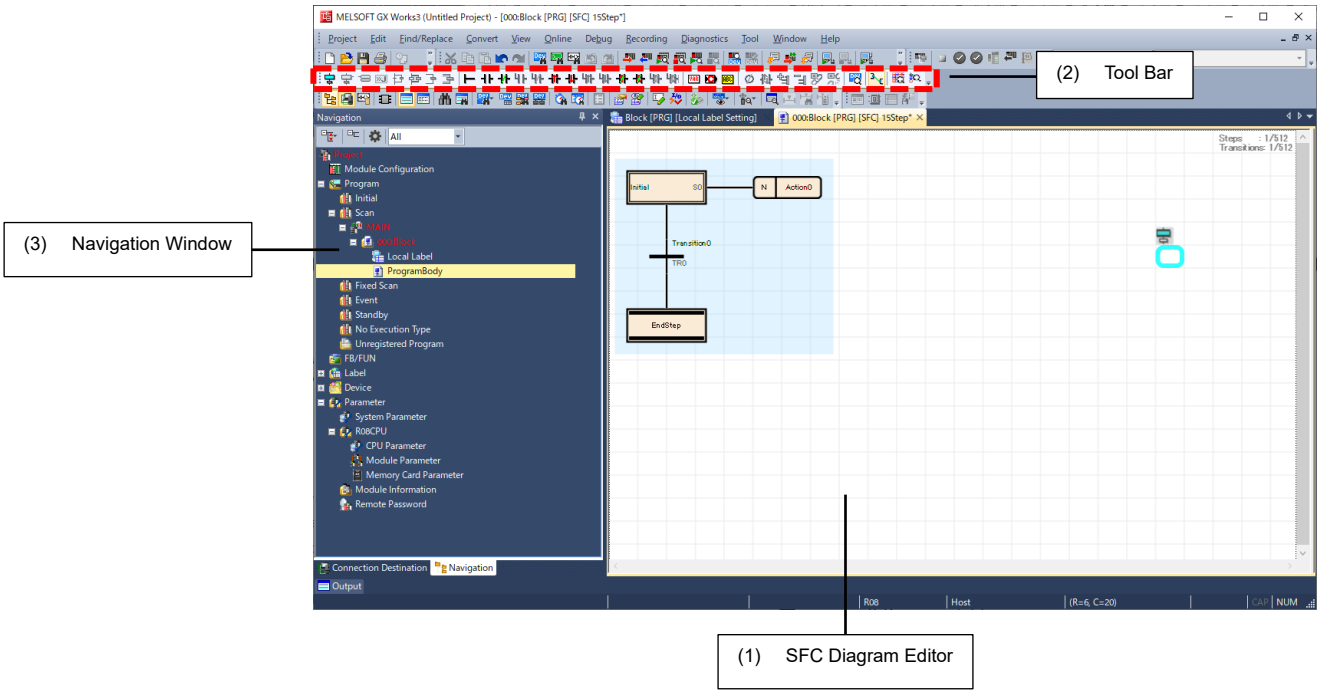
Set "1K" for the number of step relays. For details about the CPU parameters, see 3.3 SFC settings.



Then, click “Apply”.

3.2.2 Operation screen for creating SFC program

Next, the operation window of GX Works3 is described for creating the SFC program.



(1) Navigation Pane
Lists the projects in the same way as a regular ladder program.

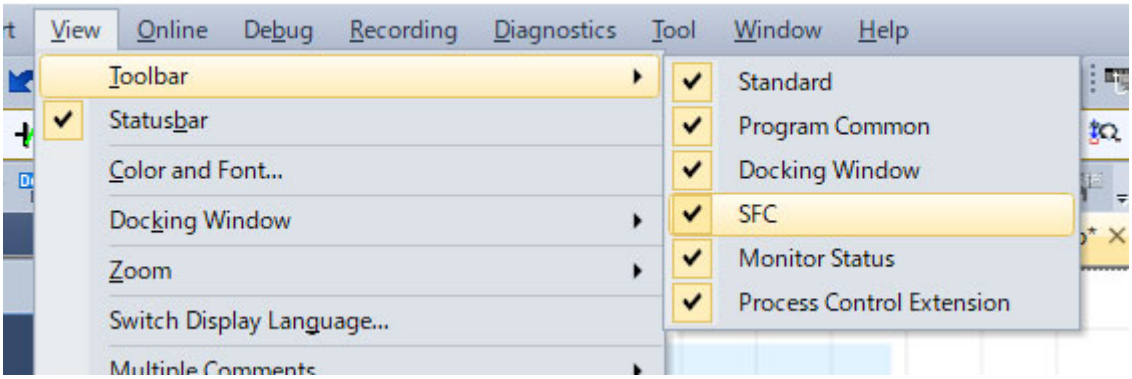
(2) Toolbar
SFC elements, FB/LD elements, and tools necessary for creating programs are placed.

(3) SFC Diagram Edit Area
Place SFC elements and create an SFC diagram.

To display the SFC toolbar:

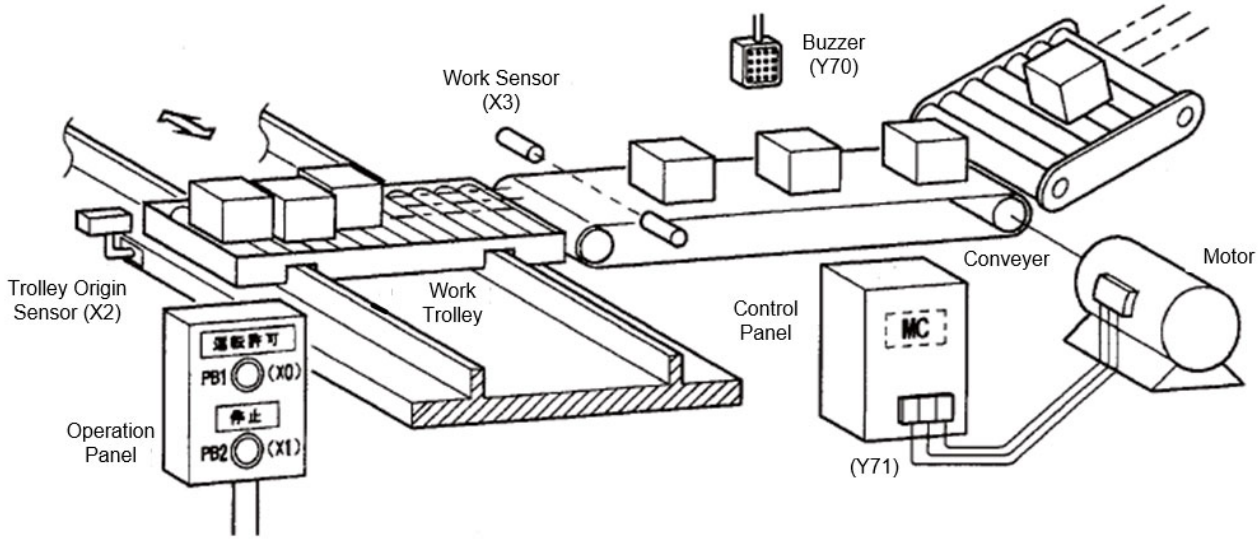
[Procedure]

Select View > Toolbars > SFC



3.2.3 Overview of the system program

This project simulates an automated operation program of the transport device system shown below.



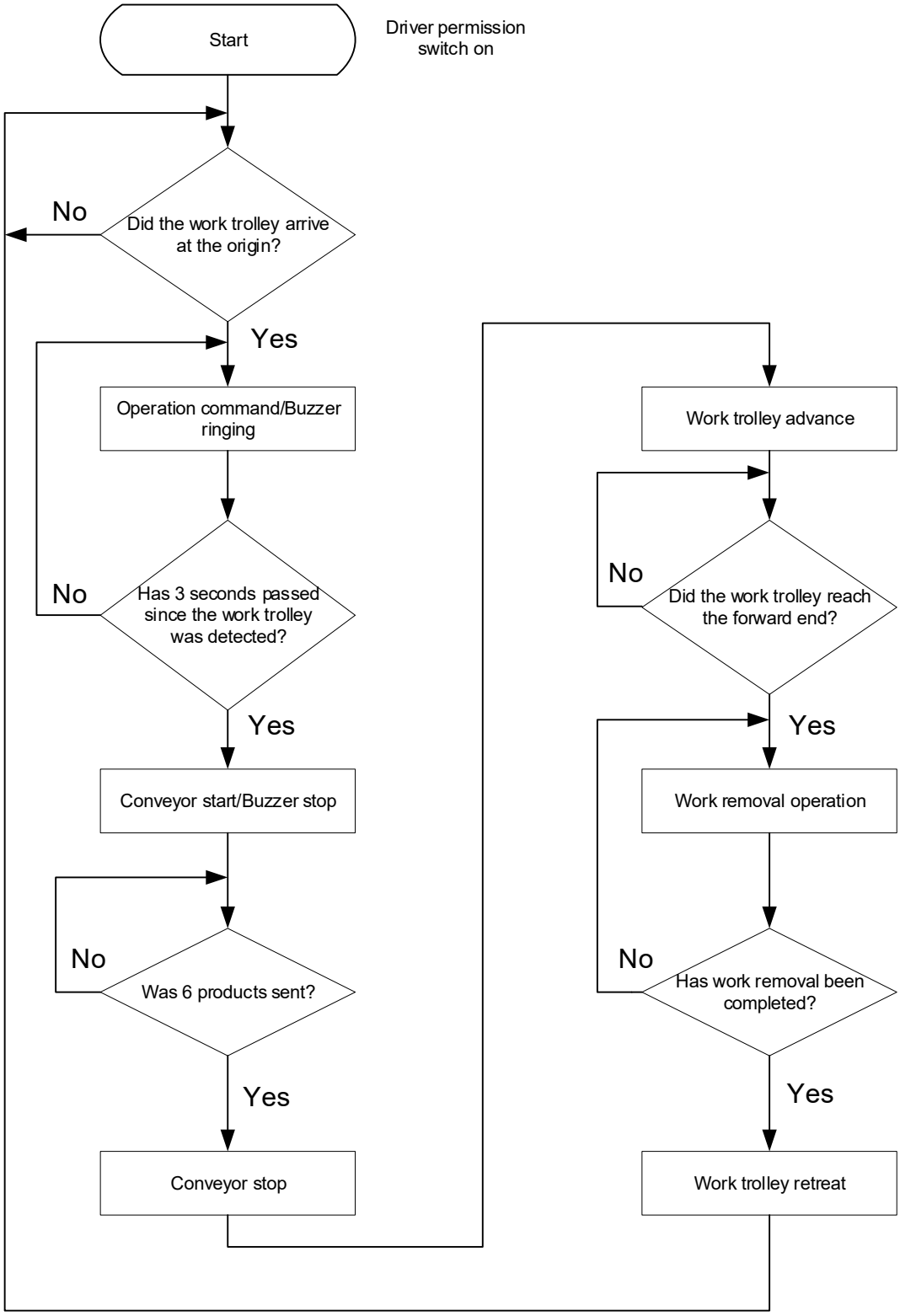
[Operation Overview]

(1) When the work truck stops in front of the conveyor, the alarm buzzer sounds for 3 seconds.
(2) The conveyor starts automatically after the buzzer stops sounding.
(3) Six products are sent to the work truck to stop the conveyor.
(4) Work Carts Deliver Products to the Next Process by Automatic Operation
(5) After unloading, empty and return to the front of the conveyor

The assignment of devices to be used are as follows:

X0	Operation permission switch	M0	Operation command
X1	Stop switch	M1	Driving memory
X2	Work trolley origin sensor	M10	Operation permission
X3	Work sensor	M11	Operation permission memory
X4	Work trolley forward end		
		T0	Alarm timer
Y70	Buzzer output		
Y71	Conveyor operation	C0	Work count
Y72	Work Trolley Forward		
Y73	Work Trolley Reverse		
Y74	Work delivery		

The following is a flowchart of the operation of the device.



3.2.4 Program Creation

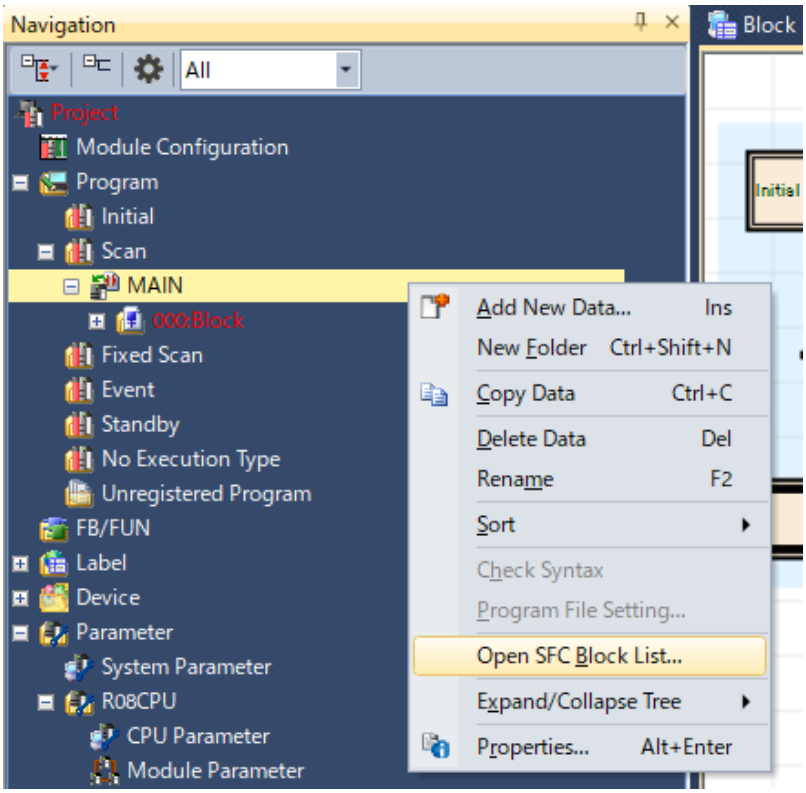
Creation of SFC Program.

In the SFC program, the blocks are divided by process, product, and control content, and programming makes debugging and trial operation easier. This time, the program is created by dividing "conveyor control" and "work truck control" into two blocks.

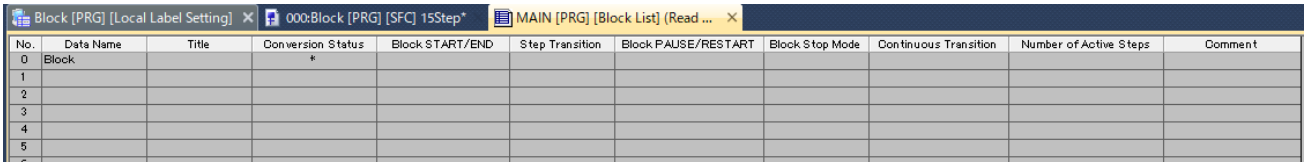
The procedure for creating an automatic control program for the device described in 3.2.3 Overview of Creation Programs is as follows:

(1) Block information setting

3.2.1 In the Project view of the navigation window created in Creating a new project, right-click "Program" → "MAIN" → click "Open SFC Block List".



The following block list opens:

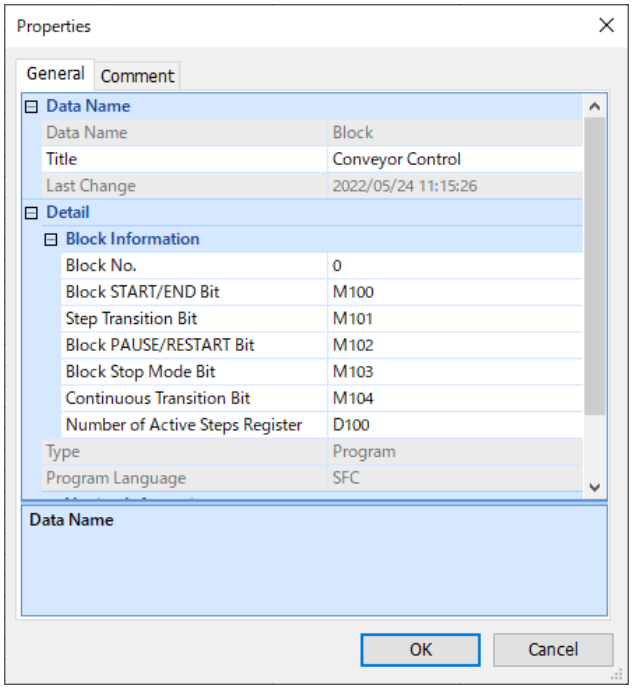


Point

The block list can also be displayed using View > Open SFC Block List.

Right-click the block line you want to set in the block list and select "Properties".

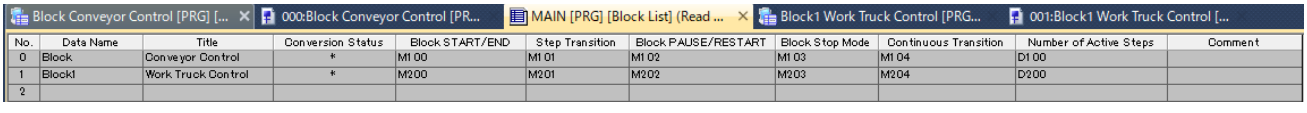
You can set block information from the properties screen.



In the Properties window, enter the following settings:

Block Setting 1 – Conveyor Control		Block Setting 2 – Work Trolley Control	
Block No.	0	Block No.	1
Block START/END Bit	M100	Block START/END Bit	M200
Step Transition Bit	M101	Step Transition Bit	M201
Block PAUSE/RESTART Bit	M102	Block PAUSE/RESTART Bit	M202
Block Stop Mode Bit	M103	Block Stop Mode Bit	M203
Continuous Transition Bit	M104	Continuous Transition Bit	M204
Number of Active Steps Register	D100	Number of Active Steps Register	D200

After the block information is set, the block list is displayed as follows, block No.0 and block No.1 have been set.



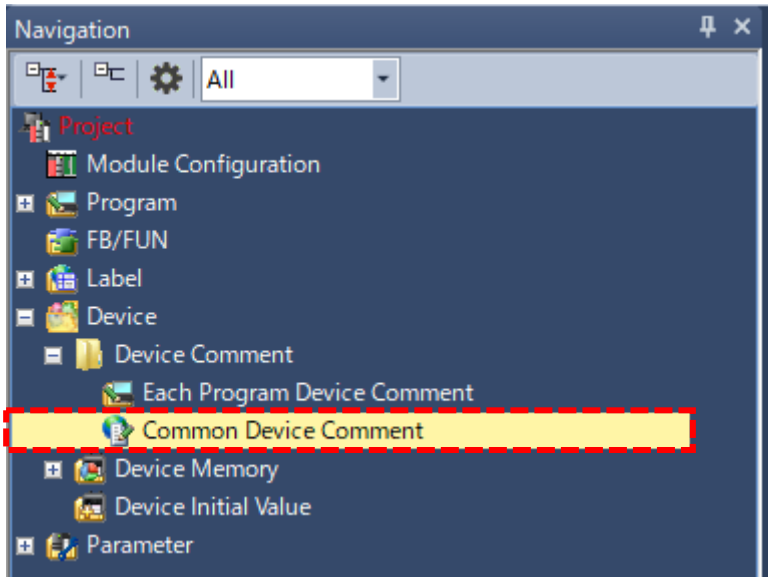
No.	Data Name	Title	Conversion Status	Block START/END	Step Transition	Block PAUSE/RESTART	Block Stop Mode	Continuous Transition	Number of Active Steps	Comment
0	Block	Conveyor Control	*	M100	M101	M102	M103	M104	D100	
1	Block1	Work Truck Control	*	M200	M201	M202	M203	M204	D200	
2										

*There is no problem if the block title is not set. However, it is recommended that you set a title because it makes it easier to manage multiple blocks.

*There is no problem even if the information device for SFC is not set, but by setting it, debugging and trial operation can be performed efficiently.

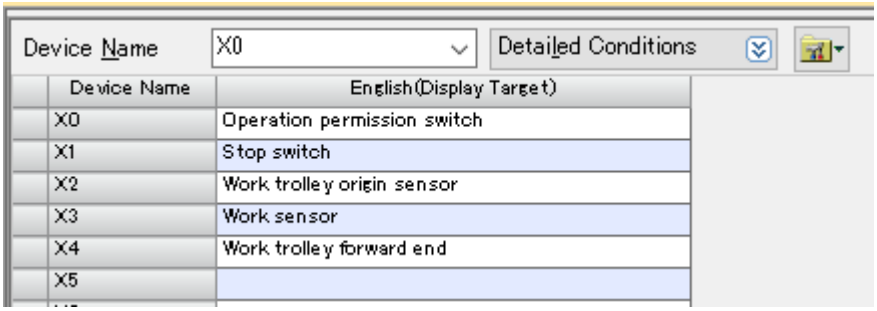
(2) Device Comment Settings

Enter a device comment. Double-click "Device" → "Device Comment" → "Common Device Comment" in the Project view to display the device comment screen.



Enter the desired device name in "Device name" and press Enter.

Click the entry field, and then enter a comment for each device.



(3) Program to create

Block No.0 "conveyor control" is as follows:

No.	Title	startup termination	Transition	Stop Resume	Stop mode	Continuous	Number of active steps
0	Conveyor Control	M100	M101	M102	M103	M104	D100

Block No.1 "Work Trolley Control" is as follows.

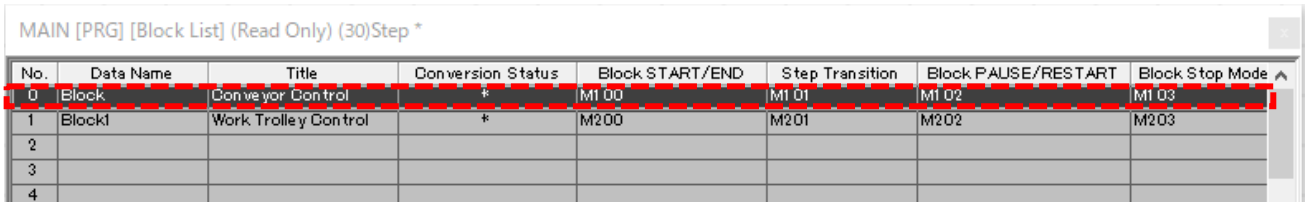
No.	Title	startup termination	Transition	Stop Resume	Stop mode	Continuous	Number of active steps
1	Work Trolley Control	M200	M201	M202	M203	M204	D200

(4) Creating an SFC Diagram (Block No.0)

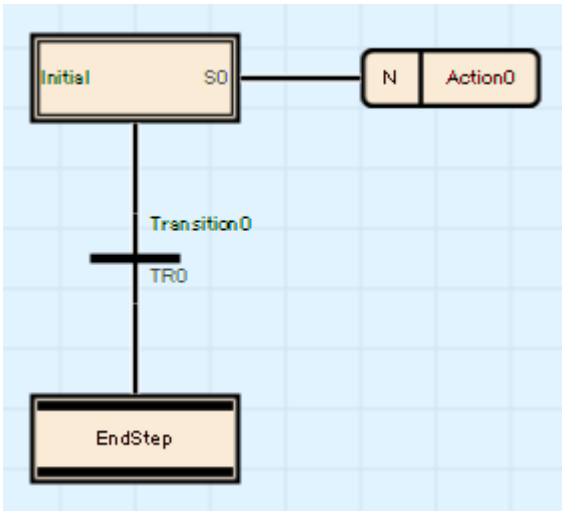
The following shows the procedure for creating an SFC diagram when creating a program for block No.0.

From the block list, select No.0 "conveyor control".

Click the View > Open SFC Diagram menu or double-click the block you want to view.



The SFC diagram for Block0 opens.

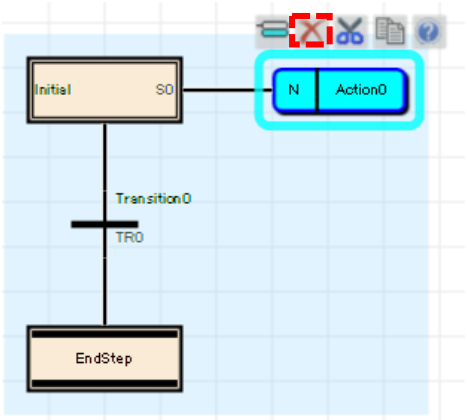


*When a new SFC program is created, the above steps and serial transitions are automatically entered.

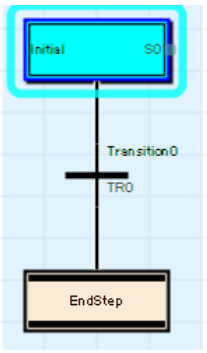
Add a step using Edit > Insert > Step. You can insert different elements depending on the selection.

Please refer to the following manual for details. GX Works3 Operating Manual

(a) Delete the operation output of "Initial".

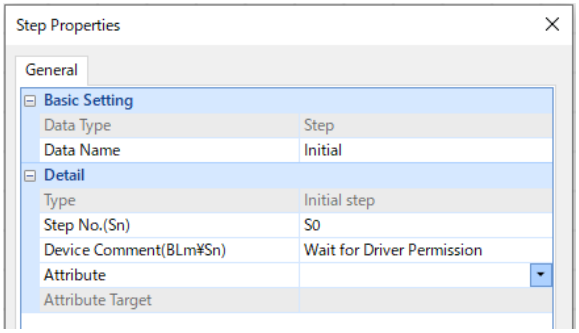


(b) Move the cursor to "Initial" and press Enter to open the step properties.



Point

- Opens when you move the cursor over an already placed SFC diagram and press Enter.
- In the Step Properties window, you can change the data name, step number, device comment, and attribute.

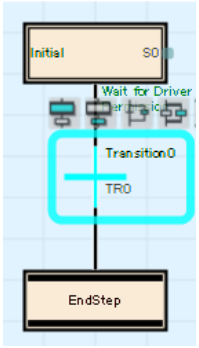


Specify the following settings, and then click the OK button.

[Settings]
Data Name: Initial
Step No (Sn): S0
Device Comment: Wait for Driver Permission

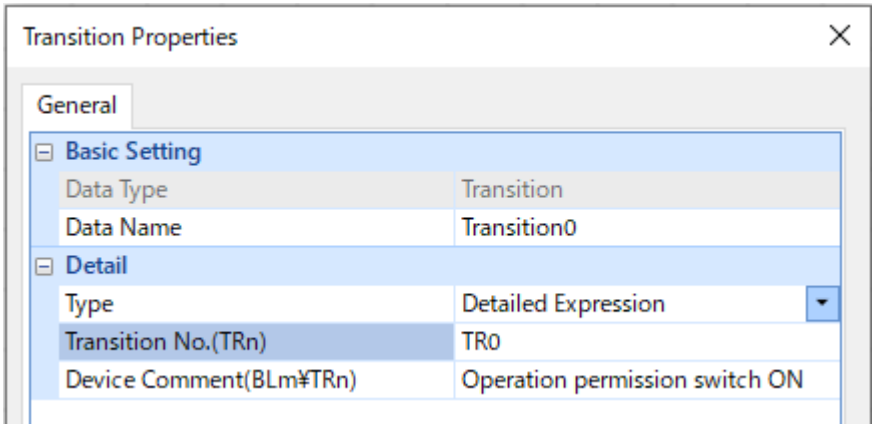
*Change the attributes when the block start step (with end check), block start step (without end check), reset step, coil hold step, operation hold step (without transition check), and operation hold step (with transition check) are used.

(c) Move the cursor to "Transition0" and press Enter to open the transition condition properties.



Transition Condition Properties Window

- Opens when you move the cursor over an already placed SFC diagram and press Enter.
- In the transition condition properties, you can change the data name, type, transition condition, and device comment.



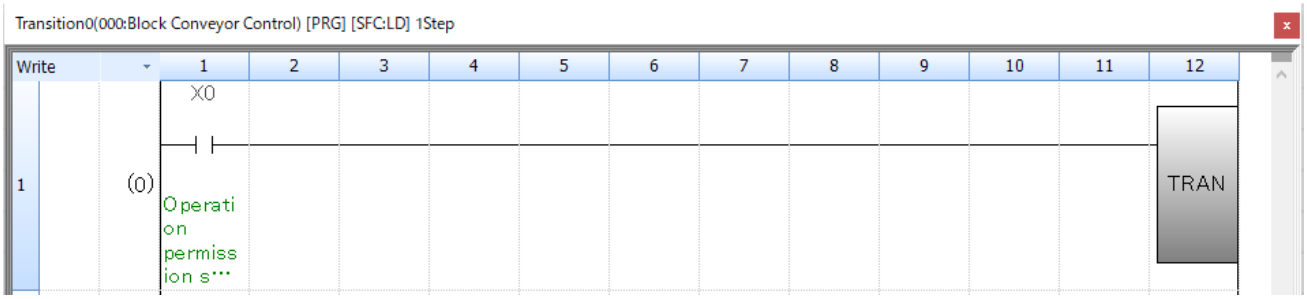
Specify the following settings, and then click the OK button.

[Settings]
Data Name: Transition0
Type: Detailed expression
Transition No. (TRn): TR0
Device comment: Operation permission switch ON

In the New Data window, change the program language to Ladder, and then click the OK button.

Point

Double-click an unset action output name or transition condition name to display the New Data window.



Zoom*1 is displayed. Enter the program in Ladder Programming Language.

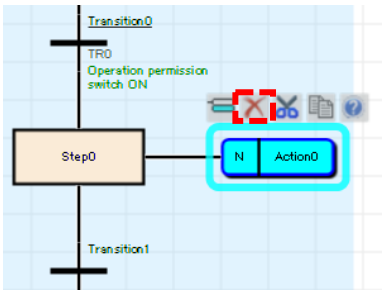
[Procedure]

1. Move the cursor to the insertion point.
2. Enter "X0" and click OK.
3. Move the cursor to the next insertion point, enter "TRAN (dummy transition condition output)", and click OK.

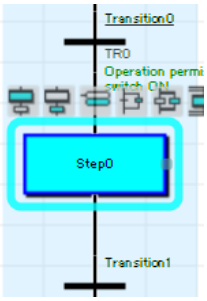
*1: You can also double-click the action output name/transition condition name that has been set on the SFC diagram.

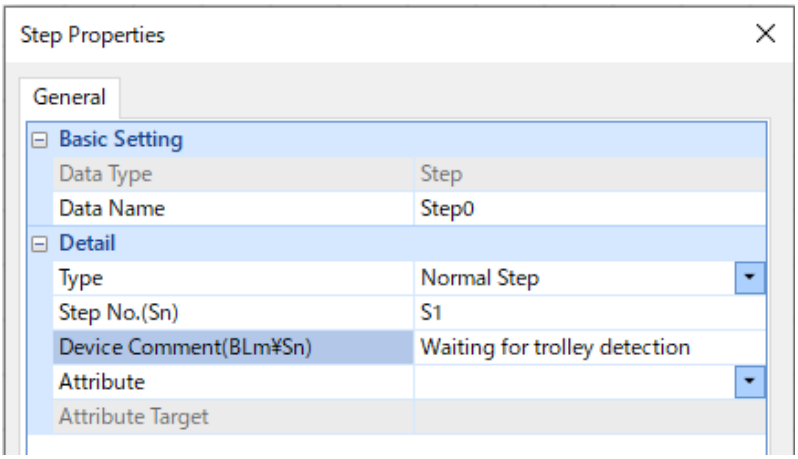
(d) Click Step () on the toolbar to add a step.

Then, delete the unnecessary "Step0" operation output.



Move the cursor to “Step0” and press [Enter] to open the step properties.

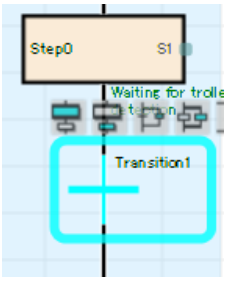


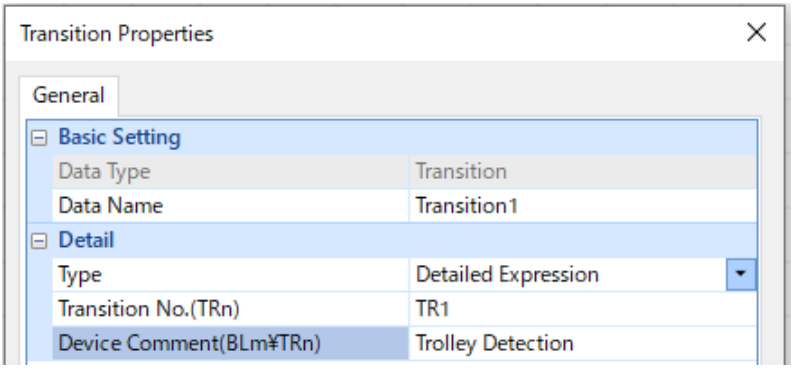


Specify the following settings, and then click the OK button.

[Settings]
Data Name: Step0
Type: Normal Step
Step No. (Sn): S1
Device Comment: Waiting for trolley detection

(e) Move the cursor to "Transition1" and press Enter to open the transition condition properties.

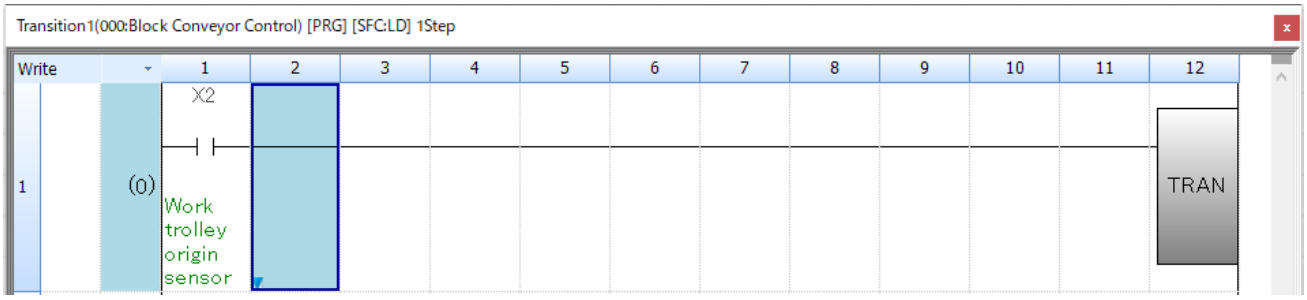




Specify the following settings, and then click the OK button.

[Settings]
Data Name: Transition1
Type: Detailed expression
Transition Condition No.: TR1
Device Comment: Trolley Detection

In the New Data window, change the program language to Ladder, and then click the OK button.



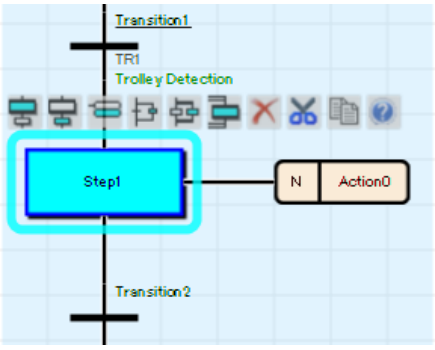
Enter the program in Ladder Programming Language.

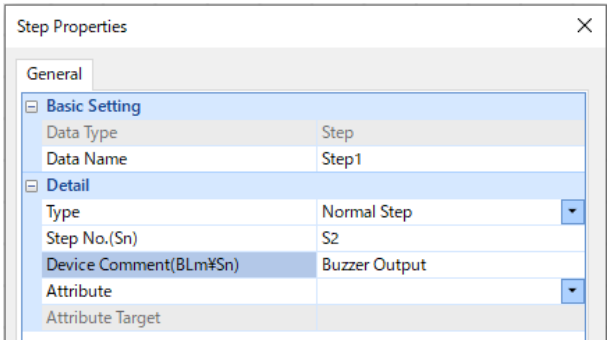
[Procedure]

1. Move the cursor to the insertion point.
2. Enter "X2" and click OK.
3. Move the cursor to the next insertion point, enter "TRAN", and click OK.

(f) Click Step () on the toolbar to add a step.

Move the cursor to "Step1" and press Enter to open the step properties.

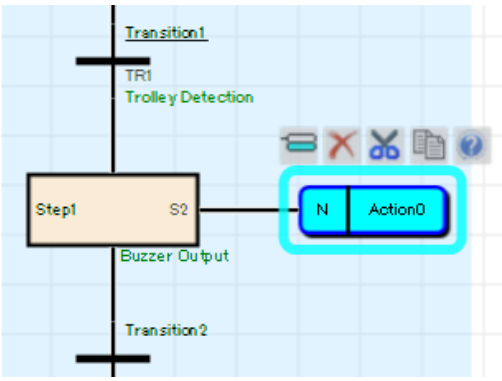




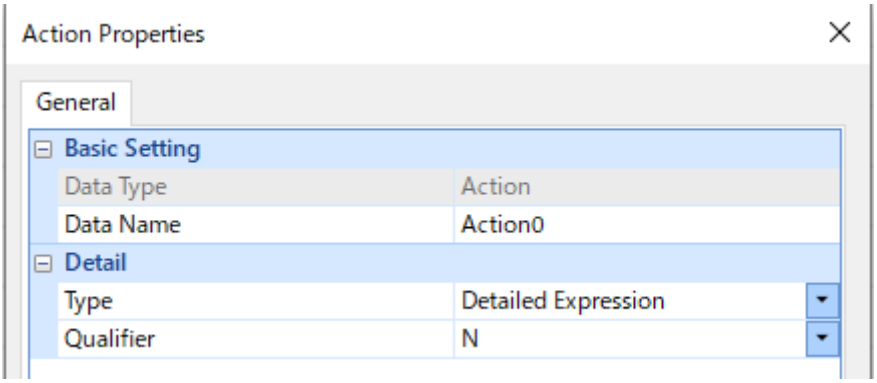
Specify the following settings, and then click the OK button.

[Settings]
Data Name: Step1
Type: Normal Step
Step No. (Sn): S2
Device Comment: Buzzer output

Next, set the operation output of "Step1".



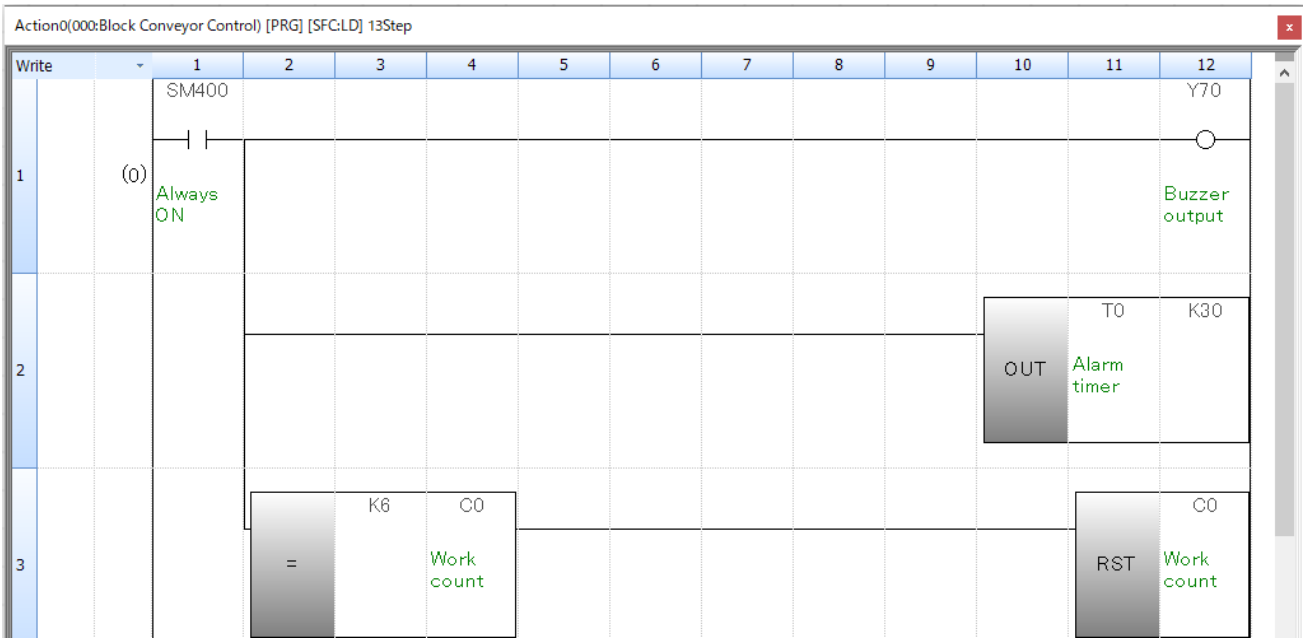
Press Enter to open the properties of the operation output.



Set the following and click the OK button.

[Settings]
Data Name: Action0
Type: Detailed expression
Qualifier: N

In the New Data window, change the program language to Ladder, and then click the OK button.

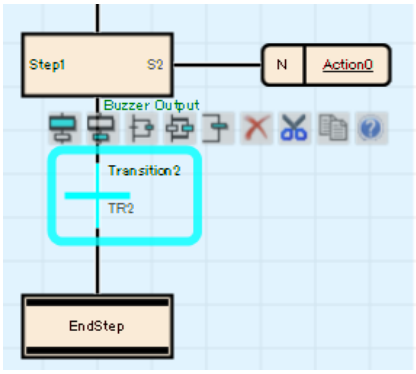


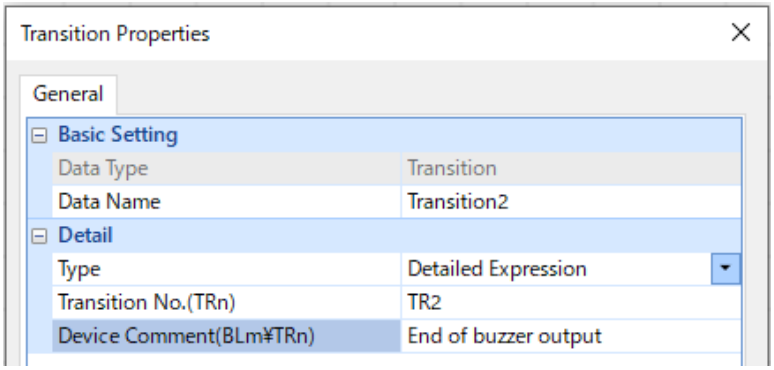
Enter the program in Ladder Programming Language.

[Procedure]

1. Move the cursor to the insertion point.
2. Enter "SM400" and click OK.
3. Move the cursor to the next insertion point, enter Y70, and click OK.
4. Create a vertical border, enter "OUT T0K 30", and click OK.
5. Create a vertical border, enter "= K6C0", and click OK.
6. Move the cursor to the next insertion point, enter "RST C0", and click OK.

(g) Move the cursor to "Transition2" and press Enter to open the transition condition properties.

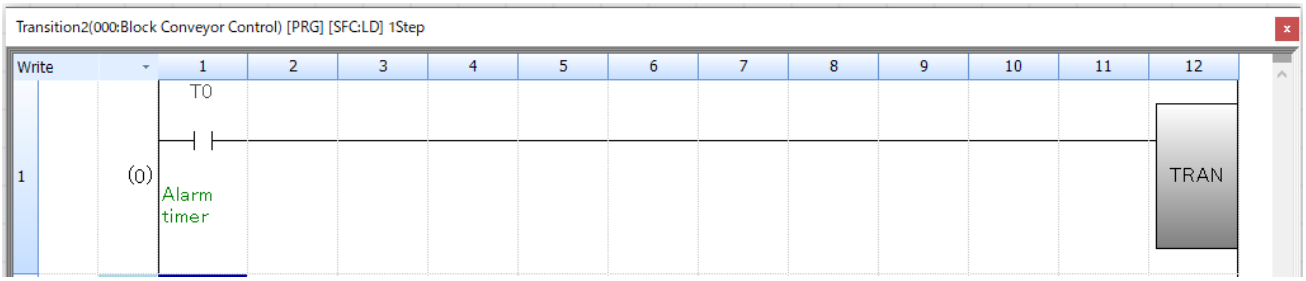




Set the following and click the OK button.

[Settings]
Data Name: Transition2
Type: Detailed expression
Transition No. (TRn): TR2
Device comment: End of buzzer output

In the New Data window, change the program language to Ladder, and then click the OK button.

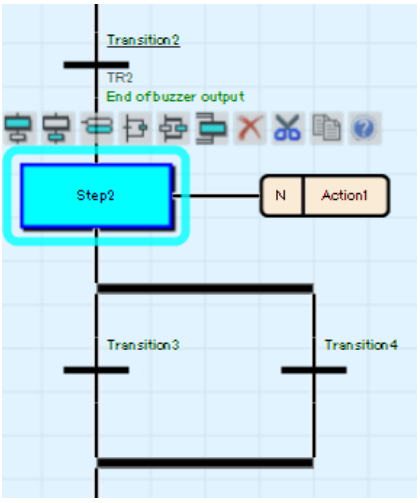


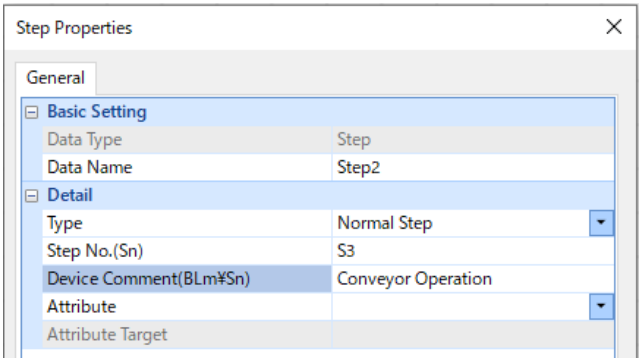
Enter the program in Ladder Programming Language.

[Procedure]
1. Move the cursor to the insertion point.
2. Enter "T0" and click OK.
3. Move the cursor to the next insertion point, enter "TRAN", and click OK.

(h) Select "Transition2" and click the Selection branch on the toolbar to add a step.

Move the cursor to "Step2" and press Enter to open the transition condition properties.

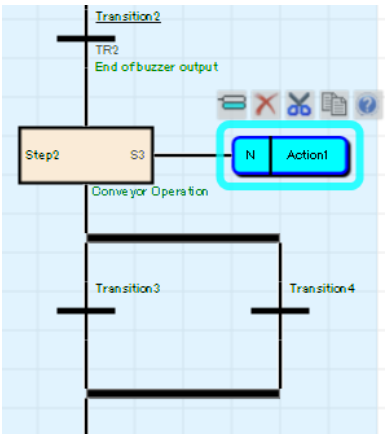




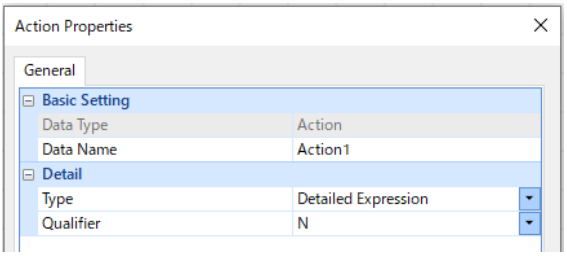
Set the following and click the OK button.

[Settings]
Data Name: Step2
Type: Normal Step
Step No. (Sn): S3
device comments: Conveyor Operation

Next, set the operation output of "Step2".



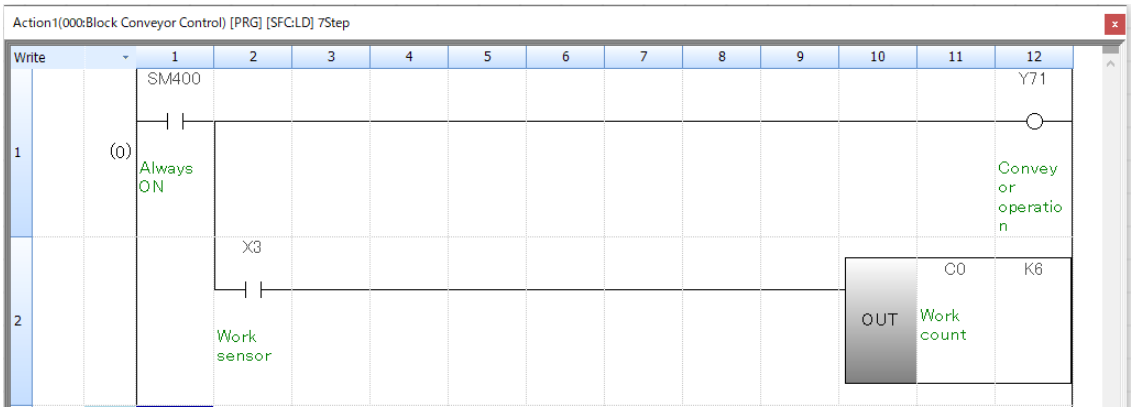
Press Enter to open the properties of the operation output.



Set the following and click the OK button.

[Settings]
Data Name: Action1
Type: Detailed expression
Qualifier: N

In the New Data window, change the program language to Ladder, and then click the OK button.

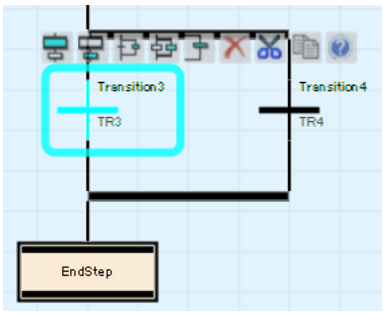


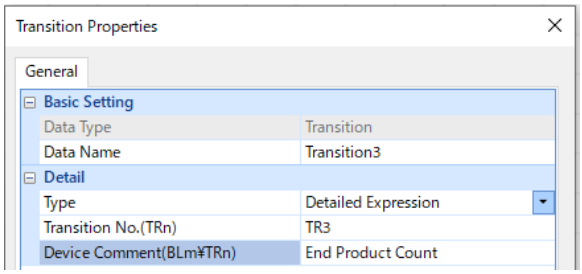
Enter the program in Ladder Programming Language.

[Procedure]

1. Move the cursor to the insertion point.
2. Enter "SM400" and click OK.
3. Move the cursor to the next insertion point, enter "Y71", and click OK.
4. Create a vertical border, enter "X3", and click OK.
5. Move the cursor to the next insertion point, enter "OUT C0K6", and click OK.

(i) Move the cursor to "Transition3" and press Enter to open the transition condition properties.

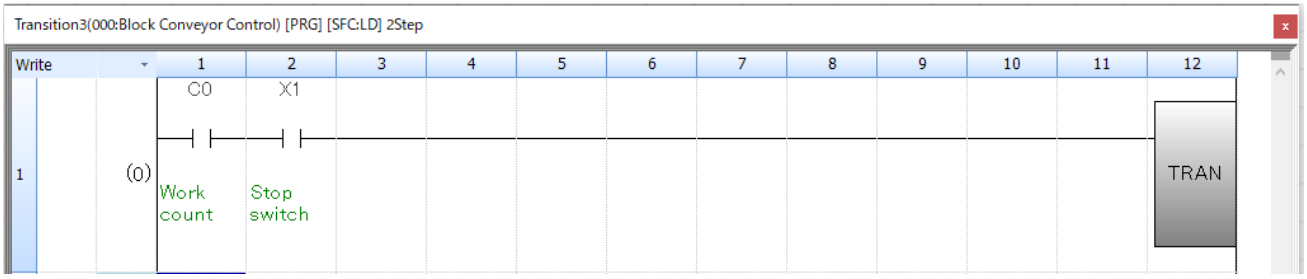




Set the following and click the OK button.

[Settings]
Data Name: Transition3
Type: Detailed expression
Transition No. (TRn): TR3
Device Comment: End Product Count

In the New Data window, change the program language to Ladder, and then click the OK button.



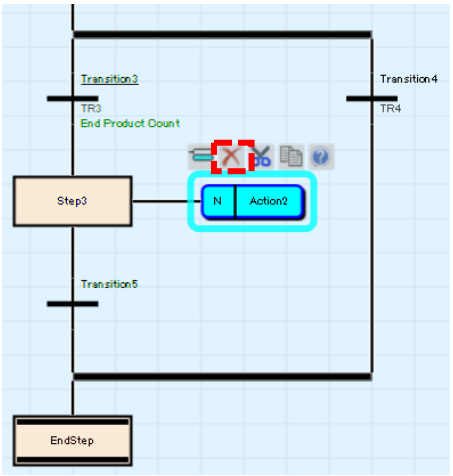
Enter the program in Ladder Programming Language.

[Procedure]

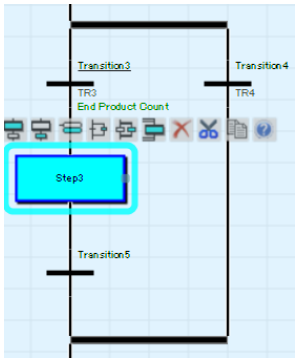
1. Move the cursor to the insertion point, enter "C0", and click OK.
2. At the next insertion point, select the b contact and enter "X1". Click the OK button after entering.
3. Move the cursor to the next insertion point, enter "TRAN", and click OK.

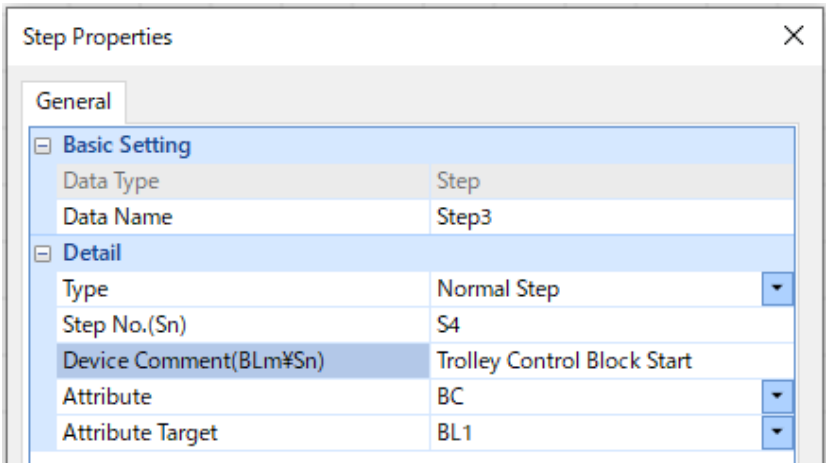
(j) Click Step () on the toolbar to add a step.

Then, delete the unnecessary "Step3" operation output.



Move the cursor to "Step3" and press Enter to open the step properties.

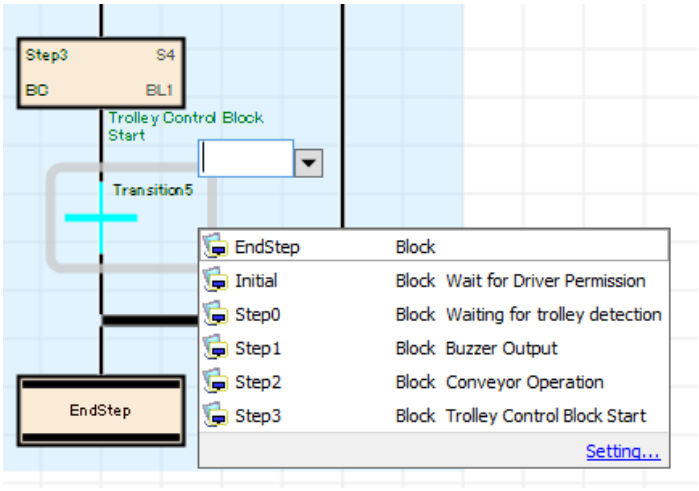




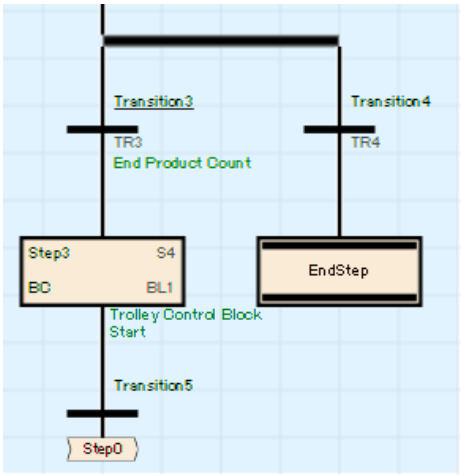
Set the following and click the OK button.

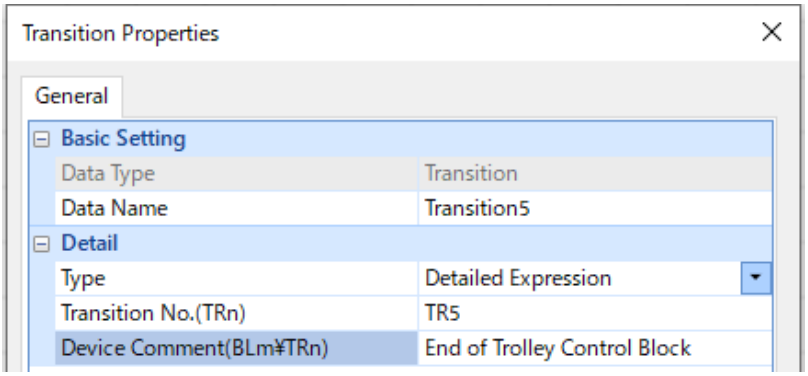
[Settings]
Data Name: Step3
Type: Normal Step
Step No. S4
Device Comment: Trolley Control Block Start
Attributes: BC
Attribute Target: BL1

(k) Move the cursor to "Transition5", then right-click and select Edit > Toggle Jump Symbol and Connection Line. Select the step name "Step0" and press Enter.



Move the cursor to "Transition 5" and press Enter to open the transition condition properties.



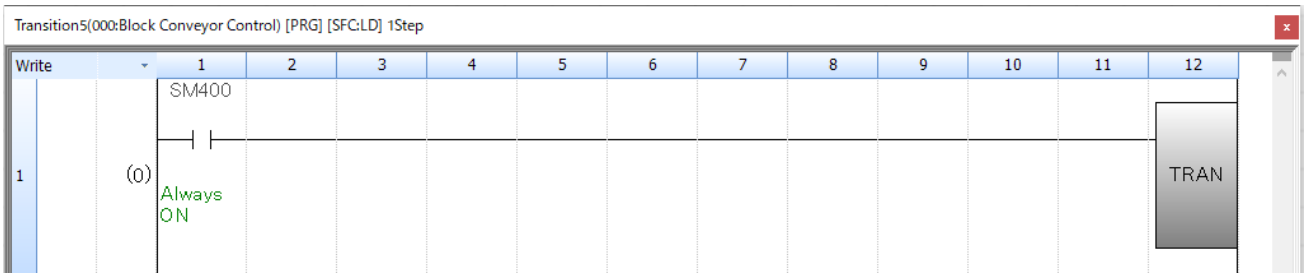


Set the following and click the OK button.

[Settings]

Data Name:	Transition5
Type:	Detailed expression
Transition No. (TRn):	TR5
Device Comment:	End of Trolley Control Block

In the New Data window, change the program language to Ladder, and then click the OK button.

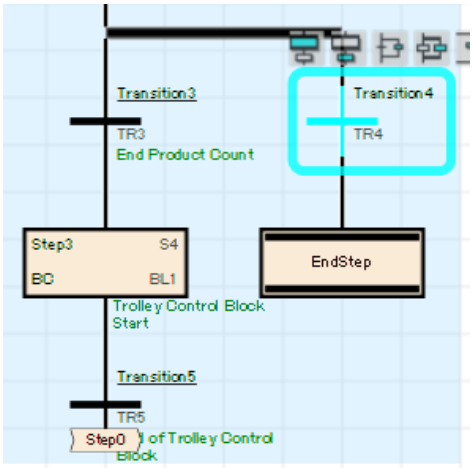


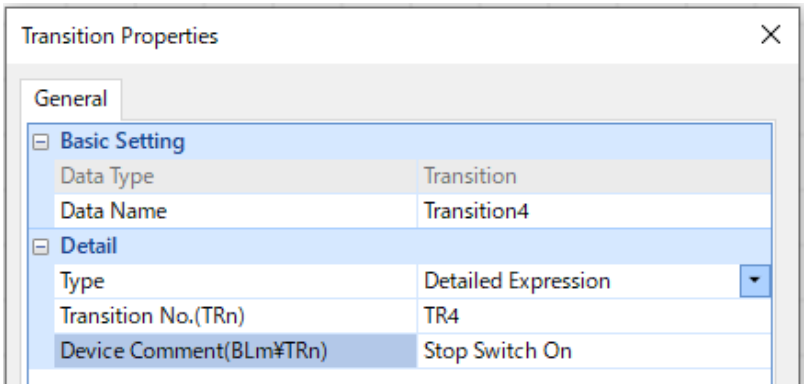
Enter the program in Ladder Programming Language.

[Procedure]

1. Move the cursor to the insertion point.
2. Enter "SM400" and click OK.
3. Move the cursor to the next insertion point, enter TRAN, and click OK.

(I) Move the cursor to "Transition 4" and press Enter to open the transition condition properties.



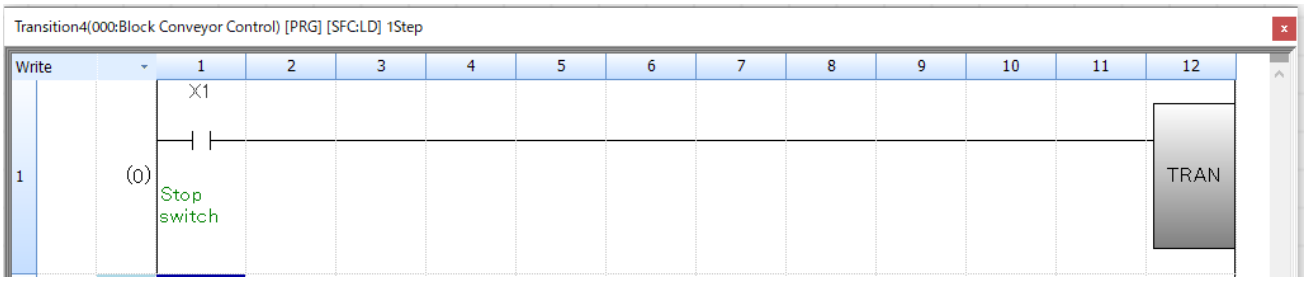


Set the following and click the OK button.

[Settings]

Data Name:	Transition4
Type:	Detailed expression
Transition No. (TRn):	TR4
Device comments:	Stop Switch On

In the New Data window, change the program language to Ladder, and then click the OK button.



Enter the program in Ladder Programming Language.

[Procedure]

1. Move the cursor to the insertion point.
2. Enter "X1" and click OK.
3. Move the cursor to the next insertion point, enter "TRAN", and click OK.

m) When you are finished creating the SFC diagram, click Convert - > Convert All in the menu.

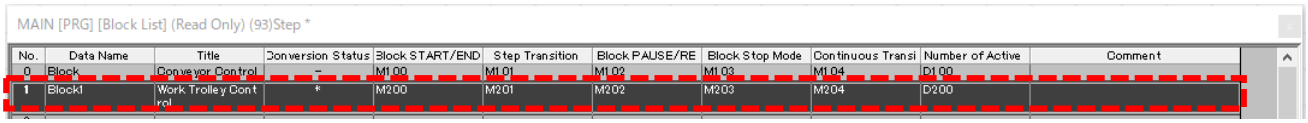
Point

If you want to convert only blocks in an SFC diagram, use Convert > Block Conversion from the menu.

(5) Creating an SFC Diagram (Block No.1)

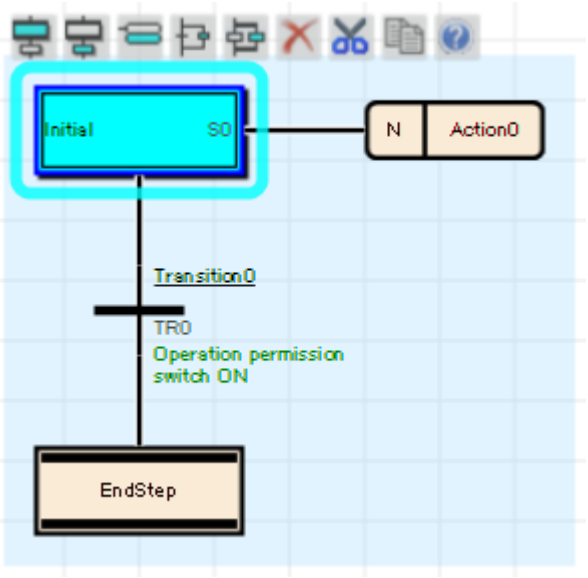
The following shows the procedure for creating an SFC diagram when creating a program for block No.1. From the block list, select No.1 "Work trolley control".

Click the View > Open SFC Diagram menu or double-click the block you want to view.



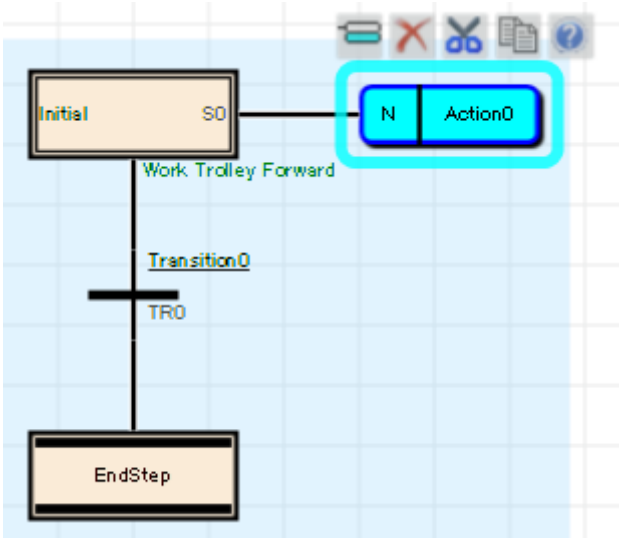
The SFC diagram for Block1 opens.

(a) Select "Initial" and specify the following settings:



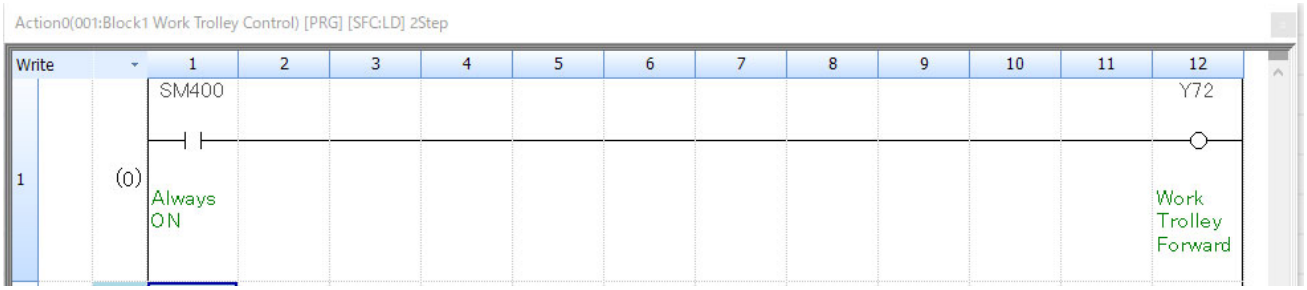
[Settings]
Data Name: Initial
Step No: S0
Device Comment: Work Carriage Forward

Next, set the operation output of "Initial" as follows.



[Settings]
Data Name: Action0
Type: Detailed expression
Qualifier: N

In the New Data window, change the program language to Ladder, and then click the OK button.

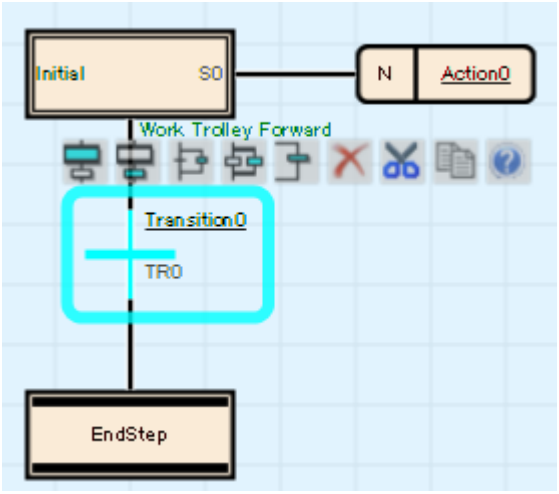


Enter the program in Ladder Programming Language.

[Procedure]

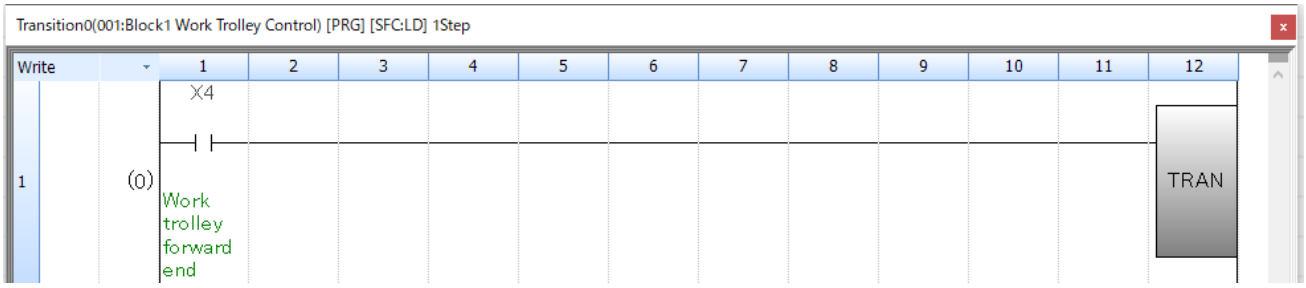
1. Move the cursor to the insertion point.
2. Enter "SM400" and click OK.
3. Move the cursor to the next insertion point, enter "Y72", and click OK.

(b) Select "Transition0" and set as follows:



[Settings]
Data Name: Transition0
Type: Detailed expression
Transition No. (TRn): TR0
Device Comment: Work Trolley Forward End

In the New Data window, select the ladder for the program language and click the OK button.

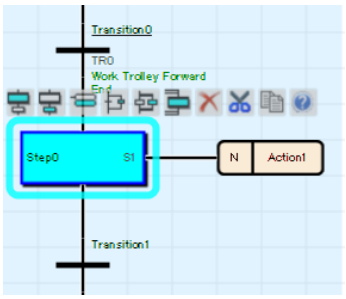


Enter the program in Ladder Programming Language.

[Procedure]

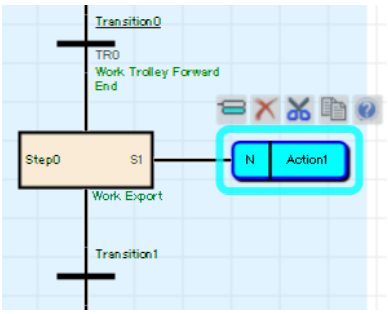
1. Move the cursor to the insertion point.
2. Enter "X4" and click OK.
3. Move the cursor to the next insertion point, enter "TRAN", and click OK.

(c) Add a step and set "Step0" as follows:



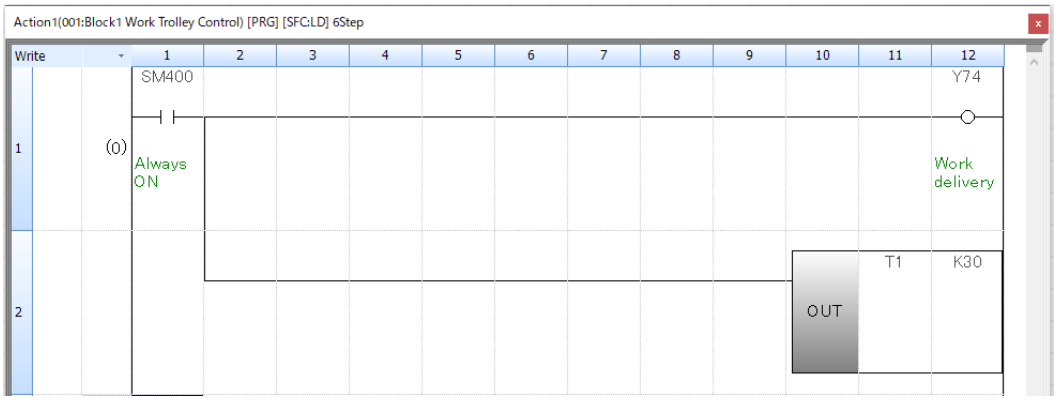
[Settings]
Data Name: Step0
Type: Normal Step
Step No. (Sn): S1
Device Comment: Work Export

Next, set the operation output of "Step0" as follows:



[Settings]
Data Name: Action1
Type: Detailed expression
Qualifier: N

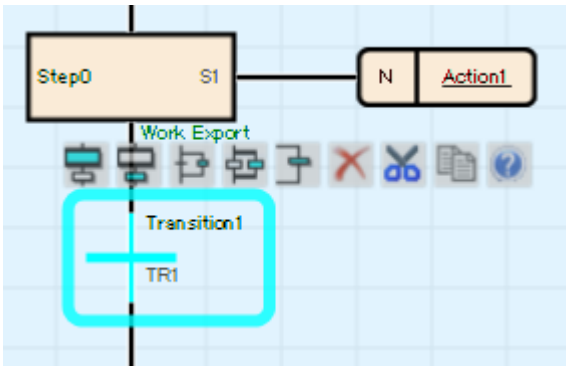
In the New Data window, change the program language to Ladder, and then click the OK button.



Enter the program in Ladder Programming Language.

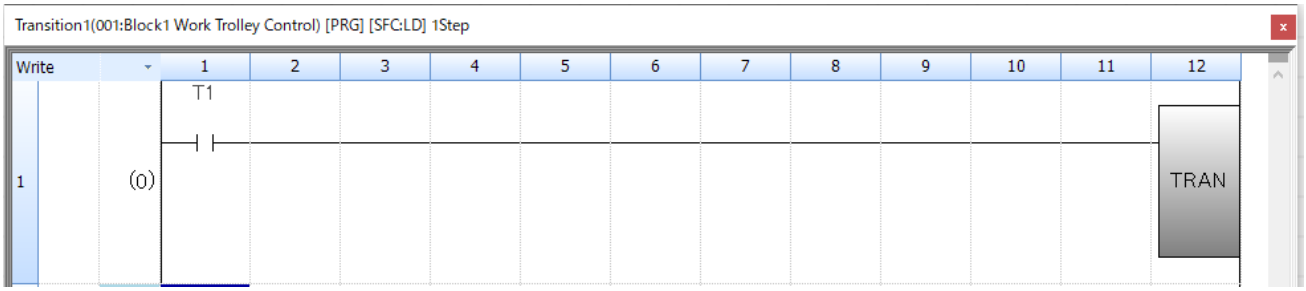
[Procedure]
1. Move the cursor to the insertion point.
2. Enter "SM400" and click OK.
3. Move the cursor to the next insertion point, enter "Y74", and click OK.
4. Create a vertical border and enter "OUT T1 K30". Click the [OK] button.

d) Select "Transition1" and set as follows:



[Settings]
Data Name: Transition1
Type: Detailed expression
Transition No. (TRn): TR1
Device Comment: Work Export Time

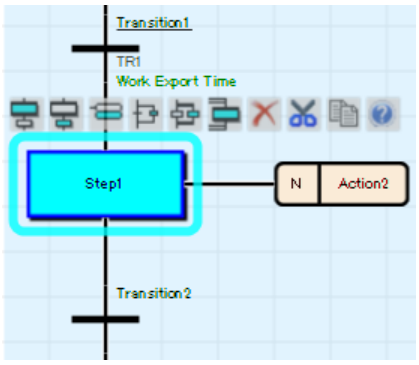
In the New Data window, change the program language to Ladder, and then click the OK button.



Enter the program in Ladder Programming Language.

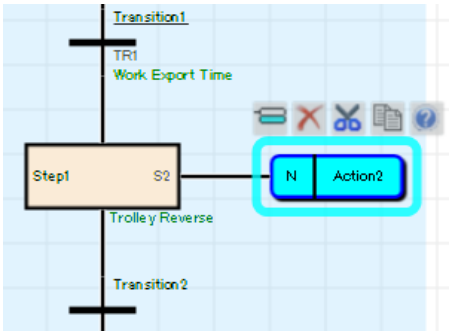
[Procedure]
1. Move the cursor to the insertion point.
2. Enter "T1" and click OK.
3. Move the cursor to the next insertion point, enter "TRAN", and click OK.

e) Add a step and set "Step1" as follows:



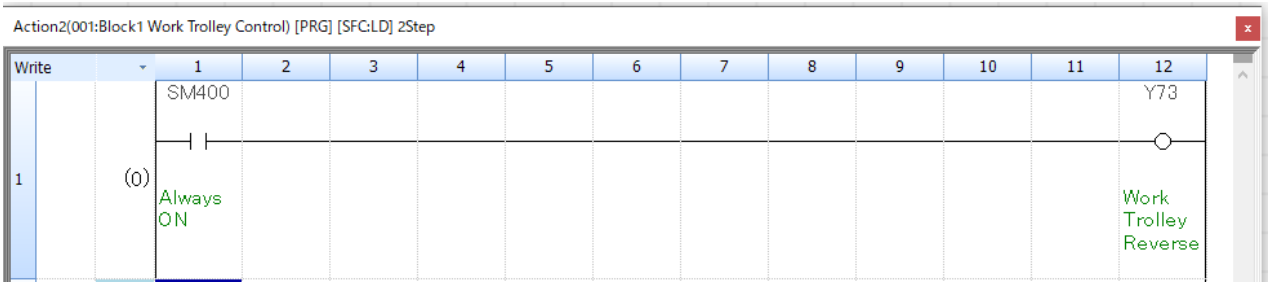
[Settings]
Data Name: Step1
Type: Normal Step
Step No. (Sn): S2
Device Comment: Trolley Reverse

Next, set the operation output of "Step1" as follows.



[Settings]
Data Name: Action2
Type: Detailed expression
Qualia File: N

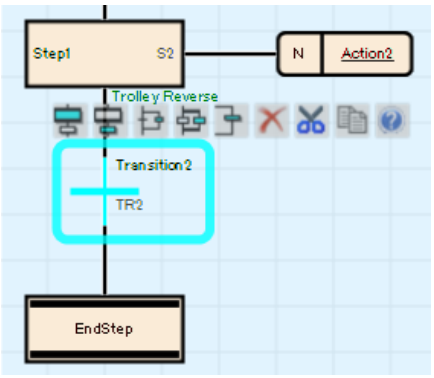
In the New Data window, change the program language to Ladder, and then click the OK button.



Enter the program in Ladder Programming Language.

[Procedure]
1. Move the cursor to the insertion point.
2. Enter "SM400" and click OK.
3. Move the cursor to the next insertion point, enter "Y73", and click OK.

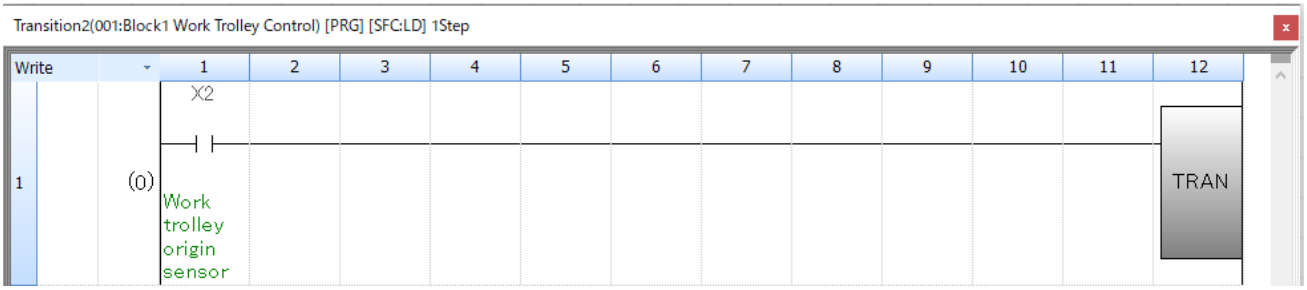
(f) Select "Transition2" and set as follows:



[Settings]

Data Name:	Transition2
Type:	Detailed expression
Transition Condition No.:	TR2
Device Comment:	Work Trolley Origin LS

In the New Data window, change the program language to Ladder, and then click the OK button.



Enter the program in Ladder Programming Language.

[Procedure]

1. Move the cursor to the insertion point.
2. Enter "X2" and click OK.
3. Move the cursor to the next insertion point, enter "TRAN", and click OK.

When you are finished creating the SFC diagram, click Convert - > Convert All in the menu.

3.3 SFC Configuration

In the CPU parameters and SFC block settings, set the start conditions for the SFC program.

Note that the default settings remain for all programs created in 3.2 Creating Programs.

(1) CPU Parameters

The following is a list of SFC settings:

Type	Items	Contents
SFC Configuration	SFC Program Start Mode Setting	Set whether to start with initial status (Initial Start) or to start HOLD the previous execution status (Resume Start) at the start-up of SFC program.
	Start Conditions Setting	Set whether to automatically start and activate Block0 or to keep it inactive until a start request is issued, when starting the SFC program.
	Output Mode Setting at Block Stop	Set whether to turn off the coil output or to hold it when stopping a block.

Point

Keep the certain number of step relay (S) points before using the SFC program. (Default number of step relay (S) points are 0.)
Set the number of step relay (S) points in units of 1024 points in [CPU Parameter] > [Memory/Device Setting] > [Device/Label Memory Area Setting] > [Device Setting].

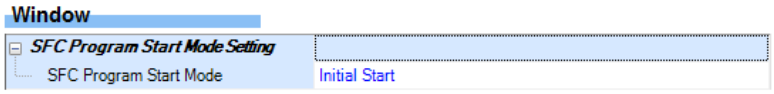
(2) SFC Block Settings

Set operation settings for block double start. (3.4.1 Operation Setting for Dual Block Startup)

3.3.1 SFC program start mode setting

The SFC program start mode sets whether to start the SFC program in the initial state (initial start) when the SFC program starts (SM321 OFF → ON) or to start it while maintaining the previous execution state (continued start).

Set from [CPU Parameters] > [SFC Settings] > [SFC Program Start Mode Settings].



Type	Contents
Initial Start (default)	The program is started after the active state at a previous stop is cleared. The operation after a start is performed according to the start condition setting of the SFC setting. (エラー! 参照元が見つかりません。)
Continue Start	The program starts while HOLD the active state at a previous stop.

Whether to start an SFC program with initial status or the previous execution status is determined by the combination of the SFC program start mode setting and the SM322 (SFC program start mode) status.

Operation		SFC program start mode setting: Initial Start		SFC program start mode setting: Resume Start	
		SM322: OFF (Initial status) *1	SM322: ON (When the setting is changed)	SM322: ON (Initial status) *1	SM322: OFF (When the setting is changed)
(1)	SM321 is turned off and on.	Initial Start		Resume Start	Initial Start
(2)	CPU module is powered off and on.			Resume Start/Initial Start*4	
(3)	SM321 is turned on and off, or CPU module is powered off and on after changing the operating status from RUN to STOP.			Resume Start	
(4)	CPU module is reset, and the operating status is changed to RUN.			Resume Start/Initial Start*4	
(5)	SM321 is turned on and off, or CPU module is reset, and the operating status is changed to RUN after RUN to STOP.			Resume Start	
(6)	Operating status is changed from STOP to RUN.	Resume Start*3			
(7)	Operating status is STOP, write a program, and the status is changed to RUN.	Initial Start*2			

*1 The initial status of SM322 is determined when the operating status of the CPU module is changed from STOP to RUN according to the setting of the SFC program start mode.
*2 When the Resume Start is set for the SFC program start mode, a program is resumed unless there is any change before and after program writing.
*3 The on/off state of an action is determined according to the setting of "Output Mode at STOP to RUN" of parameter setting.
*4 Depending on the timing, a program cannot be resumed and starts with initial status.

(1) Cautionary Notes

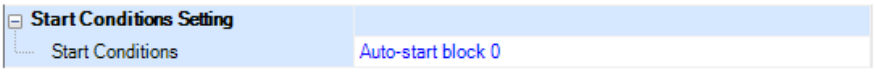
- When a program is resumed, the SFC program stop position is held but the status of the label or device used for an action is not held. Therefore, if labels or devices are required to be held to start with previous status, set them to be latched.
- When a program is resumed with conditions other than the ones ((1), (3), (5) in the table) where the coil output of the coil HOLD step [SC] is turned off, the coil HOLD step [SC] that holds the operation is restarted but the output is not turned on. To continue the output, set the labels and devices required to be held to be latched. The on/off state of the output at the time of changing STOP to RUN is determined according to the setting of "Output Mode Setting at STOP to RUN" of CPU parameter setting. (MELSEC iQ-R CPU Module User's Manual (Application))
- At power-off or reset, the intelligent function module is initialized. To resume a program, creating an initial program for the intelligent function module in the block which is always active or in a sequence program is recommended.
- At power-off or reset, labels and devices are also cleared. When the SFC information device is set, the values are held only when latch setting is performed.
- Depending on the timing, a program may not be resumed after power-off or reset. If a program is started with initial status while the start mode is set to Resume Start, an event indicates that a program cannot be resumed is stored in the event history. To resume a program without fail, turn off SM321 or switch the operating status of the CPU module from RUN to STOP, and then power off or reset the CPU module.

-

3.3.2 Start condition setting

Set whether to automatically start and activate Block0 or to keep it inactive until a start request is issued, when starting the SFC program.

Set from [CPU parameter] > [SFC Setting] > [Start Conditions Setting]



Settings	Contents	
	At SFC Program START	At the end of Block0
Auto-start Block0 (default)	Block0 is started automatically and starts execution from its initial step.	Block0 is restarted automatically and restarts execution from its initial step.
Do not auto-start Block0	Block0 is activated by a start request resulting from the SET (Starting a block) instruction or a block start step, in the same manner as other blocks.	Block0 is not restarted automatically and remains inactive until another start request is issued.

Use the start condition setting when it is desired to specify the start block at the start of SFC program according to the product type.
"Auto-start Block0" is useful when Block0 is used as described below.

- Management block
- Preprocessing block
- Continuous monitoring block

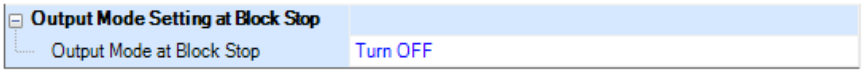
(1) Cautionary Notes

- To execute the SFC program when "Do not auto-start Block0" is set, execute the SET instruction (Starting a block) from the sequence program or turn on the block START/END bit that is set in the SFC information device.
- When "Auto-start Block0" is set, be sure to create Block0.

3.3.3 Output mode setting at block stop

Set whether to turn off the coil output or to hold it when stopping a block.

Set from [CPU parameter] > [SFC Setting] > [Output Mode Setting at Block Stop]



Type	Contents
OFF (default)	Turns off the coil output.
Leave ON	Keeps the coil output in the state just before stopping.

- The settings made are reflected to the initial value of SM325 (Output mode at block stop) at power-on, reset, or switching from STOP to RUN, and follow the settings of SM325 when the SFC program operates. CPU parameter settings are ignored.

■ Operation at the time of block scheduled restart

Operation when the block is paused or restart depends on the combination of the SM325 (Output mode at block stop) status, block stop mode bit setting of the SFC information device, and step hold status.

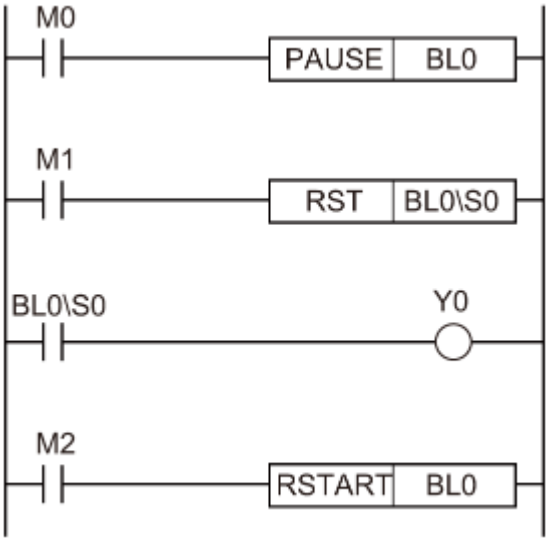
The following table lists the operations at block PAUSE/RESTART.

<table>
<tr><td rowspan="3">Output mode setting at block stop</td><td rowspan="3">Setting of block stop mode bit</td><td colspan="4">Operation</td></tr>
<tr><td rowspan="2">Active step other than step that holds operation
(Including SC, SE, and ST whose transition does not become TRUE)</td><td colspan="3">HOLD Step</td></tr>
<tr><td>Coil HOLD step [SC]</td><td>Operation HOLD step (without transition check) [SE]</td><td>Operation HOLD step (with transition check) [ST]</td></tr>
<tr><td rowspan="2">SM325=OFF
(Coil output OFF)</td><td>OFF or not set
(Immediate Stop)</td><td>Immediately after a stop request is made, the coil output of the action is turned off and the block is stopped. The status remains active.</td><td rowspan="2">Immediately after a stop request is made, the coil output of the action is turned off and the block is deactivated.</td><td colspan="2" rowspan="2">Immediately after a stop request is made, the coil output of the action is turned off and the block is stopped. The status remains active.</td></tr>
<tr><td>ON
(Stop after transition)</td><td>After the transition becomes TRUE, step end processing is performed and simultaneously the transition destination step becomes active, and the block is stopped before execution of the action.</td></tr>
<tr><td rowspan="2">SM325=ON
(Coil output held)</td><td>OFF or not set
(Immediate Stop)</td><td>Immediately after a stop request is made, the block is stopped with the coil output of the action being held. The status remains active.</td><td colspan="3" rowspan="2">Immediately after a stop request is made, the block is stopped with the coil output of the action being held. The status remains active.</td></tr>
<tr><td>ON
(Stop after transition)</td><td>Normal operation is performed until the transition becomes TRUE. After the transition becomes TRUE, step end processing is performed and simultaneously the transition destination step becomes active, and the block is stopped before execution of the action.</td></tr>
<tr><td colspan="2">At restart</td><td>Returns to normal operation.</td><td>Coil output is off: Becomes inactive and restart is disabled
Coil output is held Restarts with the hold state</td><td>Restarts the execution of the action in a HOLD status.</td><td>In the hold status, the action is restarted, and the transition is also checked.</td></tr>
</table>

(2) Cautionary Notes

- When the block specified with the LD instruction (Checking the status of a block) has stopped, the coil output is turned on. Also, when the step specified with the LD instruction (Checking the status of a step) has stopped, the coil output is turned on.
- If the block is started while the PAUSE/RESTART bit of the SFC information device is on, the initial step stops before it becomes active. If the SET instruction (Activating a step) is executed for an inactive block, the specified step stops before it becomes active.
- When SM325 (Output mode at block step) is on, the block can be stopped while HOLD the coil output. Even when SM325 is turned on and off in stopped state, the state of the coil output does not change. When a block restart request is issued, the coil output restarts while keeping the hold state.
- If the block is stopped when SM325 is on, the coil HOLD step [SC] in the hold state keeps its state even after restart but the step operation does not restart. To make the coil HOLD step [SC] inactive, execute the RST instruction (Deactivating a step).
- When a stop request is issued in the action to the block, the step being executed currently is executed until it ends, and then the stop request is executed. Therefore, when the block stop mode bit is off (immediate stop), the step being executed does not stop even if a stop request is issued within the step. If the block stop mode bit is changed to on (stop after transition) afterwards in the same step, a stop request is executed in stop mode after transition.

Block PAUSE/RESTART when the RST instruction (Deactivating a step) is used



(1) When M0 is turned on, Block0 is stopped.
(2) When M1 is turned on, a termination request is executed for step No. 0 and BL0\S0 of the step relay is turned off, but step No. 0 is left active on the monitor of the engineering tool.
(3) BL0\S0 is turned off, so Y0 is also turned off.
(4) When M2 is turned on while M0 and M1 are off, Block0 restarts and step No. 0 ends.

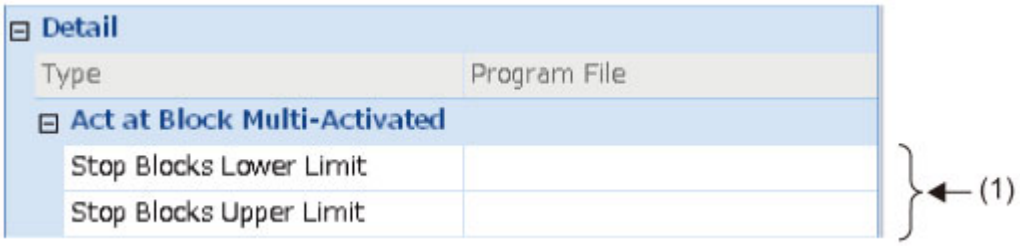
- If the block stop mode bit (stop after transition mode) is turned off while a step in a state that is waiting to stop operation after transition exists, the step remains in that state. To immediately stop after clearing this state, restart the block and issue a stop request again while the block stop mode bit is off.
- When the step transition destination is an end step in stop after transition mode, end step processing is executed and therefore the step is not put in the stopped state.
- To check that a stop request has been issued, monitor the block list display of the engineering tool, or monitor the bit that has been set in the block PAUSE/RESTART bit. However, whether the step is in stop state or operating to wait to stop cannot be checked from the monitor of the engineering tool.
- The stop after transition state can be cleared by turning off the block PAUSE/RESTART bit or executing the RESTART instruction before the transition becomes TRUE. If a restart request is issued while steps that is already stopped and steps that is waiting to stop operations coexist, the former starts, and the latter continues the operation. The stop request is cleared.

3.4 SFC Block Configuration

3.4.1 Operation setting at block dual start

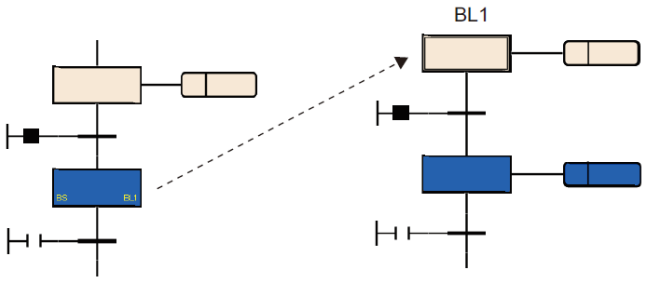
Set the operation mode to stop the operation of the CPU module when a start request is issued by the block start step (with end check) [BC] or block start step (without end check) [BS] for an already active block. For the setting range, set the range of the block to be stopped.

Set from [Navigation window] > [Program] > [Properties of SFC program file to be set]



(1) Set the range of blocks you want to stop.

Settings	Contents	
No setting (default)	Standby	CPU module operation continues, and standby until the start destination block becomes inactive while the transition becomes TRUE. When the start destination block is deactivated, the block is reactivated. If a transition in standby state, the previous step is deactivated, the output is switched OFF, and the action will not be executed.
Block stop range is set.	Stop	An error results.



(1) Cautionary Notes

- When the SET instruction (Activating a block) is executed for the block that is already active, the start request is ignored and the processing of the SFC program is continued as is.
- If an attempt to transition to an active block start step is made, the activation of the block start step is ignored. The block is not executed again from the initial step.

3.5 Creating an SFC Diagram

Shows the basic procedure for creating an SFC diagram.
You can insert different elements depending on the selection.

The size and position of each element/connection line are determined automatically and cannot be changed freely.

1. Cautionary Notes

   If any of the following items is entered or selected, a red frame appears in the edit box, and you cannot set it.
   - Duplicate Step Name/Step No./Transition Condition No.
   - Invalid step attribute
   - Step name that cannot be specified as jump destination

2. Insert Initial Step

   When a new SFC program is created, one initial step is inserted.
   To execute multiple processes in parallel, add an initial step.
   Select Edit > Insert > Step () on the empty cell.
   An SFC diagram consisting of initial steps, transition conditions, and end steps is inserted.

3. Insert Normal Step

   Select Step > Transition Conditions > Jump and select Edit > Insert > Step ().

4. Insert Transition Criteria

   Select Step > Transition Conditions > Jump and select Edit > Insert > Transition Conditions ().

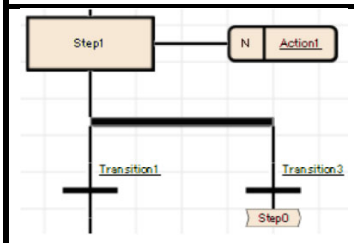
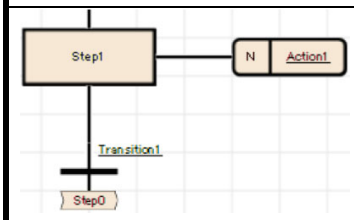
5. Insert operation output

   Select Step > Operation Output and select Edit > Insert > Operation Output ().
   You can insert multiple operation outputs in a step.

Point

- Setting CPU parameters enables only Block0 to be started automatically when the SFC program starts. In this case, when the end step is activated and the Block0 is finished, the Block0 is automatically restarted and execution of steps is started again from the initial step. (Start condition setting)
- If a start request is issued to a step in an inactive block by using the SET instruction (activating a step), the block is activated to execute processing from the specified step.

(6) Insert Jump

Insert position	Procedure
	1. Select the transition condition and select Edit > Insert > Jump (). 2. Select the name of the step you want to jump to.
	1. Select the transition condition and select Edit > Modify > Toggle Jump Symbol and Connection Line. 2. Select the name of the step you want to jump to. All SFC diagrams below the inserted jump are deleted.

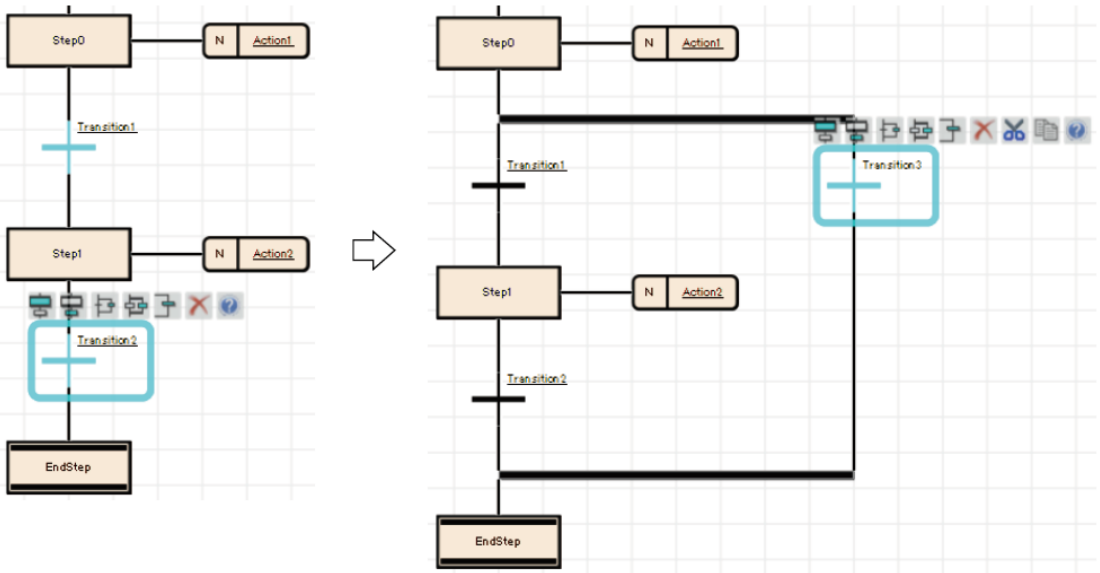
(7) Insert a branch under a step/transition condition

Select Step > Transition Condition and then select Edit > Insert > Insert Selected Branch () > Insert Parallel Branch ().

If you insert a selected branch or a parallel branch, the SFC elements that are not sufficient for the correct SFC diagram are automatically inserted.

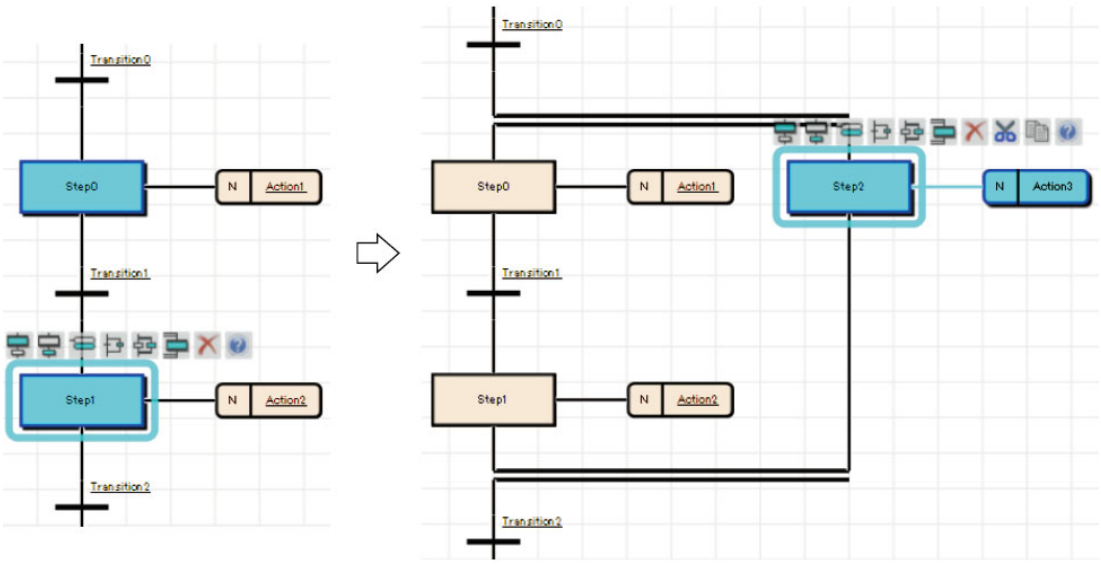
(8) Add a selection branch to the right of the transition condition/selection branch

Select the transition/selection branch to add and select Edit > Insert > Add Selection (). (Multiple selections allowed)



(9) Add a parallel branch to the right of the step/parallel branch

Select the step/parallel branch where you want to add it, then select Edit > Insert > Add Parallel Branch (). (Multiple selections allowed)

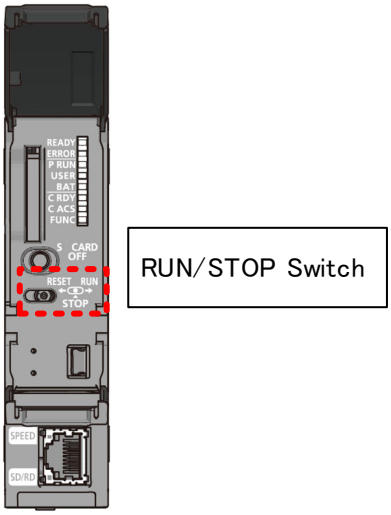

Transition0
Step0
N
Action1
Transition1
Step1
N
Action2
Transition2
Transition0
Step0
N
Action1
Step2
N
Action3
Transition1
Step1
N
Action2
Transition2

3.6 Writing an SFC Program to the CPU

After preparing the switch settings, write the program created in 3.2.4 Program Creation to the CPU. After writing, monitor and test.

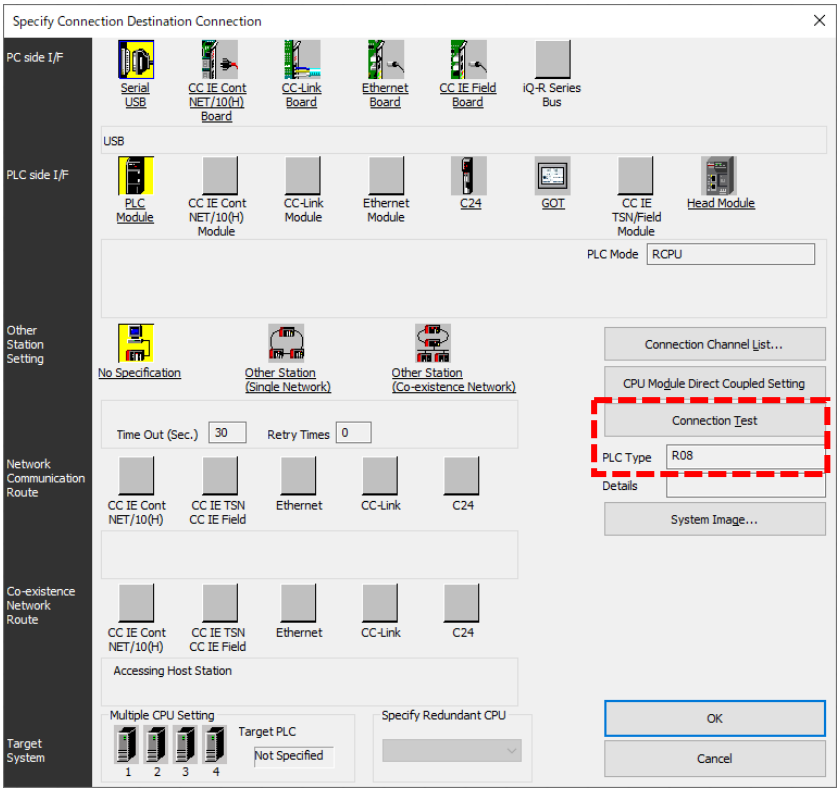
（1） Switch Settings

Make sure that the RUN/STOP switch is set to STOP.



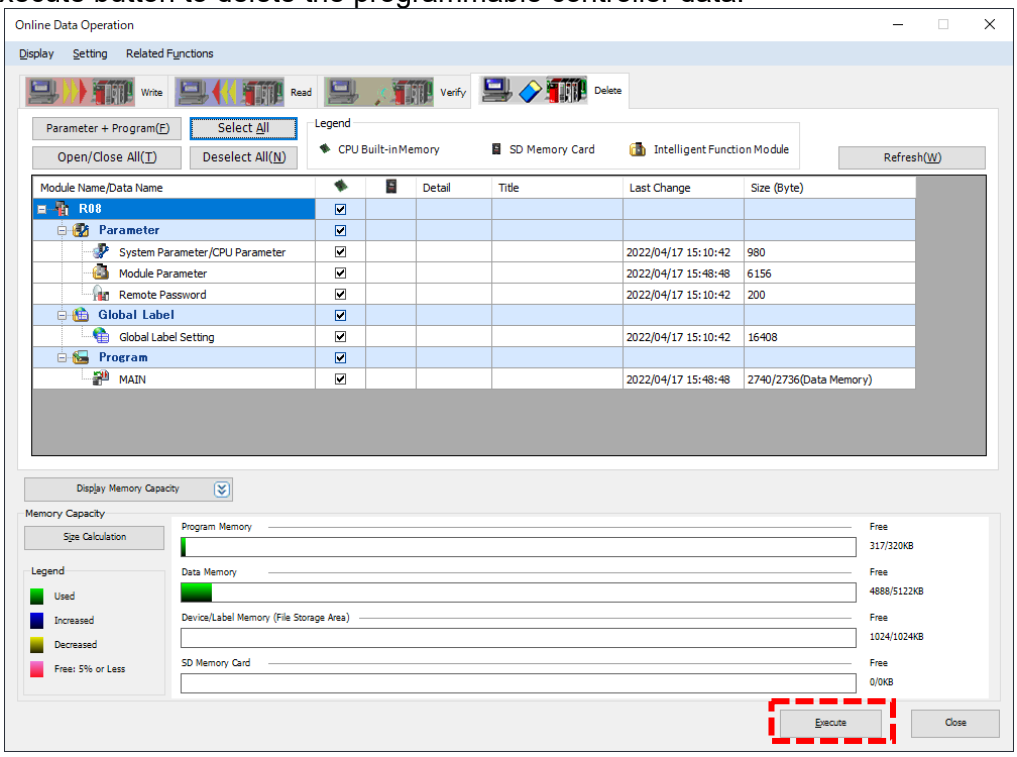
（2） Specify connection destination

Click the Online > Current Destination menu.
In the Connection Settings window, input the connection settings.
Selected “Connection Test”. If successful, the PLC Type will be filled and click “OK”.



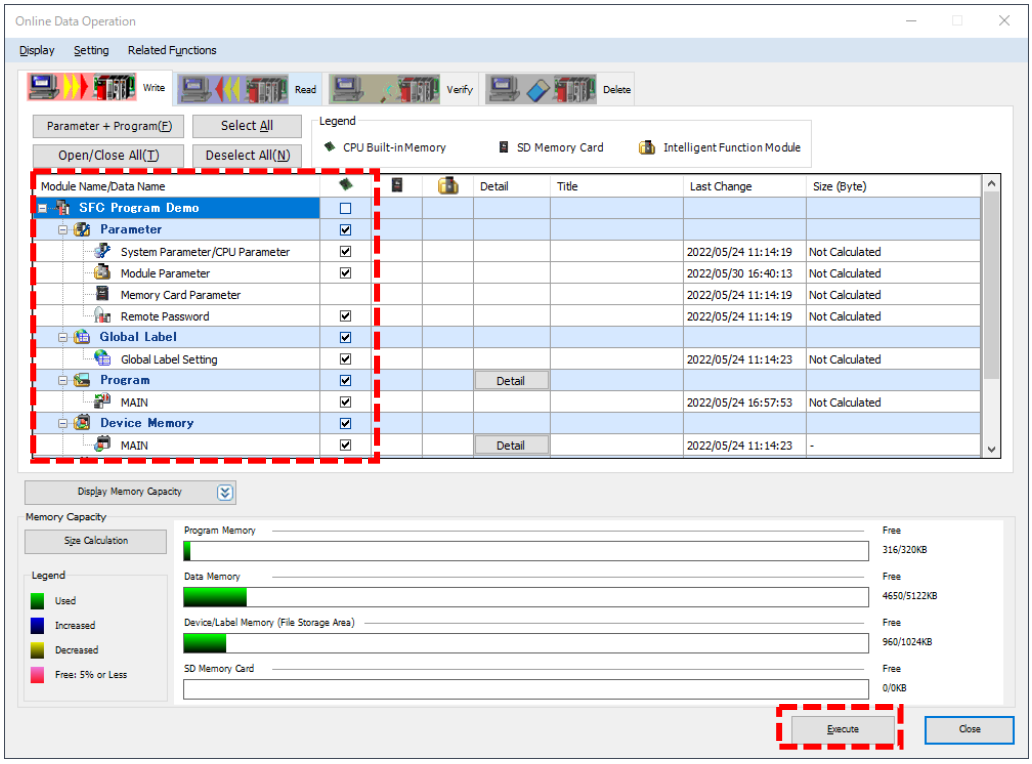
（3） Deleting data from programmable controller

Click the Online > Delete PLC Data menu and click the Select All button.
Click the Execute button to delete the programmable controller data.



（4） Writing Programs

Click the Online > Write to PLC menu (on the toolbar), then click the Select All button. Click the “Execute” button to write the program to the CPU.



4 Run the SFC program

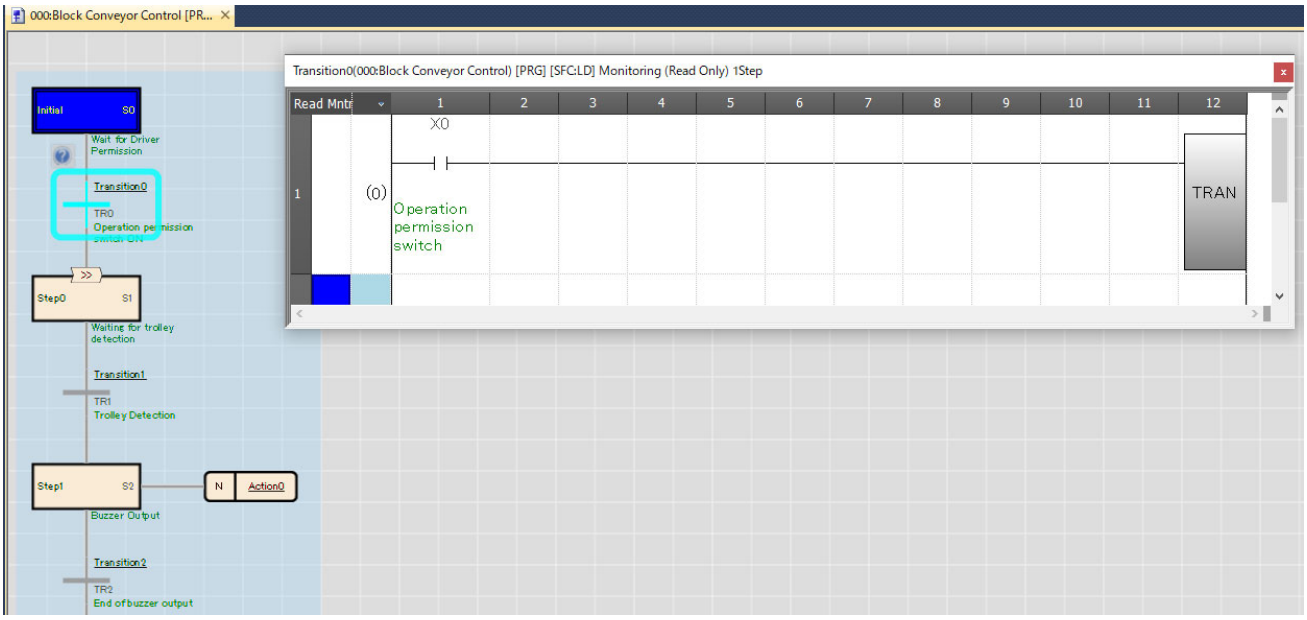
4.1 Using Monitor Operations to Monitor SFC

Use the SFC diagram to monitor the operation and control status of CPU module and perform test operations.

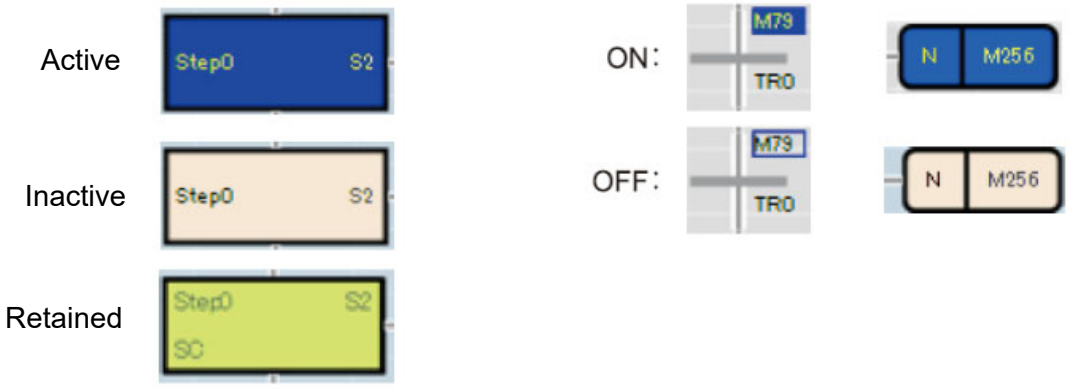
[Procedure]

- When monitoring
  Online > Monitor > Monitor Mode menu or F3
- Stopping the monitor
  Online > Monitor > Stop Monitor menu or  Alt + F3
- When restarting the monitor
  Online > Monitor > Start Monitor menu or  , F3 key

[Screen]



(1) The status of a monitored SFC element is displayed as follows:



(2) To monitor Zoom, select View > Zoom, open Zoom, and then monitor it.

(3) The SFC block list monitor displays the current block information on the SFC block list.

Select View > Open SFC Block List to open the SFC block list before monitoring. You can display the SFC diagram of a specified block by double-clicking the block field during monitoring.

No.	Data Name	Title	Conversion Status	Block START/END	Step Transition	Block PAUSE/RE	Block Stop Mode	Continuous Transi	Number of Active	Comment
0	Block	Conveyor Control	-	M100	M101	M102	M103	M104	D100	
				M100 Comment	M101 Comment	M102 Comment	M103 Comment	M104 Comment	D100 Comment	
1	Block1	Work Trolley Control	-	M200	M201	M202	M203	M204	D200	
				M200 Comment	M201 Comment	M202 Comment	M203 Comment	M204 Comment	D200 Comment	

Point

- Automatic scroll monitor
  When a step that is not visible on the screen is activated during monitoring, the system automatically scrolls to display the activated step on the screen again.

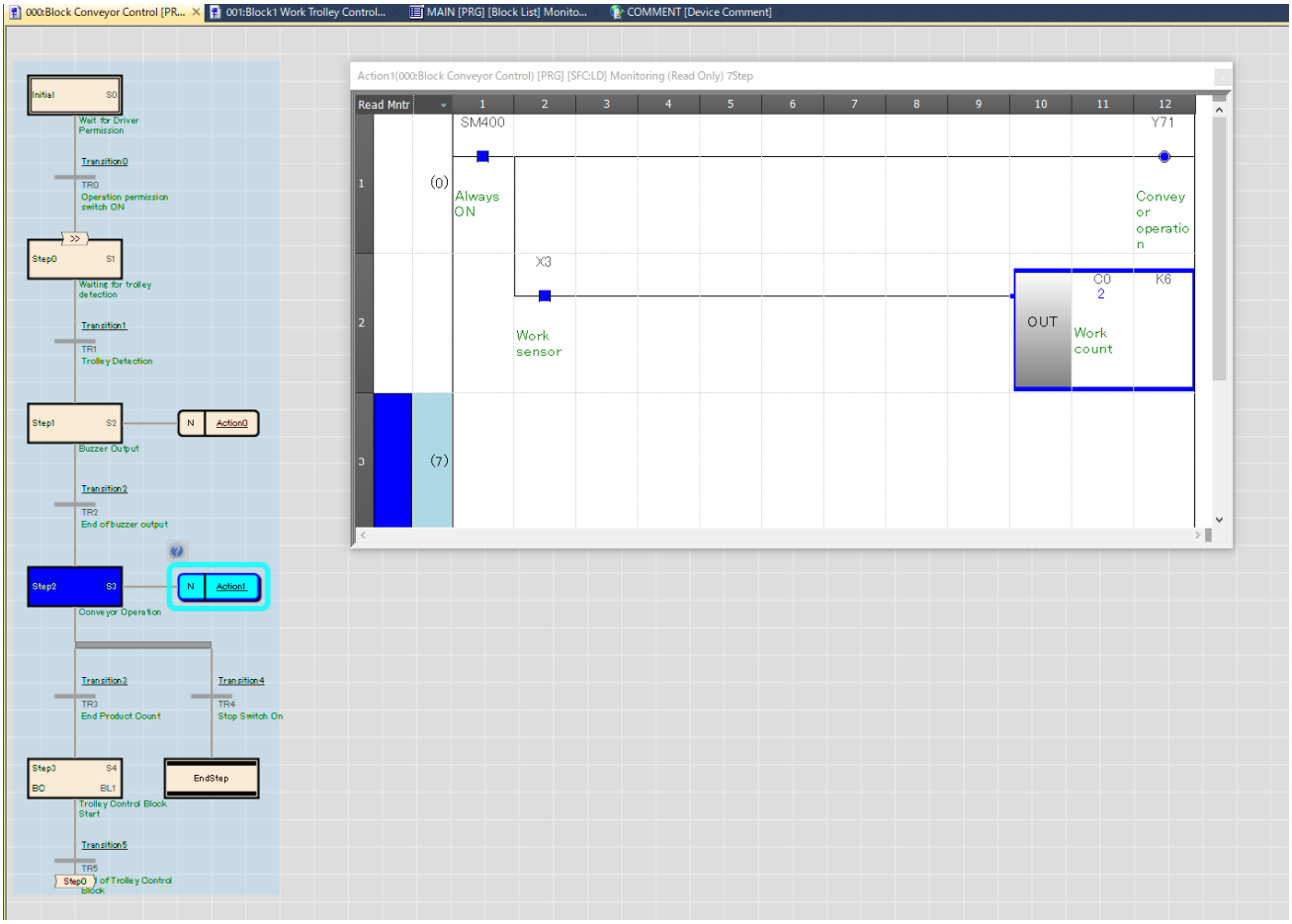
  Click Scroll or select Online > Monitor > SFC Auto-Scroll Monitor.
  If multiple steps are active, steps close to the initial step column are displayed with priority.
  The automatic scroll monitor stops when you open the screen for writing while automatic scrolling or writing while monitoring. When you restart the monitor, the automatic scroll monitor also resumes.
- Displaying the Destination Block During Automatic Scrolling Monitor
- You can set the target block to be displayed automatically by selecting Tools > Options > "Monitor" > "SFC Diagram Editor" > "Auto Scroll Monitor Settings" > "Block Startup Opens and Monitors a New Window".
- When the active step moves to the block start step during automatic scroll monitoring, you can automatically open the SFC diagram editor of the block to start and start monitoring.

[Operation of the actual machine]

Perform the following operations while viewing the SFC monitor screen.

(1) Display operations on the monitor screen

To monitor the currently active steps, click Scroll Monitor, or use Online - > Monitor - > SFC Auto-Scroll Monitor to turn it on.



(2) Procedure

[Operation of Block0]

(1) Operation in step 0 (S0)
When X0 (operation permission switch) is turned on, the transition condition is satisfied, and the process moves to Step 1 (waiting for detection of the work truck).

(2) Operation in step 1 (S1)
When X2 (work truck origin) is turned on, the transition condition is satisfied and the operation proceeds to Step 2 (buzzer output).

(3) Operation in Step 2 (S2)
The alarm buzzer for starting the conveyor sounds, and the transition condition is established by the time up of T0 (alarm timer), and the operation proceeds to Step 3 (conveyor operation).

(4) Step 3 (S3)
The OFF → ON operation of X3 (work sensor) is repeated 6 times, and when a predetermined number of workpieces are carried to the work truck, the transition condition is satisfied, and the process proceeds to Step 4 (start of Block1).

[Operation of Block1]

(5) Operation in step 0 (S0)
When Y 72 (conveyor advance) is turned on and X 4 (work truck advance end) is turned on, the transition condition of step 0 is established and steeped.
Go to step 1 (work export).

(6) Operation in step 1 (S1)
Y 74 (work carryout) is turned on, and the transition condition is established by the time up of T1 (carryout time), and the process proceeds to Step 2 (work truck retraction).

(7) Operation in Step 2 (S2)
When Y 73 (Work Trolley Retraction) is turned ON and X 2 (Work Trolley Origin) is turned ON, the transition condition is established and the block end and returns to Block0.

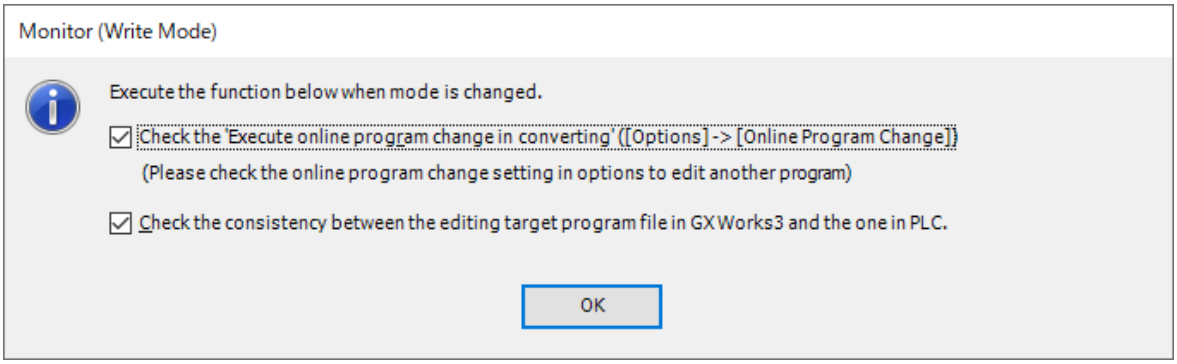
(8) The transition condition in Step 4 is satisfied by the operation in (7), and the process moves to Step 1 by the jump command.
Repeat steps (2) through (7). (Cycle Operation)

(9) If X1 (operation switch) is turned on during conveyor operation, conveyor operation stops and becomes a block end. (Block0 reactivates the initial step.)

4.2 Modifying a program during CPU operation (Writing during RUN)

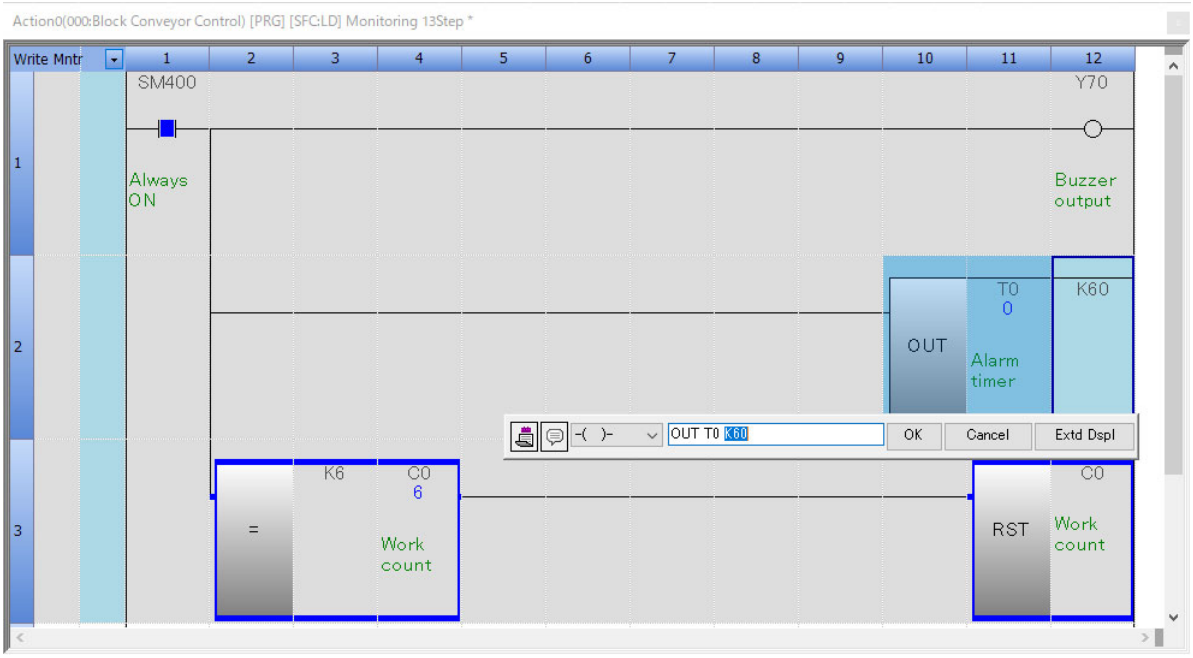
This command corrects an operation output/transition condition program written to the programmable controller CPU once while the CPU is running.
For example, change the timer T0 setting from K30 (3 seconds) to K60 (6 seconds).

(1) Double-click the action output name/transition condition name on the SFC diagram to open the ladder program you want to modify.
Click  to change to monitor (write mode).
When the following dialog box appears, click the OK button.



(2) Perform a program modification operation
Program modifies the timer (T0) setting used in the operation output from 3 seconds to 6 seconds.

(a) Double-click the timer (T0) of the operation output program in step 2 (S2) of Block0.



(b) Change the T0 setting from K30 (3 seconds) to K60 (6 seconds) and click OK.
(c) Click the Convert > Convert + Write during RUN menu.
When the "NOTICE" message appears, confirm the contents, and click the [Yes] button.

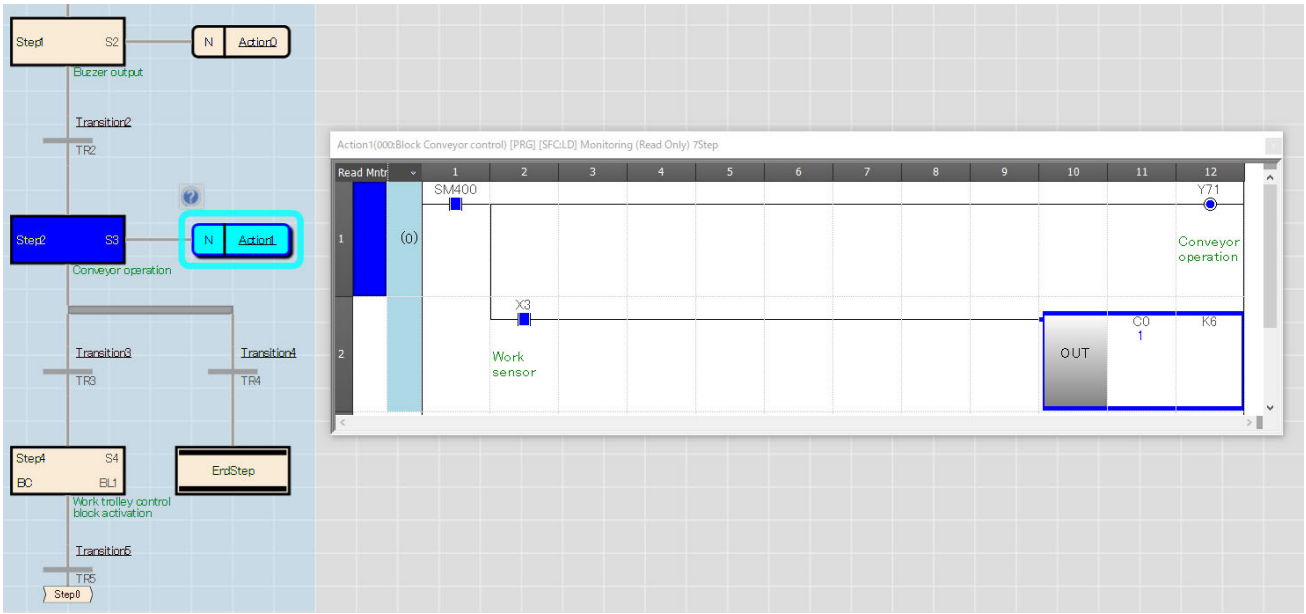
(3) Check the actual machine.
Check that the lighting time of Y70 in [Operation] has changed from 3 seconds to 6 seconds.

4.3 Controlling Blocks with Information Devices for SFCs

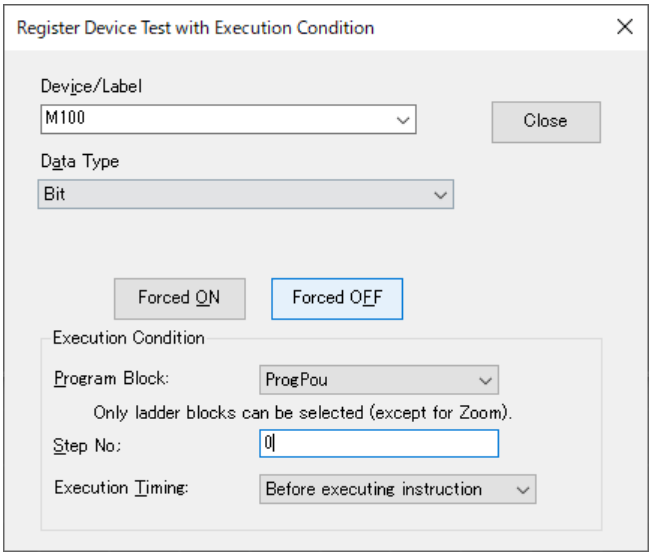
By turning on/off the SFC information device that was set when the SFC diagram was created using a program or GX Works3 test operation, you can suspend or terminate (deactivate) the corresponding block.
This section describes block control using information devices for SFCs.

(1) Block termination by block start termination bit
When the specified block starts, the block start end bit is automatically turned on.
When the specified block is active, turning off the block start end bit stops the execution of the specified block, turns off the output of all the steps being executed, and terminates the block.
The block start/end bit can also be turned ON/OFF from engineering tool test operations.

Confirm the end of the block as follows:
(a) Set the screen to SFC automatic scroll monitor by operating 4.1 monitor operation to monitor SFC.
(b) To do so:
(i) Turn on X0 and X2 and move the activation step to other than the initial step (0 step).



(ii) Turn off X0, X2 and select Debug > Device Test with Execution Condition > Register.
(iii) In the device test registration window with execution conditions, set the following settings, and then click the [Forced OFF] button.



[Settings]
Device/Label: M100
Data types: Bit
Program blocks: ProgPou
Step No: 0
Execution timing: Before executing instruction

(iv) Check that the activation step has returned to the initial step.

(2) Pausing blocks with stop restart bits

When the bit with the block stop restart bit set is ON, the block is stopped at the step being executed and the active block is paused.

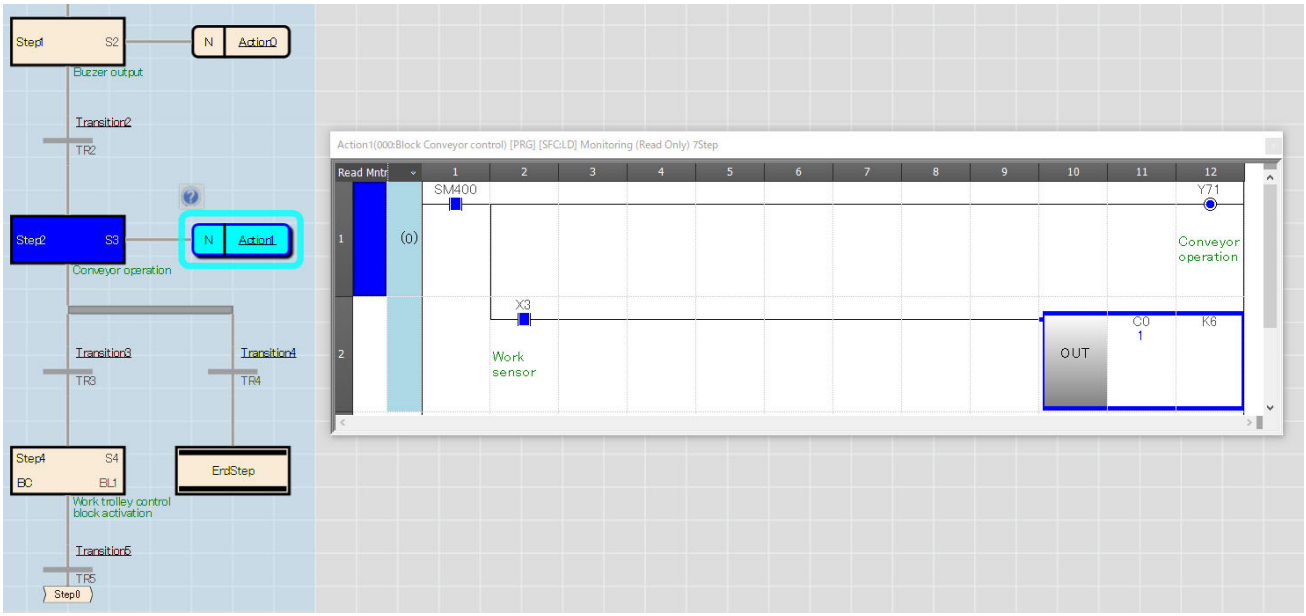
If the block stop restart bit is set to OFF, execution of the block resumes from the stopped step.

Confirm the block pause as follows:

(a) Select "SFC Auto Scroll Monitor".

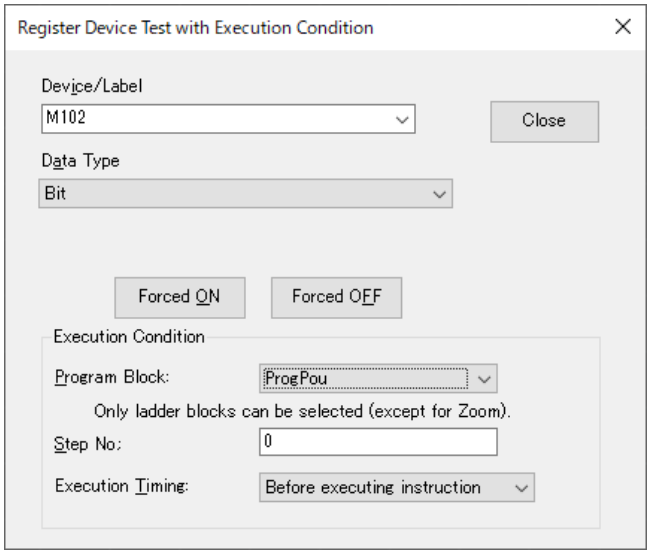
(b) To do so:

(i) Turn on X0 and X2 to activate Step 3 (S3).



(ii) Select Debug > Device Test with Execution Condition > Register.

(iii) In the device test registration window with execution conditions, set the following settings, and then click the [Force ON] button.



[Settings]
Device/Label: M102
Data types: Bit
Program blocks: ProgPou
Step No: 0
Execution timing: Before executing instruction

(iv) Check to see if it has been paused.
- Output Y71 (conveyor operation) is OFF.
- Even if the input X3 (counter input) is turned ON/OFF, the current value of the counter C0 does not change.

(v) When (iv) confirms that it has been paused, turn off the block stop restart bit to release the stop.
- Select [Debug] > [Device Test with Execution Conditions] > [Register] on the monitor screen in the same way as in and turn OFF [M102] forcibly.

(vi) Verify that the pause has been released. Output Y71 (conveyor operation) is ON.
- When the input X3 (counter input) is turned ON/OFF, the current value of the counter C0 is increased.

5 Control blocks with SFC control instructions

By using SFC control instructions, you can check the active status of blocks and steps, forcibly start them, and terminate them.

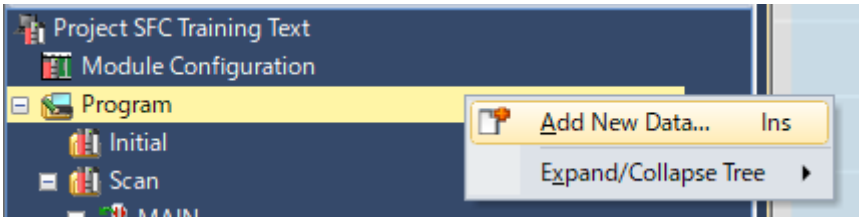
The active state of a block or step can also be handled by a contact command.

This chapter describes how to create a program file for controlling blocks in an SFC and how to execute the control.

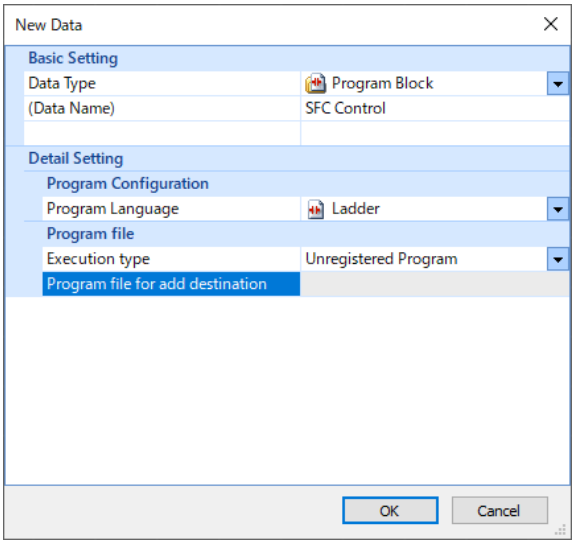
5.1 Creating Programs Using SFC Control Instructions

5.1.1 Add New Program

(1) From the Project view, select a program, right-click and click New Data.



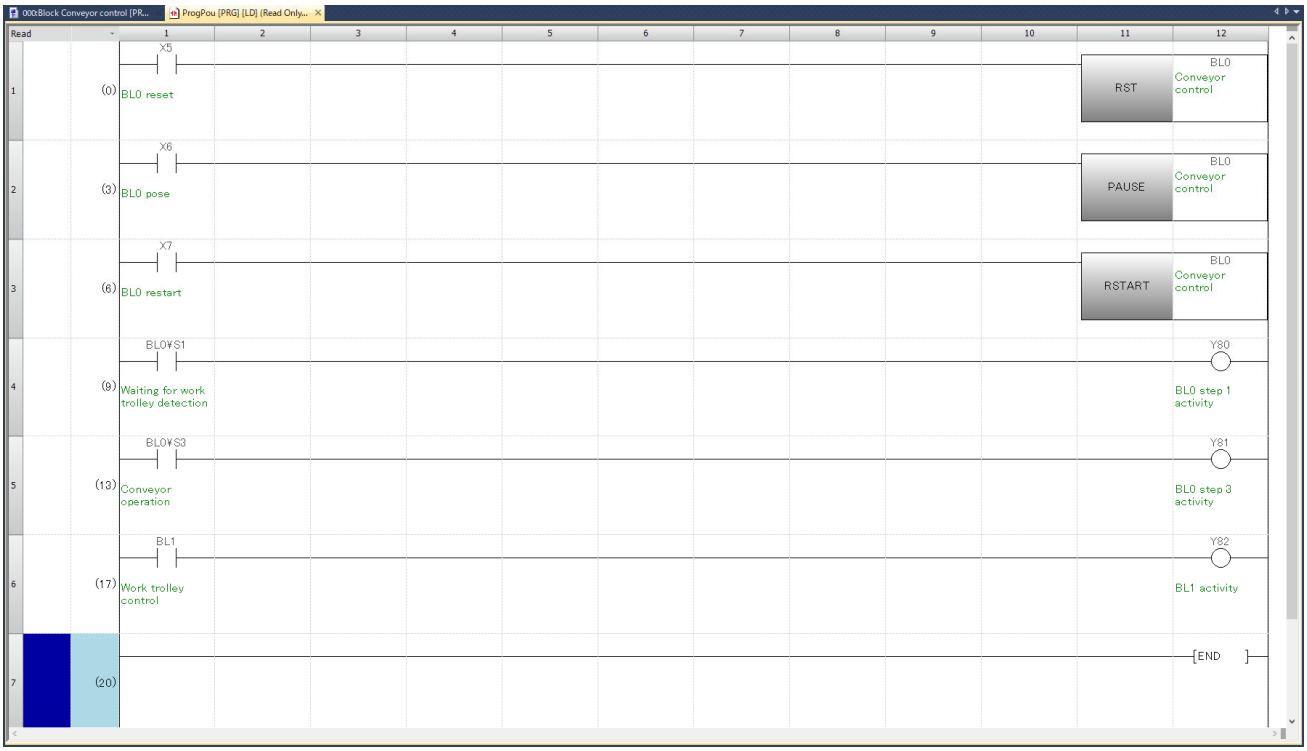
(2) Enter "SFC control" for the data name, select "ladder" *1 for the program language and click the [OK] button.



*1: The SFC control instruction can also be used in the SFC program. In this chapter, you will create a program that uses SFC control instructions in addition to the SFC program so that you can practice how to set up the SFC program and other programs.

5.1.2 Create Program

The following programs are created:



a. Press the F5 key, enter "X5" and click the OK button. Then press the F8 key, enter "RST BL0" and click the OK button.
b. Press the F5 key, enter "X6" and click the OK button. Then press the F8 key, enter "PAUSE BL0" and click the OK button.
c. Press the F5 key, enter "X7" and click the OK button. Then press the F8 key, enter "RSTART BL0" and click the OK button.
d. Press the F5 key, enter "BL0¥S1" and click the OK button. Then press the F7 key, enter "Y80" and click the OK button.
e. Press the F5 key, enter "BL0¥S3" and click the OK button. Then press the F7 key, enter "Y81" and click the OK button.
f. Press the F5 key, enter "BL1" and click the OK button. Then press the F7 key, enter "Y82" and click the OK button.

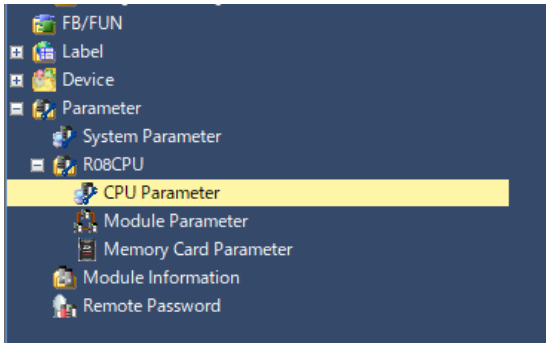
After creating the program, press Shift+Alt+F4 to convert all programs.

For details about each SFC control instruction, see 2.7 SFC control instruction.

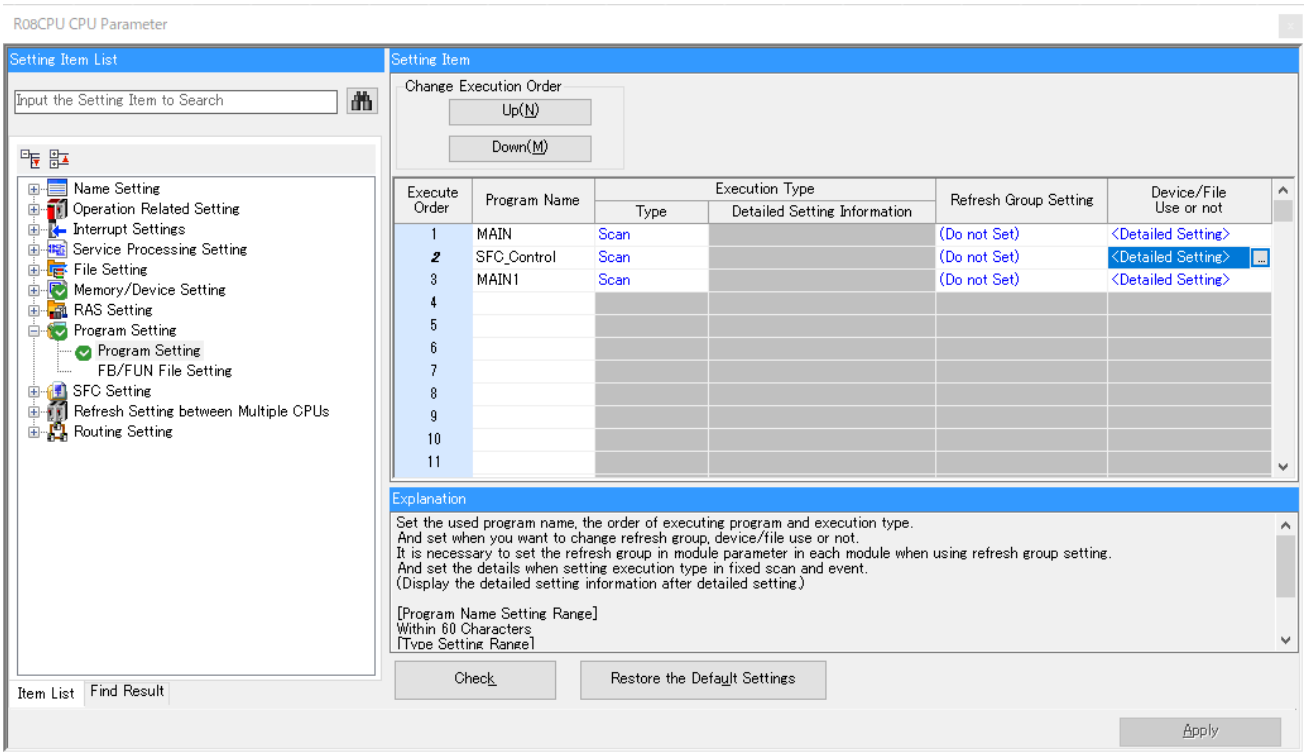
5.1.3 Setting Parameters and CPU Writing

In addition to the SFC program, we created a ladder program using 5.1.2 Program Creation. To write multiple programs to the CPU module, you must set the program's file name and execution type (execution condition).

(1) In the project view, double-click Parameters > R08 CPU > CPU Parameters.



(2) Select Program Settings to set the program name and execution type. Select "Scan" for both execution types. For details about the CPU parameters, see the following manuals:
MELSEC iQ-R CPU module User's Manual (Application)



(3) Write a program to the CPU in the same way as in 3.6 Writing an SFC Program to the CPU.

5.2 Control of SFC Program by SFC Control Instruction

5.2.1 Block and step active state monitoring by activation check command

The execution status (active status) of the SFC program can be treated as a contact point by the step activity check command and the block activity check command.

In 5.1.2 Program Create, the activation check command checks the following:

BL0¥S1	Step 1 of Block0 turns ON while activated.
BL0¥S3	Step 3 of Block0 turns ON while activated.
BL0¥S3	Turns ON while Block1 is active.

In the program we created this time, we used the activation check command in the ladder program to practice monitoring.

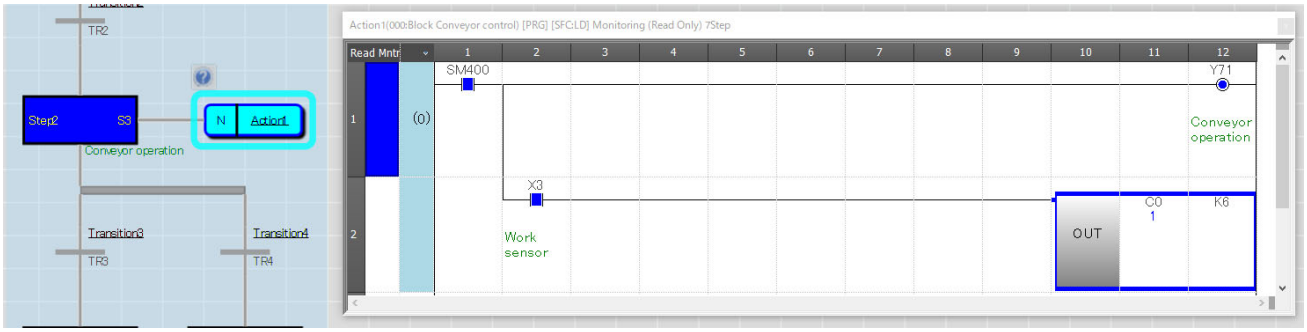
If the activation check command is used as the transition condition of the SFC program, synchronization between blocks and steps can be established.

Program in which the transition condition is satisfied when step 5 of Block1 is activated.

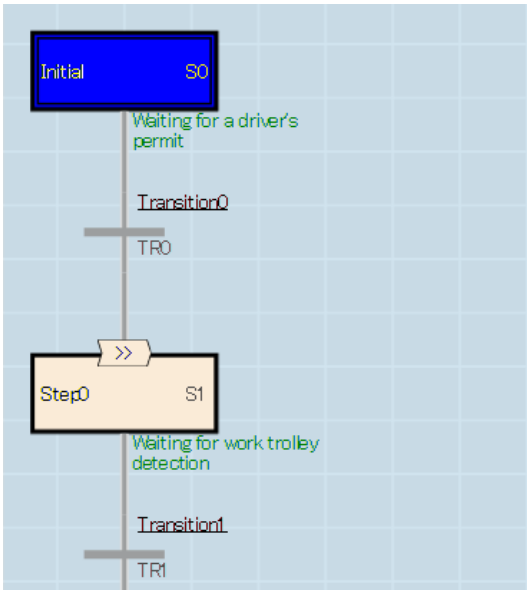
5.2.2 Forced termination of block by SFC control instruction

Forced block termination is a function that executes block end processing to inactivate a block, regardless of which step in the block is active.
Forced block termination is used when work cannot continue because of a machine problem.
To check whether a block is forcibly terminated:

(1) Start the monitor with the Auto Scroll Monitor.
(2) To do so:
    a. Turn on X0 and X2 and move the active step to other than the initial step.



    b. When X5 is turned ON, the active step returns to the initial step.



When Block0 is forcibly terminated, the initial step is automatically activated. If a block other than Block0 is forcibly terminated, the block is inactive until a start request is issued from another block.
If Block0 is not forcibly started is set in the SFC setting of the parameter, Block0 is deactivated in the same way as other blocks.
*1 — See 3.3.2 Start Condition Settings.

5.2.3 Suspension of blocks by SFC control command (block stop)

Suspending a block temporarily suspends the processing of that block.
Use this command to continue starting from the interrupted state after manual operation when work is suspended due to machine trouble.

To check whether a block is paused (block stopped):

(1) Start the monitor with the Auto Scroll Monitor.
(2) To do so:
    a. Turn on X0 and X2 to activate step 3.
    b. Turn on X6 and execute the block pause command.
    c. Check to see if it has been paused.
        i. Indicates whether the OUT command (Y71) is OFF.
        ii. Does the current value of the counter change even if the counter input X3 is turned ON/OFF?
    d. When you have confirmed that the command has been paused, turn on X7 to release the pause.
    e. Verify that the pause has been released.
        i. Whether the OUT command (Y71) is ON.
        ii. Does the current value of the counter change when the counter input (X3) is turned ON/OFF?

When the stop mode bit (Block0: M103, Block1: M203) is turned ON or OFF, the stop timing of the block stop request is as follows:

ON: Stops when the transition condition immediately after the step that is active at the time of the stop request is satisfied.

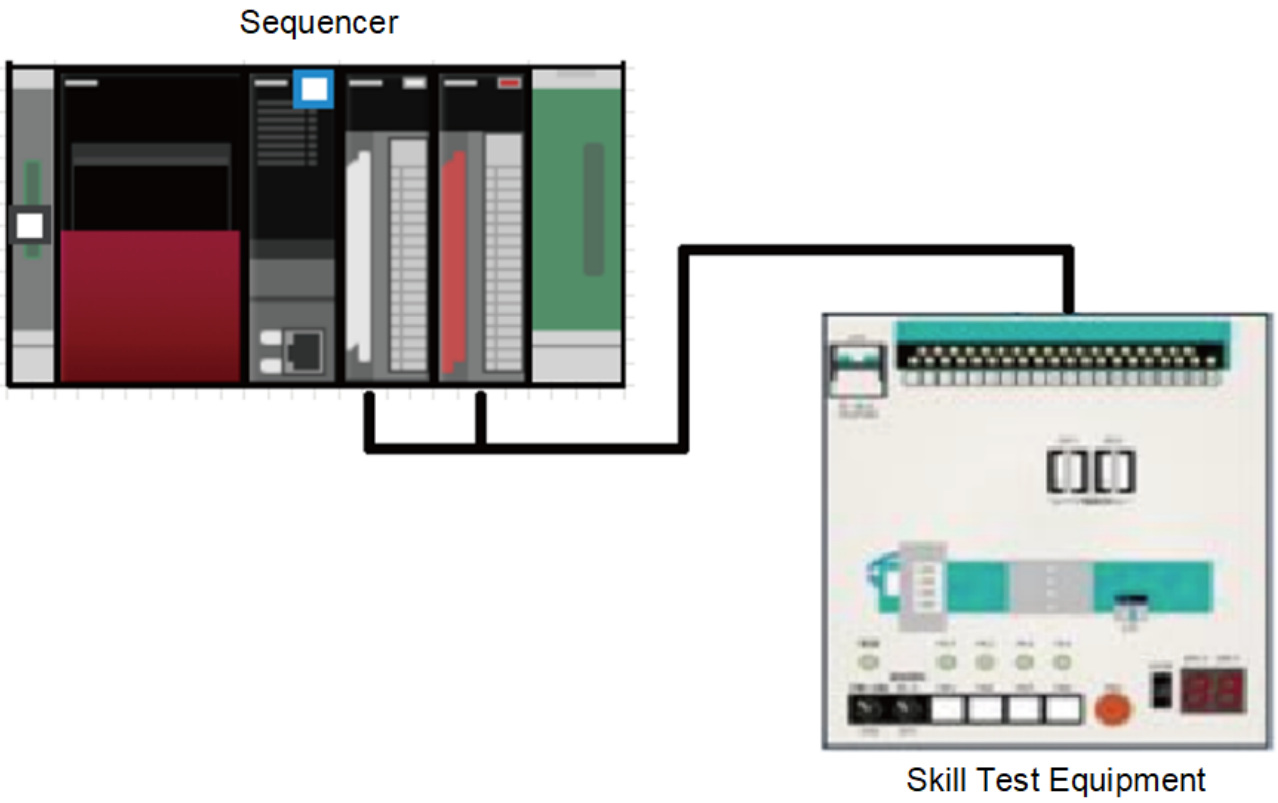
OFF: Stopped immediately when a stop request is made
When the block is stopped, you can select "turn off" or "Leave ON" from the SFC setting of the CPU parameter to turn off or hold the coil output.

Appendix 1.1: Practical Programming Tasks Using Demo Test Equipment

Let's program the exam preparation task 1~3 corresponding to the skill test practical skill test electrical equipment assembly (sequence control work) sponsored by Japan Vocational Ability Development Association in SFC.

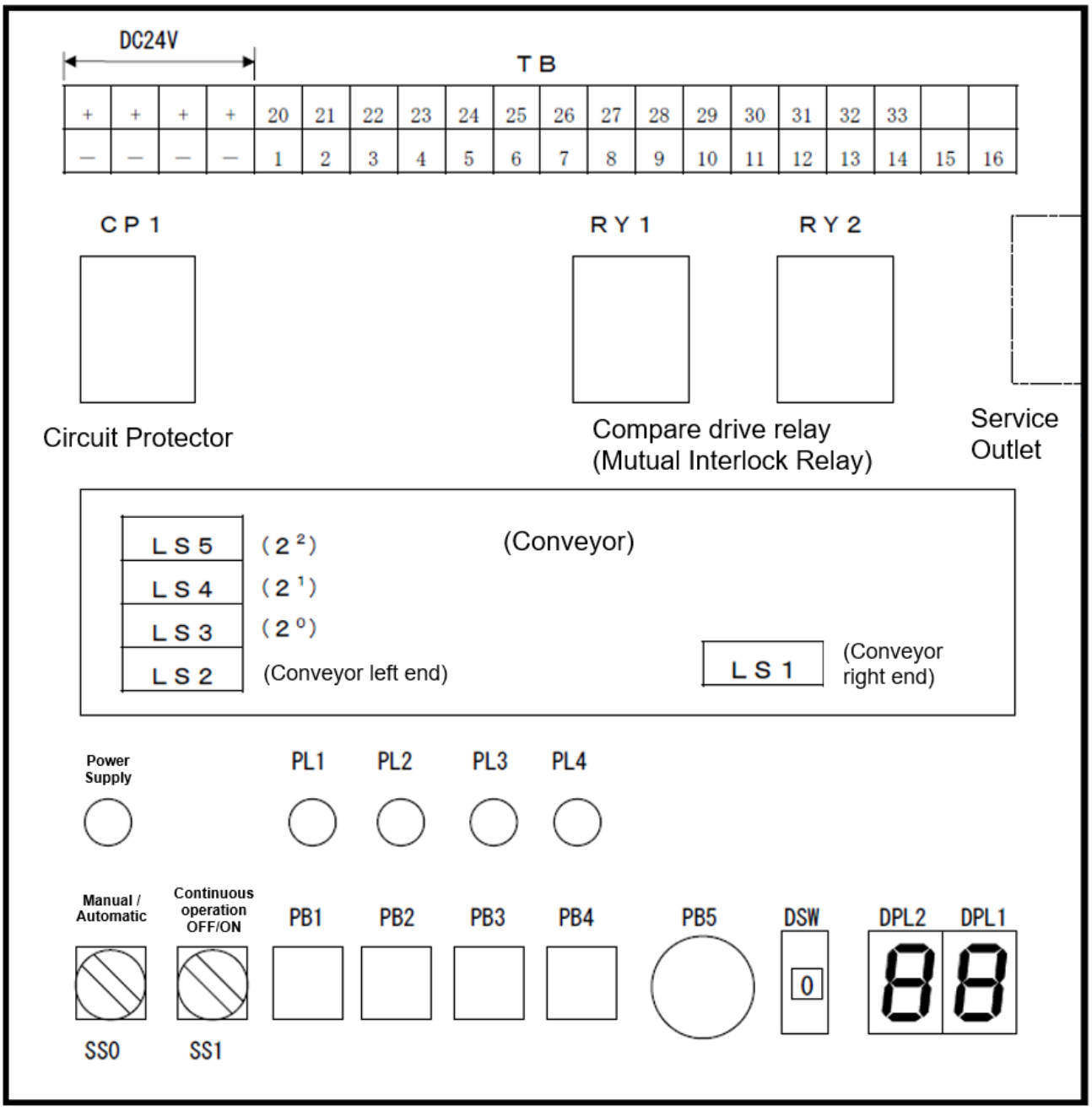
1.1 Description of equipment

The system configuration is shown below.

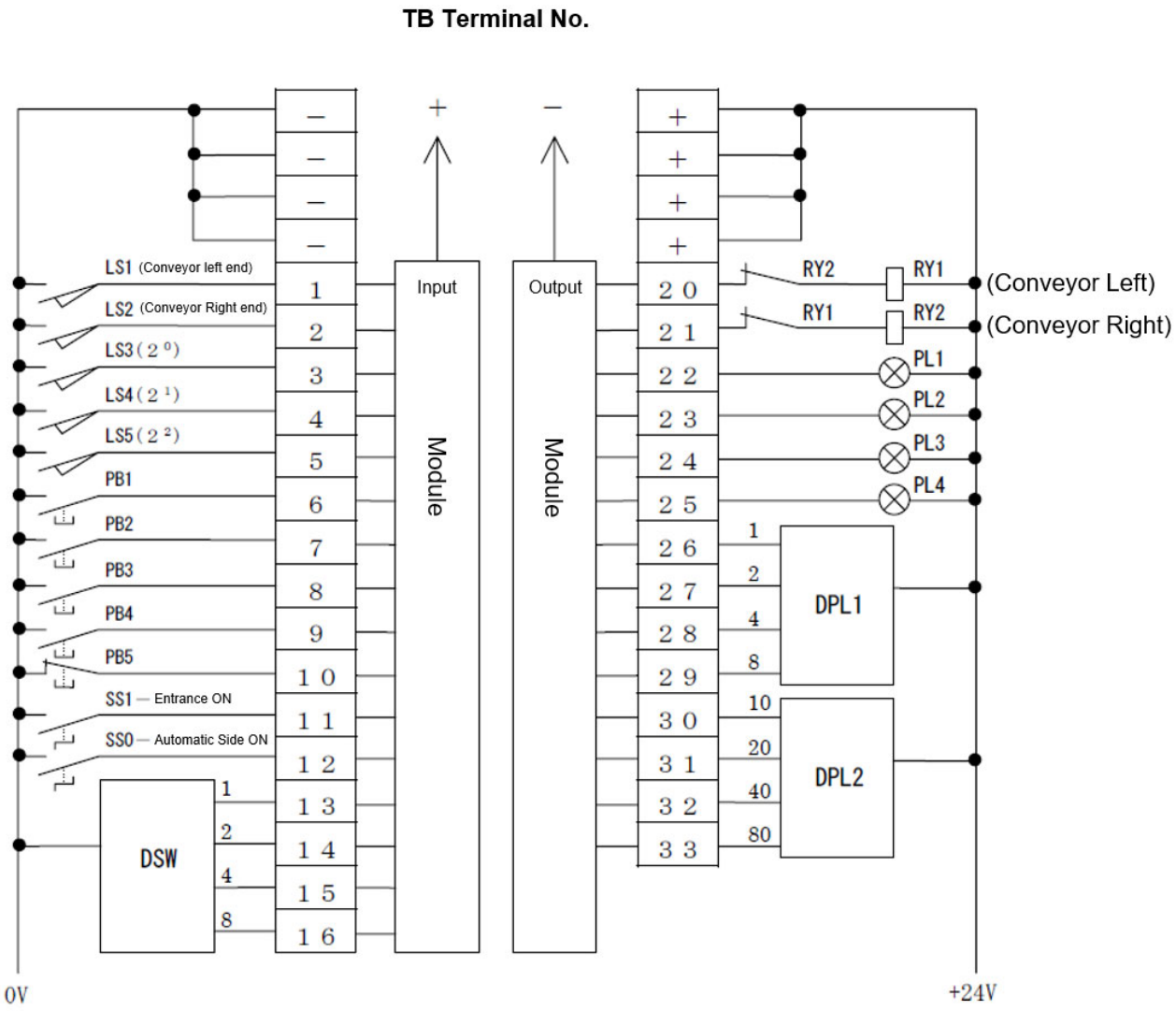


No.	Device Name	Quantity
1	R33B	1
2	R61P	1
3	R08CPU	1
4	RX40C7	1
5	RY40NT5P	1
6	FA-T-P01 (Skill Test Equipment)	1
7	Electric Wire	36

1.1.1 Skill Test Equipment



1.1.2 Input/Output wiring diagram

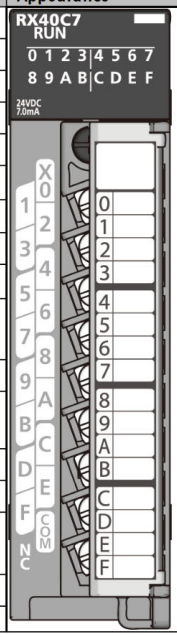


1.2 Programmable controller

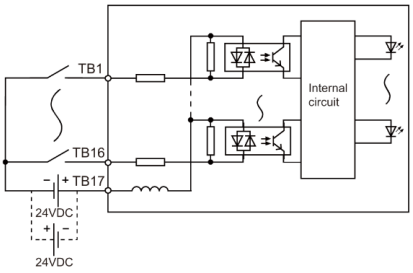
The following describes the specifications of the programmable controller I/O Modules to be used.

1.2.1 RX40C7 Type DC Input module

RX40C7 DC input module

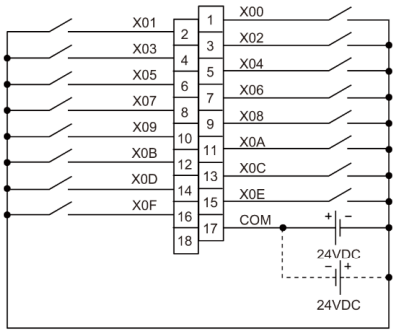
Item	Specifications	Appearance
Number of input points	16 points	
Rated input voltage	24VDC (ripple ratio: within 5%) (allowable voltage range: 20.4 to 28.8VDC)	
Input current	7.0mA TYP. (at 24VDC)	
ON voltage/ON current	15V or higher/4mA or higher	
OFF voltage/OFF current	8V or lower/2mA or lower	
Input resistance	3.3k Ω	
Response time	☞ ■ Input response time	
Withstand voltage	510VACrms, 1 minute	
Isolation resistance	10MΩ or higher by isolation resistance tester	
Noise immunity	Simulator noise 500Vp-p, noise width 1 μs, noise frequency 25 to 60Hz (noise simulator condition)	
Protection degree	IP2X	
Wiring method for common	16 points/common (common terminal: TB17) Positive/negative common shared type	
Number of occupied I/O points	16 points (I/O assignment: Input 16 points)	
Interrupt function	Available (can be set in the "Module Parameter")	
External interface	18-point screw terminal block (M3 × 6 screw) ☞ 18-point screw terminal block type module	
Internal current consumption (5VDC)	120mA (TYP. all points ON)	
Weight	0.16kg	

■ **Circuit configuration**



■ **Terminal connection**

Connection diagram viewed from the front of the module



X00 to X0F are signal names.
The number of 1 to 18 indicates a terminal number.
The terminal number 18 is empty.

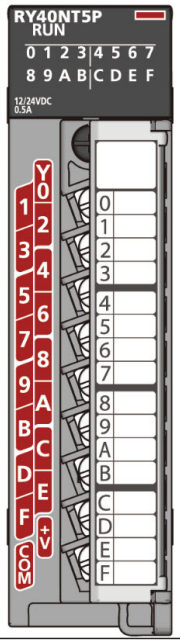
■ **Input response time**

Timing	Setting value								
	0.1ms	0.2ms	0.4ms	0.6ms	1ms	5ms	10ms*1	20ms	70ms
OFF → ON (MAX)	0.1ms	0.2ms	0.4ms	0.6ms	1ms	5ms	10ms	20ms	70ms
ON → OFF (MAX)	0.35ms	0.4ms	0.5ms	0.7ms	1ms	5ms	10ms	20ms	70ms

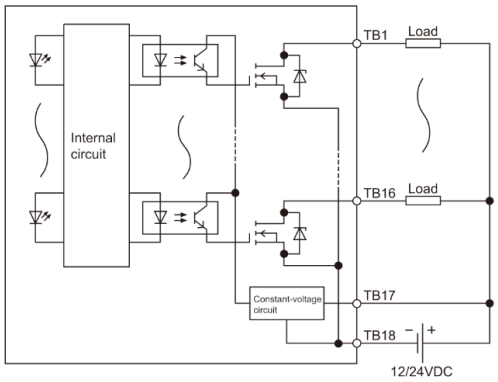
*1 The default value of input response time is 10ms.

1.2.2 RY40NT5P Transistor Output module

RY40NT5P transistor output module

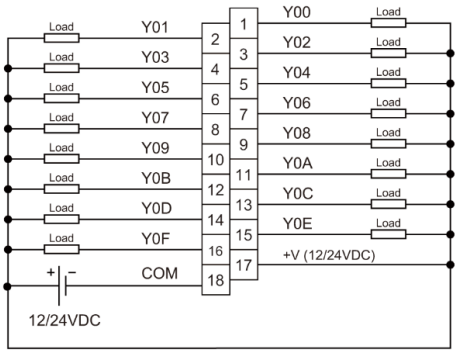
Item		Specifications	Appearance
Number of output points		16 points	
Rated load voltage		12/24VDC (allowable voltage range: 10.2 to 28.8VDC)	
Maximum load current		0.5A/point, Pilot Duty, 5A/common	
Maximum inrush current		Current is to be limited by the overload protection function.	
Leakage current at OFF		0.1mA or lower	
Maximum voltage drop at ON		0.2VDC (TYP.) 0.5A, 0.3VDC (MAX.) 0.5A	
Response time	OFF → ON	0.5ms or less	
	ON → OFF	1ms or less (rated load, resistive load)	
Surge suppressor		Zener diode	
Fuse		None	
External power supply	Voltage	12/24VDC (ripple ratio: within 5%) (allowable voltage range: 10.2 to 28.8VDC)	
	Current	4mA TYP. (at 24VDC), 9mA MAX. (at 24VDC)	
Withstand voltage		510VACrms, 1 minute	
Isolation resistance		10MΩ or higher by isolation resistance tester	
Noise immunity		Simulator noise 500Vp-p, noise width 1 μs, noise frequency 25 to 60Hz (noise simulator condition)	
Protection degree		IP2X	
Wiring method for common		16 points/common (common terminal: TB18) Sink type	
Number of occupied I/O points		16 points (I/O assignment: Output 16 points)	
Protection functions	Overload protection	Limited current when detecting overcurrent: 1.5 to 3.5A/point Activated to each point. (☞ Output modules)	
	Overheat protection	Activated to each point. (☞ Output modules)	
External interface		18-point screw terminal block (M3 × 6 screw) ☞ 18-point screw terminal block type module	
Internal current consumption (5VDC)		140mA (TYP. all points ON)	
Weight		0.16kg	

■ **Circuit configuration**



■ **Terminal connection**

Connection diagram viewed from the front of the module

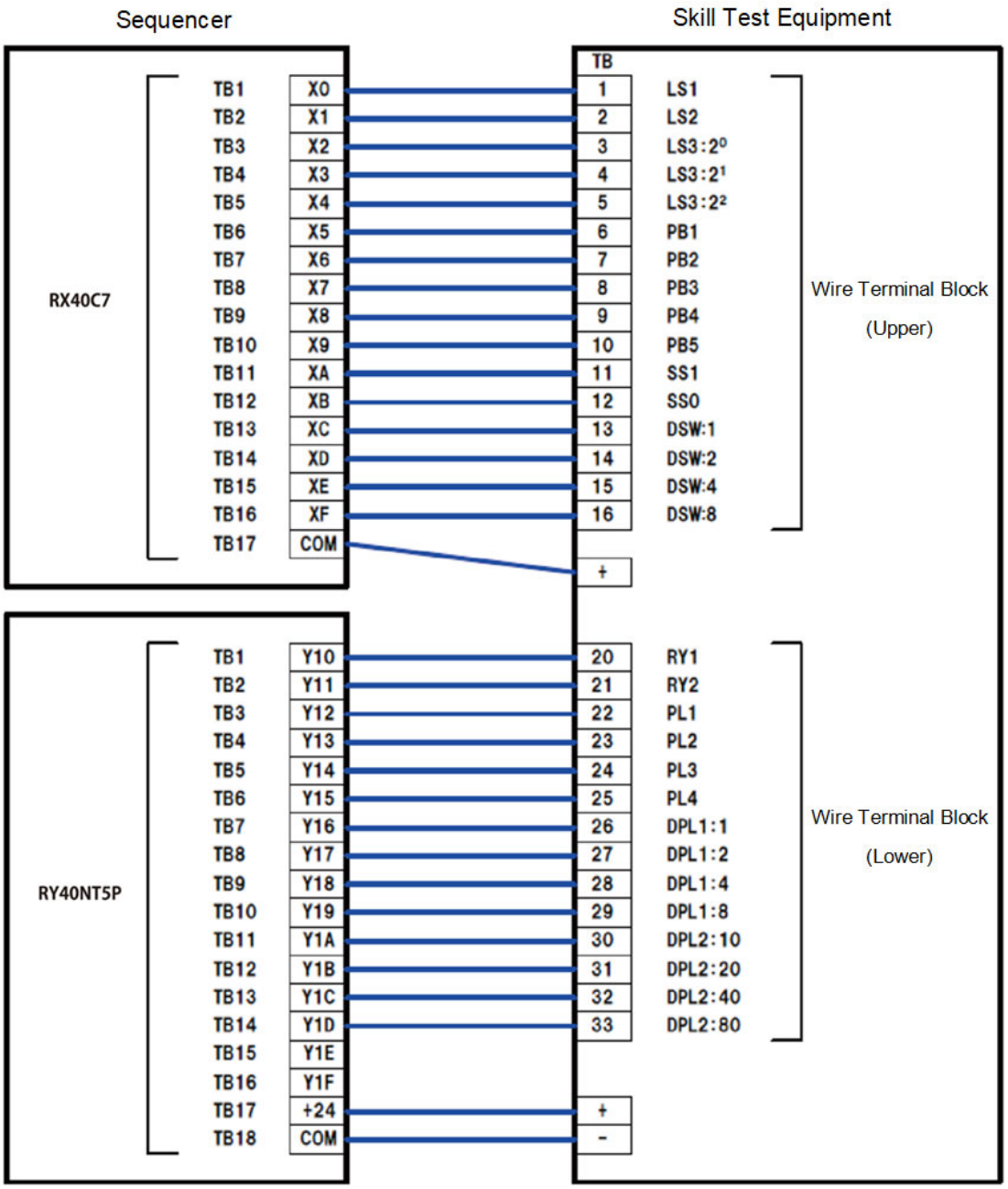


Y00 to Y0F are signal names.

The number of 1 to 18 indicates a terminal number.

1.3 Wiring

Route the wires as shown in the wiring diagram below.



1.3.1 Precautions

(1) Do not perform wiring work while the power of the programmable controller and skill test equipment is on.
(2) The Y-terminal of M3.5 is used for the skill test equipment side and the Y-terminal of M3 is used for the programmable controller I/O side, so do not wire them incorrectly.
(3) When wiring 24 VDC, do not use the wrong combination of [+] and [-]. (Equipment malfunctions)
(4) Check wiring thoroughly before turning on the power.

1.4 Practical Test 1

When Manual of [SS0: Manual/Automatic changeover switch] and OFF [SS1: Continuous operation selection switch] are selected,
Write a program that does the following:

(1) While pushing PB1, the pallet on the conveyor moves to the left.
(2) While the PB2 is pressed, the pallet on the conveyor moves to the right.

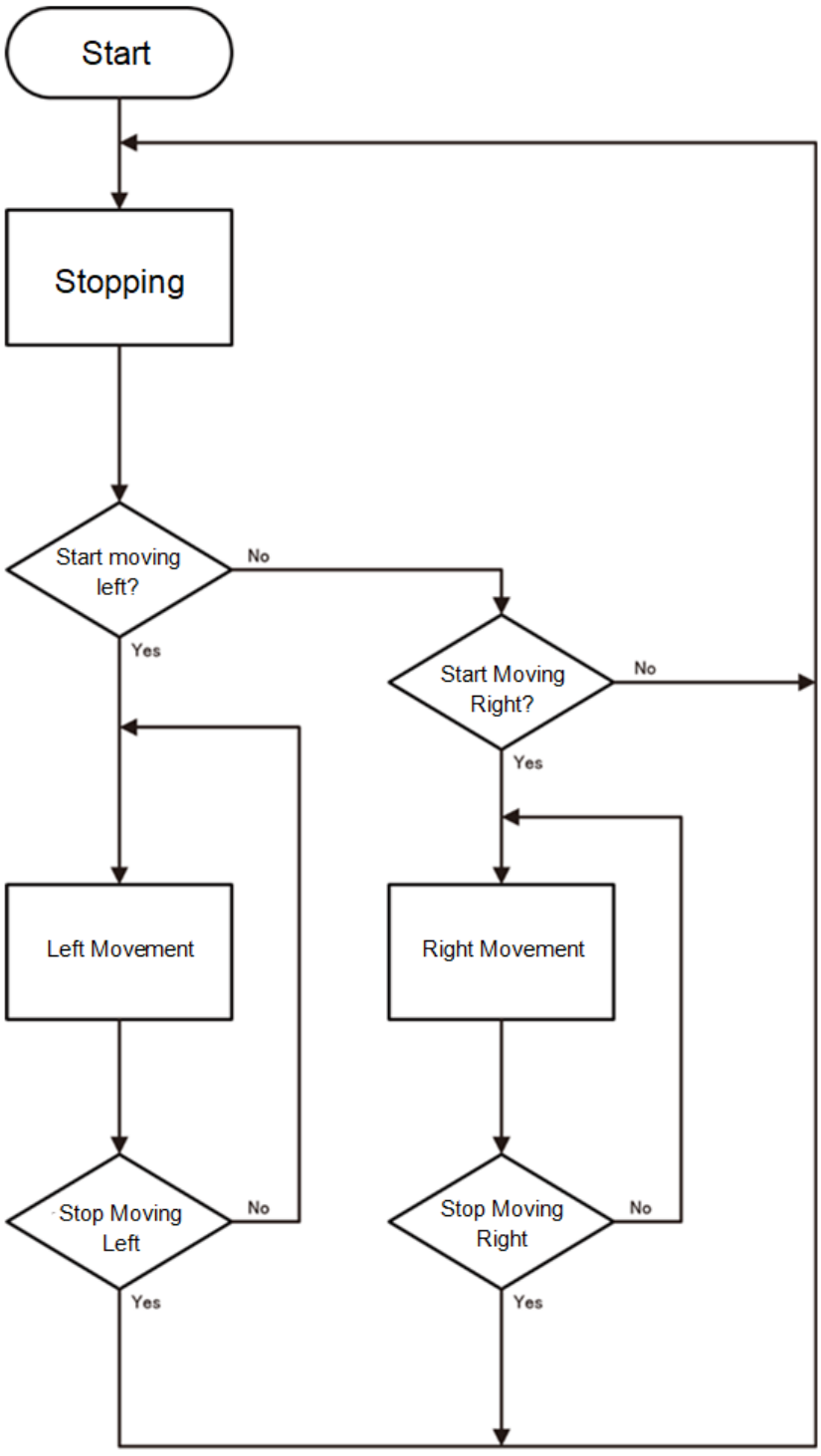
In this case, the following conditions shall be satisfied:

i. When moving to the left, stop the conveyor when the pallet reaches the left end.
ii. When moving to the right, stop the conveyor when the pallet reaches the right end.
iii. Turn on PL2 only when the pallet is on the far left.
iv. Turn on PL3 only when the pallet is on the far right.
v. Flashes PL2 at 1-second intervals only when the palette moves to the left. (Lights up for 0.5 seconds, turns off for 0.5 seconds)
vi. Flashes PL3 at 1-second intervals only when the palette moves to the right. (Lights up for 0.5 seconds, turns off for 0.5 seconds)
vii. If PB1 and PB2 are pressed at the same time, the conveyor is stopped immediately.
viii. If [SS0: Manual / automatic changeover switch] is selected as [Automatic] or [SS1: Continuous operation selection switch] is selected as [On] during operation, the conveyor is stopped immediately.

- I/O Allocation Table

Bit Position	TB Terminal Number	Signal Name	Signal Content	Bit Position	TB Terminal Number	Signal Name	Signal Content
0	1	LS1	Right end detection limit switch	0	20	RY1	Conveyor left drive relay
1	2	LS2	Left end detection limit switch	1	21	RY2	Conveyor right drive relay
5	6	PB1	Conveyor Left Row Driving Button	3	23	PL2	On: Left detection lamp Blinking: Left driving lamp
6	7	PB2	Conveyor right-row drive button	4	24	PL3	On: Right edge detection lamp Blinking: Right driving lamp
10	11	SS1	Emergency stop button				
11	12	SS0	Continuous operation selection switch				

1.4.1 Flowchart Example



1.5 Practical Test 2

[Automatic] and [SS1: Continuous Operation Selection] of [SS0: Manual/Automatic Switch] while maintaining the function of Exercise 1
When [OFF] of [Switch] is selected, the following operations (1) to (4) are performed (one cycle).

(1) When PB1 is pressed, the conveyor is moved to the left and the pallet is moved to the left.
(2) Stop the conveyor when the pallet reaches the left end.
(3) 3 seconds after the conveyor stops, the conveyor is moved to the right, and the pallet is moved to the right.
(4) Stop the conveyor when the pallet reaches the right end.

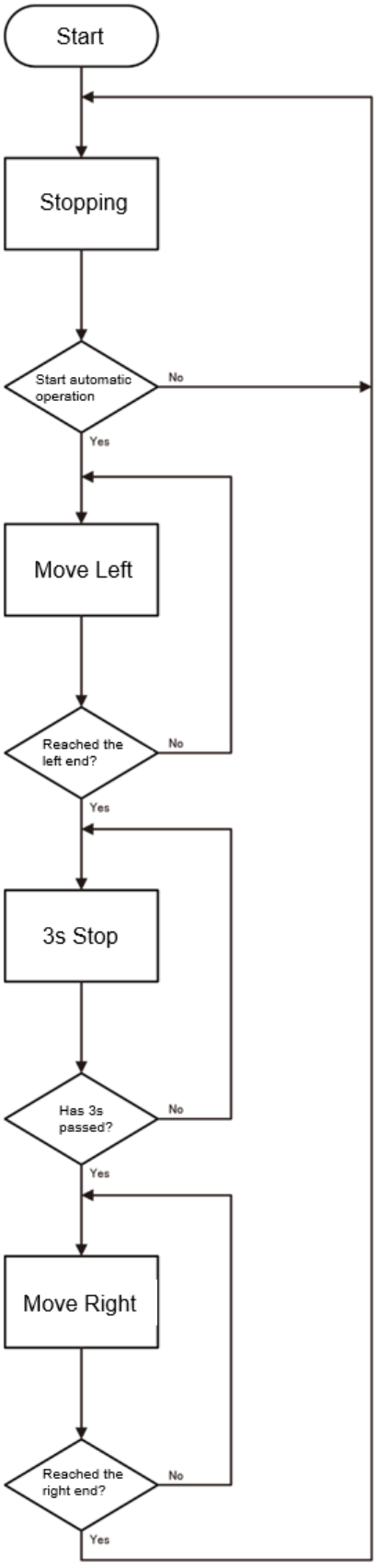
In this case, the following conditions shall be satisfied:

i. PB1 is valid when the pallet is on the far right.
ii. Turns on PL1 during cycle operation.
iii. Turn on PL2 only when the pallet is on the far left.
iv. Turn on PL3 only when the pallet is on the far right.
v. Flashes PL2 at 1-second intervals only when the palette moves to the left. (Lights up for 0.5 seconds, turns off for 0.5 seconds)
vi. Flashes PL3 at 1-second intervals only when the palette moves to the right. (Lights up for 0.5 seconds, turns off for 0.5 seconds)
vii. The conveyor stop time during cycle operation is displayed on DPL1 and DPL2 in 0.1 second increments while the conveyor is stopped.
viii. During cycle operation, [SS0: Manual / automatic changeover switch] is set to [Manual] or [SS1: Continuous operation selection switch] is set to [On].
ix. When selected to and [PB5: Emergency stop button] is pressed, the conveyor is immediately stopped and PL1 is turned off.

■I/O Allocation Table

Bit Position	TB Terminal Number	Signal Name	Signal Content	Bit Position	TB Terminal Number	Signal Name	Signal Content
0	1	LS1	Right end detection limit switch	0	20	RY1	Conveyor left drive relay
1	2	LS2	Left end detection limit switch	1	21	RY2	Conveyor right drive relay
5	6	PB1	Cycle operations start switch Conveyor Left Row Driving Button	2	22	PL1	Ramp during cycle operation
6	7	PB2	Conveyor right-row drive button	3	23	PL2	On: Left detection lamp Blinking: Left driving lamp
9	10	PB5	Emergency stop button	4	24	PL3	On: Right edge detection lamp Blinking: Right driving lamp
10	11	SS1	Continuous operation selection switch	6	26	DPL 1	Stop time display (0.1 second digits)
11	12	SS0	Manual and automatic switch	7	27	DPL 1	
				8	28	DPL 1	
				9	29	DPL 1	
				10	30	DPL 2	Stop time display (1 second digit)
				11	31	DPL 2	
				12	32	DPL 2	
				13	33	DPL 2	

1.5.1 Flowchart Example



1.6 Practical Test 3

[Automatic] and [SS1: Continuous Operation] of [SS0: Manual/Automatic Switch] while maintaining the functions of Exercise 1 and Exercise 2
Create a program that performs the following actions when [ON] is selected in [Roll selection switch].

(1) The number of continuous operations 1 ~ 9 is specified in the DSW 1.
(2) After the continuous operation frequency is designated, the continuous operation frequency is set by pressing PB2.
(3) After setting, it is displayed on the DPL1 as the target continuous operation number.
(4) The operations (1) to (4) in Exercise 2 are continuously operated for a set number of times.
(5) When the PB3 is pressed during continuous operation, it stops after the end of the cycle during operation.
(6) The number of completed cycles is displayed in DPL2.

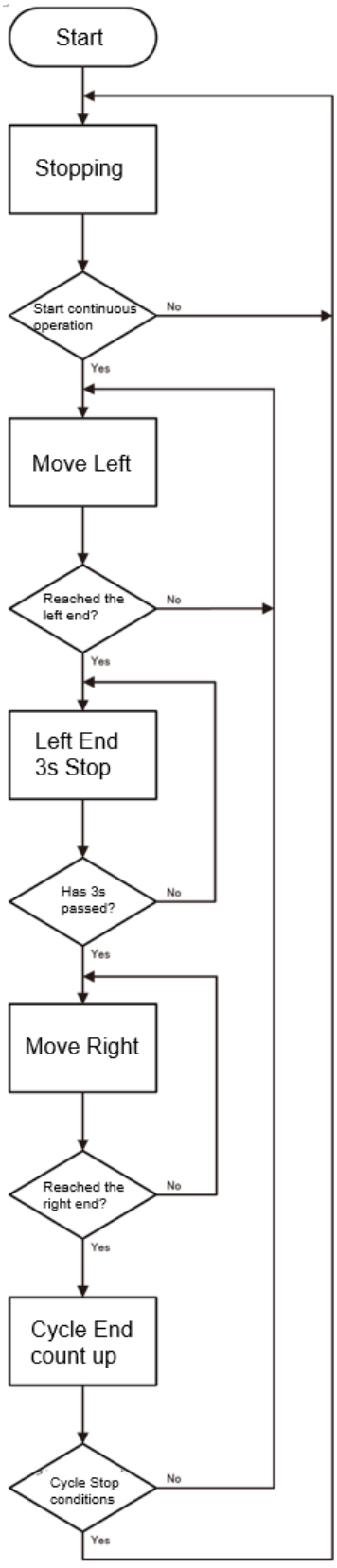
In this case, the following conditions shall be satisfied:

i. PB1 is valid when the pallet is on the far right.
ii. Turns on PL1 during automatic operation.
iii. Turn on PL2 only when the pallet is on the far left.
iv. Turn on PL3 only when the pallet is on the far right.
v. Flashes PL2 at 1-second intervals only when the palette moves to the left. (Lights up for 0.5 seconds, turns off for 0.5 seconds)
vi. Flashes PL3 at 1-second intervals only when the palette moves to the right. (Lights up for 0.5 seconds, turns off for 0.5 seconds)
vii. After PB3 is pressed, PL4 flashes at 0.6 second intervals until the end of the cycle. (Lights up for 0.3 seconds, turns off for 0.3 seconds)
viii. The conveyor stop time during cycle operation is displayed on DPL1 and DPL2 in 0.1 second increments while the conveyor is stopped.
ix. The target number of continuous operations is displayed on DPL1 and the number of completed cycles is displayed on DPL2 except when the conveyor is stopped during cycle operation.
x. If the number of continuous operations is 0, automatic operation is not performed.
xi. If [SS0: Manual / automatic changeover switch] is selected as [Manual] or [SS1: Continuous operation selection switch] is selected as [Off] and [PB5: Emergency stop button] is pressed during cycle operation, the conveyor is immediately used. Is stopped and PL1 is turned off.

■I/O Allocation Table

Bit Position	TB Terminal Number	Signal Name	Signal Content	Bit Position	TB Terminal Number	Signal Name	Signal Content
0	1	LS1	Right end detection limit switch	0	20	RY1	Conveyor left drive relay
1	2	LS2	Left end detection limit switch	1	21	RY2	Conveyor right drive relay
5	6	PB1	Cycle operations start switch Conveyor Left Row Driving Button	2	22	PL1	Ramp during cycle operation
6	7	PB2	Conveyor right-row drive button	3	23	PL2	On: Left detection lamp Blinking: Left driving lamp
7	8	PB3	Emergency stop button	4	24	PL3	On: Right edge detection lamp Blinking: Right driving lamp
9	10	PB5	Continuous operation selection switch	5	25	PL4	Stop time display (0.1 second digits)
10	11	SS1	Manual and automatic switch	6	26	DPL 1: 20	stop time display (0.1 second digits) Stop time display (1 second digit)
11	12	SS0	Right end detection limit switch	7	27	DPL 1: 21	
12	13	DSW 1: 20	Continuous operation frequency setting digital switch	8	28	DPL 1: 22	
13	14	DSW 1: 21		9	29	DPL 1: 23	
14	15	DSW 1: 22		10	30	DPL 2: 20	stop time display (1 second digit)
15	16	DSW 1: 23		11	31	DPL 2: 21	
				12	32	DPL 2: 22	
				13	33	DPL 2: 23	

1.6.1 Flowchart Example



1.7 Examples of answers

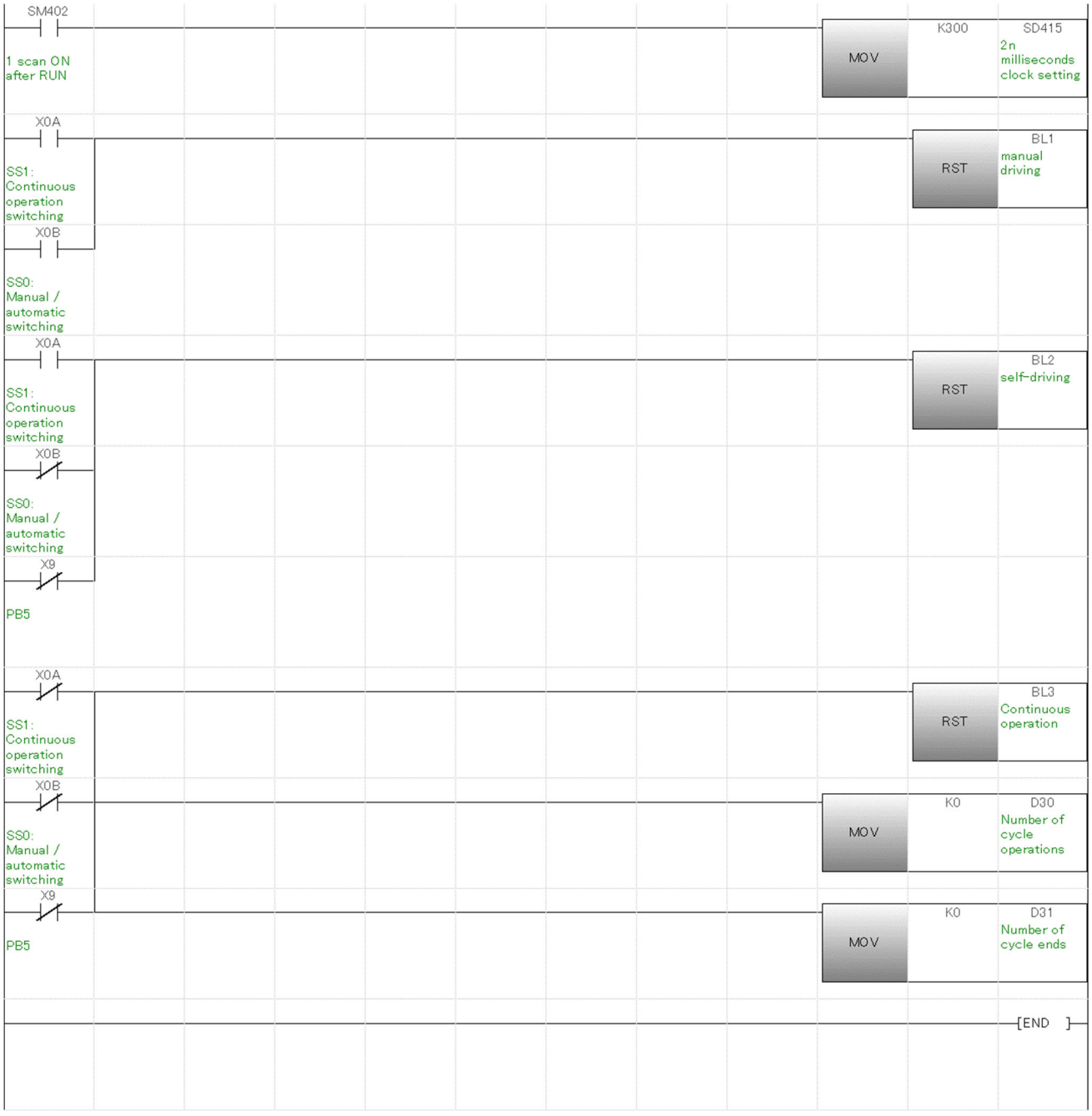
No.	Data Name	Title	START/ END	Transition	STOP/ RESUME	Stop mode	Continuous Transition	Number of Active Steps
0	Block	Mode switching	M100	M101	M102	M103	M104	D100

No.	Data Name	Title	START/ END	Transition	STOP/ RESUME	Stop mode	Continuous Transition	Number of Active Steps
1	Block1	Manual operation	M105	M106	M107	M108	M109	D101

No.	Data Name	Title	START/ END	Transition	STOP/ RESUME	Stop mode	Continuous Transition	Number of Active Steps
2	Block2	Manual operation	M110	M111	M112	M113	M114	D103

No.	Data Name	Title	START/ END	Transition	STOP/ RESUME	Stop mode	Continuous Transition	Number of Active Steps
3	Block3	Manual operation	M115	M116	M117	M118	M119	D104

1.8 SFC Program for Emergency Stop



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