MITSUBISHI

Changes for the Better

PROGRAMMABLE CONTROLLERS

MELSEC-F

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EXERCISES	B
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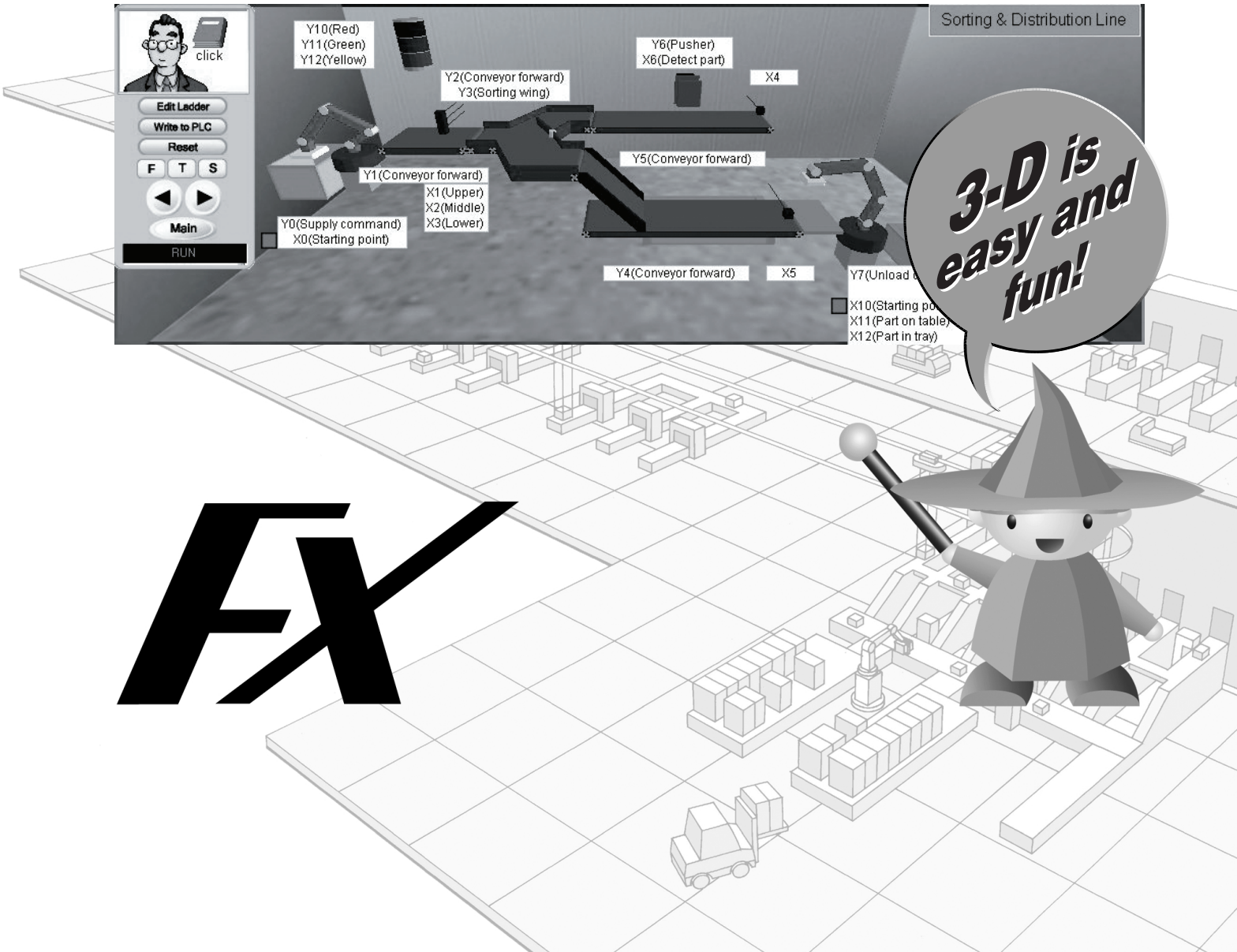
USER'S MANUAL

FX-TRN-BEG-E



FX

FX-TRN-BEG-E

USER'S MANUAL

Manual number : JY997D02901
Manual revision : B
Date : NOVEMBER 2002

FAX BACK

Mitsubishi has a world wide reputation for its efforts in continually developing and pushing back the frontiers of industrial automation. What is sometimes overlooked by the user is the care and attention to detail that is taken with the documentation. However, to continue this process of improvement, the comments of the Mitsubishi users are always welcomed. This page has been designed for you, the reader, to fill in your comments and fax them back to us. We look forward to hearing from you.

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Which explanation was most difficult to understand: .....
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If there one thing you would like to see improved, what is it? .....
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Could you find the information you required easily using the index and/or the contents, if possible please identify your experience: .....
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Do you have any comments in general about the Mitsubishi manuals? .....
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Thank you for taking the time to fill out this questionnaire. We hope you found both the product and this manual easy to use.

INTRODUCTION

The method to set up the software and the flow of the lessons are explained in this section. Please read to improve the effectiveness of the later lessons.

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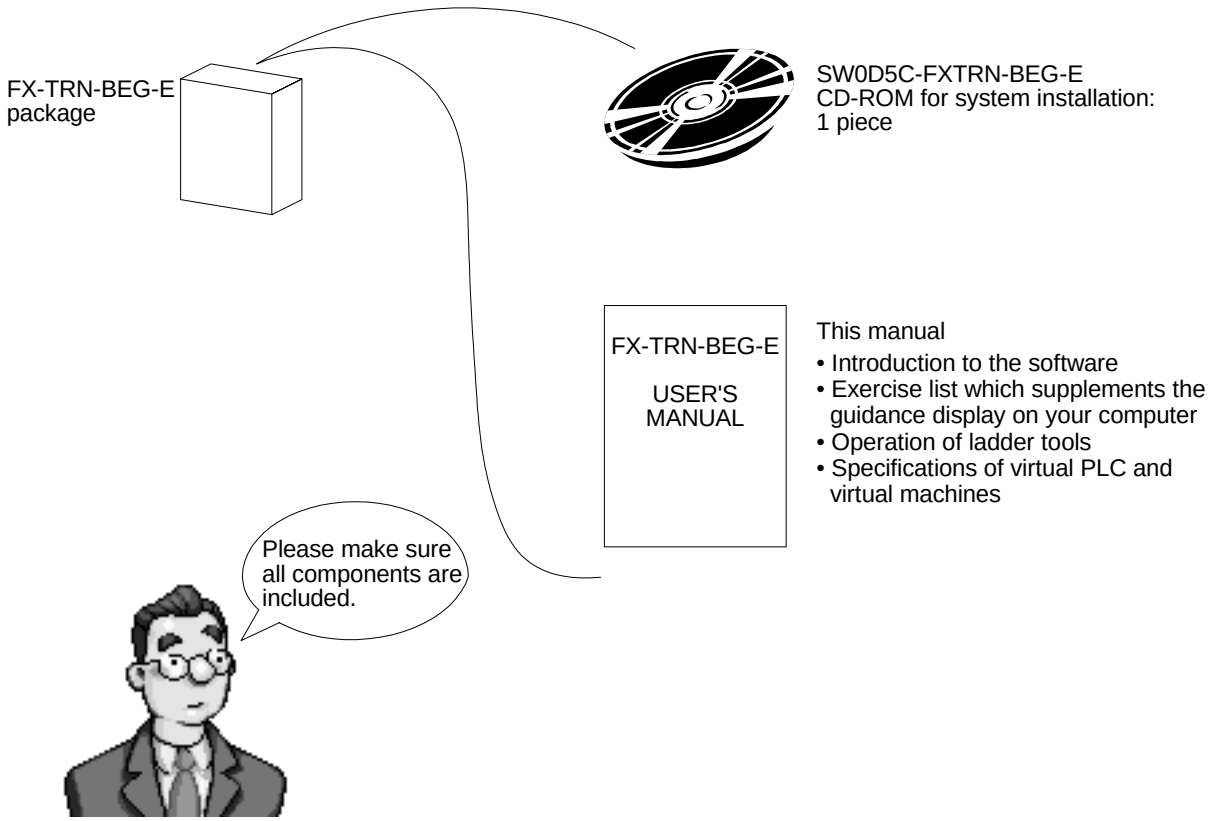
MEMO

1. Introduction

The FX-TRN-BEG PLC Training Software creates a virtual manufacturing cell within in your personal computer that enables the user to study PLC programming any time or place a personal computer is available. The manufacturing cell and machines are shown in 3-D graphic simulations that provide an enjoyable visual element to the PLC training. Watch the programs that you create control the machines inside the virtual arena!
The structured lesson plans let the user decide at what level to begin the exercises. Clear objectives are given for each exercise along with programming tips and examples to aid in the learning process. The large number of exercises provide complete beginners and slightly more advanced users with challenges appropriate to each skill level. Proceed through the exercises at the speed that is right for you.
The software setup and the flow of the lessons are explained in Chapter 2. Please read Chapter 2 to improve the effectiveness of the later lessons.

The 3-D graphic simulations will be controlled by the user program.
The software package includes the following items.



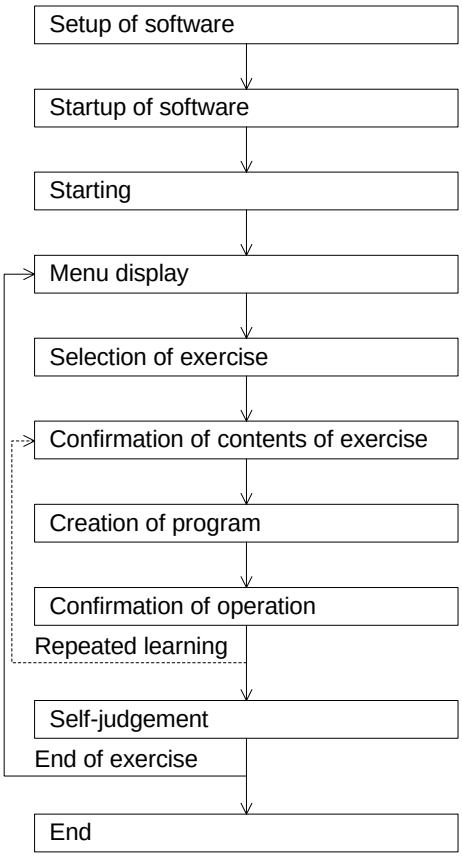
MEMO

2. Outline of the Lesson Plan

Follow the Lesson Plan Flowchart below to better understand the setup of the PLC programming lessons.

2.1 Outline

The chart below shows the overall flow of the training software.



- Install the data from the CD-ROM (☞ 2.2).
- Register as a User (☞ 2.3).
- Select a category in the main menu (☞ 2.4 or Exercise Section).
- Select an exercise you would like to try (☞ 2.5).
- Read the guidance and understand the contents of the exercise (☞ 2.5).
- Write a program following the guidance (☞ 2.6 or Ladder Tool Section).
- Transfer the program to the virtual PLC in your computer, and confirm the machine operation. (☞ 2.7).
- Judge the simulation result yourself. If you are a registered User, points are added and your progress is updated. (☞ 2.8).
- Exit the learning software. (☞ 2.9).

2.2 Setup of Software

Set up the software following the procedure below.

- System requirements for your computer

OS	Microsoft Windows 98, 98SE, Me Microsoft Windows 2000	Microsoft Windows NT4.0 (SP3 or later) Microsoft Windows XP*1
CPU	Pentium 500 MHz or more is recommended.	
Memory	64 MB or more (128 MB or more is recommended.)*2	
Hard disk	150 MB or more	
CD-ROM drive	1 unit (for installation)	
Display	XGA (1,024 × 768) or more is mandatory.	
Video	Video card compatible with Direct3D whose VRAM capacity is 4 MB or more (8 MB or more is recommended.)	
Browser	Internet Explorer 4.0 or later is mandatory.	

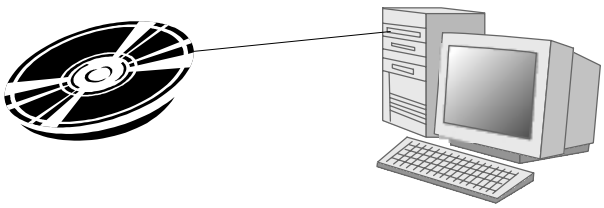
*1 Only users having the administrator privilege are allowed to set up the software to the Windows XP and start it up.

*2 Mount the memory having a capacity larger than the value recommended by the used OS.

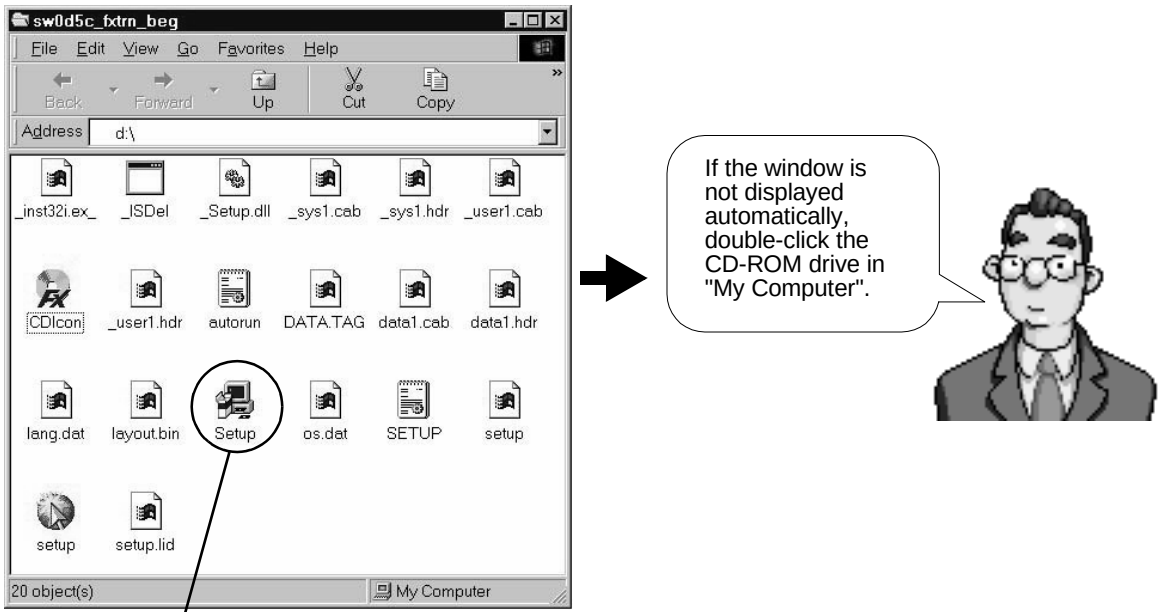
"Microsoft", "Windows" and "Windows NT" are registered trademarks or trademarks of Microsoft Corporation USA in the USA and other countries. Other company names and product names are trademarks or registered trademarks of each company.

Operating Procedure

1) Start Windows and insert the CD (SW0D5C-FXTRN-BEG-E) included in the package into the CD-ROM drive to begin system installation. It is recommended to end other application software before beginning the installation process.



2) The window below should be automatically displayed.



Double-click this "Setup" icon on the window to start installation of the software.

* Three types of "Setup" icons are displayed. Double-click the one with a picture of a computer.

3) When "Setup" is executed, the window shown below is displayed.

- After reading and understanding the messages, click [Next].
- Click [Cancel] to cancel installation.

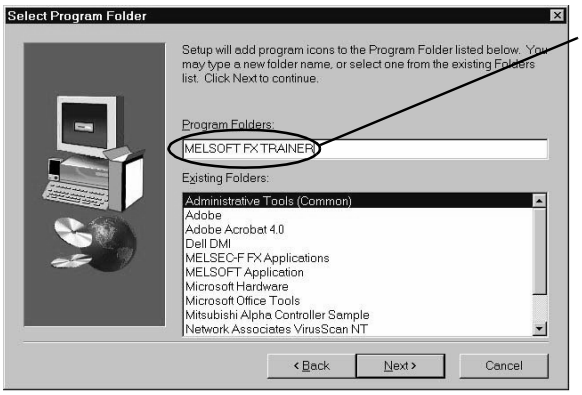
4) Select a folder for the installation destination.

Installation destination folder

- If you wish to install it to the folder displayed, click [Next].
- If you would like to change the folder, click the [Browse] button to select the folder.

Click [Cancel] to cancel installation.

5) Determine the program folder name.

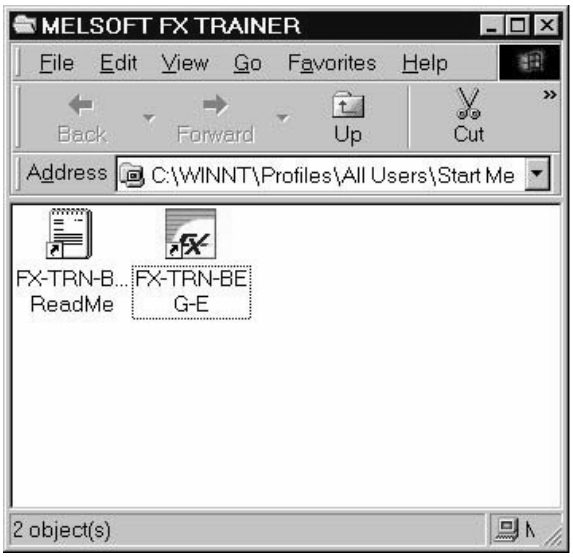


- The training software will be installed in this program folder or another folder name can be entered.
  A folder of the same name would be overwritten if it exists.
- Click [Next] to start the installation.

6) Complete the setup.

- It takes about 10 seconds to perform installation. If you take the CD out of the CD-ROM drive or shut down your computer during installation, the software will not install properly.
- Click the [Finish] button to finish the setup.
  * Take out the CD and carefully store it for later use.

7) Program folders are displayed.

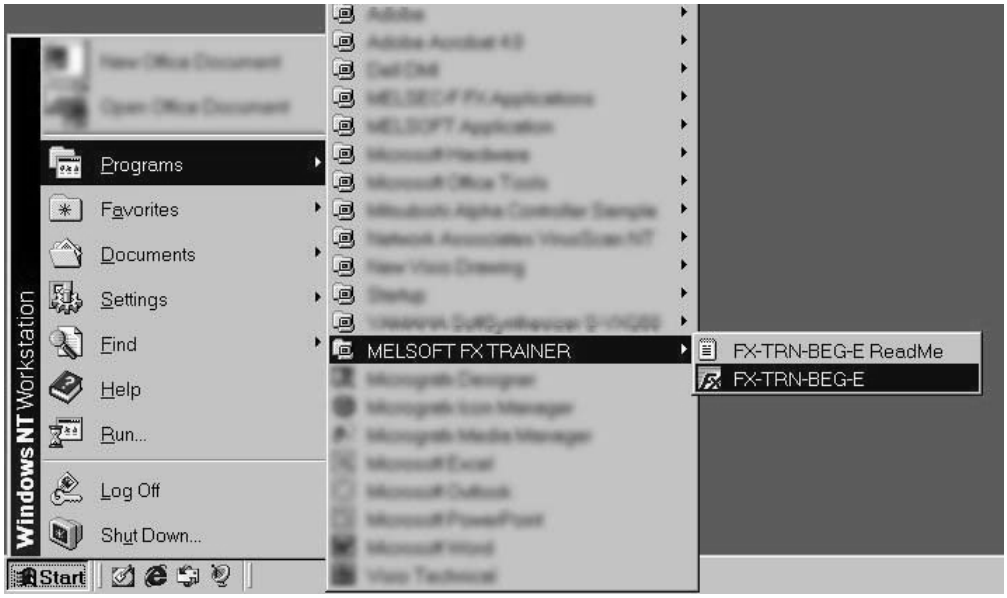


- When installation is completed, the window shown on the left is displayed.

2.3 Begin to Learn PLC Programming

2.3.1 Start the Training Software

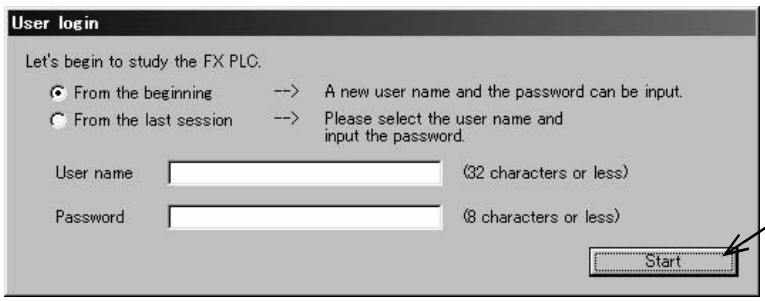
Let's open the training software.
Select [Start] → [Programs] → [MELSOFT FX Trainer] → [FX-TRN-BEG-E].



Note: Do not use this software and MELSOFT GX Developer at the same time.

2.3.2 User Registration

When the software is opened the user registration window is displayed.
If registered as a user, exercises that have been successfully completed will be indicated on the menu and points will be added to the user score.



If you do not wish to register as a user, click [Start] leaving the boxes blank.

- Fill in the name and password fields to register for the first time.

  Name: Alphabetic and numeric ... 32 characters or less

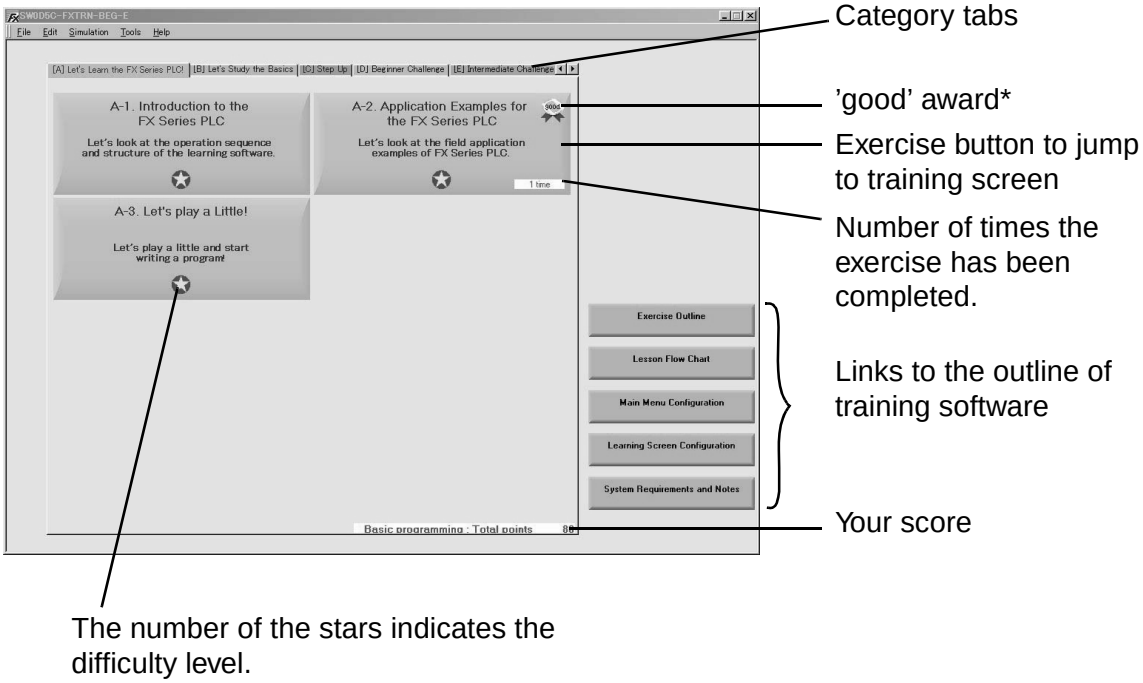
  Password: Numeric ... 8 characters or less

- If already registered as a user, select the user name on the pull-down menu and enter the password.
  If the password does not match, an error message will occur and the password must be re-entered. The main menu is not accessible.
  Register as a new user if the password is forgotten.
  User registrations can be deleted by selecting "File" → "Delete user information" from the tool menu.

2.4 Configuration of Main Menu

You can select an exercise from the main menu.

Main menu screen

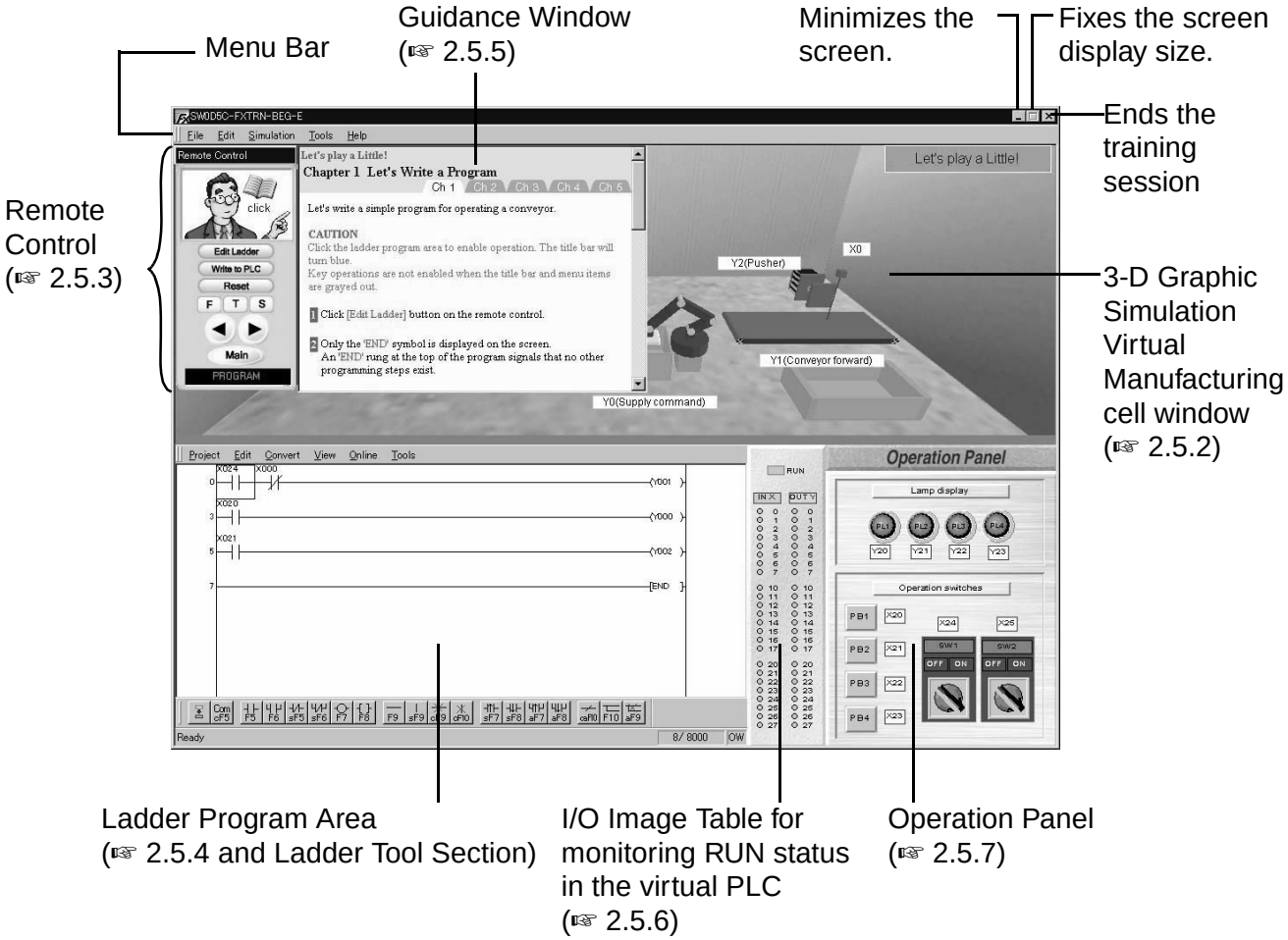


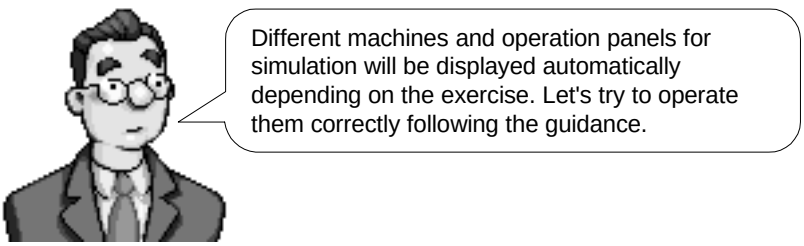
* If you have registered as a user, the award is displayed on the exercise buttons that have been completed.

2.5 Configuration of Training Screen

When you select an exercise, the Ladder Program Area, Virtual Manufacturing Cell, and the Operation Panel are displayed as shown below.

2.5.1 Training Screen



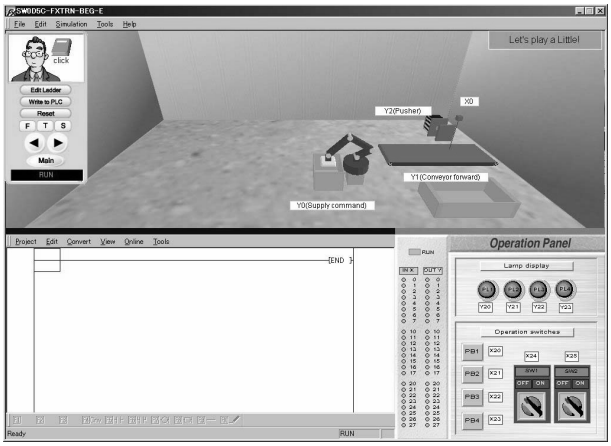


2.5.2 3-D Virtual Manufacturing Cell

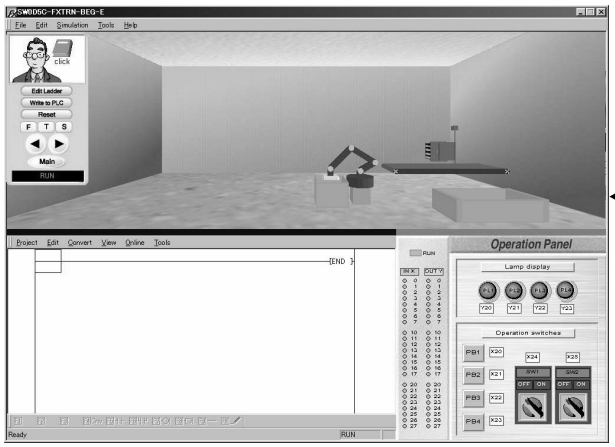
A different machine is displayed for each exercise to be simulated.

- You can choose the view the machine by pressing the [F] / [T] / [S] button on the remote control or selecting the direction on the "Tools" menu.

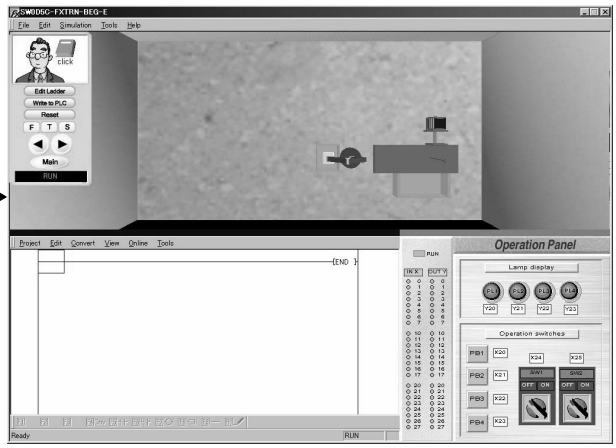
Side view



Front view



Top view



- The device numbers are assigned to all the inputs and outputs of the machine as seen in the 3-D graphic simulation.
  The I/O list can be displayed selecting "Edit" → "I/O list" on the simulation menu. The lists are also found on the pages in the 'EXERCISES' section in this manual.

Example of I/O list display

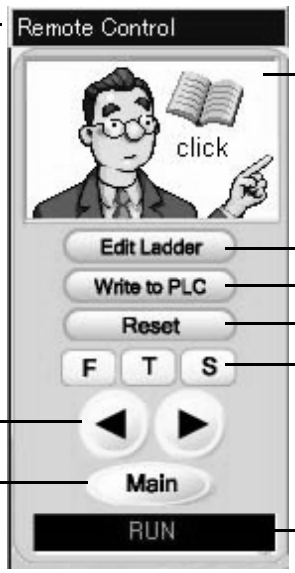
I/O list

Device	Type	Comment
X0	Sensor	ON when part is detected. Conveyo...
---	---	---
Y0	Supply command	One part is supplied when Y0 is ON...
Y1	Conveyor forward	Conveyor moves forward when Y1 i...
Y2	Pusher	Extends when Y2 is ON and retract...

2.5.3 Remote Control

Switches the mode in the virtual PLC from RUN to STOP.

Remote control



Tutor box
Displays or hide the guidance window.

[Edit Ladder]
Allows to create and modify programs in the ladder program area.
Switches the mode in the virtual PLC from RUN to STOP.

[Write to PLC]
Transfers the program you create in the ladder program area to the virtual PLC.

[Reset]
Returns the simulated machine to the initial condition.
- Resets the simulation in case of unwanted occurrence (such as parts are stuck) takes place.
- Initializes the virtual PLC.
  Initializes outputs or devices.
  (The same operation as an actual PLC is switched from STOP to RUN mode.)

[F] / [T] / [S]
Changes over the view point of the 3D screen.

Learning status display
Indicates the status such as “LEARN”, “PROGRAM” and “RUN”.

[Main]
Displays the main menu, or saves the program being edited and then displays the main menu.

Jump buttons
Clicked to go to the next/previous page in the guidance.
(Use these buttons when indicated on the page.)

Title bar
Click the tutor on the remote control to alternately hide and display the guidance window.
Or select “Tool” → “Fix remote control bar” and delete the check mark to display the title bar at the top of the remote control. By dragging the title bar using the mouse, you can move the guidance window to an arbitrary position.

- The remote control can be displayed or hidden selecting “Tools” → “Remote Control“.

2.5.4 Ladder Program Area

Use this area to edit, create, monitor, save and print programs.

The details are explained in the ’LADDER PROGRAMS’ Section in this manual.

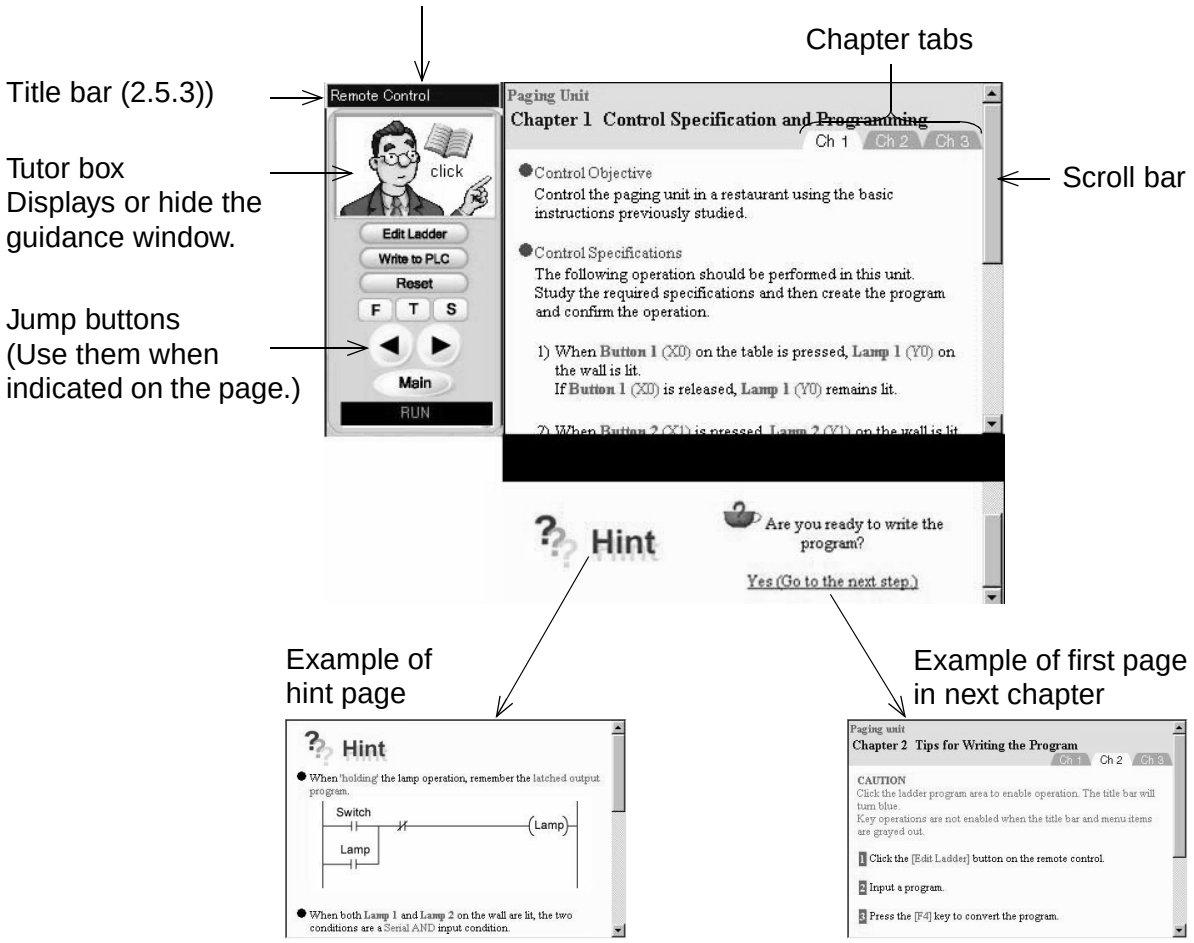
2.5.5 Guidance Window

The guidance window displays the programming objectives, lessons, hints, and instructions for the training software. (The display position is determined by the display position of the remote control.)

- Outline of guidance

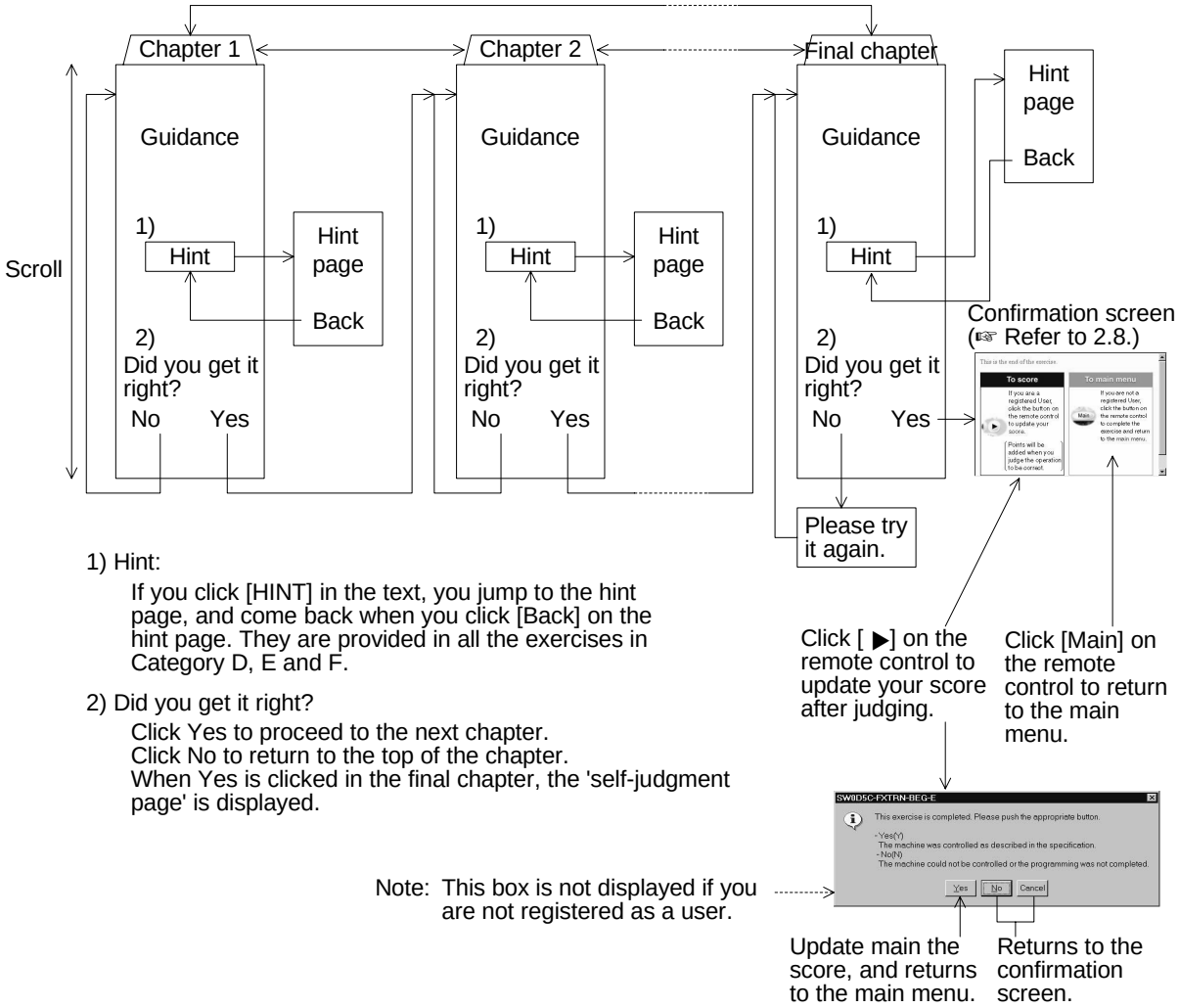
  Example of guidance display

You can move it to an arbitrary position by dragging the title bar using the mouse.
When it comes near a corner of the training software, it is absorbed.
If the title bar is not displayed on the remote control, select “Tool” → “Fix remote control bar” from the tool menu, then delete the check mark.



- Guidance Layout

  An example of the setup for the guidance pages in an exercise is shown below.



1) Hint:

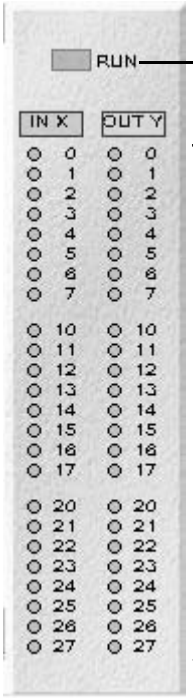
If you click [HINT] in the text, you jump to the hint page, and come back when you click [Back] on the hint page. They are provided in all the exercises in Category D, E and F.

2) Did you get it right?

Click Yes to proceed to the next chapter.
Click No to return to the top of the chapter.
When Yes is clicked in the final chapter, the 'self-judgment page' is displayed.

2.5.6 I/O Image Table for Virtual PLC

The status of the virtual PLC, the Inputs, and Outputs are monitored here.

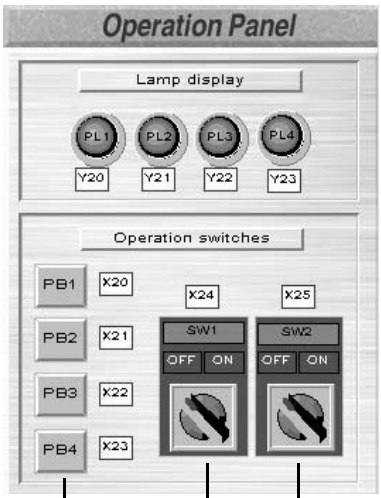


Green indicates the RUN status.
Gray indicates the STOP status.

Red indicates the ON status.
Gray indicates the OFF status.

2.5.7 Operation Panel

The configuration of the operation panel for each exercise differs.
I/O device numbers shown correspond to the ones on the specific virtual manufacturing cell.



Lamp display
Lit by outputs from the virtual PLC.

Operation switches
Used to operate the machine in the simulation.

Switches
Hold the ON or OFF status.
Turn ON and OFF with the mouse.

Pushbuttons
Turns the input ON while the button is pressed.

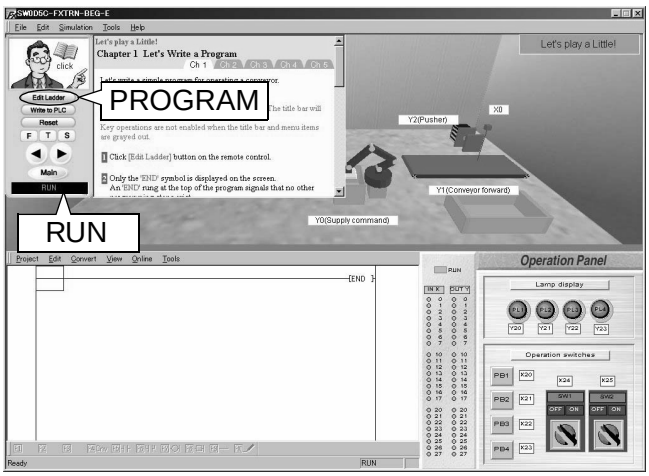
2.6 Writing a Program

When reading the first two categories, 'A: Let's Learn the FX Series PLC!' and 'B: Let's Study the Basics', the procedures to write the program are indicated in the guidance.
In higher level lessons, example programs are provided but not the individual keystrokes.

2.6.1 Preparation for Ladder Editing

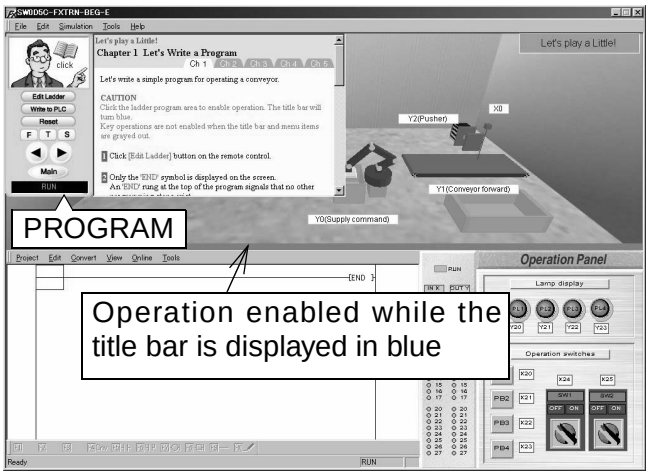
The following operations are required in order to start ladder editing.
The PLC is in RUN mode immediately after the training screen is displayed. Ladder editing cannot be performed in RUN mode.

1) Click [Edit Ladder] on the remote control.
   The status display is changed from "RUN" to "PROGRAM".



2) Click the Ladder Program Area or click [Edit Ladder] on the remote control to enable operation. The title bar will turn blue.

   Key operations are not enabled when the title bar and menu bar are grayed out.

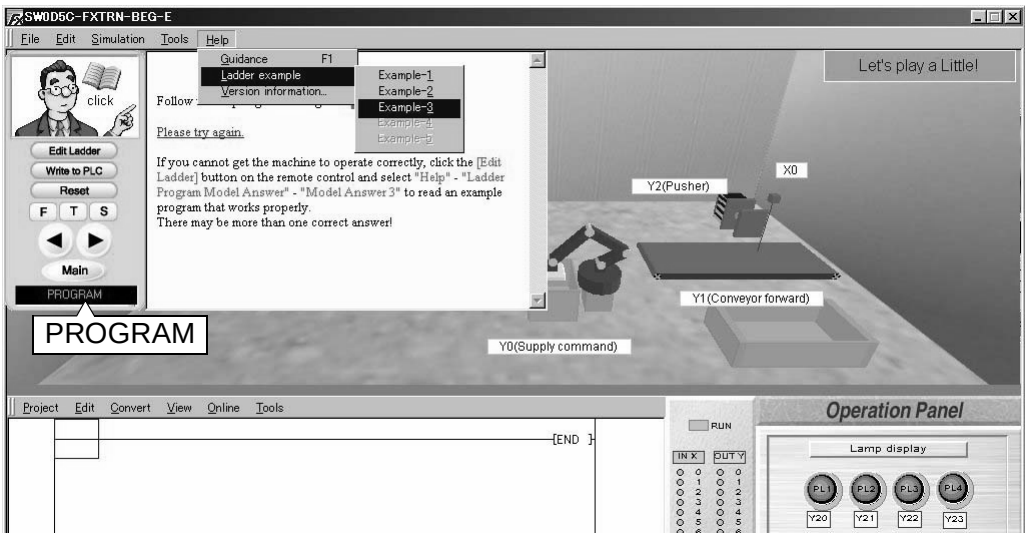


2.6.2 Reading out the Model Answer

The model answer for each exercise can be read out as follows.

1) Click [Edit Ladder] on the remote control and confirm that [PROGRAM] is indicated.

2) Select “Help” → “Ladder example” → “Example 1 to 5” on the simulation menu bar. Up to five model answers are provided for each exercise. You cannot select model answers displayed in gray.



Cautions

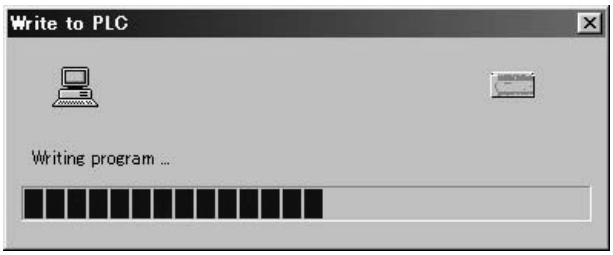
- If you edit a model answer and overwrite it, the contents of the model answer are changed.
- If you wish to edit a model answer file, select “Project” → “Save As” to create another model answer file with a different name for editing.
- The contents of model answers are offered as examples of the control program.

2.7 Operation Confirmation

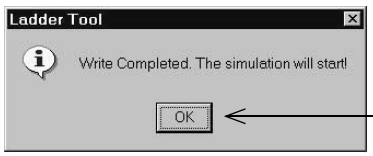
After writing the program, transfer it to the virtual PLC.

2.7.1 Program Transfer

* Click [Write to PLC] on the remote control or select "Online" → "Write to PLC" on the ladder menu to transfer the program to the virtual PLC.
  While transfer is performed, the window shown below is displayed.



When transfer is finished, the message 'Write completed. The simulation will start.' is displayed.

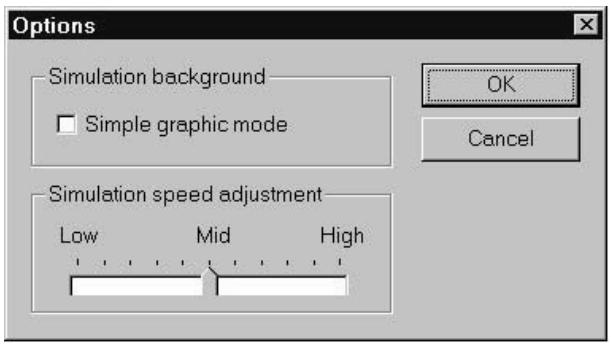


Press [OK] to start the simulation.

2.7.2 Adjustment of Simulation Speed

If you are using a computer with high performance, the operation speed of the machine simulation may be too high to realize the desired control.
If the message 'part does not stop in front of a sensor' or the 'input data is not received properly' is received, select "Tools" → "Options" on the ladder menu and reduce the speed. The adjusted speed is remembered.

* 'High' on the scale bar means high speed. Try the operation at medium speed.



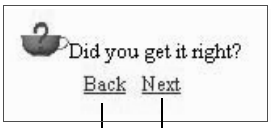
If you choose the 'Simple graphic mode', the background in the 3-D graphic simulation is omitted. However, troubles may occur in some exercises where the background is necessary.
In the 'Simple graphic mode', the simulation speed is higher. If a problem occurs, cancel the 'Simple graphic mode' or reduce the speed of the simulation.

2.8 Self-judgement

If you are a registered user, the software will update your score whenever an exercise is successfully completed.

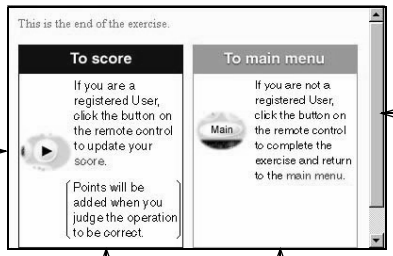
- In the final chapter of each exercise, a dialog box requests confirmation that the exercise has been successfully completed. The user can judge whether the exercise has been completed successfully or not.

In the final chapter



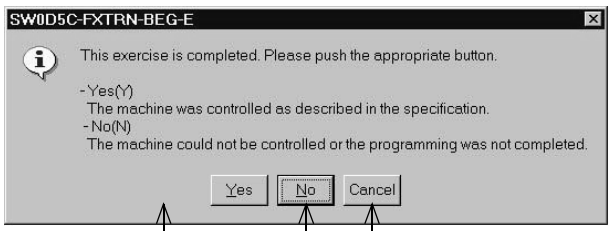
Returns to the top of the chapter.

Self-judgement page



If you are registered as a user, click the [▶] button on the remote control.

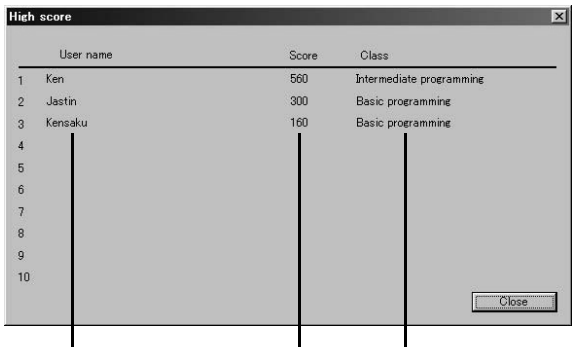
If you are not registered as a user, click [Main] on the remote control to return to the menu screen.



Return to the self-judgement page.

Adds the score, and returns to the menu menu.
(If you are editing the ladder program, the message 'Do you want to save the ladder program?' is displayed as shown on the next page.)
The exercise button should have the 'good' award and the 'number of times completed' should be updated.

- The updated score can be confirmed by selecting "File" → "Display High Score" on the simulation menu.



User name

Updated score

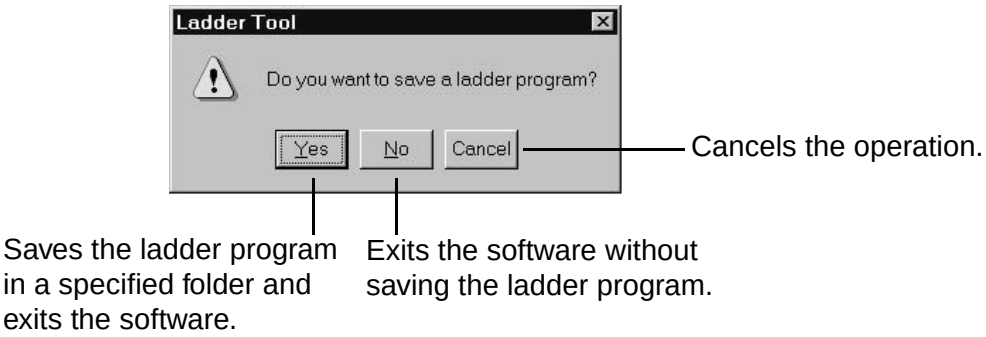
Class

- Additional points are earned if you complete the exercises repeatedly.
- The score can be deleted from the score board selecting "File" → "Delete user information" on the simulation menu.

2.9 Exit

You can exit the training software by clicking [×] in the upper right corner of the screen or selecting "File" → "Exit" on the simulation menu.

- If you are editing the ladder program, the dialog box below is displayed.



MEMO

EXERCISES

This section gives details about each exercise, the exercise objectives, and the I/O device assignments.

Contents

List of Exercises

A: Learn the FX Series PLC!

Exercise	Objective	Difficulty level	Object to Control	Chapter
A-1. Introduction to the FX Series PLC	Look at a typical operation sequence and structure of the training software.	1	Door	1.1
A-2. Application Examples for the FX Series PLC	Look at field application examples for the FX Series PLC.	1	—	1.2
A-3. Let's play a Little!	Let's play a little and start writing a program!	1	Conveyor	1.3

B: Let's Study the Basics

Exercise	Objective	Difficulty level	Object to Control	Chapter
B-1. Basic I/O Program	Learn input and output programs.	1	Indicator lamp	2.1
B-2. Standard Program	Learn a latched output program and SET/RST program.	1	Indicator lamp	2.2
B-3. Control Precedence Program	Learn an interlock program which controls conflicting operations.	1	Traffic light with two signal lamps	2.3
B-4. Reading the Input Status	Learn how to initiate instructions at the detection of rising or falling edge of a pulse.	2	Conveyor	2.4

C: Easy Does It!

Exercise	Objective	Difficulty level	Object to Control	Chapter
C-1. Basic Timer Operation	Learn the On-delay time function.	1	Door	3.1
C-2. Application Timer Program - 1	Learn the Off-delay time function and the one shot timer.	1	Door	3.2
C-3. Application Timer Program - 2	Learn a "flicker" program executed by timers.	2	Traffic light with two signal lamps	3.3
C-4. Basic Counter Program	Learn control methods using counters.	2	Conveyor	3.4

D: Beginner Challenge

Exercise	Objective	Difficulty level	Object to Control	Chapter
D-1. Paging Unit	Control the paging unit in a restaurant.	1	Paging unit	4.1
D-2. Detect Sensor Light	Turn the flashing lights turn ON when an object is detected.	1	Flashing light	4.2
D-3. Time Control for Traffic Light	Control a traffic light where the signals are changed at specified time intervals.	1	Traffic light with three signal lamps	4.3
D-4. Part Sorting by Size (I)	Sort different sized parts using sensors.	1	Conveyor and supply robot	4.4
D-5. Conveyor Start/ Stop	Start and stop the conveyor according to the predetermined procedure.	2	Conveyor	4.5
D-6. Conveyor Drive	Operate the conveyor according to the sensor data.	2	Conveyor	4.6

E: Intermediate Challenge

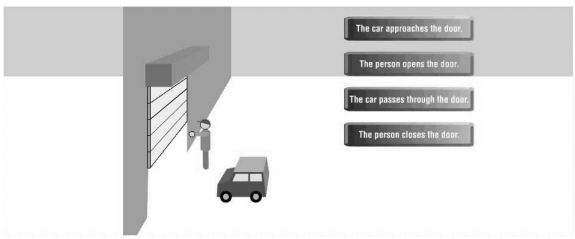
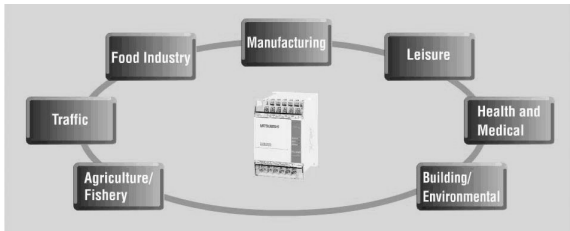
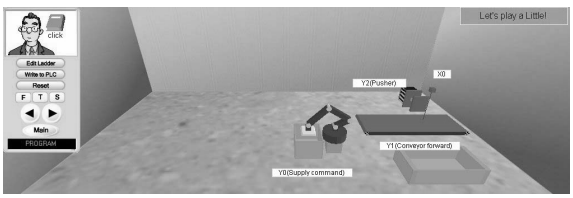
Exercise	Objective	Difficulty level	Object to Control	Chapter
E-1. Pushbutton Signal	Switch the traffic signals in response to a pushbutton.	2	Traffic light with three signal lamps	5.1
E-2. Part Sorting by Size (II)	Distribute each part to its proper destination according to its size.	2	Branch conveyor	5.2
E-3. Part Separation	Give the command to a robot to move a part to a new location.	2	Conveyor and unloading robot	5.3
E-4. Drilling	Control the drill and other devices.	2	Conveyor, supply robot, and drill	5.4
E-5. Part Supply Control	Supply a specified number of parts according to the control specifications.	3	Conveyor and supply robot	5.5
E-6. Conveyor Control	Move the conveyor forward or backward according to the control specifications.	3	Conveyor and supply robot	5.6

F: Advanced Challenge

Exercise	Objective	Difficulty level	Object To Control	Chapter
F-1. Automatic Door Operation	Control the door which opens or closes when detecting an object.	3	Door	6.1
F-2. Stage Settings	Control stage settings according to the control specifications.	3	Stage settings	6.2
F-3. Part Distribution	Distribute the specified number of parts according to the size.	3	Conveyor and pusher	6.3
F-4. Sorting Defective Parts	Distinguish between defective parts and good parts by their signals.	3	Conveyor supply robot and drill	6.4
F-5. Forward/Reverse Rotation Control	Move the conveyor forward or backward according to the detected size.	3	Conveyor supply robot and drill	6.5
F-6. Lifter Control	Carry parts to three positions using the lift.	3	Lifter and conveyor	6.6
F-7. Sorting & Distribution Line	Sort each part to the specified place according to the size.	4	Conveyor supply robot and unloading robot	6.7

* The number for the difficulty level corresponds to the number of stars displayed on the exercise button on the main menu.

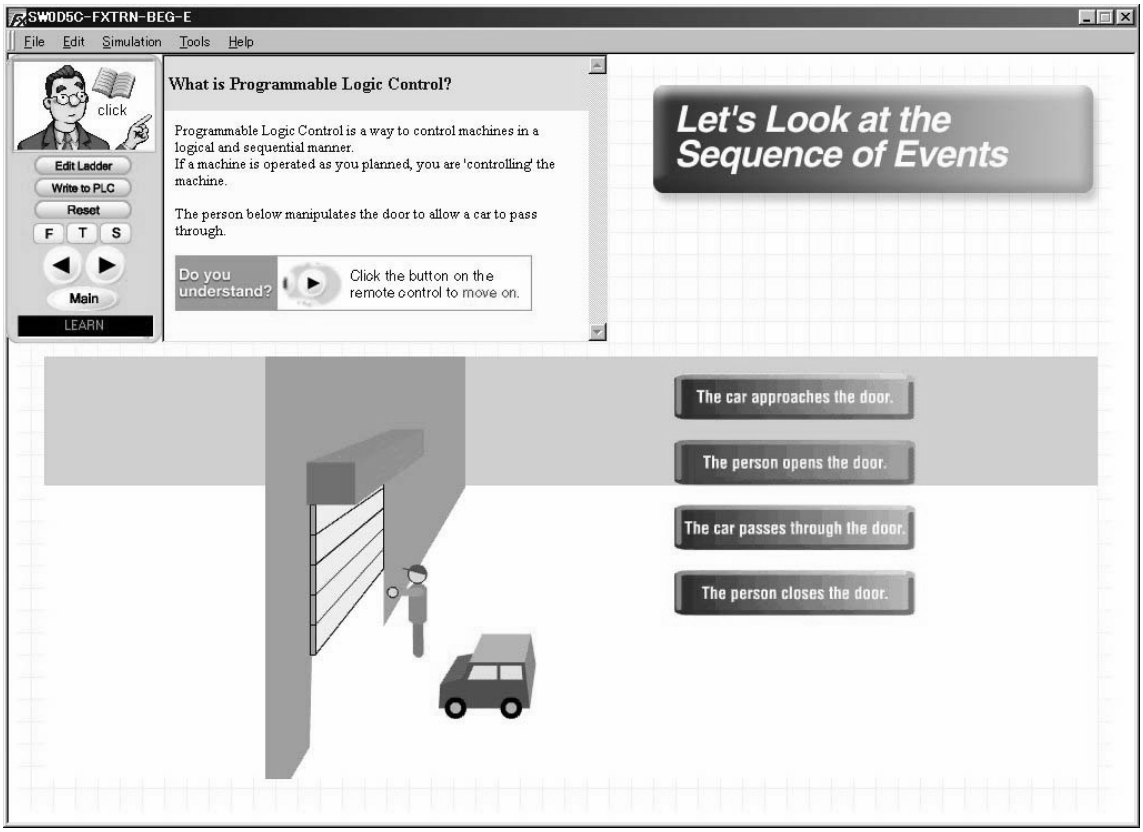
1. A: Let's Learn the FX Series PLC!

A-1. Introduction to the FX Series PLC	A-2. Application Examples for the FX Series PLC
	
A-3. Let's play a Little!	—
	—

1.1 Introduction to the FX Series PLC

Category	A: Let's Learn the FX Series PLC!
Exercise	A-1. Introduction to the FX Series PLC
Objective	Study the introductory information.
Difficulty Level	1 (★)
Score (Class)	80 (Basic programming)

1.1.1 Training Screen



1.1.2 Outline of Operation

Click [◀] or [▶] to return to the previous screen or to go to the next screen.

1.1.3 Points of Learning and Control Specifications

1) What is sequence control?

"Sequence control"
This is not a familiar term generally but sequence control happens around us every day. You probably have seen or touched objects under sequence control.

In a dictionary*, the word "sequence" is explained as follows:

a)succession

b)connected line of events, ideas, etc.

c)the order in which they occur

d)three or more next to each other in value

* Oxford Advanced Learner's Dictionary of Current English" (Oxford University Press)

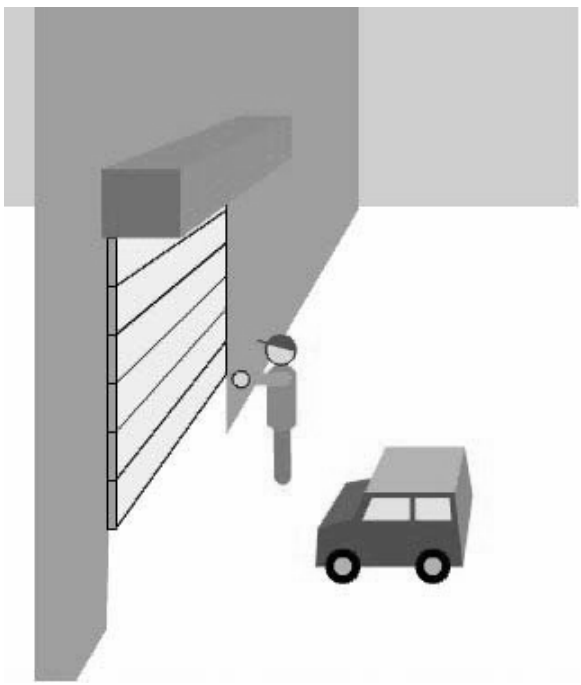
Based on the above, we can see that the word "sequence" indicates "succession" and "the order in which they occur".

The meaning of the term "sequence control" is derived from the word "sequence", and indicates the control of operations in accordance with the predetermined order. The word "control" indicates "means by which a machine, etc. is operated or regulated".

Let's take a look at a familiar example and see how the PLC is used.

In the picture below, a door is opened and closed.
The person follows the necessary procedure and manipulates the door to allow a car to pass through.

Opening and closing of the door (manual)



Operation sequence

The car approaches the door.
↓
The person opens the door.
↓
The car passes through the opening.
↓
The person closes the door.

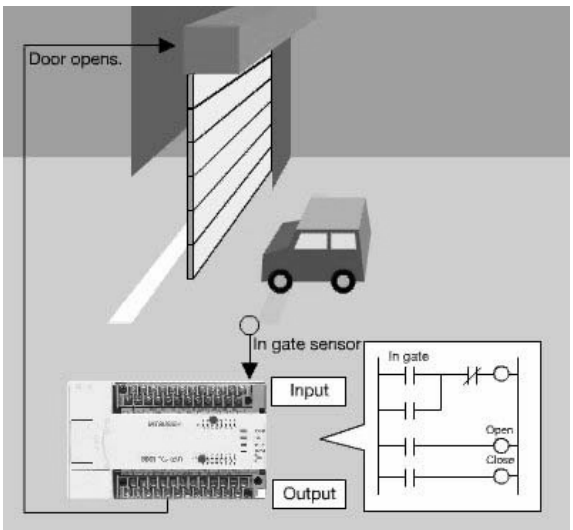
2) Function of the PLC

On the previous page, the person opens and closes the door manually.
The door can be automatically opened and closed using the PLC.

The screen below shows the concept of the sequence, "predetermined order of work". Sequence control indicates "let the sequence repeat automatically and correctly as many times as desired".

By using the PLC, the door can be automatically opened and closed.

Control of automatic opening / closing of the door using the PLC



Operation	Control
The car approaching the door is detected.	The In gate sensor turns ON.
The loading bay door is opened.	The door motor is driven.
Passage of the car is confirmed.	The Out sensor turns ON.
The loading bay door is closed.	The door motor is driven in reverse.

3) Control targets and control specifications

In the previous automatic door example, control targets are "sensors detecting the approaching vehicle" and "motors to open and close the door".
The PLC can control a variety of equipment.

Relationship between inputs and outputs

Parts of control related equipment are mainly classified into two types as shown in the screen below.

- Devices controlled by the operator → Such as switches and push buttons
- Devices which indicate the machine status → Such as sensors

} In PLC control, they are regarded as the 'conditions' for operation, and called 'inputs' in the PLC.

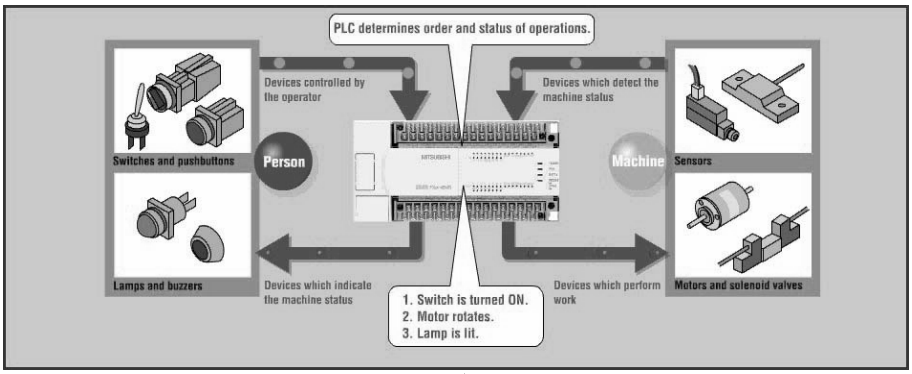
- Devices which detect the machine status → Such as lamps and buzzers
- Devices perform work → Such as motors and solenoid valves

} In PLC control, they are regarded as what are 'operated', and called 'outputs' in the PLC.

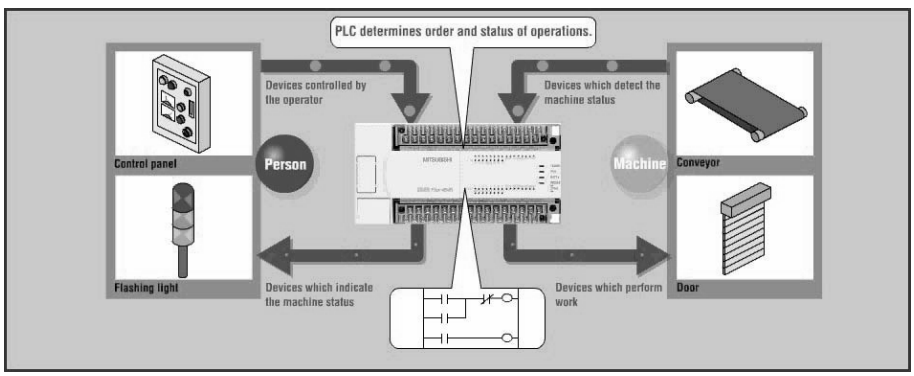
Each of the "input" and "output" equipment is individually connected to the PLC. The operation of each piece of equipment is determined by the sequence program in the PLC.

Control target classification

Example of inputs and outputs in the PLC (in the unit of part)



Example of inputs and outputs in the PLC (in the unit of machine)

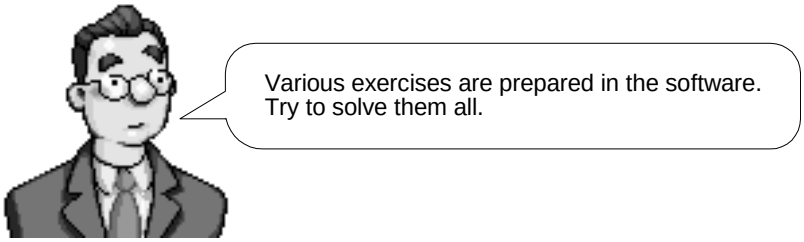


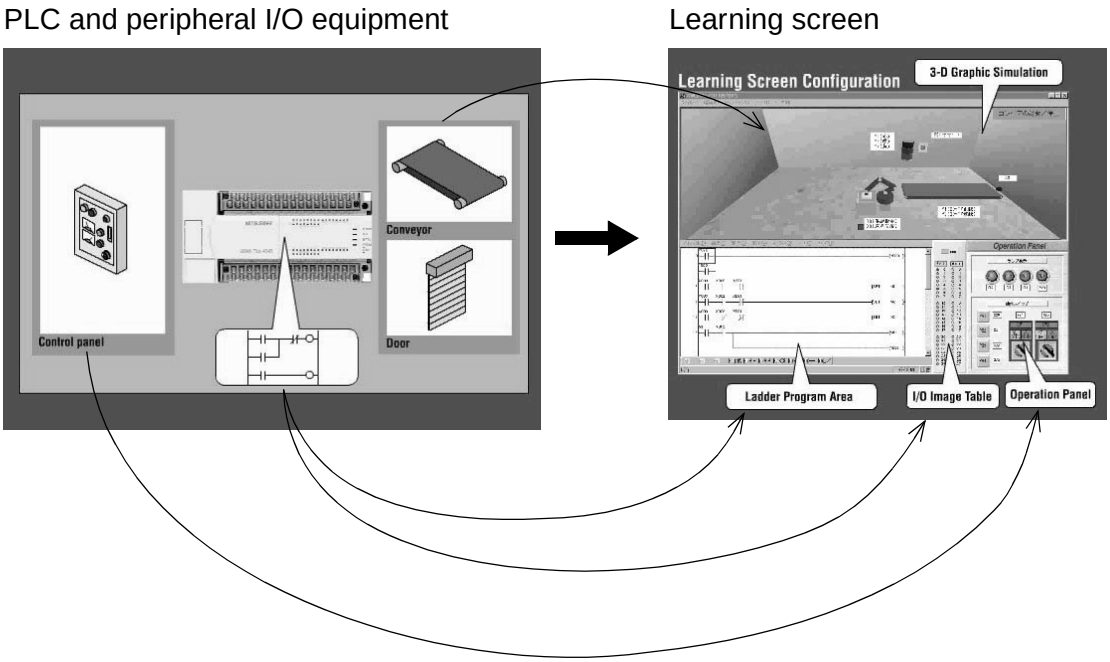
4) Configuration of the training software

In this training software, machine parts such as sensors or conveyor motors in the 3-D graphic simulation are already wired to the virtual PLC.

Write a program confirming the control specifications indicated in the guidance with pre-assigned input (X) and output (Y) device numbers.

The machines in the 3-D graphic simulation will operate according to downloaded program.

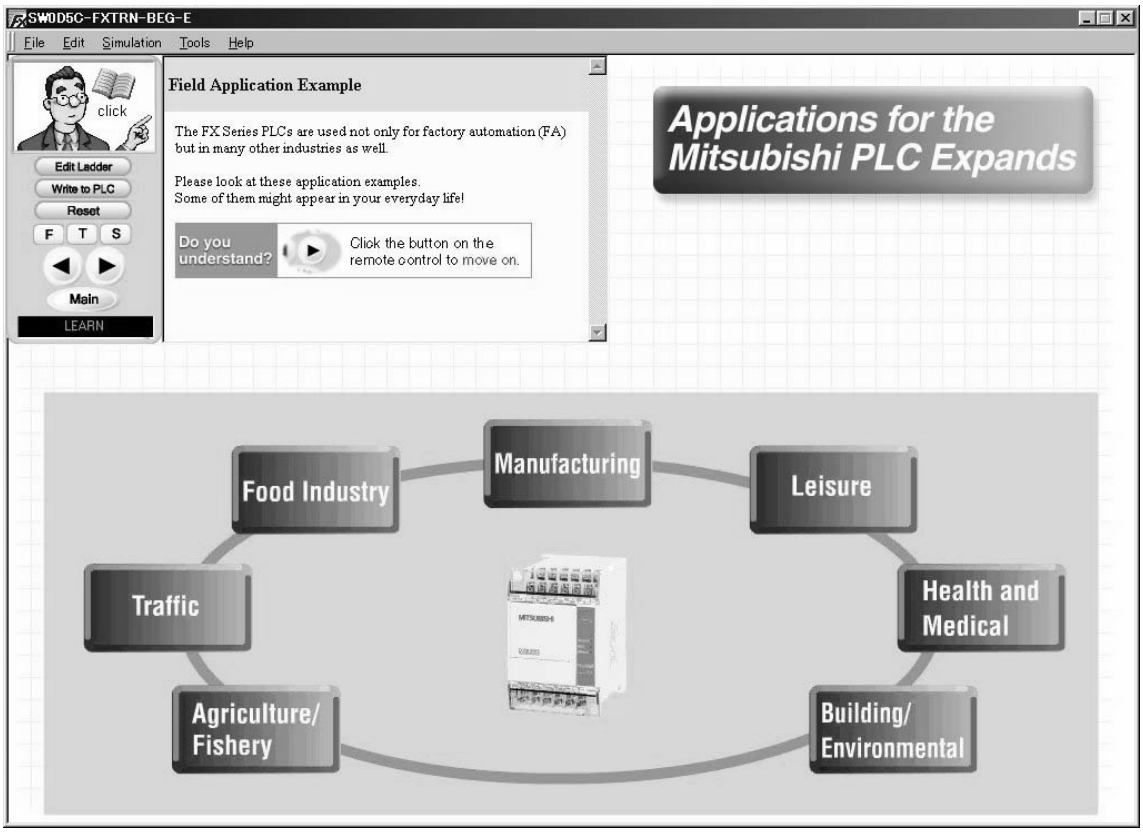




1.2 Application Examples for the FX Series PLC

Category	A: Let's Learn the FX Series PLC!
Exercise	A-2. Application Examples for the FX Series PLC
Objective	Look at the introductory lessons.
Difficulty Level	1 (★)
Score (Class)	80 (Basic programming)

1.2.1 Training Screen



1.2.2 Outline of Operation

Click [◀] or [▶] to return to the previous screen or to go to the next screen.

1.2.3 Points of learning and control specifications

The PLC is used for various purposes in various fields.
Let's look at various applications on the screen. You should have seen the equipment operated by the PLC.
After confirming the application examples, try to find various places in which use of the PLC is expected.

1.3 Let's play a Little!

Category	A: Let's Learn the FX Series PLC!
Exercise	A-3. Let's play a Little!
Objective	Look at the introductory lessons.
Difficulty Level	1 (★)
Score (Class)	80 (Introductory/Basic)

1.3.1 Training Screen

1.3.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Sensor	ON when part is detected. Conveyor is stopped.
	Y0	Supply command	One part is supplied when Y0 is ON. A process cycle begins.
Output	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Pusher	Extends when Y2 is ON and retracts when Y2 is OFF. The pusher cannot be stopped in mid stroke.

1.3.3 Points of Training and Control Specifications.

1) As a first step

Let's follow the guidance and see how the PLC works.

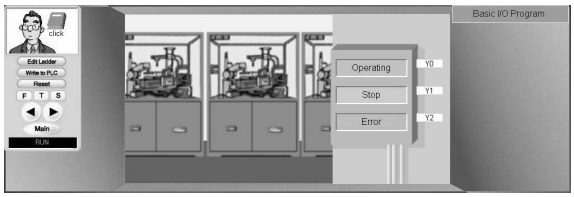
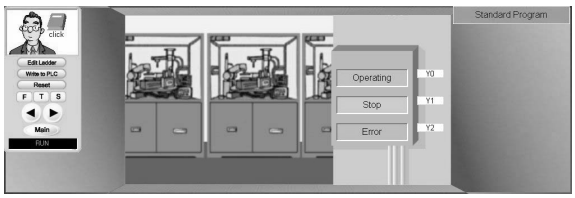
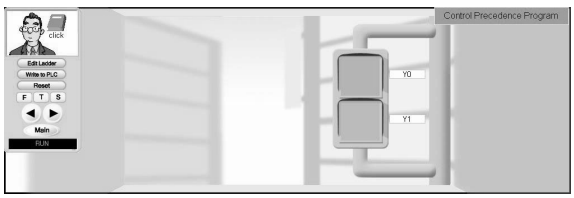
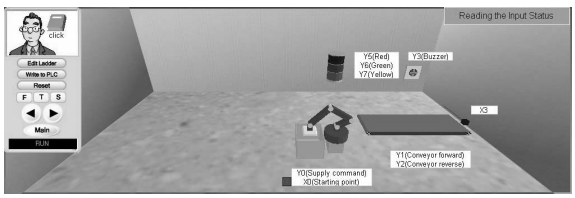
- Confirm that the operations change according to the programs.

  * The machines and the PLC on the screen are virtually simulated and are never damaged. Don't hesitate to use them!

- If you would like to learn the details of the key operations for the ladder programming, refer to 'LADDER PROGRAMS' in this manual.

MEMO

2. B: Let's Study the Basics

B-1. Basic I/O Program	B-2. Standard Program
	
B-3. Control Precedence Program	**B-4. Reading the Input Status**
	

2.1 Basic I/O Program

Category	B: Let's Study the Basics
Exercise	B-1. Basic I/O Program
Objective	Learn input and output programs.
Difficulty Level	1 (★)
Score (Class)	80 (Basic programming)

2.1.1 Training Screen

2.1.2 Device Assignment

Type	Device No.	Device name	Operation
Output	Y0	Operating lamp	Green lamp is lit when Y0 is ON.
	Y1	Stop lamp	Yellow lamp is lit when Y1 is ON.
	Y2	Error lamp	Red lamp is lit when Y2 is ON.

2.1.3 Points of Training and Control Specifications

1) Inputs, outputs and other devices

The PLC is equipped with input points and output points which are connected to control equipment and a variety of devices the aid in sequencing operations.

- What are devices?

  Control equipment such as switches and lamps are connected to the PLC and symbols such as X, Y, M, T and C are asssigned as their names. Each symbol represents a different function and has a serial number to identify it.
  Symbols and numbers handled inside the PLC are device symbols and device numbers, most times these are generally called devices.

Input: From X000
Inputs are terminals to receive signals from external equipment (such as switches and sensors) and their device symbol is represented by "X".
Numbers are assigned starting from '000'.

Output: From Y000
Outputs are terminals to drive external equipment (such as lamps and motors) and their device symbol is represented by "Y".
Numbers are assigned starting from '000'.

Auxiliary relay: From M0
Auxiliary relays (which are also called internal relays) are provided inside the PLC and their device symbol is represented by "M".
Auxiliary relays are convenient when using dual OUT instructions and two or more contacts at a time. (Refer to the explanation in Section 3).

Timer: From T0
Timers are provided inside the PLC and their device symbol is represented by "T". Timers are used provide a set period of delay time before their nominated contacts are either opened or closed depending upon the program instructions.
Timers will be studied in the exercises in the category 'C: Step-up'.

Counter: From C0
Counters are provided inside the PLC and their device symbol is represented by "C". Counters are used to increment or decrement in steps of one to a preset value and subsequently open or close their nominated contacts depending on the program instructions.
Counters will be studied in the exercises in the category 'C: Step-up'.

- Device number and number of devices

  Inputs (X) and outputs (Y) are expressed in octal - X000 to X007, X010 to X017 (and so on), Y000 to Y007, Y010 to Y017 (and so on).
  Auxiliary relays (M), timers (T) and couners (C) are expressed in decimal - M0 to M10, M11, M12 (and so on).
  The number of devices available varies depending on the PLC. For the number of available devices in the virtual PLC, refer to the appendix.

2) Contact instruction and OUT instruction

As you studied in 'A: Let's Learn the FX Series PLC!', the input/output equipment is individually connected to the PLC.
The operation of individual control equipment is determined by the internal wiring within the PLC. This internal wiring work is called programming.
In this software, connection (programming) can be easily performed using instruction symbols.

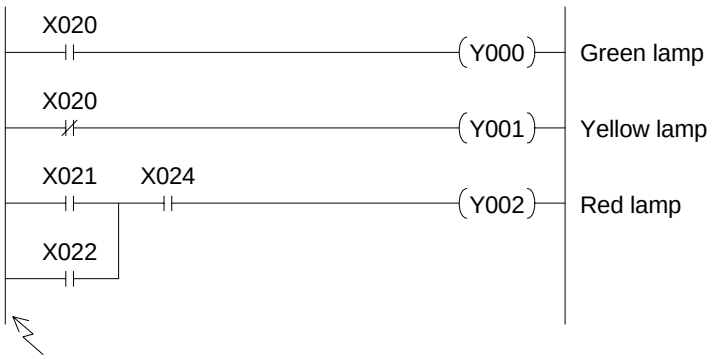
Contact symbols

—┤├—	NO contact	Is normally open (OFF), and is closed (turned ON) when a signal is received from the input equipment.
—┤/├—	NC contact	Is normally closed (ON), and is opened (turned OFF) when a signal is received from the input equipment.

OUT instruction symbol

—( )—	Is driven (turned ON) when signals for all the contacts connected to the OUT instructions are received (turned ON).

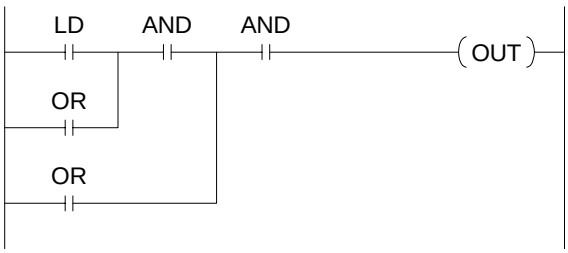
Example of program (See Chapter 1 in the guidance.)



Bus: The left vertical line is used as the base for in writing a program.

Reference: Instruction word

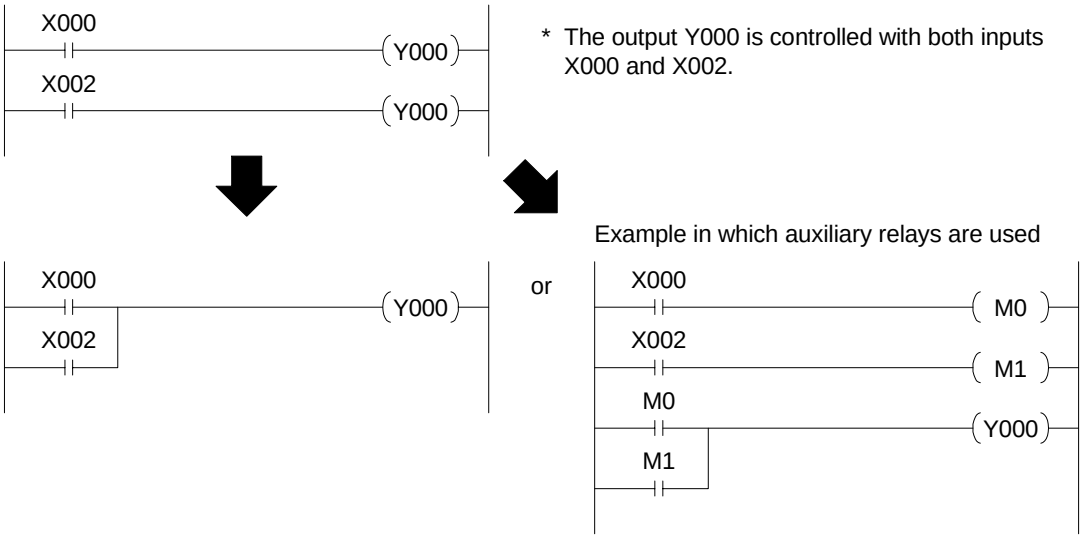
Inside the PLC, contact symbols and Out instruction symbols are handled in "instruction words".



3) How to write dual coils and auxiliary relays

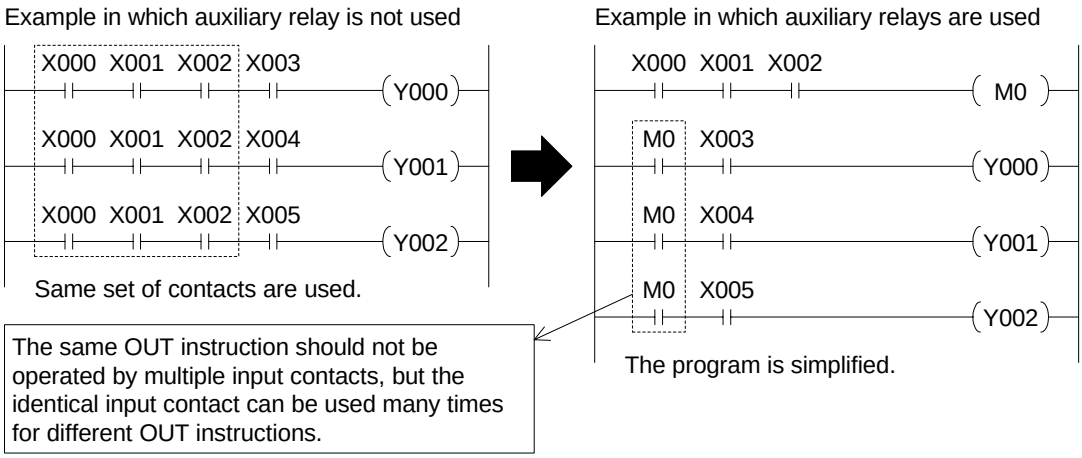
'Writing dual coils' means to construct a program with two or more control steps for the same output.
If you wish to control an identical output with multiple input conditions, try to combine the input conditions as in the program below.

Example of dual coil



Tips for using auxiliary relays

Auxiliary relays are convenient when avoiding dual coils as shown or when writing similar input conditions as shown below.



Instruction words

LD (load)	: NO contact starting from a bus
LDI (load inverse)	: NC contact starting from a bus
AND (and)	: NO contact connected in serial to a contact LD (or LDI)
ANI (and inverse)	: NC contact connected in serial to a contact LD (or LDI)
OR (or)	: NO contact connected in parallel to a contact LD (or LDI)
ORI (or inverse)	: NC contact connected in parallel to a contact LD (or LDI)
OUT (out)	: Coil drive instruction

* For the method to enter instruction words, refer to the 'LADDER PROGRAMS' section or to Appendix 1.

2.2 Standard Program

Category	B: Let's Study the Basics
Exercise	B-2. Standard Program
Objective	Learn a latched output program and SET/RST program.
Difficulty Level	1 (★)
Score (Class)	80 (Basic programming)

2.2.1 Training Screen

2.2.2 Device Assignment

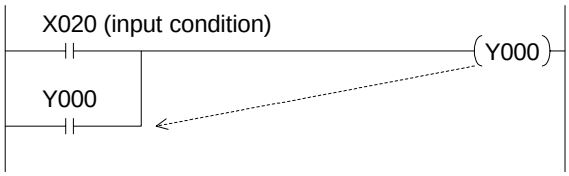
Type	Device No.	Device name	Operation
Output	Y0	Operating lamp	Green lamp is lit when Y0 is ON.
	Y1	Stop lamp	Yellow lamp is lit when Y1 is ON.
	Y2	Error lamp	Red lamp is lit when Y2 is ON.

2.2.3 Points of training and control specifications

1) Latched output instruction

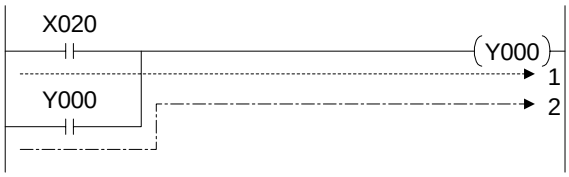
The latched output instruction is frequently used in PLC programming. The Output contact latches On when first energized by an Input(s), remaining On until forced Off by another programming condition.

Example of latched output instruction



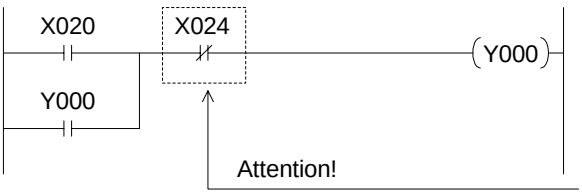
- Write the contact of OUT instruction Y000 in parallel to the input condition X020.

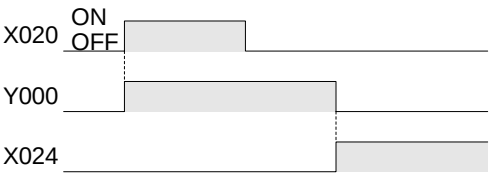
Operation



- When X020 is set ON, Y000 is driven (turned ON) as indicated with the dotted line 1.
- Even if X020 is set OFF the ON status of the output Y000 is held as indicated with the dotted line 2.

Example to shut down the latched output instruction





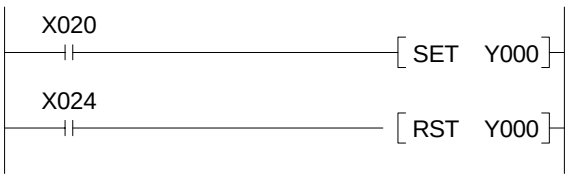
- Enter another input condition X24 so that the route 1 and 2 are shut down and the latched output status is not operated.

* X024 is an NC contact and normally ON. When an input signal is given, X024 is set OFF, and the operation is stopped.

2) Holding an output status using other methods

Another instructions provided in the PLC can be used to easily hold the output status.

Example of SET (Set) / RST (Reset) instructions



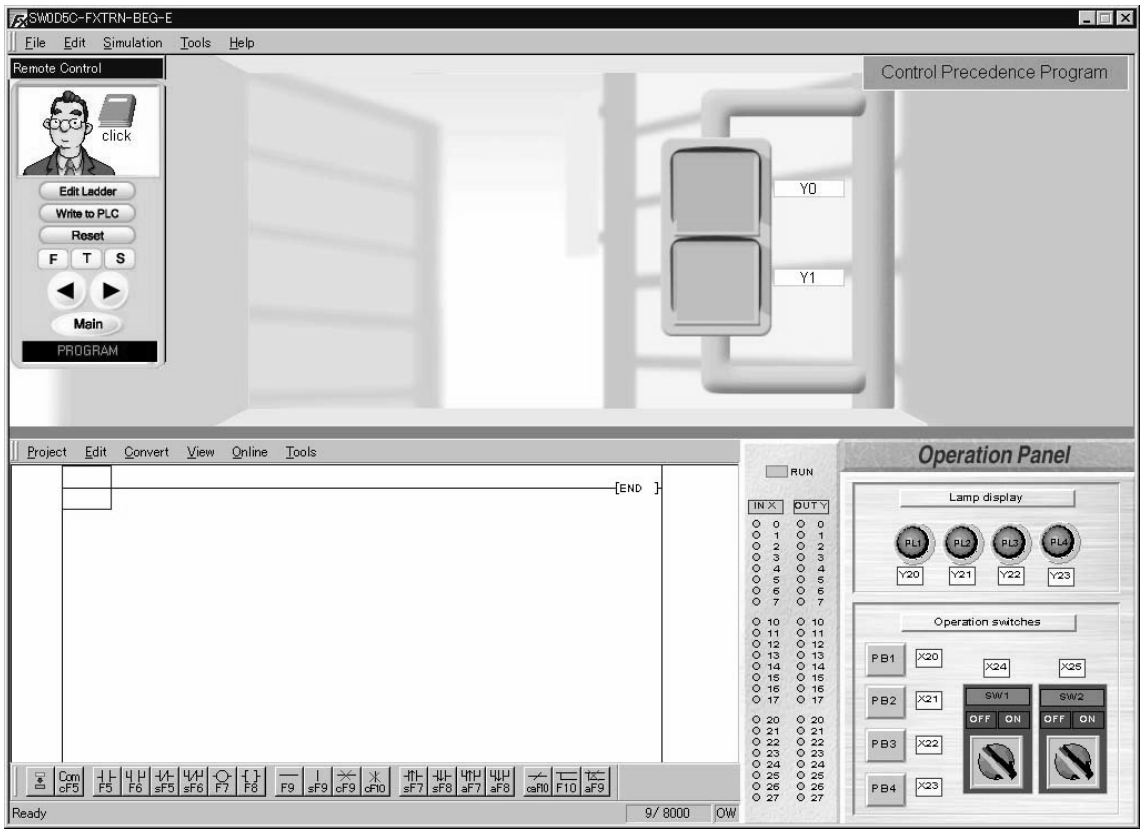
- When X020 is set ON, the output Y000 turns ON.
  Even if the X020 is set OFF, the output status of Y000 remains On.
- When X024 is set ON, Y000 is Reset (turned Off).

The operation of this program is the same as the operation described above where the latched output instruction is shut down by another input condition.

2.3 Control Precedence Program

Category	B: Let's Study the Basics
Exercise	B-3. Control Precedence Program
Objective	Learn a latched output program and SET/RST program.
Difficulty Level	1 (★)
Score (Class)	80 (Basic programming)

2.3.1 Training Screen



2.3.2 Device Assignment

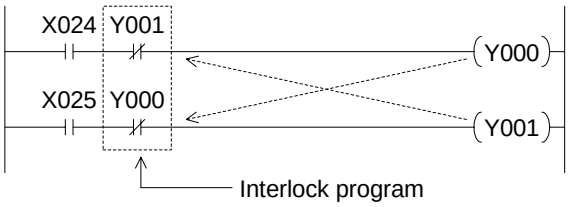
Type	Device No.	Device name	Operation
Output	Y0	Red signal	Lit when Y0 is ON.
	Y1	Green signal	Lit when Y1 is ON.

2.3.3 Points of training and control specifications

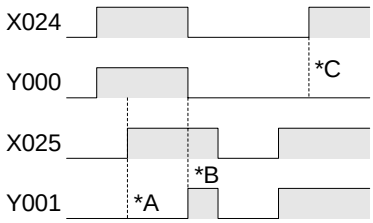
1) Interlock program (in which precedence is given to the first input)

The interlock program is used to give precedence to an input operated first to avoid any unwanted interruption by another operation.
The principle is often used to control the forward/reverse rotation command of motors or the ON/OFF status of a solenoid valve with possible safety hazards.

Example



- Enter Y001 as the NC contact for OUT instruction Y000.
  Enter Y000 as the NC contact for OUT instruction Y001.
- The example demonstrates an interlock operation whereby Y0 and Y1 can never be set ON simultaneously.



*A: As Y000 is set ON by X024, Y001 does not turn ON even if X025 turns ON.

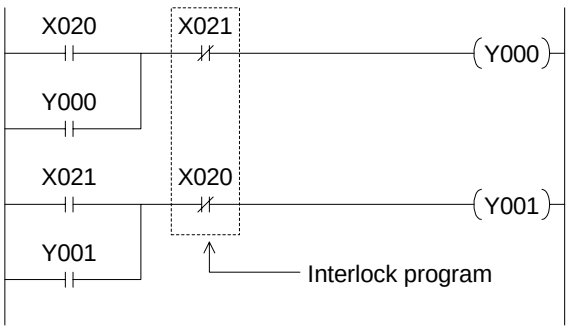
*B: When X024 turns OFF, Y000 is turned OFF. Subsequently, Y001 turns ON.

*C: As Y001 is set ON by X025, Y000 is not turned ON even if X024 turns ON.

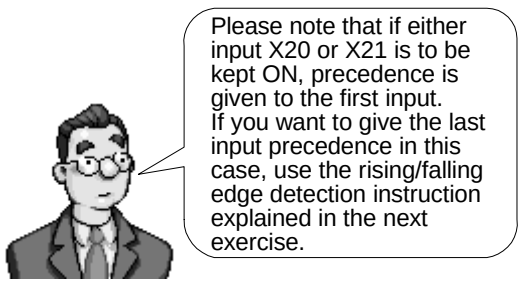
2) Interlock program (in which precedence is given to the last input)

In the interlock program in example 1) outlines a precedence to the first input. However, the precedence can similarly be given to the input condition that has most recently come true.

Example



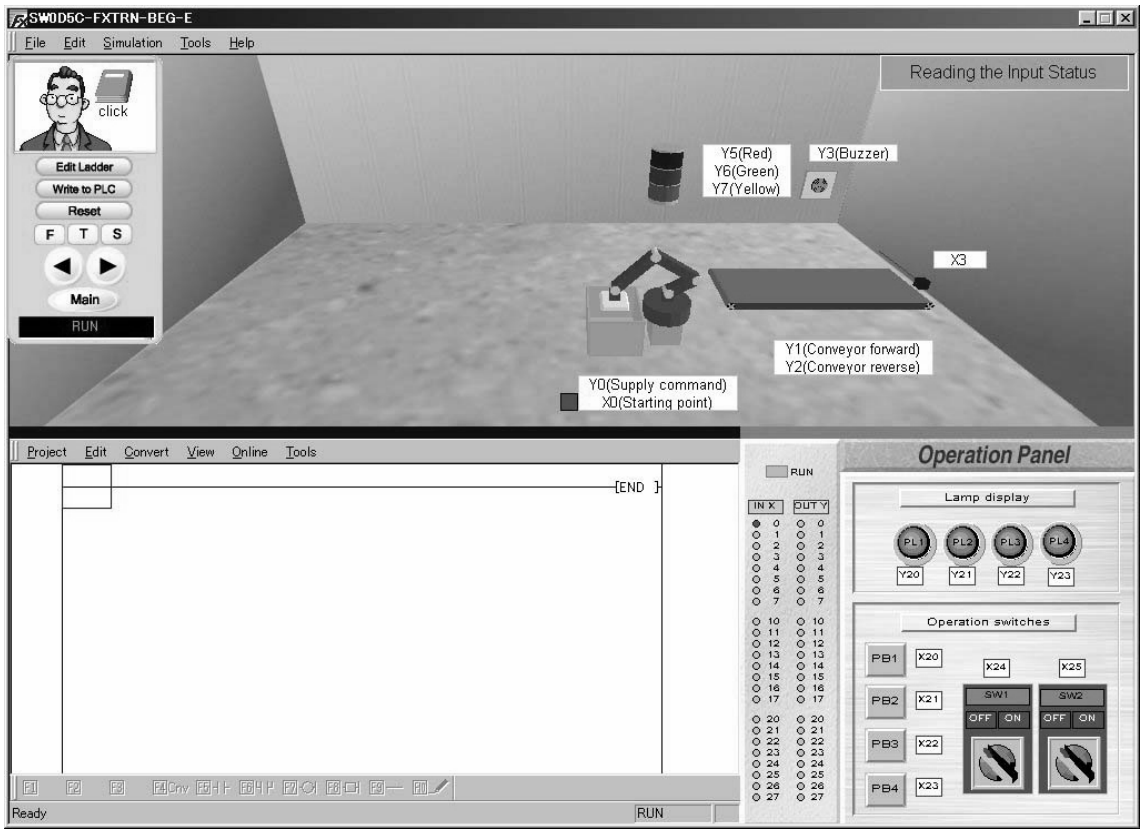
- The precedence is given to either X020 or X021 which is input last, and the Y000 or the Y001 turns ON accordingly.



2.4 Reading the Input Status

Category	B: Let's Study the Basics
Exercise	B-4. Reading the Input Status
Objective	Learn how to initiate instructions at the detection of rising or falling edge of a pulse.
Difficulty Level	2 (★★)
Score (Class)	110 (Basic programming)

2.4.1 Training Screen



2.4.2 Device Assignment

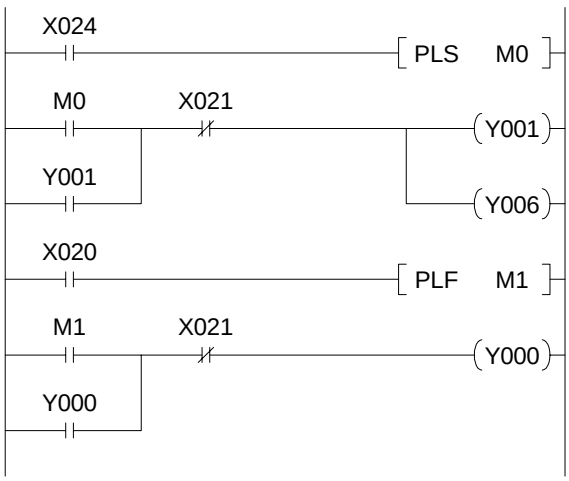
Type	Device No.	Device name	Operation
Input	X0	Starting point	ON when robot is at starting point.
	X3	Sensor	ON when part is detected.
Output	Y0	Supply command	One part is supplied when Y0 is ON. A process cycle begins.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Conveyor reverse	Conveyor moves backward when Y2 is ON.
	Y3	Buzzer	Sounds when Y3 is ON (Lamp on screen is lit).
	Y5	Red	Lit when Y5 is ON.
	Y6	Green	Lit when Y6 is ON.
	Y7	Yellow	Lit when Y7 is ON.

2.4.3 Points of training and control specifications

1) Input rising / falling edge detection instruction

Let's learn programs which operate only when an input is set to ON or OFF.
The rising / falling edge detection instruction captures the alternate status of ON to OFF and OFF to ON.
It is used for control where the input signal should not be kept either ON or OFF.

Example



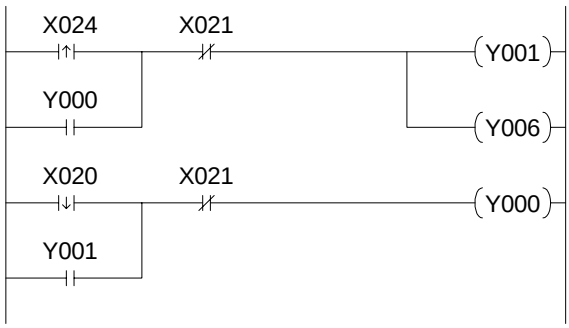
- X024 is an alternate switch which is always either ON or OFF. However, because the PLS instruction is used here, the OUT instruction M0 is operated only on the rising edge of input X024 for a single scan cycle.
- X020 is a momentary pushbutton switch which turns ON when pressed. However, because the PLF instruction is used here, the OUT instruction M1 is operated on the falling edge of input X020 for a single scan cycle.

* Even if inputs X024 or X020 are set ON or OFF by the PLS or PLF instruction, the latched output instruction program for Y000, Y001 and Y006 can be shut down by the input of X021.

2) Contact type rising/falling edge detection instruction

There is another type of rising/falling edge detection instruction which turns a contact only for a moment.

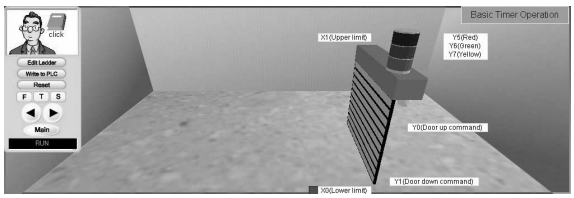
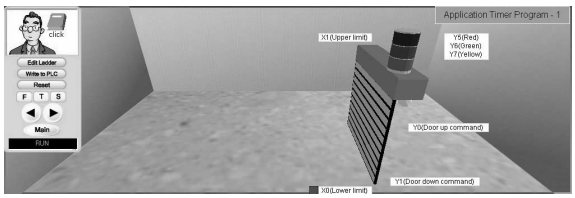
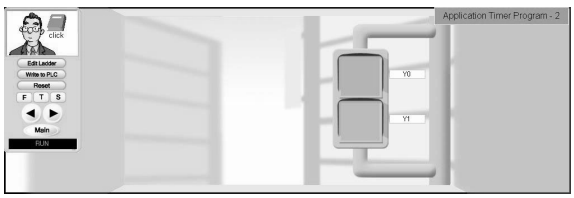
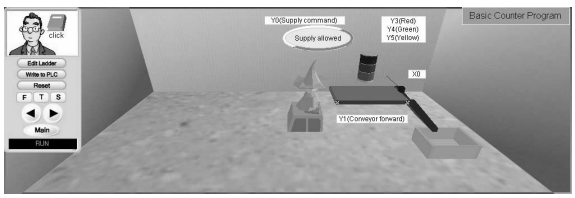
Example



- The program shown on the left performs the same operation with the program shown above in which the PLS and PLF instructions are used for rising/falling edge detection.

MEMO

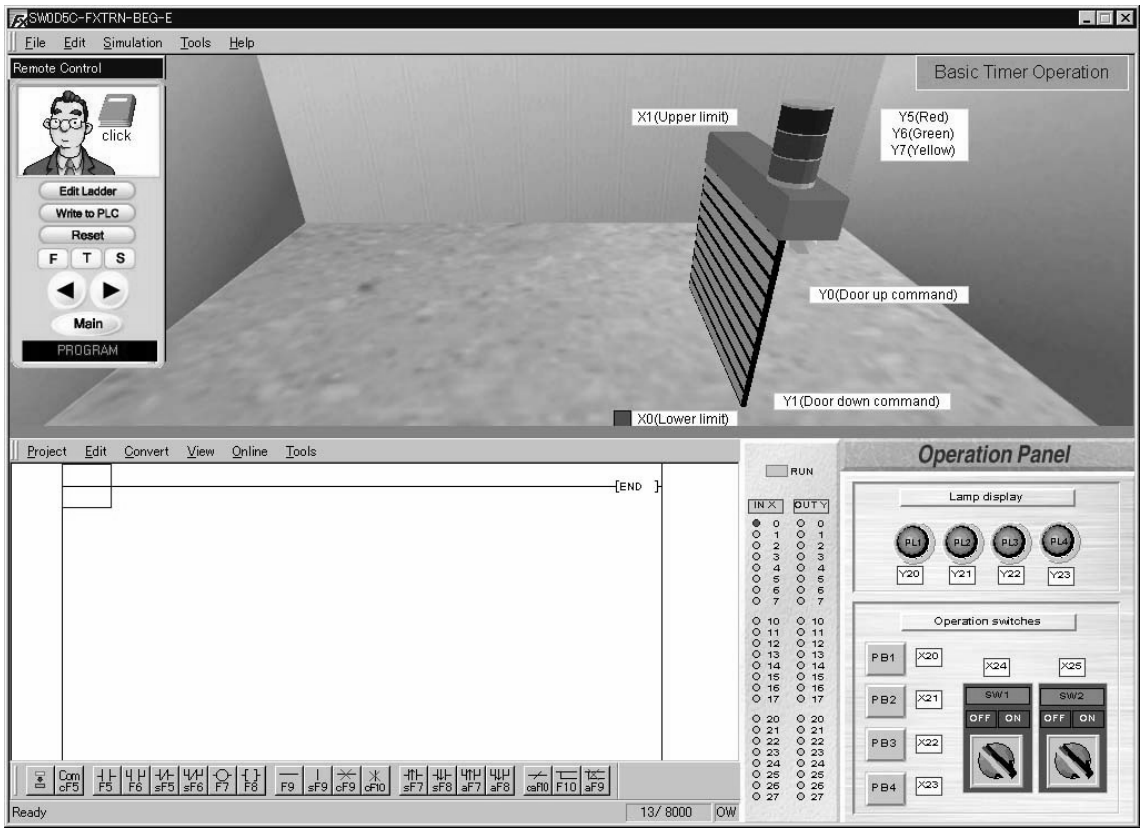
3. C: Easy Does It!

C-1. Base of timer circuit	C-2. Application of timer circuit 1
	
C-3. Application of timer circuit 2	**C-4. Base of counter circuit**
	

3.1 Basic Timer Operation

Category	C: Step Up
Exercise	C-1. Basic Timer Operation
Objective	Learn the On-delay time function.
Difficulty Level	1 (★)
Score (Class)	80 (Basic programming)

3.1.1 Training Screen



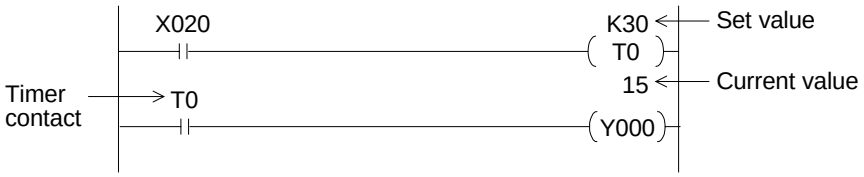
3.1.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Lower limit	ON when door reaches lower limit.
	X1	Upper limit	ON when door reaches upper limit.
Output	Y0	Door up command	Door moves up when Y0 is ON.
	Y1	Door down command	Door moves down when Y1 is ON.
	Y5	Red	Lit when Y5 is ON.
	Y6	Green	Lit when Y6 is ON.
	Y7	Yellow	Lit when Y7 is ON.

3.1.3 Points of training and control specifications

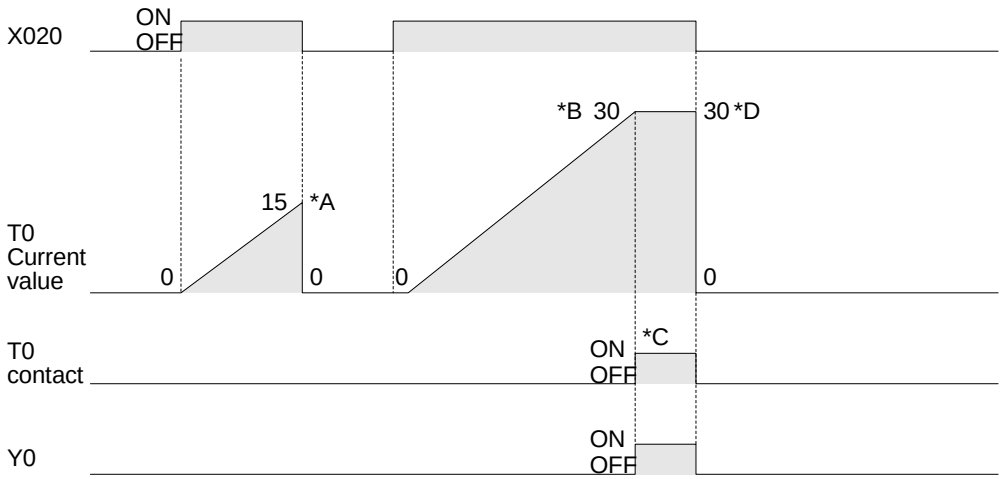
1) Basic operation of the timer

The timer in the PLC is expressed with the timer device number and the set value.



Set value : Expressed in decimal. K is added in front of the value.

Present value : Increases from 0 until it reaches the set value. (See the value by clicking "Online" → "Monitor" in the ladder menu.)



- The output driven by the time contact is kept On for a set period of time after the input is turned ON.
  (This is an ON-delay timer.)
  If the timer operation is shut down before it reaches the set value, the current value resets to 0 (See *A above).
- When the timer reaches the set value (*B), the current value becomes constant and the timer contact turns ON (*C).
- When the input to operate the timer is turned OFF, the timer contact is also OFF and the current value is cleared (*D).
- How to determine the set value depends on the device number. (Refer to the Appendix.) For example, T0 is the time with the base time 100ms (0.1 sec). If the set value is 'K30', the operation starts after 3 seconds because 100ms x 30 = 3000ms = 3 sec.

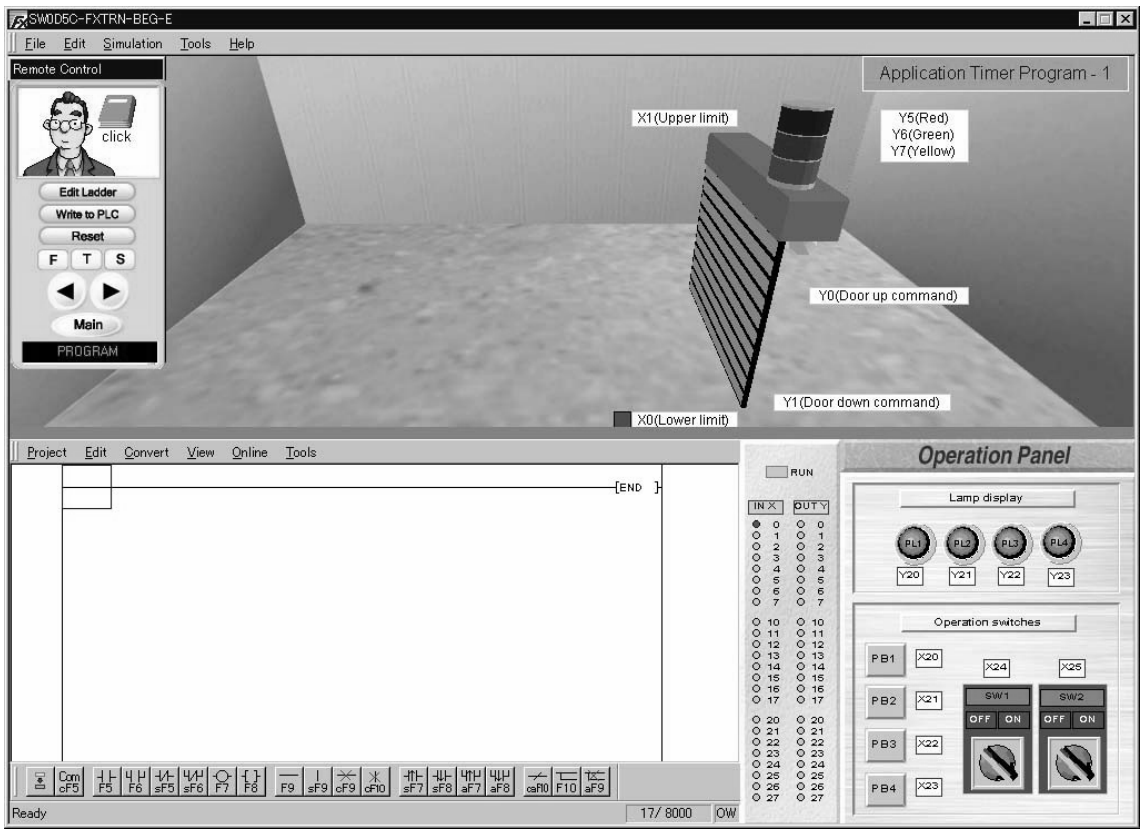
2) Opening and closing of the door using timers

- When X020 is set ON, the timer T0 is operated. Three seconds later, Y000 turns ON (the door is opened).
- When X021 is set ON, the timer T1 is operated. Four seconds later, Y001 turns ON (the door is closed).

3.2 Application Timer Program - 1

Category	C: Step Up
Exercise	C-2. Application Timer Program - 1
Objective	Learn the Off-delay time function and the one shot timer.
Difficulty Level	1 (★)
Score (Class)	80 (Basic programming)

3.2.1 Training Screen



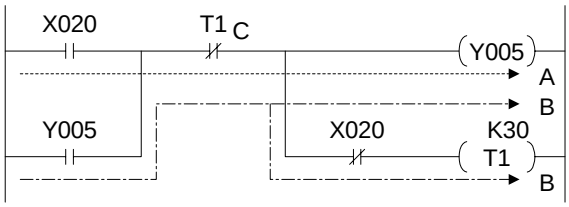
3.2.2 Device Assignment

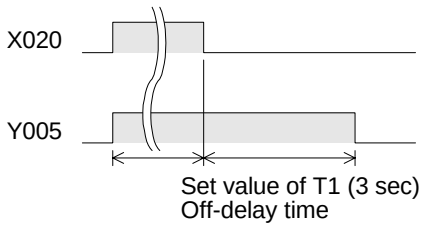
Type	Device No.	Device name	Operation
Input	X0	Lower limit	ON when door reaches lower limit.
	X1	Upper limit	ON when door reaches upper limit.
Output	Y0	Door up command	Door moves up when Y0 is ON.
	Y1	Door down command	Door moves down when Y1 is ON.
	Y5	Red	Lit when Y5 is ON.
	Y6	Green	Lit when Y6 is ON.
	Y7	Yellow	Lit when Y7 is ON.

3.2.3 Points of training and control specifications

1) Off-delay timer

The timer turns the output OFF after a set period of time.

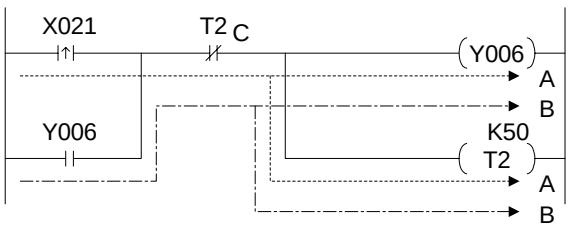


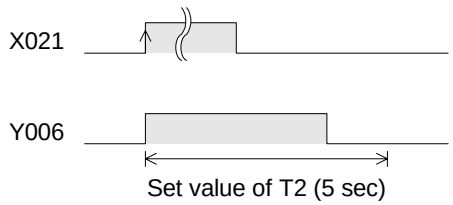


- When X020 is set ON, Y005 turns ON as indicated in line A.
- When X020 is set OFF, Y005 is latched and timer T1 turns ON as indicated in line B.
- After the set value of timer T1 elapses (K30 = 3 sec), C turns OFF, and the OUT instruction Y005 and T1 are turned OFF.

2) One-shot timer

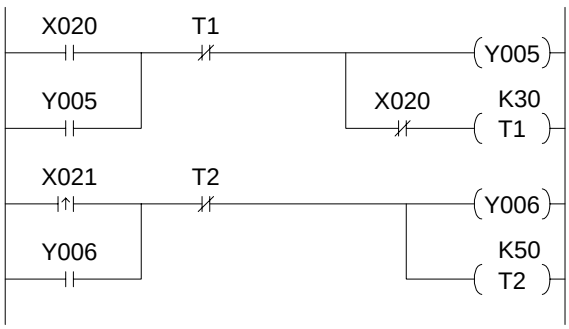
The timer keeps the output ON for a set period of time.
(Even if the input for operating the timer remains ON, the output is turned OFF after a set period of time.)





- When X021 is set ON, Y006 and T2 turn ON as indicated in line A. X021 is turned ON instantaneously by the rising edge detection instruction. Even if the input of X021 is kept ON, the contact turns OFF.
- The latched output instruction enables Y006 and T2 to remain ON as indicated in line B.
- After the set time of the timer T2 elapses (K50 = 5 sec), C turns OFF and then the OUT instruction Y006 and T2 are turned OFF.

3) Lighting the lamps using timers

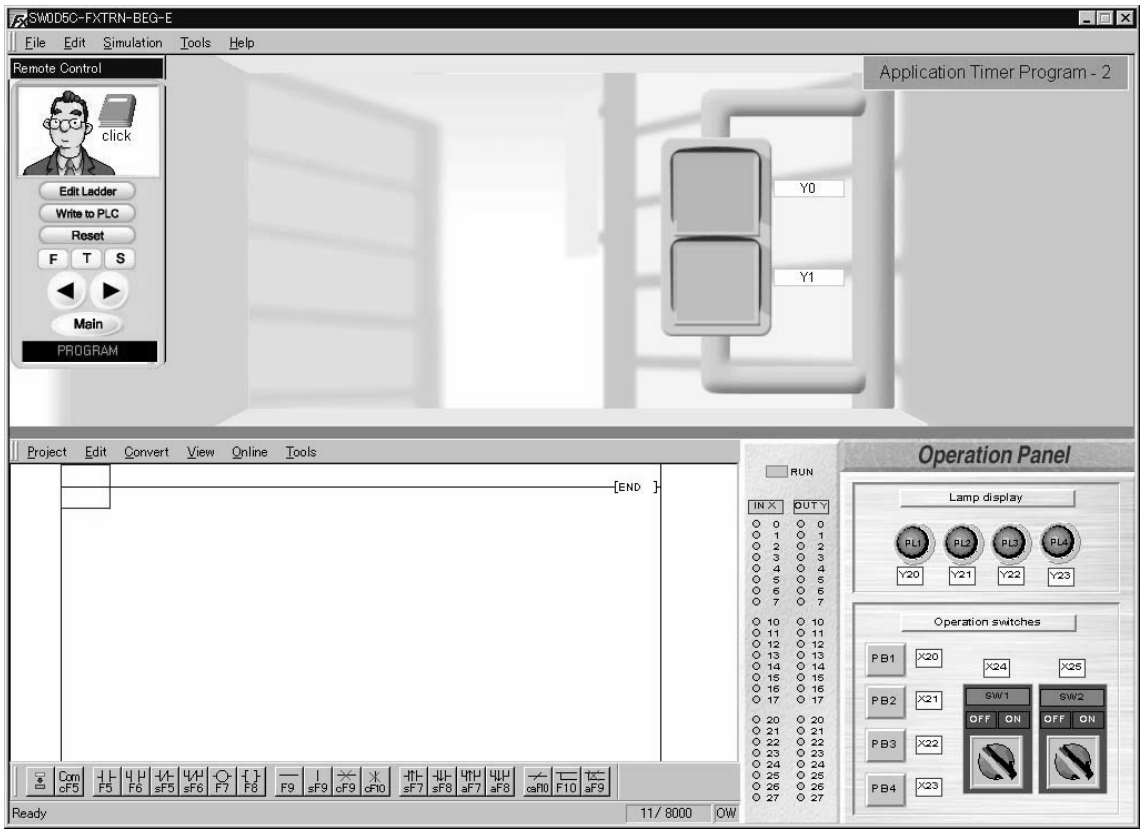


- When the switch (X020) is set ON, the "red" lamp (Y005) is lit. Three seconds (T1) after the switch (X020) is set, the "red" lamp is extinguished.
- When the switch (X021) is set ON, the "green" lamp (Y006) is lit. Even if the switch (X021) remains ON, the "green" lamp is extinguished five seconds (T2) later.

3.3 Application Timer Program - 2

Category	C: Step Up
Exercise	C-3. Application Timer Program - 2
Objective	Learn a "flicker" program executed by timers.
Difficulty Level	2 (★★)
Score (Class)	110 (Basic programming)

3.3.1 Training Screen



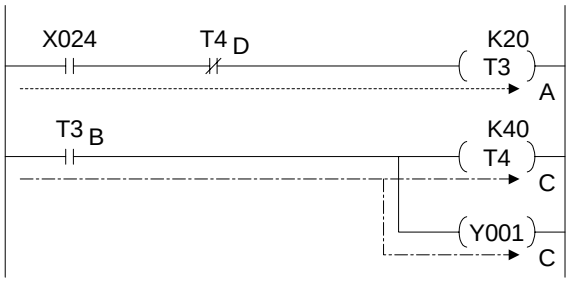
3.3.2 Device Assignment

Type	Device No.	Device name	Operation
Output	Y0	Red signal	Lit when Y0 is ON.
	Y1	Green signal	Lit when Y1 is ON.

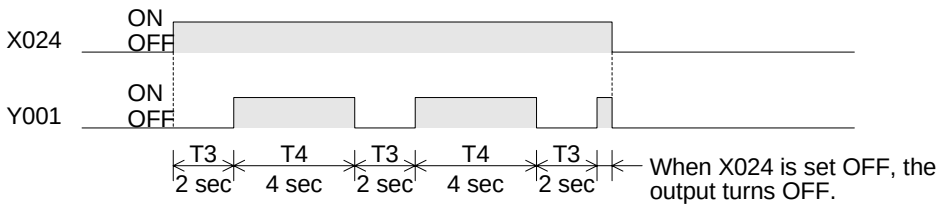
3.3.3 Points of training and control specifications

1) Flicker circuit

Two timers drive the output ON and OFF at set intervals.



- When X024 is set ON, the OUT instruction of T3 turns ON as indicated in line A.
- Two seconds later (the set value of K20 in T3), T3 indicated by B turns ON. Y001 and T4 turn ON as indicated in line C.
- Four seconds later (set value of K40 in T4), the contact D turns OFF and thus T3 turns OFF as indicated in line A.
- While X024 is ON, Y001 repeats an OFF for 2 seconds and ON for 4 seconds cycle.



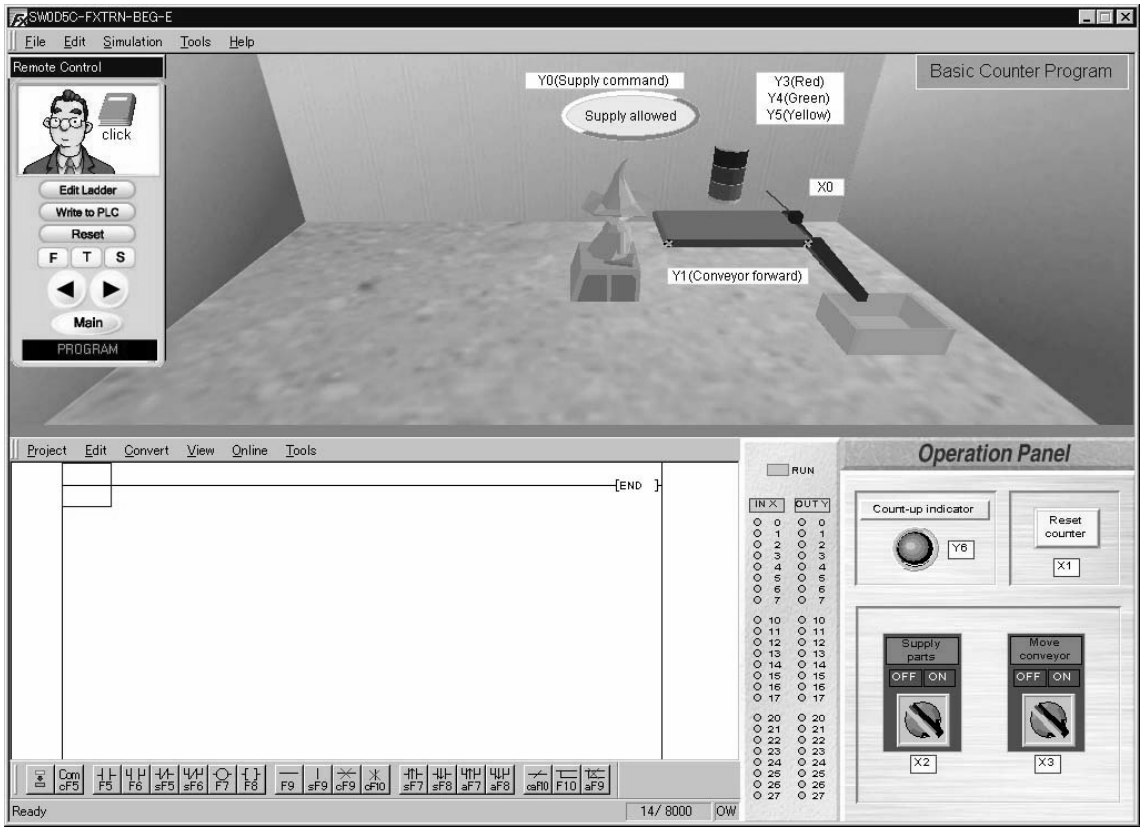
2) Flickering the signal lamps

In the program above, Y001 flickers OFF for 2 seconds and ON for 4 seconds while the switch X024 is ON.

3.4 Basic Counter Program

Category	C: Step Up
Exercise	C-4. Basic Counter Program
Objective	Learn control methods using counters.
Difficulty Level	2 (★★)
Score (Class)	110 (Basic programming)

3.4.1 Training Screen



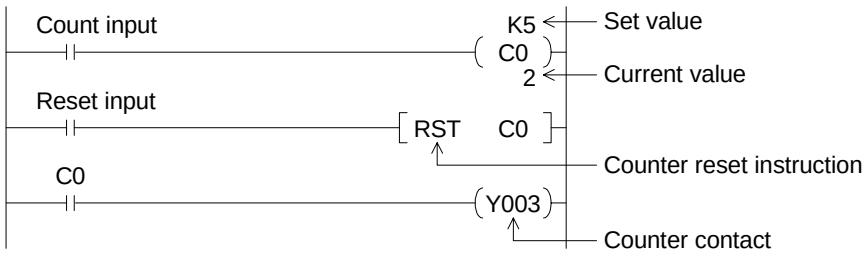
3.4.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Sensor	ON when part is detected at the right end.
Output	Y0	Supply command	Indicator on screen is lit when Y0 is ON. Operator supplies parts while indicator is lit.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y3	Red	Lit when Y3 is ON.
	Y4	Green	Lit when Y4 is ON.
	Y5	Yellow	Lit when Y5 is ON.

3.4.3 Points of training and control specifications

1) Basic operation of the counter

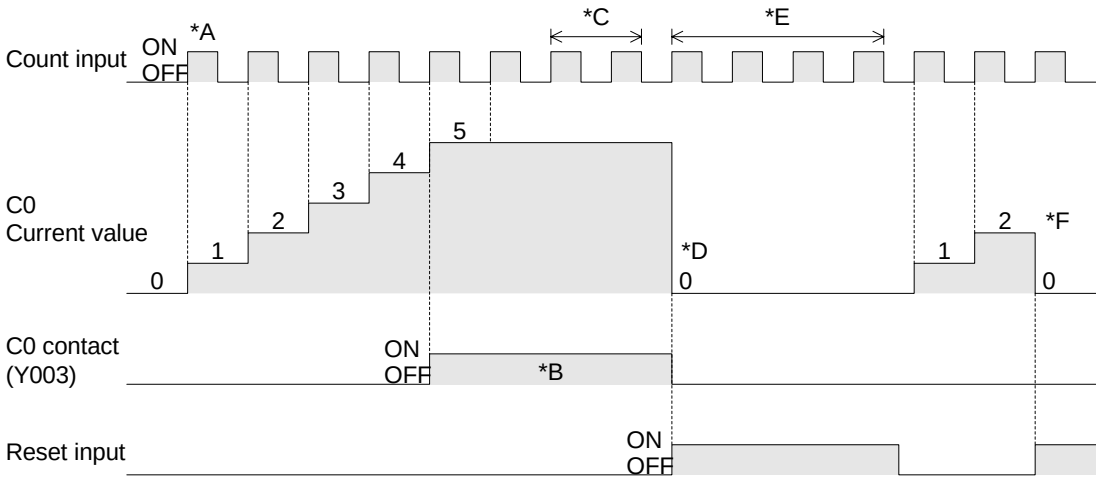
The counter in the PLC is expressed with the device number and the set value.



Set value : Expressed in decimal. K precedes the value.

Present value : Increments from 0 until it reaches the set value. (To monitor select "Online" → "Monitor" in the ladder menu.)

Reset : Returns the current value of the counter to 0, and sets OFF the contact of the counter (RST instruction).



- For each count input received (*A), the current value of the counter is incremented by 1. When the current value reaches the set value, the contact of the counter turns ON (*B).
- After the counter reaches the set value, the current value is not changed even if the count input (*C) is set ON and OFF, and the counter contact remains ON (*B).
- When the counter reset instruction (RST) is set ON, the current value of the counter becomes 0 (*D) and the contact turns OFF. While the RST instruction is ON, any count input is not counted (*E).
- When the RST instruction is set OFF, count inputs are counted. However, if the RST instruction is set ON before the current value of the counter reaches the set value, the current value is reset to 0 and thus the counter contact does not turn ON (*F).

2) Counting the number of parts

Control specifications

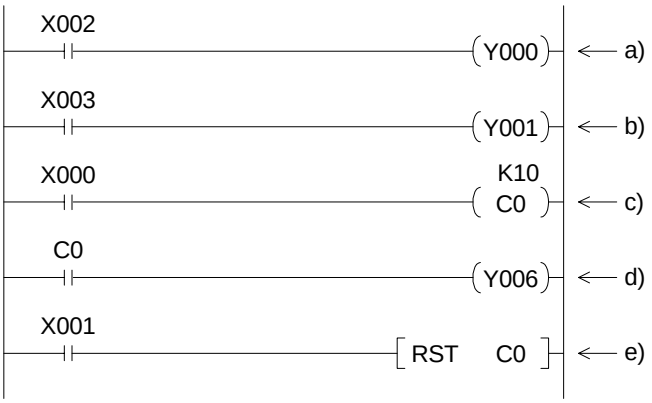
a) When the part supply command (X002) is set ON, the part supply output (Y000) is initiated.

b) The conveyor operation command (X003) initiates the conveyer forward output (Y001).

c) The number of parts is counted (counter C0) by the detection sensor (X000).

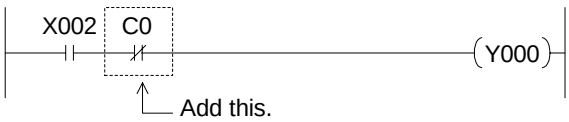
d) When the number of parts reaches 10, the count-up indicator lamp (Y006) is lit.

e) The counter is reset by input (X001).



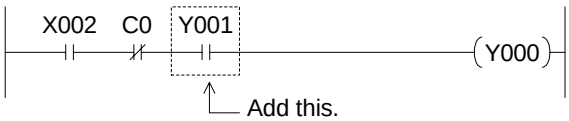
Minor Addition

Let's stop the supply of parts when the current value of the counter reaches the set value (K10).

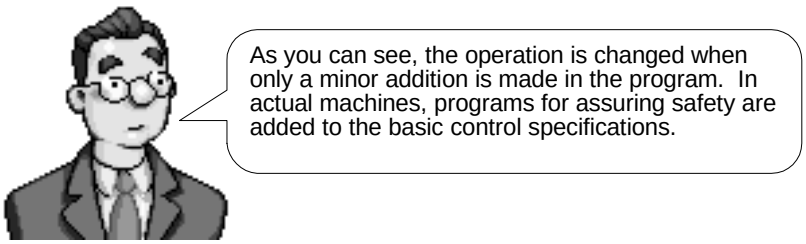


- Include a NC contact for the counter to line a) above.

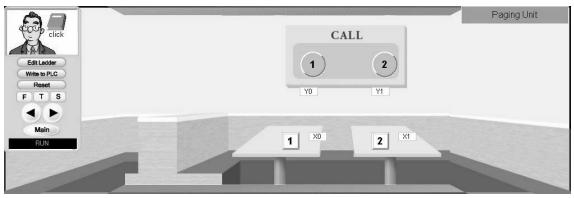
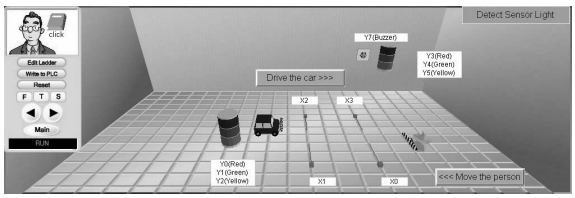
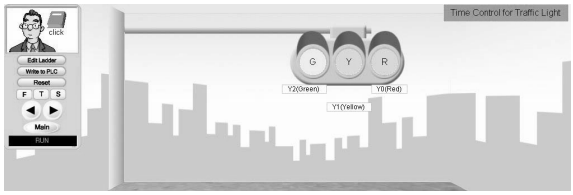
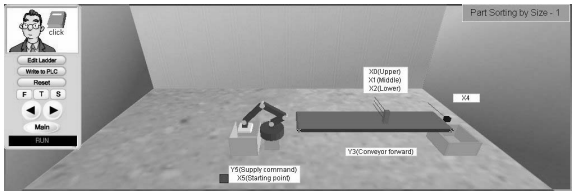
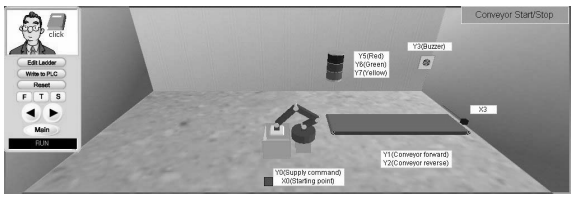
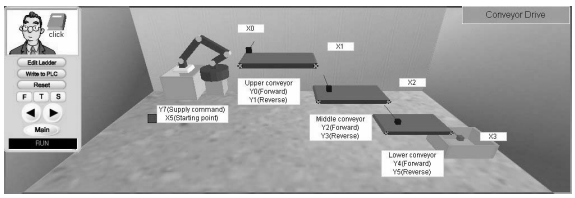
Let's supply parts only while the conveyor is moving.



- Include a NC contact for the conveyor operation (Y001) to line a) above.



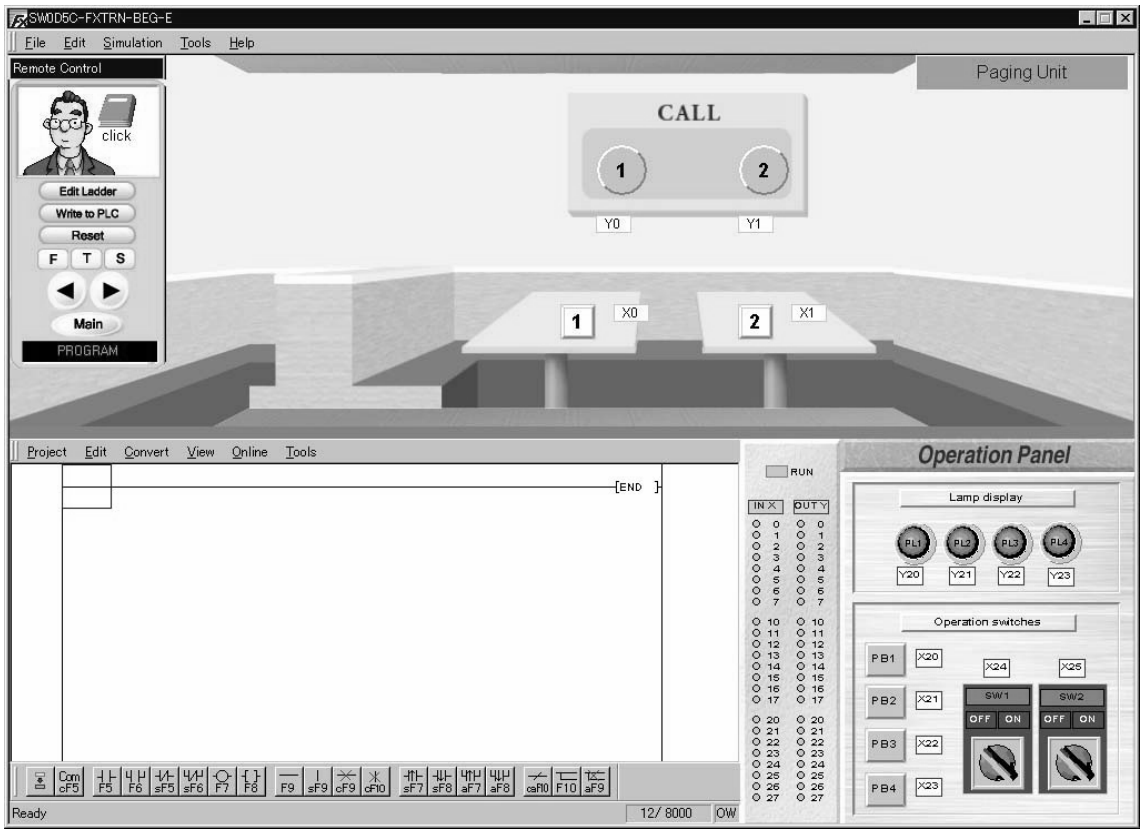
4. D: Beginner Challenge

D-1. Paging Unit	D-2. Detect Sensor Light
	
D-3. Time Control for Traffic Light	**D-4. Part Sorting by Size (I)**
	
D-5. Conveyor Start/Stop	**D-6. Conveyor Drive**
	

4.1 Paging Unit

Category	D: Beginner Challenge
Exercise	D-1. Paging Unit
Objective	Control the paging unit in a restaurant.
Difficulty Level	1 (★)
Score (Class)	130 (Beginner programming)

4.1.1 Training Screen



4.1.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Button 1	Momentary ON/OFF (mouse click).
	X1	Button 2	Momentary ON/OFF (mouse click).
Output	Y0	Lamp 1	Lit when Y0 is ON.
	Y1	Lamp 2	Lit when Y1 is ON.

4.1.3 Control Objective

Control the paging unit in a restaurant using the basic instructions previously studied.

4.1.4 Control Specifications

1) When **Button 1** (X0) on the table is pressed, **Lamp 1** (Y0) on the wall is lit.
   If **Button 1** (X0) is released, **Lamp 1** (Y0) remains lit.

2) When **Button 2** (X1) is pressed, **Lamp 2** (Y1) on the wall is lit.
   If **Button 2** (X1) is released, **Lamp 2** (Y1) remains lit.

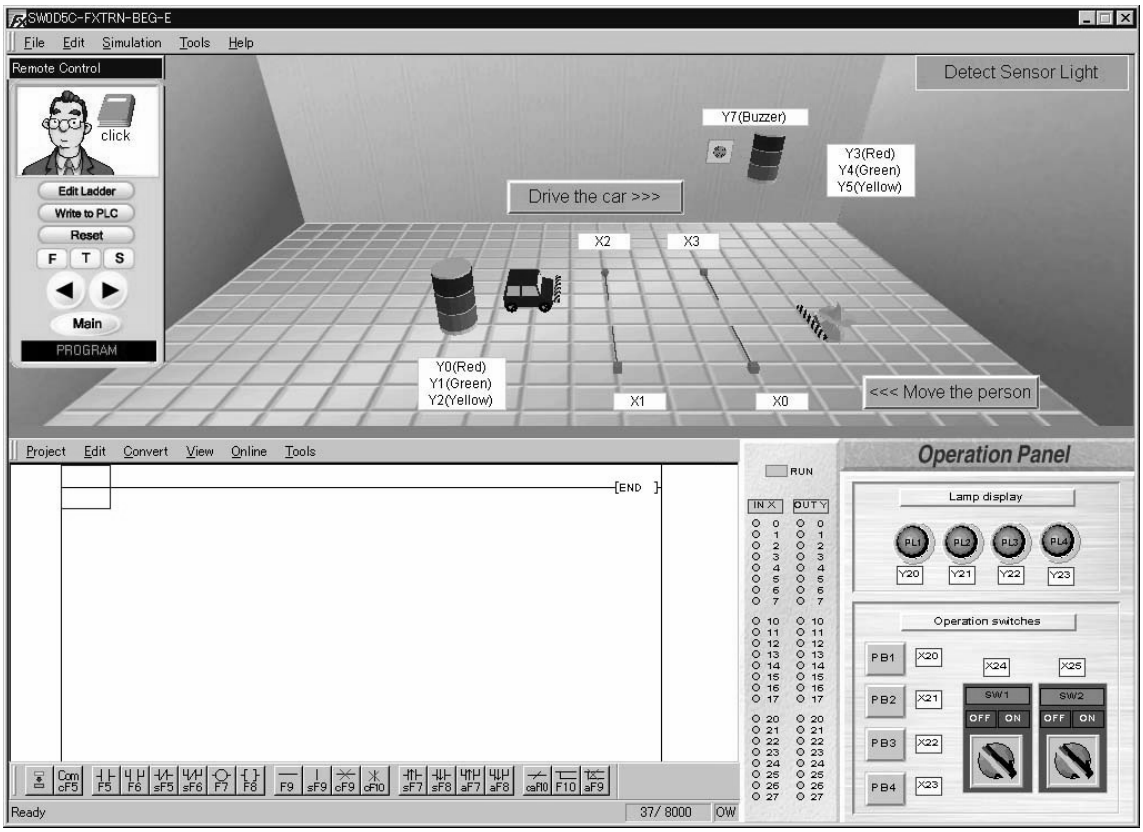
3) When both **Lamp 1** (Y0) and **Lamp 2** (Y1) are lit, [PL4] (Y23) on the operation panel lights.

4) When [PB1] (X20) on the operation panel is pressed, both **Lamp 1** (Y0) and **Lamp 2** (Y1) on the wall and [PL4] (Y23) on the operation panel are extinguished.

4.2 Detect Sensor Light

Category	D: Beginner Challenge
Exercise	D-2. Detect Sensor Light
Objective	Turn the flashing lights ON when an object is detected.
Difficulty Level	2 (★★)
Score (Class)	160 (Beginner programming)

4.2.1 Training Screen



4.2.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	In gate (person)	ON when person is detected.
	X1	Out (person)	ON when person is detected.
	X2	In gate (car)	ON when car is detected.
	X3	Out (car)	ON when car is detected.
Output	Y0	Red (person)	Lit when Y0 is ON.
	Y1	Green (person)	Lit when Y1 is ON.
	Y2	Yellow (person)	Lit when Y2 is ON.
	Y3	Red (car)	Lit when Y3 is ON.
	Y4	Green (car)	Lit when Y4 is ON.
	Y5	Yellow (car)	Lit when Y5 is ON.
	Y7	Buzzer	Sounds when Y7 is ON (Lamp on screen is lit).

4.2.3 Control Objective

Have the flashing lights turn ON when a person or car is detected.
Use the basic instructions and timers previously studied.

4.2.4 Control Specifications

Human side

1) When the sensor **In gate** (X0) detects a person, the flashing light **Green** (Y1) comes ON.
2) 5 seconds after the sensor **Out** (X1) detects the passage of the person, the flashing light **Green** (Y1) is extinguished.

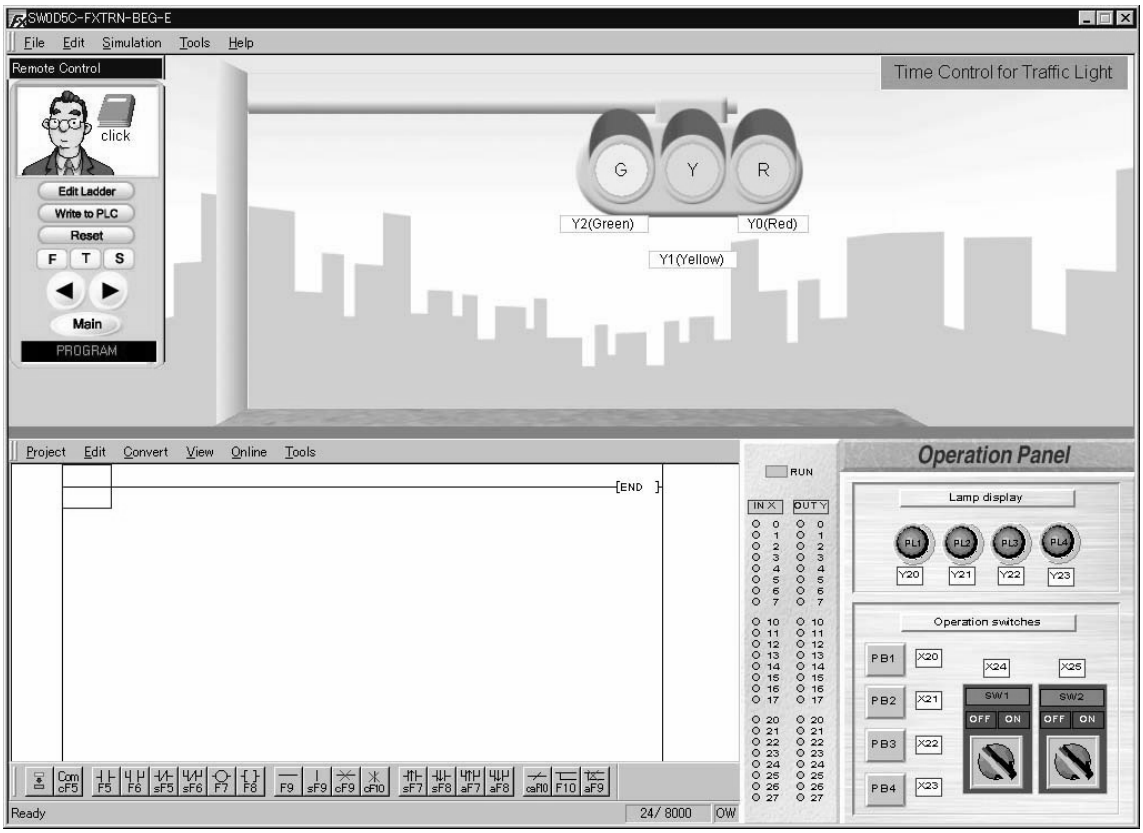
Car side

1) When the sensor **In gate** (X2) detects a car, the flashing light **Green** (Y4) is lit.
2) 5 seconds after the sensor **Out** (X3) detects the passage of the car, the flashing light **Green** (Y4) is extinguished.
3) If the car does not pass through the area between **In gate** (X2) and **Out** (X3) within 10 seconds, the flashing light **Red** (Y3) is lit and **Buzzer** (Y7) sounds.
4) As soon as the car has passed the sensor **Out** (X3), the flashing light **Red** (Y3) is extinguished and **Buzzer** (Y7) stops.

4.3 Time Control for Traffic Light

Category	D: Beginner Challenge
Exercise	D-3. Time Control for Traffic Light
Objective	Control a traffic light where the signals are changed at specified time intervals.
Difficulty Level	2 (★★)
Score (Class)	160 (Beginner programming)

4.3.1 Training Screen



4.3.2 Device Assignment

Type	Device No.	Device name	Operation
Output	Y0	Red	Lit when Y0 is ON.
	Y1	Yellow	Lit when Y1 is ON.
	Y2	Green	Lit when Y2 is ON.

4.3.3 Control Objective

Control a traffic light where the signals are changed at specified time intervals. Use the basic instructions and timers previously studied.

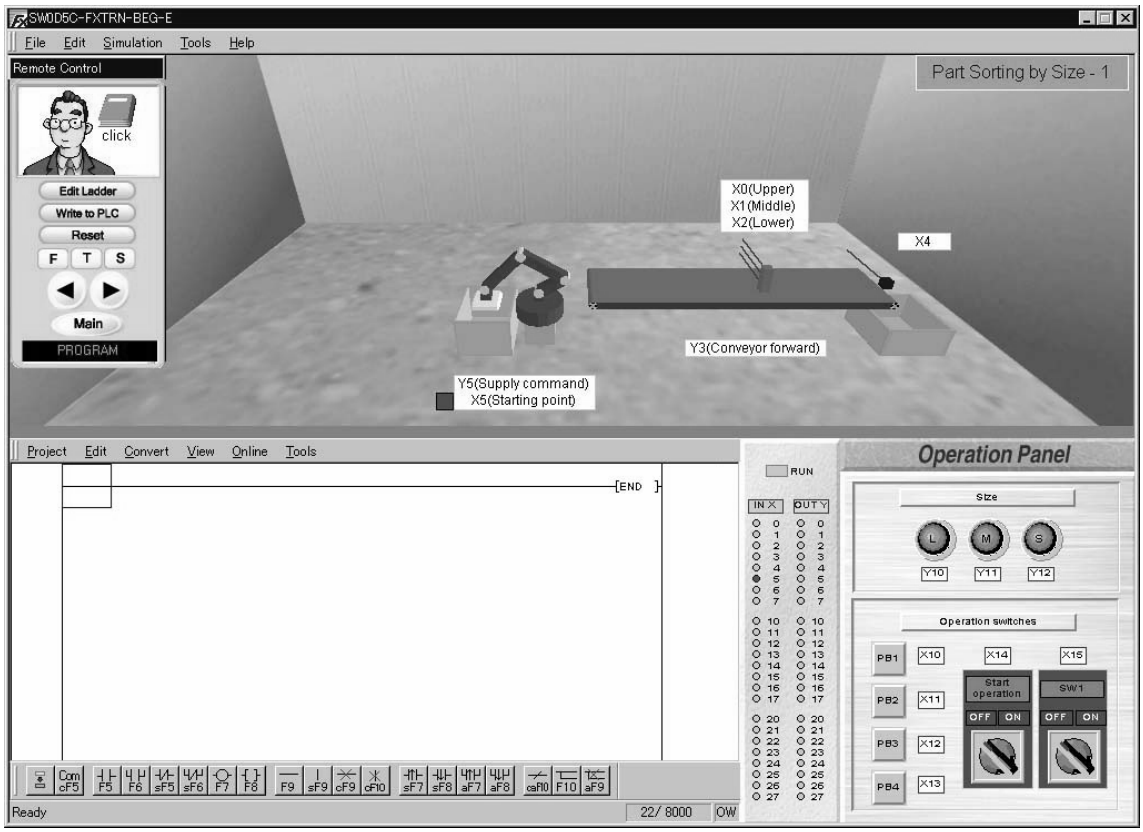
4.3.4 Control Specifications

1) When [PB1] (X20) on the operation panel is pressed, the process is started.
2) First, the signal lamp **Red** (Y0) is lit for 10 seconds.
3) he signal lamp **Red** (Y0) is extinguished after it has been lit for 10 seconds. The signal lamp **Yellow** (Y1) is lit for 5 seconds.
4) The signal lamp **Yellow** (Y1) is extinguished after it has been lit for 5 seconds. The signal lamp **Green** (Y2) is lit for 10 seconds.
5) The signal lamp **Green** (Y2) is extinguished after it has been lit for 10 seconds.
6) The operations starting from 2) above are repeated.

4.4 Part Sorting by Size (I)

Category	D: Beginner Challenge
Exercise	D-4. Part Sorting by Size (I)
Objective	Sort different sized parts using sensors.
Difficulty Level	2 (★★)
Score (Class)	160 (Beginner programming)

4.4.1 Training Screen



4.4.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Upper	ON when part is detected.
	X1	Middle	ON when part is detected.
	X2	Lower	ON when part is detected.
	X4	Sensor	ON when part is detected at the right end.
	X5	Starting point	ON when robot is at starting point.
Output	Y3	Conveyor forward	Conveyor moves forward when Y3 is ON.
	Y5	Supply command	One part is supplied when Y5 is ON. A process cycle begins.

4.4.3 Control Objective

Sort three different sized parts carried a conveyor.

4.4.4 Control Specifications

1) When [PB1] (X10) on the operation panel is pressed, **Supply command** (Y5) for the robot is turned ON.
   When [PB1] (X10) is released, **Supply command** (Y5) is turned OFF.

2) When [Operation start] (X14) on the operation panel is turned ON, **Conveyor forward** (Y3) is ON.
   When [Operation start] (X14) on the operation panel is turned OFF, **Conveyor forward** (Y3) is OFF.

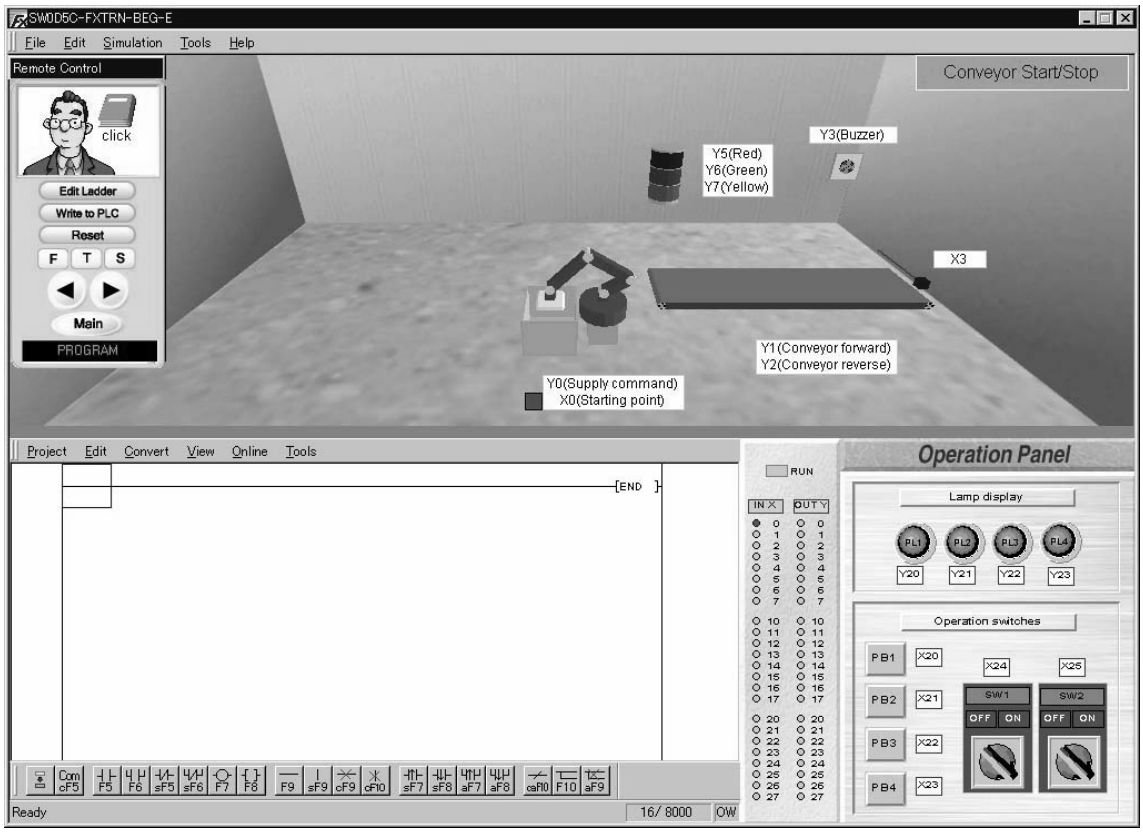
3) Large, medium or small parts carried on the conveyor are sorted by the input of sensors **Upper** (X0), **Middle** (X1) or **Lower** (X2), then a corresponding lamp is lit.
   - Large → Y10
   - Medium → Y11
   - Small → Y12

4) A lamp is lit immediately after the **sensors** (X0, X1, X2) sort the size, then is extinguished when the part has passed **Sensor** (X4).

4.5 Conveyor Start/Stop

Category	D: Beginner Challenge
Exercise	D-5. Conveyor Start/Stop
Objective	Start and stop the conveyor according to the predetermined procedure.
Difficulty Level	2 (★★)
Score (Class)	160 (Beginner programming)

4.5.1 Training Screen



4.5.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Starting point	ON when robot is at starting point.
	X3	Sensor	ON when part is detected at the right end.
Output	Y0	Supply command	One part is supplied when Y0 is ON. A process cycle begins.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Conveyor reverse	Conveyor moves backward when Y2 is ON.
	Y3	Buzzer	Sounds when Y3 is ON (Lamp on screen is lit).
	Y5	Red	Lit when Y5 is ON.
	Y6	Green	Lit when Y6 is ON.
	Y7	Yellow	Lit when Y7 is ON.

4.5.3 Control Objective

Start and stop the conveyor according to the predetermined procedure.

4.5.4 Control Specifications

1) When [PB1] (X20) on the operation panel is pressed, the flashing light **Yellow** (Y7) is lit and **Buzzer** (Y3) sounds for 5 seconds.
   If [PB1] (X20) is released, **Yellow** (Y7) remains lit.

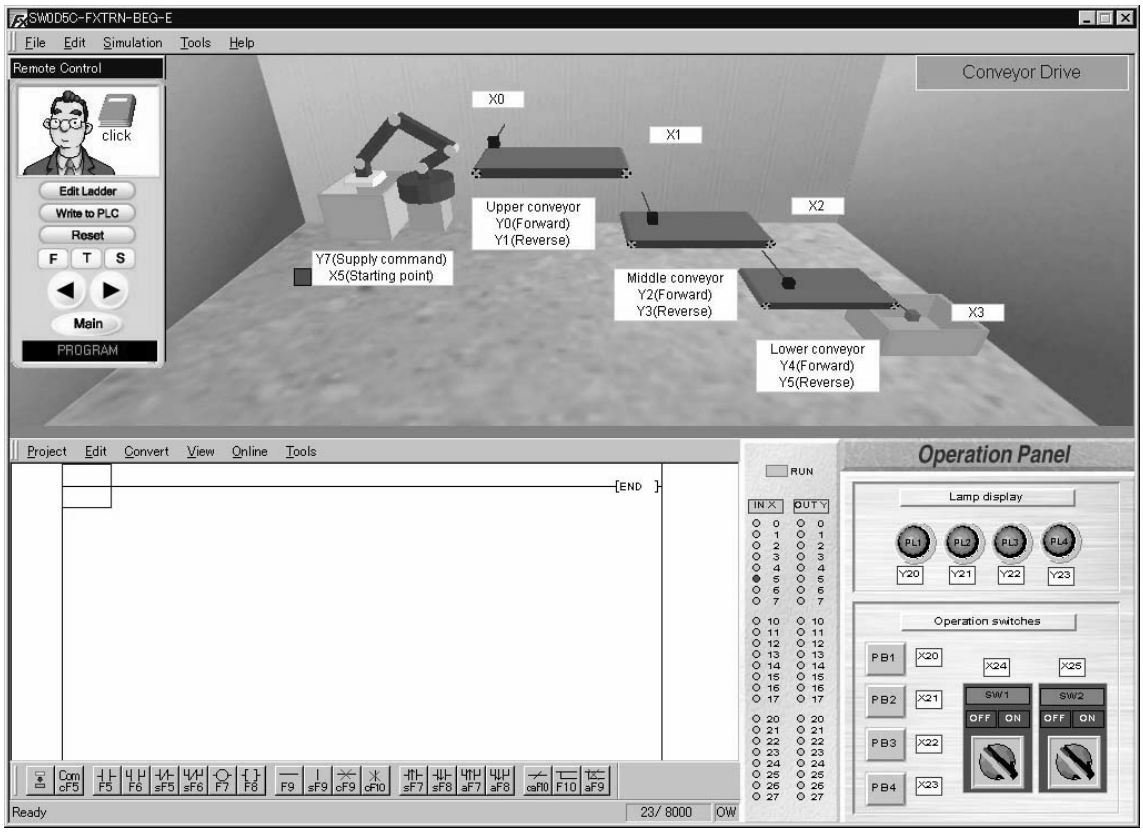
2) After the flashing light **Yellow** (Y7) is extinguished and **Buzzer** (Y3) stops, **Conveyor forward** (Y1) is set ON.
   The flashing light Green (Y6) remains lit while the **Conveyor forward** (Y1) is ON.

3) When [PB2] (X21) on the operation panel is pressed, the operations described in 1) and 2) stop.
   The operations should be repeated when the procedure described in 1) is executed.

4.6 Conveyor Drive

Category	D: Beginner Challenge
Exercise	D-6. Conveyor Drive
Objective	Operate the conveyor according to the sensor data.
Difficulty Level	2 (★★)
Score (Class)	160 (Beginner programming)

4.6.1 Training Screen



4.6.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Sensor	ON when part is detected at the left end.
	X1	Sensor	ON when part is detected at the left end.
	X2	Sensor	ON when part is detected at the left end.
	X3	Sensor	ON when part is detected at the right end.
	X5	Starting point	ON when robot is at starting point.

Type	Device No.	Device name	Operation
Output	Y0	Upper conveyor forward	Conveyor moves forward when Y0 is ON.
	Y1	Upper conveyor reverse	Conveyor moves backward when Y1 is ON.
	Y2	Middle conveyor forward	Conveyor moves forward when Y2 is ON.
	Y3	Middle conveyor reverse	Conveyor moves backward when Y3 is ON.
	Y4	Lower conveyor forward	Conveyor moves forward when Y4 is ON.
	Y5	Lower conveyor reverse	Conveyor moves backward when Y5 is ON.
	Y7	Supply command	One part is supplied when Y7 is ON. A process cycle begins.

4.6.3 Control Objective

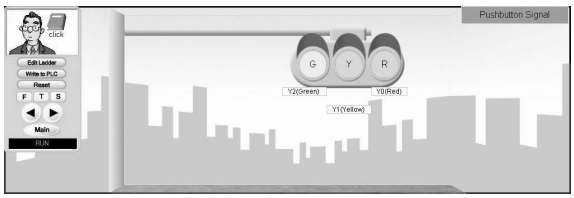
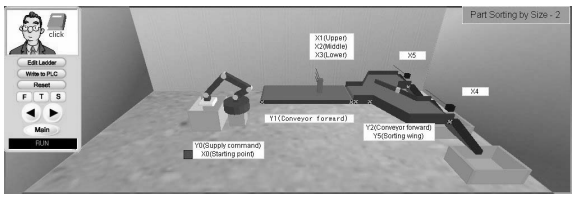
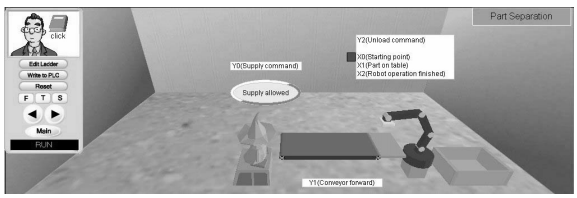
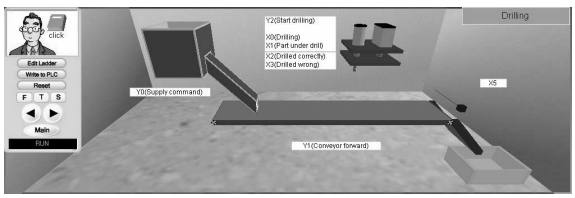
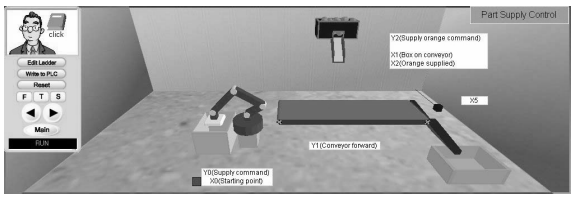
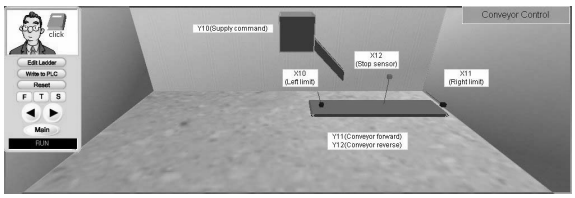
Operate the conveyor according to the sensor data.

4.6.4 Control Specifications

1) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y7) for the robot is turned ON if the robot is at **Starting point** (X5).
   When [PB1] (X20) is released, **Supply command** (Y7) is latched on until the robot returns to the **Starting point** (X5).
2) When **Sensor** (X0) detects a part, **Upper conveyor forward** (Y0) is set ON.
3) When **Sensor** (X1) detects a part, **Middle conveyor forward** (Y2) is set ON and **Upper conveyor forward** (Y0) stops.
4) When **Sensor** (X2) detects a part, **Lower conveyor forward** (Y4) is set ON and **Middle conveyor forward** (Y2) stops.
5) When **Sensor** (X3) detects a part, **Lower conveyor forward** (Y4) stops.
6) When **Sensor** (X3) is set ON, **Supply command** (Y7) for the robot is turned ON and a new part is supplied if the robot is at **Starting point** (X5).

MEMO

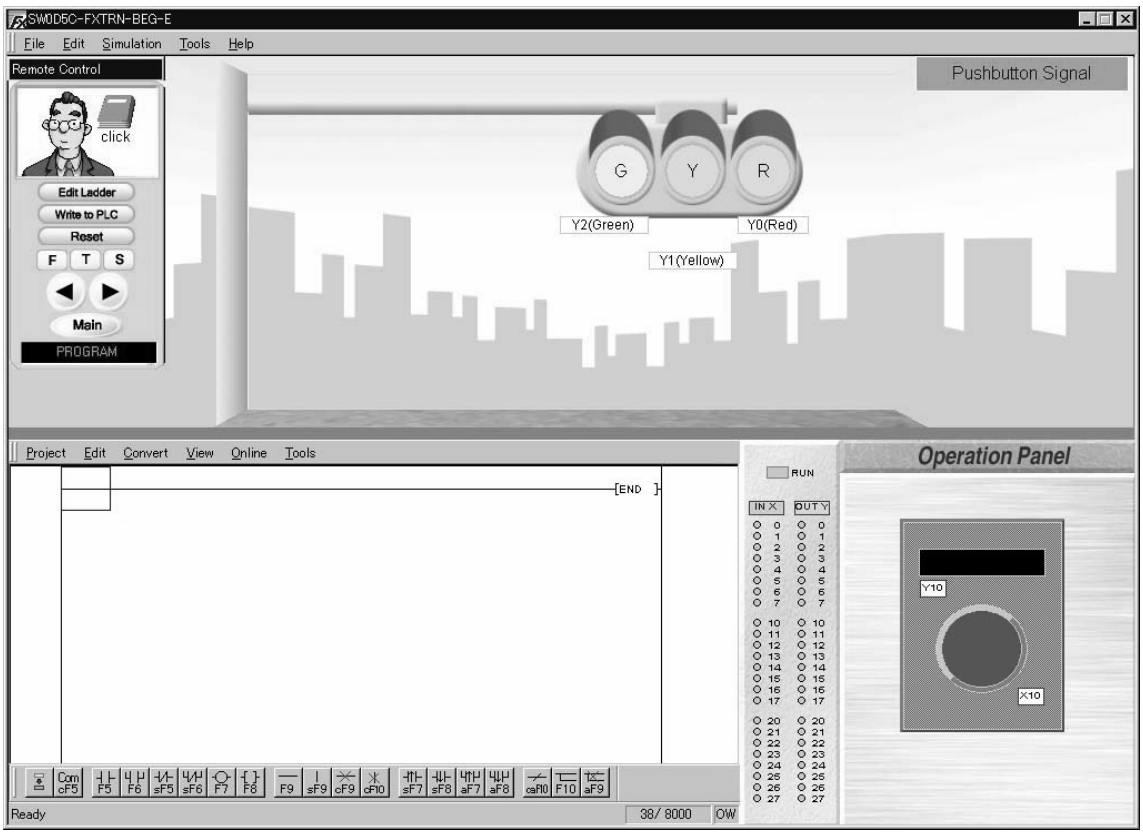
5. E: Intermediate Challenge

E-1. Pushbutton Signal	E-2. Part Sorting by Size (II)
	
E-3. Part Separation	**E-4. Drilling**
	
E-5. Part Supply Control	**E-6. Conveyor Control**
	

5.1 Pushbutton Signal

Category	E: Intermediate Challenge
Exercise	E-1. Pushbutton Signal
Objective	Switch the traffic light signals in response to a pushbutton.
Difficulty Level	2 (★★)
Score (Class)	210 (Intermediate programming)

5.1.1 Training Screen



5.1.2 Device Assignment

Type	Device No.	Device name	Operation
Output	Y0	Red	Lit when Y0 is ON.
	Y1	Yellow	Lit when Y1 is ON.
	Y2	Green	Lit when Y2 is ON.

5.1.3 Control Objective

Switch the traffic light signals in response to a pushbutton.

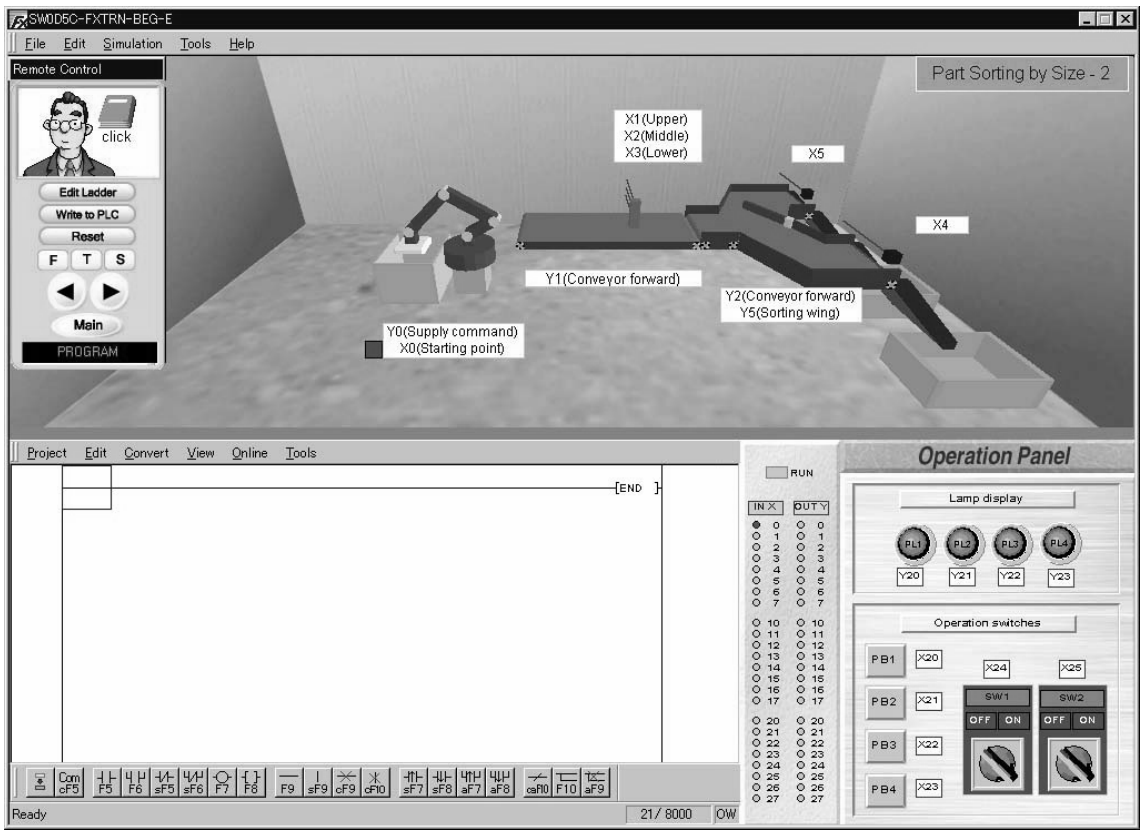
5.1.4 Control Specifications

1) The signal lamp **Red** (Y0) flickers at one-second intervals (ON for 1 second and OFF for 1 second).
2) When the pushbutton (X10) on the operation panel is pressed, the indicator (Y10) on the operation panel is lit.
   If the pushbutton (X10) is released, the indicator (Y10) remains lit.
3) After the indicator (Y10) is lit for 5 seconds, the operation of the signal is changed as described in 4) to 7).
4) First, the signal lamp **Red** (Y0) flickers for 5 seconds while indicator (Y10) is lit.
5) The signal lamp **Red** (Y0) turns off. The signal lamp **Yellow** (Y1) is lit for 5 seconds.
6) After the lamp **Yellow** (Y1) is extinguished, signal lamp **Green** (Y2) is lit for 10 seconds.
7) After the signal lamp **Green** (Y2) turns OFF, the signal lamp **Red** (Y0) flickers at one-second intervals (ON for 1 second and OFF for 1 second). The operations starting from 1) are repeated.

5.2 Part Sorting by Size (II)

Category	E: Intermediate Challenge
Exercise	E-2. Part Sorting by Size (II)
Objective	Distribute each part to its proper destination according to its size.
Difficulty Level	2 (★★)
Score (Class)	210 (Intermediate programming)

5.2.1 Training Screen



5.2.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Starting point	ON when robot is at starting point.
	X1	Upper	ON when part is detected.
	X2	Middle	ON when part is detected.
	X3	Lower	ON when part is detected.
	X4	Sensor	ON when part is detected at the right end.
	X5	Sensor	ON when part is detected at the right end.
Output	Y0	Supply command	One part is supplied when Y0 is ON. A process cycle begins: Metal cylinder repeats in order L, S, S, L and S.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Conveyor forward	Conveyor moves forward when Y2 is ON.
	Y5	Sorting wing	Moves toward front when Y5 is ON.

5.2.3 Control Objective

Distribute each part to its proper destination according to its size.

5.2.4 Control Specifications

1) When [SW1] (X24) on the operation panel is turned ON, the conveyors move forward.
   When [SW1] (X24) is turned OFF, the conveyors stop.

2) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y0) for the robot is turned ON.
   Supply command (Y0) is turned OFF when the robot has moved from the starting point.
   (The robot will complete the part loading cycle.)

3) The robot supplies large, medium or small parts.

4) Large parts are led to the rear conveyor and small parts are led to the front conveyor.
   The part size is detected by the input **Upper** (X1), **Middle** (X2) and **Lower** (X3) on the conveyor.

5.3 Part Separation

Category	E: Intermediate Challenge
Exercise	E-3. Part Separation
Objective	Give the command to a robot to move a part to a new location.
Difficulty Level	2 (★★)
Score (Class)	210 (Intermediate programming)

5.3.1 Training Screen

5.3.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Starting point	ON when robot is at starting point.
	X1	Part on table	ON when part is on table.
	X2	Robot operation finished	ON when robot operation finished.
Output	Y0	Supply command	Indicator on screen is lit when Y0 is ON. Operator supplies parts while indicator is lit.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Unload command	Robot moves part to tray when Y2 is ON. A process cycle begins.

5.3.3 Control Objective

Give the command to a robot to move a part to a new location.

5.3.4 Control Specifications

1) The operator supplies parts.
   The operator confirms the indicator lamp [Supply allowed] is lit and supplies a part to the conveyor.
   If the indicator lamp is always lit, the operator continuously supplies parts.

2) While the PLC is in RUN status, the conveyor always moves forward.

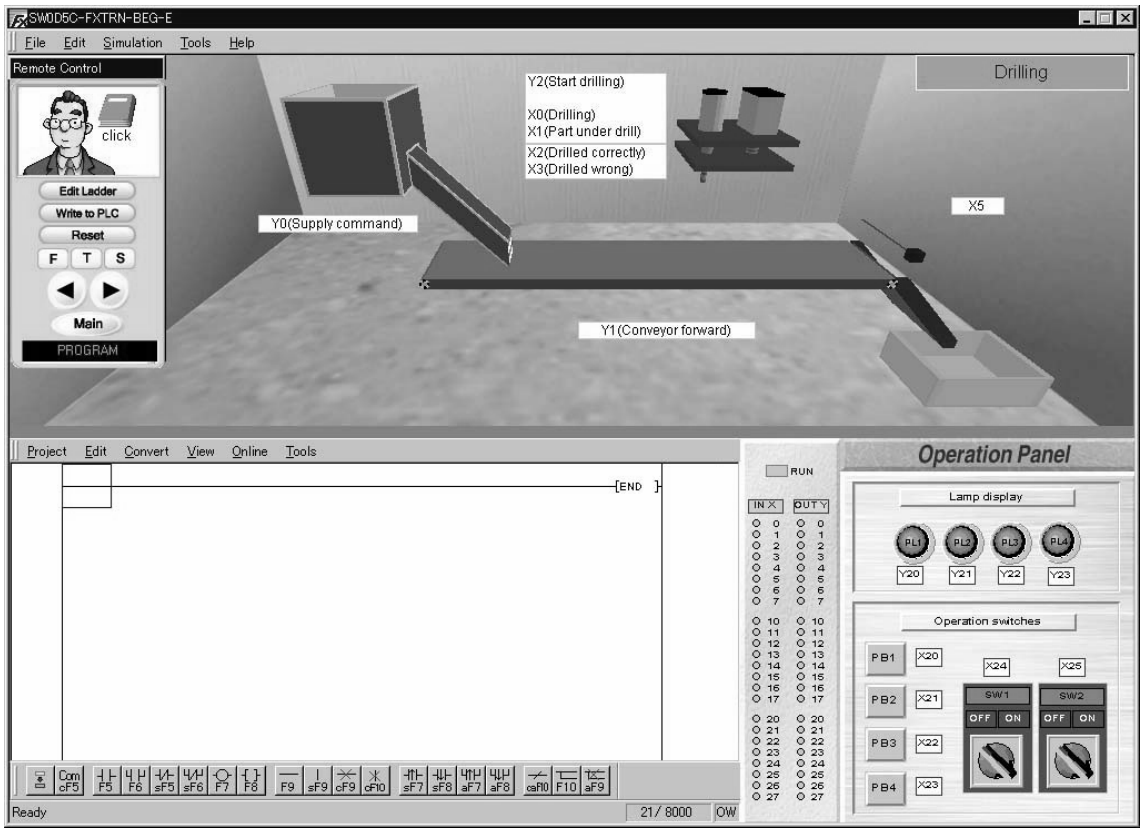
3) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y0) is turned ON and the [Supply allowed] indicator lamp is lit. The operator supplies a part.
   When [PB1] (X20) is released, the indicator lamp is extinguished.
   However, if a part is still located on the table, **Supply command** (Y0) is not turned ON so that the indicator lamp [Supply allowed] is not lit.

4) When **Part on table** (X1) is turned ON in the robot, **Unload command** (Y2) is set ON.
   When **Robot operation finished** (X2) is turned ON (it is ON when a part is placed on the tray), **Unload command** (Y2) is set OFF.
   Unload command (Y2) should be set ON only when the robot is at the starting point.

5.4 Drilling

Category	E: Intermediate Challenge
Exercise	E-4. Drilling
Objective	Control the drill and other devices.
Difficulty Level	2 (★★)
Score (Class)	210 (Intermediate programming)

5.4.1 Training Screen



5.4.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Drilling	ON while drilling.
	X1	Part under drill	ON when part is under the drill.
	X2	Drilled correctly	ON when part is drilled correctly. Previous result is cleared when drilling starts.
	X3	Drilled wrong	ON when part is not drilled correctly. Previous result is cleared when drilling starts.
	X5	Sensor	ON when part is detected at the right end.
Output	Y0	Supply command	One part is supplied when Y0 is ON. A process cycle begins: Large metal cube.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Start drilling	Starts drilling when Y2 is ON (A process cycle that cannot be stopped partway).

5.4.3 Control Objective

Drill holes in parts supplied from the hopper.

5.4.4 Control Specifications

Overall control

1) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y0) for the hopper is turned ON.
   When [PB1] (X20) is released, **Supply command** (Y0) is turned OFF.
   When **Supply command** (Y0) is turned ON, the hopper supplies a part.

2) When [SW1] (X24) on the operation panel is turned ON, the conveyor moves forward.
   When [SW1] (X24) is turned OFF, the conveyor stops.

Control of drill

1) When the sensor for **Part under drill** (X1) in the drill is turned ON, the conveyor stops.

2) When **Start drilling** (Y2) is turned ON, the drilling starts.
   Start drilling (Y2) is turned OFF when **Drilling** (X0) is set ON.

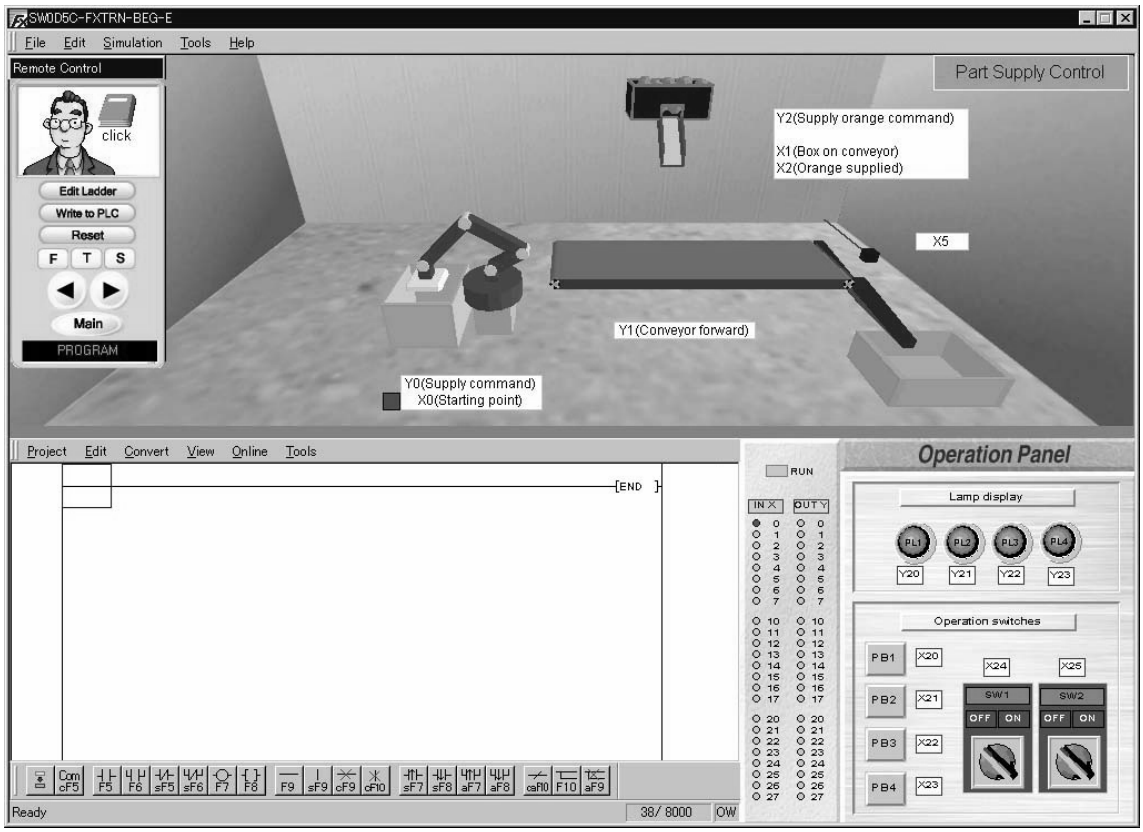
3) When **Start drilling** (Y2) is turned ON, either **Drilled correctly** (X2) or **Drilled wrong** (X3) is set ON after the drill machine has operated for one complete cycle.
   (The drill cannot be stopped in the middle of an operation.)

4) After **Drilled correctly** (X2) or **Drilled wrong** (X3) is confirmed, the work is carried and put on the tray at the right.
   When multiple holes are drilled, **Drilled wrong** (X3) is set ON. In this exercise no specified control for scrap parts exists.

5.5 Part Supply Control

Category	E: Intermediate Challenge
Exercise	E-5. Part Supply Control
Objective	Supply a specified number of parts according to the control specifications.
Difficulty Level	3 (★★★)
Score (Class)	240 (Intermediate programming)

5.5.1 Training Screen



5.5.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Starting point	ON when robot is at starting point.
	X1	Box on conveyor	ON when box is under orange feeder.
	X2	Orange supplied	ON when orange is detected (for counting).
	X5	Sensor	ON when part is detected at the right end.
Output	Y0	Supply command	One part is supplied when Y0 is ON. A process cycle begins: Large box.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Supply orange command	Oranges are supplied while Y2 is ON.

5.5.3 Control Objective

Place a specified number of oranges into a box located on the conveyor.

5.5.4 Control Specifications

Overall control

1) When [SW1] (X24) on the operation panel is turned ON, the conveyor moves forward.
   When [SW1] (X24) is turned OFF, the conveyor stops.

2) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y0) for the robot is turned ON.
   Supply command (Y0) is turned OFF when the robot has moved from the starting point.
   When **Supply command** (Y0) is turned ON, the robot supplies a box.

Control of oranges

1) When the sensor for **Box on conveyor** (X1) in the orange feeder is turned ON, the conveyor stops.

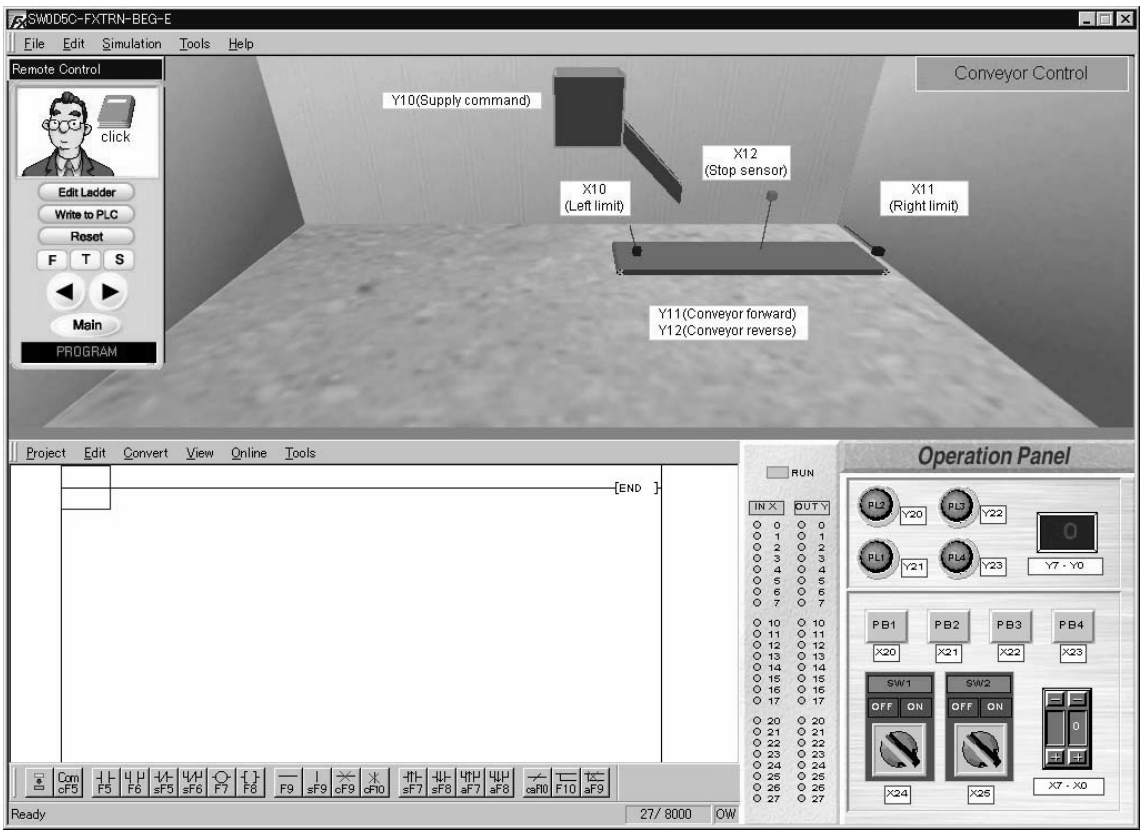
2) Five oranges are placed in the box.
   Boxes containing 5 oranges are carried to the tray at right.

3) Oranges are supplied when **Supply orange command** (Y2) is set ON and the number of oranges supplied are counted when **Orange supplied** (X2) is set ON.

5.6 Conveyor Control

Category	E: Intermediate Challenge
Exercise	E-6. Conveyor Control
Objective	Move the conveyor forward or backward according to the control specifications.
Difficulty Level	3 (★★★)
Score (Class)	240 (Intermediate programming)

5.6.1 Training Screen



5.6.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X10	Left limit	ON when part is detected at the left end.
	X11	Right limit	ON when part is detected at the right end.
	X12	Stop sensor	ON when part is detected.
Output	Y10	Supply command	One part is supplied when Y10 is ON. A process cycle begins.
	Y11	Conveyor forward	Conveyor moves forward when Y11 is ON.
	Y12	Conveyor reverse	Conveyor moves backward when Y12 is ON.

5.6.3 Control Objective

Move the conveyor forward or backward according to the control specifications.

5.6.4 Control Specifications

1) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y10) for the hopper is turned ON.
   When [PB1] (X20) is released, **Supply command** (Y10) is turned OFF.
   When **Supply command** (Y10) is turned ON, the hopper supplies a part.

2) When [PB2] (X21) on the operation panel is pressed, the conveyor is operated in a sequence as described in 3) to 6) below.
   If [PB2] (X21) is released, the sequence of operation continues.

3) The conveyor starts moving when **Conveyor forward** (Y11) is set ON and stops when **Right limit** (X11) for the part is turned ON.

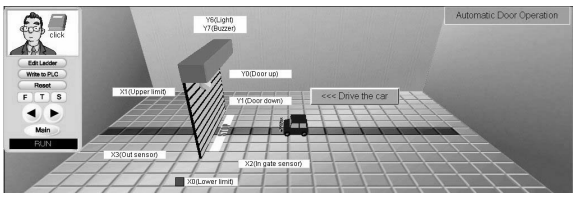
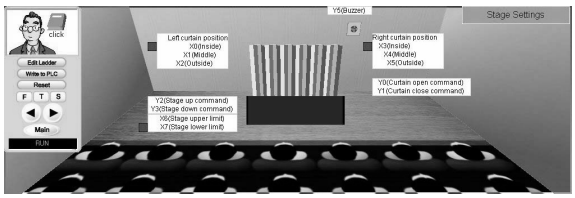
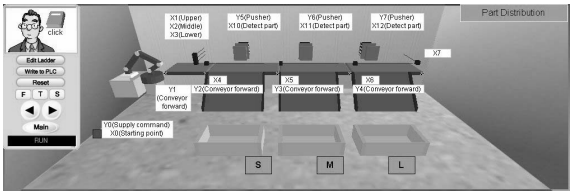
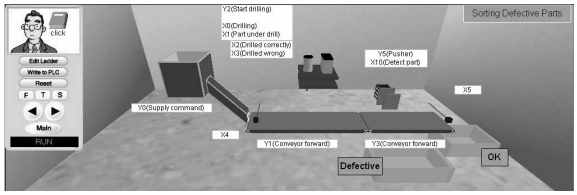
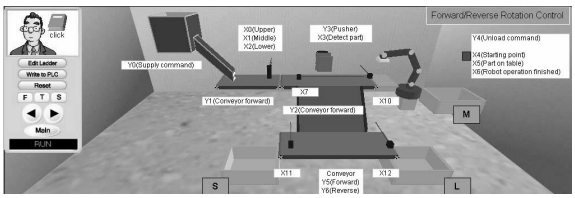
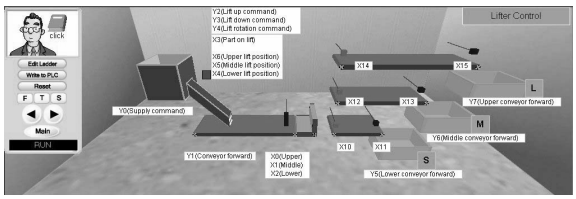
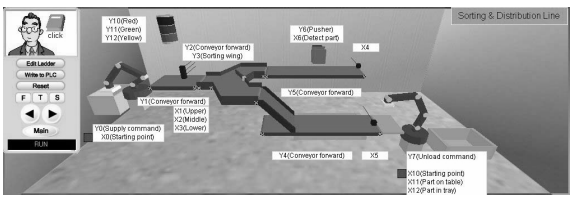
4) The conveyor moves in reverse when **Conveyor reverse** (Y12) is set ON until **Left limit** (X10) is turned ON.

5) The part stays at the left limit for 5 seconds.

6) 5 seconds later, **Conveyor forward** (Y11) is set ON and the conveyor moves until **Stop sensor** (X12) is turned ON.

MEMO

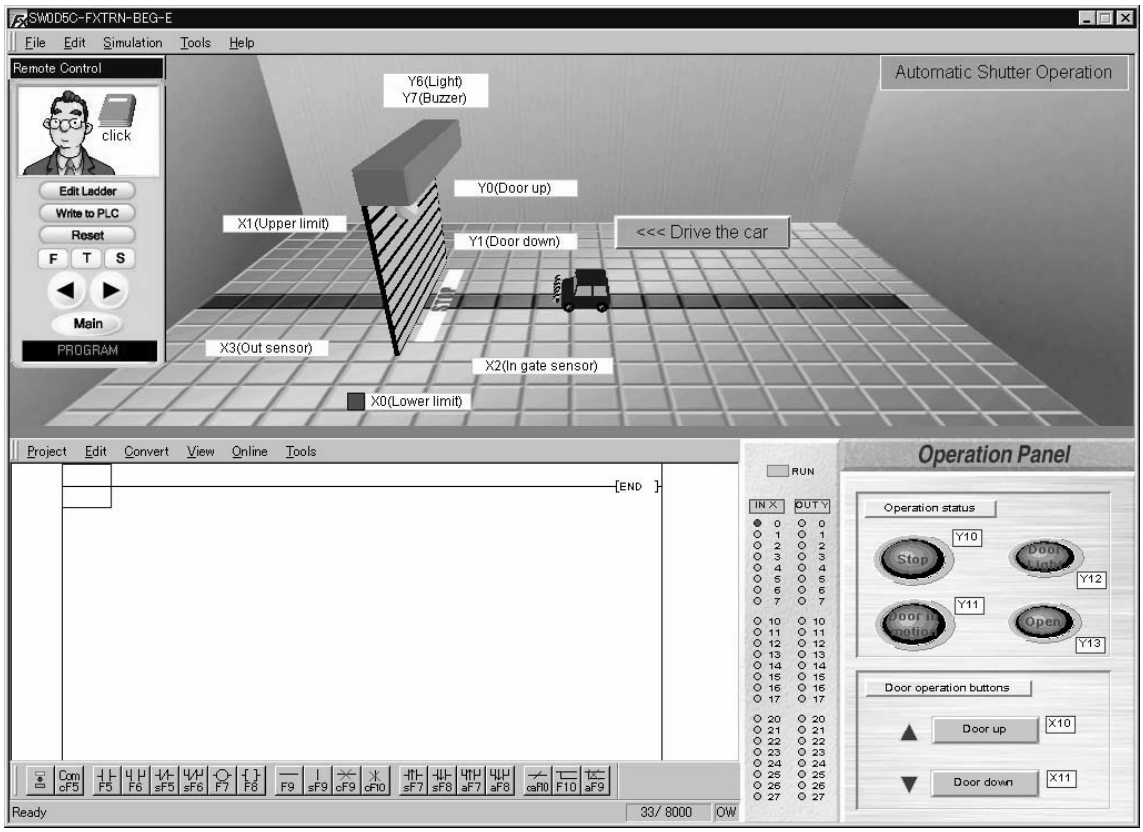
6. F: Advanced Challenge

F-1. Automatic Door Operation	F-2. Stage Settings
	
F-3. Part Distribution	**F-4. Sorting Defective Parts**
	
F-5. Forward/Reverse Rotation Control	**F-6. Lifter Control**
	
F-7. Sorting & Distribution Line	—
	—

6.1 Automatic Door Operation

Category	F: Advanced Challenge
Exercise	F-1. Automatic Door Operation
Objective	Control the door which opens or closes when detecting an object.
Difficulty Level	3 (★★★)
Score (Class)	290 (Advanced programming)

6.1.1 Training Screen



6.1.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Lower limit	ON when door reaches lower limit.
	X1	Upper limit	ON when door reaches upper limit.
	X2	In gate sensor	ON when object approaches the door.
	X3	Out sensor	ON when object leaves the door.
Output	Y0	Door up	Moves up when Y0 is ON.
	Y1	Door down	Moves down when Y1 is ON.
	Y6	Light	Lit when Y6 is ON.
	Y7	Buzzer	Sounds when Y7 is ON (Lamp on screen is lit).

6.1.3 Control Objective

Control the door which opens or closes when detecting a car.

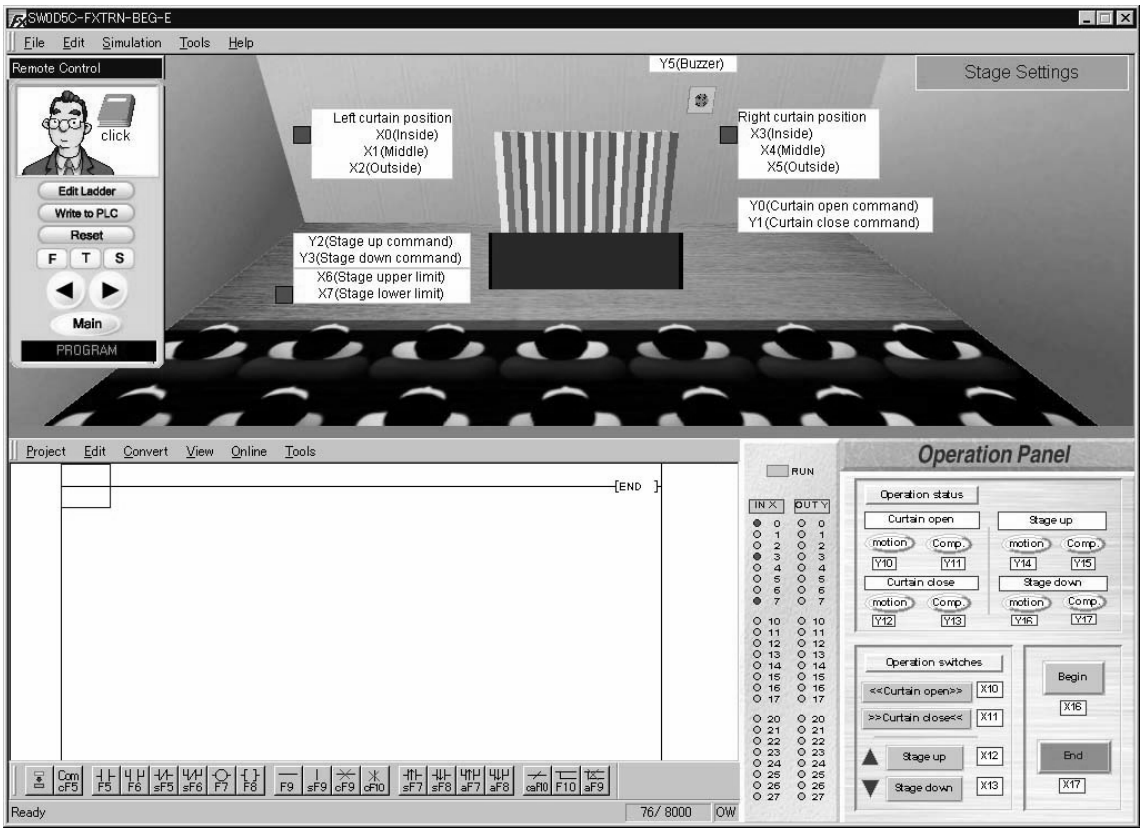
6.1.4 Control Specifications

1) When the car comes near the opening, the door moves up.
2) When the car passes through the door, the door moves down.
3) The door stops moving up when **Upper limit** (X1) is turned ON.
4) The door stops moving down when **Lower limit** (X0) is turned ON.
5) While the car is still in the detection range between **In gate sensor** (X2) and **Out sensor** (X3), the door will not move down.
6) **Buzzer** (Y7) sounds while the door is in motion.
7) **Light** (Y6) is lit while the car is in the detection range between **In gate sensor** (X2) and **Out sensor** (X3).
8) Four indicator lamps on the operation panel are lit or extinguished according to the movement of the door.
9) The door can be opened/closed manually by pressing the buttons [▲ Door up] (X10) and [▼ Door down] (X11) on the operation panel.

6.2 Stage Settings

Category	F: Advanced Challenge
Exercise	F-2. Stage Settings
Objective	Control stage settings according to the control specifications.
Difficulty Level	3 (★★★)
Score (Class)	290 (Advanced programming)

6.2.1 Training Screen



6.2.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Inside (Left curtain)	ON when curtain closes completely.
	X1	Middle (Left curtain)	ON when curtain is halfway.
	X2	Outside (Left curtain)	ON when curtain opens completely.
	X3	Inside (Right curtain)	ON when curtain closes completely.
	X4	Middle (Right curtain)	ON when curtain is on its half way.
	X5	Outside (Right curtain)	ON when curtain opens completely.
	X6	Stage upper limit	ON when stage reaches upper limit.
	X7	Stage lower limit	ON when stage reaches lower limit.

Type	Device No.	Device name	Operation
Output	Y0	Curtain open command	Curtains open when Y0 is ON. Curtains stop when Y0 is OFF.
	Y1	Curtain close command	Curtains close when Y1 is ON. Curtains stop when Y1 is OFF.
	Y2	Stage up	Stage moves up when Y2 is ON. Stage stops when Y2 is OFF.
	Y3	Stage down	Stage moves down when Y3 is ON. Stage stops when Y3 is OFF.
	Y5	Buzzer	Sounds when Y5 is ON (Lamp on screen is lit).

6.2.3 Control Objective

Control stage settings including opening/closing curtains and raising/lowering the stage.

6.2.4 Control Specifications

Specifications for automatic operation

1) When [Begin] (X16) on the operation panel is pressed, **Buzzer** (Y5) sounds for 5 seconds. [Begin] (X16) can be set ON only while the curtains are closed and the stage is located at the lower limit.
2) When the buzzer stops, **Curtain open command** (Y0) is set ON and the curtains are opened until they reach their outward limits (X2 and X5).
3) After the curtains are completely opened, the stage starts to move up when **Stage up** (Y2) is set ON and it is stopped when **Stage upper limit** (X6) is set ON.
4) When [End] (X17) on the operation panel is pressed, **Curtain close command** (Y1) is set ON and the curtains are closed until they reach their inward limits (X0 and X3).

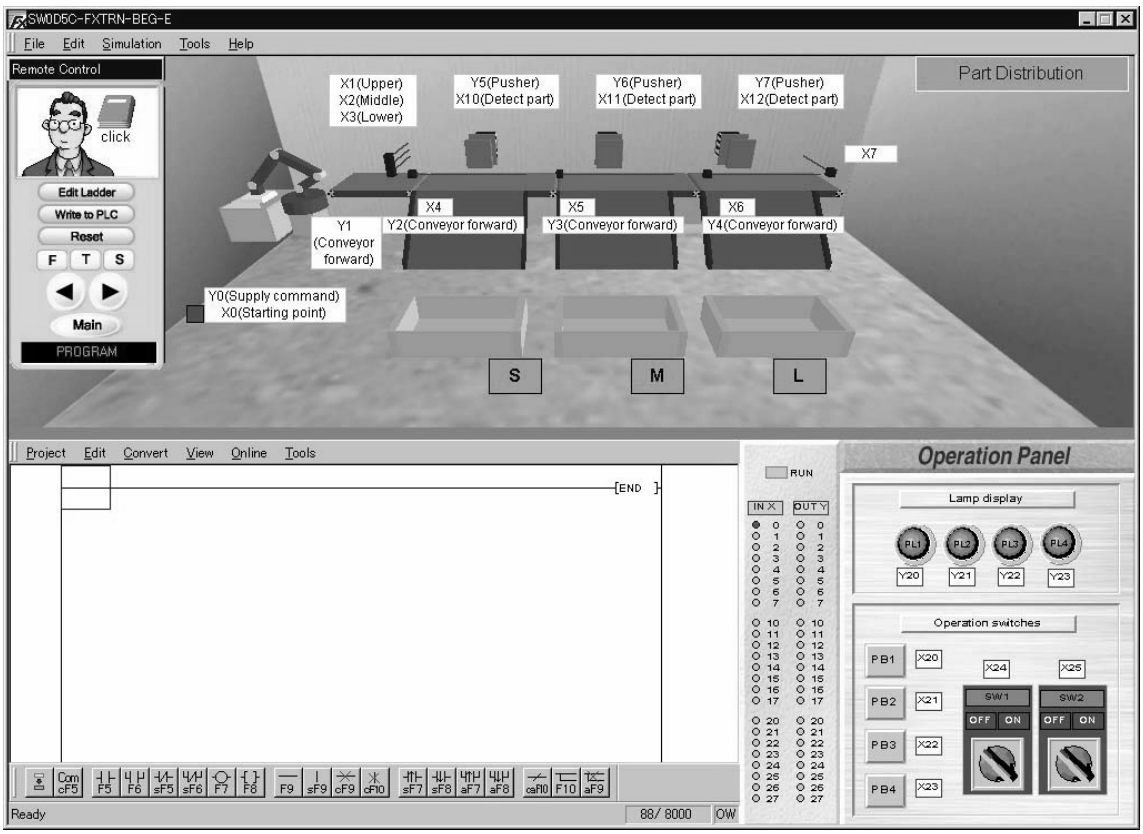
Specifications for manual operation

1) The following operations are enabled only while the automatic operation described above is not in operation.
2) The curtains can be opened only while [Curtain open] (X10) on the operation panel is being pressed. The curtains stop at their outward limits (X2 and X5).
3) The curtains can be closed only while [Curtain close] (X11) on the operation panel is being pressed. The curtains close until their inward limits (X0 and X3).
4) The stage can be moved up only while [▲ Stage up] (X12) on the operation panel is being pressed. The stage stops when it reaches the upper limit (X6).
5) The stage can be moved down only while [▼ Stage down] (X13) on the operation panel is being pressed. The stage stops when it reaches the lower limit (X7).
6) The indicator lamps on the operation panel are lit or extinguished according to the operation of the curtains and stage.

6.3 Part Distribution

Category	F: Advanced Challenge
Exercise	F-3. Part Distribution
Objective	Distribute the specified number of parts according to the size.
Difficulty Level	3 (★★★)
Score (Class)	290 (Advanced programming)

6.3.1 Training Screen



6.3.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Starting point	ON when robot is at starting point.
	X1	Upper	ON when part is detected.
	X2	Middle	ON when part is detected.
	X3	Lower	ON when part is detected.
	X4	Sensor	ON when part is detected on the incline.
	X5	Sensor	ON when part is detected on the incline.
	X6	Sensor	ON when part is detected on the incline.
	X7	Sensor	ON when part is detected at the right end.
	X10	Detect part	ON when part is detected in front of pusher.
	X11	Detect part	ON when part is detected in front of pusher.
	X12	Detect part	ON when part is detected in front of pusher.

Type	Device No.	Device name	Operation
Output	Y0	Supply command	One part is supplied when Y0 is ON. A process cycle begins: Wooden part repeats in order M, S, L, M, M, L, S, S, L, L.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Conveyor forward	Conveyor moves forward when Y2 is ON.
	Y3	Conveyor forward	Conveyor moves forward when Y3 is ON.
	Y4	Conveyor forward	Conveyor moves forward when Y4 is ON.
	Y5	Pusher	Extends when Y5 is ON and retracts when Y5 is OFF. The pusher cannot be stopped in the mid stroke.
	Y6	Pusher	Extends when Y6 is ON and retracts when Y6 is OFF. The pusher cannot be stopped in the mid stroke.
	Y7	Pusher	Extends when Y7 is ON and retracts when Y7 is OFF. The pusher cannot be stopped in the mid stroke.

6.3.3 Control Objective

Distribute the specified number of parts according to the size.

6.3.4 Control Specifications

1) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y0) for the robot is turned ON.
   Supply command (Y0) is turned OFF when the robot has finished moving the part and returned to the starting point.

2) When [SW1] (X24) on the operation panel is turned ON, the conveyors move forward.
   When [SW1] (X24) is turned OFF, the conveyors stop.

3) Large, medium and small parts on the conveyors are sorted by the input of sensors **Upper** (X1), **Middle** (X2) and **Lower** (X3) and carried to the specified trays.

4) When the sensor for **Detect part** (X10, X11 or X12) in the pusher is turned ON, the conveyor stops and the part is pushed onto the tray.

   Note: When the actuating command for the pusher is set ON, it extends completely.
   When the actuating command is set OFF, the pusher retracts.

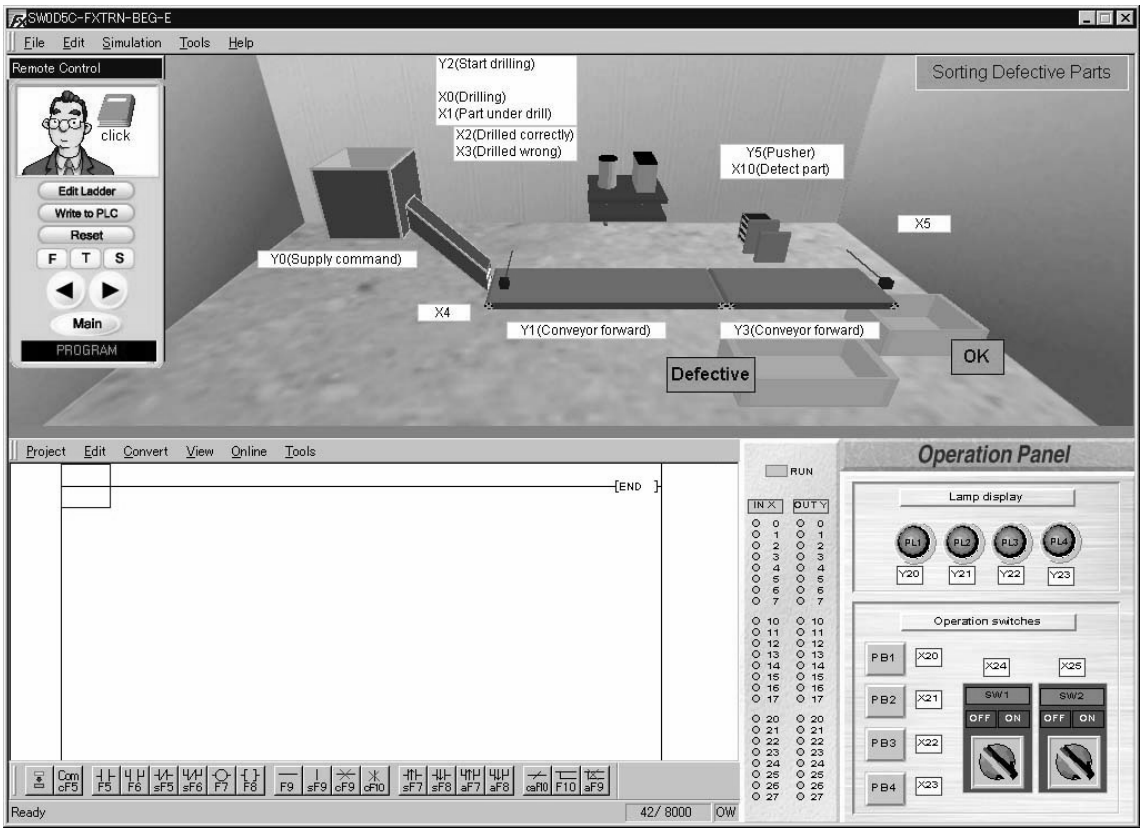
5) The following number of parts for each size are to be placed in the trays.
   Excess parts are to pass in front of the pushers and fall from the right end.

   - Large: 3 parts
   - Medium: 2 parts
   - Small: 2 parts

6.4 Sorting Defective Parts

Category	F: Advanced Challenge
Exercise	F-4. Sorting Defective Parts
Objective	Distinguish between defective parts and good parts by their signals.
Difficulty Level	3 (★★★)
Score (Class)	290 (Advanced programming)

6.4.1 Training Screen



6.4.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Drilling	ON while drilling.
	X1	Part under drill	ON when part on conveyor is detected by drill.
	X2	Drilled correctly	ON when part is drilled correctly. Previous result is cleared when drilling starts.
	X3	Drilled wrong	ON when part is not drilled correctly. Previous result is cleared when drilling starts.
	X4	Sensor	ON when part is detected at the left end.
	X5	Sensor	ON when part is detected at the right end.
	X10	Detect part	ON when part is detected in front of pusher.

Type	Device No.	Device name	Operation
Output	Y0	Supply command	One part is supplied when Y0 is ON: Large metal cube.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Start drilling	Starts drilling when Y2 is ON (A process cycle that cannot be stopped partway).
	Y3	Conveyor forward	Conveyor moves forward when Y3 is ON.
	Y5	Pusher	Extends when Y5 is ON and retracts when Y5 is OFF. The pusher cannot be stopped in the mid stroke.

6.4.3 Control Objective

Distinguish between defective parts and good parts by their signals and distribute them accordingly.

6.4.4 Control Specifications

Overall control

1) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y0) for the hopper is turned ON.
   When [PB1] (X20) is released, **Supply command** (Y0) is turned OFF.
   When **Supply command** (Y0) is turned ON, the hopper supplies a part.

2) When [SW1] (X24) on the operation panel is turned ON, the conveyors move forward.
   When [SW1] (X24) is turned OFF, the conveyors stop.

Control of drill

1) When the sensor for **Part under drill** (X1) in the drill is turned ON, the conveyor stops.

2) When **Start drilling** (Y2) is turned ON, the drilling starts.
   Start drilling (Y2) is turned OFF when **Drilling** (X0) is set ON.

3) When **Start drilling** (Y2) is turned ON, either **Drilled correctly** (X2) or **Drilled wrong** (X3) is set ON after the drill machine has operated for one complete cycle.
   (The drill cannot be stopped in the middle of an operation.)
   In this simulation, one out of three parts is to be a defective part.
   (When multiple holes are drilled on a part, it is also a defective part.)

4) When a defective part is detected by **Detect part** (X10) in the pusher, the conveyor stops and the pusher pushes it onto the 'Defective' tray.

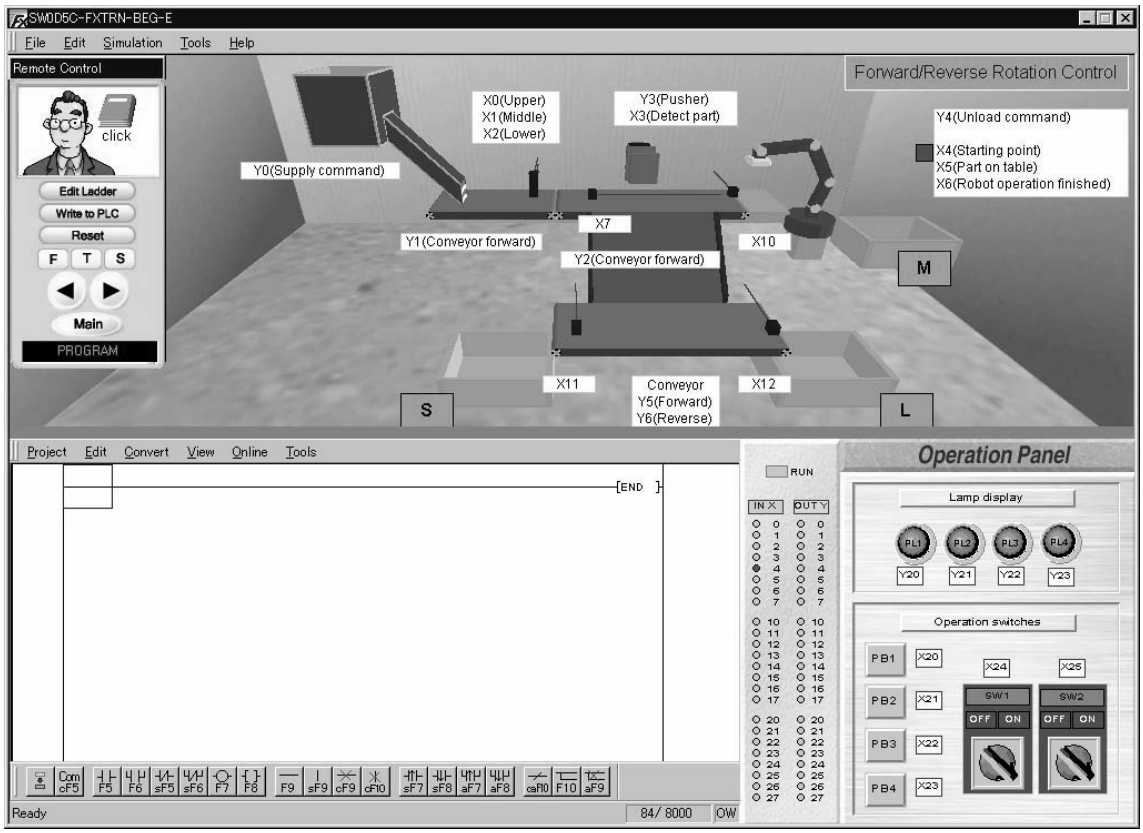
   Note: When the actuating command for the pusher is set ON, it extends completely.
   When the actuating command is set OFF, the pusher retracts completely.

5) A good part is carried on the conveyor to the 'OK' tray located at the right end.

6.5 Forward/Reverse Rotation Control

Category	F: Advanced Challenge
Exercise	F-5. Forward/Reverse Rotation Control
Objective	Move the conveyor forward or backward according to the detected size.
Difficulty Level	3 (★★★)
Score (Class)	290 (Advanced programming)

6.5.1 Training Screen



6.5.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Upper	ON when part is detected.
	X1	Middle	ON when part is detected.
	X2	Lower	ON when part is detected.
	X3	Detect part	ON when part is detected in front of pusher.
	X4	Starting point	ON when robot is at starting point.
	X5	Part on table	ON when part is on table.
	X6	Robot operation finished	ON when robot operation finished.
	X7	Sensor	ON when part is detected on the incline.
	X10	Sensor	ON when part is detected at the right end.
	X11	Sensor	ON when part is detected at the left end.
	X12	Sensor	ON when part is detected at the right end.

Type	Device No.	Device name	Operation
Output	Y0	Supply command	One part is supplied when Y0 is ON: Wooden part repeats in order L, M, S, M, S, L.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Conveyor forward	Conveyor moves forward when Y2 is ON.
	Y3	Pusher	Extends when Y3 is ON and retracts when Y3 is OFF. The pusher cannot be stopped in the mid stroke.
	Y4	Unload command	Robot moves part to tray when Y4 is ON. A process cycle begins.
	Y5	Conveyor forward	Conveyor moves forward when Y5 is ON.
	Y6	Conveyor reverse	Conveyor moves backward when Y6 is ON.

6.5.3 Control Objective

Detect the size of each part and distribute it to the specified place.

6.5.4 Control Specifications

1) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y0) for the hopper is turned ON.
   When [PB1] (X20) is released, **Supply command** (Y0) is turned OFF.
   When **Supply command** (Y0) is turned ON, the robot supplies a part.

2) When [SW1] (X24) on the operation panel is turned ON, the conveyors move forward.
   When [SW1] (X24) is turned OFF, the conveyors stop.

3) Large, medium and small parts on the conveyors are sorted by the input of sensors **Upper** (X0), **Middle** (X1) and **Lower** (X2) and carried to the specified trays.
   - Large part: Pushed to the lower conveyor and carried to the right tray.
   - Medium part: Moved to the tray by the robot.
   - Small part: Pushed to the lower conveyor and carried to the left tray.

4) When the sensor **Detect part** (X3) is turned ON, the conveyor stops and a large or small part is pushed to the lower conveyor.

   Note:When the actuating command for the pusher is set ON, it extends completely.
   When the actuating command is set OFF, the pusher retracts completely.

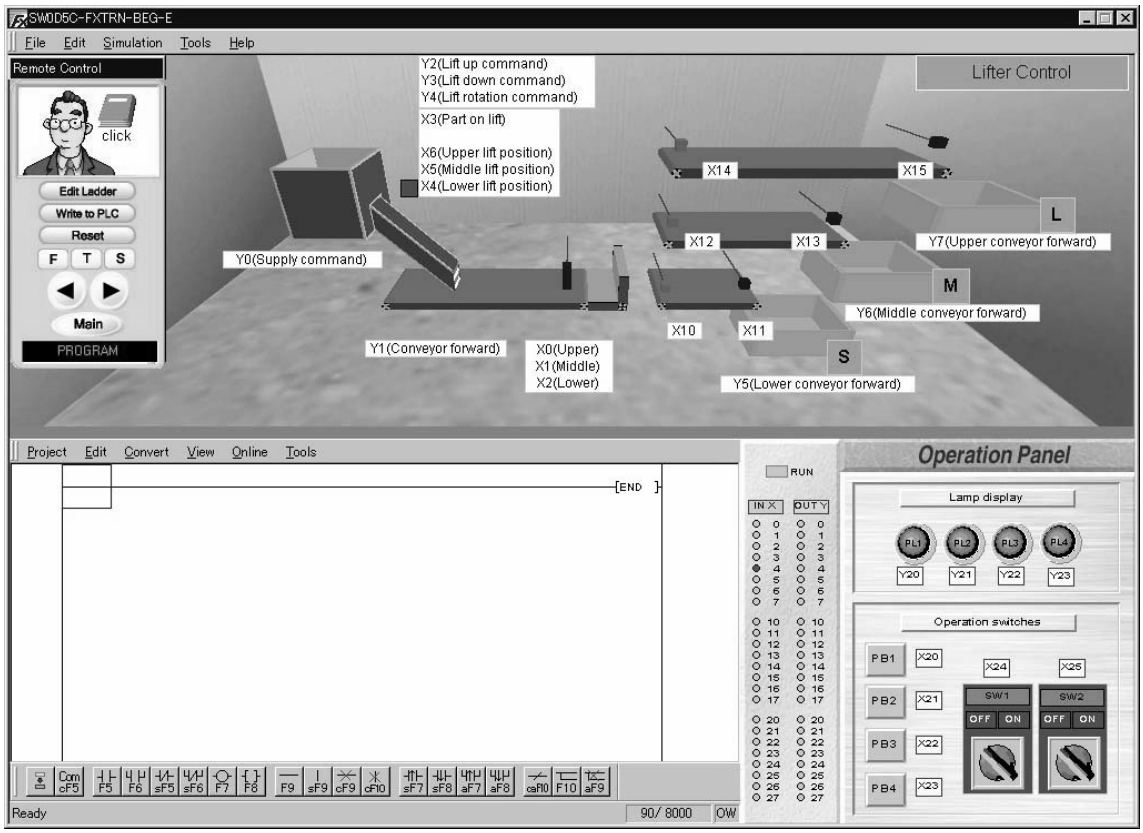
5) When **Part on table** (X5) is turned ON in the robot, **Unload command** (Y4) is set ON.
   When **Robot operation finished** (X6) is turned ON (it is ON when a part is placed on the tray), **Unload command** (Y4) is set OFF.

6) While [SW2] (X25) on the operation panel is ON, a new part is to be automatically supplied at the following time.
   - When the robot starts to carry a medium part
   - When a small or large part is put into a tray

6.6 Lifter Control

Category	F: Advanced Challenge
Exercise	F-6. Lifter Control
Objective	Carry parts to three positions using the lift.
Difficulty Level	3 (★★★)
Score (Class)	290 (Advanced programming)

6.6.1 Training Screen



6.6.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Upper	ON when part is detected.
	X1	Middle	ON when part is detected.
	X2	Lower	ON when part is detected.
	X3	Part on lift	ON when part is on the lift.
	X4	Lower lift position	ON when the lift is at lower position.
	X5	Middle lift position	ON when the lift is at middle position.
	X6	Upper lift position	ON when the lift is at upper position.
	X10	Sensor	ON when part is detected at the left end.
	X11	Sensor	ON when part is detected at the right end.
	X12	Sensor	ON when part is detected at the left end.
	X13	Sensor	ON when part is detected at the right end.
	X14	Sensor	ON when part is detected at the left end.
	X15	Sensor	ON when part is detected at the right end.

Type	Device No.	Device name	Operation
Output	Y0	Supply command	One part is supplied when Y0 is ON: Metal cylinder repeats in order S, L, M, L, M, S.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Lift up command	Lift moves up when Y2 is ON. Lift stops when Y2 is OFF.
	Y3	Lift down command	Lift moves down when Y3 is ON. Lift stops when Y3 is OFF.
	Y4	Lift rotation command	Lift rotates to transfer part to conveyor when Y4 is ON. Lifts rotates back to original position when Y4 is OFF.
	Y5	Lower conveyor forward	Conveyor moves forward when Y5 is ON.
	Y6	Middle conveyor forward	Conveyor moves forward when Y6 is ON.
	Y7	Upper conveyor forward	Conveyor moves forward when Y7 is ON.

6.6.3 Control Objective

Carry parts to three positions using the lift.

6.6.4 Control Specifications

Overall control

1) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y0) for the hopper is turned ON.
   When [PB1] (X20) is released, **Supply command** (Y0) is turned OFF.
   When **Supply command** (Y0) is turned ON, the hopper supplies a part.

2) When [SW1] (X24) on the operation panel is turned ON, the conveyors move forward.
   When [SW1] (X24) is turned OFF, the conveyors stop.

3) After the sensor X10, X12 or X14 at the left of conveyor has detected a part, the corresponding conveyor is set ON and carries it to the tray at the right end.
   The conveyor stops 3 seconds after a part has passed the sensor X11, X13 or X15 at the right of conveyor.

4) Large, medium and small parts on the conveyor are sorted by the input of sensors **Upper** (X0), **Middle** (X1) and **Lower** (X2).

Lift Control

1) When the sensor for **Part on lift** (X3) in the lift is turned ON, a part is carried to either of the following conveyors according to its size.
   - Large part : Upper conveyor
   - Medium part : Medium conveyor
   - Small part : Lower conveyor

2) **Lift up command** (Y2) and **Lift down command** (Y3) are controlled according to the lift position detected by the following sensors.
   - Upper : X6
   - Meddle: X5
   - Lower : X4

3) When a part is transferred from the lift to the conveyor, **Lift rotation command** (Y4) is set ON.

4) After a part is transferred, the lift is to return to the initial position and stand by.

6.7 Sorting & Distribution Line

Category	F: Advanced Challenge
Exercise	F-7. Sorting & Distribution Line
Objective	Sort each part to the specified place according to the size.
Difficulty Level	4 (★★★★)
Score (Class)	320 (Advanced programming)

6.7.1 Training Screen

6.7.2 Device Assignment

Type	Device No.	Device name	Operation
Input	X0	Starting point (Supply)	ON when supplying robot is at start point.
	X1	Upper	ON when part is detected.
	X2	Middle	ON when part is detected.
	X3	Lower	ON when part is detected.
	X4	Sensor	ON when part is detected at the right end.
	X5	Sensor	ON when part is detected at the right end.
	X6	Detect part	ON when part is detected in front of pusher.
	X10	Starting point (Unload)	ON when unloading robot is at start point.
	X11	Part on table	ON when part is on table.
	X12	Robot operation finished	ON when robot operation finished.

Type	Device No.	Device name	Operation
Output	Y0	Supply command	One part is supplied when Y0 is ON. A process cycle begins: Wooden part repeats in order S, M, L, S, L, M.
	Y1	Conveyor forward	Conveyor moves forward when Y1 is ON.
	Y2	Conveyor forward	Conveyor moves forward when Y2 is ON.
	Y3	Sorting wing	Moves toward front when Y3 is ON.
	Y4	Conveyor forward	Conveyor moves forward when Y4 is ON.
	Y5	Conveyor forward	Conveyor moves forward when Y5 is ON.
	Y6	Pusher	Extends when Y6 is ON and retracts when Y6 is OFF. The pusher cannot be stopped in the mid stroke.
	Y7	Unload command	Robot moves part to tray when Y7 is ON. A process cycle begins.
	Y10	Red	Lit when Y10 is ON.
	Y11	Green	Lit when Y11 is ON.
	Y12	Yellow	Lit when Y12 is ON.

6.7.3 Control Objective

Detect the part size, and sort each part to the specified place according to the size.

6.7.4 Control Specifications

1) When [PB1] (X20) on the operation panel is pressed, **Supply command** (Y0) for the robot is turned ON.
   Supply command (Y0) is turned OFF when the robot has finished moving the part and returned to the starting point.
   When **Supply command** (Y0) is turned ON, the robot supplies a part.
2) When [SW1] (X24) on the operation panel is turned ON, the conveyors move forward.
   When [SW1] (X24) is turned OFF, the conveyors stop.
3) Large, medium and small parts on the conveyors are sorted by the input of sensors **Upper** (X1), **Middle** (X2) and **Lower** (X3) and carried to the specified trays.
   - Large part : Led to the rear conveyor when **Sorting wing** (Y3) of the branch conveyor is set ON and then carried on the conveyor and dropped from the right end.
   - Medium part: Led to the front conveyor when **Sorting wing** (Y3) of the branch conveyor is set OFF and then moved onto the tray by the robot.
   - Small part : Led to the rear conveyor when **Sorting wing** (Y3) of the branch conveyor is set ON.
     When the sensor for **Detect part** (X6) in the branch conveyor is turned ON, the conveyor stops and the part is pushed onto the tray.
4) When **Part on table** (X11) is turned ON in the robot, **Unload command** (Y7) is set ON.
   When **Robot operation finished** (X12) is turned ON (it is ON when a part is placed on the tray), **Unload command** (Y7) is set OFF.
5) While [SW2] (X25) on the operation panel is ON, a new part is to be automatically supplied at the following time.
   - When the robot starts to carry a medium part.
   - When a small part is put into the tray, or when a large part is dropped from the right end of the conveyor.
6) The flashing lights are lit as follows.
   - Red : Lit while the robot is supplying a part.
   - Green : Lit while the conveyor is moving.
   - Yellow : Lit while the conveyor is stopped.

MEMO

LADDER PROGRAMS

The method to write a PLC program in the ladder program area is explained in this section. The key operations are mostly the same as those in GX Developer, the FX Series Programming Software.

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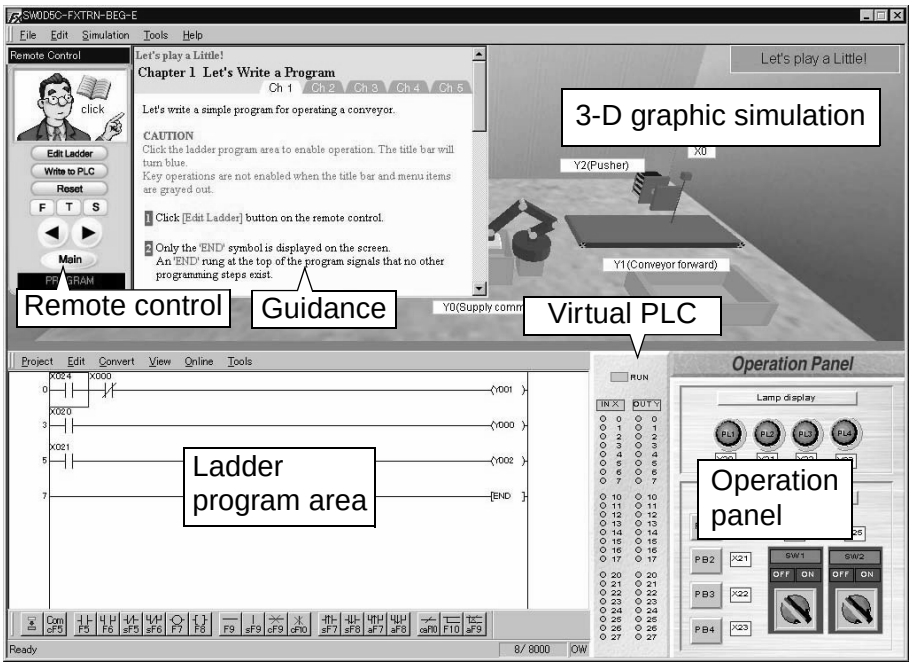
1. Outline

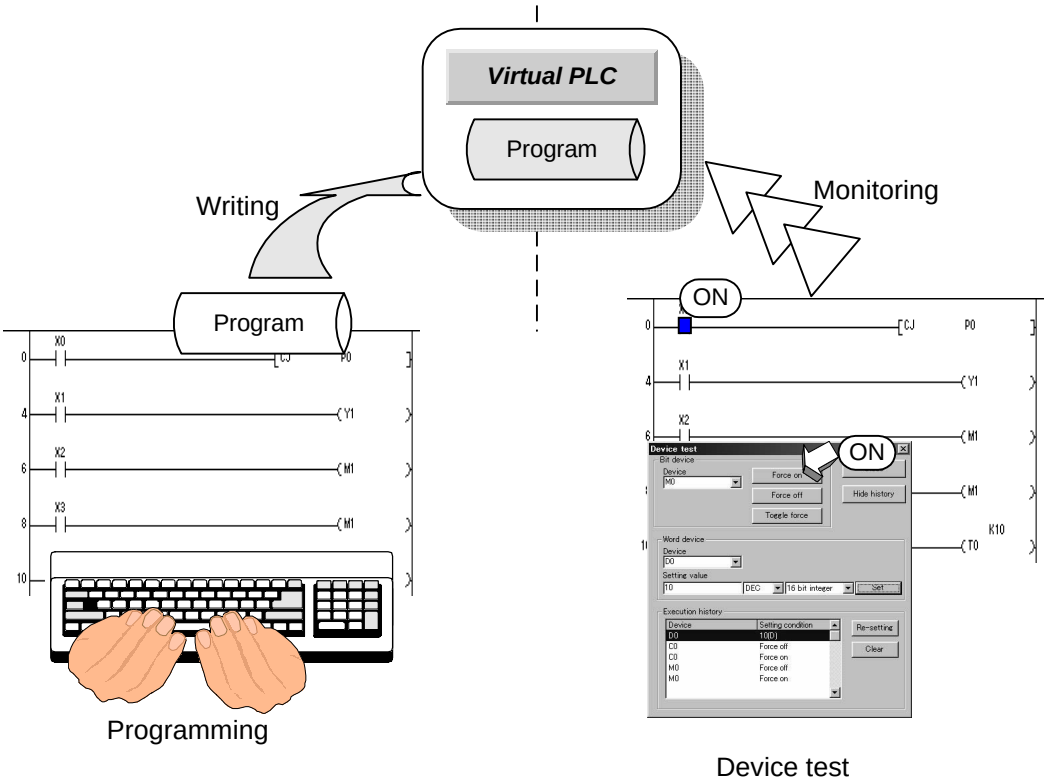
The learning software consists of the 3-D graphic simulation, the ladder program area and the operation panel. This section explains how to use the ladder.



Click [Edit Ladder] on the remote control to activate the ladder program area.
(Refer to 3.4.)

1.1 Role of ladder tool

In the ladder program creates, area, you write, edit and monitor ladder programs. Machines in the simulation are operated by the ladder programs you create here.



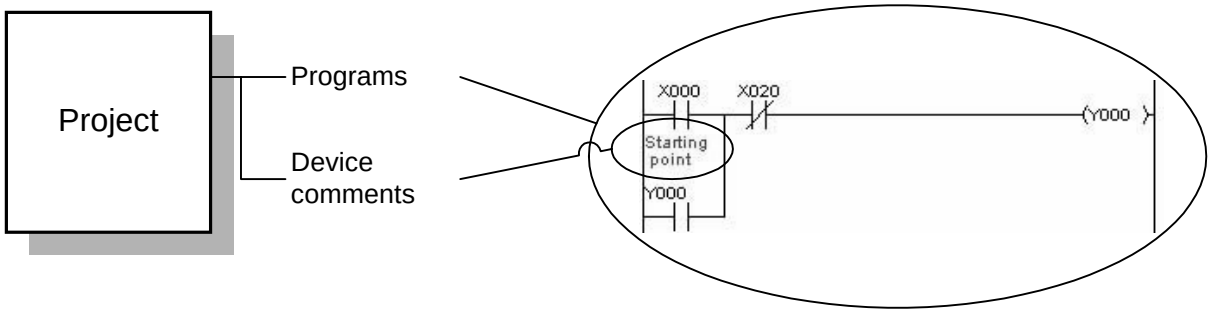
MEMO

2. Preparation befor Operating

This chapter explains the basic knowledge required before creating ladder programs by using the ladder tool.

2.1 What is a Project

A project consists of programs and device comments.



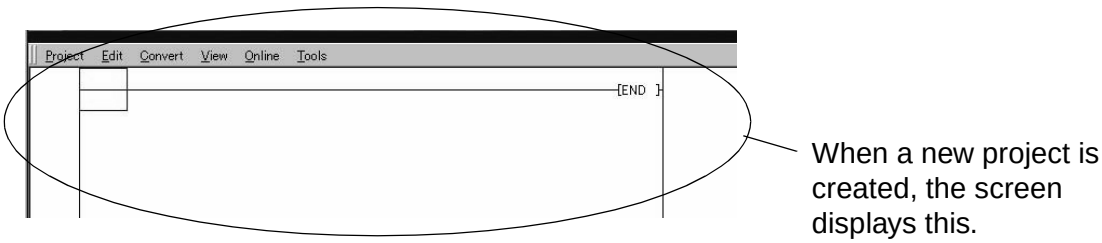
Item	Description
Program	Program to operate the CPU of the PLC
Device comment	Comment on device

2.2 Creating and Saving Project

2.2.1 Creating a new project

1) Select "Project" → "New project".

2) A new project is created.

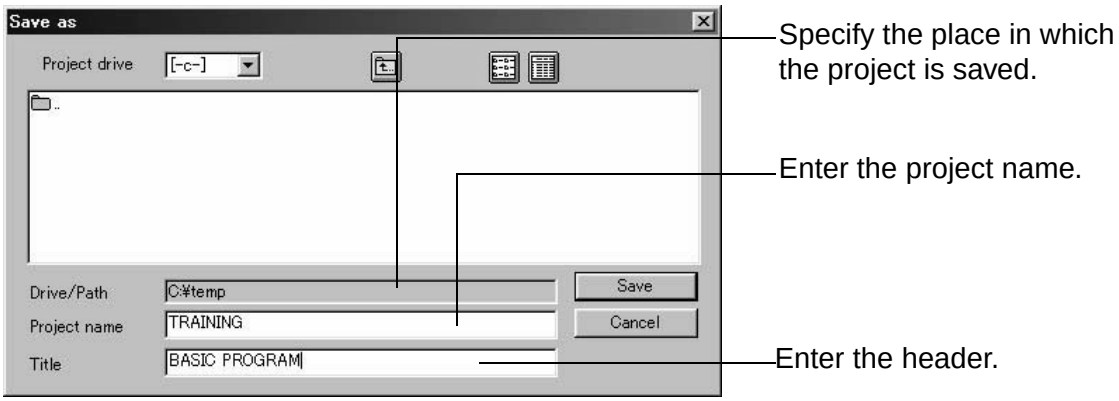


2.2.2 Saving of a Project with a Different Name

1) Select "Project" → "Save as".

2) The screen shown below is displayed.

Enter the project name and the header, then click the [Save] button.



2.2.3 Overwriting of a project

1) Select "Project" → "Save".

2) The open project is overwritten with the contents displayed on the screen.

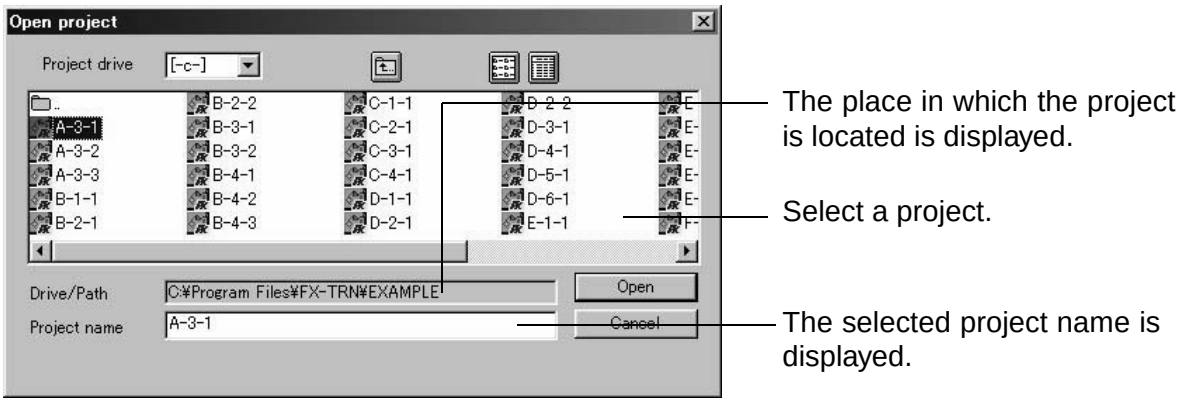
When "Save" is selected for the first time since the project is created, the 'Save as' dialog box is displayed in the same way as explained above.

2.3 Opening a project

Open an existing project from a floppy disk or hard disk.

1) Select "Project" → "Open project".

2) When the 'Open' dialog box is displayed, select a project to open.



You can open only one project at a time. If you try to open another project while editing a project, the message is displayed asking if you want to save it.

POINT

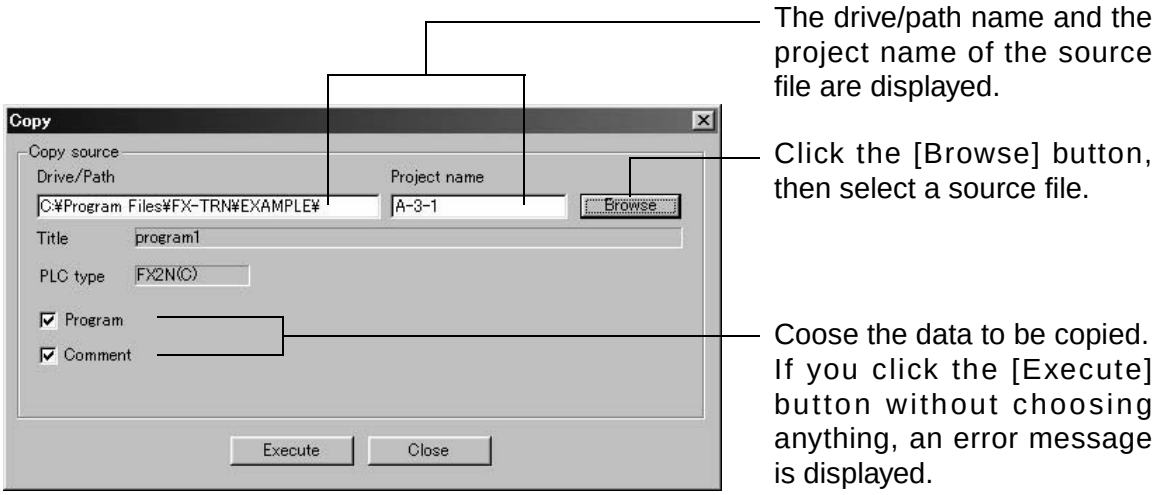
For reading and handling of model answers, refer to the 'Introduction Section' in this manual.

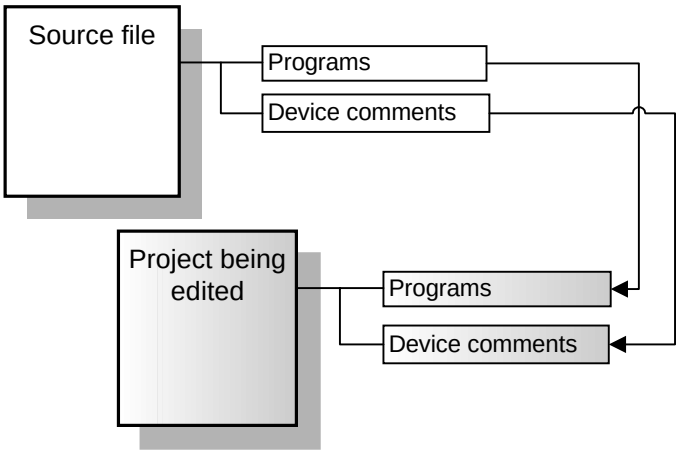
2.4 Copying a project

You can copy the data (programs and comments) of another project to the currently open project.

1) Select "Project" → "Copy". The 'Copy' dialog box is displayed.

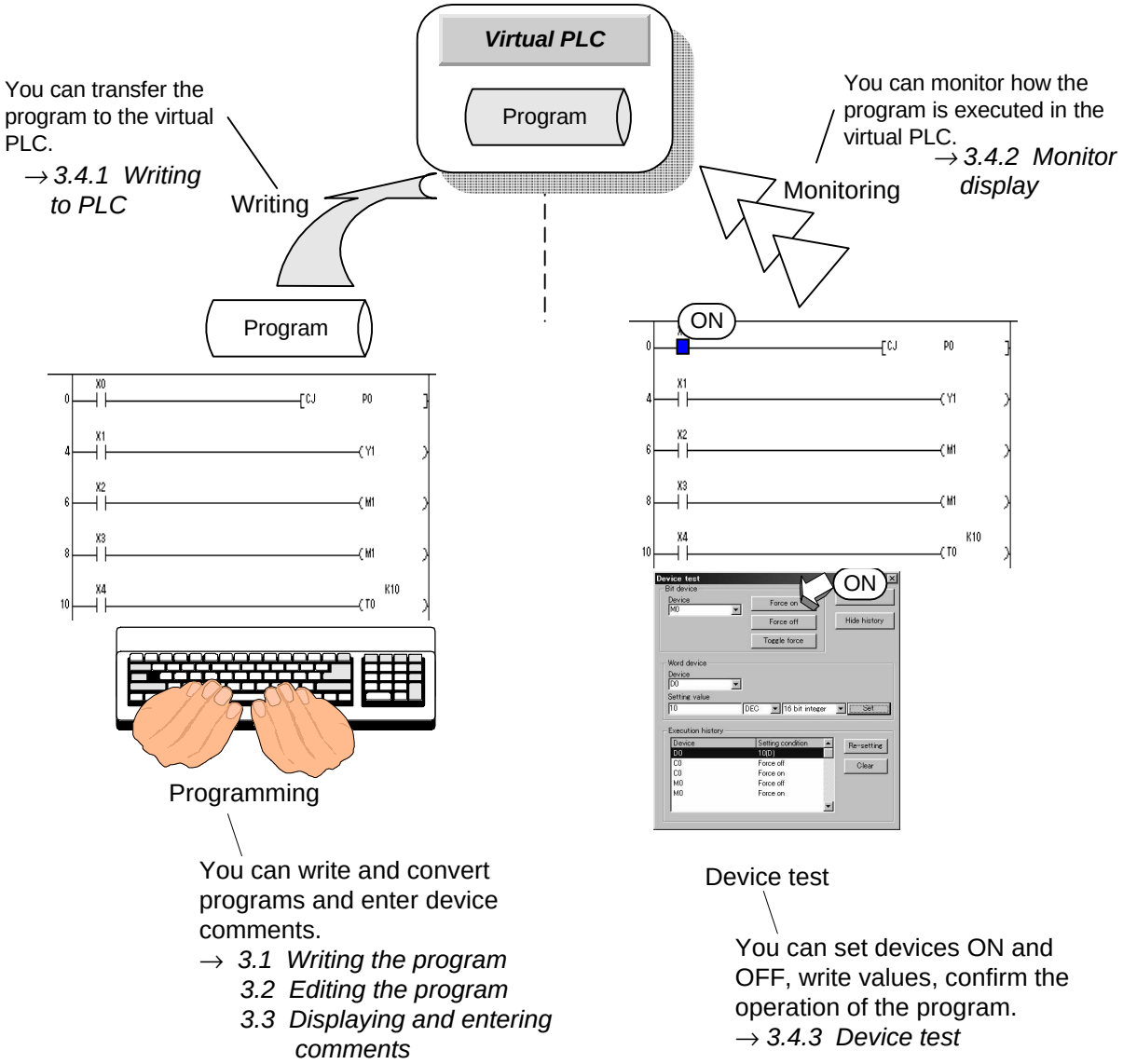
2) Select a source file and the data to be copied, then click the [Execute] button.





3. Operation

This chapter explains how to perform programming, online operations and printing.

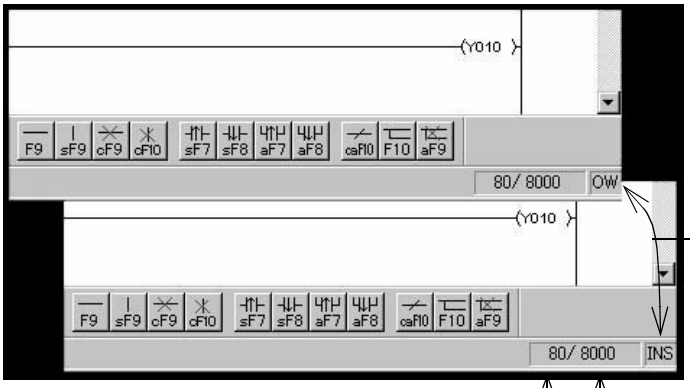


3.1 Writing the program

The program can be writen or edited in the overwrite mode or in the insert mode. Choose the mode as follows.

1) Press the [Insert] key.

2) Every time you press the [Insert] key, the overwrite mode and the insert mode are changed over alternately. The currently selected mode is indicated on the status bar.



Check the current mode here.

Number of steps programmed

Program capacity (8000 steps)

3.1.1 Basic instruction

This is how to write basic instructions.
When writing a basic instruction, specify a symbol pressing a function key, the device number and the set value.

- How to write NO contact

(1) Place the cursor where you write an NO contact.

(2) Press the [F5] key. The 'Enter symbol' dialog box is displayed.

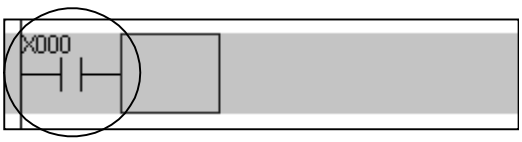
(3) Type a device, and click the [OK] button.

If you click this button, the dialog box will not be closed after you finish writing a program. You can continue writing.

Type a device.

The instruction symbol to be written on the screen is displayed.

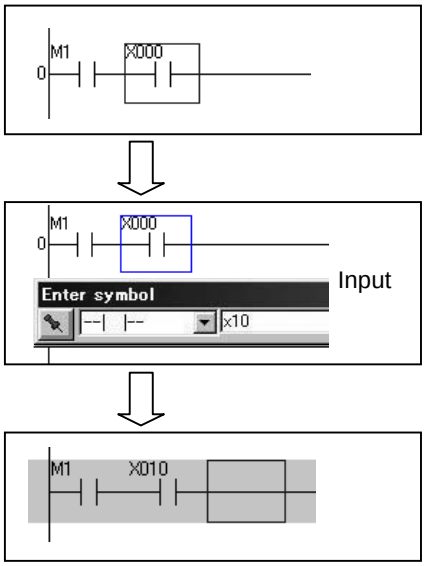
NO contact is written. After the program is written, the background is displayed in gray.



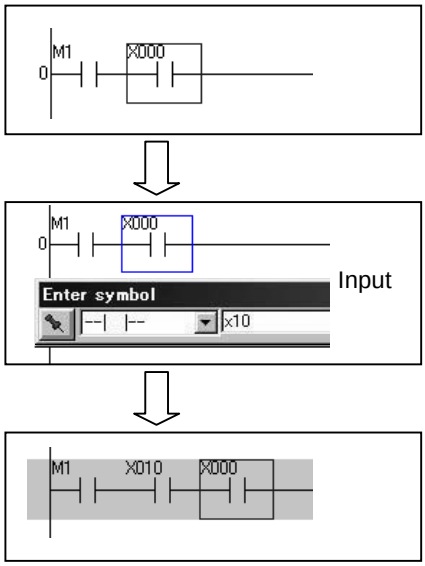
POINT

If you write a program placing a cursor on a program symbol already written, the results differ as shown below depending on the mode.

Overwrite mode

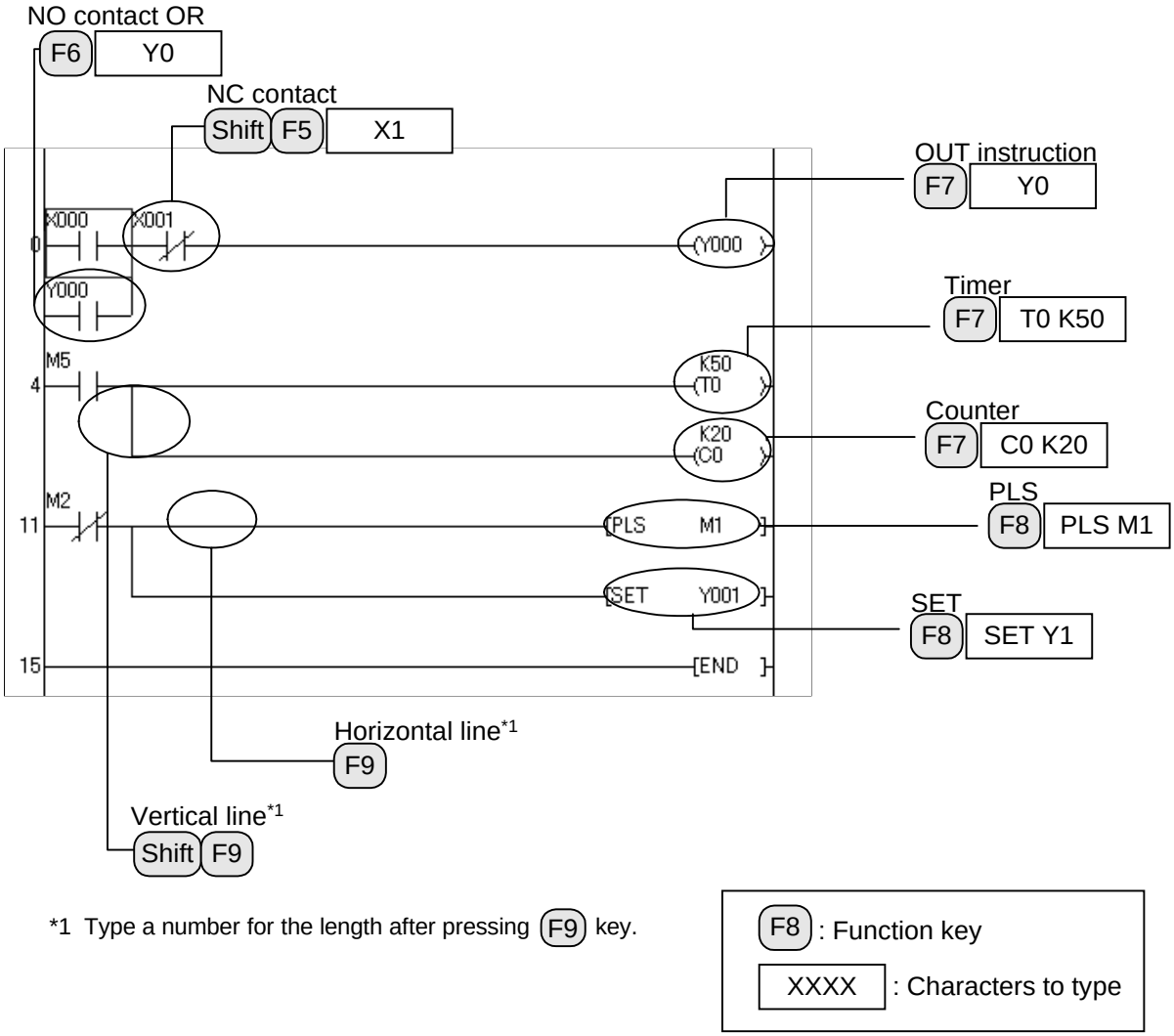


Insert mode



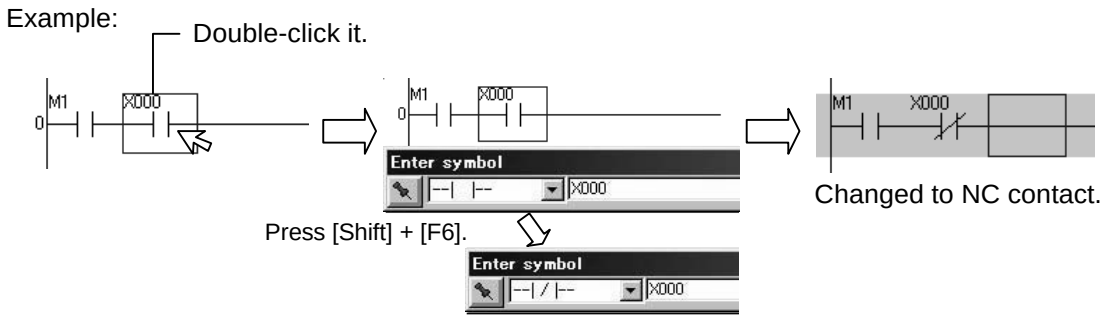
- How to write basic instructions

  The figure below shows the function keys, the device numbers and the set values for basic instructions.



POINT

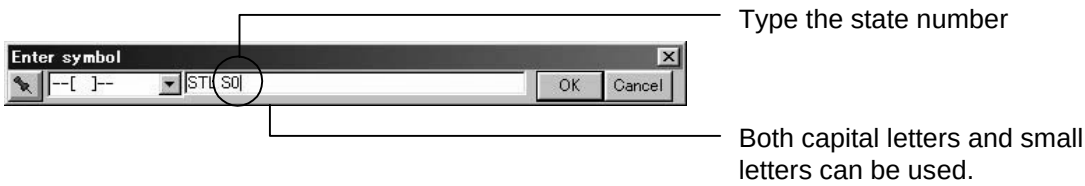
- If you double-click a contact, the instruction symbol and the device entered are displayed in the dialog box 'Enter symbol'.
  The contact data can be changed.



- You can input basic instructions not only by pressing the function keys but also by typing letters. For its method, refer to the Appendix 1.2.

3.1.2 Writing STL Instruction

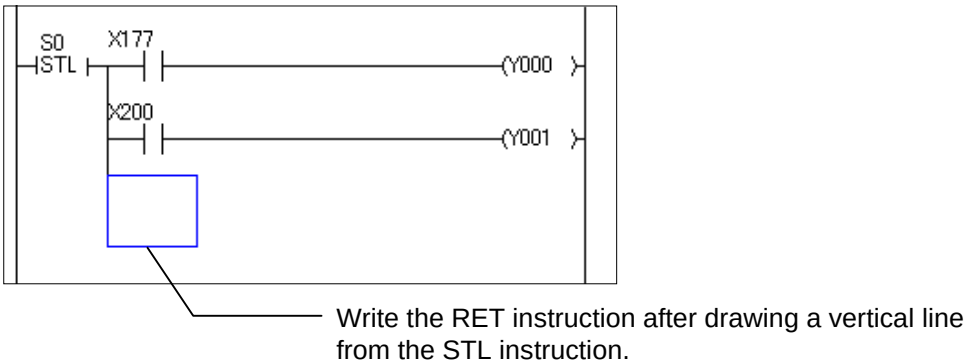
1) Place the cursor where the STL instruction is to be written.
2) Press the [F8] key. The 'Enter symbol' dialog box is displayed.
3) Type STL S0.



4) Click the [OK] button.

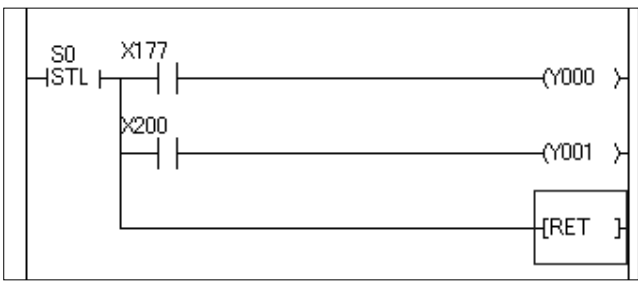
Writing the RET instruction.

1) Draw a vertical line from the STL symbol and place the cursor where the RET instruction is to be written.



2) Press the [F8] key. The 'Enter symbol' dialog box is displayed.
3) Type RET.

4) Click the [OK] button.



3.1.3 Application instruction

The following is how to input application instructions.
The MOV instruction and the LD= instruction are explained up as examples.

- MOV instruction

1) Place the cursor where the MOV instruction is to be written.
   Press the [F8] key. The 'Enter symbol' dialog box is displayed.
   Type MOV K100 D0.

2) Click the [OK] button.

Write the MOVP instruction and the DMOVP instruction as follows.

MOVP instruction

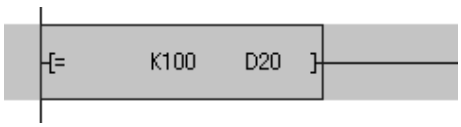
DMOVP instruction

- LD= instruction

1) Place the cursor where the LD= instruction is to be written.
   Press the [F8] key. The 'Enter symbol' dialog box is displayed.
   Type LD= K100 D20.

Both capital letters and small letters can be used.

2) Click the [OK] button.



POINT

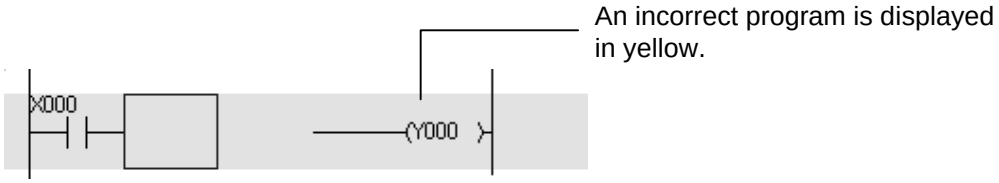
For the list of available instructions and input procedures, refer to the Appendix 1.

3.1.4 Conversion

The programs you write should be converted into the form which can be processed by the virtual PLC.
This is how to convert them.

1) After writing the programs, press the [F4] key.

2) The programs are converted. The background of the programs should be displayed in white. If there is an incorrect program, an error message is displayed and the part is displayed in yellow. Correct the program.



POINT

Programs you write are determined when they are converted.

3.2 Editing the Program

3.2.1 Insert and Delete

- Insert line and delete line

  Insert a line as follows.

  1) Place the cursor where a line is to be inserted.
  2) Press the [Shift] + [Insert] keys.
     One line is inserted in the cursor position.

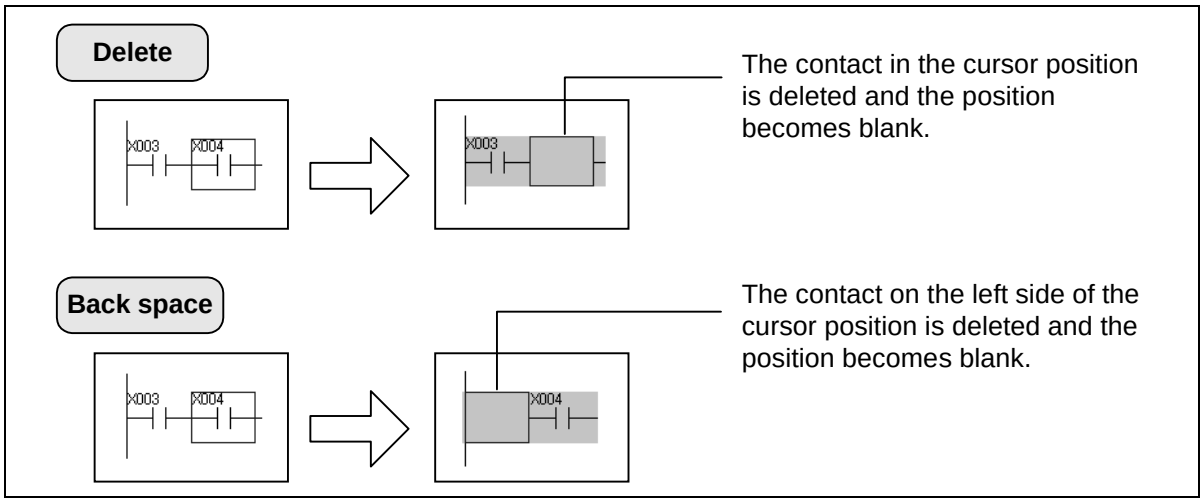
  Delete a line as follows.

  1) Place the cursor where a line is to be deleted.
  2) Press the [Shift] + [Delete] keys.
     One line is deleted in the cursor position.

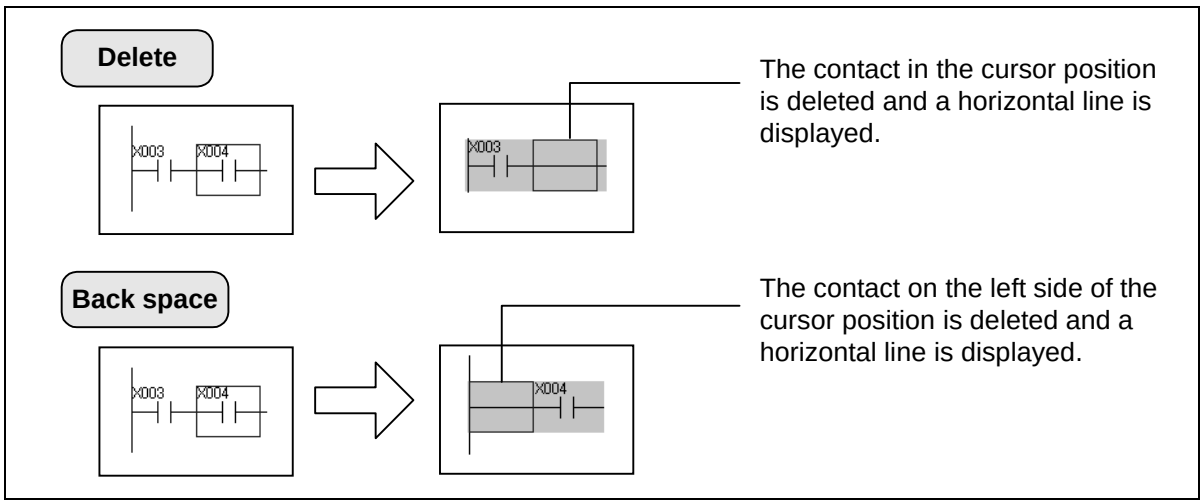
- Deleting contacts

  Delete a contact pressing the [Delete] or [Back space] key.
  The result displayed on the screen differs depending on the mode as shown below.

Overwrite mode



Insert mode

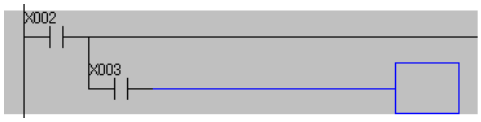


- Writing and deleting ines

  Write ruler lines as follows.

  1) Press the [F10] key first.

  2) When writing a horizontal line, press the [Shift] + [→] keys to move the cursor. When writing a vertical line, press the [Shift] + [↓] keys to move the cursor.



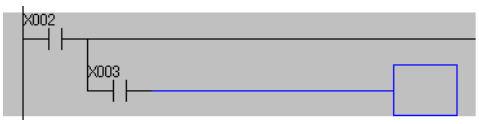
Shift + →

  3) When you release the [Shift] key, a horizontal or vertical line is written.

  Delete lines as follows.

  1) Press the [Alt] + [F9] keys first.

  2) When deleting a horizontal line, press the [Shift] + [→] keys to move the cursor. When deleting a vertical line, press the [Shift] + [↓] keys to move the cursor.



Shift + →

  3) When you release the [Shift] key, a horizontal or vertical line is deleted.

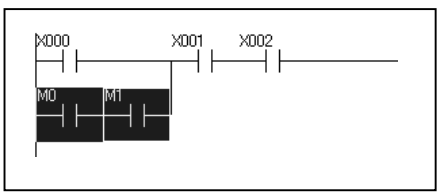
POINT

Only horizontal and vertical lines can be deleted using this method. Even if you operate the above explained procedure on a contact, the contact is not deleted.

3.2.2 Cut, Copy and Paste

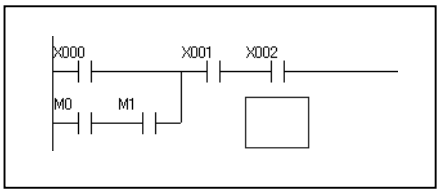
The method to cut, copy and paste a program is explained here.
You can efficiently edit programs using these functions.

1) Press the [Shift] + [→] keys to select the range to be cut or copied.



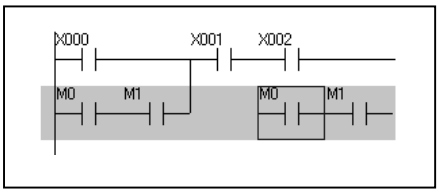
2) Select "Edit" → "Cut" or "Edit" → "Copy".

3) Move the cursor to the position where the selected range is to be pasted, then select "Edit" → "Paste".

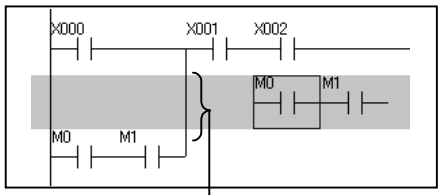


4) The paste result is different between the overwrite mode and the insert mode as shown below.

Overwrite mode



Insert mode



The vertical line is extended.

3.2.3 Undo

- Return to the former status

  After you write, insert, delete, cut or paste a program, you can undo the operation to return to the former status.

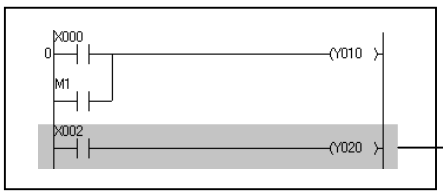
  1) After performing those operations, select "Edit" → "Undo".

     * You can undo up to ten operations. However, you cannot delete comments by "Undo".

- Return to the status after circuit conversion

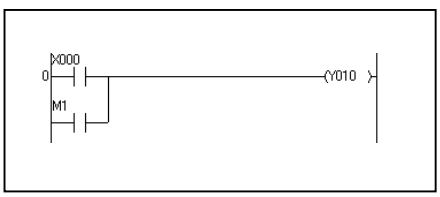
  You can delete the programs currently being edited, and return to the status immediately after the previous conversion.

  1) A program is edited.



Newly created circuit

  2) Select "Edit" → "Restore after ladder conversion". When the confirmation dialog box is displayed, click [Yes]. The program edited in 1) is deleted and the screen returns to the status just after the previous conversion.



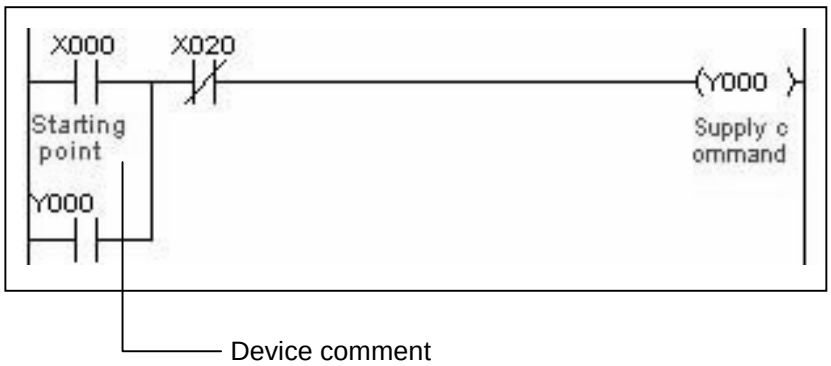
3.3 Display and input of comments

This chapter explains how to display and input device comments.

3.3.1 Display of comments

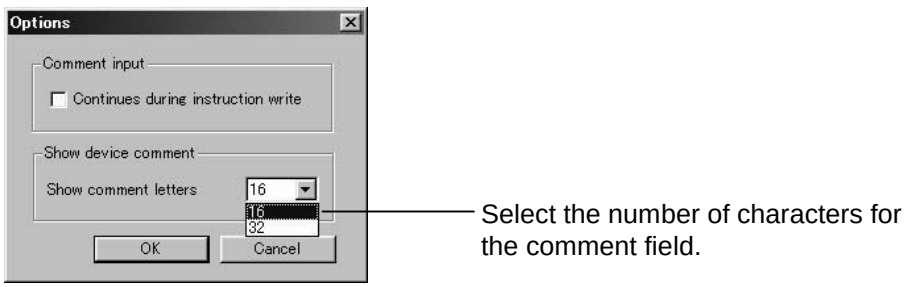
The following is how to display device comments for devices in the program being edited.

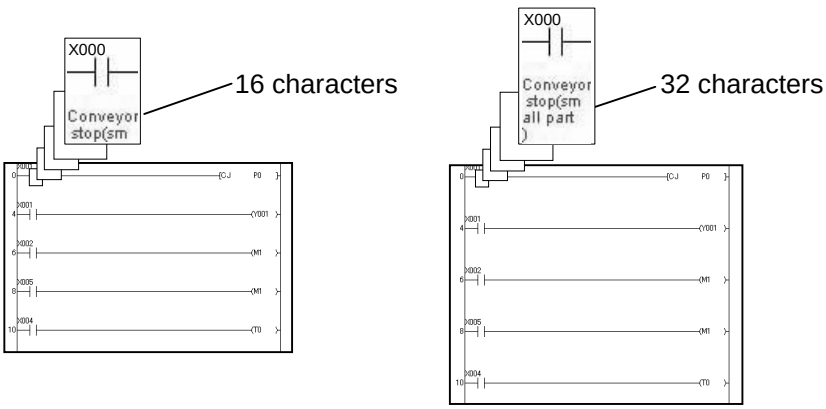
- Displaying a comment
  1) Select "View" → "Comment".
  2) Comments are displayed.



- Changing the number of characters for device comments

  You can select the number of characters of each displayed device comment between 16 and 32. When changing the number of displayed characters, follow the below procedure.
  1) Select "Tools" → "Options".
  2) When the 'Options' dialog box is displayed, select 16 or 32 at 'Show device comment'.



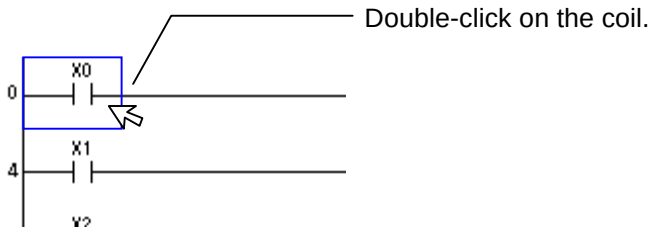


3.3.2 Input of comments

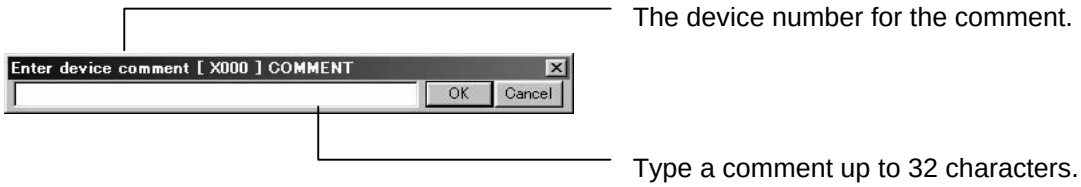
This chapter explains how to input a device comment.

1) Select "Edit" → "Documentation" → "Comment".

2) Place the cursor on the device for which a comment is to be input and double-click it.



3) When the 'Enter device comment' dialog box is displayed, type a comment. Up to 32 characters are available.



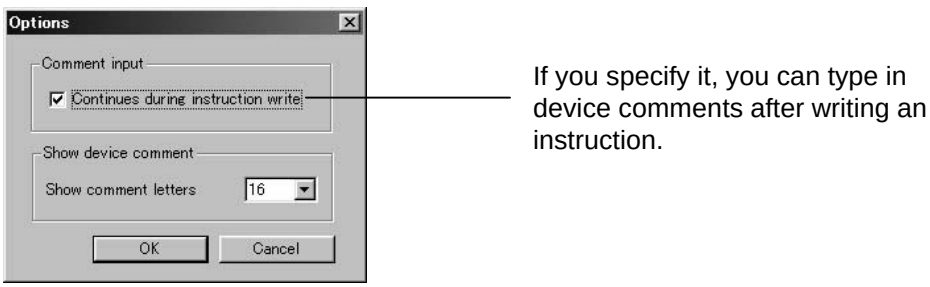
You cannot delete a comment selecting "Undo".

POINT

You can type device comments when you are writing an instruction.

1) Select "Tools" → "Options".

2) When the 'Options' dialog box is displayed, specify 'Continues during instruction write'.



Enter an instruction and comment as follows.

1) Write an instruction.

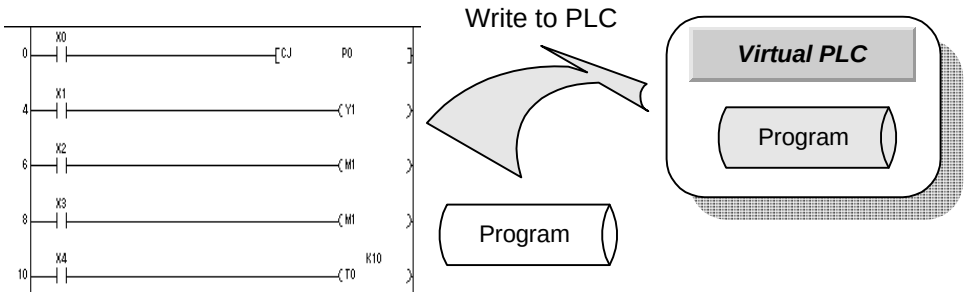
2) The 'Enter device comment' dialog box is displayed next.

3.4 Communication with virtual PLC

This chapter explains how to write your programs to the virtual PLC and how to confirm the operation.

3.4.1 Write to PLC

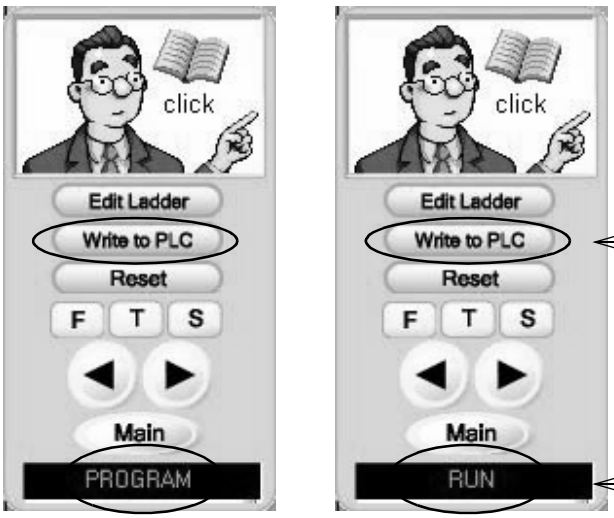
"Writing to PLC" means to transfer programs to the virtual PLC. After writing programs to the virtual PLC, you can operate the machines in the simulation as well as the lamps on the operation panel.



1) Write a program, and convert it.
2) Select "Online" → "Write to PLC". (Or you can use the remote control.)
   The 'Write to PLC' dialog box is displayed, and you can check the writing status there. (If the virtual PLC is in RUN mode, it is automatically and writing is executed.)
3) When writing is completed, the dialog box 'Write completed. The simmulation will start!' is displayed.
   Click the [OK] button to run the virtual PLC.

POINT

- Status display of the virtual PLC and [Write to PLC] on the remote control

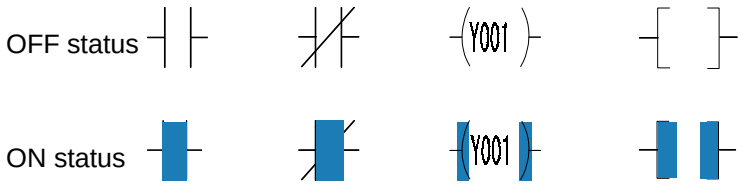


Click the [Write to PLC] button to write a program to the virtual PLC. This button functions the same way as selecting "Online" → "Wite to PLC" as described above.

The virtual PLC status is indicated here.
You can write and edit a program if you click [Edit Ladder] when the PLC is in RUN mode.

3.4.2 Monitor display

When you write a program to the virtual PLC, the ladder program area automatically displays the monitoring result and you can check the ON/OFF status and stored values of devices.
The device status is displayed as follows.

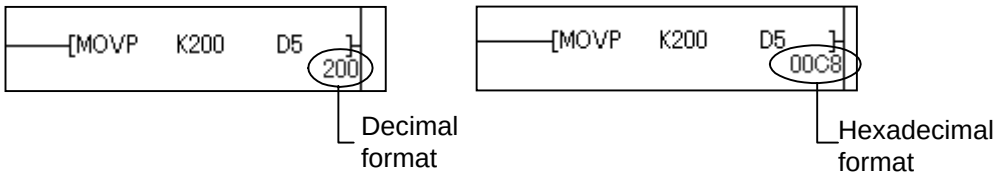


In order would to finish monitoring and write or edit a program, click the [Edit Ladder] button on the remote control.

- Changing the current value display format

  The current values of devices can be expressed in decimal or hexadecimal.

  1) Select "Online" → "Monitor", → "Change current value monitor (Decimal)" or "Change current value monitor (Hexadecimal)".
     Then, the present values of timers and counters as well as the present values of operand devices of application instructions are displayed in the selected display format.



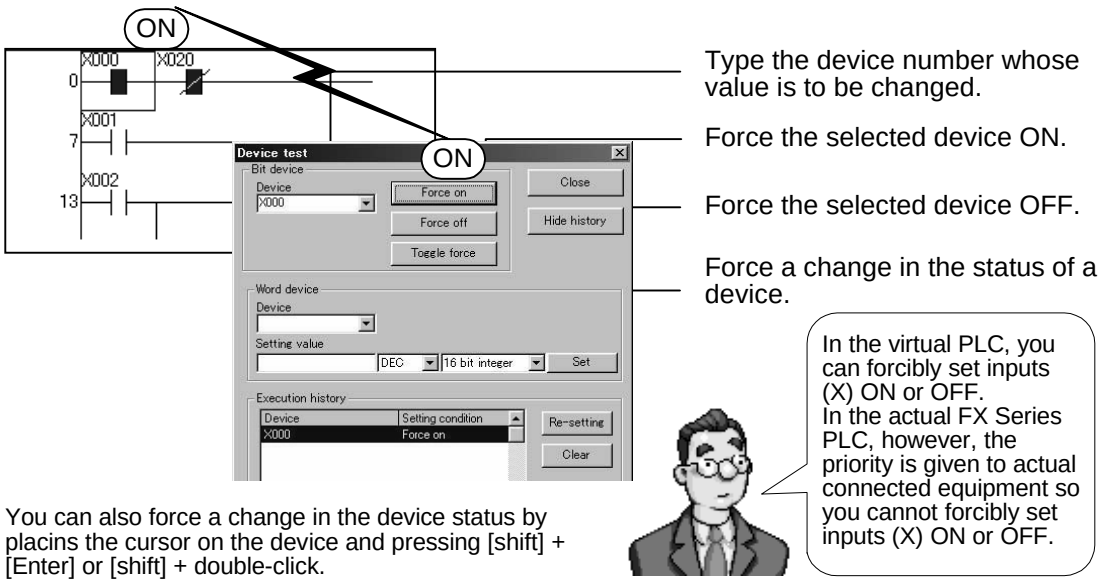
The present values are displayed in real numbers if the instructions take real numbers.

3.4.3 Device test

During monitoring, you can confirm the program operation by setting devices to ON or OFF and changing the present values.

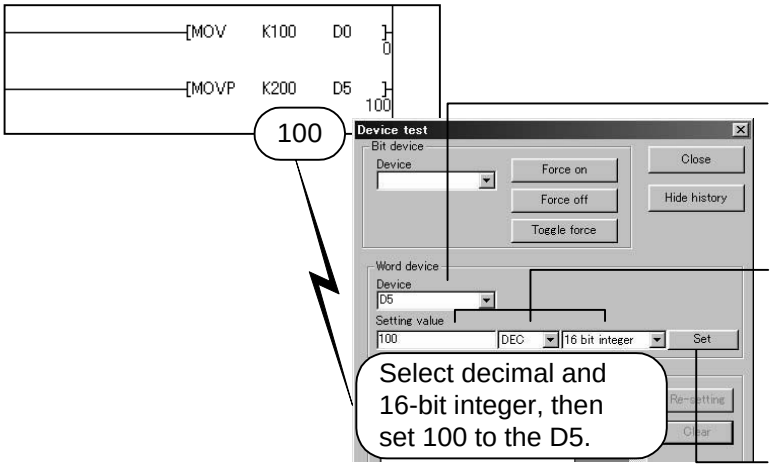
1) Select "Online" → "Devece Test".
2) When the 'Device Test' dialog box is displayed, type the device number to the 'Device' field.

- Bit device



You can also force a change in the device status by placins the cursor on the device and pressing [shift] + [Enter] or [shift] + double-click.

- Word device



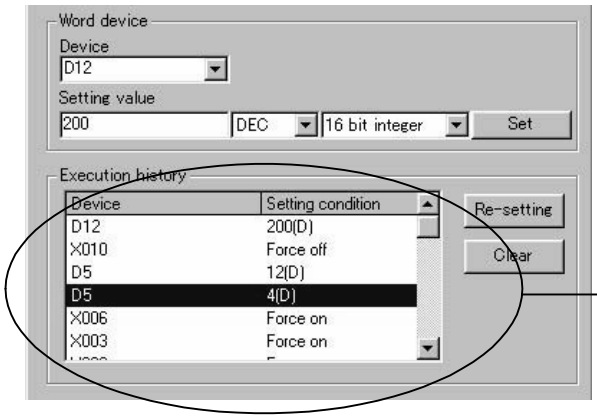
Type the device number whose value is to be changed.

Enter the device number to be changed.
Specify decimal or hexadecimal. Specify 16-bit integer, 32-bit integer or real number, then type a desired value.

After specifying the value, click the [set] button.
The value will be set for the selected device.

POINT

- The devices to which the device test was executed and the setting status are displayed in the 'Execution history' field. You can execute again the test displayed in the 'Execution history' field.



Devices which have been tested are displayed.

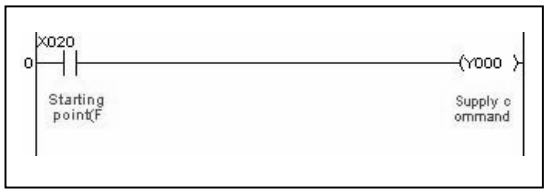
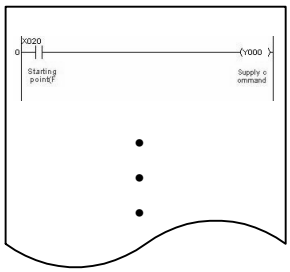
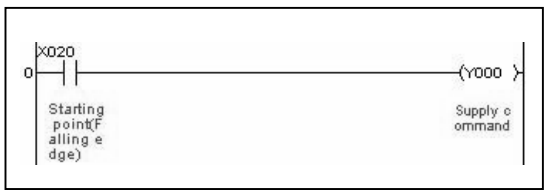
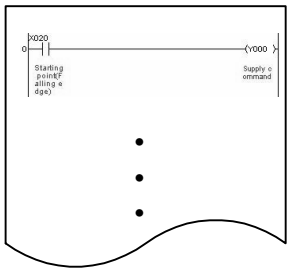
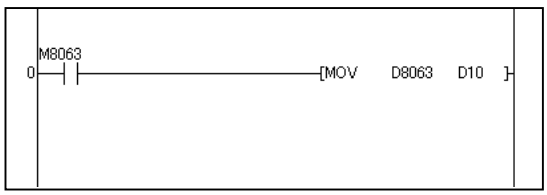
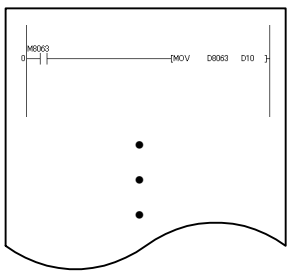
- If you change the value of a device by the device test while simulation is being executed, the machines simulated and the operation panel in which the same device is set are also affected in the same way.

3.5 Print

This chapter explains how to print the programs and device comments.

1) Select "View" → "Comment" to display device comments in the ladder program area.
2) Select "Project" → "Print".

Printing is executed according to the device comment display status as shown below.

Display in ladder program area	Printing result
Each device comment is displayed in up to 16 characters. 	Each device comment is printed in up to 16 characters. 
Each device comment is displayed in up to 32 characters. 	Each device comment is printed in up to 32 characters. 
Device comments are not displayed. 	Device comments are not printed. 

POINT

- All the programs are printed.
- If printing is executed during monitoring, the contents of the monitor display are also printed.

Appendix A: Instruction List for Virtual PLC

The Instructions available in the training software and their functions are listed.

A-1: Basic instructions

Mnemonic	Function	Input method (Symbol)	Input method (Instruction)	Program and target device
LD (LoaD)	Initial logical operation contact type NO (normally open)	[F5] → X0	LD_X0	XYMSTC
LDI (LoaD Inverse)	Initial logical operation contact type NC (normally closed)	[Shift] + [F5] → X0	LDI_X0	XYMSTC
LDP (LoaD Pulse)	Initial logical operation Rising edge pulse	[Shift] + [F7] → X0	LDP_X0	XYMSTC
LDF (LoaD Falling pulse)	Initial logical operation Falling / trailing edge pulse	[Shift] + [F8] → X0	LDF_X0	XYMSTC
AND (AND)	Serial connection of NO (normally open) contacts	[F5] → X0	AND_X0	XYMSTC
ANI (AND Inverse)	Serial connection of NC (normally closed) contacts	[Shift] + [F5] → X0	ANI_X0	XYMSTC
ANP (ANd Pulse)	Serial connection of Rising edge pulse	[Shift] + [F7] → X0	ANDP_X0	XYMSTC
ANF (ANd Falling pulse)	Serial connection of Falling / trailing edge pulse	[Shift] + [F8] → X0	ANDF_X0	XYMSTC
OR (OR)	Parallel connection of NO (normally open) contacts	[F6] → X0	OR_X0	XYMSTC
ORI (OR Inverse)	Parallel connection of NC (normally closed) contacts	[Shift] + [F6] → X0	ORI_X0	XYMSTC
ORP (OR Pulse)	Parallel connection of Rising edge pulse	[Alt] + [F7] → X0	ORP_X0	XYMSTC
ORF (OR Falling pulse)	Parallel connection of Falling / trailing edge pulse	[Alt] + [F8] → X0	ORF_X0	XYMSTC

Mnemonic	Function	Input method (Symbol)	Input method (Instruction)	Program and target device
ANB (ANd Block)	Serial connection of multiple parallel circuits	—	—	
ORB (OR Block)	Parallel connection of multiple contact circuits	—	—	
OUT (OUT)	Final logical operation type coil drive	[F7] → Y0	OUT_Y0	YMSTC
SET (SET)	Sets a bit device permanently ON	[F8] → SET_Y0	SET_Y0	SET YMS
RST (ReSeT)	Resets a bit device permanently OFF	[F8] → RST_Y0	RST_Y0	RST YMSTCD
PLS (PuLSe)	Rising edge pulse	[F8] → PLS_X0	PLS_X0	PLS YM
PLF (PuLse Falling)	Falling / trailing edge pulse	[F8] → PLF_X0	PLF_X0	PLF YM
MC (Master Control)	Denotes the start of a master control block	[F8] → MC_N0_X0	MC_N0_X0	MC N YM
MCR (Master Control Reset)	Denotes the end o a master control block	[F8] → MCR_N0	MCR_N0	MCR N
MPS (Master Point Store)	Stores the current result of the internal PLC operations	—	—	MPS
MRD (Master ReaD)	Reads the current result of the internal PLC operations	—	—	MRD
MPP (Master PoP)	Pops (recalls and removes) the currently stored result	—	—	MPP
INV (INVerse)	Invert the current result of the internal PLC operations	[Alt] + [Ctrl] + [F10]	INV	INV
END (END)	Forces the current program scan to end	—	—	END

—: Cannot be written.
_ (underline): Leave a space here.

A-2: Stepladder instructions

Mnemonic	Function	Input method (Symbol)	Input method (Instruction)	Program and target device
STL (STep Ladder)	Starts stepladder	[F8] → STL_S0	STL_S0	S STL
RET (RETurn)	Ends stepladder	[F8] → RET	RET	[RET]

_ (underline): Leave a space here.

A-3: Application instructions

Category	Function number	Instruction symbol	Function	32-bit instruction	Execution of PLS instruction
Program flow	00	CJ	Conditional jump	—	✔
	01	CALL	Call Subroutine	—	✔
	02	SRET	Subroutine Return	—	—
	06	FEND	First End	—	—
	08	FOR	Start of a For/Next Loop	—	—
	09	NEXT	End a For/Next Loop	—	—
Transfer / Compare	10	CMP	Compare	✔	✔
	11	ZCP	Zone Compare	✔	✔
	12	MOV	Move	✔	✔
	13	SMOV	Shift Move	—	✔
	14	CML	Compliment	✔	✔
	15	BMOV	Block Move	—	✔
	16	FMOV	Fill Move	✔	✔
	17	XCH	Exchange	✔	✔
	18	BCD	Binary Coded Decimal	✔	✔
	19	BIN	Binary	✔	✔
Four rules / Logical operation	20	ADD	Addition	✔	✔
	21	SUB	Subtraction	✔	✔
	22	MUL	Multiplication	✔	✔
	23	DIV	Division	✔	✔
	24	INC	Increment	✔	✔
	25	DEC	Decrement	✔	✔
	26	WAND	Word AND	✔	✔
	27	WOR	Word OR	✔	✔
	28	WXOR	Word Exclusive OR	✔	✔
	29	NEG	Negation	✔	✔
Rotation shift	30	ROR	Rotation Right	✔	✔
	31	ROL	Rotation Left	✔	✔
	32	RCR	Rotation Right with Carry	✔	✔
	33	RCL	Rotation Left with Carry	✔	✔
	34	SFTR	(Bit) Shift Right	—	✔
	35	SFTL	(Bit) Shift Left	—	✔
	36	WSFR	Shift Register Write	—	✔
	37	WSFL	Word Shift Left	—	✔
	38	SFWR	Shift Register Write	—	✔
	39	SFRD	Shift Register Read	—	✔

Category	Function number	Instruction symbol	Function	32-bit instruction	Execution of PLS instruction
Data process	40	ZRST	Zone Reset	—	✔
	41	DECO	Decode	—	✔
	42	ENCO	Encode	—	✔
	43	SUM	The Sum Of Active Bits	✔	✔
	44	BON	Check Specified Bit Status	✔	✔
	45	MEAN	Mean	✔	✔
	46	ANS	(Timed) Annunciator Set	—	—
	47	ANR	Annunciator Reset	—	✔
	48	SQR	Square Root	✔	✔
	49	FLT	Float, (Floating Point)	✔	✔
Useful instruction	60	IST	Initial State	—	—
	61	SER	Search	✔	✔
	62	ABSD	Absolute Drum	✔	—
	63	INCD	Incremental Drum	—	—
	64	TTMR	Teaching Timer	—	—
	65	STMR	Special Timer - Definable	—	—
	66	ALT	Alternate State	—	—
	67	RAMP	Ramp - Variable Value	—	—
	69	SORT	Sort Data	—	—
External equipment/ I/O	76	ASC	ASCII Code	—	—
	78	FROM	Read From A Special Function Block	✔	✔
	79	TO	Write To A Special Function Block	✔	✔
External equipment/ SER	82	ASCI	Hexadecimal to ASCII	—	✔
	83	HEX	ASCII to Hexadecimal	—	✔
Floating decimal point	110	ECMP	Float Compare	✔	✔
	111	EZCP	Float Zone Compare	✔	✔
	118	EBCD	Float to Scientific	✔	✔
	119	EBIN	Scientific to Float	✔	✔
	120	EADD	Float Add	✔	✔
	121	ESUB	Float Subtract	✔	✔
	122	EMUL	Float Multiplication	✔	✔
	123	EDIV	Float Division	✔	✔
	127	ESQR	Float Square Root	✔	✔
	129	INT	Float to Integer	✔	✔
	130	SIN	Sine	✔	✔
	131	COS	Cosine	✔	✔

Category	Function number	Instruction symbol	Function	32-bit instruction	Execution of PLS instruction
Floating decimal point	132	TAN	Tangent	✔	✔
	147	SWAP	Float to Scientific	✔	✔
Clock operation	160	TCMP	Time Compare	—	✔
	161	TZCP	Time Zone Compare	—	✔
	162	TADD	Time Add	—	✔
	163	TSUB	Time Subtract	—	✔
	166	TRD	Read RTC data	—	✔
Others	170	GRY	Decimal to Gray Code	✔	✔
	171	GBIN	Gray Code to Decimal	✔	✔
Contact comparison	224	LD=	LoaD compare	✔	—
	225	LD>	LoaD compare	✔	—
	226	LD<	LoaD compare	✔	—
	228	LD<>	LoaD compare	✔	—
	229	LD<=	LoaD compare	✔	—
	230	LD>=	LoaD compare	✔	—
	232	AND=	AND compare	✔	—
	233	AND>	AND compare	✔	—
	234	AND<	AND compare	✔	—
	236	AND<>	AND compare	✔	—
	237	AND<=	AND compare	✔	—
	238	AND>=	AND compare	✔	—
	240	OR=	OR compare	✔	—
	241	OR>	OR compare	✔	—
	242	OR<	OR compare	✔	—
	244	OR<>	OR compare	✔	—
	245	OR<=	OR compare	✔	—
	246	OR>=	OR compare	✔	—

—: Application instructions available only in 16-bit or only as consecutive-execution type instruction

Appendix B: Device List for Virtual PLC

B-1: Device range list

Devices			Device range (points)	Remark
Bit devices	Inputs (X)		X000 to X177 (128)	Octal number
	Outputs (Y)		Y000 to Y177 (128)	Octal number
	Auxiliary relays (M)	General	M0 to M512 (512)	—
		Special	M8000 to M8255 (256)	—
	State relays (S)	Initial	S0 to S9 (10)	—
		General	S10 to S511 (502)	—
Word devices	Timers (T)	100ms	T0 to T199 (200)	—
		10ms	T200 to T245 (46)	—
		1ms retentive*1	T246 to T249 (4)	—
		100ms retentive*1	T250 to T1255 (6)	—
	Counters (C)	16-bit up	C0 to C T199 (200)	—
		32-bit up/down	C200 to C234 (35)	—
	Data registers (D) Pair for 32-bit device	General	D0 to D511 (512)	—
		Latched	D8000 to D8255 (256)	—
		Index	V0 to V7 and Z0 to Z7 (16)	—
Nest levels (N)		For master control block	N0 to N7 (8)	—
Pointers (P)		For use with CALL / JUMP	P0 to P127 (128)	—
Decimal K		16-bit	-32768 to 32767	—
		32-bit	-2147483648 to 2147483647	—
Hexadecimal H		16-bit	H0 to HFFFF	—
		32-bit	H0 to HFFFFFFFF	—

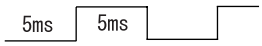
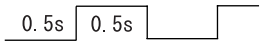
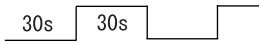
*1 The current value of the elapsed timer can be cleared by the following operations.

- When the [Reset} button on the remote control is pressed
- When the program is written to the PLC
- When returning to the main menu

In programming, RST or MOV instruction can be used to clear the current value.

B-2: Special device list

B-2-1: Special auxiliary relays

Diagnostic Device	Name	Operation
M8000	RUN monitor NO contact	OFF: STOP ON: RUN
M8001	RUN monitor NC contact	OFF: RUN ON: STOP
M8002	Initial pulse NO contact	1 scan ON after RUN
M8003	Initial pulse NC contact	1 scan OFF after RUN
M8004	Error occurrence	
M8011	10ms clock pulse	
M8012	100ms clock pulse	
M8013	1 sec clock pulse	
M8014	1 min clock pulse	
M8018	RTC available	When ON Real Time Clock is installed
M8020	Zero	Set when the result of an ADD or SUB is “0”
M8021	Borrow	Set when the result of a SUB is less than the min. negative number
M8022	Carry	Set when ’carry’ occurs during an ADD (FNC 20) or when an overflow occurs as a result of a data shift operation
M8024	BMOV reverse mode	ON: Write OFF: Read
M8026	RAMP hold mode	ON: Hold output value OFF: Reset output value
M8029	Instruction execution complete	OFF: Executing ON: Execution complete
M8031	Non-latch memory all clear	OFF: Hold ON: Clear
M8033	Memory hold in ’stop’ mode	OFF: Hold ON: Clear
M8034	All outputs disable	OFF: Output enable ON: Output disable
M8040	STL transfer disable	OFF: Transfer enable ON: Transfer disable
M8041	Transfer start	ON: Stop OFF: Transfer disable
M8042	Start pulse	ON: IST instruction start command
M8043	Zero return complete	ON: IST instruction zero return command
M8044	Zero point condition	ON: Zero point position OFF: Zero point undecided

Diagnostic Device	Name	Operation
M8045	All output reset disable	ON: Reset disable OFF: Reset enable
M8046	STL state ON	ON: STL monitoring has been enabled (M8047) and there is an active STL state
M8047	Enable STL monitoring	ON: D8040 to D8047 are enabled for active STL step monitoring
M8048	Annunciator ON	ON: Annunciator monitoring has been enabled (M8049) and there is an active Annunciator flag
M8049	Enable Annunciator monitoring	ON: D8049 is enabled OFF: D8049 is not enabled
M8067	Operation error	ON: Operation error OFF: No operation error
M8068	Operation error latch	Hold occurrence of M8067
M8160	Selection of XCH operation to swap bytes in a single data word	ON: 8-bit conversion OFF: Normal bit
M8161	Mode of 8 bit operation	Selection of 8 bit operations for applied instructions ASC, RS, ASCI, HEX, CCD
M8164	When ON, a value in D8164 is used as the number of FROM/TO exchange points.	Transfer points exchange command
M8168	Selection of BCD mode for use with the SMOV instruction	Digit shift in 4-bit unit
M8200	Up/Down Counter Control	ON: C200 functions as a down counter. OFF: C200 functions as an up counter.
M8201	Up/Down Counter Control	ON: C201 functions as a down counter. OFF: C201 functions as an up counter.
M8202	Up/Down Counter Control	ON: C202 functions as a down counter. OFF: C202 functions as an up counter.
M8203	Up/Down Counter Control	ON: C203 functions as a down counter. OFF: C203 functions as an up counter.
M8204	Up/Down Counter Control	ON: C204 functions as a down counter. OFF: C204 functions as an up counter.
M8205	Up/Down Counter Control	ON: C205 functions as a down counter. OFF: C205 functions as an up counter.
M8206	Up/Down Counter Control	ON: C206 functions as a down counter. OFF: C206 functions as an up counter.
M8207	Up/Down Counter Control	ON: C207 functions as a down counter. OFF: C207 functions as an up counter.
M8208	Up/Down Counter Control	ON: C208 functions as a down counter. OFF: C208 functions as an up counter.
M8209	Up/Down Counter Control	ON: C209 functions as a down counter. OFF: C209 functions as an up counter.
M8210	Up/Down Counter Control	ON: C210 functions as a down counter. OFF: C210 functions as an up counter.
M8211	Up/Down Counter Control	ON: C211 functions as a down counter. OFF: C211 functions as an up counter.

Diagnostic Device	Name	Operation
M8212	Up/Down Counter Control	ON: C212 functions as a down counter. OFF: C212 functions as an up counter.
M8213	Up/Down Counter Control	ON: C213 functions as a down counter. OFF: C213 functions as an up counter.
M8214	Up/Down Counter Control	ON: C214 functions as a down counter. OFF: C214 functions as an up counter.
M8215	Up/Down Counter Control	ON: C215 functions as a down counter. OFF: C215 functions as an up counter.
M8216	Up/Down Counter Control	ON: C216 functions as a down counter. OFF: C216 functions as an up counter.
M8217	Up/Down Counter Control	ON: C217 functions as a down counter. OFF: C217 functions as an up counter.
M8218	Up/Down Counter Control	ON: C218 functions as a down counter. OFF: C218 functions as an up counter.
M8219	Up/Down Counter Control	ON: C219 functions as a down counter. OFF: C219 functions as an up counter.
M8220	Up/Down Counter Control	ON: C220 functions as a down counter. OFF: C220 functions as an up counter.
M8221	Up/Down Counter Control	ON: C221 functions as a down counter. OFF: C221 functions as an up counter.
M8222	Up/Down Counter Control	ON: C222 functions as a down counter. OFF: C222 functions as an up counter.
M8223	Up/Down Counter Control	ON: C223 functions as a down counter. OFF: C223 functions as an up counter.
M8224	Up/Down Counter Control	ON: C224 functions as a down counter. OFF: C224 functions as an up counter.
M8225	Up/Down Counter Control	ON: C225 functions as a down counter. OFF: C225 functions as an up counter.
M8226	Up/Down Counter Control	ON: C226 functions as a down counter. OFF: C226 functions as an up counter.
M8227	Up/Down Counter Control	ON: C227 functions as a down counter. OFF: C227 functions as an up counter.
M8228	Up/Down Counter Control	ON: C228 functions as a down counter. OFF: C228 functions as an up counter.
M8229	Up/Down Counter Control	ON: C229 functions as a down counter. OFF: C229 functions as an up counter.
M8230	Up/Down Counter Control	ON: C230 functions as a down counter. OFF: C230 functions as an up counter.
M8231	Up/Down Counter Control	ON: C231 functions as a down counter. OFF: C231 functions as an up counter.
M8232	Up/Down Counter Control	ON: C232 functions as a down counter. OFF: C232 functions as an up counter.
M8233	Up/Down Counter Control	ON: C233 functions as a down counter. OFF: C233 functions as an up counter.
M8234	Up/Down Counter Control	ON: C234 functions as a down counter. OFF: C234 functions as an up counter.

B-2-2: Special data registers

Diagnostic Device	Name	Operation
D8000	Watchdog timer	200ms*1
D8001	PLC type and version	24000
D8002	Memory capacity	8000
D8004	Error number M****	The contents of this register ☆☆☆☆ identifies which error flag is active, i.e. if ☆☆☆☆ = 8060 identifies M8060
D8006	Low battery voltage	The level at which a low battery voltage is detected
D8010	Present scan time	Current operation cycle / scan time in units of 0.1ms
D8011	Minimum scan time	Minimum cycle / scan time in units of 0.1ms
D8012	Maximum scan time	Maximum cycle / scan time in units of 0.1ms
D8013	Second data	Seconds data for use with an RTC (0-59)
D8014	Minute data	Minute data for use with an RTC (0-59)*2
D8015	Hour data	Hour data for use with an RTC (0-23)*2
D8016	Day data	Day data for use with an RTC (1-31)*2
D8017	Month data	Month data for use with an RTC (1-12)*2
D8018	Year data	Year data for use with an RTC (00-99 or 1980-2079, can be selected)*2
D8019	Weekday data	
D8028	Current value of the Z0 index register	Current value of the Z0 index register
D8029	Current value of the V0 index register	Current value of the V0 index register
D8040	Lowest active STL step	Lowest active STL step
D8041	2nd active STL state	2nd active STL state
D8042	3rd active STL state	3rd active STL state
D8043	4th active STL state	4th active STL state
D8044	5th active STL state	5th active STL state
D8045	6th active STL state	6th active STL state
D8046	7th active STL state	7th active STL state
D8047	8th active STL state	8th active STL state
D8049	Lowest active Annunciator	Lowest active Annunciator
D8067	Error code identifying operation error.	Error code identifying operation error.
D8068	Operation error step number latched	Operation error step number latched
D8069	Step numbers for found errors corresponding to flags M8065 to M8067	Step numbers for found errors corresponding to flags M8065 to M8067
D8102	Memory Capacity	8000
D8164	Number of FROM/ TO exchange points	Number of FROM/TO exchange points

Diagnostic Device	Name	Operation
D8182	Value of Z1 index register	Value of Z1 index register
D8183	Value of V1 index register	Value of V1 index register
D8184	Value of Z2 index register	Value of Z2 index register
D8185	Value of V2 index register	Value of V2 index register
D8186	Value of Z3 index register	Value of Z3 index register
D8187	Value of V3 index register	Value of V3 index register
D8188	Value of Z4 index register	Value of Z4 index register
D8189	Value of V4 index register	Value of V4 index register
D8190	Value of Z5 index register	Value of Z5 index register
D8191	Value of V5 index register	Value of V5 index register
D8192	Value of Z6 index register	Value of Z6 index register
D8193	Value of V6 index register	Value of V6 index register
D8194	Value of Z7 index register	Value of Z7 index register
D8195	Value of V7 index register	Value of V7 index register

*1 The initial value is 200ms. Can be rewritten, but WDT check is not executed.
*2 The time which the clock in your computer indicates is displayed.

Appendix C: Details of Simulated Machine Components

This section explains each component of machines simulated used in each exercise.

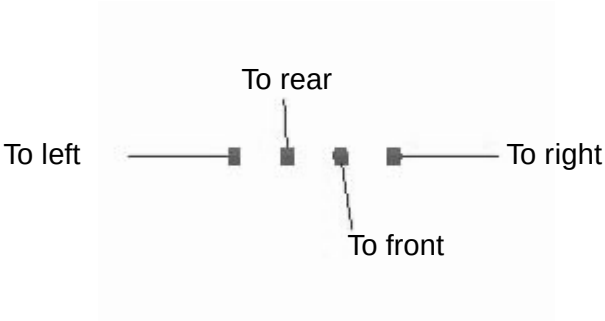
C-1: Component List

Component name		Outline of operation	Outline of control	Reference chapter
Sensor	Sensor	Sensor detects passage and contact of parts.	Sensor turns ON when it detects a part (Normally Open contact).	C-2
Part supplier	Person	Person supplies parts.	Supply command is given for output drive.	C-3
	Robot	Robot supplies parts.		
	Hopper	Hopper supplies parts.		
	Hopper (Orange)	Hopper supplies oranges.		
Lamp	Traffic light (two colors)	Red and green signal lamps light.	Output must be driven.	C-4
	Traffic light (three colors)	Red, green and yellow signal lamps light.		
	Rotating beacon	Red, green and yellow flashing lights light.		
Machine	Conveyor (standard type)	Conveyor carries parts.	Output must be driven.	C-5
	Conveyor (branch type)	Conveyor distributes parts into two directions.		
	Lifter	Lifter carries parts to upper and lower positions.		
	Door	Door is opened and closed vertically.		
	Pusher	Pusher pushes out parts.		
	Drill	Drill makes holes in parts.		
	Stage settings	Curtains are opened and closed horizontally.		
		Stage is moved up and down.		
Moving device	Robot	Robot moves parts.	Output must be driven.	C-6
Others	Tray	Tray stores parts. (When a certain amount of parts are stored, person automatically collects them.)	Control is not required.	C-7
	Buzzer	Buzzer indicator lamp flickers and buzzer sounds at same time.	Output must be driven.	
	Person and car	Person/car moves when button on screen is clicked.	Button should be clicked.	

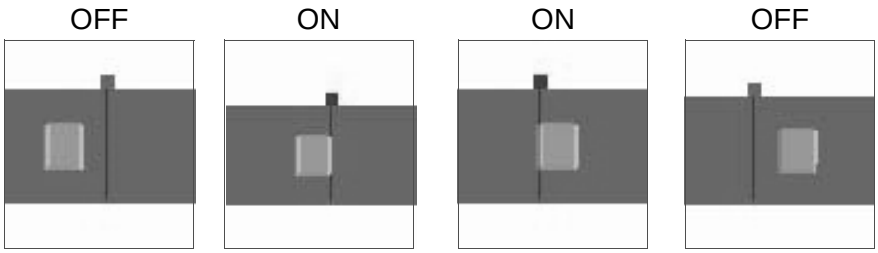
C-2: Sensor

Each sensor detects the passage and contact of a part.

- Appearance (side view)



- Operation
  - A sensor is assigned to an input (X).
  - When an object such as a part passes a sensor, the corresponding input turns ON.



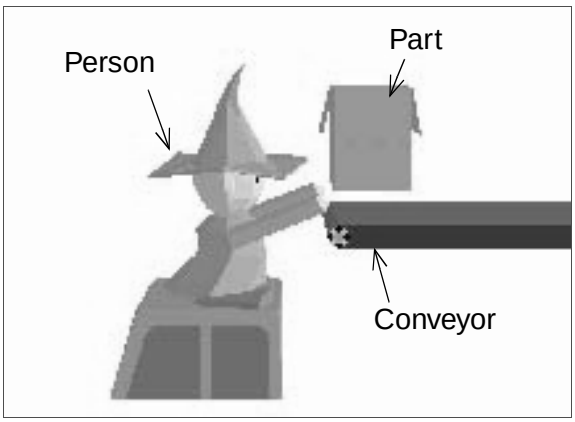
C-3: Part Supplier

The mechanisms to supply parts are explained.

C-3-1: Person

The person supplies parts.

- Appearance (front view)



- Operation

Supply command

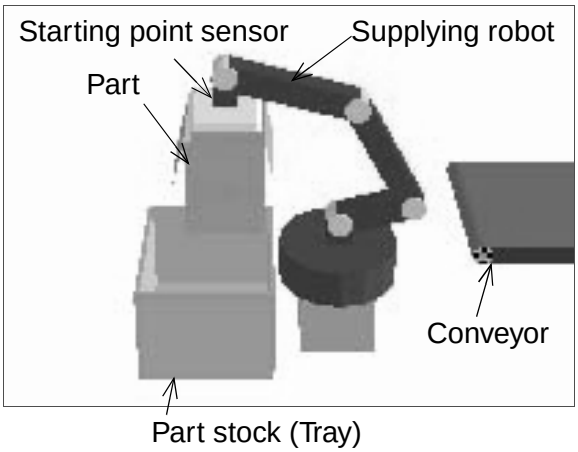
- As a supply command, a lamp output (Y) is assigned.
- When the supply command lamp turns ON, the person supplies a part.

  * If two or more parts are supplied at a time, they will be crushed.

C-3-2: Robot

The robot arm supplies parts.

- Appearance (side view)



- Operation

Supply command

- As a supply command, an output (Y) is assigned.
  When the output (Y) is set ON, the robot starts to supply a part.
- Even if the driving output for the robot is set OFF while it is supplying a part, the robot continues the operation until it places the part on the conveyor.
- Even if the next supply command is given to the robot while it is supplying a part, the robot does not accept the command. Make sure to give the command to the robot while the starting point sensor is ON.
- Supply command should be set OFF by rising/falling edge detection.

  * If two or more parts are supplied at a time, they will be crushed.

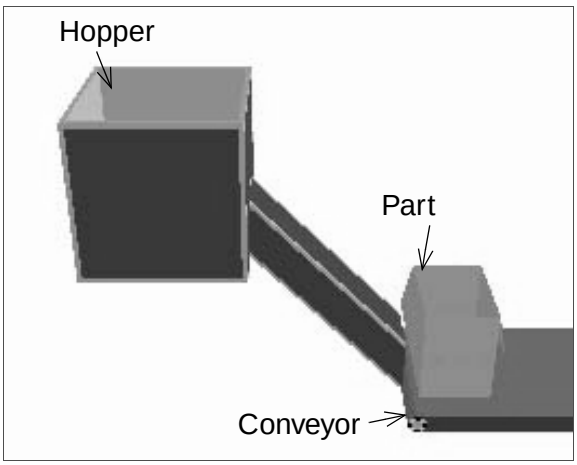
Starting point sensor

- While the robot is located at the starting point, the input (X) is ON.

C-3-3: Hopper

The hopper supplies parts.

- Appearance (side view)



- Operation

Supply command

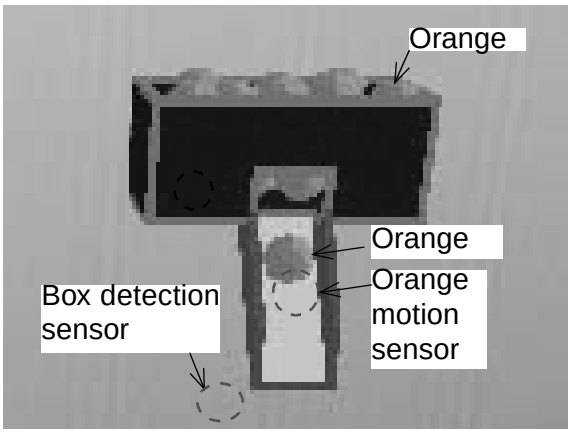
- As a supply command, an output (Y) is assigned.
  When the supply command output (Y) is set ON, the hopper supplies a part.
  The hopper supplies one part when the output (Y) is turned ON once.
  Set the output ON and OFF alternately if continuous supply is required.

  * If two or more parts are supplied at a time, they will be crushed.

C-3-4: Orange

The hopper supplies oranges.

- Appearance (side view)



- Operation

Orange supply command

- As an orange supply command, an output (Y) is assigned.
  When the supply command output (Y) is set ON, oranges are continuously supplied.

Box detection sensor

- This sensor turns ON when it detects a box under the feeder (NO contact).
  This sensor is built in the feeder, and is not displayed.

Orange passage sensor

- The input (X) of this sensor turns ON when an orange is supplied and passes it (NO contact).
  Use this sensor to count the number of oranges.
  This sensor is built in the supplier, and is not displayed.

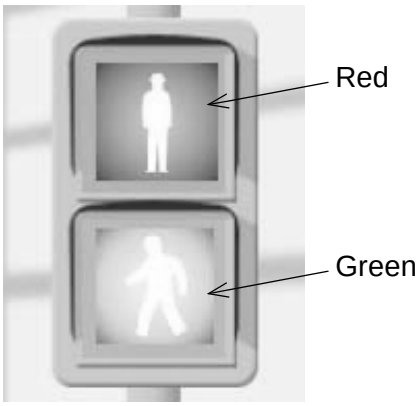
C-4: Lamp

Indicator lamps such as signal lamps and flashing lights are explained.

C-4-1: Signal (two colors)

Red and green signal lamps come ON.

- Appearance

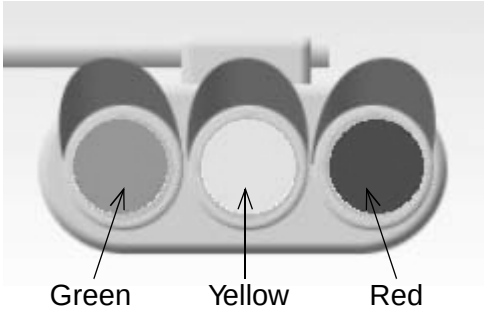


- Operation
  - An individual output (Y) is assigned to each of red and green lamp.
  - Each lamp is lit when the output is ON, and extinguished when the output is OFF.
    - * Mechanical interlock is not provided between the two lamps. (The two lamps can be lit at the same time.)
    - * Do not specify the 'Simple graphic mode'. The 3-D graphic would not be displayed properly.

C-4-2: Signal (three colors)

Red, green and yellow signal lamps come ON.

- Appearance

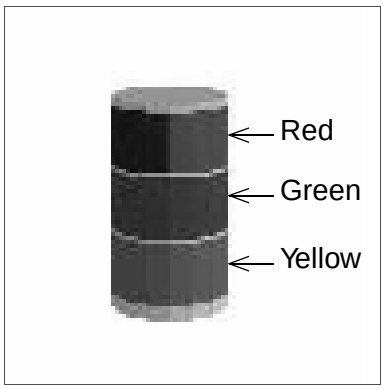


- Operation
  - An individual output (Y) is assigned to each of red, green and yellow lamp.
  - Each lamp is lit when the output is ON, and extinguished when the output is OFF.
    - * Mechanical interlock is not provided between the three lamps. (The three lamps can be lit at the same time.)
    - * Do not specify the 'Simple graphic mode'. The 3-D graphic would not be displayed properly.

C-4-3: Flashing Light

Red, green and yellow flashing lights come ON.

- Appearance



- Operation
  - An individual output (Y) is assigned to each of red, green and yellow flashing light.
  - Each flashing light is lit when the output is ON, and extinguished when the output is OFF.
    - * Mechanical interlock is not provided between the three flashing lights. (The three flashing lights can be lit at the same time.)

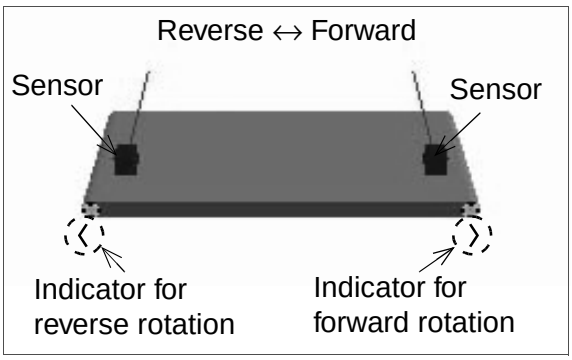
C-5: Machine

Machine parts such as conveyors and lifters are explained here.

C-5-1: Conveyor (standard)

The conveyor carries parts.

- Appearance (side view)



- Operation

Conveyor forward/reverse command

- An output (Y) is assigned to each of forward and reverse movement.
  When the output (Y) is set to ON, the conveyor moves.
  * In some exercises, an output (Y) is assigned to either normal or reverse movement.

* The motors for forward rotation and reverse rotation are built in the conveyor and not displayed.
* The mechanical interlock between the motor for forward rotation and the motor for reverse rotation is provided inside the machine simulated. Even if both of them are operated at the same time, they are not damaged, but the conveyor does not move.

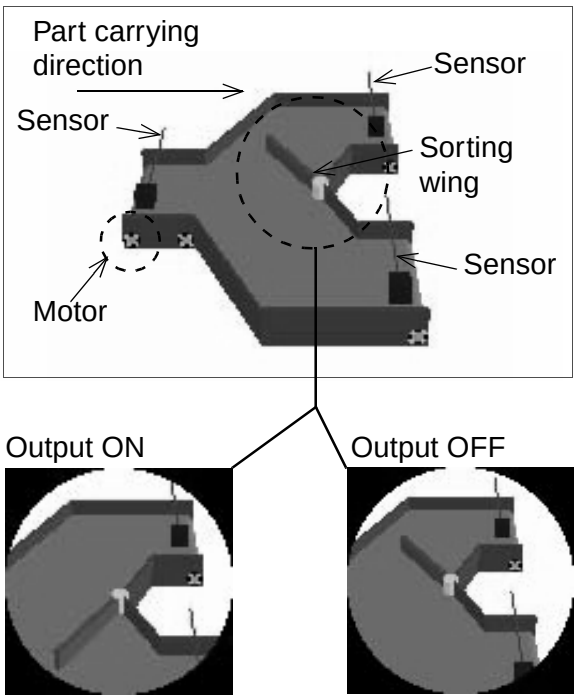
Sensor

- Sensors are provided according to the exercise.

C-5-2: Conveyor (with sorting wing)

The conveyor distributes parts (large ones and small ones, for example) in two directions.

- Appearance (side view)



- Operation

Conveyor operation command

- An output (Y) is assigned to the conveyor.
  When the conveyor output is set ON, it moves to the right.
- The motor built in the conveyor is not displayed.

Sorting wing

- An output (Y) is assigned to the sorting wing.
  While the output is ON, the sorting wing turns to the front and parts are carried to the rear conveyor.
  While the output is OFF, the sorting wing turns to the rear and parts are carried to the front conveyor.

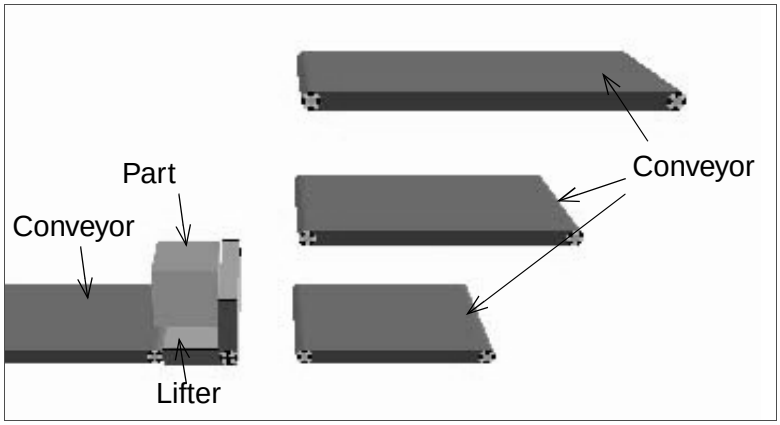
Sensor

- Sensors are provided according to the exercise.

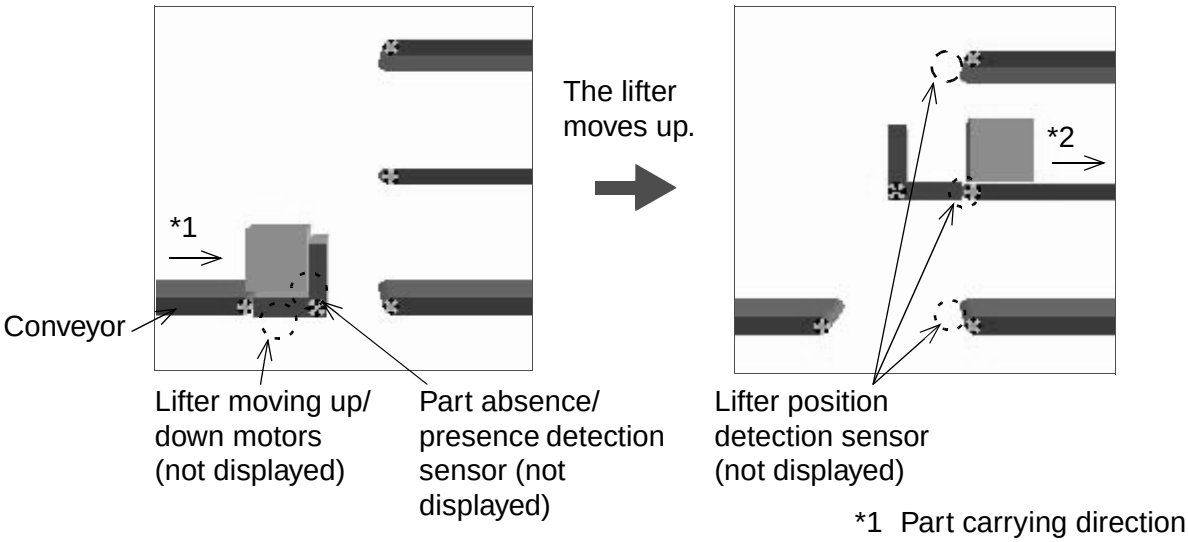
C-5-3: Lifter

The lifter carries parts upward or downward.

- Appearance (side view)



- Appearance (front view)



*1 Part carrying direction
*2 Part carrying direction

- Operation

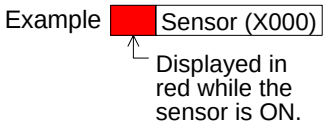
  Lifter moving up/down

  - An individual output (Y) is assigned to each lifter for each direction of movement. When the output is set ON, the lifter moves up or down respectively. The motors are built in the lifter and are not displayed.

    * The mechanical interlock between the up and down movements of the lifter is provided inside the machine simulation. If both inputs are ON at the same time, the lifter is not damaged but neither does it move.

Sensor

- An input (X) is assigned to the part detection sensor. The sensor turns ON when it detects a part and is OFF when it does not detect a part.
  The sensor is not displayed.
- An input (X) is assigned to the lifter position sensor. This sensor is used to determine the stop position when the lifter is in motion.
  The sensor is not displayed.
  * The ON/OF status for part detection and lifter position sensors can be monitored by the red indicator at the left of the device numbers in the simulation or on the I/O image table in the virtual PLC.



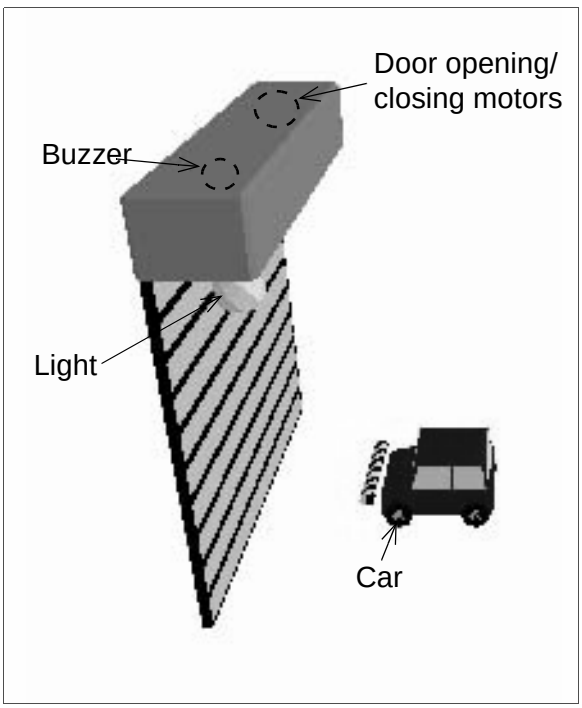
Lifter rotation

- An output (Y) is assigned to the lifter rotation. When the output (Y) is set to ON, the lifter rotates clockwise to transfer a part.
  * If the setting is incorrect, the lifter may rotate to a spot where no conveyor is available. The part may fall down or become stuck.

C-5-4: Door

The door is opened and closed vertically.

- Appearance (side view)

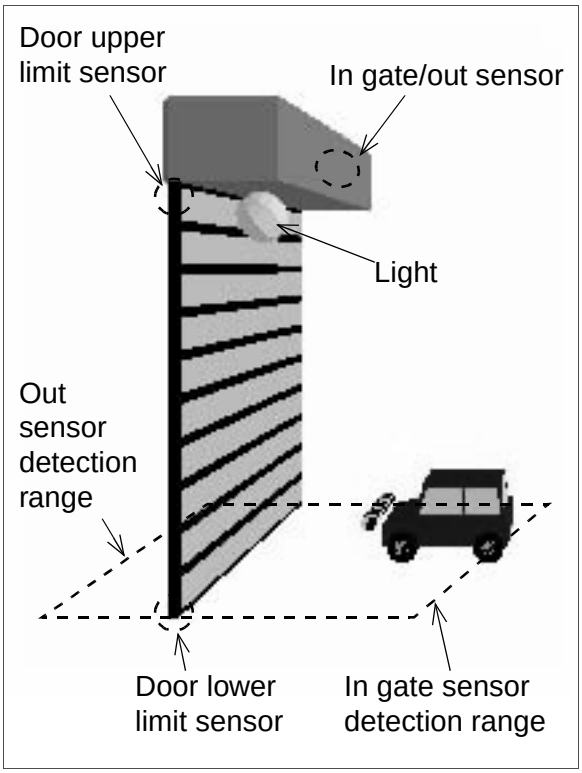


- Operation

Door opening/closing

- An individual output (Y) is assigned to each of the door opening and the door closing. (The door opening and closing motors are built in the door, and are not displayed.)
- When the output (Y) is set ON, the door is opened or closed.
  * The mechanical interlock between the opening motor and the closing motor is provided inside the virtual machine. Even if the two motors are operated at the same time, they are not damaged, but the door does not move.
  * If an object such as car collides the closed door, the object disappears and the screen returns to the initial status.

- Appearance (front view)

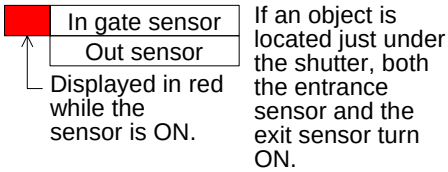


In gate/out sensor

- The door is provided with an in gate/out sensor to detect objects. An input (X) is assigned to each sensor.
  When the sensor detects an object, it turns ON (NO contact).

  * The ON/OF status of the in gate and out sensors which are not displayed graphically can be monitored by the red indicator at the left part of the device numbers on the simulation or indicators on the I/O image table in the virtual PLC.

Example



Upper limit/lower limit sensor

- When the door reaches the lower limit, the lower limit sensor (X) turns ON (NO contact).
- When the door reaches the upper limit, the upper limit sensor (X) turns ON (NO contact).

  * The sensors are not displayed on the screen. Their ON/OFF status is indicated on the side of the device numbers in the simulation.

Buzzer

- The buzzer is built in the door.
  An output (Y) is assigned to the buzzer and when the buzzer is set ON, "bing-bong" sound is intermittently issued.

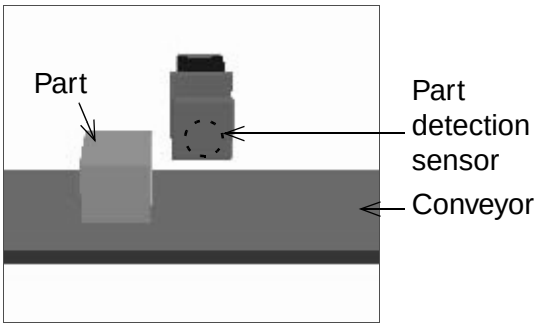
Light

- An output (Y) is assigned to the light. When the output is set ON, the light is lit in yellow.

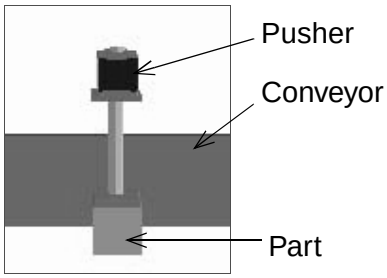
C-5-5: Pusher

The pusher extends and moves a part.

- Appearance (side view)



- Appearance (top view) when the pusher is pushing out a part



- Operation

Part pushing out command

- An output (Y) is assigned to the push command. When the output is set ON, the pusher extends. When the output is set OFF, the pusher pulls.

  * If the output is kept ON, parts may be stuck. Set the output ON for 0.5 to 1 second, then set it OFF.

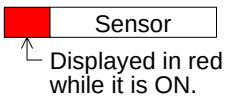
  * Even if the push command is set OFF while the pusher is extending, the operation is not stopped until the pusher extends completely.

Part detection sensor

- The part detection sensor turns ON when it detects a in front of the pusher (NO contact).
  Use the sensor data to push out a part.

- An input (X) is assigned to the sensor. The sensor is built in the pusher and is not displayed.

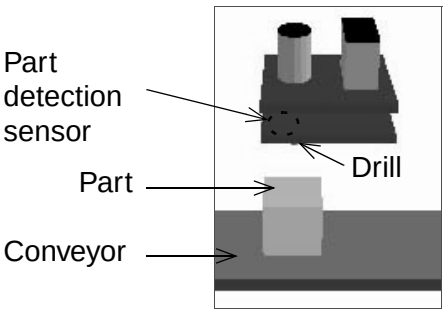
  * The sensor itself is not displayed on the screen. Its ON/OFF status is indicated on the side of the I/O number and on the I/O image table in the virtual PLC.

Example 

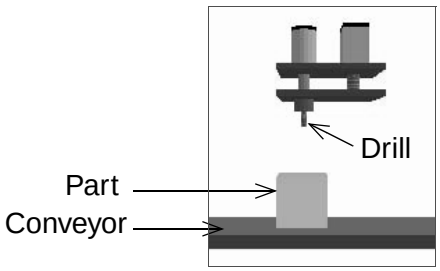
C-5-6: Drill

The drill makes holes in parts.

- Appearance (side view)



- Appearance (front view)



- Operation

Drilling start command

- An output (Y) is assigned to the drilling start command. When the output is set ON, the drill starts drilling.

Drilling signal

- When the drill starts drilling, the input (X) of the drilling signal turns ON. Write the program to turn OFF the drilling start command using this input signal.
- Once the drilling operation is started, the drill does not stop until it completes a cycle of operation even if the drilling start command is set OFF.

Correct/wrong signal

- If a part is located under the drill, a hole is drilled in the center of the part and the correct completion (Y) is set ON. If a part is not located under the drill or if multiple holes are drilled on a part, the wrong drilling (Y) is set ON. (When the wrong drilling is performed, the part is crushed.)

  * In some exercises, one out of certain number of parts is to be a defective part.

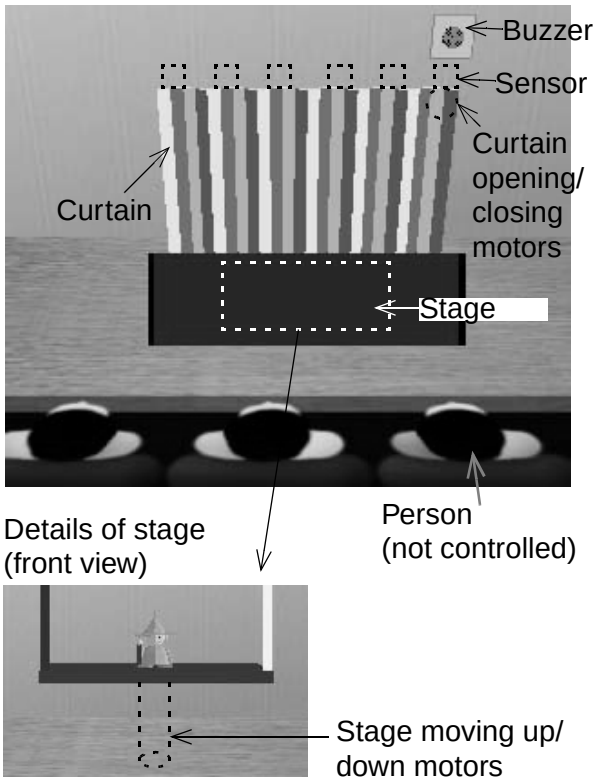
Part detection sensor

- The part detection sensor turns ON when it detects a part is coming close (NO contact). Use this sensor to take the timing to start drilling or stop the conveyor.
- An input (X) is assigned to the sensor. The sensor is built in the drill and is not displayed on the screen.

C-5-7: Stage Settings

The curtains are opened and closed horizontally, and the stage is moved up and down.

- Appearance (side view)



- Operation

Curtain opening/closing

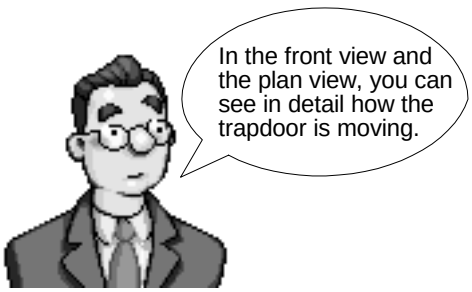
- An individual output (Y) is assigned to each of the curtain opening and the curtain closing.
  The opening output or the closing output is held while it is set ON.
  * The curtain opening and closing motors are not displayed on the screen.

Curtain position sensor

- In the upper portion of the curtains, the inside, middle and outside sensors are provided (six sensors in all).
  These sensors are used to detect the curtain opening/closing position.
  * The ON/OF status of the sensors not displayed graphically can be monitored by the red indicator at the left part of the device numbers on the simulation or indicators on the I/O image table in the virtual PLC.

Stage moving up/down

- The stage carries up and down the person.
  An output (Y) is assigned to each of the stage moving up and the stage moving down respectively. While either output is ON, the stage is moved up or down. If the both outputs are set ON at the same time, the stage is stopped. The motors are not displayed on the screen.



Stage upper limit/lower limit sensor

- Sensors are provided in the upper limit and the lower limit of the stage.
  Use these sensors to stop (set OFF) the stage moving up and moving down motors.
  * The sensors are not displayed on the screen.
- Control of the person located on the stage is not required. (The person remains on the stage and does not move.)

Buzzer

- An output (Y) is assigned to the buzzer. When the output is set ON, the buzzer flickers in yellow and continuous "bing-bong" sound is issued intermittently.

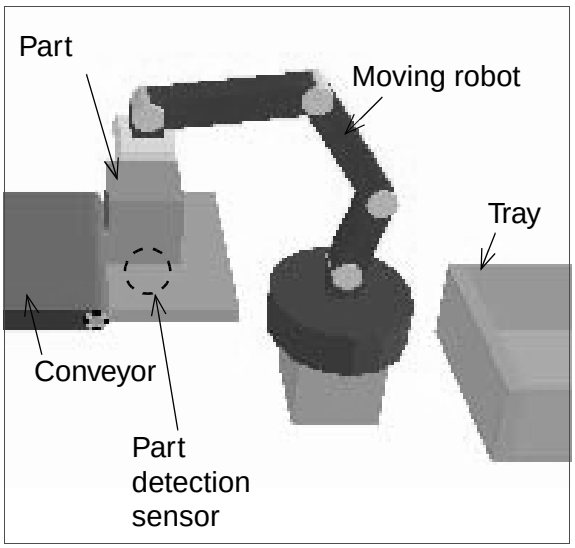
C-6: Unloading Robot

The robot operation to unload parts is described in this section.

C-6-1: Robot

The robot moves a part to the tray.

- Appearance (side view)



- Operation

Moving command

- An output (Y) is assigned to the moving command.
  When the output is set ON, the moving robot turns clockwise and carries a part.
- When the moving command is set ON, the robot performs one complete cycle of operation without regard to presence/absence of part.

Robot operation finished

- When a part is put into the tray, the part in tray signal (X) turns ON. Write the program to turn OFF the moving command using this input signal.

Starting point signal

- While a part is located at the starting point as shown in the figure, the starting point signal input (X) is ON.
  It is recommended to use this starting point signal for interlock of the part moving command.

Part detection sensor

- This sensor detects presence/absence of a part.
- An input (X) is assigned to the sensor. The sensor turns ON when it detects a part (NO contact).

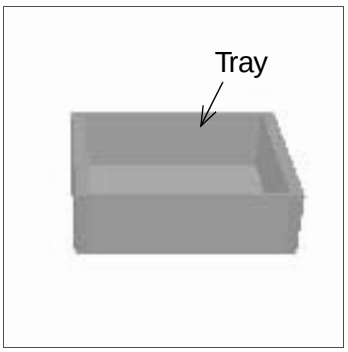
C-7: Others

Auxiliary operations and parts for the simulation are explained in this section.

C-7-1: Tray

The tray stores parts.

- Appearance (side view)



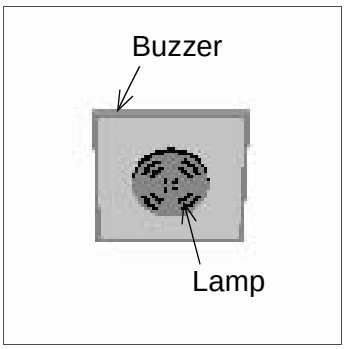
- Operation

  Control is not required.
  When the specified number of parts are stored, the person automatically appears to collect the parts.

C-7-2: Buzzer

The buzzer sounds.

- Appearance (side view)



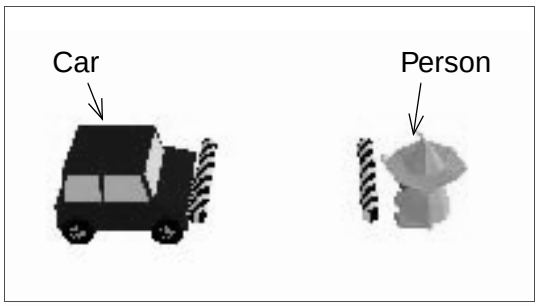
- Operation

  An output (Y) is assigned.
  When the output (Y) is set ON, "bing-bong" sound is intermittently issued. In addition, the lamp provided in the center of the buzzer flickers in yellow.

C-7-3: Person and Car

The person and the car appear on the screen.

- Appearance (side view)



- Operation

  Control is not required.

  * In some exercises, buttons are displayed on the 3-D graphic simulation. While a button is being pressed, the person or the car moves.
    When the person or the car collides with an object or wall, it disappears and the screen returns to the initial status.

Appendix D: Questions & Answers and

Please refer to the Q&A listed here for information on the training software.

D-1: Frequently Asked Questions

General	
Question	Answer
How do I connect the PLC?	Actual PLC and connection cables are not required. When the software is installed, the virtual PLC is set up in your computer.
Where should I begin learning?	You can choose any exercise in the main menu. However, it is recommended to start from the category 'Let's Learn the FX Series PLC' to understand the structure and operation procedures of the software.
What do I learn using this software?	You learn how to control various machines using basic PLC instructions.
Can I use the software without installing it to my computer?	No.
I have finished the exercise. Where do I go next?	If you are a registered user, update your score and return to the main menu as instructed on the self-judgment page. If you are not a registered user, click [Main] on the remote control to return to the main menu.
What does the 'good' award on an exercise button on the main menu indicate?	It indicates a completed exercise. Awards are only displayed for registered users.
How do I hide the guidance window to look at the simulation?	Click the tutor on the remote control to alternately hide and display the guidance window. Or select “Tool” → “Fix remote control bar” and delete the check mark to display the title bar at the top of the remote control. By dragging the title bar using the mouse, you can move the guidance window to an arbitrary position.
Ladder Program	
Question	Answer
Can I transfer the program to an actual PLC?	The program can be transferred only to the virtual PLC inside your computer. The ladder program area is internally connected to the virtual PLC.
How can I write a program while the PLC is in RUN mode?	You cannot write a program while the PLC is in RUN mode. Click [Write to PLC] on the remote control to write a program easily. (Or select "Online" → "Write to PLC" on the ladder menu.)
Which instructions are available?	Basic instructions, Application instructions and stepladder instructions. For the details, refer to the tables in the appendix in this manual.
Can I use the program later?	You can store the program selecting "Project" → "Save as". You can read and edit data.
How can I display comments in the ladder program?	Select "View" → "Comment".

Ladder Program	
Question	Answer
Can I type in the instructions in the ladder program?	Yes. Type in the instructions after clicking the ladder program area. The instruction list is not available in the software. Refer to the table in the appendix in this manual.
Can I change the window size?	No, the display size is fixed.
Why are some contacts highlighted in blue?	A feature of the I/O monitor display is that when a contact or a program is set ON, it is highlighted in blue.
What are the numbers under the timers and counters?	The numbers under the timers and counters are their current values.
Does the program I write in this software run in an actual PLC?	Yes, but this software is not equipped with the function to write a program to an actual PLC. The program must be entered in a general release software package such as GX-Developer and then transferred to the PLC.
Ladder example	
Question	Answer
How do I see the ladder example?	Click [Edit Ladder] on the remote control. Then select "Help" → "Ladder example" → "Example" on the simulation menu.
Should my program be exactly the same as the ladder example?	No. Refer to the ladder example only as examples of one correct control method.
How do I study the details of the programs of ladder example?	Device comments are provided to the ladder example. Select "View" → "Comment" to study them.
Can I print out the ladder example?	Yes. Select "Project" → "Print".
Can I edit the ladder example?	Yes. Select "Project" → "Save as" on the ladder menu to create another file for editing so that the original model answer is not deleted.
How do I save a ladder example with a different name?	Select "Project" → "Save as" and name the file.
Can I confirm the operation after editing the ladder example?	Yes. Let's see how your program operates!
Can I register my program as a ladder example?	Yes. Read out one of the ladder example, edit and overwrite it selecting "Project" → "Save" on the ladder menu. (You cannot 'add' a new ladder example.)
Virtual PLC	
Question	Answer
What is the virtual PLC?	It is a PLC in which the program you write in your computer is virtually transferred and run.
Which instructions and devices are available in the virtual PLC?	Refer to the tables in the appendix in this manual.
How do I know the status in the virtual PLC?	RUN indicator and ON/OFF lamps for I/O on the 'I/O image table' are lit or extinguished according to the status in the virtual PLC.

Virtual PLC	
Question	Answer
How can I switch the RUN mode and STOP mode in the virtual PLC?	There are several ways to do it. (No RUN/STOP switch) • Switched to STOP mode when you click [Edit Ladder] on the remote control. • Switched to RUN mode when you write your program to the PLC in STOP mode. • Switched to STOP mode and then to RUN mode when you click [Reset] on the remote control. • Switched to STOP mode when you write your program to the PLC in RUN mode.
When is the program inside the virtual PLC cleared?	The program is cleared when you go to the main menu or exit the software.
Simulated Machine	
Question	Answer
Can I add sensors?	No. The device assignment in machines is determined in advance. You cannot add or change them.
Can I change the device assignment?	
Can I change the operations of machines?	
Do I need to wire the virtual PLC to the machines?	No. They are wired virtually inside your computer.
Can I restart the operation of the machine if the machine stops or parts are stuck?	Yes. Click [Reset] on the remote control to reset the I/O status of the PLC and return the screen to the initial status. (The program is saved in the PLC.)
Can I perform the operations different from the ones shown in the guidance?	Yes. There is more than one way to control the machines.
When does the person appear in the 3-D graphic simulation?	In most cases, the person appears to collect parts when certain amount of parts are put in the tray.
How do I speed up the operation of the simulation machines?	When the performance of the computer is improved, the operation speed of the machines is improved accordingly. If you have the unwanted situation such as 'the input data from a sensor is not received properly', speed adjustment is required.
Operation panel	
Question	Answer
Can I add switches and lamps?	No. Assignment of switches and lamps on the panel are determined in advance and cannot be added or changed.
Can I change the device assignment?	
Can I change or add letters and phrases displayed?	
Can I change the lamp colors?	
Can I use the switches and lamps the guidance does not talk about?	Yes. Such switches are wired to the virtual PLC. You can use them as your own operation switches and indicator lamps.
User registration/self-judgement	
Question	Answer
What is the advantage of being a registered user?	In the main menu, a 'good' award and the number of times the exercise has been completed is displayed on the exercise button and your total score is listed at the bottom.

User registration/self-judgement	
Question	Answer
I am on the self-judgment page. What do I do?	Follow the instructions in the box. If you are a registered user, you are asked to judge your understanding in a dialog box. If you click [Yes], the score and the number of times the exercise has been completed is updated.
I am a registered user, but I forgot my password. What should I do?	Register yourself as a new user.
What is the score I gain for finishing each exercise?	Scores have been set according to the difficulty level of the lesson. When an exercise has been completed, the score is added to the registered user's overall total.
What if I don't register myself as a user?	An unregistered user can learn the lessons in the same manner as a registered user. Unregistered users do not collect points nor award stickers. This makes it more difficult to monitor which lessons have been successfully completed.
System requirement	
Question	Answer
Is a Pentium 500MHz CPU mandatory?	No, the software runs at approximately 300 to 400MHz. Lower specification equipment will cause the overall operation to be slow.
Is 64MB of RAM memory mandatory?	64MB or more is mandatory. It is recommended to use 128MB or more for cases in which other softwares are running at the same time.
Is 4MB of VRAM (video memory) or more mandatory?	In order to assure the operation speed and the display contents of the simulation, use a computer equipped with a video memory of 4MB or more.
Is the screen display of XGA (1024 × 768) or more mandatory?	Yes. This software is designed at the fixed size of the XGA (1024 × 768).

D-2: What to do if...

It indicates that you completed the exercise. (It is not displayed if you are not registered as a user when starting the software.)	Print out the program you have written, and check the contents. Refer to model answers if needed.
The machine in the simulation does not operate.	Check whether the device assignments in the program are equivalent to those shown in the guidance. A conveyor does not move if the forward and reverse motors are ON at the same time.
I would like to speed up the operations in the virtual manufacturing cell.	When the performance of the computer is improved, the operation speed of the machines is improved accordingly. If you have an error situation such as 'the input data from a sensor is not received properly', speed adjustment is required.
The program cannot receive the input data from the sensor.	Select "Tools" → "Options" and reduce the simulation speed.
A part does not stop where it should	
Something is wrong with the 3-D screen. (The display is disturbed, etc.)	• Check whether the video card of your computer supports the direct 3-D. • Select “My computer” → “Control panel” → “Screen” → “Settings” tab → “Details” button → [Performance or troubleshooting] tab, then decrease the set value of “Hardware accelerator” to “zero”. If the problem is solved, increase the set value one by one up to a highest allowable value. • Select “My computer” → “Control panel” → “Screen” → “Settings” tab, then increase [Screen color] to "24 bits" or decrease it to "16 bits". Or the problem may be solved if you update the video driver to the latest version provided by the computer manufacturer. (For details, consult with the computer administrator.)

MEMO

USER'S MANUAL

FX-TRG-BEG-E

MITSUBISHI ELECTRIC CORPORATION

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Specification are subject
to change without notice.