Featuring
Infinite
Technologies

FS Ladder

User's Manual

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FIT CO.,LTD.

Change log

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1 Introduction

FS Ladder application serves as a ladder diagram editor and compiler from the ladder diagram to a mnemonic program used by the smartPLC.

1 - 1 System Requirements

In order to use the FS Ladder application, the following environment is necessary.

Operating system

Windows 7 or Windows 10
(Mac and Linux are not supported)

* Windows is trademark of Microsoft Corporation.

Requirements

Hard disk free space 20MB or more

Microsoft .NET Framework 4.5 or higher installed
* For installation, please visit the website of Microsoft Corporation

1 - 2 Installation of software

The chapter is explaining how to install FS Ladder on the hard disk of the computer.

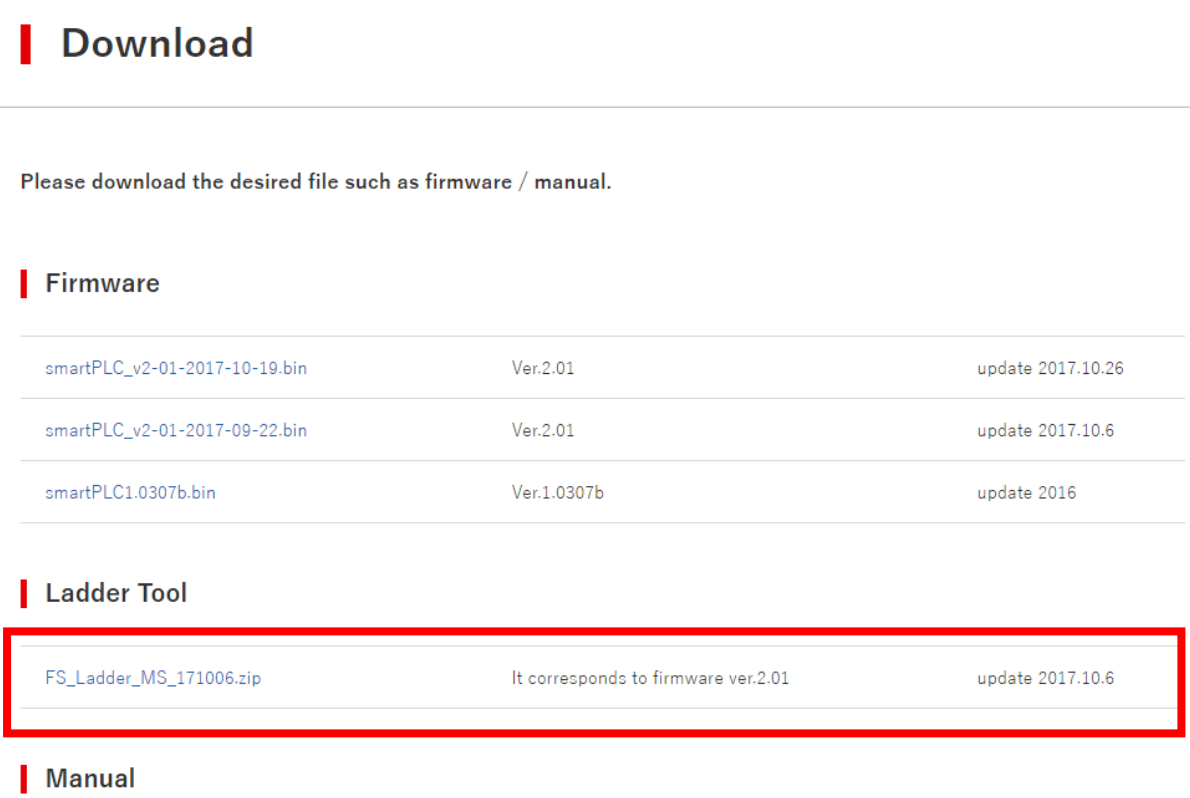
1 - 2 - 1 Preparing for installation

Check the following.

- Windows 7 or 10 is installed on your computer and it is working properly.
- There is minimum 20 of a free space on your hard drive. If there is no space, please free it in advance.
- You will need USB port for a direct transferring programs to smartPLC. You can also use SD card reader/writer to save program to SD Card as the smartPLC can read the program from it.
- A PDF reader is installed on your computer. It is used to open and display user's manual file.
- Uninstall the previous FS Ladder if installed.

1-2-2 Installation

1. Access the smartPLC product download page https://smartplc.org/about/downloadsEN.html
2. Click on the latest version of FS Ladder. In this case the latest version is from October 6, 2017.



Download

Please download the desired file such as firmware / manual.

Firmware

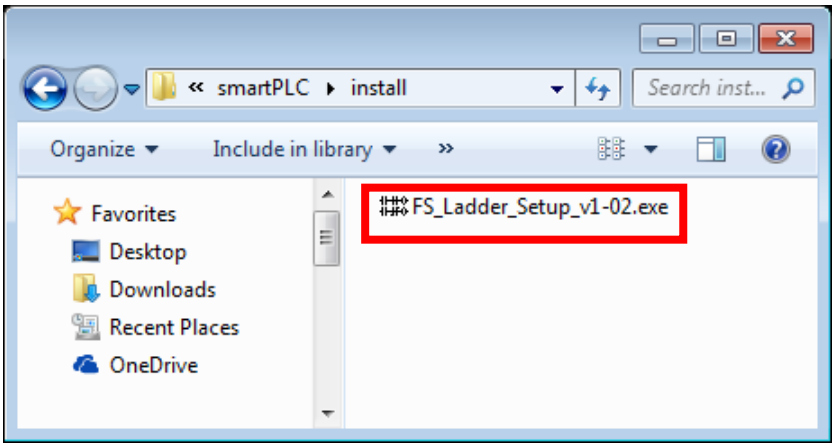
smartPLC_v2-01-2017-10-19.bin	Ver.2.01	update 2017.10.26
smartPLC_v2-01-2017-09-22.bin	Ver.2.01	update 2017.10.6
smartPLC1.0307b.bin	Ver.1.0307b	update 2016

Ladder Tool

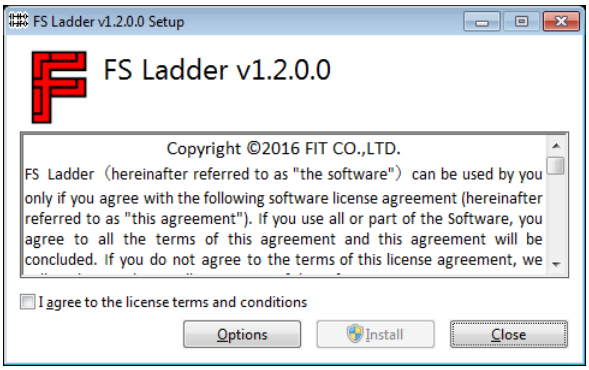
FS_Ladder_MS_171006.zip	It corresponds to firmware ver.2.01	update 2017.10.6

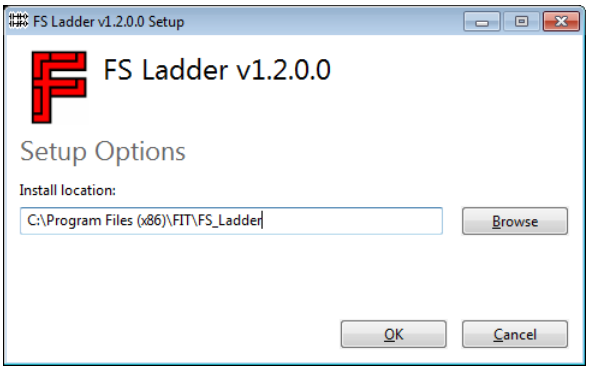
Manual

3. Save the file in an arbitrary location and unzip the zip file.
4. Uninstall the previous FS Ladder in advance.
5. When you are ready for installation, please double click on the setup file to execute the installation process. The file name differs with version, in this case it is "FS_Ladder_Setup_v1-02.exe".

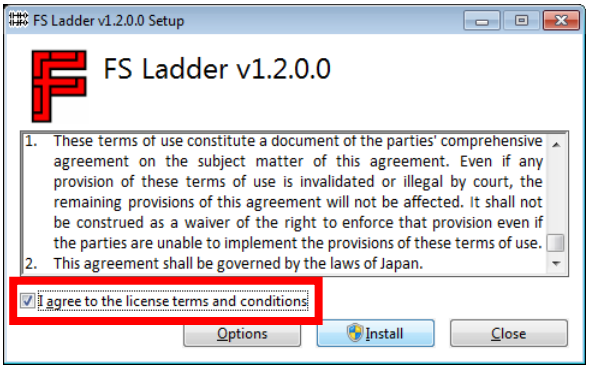


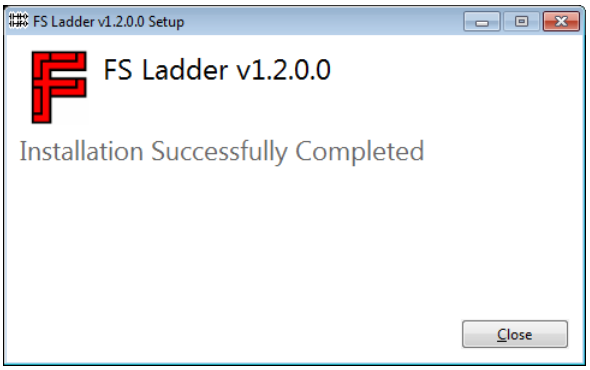
6. The installation screen will be displayed. If you would like change the installation destination, please click on "Options" and use "Browse" to select the destination folder.



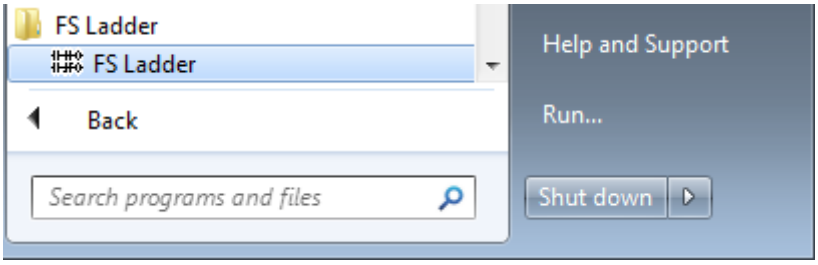


7. If you agree to all the terms of the license agreement, please check "I agree to license terms and conditions" and click "Install". Click "Close" when installation is completed.



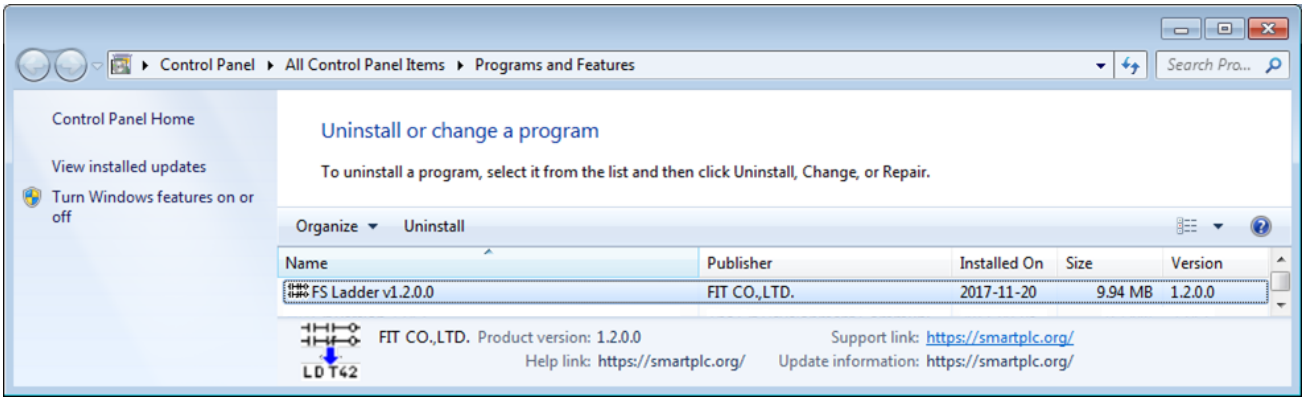


8. FS Ladder will be added to the program menu in folder “FS Ladder”.



1-2-3 Uninstalling FS Ladder

When FS Ladder is no longer needed, uninstall it by using "Programs and Features" from Windows Control Panel.

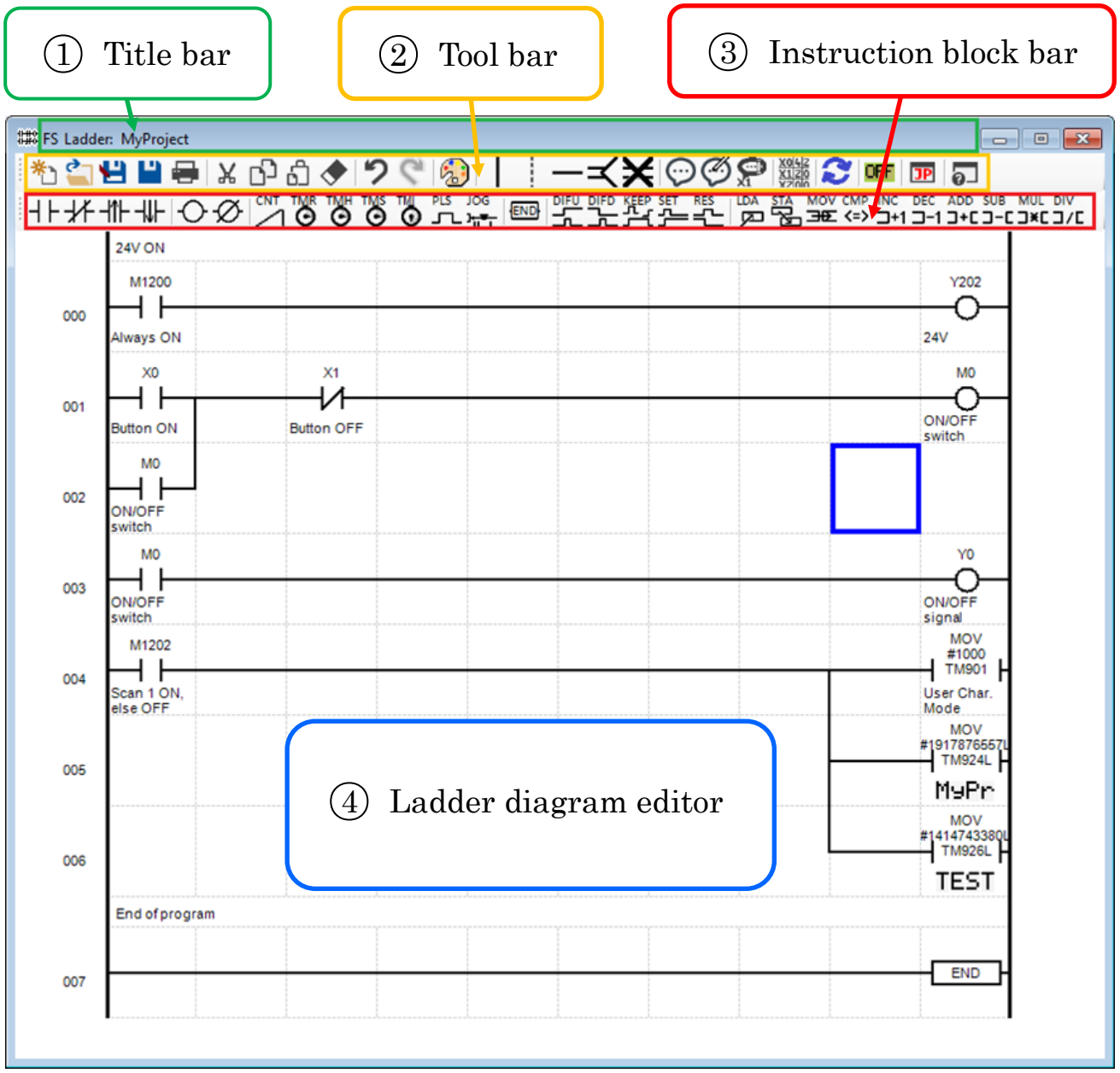


2 Basics

This chapter explains the basic operation.

2 - 1 Application Window

When you start FS Ladder, the following window will be displayed.



①Title bar	Application name and the name of actually opened file
②Tool bar	Function buttons
③Instruction block bar	Buttons of instruction blocks
④Ladder diagram editor	Area of ladder diagram editor

2-2 Tool Bar

Icon	Name	Function
	New	Create a new file.
	Open	Open an existing file.
	Save as	Save the current file with a different name.
	Save	Save the current file. The file will be overwritten with new content.
	Print	Print ladder diagram.
	Cut	Copy and Cut selected cells.
	Copy	Copy selected cells.
	Paste	Paste the copied cells.
	Delete	Delete the selected cells.
	Undo	Cancel the previous operation
	Redo	Redo the operation you canceled with "Undo"
	Relay palette display	Show a relay and an instruction palette.
	Left vertical line	Insert a vertical connection line
	Left vertical line delete	Delete the vertical connection line
	Horizontal line	Insert a horizontal connection line.
	Insert row	Insert a blank row.
	Delete row	Delete the selected row.
	Insert comment line	Insert an empty comment line.
	Edit comment line	Edit selected comment line.
X1	Edit comments of operands	Edit the comments of device relays and memory registers (operands except the numeric constants).
X0 4 2 X1 2 0 X2 0 0	Device usage status	Show a list of usage status of each device relay/memory register.
	Make a Program	Create a program text file from ladder diagram.
ON OFF	Switch tooltip display	Show/Hide a character display on tooltip.
JP EN	Switch Language	Switch language to Japanese or English
	Help	Show a Help window with shortcuts, software version, License and link to the user manual.

2-3 Instruction block bar

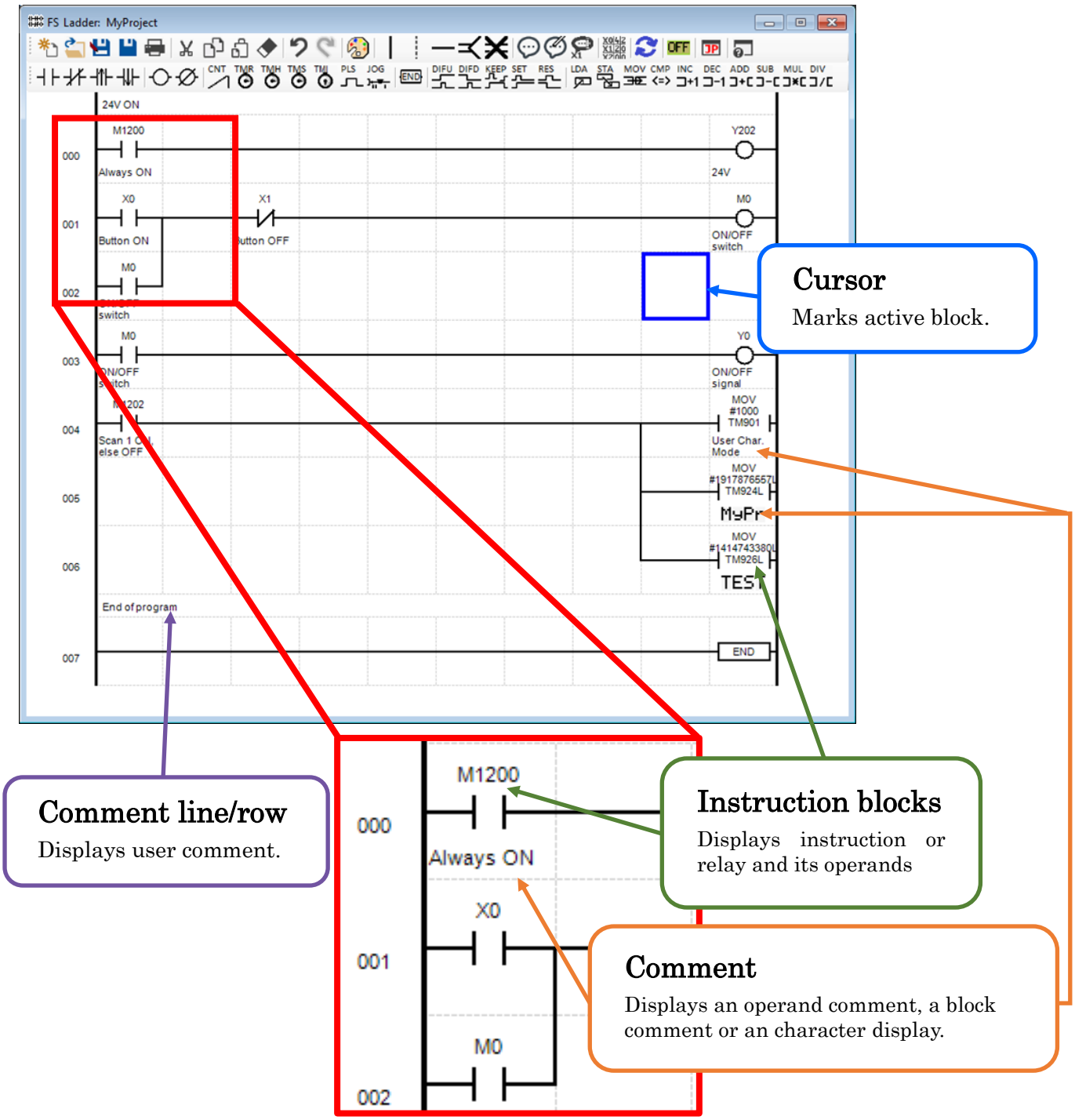
Icon	Name	Function
	Contact A (N.O)	Connect A contact (normally open)
	Contact B (N.C)	Connect B contact (normally closed)
	Contact A of Raising Edge Detector	Connect an A contact of the Raising Edge Detector to the beginning of the circuit.
	Contact A of Falling Edge Detector	Connect an A contact of the Falling Edge Detector to the beginning of the circuit.
	Coil	ON / OFF status of the circuit to the Output Relay.
	Coil bar	Inverted ON / OFF status of the circuit to the Output Relay.
CNT	Counter	It is 16bit incremental counter.
TMR	Timer (100ms)	A timer instruction with delay in 0.1s.
TMH	Timer (10ms)	A timer instruction with delay in 0.01s.
TMS	Timer (1ms)	A timer instruction with delay in 0.001s. (1*)
TMI	Timer interval in ms	A timer measures time in ms (1*)
PLS	Pulse	Send positioning pulses to the output specified in the operand2 according to the selected preset position specified by operand1.
JOG	Jog	Send positioning pulses to the output relay specified in the operand.
END	End	Indicates the end of the program
DIFU	Differentiate UP	When a rising edge on the input is detected then the relay specified by the operand is set ON for one scan cycle.
DIFD	Differentiate Down	When a falling edge on the input is detected then the relay specified by the operand is set ON for one scan cycle.
KEEP	Keep relay	When input SET is ON, the relay specified by the operand is set ON and when input RES is ON the relay is set OFF.
SET	Set	When the input condition is ON then set ON the relay specified by the operand.
RES	Reset	When the input condition is ON then set OFF the relay specified by the operand.
LDA	Load	Load the value specified by the operand to the internal register.
STA	Store	Store the value of the internal register to the destination specified by the operand.
MOV	Move	Transfer the value specified by the first operand to the destination specified by the second operand.
CMP <=>	Comparison	Compare the internal register with the value specified by the operand.
INC +1	Increment	Increment by one a value of the memory (DM, TM, CM) specified by the operand.
DEC -1	Decrement	Decrement by one a value of the memory (DM, TM, CM) specified by the operand.

Icon	Name	Function
ADD ⊐+⊏	Addition	Add a value specified by operand to the value of the internal register, the result is saved to the internal register.
SUB ⊐−⊏	Subtraction	Subtract a value specified by operand from the value of the internal register, the result is saved to the internal register.
MUL ⊐×⊏	Multiplication	Multiply the internal register with the value specified by the operand.
DIV ⊐/⊏	Division	Divide the internal register by the value specified by the operand.

(1*) Accuracy of TMS (Timer 1ms) and TMI are limited by the length of SCAN time which is typically 1~10ms.

2-4 Ladder diagram editor

A description of the of the ladder diagram editor.



2-5 File operation

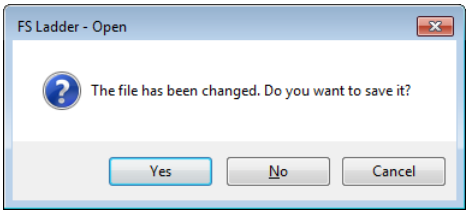
A description of the commands related to file operation

2-5-1 Create a new file

- Click on "New" or press [CTRL + N] to create a new file.
- When you working with a file that has not been saved, a confirmation screen will be displayed asking whether to save the file.

2-5-2 Open a file

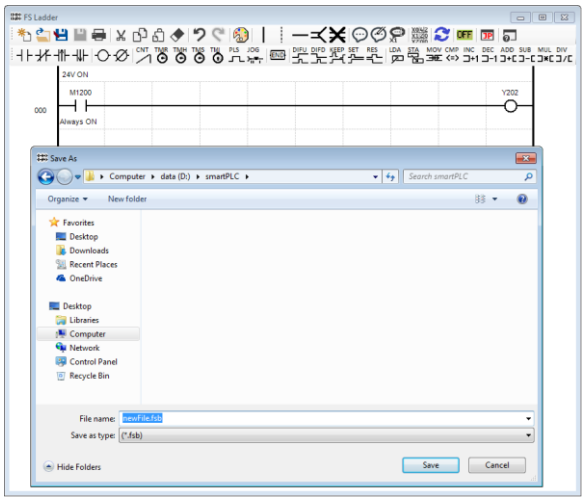
- Click on "Open" or press [CTRL + O] to open a saved file. An Open file dialog where you can choose the file will be displayed.
- When you working with a file that has not been saved, a confirmation screen will be displayed asking whether to save the file.

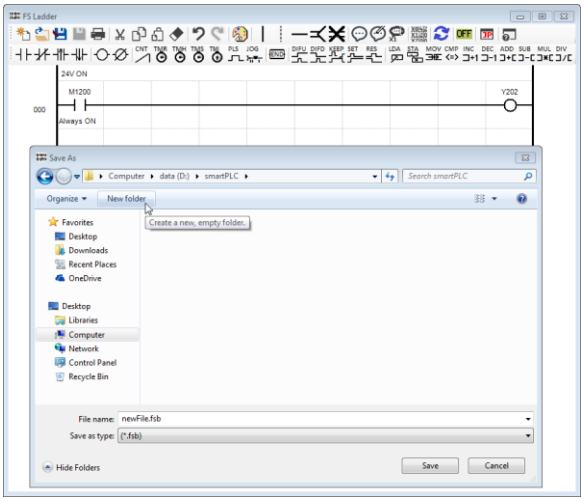


2-5-3 Save as

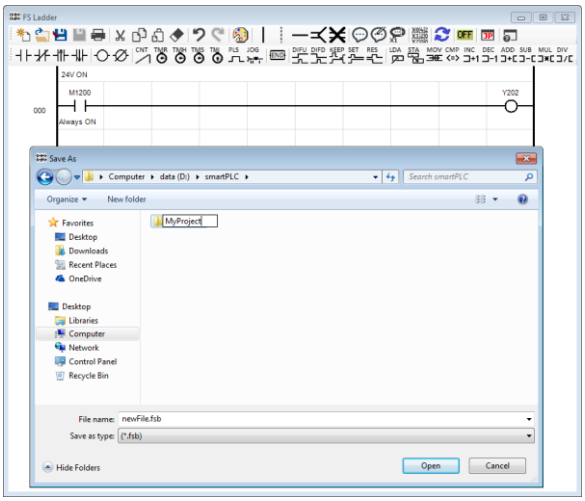
"Save As" can be used to create a project folder in the document folder and save the file with the ladder diagram in it.

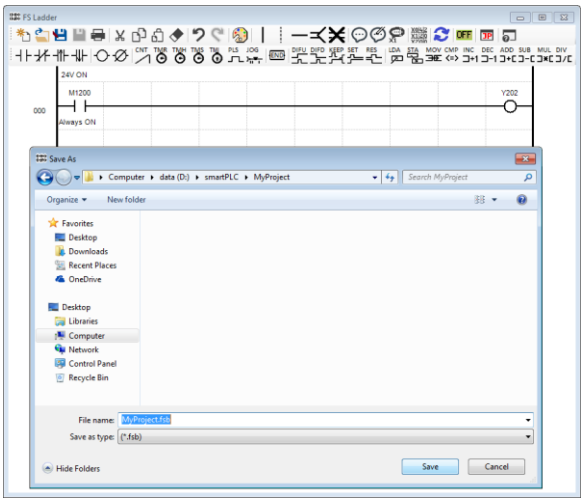
1. Click on "Save As" or press [CTRL + S] to save the file with a new name. A Save As file dialog where you can choose the file will be displayed.
2. Click on "New Folder".





3. Give a name to the created project folder.
4. Open the project folder, edit a file name and save.



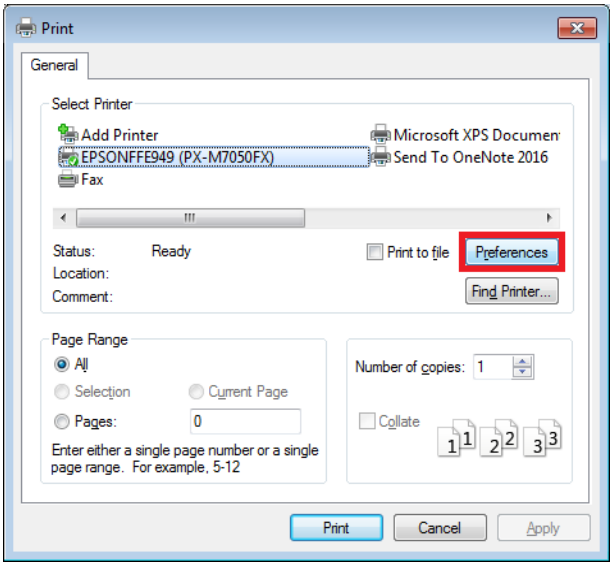


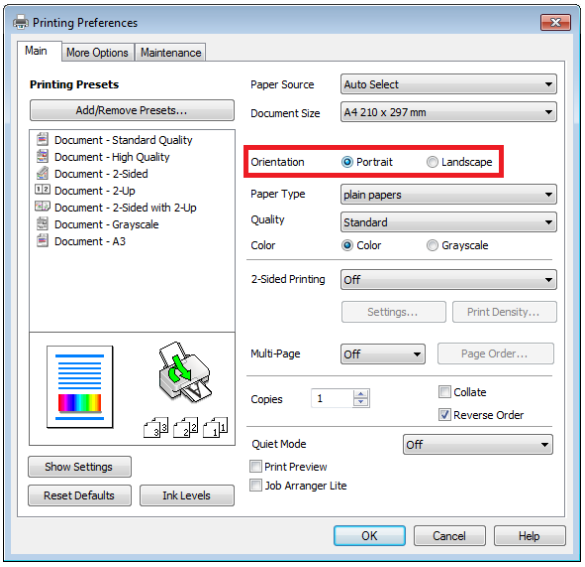
2-5-4 Save

- Click on "Save" or press [CTRL + Shift + S] to save the file. Previous content of the file will be overwritten. When save is finished icon become inactive .
- "Save" is inactive if you are editing a new file or if you haven't done any changes to the opened file.

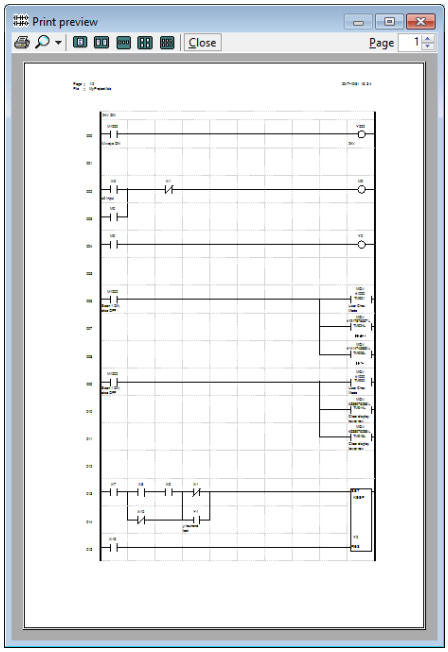
2-5-5 Print the ladder diagram

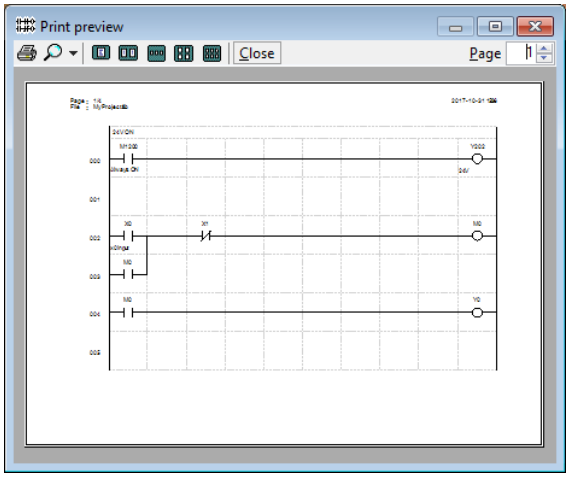
1. Click on "Print" [CTRL + SHIFT + P] to print a ladder diagram.
2. The orientation of a printing of ladder diagrams will be automatically changed by the switching the printing orientation (portrait and landscape).





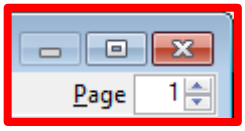
3. Please specify page range, number of copies, other detailed settings etc.
4. Pressing Print (P) will show the print preview screen as shown below.



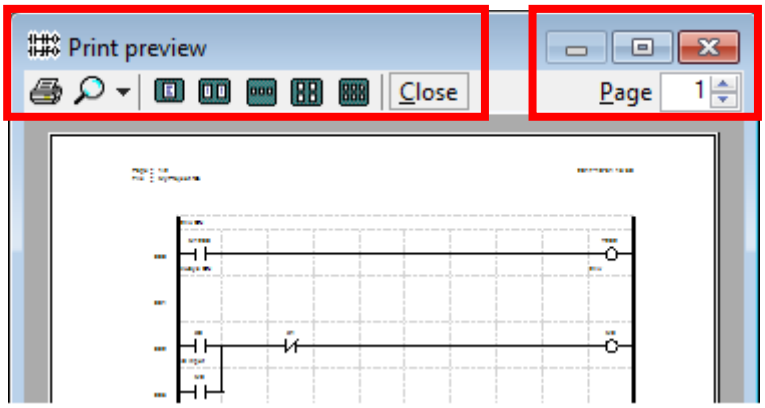


5. There are following buttons on the print preview screen.

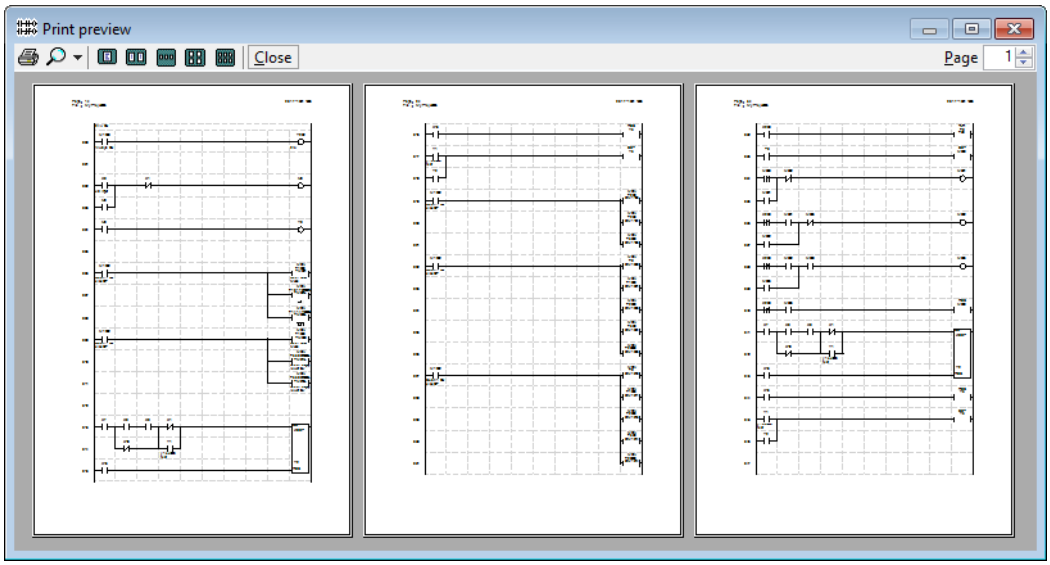
① : Start printing
② : Zoom
③ : Change a number of pages on the preview screen
④ : Close
⑤ : Change page



① ② ③ ④ ⑤



By clicking on "③ Change a number of pages on the preview screen ", you can see multiple pages at a time.



6. Check the print preview and start printing.

3 Creation of the Program

3-1 Flow of program execution

Create a program with the following procedure and control it with smartPLC.

Create a ladder diagram

Create a ladder diagram using FS Ladder

Save

Save the ladder diagram with “Save As”.

Make a Program

Create a program file from the ladder diagram.

Program update

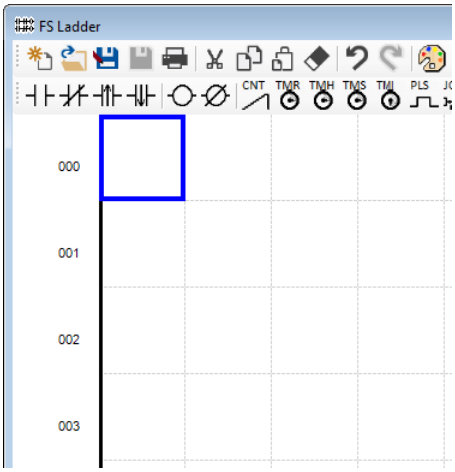
Copy the program file to the “smartPLC” drive

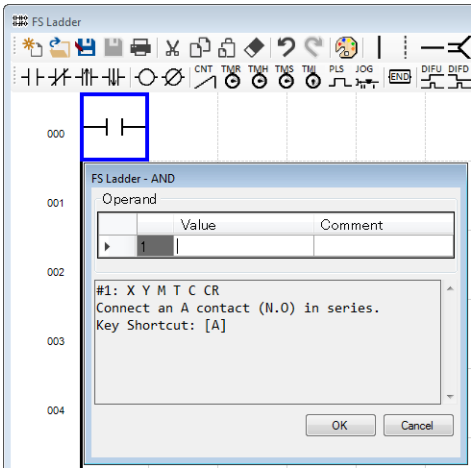
Program execution

The program execution starts with a smartPLC restart.

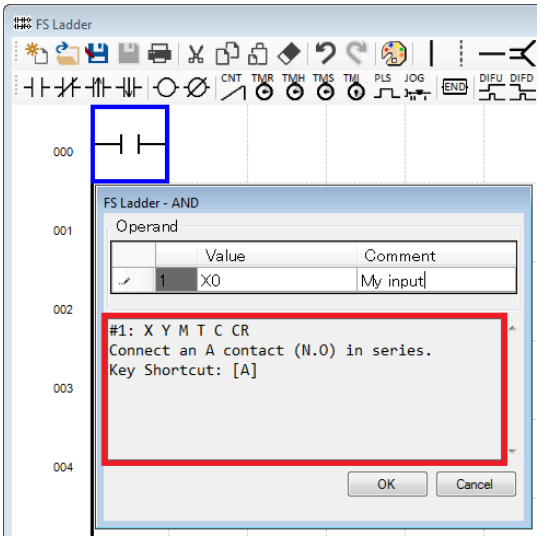
3-2 Inserting instruction block

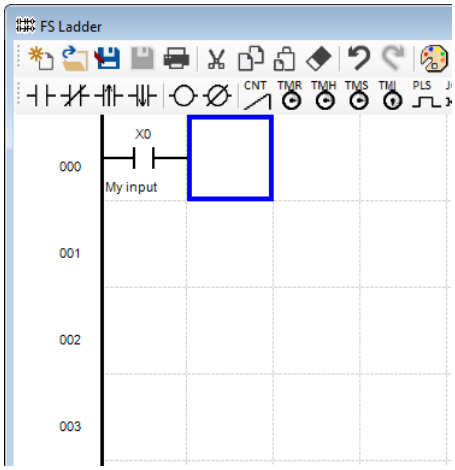
1. Click on a cell where you would like to insert an instruction block or move a cursor (the blue frame around the cell) with arrow keys.
2. Click on a required instruction block on the instruction block bar or press the shortcut of the block on the keyboard.





3. Set the operand values if any. You can also edit the operand comments.
   Notes:
   - The comments for numeric constants are ignored and they will not be saved.
   - There is an instruction description marked by the red frame on the picture.
   - You can see valid operand types for the operands in the instruction description.
   - The "#1:" is followed by the valid operand types for the first operand
4. Press OK to insert the instruction block.

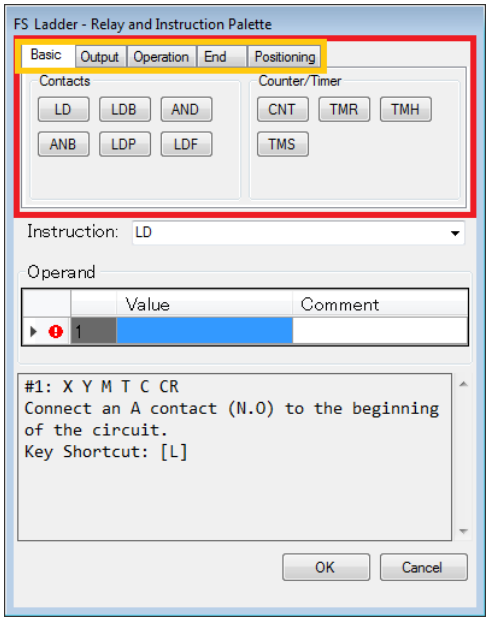




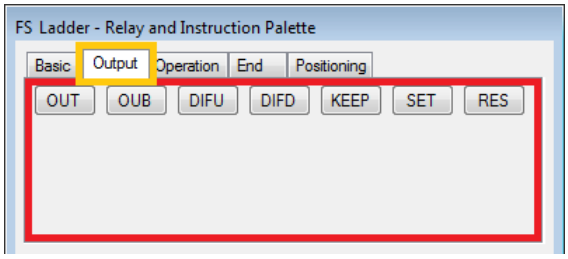
3-3 Relay and instruction palette

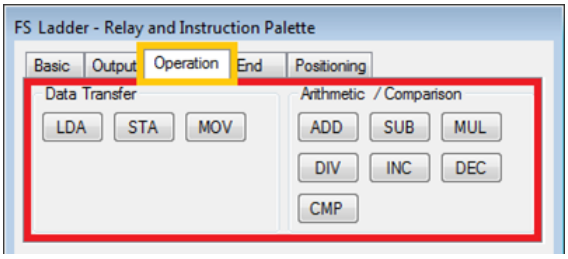
The palette dialog window allows you to choose a required instruction block.

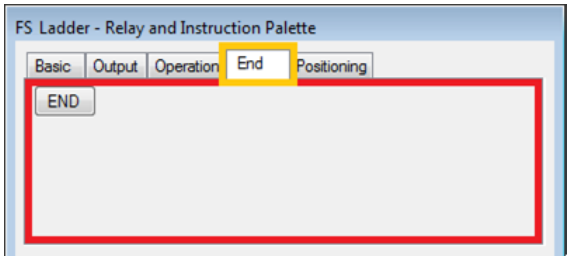
- Instruction blocks are split into groups (basic, output, operation, end, positioning).

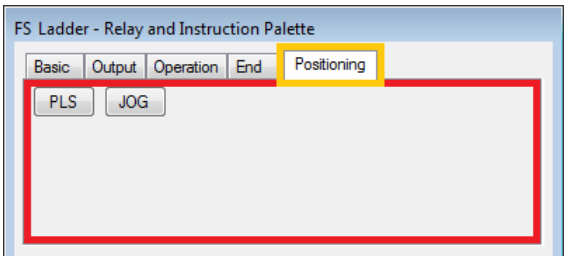


- By selecting the tab label (marked by the orange frame), the tab area (marked with red frame) will switch to appropriate group as shown below.







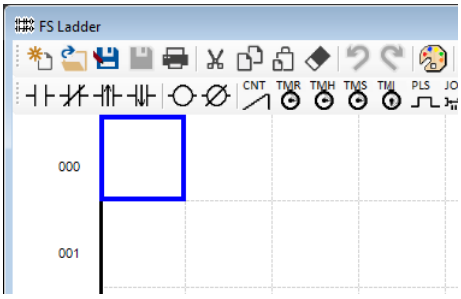


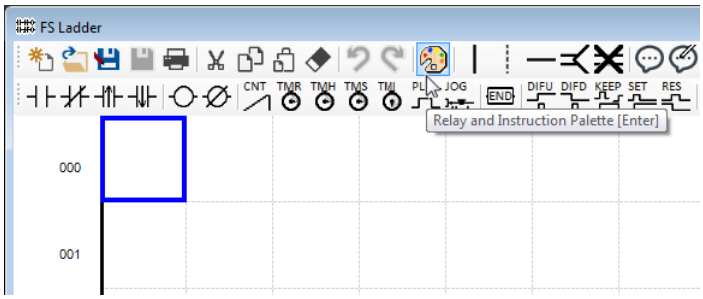
3-4 Usage of the palette

Steps to insert a block instruction to the ladder diagram using the relay and instruction pallet.

1. Click on a cell where you would like to insert an instruction block or move a cursor (the blue frame around the cell) with arrow keys.

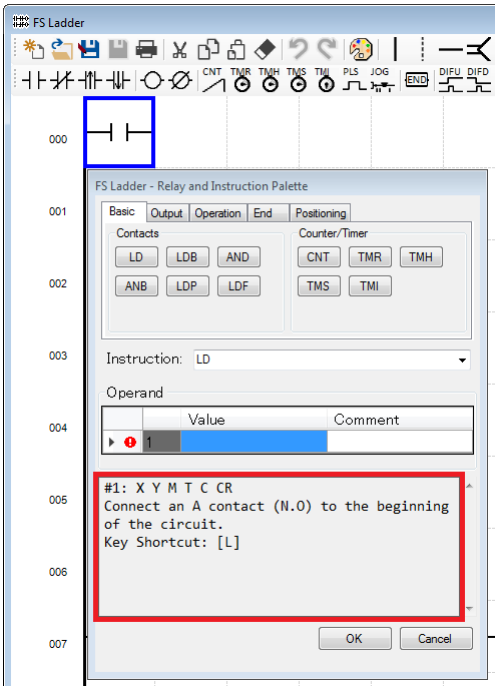
2. Click on "Relay and Instruction Palette" on the instruction block bar or press [Enter] key.

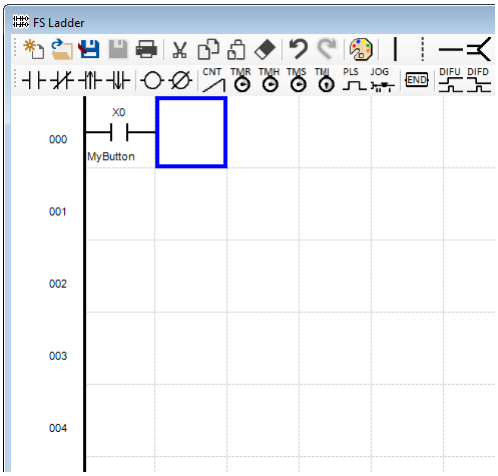




3. Choose the required instruction type and click on it. Set the operand values if any. Edit the operand comments if you need.
   Notes:
   - The comments for numeric constants are ignored and they will not be saved.
   - There is an instruction description marked by the red frame on the picture.
   - You can see valid operand types for the operands in the instruction description. The "#1:" is followed by the valid operand types for the first operand
   - MOV, PLS and END instruction allows you to edit a block comment which will be displayed in the ladder diagram.

4. Press OK to insert the instruction block

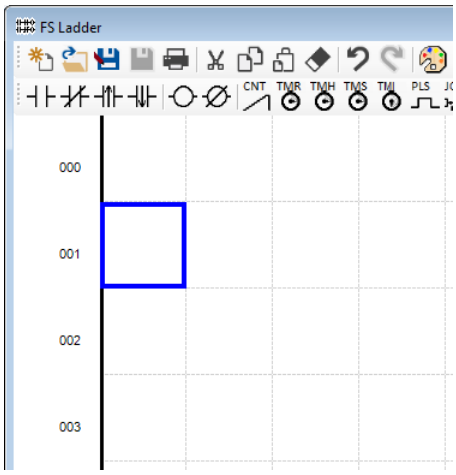


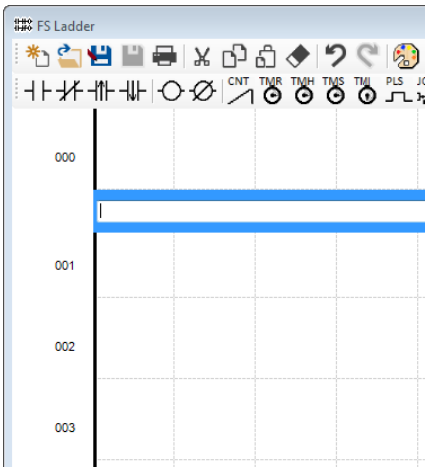


3 - 5 Comment Lines

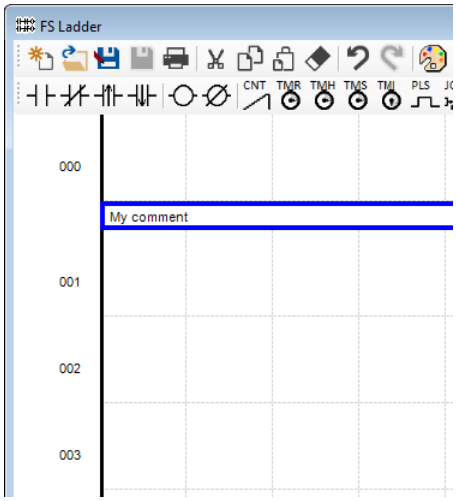
Steps to insert a comment line.

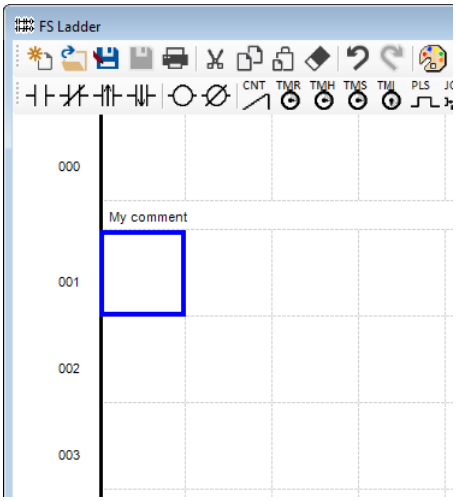
1. Move the cursor (by clicking or by arrow keys) to a row or to a comment line beneath the place where you would like to insert a comment line.
2. Click on the or press the [Insert] key.





3. Edit your comment and press the [Enter] key when editing is finished.
4. Use arrow keys or mouse click to return to a normal cell.





Notes:

- You can select a comment line by clicking on it or by pressing [Ctrl + ↑] or [Ctrl + ↓].
- To edit already inserted comment move cursor on it and click on or press the [Enter] key.
- To remove already inserted comment move cursor on it and click on or press the [Delete] key.

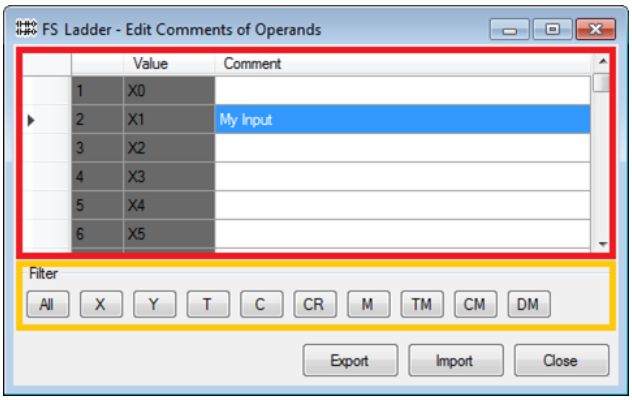
3-6 Edit comments of operands

Steps to edit comments of operands.

1. Open the editor of comments of operands by clicking on or press [F3] key.
2. There are two ways how to edit comments.

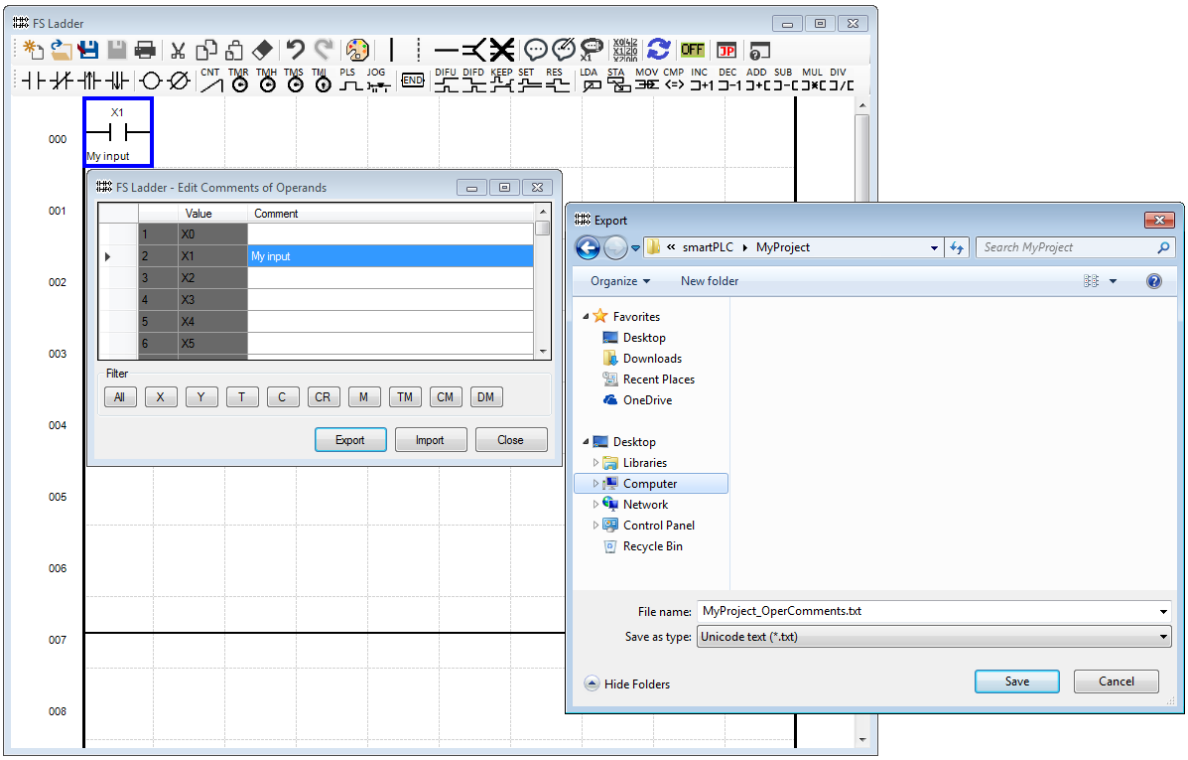
   I. Edit the requested operand comment in data grid (marked with the red frame). When you leave the edited cell, the ladder diagram will be updated automatically.

   You can use the operand type filter (marked with the orange frame) to show requested operand type.



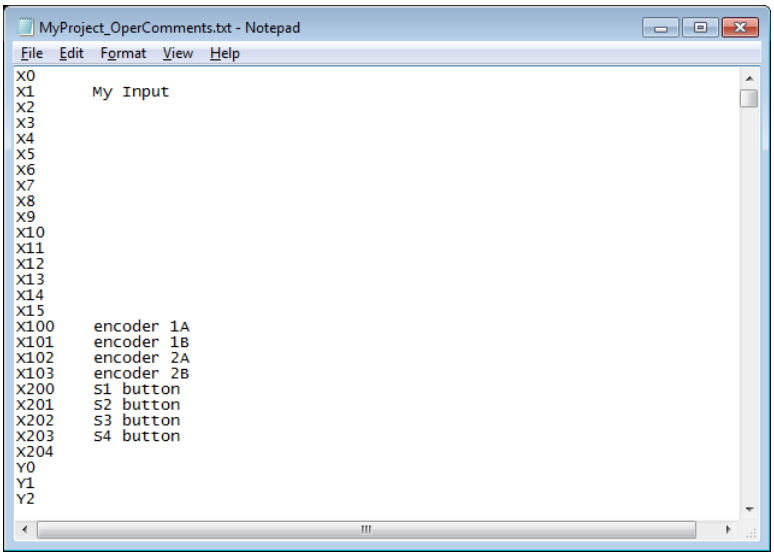
   II. Export, Edit, Import

   ① Use the Export button to export the comments of operands as a Unicode text file.



② Edit the file.

The file format is simple, between operand and comment is tabulator as a delimiter. Make sure that the editor supports Unicode text and also it does not replace tabulators with spaces. As long as you will keep the file format you can use your favorite text editor or Microsoft Excel to edit it.

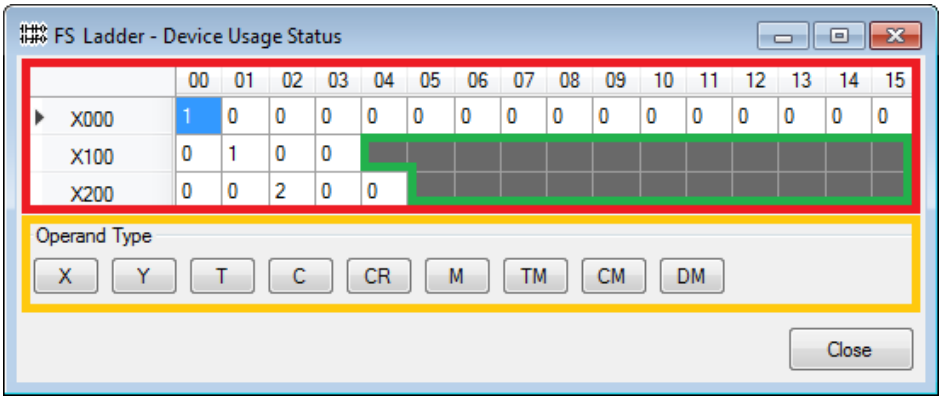


③ Use the Import button to import the comments of operands from the Unicode text file. Note all lines of the text file which have invalid format are ignored without any warning, and so if nothing had been imported, check the file format.

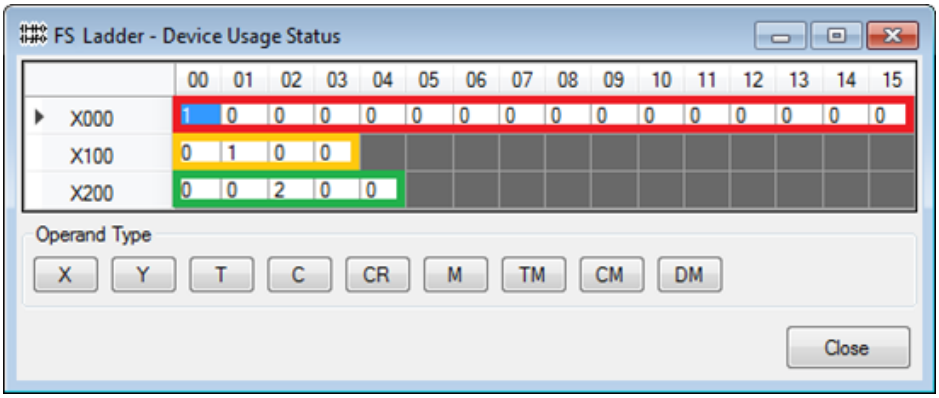
3-7 Device Usage Status

The usage status of the device informs you about device elements (relay, timer, data memory, etc.) used as operands in the program.

1. Open the device usage status window by clicking on or press [F2] key.
2. The screen composition is as follows.
   - Orange Frame: a device element (operand type) selection
   - Red frame: a number of occurrences
   - Green frame: nonexistent device elements (invalid operands)



3. The number in the table indicates the number of occurrences of the operand (the concrete part of the device facility).
   - Red frame: X000 ~ X015
   - Orange Frame: X100 ~ X103
   - Green frame: X200 ~ X204



From the data grid of the example above, you can see that there are used following inputs in ladder diagram: one X0, one X101 and two X202.

3-8 Character Display

- You can display any character of display font (Alphabet, numbers, katakana, symbols) on the display.
- You can display a total of 16 letters, 8 letters on the upper row and 8 letters on the lower row of the display.
- Kanji cannot be used. FS ladder converts Hiragana and katakana full-width characters to katakana half-width characters.
- Characters from a row are split in groups of 2 or 4 characters. Each of the groups is saved in one 16bit or 32bit (two 16bit registers) special register in temporary memory.
- **Escape character**
  To write a Double Quotation Mark ["] an escape character has to be used before the character. The escape character is backslash [＼] on English keyboard or halfwidth en character [¥] on Japanese keyboard, it has 8bit code 92 (5Ch). There is no backslash [＼] character in display font, the en character [¥] will be displayed instead. If you would like to write halfwidth en character (¥) two have to be used.

Display characters in relation to temporary memory (16bit access)

TM924 **"CH"**	TM925 **"AR"**	TM926 **"#0"**	TM927 **"13"**
TM914 **"ｹﾞ"**	TM915 **"ｰﾑ"**	TM916 **"¥¥¥""**	TM917 **"1¥""**

Display characters in relation to temporary memory (32bit access)

TM924L **"CHAR"**	TM926L **"#013"**
TM914L **"ｹﾞｰﾑ"**	TM916L **"¥¥¥"1¥""**

Procedure to display characters defined in TM memory (TM914L, TM916L and TM924L, TM926L)

① Set TM900 (or TM901) of display mode selection to 1000

② Specify characters in the TM memory with MOV or LDA + STA instructions

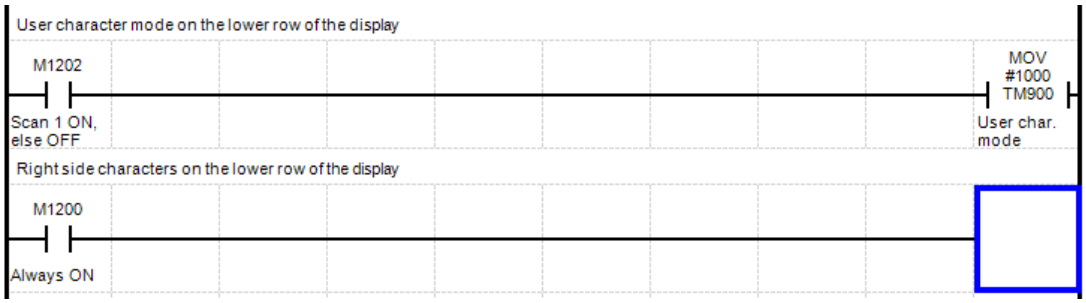
Concrete methods are explained in the following sections.

For more details on the topic, please refer to smartPLC user's manual.

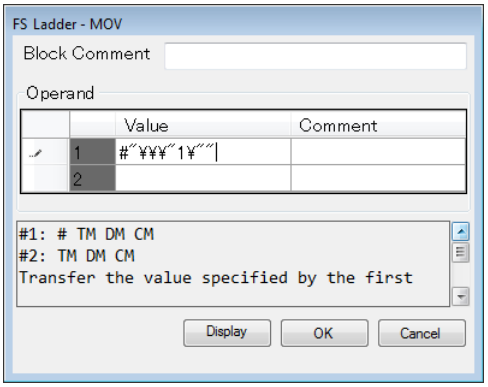
3-8-1 Character input from keyboard

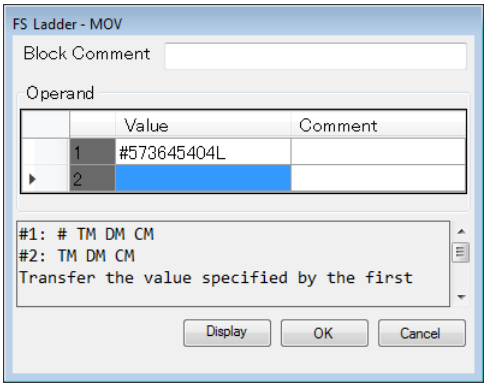
Example: Display letters on the right side of the lower row of the display

1. Set TM900 (lower row display mode selection) to 1000 (user defined character)

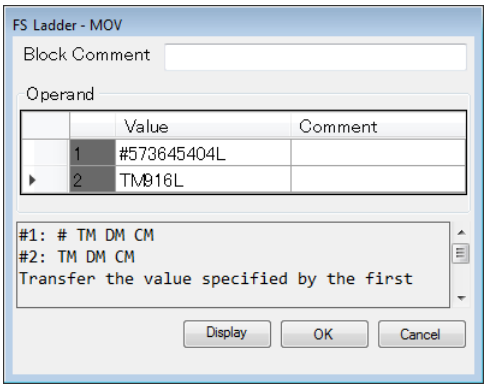


2. Insert MOV instruction. For example, as the first operand enter #"¥¥¥"1¥"".
3. Press Enter. It changes to a numerical value.

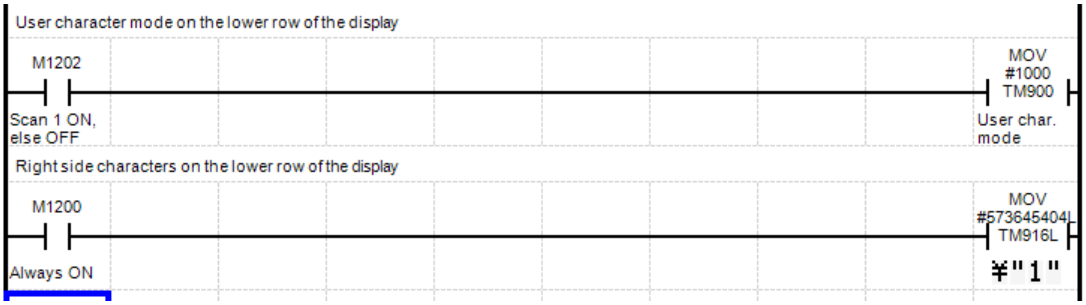




4. Enter the TM916L register for the right side of the lower row of the display (do not forget L) → click on OK.



5. The characters are displayed at the position of the block comment. [**¥"1"**] will be displayed on the right side of the lower row of the display when the program is executed.

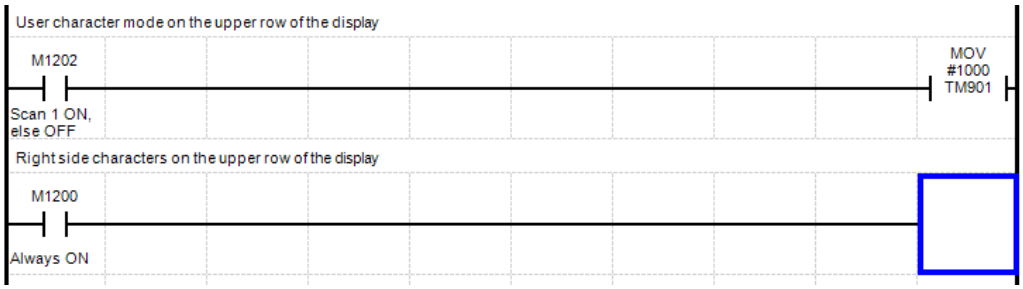


Note: The characters are displayed at the position of the block comment only for MOV instruction and only when moving a numeric constant to the special registers for the display (TM914L, TM916L or TM924L, TM926L) and also the block comment is not set.

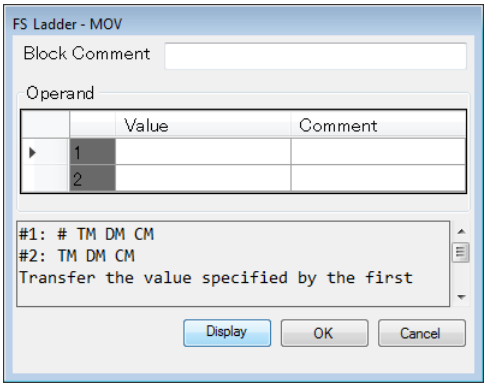
3-8-2 Character input from display character list

Example: Display letters on the right side of the upper row of the display

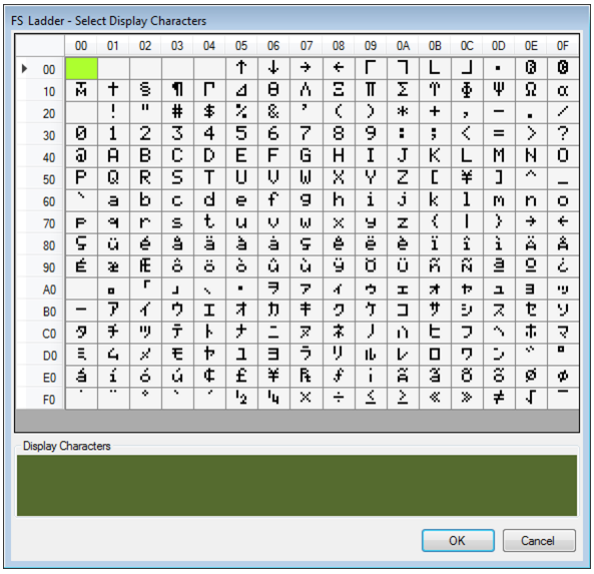
1. Set TM901 (upper row display mode selection) to 1000 (user defined character).

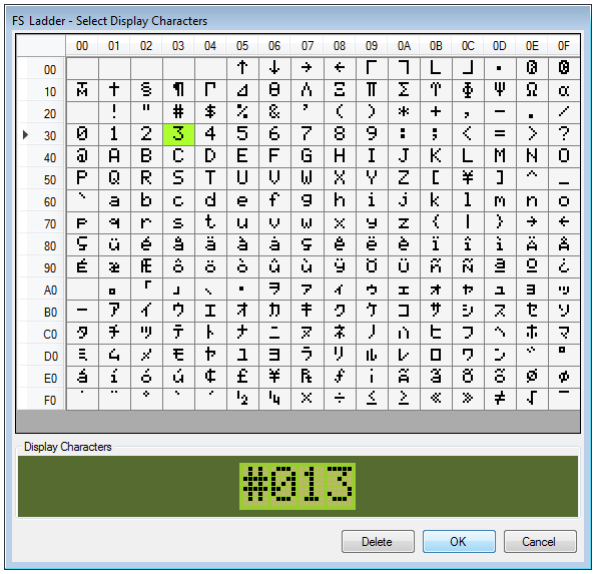


2. Insert MOV instruction. Click on “Display”

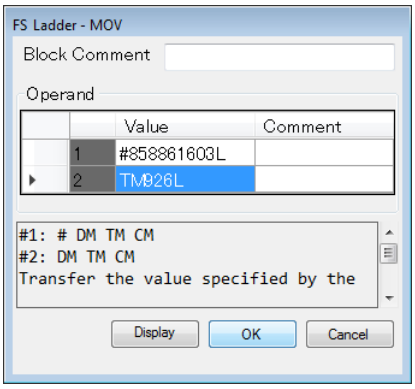


3. A table with all display characters appears.
4. Click on the characters to be displayed in required order → click on OK. If you need to change character just, click "Delete" to remove last character and after click on the correct character.

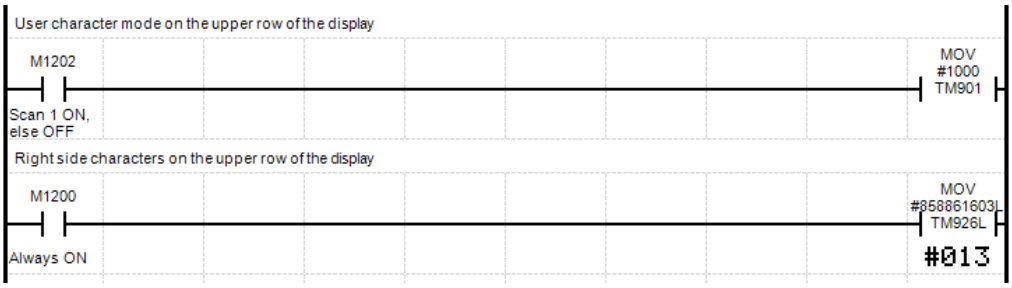




5. Enter the TM926L register (do not forget L) → click on OK.



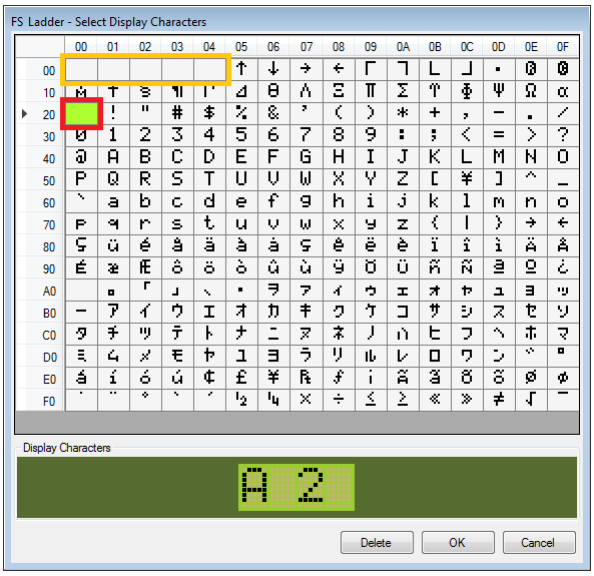
6. The input character is displayed at the position of the block comment. [#013] is displayed on the right side of the upper row of the display when the program is executed.



Note: The characters are displayed at the position of the block comment only for MOV instruction and only when moving a numeric constant to the special registers for the display (TM914L, TM916L or TM924L, TM926L) and also the block comment is not set.

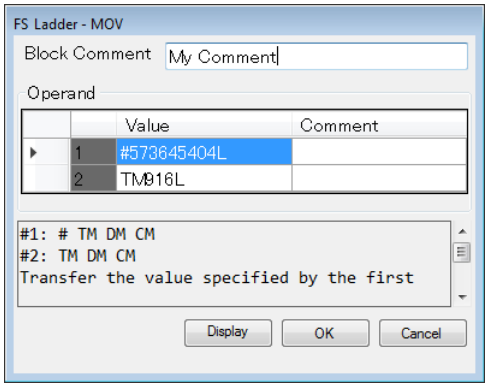
Space character

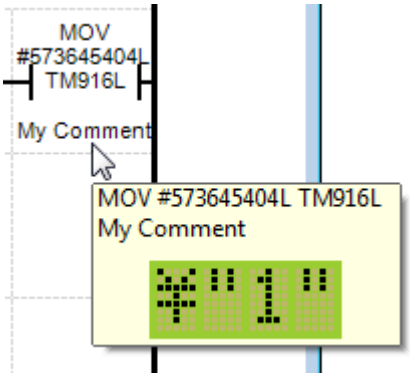
As the characters in the orange frame can be changed in the future firmware, it is strongly recommended to use the character marked by red frame as a space character (8bit code 20h).



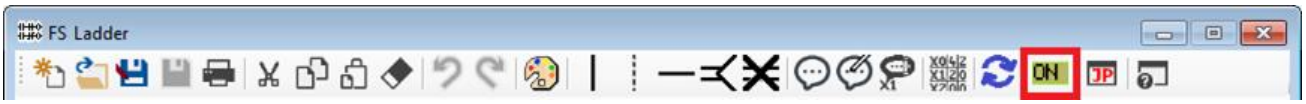
3-8-3 character display in FS Ladder

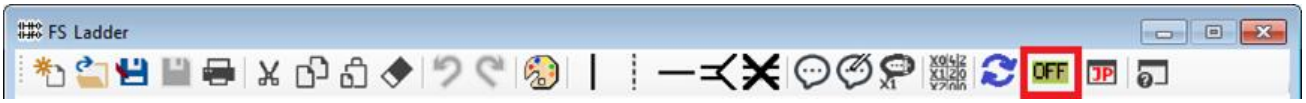
- When you set a block comment. It will be shown on ladder diagram instead of display characters.
- If you move the mouse cursor over the instruction block a tooltip will be displayed, there you can see displayed characters. If the character display is not displayed on the tooltip you need to switch it on as you can see below.





- You can switch character display ON/OFF on the tooltip by clicking「ON」/「OFF」on the tool bar.

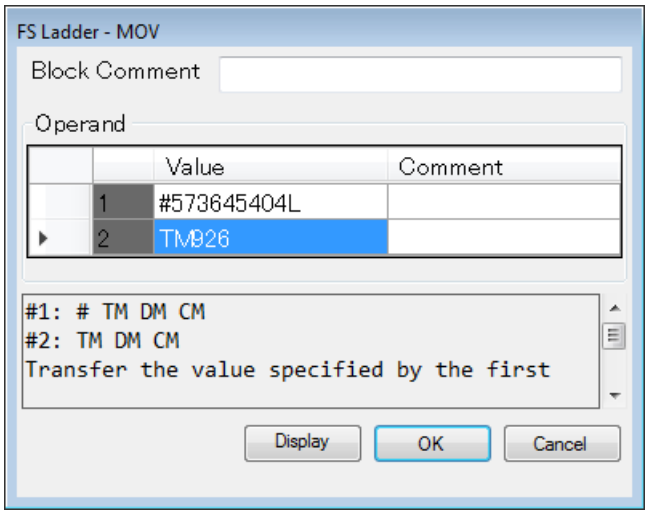


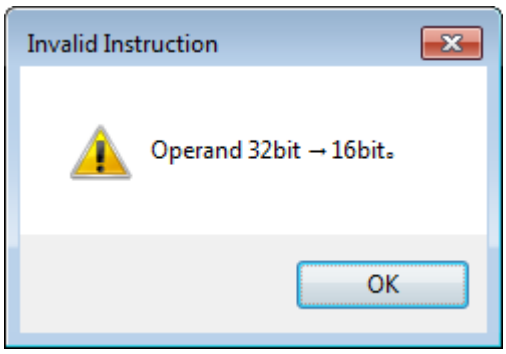


3-8-4 32bit → 16bit error

If you forget to attach "L" next to TM926 as shown below, an error will occur, because 32bit number does not fit to 16bit number.

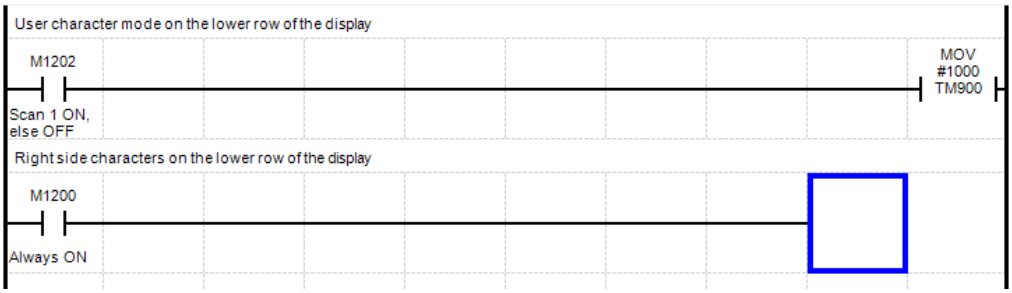
To fix the error add 'L' to the end of TM926 → TM926L.



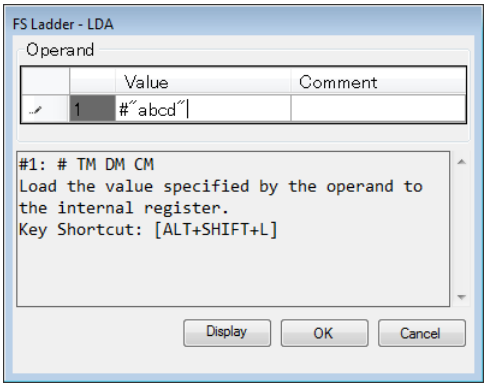


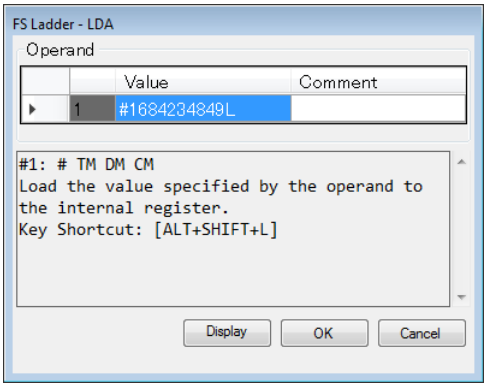
3-8-5 Character input using LDA and STA

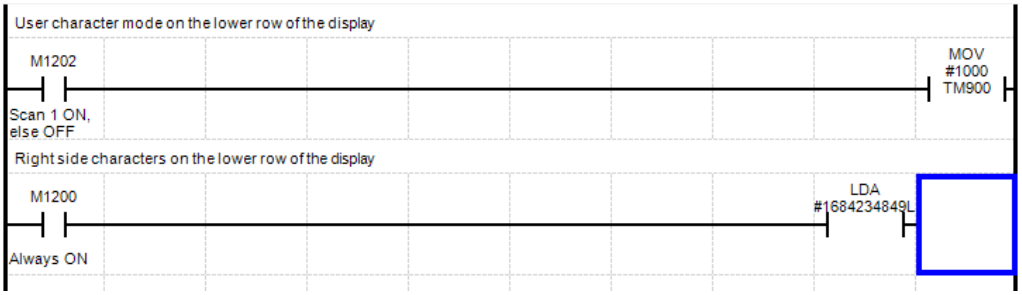
1. Even when LDA and STA instructions are used, you can input characters in the same way as in case of MOV. Set TM900 (lower row display mode selection) to 1000 (user defined character).



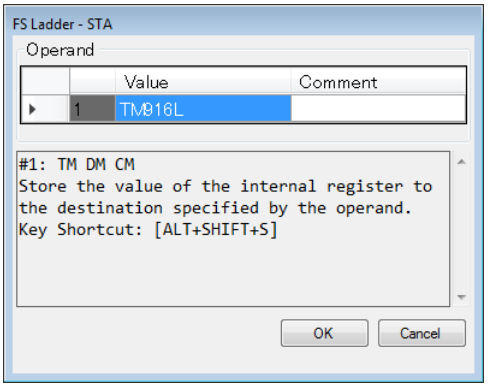
2. Insert LDA instruction. Enter characters using keyboard or display character button.

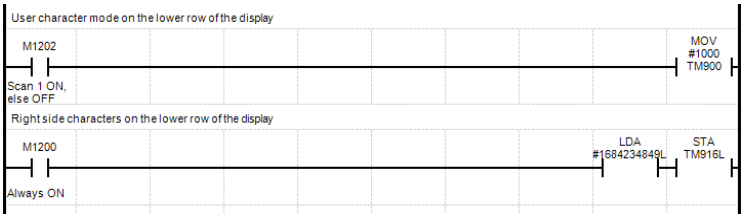




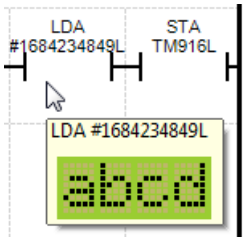


3. Insert STA instruction and enter the TM register number as operand (do not forget L) → OK





4. You can check the display characters letters by moving the mouse cursor over LDA instruction block.
If the character display is not displayed on the tooltip you need to switch it on (refer to 3-8-3 character display in FS Ladder).



3-8-6 2 characters input

If you do not specify L at the end of the TM register number, the 16bit access will be used.

Display characters in relation to temporary memory (16bit access)

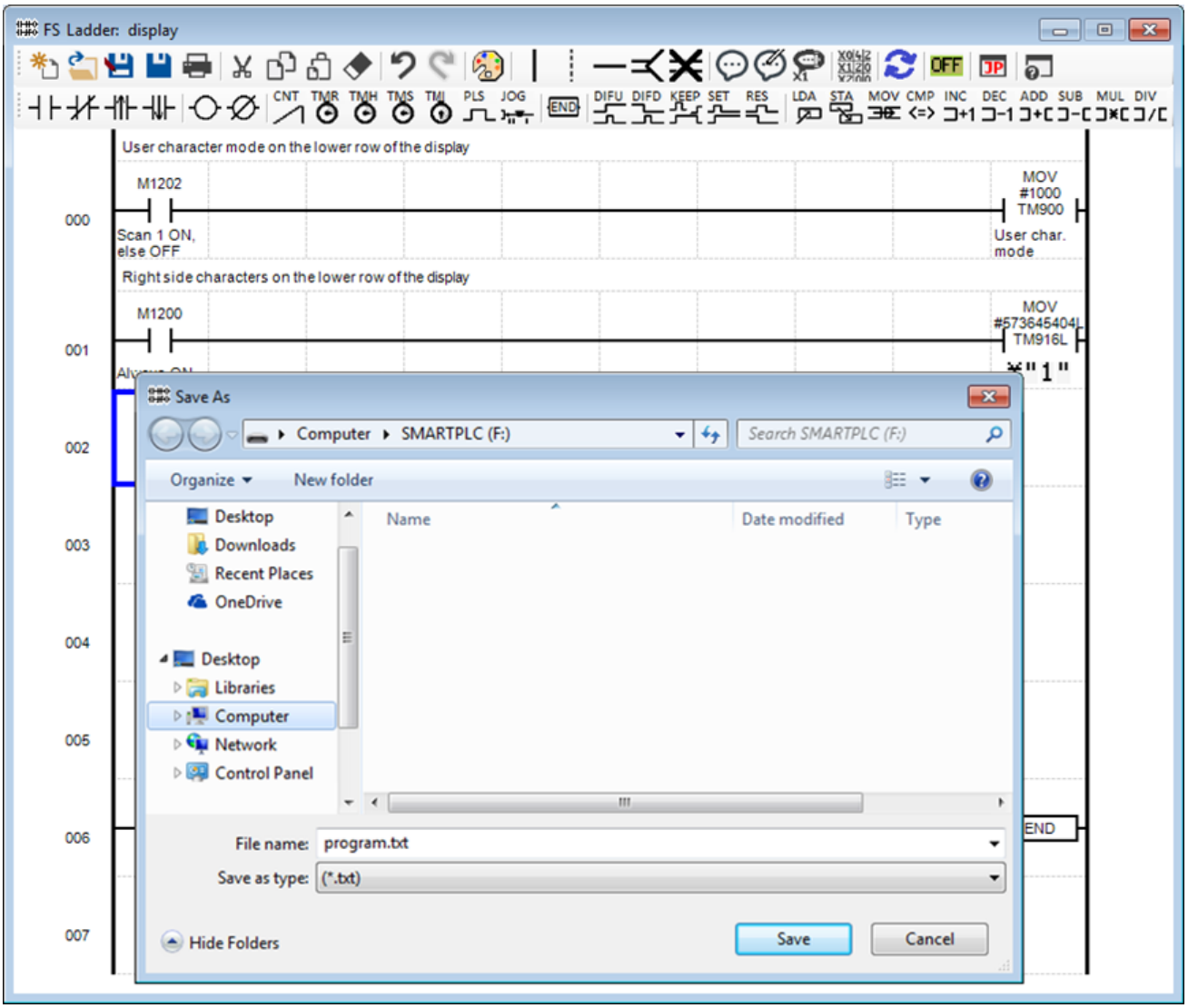
TM924 "CH"	TM925 "AR"	TM926 "#0"	TM927 "13"
TM914 "ｹﾞ"	TM915 "ｰﾑ"	TM916 "¥¥¥""	TM917 "1¥""

By using TM914 to TM917 and TM924 to TM927 without specifying L at the end of TM, it is possible to change two display characters at a time.

3-9 Make a Program

When you finish ladder diagram you will need to save it as mnemonic program which is readable by the smartPLC.

1. Click on placed on the instruction block bar or press [F5] key.
2. The file name is automatically "program.txt", because SmartPLC executes only a user program with the file name "program.txt".



Note: In case of error an error message will be displayed and the cursor (the blue frame) will move to the place where the error occurred.

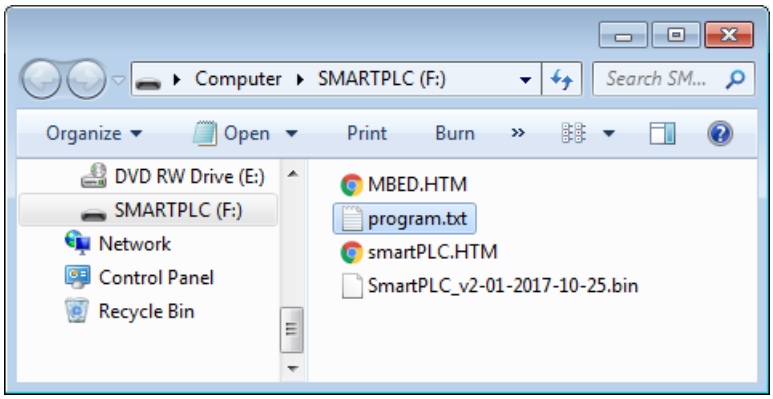
4 Run the program

This chapter explains how to run the program on the smartPLC.

4-1 Connection between smartPLC and computer

You can change the program of the smartPLC from a PC via USB.

When you connect the smartPLC with a personal computer with the included USB mini cable. The smartPLC drive will be recognized by the operating system (Windows7 or 10).



The following files are stored in the smartPLC virtual drive.

File name	Description
SmartPLC_v2-xx-YYYY-MM-DD.bin	Firmware, v2 version, xx subversion, YYYY-MM-DD build date
smartPLC.HTM	smartPLC homepage, download site
program.txt	Mnemonic program
MBED.HTM	Mbed microcontroller home page

About MBED.HTM

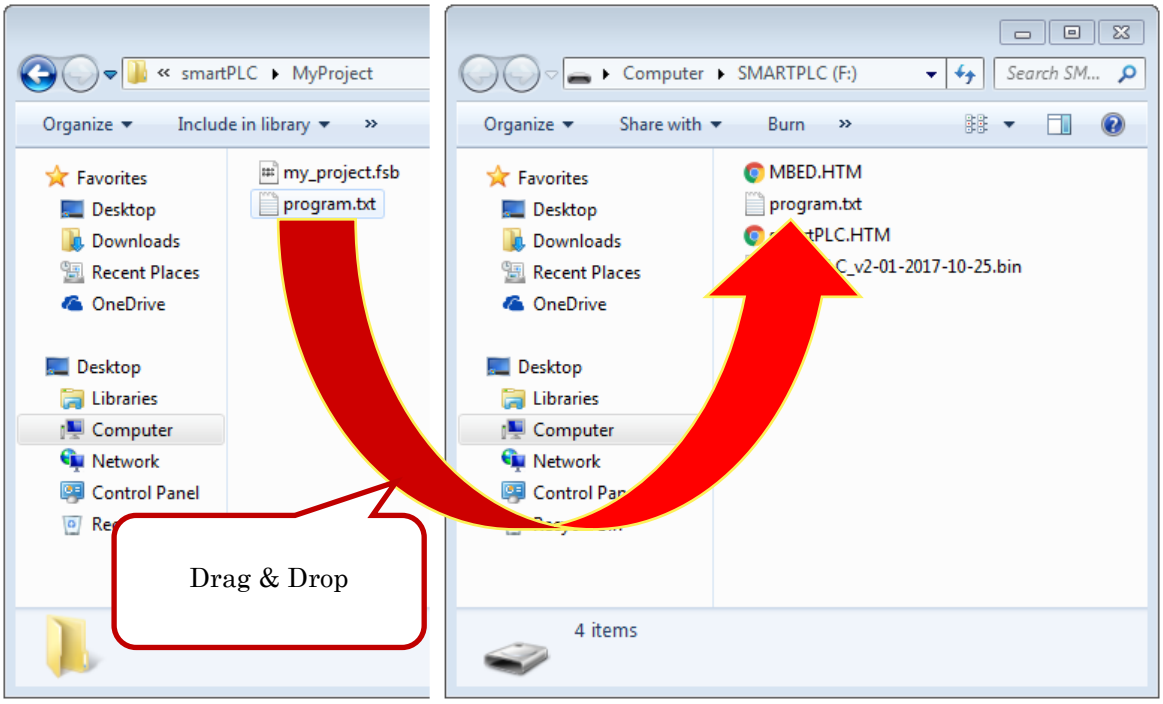
SmartPLC uses the Arm Mbed IoT Device Platform developed by ARM, UK. Therefore, the Mbed home page MBED.HTM (English) is saved on the smartPLC drive. There is no problem opening the link, but Mbed and smartPLC are not related.

Please **DO NOT** ask about smartPLC at Mbed or ARM web pages or contacts.

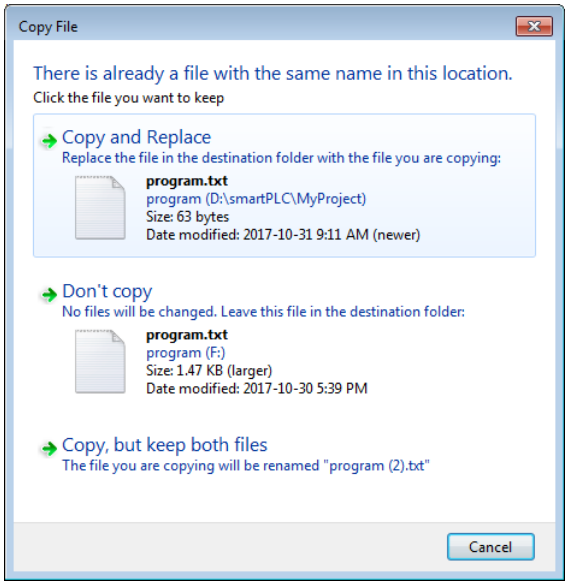
* Mbed is a registered trademark of ARM, UK.

4-2 Copy the program to the smartPLC

1. Open the project folder where program.txt is saved.
2. Connect the smartPLC to the personal computer with a USB cable.
   Open the "SMARTPLC" drive.
3. Copy the program.txt from the project folder to the SMARTPLC drive.

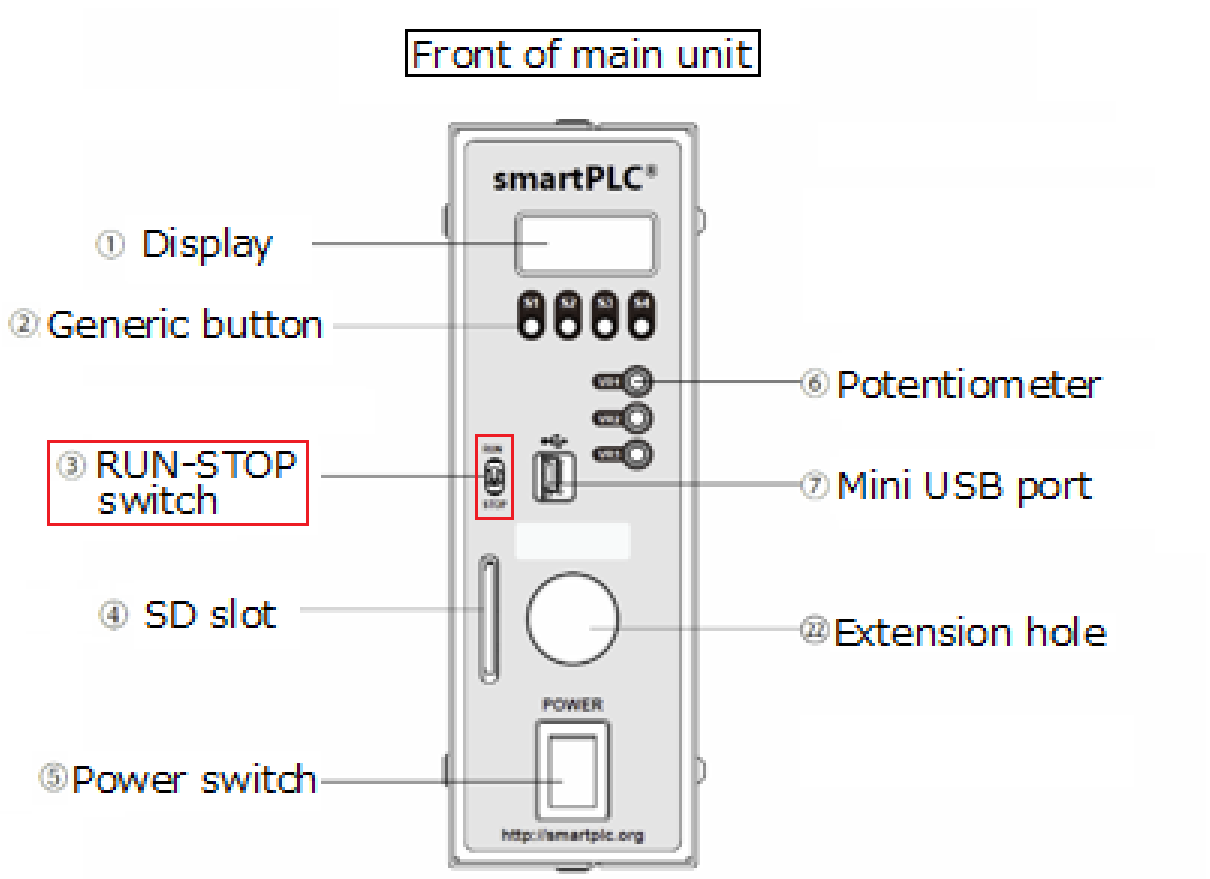


4. If the program.txt already exists on the SMARTPLC drive, a following dialog box will be displayed.
   Select "Copy and Replace" to overwrite a previous program with the new one.



4-3 Execute the program

1. Turn on the power switch of the smartPLC.
2. Read the program with [RUN →] STOP → RUN on the RUN - STOP switch SW on the front of the main body of the smartPLC and start the control.



5 Appendix

5 - 1 Shortcuts

The list with all shortcuts can be found in the help window [F1].

Action	Shortcut
Help	F1
Device Usage Status	F2
Edit Comments of Operands	F3
Switch Language	SHIFT+F1
Switch ToolTip Display	SHIFT+F4
New	CTRL+N
Open	CTRL+O
Save As	CTRL+S
Save	CTRL+SHIFT+S
Print	CTRL+SHIFT+P
Cut	CTRL+X
Copy	CTRL+C
Paste	CTRL+V
Undo	CTRL+Z
Redo	CTRL+Y
Make a Program	F5
Relay and Instruction Palette	Enter
A-B Contact Change	Tab
Insert Comment Line	Insert
Delete	Delete
Insert Row	SHIFT+Insert
Delete Row	SHIFT+Delete
Horizontal Line	F9

Action	Shortcut
Horizontal Line	Hyphen
Left Vertical Line	F6
Delete Left Vertical Line	SHIFT+F6
Top	Home
End	End
Select Upper Block	Up
Select Lower Block	Down
Select Left Block	Left
Select Right Block	Right
Select Upper Block	NumPad8
Select Lower Block	NumPad2
Select Left Block	NumPad4
Select Right Block	NumPad6
Select Multiple Blocks Above	SHIFT+Up
Select Multiple Blocks Below	SHIFT+Down
Select Multiple Blocks Left	SHIFT+Left
Select Multiple Blocks Right	SHIFT+Right
Select Comment Line Above	CTRL+Up
Select Comment Line Below	CTRL+Down
Select Multiple Rows Above	CTRL+SHIFT+Up
Select Multiple Rows Below	CTRL+SHIFT+Down
Left Horizontal Line	ALT+Left
Horizontal Line	ALT+Right
Left Upper Vertical Line	ALT+Up
Left Lower Vertical Line	ALT+Down

5-2 Instruction block overview

The shortcut list is in the help screen [F1].

Icon	Shortcut	Action	Name
	L or A	LD, AND	Contact A (normally open)
	SHIFT+L or B	LDB, ANB	Contact B (normally closed)
	P	LDP	Contact Rising Edge Detector
	F	LDF	Contact Falling Edge Detector
	O	OUT	Coil (Output Relay)
	SHIFT+O	OUB	Coil Bar (Inverted Output)
CNT	C	CNT	16bit Counter
TMR	T	TMR	Timer (100ms)
TMH	SHIFT+T	TMH	Timer (10ms)
TMS	ALT+T	TMS	Timer (1ms)
TMI	ALT+SHIFT+T	TMI	Timer-interval ms*
PLS	ALT+P	PLS	PLS positioning
JOG	ALT+J	JOG	JOG positioning
END	E	END	End of program

Icon	Shortcut	Action	Name
DIFU	U	DIFU	Differentiate UP
DIFD	D	DIFD	Differentiate Down
KEEP	K	KEEP	Keep Relay
SET	S	SET	Set
RES	R	RES	Reset
LDA	ALT+SHIFT+L	LDA	Load
STA	ALT+SHIFT+S	STA	Store
MOV	ALT+SHIFT+M	MOV	Move
CMP <=>	ALT+C	CMP	Comparison
INC +1	ALT+I	INC	Increment by one
DEC -1	ALT+D	DEC	Decrement by one
ADD +	ALT+A	ADD	Addition
SUB -	ALT+S	SUB	Subtraction
MUL *	ALT+M	MUL	Multiplication
DIV /	ALT+SHIFT+D	DIV	Division

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