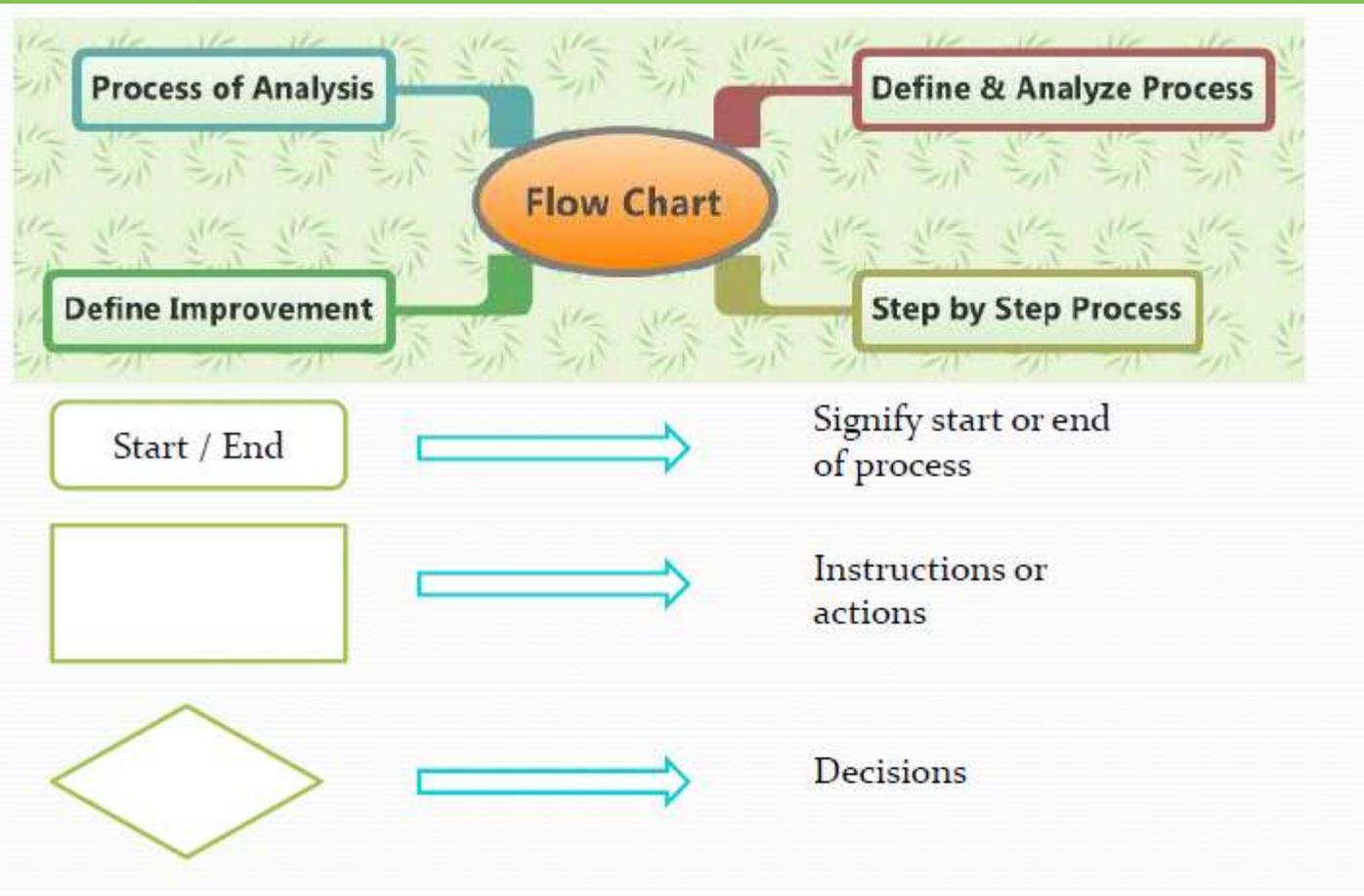


Basic PLC Programming

Outline

- Introduction to Programming Software**
- Ladder Diagram**
- Basic Logic Functions**
- Mnemonic Code**
- CX-Programmer**

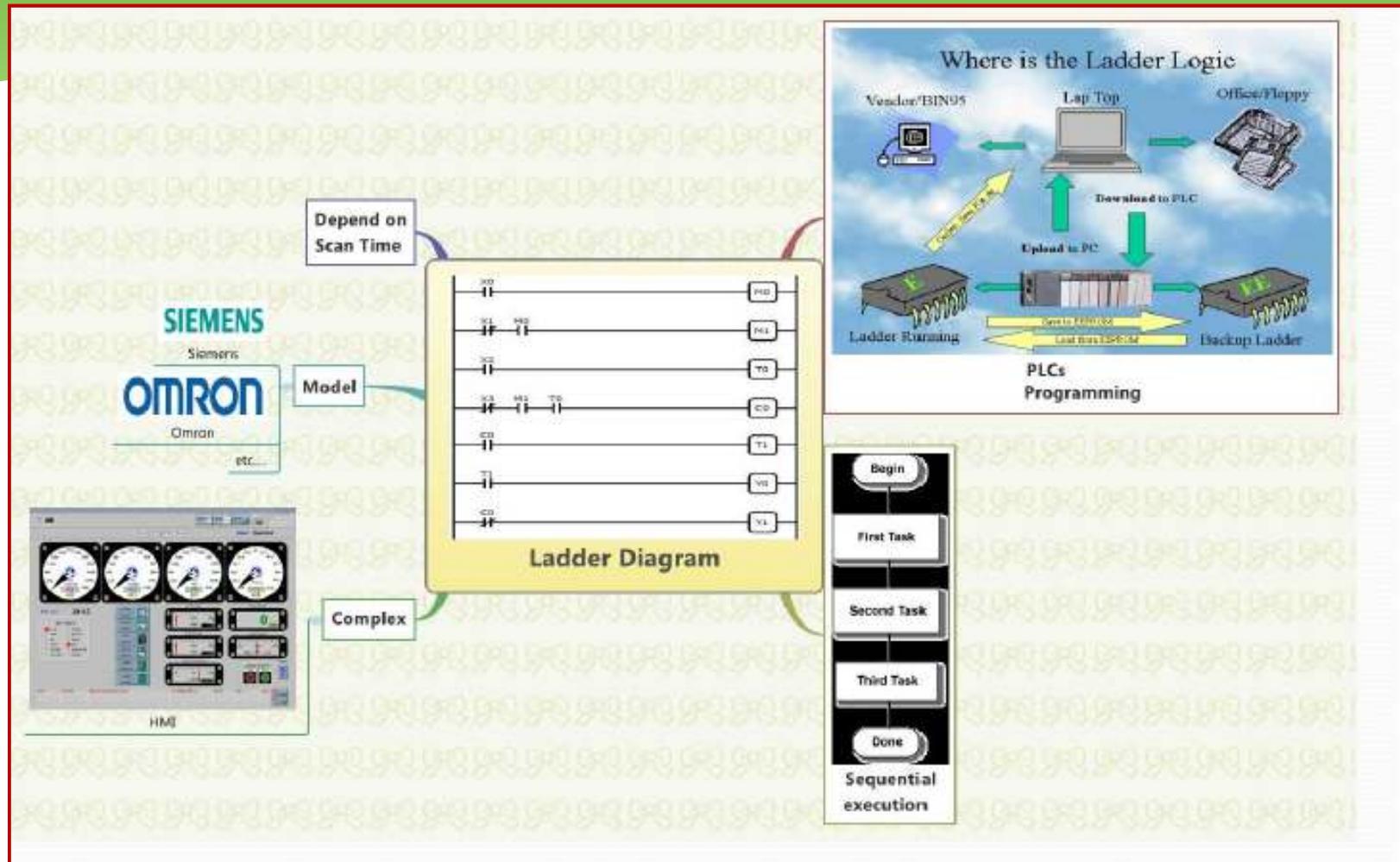
Flowchart



Ladder Diagram

- ❑ **Primary** programming language for PLCs.
- ❑ Other programming methods include:
 - Function block diagrams (FBDs)
 - Structured text (ST)
 - Instruction List (IL)
 - Sequential function charts (SFCs)
- ❑ **Visual** and **Graphical** language unlike textual high-level, such as C, C++, Java...
- ❑ Derived from relay logic diagrams
- ❑ Primitive Logic Operations
 - ❖ OR
 - ❖ AND
 - ❖ NOT

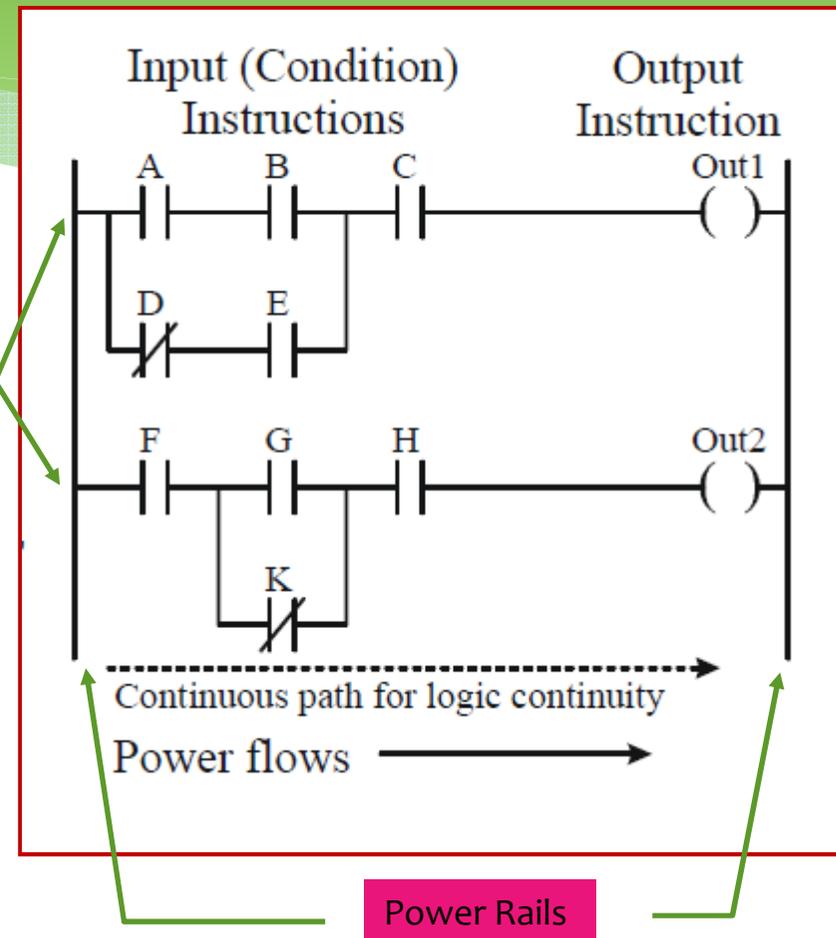
Ladder Diagram



Ladder Diagram

Terminologies

- ❑ Power Rails - Pair of vertical lines
- ❑ Rungs - Horizontal lines
- ❑ Contacts A, B, C, D... arranged on rungs
- ❑ Note in PLC Ladder Logic:
 - No Real Power Flow (like in relay ladder)
 - There must be continuous path through the contacts to energize the output



Ladder Diagram

Binary Input Devices

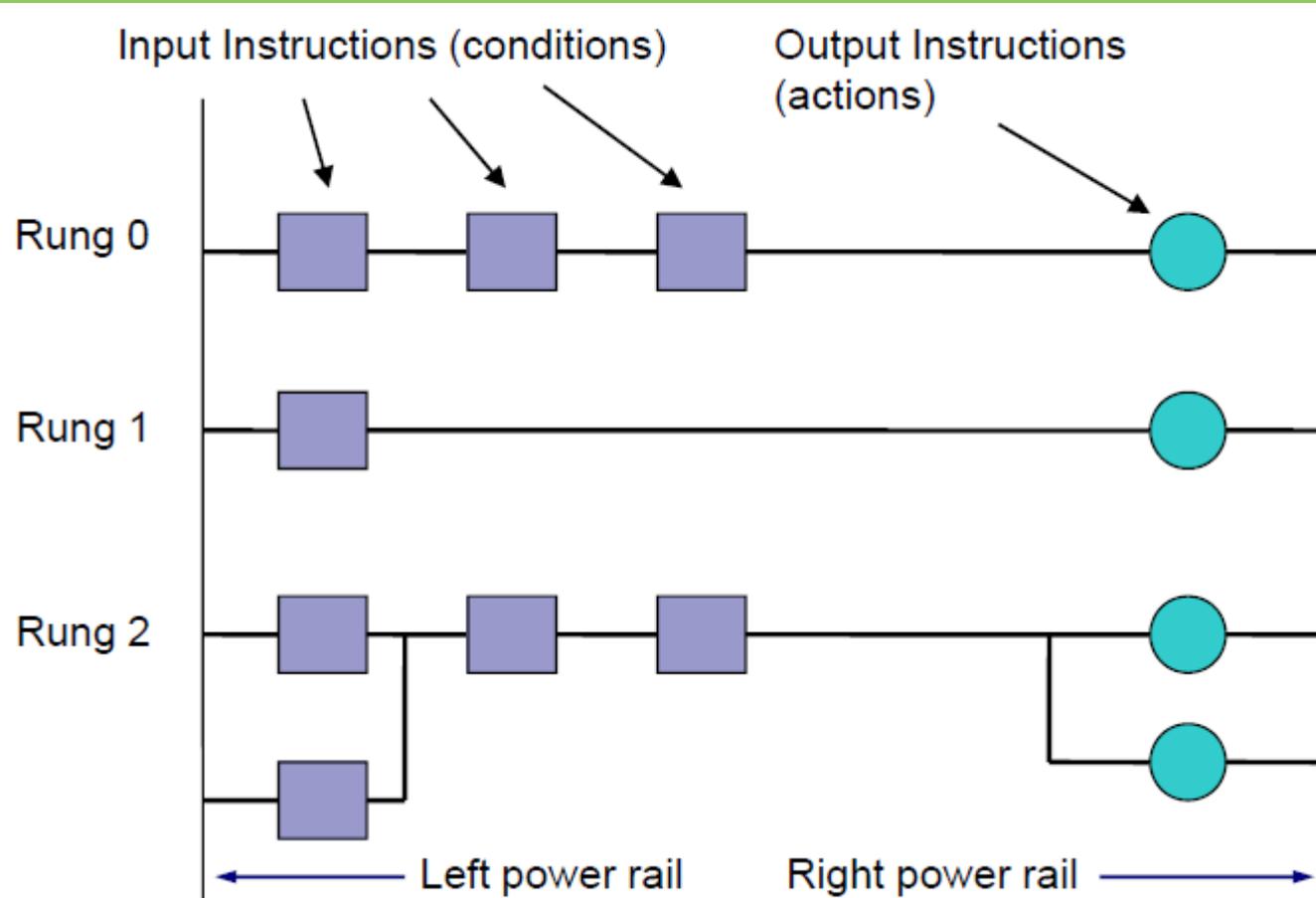
Device	One/Zero Interpretation
Limit switch	Contact/no contact
Photodetector	Contact/no contact
Pushbutton switch	On/off
Timer	On/off
Control relay	Contact/no contact
Circuit breaker	Contact/no contact

Ladder Diagram

Binary Output Devices

Device	One/Zero Interpretation
Motor	On/off
Alarm buzzer	On/off
Lights	On/off
Control relay	Contact/no contact
Valves	Closed/open
Clutch	Engaged/not engaged
Solenoid	Energised/not energised

Anatomy of Ladder Diagram



Anatomy of Ladder Diagram

- ❑ Input instructions are entered on the left
- ❑ Output instructions are entered on the right
- ❑ The power rails simulate the power supply lines
 - L1 and L2 for AC circuits and +24V and ground for DC circuits
- ❑ Most PLCs allow more than one output per rung
- ❑ The processor (or “controller”) scans ladder rungs from top-to-bottom and from left-to-right.
 - The basic sequence is altered whenever jump or subroutine instructions are executed.

Basic Ladder Logic Symbols



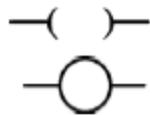
Normally open contact

Passes power (ON) if coil driving the contact is ON (closed)
Allen-Bradley calls it **XIC** - e**X**amine If **C**losed



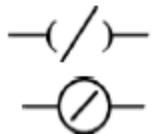
Normally closed contact

Passes power (ON) if coil driving the contact is **off** (open)
Allen-Bradley calls it **XIO** - e**X**amine If **O**pen



Output or coil

If any left-to-right path of inputs passes power, output is energized
Allen-Bradley calls it **O**TE - **O**u**T**put **E**nergize



Not Output or coil

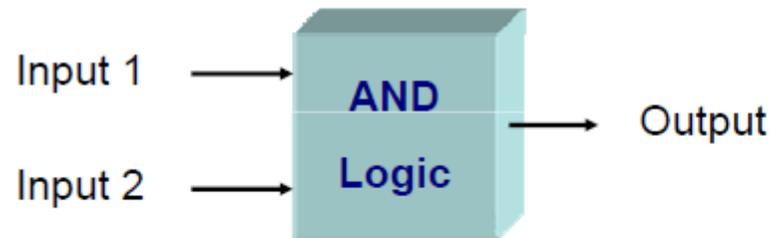
If any left-to-right path of inputs passes power, output is de-energized

Logic Functions

- ❑ PLC programming is a logical procedure
- ❑ In a PLC program, “things” (inputs and rungs) are either TRUE or FALSE
- ❑ If the proper input conditions are **TRUE**:
 - The rung becomes TRUE and an output action occurs (for example, a motor turns on)
- ❑ If the proper input conditions are **not TRUE**:
 - The rung becomes FALSE and an output action does not occur

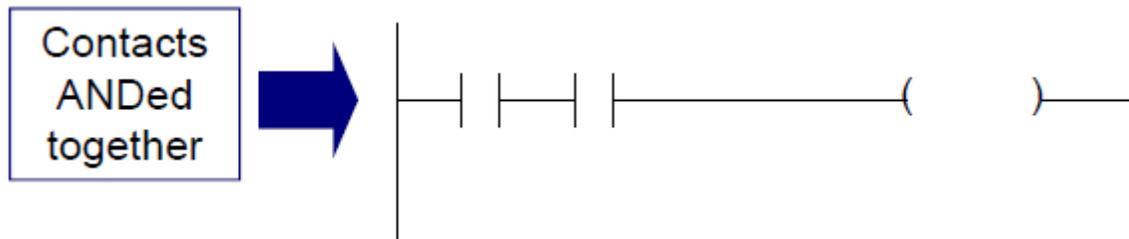
Logic Functions

AND



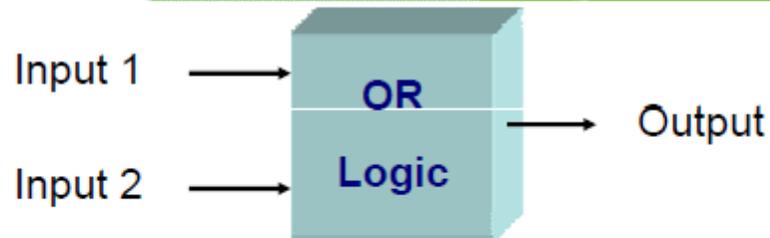
Input 1	Input 2	Output
0	0	0
0	1	0
1	0	0
1	1	1

0 → False
1 → True



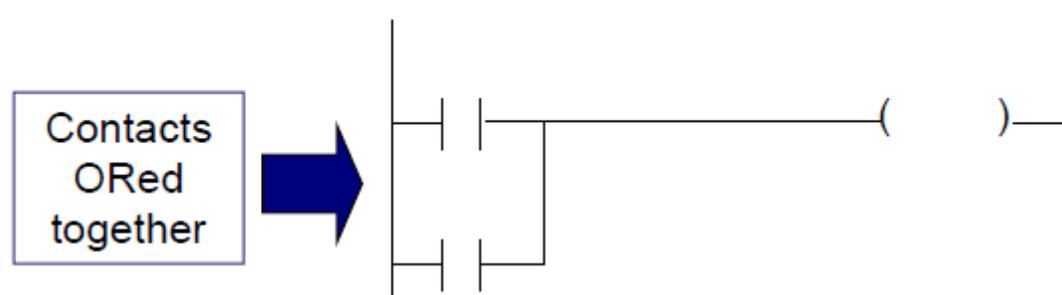
Logic Functions

□ OR



Input 1	Input 2	Output
0	0	0
0	1	1
1	0	1
1	1	1

0 → False
1 → True

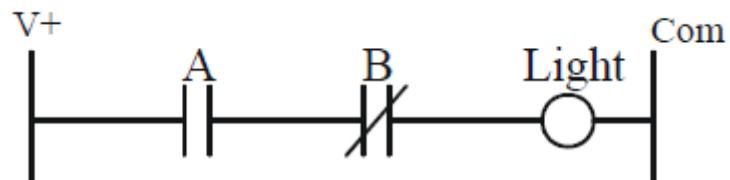


Logic Functions

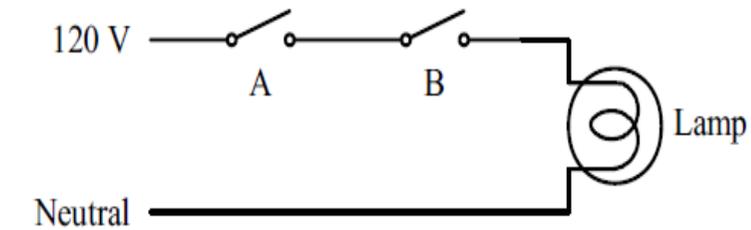
□ NOT

NOT Truth Table

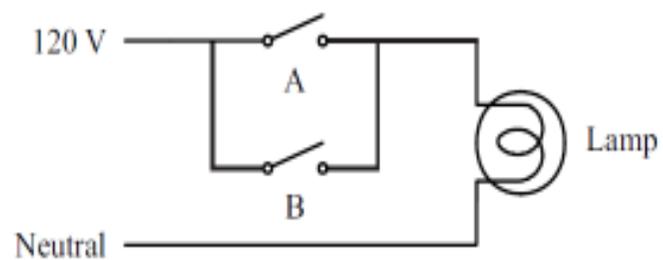
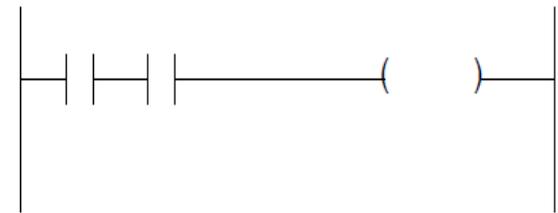
A	B	Light
OFF	OFF	OFF
OFF	ON	OFF
ON	OFF	ON
ON	ON	OFF



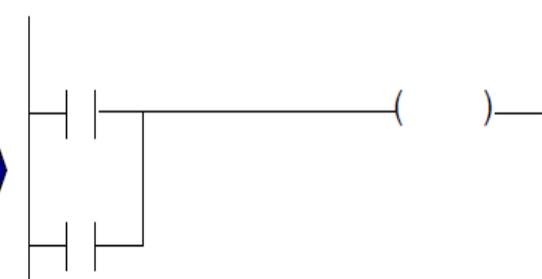
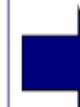
Relay to Ladder Diagram



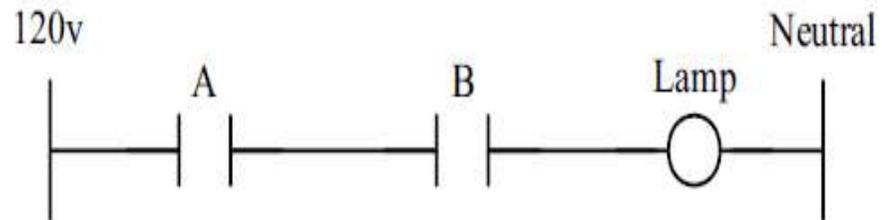
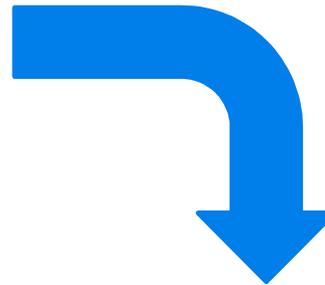
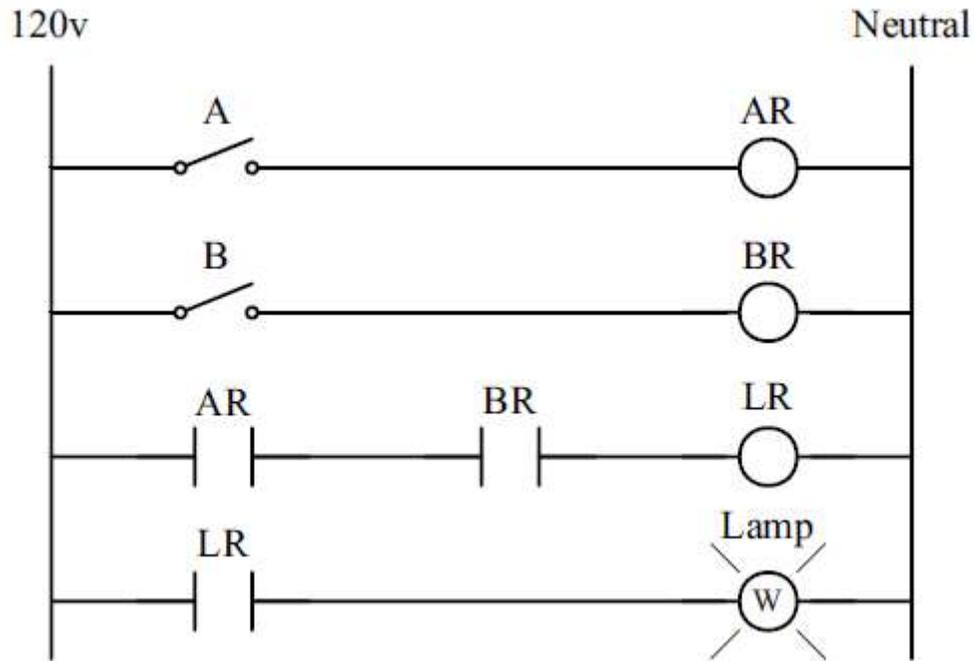
Contacts
ANDed
together



Contacts
ORed
together



Relay to Ladder Diagram

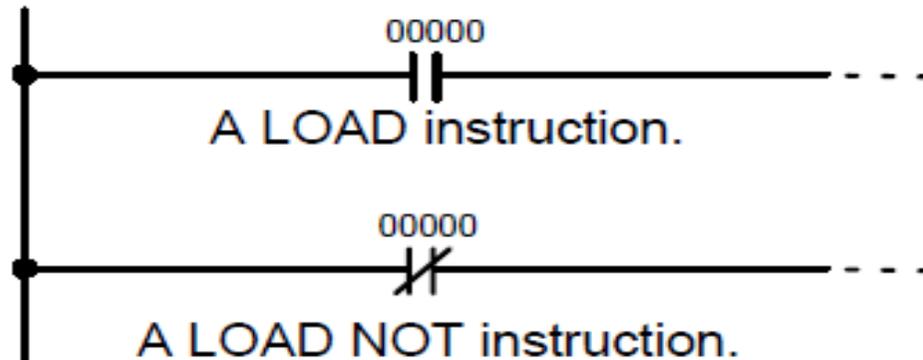


Mnemonic Codes

- ❑ These instructions can be derived directly from the ladder logic diagrams and entered into the PLC through a simple programming terminal.
- ❑ Ladder logic diagrams can be read by the programming console
- ❑ For this reason, ladder diagrams need to be converted into mnemonic codes that provides same information as ladder diagrams and to be typed directly using programming console.

Examples of Mnemonic Codes

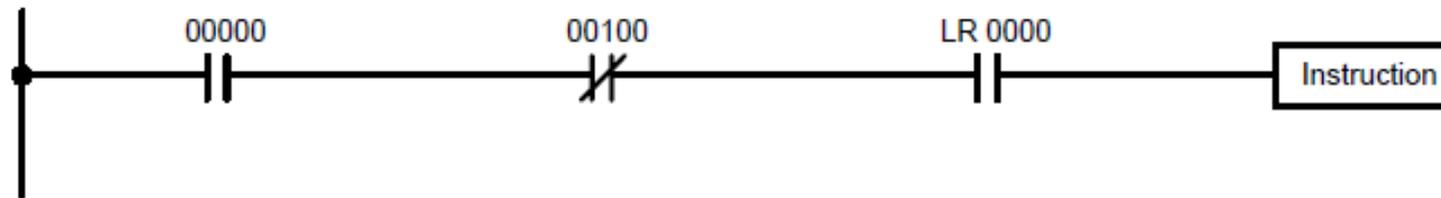
LOAD and LOAD NOT



Address	Instruction	Operands
00000	LD	00000
00001	Instruction	
00002	LD NOT	00000
00003	Instruction	

Examples of Mnemonic Codes

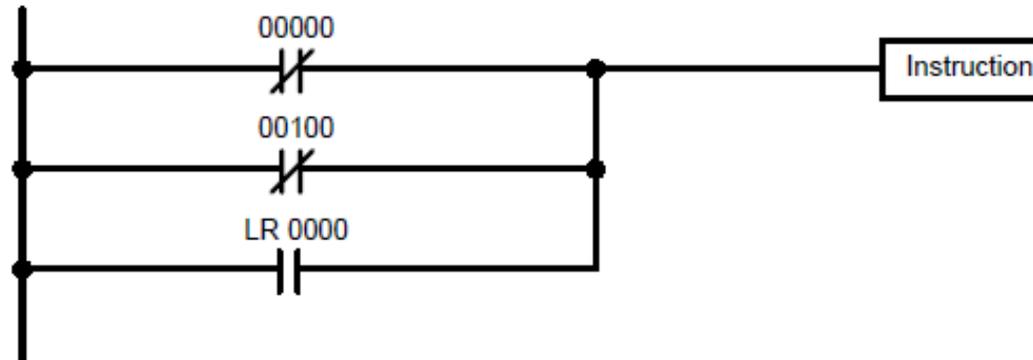
□ AND and AND Not



Address	Instruction	Operands
00000	LD	00000
00001	AND NOT	00100
00002	AND	LR 0000
00003	Instruction	

Examples of Mnemonic Codes

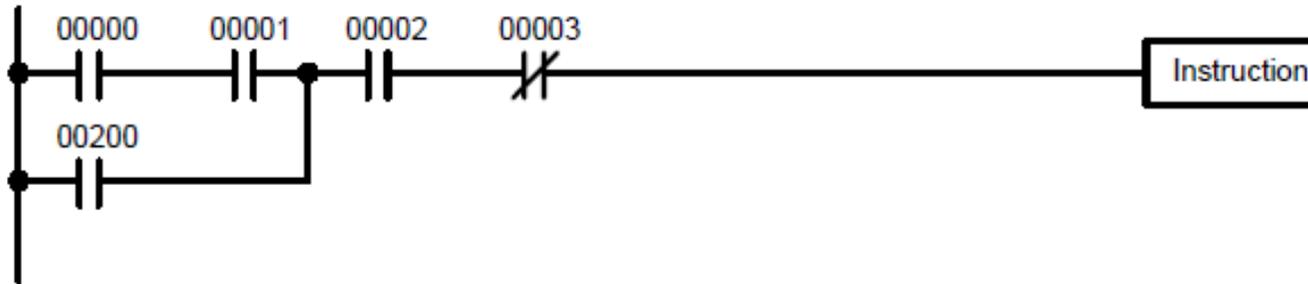
OR and OR Not



Address	Instruction	Operands
00000	LD NOT	00000
00001	OR NOT	00100
00002	OR	LR 0000
00003	Instruction	

Examples of Mnemonic Codes

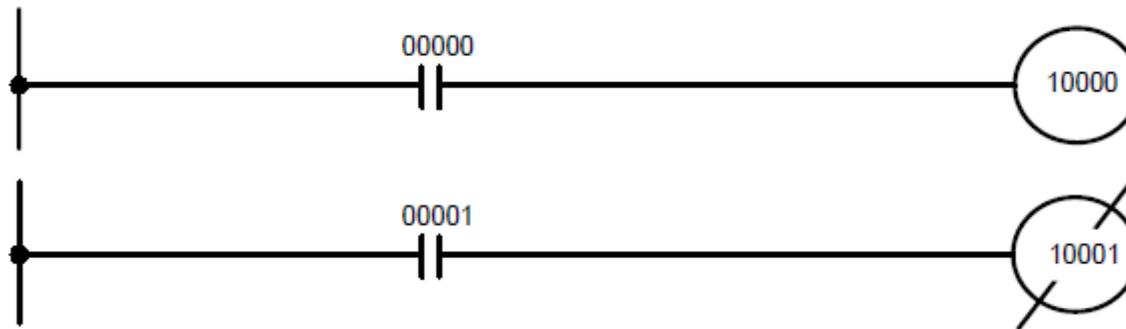
Combine AND and OR



Address	Instruction	Operands
00000	LD	00000
00001	AND	00001
00002	OR	00200
00003	AND	00002
00004	AND NOT	00003
00005	Instruction	

Examples of Mnemonic Codes

□ OUTPUT and OUTPUT Not

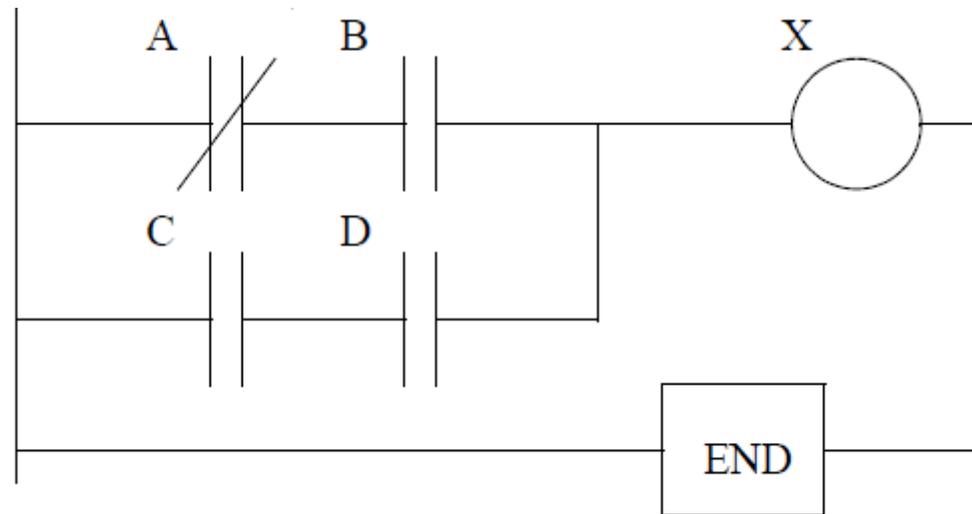


Address	Instruction	Operands
00000	LD	00000
00001	OUT	10000

Address	Instruction	Operands
00000	LD	00001
00001	OUT NOT	10001

Examples of Mnemonic Codes

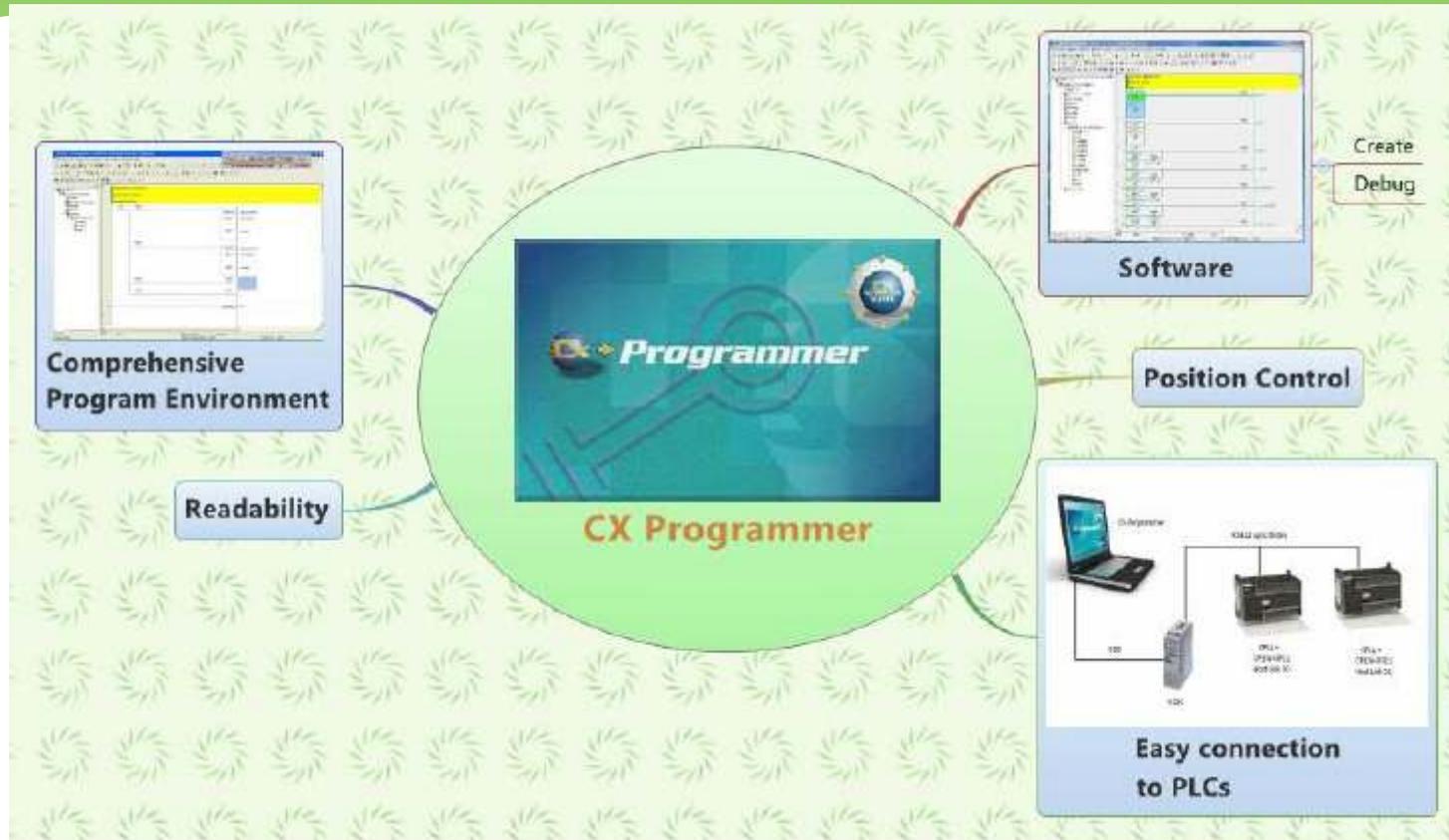
- Write the mnemonic code for the following ladder diagram



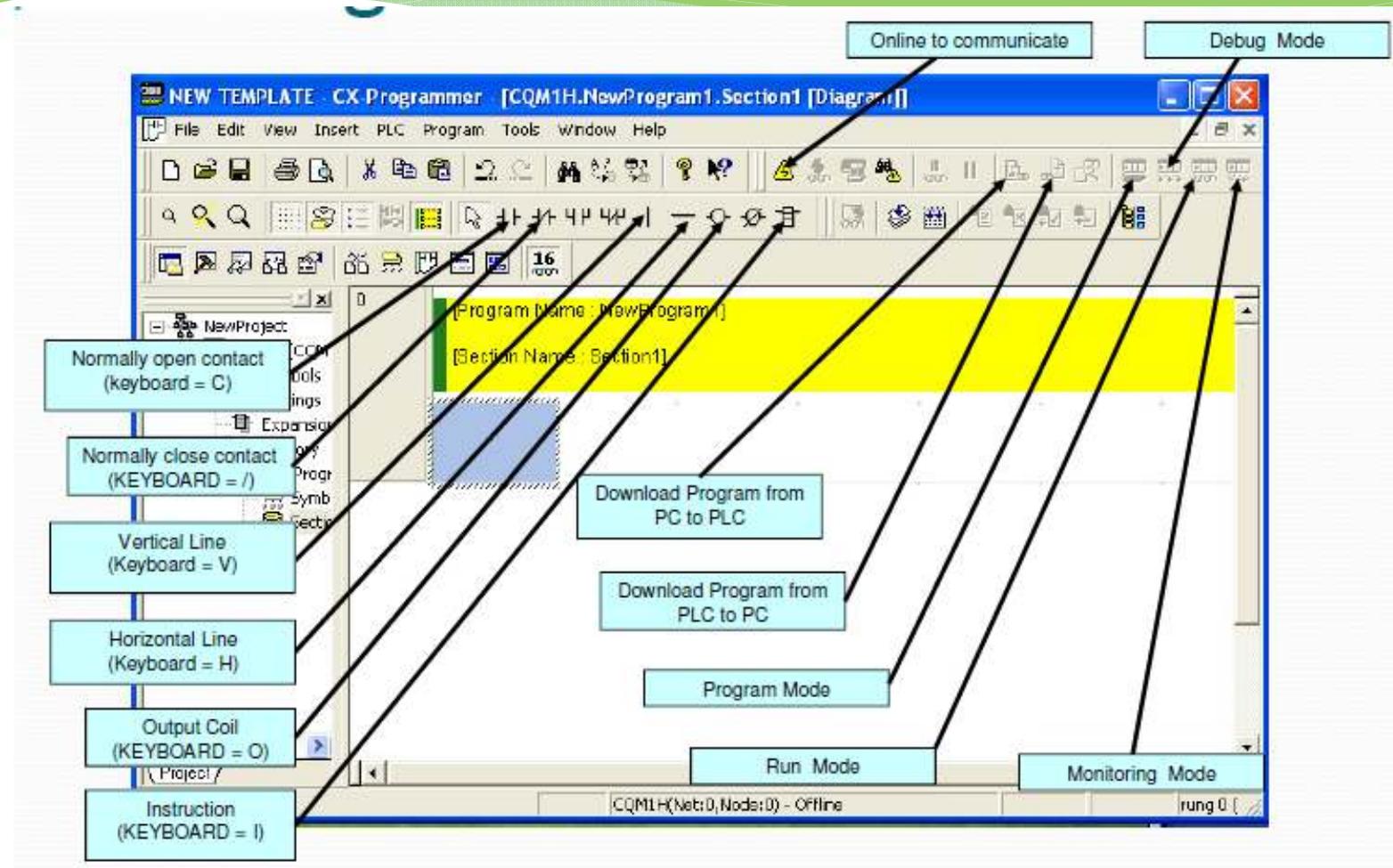
Entering the Ladder Diagram: CX Programmer

- ❑ CX-Programmer, the programming software for all Omron's PLC series, is fully integrated into the CX-One software suite.
- ❑ CX-Programmer includes a wide variety of features to speed up the development of your PLC program. New parameter-setting dialogues reduce setup time, and with standard function blocks in IEC 61131-3 structured text or conventional ladder language, CX-Programmer makes development of PLC programs a simple drag & drop configuration.

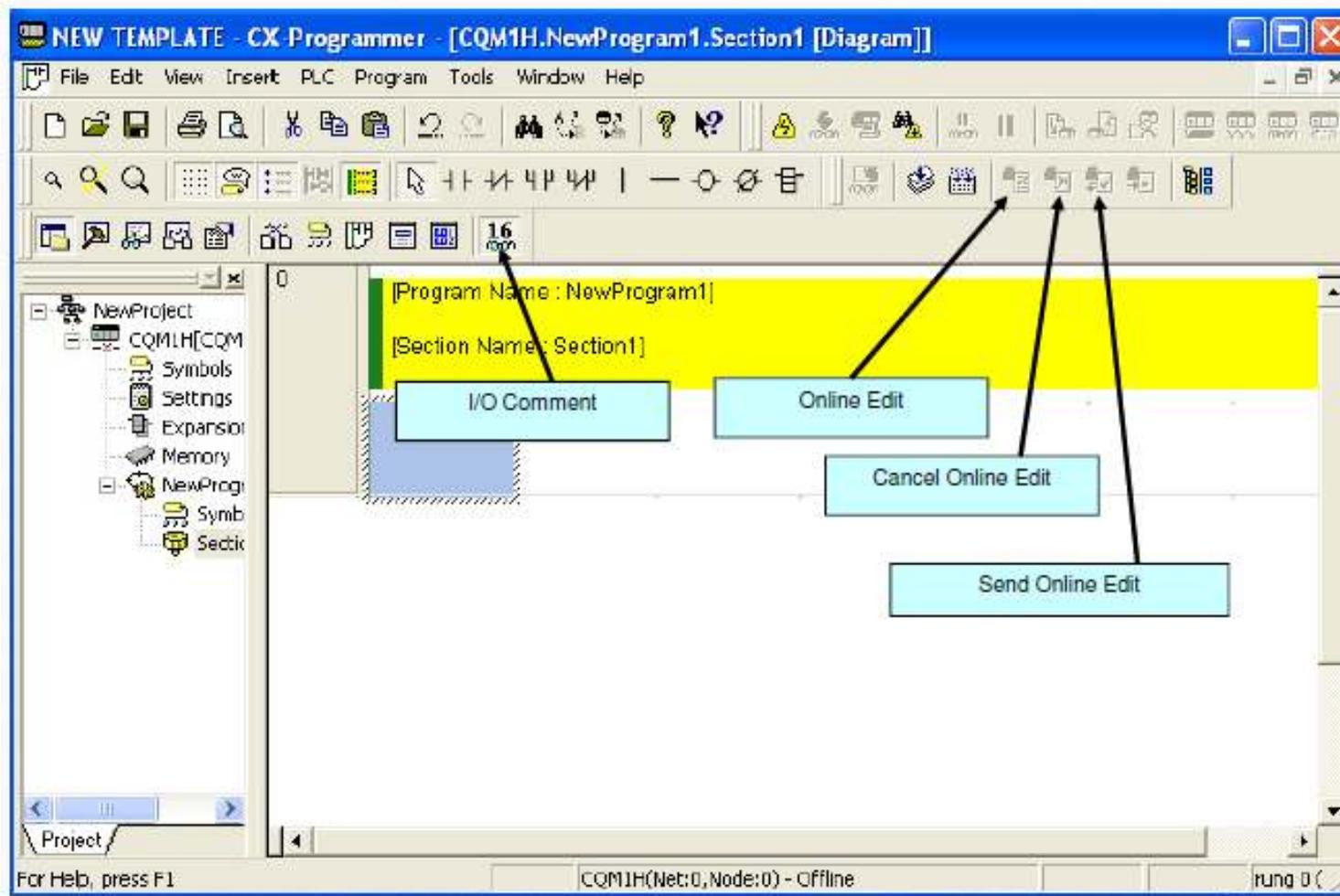
CX Programmer



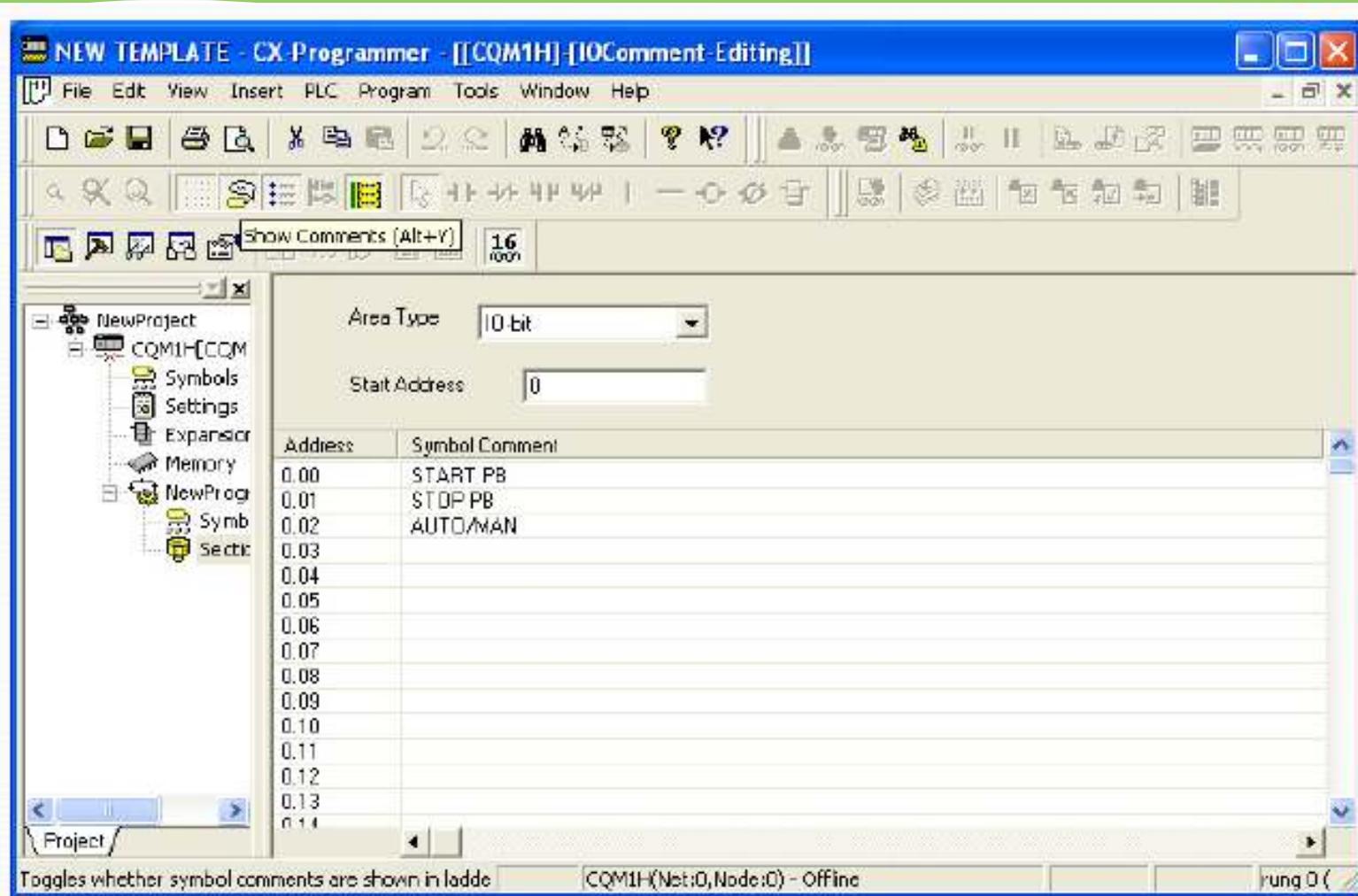
CX Programmer: Overview



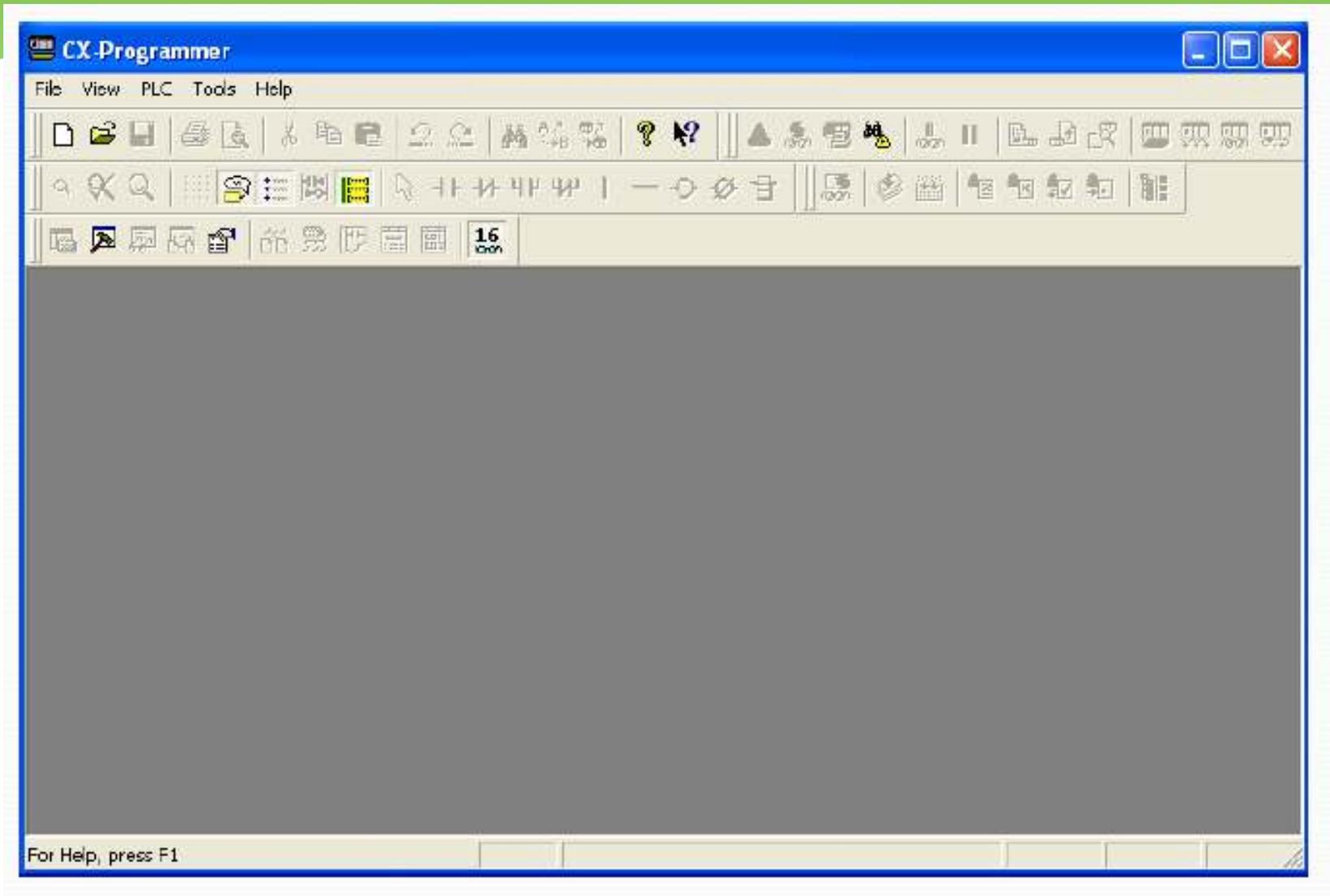
CX Programmer: Overview



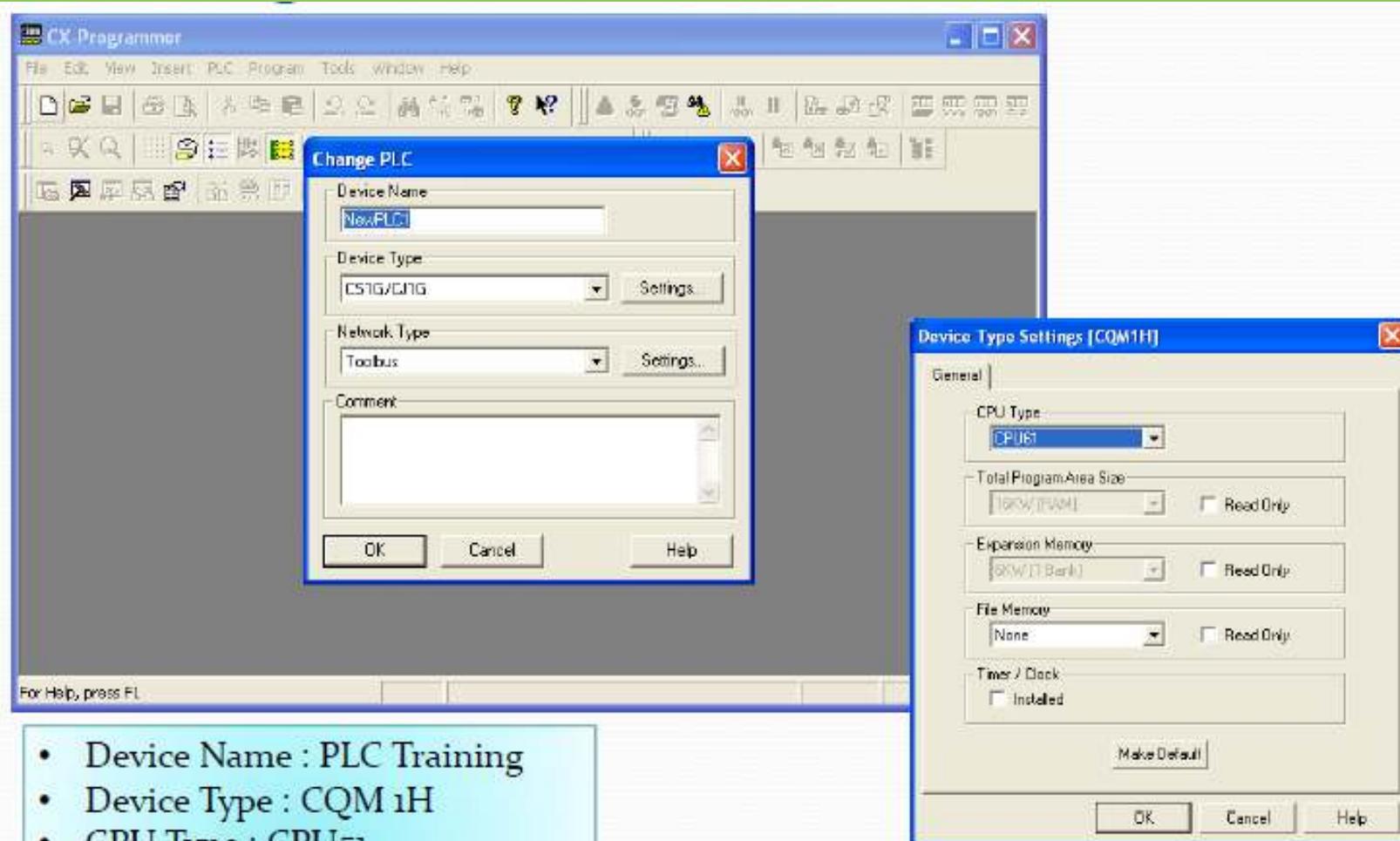
CX Programmer: Input/Output



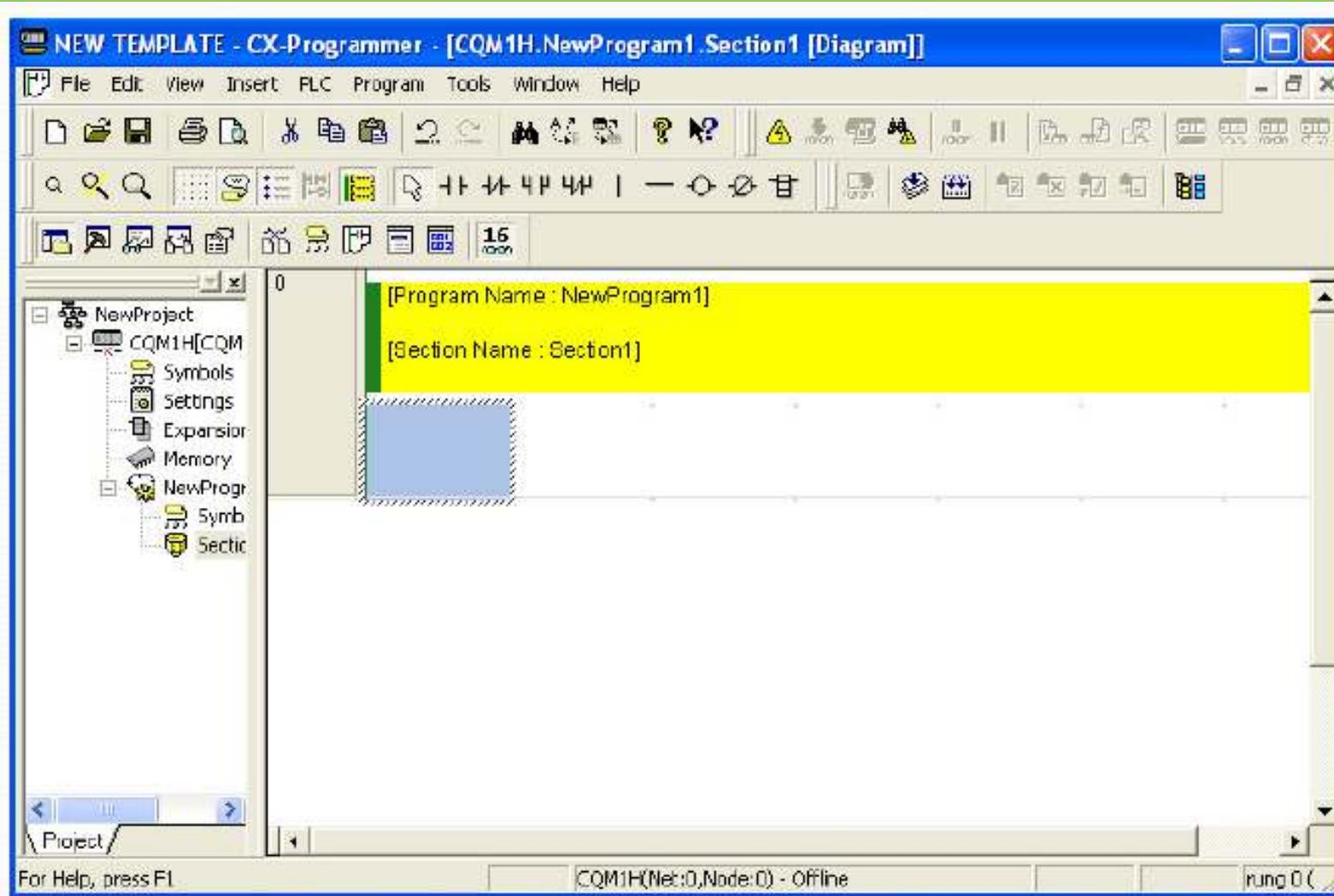
Opening New File



Configure PLC Devices



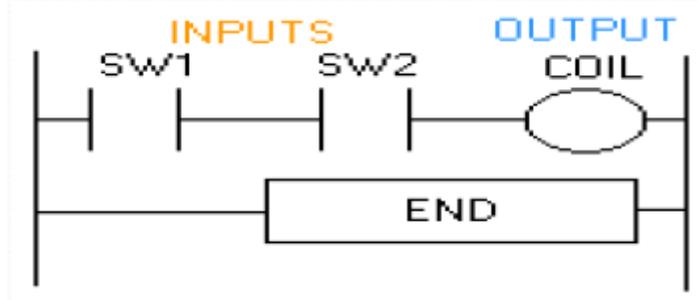
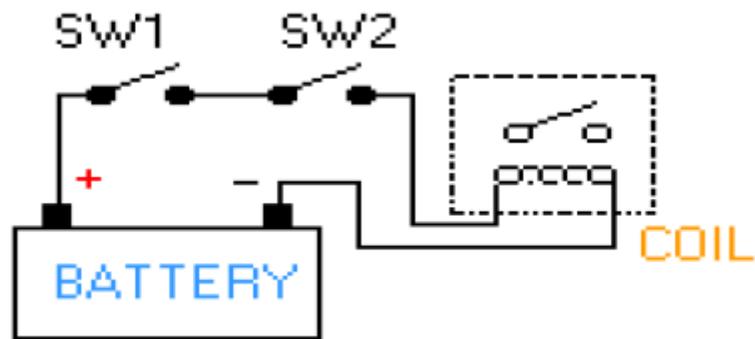
CX Programmer: Programming



PLC Mode

	Program	Monitor	Run
Delete	✓	✗	✗
Transfer	✓	✗	✗
On line edit	✓	✓	✗
Timer/Counter/DM SV change	✓	✓	✗
Run Indicator	OFF	ON	ON

Exercise

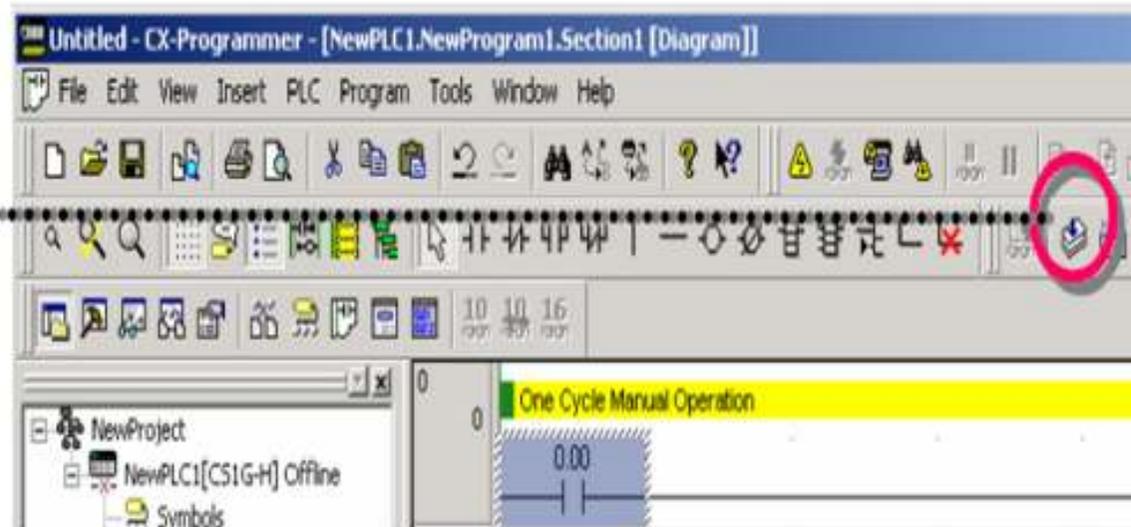


- ❑ Draw process flowchart for a given system
- ❑ Create the ladder diagram in CX Programmer

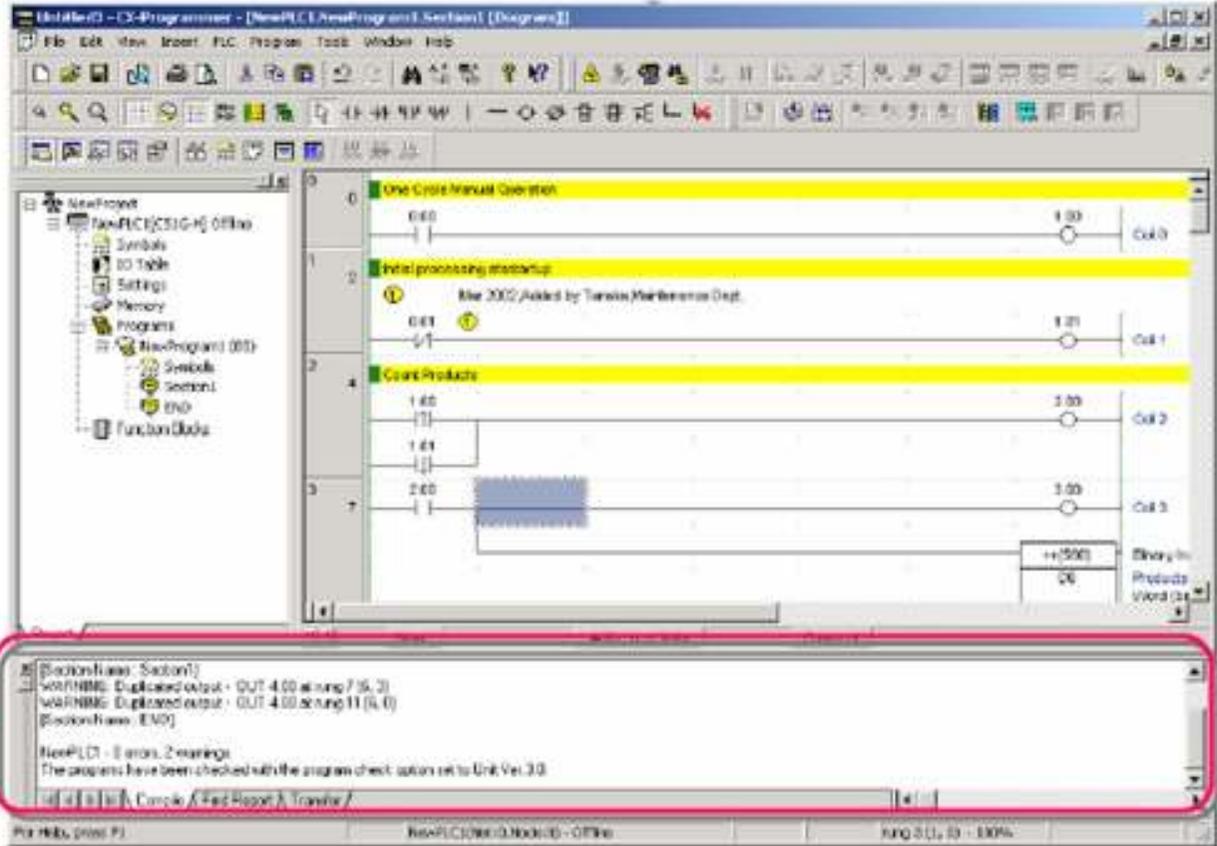
Program Error Check (Compile)

Before program transfer, check errors.

Click



Program Error Check (Compile)



The screenshot displays a PLC programming software interface. The main window shows a ladder logic diagram with three rungs. Rung 0 is labeled "One Cross Manual Operation" and contains a normally open contact labeled "000" and a coil labeled "1.00" with "Out 0" next to it. Rung 1 is labeled "Initial processing startup" and contains a normally open contact labeled "001" and a coil labeled "1.01" with "Out 1" next to it. Rung 2 is labeled "Count Products" and contains a normally open contact labeled "1.00" and a coil labeled "1.01" with "Out 2" next to it. Below the rungs, there is a timer block labeled "T1" and a counter block labeled "C1".

The Output Window at the bottom of the screen displays the following error messages:

```
[Position Name: Section7]
[Warn]ERR: Duplicated output - OUT 4.00 at rung 7 (S, 3)
[Warn]ERR: Duplicated output - OUT 4.00 at rung 11 (S, 4)
[Position Name: END]

NewPLC1 - 3 errors, 2 warnings
The programs have been checked with the program check option set to Unit Ver. 3.0
[OK] [Cancel] [Print Report] [Transfer]
```

Errors and addresses are displayed on Output Window.

Program Error Check (Compile)

Double-click a displayed error, and the cursor in Ladder Diagram will go to the corresponding error location and the error rung will be shown in red.



Modify the error.

The screenshot displays the SIMATIC Manager interface. The top part shows a ladder logic diagram with a rung highlighted in red, indicating an error. A red circle highlights the error location, and a red arrow points from the error message in the Output Window to this location. The Output Window shows the following error messages:

```
PLC: SIMATIC (PLC model: SIMATIC 300)
[PLC Program Name: NewPLC1NewProgram1]
[Section Name: Section1]
WARNING: Duplicated output - OUT 4.00 at rung 2.8. 31
WARNING: Duplicated output - OUT 4.00 at rung 11.8. 31
```

The Output Window also shows the text: "NewPLC1 - (3 errors, 2 warnings) The programs have been checked with the program check option set to Unit Ver.3.0."

- Output Window automatically opens at program check.
- The cursor moves to an error location by pressing J or F4 key.
- Output Window closes by pressing the ESC key.

Going Online

CX-Programmer provides three kinds of connecting methods depending on usage.



Normal online. Enables you to go online with a PLC of the device type and method specified when opening a project.



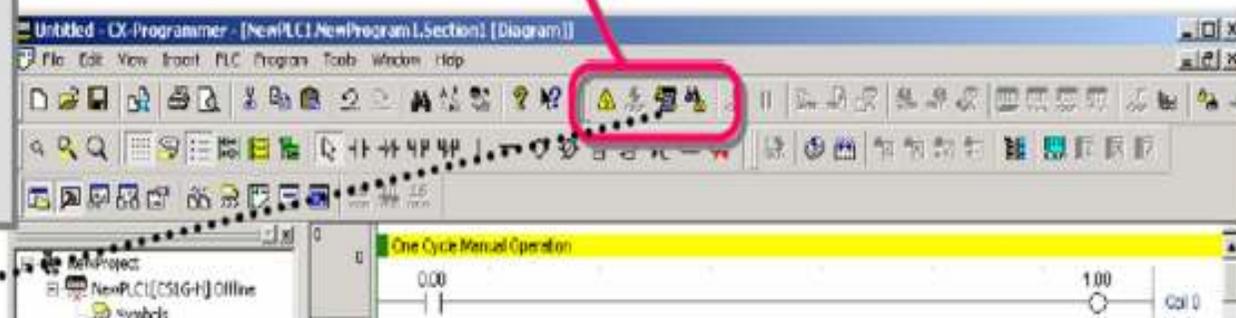
Auto online. Automatically recognizes the connected PLC and enables you to go online with a PLC with one button.
-> Uploads all data such as programs from the PLC.



Online with Simulator. Enables you to go online with CX-Simulator with one button (You need to install CX-Simulator.)

This time, online/debug functions when working online with CX-Simulator are explained in this guide (Install CX-Simulator separately).

Click



Going Online

Click [OK].

Click [OK].

Program transfer starts.

The CX-Simulator Console box is shown.

The operating mode of the active PLC is shown.

The background color of Ladder Window changes to gray.

Scan time is displayed (except for Program Mode).

The screenshot shows the 'Download options' dialog box with the 'OK' button circled in red. A green arrow points to the 'Download' dialog box, which also has its 'OK' button circled in red. Below these, the main software interface is shown with several callouts: 'The CX-Simulator Console box is shown.' points to the console window on the left; 'The operating mode of the active PLC is shown.' points to the 'One Cycle Manual Operation' mode indicator; 'The background color of Ladder Window changes to gray.' points to the grayed-out ladder logic; and 'Scan time is displayed (except for Program Mode).' points to the scan time display at the bottom of the ladder window.