EXPERIMENT 3
PROGRAMMABLE LOGIC CONTROLLER (PLC) - SIEMENS

OBJECTIVE

Understand automation process in the industrial field is essential for an engineer. Should engineer student used to work and practice likely in this environment, so when it comes to real system they are not surprised. In this experiment, we will use PLC Siemens that shows basic automation command clearly and easy to understand. We would introduced about basic instruction, counter, and timer.

REFERENCE

David W. Pessen, Industrial Automation: Circuit Design and Components, 2008.

EQUIPMENT REQUIRED

PLC SIEMENS S7-300 kit	1 piece
PC with STEP 7	1 piece.

PRE-EXPERIMENT TASK

1. What industries used to apply PLC to their system? Why is that?
2. What is the company that produces the PLC?

INTRODUCTION

Automation System is a system that makes human life easier. It has so many advantages, because it can work effectively and efficiently in case of time, energy, and cost needed. So that we can achieve it all, many industries use PLC. A PLC is an industrial computer control system that continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices. Almost any production line, machine function, or process can be greatly enhanced using this type of control system. However, the biggest benefit in using a PLC is the ability to change and replicate the operation or process while collecting and communicating vital information.

There is two type of PLC, that is Compact and Modular PLC. Compact PLCs are used in automation as replacements of relays. A PLC does not cost more than a handful of relays and the programming is as flexible as wiring. The weak points of this type PLC are low memory for the program and data, low processor performance, low number of PLC timers and counters, and missing data types (like floating point, string). On the other hand, today's more expensive compact PLCs have the same functionalities as other PLC types, the only flaw is the fixed number of I/Os. Examples of compact PLC are Festo FEC PLC, Siemens Logo and S7-200 PLC.

A modular PLC contains several different modules that can be coupled together to build a customized controller. Typically, a base module contains core functions such as electrical power regulation, the computer processor, and input connections. Additional modules, including analog to digital signal converters or additional outputs, can be added to this core unit as needed. This modular design allows a PLC to be customized and changed easily. The actual number of connections can be expanded easily by adding modules. This provides a wide range of flexibility and is typical of a modular PLC. While Ladder Logic is the most commonly used PLC programming language, it is not the only one. There are five programming language used to put in use:

- **Ladder Diagram (LD)**
  Traditional ladder logic is graphical programming language. Initially programmed with simple contacts that simulated the opening and closing of relays, Ladder Logic programming has been expanded to include such functions as counters, timers, shift registers, and math operations.
- **Function Block Diagram (FBD)**
  A graphical language for depicting signal and data flows through re-usable function blocks. FBD is very useful for expressing the interconnection of control system algorithms and logic.
- **Structured Text (ST)**
  A high level text language that encourages structured programming. It has a language structure (syntax) that strongly resembles PASCAL and supports a wide range of standard functions and operators.
- **Instruction List (IL)**
  A low level “assembler like” language that is based on similar instructions list languages found in a wide range of today’s PLCs.
- **Sequential Function Chart (SFC)**
  A method of programming complex control systems at a more highly structured level. A SFC program is an overview of the control system, in which the basic building blocks are entire program files. Each program file is created using one of the other types of programming languages. The SFC approach coordinates large, complicated programming tasks into smaller, more manageable tasks.

In this experiment, we will use PLC Siemens and STEP 7 for its software. PLC Siemens has many types that were S7-300 series, S7-400 series, S7-1200 series, and S7-1500 series. For this experiment we use a S7-300 series that is shown in Figure 1.

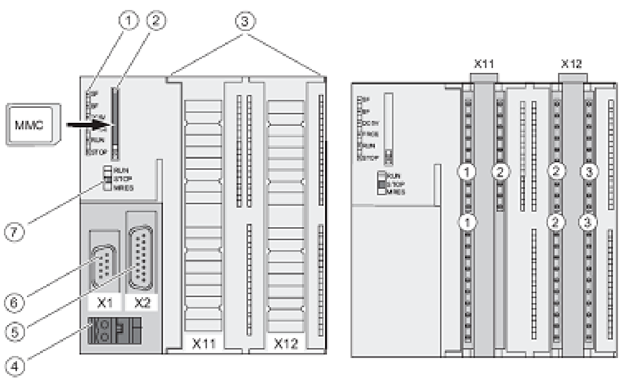


Figure 1. Siemens S7-300

Addressing PLC Siemens S7-300

Every input and output has an absolute address predefined by the hardware configuration. This address is specified directly. The absolute address can be replaced by any symbolic name you choose

1. Input Address
   Input for PLC Siemens start for address I0.0 until I65535.7. For this module, address can be use is form I124.0 until I124.7 and I125.0 until I125.1.
2. Output Address
   Output for PLC Siemens S7-300 start for address Q0.0 until Q65535.7. For this module, address can be use is form Q124.0 until Q124.5
3. Memory Address
   PLC Siemens provide a memory location with a very unique addressing. We can choose which memory will use by first selecting the address specification, which includes memory area, its address and bit and byte number. Memory area on the PLC there are 5 kinds: I, QV, and M all of which can be accessed as a byte, word, or double word.

Configuration PLC SIEMENS S7-300 with STEP 7

1. First, run SIMATIC Manager.

Figure 2. Symbol STEP 7 SIMATIC Manager

2. Create a new project by choosing **File → New,** and give a name project you create with **“Project 1”,** and then click **OK**

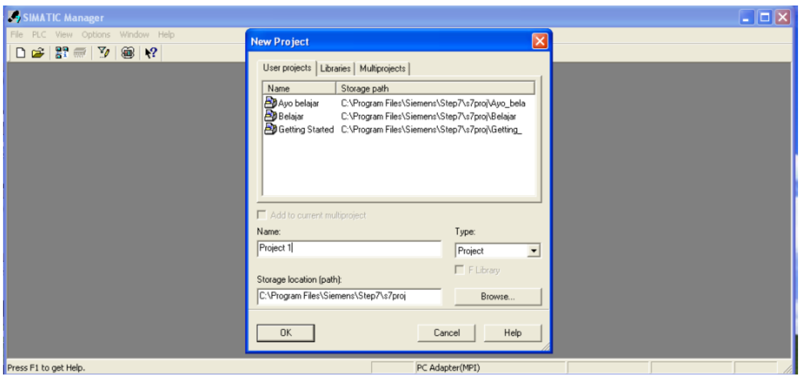


Figure 3. Menu will we create a new project

3. Choose a PLC can we used, in SIMATIC Manager, **right click → insert new object → Simatic 300 Station**

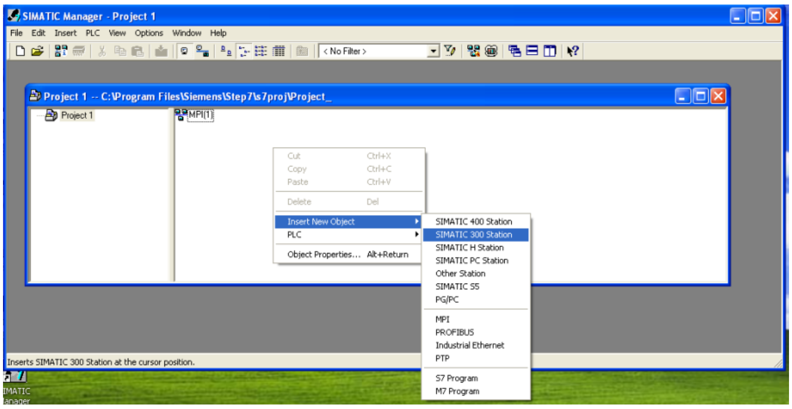


Figure 4. Screen we will choose PLC type

After we will insert SIMATIC 300 station, it will appear as shown in Figure 5.

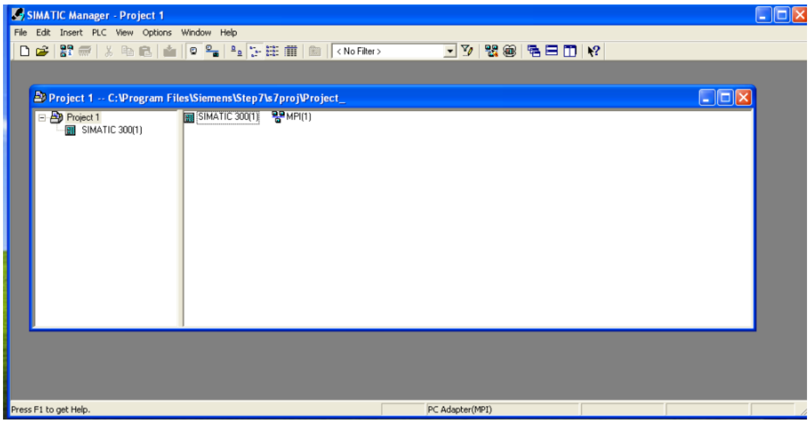


Figure 5. Screen after we insert PLC type

4. Configure hardware a PLC will we used, click **SIMATIC 300(1) → Hardware**

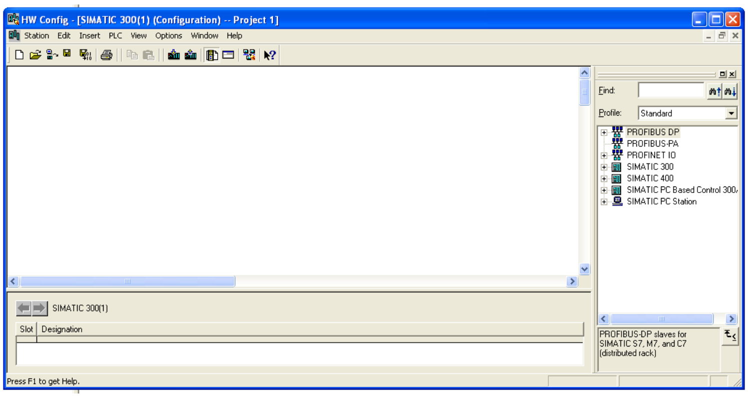


Figure 6. Screen for configuration hardware

5. Choose a CPU and I/O module will we use with choose RACK-300, CPU 300 → CPU 312C, and SM-300 → AI/AO-300

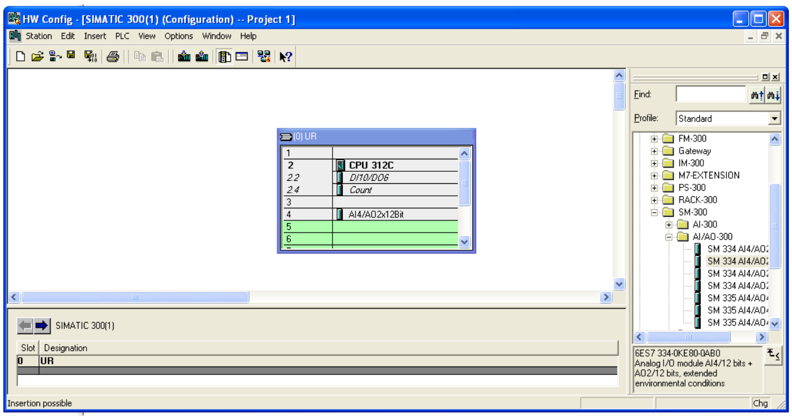


Figure 7. Select a component in hardware configuration

After choose CPU and I/O module, click **save and compile**

6. To start programming to PLC, start on click **CPU 312C → S7 Program (1) → Blocks → OB1**, then choose a programming language. Click on LAD (ladder) for programming language, and then screen to start programming will be open like in figure 9.

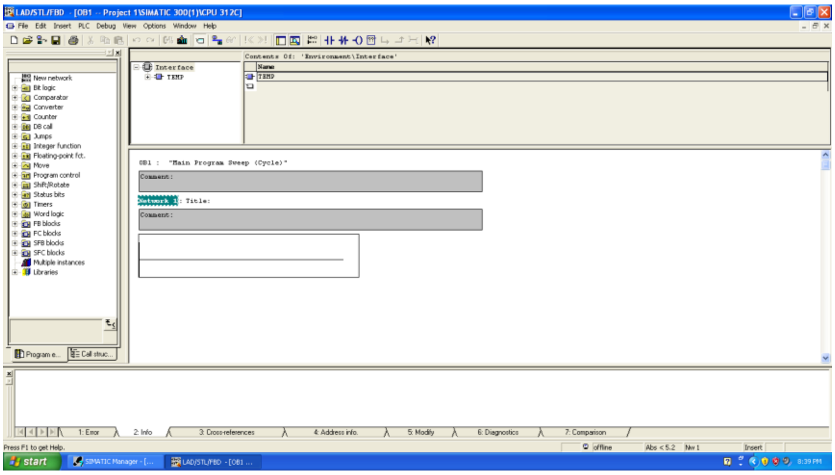


Figure 9. Block OB1

Communication PLC SIEMENS S7-300 with STEP 7

1. In Window SIMATIC Manager, choose **option → Set PG/PC Interface**

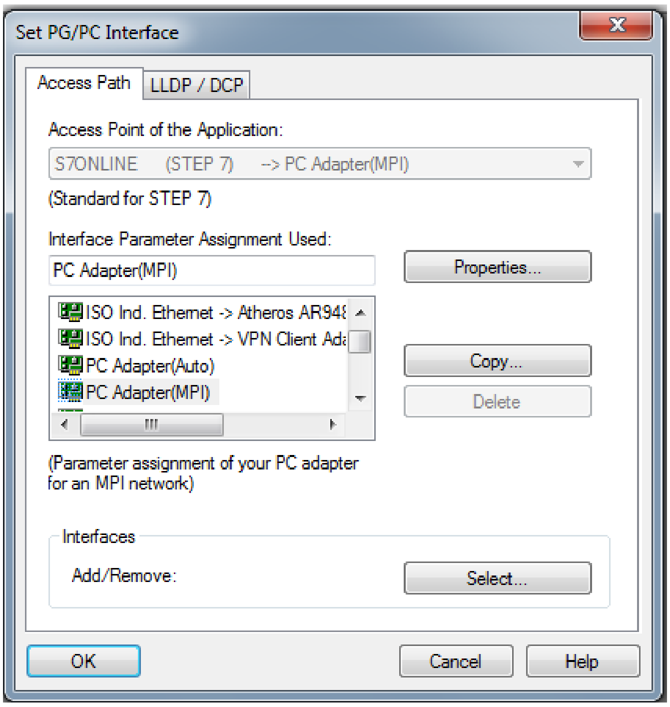


Figure 10. Menu Set PG/PC Interface

2. In the **Interface Parameter Assignment Used**, choose **PC Adapter MPI**, and then click **OK**

Programming Instruction STEP 7

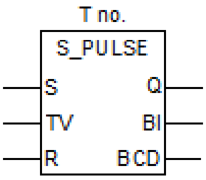
A. Bit Logic

1. Normally Open Contact **---| |---**
   This bit is used to enter input which is open normal state
2. Normally Closed Contact **---| / |---**
   This bit is used to enter input which normally closed state
3. Invert Power Flow **--|NOT|--**
   This bit is used to reverse the value of the logic operation before
4. Output Coil **---( )**
   Output coil work like a coil in a relay logic diagram. This bit is used to indicate the value of the result of logic operation

B. Timer

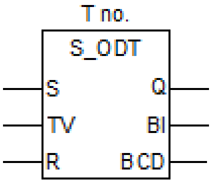
Timer is an instruction which serves to provide a time delay (delay). The timer can be used to set the length of time on or off an output. In STEP 7 Programming, there are various kinds of timers, such as pulse timer (S_Pulse), on delay timer (S_ODT), and off delay timer (S_OFFDT).

1 Pulse Timer (S_PULSE)



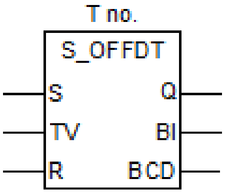
The timer is used to specify the delay time a logic operation

2 On Delay Timer (S_ODT)



This timer is used to delay on a logic operation

3 Off Delay Timer (S_OFFDT)

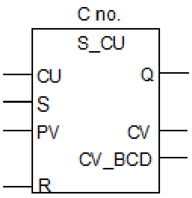


This timer is used to delay off a logic operation

C. Counter

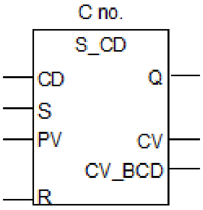
Counter is an instruction that is used for the calculation operation. There are several types of programming counter at STEP 7, such as counter up (S_CU), counter down (S_CD), and counter up / down (S_CUD)

1 Counter Up (S_CU)



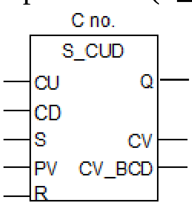
This counter is a function that could counting from zero to a value that have assigned

2 Counter Down (S_CUD)



Counter down is a function that could counting from value that have assigned to zero

3 Counter Up / Down (S_OFFDT)



Counter up / down is used to calculate a sequence of up or down

EXPERIMENT

Experiment 1. Basic Instructions and Logic Circuit

A. Operational Procedure

1. Configure Ladder Diagram for contacts and coils as shown in Figure 12.
2. Place each contact (Normally Open and Normally Close) for NO coil
3. Write condition of lamp when it is depressed and released

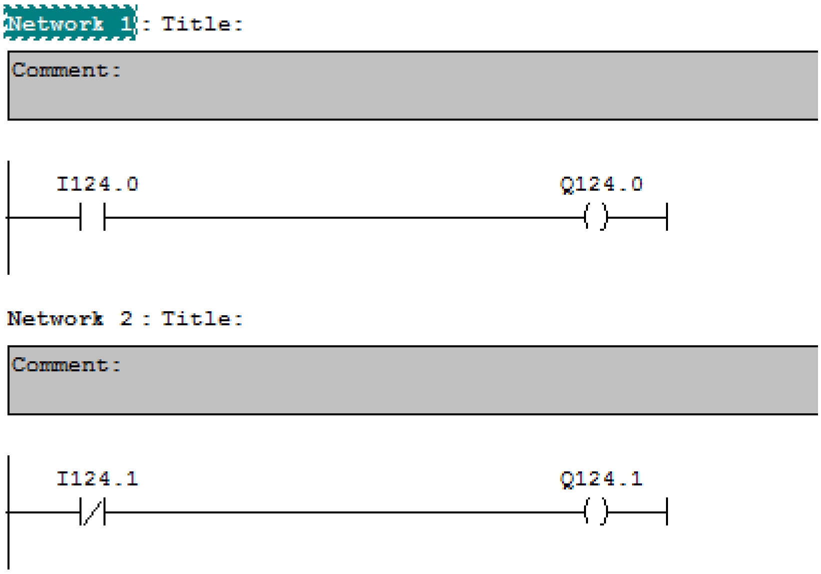


Figure 12. Ladder diagram of contacts and coil circuit experiment

4. Configure ladder diagram for AND circuit as shown in Figure 13
5. Place two NO contact consecutively with a NO coil. Place both of them in same row with NO coil
6. Write condition of lamp when it is depressed and released

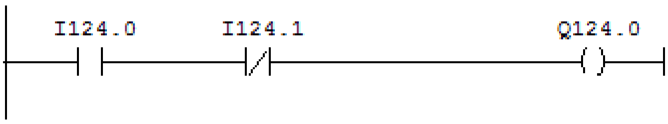


Figure 13. Ladder diagram of AND circuit

7. Configure Ladder Diagram for OR circuit as shown in Figure 14.
8. Place two NO contact consecutively with a NO coil. Place one of them in same row with NO coil and the other one in second row, connected vertically with first row
9. Write condition of lamp when it is depressed and released

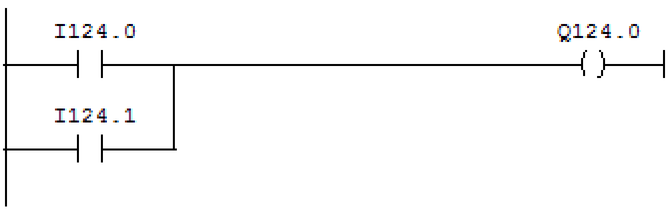


Figure 14. Ladder diagram of OR circuit

B. Experimental Data

All of condition, experience and image that you observe after contacts and coils experiment can be written in Table B, for AND & OR circuit experiment can be written in Table

		Lamp Condition	
		Normally Open	Normally Close
Contact Condition	Depress		
	Release		

	Contact State		Lamp Condition
	Normally Open	Normally Open 2	
AND	0	0	
	0	1	
	1	0	
	1	1	
OR	0	0	
	0	1	
	1	0	
	1	1	

Information: 0 = Released
1 = Depressed

C. Analysis and Experiment Task

1. What is difference between contacts and coils? How about Normally Open and Normally Close

Experiment 2. Self Holding Circuit

A. Operational Procedure

1. Configure ladder diagram for self-holding circuit as shown in Figure 15.

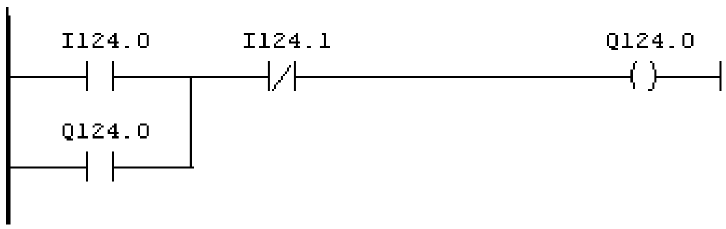


Figure 15. Self-holding circuit

2. Place two NO contact, and one NC contact with a NO coil. Place NO contact in same row with NC contact, and connect with NO coil. The other NO contact in second row, connected vertically with first row. Address for this contact is same with NO coil.
3. Write condition of lamp when it is depressed and released

B. Experimental Data

All of condition, experience and image that you observe after contacts and coils experiment can be written in Table B, for AND & OR circuit experiment can be written in Table

		Lamp Condition	
		Normally Open	Normally Close
Contact Condition	Depress		
	Release		

C. Analysis and Experiment Task

1. Why should we put an NC contact in the self-holding circuit?
2. Make a ladder design of blinking lamp with self-holding circuit. Explain your design!

Experiment 3. Timer

A. Operational Procedure

1. Configure ladder diagram for timer on delay as shown in Figure 16.

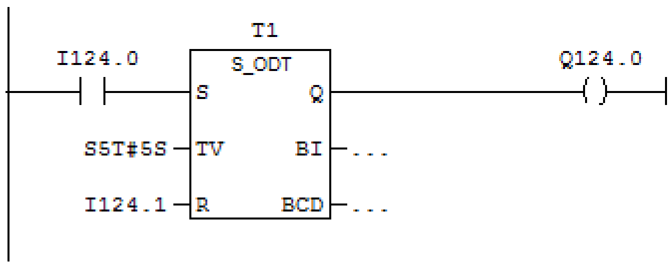


Figure 16. Ladder diagram of Timer On Delay

2. Write condition of lamp when the contact is depressed and released
3. Configure ladder diagram for timer off delay as shown in Figure 17.

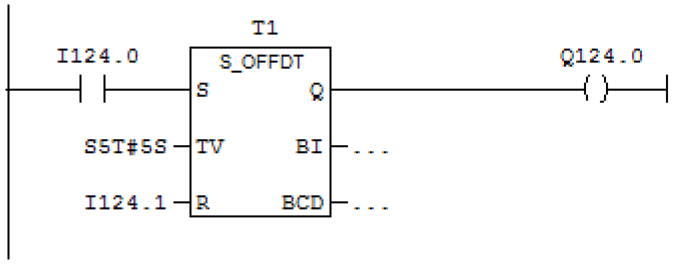


Figure 17. Ladder diagram of Timer Off Delay

4. Write condition of lamp when the contact is depressed and released

B. Experimental Data

All of condition, experience and image that you observe after timer on delay experiment can be written in Table e and Timer Off-Delay experiment in Table F

	Time (seconds (s))	Lamp Condition
Contact Condition	0	
	5	
Timing Diagram		
Input		
Output		

	Time (seconds (s))	Lamp Condition
Contact Condition	0	
	5	
Timing Diagram		
Input		
Output		

C. Analysis and Experiment Task

1. How many variables in the timer function? Explain!
2. Could we make two Timer function in a rung? If cannot, why is there?

Experiment 4. Counter

A. Operational Procedure

1. Configure ladder diagram for counter up as shown in Figure 18

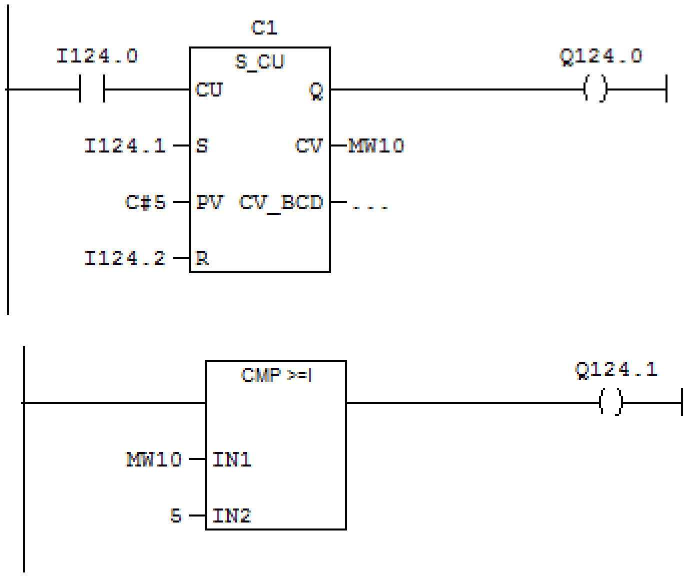


Figure 18. Ladder diagram of Counter Up

2. For counter down, configure ladder diagram as shown in Figure 19

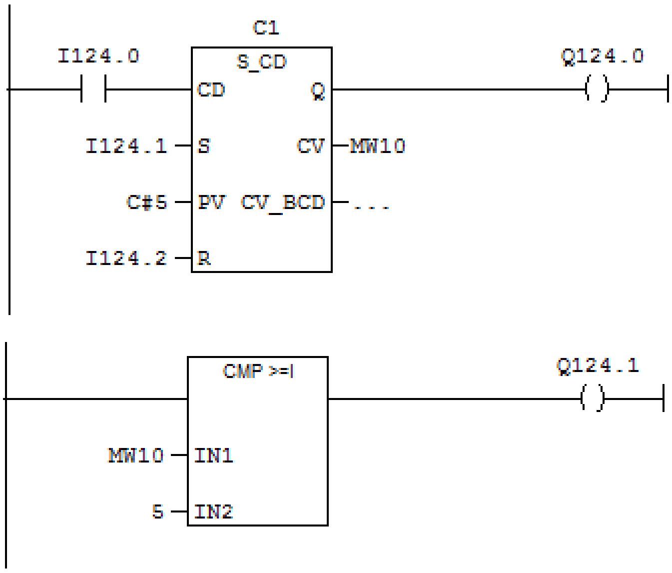


Figure 19. Ladder diagram of Counter Down

3. Write condition of lamp

B. Experimental Data

All of condition, experience and image that you observe after counter up experiment can be written in Table e and counter down experiment in Table F

	Count	Lamp Condition
Contact	0	
	5	

	Count	Lamp Condition
Contact	0	
	5	

C. Analysis and Experiment Task

1. How many variables in the counter function? Explain?
2. Draw a state diagram input and output for counter experiment