

**KING FAISAL UNIVERSITY**  
**College Of Engineering**

**DEPARTMENT OF ELECTRICAL ENGINEERING**

**EE484: INDUSTRIAL CONTROL**

**“Lab Manual”**



## Major Topics covered and schedule in weeks:

Topic	Week #	Courses Covered
Basic PLC Trainer Operations	10	EE484
Basic Timer and Counter Operations	11	

### Specific Outcomes of Instruction (Lab Learning Outcomes):

1. Get familiar with PLC programming
2. Use the PLC to design and build industrial application

### Student Outcomes (SO) Addressed by the Lab:

z	Outcome Description	Contribution
	General Engineering Student Outcomes	
1.	an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics	M
2.	an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors	
3.	an ability to communicate effectively with a range of audiences	M
4.	an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts	
5.	an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives	M
6.	an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions	H
7.	an ability to acquire and apply new knowledge as needed, using appropriate learning strategies	

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# Experiment 1: Basic PLC Trainer Operations

## I. Objective:

Through this experiment, the students will be introduced to OMRON LABTECH LDA-PLC-03 Trainer, its components, features and capabilities. They will be given also some basic understanding on how to work with the OMRON PLCs.

## II. Test Standard

IEEE 3001.11-2017 - IEEE Recommended Practice for Application of Controllers and Automation to Industrial and Commercial Power Systems

## III. Theory:

### III.1. Hardware:

#### III.1.1. PLC Trainer Kit:

The LDA-PLC-03 trainer is a kit based on the Omron PLC, a leader in industrial automation. The trainer is compatible with a variety of accessories and peripherals, thus allowing it to be easily expanded into larger systems.

When observing the main unit, you should find the following

- An OMRON CPM2A CPU
- The I/O simulation with toggle switches (internal)
- LED display (internal)
- Series of 4mm sockets connected to the PLC I/Os.

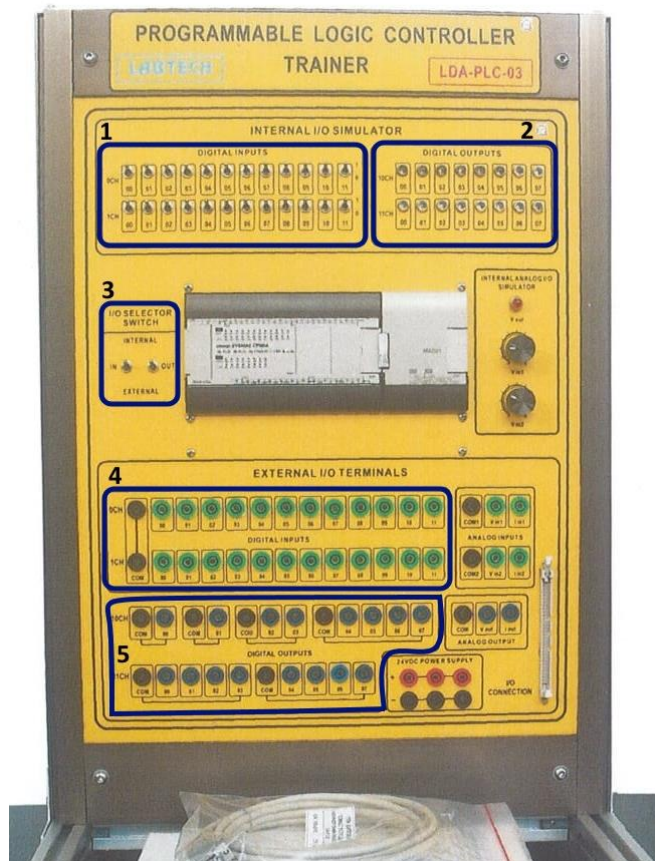


Figure 1: overview of the LDA-PLC-

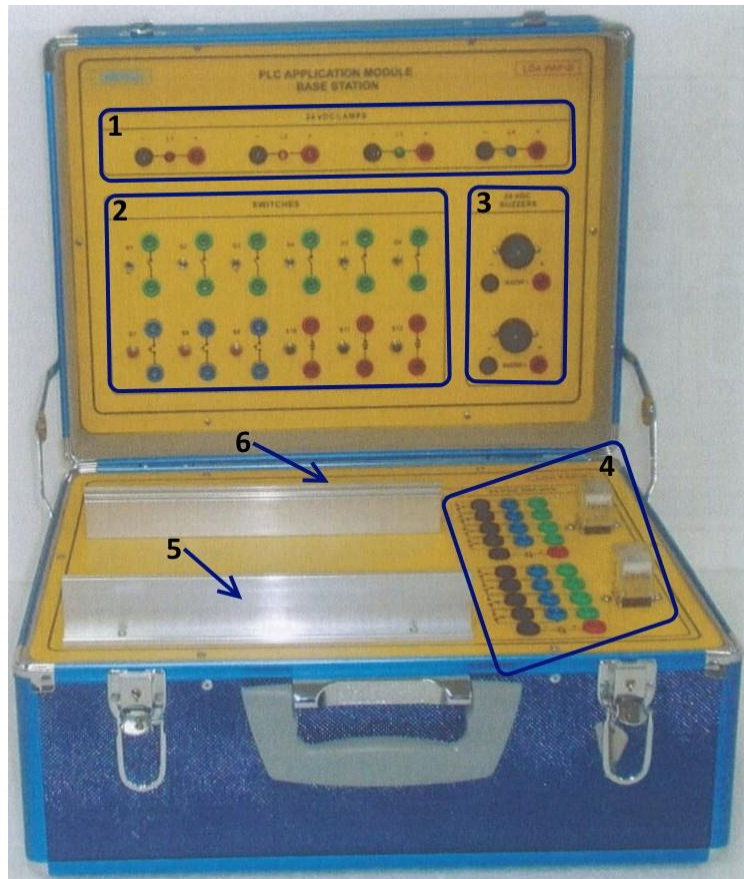
03 trainer kit

- 1: The Internal simulation inputs on the PLC consist of toggle switches
- 2: The Internal simulation outputs consist of LEDs and can be used to monitor the status of the output ports
- 3: The testing mode can be changed between the internal mode (with switches & LEDs) or external mode (using external components) (this can be done using IN / OUT pins on field 4 & 5)
- 4: External input pins come from the base station LDA-PAP-B. Note, however, that the input ground must be connected to the base station ground too.
- 5: External output pins also come from the base station LDA-PAP-B, and can be LEDs, or Relays, or a Buzzer.

### 1.2. LDA-PAP-B Base Station:

The LDA-PAP-B is a part of the LDA-PLC-03 Trainer. It provides external components to use with the PLC trainer. It has the following components:

- 1: External LEDs
- 2: External inputs are composed of toggle switches and push-buttons
- 3: A Buzzer, which can be considered as solenoids
- 4: Control relays
- 5: Extension modules holder: it is used to plug extension modules available with the kit in order to try real life scenarios
- 6: Power supply (hidden by 5) pins (+ & -), they are used for different purpose with the switches to power the LEDs or relays etc.



### III.2. CX software:



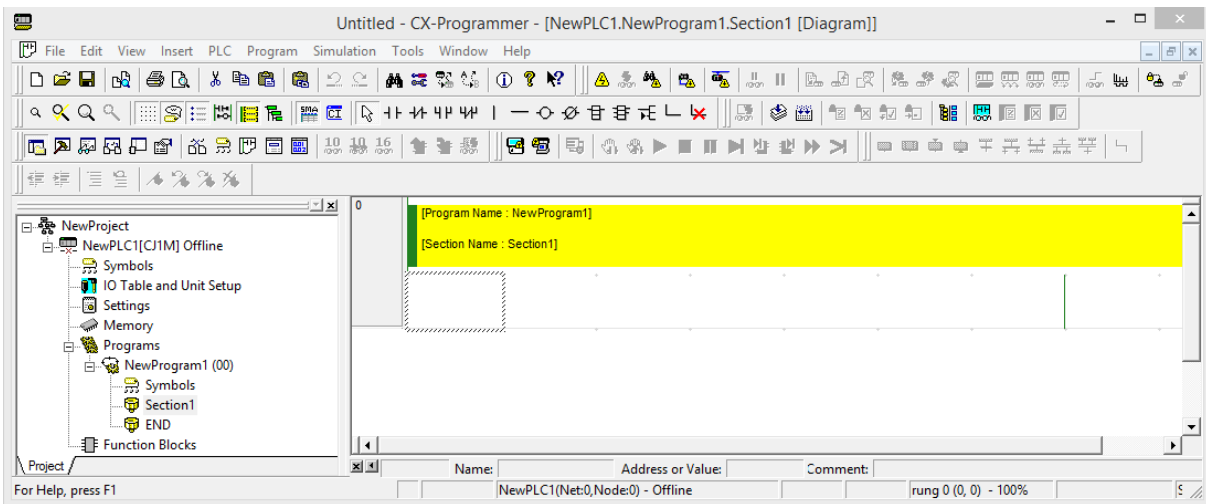
The CX software is part of OMRON CX-One suite for creating, editing and transferring PLC programs. It has the ability to communicate with the PLC and monitor the state of its inputs and outputs at real time.

#### IV. Apparatus:

- LabTech LDA-PLC-03 Trainer.
- LDA-PAP-B Base station
- CX controller software.

#### V. Procedure:

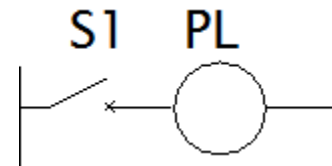
1. Verify that the PLC is connected to the PC through the COM port (via the RS232 cable).
2. Open the CX programmer and create a new file, you will get the screen below:



We consider a sample control system:

#### 3. Develop the:

- truth table
- Boolean logic expression
- Ladder program



#### 4. Use the programming icons for creating inputs and outputs to write the ladder program.



5. When creating the program, the address for each input & output needs to be specified, usually, the user lists all the possible inputs and outputs for his system in the Input/Output Table:

Module Type	I/O Address	Device	Description
Input	x.xx		

Output	x.xx		
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The Table is composed of:

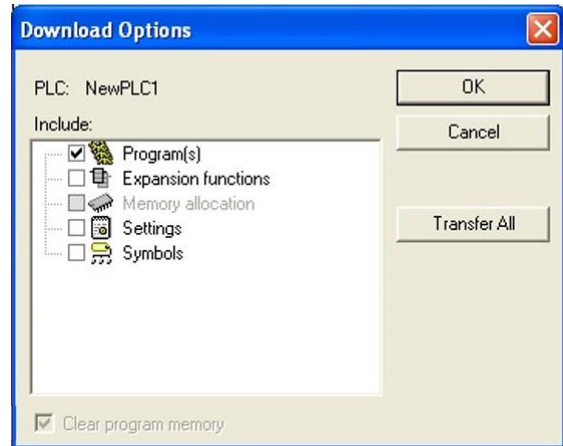
- Module type: to specify the type of the component to connect to the PLC: input or output
- I/O address: the PLC pin where the component is connected. For this trainer kit, there are 24 inputs with addresses (0.00 → 0.011 & 1.00 → 1.11) and 16 outputs with addresses (10.00 → 10.07 & 11.00 → 11.07)
- Device: the name (abbreviation of the component to be connected to the PLC, it help understanding the wiring to be done between the PLC and the component
- Description: a more detailed description of the device, though optional, it is very helpful for understanding the role of that component in the system, especially big ones.

In this example, we have S1 as input and PL as output, we choose to assign the address 0.00 to S1 and the address 10.00 to PL, the I/O Table would be :

Module Type	I/O Address	Device	Description
Input	0.00	S1	Switch
Output	10.00	PL	LED

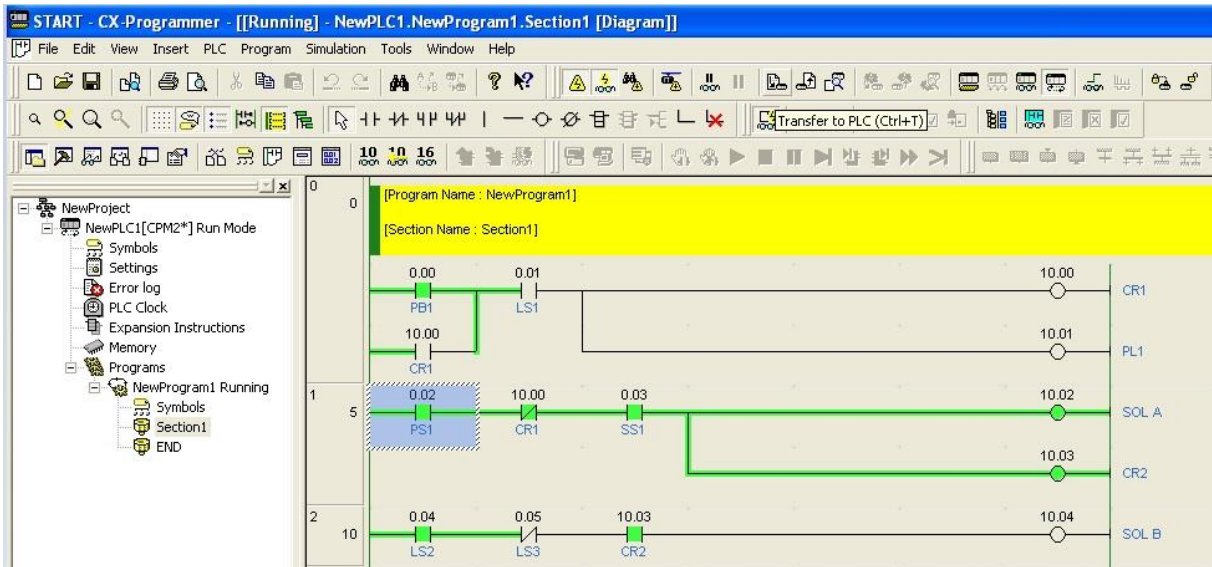
6. After creating the ladder program, click on “**Compile**” from the “**program menu**” interface to check that there are no errors in the program.

7. Now that the program is successfully compiled, it is time to communicate with the PLC. Click on the "work online" icon (⚠). Then select the option "Transfer to PLC" (📁) to download the program to the PLC as shown in figure below. Download the Programs only, there is no need to transfer anything else.



CX software will ask the user confirmation to switch to “program mode.” Since it is going to affect the state of the connected PLC, download the program to the PLC then switch back to the “run mode”,

8. Now, you have downloaded the program to the PLC. If you are working online, the changes on PLC inputs and outputs are displayed in real-time on the computer screen. The changes are marked in green as illustrated in figure 4



Select the I/O selector switch on the PLC trainer to be "Internal", and then try to make changes on the inputs. Observe the outputs. If your program is correct, the output will follow the input condition. Also, observe the computer screen while you are changing the PLC input status.

9. Record the truth table for that program

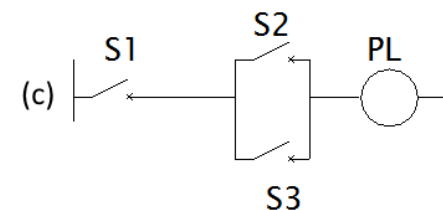
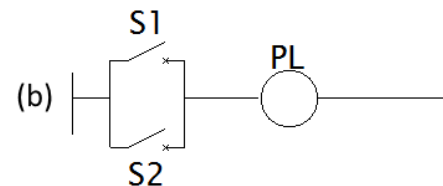
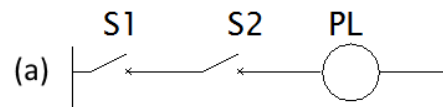
10. After finishing, Disconnect the PLC from the computer by clicking on the "work online" icon.

## VI. Experimental Work:

### 1. Preliminary exercise:

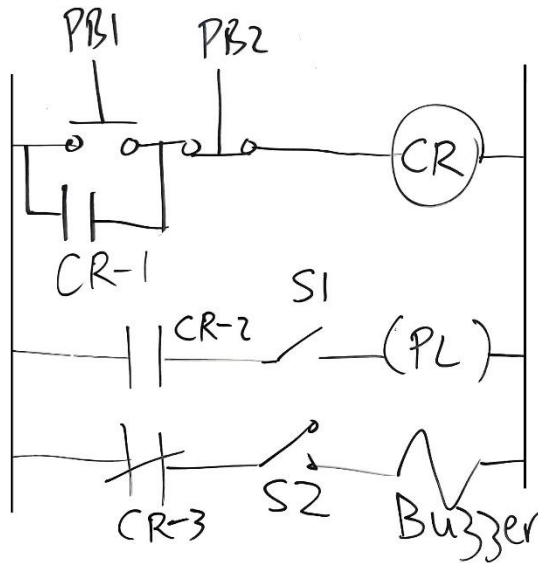
In this section, we will test simple control systems involving switches and LEDs. We will use the internal components (toggle switches & LEDs).

For each of the following control systems (a), (b) and (c), repeat the steps 3 → 9



### 2. Industrial control system

We consider the following control system



1. Repeat the same steps as in the preliminary exercise
2. Test the program using external components from the base station.

After completing the experiment, students have to report the following questions:

In the report, provide the following:

- Identify all the I/O devices of the experiment.
- Write the Boolean expression for each of the outputs of the experiment. Can you minimize any of the expressions?

Cross-check your results with the theoretical ones

## References:

LabTech LDA manual

## Experiment 2: Basic Timer and Counter Operations

### I. Objective:

- Work with timers
- Work with counters


### II. Test Standard

### III. Theory:

#### 1. Timer On-Delay



A timer is a PLC instruction, when activated (upon pressing a button for example), the timer will start counting for a period for time specified by the program developer. When time reaches 0, the contact will be activated.

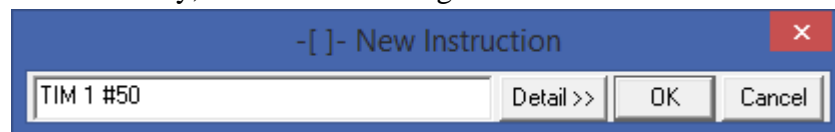
5. To create the timer instruction, go to the “insert” menu and choose “instruction”, or click on the instruction icon  in the CX interface. There are many timer instructions, in this lab, we will work with the “TIM” instruction, a short timer that works on units of 0.1s and can have a maximum delay of ~25s.

6. The timer instruction requires two parameters:

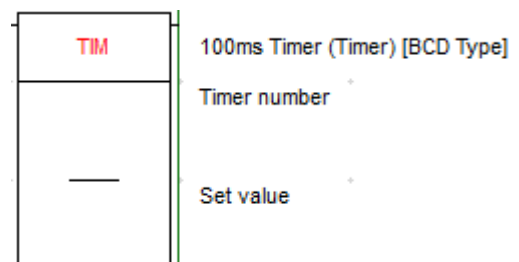
- **Timer number:** it is possible to put up to 256 timers, each timer need to be identified by a number
- **Set Value (delay):** the duration of the timer, the unit is 0.1s (e.g: putting 10 means 1s delay), the “#” must be put before the number (#10 instead of just 10)

7. There are two methods to configure the timer instruction:

- Configure the instruction directly while creating it: when adding the timer, write the instruction followed by the parameters separated by space. For example, to create timer 1, with a 5 seconds delay, write the following:



- After creating the instruction, it will be displayed in the CX interface as follows: double click on the “timer number” or “set value” fields to enter the missing information, the color of the “TIM” instruction will turn then from red to black, meaning that the timer block is now correctly configured.



8. To use the timer later as a contact, you should name the contact as follows: **TIMxxx** (or **Txxx** for some versions), where xxx is the timer number (e.g. for timer 1, the contact name is TIM1 OR TIM001)

## 2. Counter:

A counter is another PLC instruction, when activated (upon pressing a button for example), the counter will start counting for a given number time specified by the program developer. When the counter reaches that limit, the contact will be activated.

Adding and configuring a counter share many similarities with the **TIM** instruction such as steps 5-8:

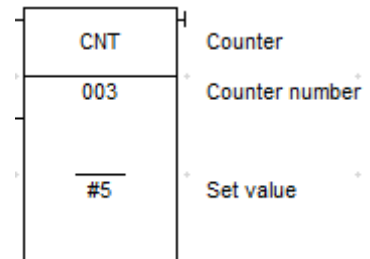
-Add a new instruction and write **CNT**

-The counter has two parameters also: the ID number and the counter limit. Be careful though that the ID number must not be used anywhere, whether for counters, or even timers. For example, if the program contains a timer that has 1 as the ID, assigning the ID 1 to the counter will result in a compilation error → the ID number is common to all instructions.

-The counter block requires two inputs from the ladder program to:

- Activate the counter

Reset the counter (it must be reset at the beginning of the execution)

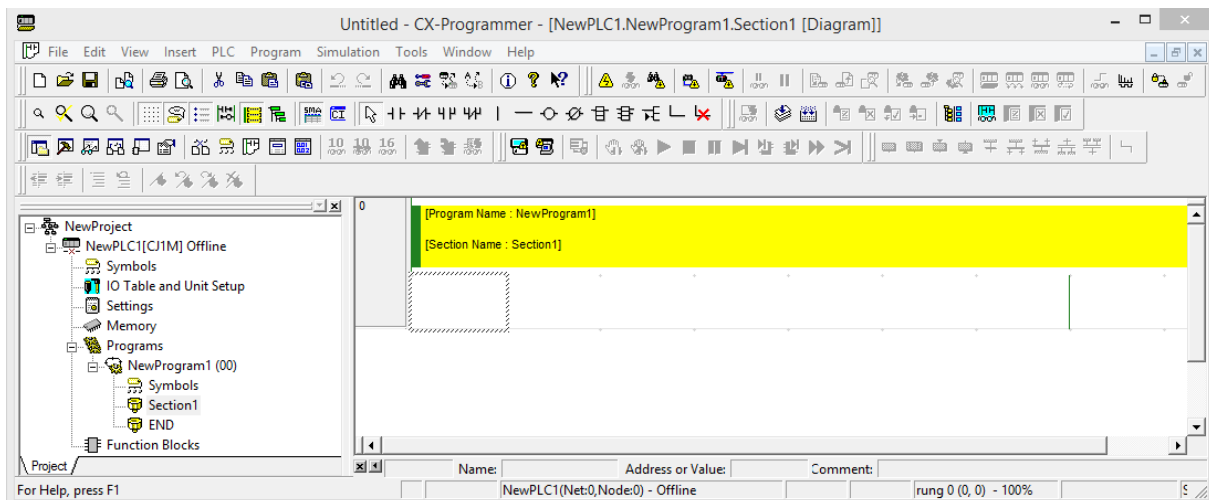


#### IV. Apparatus:

- LabTech LDA-PLC-03 Trainer.
- LDA-PAP-B Base station
- CX controller software.

#### V. Procedure:

1. Verify that the PLC is connected to the PC through the COM port (via the RS232 cable).
2. Prepare the connection and make sure all power connections are made.
3. Now connect the PLC to the PC through COM port and start the CX-controller software
4. Open the CX programmer and create a new file, you will get the screen below:



#### VI. Experimental Work:

##### Preliminary exercise:

In this section, we will test simple control systems involving timers and counters, following the experimental procedure shown in the previous section:

1-Create a ladder program that activates a buzzer, 5 seconds after pushing a button. Draw the truth Tables for the inputs and outputs immediately when the input switch is connected, and 5s after the switch is connected.

2-Create a ladder program that activates a LED, after pushing a button 5 times. Draw the truth Tables for the inputs and outputs immediately when the input switch is connected, and after pushing the button 5 times.

## Industrial control systems:

### 4.1. Traffic light:

Create a program that launches the traffic light system upon activating a switch

The ON duration for each light is as follows:

RED:	10s
GREEN	5s
ORANGE	2s

### 4.2. Password started process:

The responsible of a production chain noticed that sometimes, the production sequence is launched accidentally by pressing the wrong button. He wants to eliminate the human error factor and make sure that the process is launched upon typing a “password”. His idea consists on using two buttons, they need to be activated in a particular sequence to start the process.

Develop the ladder program that activates the process (symbolized by a LED) after entering the following sequence:

- Button1: press 3 times
- Button2: press 2 times
- Button1: press 1 time
- Button2: press 4 times

A third button is used to reset the sequence in case of error while entering it.

1. Present the results for the on-delay and counter timer
2. From the ladder logic program, provide a detailed description of the functioning of the aforementioned industrial control systems
3. Draw conclusions from the results of the experiments

## References:

LabTech LDA manual