DRONACHARYA
Group of Institutions

INDUSTRIAL AUTOMATION AND PLC
LABORATORY MANUAL

B.TECH.(EEE) SEMESTER –VII
Subject Code: KEN 751

Session: 2024-25, Odd Semester

Name:	
Roll. No.:	
Group/Branch:	

DRONACHARYA GROUP OF INSTITUTIONS
DEPARTMENT OF EEE
#27 KNOWLEDGE PARK 3

GREATER NOIDA

AFFILATED TO Dr. ABDUL KALAM TECHNICAL UNIVERSITY, LUCKNOW

Table of Contents

Vision and Mission of the Institute

Vision:

"Dronacharya Group of Institutions, Greater Noida aims to instill core human values and facilitating competence to address global challenges by providing Quality Technical Education."

Mission:

M1: Enhancing technical expertise through innovative research and education, fostering creativity and excellence in problem-solving.

M2: Cultivating a culture of ethical innovation and user-focused design, ensuring technological progress enhances the well-being of society.

M3: Equipping individuals with the technical skills and ethical values to lead and innovate responsibly in an ever-evolving digital landscape.

Vision and Mission of the Department

Vision

To be a Centre of Excellence in Globalizing Education and Research in the field of Electrical and Electronics Engineering.

Mission

M1: To empower technocrats with state-of-art knowledge to excel as eminent electrical engineers with multi-disciplinary skills.

M2: To emphasize social values and leadership qualities to meet the industrial needs, societal problems and global challenges.

M3: To enable the technocrats to accomplish impactful research and innovations

Programme Educational Objectives (PEOs)

PEO 1. To foster strong knowledge in basic sciences and electrical engineering that enable technocrats to have successful careers.

PEO 2. Imbibed with the state of art knowledge to adapt ever transforming technical scenario.

PEO 3. Inspire engineers to provide innovative solutions to real-world challenging problems by applying electrical and electronics engineering principles.

Programme Outcomes (POs)

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1: Graduates will be capable to gain knowledge in diverse areas of electrical and electronics engineering and apply that to a successful career, entrepreneurship and higher education.

PSO2: Enhance the competence of graduates to design and analyze systems used in advanced power applications, renewable energy, electrical drives in allied technical fields.

PSO3: Graduate will use advance tools to analyze, design and develop electrical and electronic systems for feasible operation and meet the industry requirements.

University Syllabus

A) Industrial Automation:

1. Study hardware and software platforms for DCS
2. Simulate analog and digital function blocks
3. Study, understand and perform experiments on timers and counters
4. Logic implementation for traffic Control Application
5. Logic implementation for Bottle Filling Application
6. Tune PID controller for heat exchanger using DCS
7. FBD for auto-clavable laboratory fermenter
8. Develop graphical user interface for the fermenter plant

B) PLC

1. Study hardware and software used in PLC
2. Implementation Logic Gates
3. Implementation of DOL Starter
4. Implementation of On-Delay Timer
5. Implementation of Off-Delay Timer
6. Implementation of Up-Down Counter
7. Implementation of PLC Arithmetic Instructions
8. Implementation of PID Controller

Course Outcomes (COs)

Upon successful completion of the course, the students will be able to:

CO 1	Understand and analyse Ladder diagram concept to test digital logic gates, Boolean expression
CO 2	Illustrate the Ladder program for DOL starter, Stair case light, Water level controller, Conveyer control, and Lift control applications.
CO 3	Qualified PLC programming engineers to meet the requirements of designing appropriate industrial automation systems.
CO 4	On completion of these modules, Engineers are ready to take on any Machine, Process or Plant Automation assignment.

CO-PO Mapping

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO 1	3	-	-	-	1	-	-	-	1	2	-	2
CO 2	3	2	-	-	2	-	-	-	1	2	-	2
CO 3	2	2	2	2	-	-	-	-	1	1	-	1
CO 4	2	-	2	2	2	-	-	-	1	1	-	1
CO 5	1	2	3	2	2	-	-	-	1	1	-	2
Course Correlation mapping	**2.2**	1.2	**1.4**	1.2	**1.4**	-	-	-	**1**	**1.4**	-	**1.6**

Correlation Levels: High-3, Medium-2, Low-1

CO-PSO Mapping

	PSO1	**PSO2**	**PSO3**
CO 1	2	3	1
CO 2	2	3	1
CO 3	2	3	1
CO 4	2	3	1
CO 5	2	3	1

Course Overview

To provide technical training to the students to program Microcontrollers using Embedded C Motivate and guide the students to participate in National and International level Competitions. To develop new technologies applicable to Industry 4.0. To take Consultancy work from Industries and generate revenue from developing the Laboratory. To provide the Placements for the Students through applied Lab.

List of Experiments mapped with COs

Si No.	Name of the Experiment	Course Outcome
1	To develop a ladder program for DOL starter.	CO 1
2	To develop an application using On-Delay timer.	CO 1
3	To Study computational/arithmetic instructions used in PLC ladder programming	CO 2
4	To understand working of PID function block.	CO 2
5	To develop an application using Off-Delay timer	CO 3
6	To Develop an application using UP/DOWN counter	CO 2
7	To simulate analog and digital function blocks	CO 4
8	To study, understand and perform experiments on timers and counters.	CO 2
9	Implementation of PID Controller	CO 3
10	Implementation of PLC Arithmetic Instructions	CO 2

DOs and DON'Ts

DOs

1. Login-on with your username and password.
2. Log off the computer every time when you leave the Lab.
3. Arrange your chair properly when you are leaving the lab.
4. Put your bags in the designated area.
5. Ask permission to print.

DON'Ts

1. Do not share your username and password.
2. Do not remove or disconnect cables or hardware parts.
3. Do not personalize the computer setting.
4. Do not run programs that continue to execute after you log off.
5. Do not download or install any programs, games or music on computer in Lab.
6. Personal Internet use chat room for Instant Messaging (IM) and Sites is strictly prohibited.
7. No Internet gaming activities allowed.
8. Tea, Coffee, Water & Eatables are not allowed in the Computer Lab.

General Safety Precautions

Precautions (In case of Injury or Electric Shock)

1. To break the victim with live electric source, use an insulator such as fire wood or plastic to break the contact. Do not touch the victim with bare hands to avoid the risk of electrifying yourself.
2. Unplug the risk of faulty equipment. If main circuit breaker is accessible, turn the circuit off.
3. If the victim is unconscious, start resuscitation immediately, use your hands to press the chest in and out to continue breathing function. Use mouth-to-mouth resuscitation if necessary.
4. Immediately call medical emergency and security. Remember! Time is critical; be best.

Precautions (In case of Fire)

1. Turn the equipment off. If power switch is not immediately accessible, take plug off.
2. If fire continues, try to curb the fire, if possible, by using the fire extinguisher or by covering it with a heavy cloth if possible isolate the burning equipment from the other surrounding equipment.
3. Sound the fire alarm by activating the nearest alarm switch located in the hallway.
4. Call security and emergency department immediately:

Emergency : 201 (Reception)

Security : 231 (Gate No.1)

Guidelines to students for report preparation

All students are required to maintain a record of the experiments conducted by them. Guidelines for its preparation are as follows: -

1) All files must contain a title page followed by an index page. ***The files will not be signed by the faculty without an entry in the index page.***

2) Student's Name, Roll number and date of conduction of experiment must be written on all pages.

3) For each experiment, the record must contain the following

(i) Aim/Objective of the experiment
(ii) Pre-experiment work (as given by the faculty)
(iii) Lab assignment questions and their solutions
(iv) Test Cases (if applicable to the course)
(v) Results/ output

Note:

1. Students must bring their lab record along with them whenever they come for the lab.

2. Students must ensure that their lab record is regularly evaluated.

Lab Assessment Criteria

An estimated 10 lab classes are conducted in a semester for each lab course. These lab classes are assessed continuously. Each lab experiment is evaluated based on 5 assessment criteria as shown in following table. Assessed performance in each experiment is used to compute CO attainment aswell as internal marks in the lab course.

Grading Criteria	Exemplary (4)	Competent (3)	Needs Improvement (2)	Poor (1)
AC1: Designing experiments	The student chooses the problems to explore.	The student chooses the problems but does not set an appropriate goal for how to explore them.	The student fails to define the problem adequately.	The student does not identify the problem.
AC2: Collecting data through observation and/or experimentation	Develops a clear procedure for investigating the problem	Observations are completed with necessary theoretical calculations and proper identification of required components.	Observations are completed with necessary theoretical calculations but without proper understanding. Obtain the correct values for only a few components after calculations. Followed the given experimental procedures but obtained results with some errors.	Observations are incomplete. Lacks the appropriate knowledge of the lab procedures.
AC3: Interpreting data	Decides what data and observations are to be collected and verified	Can decide what data and observations are to be collected but lacks the knowledge to verify	Student decides what data to gather but not sufficient	Student has no knowledge of what data and observations are to be collected
AC4: Drawing conclusions	Interprets and analyses the data in order to propose viable conclusions and solutions	Incomplete analysis of data hence the quality of conclusions drawn is not up to the mark	Cannot analyse the data or observations for any kind of conclusions.	Lacks the required knowledge to propose viable conclusions and solutions
AC5: Lab record assessment	Well-organized and confident presentation of record & ability to correlate the theoretical concepts with the concerned lab results with appropriate reasons.	Presentation of record is acceptable	Presentation of record lacks clarity and organization	No efforts were exhibited

LAB EXPERIMENTS

Experiment No. 1

Aim : To develop a ladder program for DOL starter.

Objective:-

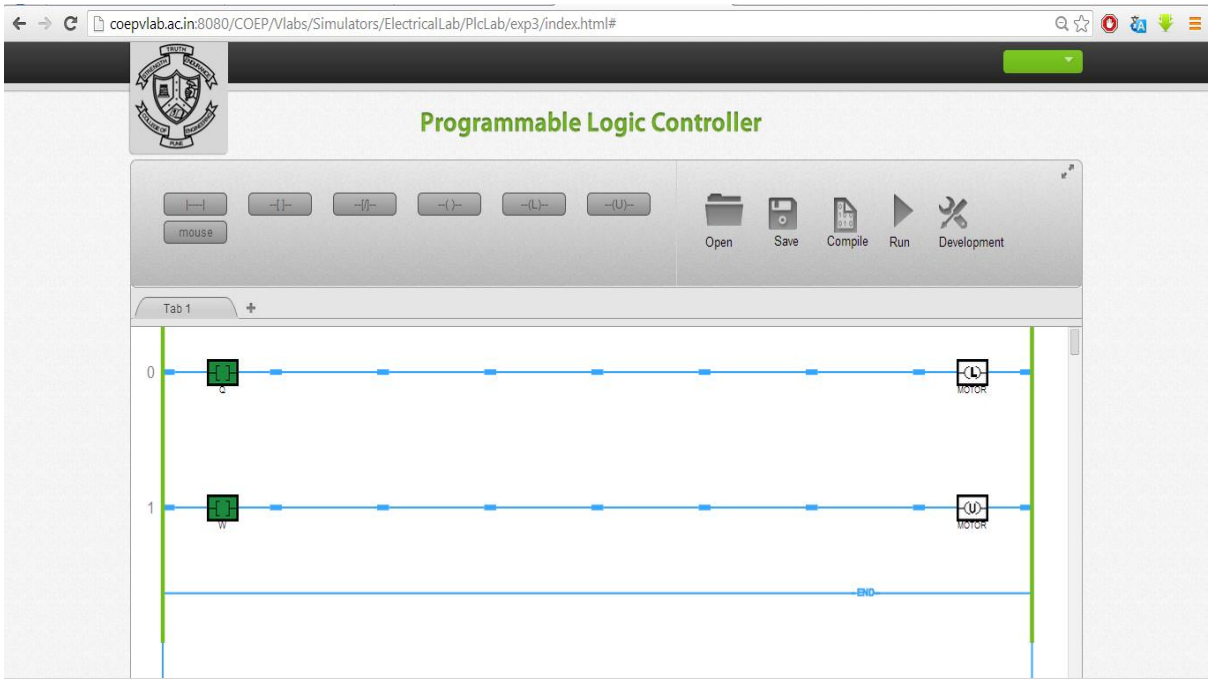
1. To understand working of DOL starter
2. Develop a ladder program for starting an electrical motor using DOL starter

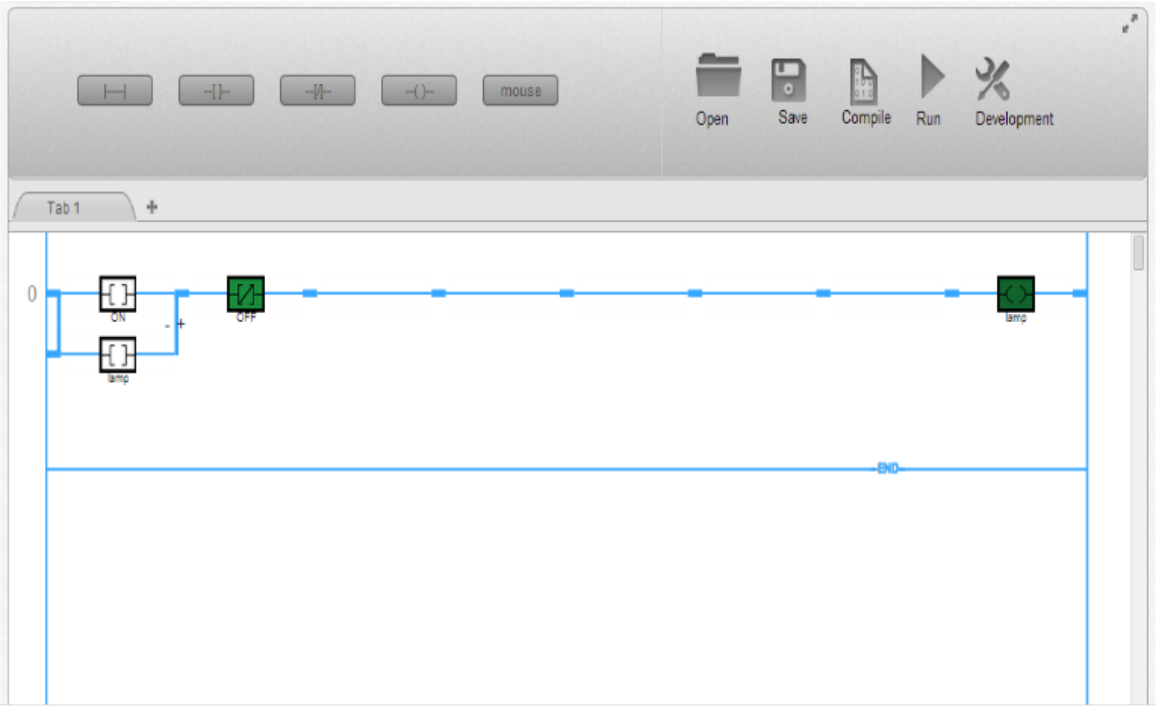
Procedure

Open the Simulator window as described in the last experiment

1. The Latch and unlatch instructions are used for holding the output status.
2. The tag name of latch and unlatch output bit must be same.
3. Once you toggle the input bit for the latch; even if you release it by toggling once again, the output bit remains latched.
4. To unlatch the output you will have to toggle the input bit in the unlatch rung and the output will be de-energised.

Execute the following ladder on simulator and observe the output status:





- You can develop ladder for a DOL "Direct On Line" starter using these instructions.
- You can also develop the logic using start and stop push buttons as explained under theory tab.
- Observe the output status at different input conditions.

Experiment No. 2

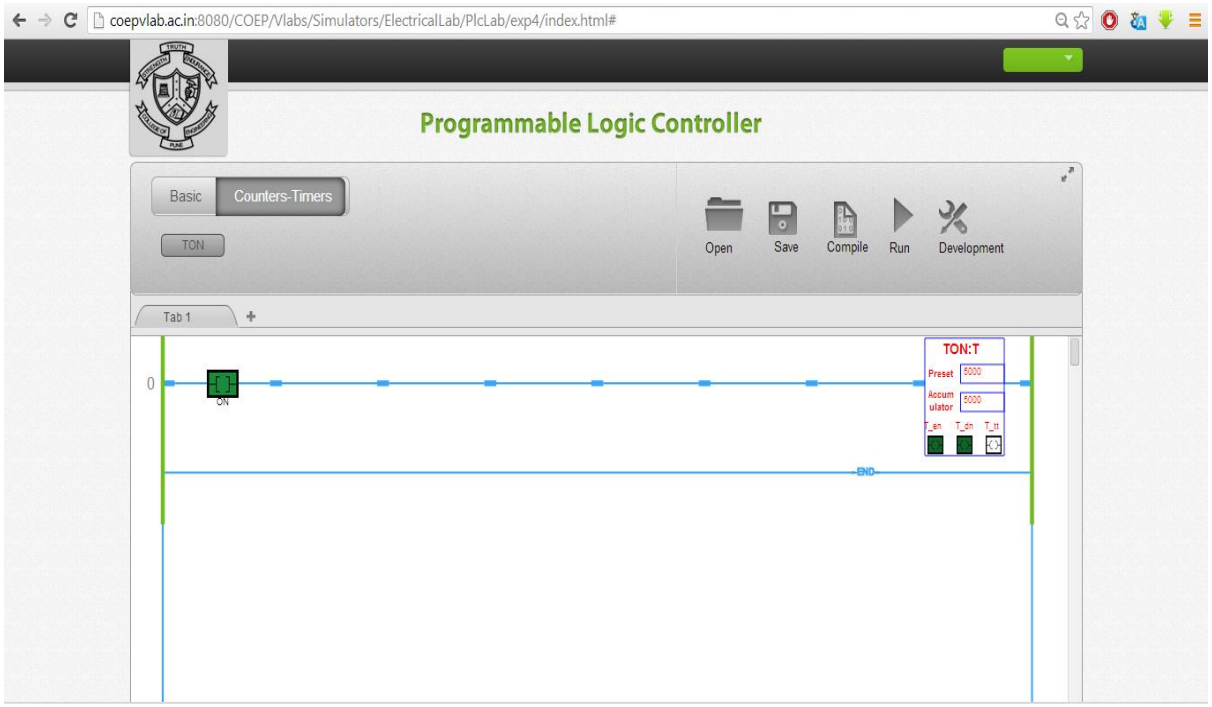
Aim : To develop an application using On-Delay timer.

Objective:

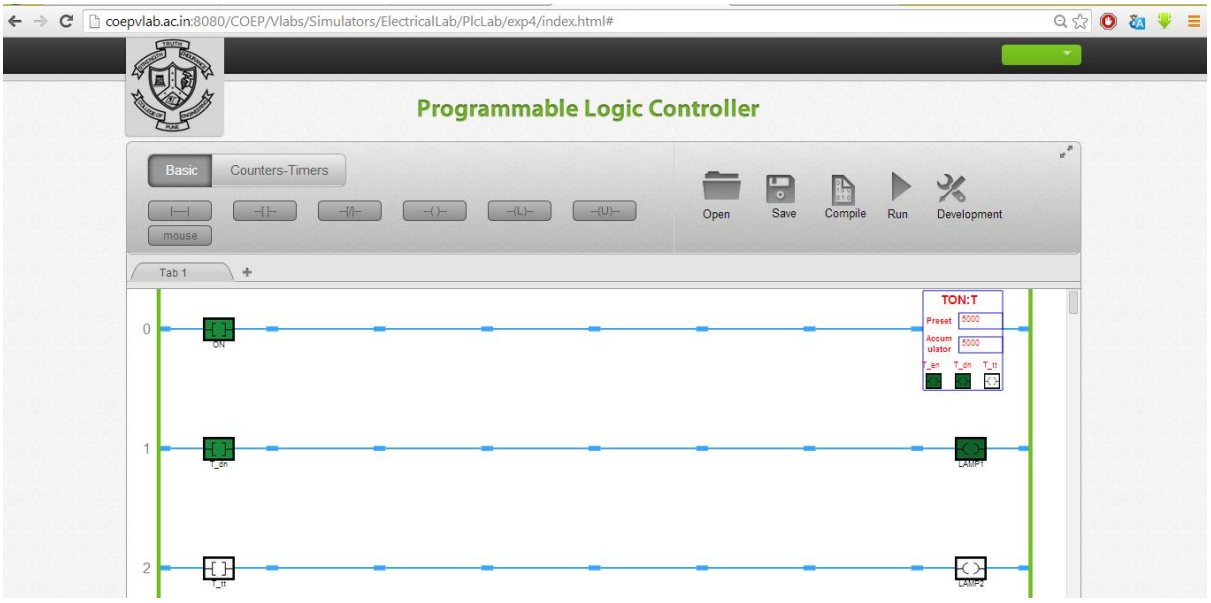
1. Study the timing diagram of On Delay Timer
2. Solve the assignment of Ton timer

Develop an application using On-Delay Timer

- In this experiment the on delay timer will be tested for its functionalities using Simulator. Following bits of the
- timer are to be observed.
- Initialising bit "ON" in this case.
- Enable bit "T_en"
- Done bit "T_dn"
- Timer timing bit "T_tt"
- Preset value needs to be entered by the user.
- While configuring the timer thedefault time is 1 mS. Select appropriate preset value as per the need of the application. The screen shot of the configured timer will appear like this.
- To test the EN, DN, and TT bits;configure the timer by right clicking anywhere on the timer block. Submit tag and preset value.



-
- Add new rung to test the timer status or to energies the output. You can also test the cascading of the timer using these bits.
- Observe the tag name for timer DN bit. See following screen shot to observe the output bit status when delay is over.



- Observe the bit status in Run mode when input a is toggled again

Experiment No. 3

Aim: To Study computational/arithmatic instructions used in PLC ladder programming

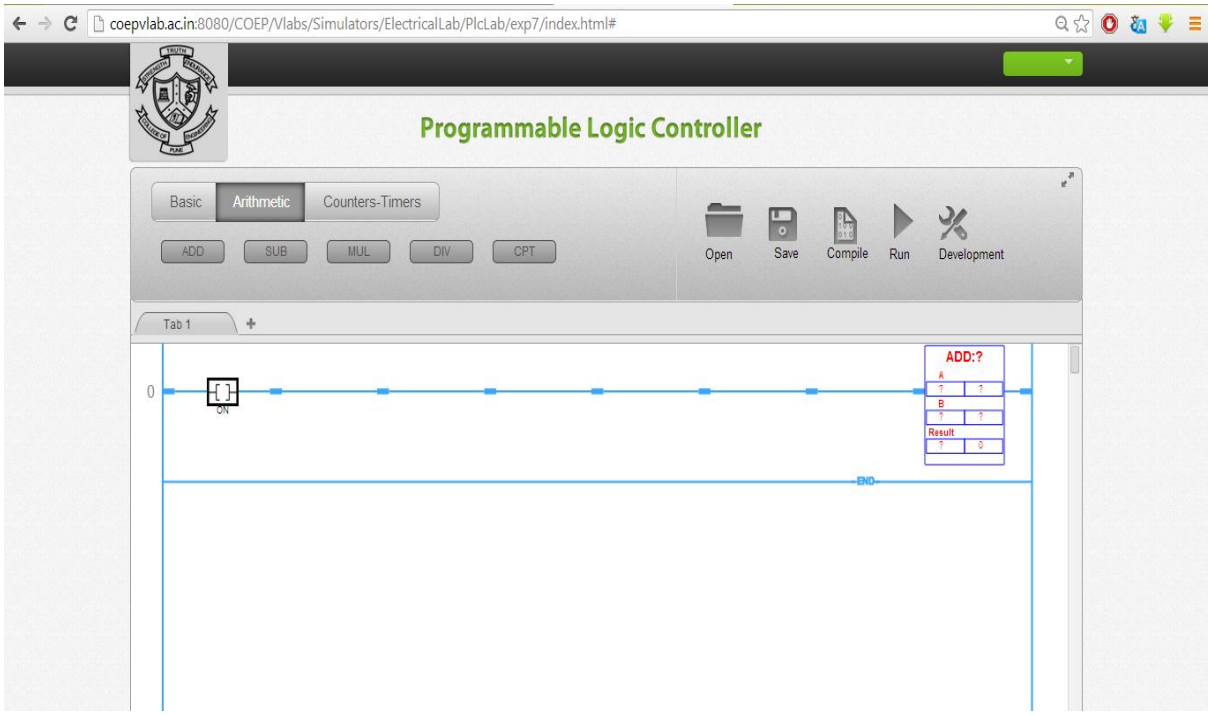
Objective:

1. Study computational Instructions available in PLC
2. Understand the use of arithmetic instructions

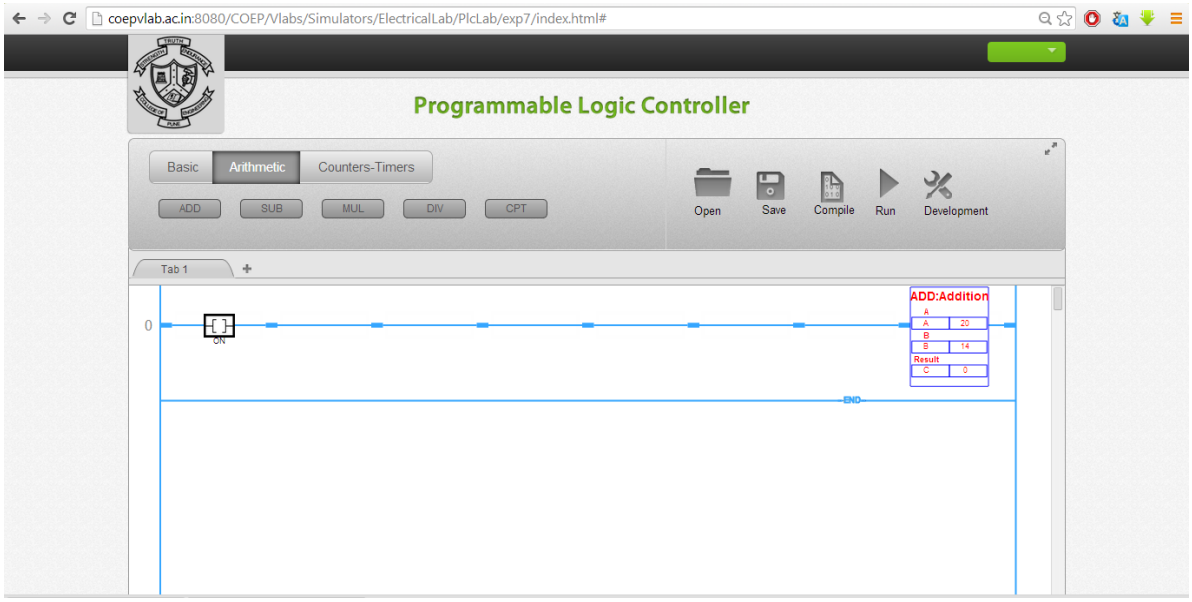
Implementation of ADD instruction using Simulator

First click on simulator tab and open the simulator by clicking on the link.

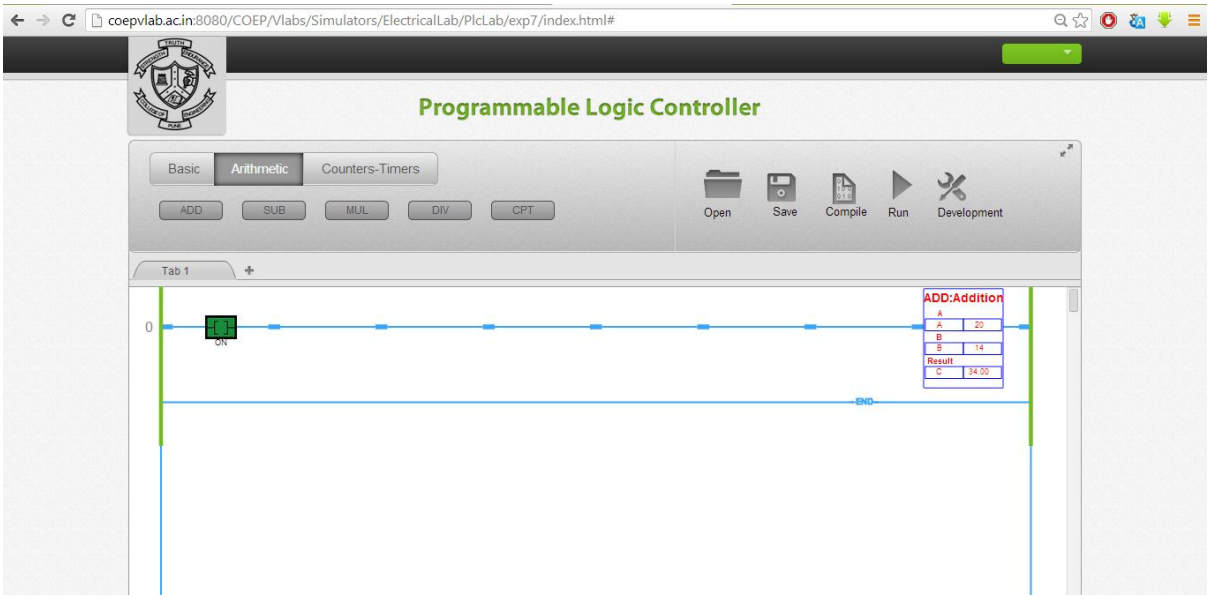
1. Add a new rung.
2. Insert NO contact. Add the ADD block provided in the simulator. The screen shot will look as follows.



3. Assign tag to NO contact and enter the addresses. Enter values for source A and B. Observe following screen shot.



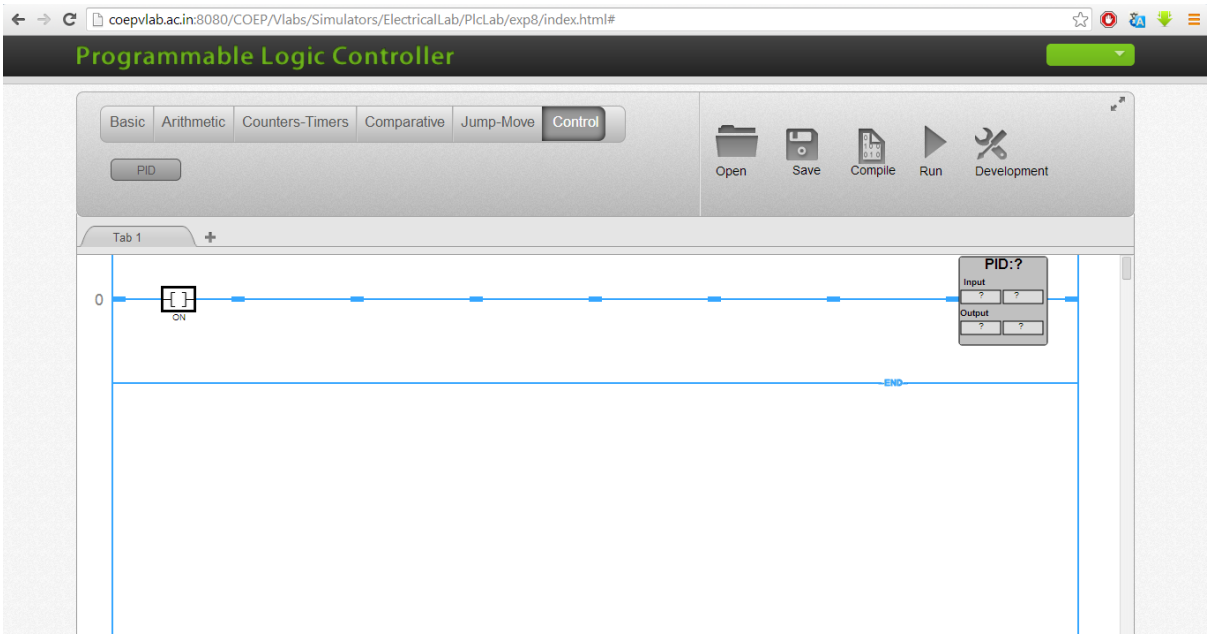
4. For executing the instruction switch to run mode. Toggle the input contact and see the result at output Y as shown below.



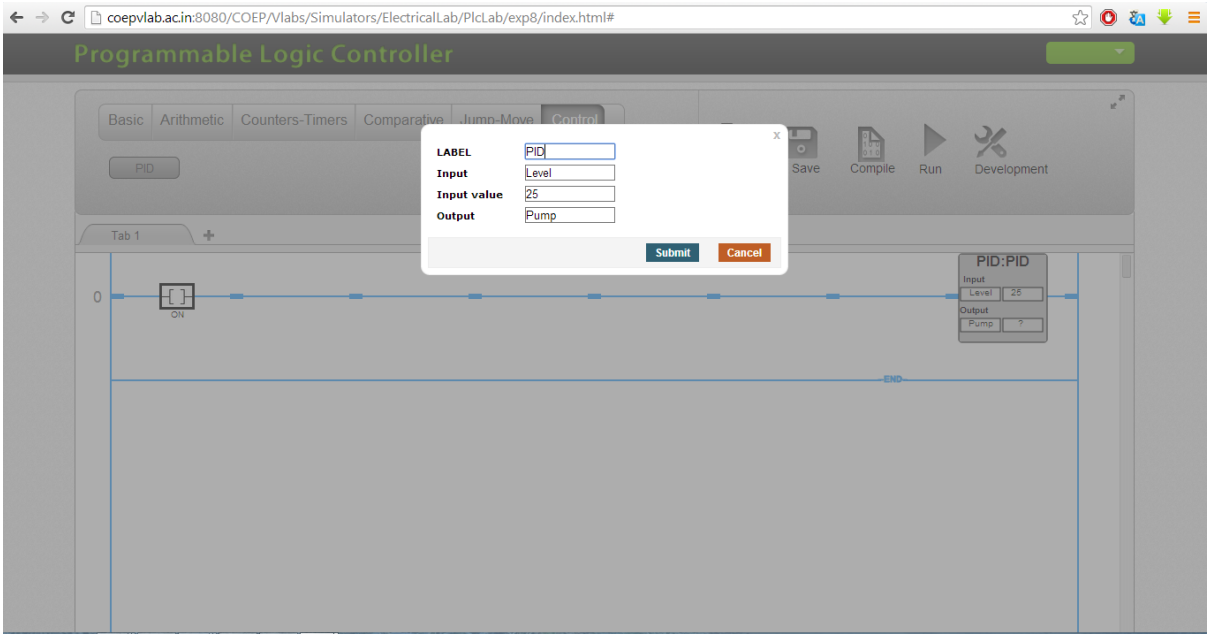
Experiment No. 4

Aim: Add a new to rung.

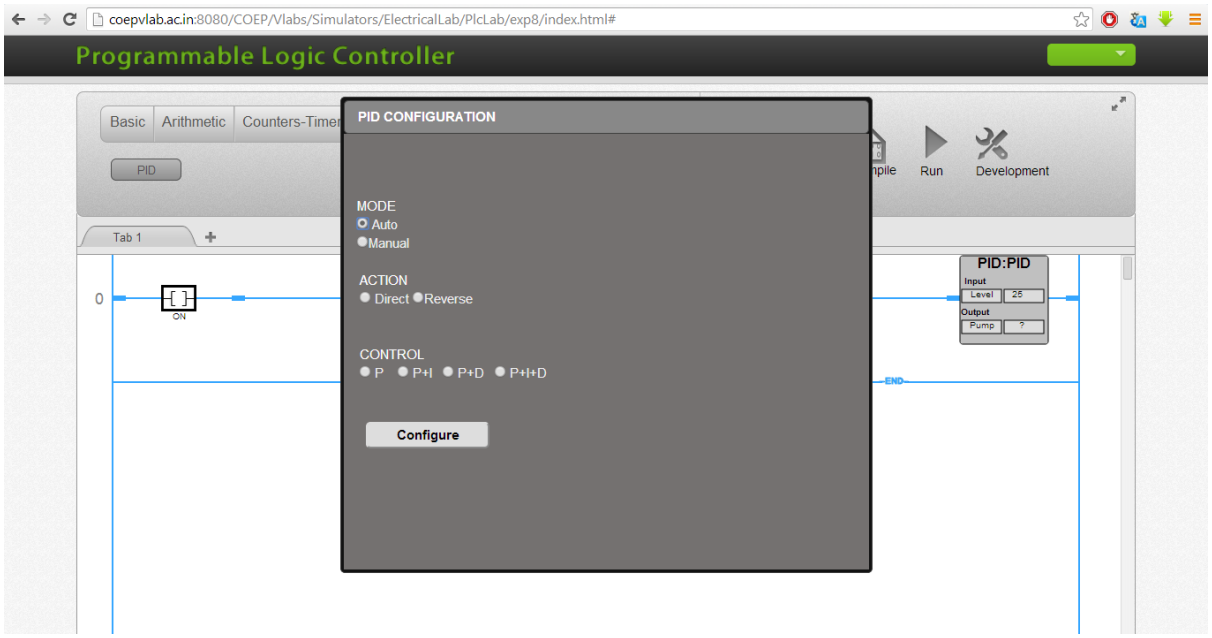
1. Click on PID tab to insert PID function block in the rung.
2. The screen will appear as follows.



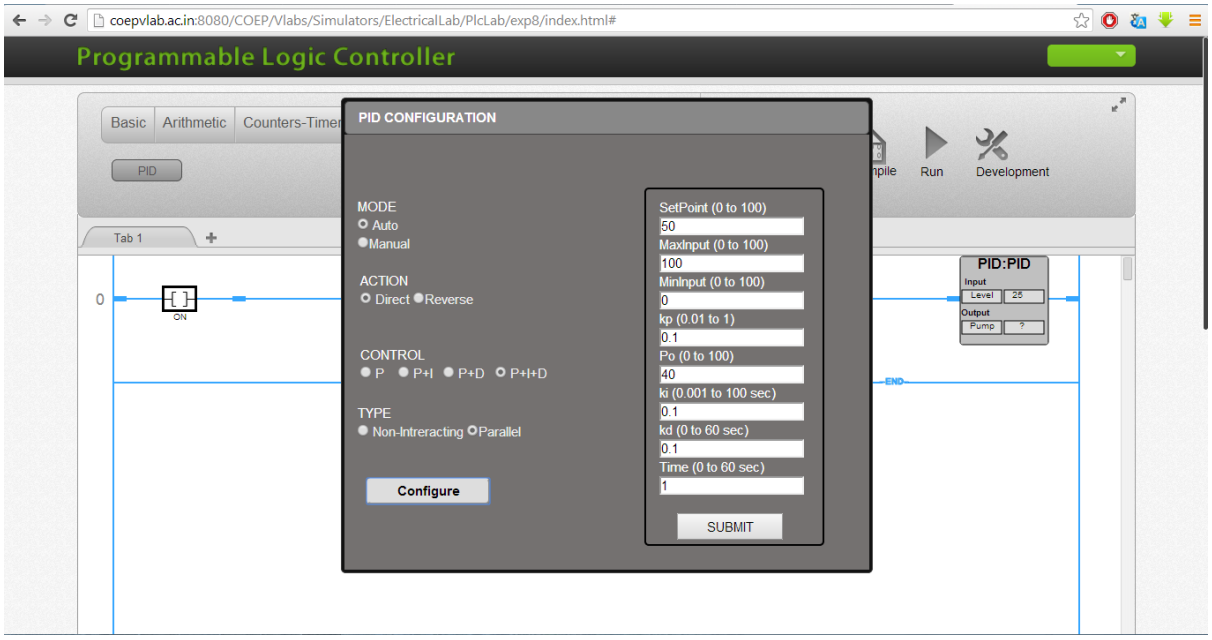
4. Now right click anywhere on PID function block to configure the bolck.



5. Once you configure the tags , You can set the action, PID mode, type of PID etc. The screen will be as follows:



6. Click on Configure tab. Now you can set the tuning parameters and submit the same. See the following screen shot.



7. Now go to run mode and observe the PID output.

Repeat steps 3 to 7 for various configurations and different tuning parameters

Experiment No. 5

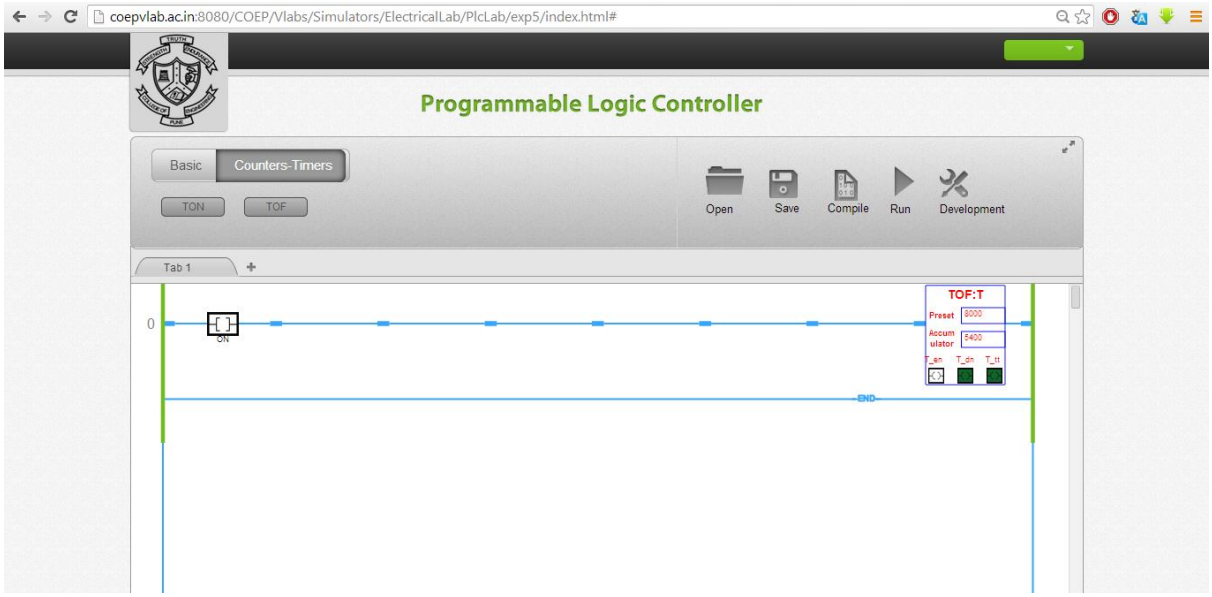
Aim: To develop an application using Off-Delay timer

Objective:

1. Study the timing diagram of OFF Delay Timer
2. Solve the assignment of Toff timer

Implement the operation using Simulator. The configuration of off delay timer is same as 'on delay timer'. A typical difference can be observed in the operation (in Run mode) . When the q bit is energised the output DN bit goes high. The timer starts only after toggling the initialisation bit again.

Implement the operation using Simulator. To test the EN, DN, and TT bits; Configure the timer. The same tag name is to be used in the new rung to test the status or to verify the output status. You can also test the cascading of the timer using these bits.



Experiment No. 6

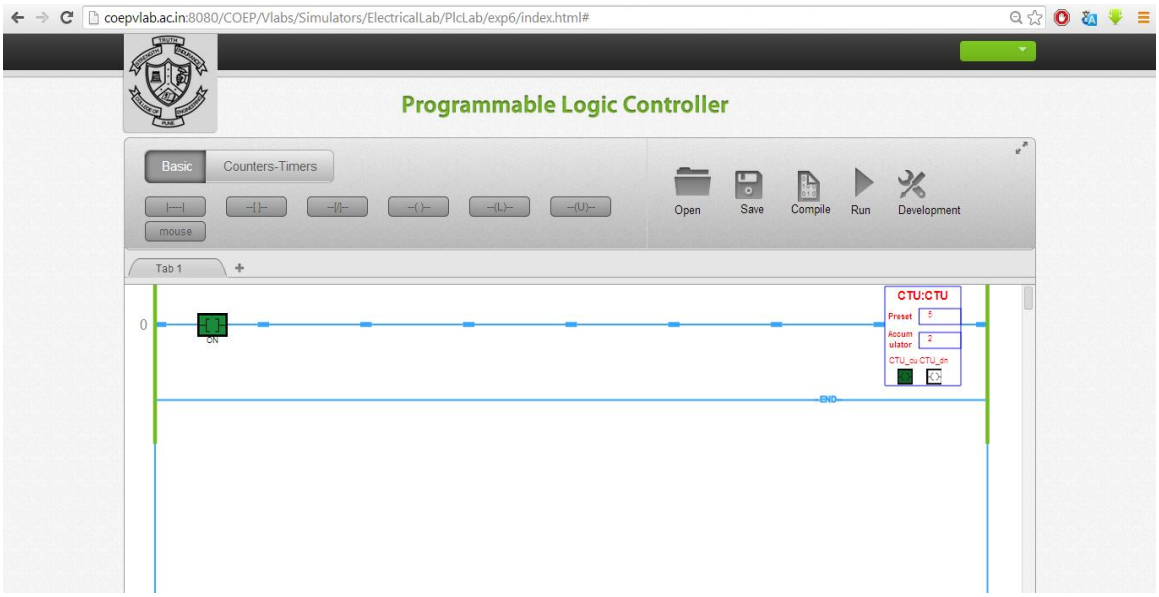
Aim: To Develop an application using UP/DOWN counter

Objective:

1. Study Counter timing diagram
2. Develop an application specific ladder program using counters

Implement the counter using Simulator

3. The counter counts the pulses received at input. The pulses can be given by toggling the input bit "ON" in this case. The counter will keep on counting till it reaches the preset value set by the user. Once the accumulator is equal to preset the DN bit will be energised. After this instant if next pulse is detected the accumulator will increment without changing the status of DN bit. To reset the counter use "Reset" command so that the counter can be configured for new counts without reloading the Page. Please note the tag of the reset bit must be the tag of counter e.g."CTU". The screen shot will appear as shown below.



4. In case of down counter the entire procedure will remain same. Only the number of counts are to be entered in the accumulator tab. The preset value is zero. When the input contact closes, the accumulator will go on decrementing, will reach to zero '0' value and the status of done bit will change. To reset the DN counter use "Reset" command so that the counter can be configured for new counts without reloading the page. Please note the tag of the reset bit must be the tag of counter.

Experiment No. 7

Aim: To simulate analog and digital function blocks

Objective:

1. Study various Function Blocks available in DCS.
2. Develop FBD program using basic digital and analog function blocks.

The procedure for using simulator is as follows:

Click on the link provided under simulator tab to open the simulator. You need to configure the required logic.

Part 1: Understanding the operation of AI and AO function block

1. First **left click** on AI block available under IO tab. Drag this block to required position preferably left side and vertically at center.
2. Now **left click** on AO block. Drag it and put it next to AI block.
3. Take the cursor to the color dot at the output side of AI block. Move it by **left clicking** and take it to the color dot at the Input side of AO block.
4. Now click on Compile tab. If any compilation errors are there, it will be shown. Otherwise Run tab gets activated.
5. When user clicks on Run tab, default value of AI will get displayed on wired connection. To change the input value and observe the output change, **right click** on the AI block. Select edit and enter an input value in the range 0-100. You will observe the change at the AO block output. When you click on the block, the properties of the block gets displayed at left hand bottom corner. To delete the connection, **click** on the wire **question mark** at the output side of the block and press delete key. Other options like delete, disable and configure are available on **right clicking** the block. For modifying the logic, user need to first press Stop tab and enter into Configure tab. For clearing the workspace, Clear tab is available.

Part 2: Understanding the operation of DI and DO function block

Follow same procedure as above to get the bolcks in the workspace and connect DI and DO blocks. In RUN mode, change the digital input value to 0 from1 or vice-versa and observe the effect.

Part 3: Understanding the operation of Logic function block

To configure the logic circuit, first reload the page by clicking Clear tab

1. First **left click** on digital input (DI) block to get it in the workspace. Repeat this procedure for getting 2 DI blocks. They will be by default DI1 and DI2. Similarly get 1 DO block in the workspace.
2. **Left click** on any logic function block e.g. AND function from Logic Tab available in the left hand panel.
3. Connect output of DI1 to one of the inputs of AND block.

Initially only one input connection is available with the logic block. As you make DI connection with this input, another connection appears for this logic block. Connect DI2 output to this second AND block input. Connect

output of AND block to input of DO. 4. Now click on Compile tab. If any compilation errors are there, it will be shown. Otherwise Run tab gets activated. 5. Now change one of the inputs to AND gate by toggling DI value from 0 to 1. Observe the DO status. 6. Change another input to AND gate in the similar manner and observe DO status. 7. Verify the AND gate truth table by changing DI status. Similarly verify the truth tables for OR and NOT Logic Gates.

Simulation:

Outcome:

Aim: To study, understand and perform experiments on timers and counters.

Objective:

1. To understand timers and counters used in DCS
2. Development of application using Timer and Counter blocks

Make use of simulator available under Simulator tab, to understand the operation of Timer and Counter function blocks

The procedure for using simulator is as follows:

Part 1: Understanding the operation of On Delay Timer and Off Delay Timer

1. From the panel at left side, click on IO tab and click on DI.
2. Use left click and drag the DI block at center location in the workspace.
3. Take TON block available under TIMERS tab by clicking on it. Put this block next to DI block.
4. Next to TON block, take DO block to observe On delay timer operation. Follow the procedure mentioned in step 1.
5. Connect the output of DI block to input of TON block and output of TON block to input of DO block.
6. Right click on Timer block and configure it. Enter required delay (preset value by which the output is to be delayed) in terms of milli seconds. e.g. For a delay of 1 second, require preset value is 1000.
7. When configuration is done, click on Compile tab to activate the Run tab. Run the logic now.
8. To start the Timer operation, Change the DI value. You need to toggle the input value by using right click.
9. Observe the accumulated timer value. When it becomes equal to preset value, the timer output and the Do block output is set to 1.
10. Change the DI value to 0 again and observe the output status.
11. To observe the operation of off delay timer, first click on Stop tab. Go to compile mode. You need to replace the TON block with TOFF Timer block.
12. Right click on TON block. Select and delete the block. Form panel, select TOFF block available under Timer tab.
13. Repeat steps 5 to 9. The output of Off delay timer is set to 1 without any delay, when DI is set to 1. But when DI is changed back to 0, the timer operation starts, delay is provided and the output is changed to 0 or Off state.

Part 2: Understanding the operation of Up and Down counter

1. To configure the counter circuit, first reload the page by clicking Clear tab.

2. Refer step 1 mentioned in part 1 to drag DI block.

From the panel, click on COUNTER; click on UP, to select Up Counter block. Put this block next to DI block.

3. Next to UPCTR block, take DO block to observe Up Counter operation. Follow the procedure mentioned in step 2.
4. Connect the output of DI block to input of UPCTR block and output of UPCTR block to input of DO block.
5. Rght bclick on the UPCTR block to configure. Enter required count (preset) value after which the output is to be set.
6. When configuration is done, click on complile tab to activate Run tab.
7. To understand the counter operation, Change the DI value by toggling. You need to use right click for this.
8. Observe the accumulated count value.
9. Change the DI value to 0 again and observe the output status.
10. Repeat step 8 to 10 till the accumulated value becomes equal to preset. When accumulated value becomes equal to preset, the counter output and the Do block output is set to 1.
11. Do not forget to drag and drop Reset block available under Counter tab to restart the counter.
12. To observe the operation of down counter, go back to compile mode by pressing Stop tab. Now replace the UPCTR block with DWCTR counter block.
13. Right click on UPCTR block. Select delete and delete the block. From the panel, select DOWN block available under Counter tab.
14. Repeat steps 5 to 11. In case of down counter, the preset value is loaded in accumulator when the simulator is taken to Run mode. On every transition of input from 0 to 1, accumulated value is decremented by 1. When accumulated value becomes equal to 0 the output of counter is set to 1.

Simulation:

Outcome:

This lab manual has been updated by

Industrial Automation & PLC Lab (KEN-751)

Dr. Pallavi Verma

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Crosschecked By
HOD EEE

Verified By
Director, DGI Greater Noida

Please spare some time to provide your valuable feedback.