



# INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal - 500 043, Hyderabad, Telangana

## COURSE CONTENT

PLC AND INDUSTRIAL AUTOMATION LABORATORY								
VI Semester: EEE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AEEC32	Core	L	T	P	C	CIA	SEE	Total
		1	-	3	2.5	30	70	100
Contact Classes: 15		Tutorial Classes: Nil		Practical Classes: 36			Total Classes: 51	
Prerequisite: Microprocessors and Microcontrollers, DC Machines								

### I. COURSE OVERVIEW:

The objective of this laboratory course is to measure the physical input variables and to analyze and control and output variables in an industrial automation process using programmable logic controllers (PLCs). The lab emphasizes on the software and hardware skills to design and realize an automation process. The lab is mainly intended to implement the software timers, counters and their usage in traffic signal control, sequential control, speed control of motors etc.

### II. COURSES OBJECTIVES:

The students will try to learn

1. The operation of PLCs, its ladder diagram programming and wiring of hardware equipment with PLC.
2. The measurement and control of digital, analog input/output variables using PLC.
3. The use of Human Machine Interface (HMI) to monitor and control the operation of a process.

### III. COURSE OUTCOMES:

At the end of the course students should be able to:

- CO 1: Use of the PLC logic gates, timers and Counters for delaying a particular control process and counting the production rate in an industrial system.
- CO 2: Design a system for starting, speed control and braking of DC/AC motors using PLC digital module.
- CO 3: Measure the temperature, speed, voltage and current using PLC analog module to control the operation of motors, relays and circuit breakers.
- CO 4: Construct the PLC based automatic traffic signal system to control the vehicle congestion at a three-way or four-way road junction.
- CO 5: Develop the ladder diagram logic programs for lift control, water level monitoring and fault annunciation systems.
- CO 6: Design a PLC ladder logic program for digital clock and solar tracking system.

### DO's

1. Once the operation is completed pull the plug itself rather chord attached to it.
2. To repair the equipment switch-off the supply and go on.
3. To operate the equipment on supply, see that hands are dry, if that is not possibly hide the hand in the pockets.
4. If a person meets current unexpectedly do not touch the person with hands but immediately use any insulator material and shut down the power (like leather belts, wood and plastic bars etc).
5. If water is nozzles on the equipment, immediately shunt down the power using circuit breaker or pull out the plug.
6. Use the connecting wires of good continuity, short circuit of connecting wire leads damage of circuit parameters.

### **DON'Ts**

1. Do not wear loose clothing and do not hold any conducting materials in contact with skin when the power is on.
2. Do not pull out the connections until unless all the currents are dead.
3. Do not wait for switches to de-magnetize when there is a delay but pull out the plug.
4. Do not overload the circuit by plugging in too many appliances.
5. If you are mentally and physically stressed don't operate the power equipment.
6. Never operate the equipment under wet conditions.
7. Do not interconnect two or more wires, take appropriate length of wire.

### **SAFETY NORMS**

1. The lab must be equipped with fire extinguisher.
2. See that the connections are made tight.
3. Use single plug for each equipment.
4. Cover the body completely to avoid arc effect.
5. To change the connections during the experiment, switch off the supply and carry on.
6. Used equipment may get heated, so take care handling the equipment after it is used.
7. Do the wiring, all set ups and check the circuit connections before the supply is on

## IV. COURSE CONTENT:

# EXERCISES FOR PLC AND INDUSTRIAL AUTOMATION LABORATORY

**Note:** Students are encouraged to bring their own laptops for laboratory practice session

## 1. Getting Started Exercises

### Introduction to PLC and Industrial Automation

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A Programmable Logic Controller (PLC) is a specialized digital computer used in industrial automation and control systems. It plays a crucial role in automating processes in manufacturing plants, power generation facilities, water treatment plants, and various other industrial applications. PLCs are designed to monitor inputs, make decisions based on a programmed logic, and control outputs to automate machinery and processes.

Basic introduction to a Programmable Logic Controller (PLC) and an industrial automation laboratory:

#### Programmable Logic Controller (PLC):

**a. Purpose:**

- PLCs are used for automating and controlling industrial processes.
- They replace traditional relay-based control systems with a more flexible and efficient digital control.

**b. Components:**

- CPU (Central Processing Unit): The brain of the PLC, responsible for executing the control program.
- Input Modules: Receive signals from sensors and other devices.
- Output Modules: Control actuators, motors, and other output devices.
- Memory: Stores the control program and data.
- Facilitate communication with other devices and systems.

**c. Programming:**

- PLCs are programmed using specialized software that often employs ladder logic diagrams, resembling relay logic.
- Programming involves defining inputs, outputs, and the logic that determines the system's behavior.

**d. Applications:**

- PLCs are used in various industries, including manufacturing, chemical processing, power plants, and more.
- They control processes such as assembly lines, batch processing, and continuous production.

#### Industrial Automation Laboratory:

An industrial automation laboratory is a controlled environment where students, engineers, or technicians can learn and experiment with various aspects of industrial automation using PLCs. Such a lab typically includes:

**a. Hardware Setup:**

- PLCs and associated input/output modules.
- Sensors and actuators representing real-world industrial equipment.

- Communication interfaces for networking and data exchange.

**b. Programming Tools:**

- Computers with PLC programming software.
- Simulation tools to test programs before deploying them to actual PLCs.

**c. Training Stations:**

- Workstations equipped with PLCs, input/output devices, and connection terminals for hands-on learning.

**d. Experiments and Projects:**

- Laboratory sessions designed for students to implement control strategies, troubleshoot, and optimize industrial processes.
- Projects that involve designing and implementing automation solutions.

**e. Safety Measures:**

- Protocols to ensure safe experimentation, especially when dealing with real-world industrial equipment.

**f. Documentation and Analysis:**

- Tools and methodologies for documenting PLC programs, analyzing system performance, and identifying area for improvement.

**PLC Ladder Diagrams:**

- Analyze the results of operations of timers, counters, DC/AC motors and traffic signal control using PLC ladder diagrams in terms of concepts introduced in the Industrial Automation and Control course.

**Hardware Connections:**

- Train to get hands-on experience on wiring the Delta make DVP series Programmable Logic Controller and Human Machine Interface.

**1.1 Simple ladder logic program for AND gate**

Implement a simple ladder logic program to study and verify AND gate using digital inputs and outputs for PLC.

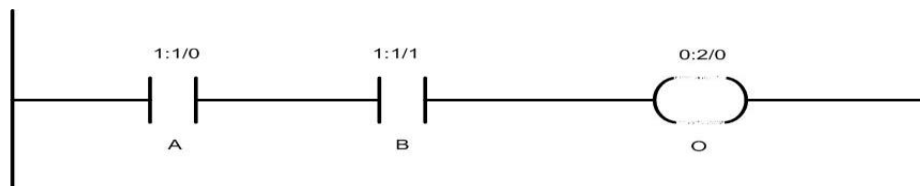


Fig.1 AND gate ladder logic program

**1.2 Simple ladder logic program for OR gate**

Implement a simple ladder logic program to study and verify OR gate using digital inputs and outputs for PLC.

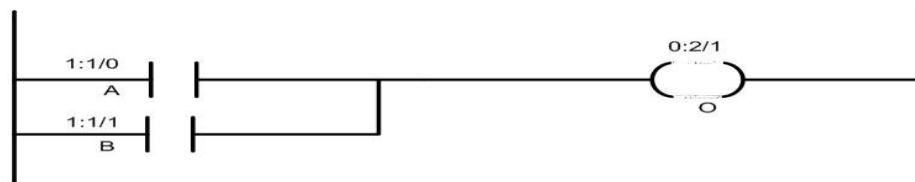


Fig.2 OR gate ladder logic program

**Try**

1. Test the truth table of EX-OR gate using PLC software.
2. Test the truth table of EX- NOR gate using PLC software.

## 2. Exercises on Timers

### 2.1 ON delay Timer

Implement the ON delay timer using Programmable Logic Controller for delaying a particular control process in an industrial system.

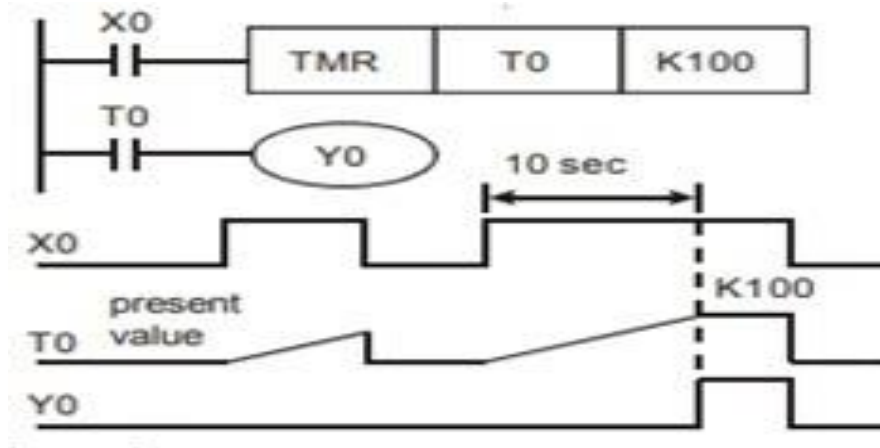


Fig.3 ON delay timer using Programmable Logic Controller

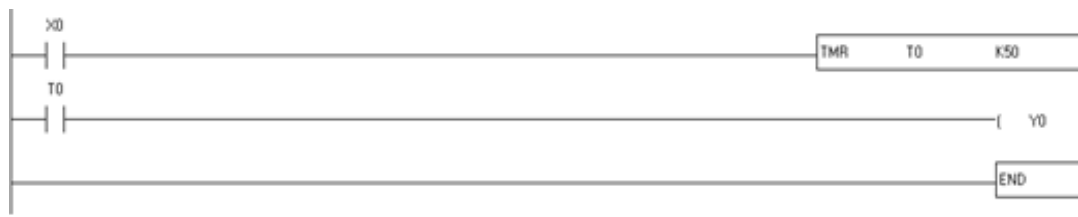


Fig.4 PLC Ladder Diagram for ON Delay Time

### Try

1. Analyze the results of ON delay timer operation for fig.3 using ladder diagram in terms of concepts.
2. Verify the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

### 2.2 OFF delay Timer

Implement the OFF-delay timer using Programmable Logic Controller for delaying a particular control process in an industrial system.

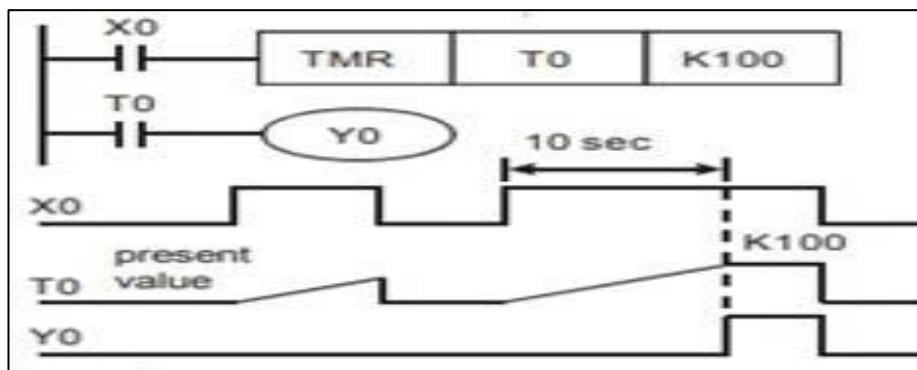


Fig.5 PLC Ladder Diagram for OFF Delay Timer

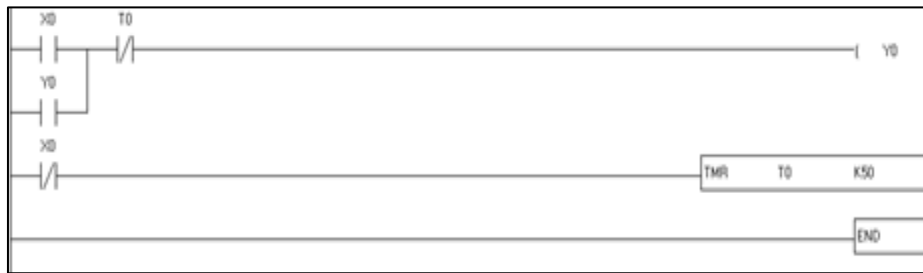


Fig.6 OFF delay timer using Programmable Logic Controller

**Try**

1. Analyze the results of OFF delay timer operation for fig.5 using ladder diagram in terms of concepts.
2. Verify the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

**2.3 Accumulative Timer**

Implement the accumulative timer using Programmable Logic Controller for delaying a particular control process in an industrial system.

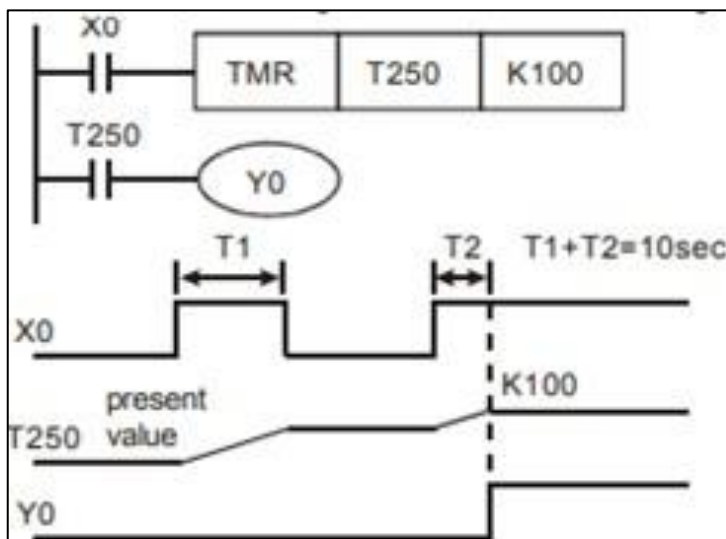


Fig.7 Accumulative timer using Programmable Logic Controller

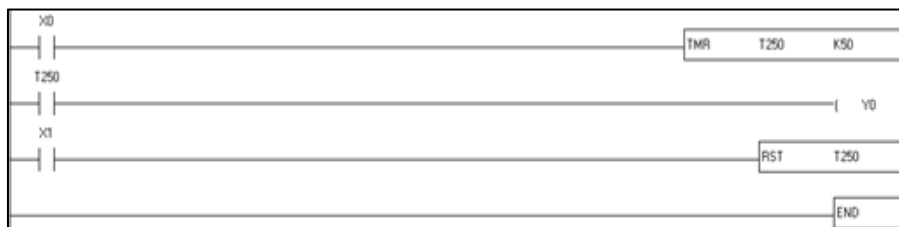


Fig.8 PLC Ladder Diagram for Accumulative Timer

**Try**

1. Analyze the results of accumulative timer operation for fig.7 using ladder diagram in terms of concepts.
2. Verify the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

### 3 Exercises on Counters

#### 3.1 Up Counter Operation

Implement the Up-counter operation using Programmable Logic Controller for counting the production rate in an industrial system.

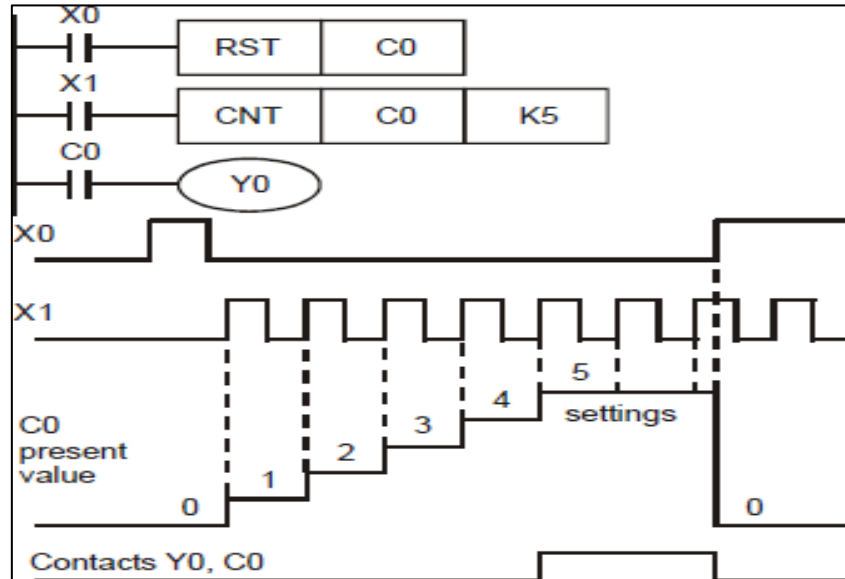


Fig.9 Counter operation using Programmable Logic Controller

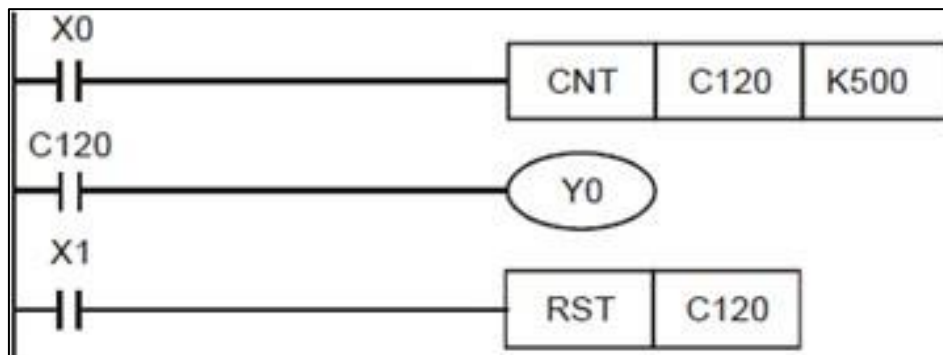


Fig.10 Up Counter ladder program

#### Try

1. Compare the results of Up counter operation for fig.9 using ladder diagram in terms of concepts.
2. Verify the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

#### 3.2 Up – Down Counter

Implement the Up-Down counter using Programmable Logic Controller to maintain or record the products in a warehouse.

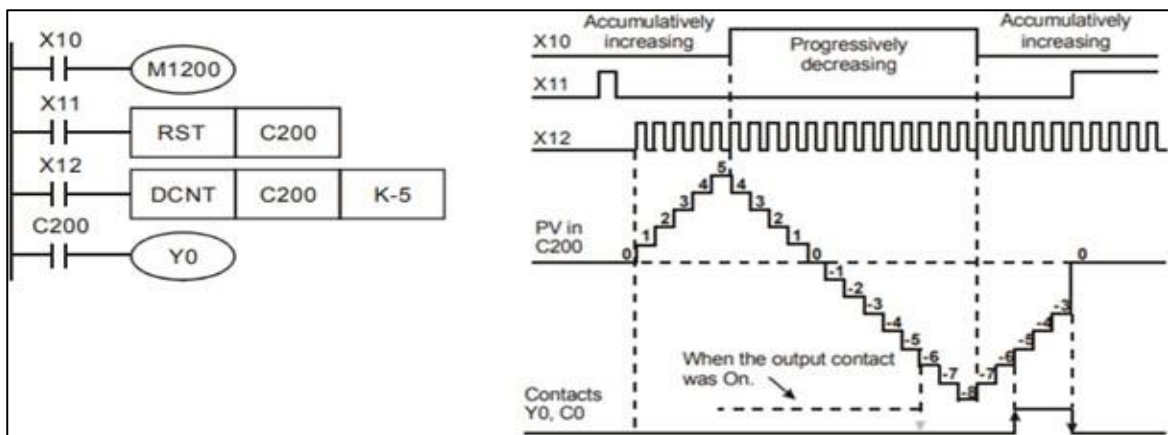


Fig.11 Up-Down counter using Programmable Logic Controller

**Try**

1. Compare the results of Up-Down counter operation for fig.11 using ladder diagram in terms of concepts.
2. Verify the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

**4. Sequential Control**

Implement the PLC program for a sequential control of three motors.

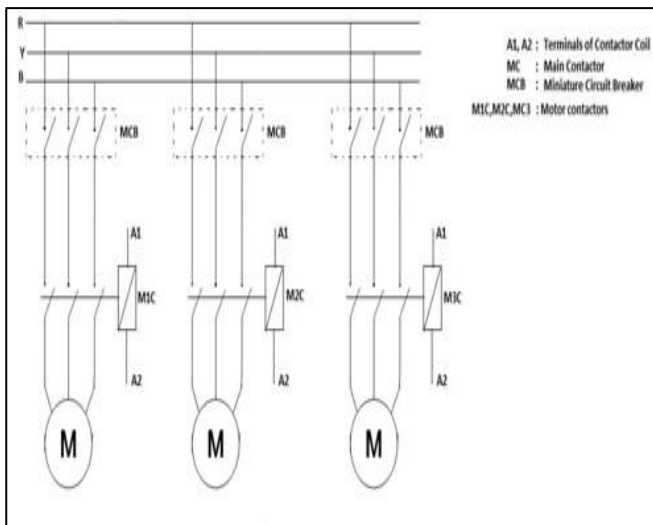


Fig.12 Sequential control of three motors

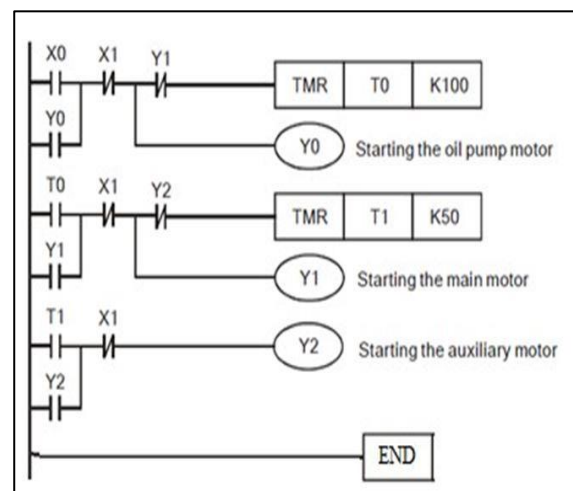


Fig.13 Ladder diagram for sequential control of three motors.

**Try**

1. Verify about the component's importance of sequential control operation for fig.12 using ladder diagram in terms of concepts.
2. Conclude the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.



## 5. Direct Online (DOL) Starter

Implement the direct online (DOL) starter for three phase induction motor using Programmable Logic Controllers.

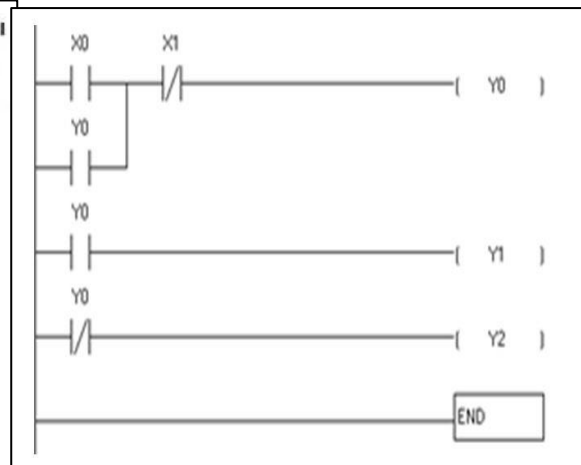
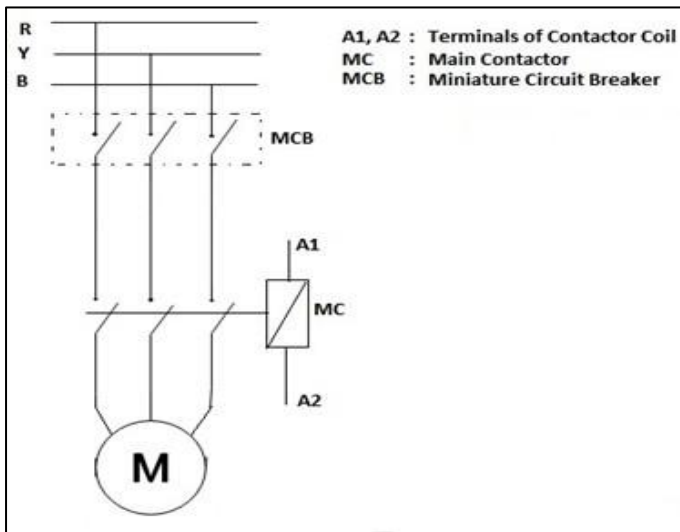


Fig.14 Direct online (DOL) starter for three phase induction motor

Fig. 15 Ladder diagram for Direct online starter

### Try

1. Analyze about the components and operation of direct online starter for fig.15 using ladder diagram in terms of concepts.
2. Conclude the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

## 6. STAR-DELTA Starter

Implement the Star Delta starter for three phase induction motor using Programmable Logic Controllers.

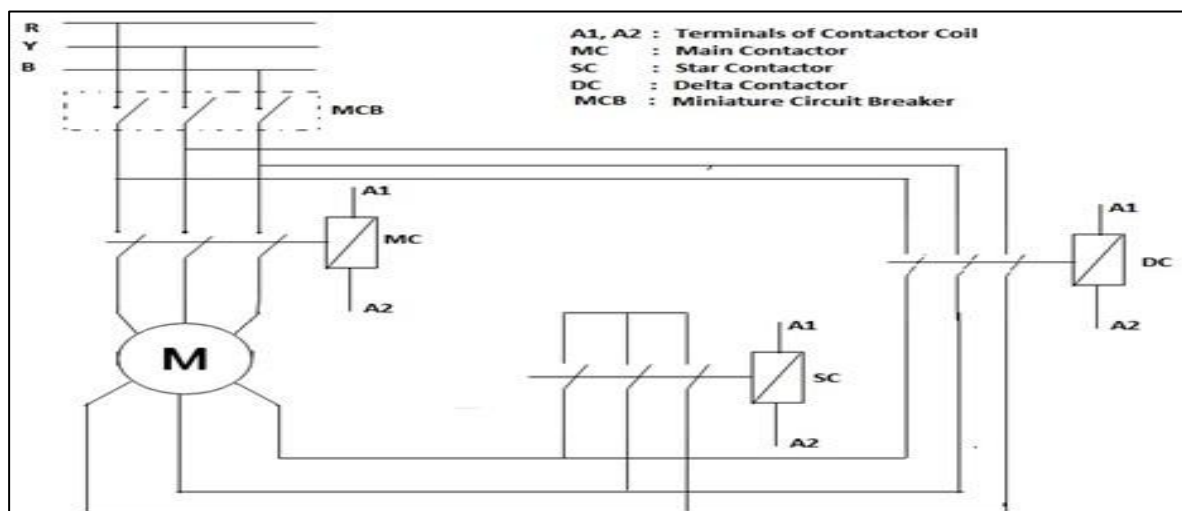


Fig:16 Electrical connection of direct online (DOL) Direct online (DOL) starter diagram

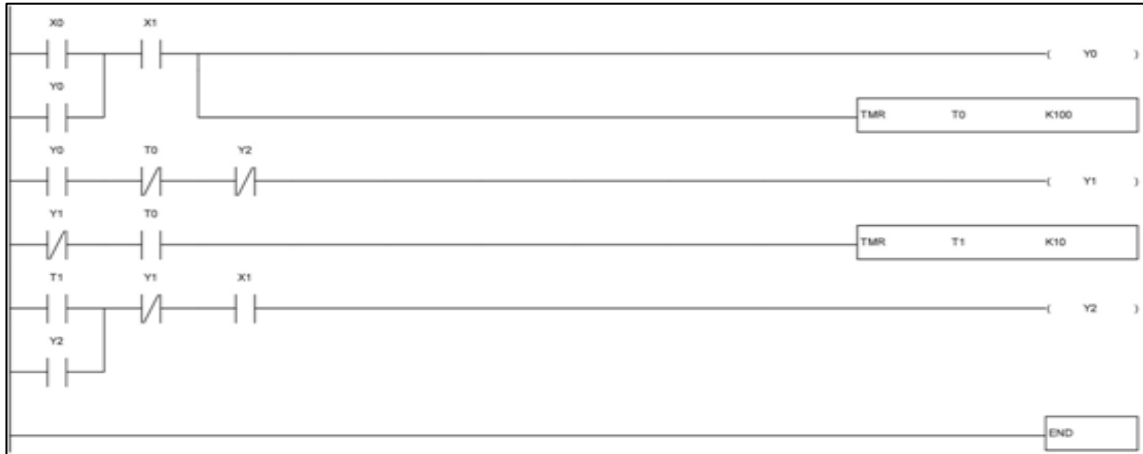


Fig.17 Star-Delta starter ladder diagrams

### Try

1. Analyze about the components and operation of star-delta starter for fig.16 using ladder diagram in terms of concepts.
2. Conclude the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

### 7. Automatic Forward and Reverse Control of Motor

Implement an automatic forward and reverse control of three phase squirrel cage induction motor for milling operation using PLC.

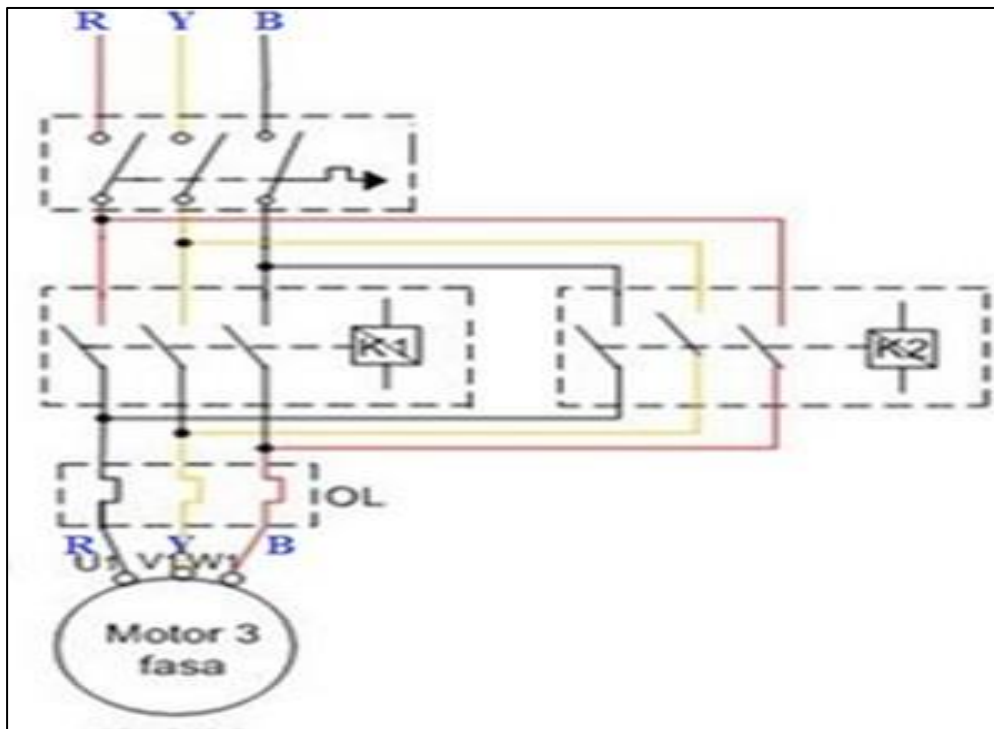


Fig.18 Automatic forward and reverse control of three phase squirrel cage induction motor

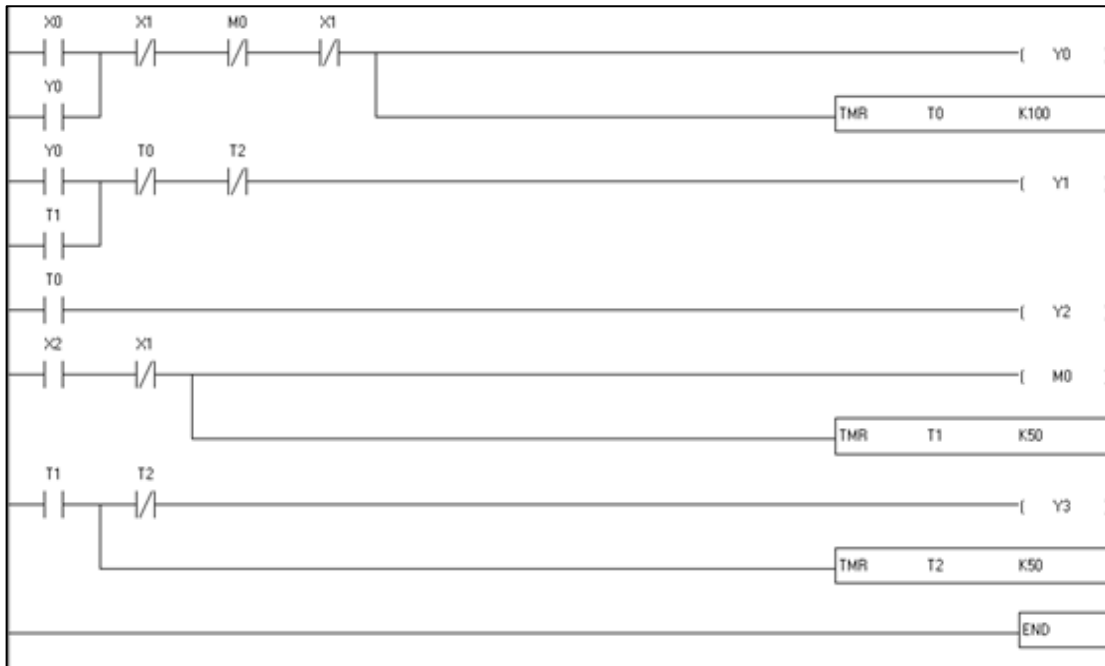


Fig.19 Ladder diagram of automatic forward and reverse control of motor

**Try**

1. Analyze the forward and reverse control operation of three phase induction motor for fig.18 using ladder diagram in terms of concepts.
2. Conclude the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

**8. Reverse Current Breaking of 3-phase Induction Motor**

Implement the reverse current breaking method for three phase induction motor using Programmable Logic Controller.

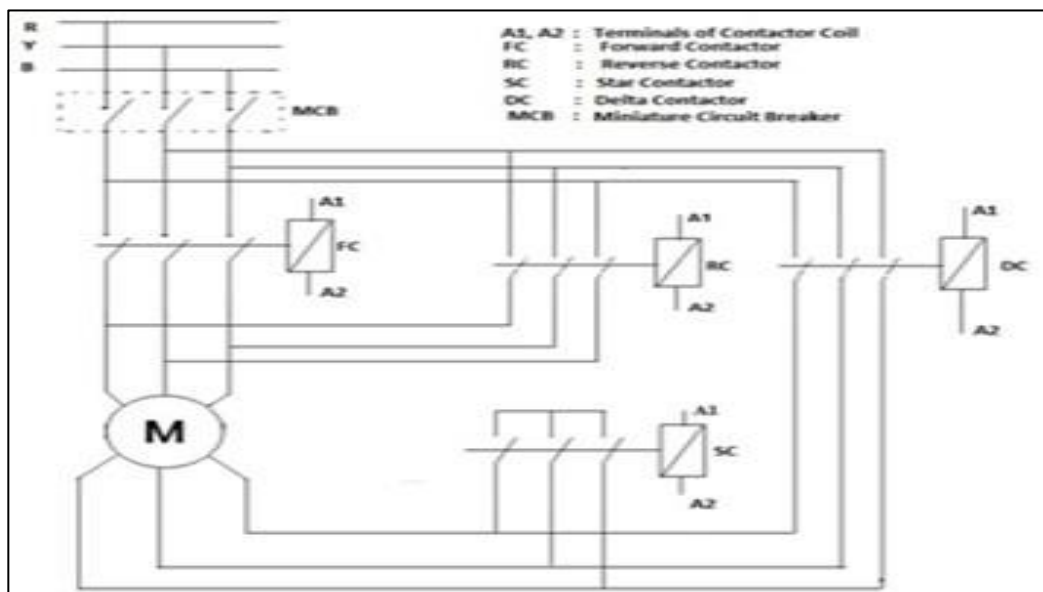


Fig.20 Reverse current breaking method for three phase induction motor

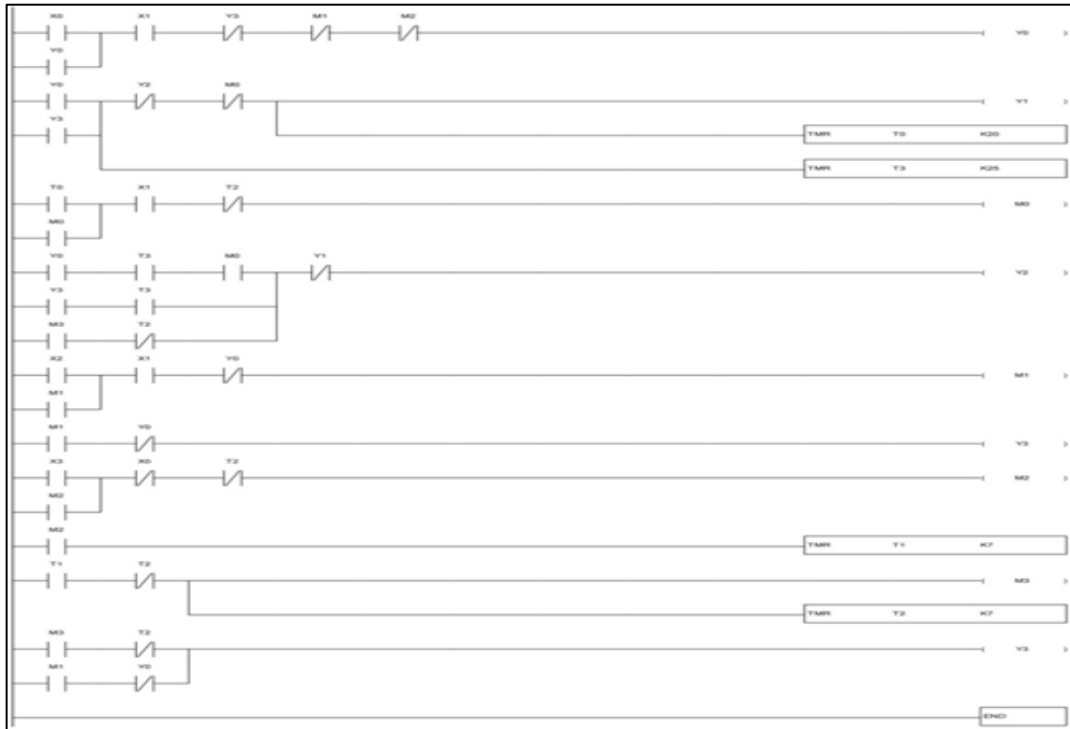


Fig.21 Ladder diagram of plugging method of breaking the motor

**Try**

1. Compare the reverse current breaking method for three phase induction motor for fig.20 using ladder diagram in terms of concepts.
2. Conclude the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

**9. Traffic Signal Control**

Examine the traffic signal control system for a three-way junction road using Programmable Logic Controller.

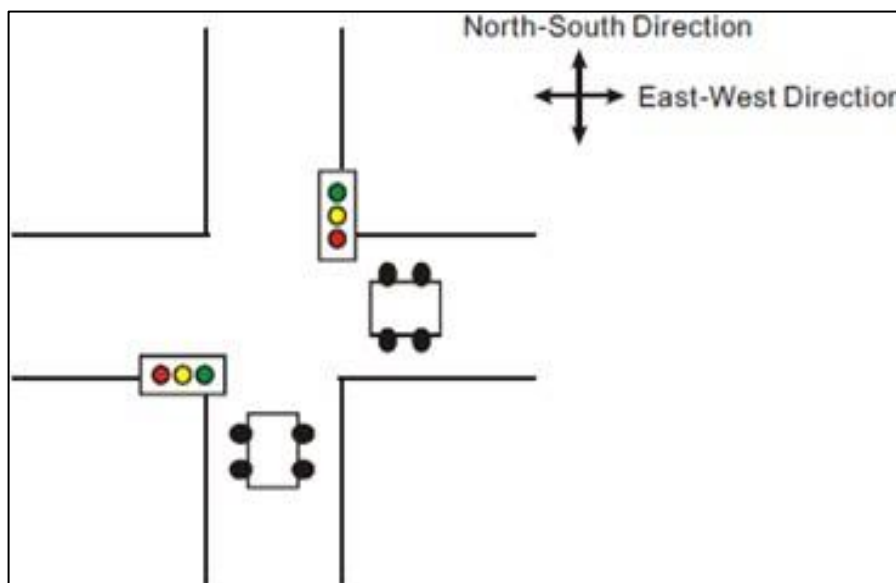


Fig.22 Traffic signal control system for a three-way junction road

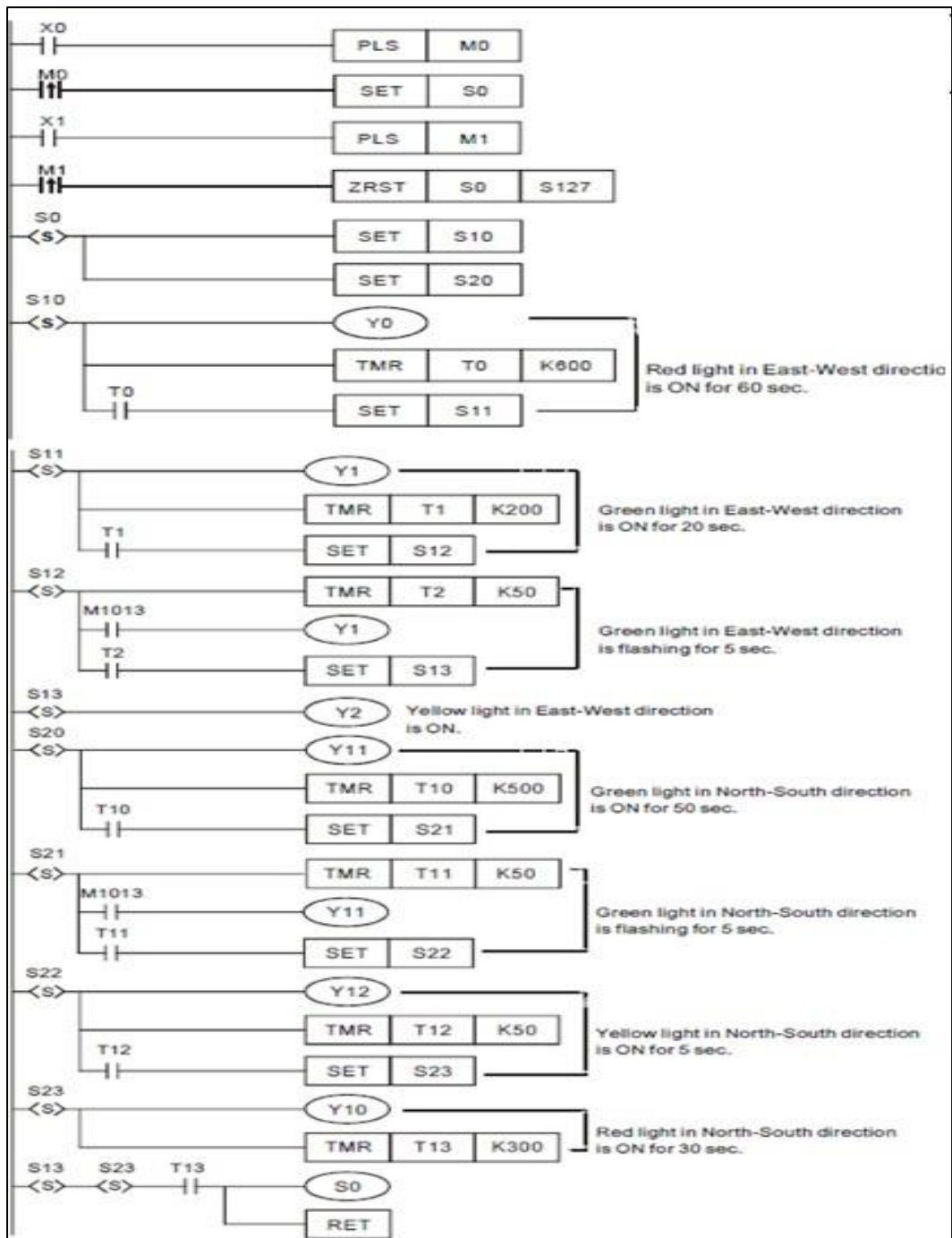


Fig.23 Ladder diagram for traffic signal system

**Try**

1. Design a traffic signal control system for a three-way junction road for fig.22 using ladder diagram in terms of concepts.
2. Compare the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

## 10. Temperature Control in a Room

Examine the temperature control system to monitor the temperature of a room using Programmable Logic Controller.

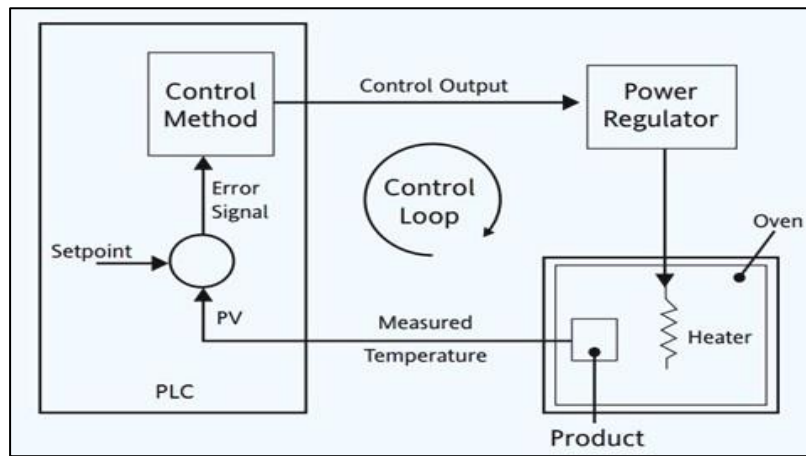


Fig.24 Temperature control system

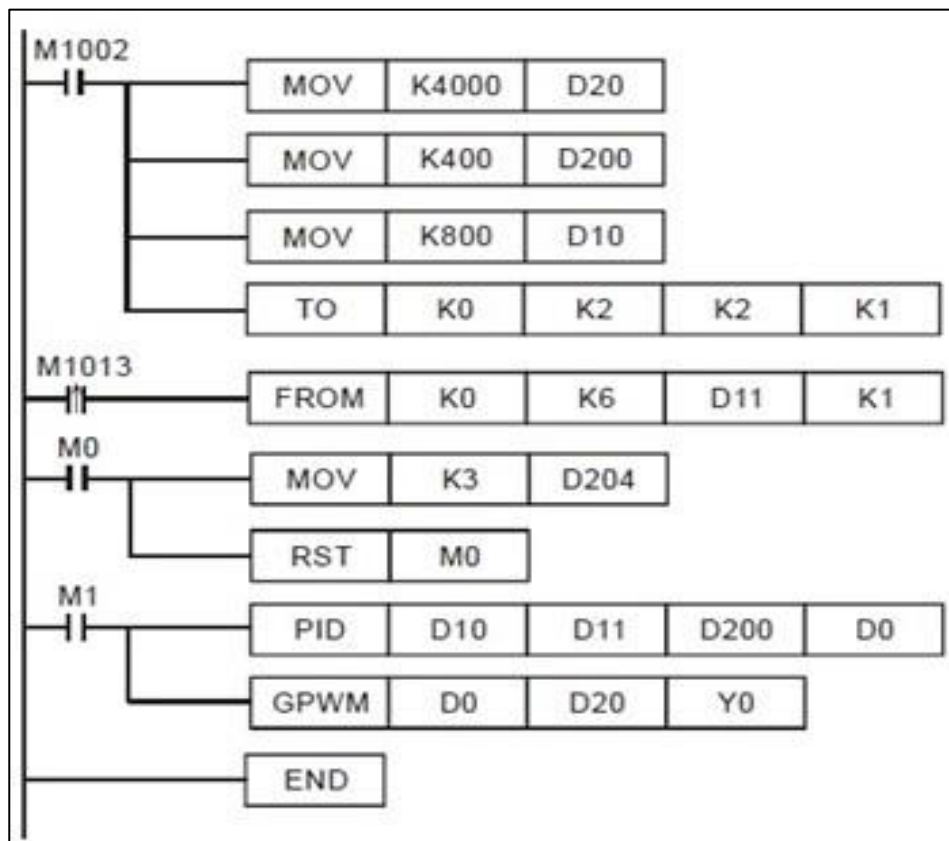


Fig.25 Ladder diagram for Temperature control system

### Try

1. Design a temperature control system by different types of sensors for fig.24 using ladder diagram in terms of concepts.
2. Compare the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

## 11. Solar Tracking

Implement the solar tracking system using Programmable Logic Controller.

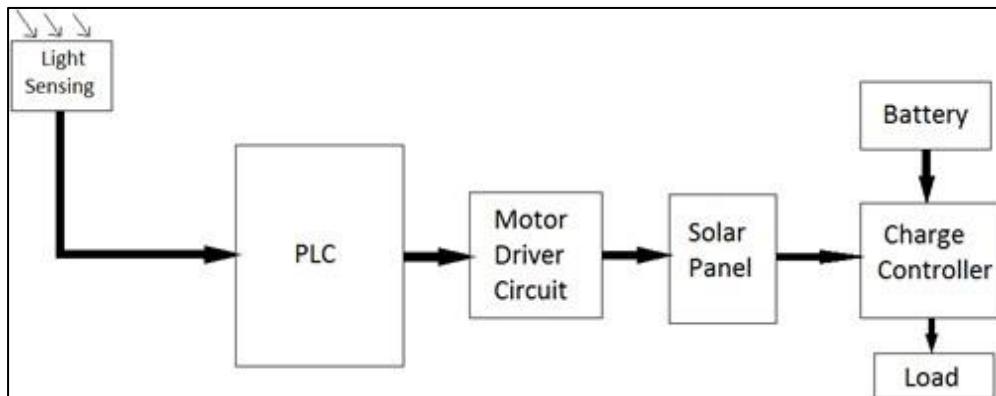


Fig.26 Solar tracking system

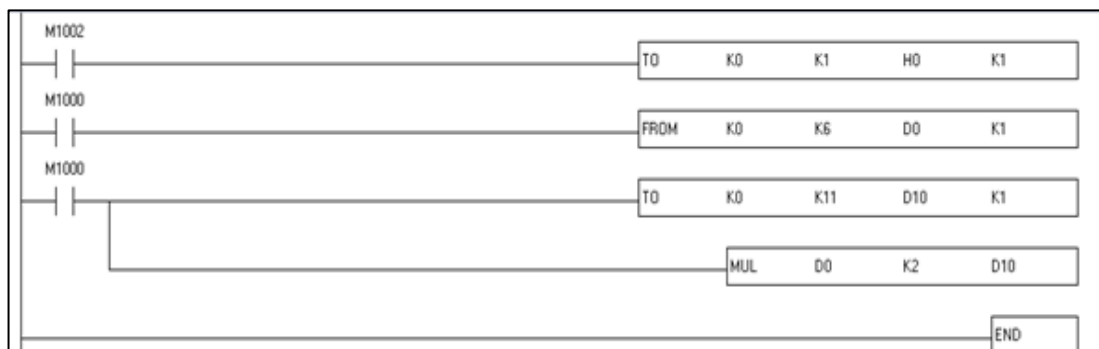


Fig.27 Ladder diagram for solar tracking

### Try

1. Design a solar tracking system with related components for fig.26 using ladder diagram in terms of concepts.
2. Conclude the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

## 12. Digital Clock

Construct a 24-hour digital clock to measure time using Programmable Logic Controller.



Fig.28 24-hour digital clock

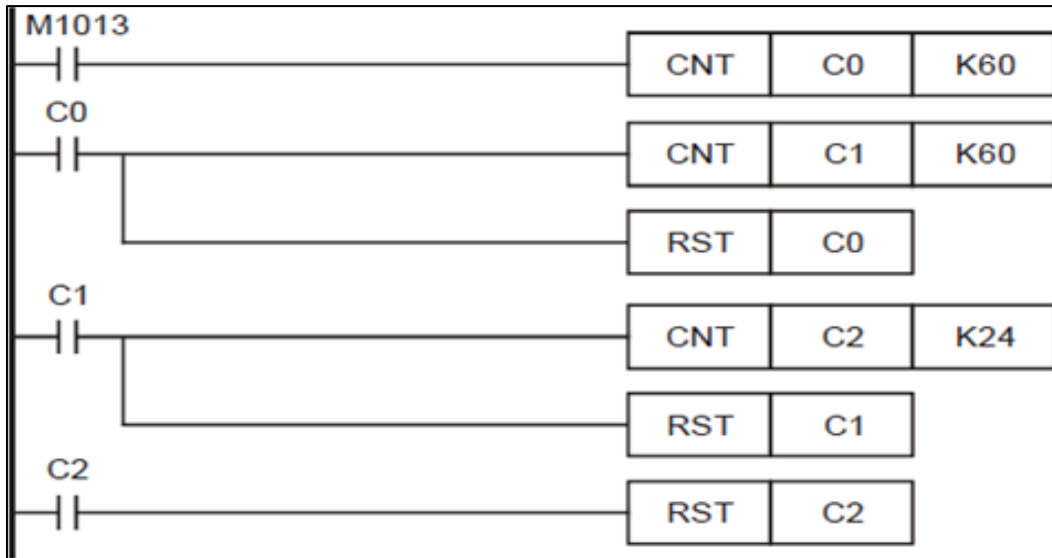


Fig.29 Ladder diagram for digital clock

**Try**

1. Design a digital clock using three PLC counters for fig.28 using ladder diagram in terms of concepts.
2. Conclude the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

**13. Control of Lift**

Examine a lift operation used in public buildings using Programmable Logic Controller.

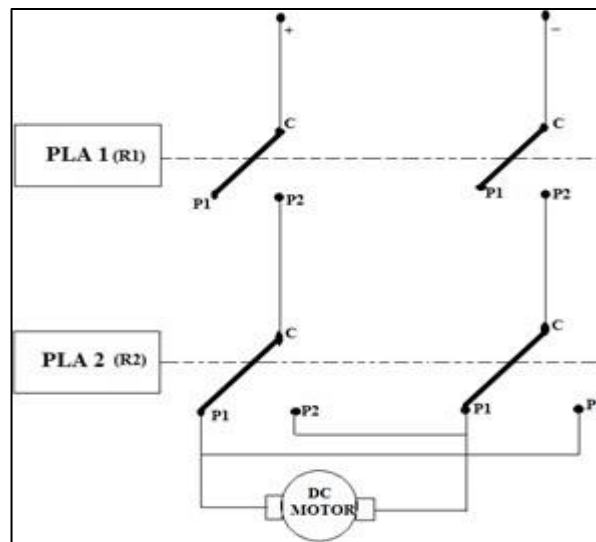


Fig.30 Lift operation logic controller

**Try**

1. Analyze the lift control which is a form of vertical transportation between building floors for fig.30 using ladder diagram in terms of concepts.
2. Compare the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.



## 14. Fault Annunciation System

Implement the fault annunciation system using Programmable Logic Controller.

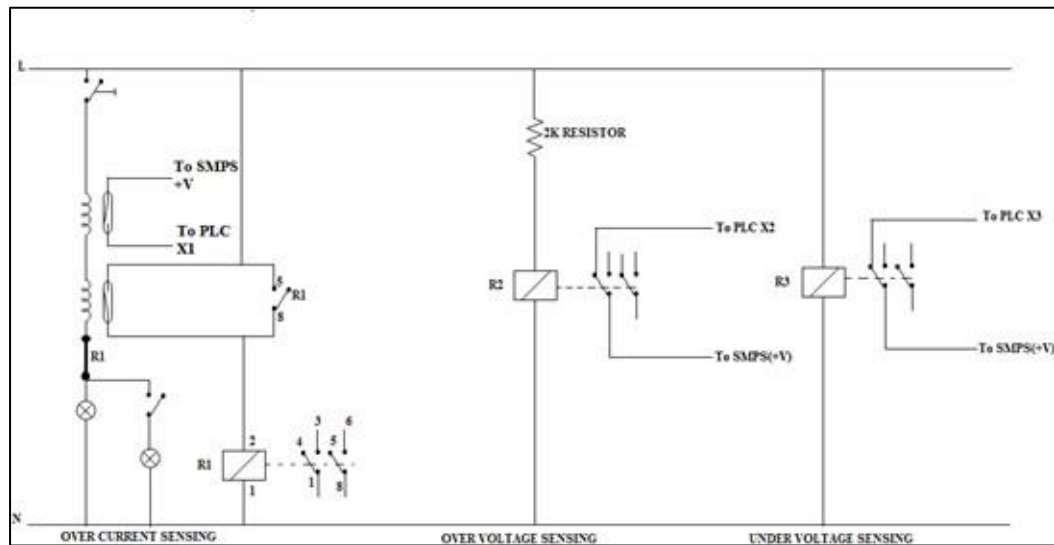


Fig.31 Fault annunciation system

### Try

1. Design a fault detector of electrical transmission system for fig.31 using ladder diagram in terms of concepts.
2. Compare the above obtained results with wiring the Programmable Logic Controller and Human Machine Interface.

### V. TEXT BOOKS:

1. Madhu Chanda Mitra, Samarjit Sen Gupta, "Programmable Logic Controllers and Industrial Automation: An Introduction", Penram International Publishing (India) Pvt. Ltd., 1<sup>st</sup> edition, 2008.
2. K Krishnaswamy, S Vijayachitra, "Industrial Instrumentation", New Age Publications, 1<sup>st</sup> edition, 2010.
3. Rajesh Mehra, Vikrant Vij, "PLCs & SCADA: Theory and Practice", Laxmi publications, 2<sup>nd</sup> edition, 2016.
4. Stuart A. Boyer: SCADA-Supervisory Control and Data Acquisition, Instrument Society of America Publications, USA, 1999.

### VI. REFERENCE BOOKS:

1. John R. Hack Worth, Frederick D. Hack Worth, Jr., "Programmable Logic Controllers: Programming Methods and Applications", Pearson Education, 4<sup>th</sup> edition, 2008.
2. W Bolton "Programmable logic controllers", Newnes Elsevier, 4<sup>th</sup> edition, 2006.
3. Luis A Bryan, E A Bryan, "Programmable Controllers theory and implementation", American Technical Publisher, 4<sup>th</sup> edition, 2002.
4. Frank D. Petruzella, "Programmable Logic Controllers", Tata McGraw Hill, 3<sup>rd</sup> edition, 2010.

### VII. ELECTRONICS RESOURCES:

1. <http://DVP-ES2/EX2/SS2/SA2/SX2/SE&TP> Operation Manual - Programming (deltronics.ru)
2. [http://DELTA\\_IA-PLC\\_DVP\\_TP\\_C\\_EN\\_20231023.pdf](http://DELTA_IA-PLC_DVP_TP_C_EN_20231023.pdf) (deltaww.com)
3. [http://Free PLC Books Download | Ebooks Online Textbooks Tutorials PDF \(freebookcentre.net\)](http://Free PLC Books Download | Ebooks Online Textbooks Tutorials PDF (freebookcentre.net))
4. <http://PLC Handbook | Free eBook Download | Library.AutomationDirect.com>

### VIII. MATERIALS ONLINE

1. Course template
2. Lab manual