Applied Industrial Automation with Delta PLC

Programming, Ladder Logic, and Control Systems

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DeepScience

Applied Industrial Automation with Delta PLC: Programming, Ladder Logic, and Control Systems

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Abstract

This book is a journey into the world of technology, a journey designed for every higher secondary student who believes that education is power and a tool to spread equality. In an era where technology shapes our future, understanding the foundational concepts of Automation, Mechatronics, IoT, Information Technology, AI, and Machine Learning is not merely an advantage – it is an imperative. This book aims to equip you with that understanding, opening doors to innovation and opportunity for everyone.

Practical knowledge is emphasized in this book. It is built on the principle that true learning comes from "doing" rather than just passively receiving information. You'll find explanations coupled with practically executed examples, designed to foster a deeper and more intuitive understanding of complex concepts. The goal is to make this material accessible by breaking down potentially intimidating topics into manageable and engaging learning experiences.

Whether your ambition lies in designing intelligent systems, building robotic marvels, or simply understanding the digital world around you, this book provides a solid foundation. The hope is that through these pages, readers will gain valuable knowledge and discover the passion and potential that lies within the ever-evolving world of technology, becoming empowered to shape a more equitable and technologically advanced future for all.

BIOGRAPHY

Author1:

Mr. T. Jones Daniel, M.Th, M.Tech, (Ph.D.), is currently serving as an Assistant Professor in the Department of Information Technology at JACSI Engineering College, Nazareth. He is also pursuing his Ph.D. in the same discipline at Kalasalingam Academy of Research and Education. Beyond academia, he holds the role of Secretary at Light Social Welfare Trust, an organization committed to supporting destitute elderly individuals and those suffering from mental illness.

His research focuses on leveraging Artificial Intelligence and Machine Learning to extend the lifespan and enhance the quality of life for bedridden elderly individuals.

Mr. Jones journey began during his final year of B.Tech, when he was selected through campus recruitment as a website designer and contributed to projects via the "Design Crowd" platform, collaborating with clients in Australia, the Philippines, and the United States. However, in 2013, he made a pivotal career shift, enrolling in an M.Tech program with a vision of mentoring students and shaping young minds.

A life-altering experience occurred during his final year of M.Tech at Trichy Railway Station, where he witnessed an elderly man attempting suicide. The older man was rescued—though severely injured—after bystanders, including Mr. Jones, stopped the train. The older man's quiet despair left a profound impact on Mr. Jones, inspiring him to dedicate his life to serving the elderly, mentally ill, physically challenged, visually impaired, and other disabled people.

He strongly believes that "Education imparts essential life skills such as problem-solving and logical thinking, which are crucial for personal growth and development, and it has the power to break the cycle of poverty." In alignment with this philosophy, he has helped over 26 students from underprivileged urban and rural areas secure employment opportunities since 2016.

Mr. Jones has authored and published numerous research papers and launched Deep learning book (CNN Topic ISBN : 978-93-6786-496-8) . Mr. Jones completed second book AI ML & DL book volume 1-is published for students. After seven years of dedicated research, he recently published a noteworthy paper titled "Optimized AI Bed for Maim and Bedridden Elder Person Based on Mobile Application" (Springer Link below). He presented this paper at an international conference in Singapore (organized by Springer Nature), through online while his mother underwent surgery at CMC Hospital. His work earned him the Best Paper Award.

In addition, he developed a mobile application titled "Deaf, Dumb, and Maim Assistant Application", published on the Google Play Store. This application, created in collaboration with his former students Er. Munish and Er. Mahendran, has been widely used by people from various countries around the world, free of charge.

As of 2025, the Light Social Welfare Trust shelters and cares for 158 abandoned individuals. With over nine years of teaching experience and five years as a Research & Development Coordinator, Mr. Jones continues to guide students in innovative research endeavors. He also runs a free educational website: https://jodaeducation.blogspot.com.

Various links:

YouTube: https://youtube.com/@lightsocialwelfaretrust5522?si=IMsPs4NYG98WTml5

Research Old Age people: https://link.springer.com/chapter/10.1007/978-981-97-5862-3_5

Education Web: https://lightsocialwelfare.blogspot.com

App:https://play.google.com/store/apps/details?id=com.lightoldagehomeapplication.lightoldagehome

Author 2:

Ms. J.Bercy Miraclin, is currently pursuing her Bachelor of Engineering in the Department of Robotics and Automation at Rajalakshmi Engineering College. Like many students entering a technical field, she faced early challenges—academic pressure, self-doubt, and uncertainty about her future. At times, she questioned whether she had made the right choice.

She holds a quiet belief that "In the moments we doubt our path, every step is still preparing us for a greater purpose." This belief kept her moving forward even when things were unclear.

Everything changed when a mentor encouraged her and recognized her potential. That moment gave her clarity, confidence, and a deep interest in her field. With a stronger mindset, she moved forward with focus and determination.

Slowly, her struggles became her strength. Her consistent effort and positive attitude led her to a major personal milestone: becoming the author of her first book. This achievement stands as a symbol of her growth, resilience, and commitment.

This success would not have been possible without the unwavering support of her parents. Their emotional and financial strength helped her move through difficult times. Even when she doubted herself, they stood by her with unconditional belief.

Her book is not just a personal victory but also a heartfelt tribute to her parents' sacrifices and support. Bercy's journey is a reminder that with faith, persistence, and the right people beside you, anything is possible.

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1. INTRODUCTION TO INDUSTRIAL AUTOMATION

1.1Automation

As we know about “automation” origin of this word from Greek "automata", meaning self-moving. Automation is widely used in manufacturing and industrial processes to achieve:

- High productivity
- Superior product quality
- Optimal utilization of energy and raw materials
- Reduction about human effort
- Elimination of high operational costs

1.1.1Objectives of Industrial Automation

The primary goals of industrial automation include:

- Improving product quality
- Increasing the rate of production
- Enhancing safety in the work environment
- Improving efficiency
- Reducing downtime in industrial operations

1.1.2. Definition of Industrial Automation

Industrial Automation refers to the use of advanced systems and control techniques (such as computers, PLCs, and electronics) to operate machines and processes with minimal human intervention.

1.1.3. Components of Industrial Automation

1. Sensors – Detect physical parameters like temperature, pressure, proximity, etc.

2. PLC (Programmable Logic Controller) – A digital device designed to automate electromechanical operations.

3. SCADA (Supervisory Control and Data Acquisition) – A platform that enables real-time supervision and management of industrial processes.

4. HMI (Human Machine Interface) – An interface facilitating interaction between operators and the automation system.

5. VFD (Variable Frequency Drive) – Modulates the frequency and voltage supplied to electric motors to control their speed and torque.

1.1.4. History of Industrial Automation

The first Programmable Logic Controller (PLC) was introduced by Modicon in the late 1960s to replace complex relay-based control systems, marking the start of flexible and programmable industrial automation. By the 1970s, industries began widely adopting PLCs due to their ease of reprogramming, compact size, and reduced wiring, which significantly improved automation efficiency and reduced downtime.

This shift laid the foundation for modern automation systems, enabling faster, more reliable, and scalable industrial operations.

1.1.5.Hard-Wired Control

Hard-wired control involves controlling a process using switching devices such as:

Relays, Contactors, Timers, Counters, Uncontroller and Power circuits

Disadvantages:

- Difficult to troubleshoot
- Expensive to implement and modify
- Complex wiring and logic

1.1.6.Electronic Control

In electronic control systems, microcontrollers and microprocessors replace existing control systems in industries.

Disadvantages:

- Lack of a common platform for communication between all devices

- Inability to withstand high-temperature industrial environments

1.1.7.Relay

A relay is an electromechanical switching device used in the design of various control circuits. In modern automation systems, Programmable Logic Controllers (PLCs) have largely replaced traditional relay panels due to their flexibility and programmability.

A relay typically consists of:

- A coil (electromagnet),
- A common contact (COM),
- A Normally Open (NO) contact,
- An NC (Normally Closed) contact.

Working Principle:

When the relay is de-energized (OFF), the common (COM) is connected to the Normally Closed (NC) contact. When the relay is energized (ON), the coil generates a magnetic field that pulls the switch, shifting the connection of the common (COM) to the Normally Open (NO) contact. Classification of Relays: Relays can be classified based on:

1. Coil Voltage (e.g., 5V, 12V, 24V DC/AC),

2. Number of Poles (Single Pole, Double Pole, etc.),

3. Contact Current Rating (e.g., 5A, 10A, 30A).

1.2. Definition about PLC

A Programmable Logic Controller (PLC) is a digital industrial computer designed to automate electromechanical processes. It utilizes programmable memory to store user-defined instructions for executing functions such as logic operations, timing, counting, sequencing, arithmetic, and process control.

1.2.1. Advantages of PLC

- Compact in size and easy to integrate
- Excellent communication capabilities with external devices and networks
- Supports timing, counting, and PID calculations

- Fast response time and easy troubleshooting

1.2.2. Anatomy of a PLC

A standard PLC comprises the following components:

- **Power Supply** – Supports input voltages of 24V DC, 120V AC, or 220V AC
- **CPU (Central Processing Unit)** – Runs and manages the control program
- **Memory** – Holds user-defined programs and system data
- **Input Module** – Captures signals from field devices such as sensors and switches
- **Output Module** – Delivers signals to actuators like relays, motors, and indicator lamps
- Bus System – Connects internal PLC modules for data transfer
- Communication Port – Connects PLC to external devices (HMIs, SCADA)
- Display/Image Interface – For monitoring and diagnostics

1.2.3.PLC Inputs and Outputs

PLC I/O s are categorized into two types:

Logical (Digital): Used for discrete control, such as switching a light ON or OFF.

Continuous (Analog): Used for variable control, such as adjusting the brightness of a light.

1.2.4. Output Types from PLC:

Relay Outputs – Mechanical switching

Solid-State Outputs:

- Transistor – Typically used for DC output signals
- Triac – Typically used for AC output signals
- Analog Outputs – Generated using dedicated output cards equipped with Digital-to-Analog Converters (DACs) to produce continuous signals

1.2.5. Control programming interface

A **programming device or terminal** is used to develop and load the control program into the PLC's memory. Programs are commonly written in **Ladder Logic**, a graphical programming language that mimics electrical relay logic diagrams. Ladder Logic is one of the most widely used PLC programming languages, supported by nearly all manufacturers. It enables users to design control sequences in an intuitive and easy-to-understand format. A **programming device** is used to create and transfer control programs to the PLC. It can be:

- A Handheld Unit
- A Personal Computer with appropriate PLC programming software

1.2.6. Programming Languages

Programming Languages (IEC 61131-3 Standard)

PLC programs can be written using various standard languages:

Ladder Diagram (LD) – Graphical, widely used.

Structured Text (ST) – High-level language similar to Pascal.

Instruction List (IL) – Low-level, similar to assembly (deprecated).

Sequential Function Charts (SFC) – Flowchart-based.

Function Block Diagram (FBD) – Functional block representation.

1.2.7. Criteria for PLC Types

PLC types are generally classified based on several key criteria that determine their suitability for different applications:

1. Input-Output (I/O) Range

Defines the number of digital and analog inputs and outputs a PLC can handle.

Low-end PLC: Suitable for small applications (e.g., 10–50 I/O points)

Medium-end PLC: Used for moderate control systems (e.g., 100–500 I/O points)

High-end PLC: Designed for complex systems (e.g., >1000 I/O points)

2. Packing and Cost per Point

Packing: Refers to how compactly I/O modules and CPUs are integrated.

Cost per point: Cost of one I/O point; low-end PLCs usually have a lower cost per point, making them economical for small setups.

High-end PLCs are modular and may cost more per point due to advanced features.

3. Memory Capacity

The size of the program and data memory varies by type:

Low-end: Limited memory, used for basic logic operations

Medium-end: Moderate memory for multiple control tasks

High-end: Large memory to handle complex programs, multiple tasks, and data logging

4. Scan Time / Response Time
Scan time describes the total duration taken to:

Input scanning

Program execution

Output update

Shorter scan times mean faster response and better real-time control.

High-end PLCs have lower scan times, suitable for fast processes (like motion control)

Scan Cycle Breakdown:

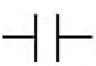
Total Scan Time = Input Scan Time + Program Execution Time + Output Update Time

1.3. Ladder Logic Elements

1.3.1. Contacts

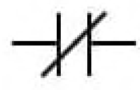
Normally Open (NO) - Conducts when the control bit is True (1).

Symbol:



Normally Closed (NC) - Conducts when the control bit is False (0).

Symbol:



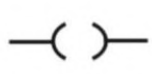
1.3.2. Coil

Represents a relay coil or output device.

The coil is energized when the rung conditions are true.

This sets the corresponding output bit to 1 (ON).

Symbol: Output Coil



1.3.3. Rung

A rung is one horizontal line in the ladder logic.

Example:

|--[A]----(C)---|

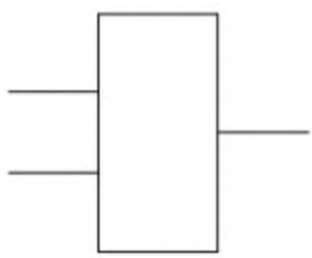
When input A is ON, output coil C is energized.

1.3.4. Boxes

Represent function blocks or instructions such as: Timers, Counters, Arithmetic Operations

These execute when the power flows through the rung.

Symbol:



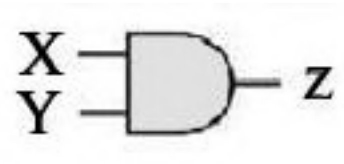
Box

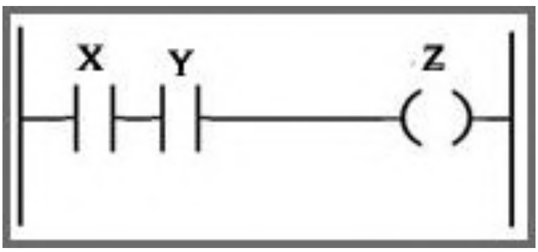
1.4. Basic Logic operations in PLC:

1.4.1.AND gate

All inputs must be true (closed contacts) for output to be true.

It performs logical multiplication; if any input is false, output is false.





X	**Y**	**Z**
0	0	0
0	1	0
1	0	0
1	1	1

1.4.2. OR Gate:

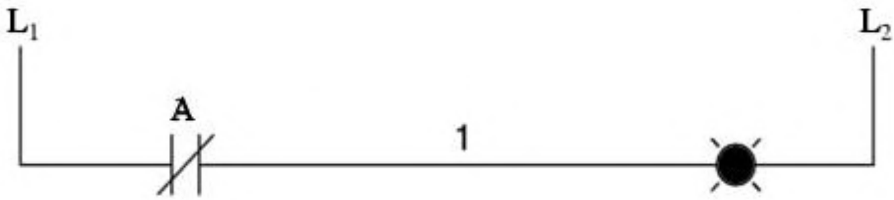
Any one input true (closed contact) gives true output.

It performs logical addition; output is false if all inputs are false.

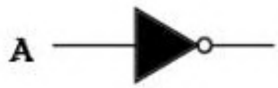
1.2.3.NOT Gate:

Reverses the input signal; true becomes false, false becomes true.

Used as a normally closed (NC) contact in ladder logic.



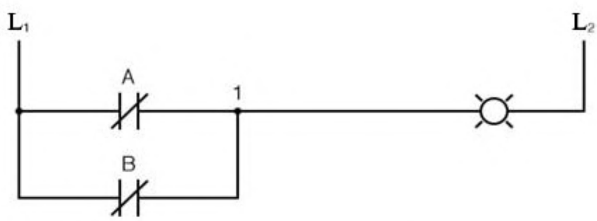
A	Output
0	1
1	0

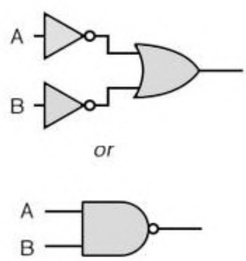


1.2.4.NAND Gate:

Condition is given input are true, Output is false.

Here Combination of AND followed by NOT, represented using NC coil after AND.



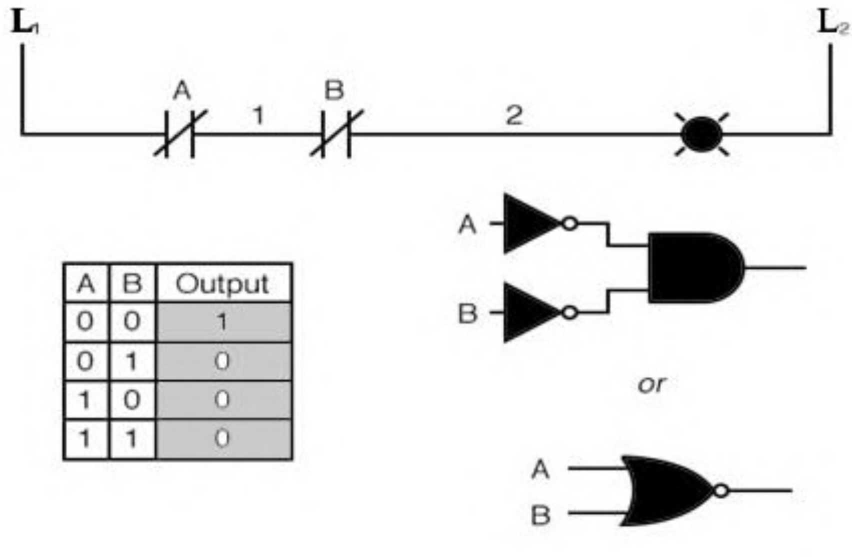


A	B	Output
0	0	1
0	1	1
1	0	1
1	1	0

1.2.5.NOR Gate:

The output is high only if all inputs are low.

It is OR followed by NOT, used by NC coil after parallel contacts.

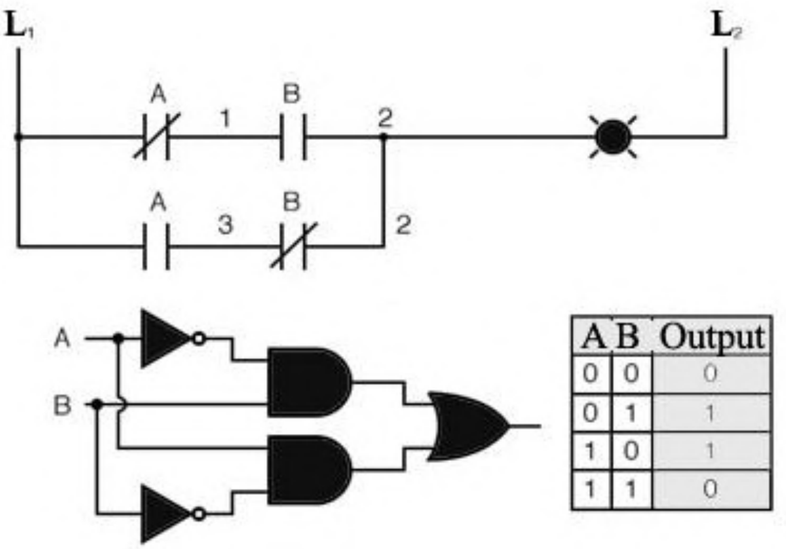


A	B	Output
0	0	1
0	1	0
1	0	0
1	1	0

1.3.6.XOR Gate:

Output is true when inputs are unequal.

Used to detect change or toggle state in ladder logic.



A	B	Output
0	0	0
0	1	1
1	0	1
1	1	0

1.4. Online Starter- Direct (DOL Starter / DOS)

A Direct Online Starter (DOL Starter or DOS) is the simplest and most widely adopted method for initiating three-phase induction motors.

1.4.1Working Principle:

In a DOL starter, the motor is connected directly to the full supply voltage, enabling it to start immediately with maximum torque.

1.4.2. Main Components:

Contactor – Connects and disconnects the motor from the power supply.

Overload Relay – Safeguards the motor against overcurrent situations.

Start Button – Activates the contactor coil to initiate motor operation.

Stop Button – Deactivates the contactor coil to halt the motor.

Fuses or Circuit Breaker – Provides protection against short circuits.

1.4.3. Basic Operation:

Pressing the start button energizes the contactor coil, closing the contacts and connecting the motor directly to the three-phase supply. When the stop button is pressed or an overload condition arises, the supply is cut off.

1.4.4. Advantages:

Simple and easy to use

Cost is Low

Initial torque level is high

1.4.5. Disadvantages:

- Experiences high starting current, typically 6 to 8 times the full load current
- Unsuitable for operating large motors
- Can lead to voltage drops in the electrical system

1.5. SCADA

SCADA (Supervisory Control and Data Acquisition) is a system designed for real-time monitoring and control of industrial processes. It gathers data from sensors and field devices, and interacts with PLCs or RTUs to manage plant operations. SCADA provides operators with a graphical interface to visualize and control processes, enhancing automation, efficiency, and security in industrial facilities.

1.6. Frequency Drive - Variable (VFD)

A Variable Frequency Drive (VFD) is a motor controller that operates an electric motor by adjusting the frequency and voltage of the power supplied to it. Additionally, a VFD can regulate the motor's acceleration and deceleration during startup and shutdown.

1.7.HMI (Interface between Human-Machine)

An HMI serves as an operator control panel for PLCs, RTUs, and in some cases, connects directly to IEDs. It replaces traditional manual controls such as switches, dials, and knobs with graphical displays and digital interfaces, allowing operators to monitor and interact with the control process more intuitively.

1.8.DCS -Distributed Control System

It is a control system in which the control elements are distributed across various locations rather than centralized. Each subsystem is managed by one or more controllers, all of which are interconnected through networks to enable communication and monitoring of the entire system.

1.8.1. Components of DCS

Engineering Station, Field Control Station and Human Interface Station.

Some basic problems

Example 1.1:

Design a control system for a bell that begins ringing when the Start push button is pressed. The bell should keep ringing even after the Start button is released, and it should stop only when the Stop button is pressed.

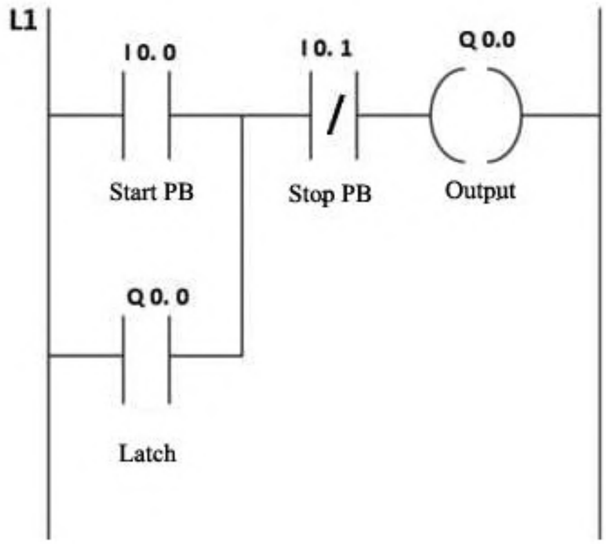


Figure 1.1

Symbol Reference:

I0.0 - push button start (NO)

I0.1 - push button stop (NC)

Q0.0 - Bell output (latched)

Explanation:

Pressing Start (I0.0) energizes Q0.0 (Bell).

The self-holding contact of Q0.0 maintains the circuit even after Start is released.

Pressing Stop (I0.1) breaks the circuit and stops the bell.

Figure1.1 shows the ladder logic

Figure 1.2 towards the ladder - logic in WPL soft, This logic remains same for every software but addressing changes, here we are using Delta PLC.

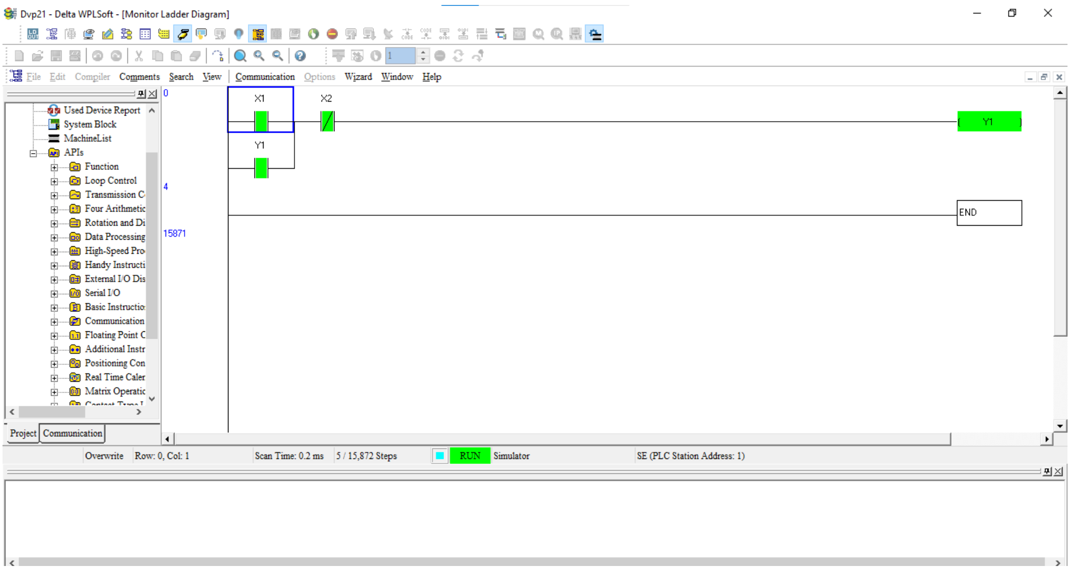


Figure 1.2

Example 1.2:

In a manufacturing unit, there are three motors, each rated at 20 kW. The available power supply from the transformer is limited to 30 kVA. Design a PLC logic to ensure that only one motor operates at any given time. If a second motor is attempted to be turned ON while one is already running, the PLC should prevent it from starting and retain the state of the first motor.

Solution:

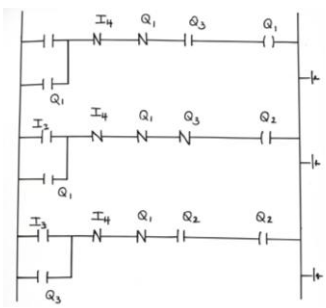


Figure 1.3

Here in the above figure1.3, I1, I2 and I3 represents the start buttons

I4 is the common stop button and

Q1, Q2 and Q3 represents the three motors

The ladder logic In WPL soft is shown in figure 1.4

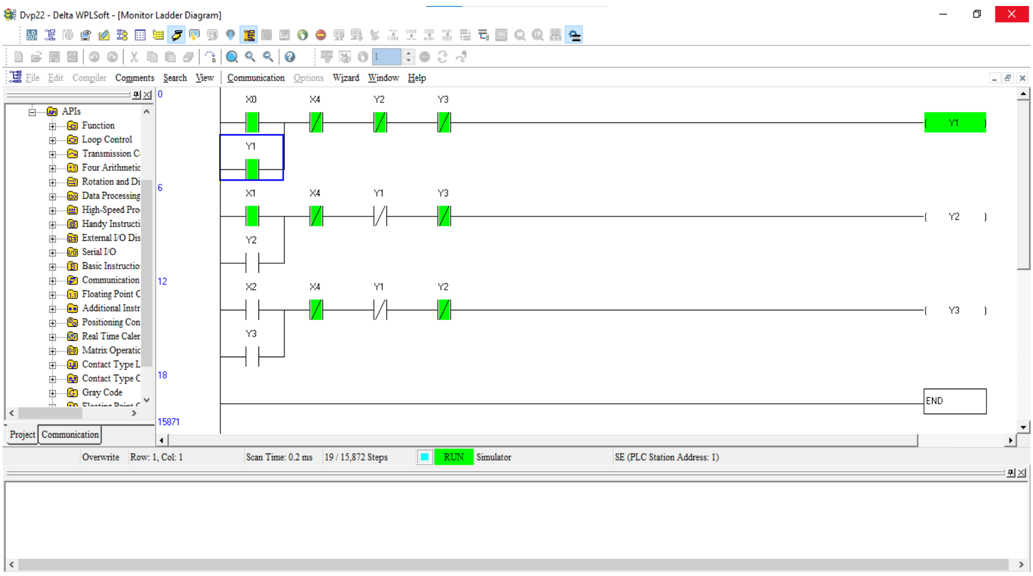


Figure 1.4

Example 1.3:

Design PLC ladder diagram for conveyor choosing system. An operator should be able to operate the system in the manual mode using four push button on switches and a common off switch. The company is producing four different types of products which are categorized in blue, green, yellow and red colors for identification. These products are to be transported through different conveyors for further process. In the four output signals to control the system, only one output signal is supposed to be on at a time. If the operator tries to switch conveyor, the previous output should go OFF and the chosen conveyor output should be turned on.

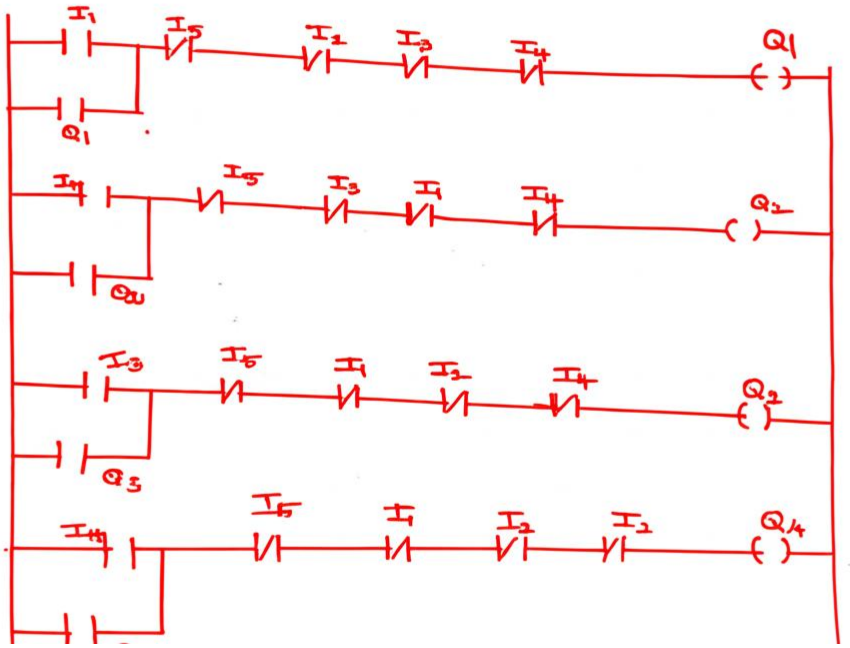


Figure 1.5

Here in the above figure1.5, I1, I2, I3 and I4 represents push button on switches

I5 is the common off switch and

Q1, Q2, Q3 and Q4 represents the conveyor output

The ladder logic In WPL soft is shown in figure 1.6

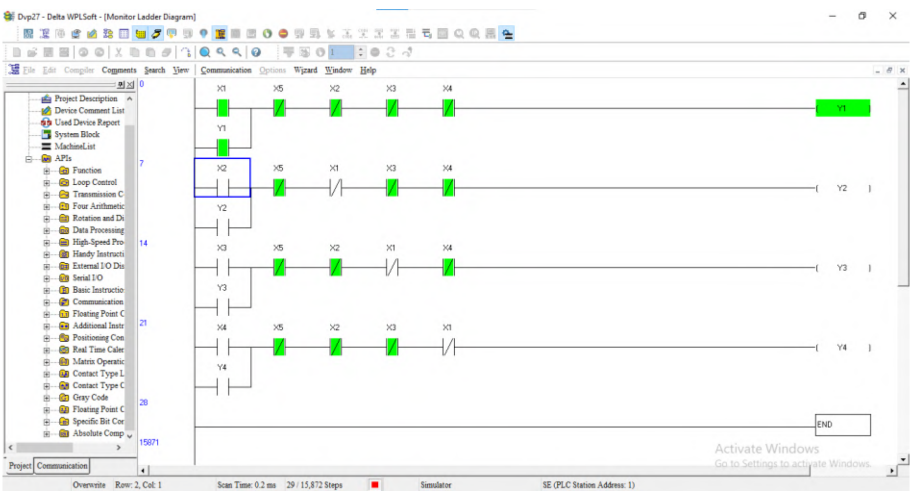


Figure 1.6

2.TIMER AND COUNTER

2.1. Timer Definition

Used to create a time delay between operation or activate and deactivate a device after a preset interval of time.

2.2. Types

- Off-Delay Timer
- Retentive Timer
- On-delay Timer

2.3. Timer specification

Timer Number

Preset Value

Accumlator value

Time Base

Enable bit/ Done bit/ Timer timing bit

Example 2.1:

In an automated system controlled by push-buttons, pressing the start button triggers a sequence where the first conveyor starts after 20 seconds, followed by the second after 30 seconds. This circulation process continues until the stop button is pressed. Identify the logic used to implement this operation.

Solution

The above question can be solved in 2 ways

Method 1

Figure 2.1 illustrates Method 1, where the lighting sequence is controlled using timers without a reset button. In this method, when input I1 is pressed, the signal passes through the normally closed contact of T2 (NC-T2), which allows the timer T1 to start. After the delay, T1 activates output Q1 and starts timer T2. Once T2 is activated, its NC contact opens, preventing I1 from retriggering the cycle again — thus acting as a self-reset mechanism. This replaces the need for a separate reset button. Finally, Q2 is turned ON after the T2 delay, completing the sequence.

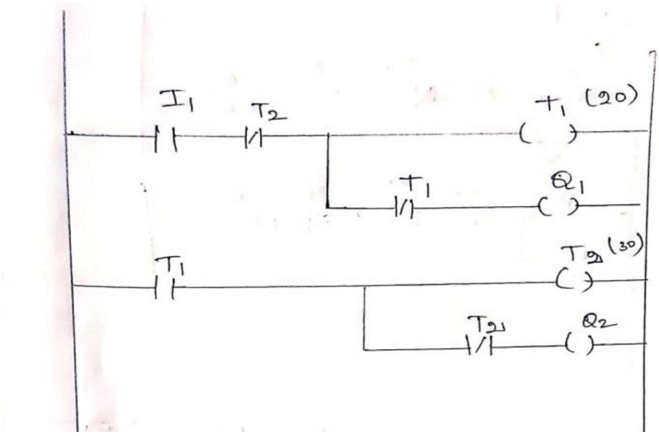


Figure 2.1

Method 2

It can also be solved using the reset button, as the ladder logic is shown in Figure 2.2 and the corresponding ladder logic in WPL soft is represented in Figure 2.3.

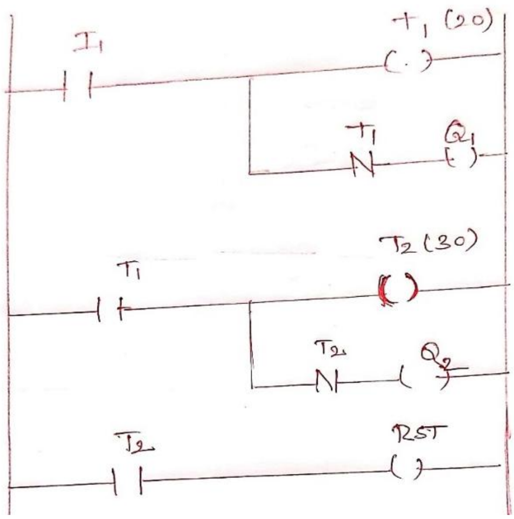


Figure 2.2

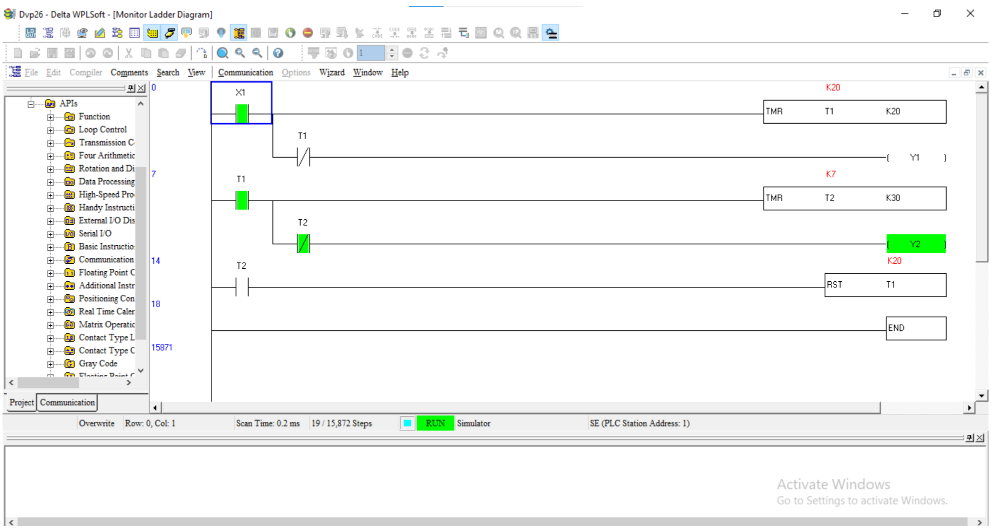


Figure 2.3

2.4. Memory elements

2.4.1. Memory with Toggle Switch (Simple Memory Set)

Description:

Input: I1 (NO switch)

When I1 is pressed, the memory coil M1 gets energized.

This is like turning ON a memory marker when a condition is TRUE (e.g., pressing a toggle switch). This operation is shown in Figure 2.4.

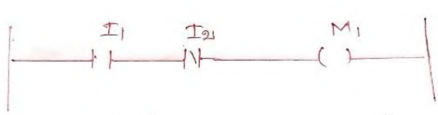


Figure 2.4

2.4.2. Latching using Push Button (Seal-in or Self-Holding Circuit)

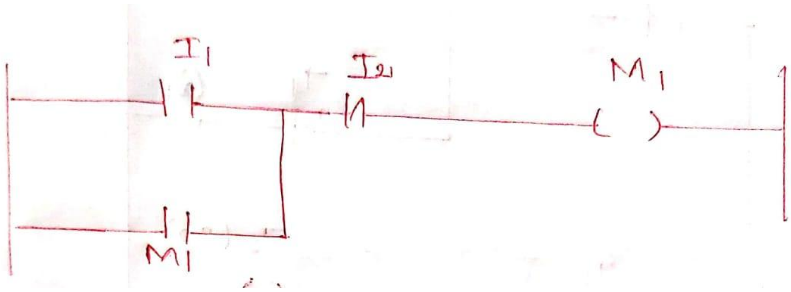


Figure 2.5

Description:

Inputs: I1 (NO start push button), I2 (NC stop push button)

Memory coil: M1

Latch circuit: I1 is in parallel with M1, and both are in series with I2

Working:

Pressing I1 turns ON M1.

Once M1 is ON, it keeps itself ON through the parallel path.

Pressing I2 (NC becomes open) breaks the circuit and resets M1.

This can be illustrated using Figure 2.5.

Use Case:

Common in start-stop circuits, like starting a motor with one pushbutton and stopping with another.

2.4.3. Set and Reset Memory using Multiple Inputs

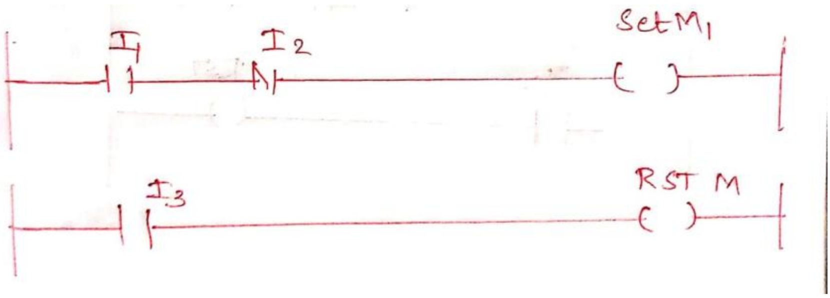


Figure 2.6

Description:

Inputs: I1 (NO), I2 (NC), I3 (NO)

Set Memory Coil: M1 (Set)

Reset Memory Coil: M1 (Reset)

Working:

If I1 is pressed and I2 is not pressed (still closed NC), M1 is SET.

If I3 is pressed, M1 is RESET (refer Figure 2.6).

Use Case:

Used where you want to set and reset states explicitly, like turning a machine ON with one input and OFF with a different one.

Example 2.2:

Here the on and off switches are pushbutton.

Feeder Conveyor, Crusher Unit, Lubricating Oil Valve and Product Conveyor

Each outputs should get on and off in a sequential manner

<u>On Sequence</u>

If push button ON is pressed the Feeder Conveyor should be ON instantly. Crusher Unit has to be ON 20 seconds after the Feeder Conveyor is ON. The Product conveyor should work 15 seconds after the Crusher unit is ON. When the Product Conveyor is ON, the Feeder Conveyor and Crusher unit will remain as ON.

<u>Off Sequence</u>

As the ON sequence the OFF sequence has to work, If the OFF switch is pressed. first the feeder conveyor should be OFF at the same instant, 20 seconds after that the Crusher unit should be OFF, 15 seconds after that the product conveyor should be OFF. When the whole crusher unit is stopped lubricating oil is to be applied for I5 seconds.

Solution:

The solution to the problem is illustrated by the manual diagram in Figure 2.7 and the software logic in Figure 2.8 and Figure 2.9.

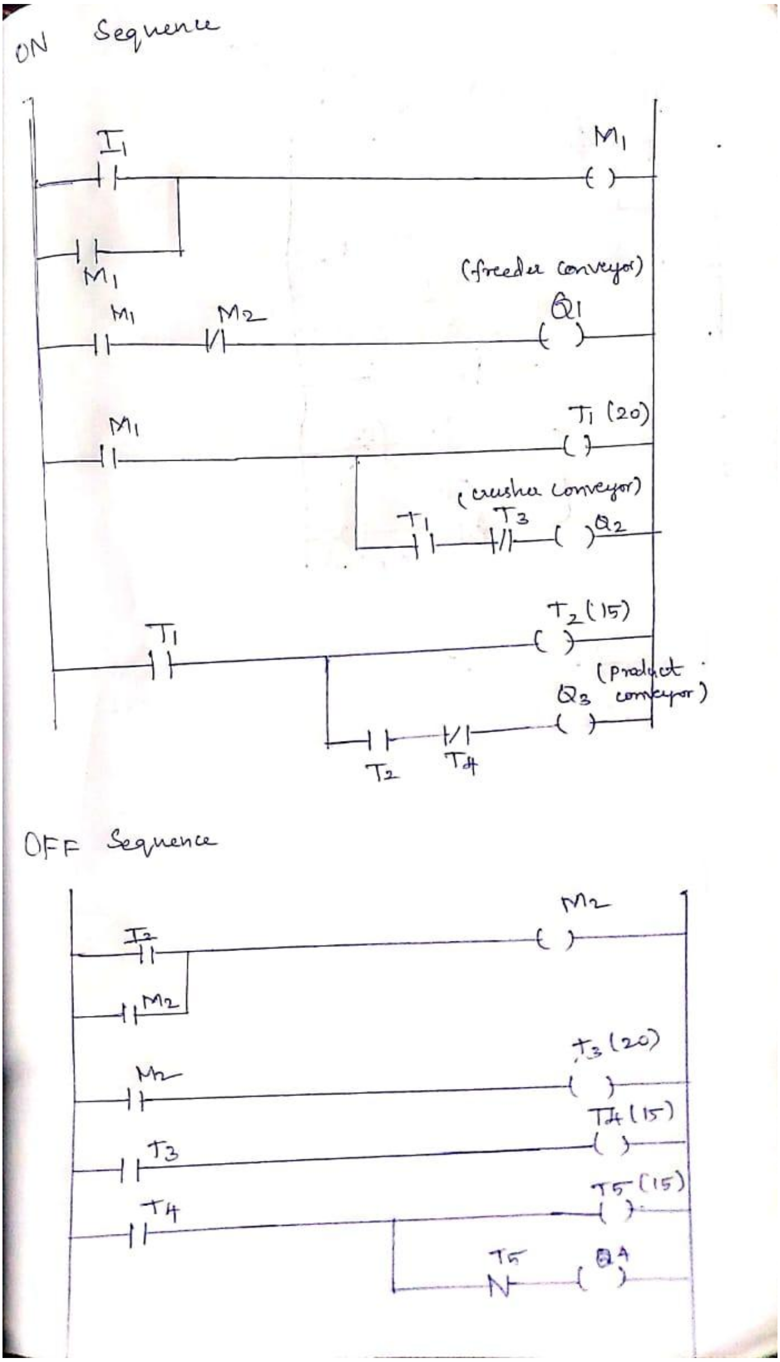

ON Sequence
I1
M1
M1
(feeder conveyor)
M1
M2
Q1
M1
T1 (20)
(crusher conveyor)
T1
T3
Q2
T1
T2 (15)
(product conveyor)
Q3
T2
T4
OFF Sequence
M2
I2
M2
T3 (20)
M2
T4 (15)
T3
T5 (15)
T4
T5
Q4

Figure 2.7

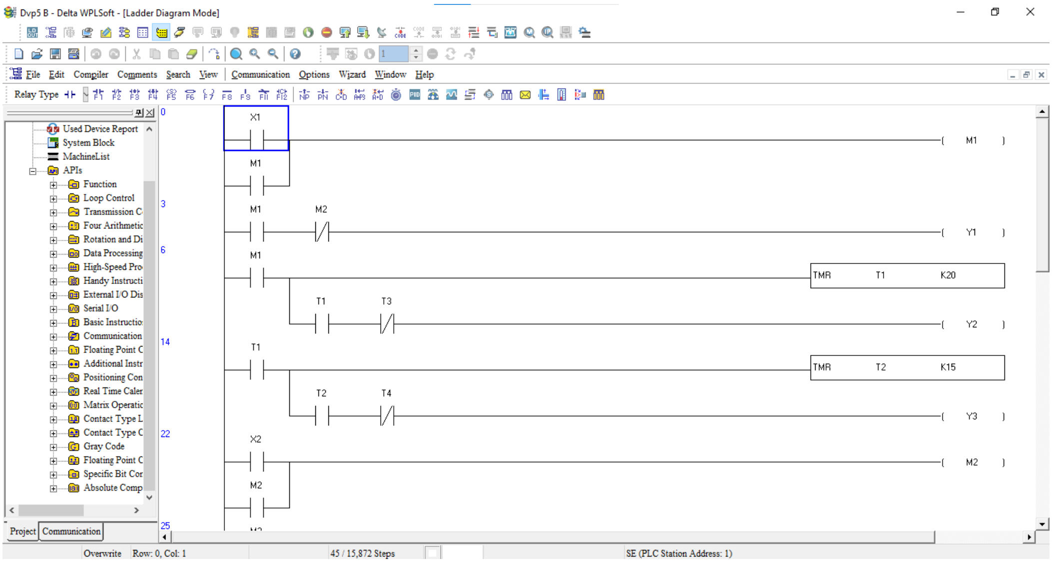


Figure 2.8

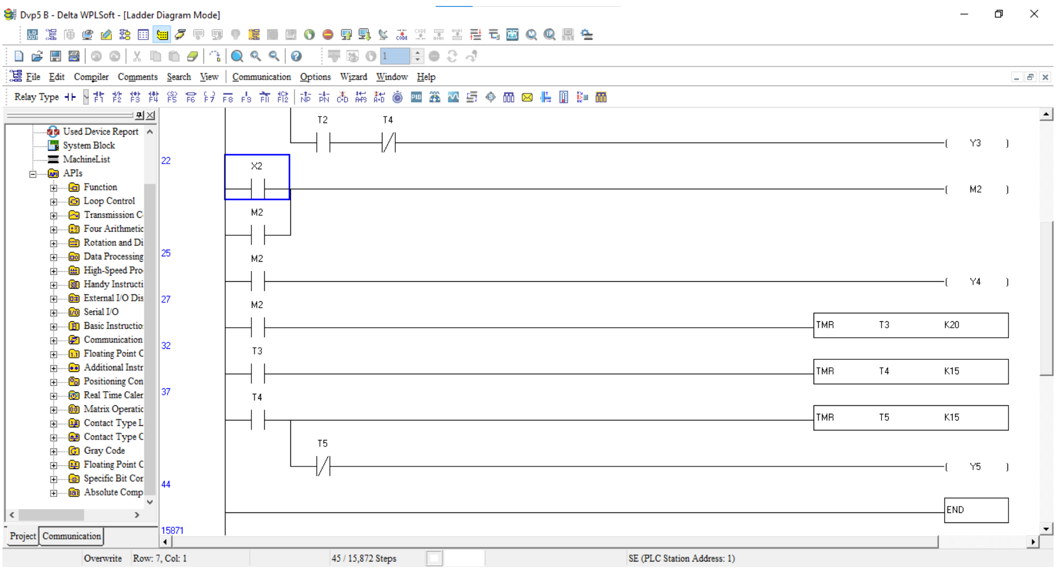


Figure 2.9

2.5. counter

A counter in a PLC is a function used to count events like button presses or object detections. Once input signal received its value may changed. If the count reaches a preset number, it can activate an output or perform a specific task.

2.5.1. Types

1. Up Counter (CTU) – Counts upward each time an input signal is received.

2. Down Counter (CTD) – Counts downward from a preset value with each signal.

2.5.2. problems

Example 2.3

Automate a car parking system using a PLC. The parking lot can accommodate a maximum of ten cars. Sensors are installed on both the entry and exit paths. When the lot reaches full capacity, operate a motor in the forward direction for 10 seconds to close the entry gate. Once the number of cars drops below ten, run the motor in reverse (via a separate output) to open the gate and allow more cars to enter.

Solution:

The ladder logic diagram is drawn and shown in the figure 2.10

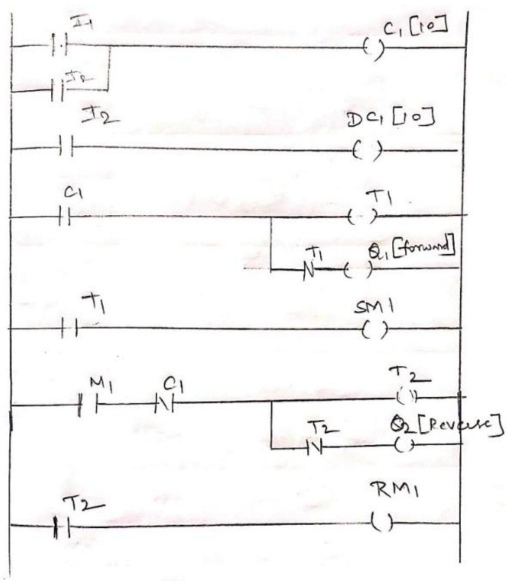


Figure 2.10

Figure 2.11 shows the ladder diagram in WPL soft

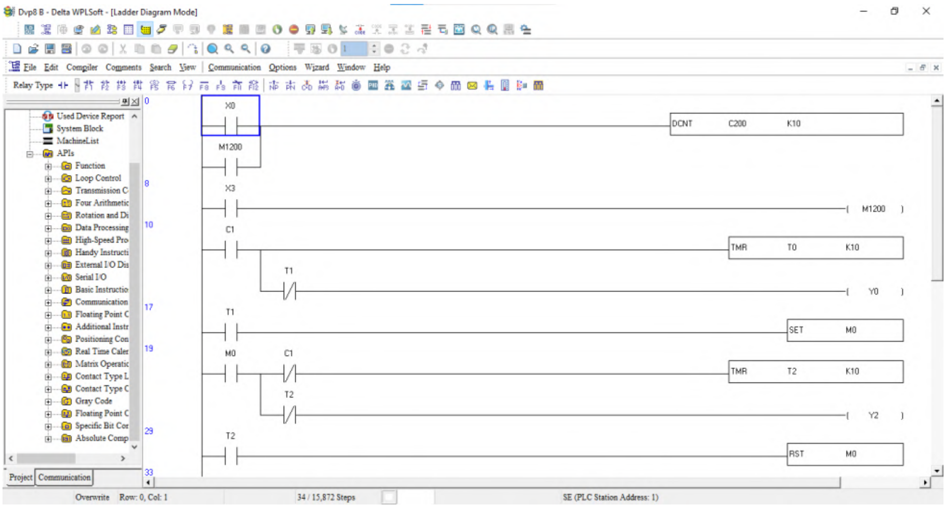


Figure 2.11

In PLC programming, both up and down counters are used based on the requirement. However, when both are present in the same problem, we prioritize and use only the down-counter for control. In this case, the down-counter manages the available parking slots from the maximum count. Memory bits like M1200 are used to hold and control the logic during the counting process.

Example 2.4

In fire alarn system there are four channels. In each channel there are two sensors. If the sensor(s) in two different channels are activated, a light should blink. If sensor(s) in three lifferent channels are activated, a hooter is to be energized. If sensor(s) in four channels are activated then motor is to be switched on.

Solution

the ladder logic diagram is drawn as shown in the figure 2.12

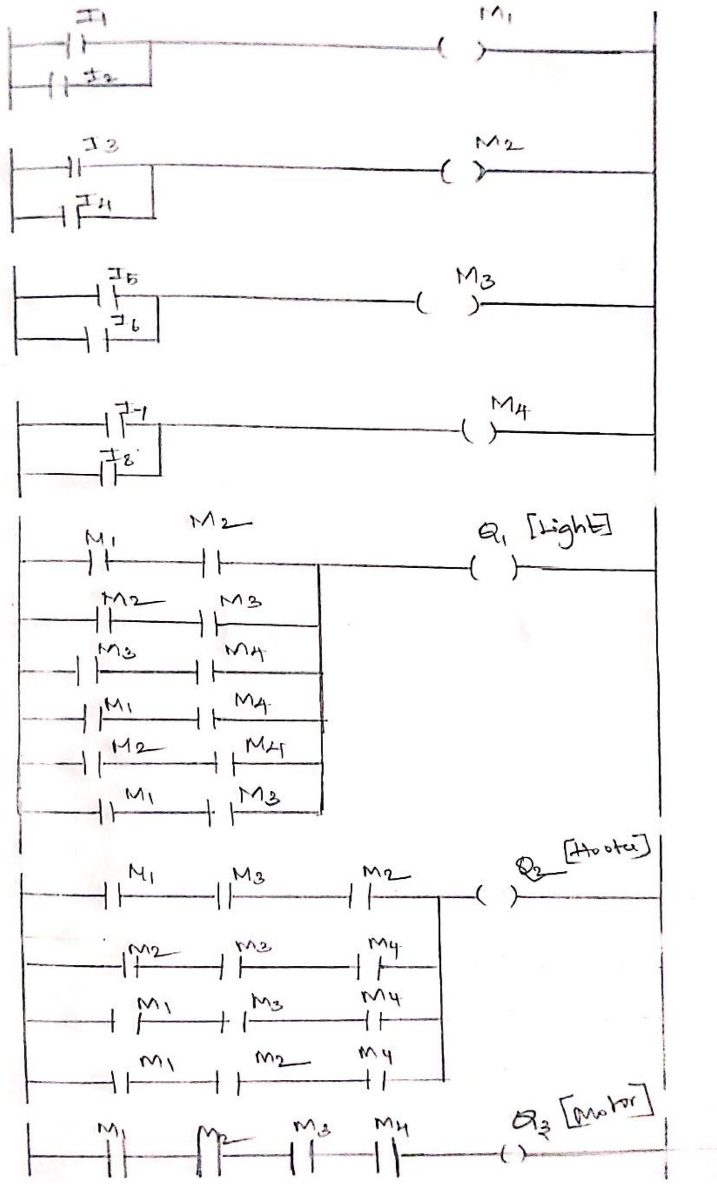


Figure 2.12

Figure 2.13, Figure 2.14 and Figure 2.15 shows the ladder diagram in WPL soft

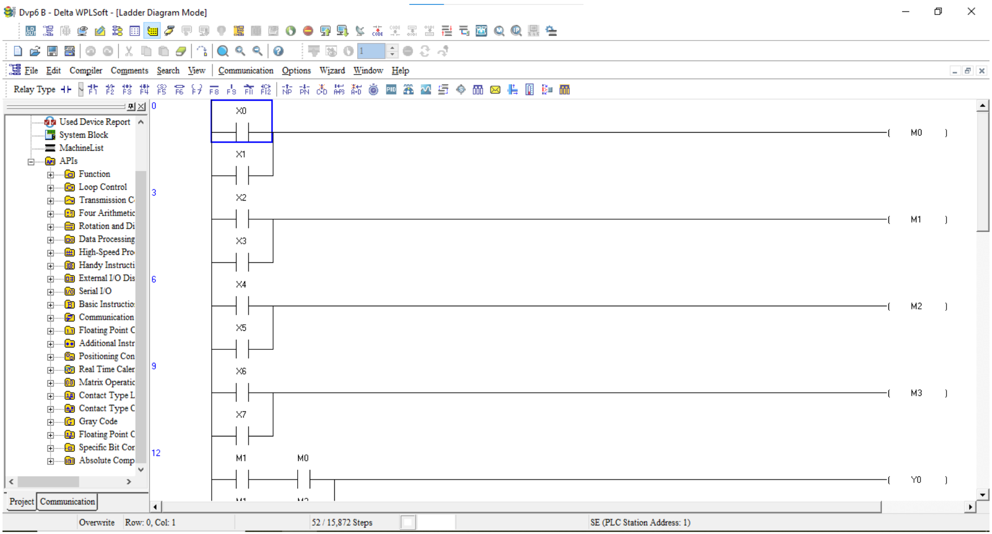


Figure 2.13

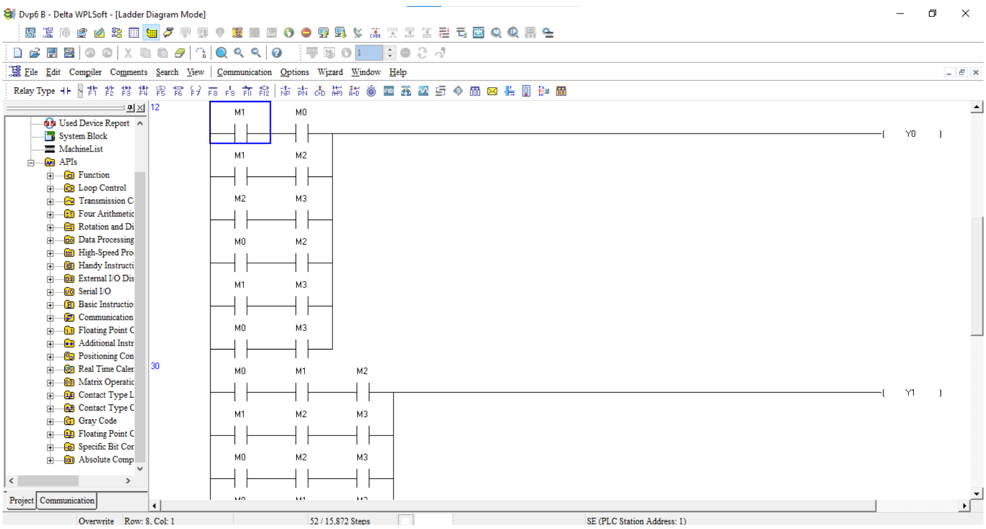


Figure 2.14

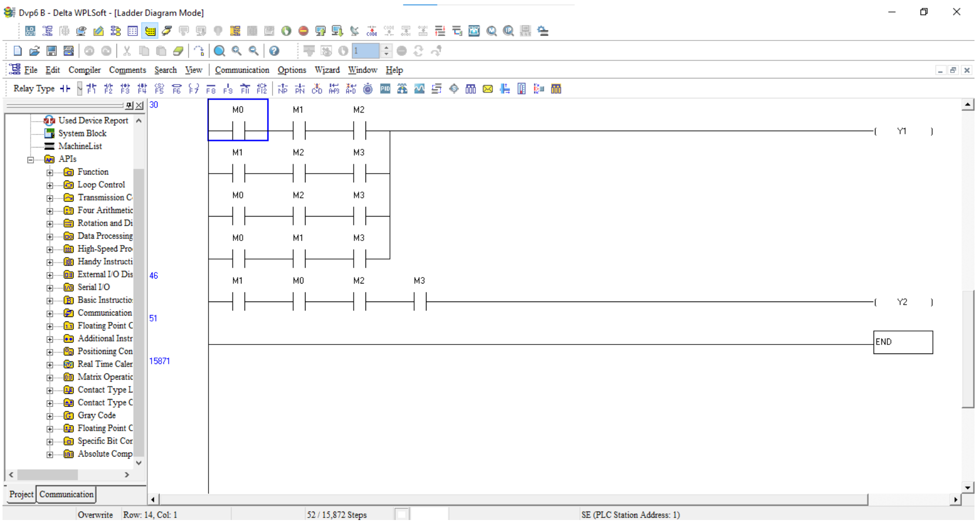

Dvp6 B - Delta WPLSoft - [Ladder Diagram Mode]
File Edit Compiler Comments Search View Communication Options Wizard Window Help
Relay Type
Used Device Report
System Block
MachineList
APIs
Function
Loop Control
Four Arithmetic
Data Processing
Serial I/O
Gray Code
30
M0
M1
M2
Y1
M3
46
Y2
51
END
15871
Project
Communication
Overwrite
Row: 14, Col: 1
52 / 15,872 Steps
SE (PLC Station Address: 1)

Figure 2.15

3.INSTRUCTIONS IN DELTA PLC

3.1. Compare instruction

A Compare Instruction is used in PLC programming to compare two values — like sensor readings, setpoints, or data registers. It checks whether the value is equal, great or less than the other, and turns ON specific outputs based on the result. In Delta PLC, compare instructions are helpful when you want to make decisions based on data comparison — such as temperature, speed, level, or count.

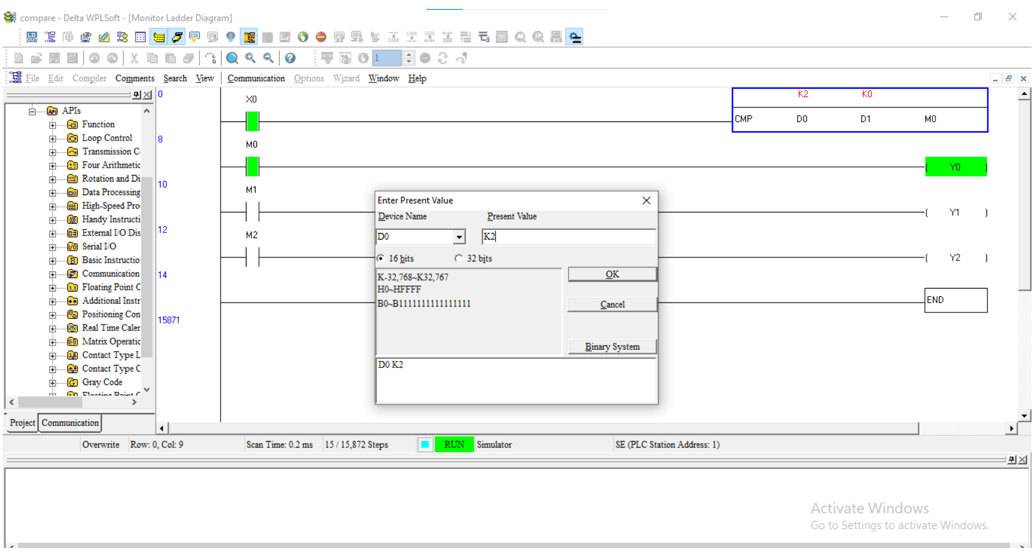


Figure 3.1

3.1.1. Explanation

Let’s consider D0 and D1 as values from two sensors or memory registers. Based on the comparison:

Condition	Then Output
If D0 = D1	then M1 ON
If D0 < D1	then M2 ON
If D0 > D1	then M0 ON

D0 and D1 can be values from sensors, like temperature or pressure. The PLC compares D0 with D1. Based on the result, it turns ON an output (M0, M1, or M2). You can use these outputs to trigger alarms, motors, fans, or indicators. This operation is illustrated in Figure 3.1.

3.2. MOV Instruction

The MOV (Move) instruction in PLC programming is used to copy a value from one location (source) to another (destination). It is commonly used to move constants or data from memory registers, sensors, or counters into specific data registers

(Refer Figure 3.2 and Figure 3.3)

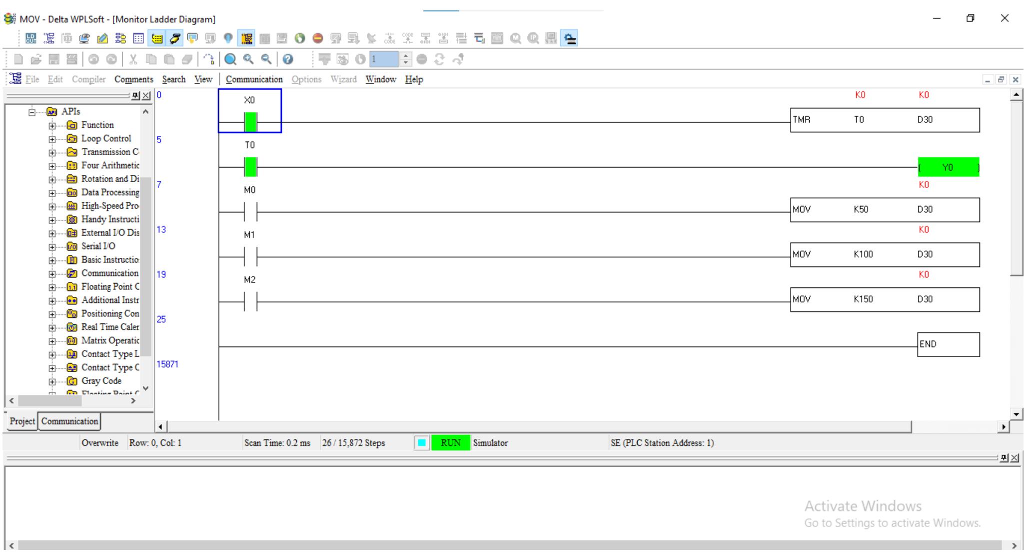


Figure 3.2

3.2.1. Explanation

- If M0 is ON, MOV K50 D30
  →Move condition will be ON.

→Then by this condition, K50 moves to D30.
→ Instead of showing D30, K50 will be shown.

- Same goes to M1, M2.
- After pressing the memory button (M0, M1, or M2), then press the X0 button to run the timer and output the value.

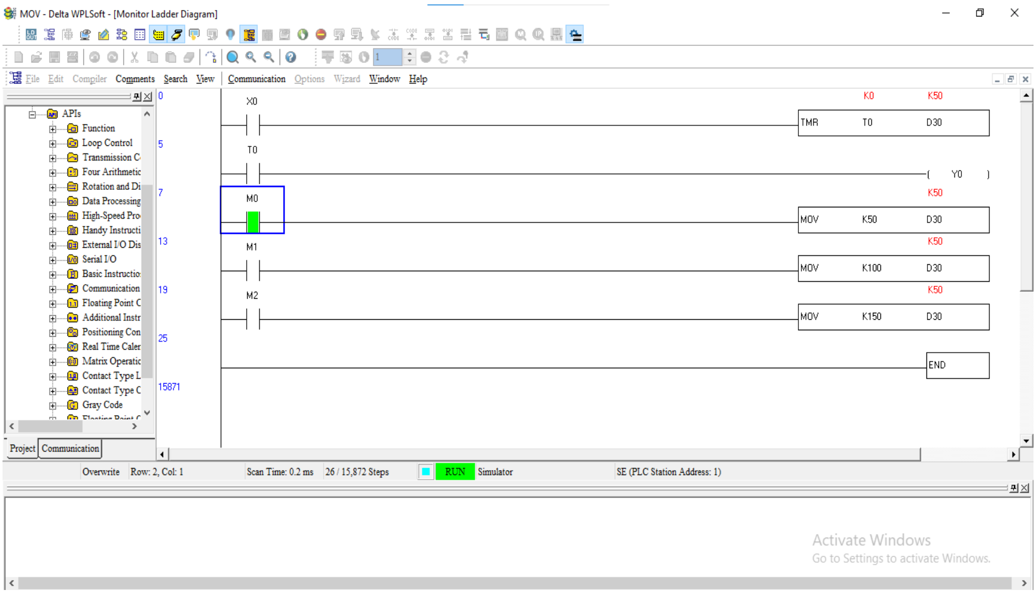


Figure 3.3

3.3. Timer:

A timer in PLC is used to delay the operation of an output for a defined time after the input condition is met. It is used to perform time-based control in automation processes.

3.3.1. Explanation

1.If the switch (X0) is ON:

- M0 and M1 will be activated.
- After the timer T0 finishes running, M2 and M3 will be activated.

2.If the switch (X0) is OFF:

- The timer will start again.
- During this time, M2 and M3 will remain ON.
- After the timer completes, the entire system will turn OFF.

The ladder logic is shown in Figure 3.4

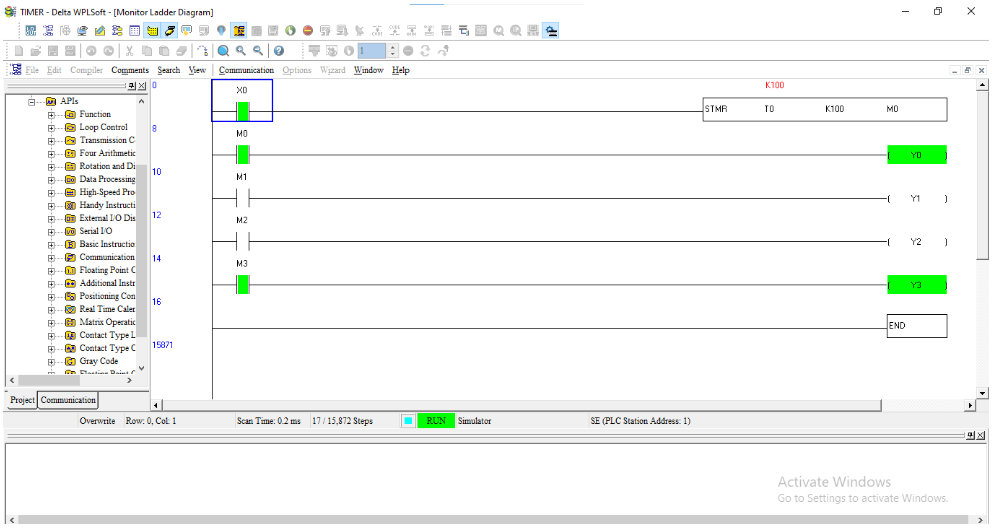


Figure 3.4

3.4. Condition Jump Instruction

A Condition Jump (CJP) in ladder logic is used to skip or jump over a specific section of code depending on a condition. When a condition is true (ON), the program control jumps to a label (like P0), thereby skipping the logic between the jump and the label (Refer Figure 3.5).

3.4.1. Explanation

1.If X0 is ON

X0 = ON, P0 ⇒ Condition Jump to X3

- When X0 is ON, the program encounters CJ P0, which causes a conditional jump to label P0.
- Therefore, the program jumps to the P0 block, and X3 is executed.
- In this state, if you try to turn ON X1, it will not work, because the program has jumped past that part of the logic.

2.If X1 is ON then turn ON X0

- When P0 is placed, only the logic within P0 will execute.

- So, when X1 is ON continuously and P0 is active, even if you turn OFF and then ON X1 again, the output associated with X1 will not respond, because the logic outside the P0 block is being skipped.
- In this state, the output controlled by X1 will remain OFF or unchanged, regardless of changes to X1, since it is not being scanned by the PLC due to the jump.

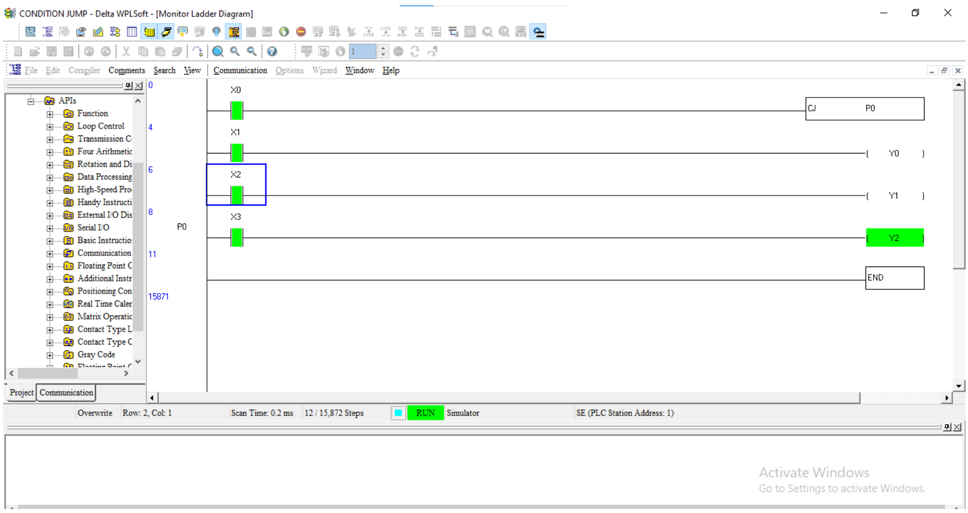


Figure 3.5

3.5. Master Control Instruction

The Master Control (MC) instruction is used in ladder logic to control a group of rungs (logic blocks) together using a single condition — typically like a main switch.

It enables or disables all rungs between Master Control and Master Control Reset.

This master control instruction is shown in the Figure 3.6 and Figure 3.7).

3.5.1. Explanation

1. MC (Master Control) works like a main switch in ladder logic programming.

2. X0 acts as the master control input.

   - When X0 is ON, the MC is enabled, and the outputs Y0 and Y1 (between MC NO and MCR NO) will work if their respective inputs (X1, X2) are pressed.

- If X0 is OFF, then even if X1 or X2 is pressed, Y0 and Y1 will not work.

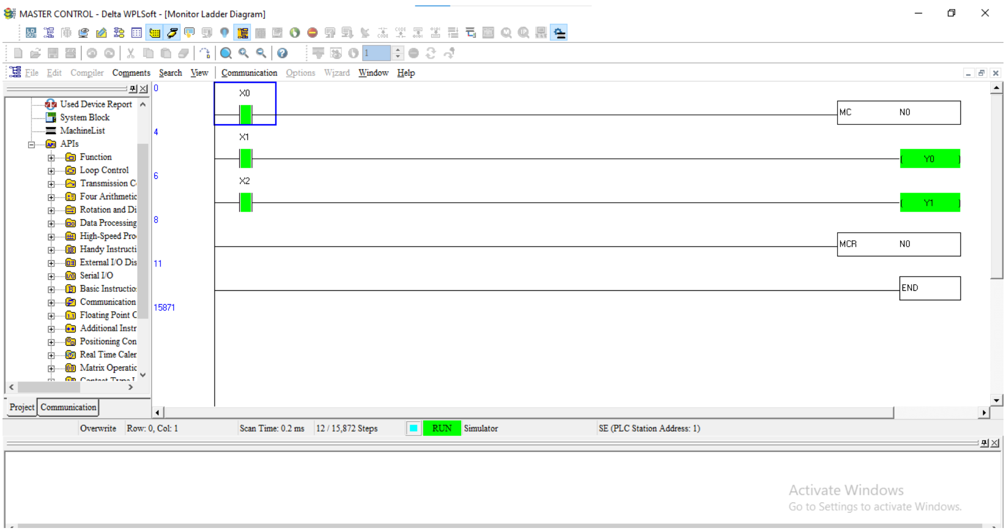


Figure 3.6

3. MC NO marks the start, and MCR NO marks the end of the master control block.

All operations in between are only executed when X0 is ON.

4. This is useful for group control, where multiple outputs depend on one master input.

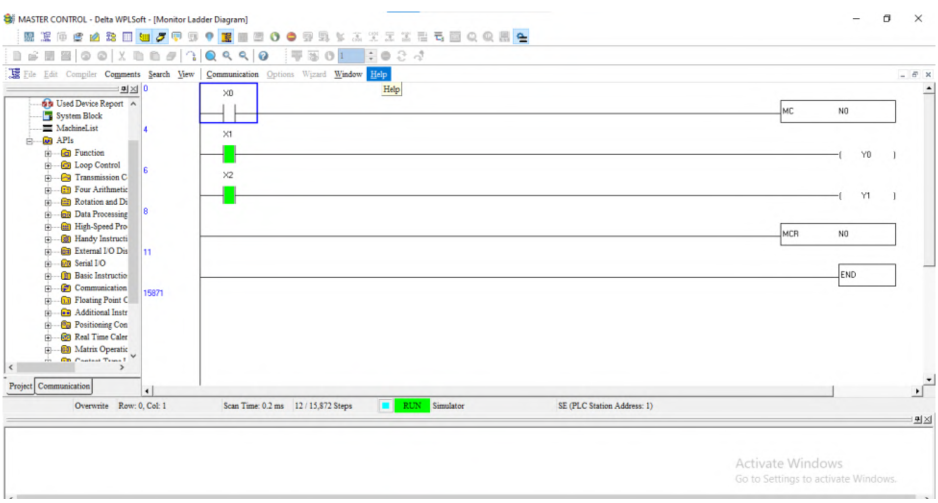


Figure 3.7

4. ABOUT DELTA PLC

It comes in different series.

AH500 series PLC comes with modularized hardware structure. An abundant selection of extension modules gives the AH500 series PLC exceptional system expandability for a broad range of applications.

4.1.DVP series PLC

S Series (Slim Series)	E Series
Power supply & outputs are usually DC.	Power supply & outputs are usually DC.

- Max. I/O points that PLC supports (I/O in PLC + Modules)) is 256.
- Each PLC and most of the analog modules are equipped with built-in RS-485, which can communicate with MODBUS ASCII / RTU.
- SX, SX2, EX and EX2 have got built-in Analog I/O s.

4.2. Motion control PLC

- PM series
- 10PM series
- MC series

4.3. Digital expansion modules

DVP-16SP

- Digital I/O Expansion module for S Series PLC/RTU
- 8 Digital Inputs and 8 Digital Outputs
- Expansion on right side of the controller
- The expansion Module Input ranges from X20 – X377
- The expansion Module Output ranges from Y20 – Y377

4.4. Analog expansion modules

DVP-06XA

- Analog I/O Expansion module for S Series PLC/RTU
- Comprising 4 analog inputs and 2 analog outputs
- Expansion on right side of the controller
- Supports both current and voltage signal
- Uses FROM instruction to read data from input channels
- Uses TO instruction to write data to the output channels

4.5. Addressing in DVP series

4.5.1. Input, Output, and Memory

Type	Device	Range	Function
Input	X	0 to 177	Total 128, follows octal structure. Expansion Inputs start from X20
Output	Y	0 to 177	Total 128, follows octal structure. Expansion Outputs start from Y20
Memory	M	0 to 511	General
		512 to 999	Latched
		1000 to 1999	Special Purpose
		2000 to 4095	Latched

Table 4.1

- **Expansion Module Input Range**: X20 to X377
- **Expansion Module Output Range**: Y20 to Y377
- **Word-Level Addressing Format**: KnX0, KnY0, KnM0
  - n = number of nibbles (1 nibble = 4 bits)
  - Example: K2X0 means an 8-bits byte starting from X0 (i.e., word formed by X7 to X0)

4.5.2. Timers And Counters

T	Timer	100ms	T0–T199, 200 points (*1)	Total 256 points	Once the timer defined by the TMR instruction reaches the preset time, the T contact with the same number is activated.
			T192–T199 for subroutine		
			T250–T255, 6 points (accumulative type)(*4)		
		10ms	T200–T239, 40 points (*1)		
			T240–T245, 6 points (accumulative type) (*4)		
		1ms	T246–T249, 4 points (accumulative type *4)		

Table 4.2

C	counter	16-bit count up	C0–C95, 96 points (*1)	Total 250 points	Once the counter indicated by the CNT (DCNT) instruction reaches its preset value, the associated C contact is activated.
			C96–C199, 104 points (*3)		
		32-bit count up/down	C200–C215, 16 points (*1)		
			C216–C234, 19 points (*3)		
		32-bit high-speed counter	C235–C244, 1-phase 1 input, 9 points (*3)		
			C246, C247, C249 1-phase 2 input, 3 points (*3)		

			C251, C252, C254, 2-phase 2 inputs, 3 points (*3)		

Table 4.3

4.5.3. Word Level Address

D	Data Register	For general	D0–D199, 200 points (*1)	Total is 5000 points	It refers to the memory area designated for data storage, where E and F are used specifically for index indication purposes.
		For latched*	D200–D999, 800 points (*3)		
			D2000–D4999, 3000 points (*3)		
		For special	D1000–D1999, 1000 points		
		For index indication	E0–E3, F0–F3, 8 points (*1)		

Table 4.4

4.5.4. Step Point

S	Step Point	Initial step point	S0–S9, 10 points (*1)	Total is 1024 points	Application device in a step ladder diagram
		Zero point return	S10–S19, 10 points (use with IST command) (*1)		
		For general	S20–S512, 492 points (*1)		
		For latched*	S512–S895, 384 points (*3)		
		For alarm	S896–S1023, 128 points (*3)		

Table 4.5

4.5.5. Pointer Address

Pointer	N	Master control nested	N0–N7,8 points	Control point within a nested master control structure
	P	For CJ, CALL commands	P0–P255,256 points	The designated point for CJ and CALL operations
	I (For interrupt)	External interrupt	I001, I101, I201, I301, I401, I501,6 points	The location point of interrupt subroutine
		Time interrupt	I6□□–I7□□, 2 points (□□=1~99ms, time base=0)	
		High-speed counter reaches interrupt	I010, I020, I030, I040, I050, I060, 6 points	
		Communication interrupt	I150, 1 point	

Table 4.6

4.5.6. Constants

It's a must that we should prefix alphabets to identify the constants.

Type	Representation
Decimal	K
Hexadecimal	H
Float (Real)	F

Table 4.7

4.6. Predefined Memory Functions

Memory Bits	**Functions**
M1000	Always On.
M1001	Always Off.
M1002	On in the first scan.
M1003	Off in the first scan.
M1004	On when error occurs.
M1013	1s clock, 0.5s On / 0.5s Off
M1020	Zero flag.
M1021	Borrow flag.
M1022	Carry flag.
D1313–D1319	Real time clock: Second, Minute, Hour, Day, Week, Year

Table 4.8

4.7. Remote Access of PLC

- PLCs with Ethernet communications allow communication from remote mobile platforms
- Delta provides an Android application to read/write data in PLC
- It uses **Modbus TCP/IP** protocol for communication
- Android application called **Delta Smart VIEWer**
- Use **Wi-Fi connection** and connect to the same network as the device
- Connect to the device by entering:
    - PLC IP address
    - Port number
    - Station ID

5.PROGRAMMING AND EXECUTION FLOW IN DELTA PLC SYSTEMS

Software used is WPLsoft

Step 1:open WPLsoft

- Go to **File > New**, and select the PLC model.
- Since we are using a **Delta SE Series PLC**, select **SE**,as shown in figure 5.1.
- Click **OK**.

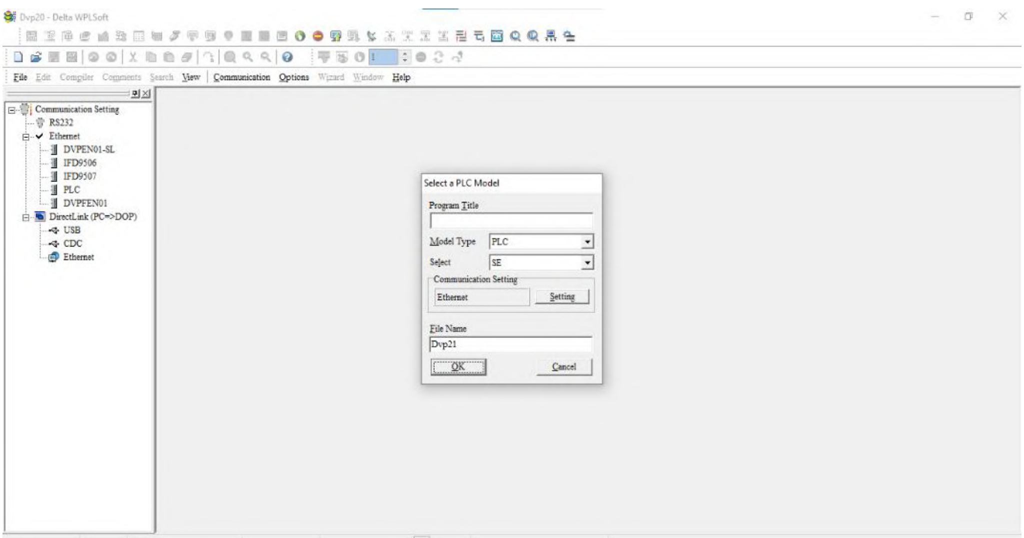


Figure 5.1

Step 2: Open Ladder Diagram and Instruction List Modes

- After selecting the PLC model, both **Ladder Diagram Mode** and **Instruction List Mode** will open automatically as in figure 5.2.

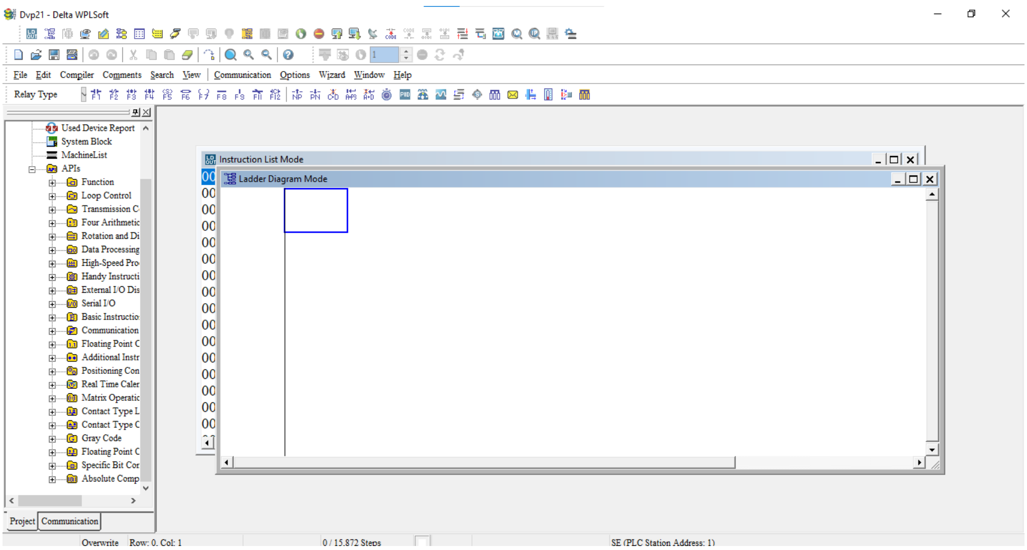


Figure 5.2

step 3 :start ladder programming

- Begin ladder programming by typing the address and pressing **Enter**.
- LD is used for **Normally Open (NO)** contacts.
- LDI is used for **Normally Closed (NC)** contacts.

Input Addresses:

- Use LD X0 to LD X7, LD X10 to LD X17, and so on.
  (Delta PLCs use 8-bit addressing.)
- Refer Figure 5.3

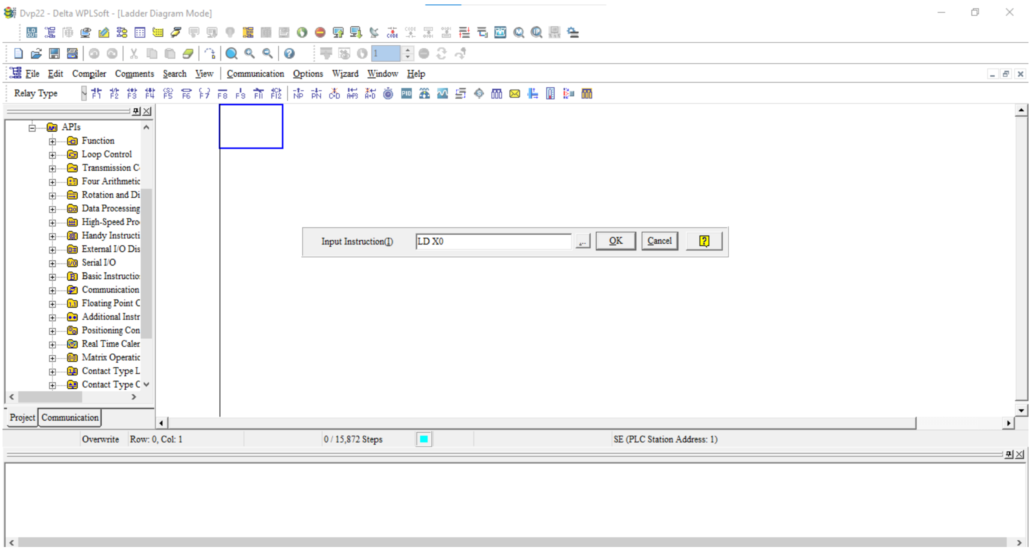


Figure 5.3

Output Addresses:

- Use OUT Y0 to OUT Y7, then press **Enter** (Refer Figure 5.4).

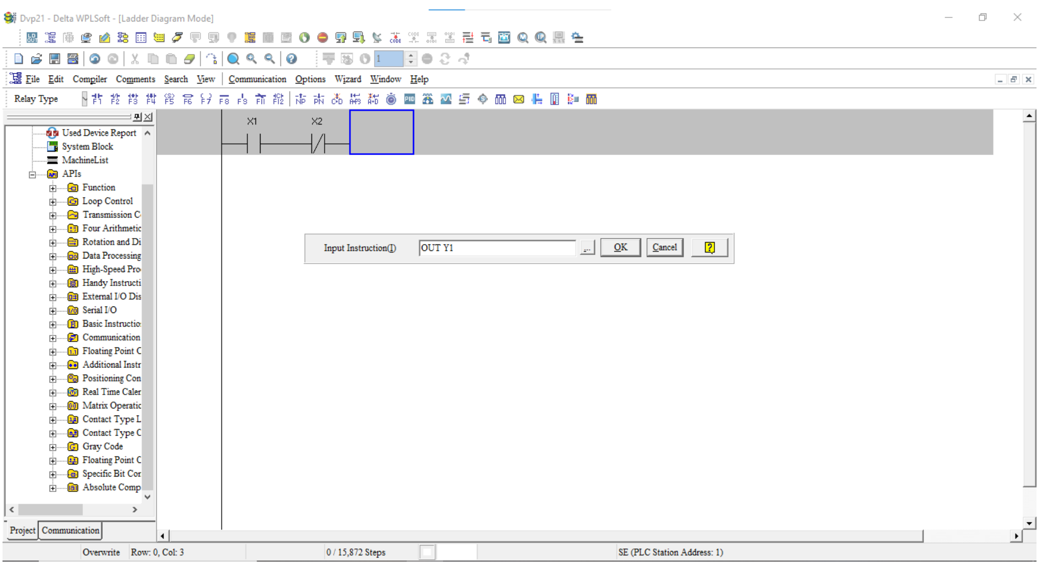


Figure 5.4

Step 4: Simulate the Ladder Diagram *(Optional)*

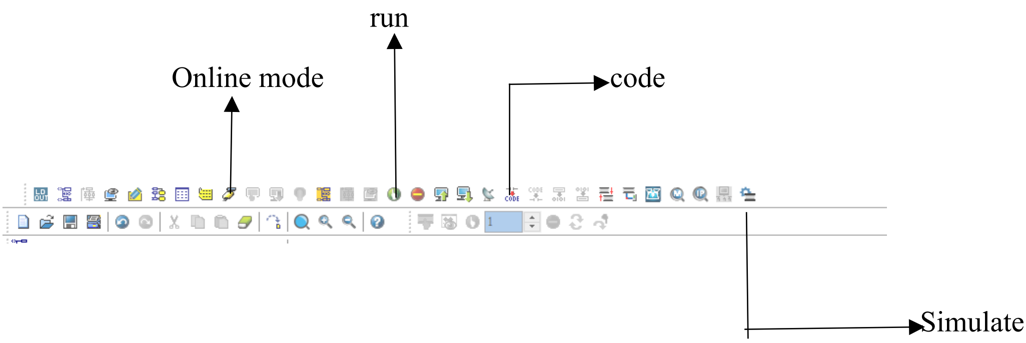


Figure 5.5

- Click the **"Code"** tab on the toolbar.
- Navigate to **Simulate** and click it.
- Enable **Online Mode**.
- Click the **Run** button in the toolbar to start simulation.

Note: Simulation is used only to verify logic before writing the program to a real PLC.

Step 5: Seed the software program to - PLC

- Go to the **Options** menu at the top (Figure 5.6)

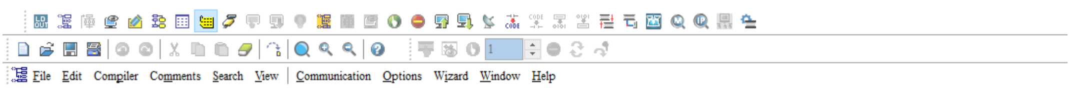


Figure 5.6

- Select **Communication Settings**, and choose the correct **COM port** and **PLC model** as in Figure 5.7.

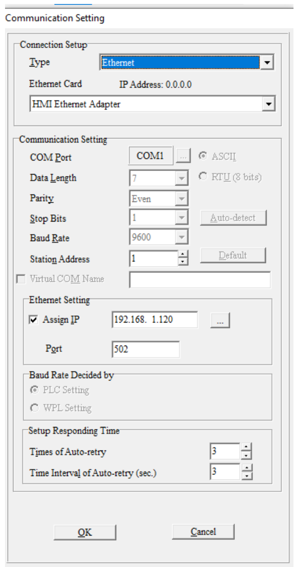


Figure 5.7

- Click **"Write to PLC"** from the toolbar.

Write to plc

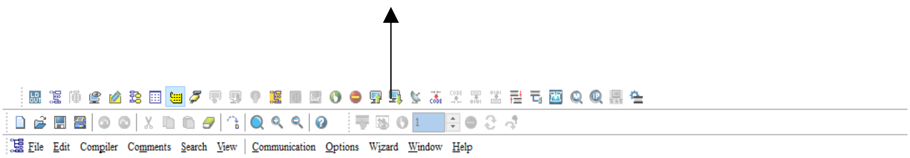


Figure 5.8

- Switch to **Online Mode**.
- Click **Run** to execute the program on the actual hardware.

Note: Step 5 is required only when running the program on real PLC hardware.

6. ADDITIONAL EXERCISES

Example 6.1

When Switch A is pressed Light should flash for 10 sec (ON for 7sec & OFF for 3sec). If continuously switch A is pressed for 4 times light should go OFF. until system 1s reset by switch B.

Solution:

Refer to the following ladder logic diagram in Figure 6.1.

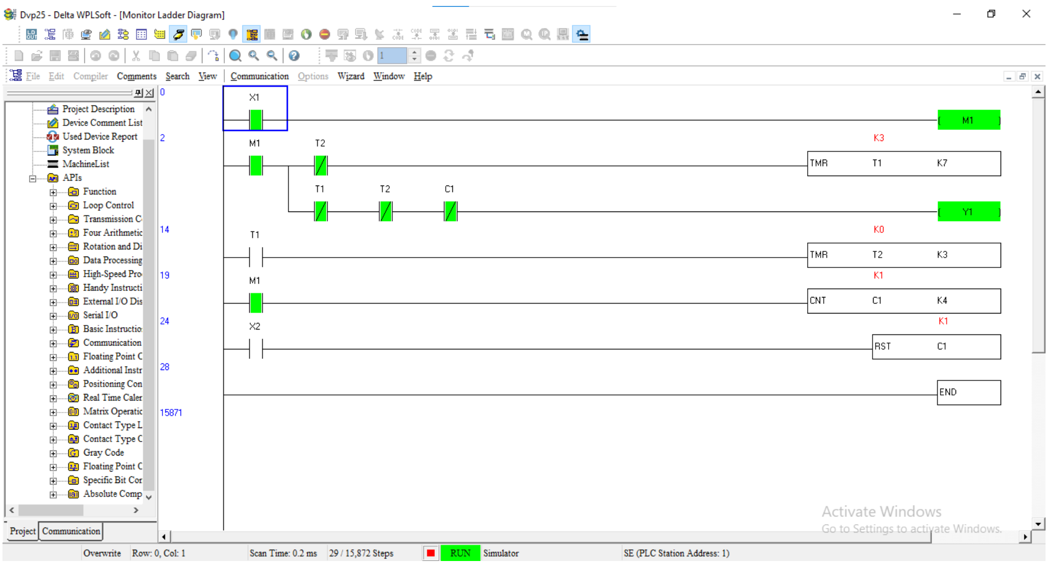


Figure 6.1

Example 6.2

Design PLC ladder diagram for a 4valve control system., Here the four valves are controlled by 4 level sensors. In these four valves only one should be on at a time When a valve gets on, the other valves which were working should go OFF

Solution:

Refer to the following ladder logic diagram in Figure 6.2.

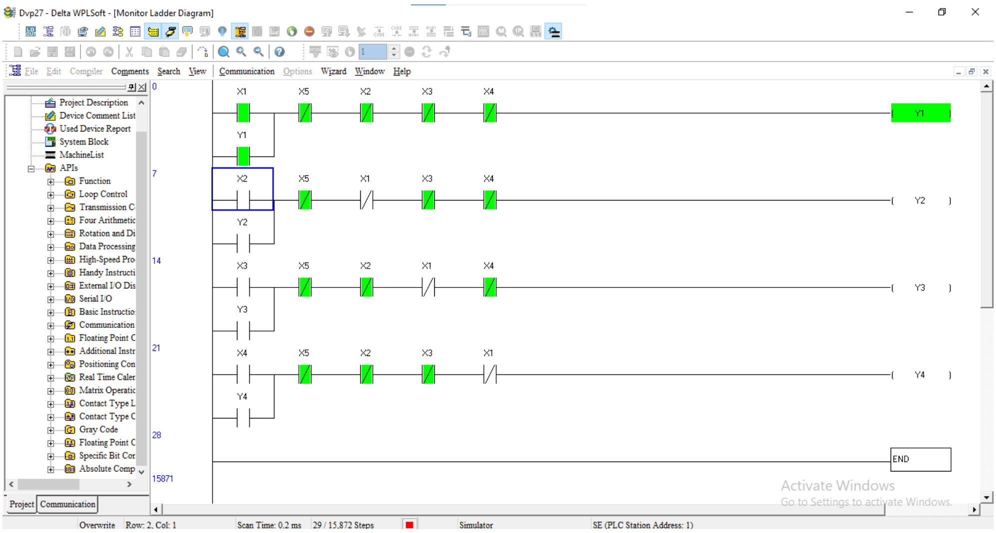


Figure 6.2

Example 6.3

Do the program based on Working of Industrial Furnace/Oven. When switch SW1 is momentarily turned ON alarm and fan should get ON after 20 sec alarm should go OFF while heater should get ON. Once OFF switch SW2 is Pressed, Heater should get OFF and Fan should work for another 10 sec and it should get OFF.

Solution:

Refer to the following ladder logic diagram in Figure 6.3.

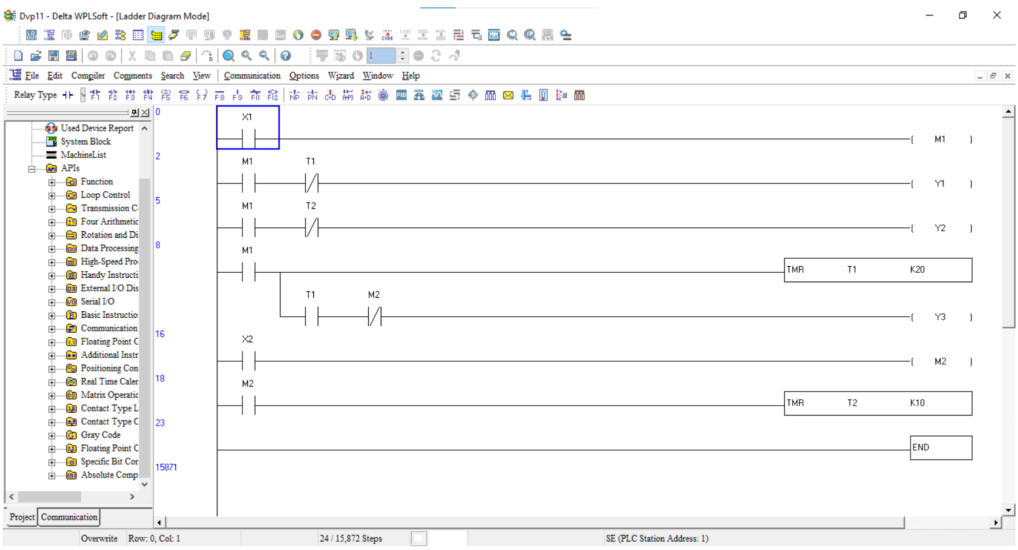


Figure 6.3

Example 6.4

The system to he controlled by PLC consists of three sensors. If both First & Second sensor is high Conveyor will-begin to run Whenever second sensor is tried to switch off, the conveyor should not go off. it should be in- previous state. Conveyor should go off when third sensor is high.

Solution:

Refer to the following ladder logic diagram in Figure 6.4.

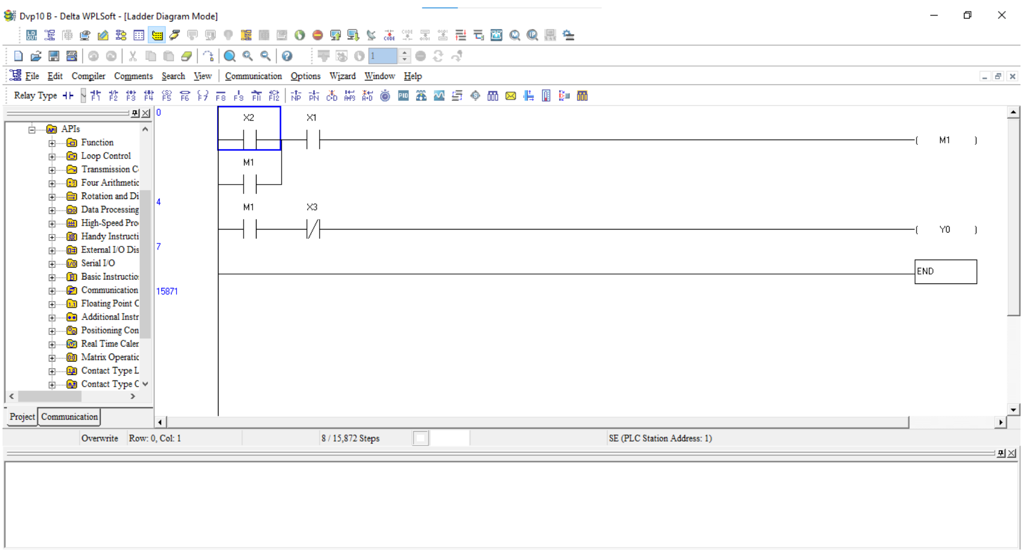


Figure 6.4

Example 6.5

The PLC’s task is to control a simple machine that counts and batches components moving along a conveyor belt. The system must channel ten components to route A and twenty components to route B, and it should also provide a reset capability.

Solution:

Refer to the following ladder logic diagram in Figure 6.5.

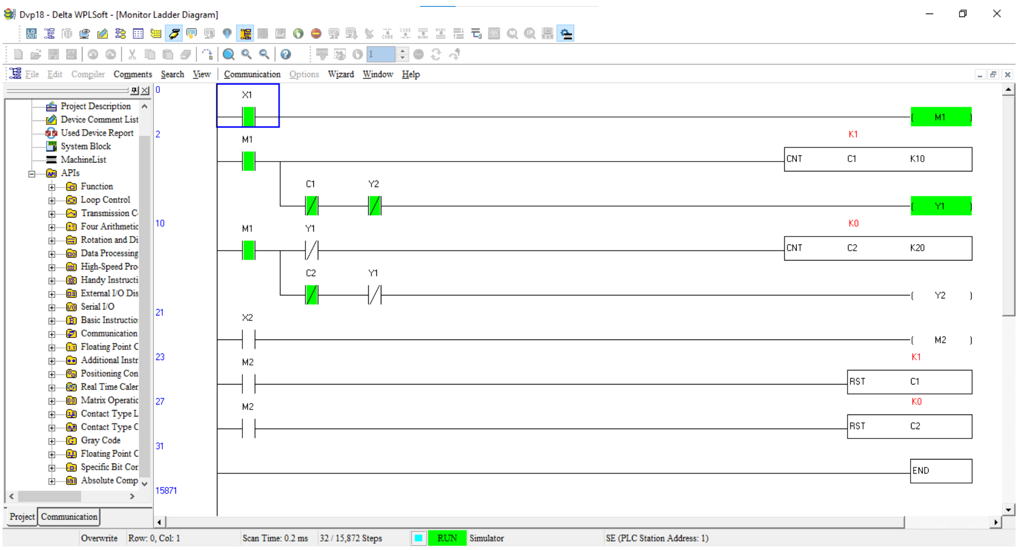


Figure 6.5

Example 6.6

In a fire alarm system there are four channels. In each channel there are two sensors. If the sensor(s) in two different channels are activated, a light should blink. If sensor(s) in three different channels are activated, a hooter is to be energized. If sensor(s) in four channels are activated then motor is to be switched on.

Set a NO push button as acknowledgement for the light and hooter. If it is pressed when the light blinks, the light should become steady. If acknowledgement is pressed while hooter is working the hooter should be switched off.

Please note that if there is a change in the no of channels that are high, then:

1. The light should blink again (even if the light was made steady), if two or more channels are high
2. The hooter should work again (even if the Hooter was acknowledged), if three or more channels are high
3. The working of the motor does not depend on acknowledgement button

Solution:

Refer to the following ladder logic diagram in Figure 6.6 and Figure 6.7.

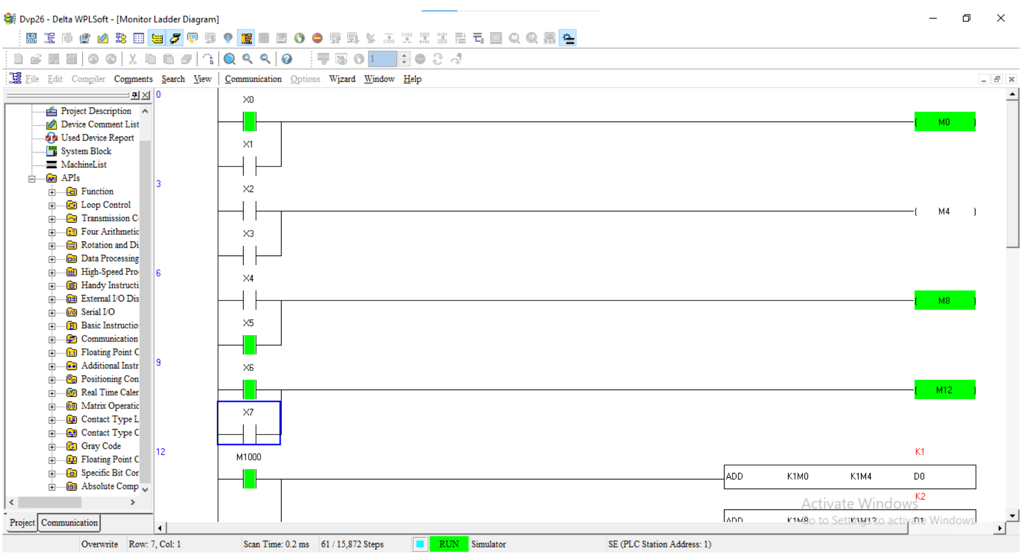


Figure 6.6

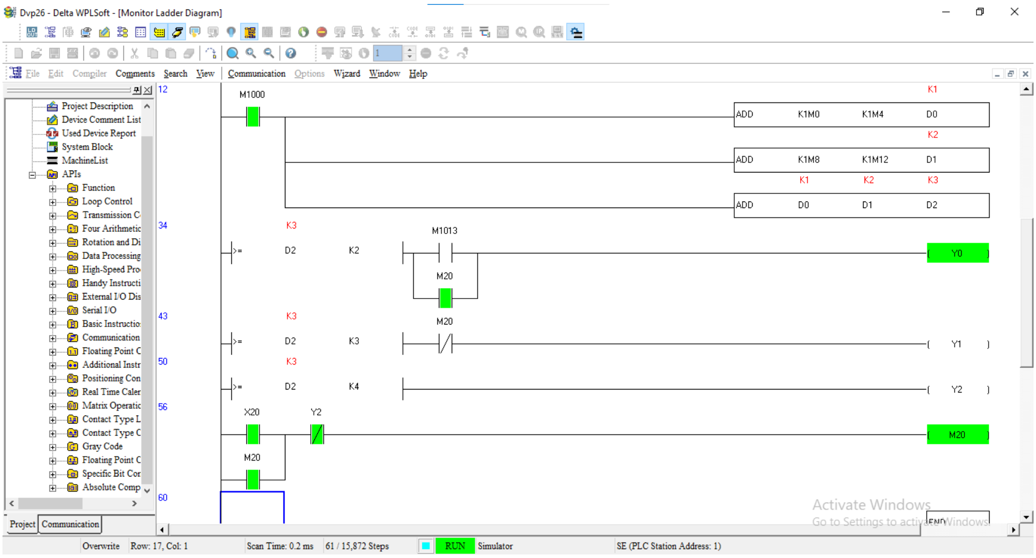

Dvp26 - Delta WPLSoft - [Monitor Ladder Diagram]
File Edit Compiler Comments Search View Communication Options Wizard Window Help
Project Description
Device Comment List
Used Device Report
System Block
MachineList
APIs
Function
Loop Control
Four Arithmetic
Data Processing
Handy Instructi
Serial I/O
Communication
Additional Instr
Real Time Caler
Gray Code
Absolute Comp
Project
Communication
12
M1000
ADD K1M0 K1M4 D0
ADD K1M8 K1M12 D1
ADD D0 D1 D2
34
>= D2 K2
M1013
M20
Y0
43
>= D2 K3
Y1
50
>= D2 K4
Y2
56
X20
Y2
M20
60
END
Overwrite Row: 17, Col: 1
Scan Time: 0.2 ms
61 / 15,872 Steps
RUN
Simulator
SE (PLC Station Address: 1)

Figure 6.7