Sequential Control of Industrial Loads Using PLC

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Abstract-A PROGRAMMABLE LOGIC CONTROLLER (PLC) is an industrial computer control system that continuously monitors the state of input devices and makes decisions based upon a custom program to control the state of output devices. PLC is commonly used in industrial applications all over the world. This project introduces the basic software components of a PLC. The sequence control of industrial load is fully controlled by the SELPRO software, which acts as a heart of the system. This sequence of operation is designed by ladder logic diagram. In industrial sector PLC's offers several advantages, hence it is widely used. The devices that usually controlled by PLC are push button, relays, motors, timers and other devices.
Keywords- Push buttons, Motors, Timers, Ladder Logic.

1. Introduction

Sequential control of industrial loads using Programmable Logic Controllers (PLCs) is a fundamental aspect of modern industrial automation. PLCs are specialized computing devices tailored for the precise control of machinery and processes. In this context, sequential control refers to orchestrating a series of operations in a predefined order, ensuring that industrial loads, such as motors, conveyors, and valves, are activated and deactivated as needed during the manufacturing or production process. PLCs receive input signals from various sensors and switches, which convey information about the state of the system. Through carefully programmed logic, these controllers execute operations in a deterministic and coordinated manner. This capability makes PLCs vital for maintaining efficiency and safety in industrial settings, as they can handle complex sequences, detect errors, and incorporate safety measures while offering a robust and reliable solution for industrial control.

2. Literature Survey

A programmable logic controller, also called a PLC or programmable controller, is a computer- type device used to control equipment in an industrial facility. The kinds of equipment that PLCs can control are as varied as industrial facilities themselves. Conveyor systems, food processing machinery, auto assembly lines...you name it and there's probably a PLC out there controlling it. In a traditional industrial control system, all control devices are wired directly to each other according to how the system is supposed to operate. In a PLC system, however, the PLC replaces the wiring between the devices. Thus, instead of being wired directly to each other, all equipment is wired to the PLC. Then, the control program inside the PLC provides the "wiring" connection between the devices. The control program is the computer program stored in the PLC's memory that tells the PLC what's supposed to be going on in the system. The use of a PLC to provide the wiring connections between system devices is called soft wiring.

3. Block Diagram

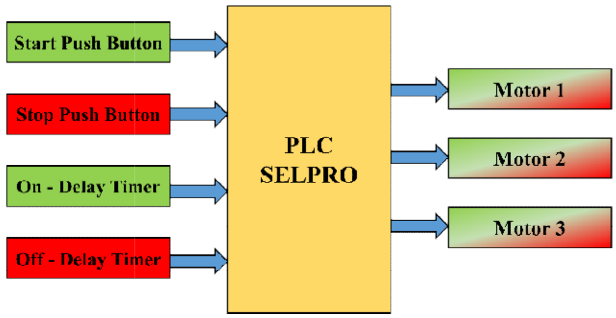

Fig 1: Block Diagram

4. Selpro Software

The software we have used in this project is SELPRO Software.SELPRO is a software developed by Selec Controls, a company that provides electrical and industrial automation solutions . SELPRO is used to program and configure Selec products, such as PLCs, HMIs, timers, counters, etc., SELPRO is an open source software.Steps to open SELPRO Software:

1. Open SELPRO Software
2. Open New File
3. Select Product, Enter Name and Click on Next
4. Then Click on Finish
5. A graphic editor page gets opened then start drawing the ladder logic diagram

5. Programming

There are five different types of PLC programming languages. They are:

1. **Ladder Diagram (LD):** A graphical diagram that represents a program.
2. **Function Block Diagram (FBD):** A graphical type like a Ladder Diagram (LD).
3. **Structured Text (ST):** A language that uses text-based instructions.
4. **Instruction List (IL):** A language that uses a series of instructions.
5. **Sequential Function Chart (SFC):** A language that uses a flowchart-like structure.

The programming language we have used in this project is ladder logic programming. Ladder logic is one of the most popular and widely used PLC programming languages because it is easy to learn, intuitive to understand, and compatible with many PLC brands and models.Ladder logic programming is a graphical programming language used to program and control industrial automation systems, especially programmable logic controllers (PLCs). It was originally developed to resemble the electrical relay circuits that were used to control machinery before the advent of PLCs. Ladder logic consists of symbols that represent logic operations, such as AND, OR, NOT, timers, counters, etc. These symbols are arranged in horizontal lines called rungs and vertical lines called rails, forming a ladder-like structure. Each rung represents a condition or an action that is executed by the PLC. The PLC scans the ladder logic program from left to right and top to bottom, updating the inputs and outputs according to the logic diagram.

Ladder Logic:

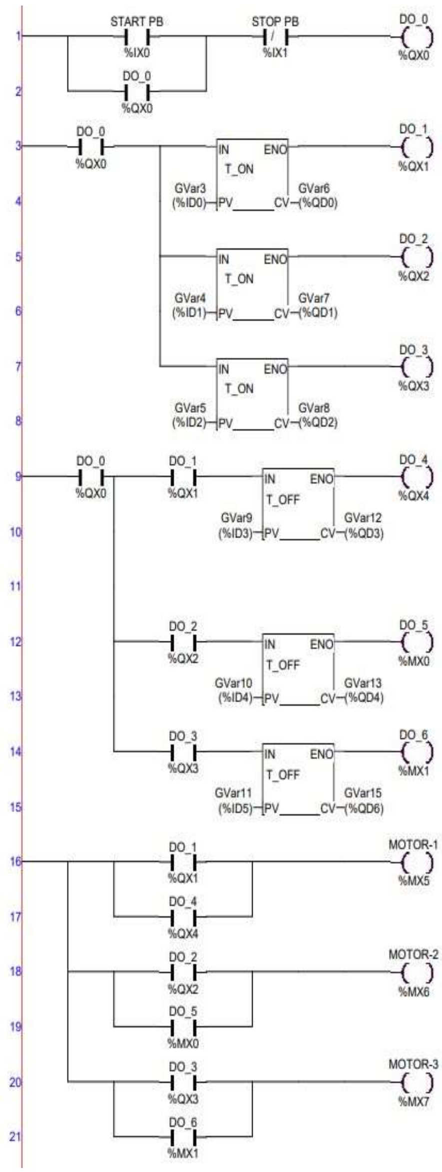

Figure 2: Ladder Logic

The above figure shows the program for Sequence control of motors with the help of PLC.

6. Working

The working of Sequential control of motors is a method of controlling the operation of multiple electric motors in a predefined order. It utilizes various control components such as relays, timers, and contactors to activate and deactivate the motors in a predetermined sequence. The circuit ensures that the motors start and stop in a sequence, allowing for smooth operation and preventing overload or mechanical stress.
In this ladder logic programming we are taking two push buttons i.e., Start Push button and Stop Push button for turning-on and turning-off the motors. Whenever the Start Push button is pressed this will turn on input D0_0, closing the circuit and activating output D0_0.The D0_0 output is given as input to the Timer-ON delays and Timer-off delays. Every motor has individual timer-on delay and timer-off delay. The output of the timer-on and timer-off delays are given as input to the motors. The logic is programmed in such a way that each motor given a specific time to turn-on and turn-off with a delay of 5sec.

Sequence of Operation:

1. **Sequentially turning-on the motors:**
   1. **Motor "M1"** = Pressing the Start Push button closes the contacts of input "DO_0", causing Motor "M1" to start operating. At the same time, the coil of Timer On-Delay "T1" is energized and begins counting time of t=5sec.
   2. **Motor "M2"** = Once Timer "T2" reaches the preset time, its normally open contact closes, supplying power to contactor "DO_2" and causing Motor M2 to start operating. At this point, the normally closed contacts of contactor DO_2 opens, at the same time the coil of Timer On-Delay "T2" is energized and begins counting time of t=10sec.
   3. **Motor "M3"** = When Timer "T3" reaches the preset time, contactor "DO_3" is energized, causing Motor M3 to start operating. At the same time the coil of Timer On-Delay "T3" is energized and begins counting time of t=15sec.
      - The operation of Motor "M2" and Motor "M3" is dependent on the running status of Motor "M1".
      - Motor "M2" can only run when Motor "M1" is already in operation.
      - Motor "M3" can only operate when both Motor "M1" and Motor "M2" are already running.
2. **Sequentially turning-off the motors:**
   1. **Motor "M3"** = Whenever the Stop Push button is pressed the DO_6 gets de-energized at a time of t=5sec then the Motor "M3" automatically stops working.
   2. **Motor "M2"** = Whenever the Stop Push button is pressed the DO_5 gets de-energized at a time of t=10sec then the Motor "M2" automatically stops working.
   3. **Motor "M1"** = Whenever the Stop Push button is pressed the DO_4 gets de-energized at a time of t=15sec then the Motor "M1" automatically stops working.

7. Simulation Results

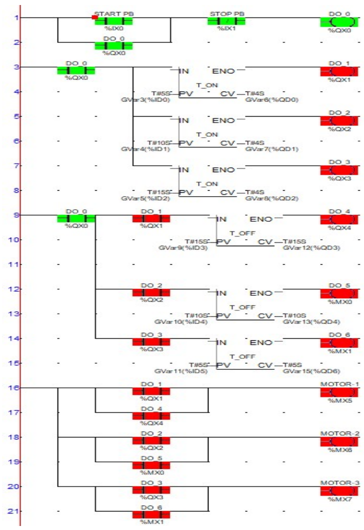

Figure 3: This above figure shows the simulation result of pressing the Start Push button for sequentially turning-on the motors.

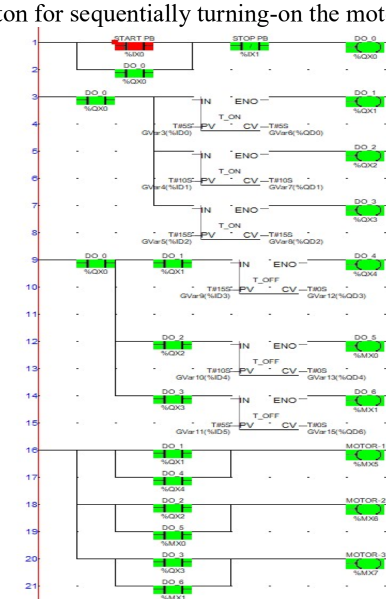

Figure 4: This above figure shows the simulation result of Sequentially turning-on the motors.

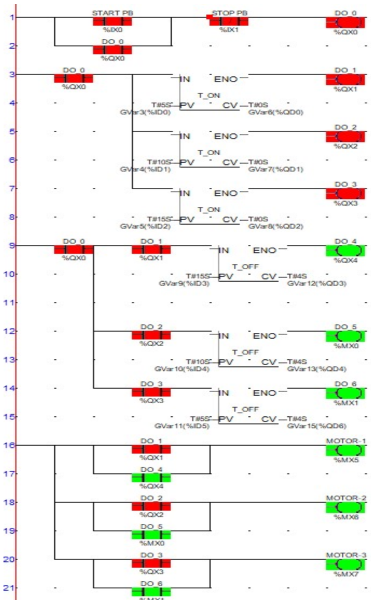

Figure 5: This above figure shows the simulation result of pressing the Stop Push button for sequentially turning-off the motors.

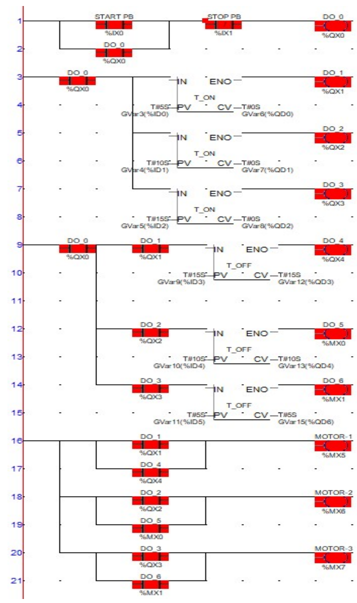

Figure 6:This above figure shows the simulation result of Sequentially turning-off the motors.

8. Advantages

1. Faster response time compared to manual control
2. Optimized Process Flow
3. Reliability and accuracy in controlling complexsequences
4. Low cost
5. PLCs operate in real-time, ensuring quick response tochanging conditions
6. Improving efficiency, safety, reliability, and quality
7. Flexibility to modify sequences without major hardware changes

9. Applications

Sequential motor control circuits have a wide range of applications in various industries. The following are some common applications of sequential motor control circuits:

1. Sequential motor control circuits are widely used in conveyor systems to control the movement of materials. The circuit ensures that each motor is activated in sequence to move the material along the conveyor.
2. In pump systems, sequential motor control circuits are used to control the flow of liquids or gases. The circuit activates each pump in sequence to ensure a smooth and efficient flow of fluids.
3. HVAC (Heating, Ventilation, and Air Conditioning) systems require precise control of multiple components, including motors. Sequential motor control circuits are used to ensure that each motor is activated in the correct sequence to achieve optimal performance.
4. Sequential motor control circuits are used in various manufacturing processes, such as assembly lines, to control the movement of materials and machinery.
5. In industrial automation, sequential motor control circuits are used to control the operation of machines and equipment in a precise sequence to ensure maximum efficiency and productivity.

Future Scope

PLCs can benefit from advanced simulation and virtualization tools that allow engineers to model and test control sequences before implementation. This reduces downtime and risks associated with changes to motor control logic. Energy conservation is a growing concern. PLCs will continue to play a significant role in optimizing motor control to reduce energy consumption and environmental impact. The future of sequential control of motors in PLCs holds great potential for innovation and improvement. Advancements in connectivity, AI, safety, and efficiency will continue to shape the field, offering manufacturers more robust, flexible, and sustainable solutions for motor control in various industrial applications.

Conclusion

We conclude that the sequential control of motors in PLCs is a fundamental component of modern industrial automation, offering precision, reliability, and adaptability to meet the needs of various manufacturing processes. Effective PLC programming and maintenance play a vital role in ensuring the smooth and efficient operation of motor-driven machinery in industrial settings. The sequential control of motors in a

Programmable Logic Controller (PLC) is a crucial aspect of industrial automation and manufacturing processes. PLCs provide a robust and reliable platform for managing the operation of motors in a systematic and coordinated manner. By using ladder logic programming or other programming languages, PLCs can control the activation, deactivation, speed, and direction of motors to achieve precise and efficient control over various processes.

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