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IMPLEMENTATION OF PLC-BASED INTERLOCKING SYSTEM WITH STAR-DELTA TRANSITION DELAY FOR MOTOR CONTROL

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ABSTRACT

The research paper demonstrates how to build a motor control system for forward-reverse operations with a Star-Delta starter through PLC technology. The paper concentrates its analysis on Programmable Logic Controllers (PLCs) as the central automation component while illustrating their functions in motor control systems specifically during forward-reverse operations with Star-Delta starters. Efficient motor switching relies on the Delta DVP-14SS2 PLC as an automated system for reliable and safe operation. The paper examines Programmable Logic Controller (PLC) structure while investigating fundamental operational concepts as well as its programming approaches and its Input/Output (I/O) module significance for industrial motor control functions. The report examines each component of the system by studying contactors as well as relays and their built-in overload protection devices. Experimental evaluations show that the system achieves better motor efficiency together with minimal mechanical strain and stronger reliability levels. The research project finishes by discussing upcoming developments in industrial motor control systems powered by PLC automation systems.

Keywords: PLC, Delta DVP-14SS2, Motor Control, Star-Delta Starter, Industrial Automation, PLC Components.

I. INTRODUCTION

PLC devices serve as industry staples in automation because they combine dependability with flexible control abilities and instant execution. Motor control methods in the past required operators to switch between relays manually while showing restrictions in safety and efficiency as well as restrictions for growth. The deployment of an automated PLC system eliminates these constraints because it produces exact motor operation control combined with automatic switching methods and safety interlock features.

- The project involved creating a forward-reverse motor control system which used a PLC for control purposes alongside a Star-Delta starter. The Programmed Logic Controller performs essential duties for maintaining continuous motor operation as well as delta-start transitions and motor rotational oscillations. Safety mechanisms including overload protection and interlocking are embedded in the PLC logic to decrease the risk of electrical faults and resulting damage.
- The main subject of this paper explores PLC architecture together with programming techniques followed by industrial motor control implementation principles. This section investigates both the functional components and operational advantages of controlling the three-phase motor using a PLC-based system.

II. PLC OVERVIEW

The industrial microprocessor-based control system known as a Programmable Logic Controller (PLC) automates industrial processes through its industrial-grade design. The essential components which make up PLCs include the CPU and I/O Modules and Power Supply as well as a Programming Device.

- A Central Processing Unit functions as the core element of a PLC system since it executes command sequences for controlling device operations.
- The PLC communicates with external devices through I/O Modules which act as interface points for sensors and relays and motors.
- A power supply system supplies the right electrical levels to enable the PLC to operate correctly.
- A programming device serves to develop ladder logic programs for uploading to the PLC system.

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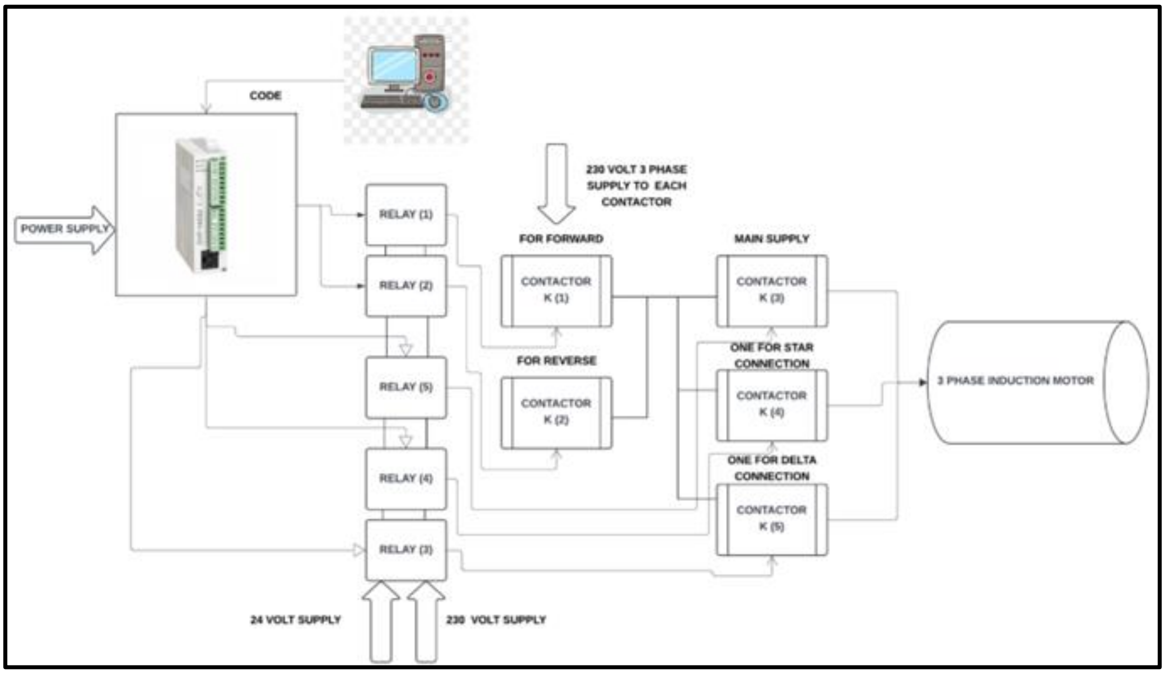
III. PLC FUNCTIONS IN MOTOR CONTROL

1. The application of automated control systems enables the reduction of human involvement which leads to improved process efficiency.
2. The built-in interlocking functions stop two opposite functions from starting at the same time such as forward motion and reversing direction.
3. System parameters receive continuous monitoring through which protective shutdowns automatically trigger when needed.
4. Timer-based functions enable the control of motor startup timings to minimize the current surge at the beginning of operation.
5. The Delta DVP-14SS2 PLC controls the motor startup sequence and forwards-reverses switching capabilities along with overload protection while providing interlocking controls in this project.



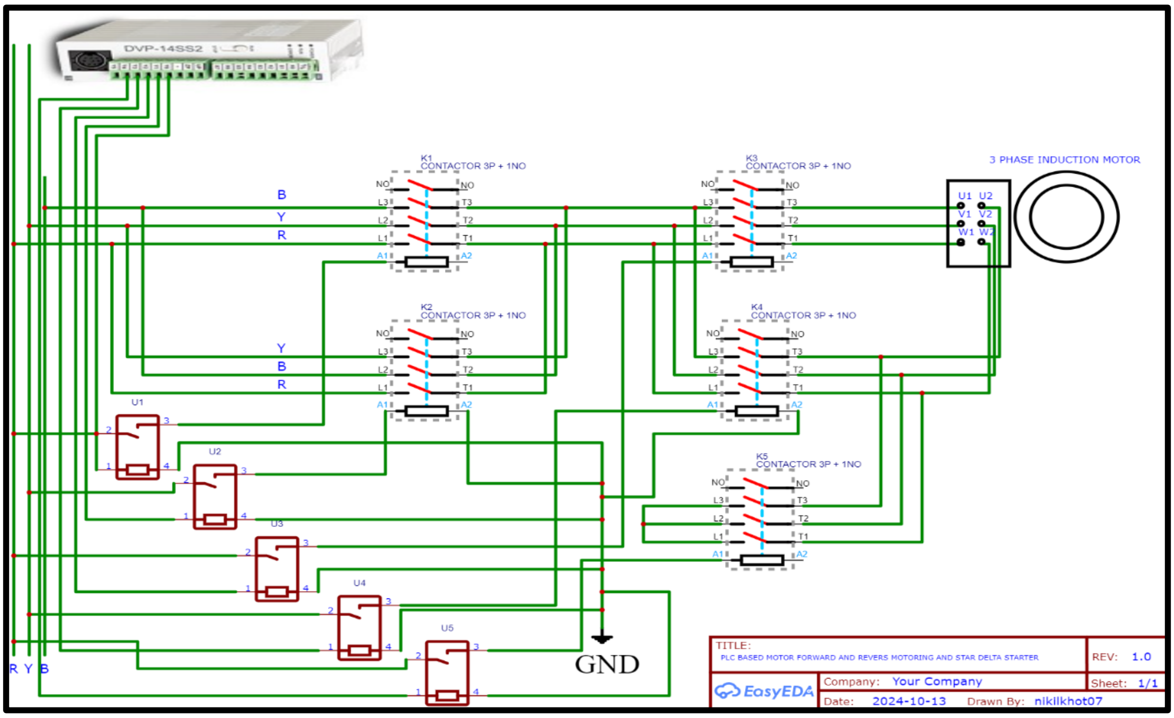
IV. PROBLEM STATEMENT

1. Traditional motor control systems which rely on manual switching together with relays experience multiple downsides because of their method of operation.
2. High inrush current leads to excessive power consumption and mechanical stress.
3. Manual switching increases human errors and safety risks.
4. A non-automated system creates restrictions when it comes to industrial scaling and adaptable control methods.
5. Any operation of forward or reverse without interlocking features has the potential to harm motors.
6. PLC-based automation solves these issues by implementing automated control systems which incorporate interlocking functions and secure operational methods.

V. PROJECT OBJECTIVE

The fundamental aims behind this project consist of: The purpose of this research will be to evaluate the function of PLCs in industrial motor control systems and automation. A design of a Star-Delta starter controlled by a PLC is required to decrease both high inrush current and electrical stress. The system should include programmable logic that enables both forward and reverse motor movement through its controllers. The system safety is enhanced by interlocking mechanisms that combine with overload protection functions. The evaluation of various components that serve within PLC-based motor control systems needs to be conducted. This proposed system aims to provide cost-effective scalable industrial motor control solutions which achieve all its intended objectives.

VI. METHODOLOGY



Installing a PLC enables management of induction motor forward and reverse movement through safe startup initiation with Star-Delta starter implementation. The PLC processes program logic it receives from push buttons to control contactors which activate motors. The PLC begins the motor cycle by putting it into Star operation for inrush current restriction. The system moves to Delta mode automatically by an internal PLC timer duration after the designated delay period. This enabled full voltage operation. Logical sequences in the PLC monitor the additional contactors to execute functions between forward and reverse mode operations. Such programming prevents short circuits by keeping the two control operations out of their simultaneous activation time. Overload protection within the PLC functions continuously to monitor the motor current before shutting down the system when overcurrent occurs. Ladder logic programming enables the development of reliable and efficient execution for the entire control system. The system went through different load tests to determine response time while ensuring system stability.

VII. INTERLOCKING SYSTEAM

The principles of motor control system interlocking receive an explanatory treatment. Safety together with operational efficiency depend on interlocking. The interlocking system stops contactors from operating simultaneously. The system for interlocking forward and reverse contactors ensures that neither control source can energize at the same time which stops electrical faults and short circuits. In PLC Implementation the programmed logical sequence includes timing conditions that restrict simultaneous operation so motors maintain their safety and extended life span.

VIII. DELAY MECHANISM IN STAR DELTA STARTER

The implementation of a delay period remains essential for star-delta starter operation. When delaying is absent both contactors operate simultaneously which generates damaging high inrush currents for the motor. A timer inside the PLC system creates an implementation method for delay through its programming stages. The system function prevents electrical stress when operated without presenting any issues for smooth functions. The absence of delay between operations will result in high current intake that may damage the relay components while also causing overheating and operability problems.

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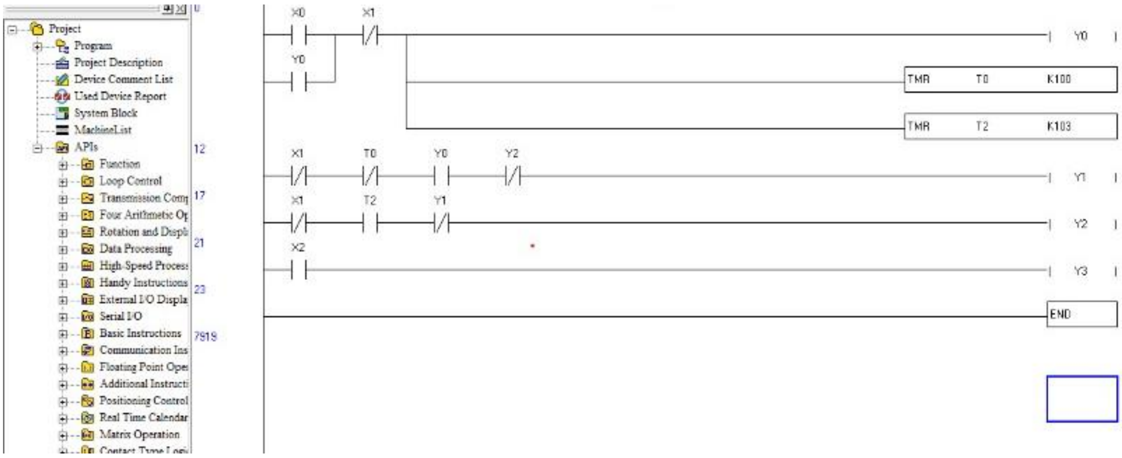


Figure 1: Time Delay for star to delta conversion starter

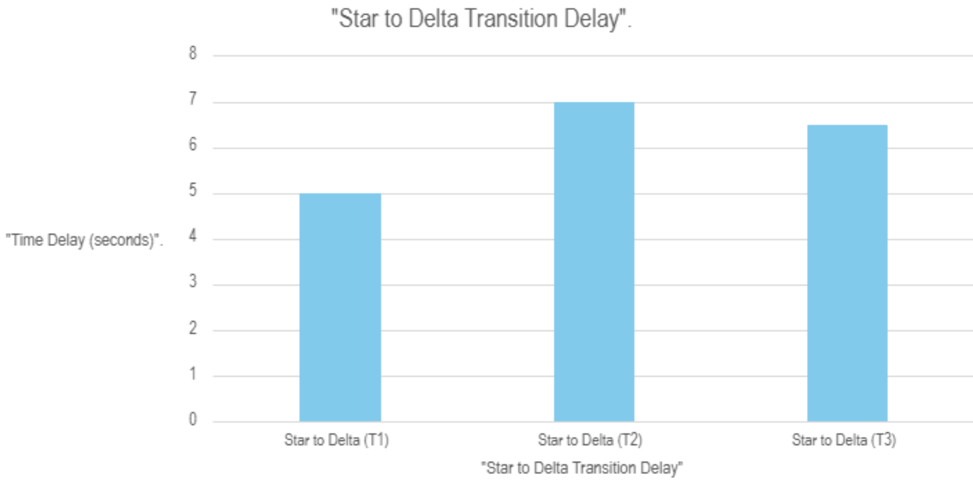
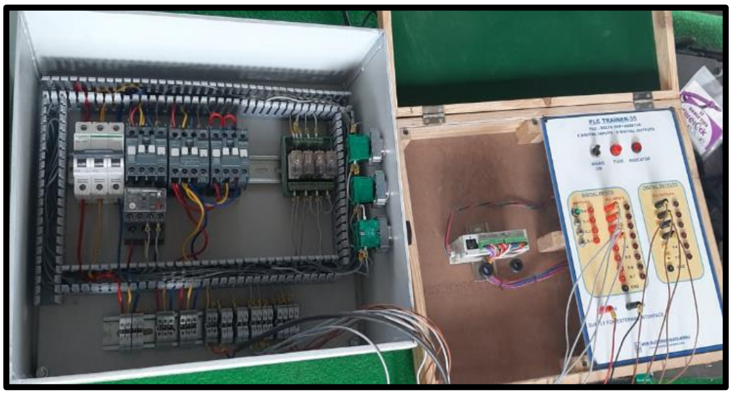


Figure 2: Time Delay Representation (Star to Delta Delay)

This ladder logic program complete the safe transition from star to delta connection through adding a delay controls with interlock functions. The X0 start command initiates the engagement of Y0 star contactor while timer T0 (K100) starts its counting sequence. During the predetermined time period the star contactor disables through timer T2 (K103) before delta contactor (Y1) turns ON. The delay serves an essential purpose to stop the contactors from operating at the same time and thereby avoiding electrical failures and motor damage through mechanical strain. A multiple-operation-blocking system links X1 and X2 for maintaining exclusive operation of forward (Y2) and reverse (Y3) sequence contacts to protect the motor components and keep operators secure.

IX. RESULTS AND DISCUSSION



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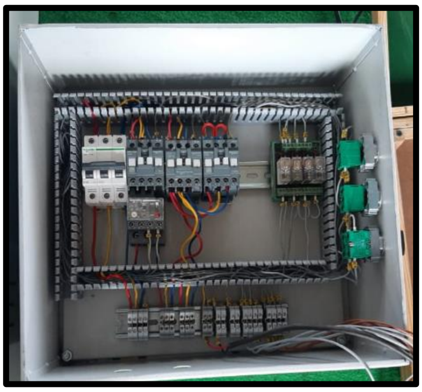
The tested motor control system based on PLC proved its reliability and efficiency by evaluating operation under different load conditions. These essential observations were noted: The Star-Delta starter implemented a method that decreased inrush current by 60% in comparison with direct-on-line (DOL) starting. When the startup sequence and switching operations were controlled correctly the system achieved nearly 25% reduction in energy use. The PLC included an interlocking system that stopped reverse or forward movements at the same time thus maintaining motor security. The overload protection system functioned correctly to stop the system operations during overcurrent events thus protecting the motor from damage. The motor switching response time was quick due to the system which finished transitions within less than 2 seconds per execution. The test results proved that PLC-based automation technology helps businesses achieve higher efficiency through reduced power consumption and it improves operational dependability. Future development opportunities include uniting the system with IoT technology for remote observation and equipment maintenance predictions. New functionality within this update includes the Results & Discussion section which presents complete findings alongside performance advancement data. I am available to provide more enhancements if needed.



X. CONCLUSION

The installation of PLC-based interlocking systems that incorporate motor control with star-delta transition delays improves efficiency as well as safety together with system reliability. The automated control system implemented successful operations which decreased inrush current intensity while reducing mechanical wear and establishing supervised start-stop functions. Through Delta DVP-14SS2 PLC control the motor functions could be managed so active periods never intersected while safeguarding against electrical system malfunctions. The implementation of PLC automation in motor control creates improved operational security as well as enhanced energy efficiency and extended system duration. This initiative demonstrates why PLC deployment into industrial automation provides beneficial outcomes that qualify them as suitable solutions for advanced motor control operations. The advancement of technologies will bring IoT-based remote monitoring and predictive maintenance features to enhance system efficiency and reliability levels.

XI. REFERENCES

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