Synchronization of two motors for precise positioning application using PLC

Submitted in partial fulfillment of the requirements of the degree of

Bachelor of Engineering

in

Electrical Engineering

Submitted by

Prachi Manadadkar (Roll no.26)

Omkar More (Roll no.29)

Silvan Rosario (Roll no.40)

Ezam Shaikh (Roll no.45)

Supervisor:

Mr. Pratik Rahate

Department of Electrical Engineering

St. Francis Institute of Technology, Mumbai

University of Mumbai

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CERTIFICATE

This is to certify that **Prachi Mandadkar, Omkar More, Silvan Rosario, Ezam Shaikh** are the bonafide students of St. Francis Institute of Technology, Mumbai. They have successfully carried out the project titled **'Synchronization of two motors for precise positioning application using PLC'** in partial fulfillment of the requirement of B.E Degree in Electrical Engineering of Mumbai University during the academic year 2024-2025. The work has not been presented elsewhere for the award of any other degree or diploma before this.

(Pratik Rahate)

(Megha Fernandes)
EE HOD

(Dr. Sincy George)
Principal

Project Report Approval for B.E.

This project entitled ***'Synchronization of two motors for precise positioning applications using PLC'*** by **Prachi, Omkar, Silvan, Ezam** is approved for the degree of Bachelor of Engineering in Electrical from the University of Mumbai.

Examiners

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Date:

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Signatures of all the students in the group

(Prachi Mandadkar)

(Omkar More)

(Silvan Rosario)

(Ezam Shaikh)

Declaration

We declare that this written submission represents our ideas in our own words and where others' ideas or words have been included; we have adequately cited and referenced the original sources. We also declare that we have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in this submission. We understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Signatures of all the students in the group

(Prachi Mandadkar)

(Omakr More)

(Silvan Rosario)

(Ezam Shaikh)

Abstract

The project ***"Synchronization of Two Motors for Precise Positioning Applications Using PLC"*** *aims to improve accuracy and reliability in industrial systems where precise motor coordination is essential. Traditional control methods lack the needed precision, so this project leverages PLC-based automation to ensure efficient motor synchronization, enhancing productivity and operational efficiency in industries like manufacturing and robotics. This project focuses on utilizing Programmable Logic Controllers (PLCs) to ensure real-time coordination of motor speed, direction, and positioning through continuous feedback and advanced control algorithms. By leveraging PLC technology, the system achieves high levels of synchronization, making it suitable for applications requiring precise motor coordination, such as conveyor systems and automated machinery. The integration of PLCs ensures not only improved motor performance but also enhanced safety, reliability, and adaptability in industrial environments.*

Keywords: Motor Synchronization, Programmable Logic Controller, Automation, Precision, PLC Technology, Industrial Applications, Motor Control.

Contents

Chapter 1

Introduction

1.1 Motivation

Automation is playing an increasingly crucial role in enhancing productivity and efficiency in industrial applications, driven by rapid advancements in manufacturing technology. As industries face growing pressure to meet high global demand while maintaining profitability, the need for precision and reliability in automated processes has never been more important. The project "Synchronization of Two Motors for Precise Positioning Applications Using PLC" aims to address these challenges by modernizing traditional motor control systems.

This project utilizes a Programmable Logic Controller (PLC) to achieve accurate and reliable synchronization of two motors in industrial environments. PLCs are widely used in automation for their ability to streamline control tasks, integrating sensors and actuators to ensure seamless operation. They replace older, less adaptable control systems by incorporating functions such as relay control, timers, and networking into a single, compact unit. This flexibility makes PLCs invaluable in automation, as they provide precise, real-time control over motion, speed, and positioning.

The objective of this project is to enhance the accuracy and efficiency of systems where multiple motors must operate in perfect synchronization. In applications like automated manufacturing lines, robotics, or conveyor systems, even small variations in motor synchronization can lead to errors, inefficiencies, or production delays. By implementing PLC-based control, this project ensures both motors maintain the same speed, position, and direction, improving operational performance and reducing downtime.Through real-time feedback loops and advanced control algorithms, the PLC continuously adjusts motor output to achieve the desired synchronization, making the system highly reliable and adaptable to varying conditions.

1.2 Problem Statement

In industrial applications, precise synchronization of two motors is essential for tasks like material handling and robotic systems. Variations in motor speed, load, and external factors can cause misalignment, reducing efficiency and increasing wear. This project aims to develop a PLC-based control system that synchronizes two motors by using feedback from sensors to ensure accurate and synchronized motion. The solution will enhance precision, reliability, and efficiency in positioning applications.

1.3 Methodology

The methodology employed for this project follows a structured and systematic approach to ensure the successful synchronization of two motors for precise positioning applications using PLC. Initially, we conduct a thorough analysis of the motor systems, focusing on understanding the mechanics, electrical circuits, and control requirements essential for synchronization. This foundational study provides insights into the specific operational needs and challenges, allowing for the development of a detailed control strategy.

1.4 Organization of Project Report

This project report is organized as follows:

Chapter 2 presents the literature survey on the existing techniques

Chapter 3 provides a brief explanation of Hardware and Software Requirements

Chapter 4 provides a brief explanation of the Design Methodology

Chapter 2

Literature Review

The literature review delves into the fundamental concepts of Programmable Logic Controllers (PLCs) and their applications in industrial processes, providing essential insights for the project success.

- Dubey, Pankaj Kumar, Bindeshwar Singh, and Deependra Singh. "A Review of Automation Technology." [4] Dubey et al. provide a comprehensive analysis of the current state and future trajectory of automation technology in their review. The paper highlights the global shift towards technological advancements that prioritize automation, efficiency, and stability across industries. Projections indicate a remarkable growth trend in the global factory automation market, with an estimated value exceeding USD 400 billion by 2030, reflecting a robust Compound Annual Growth Rate (CAGR) of 8.59 percent from 2022 onwards. This growth is attributed to advancements in automated machinery, human-machine interfaces (HMI), and business sensors, which are pivotal elements of factory automation systems.

- In the paper "The Impact of Motor Synchronization on Industrial Automation Efficiency," Chen et al. (2021) analyze how synchronized motors enhance operational efficiency in industrial automation. The authors highlight that synchronization improves the performance of automated processes, such as conveyor systems and robotic assembly lines, by ensuring precise alignment and timing. They emphasize that effective synchronization minimizes delays, reduces wear on components, and optimizes energy consumption. The study concludes that advanced control algorithms and investment in motor synchronization technologies significantly boost productivity and efficiency, providing a competitive advantage in the automation industry.

- "Master-Slave Control of Servo Motors," Krajnc et al. (2014) investigate a master-slave configuration for synchronizing servo motors in manufacturing applications. The authors detail the control strategy, where one motor (the master) sets the reference position for the other motor (the slave), ensuring precise movement and coordination between the two. The study employs a combination of feedback control mechanisms and PID tuning to enhance synchronization accuracy and response time. Experimental results demonstrate that this approach effectively reduces tracking errors and improves overall system performance in tasks requiring high precision. The findings highlight the master-slave control method as a reliable solution for achieving effective motor synchronization in advanced manufacturing processes.

Chapter 3

Hardware and Software Requirements

3.1 Hardware Requirements

The project requires essential hardware components like a Programmable Logic Controller (PLC), Human Machine Interface (HMI), Switch Mode Power Supply (SMPS), relay modules, and a mounting frame. Supplementary needs include fabrication tools, wires, alignment tools, and safety equipment for assembly. These components enable control, monitoring, and power distribution. Fabrication tools ensure secure assembly, while wires and connectors establish electrical connections. Alignment tools ensure accurate positioning, and safety equipment protects personnel. Comprehensive documentation aids installation and maintenance. Overall, these elements are crucial for the successful implementation of the automation system, ensuring quality, reliability, and safety.

3.1.1 Programmable Logic Controller

The Mitsubishi PLC FX5U is an advanced control solution ideal for synchronizing two motors in precise positioning applications. With its high-speed processing capabilities and extensive I/O options, the FX5U can efficiently manage complex tasks, ensuring both motors operate in perfect harmony. The PLC's built-in motion control features, including advanced positioning and interpolation functions, allow for accurate control of motor speeds and positions, making it suitable for applications like CNC machining or robotic automation. Additionally, the FX5U supports various communication protocols, facilitating seamless integration with other devices and systems. By utilizing the FX5Uâ€™s intuitive programming environment, engineers can easily implement synchronization algorithms, enhancing system performance and reliability while minimizing setup time. This makes the Mitsubishi FX5U a robust choice for projects requiring high precision and coordination between multiple motors.

Figure 3.1: Programmable Logic Controller

3.1.2 Human Machine Interface

Delta Electronics HMI is designed for industrial use and offers robust features which are ideal for implementation in an injection moulding machine. It has a 4.3-inch TFT LCD screen displaying vivid colors, it provides clear visualization of critical parameters. It offers two sets of COM ports support various protocols, ensuring seamless integration with machinery. Compliance with the IP65 standard ensures durability in harsh environments. The HMIâ€™s support for M2M communication via OPC UA enables efficient monitoring and control of injection moulding processes. The Human Machine Interface enables us to add additional infinite Inputs and uses bit addressing to establish communication with the input port of PLC. To elaborate, all the inputs can be designed on HMI and will share the same address as the respective input pin on PLC.

Figure 3.2: Human Machine Interface

3.1.3 Switched Mode Power Supply

Switched Mode Power Supply (SMPS) stands as a prevalent power supply choice across electronic devices and systems. Diverging from linear power supplies reliant on transformers and regulators for AC to DC voltage conversion, SMPS harnesses high-frequency switching circuits to regulate output voltage. This innovative approach yields enhanced efficiency, reduced size, and lighter weight in comparison to traditional linear alternatives. Notably, it transforms 220-240V AC voltage into a 24V DC output with a load capacity of 10A, catering to various power requirements in diverse settings. It is essentially used in our project to supply DC power to the Programmable Logic Controller (PLC) from traditional switch plugs.

Figure 3.3: Relay Module

3.1.4 Relay Module

The relay module serves a critical role in the overall control architecture. This module acts as an interface between the PLC and the motors, facilitating control over motor functions while ensuring safety and reliability. It allows the PLC to manage the on/off status of each motor, enabling precise operation. Additionally, the relay module efficiently handles input and output signals, providing a seamless connection that ensures real-time communication between the PLC and the motors. By offering electrical isolation, the relay module protects the PLC from high voltages and potential damage, enhancing overall system safety. Its compatibility with PLC logic programming allows for the execution of complex control algorithms essential for achieving synchronized operation, as the PLC can precisely time and sequence motor commands. The modular design of the relay module further enables customization based on specific application requirements, accommodating various motor types and configurations. Overall, the relay module enhances precision and reliability in motor control, while also ensuring safety, making it an indispensable component of the PLC-based synchronization system for accurate positioning in industrial applications.

Figure 3.4: Relay Module

3.2 Software Requirements

GSWorks3 is an advanced software tool developed by Mitsubishi Electric, designed for programming and configuring the company's range of programmable logic controllers (PLCs), particularly the FX5U series. This intuitive software provides a user-friendly environment for creating, editing, and managing automation projects, making it easier for engineers and technicians to develop complex control systems.

One of the standout features of GSWorks3 is its graphical programming interface, which supports ladder diagram (LD), structured text (ST), function block diagram (FBD), and other programming languages in accordance with IEC 61131-3 standards. This flexibility allows users to select the most suitable programming method for their specific application, enhancing productivity and reducing development time.

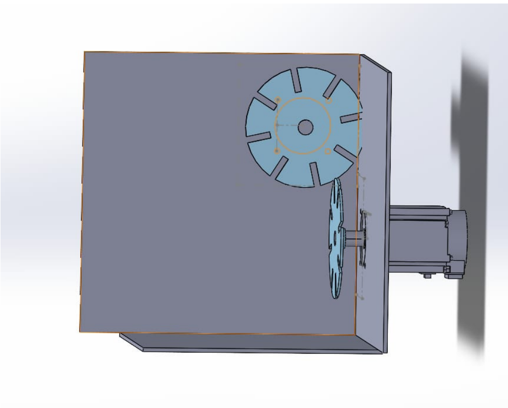
GSWorks3 also includes powerful debugging and simulation tools, enabling users to test and troubleshoot their programs in a virtual environment before deployment. This capability helps identify and rectify issues early in the development process, ensuring reliable operation once the system is in place.Moreover, GSWorks3 supports data logging and monitoring, allowing users to visualize real-time data and system performance. This feature is essential for fine-tuning processes and ensuring optimal operation. The software also facilitates seamless communication with various Mitsubishi devices and third-party systems, enhancing integration capabilities.

Figure 3.5: Gxworks3 Software

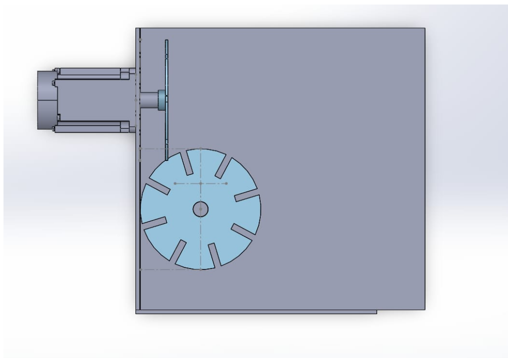
Chapter 4

Design Methodology

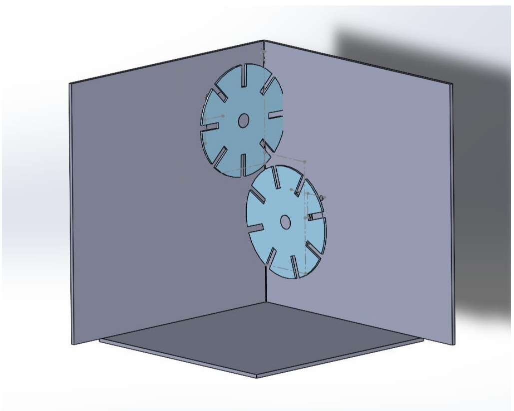
The demonstration of motor synchronization for precise positioning will be showcased through a dedicated Control Panel.



(a) Side View



(b) Front View



(c) Isometric View

Figure 4.1: Design in Solidworks

Chapter 5

Conclusion

5.1 Conclusion

In conclusion, the synchronization of two motors for precise positioning applications using a PLC has proven to be a valuable project that highlights the power of automation in industrial settings. Throughout this project, we gained a comprehensive understanding of ladder logic, particularly in the context of a blow molding machine, which enabled us to effectively program and control the motor operations. As we work on the design setup for the system, we are focused on ensuring that both motors operate in perfect harmony, aiming to achieve the desired precision and reliability in positioning. The use of a robust PLC system, such as the Mitsubishi FX5U, allows for advanced control strategies and real-time monitoring, enhancing our ability to troubleshoot and optimize performance. This experience not only reinforces our technical skills but also demonstrates the significant impact of synchronized motor control in improving productivity and efficiency. As we look to the future, the methodologies developed in this project will serve as a foundation for further innovations in automated systems and smart manufacturing.

5.2 Future Scope

- Integration of IoT and Data Analytics: Incorporating Internet of Things (IoT) technology can enable real-time monitoring and data collection from the injection moulding process. Data analytics tools can then analyze this data to identify patterns, optimize machine parameters, predict maintenance needs, and enhance overall efficiency.

- Implementing AI and Machine Learning: Integrating artificial intelligence (AI) and machine learning algorithms can enable the system to learn from historical data and optimize process parameters autonomously. This can lead to improved quality control, reduced scrap rates, and enhanced productivity.

- Advanced Safety Features: Incorporating advanced safety features such as machine vision systems, safety sensors, and collaborative robotics can further enhance workplace safety and minimize the risk of accidents.

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