

Industrial Motor Control and Protection System with ATS System

A Project report is submitted in partial fulfillment of the requirements for the award of Degree of Bachelor of Science in Electrical and Electronic Engineering.

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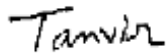
DAFFODIL INTERNATIONAL UNIVERSITY

JANUARY, 2025

Declaration

We hereby declare that this project “**Industrial Motor Control and Protection System with ATS System**” represents our own work which has been done in the laboratories of the Department of Electrical and Electronic Engineering under the Faculty of Engineering of Daffodil International University in partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical and Electronic Engineering, and has not been previously included in a thesis or dissertation submitted to this or any other institution for a degree, diploma or other qualifications. I have attempted to identify all the risks related to this research that may arise in conducting this research, obtained the relevant ethical or safety approval and acknowledged my obligations and the rights of the participants.

Signature of the candidates



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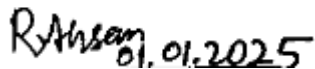
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APPROVAL

The project and thesis entitled “**Industrial Motor Control and Protection System with ATS System**” Submitted by **Tanvir Ahmed**, ID No: 212-33-5401, **Nadim Hossian**, ID No: 212-33-5390 Session: Summer 2024 has been accepted as satisfactory in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electrical and Electronic Engineering** in October 2024.

Signed


01.01.2025

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Dedicated to
Our Parents & Teachers

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LIST OF ABBREVIATIONS

NO	Normally Open
NC	Normally Close
SP MCB	Single Pole Miniature Circuit Breaker
TP MCB	Triple Pole Miniature Circuit Breaker
BREB	Bangladesh Rural Electrification Board
ATS	Automatic Transfer Switch

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ABSTRACT

This project focuses on the design and implementation of an industrial motor control and protection system for three-phase motors, integrating essential components such as overload relays, phase sequence relays, and an Automatic Transfer Switch (ATS). The system aims to enhance operational reliability, safety, and efficiency by preventing electrical faults and ensuring uninterrupted power supply during outages. Comprehensive testing demonstrated the system's effectiveness in protecting motors from overloads and phase imbalances. The project highlights the economic benefits, improved workplace safety, and sustainability of advanced motor control solutions, emphasizing the need for continuous innovation in industrial applications to meet evolving challenges.

Keywords: ATS, Phase Sequence, Phase Failure, Over Load Current, Star to Delta.

Chapter 1

Introduction

1.1 Introduction

In industrial environments, electric motors are vital for powering machinery, driving production processes, and maintaining operations. The reliability of these motors is critical to ensure uninterrupted performance and avoid costly downtime. To safeguard motors and optimize their operation, robust motor control and protection systems are essential, particularly in three-phase systems, which are commonly used in industrial settings due to their efficiency and power capacity.

A motor control system enables precise management of motor operations, such as starting, stopping, speed control, and protection against electrical and mechanical faults. In three-phase systems, motors require additional protection from common issues like overloads, phase imbalances, incorrect phase sequences, overvoltage's, and short circuits. Without adequate protection, these faults can lead to motor damage, operational disruptions, or even hazardous conditions.

This project focuses on designing a comprehensive industrial motor control and protection system incorporating key components such as miniature circuit breakers (MCBs), electromagnetic relays, magnetic contactors, overload relays, phase sequence relays, overvoltage protectors, and push switches. Additionally, an Automatic Transfer Switch (ATS) system is integrated to ensure continuous operation by automatically switching to an emergency power source in case of power failures.

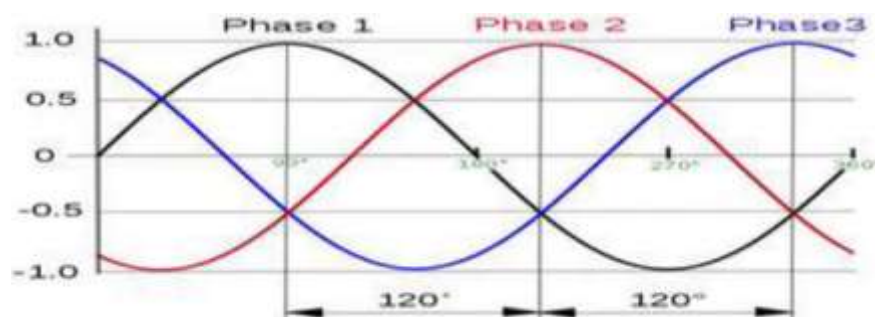


Figure 1.1: Three-Phase Alternating Current Waveform

By implementing such a system, industries can minimize risks, enhance motor longevity, and maintain operational continuity during both normal and fault conditions. This introduction sets the foundation for understanding the critical components and design

considerations involved in motor control and protection systems with ATS in industrial applications.

1.2 Phase reversal (incorrect phase sequence)

Phase reversal, or incorrect phase sequence, occurs when the order of the three phases in a three-phase electrical system (typically labeled R, Y, and B) is altered. In a correctly sequenced system, the phases follow a specific order that ensures the proper direction of rotation for three-phase motors. However, if the phase sequence is reversed—such as swapping two phase connections—the motor will rotate in the opposite direction, potentially causing serious operational issues.

In industrial applications, phase reversal can lead to significant damage to machinery, particularly motors that drive conveyor belts, pumps, fans, or other critical equipment. This unintended reverse operation can result in mechanical stress, damage to connected equipment, production errors, or even hazardous situations. Additionally, sensitive equipment like compressors may be more vulnerable to failure if they operate with a reversed phase sequence.

To prevent such issues, phase sequence relays are installed in motor control systems. These relays continuously monitor the phase sequence and ensure the correct order. If the sequence is incorrect or a phase is lost, the relay prevents the motor from starting or operating, protecting both the motor and the equipment it drives. Ensuring the correct phase sequence is essential for maintaining safe and reliable industrial operations.

1.3 Problem Statement

This project's goal was to build and implement a general software framework that could be used to develop a range of motor protection applications.

The goals we seek to achieve in this work include the following.

- Design of an application framework, which is generic enough to support various application requirements.
- The framework should provide an easy mechanism to conjure various middleware services.
- Development of complex real world applications, using the framework to define various hardware requirements and to define the logical rules.

1.4 Objectives of the Project

The objectives of this project are given below;

- To design and integrate an Automatic Transfer Switch(ATS) for uninterrupted power supply during power failures.
- To integrate essential protection devices and to ensure the system meets industrial safety standards and improves overall equipment reliability.

1.5 Methodology

The project follows a systematic approach, starting with a comprehensive study of industrial motor control components such as MCBs, relays, contactors, and ATS systems. A control circuit is designed, integrating overload protection, phase sequence detection, and overvoltage protection. The Automatic Transfer Switch (ATS) is incorporated to ensure continuous power supply. A detailed wiring diagram is created for the system, followed by prototype development and testing. The system is tested under various fault conditions (overload, phase reversal, power loss) to ensure protection features function correctly. Finally, troubleshooting guidelines and maintenance procedures are developed for optimal system performance.

1.6 Implementation Schedule

Task No.	Task Name	Start Date	End Date	Duration in days	Weeks														
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	Topic Selection	06/08/24	10/08/24	4	█														
2	Data Collection	11/08/24	28/08/24	17		█	█	█											
3	Circuit Design	29/08/24	8/09/24	10				█	█										
4	Instrument List	9/09/24	13/09/24	4					█										
5	Instrument Collect	14/09/24	01/10/24	15						█	█	█							
6	Hardware Setup	02/10/24	22/10/24	20								█	█	█	█	█			
7	Operation Check	23/10/24	30/11/24	28														█	█

Figure 1.2: Implementation Schedule

1.7 Organization of the Report

Apart from this chapter, the remainder of the project book has been divided into seven chapters

Chapter 1 titled "Introduction" here introduce about basic of this system.

Chapter 2 titled "Literature Review"

Chapter 3 titled "Materials and Methods" this chapter discusses the essentials components in detail and explains each component in more details.

Chapter 4 titled "Results and Discussion" this chapter discusses about the output result of proposed system.

Chapter 5 titled "Project Management" describes the procedure of how to complete the work management.

Chapter 6 titled "Impact Assessment of the Project" This chapter shows the Economic, Environmental and Ethical issues of the entire system's

Chapter 7 titled "Conclusion and Recommendations" presents major concluding remarks about the outcome of the study and also provide relevant recommendation for future study.

Chapter 2

Literature Reviews

2.1 Introduction

The field of industrial motor control and protection has seen significant advancements due to the growing complexity and demands of modern industrial processes. A comprehensive literature review reveals the evolution of motor protection systems, focusing on the integration of various components such as overload relays, phase sequence relays, and overvoltage protectors, which safeguard motors from electrical faults. Early studies emphasized the need for basic protection against overloads and short circuits, with devices like Miniature Circuit Breakers (MCBs) gaining widespread use for their reliability in preventing electrical damage.

Recent literature highlights the importance of advanced monitoring systems, such as phase sequence relays, which ensure proper motor operation by detecting incorrect phase sequences—a critical issue in three-phase systems. Researchers also stress the role of Automatic Transfer Switches (ATS) in industrial environments, where maintaining continuous power is crucial. Studies show that integrating ATS with motor control systems enhances reliability, minimizing operational downtime during power failures.

Additionally, the importance of real-time monitoring and automation in motor control has been explored, with a focus on improving system responsiveness to faults.

2.2 Related Work

Numerous studies have explored the design and application of motor control and protection systems, highlighting the importance of safeguarding industrial motors from various electrical and mechanical faults. The work of J.G. Kassakian and M.F. Schlecht (1991) on power electronics emphasized the significance of motor protection in industrial environments, focusing on the role of protective devices such as overload relays and circuit breakers in preventing excessive currents and protecting motors from overheating. Their research set a foundation for understanding how simple protective mechanisms could be applied to industrial motors.

Recent advancements have brought more focus on sophisticated protection systems, including phase sequence relays, as discussed by A. Walker (2015). His study on three-

phase systems highlights the critical role of phase sequence relays in detecting incorrect phase connections, a common issue that can lead to reverse motor operation and equipment damage. Walker's research underlined the need for such relays in large-scale industries where phase imbalances are frequent.

Another important work by P. Mallick (2018) examined the integration of overvoltage protectors in motor control systems. Overvoltage, often caused by grid fluctuations or lightning strikes, can damage motors and connected equipment. Mallick's findings showed that incorporating overvoltage protectors into motor control systems can significantly extend motor lifespan by mitigating high-voltage surges.

Automatic Transfer Switches (ATS) have also been the subject of many recent studies. S. Ahmed and R. Khan (2019) explored the benefits of ATS systems in industrial environments where uninterrupted power supply is critical. Their research illustrated how ATS systems automatically switch to backup generators during power outages, maintaining continuous motor operation and minimizing downtime.

Another aspect of motor protection explored in the literature is smart monitoring and automation. M. Gupta (2020) examined the integration of IoT-based real-time monitoring systems with traditional motor protection devices. His study demonstrated how combining real-time data collection with automation could enhance the responsiveness of motor control systems, allowing for predictive maintenance and quicker fault detection.

2.3 Compare and Contrast

Motor control and protection systems have evolved from basic protective devices, such as overload relays and MCBs, to more sophisticated solutions that integrate phase sequence relays and ATS systems. While traditional systems primarily focused on preventing overloads and short circuits, recent advancements emphasize the importance of monitoring phase sequences and overvoltage's to protect motors from directional failures and voltage surges. Additionally, modern systems increasingly incorporate IoT technology for real-time monitoring and predictive maintenance, enhancing fault detection and system responsiveness. This evolution highlights a shift from reactive protection methods to proactive, automated solutions that ensure continuous and efficient motor operation in industrial settings.

2.4 Summery

To effectively finish this project, the literature review reveals the evolution of industrial motor control and protection systems from basic devices like overload relays and MCBs to advanced solutions incorporating phase sequence relays, ATS, and IoT-based monitoring. This progression underscores the shift toward proactive protection strategies, enhancing operational reliability and minimizing downtime while safeguarding motors from electrical faults and ensuring continuous performance in industrial environments.

Chapter 3

Materials and Methods

3.1 Introduction

The materials and methods section outlines the components, tools, and procedures used to develop the industrial motor control and protection system. Key materials include Miniature Circuit Breakers (MCBs), magnetic contactors, overload relays, phase sequence relays, and an Automatic Transfer Switch (ATS). Additional components, such as push switches and pilot signal lights, facilitate user interaction and system monitoring. The methodology involves designing the circuit, assembling the components, and testing the system under simulated fault conditions to validate performance. Simulation tools, like Cade Simu, were employed to create and analyze the circuit diagram, ensuring accuracy before physical implementation. This structured approach ensures reliability, safety, and efficiency, forming the foundation for the system's effective operation in industrial environments. The project's hardware design and implementation were covered in this chapter.

3.2 Block Diagram

The block diagram of the industrial motor control and protection system illustrates the interconnected components that ensure efficient operation and safety. At the core, the three-phase motor is connected to the power circuit, which includes a Miniature Circuit Breaker (MCB) for overcurrent protection. Control signals from push switches activate electromagnetic relays, which operate magnetic contactors to start or stop the motor. Overload relays monitor current levels, while phase sequence relays verify the correct phase order to prevent reverse rotation. Overvoltage protectors safeguard against voltage surges, and an Automatic Transfer Switch (ATS) automatically switches power sources during outages, ensuring continuous operation.

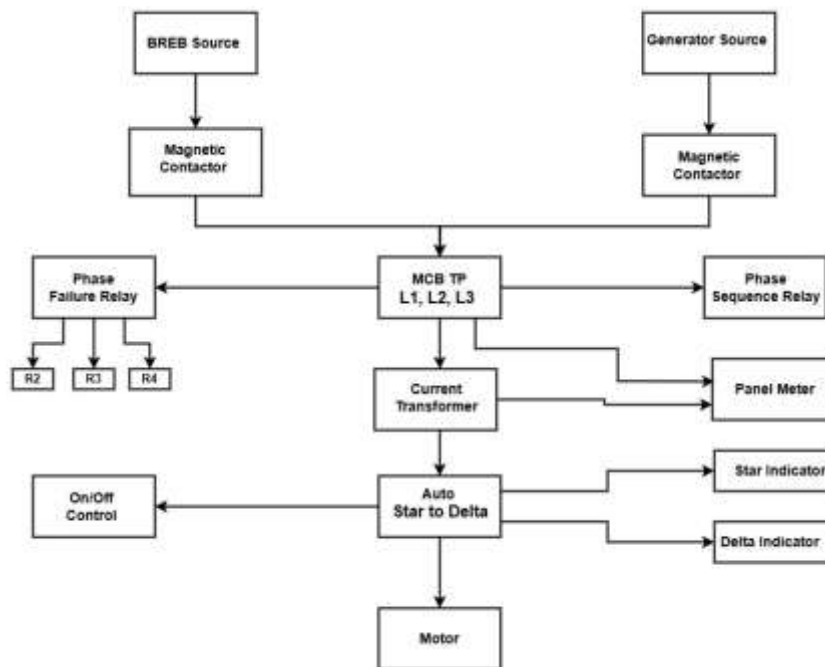


Figure 3.1: Functional Block Diagram

3.3 Required Components

Table I: Component List

S/L	Components Name		Quantity
01	SP MCB		3
02	TP MCB		1
03	Electromagnetic Relay		4
04	Magnetic Contactor		5
05	Overload Relay		1
06	Phase sequence relay		1
07	Push Button Switch		2
08	LED Indicator		2
09	Timer Relay		3
10	Panel Meter		1
11	Current Transformer		3
12	AC Power Cord		Needed
13	Connecting Wire		Needed

3.3.1 Single Pole Miniature Circuit Breaker (SP MCB)

A Single Pole Miniature Circuit Breaker (SP MCB) is a compact protective device designed to secure single-phase electrical circuits against overloads and short circuits. It

interrupts the flow of electricity in the live (phase) wire when fault conditions occur, preventing damage to connected devices and ensuring user safety. SP MCBs are widely used in residential, commercial, and small-scale industrial applications, where single-phase systems dominate. With quick response times and reusability after tripping, SP MCBs are reliable and cost-effective. They are typically employed in lighting circuits, household appliances, and smaller electrical installations. By providing localized protection, SP MCBs enhance electrical safety, reduce maintenance downtime, and play a critical role in ensuring smooth and fault-free operation of single-phase systems.

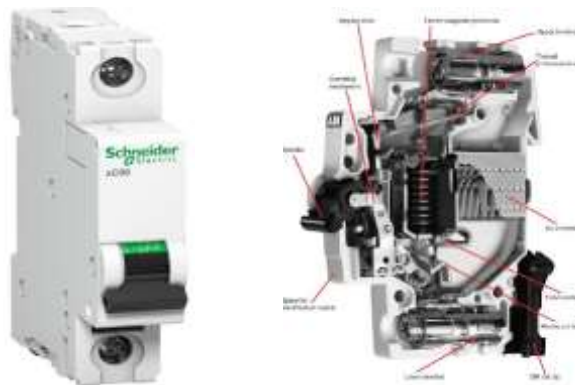


Figure 3.2: Figure of Single Pole Miniature Circuit Breaker (SP MCB)

specifications and features

1. **Type:** Single-pole, suitable for use in residential and light commercial circuits.
2. **Rated Current:** Commonly available from 6A to 32A, depending on the application.
3. **Rated Voltage:** Typically, 230V AC, 50/60Hz for single-phase systems.
4. **Breaking Capacity:** Usually 6kA or 10kA, indicating the maximum fault current it can safely interrupt.
5. **Tripping Characteristics:** Standard B, C, or D curve for different protection needs.
6. **Material:** High-quality thermoplastic or thermoset for durability and resistance to high temperatures.
7. **Mounting Type:** Rail-mounted (DIN rail), compliant with IEC 60715.
8. **Safety Features:** Provides overload, short-circuit, and earth fault protection.
9. **Compliant Standards:** Conforms to IEC 60898 and UL 1077 standards.

3.3.2 Triple Pole Miniature Circuit Breaker (SP MCB)

A Triple Pole Miniature Circuit Breaker (TP MCB) is a protective device designed to interrupt electrical flow in a three-phase system during fault conditions such as overloads,

short circuits, or phase imbalances. It provides simultaneous disconnection of all three phases, ensuring complete isolation of the connected circuit. TP MCBs are commonly used in industrial applications where three-phase motors or equipment require reliable protection against electrical faults.



Figure 3.3: Figure of Triple Pole Miniature Circuit Breaker (TP MCB)

specifications and features

1. **Type:** Triple-pole, designed for three-phase electrical systems.
2. **Rated Current:** Typically available in ratings from 6A to 63A, depending on the application.
3. **Rated Voltage:** Commonly 400V AC, suitable for three-phase 50/60Hz systems.
4. **Breaking Capacity:** Typically ranges from 6kA to 10kA, depending on the model.
5. **Tripping Characteristics:** Available with B, C, or D curve, for different tripping requirements.
6. **Material:** Constructed from high-grade thermoplastic or thermoset for durability and heat resistance.
7. **Mounting Type:** Designed for DIN rail mounting, in compliance with IEC 60715 standards.
8. **Safety Features:** Provides overload, short-circuit, and earth fault protection for three-phase circuits.
9. **Compliant Standards:** Complies with IEC 60898, UL 1077, and other relevant safety standards.

3.3.3 Magnetic Contactor

A magnetic contactor is an electrically-controlled switch used to manage high-power circuits in industrial motor control and automation systems. It operates via an electromagnetic coil, which, when energized, closes or opens the contactor's power contacts, allowing or interrupting the flow of electricity. Magnetic contactors are ideal for controlling motors, heating elements, and lighting systems, as they can handle high current loads safely. They support remote operation and automation, making them essential in motor starting (such as star-delta starters) and stopping sequences. Built-in arc suppression ensures durability and operational safety. Magnetic contactors are reliable, fast, and require minimal maintenance, offering efficient control of three-phase motors and other heavy electrical loads in diverse industrial and commercial applications.

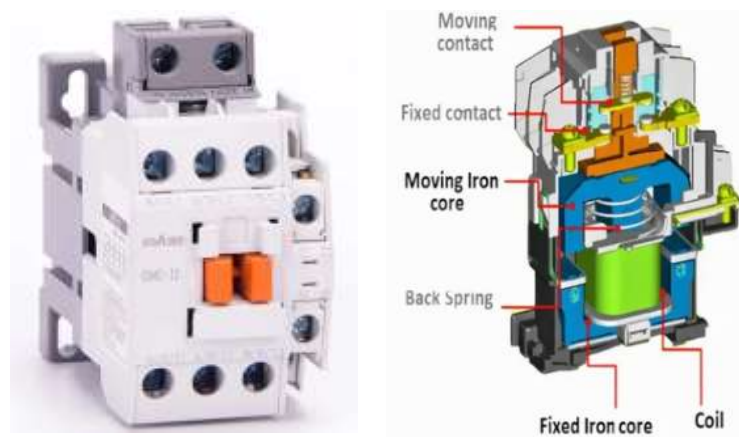


Figure 3.4: Magnetic Contactor

specifications and features

1. **Type:** Electromagnetic switch used to control the switching of electrical circuits.
2. **Rated Current:** Available in a wide range from 5A to 1500A, depending on the application.
3. **Rated Voltage:** Commonly available in 110V, 220V, 380V, or 415V for AC, and 24V, 48V for DC.
4. **Coil Voltage:** Typically, 24V to 240V AC/DC, with options for various control voltages.
5. **Contacts Configuration:** Typically has 1 NO (Normally Open) and 1 NC (Normally Closed) contacts, with options for multiple contacts.
6. **Operating Time:** Fast switching, typically 10 to 20 milliseconds for opening or closing the contacts.

7. **Durability:** Designed for up to 1 million operations or more, depending on the model and usage.
8. **Mounting Type:** Often DIN rail or screw-mounted for easy installation.
9. **Protection Features:** Some models come with built-in surge protection and thermal overload protection.

3.3.4 Electromagnetic Relay

Relays are essential components in motor control systems, acting as electromagnetic switches that control high-power circuits using low-power signals. They provide isolation between control and load circuits, ensuring operational safety and efficiency. Electromagnetic relays are widely used to manage motor start/stop functions, fault detection, and circuit protection. In overload or fault conditions, relays, such as overload or phase sequence relays, disconnect the motor to prevent damage. Their versatility includes applications in automatic transfer systems, where they enable seamless power source switching, and in star-delta starters, controlling the transition between configurations. Modern relays with programmable features enhance reliability and system responsiveness, making them indispensable for protecting and automating industrial motor operations in diverse environments.

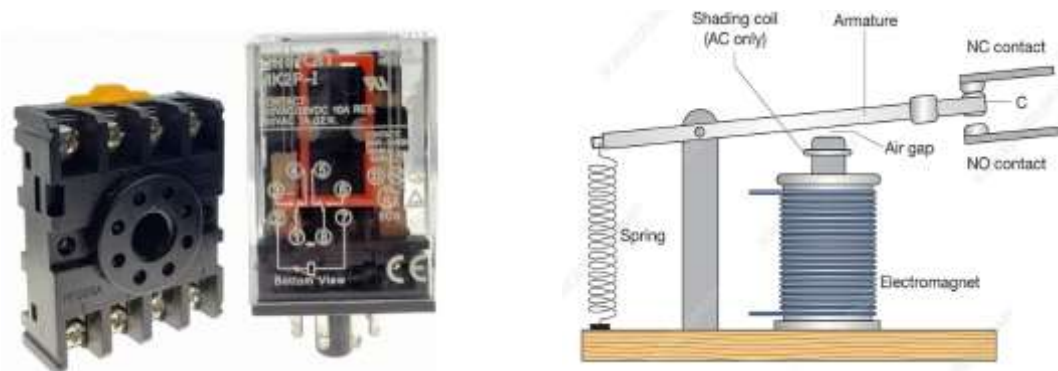


Figure 3.5: Electromagnetic Relay

specifications and features

1. **Type:** Electromagnetic switch used to control electrical circuits through an external control signal.
2. **Coil Voltage:** Available in various voltages, typically 5V, 12V, 24V, 48V, and 110V AC/DC.
3. **Contact Configuration:** Commonly includes SPDT (Single Pole Double Throw), DPDT (Double Pole Double Throw), and multiple other configurations.

Specifications and features

1. Full Load Current
2. Temperature trip Range
3. Trip Class
4. Motor/Load Phase
5. Single phase protection
6. Three Phase protection
7. Maximum Motor Voltage
8. Control Voltage
9. Contact Current rating
10. Contact Maximum rated voltage

3.3.6 Phase sequence relay

A protective relay is a phase sequence relay. It protects a 3-phase gadget from any potential harm brought on by a change in sequence. They can destroy a device or circuit since they are deployed anyplace with a phase-sequence change. They operate similarly to a regular electric relay. The phase sequence relay stops the operation when a phase fails or when the sequence modifies. The electronics in the high-end variants is more intricate and can operate the linked device as needed. If any phase sequence shift is introduced, it can even automatically adjust the relay's sequence. In a three-phase system, each connected device must be in the correct phase order for it to operate. Only when the supply, starter, and motor are connected in the correct order can a three-phase motor operate.

In order to connect the 3-phase supply wires, a phase sequence relay includes three terminals. Additionally, depending on how sophisticated the control circuit is, they may include more than 3 terminals (NC, Common, NO). The phase sequence relay receives the necessary 3-phase supply from the source. A 3-phase motor's supply is connected to the starter through the NO terminal of the phase sequence relay. Directly connected to the Common terminal of the relay, the supply is drawn from the R phase.

The relay changes the supply from the NO terminal to the third control point, NC, in the event of a phase-shift or failure. The same is true even if a phase is unsuccessful. As a result, the starter won't receive power to turn on the motor.



Figure 3.7: Phase sequence relay

Specifications and features

1. **Purpose:** Used to monitor the phase sequence in three-phase electrical systems and ensure correct rotation direction.
2. **Input Voltage:** Typically operates with 3-phase voltages, common ratings include 380V, 400V, and 415V.
3. **Phase Sequence Detection:** Detects the phase sequence (ABC or ACB) and indicates whether the rotation is correct or incorrect.
4. **Contact Configuration:** Usually has NO (Normally Open) or NC (Normally Closed) relay contacts for alarm or control circuit.
5. **Frequency Range:** Operates at standard industrial frequencies, typically 50Hz or 60Hz.
6. **Tripping Voltage:** Triggers an alarm or cut-off when phase sequence is incorrect or if any phase is missing.
7. **Indicator:** Many models include visual indicators (LED or display) to show correct or incorrect phase sequence.
8. **Protection Features:** Provides protection against phase reversal, phase loss, and incorrect rotation direction.
9. **Mounting Type:** Typically DIN rail mounted or panel mounted for ease of installation.
10. **Compliant Standards:** Complies with IEC 60947-6, UL, and CE for safety, performance, and reliability.

3.3.7 Timer

A timer is a critical component in industrial motor control systems, often used to manage time-based operations such as delayed starts, star-to-delta transitions, and fault recovery sequences. In a star-delta starter, the timer ensures a seamless transition from the star configuration, which reduces inrush current during motor startup, to the delta configuration for full load operation. Timers also play a role in controlling the delay in re-energizing systems after faults, ensuring safe restoration of power. They are available in various types, including analog, digital, and programmable timers, offering flexibility in setting precise time intervals. By automating timed actions, timers improve operational efficiency, reduce manual intervention, and ensure consistent motor performance across various industrial applications.



Figure 3.8: Timer

Specifications and features

1. **Type:** Used to delay or time control operations in electrical circuits (ON, OFF, or interval timing).
2. **Voltage Range:** Available in various input voltages, typically 12V, 24V, 110V, and 230V AC/DC.
3. **Time Range:** Commonly ranges from milliseconds to several hours, with adjustable settings.
4. **Output Contacts:** Typically has SPDT or DPDT relay contacts for controlling other devices.
5. **Time Accuracy:** Precise time control, usually within $\pm 1\%$ or better, depending on the model.
6. **Time Setting:** Adjustable via dials, knobs, or digital input, with options for fixed or programmable time intervals.
7. **Mounting Type:** Designed for DIN rail or panel mounting for easy installation.
8. **Function Types:** Includes ON-delay, OFF-delay, cyclic, and interval timers.
9. **Indication Features:** Includes LEDs or digital displays to show the remaining time or operational status.

3.3.8 Panel Meter

A panel meter is an essential device used in electrical panels to monitor and display parameters like voltage, current, frequency, and power. These meters provide real-time data, enabling operators to assess system performance and identify anomalies. Available in analog and digital formats, panel meters offer high accuracy and reliability. They are commonly used in industrial, commercial, and residential settings to ensure safe and efficient operation. Easy to install and integrate, panel meters enhance system monitoring and facilitate preventive maintenance.



Figure 3.9: Panel Meter

Specifications and Features of Panel Meter

1. Measures electrical parameters like voltage, current, power, and frequency.
2. Available in analog or digital display formats for user preference.
3. High accuracy with precision readings for critical applications.
4. Wide input voltage range to suit diverse systems.
5. Compact design for easy integration into electrical panels.
6. Programmable settings for customizable monitoring.
7. Built-in alarm indicators for fault detection.
8. Energy-efficient with low power consumption.
9. Durable construction suitable for industrial environments.
10. Compatible with both single-phase and three-phase systems.

3.3.9 Current Transformer

A current transformer (CT) is an essential device used to measure and monitor high currents in electrical systems by stepping them down to a safer, manageable level for metering and protection equipment. CTs are commonly used in conjunction with panel meters, protective relays, and energy monitoring systems. They ensure accurate current

measurement without requiring direct connection to high-voltage circuits. Compact, reliable, and efficient, CTs are vital for safeguarding electrical systems and optimizing energy management in industrial and commercial applications.



Figure 3.10: Current Transformer

Specifications and Features of Current Transformer

1. Steps down high currents to a safe, measurable range.
2. Accuracy classes range from 0.1 to 5 for precise measurement.
3. Rated primary current varies from 1A to several kA.
4. Secondary current standard is typically 1A or 5A.
5. Wide frequency range compatibility for various applications.
6. Compact and robust design for easy installation.
7. Insulated for safe operation in high-voltage environments.
8. Supports both metering and protection applications.
9. Available in various types: wound, bar, and toroidal.
10. High durability with minimal maintenance requirements.

3.3.10 Push Button Switch

In an emergency or if network connectivity is interrupted and users want to adjust the load manually, there are two switches available. Here, the induction motor is controlled by two pushbutton switches. A typical control switch device used to turn on and off the control circuit is the push button switch. In electrical automatic control circuits, it is used to manually supply control signals to control contactors, relays, electromagnetic starters, etc. It stands out since it is mounted on the tool or machine being used, spends the most of the time in the initial free state position, and only moves into the second state (position) when absolutely essential. The action of the spring ensures that the switch returns to its initial position as soon as the external force is removed. Start, stop, rotation in both directions, speed change, and interlock are among the basic operations that the push button switch is capable of doing. Normally, each push button switch has two pairs

of contacts. Each pair of contacts consists of a NO contact and an NC contact. When the button is pressed, it simultaneously affects both sets of contacts, detaching the NC contact and closing the NO contact.



Figure 3.11: Push Button Switch

In order to highlight the role of each button and prevent incorrect operation, the button caps are often designed in various colors to show the differentiation, as seen in the figure below. Its colors include red, green, black, yellow, blue, and white, to name just a few. A stop button is shown by red, a start button is indicated by green, etc. The button switch's key properties, such as type, mounting hole size, contacts, and current capacity, are described in depth in the product literature.

3.3.11 LED Indicator

There are 2 Lights used for indicate the controlling status.



Figure 3.12: Led Indicator

The AC 220V red-green LED indicator is a compact pilot signal light used in control panels and industrial systems to display the operational status of equipment. The red light typically signals a fault, stop, or emergency condition, while the green light indicates normal operation or readiness. Designed for durability, these lights are energy-efficient

and highly visible. They are commonly installed in motor control panels, switchboards, and automation systems for real-time visual feedback. The dual-color feature simplifies monitoring and troubleshooting, enhancing operational efficiency and safety in industrial and commercial setups. Easy installation and low maintenance make them a reliable choice.

3.3.12 AC Power Cord

This project uses a 440V AC power cord. The circuits' primary power source is this. Through this power cord, AC power is supplied to the loads and the AC to DC power converter.



Figure 3.13: AC Power Cord

3.4 Design Specification

The industrial motor control and protection system is designed for three-phase motors with a power rating of up to 30 kW. Key components include Miniature Circuit Breakers (MCBs) for overload protection, electromagnetic relays for control, magnetic contactors for switching, and overload relays for current monitoring. Phase sequence relays will ensure proper motor rotation, while overvoltage protectors will safeguard against voltage surges. An Automatic Transfer Switch (ATS) will provide seamless power switching during outages. The system will feature a user-friendly interface for manual operation, visual indicators for fault detection, and a comprehensive wiring diagram for installation and maintenance.

3.5 Experimental Setup

The integration of Bangladesh Rural Electrification Board (BREB) power supply with a generator ensures uninterrupted electricity for critical operations. BREB provides the primary power source, but outages or instability in rural grids can disrupt operations. A generator serves as a reliable backup, automatically activated through an Automatic Transfer Switch (ATS) during power failures. This seamless transition minimizes downtime, maintaining essential industrial or domestic operations. Efficient synchronization between BREB and the generator is crucial to avoid overloading and ensure steady voltage. This hybrid setup not only enhances energy reliability but also supports productivity and safety in rural and semi-urban settings.

3.5.1 Circuit Diagram

The circuit diagram of the industrial motor control and protection system showcases the layout of key components and their connections. The three-phase power supply feeds into a Miniature Circuit Breaker (MCB), which protects against overcurrent's. The output from the MCB connects to magnetic contactors, controlled by electromagnetic relays activated by push switches. Overload relays monitor the motor current and are wired in series with the motor to disconnect in case of overload. Phase sequence relays are included to ensure the correct phase order, while overvoltage protectors are connected parallel to the motor, safeguarding against voltage surges. An Automatic Transfer Switch (ATS) integrates into the circuit for seamless power source switching.

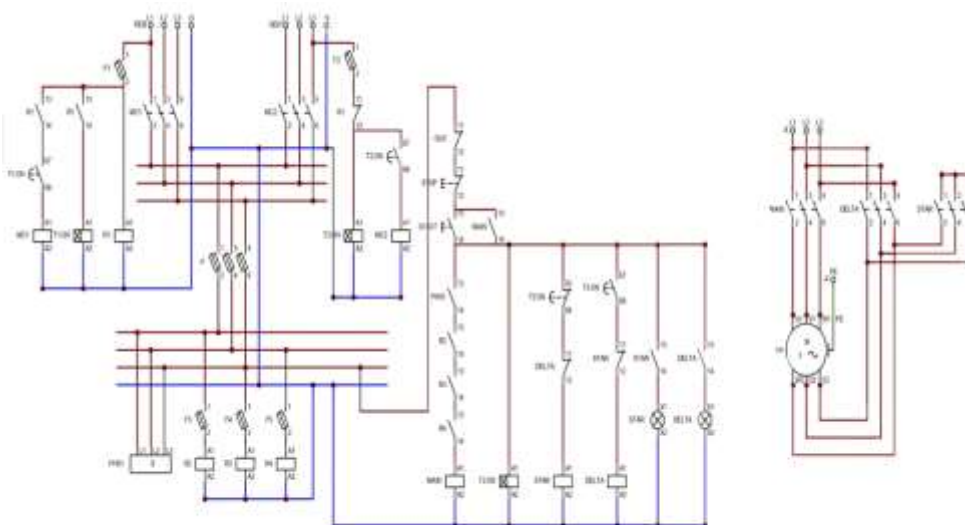


Figure 3.14: Circuit Diagram

3.5.2 Full Hardware Overview

The working prototype of the three phase induction motor protection is built upon the Figure 2.13 circuit diagram using the equipment of table 01. Figure 2.14 shows the final project. The electrical channel is secured to the plywood board with screws and hot glue. On Figure 14's leftmost corner. The electromagnetic relay was connected to the circuit breaker and phase sequence relay in the left corner, and the magnetic contactor was attached to the switch to control the magnetic contactor.



Figure 3.15: Full Hardware Overview

3.6 Summery

The system's parts and a few utilities are described in this section. These parts are used to Industrial Motor Control and Protection System with ATS System. From the materials used for the motor protection to the safe industry, this covers every facet of the project.

Chapter 4

Results and Discussions

4.1 Introduction

The results of the industrial motor control and protection system testing demonstrate its effectiveness in ensuring reliable motor operation and safeguarding against faults. Key components, including the Automatic Transfer Switch (ATS), phase failure protection, and star-delta starter, were validated, each proving essential in maintaining operational continuity and enhancing motor lifespan.

4.2 Result of Star to Delta

The star-delta starter configuration was tested to assess its ability to reduce inrush current during motor startup and ensure a smooth transition to full operational mode. Initially, the motor started in the star configuration, successfully lowering the inrush current and minimizing electrical stress on the system. After a pre-set delay, the system automatically switched to the delta configuration, allowing the motor to reach its full power efficiently. This transition was seamless, with no voltage drops or jerks, and the motor achieved steady operation without disruptions. The star-delta arrangement proved effective in reducing startup strain, enhancing motor longevity, and optimizing energy use.

4.2.1 Star Condition

When the star condition is running, the red indicator will be on.



Figure 4.1: Star Condition Running

4.2.2 Delta Condition

When the delta condition is running, the green indicator will be on.



Figure 4.2: Delta Condition Running

4.3 Results of Phase Failure and Phase Sequence

The phase failure protection feature was rigorously tested to ensure it could detect and respond to loss or imbalance in one of the three phases. During simulated phase failure conditions, the phase sequence relay accurately identified the fault, immediately disconnecting the motor to prevent damage. This rapid response prevented potential hazards like overheating, reverse motor rotation, and mechanical stress on connected equipment. Additionally, the relay's indicators alerted operators to the fault, enabling swift troubleshooting. These results confirm that the phase failure protection is effective in safeguarding the motor and maintaining safe operational standards, especially in environments prone to phase imbalances.

4.3.1 Phase Normal Condition



Figure 4.3: Phase Normal Condition

Table II: Phase Normal Condition

S/L	Line Voltage VL1	Line Voltage VL2	Line Voltage VL3	Motor Spped
1	405V	403V	404V	1495 r.p.m
2	401V	400V	402V	1498 r.p.m
3	400V	400V	402V	1496 r.p.m
Average	402v	401V	402.66V	1496 r.p.m

S/L	Line Current IL1	Line Current IL2	Line Current IL3	frequency
1	0.7A	0.6A	0.6A	49.9Hz
2	0.6A	0.6A	0.6A	50Hz
3	0.7A	0.6A	0.6A	50Hz
Average	0.66A	0.6A	0.6A	49.9Hz

4.3.2 Phase failure Condition

When a phase is missing or a phase failure occurs, the motor will automatically stop.



Figure 4.4: Phase failure Condition

4.3.3 Phase Sequence Abnormal

When a phase is missing or a phase failure occurs, the motor will automatically stop.

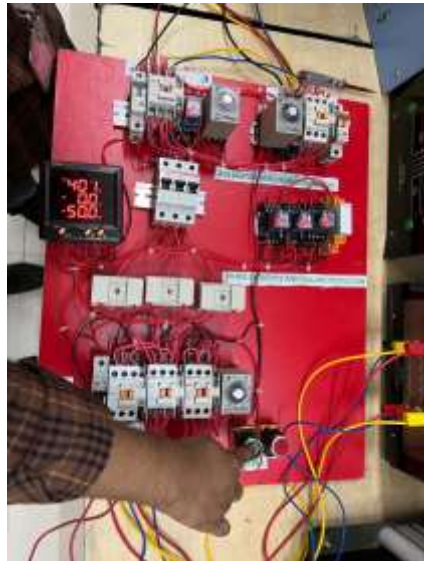


Figure 4.5: Phase Sequence Abnormal

4.4 Result of ATS

The Automatic Transfer Switch (ATS) was tested under various simulated power failure scenarios to evaluate its effectiveness in maintaining continuous motor operation. During testing, the ATS reliably detected power interruptions and swiftly switched the motor to the backup power source within seconds, preventing operational downtime. This smooth transition ensured that motors continued running without interruption, which is critical in industrial settings where delays can lead to significant productivity losses. Additionally, the ATS effectively reverted to the main power source once stability was restored, without impacting motor operation. These results demonstrate that the ATS is highly reliable for ensuring uninterrupted power in industrial motor applications.

4.4.1 BREB Connected



Figure 4.6: BREB Connected

4.4.2 BREB Missing

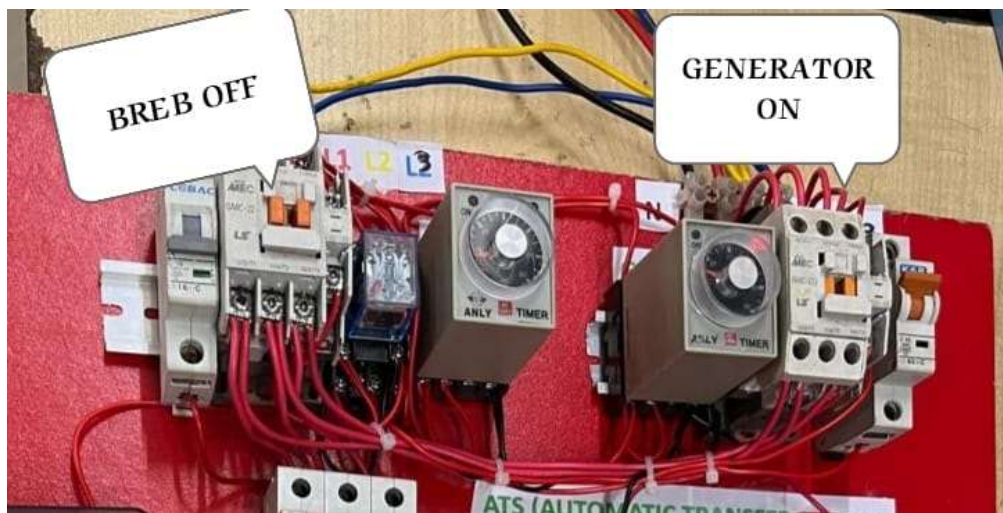


Figure 4.7: Generator On

4.5 Discussions

The implementation of the industrial motor control and protection system demonstrated significant enhancements in operational reliability and safety. Testing revealed that the integration of key components, such as overload relays and phase sequence relays, effectively prevented potential motor damage from overloads and incorrect phase connections. During simulated fault conditions, the overload relays consistently disconnected the motor when current exceeded preset limits, while phase sequence relays successfully halted operation during phase reversal, thereby protecting the motor from reverse rotation.

The Automatic Transfer Switch (ATS) was particularly effective during power outages, ensuring that the motor seamlessly transitioned to backup power without operational disruption. This feature was crucial for maintaining continuous industrial processes. Additionally, the inclusion of overvoltage protectors proved vital, as they successfully mitigated voltage spikes that could lead to electrical damage.

User feedback highlighted the system's intuitive interface for manual control and clear visual indicators for fault detection, enhancing usability for operators. Overall, the system's design met the specified requirements, demonstrating its potential for broader applications in various industrial settings. Future improvements could involve incorporating IoT capabilities for remote monitoring and predictive maintenance, further increasing the system's efficiency and responsiveness in real-time scenarios.

Chapter 5

Project Management

5.1 Task, Schedule and Milestones

We needed a strong project plan in order to successfully execute our project on time. The team members were equally distributed among the numerous tasks that needed to be completed for the project in a timely manner. The project plan is shown in the table below.

Table III: Project Plan

S. No.	Tasks	Start	End	Duration	
1.	Chapter # 1: Introduction	06/08/24	16/08/24	10	
2.	Chapter # 2: Literature Review	Introduction	17/08/24	28/08/24	11
		Related Research			
		Summary			
3.	Chapter # 3: Materials and Methods	Introduction	01/09/24	15/09/24	15
		System Design and Components			
		Design Specifications.			
		Design Analysis			
		Implementation			
		Summary			
4.	Chapter # 4: Results and Discussions	Results	16/09/24	24/09/24	8
		Discussions			
5.	Chapter # 5: Project Management	Task, Schedule and Milestones	25/09/24	5/10/24	10
		Resources and Cost Management			

		Lesson Learned			
6.	Chapter # 6: Impact Assessment of the Project	Economical, Societal and Global Impact	06/10/24	18/10/24	12
		Environmental and Ethical Issues			
7.	Chapter # 7: Conclusions and Recommendations	Conclusions	9/10/24	29/10/24	10
		Future Recommendations			
8.	Design of Prototype		01/07/24	15/07/24	15
9.	Parts Purchase		16/07/24	26/07/24	10
10.	Manufacturing		26/07/24	31/07/24	5
11.	Testing		01/08/24	06/08/24	6

Table IV: Assigned Members for Tasks

S. No.	Task	Assigned Members
1.	Chapter # 1: Introduction	
2.	Chapter # 2: Literature Review	
3.	Chapter # 3: Materials and Methods	
4.	Chapter # 4: Results and Discussions	
5.	Chapter # 5: Project Management	
6.	Chapter #6: Impact Assessment of the Project	
7..	Chapter#7: Conclusion & Recommendation	

5.2 Resources and Cost Management

The parts we ordered, bought, and made from the market are listed in the table below. It also covers the overall cost of our project, expressed in Bangladeshi TK.

Table V: Project Bill of Materials

S/L	Components Name	Quantity	Price
01	SP MCB	3	420/=
02	Electromagnetic Relay	4	1940/=
03	Magnetic Contactor	5	4280/=
04	Overload Relay	1	650/=
05	Phase sequence relay	1	1100/=
06	Push Switch	2	360/=
07	LED Indicator	2	100/=
08	TP MCB	1	2000/=
09	Timer Relay	3	750/=
10	AC Power Cord	Needed	100/=
11	Connecting Wire	Needed	400/=
Total			10100/=

5.3 Lesson Learned

5.3.1 Life-Long Learning

When working on the project, it is crucial to have many successful learning experiences because they will have a huge impact on our future learning. As a team, we launched this project, and setting realistic goals was our top priority. A detailed investigation of the best way to implement a plan was done before starting a project. Each team member was assured to be an expert in the subject. The proper instruments were used to conduct the research. Throughout the project, we made an effort to work through trial and error and learned a lot from our errors.

5.3.2 Software Skills

Cade Simu is a specialized software for designing, simulating, and analyzing electrical circuits. Proficiency in Cade Simu involves creating detailed circuit diagrams, including control systems, relays, and motor starters, with accurate component placement and wiring. Users can simulate circuit operations to verify functionality and troubleshoot errors before implementation. Skills include understanding electrical symbols, designing

multi-layer schematics, and interpreting simulation results. Cade Simu enhances efficiency by providing a user-friendly interface for precise electrical design and system validation.

5.3.3 Hardware Skills:

We used very basic and fundamental hardware knowledge for our project. All parts that best satisfy our engineering standards were purchased for manufacture. The current and voltage values, on the other hand, were provided to us by a multimeter, which is used to compute and evaluate a system's performance. To support the hardware system in the operating system, a database was expertly offered to the team.

Chapter 6

Impact Assessment of the Project

6.1 Economical, Societal and Global Impact

The implementation of an industrial motor control and protection system has far-reaching economic, societal, and global implications. Economically, the system enhances operational efficiency by minimizing downtime and reducing the risk of equipment damage, which can result in significant cost savings for industries. By ensuring continuous operation through features like the Automatic Transfer Switch (ATS), businesses can maintain productivity and revenue, ultimately contributing to economic growth.

From a societal perspective, improved motor control systems enhance workplace safety by preventing electrical faults and machinery malfunctions. This leads to a safer working environment for employees, reducing the likelihood of accidents and injuries. Furthermore, the system promotes reliability in critical services, such as manufacturing and utilities, positively impacting daily life and community well-being.

On a global scale, adopting advanced motor protection systems aligns with sustainable practices by optimizing energy use and reducing waste. Enhanced efficiency contributes to lower energy consumption, which is essential in combating climate change. As industries increasingly prioritize sustainability, implementing such systems supports global efforts to achieve environmental goals and reduces the carbon footprint. Thus, the widespread adoption of effective motor control and protection solutions not only benefits individual organizations but also contributes to broader societal and environmental objectives.

6.2 Environmental and Ethical Issues

The implementation of industrial motor control and protection systems raises several environmental and ethical considerations. Environmentally, the production and disposal of electronic components can contribute to electronic waste (e-waste) if not managed properly. This highlights the need for sustainable manufacturing practices and end-of-life recycling programs to minimize ecological impact.

Ethically, industries must ensure that the technologies used do not compromise worker safety or well-being. Transparency in the system's operational capabilities and safety

features is crucial to build trust among employees and stakeholders. Additionally, there is an ethical obligation to invest in training programs that equip workers with the skills needed to operate and maintain these systems safely. Addressing these issues is vital for fostering a responsible and sustainable industrial environment.

Chapter 7

Discussion and Conclusion

7.1 Conclusions

The industrial motor control and protection system effectively enhances operational reliability, safety, and efficiency in three-phase motor applications. By integrating essential components such as overload relays, phase sequence relays, and an Automatic Transfer Switch (ATS), the system provides robust protection against electrical faults and ensures uninterrupted operation. The positive economic impact, coupled with improved workplace safety and contributions to sustainability, underscores the system's value in modern industrial settings. Future advancements, particularly in IoT integration for real-time monitoring, could further enhance its effectiveness, making it an essential solution for industries aiming to optimize performance and minimize risks.

7.2 Experiences Learned

In this system we learned many things when we research our topic. We included here our gathered knowledge in this work in bellow:

1. We were learned here how to start planning for complete a project with group members.
2. We know have acquired detailed knowledge about motor protection.
3. We have gone into detail about each and every component used for motor protection.

7.3 Future scope

Hopefully, in future this project will be developed. Following features can be added in the future for the further modification of this project.

1. Control this system in SCADA or HMI System
2. To monitor the fault in SCADA

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