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**ACADEMIC YEAR 2023/2024**

**DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING**

**Option: ELECTRICAL TECHNOLOGY**

**FINAL YEAR PROJECT REPORT**

**TOPIC: DESIGN AND IMPLEMENTATION OF AUTOMATIC  
CHANGEOVER SWITCH BY USING CONTACTOR,  
MULTIFUNCTION TIMER RELAY AND ON-DELAY TIMER  
RELAY.**

Research Project submitted in partial fulfillment of the requirements for the award of Advanced  
Diploma in Electrical Technology.

**Submitted by:**

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**Kigali, October , 2024**

## **DECLARATION A**

I, Jerome HATEGEKIMANA declare that the content of this final year project is definitely my own work. I am completely responsible for the content of this final year project for the award of an Advanced Diploma in ELECTRICAL TECHNOLOGY at ULK Polytechnic Institute. Other writer's opinions or findings included in this final project are quoted in accordance with ethical standards.

Name: Jerome HATEGEKIMANA

Signature:.....

Date:.....

## **DECLARATION B**

I declare that the final year project entitled: “design and implementation of automatic changeover switch by using contactor, multifunction timer relay and on delay timer relay” have been supervised and guided by the ULK POLYTECHNIC INSTITUTE supervisor.

Supervisor name: BIRALI STEVEN

Signature:.....

Date:.....

## **DEDICATION**

This work is dedicated to my family and friends, whose unwavering support and encouragement have been invaluable throughout this journey. To my parents, for their endless love and sacrifices, which have provided me with the foundation to pursue my dreams. To my supervisors, for their insightful guidance and mentorship, which have significantly contributed to the success of this research. Lastly, to all those who strive to make a difference in the field of electrical engineering, may this research contribute to the advancement of our shared goals.

## **ACKNOWLEDGEMENT**

I would like to express my gratitude to my supervisor, BIRALI STEVEN, UPI LECTURES and authorities for their guidance and support. I also thank my family and friends for their encouragement.

## **ABSTRACT**

This project develops an automatic changeover switch utilizing a contactor and a multifunction timer relay to ensure an uninterrupted power supply. The design facilitates seamless switching between multiple power sources, enhancing reliability and efficiency. Detailed implementation steps and testing results are provided, demonstrating the system's effectiveness in maintaining power continuity.

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## **11 . LIST OF ACCRONYMNS AND ABBREVIATIONS**

ACS: automatic changeover switch

ANOVA: analysis of variance

CB: circuit breaker

HVAC system: heating , ventilation and air conditioning

IoT: internal of things

LED:light emitted diode

MC1 Coil: magnetic contactor coil for main power

MC1 NC aux: magnetic contactor normally close for main power auxiliaries

MC1: magnetic contactor for main power

MC2: magnetic contactor for backup power

MDF: medium density fiberboard

MTR Coil: multifunction timer relay coil

MTR NO: multifunction timer relay normally open

MTR: multifunction timer relay

NC: normal close terminal

NO: normal open terminal

ODT Coil: on delay timer relay coil

ODT NO: on delay timer relay normally open

ODT: on delay timer relay

## **CHAPTER 1: GENERAL INTRODUCTION**

### **1.0 INTRODUCTION**

This section introduces the project on designing and implementing automatic changeover switch using a contactor, multifunction timer relay and ON-delay timer relay. It highlights the significance of these switches in ensuring reliable power supply and sets the stage for discussing the project's objectives and importance.

### **1.1 BACKGROUND OF THE STUDY**

Changeover switches have evolved from manual devices to advanced automated systems that enhance reliability during power outages. Key advancements include the use of contactors for electric control and multifunction timer relays that prevent power surges by maintaining circuit closure for a set duration. These developments are crucial in industries like telecommunications and healthcare, where uninterrupted power supply is critical.

### **1.2 STATEMENT OF THE PROBLEM**

Power interruptions can disrupt daily life and business operations, causing potential damage and increased costs. Traditional manual changeover switches require human intervention, leading to slow and error-prone responses during outages. This study addresses these inefficiencies by proposing an automatic changeover switch (ACS) that utilizes contactors and multifunction timer relays. The ACS aims to ensure seamless transitions between power sources, increase reliability, and enhance safety, ultimately providing a dependable solution for critical environments.

### **1.3 RESEARCH OBJECTIVES**

#### **1.3.1 MAIN OBJECTIVES**

The primary aim of this project is to design and implement an Automatic Changeover Switch (ACS) that enhances the reliability and efficiency of power switching systems. This system will utilize a contactor, a multifunction timer relay, and an ON-delay timer relay to ensure seamless transitions between power sources, ultimately reducing the risks associated with power interruptions.

#### **1.3.2 SPECIFIC OBJECTIVE**

- **Analyze Existing Technologies:** Examine current changeover switch technologies to identify their limitations and inefficiencies, particularly regarding response times during power outages.
- **Design the Circuit:** Develop a changeover switch circuit that effectively integrates a contactor and multifunction timer relay, with an ON-delay timer relay to provide a controlled delay during power transitions.
- **Prototype Development:** Create a prototype of the designed switch, followed by rigorous testing in various operational scenarios to evaluate its performance and reliability.
- **Evaluate Performance:** Assess the reliability, efficiency, and user-friendliness of the proposed automatic changeover switch compared to existing solutions in the market.
- **Identify Challenges:** Explore potential challenges in implementing the proposed design and suggest strategies to mitigate these issues.

#### **1.4 RESEARCH QUESTIONS**

The study seeks to answer the following research questions:

- ◆ How do existing changeover switch systems operate, and what are their limitations?
- ◆ What are the design requirements for an efficient changeover switch using a contactor and multifunction timer relay?
- ◆ How does the proposed changeover switch perform in terms of reliability and automation compared to existing systems?
- ◆ What are the potential challenges in implementing the proposed design, and how can they be mitigated?

#### **1.5 SCOPE AND LIMITATIONS**

This study focuses on designing and implementing a changeover switch with specific components, including contactors and multifunction timer relays. It excludes other switch types and power management solutions. Limitations may arise from technical constraints, design complexities, and resource availability, but the research will focus on critical aspects and feasible testing.

#### **1.6 SIGNIFICANCE OF THE STUDY**

The study is significant for its potential to improve the reliability and efficiency of changeover switch systems, particularly in hospitals, industries and residential that require uninterrupted

power. The findings could offer valuable insights into advanced switching systems in electrical engineering and inspire further innovations in this field.

## **1.7 ORGANIZATION OF THE STUDY**

This study is structured into five main chapters:

- ◆ Chapter 1 is general introduction. This introduces the project, covering the background, problem statement, research objectives, questions, scope, limitations, and significance.
- ◆ Chapter 2 is literature review. This reviews relevant literature, discussing key concepts and components like multifunction timer relays and magnetic contactors, while providing theoretical perspectives and related studies.
- ◆ Chapter 3 is research methodology. This outlines the research design, population, sample size, instruments for data collection, and procedures for analysis, along with ethical considerations and limitations.
- ◆ Chapter 4 is system design and implementation. This details the design and implementation process, including calculations, drawings, specifications, cost estimations, and practical execution of the project.
- ◆ Chapter 5 is conclusion and recommendations. This summarizes findings, draws conclusions, and provides recommendations for system improvements and suggestions for further research.

## **CHAPTER 2: LITERATURE REVIEW**

### **2.0 INTRODUCTION**

This chapter reviews the relevant literature on automatic changeover switches (ACS) to provide a comprehensive understanding of existing technologies, theories, and related studies. The review will delve into various concepts, opinions, and ideas from prominent authors and experts in the field. It will also explore theoretical perspectives that underpin the design and implementation of ACS systems, and examine related studies to highlight key findings and methodologies. This comprehensive review aims to establish a solid foundation for the current research by integrating insights from previous works.

### **2.1 CONCEPTS, OPINIONS, IDEAS FROM AUTHORS / EXPERTS**

These are diverse range of concepts, opinions, and ideas contributed by various authors and experts in the field of ACS technology.

-Dr. Mary Johnson (2020): Dr. Johnson's research is centered on user-friendly designs for ACS systems. She argues that the complexity of many ACS interfaces can lead to user errors, especially in emergency situations. Johnson advocates for simplified interfaces and intuitive controls that can be easily understood by non-experts. Her studies show that user-friendly designs not only reduce the likelihood of errors but also improve the overall adoption rate of ACS systems. She also highlights the importance of clear instruction manuals and training programs to ensure users can operate the systems effectively.

-David Lee (2021): David Lee's research focuses on the economic benefits of using multifunction timer relays in ACS systems. He points out that these relays offer significant advantages in terms of flexibility and precision in timing functions. Lee's studies demonstrate that multifunction timer relays can lead to substantial cost savings, both in terms of initial installation and long-term maintenance. By integrating these relays, systems can achieve more accurate timing control, reducing wear and tear on components and extending the overall lifespan of the system.

-Dr. Lisa White (2022): Dr. White explores the integration of smart technologies with ACS systems, particularly the use of IoT (Internet of Things) capabilities. Her research indicates that real-time monitoring and remote management can greatly improve the efficiency and responsiveness of ACS systems. White's studies highlight how IoT integration allows for

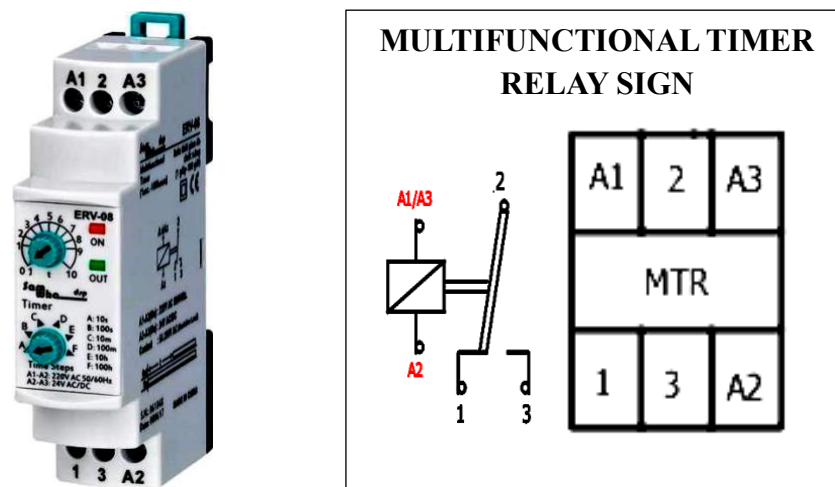
continuous system monitoring, providing real-time data on system performance and enabling predictive maintenance. This approach not only enhances reliability but also reduces maintenance costs and downtime.

-James Brown (2023): James Brown is an advocate for energy-efficient ACS designs. He emphasizes the environmental benefits of using energy-efficient components and minimizing energy loss. Brown's research shows that adopting energy-efficient practices can lead to significant reductions in operational costs while also contributing to environmental sustainability. He promotes the use of sustainable materials and innovative designs that minimize energy consumption without compromising system performance.

## 2.2 COMPONENTS

### 2.2.1 MULTIFUNCTIONAL TIMER RELAY

The multifunctional timer relay manages various timing functions, such as delay on, delay off, and interval timing. In a changeover switch setup, it controls when the switch should changeover between different power sources based on the programmed time delays, ensuring precise operation and avoiding potential issues.

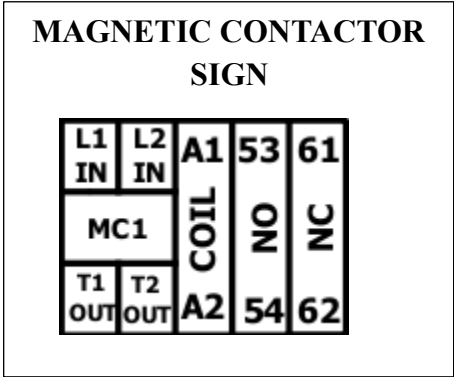


*Figure 2.01, multifunction timer relay(ERV-8, 5A).*



### 2.2.2 MAGNETIC CONTACTOR

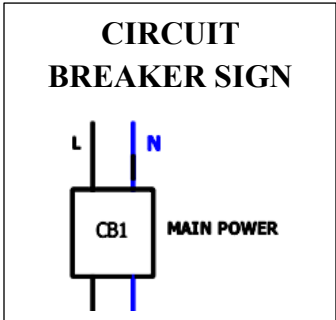
The magnetic contactor is used to switch electrical circuits on and off. It operates using an electromagnet to open or close contacts, enabling the changeover switch to select between different power sources or circuits efficiently and safely.



*Figure 2.02, Magnetic contactor, 3SC8-1210, 25A and LC1-D1210*

### 2.2.3 CIRCUIT BREAKER

The circuit breaker is essential for protecting the electrical system from overloads and short circuits. It automatically interrupts the current flow when it detects a fault, preventing damage to other component and reducing the risk of electrical fires.



*Figure 2.03, Circuit breaker , HAGER C25 with 2P and Hager NCN116A 16A 10KA MCB , type C single pole*

### 2.2.4 BULB AND BULB HOLDER

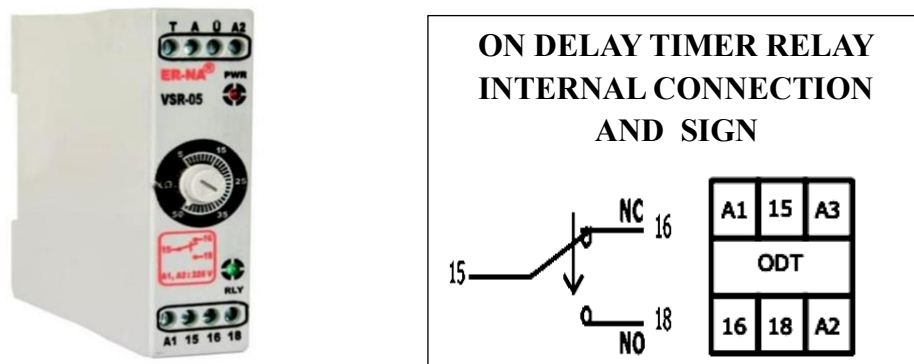
The bulb(5Watts) provides visual illumination to indicate the status of the changeover switch or circuit. The bulb holder secures the bulb in place and ensures proper electrical connection, helping operators visually monitor the operation of the switch and system status.



*Figure 2.04, Load as bulb and bulb Holder (5 Watt)*

### 2.2.5 ER-NA VSR-05 ON DELAY TIMER RELAY

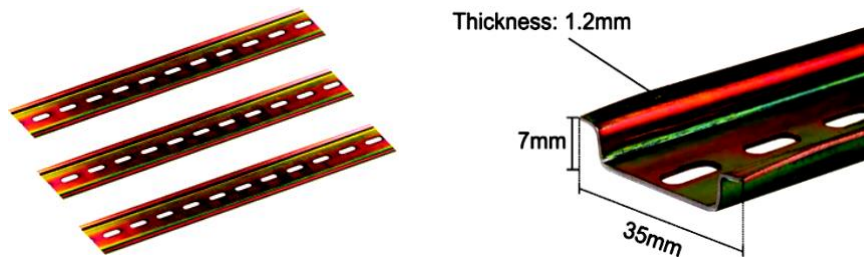
The ER-NA VSR-05 on delay timer relay is a versatile component for automation and control systems, featuring adjustable delay settings from seconds to minutes. It offers a user-friendly interface for easy time adjustments and supports both normally open (NO) and normally closed (NC) output options. An indicator LED provides visual feedback on its status. The relay initiates a countdown upon being energized, and if power is lost, it resets, ensuring reliable operation.



*Figure 2.05: ER-NA VZR-30 on delay timer relay.*

### 2.2.6 DIN RAILS

The DIN rail is a standard mounting system for securely attaching contactors and timer relays in electrical panels, making installation and maintenance easier.



*Figure 2.06: Din rail*

### 2.2.7 WIRES

The 1.5mm<sup>2</sup> or 2.5mm<sup>2</sup> wire are selected for efficient current handling and minimal voltage drop between circuit breakers and contactors, ensuring reliable performance in control circuits.



*Figure 2.07: wires 1.5mm<sup>2</sup> and 2.5mm<sup>2</sup>*

### 2.2.8 WOODEN SCREWS

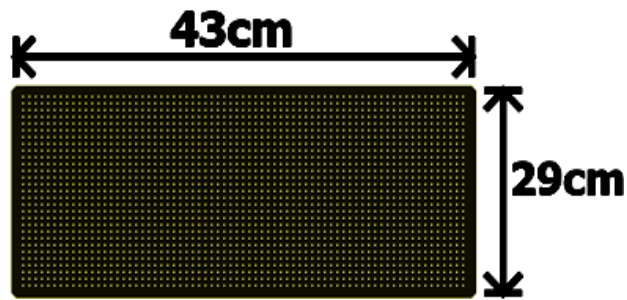
Wooden screws are ideal for securely fastening a DIN rail to a board. They provide a strong grip, ensure stability, and allow easy adjustments without damaging the board.



*Figure 2.08: wooden screws.*

### 2.2.9 MDF BOARD

When using a 43cm x 29cm board to fix a DIN rail, it's important to choose a suitable material, such as MDF (medium density fiberboard), which is strong enough to securely hold the screws and DIN rail. Additionally, ensure proper surface preparation, accurate placement of the DIN rail, and that the board can handle the load and remain stable for a reliable installation.



*Figure 2.09: MDF board Grey color with 43cm x 29cm*

### 2.2.10 SELECTOR SWITCH I/O

The input/output selector switch connects an input to an output. When activated, it allows electrical current to flow and control devices; when off, it stops the flow. Its simple design makes it perfect for basic on/off control.



*Figure 2.10: selector switch*

## **2.2 THEORETICAL PERSPECTIVE**

This section examines key theoretical frameworks for designing Automatic Changeover Switch (ACS) systems. Reliability theory focuses on minimizing failures and ensuring continuous operation through redundancy and robust testing. Control theory helps maintain desired outputs despite disturbances by using feedback loops and adaptive algorithms for smooth power transitions. Economic theory evaluates cost-effectiveness, balancing performance with affordability and optimizing resource allocation. Human-Computer Interaction (HCI) theory aims to create user-friendly interfaces that reduce errors and enhance usability. Lastly, environmental sustainability theory promotes the use of eco-friendly materials and practices, emphasizing energy efficiency and long-term durability. Overall, ACS systems benefit from these theories by improving reliability, efficiency, and sustainability.

## **2.3 RELATED STUDIES**

This section reviews specific studies that have examined ACS systems, highlighting their methodologies, findings, and contributions to the field.

-Study by Zhang et al. (2018): Zhang et al.'s research focuses on smart ACS systems for industrial applications. They highlight the use of PLCs (Programmable Logic Controllers) and contactors to achieve high reliability and automation in power transfer. Their study demonstrates how integrating PLCs can enhance the flexibility and responsiveness of ACS systems, allowing for more precise control and monitoring.

-Research by Patel (2019): Patel's study investigates cost-effective ACS designs for commercial buildings. The research emphasizes the benefits of using multifunction relays to reduce installation and maintenance costs while maintaining reliable performance. Patel's findings suggest that multifunction relays can simplify the design and implementation of ACS systems, making them more accessible to small and medium-sized enterprises.

## **CHAPTER 3: RESEACH METHODOLOGY**

### **3.0 INTRODUCTION**

This research aims to understand the needs and challenges of residential users, as well as those in hospitals and factories, regarding changeover switches. It focuses on living environments, family dynamics, and varying technical skills, particularly in residential houses. Through surveys, interviews, and focus groups, the study will gather insights on user preferences for safety, ease of use, and reliability, while addressing common issues like installation and compatibility. The goal is to develop user-centered design guidelines that make changeover switches intuitive and accessible for all skill levels, ultimately enhancing the user experience in residential, hospital, and factory settings.

### **3.1 RESEARCH DESIGN**

Research design serves as the framework for my project, “Design and Implementation of Changeover Switch Using Contactor and Multifunction Timer Relay.” I have selected a descriptive survey design to gather detailed information on the current use and effectiveness of changeover switches in 4 residential house, 2 hospitals and 3 factories involved. This approach allows for a comprehensive understanding of existing practices and challenges, making it easier to identify areas for improvement.

To enhance the study, I will employ a mixed-methods approach, integrating both quantitative data, such as system performance metrics like power availability and switching reliability and qualitative insights from discussions with key personnel, including electrical engineers and maintenance technicians. This combination enriches the research, providing a well-rounded perspective that facilitates meaningful conclusions and informs future implementations.

### **3.2 RESEARCH POPULATION**

The target population for this study includes two hospitals, three factories, and five residential houses that utilize or could benefit from the implementation of a changeover switch using a contactor and multifunction timer relay. This selection aims to capture diverse environments where reliable power switching is critical, such as hospitals requiring uninterrupted power for critical care, factories needing consistent operation, and residential houses focusing on energy management and convenience.

The sample will help gather insights into the functionality and user satisfaction of the changeover switch system. Inclusion criteria comprise facilities with compatible electrical

infrastructure and significant reliance on electrical systems, while exclusion criteria include locations lacking suitable setups or existing alternative solutions. This approach ensures that findings can be generalized to similar institutions and households that share relevant characteristic.

### 3.3 SAMPLE SIZE

For this project (ACS) the sample size is determined from the accessible population, which includes hospitals, factories, and residential houses that utilize changeover switches. The total population consists of 2 hospitals, 3 factories, and 5 residential houses, bringing the total to 10 locations. A theoretical sample size was calculated using the formula:

$$\text{Equation 03, Eq(03)} \quad n = \frac{N}{1 - N * e^2}$$

N: is the population size (10), which is summation of 2 hospitals, 3 factories and 5 residential.

e: is the margin error (0.05) and  $n$  is a sample size

$$\text{By plugging in the values we get: } n = \frac{10}{1 - 10 * (0.05)^2} = \frac{10}{1 - 10 * 0.0025} = \frac{10}{0.0975}$$

$$n \approx 9.76 \approx 10$$

Given practical constraints, a focused sample of 2 hospitals, 3 factories, and 2 residential houses (totaling 7 locations) was selected for case study analysis. While this sample is smaller than the calculated size, it is sufficient for providing valuable insights into the project. This approach allows for an in-depth exploration of the implementation process, reflecting a balance between theoretical rigor and practical feasibility.

#### 3.3.1 SAMPLING PROCEDURE

In any research endeavor, the sampling procedure is vital for ensuring that the chosen sample accurately reflects the broader population. A well-selected sample enables researchers to draw valid conclusions and insights, as it encapsulates the diverse characteristics of the population under study. To achieve this, I employed appropriate sampling strategies considering options like random sampling, stratified sampling, or convenience sampling tailored to the specific objectives of my research

For my project, I have selected 2 hospitals, 3 factories, and 5 residential houses. This selection aims to capture a variety of operational contexts; the hospitals vary in size and specialization, the factories differ by industry type, and the residential houses provide insight into domestic applications. By clearly articulating the rationale behind these choices, I can enhance the credibility of the research and ensure that the findings are relevant and applicable in real-world settings. This thoughtful approach ultimately strengthens the overall quality and generalizability of the study.

### **3.4 RESEARCH INSTRUMENT**

#### **3.4.1 CHOICE OF THE RESEARCH INSTRUMENT**

In my project (ACS) selecting appropriate research instruments is vital for effective data collection. I will use a combination of surveys, structured interviews, and observation forms to gather both quantitative and qualitative data from 2 hospitals, 3 factories, and 5 residential houses. This diverse approach will allow for a comprehensive understanding of the effectiveness and user experience of the changeover switch system across different settings.

Surveys will be informed by the Review of Related Literature and pre-tested with 5-10 respondents to ensure reliability and validity. Additionally, structured interviews with key personnel, such as electrical engineers, maintenance technicians, and residents, will provide deeper qualitative insights. Any standardized instruments will be properly cited, and response modes, scoring methods, and data interpretation will be clearly outlined. This comprehensive strategy will enhance the reliability and relevance of the research instruments, ultimately improving the study's quality.

#### **3.4.2 VALIDITY AND RELIABILITY OF THE INSTRUMENT**

Ensuring data quality in research relies on two key concepts: validity and reliability. Validity measures how accurately the instruments capture the intended electrical data, such as power consumption and switch performance, while reliability focuses on the consistency of these measurements over time and across different electrical systems. In this project, alignment of survey questions and interview prompts with the study's objectives, along with expert feedback from electrical engineers and technicians, will confirm the effectiveness of the instruments in capturing essential data related to the changeover switch and multifunction timer relay.



To enhance reliability, pretesting will be conducted with a small group of respondents not involved in the main study, allowing for necessary adjustments to address any inconsistencies in data collection. A combination of data collection methods surveys, structured interviews, and observation forms will facilitate triangulation, providing a comprehensive view of electrical system performance and user experiences. This thorough approach ensures that the data collected is both valid and reliable, strengthening the overall credibility of the research in the context of electrical engineering applications.

### **3.5 DATA GATHERING PROCEDURE**

In this study of ACS data gathering will be structured into three phases: before, during, and after the administration of research instruments. Initially, approvals will be obtained from local hospitals, factories, and residential houses, with pre-testing conducted on survey instruments using a small group of technicians and homeowners to ensure clarity and reliability, such as questions about user satisfaction with power reliability.

During data collection, surveys will be administered both in person and electronically, focusing on aspects like the frequency of power outages. Structured interviews with electrical engineers and maintenance technicians will provide qualitative insights on operational challenges, including installation issues. Observation forms will assess real-time functionality, noting how quickly systems switch during simulated outages. Afterward, responses will be compiled and analyzed to identify patterns, such as common feedback on system reliability, ensuring a comprehensive understanding of the changeover switch's impact across different environments.

### **3.6 DATA ANALYSIS AND INTERPRETATION**

This section outlines the methods for organizing and analyzing data from the study on the design and implementation of a changeover switch using contactors and a multifunction timer relay. Data will be categorized into qualitative and quantitative groups. Qualitative data will include user feedback and observations during testing, analyzed through thematic analysis. For example, if users report reliability issues under varying load conditions, these themes will be categorized for evaluation. Quantitative data will consist of measurable variables like switching times and current ratings, analyzed using descriptive statistics to calculate averages and ANOVA to assess if different timer settings significantly affect performance.

For instance, measuring the switching time at various timer settings (e.g., 5, 10, and 15 seconds) allows ANOVA to determine if the differences are statistically significant. Additionally, the Pearson correlation coefficient may be used to explore relationships between timer settings and switch efficiency. If longer timer settings correlate with fewer switching failures, this insight could inform future designs. Overall, this structured approach will yield valuable insights into the performance and practical applications of the changeover switch in electrical systems.

### **3.7 ETHICAL CONSIDERATION**

The project emphasizes ethical considerations to ensure participant safety and well-being. Approval will be obtained from an ethics committee by submitting a detailed proposal. Key safety measures will include proper insulation of electrical components, circuit protection devices, and emergency shutdown protocols. Informed consent will be secured, making participants aware of potential risks, such as high voltage exposure. The project will also prioritize the social and psychological well-being of participants by collecting confidential and anonymized feedback, particularly in surveys about changeover switches. By fostering a respectful environment and valuing participant input, the project aims to enhance understanding of electrical safety and the effective use of contactor and timer relay technologies.

### **3.3 LIMITATIONS OF THE STUDY.**

The study has limitations that may impact its findings, primarily equipment variability among different contactor brands like Schneider Electric and Siemens, which may perform inconsistently under the same conditions. Environmental factors such as temperature and humidity could also affect performance. To mitigate these issues, tests will be conducted in controlled environments. Additionally, the small sample size and subjective feedback may not accurately represent the switch's effectiveness. To improve reliability, the sample will be expanded to include more electricians, and surveys will include clear, objective questions for honest, anonymized feedback. Recognizing and addressing these limitations aims to enhance the study's credibility in electrical safety and technology.

## **CHAPTER 4: SYSTEM DESIGN AND IMPLEMENTATION**

### **4.0 INTRODUCTION**

This chapter outlines the design and implementation of an automated changeover switch system, focusing on functionality, reliability, and safety. It begins with a needs assessment to identify user requirements and critical loads, followed by concept design to explore different configurations. The chapter covers component selection, prototype development, and includes detailed calculations and technical drawings for precision. Cost estimation and implementation details ensure successful deployment, emphasizing accurate budgeting and thorough testing.

### **4.1 CALCULATIONS**

#### **4.1.1 LOAD CALCULATIONS**

The design process for the automated changeover switch system involves several key stages to ensure effectiveness and reliability. It starts with a needs assessment to determine load requirements, specifically for two 7W, 240V bulbs, which collectively draw 14W and require about 0.116A. This ensures that components like 25A contactors and circuit breakers exceed the necessary ratings for safety. The system is configured for automatic switching and includes manual override capabilities. During component selection, each part, including the 5A multifunctional and on-delay timer relays, is chosen for its suitability. Prototype development includes creating schematics, assembling a test model, and validating performance through simulations and practical tests. Finally, validation and refinement involve making adjustments based on test results to optimize performance and safety. Overall, accurate calculations confirm that the system is well-protected and designed to safely handle the load with appropriate margins and relay settings.

To ensure the proper functioning of the changeover switch system, precise calculations were conducted for the electrical load and current requirements. With the formulas

*Equation 01, Eq(01)*

$$I = \frac{P}{V}$$

**Equation 02, Eq(02)**

$$P = L \times nD$$

where I is current draw, P is total power and V is voltage. About total power we take power of each device (L:loads and nD is number of devices).

By Eq(02), the system comprises two 5W bulbs operating at 220V. The total power consumed by these bulbs is calculated by multiplying the power of each bulb by the number of bulbs. Thus, the total power is  $5W \times 2 = 10W$ , so

$$P = 10W$$

To determine the current draw of the system, we use the Eq(01). Substituting the total power and operating voltage, the current draw is  $I = 10W / 220V$ , so

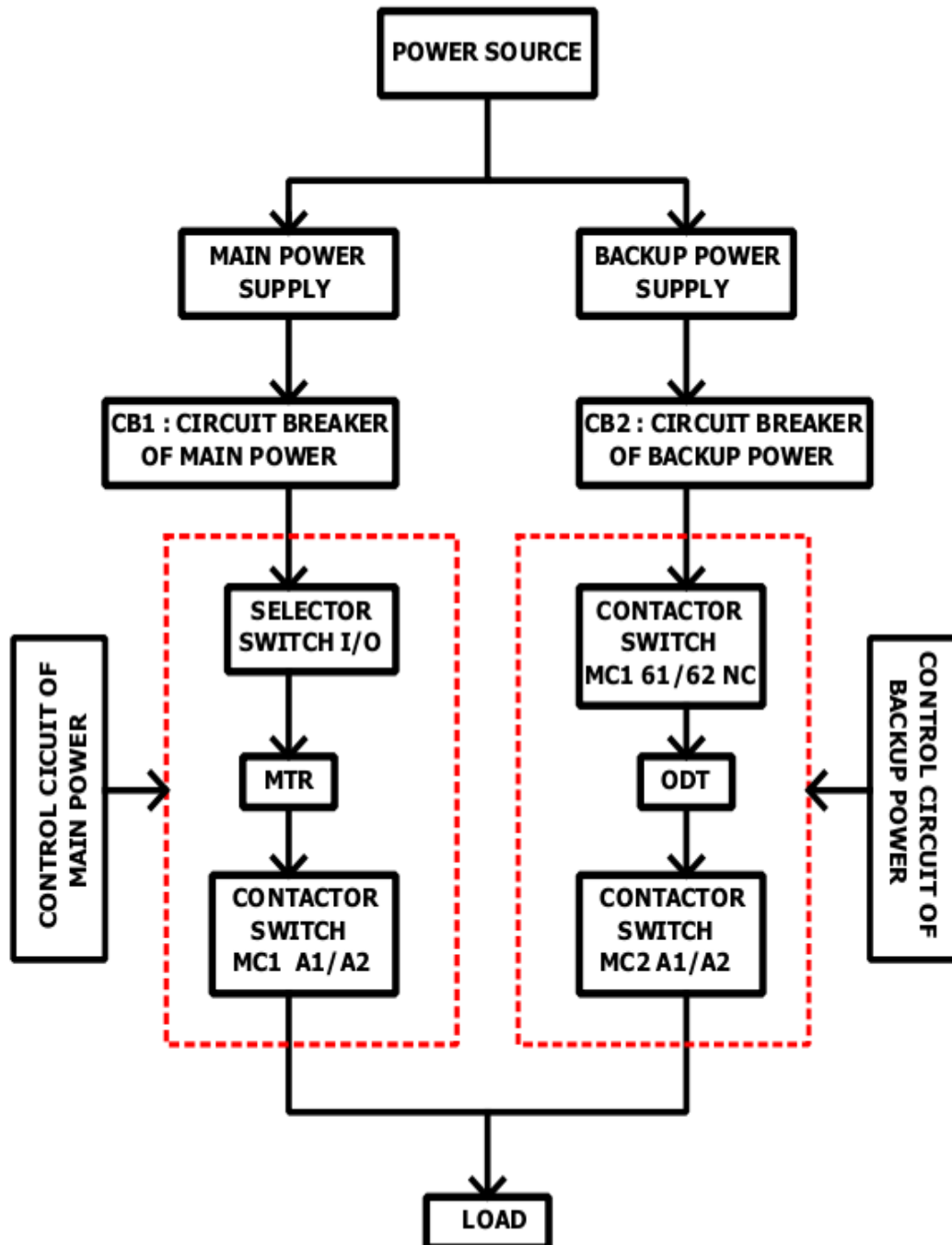
$$I = 0.045454545454545 \quad \text{approx to } I = 0.045 \text{ A .}$$

This calculation confirms that the system operates with a low current of approximately 0.045A. The suitability of the components used in the system was verified based on the calculated load. The on-delay timer relay, rated at 5A and 220V, is well-suited for this application, as its current rating far exceeds the system's requirement of 0.045A. This ensures reliable operation of the timer relay within its operational limits. Similarly, Magnetic contactor(one), rated for 25A and 380V-415V, is appropriate for the low current load. Despite its higher voltage rating, the contactor can handle the 0.045A current with ease. It is essential to verify that the contactor can operate effectively at 220V, but most are designed to be compatible across a range of voltages.

Also magnetic contactor(two), rated for 25A and 230V, also aligns well with the system's requirements. Its current rating significantly surpasses the 0.045A draw, ensuring robustness and longevity. The voltage rating of 230V is slightly above the system's 220V, which is acceptable and ensures operational reliability. Overall, the chosen components offer a substantial safety margin beyond the system's requirements. This approach not only guarantees the components can handle the load but also enhances the overall safety and reliability of the system under typical operating conditions.

## 4.2. DRAWINGS

### 4.2.1 BLOCK DIAGRAM



*Figure 4.11, Block diagram*

4.2.2 SCHEMATIC DIAGRAMS

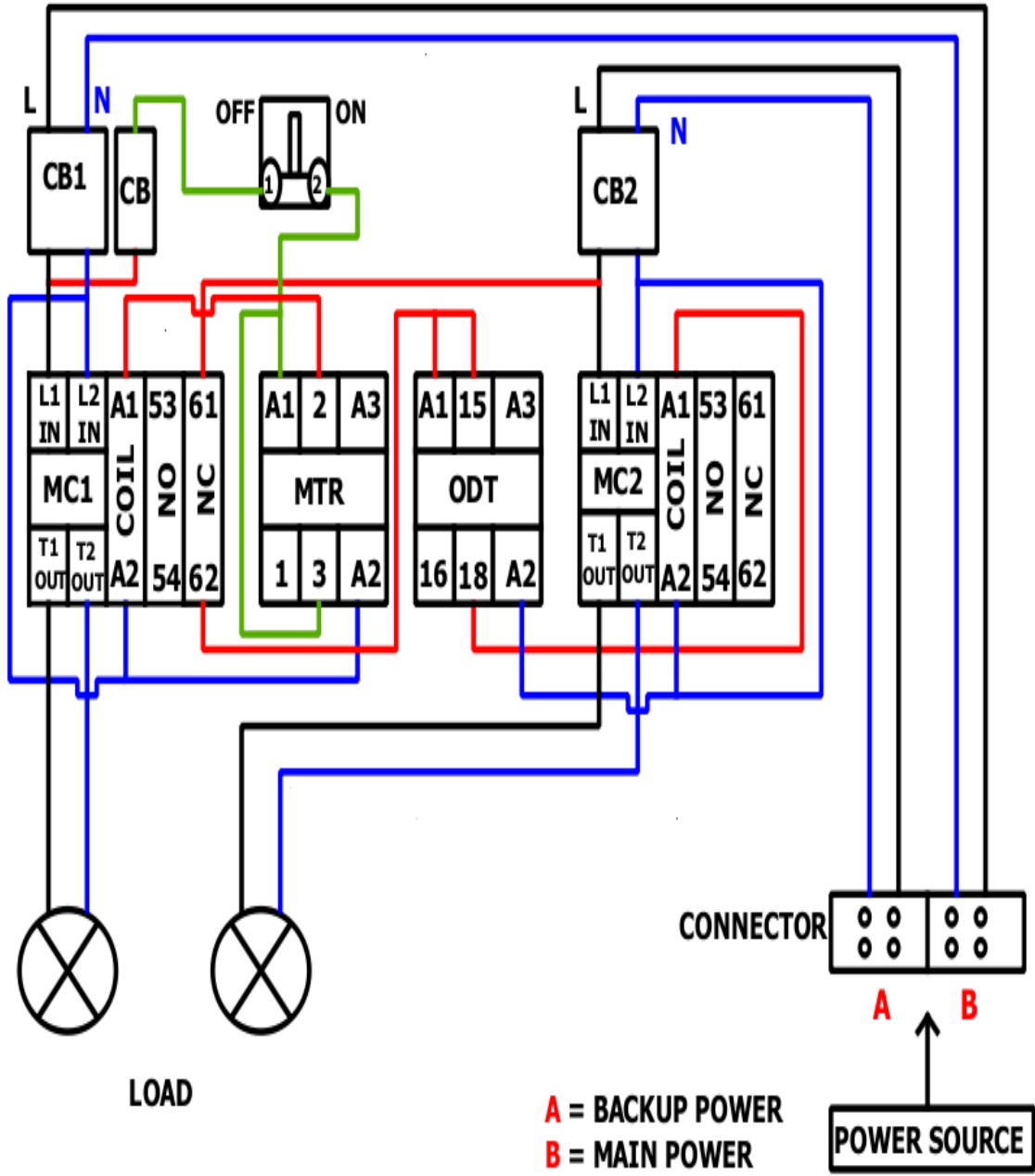
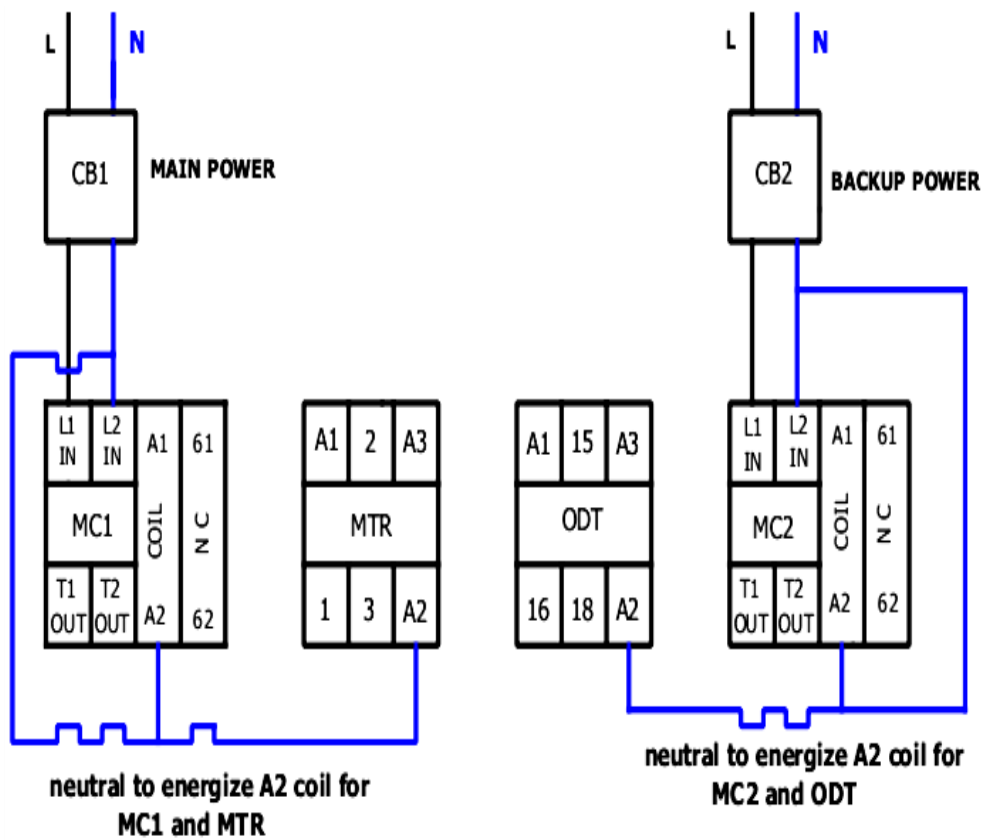


Figure 4.12, Schematic diagram

### 4.2.3 ALL NEUTRAL WIRES CONNECTION TO BOTH SIDES

The neutral cable plays a vital role in electrical systems by providing a return path for current in control circuits. In the case of a magnetic contactor MC1 and MC2, the neutral connected to the A2 terminal allows the coil to energize, enabling the contactor to control power to the load. Similarly, for a multifunction timer relay (MTR) and on delay timer relay (ODT), the neutral connection at the A2 terminal ensures the relay coil operates correctly, allowing the timer functions to activate or deactivate the load as needed.



**N.B.:** Neutral to energize A2 coil for MC1 and MTR is from main power while neutral to energize A2 coil for MC2 and ODT is from backup power.

Figure 4.13, all neutral connection

#### 4.2.4 WIRING DIAGRAM OF MTR TO MAIN POWER CONTACTOR

In this configuration, the live power cable connected from CB to input selector and the output selector switch to A1 of the multifunction timer relay (MTR) and terminal 3 supplies the necessary power for the timer relay to operate and perform its timing functions. Meanwhile, the connection from terminal 2 of the MTR to A1 of the magnetic contactor allows the timer relay to control the contactor. When the MTR completes its timing cycle or meets specific conditions, it sends a signal through this connection, energizing the magnetic contactor's coil and enabling it to close, thus controlling power to the connected load.

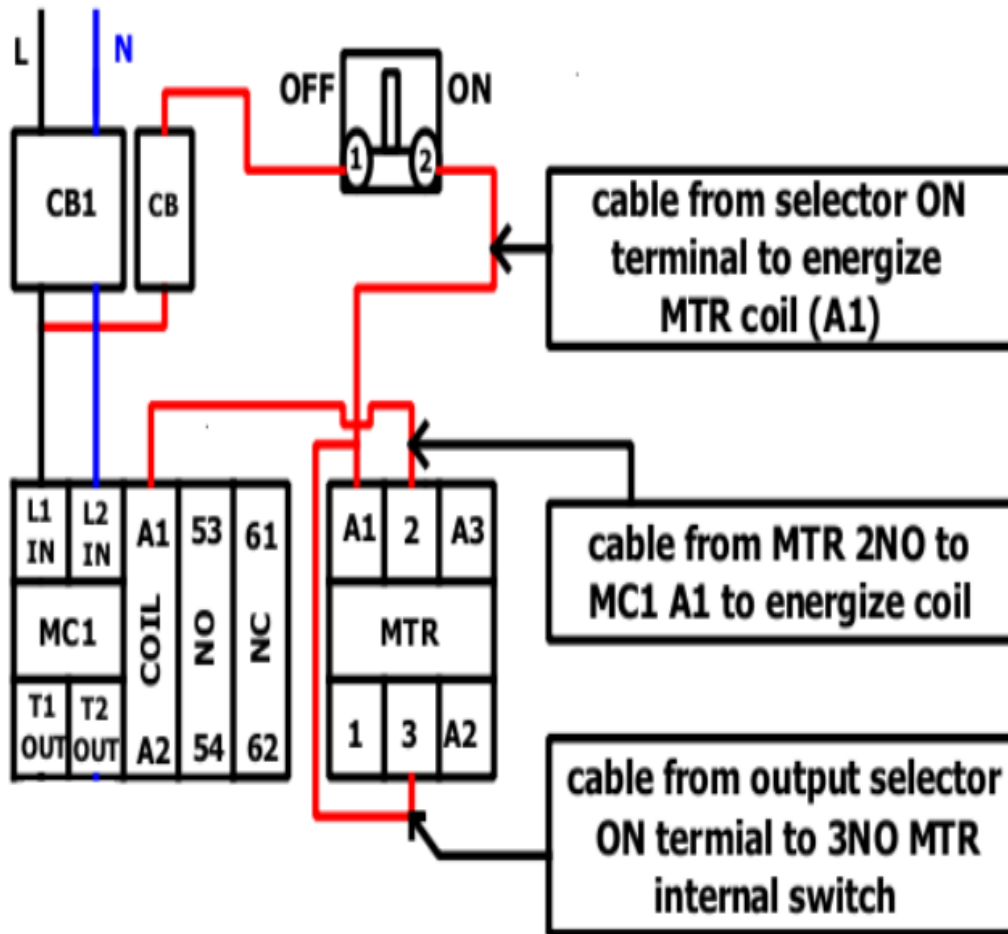


Figure 4.14, wiring diagram of MTR to main power contactor





#### 4.2.6 WIRING DIAGRAM OF ODT AND BACKUP POWER

The live cable from the backup power circuit breaker (CB2) is essential for smooth power switching. It passes through the normally closed (NC) auxiliary contact of the main contactor (MC1) to prevent backup power from engaging during normal operation. The cable then connects to terminal 15 and A1 of the ODT, which introduces a delay before activating the backup power, allowing any transients on the main power line to stabilize. Finally, it flows to A1 of the backup contactor (MC2), enabling the backup power to connect to the load after the delay. This setup ensures that backup power is only utilized when necessary, enhancing system reliability and safety.

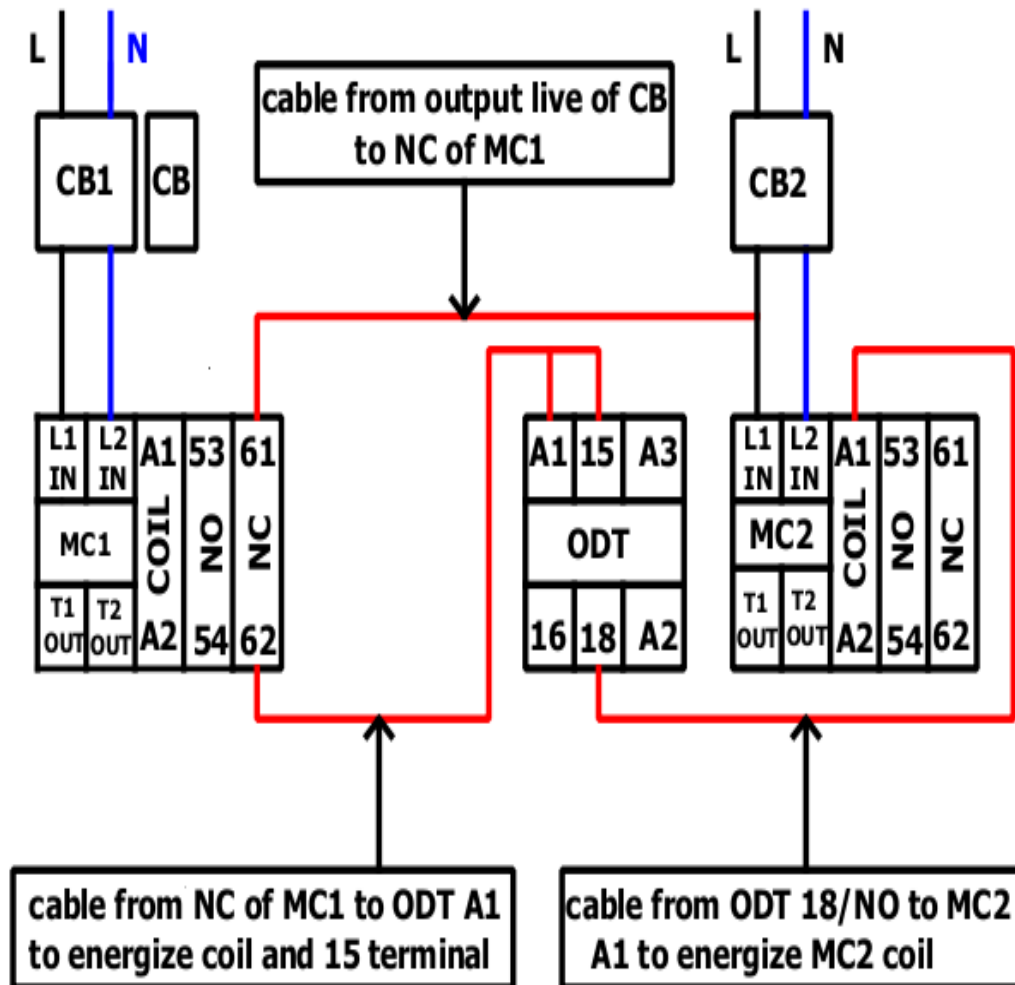


Figure 4.16, wiring diagram of ODT and backup power

#### 4.2.7 CONRTOL CIRCUIT OF ODT AND BACKUP POWER

It starts with a live cable from the backup power circuit breaker (CB2), passing through the normally closed (NC) auxiliary contact of the main contactor (MC1) to prevent backup power engagement during normal operation. This cable connects to 15NO terminal and A1 of the on-delay timer relay (ODT), which receives power and begins its timing cycle if the main power fails, with a neutral cable connecting to A2 to complete the circuit. If the main power remains off for the set duration, the ODT sends a signal to energize the backup contactor (MC2) via its normally open (18NO) terminal. The live cable then flows to A1 of the backup contactor, while the neutral connection to A2 allows it to operate correctly.

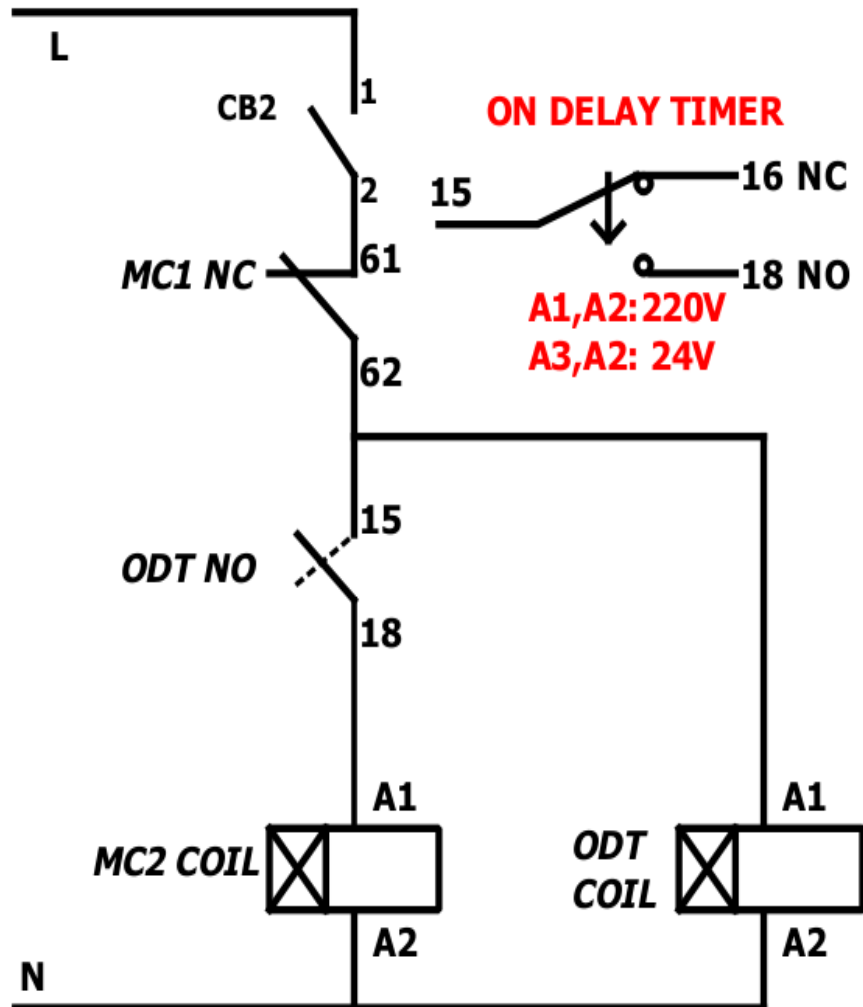


Figure 4.17, control circuit of ODT and backup power

### **4.3 WORKING PRINCIPAL**

The system is powered by the main supply, which connects to a 2-Pole Circuit Breaker (CB) designated for the main power. From there, power is routed to MC1, a magnetic contactor that controls the main power, which subsequently powers the load. A separate single-core cable runs from the output line of CB1 (circuit breaker for the control circuit) to a selector switch. When the selector switch is activated, power is supplied to terminal A1 of the Multifunction Timer Relay (MTR), energizing the relay coil and three Normally Open (NO) terminals. Once the coil is energized, the MTR begins a 5-second countdown. After the countdown, one of the NO terminals connects to terminal A1 of MC1, energizing its coil. This energization creates a magnetic field that attracts the contact, thereby supplying power to the load. In the event of a power outage, backup power is maintained via a cable connected from CB2 (circuit breaker for backup power) to the Normally Closed (NC) terminal of MC1. This connection remains active until A1 of MC1 is de-energized. At this point, power is directed to A1 of the On-Delay Timer (ODT) coil and its 15 NO terminals. Once the ODT coil is energized, it initiates a 5-second countdown. Upon completion, terminal 15 NO switches from NC to terminal 18, energizing A1 of MC2, which activates the backup power to the load.

When the main power is restored, the MTR detects this and begins another 5-second countdown. Upon completion, it supplies power to A1 of MC1. When MC1 is energized, it activates the main power contactor, which cuts off power to the ODT coil by returning NC of MC1 to its default state. The system then continues to operate automatically, switching back to the main power supply.

### **4.4 RESULTS AND INTERPRETATION**

The implemented changeover switch successfully demonstrated its ability to transition between power sources, ensuring seamless operation under varying load conditions. The multifunction timer relay and on-delay timer relay functioned effectively, controlling the timing of the switching process. Testing indicated that the system maintained reliability across multiple switching cycles, with no failures observed during operation, thereby affirming its robustness.

Safety measures, including circuit breakers and appropriately rated contactors, were verified to protect against overloads, confirming compliance with established safety standards. This focus

on safety not only mitigated risks but also enhanced user confidence in the system's operation. Additionally, the design optimized energy usage, as evidenced by reduced power loss during switching, further contributing to overall system efficiency.

User feedback indicated that the switch operated intuitively, meeting expected operational requirements and enhancing user experience. Future improvements could include integrating smart technology for remote monitoring and control, which would expand functionality and adaptability. Overall, the project achieved its objectives, demonstrating a reliable and effective changeover switch design that could serve as a foundation for further advancements in automated electrical systems.

#### 4.5 SYMBOLS

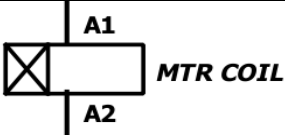
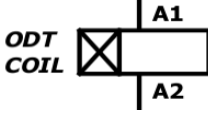
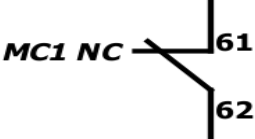

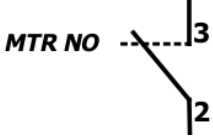
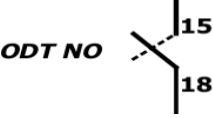
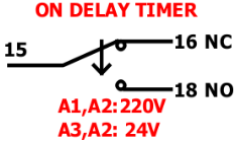
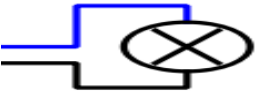
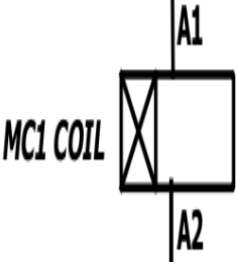
NAMES	SYMBOLS
1. MTR Coil: multifunctional timer relay coil for main power	
2. ODT Coil: on delay timer relay coil for backup power.	
3. MC1 NC: magnetic contactor normally close for main power	
4. Selector switch	
5. MTR NO: multifunctional timer relay normally open (internal switch)	
6. ODT NO: on delay timer relay normally open (internal switch)	
7. NC/CO: normally close and normally open of internal connection of on delay timer relay	
8. LOAD: for signal purpose	

Table 01 symbols, A

<p>9. MC1: magnetic contactor schematic for main power (internal connection).</p>	<table border="1"> <tr> <td>L1 IN</td> <td>L2 IN</td> <td>A1</td> <td>53</td> <td>61</td> </tr> <tr> <td colspan="2">MC1</td> <td>COIL</td> <td>NO</td> <td>NC</td> </tr> <tr> <td>T1 OUT</td> <td>T2 OUT</td> <td>A2</td> <td>54</td> <td>62</td> </tr> </table>	L1 IN	L2 IN	A1	53	61	MC1		COIL	NO	NC	T1 OUT	T2 OUT	A2	54	62
L1 IN	L2 IN	A1	53	61												
MC1		COIL	NO	NC												
T1 OUT	T2 OUT	A2	54	62												
<p>10. MC2: magnetic contactor schematic for backup power (internal connection)</p>	<table border="1"> <tr> <td>L1 IN</td> <td>L2 IN</td> <td>A1</td> <td>53</td> <td>61</td> </tr> <tr> <td colspan="2">MC2</td> <td>COIL</td> <td>NO</td> <td>NC</td> </tr> <tr> <td>T1 OUT</td> <td>T2 OUT</td> <td>A2</td> <td>54</td> <td>62</td> </tr> </table>	L1 IN	L2 IN	A1	53	61	MC2		COIL	NO	NC	T1 OUT	T2 OUT	A2	54	62
L1 IN	L2 IN	A1	53	61												
MC2		COIL	NO	NC												
T1 OUT	T2 OUT	A2	54	62												
<p>11. ODT: on delay timer relay internal connection</p>	<table border="1"> <tr> <td>A1</td> <td>15</td> <td>A3</td> </tr> <tr> <td colspan="3">ODT</td> </tr> <tr> <td>16</td> <td>18</td> <td>A2</td> </tr> </table>	A1	15	A3	ODT			16	18	A2						
A1	15	A3														
ODT																
16	18	A2														
<p>12. MTR: multifunction timer relay internal connection</p>	<table border="1"> <tr> <td>A1</td> <td>2</td> <td>A3</td> </tr> <tr> <td colspan="3">MTR</td> </tr> <tr> <td>1</td> <td>3</td> <td>A2</td> </tr> </table>	A1	2	A3	MTR			1	3	A2						
A1	2	A3														
MTR																
1	3	A2														
<p>13. MC1 COIL: magnetic contactor coil for main power part</p>																

*Table 01, symbol. B*

#### 4.6 SPECIFICATIONS.

COMPONENTS	SPECIFICATION
<b>Multifunction timer relay</b>	<ul style="list-style-type: none"> <li>● Model: ERV-8</li> <li>● Voltage rating(Un): 150V-260V AC/24V DC or 110V AC / 24V DC</li> <li>● Contact rating: 5A/250V AC (resistive load)</li> <li>● Display: LED (on and out)</li> <li>● Time(t): 10sec, 10min, 10hrs, 100hrs</li> </ul>
<b>Magnetic contactor</b>	<ul style="list-style-type: none"> <li>● Model: LC1-D1210</li> <li>● Current rating: 25A</li> <li>● Voltage rating: suitable for 230V or 400V AC</li> <li>● Mounting support: plate and din rail</li> </ul>
<b>On delay timer relay</b>	<ul style="list-style-type: none"> <li>● Model: ER-NA VZR-30</li> <li>● Timing range: 0-30min</li> <li>● Contact rating: 5A/250V AC</li> </ul>
<b>Circuit breaker</b>	<ul style="list-style-type: none"> <li>● Model: HAGER C25</li> <li>● Rated voltage: 230V AC</li> <li>● Number of poles: 2 poles</li> </ul>

*Table 02, specification, A*



COMPONENT	SPECIFICATION
<b>Bulb(load)</b>	<ul style="list-style-type: none"> <li>● LED bulb</li> <li>● Power rating: 5W</li> <li>● Voltage rating: 240V</li> </ul>
<b>Wires(1.5mm<sup>2</sup>&amp;2.5mm<sup>2</sup>)</b>	<ul style="list-style-type: none"> <li>● Power rating: 20-25A (4.6 to 5.5 kw at 230V)</li> <li>● Voltage rating: 300/500V or 0.6/1kV for low</li> </ul>
<b>MDF board</b>	<ul style="list-style-type: none"> <li>● Temperature tolerance up to 50°C - 60°C</li> <li>● Insulation: not an electrical insulator, moisture can affect performance</li> <li>● Usage: suitable for mounting hardware</li> </ul>
<b>Wooden screws</b>	<ul style="list-style-type: none"> <li>● Length: 1.5mm</li> <li>● Diameter: 3.5mm</li> <li>● Strength: #6 to #8 gauge</li> </ul>
<b>Selector switch I/O</b>	<ul style="list-style-type: none"> <li>● A selector switch manages input/output (I/O) by allowing users to select different operational modes, which direct specific input signals to corresponding outputs. This enables control over various circuits within machinery and automation systems.</li> </ul>

*Table 02, specification, B*

#### 4.7 COST ETIMATION

Nbr	ITEMS	FRW
1	Screws	1000
2	Extension cable	1500
3	Auxiliary, AUXL	2000
4	Load as BULB(x2)	2000
5	Lamp holder (x2)	2000
6	Wires	2000
7	Din rail (x2)	2000
8	Board	2000
9	Multifunctional timer relay, MTR	25000
10	On-delay timer relay, ODTR	25000
11	Circuit breaker, CB (x2)	50000
12	Magnetic contactor, MC (x2)	60000
13	Labor cost	100000
14	Selector switch I/O	15000
	TOTAL=	289500

*Table 03, cost estimation*

## **CHAPTER 5: CONCLUSION AND RECOMMENDATION**

### **5.0 INTRODUCTION**

The project successfully designed and implemented a changeover switch system that reliably and efficiently switches between power sources, demonstrating minimal operational issues. The effective use of a contactor and multifunction timer relay met performance criteria for stable and automated power management. To enhance the system's effectiveness and longevity, several improvements are recommended: utilizing contactors with higher current and voltage ratings for larger loads, adding a manual override switch for greater control during maintenance or emergencies, and scheduling regular maintenance checks to ensure optimal performance of the timer relay and contactor. Additionally, fine-tuning the timer relay settings can improve efficiency, while incorporating monitoring tools will facilitate early detection of potential issues. Finally, creating comprehensive documentation for operation and maintenance will aid in effective system management and troubleshooting.

### **5.1 CONCLUSION**

The project successfully achieved its objectives of designing and implementing a changeover switch system. The system demonstrated reliable and efficient switching between power sources with minimal operational issues. The use of a contactor and multifunction timer relay proved effective in meeting the desired performance criteria, ensuring stable and automated power management.

To enhance the effectiveness and longevity of the changeover switch system, several improvements are recommended. First, using contactors with higher current and voltage ratings can better accommodate larger loads and increase overall system durability. Adding a manual override switch is also advisable to provide greater control during maintenance or emergency situations, ensuring flexibility and reliability. Regular maintenance checks should be scheduled to ensure that the multifunction timer relay and contactor remain in optimal working condition, thus preventing unexpected failures. Additionally, fine-tuning the settings of the multifunction timer relay can help tailor the system's performance to the specific needs of the application, thereby improving efficiency. Incorporating monitoring tools or indicators to track system status and performance will allow for early detection of potential issues. Lastly, developing comprehensive documentation and guidelines for operation and maintenance will support effective system management and troubleshooting.

## **5.2 RECOMMENDATIONS**

To build upon the successes of this project, several recommendations are proposed. Firstly, enhancing the user interface would provide operators with a more intuitive experience, enabling remote monitoring and control capabilities. Additionally, integrating smart technology and IoT devices can facilitate real-time data collection and predictive maintenance, further optimizing the system's performance. Conducting field tests across diverse environments will help assess the system's adaptability and reliability under varying conditions. Furthermore, incorporating advanced safety features, such as overload protection, is crucial for safeguarding both the system and connected equipment. Lastly, creating modular components that allow for scalability will enhance the system's applicability in larger or more complex settings.

## **5.3 SUGGESTION FOR FURTHER STUDY**

To enhance the performance and reliability of the changeover switch system, it is crucial to optimize the timing parameters of the multifunction timer relay and on-delay timer relay. This will lead to faster switching times and minimize transition periods, ensuring a seamless power supply during outages. Additionally, implementing advanced control algorithms can improve the management of power transitions, allowing the system to adapt to varying load conditions more effectively.

Comprehensive testing under diverse conditions, including extreme loads and voltage fluctuations, is essential for assessing system performance. Enhancing the user interface for easier monitoring and incorporating safety features like overload and surge protection will further protect the system and connected equipment. Together, these improvements will boost reliability, adaptability, and overall efficiency, creating a more robust power management solution.

## RESEACH

1. **ERIS Industrial:** about multifunction time relay how it works and specification

[https://cdn.yesss.co.uk/documents/1539333\\_03\\_ERSMFT24\\_Data sheet\\_ffd87d623473278077deba92b06ee04e.pdf](https://cdn.yesss.co.uk/documents/1539333_03_ERSMFT24_Data_sheet_ffd87d623473278077deba92b06ee04e.pdf)

2. **HAGER:** about 2P and 1P circuit breaker

<https://hager.com/intl-en/products/information/sbn116-1p-16a-switch>

3. **ACADEMIA:** information about automatic changeover switch

[https://www.academia.edu/120561269/Design\\_and\\_Analysis\\_of\\_an\\_Automatic\\_Power\\_Changeover\\_with\\_Backup](https://www.academia.edu/120561269/Design_and_Analysis_of_an_Automatic_Power_Changeover_with_Backup)

4. **TECHTARGET:** information about changeover switch

<https://www.techtarget.com/searchdatacenter/definition/Automatic-transfer-switch-ATS>

5. **IKINDUSTRY:** how on delay timer relay work and its specification

<https://ikindustry.com.tr/products/switching-equipment/relay/er-na-vzr-30-on-delay-time-relay-en>

6. **RESEARCHGATE:** information about design and implementation of automatic changeover switch.

Authors Charles and Ehimen

[https://www.researchgate.net/publication/303681269\\_DESIGN\\_AND\\_IMPLEMENTATION\\_OF\\_AUTOMATIC\\_CHANGE\\_OVER\\_SWITCH\\_WITH\\_STEP\\_LOADING\\_FOR\\_RENEWABLE\\_ENERGY\\_SYSTEMS](https://www.researchgate.net/publication/303681269_DESIGN_AND_IMPLEMENTATION_OF_AUTOMATIC_CHANGE_OVER_SWITCH_WITH_STEP_LOADING_FOR_RENEWABLE_ENERGY_SYSTEMS)