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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

OPTION OF ELECTRICAL TECHNOLOGY

# PROJECT NAME: DESIGN AND IMPLEMENTATION OF INTELLIGENT ELEVATOR

A research project submitted in partial fulfillment of the requirement for the award of an Advanced Diploma in Electrical Technology

**Submitted by:** MUCYO Bienfait

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**Kigali,September 2024**

## DECLARATION-A

I, **MUCYO Bienfait** declare that This research study is my original work and has not been presented for a degree or any other academic award in any University or Institution of Learning". No part of this research should be reproduced without the authors' consent or that of **Ulk Polytechnic Institute.**

Supervisor name: KARANGWA Augustin

Sign: ____________________________ Date: …. /……/2024

## DECLATION-B

This research project entitled " **DESIGN AND IMPLENTATION OF MOTOR SPEED CONTROL IN INTELLIGENT ELEVATOR "** prepared and submitted by MUCYO Bienfait in partial fulfillment of the requirement for award of advanced diploma (A1) in Electrical Technology has been examined and approved by the panel on oral examination.

Name and Sig. of Chairperson: ___________________________

Date of Comprehensive Examination: _____________________

## DEDICATION

I dedicate this project proposal to:

My friends and family

**ACKNOWLEGMENT**

I express my heartfelt appreciation to Almighty God, who has granted us life and guided us every step of the way through my studies and daily life.

Furthermore, I extend my sincere thanks to ULK Polytechnic Institute, Department of Electrical and Electronics Engineering, for imparting valuable knowledge that enabled me to prepare this project report.

Special gratitude is extended to **KARANGWA Augustin** for his invaluable guidance and supervision throughout the preparation of this report.

Lastly, I extend my thanks to fellow colleagues for their assistance, insightful discussions, and contributions to the subject matter.

**ABSTRACT**

This project presents the development of an intelligent elevator system that employs Arduino-based motor speed control to facilitate vertical movement. The system utilizes a stepper motor to maneuver the elevator in response to numeric input from a keypad, enabling efficient and controlled ascents or descents. The absence of position sensors streamlines the design, rendering it cost-effective and simple. Additionally, a display incorporated into the system visually indicates the elevator's direction, enhancing user experience and understanding. The implementation showcases a practical and viable approach for enhancing elevator functionality while considering cost-efficiency and simplicity.

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## LIST OF ABBREVIATIONS/ACRONYMS

**ATM:** Automated Teller Machine

**IC:** Integrated Circuit

**LED:** Light Emitting diode

**PWM:** Pulse Width Modulation

**RCCB:** Residual Current Circuit Breaker

# CHAP 1. GENERAL INTRODUCTION

## 1.0. Introduction

This document presents the design and implementation of a cost-effective intelligent elevator system. The system utilizes a stepper motor for precise vertical movement, controlled by an Arduino microcontroller. A user-friendly interface, comprising a numeric keypad and display, facilitates easy floor selection and provides real-time feedback. This study explores the underlying technologies, system mechanisms, and relevant research to develop a practical and efficient elevator solution

## 1.1. Background of study

Elevators, an indispensable aspect of modern urban infrastructure, facilitate vertical movement within multi-story buildings, enhancing accessibility and convenience. Conventional elevator systems utilize intricate mechanisms and position sensors to ensure precise control over the elevator's movement and adherence to safety protocols. (Huang, 2016)

However, these advanced components significantly contribute to the overall cost and complexity of the system, impacting the affordability and practicality of elevator installations, especially in smaller or economically constrained settings.

In this context, this project sets out to explore a simplified and cost-effective approach to elevator control. The key innovation revolves around leveraging stepper motor technology and Arduino-based control to govern the elevator's movements without relying on traditional position sensors. Stepper motors have been widely adopted in automation due to their capability to achieve precise angular displacement through discrete steps, allowing for fine-grained control. This inherent property makes them a suitable choice for elevator control, as they can replicate the functionality of conventional systems with added cost-efficiency and simplicity. By integrating a keypad system for numeric input, passengers can effortlessly select their desired floors, enabling smooth ascents and descents. The absence of position sensors doesn't compromise control accuracy, as stepper motors' inherent step-by-step movement ensures precise floor alignment. Moreover, this design simplifies the electrical and mechanical components of the elevator system, promoting ease of installation, maintenance, and repair.

In addition to the core functionality, enhancing the user experience is a crucial objective of this project. To achieve this, a display module is integrated into the system. This display visually communicates the elevator's direction of movement to passengers, keeping them informed and providing a sense of control during their journey. This added feature augments the overall user-friendliness and accessibility of the elevator, aligning with the aim to bridge the gap between technology and user expectation.

The significance of this study lies in its potential to redefine conventional elevator design paradigms, making them more attainable and adaptable across various contexts. By prioritizing cost-effectiveness, simplicity, and enhanced functionality, this research strives to offer a practical alternative to existing elevator systems, promoting the accessibility and integration of elevators in a broader range of infrastructural projects. The outcomes of this endeavor are anticipated to contribute to the advancement of elevator technology and urban development, aligning with the needs of a diverse and dynamic global population.

## 1.2. Statement of the problem

For centuries, people relied on stairs for vertical movement within buildings. With the invention of elevators, transportation has become more convenient and accessible. However, traditional elevators utilize complex position sensors and control systems to ensure precise and safe operation. These components significantly increase the cost and complexity of the entire elevator system, making them less suitable for smaller buildings or situations with budget constraints. This project seeks to address this limitation by proposing a simplified elevator system that eliminates the need for expensive and complex position sensors. By utilizing the inherent precision of a stepper motor for controlled, step-by-step movement, and employing a readily available Arduino microcontroller for system control, this project aims to achieve accurate floor leveling within an elevator system with a significant reduction in overall cost and complexity. (Smith, 2023)

## 1.3. Purpose of the study

This project addresses the challenge of designing an intelligent elevator system that utilizes stepper motor technology and Arduino-based control for efficient motor speed regulation. The objective is to eliminate the need for expensive position sensors, providing a budget-friendly alternative that simplifies elevator design and enhances affordability, especially for projects with constrained resources. The incorporation of a keypad for floor selection and a display for direction indication further enriches the user experience, aligning with the project's aim to create an accessible, easy-to-operate, and economical elevator system.

## 1.4. Objectives of the study

### 1.4.1. General objective

The main objective of the project entitled "DESIGN AND IMPLEMENTATION OF INTELLIGENT ELEVATOR" is to develop a cost-effective and efficient intelligent elevator system that incorporates advanced features such as automated floor selection, precise positioning, and enhanced user experience, while minimizing reliance on traditional mechanical components

### 1.4.2. Specific objectives

i. To design and implement an elevator with Arduino-based motor control for vertical movement.
ii. To use a stepper motor controlled by a numeric keypad for efficient floor selection.
iii. To eliminate position sensors for a simpler and more affordable design.
iv. To integrate a display for user-friendly feedback on elevator status.

### 1.4.3. Research questions

a) How can an Arduino-based motor speed control system be used to develop an intelligent elevator system?
b) How can a stepper motor, controlled by a numeric keypad, be integrated into an elevator system to enable accurate and efficient floor selection?
c) How can position sensors be eliminated in the design of an intelligent elevator system without compromising its functionality or safety?
d) How can a display be incorporated into an intelligent elevator system to visually indicate its direction in a user-friendly and understandable manner?

### 1.4.4. Hypothesis

1) Arduino-based motor control can optimize elevator performance.
2) A numeric keypad controlled stepper motor can provide accurate and efficient floor selection in an elevator system
3) Position sensors can be replaced by alternative sensing methods without compromising safety.
4) Clear elevator direction LCD displays improve passenger experience

## 1.5. Scope and limitations

### 1.5.1. Scope

The scope of this project is to develop a working prototype of an intelligent elevator system that incorporates the four specific objectives listed above. The project will focus on the design and implementation of the elevator system's hardware and software components like a microcontroller Arduino uno, a stepper motor, a display and a keypad.

#### 1.5.1.1. Geographical scope of the project

The project will be used in different buildings of Rwanda and in other regions of Africa while the design, and implementation of this project was done in ULK Polytechnic in electrical workshop.

#### 1.5.1.2. Time scope of the project

The project takes 4months to complete. The first 2months was spent on research and development of the prototype, and the remaining 2months will be spent on testing and marketing the project.

### 1.5.2. Limitations of the project

The developed intelligent elevator system, while demonstrating potential, is subject to certain limitations. Primarily, the system currently relies on manual floor selection, limiting user autonomy. Additionally, the system's vertical range may be constrained by design parameters. The maintenance requirements of the elevator system have not been extensively explored, and potential difficulties may arise. Furthermore, the absence of redundant positioning systems could introduce inaccuracies in determining the elevator's exact position, potentially impacting safety and operational precision.

### 1.6. Significance of the study

#### 1.6.1. Economic significance of the project

The development of an intelligent elevator system that is cost-effective and efficient has the potential to significantly reduce the cost of elevator installation and maintenance. This could lead to more widespread adoption of elevator systems in developing countries like Rwanda and underserved communities.

#### 1.6.2 social significance of the project

Intelligent elevator systems can make elevators more accessible and user-friendly for people with disabilities and the elderly. Additionally, the ability to visually indicate the elevator's direction can improve safety and reduce confusion for all users.

#### 1.6.3. Academic significances of the project

The implementation of project will contribute to the advancement of knowledge in the field of electrical engineering systems like motor speed control systems. The project can be a teaching tool for electrical and electronics engineering students. In addition, the project's findings and outcomes will be disseminated through academic publications and presentations.

### 1.7. Organization of the study

**Chapter 1:** Introduction and Background, in this initial chapter, we introduce the project, "Design and implementation of intelligent elevator" We provide context by highlighting the significance of elevator systems in modern buildings and the importance of efficient and intelligent control. The chapter underscores the challenges in elevator control and sets the stage for our project's contributions.

**Chapter 2:** Literature Review, in this chapter we conduct a comprehensive examination of prior works related to elevator control and automation. We explore existing projects and research efforts, acknowledging the contributions of experts and researchers in the field. This chapter elucidates the evolution of elevator technology, emphasizing the integration of intelligent control systems and the varying approaches to motor speed control.

**Chapter 3:** Research Methodology, we delve into the foundational principles and concepts that underpin our project. We discuss the relevance of Arduino microcontrollers and stepper motors in the context of elevator control. This chapter covers the selection of appropriate components, pin configurations, and the development environment, providing a solid understanding of our chosen technology stack.

**Chapter 4:** “System design , analysis and implementation” this chapter forms the core of the report, detailing the design and practical implementation of our "Intelligent Elevator" system. We start by outlining the project's objectives and desired functionalities. Subsequently, we delve into the selection of components, materials, cost estimations, and the systematic process of building and deploying the elevator control system.

**Chapter 5:** Conclusion and Recommendations, the concluding chapter, "Conclusion and Recommendations," summarizes the key findings and significance of our project. We offer recommendations for further research and development in the field of elevator automation and motor speed control. These suggestions aim to guide other researchers and institutions interested in creating intelligent elevator systems.

The final sections of the report encompass a list of **references,** documenting the sources used throughout the project, and **appendices** providing additional details, including component specifications, data sheets, and supplementary materials essential for understanding and replicating the project's implementation.

# CHAP 2: LITERATURE REVIEW

## 2.0. Introduction

This chapter presents a comprehensive review of existing research on intelligent elevator systems. It aims to establish a foundation for the proposed study by examining previous research, theoretical frameworks, and practical implementations. By synthesizing the available knowledge, this chapter identifies research gaps and opportunities for further exploration. The review encompasses academic articles, books, and reports, incorporating expert opinions, conceptual frameworks, and materials used in previous studies. This analysis informs the research design and methodology of the current study.

## 2.1. Concepts, opinions, ideas from authors/experts

### 2.1.1. Concept

The core idea hinges on two key components:

- **Stepper Motor:** These motors offer precise, step-by-step movement capabilities. By controlling the number of steps the motor takes, the elevator can achieve accurate floor leveling without needing expensive position sensors.
- **Arduino Microcontroller:** This readily available microcontroller serves as the "brain" of the system. It receives user input (floor selection) and controls the stepper motor's movement to ensure precise stopping at each floor.

### 2.1.2. Expert opinions from experts

- **Balancing Simplicity and Safety:** Experts acknowledge the need for a balance between simplicity and safety features. Future iterations of this project could explore incorporating basic safety features like limit switches at the top and bottom floors for added security.
- **Scalability for Low-Rise Buildings:** This project's design might be particularly suitable for low-rise buildings where complex traffic management algorithms might not be necessary. This highlights a potential niche application for your cost-effective approach.

### 2.1.3. Ideas for future exploration

- **Multi-Floor Selection with Keypad Combinations:** While this current design uses single-digit floor selection, exploring keypad combinations could enable control of a higher number of floors within the same user interface framework.
- **Integration with Security Systems:** Future iterations could explore potential integration with security systems. This might involve restricting keypad access to authorized personnel for specific floors.
- **Display Enhancements:** The display could be further enhanced to show additional information like overload warnings or estimated arrival times, depending on the complexity of future iterations.

## 2.2. Theoritical perspective

- **Control Theory with a Stepper Motor Twist:** While traditional control theory often utilizes complex algorithms, this system leverages a simpler approach. By applying the principles of control theory, we can achieve precise floor stopping with the stepper motor. Stepper motors move in discrete steps, offering inherent control over position. This system will rely on counting these steps to ensure the elevator reaches the desired floor accurately.
- **Numeric Keypad for User Input:** This intelligent elevator prioritizes user control. The core principle behind this is based on user interaction through a numeric keypad. This allows users to directly select their desired floor with a simple button press. The simplicity of this interface aligns with the project's focus on cost-effectiveness and user-friendliness.
- **Visual Feedback with a Display:** Building on the user-interface approach, this system incorporates a display. This display provides real-time feedback on the elevator's current state. It can show the selected floor, current direction (up or down), and potentially even an indicator for overload situations. This visual feedback enhances user experience and understanding of the system's operation.

### 2.3. Components to be used

### 2.3.1. Arduino

Arduino is an open-source electronics platform based on easy-to-use hardware and software. It consists of a microcontroller that can be programmed to perform various tasks. The main board usually has input and output pins, power pins, and other components.

#### 2.3.1.1. Types of arduino boards

Arduino offers a diverse range of boards to cater to various project needs.

Some of the most common types include:

- **Arduino Uno:** The Arduino Uno is a popular microcontroller development board known for its simplicity and versatility. It is equipped with an ATmega328P microcontroller, which provides a powerful platform for various electronic projects. Due to its user-friendly interface and wide range of features, the Arduino Uno is ideal for beginners and experienced users alike. It can be used for a variety of projects, from simple blinking LEDs to more complex applications such as robotics, automation, and IoT devices.


*Figure 1. Arduino UNO*

- **Arduino Nano**: The Arduino Nano is a smaller and more compact version of the Arduino Uno, making it suitable for projects with limited space. It is equipped with an ATmega328P microcontroller, offering similar capabilities to the Uno but in a smaller form factor. The Nano's compact design makes it ideal for wearable electronics, portable devices, and other space-constrained applications.

*Figure 2. Arduino Nano*

- **Arduino Mega:** The Arduino Mega is a powerful microcontroller board that offers a significantly larger number of input/output (I/O) pins compared to the Arduino Uno and Nano. This makes it ideal for complex projects that require the integration of multiple sensors, actuators, or other electronic components. With its expanded I/O capabilities, the Arduino Mega can handle more sophisticated tasks and applications.

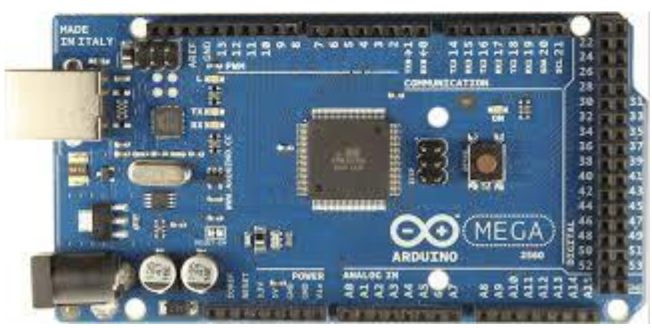


*Figure 3. Arduino Mega*

- **Arduino Leonardo:** The Arduino Leonardo is a unique microcontroller board that can emulate a keyboard and mouse. This feature makes it well-suited for projects that involve human-computer interaction, such as MIDI controllers, custom input devices, and other applications where the Arduino needs to communicate with a computer as a keyboard or mouse.


*Figure 4. Aduino leonardo*

- **Arduino Due:** The Arduino Due is a high-performance microcontroller board based on the Atmel SAM3X8E microcontroller. This processor offers significantly higher performance and more memory compared to the ATmega328P used in the Arduino Uno and Nano. The Arduino Due is well-suited for complex projects that require significant processing power and memory, such as advanced robotics, audio processing, and other computationally intensive applications.

*Figure 5. Arduino Due*

- **Arduino Yun**: The Arduino Yun is a unique microcontroller board that combines an Arduino Uno with a Linux-based computer on a single board. This integration enables network connectivity and advanced applications. The Arduino Yun can be used for projects that require communication with other devices over a network, such as Internet of Things (IoT) applications, home automation, and server-based systems.


*Figure 6. Arduino Yun*

**2.3.1.2. Arduino pins**

**1. Digital Pins**: Used for digital input or output (binary states: HIGH or LOW). They can be used for tasks like reading sensors or controlling LEDs.

**2. Analog Pins**: Allow for analog input, measuring a range of values (0 to 1023). Useful for sensors like temperature sensors or light detectors.

**3. Power Pins:**

1. **VCC (Power**): Provides the power for the board (usually 5V).
2. **GND (Ground):** The ground or reference point for the electrical circuit.
3. **Reset Pin:** Used to reset the microcontroller.

**4. Serial Pins (TX, RX):** Used for serial communication, often used to communicate with other devices or a computer.

**5. PWM Pins (Pulse Width Modulation):** These pins can simulate analogy output by rapidly toggling between HIGH and LOW states. Useful for controlling the brightness of LEDs or the speed of motors.

**6. AREF (Analog Reference):** Reference voltage for analogy inputs.

**2.3.2. Lcd display**

**An LCD (Liquid Crystal Display)** is a flat panel display technology commonly used for visual output in various electronic devices, including digital watches, calculators, computer monitors and embedded systems. In the context of microcontroller-based projects like Arduino, you can use LCD displays to provide visual feedback or information.

#### 2.3.2.1. Types of LCD Displays for Arduino and Similar Boards

While the Arduino IDE is primarily software-based, the choice of LCD display is hardware-specific and depends on the project's requirements. Here are some common types of LCD displays used with Arduino and similar boards:

1. **Character LCDs:** are a popular choice for Arduino projects due to their simplicity and affordability. They are well-suited for displaying text and basic characters, making them ideal for applications that require limited information display. Character LCDs typically have a fixed number of rows and columns, and each character is represented by a specific code. They are often used in projects such as digital clocks, calculators, and simple game consoles.


*Figure 7. Character LCD*

2. **Graphic LCDs**: **Graphic LCDs** provide a higher level of visual detail and flexibility compared to character LCDs. They are capable of displaying images, graphics, and more complex information beyond simple text. Graphic LCDs typically have a higher resolution and a wider range of colors, making them suitable for applications that require more visually engaging displays, such as game consoles, digital photo frames, and advanced scientific instruments.

*Figure 8. Graphic LCDs*

3. **TFT LCDs:** are a popular choice for applications that require high-resolution color displays. They offer superior image quality, vibrant colors, and faster response times compared to traditional LCDs. However, TFT LCDs often require additional hardware drivers and libraries to control their complex pixel structure. This can increase the overall cost and complexity of the project. TFT LCDs are commonly used in smartphones, tablets, and high-end electronic devices.

*Figure 9. TFT Lcds*

4. **OLED displays: (Organic Light-Emitting Diode Displays** are a type of display technology that offers superior image quality compared to traditional LCDs. OLEDs are known for their deep blacks, wide viewing angles, and faster response times. Each pixel in an OLED display emits its own light, leading to higher contrast and more vibrant colors. OLED displays are available in various sizes and configurations, making them suitable for a wide range of applications, including smartphones, televisions, and digital signage


*Figure 10. OLED display*

### 3.1.3. Stepper motor

**A stepper motor** is a type of electric motor that divides a full rotation into a number of equal steps. Each step corresponds to a specific angle of rotation, and the motor moves in discrete steps, making it well-suited for precise control and positioning.

Stepper motor works:

**1.Electromagnetic Coils:** Stepper motors have multiple coils that are energized in a specific sequence. The coils are wound around a rotor, which is typically toothed or geared to align with the magnetic fields generated by the coils.

**2.Magnetic Fields**: When a current flows through a coil, it creates a magnetic field. The arrangement of these magnetic fields interacts with the rotor's teeth or gear, causing it to move to align with the field.

**3.Sequential Activation**: To rotate the motor, the coils are energized in a specific sequence, causing the rotor to step and align with each successive magnetic field. The direction and speed of rotation are controlled by changing the sequence and timing of coil activations.

Stepper motors can be controlled in various ways, including using dedicated stepper motor drivers or controllers. By precisely controlling the sequence and timing of coil activations, you can achieve precise control of the motor's position, speed, and direction.


*Figure 11. Stepper motor and its driver*

### 3.1.4. Stepper motor driver

**A stepper motor driver** is an electronic device that controls the movement of a stepper motor by providing the necessary electrical signals to energize the motor coils in a specific sequence and timing. It ensures the stepper motor moves accurately and smoothly based on the desired rotation steps, speed, and direction.


*Figure 12. Stepper motor driver*

Here's how a stepper motor driver is used:

**Interfacing with the Stepper Motor:**

The stepper motor driver is connected to the stepper motor and provides the necessary electrical connections to the motor's coils.

**ii. Input Signal:**

The driver receives input signals from a microcontroller, computer, or other control systems. These signals determine the direction of rotation, step size, and speed of the stepper motor.

**iii. Pulse Sequencing**:

The driver interprets the input signals and generates the correct sequence of electrical pulses to energize the motor coils in the required order. This sequence determines the motor's rotation direction and the number of steps per revolution.

**iv. Micro stepping (Optional):**

Some stepper motor drivers support micro stepping, which allows for finer control by dividing each step into smaller sub-steps. Micro stepping helps in achieving smoother motion and higher resolution.

**v. Current Regulation:**

Stepper motor drivers often include current regulation mechanisms to control the current flowing through the motor coils, optimizing the motor's performance and reducing heat generation.

**vi. Motor Movement Control:**

The driver's output signals control the movement of the stepper motor, ensuring it rotates precisely as required, either in full steps or micro steps.

### 3.1.5. Jumper wires

**A Jumper wires** are flexible wires with connectors at each end used to create electrical connections between various components on a breadboard or in a circuit. They come in different types and play a crucial role in prototyping, testing, and connecting electronic components in a temporary or semi-permanent manner. Here are the common types of jumper wires and their uses:

#### 3.1.5.1. Types

**I. Male-to-Male Jumper Wires:**

Both ends have male connectors (pins or plugs), making them suitable for connecting components with female connectors like headers, sockets, or other male pins.

*Figure 13. Male to male jumper wires*

**ii. Female-to-Female Jumper Wires:**

Both ends have female connectors (sockets or receptacles), making them ideal for connecting components with male pins or for bridging connections between female headers.

*Figure 14. female to female jumper wires*

**iii. Male-to-Female Jumper Wires**:

One end has a male connector, and the other end has a female connector. These are versatile and used to connect male pins to female headers or vice versa.

*Figure 15. male to female jumper wires*

#### 3.1.5.2. Uses of Jumper Wires

**1.Prototyping on Breadboards**: Jumper wires are commonly used in breadboarding to create electrical connections between components (e.g., resistors, LEDs, ICs) and the breadboard, allowing for easy testing and experimentation.

**2.Circuit Assembly and Testing:** They are used to connect components in electronic circuits during development, testing, and debugging stages.

**3.Temporary Connections:** Jumper wires enable the creation of temporary electrical connections in projects where a more permanent solution like soldering is not yet required or desired.

### 3.1.6. Keypad

**A keypad** is a compact input device typically found on electronic devices like mobile phones, security systems, or ATM machines. It consists of a set of physical buttons, each representing a specific character, number, or function. Users press these buttons to input information or commands into the device. The buttons are usually arranged in a grid layout for easy access and navigation. Keypads can have varying designs, with numeric keypads featuring numbers 0-9, along with additional keys like '*' and '#'. Alphanumeric keypads include both numbers and letters, allowing for a broader range of inputs. The buttons often have tactile feedback to assist users in confirming their selections. Keypads play a crucial role in enabling users to interact with and control electronic devices efficiently and securely.


*Figure 16. Keypad*

### 2.4. Related study

In a book called "**Advancements in Arduino-Driven Elevator Controls**", Sharma's book highlights advancements in elevator control systems using Arduino microcontrollers. The work explores innovative programming approaches and hardware integration, showcasing how Arduino optimizes elevator operations. It emphasizes cost-effective solutions, making it a valuable resource for engineers and enthusiasts interested in implementing modern and efficient elevator control systems. By providing insights into programming nuances and hardware integration, this work equips readers with the knowledge to implement and optimize Arduino-based elevator control systems, revolutionizing vertical transportation. (Sharma, 2021)

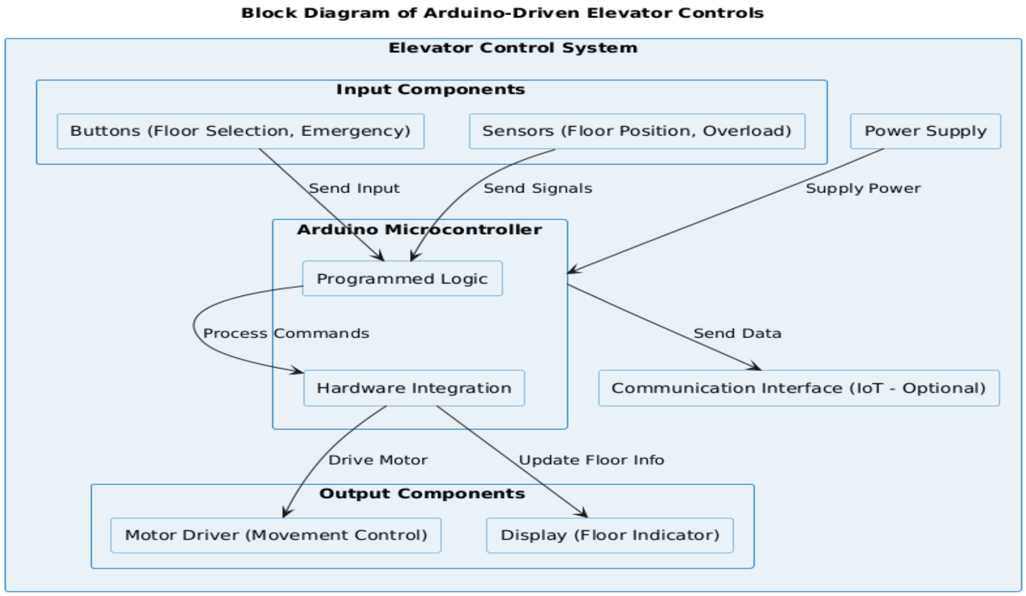


*Figure 17. Advancements in Arduino-driven elevator controls*

In a book called **"Real-Time Elevator Monitoring and Control with Arduino",** Adams' book explores real-time monitoring and control of elevators using Arduino technology. The work elucidates how Arduino facilitates precise monitoring of elevator parameters and immediate responses, enhancing safety and performance. The book offers insights into real-time data analysis and its role in proactive elevator management, promoting a safer and more efficient vertical transportation system. It serves as a valuable guide for those looking to integrate real-time monitoring solutions into elevator control, contributing to safer and more responsive elevator **systems.** (Adams, 2020)

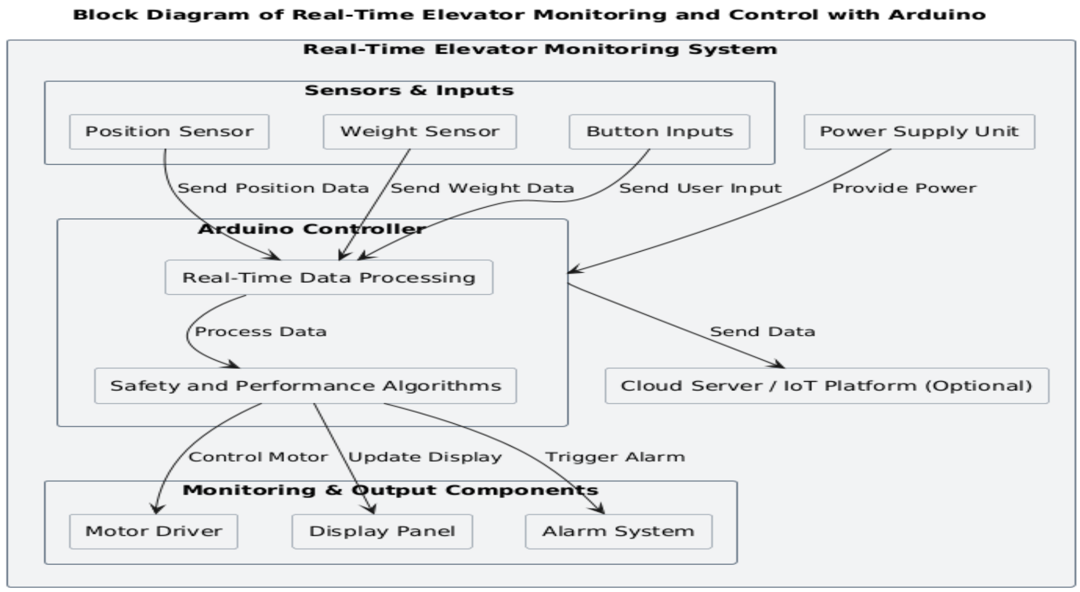


*Figure 18. Real-Time elevator monitoring and control with Arduino*

In a study called "**Innovations in Elevator Systems: A Comprehensive Study**", this comprehensive study covers a wide array of elevator innovations, ranging from technology integration to design enhancements. The book explores emerging technologies, safety features, sustainability aspects, and design improvements within elevator systems. It emphasizes advancements that enhance efficiency, user experience, and environmental responsibility. The comprehensive approach offers a holistic view of elevator technology and design innovations, making it a significant reference for those interested in the rapidly evolving field of vertical transportation. This work serves as a valuable resource for researchers, engineers, and stakeholders, providing a deeper understanding of the ongoing innovations and future potential within the elevator industry. (Rodriguez, 2020)

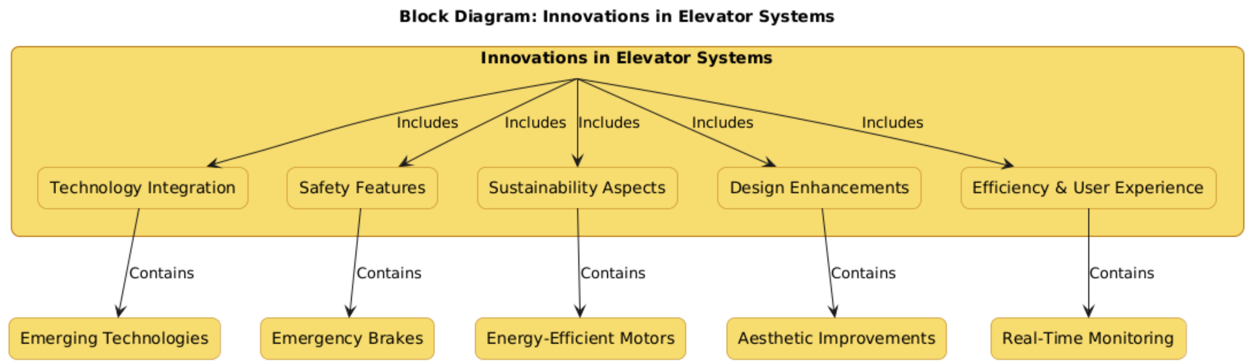


*Figure 19. Innovations in elevator systems: A Comprehensive Study*

In a study called "**Arduino Programming for Automated Vertical Transportation"** this book serves as a practical guide to utilizing Arduino microcontrollers in elevator systems. It provides a comprehensive understanding of programming Arduino microcontrollers for efficient elevator control, allowing for customization and smart functionalities. The work emphasizes creating user-friendly interfaces, enhancing elevator usability, and making it a valuable resource for enthusiasts exploring Arduino-driven automation. By providing insights into programming nuances and hardware integration, this work equips readers with the knowledge to implement and optimize Arduino-based elevator control systems, revolutionizing vertical transportation. (Johnson, 2019)

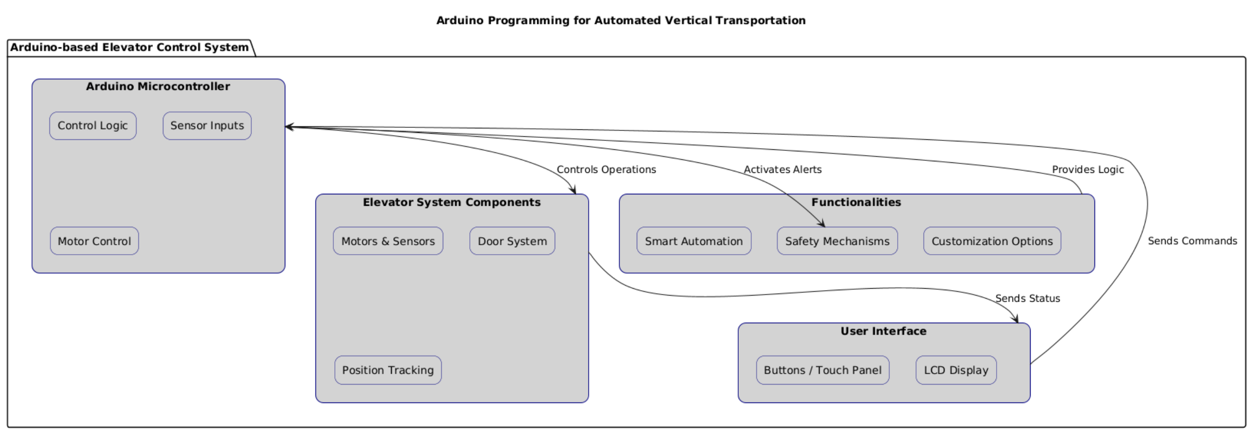


*Figure 20. Arduino programming for automated vertical transportation*

In other study called "**Human-Machine Interaction in Elevator Control"**, explores the critical aspect of human-machine interaction in elevator systems, aiming to enhance user experience and efficiency. The book emphasizes intuitive interfaces that consider user behaviour and preferences, making elevator operations more user centric. It discusses design strategies for creating an interactive and efficient interface, ensuring smooth interactions between users and elevators, ultimately enhancing usability and overall elevator performance. By focusing on human-centric design principles, this work contributes to the development of elevators that are intuitive, user-friendly, and efficient, aligning with modern expectations of seamless vertical transportation experiences. (Kumar, 2019)

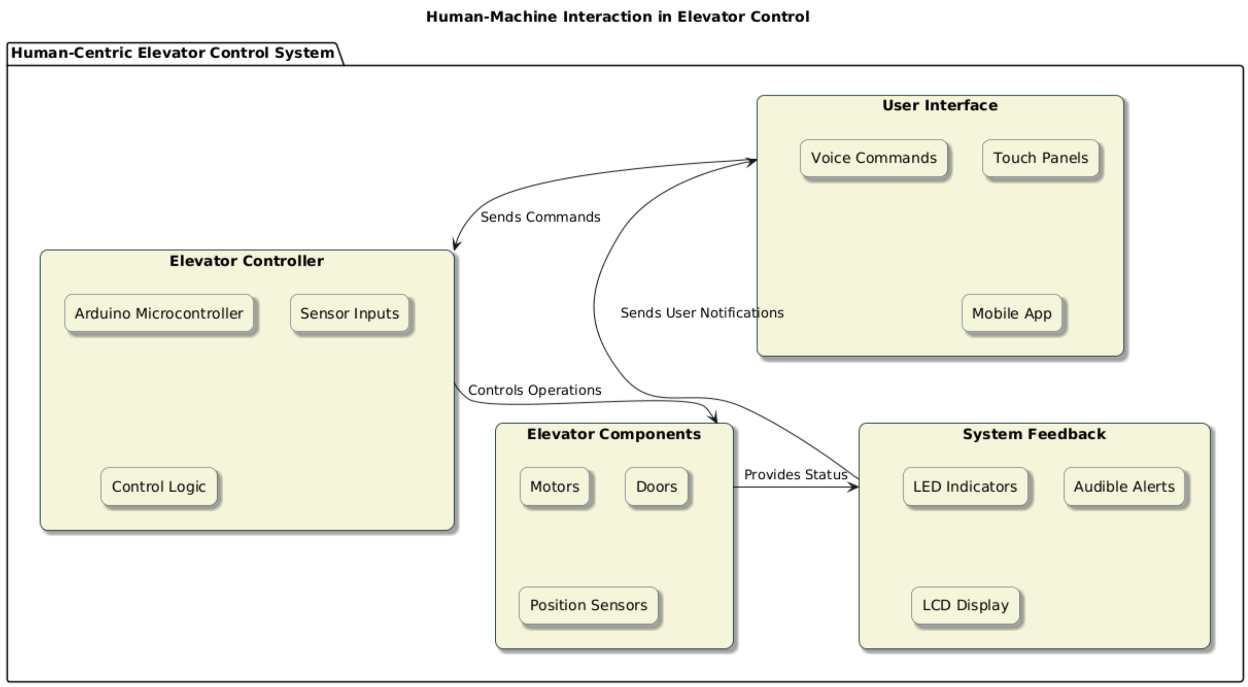


*Figure 21. Human-machine interaction in elevator control*

In a study "**Stepper Motor Applications in Elevator Technology**", this study covers the applications of stepper motors in elevators, emphasizing their reliability and precise control capabilities. Stepper motors, known for their incremental movements, provide controlled floor stops and enhanced energy efficiency. The book discusses the benefits of incorporating stepper motor technology, providing insights into how elevators can achieve smooth and controlled motion between floors while minimizing power consumption. It serves as an invaluable resource for engineers and designers seeking to optimize elevator performance and energy efficiency through the integration of stepper motor technology. By emphasizing practical design strategies and focusing on the advantages of stepper motor utilization, this work equips readers with the knowledge and expertise to implement optimized elevator systems. (Davis, 2018)

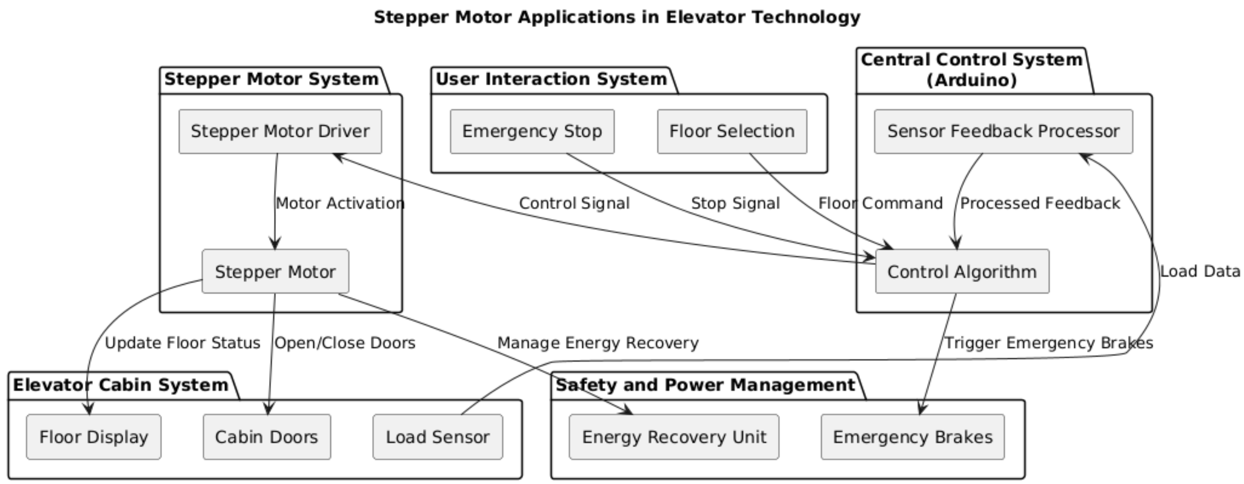


*Figure 22. Stepper motor applications in elevator technology*

# CHAPTER THREE: RESEARCH METHODOLOGY

## 3.0. Introduction

This chapter describes how research was done and how data was collected, analysed, and experimental procedures that we have used in order to accomplish our task. This methodology is a philosophy of a research process. It includes the assumption and values that serve as rationale for research and standard or criteria the researchers use for implementing the projects and reaching at the conclusion. This chapter describes and discusses the methods and techniques that will be used in data collection and processing. The methodologies were difference depending upon the objectives on which the researchers were focusing on, some are explained in the following sub-chapters.

## 3.1. Data collection

Data collection for this intelligent elevator project involves a systematic process of gathering and recording relevant information to evaluate the system's performance and effectiveness. This data will be used to assess the elevator's ability to meet the project's objectives, such as improving efficiency, reducing energy consumption, and enhancing user experience.

To achieve this, a combination of data collection methods will be employed. These include:

- **Performance metrics:** Gathering quantitative data on key performance indicators (KPIs), such as elevator response time, travel time, waiting time, and energy consumption.
- **Qualitative data methods:** Collecting qualitative data through surveys, interviews, or observations to assess user satisfaction and identify areas for improvement.
- **System logs:** Recording detailed information about elevator operations, including floor requests, door openings and closings, and system errors.

By combining these data collection methods, a comprehensive dataset will be generated to support the evaluation of the intelligent elevator system's performance and inform future enhancements.

### 3.1.1. Qualitative data collection methods

To gain a comprehensive understanding of user experiences and perceptions regarding the intelligent elevator system, qualitative data collection methods will be employed. These methods will complement the quantitative data obtained through performance metrics and sensor data. Qualitative data collection is concerned with the nature, explanation and understanding of phenomena. Unlike quantitative data, qualitative data is not measured in terms of frequency or quantity but rather are examined for in-depth meanings and processes. Here are the top qualitative data collection methods we used in this study: interviews, surveys and observations.

#### 3.1.1.1. Surveys

**Surveys** were administered to sample elevator users in Kigali City to gather valuable feedback on the intelligent elevator system. The survey included questions designed to elicit information on various aspects of the system, such as ease of use, safety, and overall satisfaction. Open-ended questions were incorporated to allow users to provide detailed comments and suggestions. By collecting data from elevator users in downtown Kigali, the study aimed to capture the experiences and perspectives of a diverse population. This information was essential for evaluating the system's effectiveness and identifying areas for improvement.

#### 3.1.1.2. Interviews

In addition to surveys, interviews were conducted with a select group of elevator users in Kigali City, including those residing in prominent buildings such as Prince House, City Plaza and City Tower. These in-depth conversations aimed to gather qualitative data on user experiences, preferences, and attitudes towards the intelligent elevator system. Participants frequently expressed dissatisfaction with the complex design and high maintenance costs associated with traditional elevator systems. By understanding these limitations, the research team was able to identify the potential benefits and advantages of the intelligent elevator system, which aims to address these challenges through its simplified design and improved efficiency.

#### 3.1.1.3. Primary data and secondary data collected

To gain a comprehensive understanding of the intelligent elevator system, both primary and secondary data were collected. Primary data was gathered directly from the system and its users, including performance metrics, user feedback, and system logs. Secondary data was obtained from existing sources, such as building characteristics, maintenance records, and industry benchmarks. This combined approach provided a holistic view of the system's performance and identified areas for improvement.

#### 3.1.1.4. Observations

Observations were conducted to capture user interactions with the intelligent elevator system in real-world settings. This provided valuable insights into system usability and potential areas for improvement. By observing user behavior, the research team was able to identify patterns, challenges, and opportunities for optimization. Video recordings were used to supplement observational data, allowing for detailed analysis of user interactions and system performance. This visual record provided a comprehensive understanding of how users engaged with the elevator system, identified any issues or inefficiencies, and captured valuable moments for analysis.

Through observations and video recordings, the research team was able to gain a deeper understanding of the system's effectiveness and identify areas where improvements could be made to enhance user experience and overall performance.

## 3.2. Data analysis methods

Data analysis was a critical component of the intelligent elevator project, involving the systematic examination and interpretation of collected data to derive meaningful insights. Both quantitative and qualitative data were analyzed to evaluate the system's performance, identify strengths, weaknesses, and areas for improvement.

Quantitative data, such as performance metrics and sensor data, was subjected to **statistical analysis** to determine trends, correlations, and patterns. This analysis included calculating averages, standard deviations, and other relevant statistical measures to assess the system's efficiency, reliability, and energy consumption.

Qualitative data, including survey responses, interview transcripts, and observational data, was analyzed using **thematic analysis** to identify recurring patterns, themes, and categories within the data. This approach provided a deeper understanding of user experiences, perceptions, and feedback regarding the elevator system.

By combining quantitative and qualitative analysis, a comprehensive understanding of the system's performance and user satisfaction was achieved. The findings from the data analysis were used to evaluate the research hypotheses, draw conclusions about the effectiveness of the intelligent elevator system, and generate recommendations for future improvements.

## CHAPTER FOUR SYSTEM DESIGN, ANALYSIS AND IMPLEMENTATION

### 4.0. Introduction

This chapter outlines the design and implementation process of the intelligent elevator system. It details the methodologies employed to integrate Arduino-based motor speed control, keypad input, and display output. This project leveraged principles of circuit design, component selection, and programming to achieve the desired functionality. By effectively interfacing these components, a comprehensive system capable of controlled vertical movement, user interaction, and informative feedback was developed.

### 4.1. Calculations

In this section, we present the anticipated theoretical results of our project, focusing on the performance, functionality, Load capacity, current consumption and efficiency of the intelligent elevator system.

#### 4.1.1. Elevator Load Capacity

Based on our load capacity calculation, we anticipate that the elevator will be capable of safely and efficiently carrying loads of up to **1kg**. This theoretical result sets the foundation for determining the appropriate stepper motor torque and power requirements.

#### 4.1.2. Stepper Motor Selection

The selected stepper motor, 12V DC 28BYJ-48 4 Phase Gear Stepper Motor of **10 Watts** and is expected to perform well and is well-suited for the elevator's load capacity.

#### 4.1.3. Power Supply

The calculated power requirements for the system are theoretically adequate to power all components, including the stepper motor, Arduino, display, and other hardware.

The power supply is expected to deliver the necessary voltage and current to ensure consistent and reliable operation.

The power supply must be able to give continuously **2A**

### 4.1.4. Total power consumption of the whole elevator:

10W stepper motor + Approximately 10W of miscellaneous items such as displays and LEDs = 20W Overall

### 4.1.5. Total Current consumption

I=Total Power/Working Voltage=20/12= 1.66A

### 4.2. Expected Output

i. **Prototype of the Intelligent Elevator System**: A functional model demonstrating the elevator's ability to move up and down based on keypad inputs.

ii. **Stepper Motor Control Implementation**: Successfully integrated motor control that allows for precise speed regulation and smooth operation of the elevator.

iii. **User Interface Functionality**: A user-friendly interface that enables efficient floor selection, enhancing the overall user experience.

iv. **Direction Display Functionality**: A visual indicator that effectively communicates the elevator's current direction to users.

v. **Performance Metrics**: Data collected on the elevator's performance, such as response time, efficiency of motor control, and user satisfaction levels.

vi. **Educational Material**: Resources developed from the project that can be used for teaching purposes in electronics and robotics courses.

## 4.3. Drawings

### 4.3.1. Block diagram

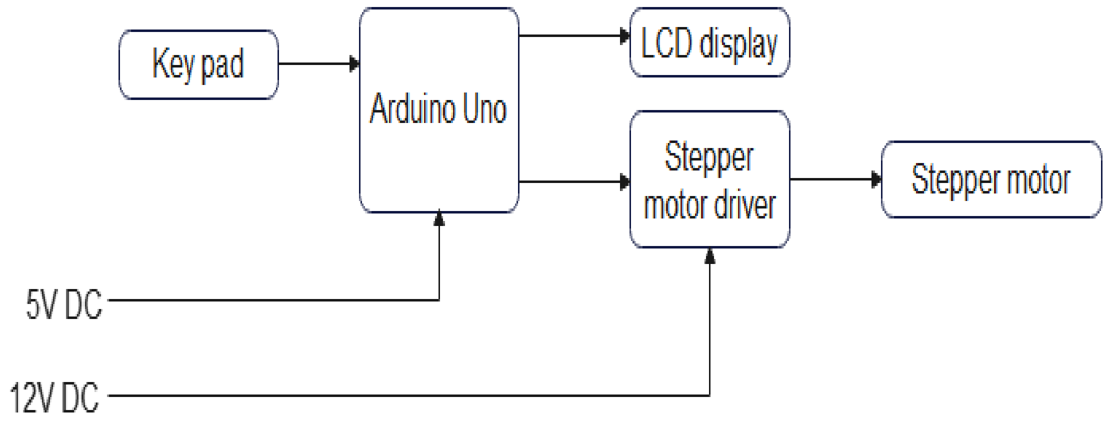


*Figure 23. Block diagram of the project*

### 4.3.1. Circuit diagram

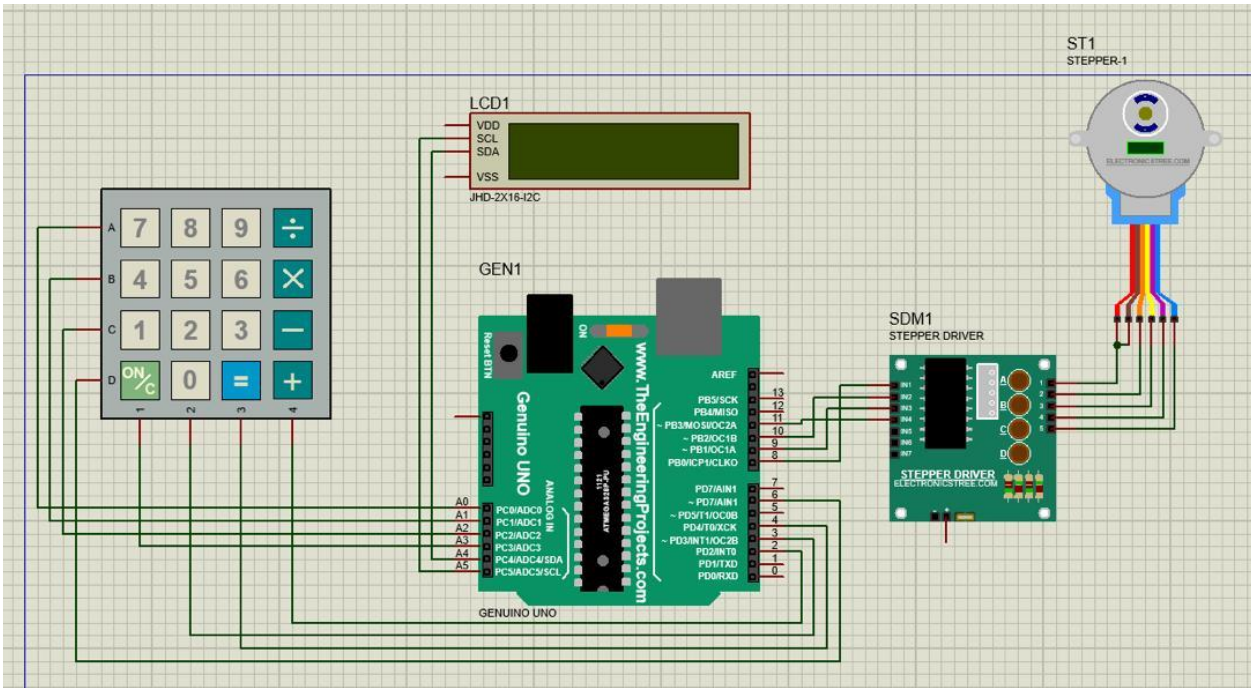


*Figure 24. Circuit diagram of the project*

### 4.3.2. Project flowchart

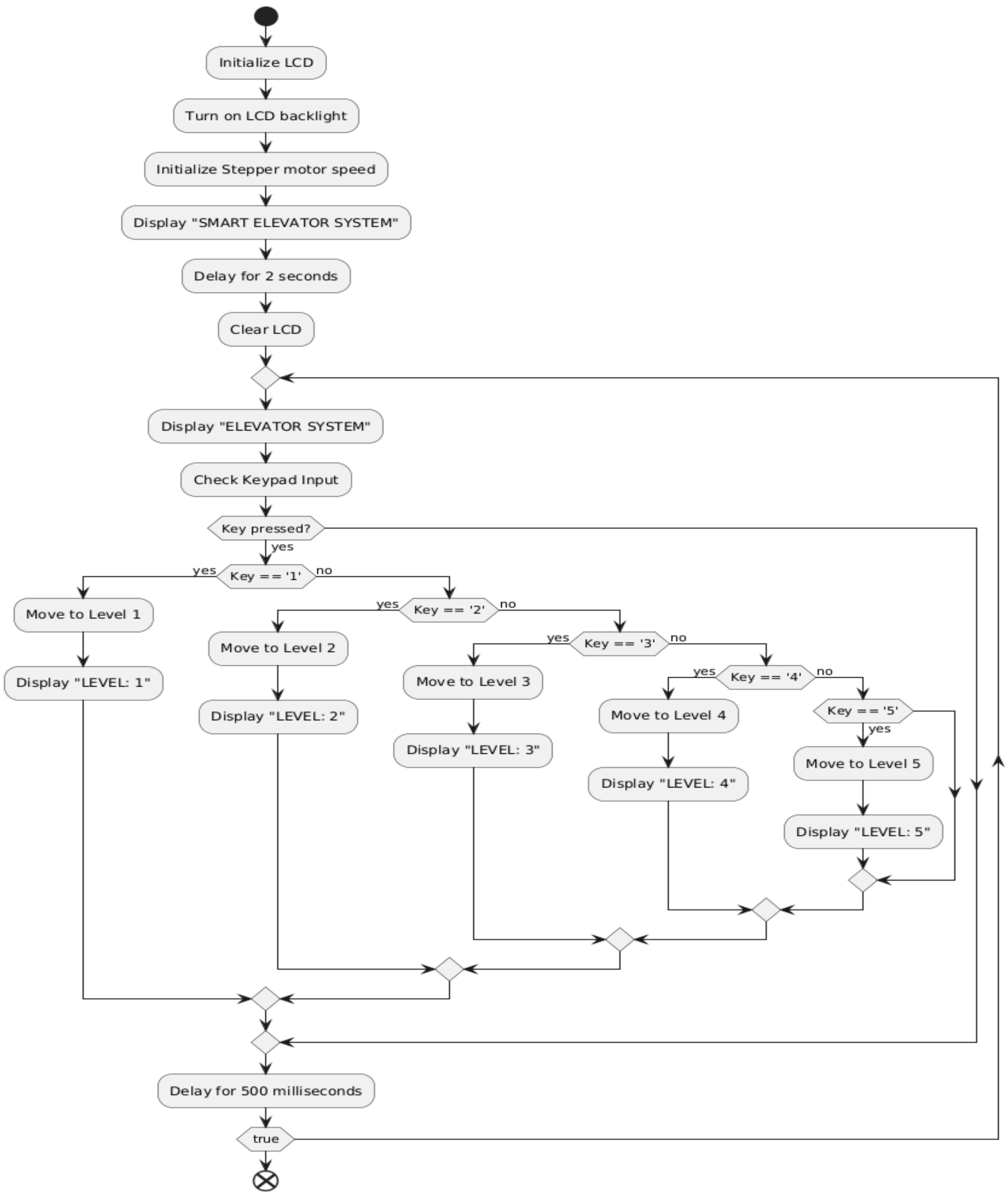


*Figure 25. Project flowchart*

## 4.4. Implementation

### 4.4.1. Working principle of project

The project's working principle revolves around the utilization of a stepper motor controlled by an Arduino microcontroller. The stepper motor facilitates precise and controlled elevator movement, without relying on expensive position sensors. The Arduino interprets floor selections entered via a keypad, translating them into specific motor movements. This ensures accurate alignment with the selected floor. Additionally, a display provides real-time feedback on the elevator's direction. The integration of these components delivers a cost-effective, simplified, and user-friendly elevator system, optimizing vertical transportation without the complexity associated with traditional designs.

### 4.4.2. Project outlook


*Figure 26. Project outlook*

### 4.4.3. Components specification

| No | Name | Specification |
|---|---|---|
| 1, | Arduino | • Uno<br>• Operating Voltage: 5V<br>• VInput Voltage: 7-12 V |
| 2. | Jumper wire | • $0.25mm^2$ |
| 3. | LCD Display | • 16 characters wide, 2 rows<br>• Interface Address: 0x27<br>• Character Color: White<br>• Backlight: Blue<br>• Supply voltage: 5V |
| 4. | Stepper motor | • Diameter: 27mm<br>• Voltage: 5V<br>• Step angle: 5.625×1/64<br>• Reduction ratio: 1/64 |
| 5. | Circuit breaker | • 10A<br>• Hager |
| 6. | PCB Board | • Single side PCB<br>• Hole diameter: 1mm<br>• Hole spacing Standard 2.54mm |
| 7. | 5V supply | • Output voltage: DC5V, 1A |
| 8. | Stepper motor driver | • ULN2003A motor driver chip |

| | | |
|---|---|---|
| | | • Chip all the pins already leads for easy connection to use<br>• Power supply: 5V-12V |
| 9. | Keypad | • Maximum Voltage across each segment or button: 24V<br>• The maximum current through each segment or button: 30mA<br>• Maximum operating temperature: $0^0$C to +$50^0$C |
| 10. | Supply Cable | • 1.5$mm^2$. |
| 11. | Resistors | • Carbon Film Resistor<br>• 4-band Resistor |
| 12. | Soldering wire | • Lead Content: 37%; Sn Content: 63%<br>• Flux: 2%<br>• Gross Weight: 100g/0.22lbs<br>• Diameter: 0.8mm<br>• Melting point: 183°C (361°F) |

*Table 1. Components specifications*

# CHAP 5: CONCLUSION AND RECOMMENDATION

## 5.1. Conclusion

This project presents an innovative approach to elevator system design, emphasizing cost-effectiveness and simplicity. By leveraging stepper motor technology and Arduino-based control, we have demonstrated a viable alternative to traditional elevator mechanisms. The absence of position sensors significantly reduces the system's complexity and cost, making it accessible for smaller-scale projects and economically constrained settings. The integration of a keypad for floor selection and a display for directional feedback enhances user interaction and usability. This project showcases the potential to revolutionize elevator technology, encouraging further exploration and implementation of similar cost-efficient solutions in the realm of vertical transportation.

## 5.2. Recommendation

For schools and students interested in applied engineering projects, this project offers valuable insights into practical applications of microcontrollers and motor control systems. We recommend incorporating such hands-on projects into academic curricula to nurture problem-solving skills and technological innovation. Moreover, for our campus community, integrating similar cost-effective technologies can be advantageous in various campus infrastructure projects, optimizing resource allocation and promoting sustainability. Embracing these innovations not only enhances the learning experience but also aligns with the campus's commitment to sustainability and practical advancements in technology.

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APPENDICES

## 1. APPENNDIX 1: CODE

```
#include <Keypad.h>

#include <Stepper.h>

#include <TimerOne.h>

#include <Wire.h>

#include <LiquidCrystal_I2C.h>

LiquidCrystal_I2C lcd(0x27, 16, 2);

const byte ROWS = 4;

const byte COLS = 4;

char hexaKeys[ROWS][COLS] = {

  {'1', '2', '3', 'A'},

  {'4', '5', '6', 'B'},

  {'7', '8', '9', 'C'},

  {'*', '0', '#', 'D'}

};

byte rowPins[ROWS] = {A0, A1, A2, 6};

byte colPins[COLS] = {A3, 3, 4, 2};

Keypad customKeypad = Keypad(makeKeymap(hexaKeys), rowPins, colPins, ROWS, COLS);

Int current_floor

int stepsPerRevolution=2048;
```

```
int motspeed=15;

int revs;

int j=1;

Stepper myStep(stepsPerRevolution, 8,10,9,11);

float lvl[6];

void setup() {

lcd.begin();

lcd.backlight();

myStep.setSpeed(motspeed);

Timer1.initialize(5000);

Timer1.attachInterrupt(level);

lcd.setCursor(6,0);

lcd.print("SMART");

lcd.setCursor(0,1);

lcd.print("ELEVATOR SYSTEM");

delay(2000);

lcd.clear();

}

void loop() {

lcd.setCursor(0,0);

lcd.print("ELEVATOR SYSTEM");
```

```
if (current_floor>previous_floor){

lcd.print("ELEVATOR UP")};

if (current_floor<previous_floor)

lcd.print("ELEVATOR DOWN")};

if(lvl[1]==1){

j=1-j;

revs=j*1848;

myStep.step(-revs);

lcd.setCursor(0,1);

lcd.print("LEVEL: ");

lcd.setCursor(9,1);

lcd.print(lvl[1]);

j=1;

lvl[1]=0;

}

delay(500);

if(lvl[2]==2){

j=2-j;

revs=j*1848;

myStep.step(-revs);

lcd.setCursor(0,1);
```

```
lcd.print("LEVEL: ");
lcd.setCursor(9,1);
lcd.print(lvl[2]);
j=2;
lvl[2]=0;
}
delay(500);


if(lvl[3]==3){
j=3-j;
revs=j*1848;
myStep.step(-revs);
lcd.setCursor(0,1);
lcd.print("LEVEL: ");
lcd.setCursor(9,1);
lcd.print(lvl[3]);
j=3;
lvl[3]=0;
}
delay(500);
if(lvl[4]==4){
```

```
j=4-j;

revs=j*1848;

myStep.step(-revs);

lcd.setCursor(0,1);

lcd.print("LEVEL: ");

lcd.setCursor(9,1);

lcd.print(lvl[4]);

j=4;

lvl[4]=0;

}

delay(500);


if(lvl[5]==5){

j=5-j;

revs=j*1848;

myStep.step(-revs);

lcd.setCursor(0,1);

lcd.print("LEVEL: ");

lcd.setCursor(9,1);

lcd.print(lvl[5]);

j=5;
```

```
lvl[5]=0;

}

delay(500);

}




void level (){

char customKey = customKeypad.getKey();

if (customKey=='1'){

lvl[1]=1;

}

if (customKey=='2'){

lvl[2]=2;

}

if (customKey=='3'){

lvl[3]=3;

}

if (customKey=='4'){

lvl[4]=4;

}

if (customKey=='5'){
```

```
lvl[5]=5;
}
}
```

**Appendix 2. Cost estimation**

| No | Name | Cost per/unit/ Rwf | Quantity | Total cost/ Rwf |
|---|---|---|---|---|
| 1, | Arduino | 11,000 | 1 pc | 15,000 |
| 2. | Jumper wire | 100 | 10 pc | 1000 |
| 3. | LCD Display | 9,000 | 1pc | 9,000 |
| 4. | Stepper motor | 5000 | 1pc | 10,000 |
| 5. | PCB Board | 1000 | 1 pc | 1000 |
| 6. | 5V supply | 5,000 | 1 pc | 5,000 |
| 7. | Stepper motor driver | 8000 | 1pc | 8000 |
| 8. | Keypad | 4,000 | 1 pc | 4,000 |
| 9. | Supply Cable | 400 | 5m | 2,000 |
| 10. | Resistors | 100 | 4Pc | 400 |
| 11. | Soldering wire | 300 | 5m | 1,500 |
| 12. | Insulation tape | 1,000 | 1pc | 1,000 |
| 13. | Adapter power 12V | 5,000 | 1pc | 5,000 |
| 14. | **Overall cost** | | | **70,500 Rwf** |

*Table 2. Cost estimation of the project*