International Journal of Scientific Research in Science, Engineering and Technology

Print ISSN - 2395-1990
Online ISSN : 2394-4099

Available Online at : www.ijsrset.com
doi : https://doi.org/10.32628/IJSRSET

Arduino Microcontroller Based Electronics Password Circuit Breaker for Distribution Side Electric Line Man Safety on Transmission Line

[#1]R. Sowmiya, [#2]Er .D. Geetha, [#3]Dr. S. Sivasakthi

[#1]PG Scholar, [#2]Assistant Professor, [#3]Professor and Head

[#1, #2, #3]Department of Electrical and Electronics Engineering, Krishnasamy college of Engineering and Technology, Cuddalore, Tamil Nadu, India

[#1]Email: sowmidevamani73@ gmail.com

ARTICLEINFO

Article History :

Accepted: 01 Feb 2024
Published: 05 Feb 2024

Publication Issue :
Volume 11, Issue 1
January-February-2024
Page Number :
157-164

ABSTRACT

The contemporary landscape necessitates the amalgamation of automation technology into various domains, particularly in enhancing safety measures. Human accidents, especially in industrial settings, have surged, warranting innovative solutions to mitigate risks and ensure worker safety. Addressing this urgency, our project centers on the integration of embedded system design, fusing mechanical and computer systems, to fortify safety protocols in electrical circuit operations. Our focus revolves around developing a system aimed at reducing and potentially eliminating accidents by implementing an OTP-based control mechanism for circuit breakers (CB). Leveraging Arduino technology, the system is devised to administer an OTP to the user for CB operation. The maintenance staff is required to input the OTP via a keypad to gain access to the circuit breaker, ensuring secure and controlled access. This project endeavors to revolutionize safety protocols in electrical operations by infusing advanced technology, thus instilling a proactive approach in preventing mishaps and safeguarding the well-being of workers in industrial settings. The innovative integration of OTP-based control aligns with the imperative of ensuring safer and more secure electrical operations, contributing to a paradigm shift in workplace safety standards.

Keywords : Human Accidents, Circuit Breakers, OTP, Electrical Operations

I. INTRODUCTION

The safety of personnel working on transmission lines stands as a paramount concern in the domain of electrical distribution systems. The hazardous nature of high-voltage electrical installations necessitates robust safety measures to protect workers from potential accidents and ensure their well-being. In this context, the utilization of innovative technologies, particularly Arduino microcontroller-based systems,

has emerged as a pioneering approach to enhance safety protocols in the electrical distribution sector.

The landscape of electrical distribution systems presents an environment rife with challenges and hazards, particularly in the domain of transmission line maintenance. The safety of line workers engaged in operations along the distribution side of electric transmission lines is a top priority. The exposure to high-voltage electrical circuits and the inherent risks associated with their maintenance underscores the critical need for innovative safety solutions. In response to this imperative, our project delves into the realm of Arduino microcontroller-based electronics to revolutionize safety measures for line workers.

Electrical accidents pose significant threats to the well-being of workers on transmission lines. In light of this, our project centers on the development and implementation of a cutting-edge electronic password circuit breaker system. At its core, this system utilizes Arduino microcontrollers to introduce a password-protected mechanism for controlling circuit breakers situated along the distribution side of electric transmission lines. This advanced solution aims to mitigate potential risks by ensuring that only authorized personnel with the requisite access credentials can operate the circuit breaker, thus significantly reducing the likelihood of unauthorized or accidental activation.

The integration of Arduino microcontrollers offers a robust platform to implement a sophisticated yet user-friendly authentication system. Through this innovative technology, line workers are empowered with a secure means of accessing and managing circuit breakers. The electronic password circuit breaker mechanism not only elevates safety standards but also streamlines operational control, providing an additional layer of security against unauthorized access. By augmenting conventional circuit breaker operations with secure electronic authentication, our system seeks to instill confidence in workers while fortifying safety measures along the distribution side of electric transmission lines.

The adoption of Arduino-based electronics in this project symbolizes a paradigm shift in safety protocols within the electrical distribution sector. This cutting-edge technology not only enhances safety but also promotes efficiency and precision in circuit breaker operations. The amalgamation of electronics and safety measures signifies a transformative step forward in ensuring a safer working environment for line workers, heralding a new era of safety standards in transmission line maintenance.

Our focus is on implementing an Arduino microcontroller-based electronic password circuit breaker tailored for enhancing safety on the distribution side of electric transmission lines. The primary objective of this system is to fortify the safety measures available to line workers by introducing a sophisticated yet user-friendly mechanism for circuit breaker operation.

This system's core functionality revolves around integrating the Arduino microcontroller to create a password-protected circuit breaker mechanism. By employing a secure password-based authentication system, this technology ensures that only authorized personnel can access and operate the circuit breaker installed on the distribution side of electric transmission lines.

Our endeavor aligns with the overarching goal of bolstering safety standards for line workers, minimizing the risk of electrical accidents, and optimizing overall operational safety within the electrical distribution infrastructure. Through the innovative application of Arduino-based electronics and password-protected circuitry, this project seeks to pave the way for a safer working environment in the challenging realm of transmission line maintenance and operation.

II. RELATED WORKS

The implementation involves integrating Arduino Uno, a widely accessible microcontroller board, with the circuit breaker mechanism. This setup enables the

authentication process, wherein users must input the correct password using a keypad or similar input method to access and manage the circuit breaker's functionality. The system prioritizes security, emphasizing controlled access and preventing tampering or accidental operation by unauthorized individuals [1].

Emphasizing the importance of safety measures and controlled access in electrical systems. The dissertation may highlight the significance of implementing secure authentication methods in preventing electrical hazards or accidents, ensuring proper control over critical circuits [2].

The circuit breaker system incorporates a secure passcode mechanism for authentication and access control. Users might need to enter a unique or encrypted passcode through the smart application to operate the circuit breaker, ensuring that only authorized individuals can control it. Emphasis is placed on implementing robust security features within the smart application and the circuit breaker system. This may include encryption protocols, secure communication channels, and stringent authentication procedures to prevent unauthorized access or tampering [3].

The main function of this system is likely to interrupt or stop electrical circuit operations upon successful authentication. The passcode-based mechanism acts as a gatekeeper, allowing authorized individuals to control the interruption process. The paper [4] may focus on enhancing safety measures within electrical systems by implementing controlled interruption through a passcode-based system. This could prevent potential hazards or accidents caused by unauthorized or inadvertent circuit interruptions.

This paper [5] aims to demonstrate the applicability and advantages of IoT technology in securing, maintaining, and managing circuit breakers within diverse electrical infrastructure scenarios, highlighting its potential benefits for safety and efficiency. Utilizing IoT connectivity for centralized management, allowing remote access and control over the circuit breaker system, thus enhancing operational efficiency and control.

The research [6] likely involves embedding IoT devices or sensors into transmission poles, transforming them into smart poles capable of real-time data collection, monitoring, and communication functionalities. The primary focus is on improving electrical linemen safety while working on transmission lines. The IoT-enabled pole might include safety sensors, alert systems, or mechanisms to detect and prevent hazards, reducing potential accidents or injuries.

The research [7] involves incorporating IoT devices and sensors into the distribution substation infrastructure, enabling real-time monitoring, data collection, and control functionalities. Utilizing IoT technology to continuously monitor various parameters within the distribution substation, such as voltage levels, current flow, power consumption, or equipment status. This enables comprehensive oversight of the power system's performance. The IoT-based system likely provides remote management and control features for the distribution substation. This may include remote adjustments, fault detection, and the ability to optimize power distribution for efficiency and reliability.

The paper [8] involves creating an innovative and secure switching operating system that combines remote password-based control and Zero Contact Code (ZCC) technology. This system aims to offer efficient and secure control over switches or devices by integrating both remote password authentication and ZCC, ensuring enhanced security measures and user-friendly access methods for managing various operations.

The research [9] focuses on developing an Android application that serves to notify the grid or relevant authorities on load zero occurrences, specifically outages in primary distribution substations. This innovative app aims to promptly alert the grid system administrators or concerned personnel when load zero instances occur in primary distribution substations,

enabling swift actions and responses to mitigate or address power outage situations efficiently.

The research [10] involves implementing a system that safeguards electrical appliances or systems from overvoltage and undervoltage situations by integrating a GSM (Global System for Mobile Communications) module. This technology allows real-time monitoring of voltage levels, and upon detecting abnormal voltages, it triggers alerts or actions sent via GSM communication, ensuring prompt notifications or automated protective measures to prevent potential damage to connected devices due to voltage fluctuations.

III. PROPOSED MODEL

The proposed system integrates a circuit breaker control mechanism facilitated by a one-time password input through a connected keypad, forming a secure and efficient means of operation. At the core of this setup lies the Arduino microcontroller, serving as the central component orchestrating the control process. Focused on enhancing safety and security, the system ensures access to the circuit breaker solely upon successful password validation. Once the entered password aligns with the stored code, the circuit breaker is enabled to perform its designated task of turning ON or OFF, emphasizing a reliable and controlled operation for electrical systems.

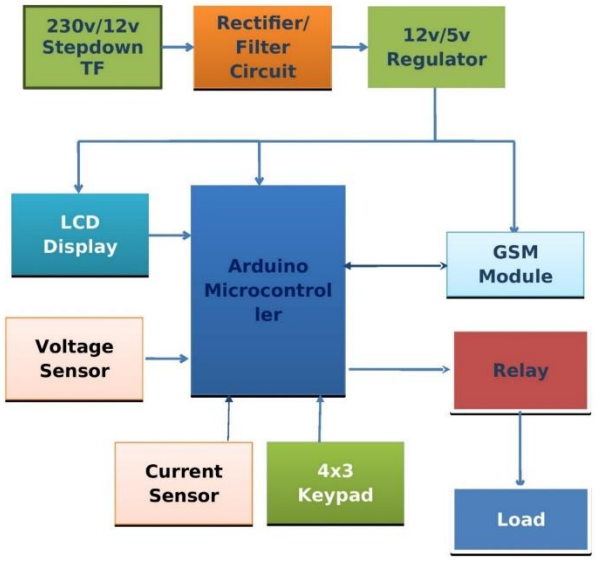

Figure 1: Block Diagram of the Proposed Model

The working model is directed by an Arduino microcontroller, overseeing voltage and current levels within the system. In cases where either parameter surpasses predefined thresholds, the circuit breaker triggers an automatic load shutdown as a safety measure. Simultaneously, notifications and a one-time password (OTP) are dispatched to the designated recipient, alerting them to the occurrence. Facilitating user interaction, a matrix keypad interfaces with the microcontroller, enabling password input. This entered password undergoes verification by comparison with the stored code within the microcontroller's Read-Only Memory (ROM) for access control. If the correct password is provided, the system allows switching ON/OFF of the line, visually indicated by a lamp that reflects the activation or deactivation status of the circuit breaker.

The working model begins with a step-down of the 230V AC supply using Current Transformers (CT) and Potential Transformers (PT), allowing safe operation at 5V or 12V. This lower voltage is generated using a bridge rectifier. The outputs from the CT and PT are fed into respective current and voltage measurement circuits. A microcontroller analyzes these measurements, comparing them against a predetermined reference value, which is input via a keypad connected to the microcontroller. If the entered password matches the reference value, the microcontroller commands relays to switch the load on or off accordingly.

The system incorporates an LCD display that exhibits the entered password and provides warning messages when necessary. All of these functionalities, including voltage and current measurement, password comparison, relay control, and display outputs, are simulated using Proteus software, ensuring a comprehensive emulation of the system's operations in a virtual environment.

The main component in the circuit is arduino microcontroller. In this project 4×3 keypad is used to enter the password. The password which is entered is

compared with the predefined password. If entered password is correct, then the corresponding electrical line is turned ON or OFF. In this project, a separate password is provided to each electrical line. Activation and deactivation of the line (circuit breaker) is indicated by the load (Light Bulbs).

Circuit Diagram

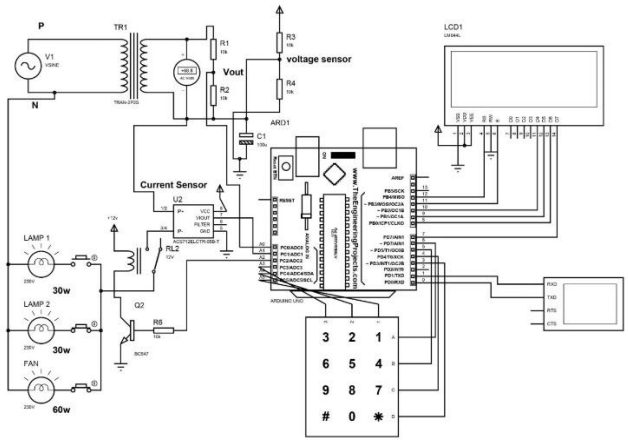

Figure 2: Circuit Diagram

The above circuit consists of Arduino series controller4×4 Matrix Keypad, 16 x 2 LCD Display, 4 – Channel Relay Module and Four Loads. LCD data pins are connected to PORT1 and control pins RS, RW and EN pins are connected to P3.0, GND and P3.1 respectively. Here, the LCD is used to display the information related to the load.

Keypad is connected to PORT2 of the microcontroller. The four Row Pins of the Keypad are connected to P2.0 to P2.3 and the four Column Pins are connected to P2.4 to P2.7. Using this keypad, we need to enter the password.

Four Lamps (acting as Electrical Lines) are connected to P0.0 to P0.3 through the 4 – Channel Relay Module. These are used to indicate circuit breaker state (Light ON – Line Active and Light OFF – Line Not Active).

If you are not using the Relay Module, then you need to use 4 BC547 NPN Transistors (along with its current limiting base Resistor) in order to drive the relays.

Algorithm

1. Initially declare the PORT1 to LCD data pins and its control pins RS and E to P3.0 and P3.2 and P3.7 respectively. Also declare PORT2 to keypad and use P0.0, P0.1, P0.2 and P0.3 to loads.
2. Initially display “enter password” on LCD.
3. Now read the five digit password from the user.
4. Compare the entered password with stored password.
5. If the password matches, correct then ON or OFF the particular load and display line or load status on LCD.
6. If the password is wrong, then display “wrong password” on the LCD.
7. After some delay, again ask to enter password.

IV. EXPERIMENTAL SETUP AND RESULTS ANALYSIS

Hardware Description: The hardware setup for the Arduino microcontroller-based electronic password circuit breaker comprises several key components:

Arduino Microcontroller: This acts as the central processing unit, controlling the entire system's operation, managing the password authentication, and executing the circuit breaker actions.

Current Transformers (CT) and Potential Transformers (PT): These transformers step down the high voltage (230V AC) of the distribution side electric line to levels suitable for measurement and processing within the system.

Bridge Rectifier: Used to convert the stepped-down AC voltage into a stable DC voltage (5V or 12V) required for the system's operation.

Voltage and Current Measurement Circuits: These circuits receive the outputs from CT and PT, respectively measuring the voltage and current levels to provide data to the Arduino for analysis.

Matrix Keypad: Connected to the Arduino microcontroller, the keypad enables user input of the password for access control.

Relays: These components are controlled by the Arduino microcontroller's output to switch the load (electric line) on or off based on successful password authentication.

LCD Display: Provides visual feedback by showing entered passwords, system status, and warning messages.

Experimental Setup: The experimental setup involves integrating these hardware components in a systematic configuration:

Connections: Establish connections between the CT and PT outputs, bridge rectifier, voltage and current measurement circuits, matrix keypad, relays, LCD display, and the Arduino microcontroller following a predefined circuit diagram.

Voltage and Current Measurement: Calibrate and configure the voltage and current measurement circuits to accurately sense and measure the electrical parameters from the CT and PT outputs.

Programming: Write and upload the necessary code to the Arduino microcontroller to manage the password comparison, relay control, LCD display output, and overall system operation.

Keypad Integration: Ensure the matrix keypad is correctly interfaced with the Arduino microcontroller and programmed to receive and process password inputs.

Relay and Load Connection: Connect the relay output to the distribution side electric line to enable the Arduino-controlled switching action.

LCD Display Integration: Set up the LCD display to exhibit entered passwords, system status messages, and warnings, in coordination with the Arduino program.

Testing and Validation: Test the system thoroughly by entering various passwords, monitoring voltage and current readings, observing the relay switching action, and verifying the LCD display outputs to validate the functionality and safety features of the electronic password circuit breaker system.

Project Circuit Design

Mount components at their appropriate place; bend the leads slightly outwards to prevent them from falling out when the board is turned over for soldering. No cut the leads so that you may solder them easily. Apply a small amount of flux at these components leads with the help of a screwdriver. Now fix the bit or iron with a small amount of solder and flow freely at the point and the P.C.B copper track at the same time. A good solder joint will appear smooth & shiny. If all appear well, you may continue to the next solder connections.

1. Use right type of soldering iron. A small efficient soldering iron (about 10-25 watts with 1/8 or 1/4 inch tip) is ideal for this work.
2. Keep the hot tip of the soldering iron on a piece of metal so that excess heat is dissipated.
3. Make sure that connection to the soldered is clean. Wax frayed insulation and other substances cause poor soldering connection. Clean the leads, wires, tags etc. before soldering.
4. Use just enough solder to cover the lead to be soldered. Excess solder can cause a short circuit.

Use sufficient heat. This is the essence of good soldering. Apply enough heat to the component lead. You are not using enough heat, if the solder barely melts and forms a round ball of rough flaky solder. A good solder joint will look smooth, shining and spread type. The difference between good & bad soldering is just a few seconds extra with a hot iron applied firmly.

Precautions:

1. Mount the components at the appropriate places before soldering. Follow the circuit description and components details, leads identification etc. Do not start soldering before making it confirm that all the components are mounted at the right place.
2. Do not use a spread solder on the board, it may cause short circuit.
3. Do not sit under the fan while soldering.
4. Position the board so that gravity tends to keep the solder where you want it.
5. Do not over heat the components at the board. Excess heat may damage the components or board.
6. The board should not vibrate while soldering otherwise you have a dry or a cold joint.
7. Do not put the kit under or over voltage source. Be sure about the voltage either dc or ac while operating the gadget.

8. Do spare the bare ends of the components leads otherwise it may short circuit with the other components. To prevent this use sleeves at the component leads or use sleeved wire for connections.
9. Do not use old dark color solder. It may give dry joint. Be sure that all the joints are clean and well shiny.
10. Do make loose wire connections especially with cell holder, speaker, probes etc. Put knots while connections to the circuit board, otherwise it may get loose.

SOFTWARE DESCRIPTION

The software architecture for the Arduino microcontroller-based electronic password circuit breaker involves various components for system control and user interaction:

Arduino IDE: The Integrated Development Environment (IDE) is used to write, edit, compile, and upload the code to the Arduino microcontroller. The code encompasses the logic for password validation, interfacing with hardware components, and controlling the circuit breaker's operation.

Arduino Programming (C/C++): The code is written in Arduino's variant of C/C++, which involves defining functions for voltage and current measurement, comparing entered passwords, controlling relay operations, managing LCD display output, and handling system status messages.

Password Verification Algorithm: This algorithm is a key part of the software, responsible for comparing the entered password from the keypad with the pre-set reference value stored in the microcontroller's memory. Upon successful verification, the system authorizes the circuit breaker's operation.

Relay Control Logic: The code contains instructions to command the relays based on the password validation status, allowing the Arduino to switch the load (electric line) on or off as required for safety.

User Interface (LCD Display): Software manages the LCD display, showing user prompts for entering the password, displaying entered passwords, indicating system status (authorized or unauthorized access), and presenting warning messages when necessary.

Error Handling and Notifications: The software is designed to handle errors or incorrect password entries, providing appropriate feedback to the user through the LCD display or other means.

Serial Communication: Utilizing serial communication, the Arduino IDE can be used to monitor and debug the system by displaying real-time information or debugging messages through the serial monitor.

Testing and Validation Procedures: The software involves testing methodologies to ensure the reliability, accuracy, and safety features of the system, simulating various scenarios, including password entry, relay switching, and LCD display feedback.

Overall, the software for the Arduino microcontroller-based electronic password circuit breaker system involves comprehensive programming to manage hardware components, user inputs, password validation, and relay control, prioritizing safety and effective circuit breaker operation on the distribution side electric line for lineman safety on transmission lines.

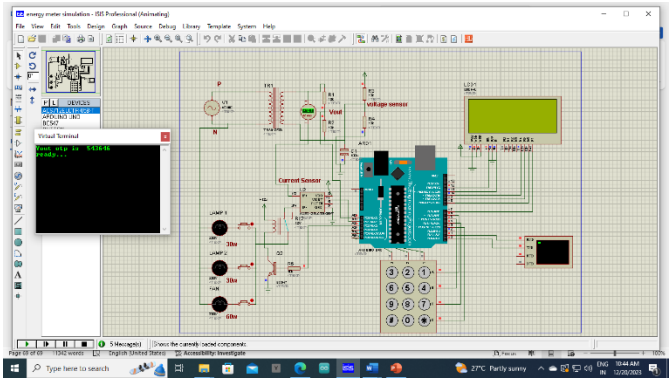

Figure 3 : Output

V. CONCLUSION

To ensure reliable and risk free operation of circuit breakers in a system, maintenance activities have to be well managed and scheduled. However, due to some financial and operational constraints, it seems reasonable to focus more on the critical circuit

breakers of the system both for the successful switching and maintenance planning. In this paper, several contributions are made. Further the project can be enhanced by using an EEPROM for user to change the password for a more secured system. It can also be interfaced with a Iot modem for remotely controlling the electronic circuit breaker via Internet.

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Cite this article as :

R. Sowmiya, Er .D. Geetha, Dr. S. Sivasakthi , "Arduino Microcontroller Based Electronics Password Circuit Breaker for Distribution Side Electric Line Man Safety on Transmission Line", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 11 Issue 1, pp. 157-164, January-February 2024.

Journal URL : https://ijsrset.com/IJSRSET2310656