

Password-Based Circuit Breaker for Secure and Authorized Control of Electrical Systems

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ABSTRACT

Electrical safety is a major concern during the operation and maintenance of electrical systems, particularly when personnel work on energized circuits. Unauthorized or accidental operation of circuit breakers can result in electrical shocks, equipment damage, and unsafe working conditions. This paper presents an embedded password-based circuit breaker system designed to provide secure and controlled access to electrical circuits. The proposed system uses a PIC16F877A microcontroller as the central control unit, interfaced with a numeric keypad, LCD display, relay, buzzer, LED indicators, and regulated power supply. Before operating the circuit, the user is required to enter a predefined password through the keypad. The microcontroller compares the entered password with the stored password and operates the relay only when authentication is successful. Incorrect password entries are rejected and an audible indication is provided through the buzzer. A lockout mechanism after three consecutive incorrect attempts improves protection against repeated unauthorized access. The system also supports password modification through an authorized procedure and provides an administrator-password facility. The developed prototype offers a low-cost and practical approach for improving electrical safety and preventing unauthorized switching of electrical equipment.

Keywords— Password authentication, circuit breaker, PIC16F877A, microcontroller, relay, keypad, electrical safety, access control.

INTRODUCTION

Electrical safety is an important requirement in homes, industries, laboratories, substations, and other electrical installations. During maintenance activities, accidental energization of a circuit can expose personnel to serious electrical hazards. Conventional circuit breakers primarily provide electrical protection against abnormal operating conditions, but they do not necessarily restrict physical access to the switching mechanism. Therefore, an additional access-control mechanism can improve safety by ensuring that only authorized personnel can operate the circuit. The project presented in the source document addresses this requirement through an embedded password-based circuit breaker system.

The proposed system integrates a digital authentication mechanism with electrical switching. A numeric keypad is used to enter the password, while the PIC16F877A microcontroller processes the user input and controls a relay connected to the circuit. When an authorized password is entered, the relay changes its state and permits the required switching operation. The LCD provides visual information to the user, while the buzzer provides audible acknowledgement and alerts for incorrect operations.

The system is particularly useful during maintenance activities because it can prevent unauthorized personnel from operating the electrical circuit. The document identifies the system as suitable for applications in which controlled access to electrical equipment is required. In addition to password authentication, the design incorporates protection against repeated incorrect password attempts, thereby increasing the security of the switching mechanism.

The proposed embedded system is designed with commonly available electronic components, making it comparatively simple and economical to implement. The PIC16F877A provides the required processing and interfacing functions, while the relay provides electrical isolation and switching control. The overall design therefore combines embedded control, user authentication, indication, and electrical switching in a single system.

LITERATURE SURVEY

Several researchers have investigated password-based access control mechanisms for improving the safety and security of electrical circuit breakers. Smith et al. [1] proposed a password-protected circuit breaker system to prevent unauthorized operation. Their approach provided a simple and effective access-control mechanism; however, it lacked multifactor authentication and remained vulnerable to password theft. Chen and Kumar [2] developed an embedded password-authentication system for secure circuit protection using keypad-based access. Although the system improved protection against unauthorized operation, weak passwords and the possibility of unauthorized password resetting were identified as limitations.

Kumar and Singh [3] developed a smart circuit breaker with password-based access intended primarily for home and office applications. Their system emphasized ease of use and cost-effectiveness, but its scalability for industrial applications was limited. Sharma and Patel [4] investigated the design and implementation of password-controlled circuit breakers with enhanced security features for physical electrical systems. While the approach improved security, its relatively high implementation cost made it less suitable for small-scale applications. Gupta and Das [5] proposed an enhanced user-authentication mechanism for industrial circuit breakers using multifactor authentication. The approach improved security by combining password-based access with biometric authentication, but required additional hardware and resulted in increased implementation complexity.

From the reviewed literature, password-based authentication provides a practical method for restricting unauthorized access to electrical switching systems. However, limitations such as password theft, weak passwords, scalability, implementation cost, and hardware complexity remain significant concerns. The proposed system addresses these issues through a relatively simple embedded architecture incorporating a PIC16F877A microcontroller, keypad, LCD, relay, buzzer, and a lockout mechanism after repeated incorrect password attempts. This provides controlled and authorized operation while maintaining a low-cost implementation.

PROBLEM STATEMENT

Malfunctioning circuit breakers and inadequate communication between maintenance personnel and electrical system operators can result in accidental energization, system outages, and electrical accidents during maintenance operations.

OBJECTIVES

The main objectives of the proposed system are:

1. To develop a password-based access-control mechanism for operating an electrical circuit breaker.
2. To prevent unauthorized operation of electrical circuits by integrating password authentication with microcontroller-based relay control.
3. To provide visual and audible indications for successful and unsuccessful authentication.
4. To improve security through password modification and lockout after repeated incorrect attempts.

PROPOSED SYSTEM

The proposed password-based circuit breaker consists of a PIC16F877A microcontroller, numeric keypad, LCD display, relay, buzzer, LED indicators, reset circuit, crystal oscillator, and regulated power supply. The microcontroller acts as the central processing unit and receives the password entered by the user through the keypad. The entered password is compared with the predefined password stored in the controller's memory.

When the entered password matches the stored password, the microcontroller generates the appropriate control signal for the relay. The relay subsequently controls the electrical circuit and allows the authorized switching operation. If the entered password is incorrect, the relay remains in the safe state and the user is alerted through the LCD and buzzer. The system can also block further attempts after three consecutive incorrect password entries.

The system is powered by a regulated 5 V supply. The source document specifies a 230/12 V step-down transformer followed by a bridge-type full-wave rectifier and voltage regulation to obtain the required DC supply. This regulated supply powers the microcontroller and associated electronic components.

Block Diagram

4

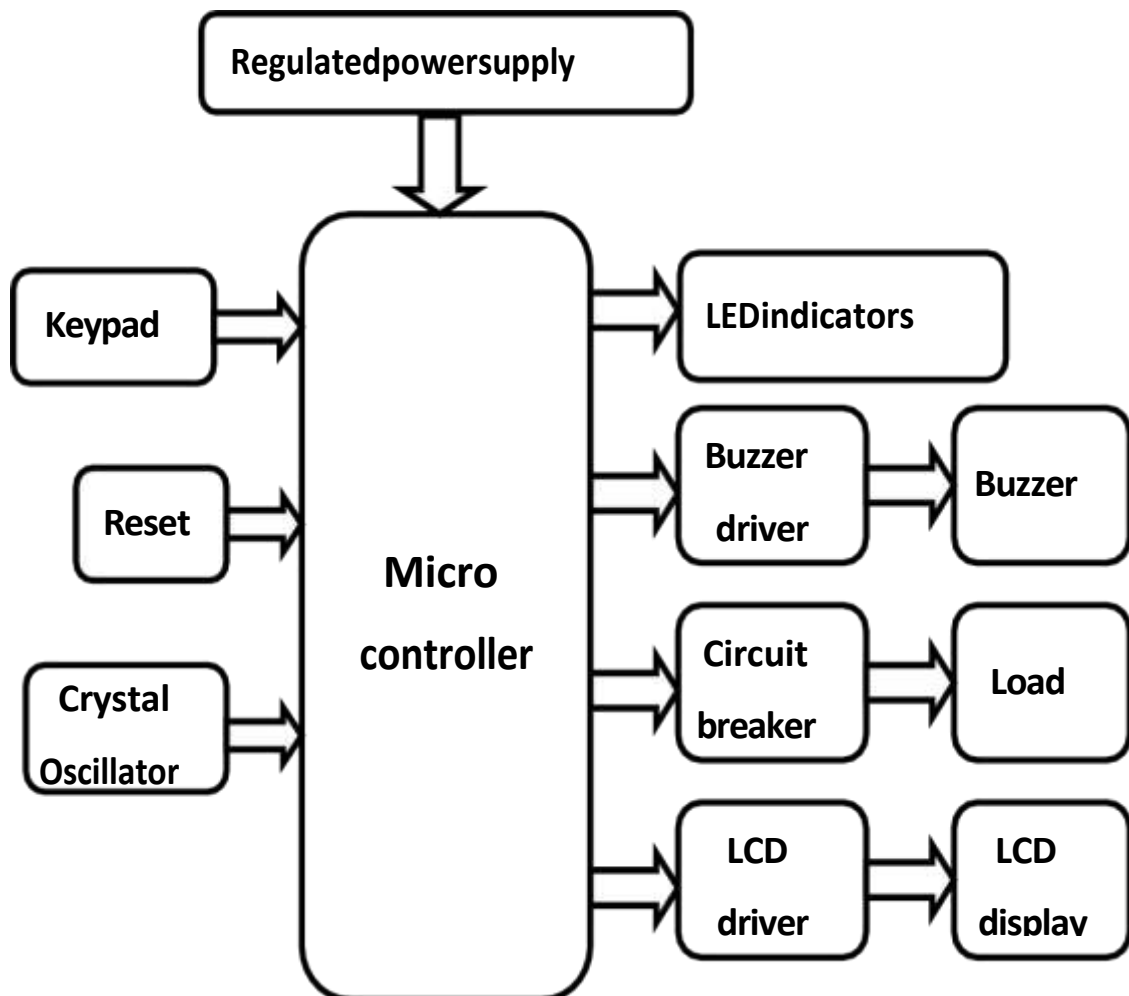


Fig 1Block diagram of embedded password-based circuit breaker

The **Fig. 1** shows the circuit diagram of the password-based circuit breaker system, consisting of a microcontroller, 4×4 keypad, LCD display, relay, buzzer, and regulated power supply. The system verifies the password entered through the keypad and controls the relay accordingly, while the LCD displays the operating status and the buzzer indicates incorrect or unauthorized access.

CIRCUIT DIAGRAM

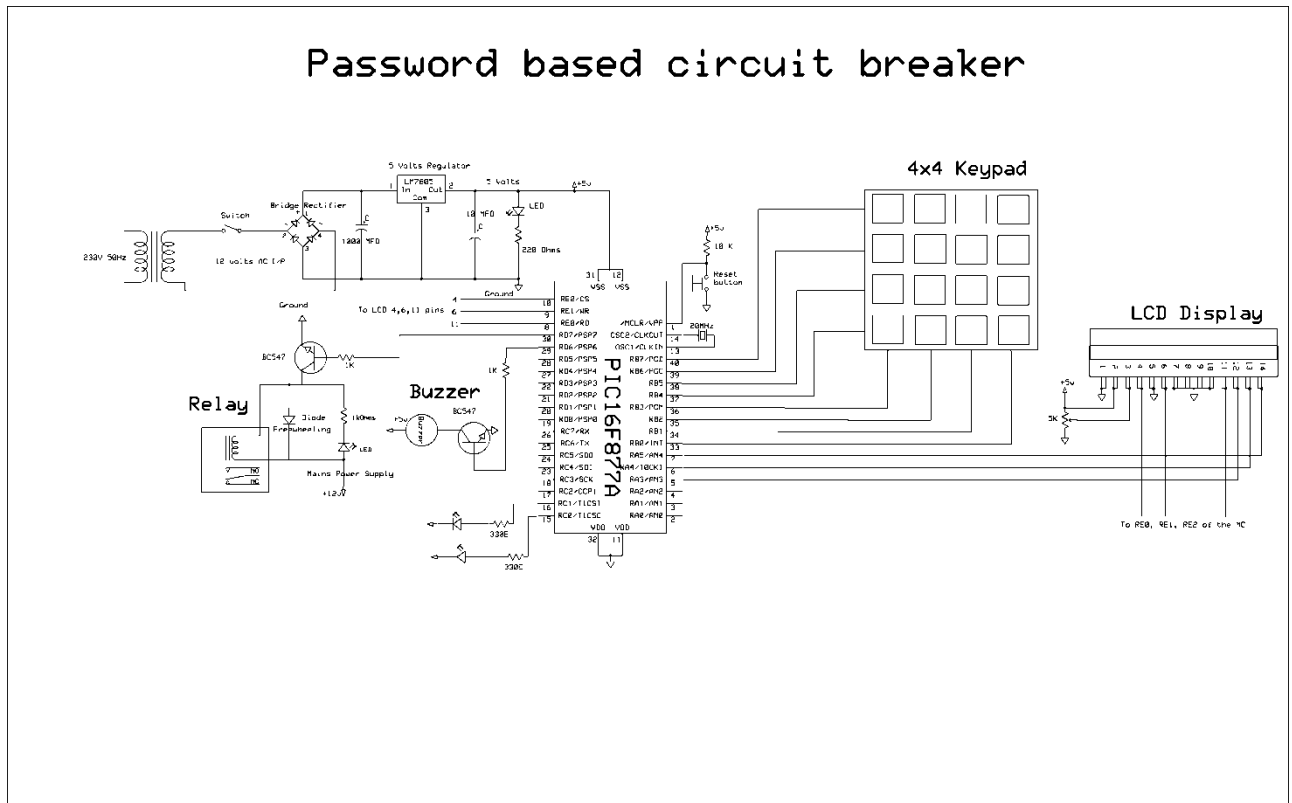


Fig 2 Connection diagram for password-based circuit breaker

The **Fig. 2** shows the circuit diagram of the password-based circuit breaker system, consisting of a microcontroller, 4×4 keypad, LCD display, relay, buzzer, and regulated power supply. The system verifies the password entered through the keypad and controls the relay accordingly, while the LCD displays the operating status and the buzzer indicates incorrect or unauthorized access.

METHODOLOGY

The proposed password-based circuit breaker system uses a PIC16F877A microcontroller as the central control unit. The system consists of a numeric keypad, LCD display, relay, buzzer, LED indicators, reset circuit, crystal oscillator, and regulated power supply. Initially, the user enters a predefined password through the keypad. The microcontroller receives and compares the entered password with the stored password. If the password is correct, the controller activates the relay to control the circuit breaker and permits the electrical circuit to operate. The LCD provides the system status, while the buzzer provides audible acknowledgement and alerts. The system is powered through a regulated 5 V supply obtained using a step-down transformer, bridge rectifier, and voltage regulator.

For security enhancement, the system verifies every password entry before allowing circuit operation. When an incorrect password is entered, the relay remains deactivated and the user is notified through the LCD and buzzer. If the password is entered incorrectly three consecutive times, the system enters a blocked mode to prevent repeated unauthorized attempts. An administrator password is provided for recovery when the user forgets the normal password, and the password can be changed after successful authentication. The complete system is tested by checking individual components and then integrating the hardware and software to verify correct authentication, invalid-password handling, lockout operation, and relay-based circuit switching. Finally, the assembled system is enclosed and connected to the controlled circuit for operation.

RESULTS AND DISCUSSION

The developed password-based circuit breaker prototype was successfully assembled and tested by integrating the PIC16F877A microcontroller with the keypad, LCD display, relay, buzzer, LED indicators, and regulated power supply. During testing, the system accepted the password entered through the keypad and compared it with the predefined password stored in the microcontroller. When the correct password was entered, the relay responded to the controller command and enabled the required circuit operation. The LCD provided visual status information, while the buzzer provided audible acknowledgement and alerts during password entry and incorrect authentication. The project setup demonstrated successful integration and operation of the hardware and software modules.

The security performance of the system was improved through incorrect-password handling and the three-attempt lockout feature. When an invalid password was entered, access to the circuit was denied and the relay remained in the inactive state. After three consecutive incorrect attempts, the system entered blocked mode, reducing the possibility of repeated password guessing. The prototype provides advantages such as automatic circuit operation, password-based access control, visual and audible alerts, low power consumption, and fast response. However, the system may be affected by weak or shared passwords, microcontroller failure, and loss of the control-system power supply. The absence of remote circuit-status information is another limitation; therefore, future integration of a GSM module can provide remote notification of the electrical equipment status.

CONCLUSION

The password-based circuit breaker provides an embedded access-control solution for improving the safety and security of electrical switching systems. The integration of the PIC16F877A microcontroller with a keypad, LCD, relay, buzzer, and LED indicators enables authorized users to control the circuit after successful password authentication. The implemented lockout mechanism further improves protection by restricting repeated incorrect password attempts. The source project reports successful design, integration, and testing of the prototype.

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