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Automated High-Current Short Circuit Test System for MCB

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Abstract:

The Automated High-Current Short-Circuit Test System for Miniature Circuit Breakers (MCBs) is designed to improve the safety, accuracy, and efficiency of circuit breaker testing. MCBs are important devices used to protect electrical systems from overload and short-circuit faults. The proposed system uses automation, IoT, and intelligent monitoring to test the performance of MCBs under high-current fault conditions. The system monitors voltage and current, automatically operates the MCB during testing, and records data for analysis. It also provides real-time monitoring and smart notifications to help detect possible faults and prevent equipment damage. This reduces manual effort and improves testing reliability.The system can be used in industries, testing laboratories, hospitals, data centers, and utility companies where reliable power protection is required. Overall, this solution improves testing efficiency, ensures safety, and supports the development of reliable electrical protection systems.

Keywords: Miniature Circuit Breaker (MCB), Short-Circuit Testing, High-Current Test System, Automation, Internet of Things (IoT), Fault Detection, Electrical Protection System.

1. Introduction

Electrical power systems require reliable protection devices to ensure the safety of equipment, infrastructure, and human life. Among these devices, Miniature Circuit Breakers (MCBs) play a vital role in protecting electrical circuits from overloads and short-circuit faults. MCBs automatically interrupt the flow of current when abnormal conditions occur, thereby preventing damage to electrical equipment and reducing the risk of fire hazards. Because of their importance in electrical protection, it is necessary to regularly test MCBs to verify their performance, reliability, and compliance with safety standards. Traditional methods used for testing MCBs often involve manual operation and conventional testing equipment, which may lead to measurement errors, safety risks, and time-consuming procedures. In addition, increasing demand for reliable power systems in industries, hospitals, data centers, and commercial buildings requires more advanced and efficient testing solutions. Therefore, the development of an automated testing system is essential to improve accuracy,

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reduce human intervention, and ensure consistent results. This project proposes an Automated High-Current Short-Circuit Test System for Miniature Circuit Breakers that integrates automation, intelligent monitoring, and modern sensing technologies. The system is designed to generate controlled high-current conditions to evaluate the tripping performance of MCBs. It continuously monitors voltage and current parameters, automatically operates the circuit breaker during test conditions, and records the results for analysis. By incorporating automated monitoring and data logging features, the proposed system improves testing efficiency, enhances operator safety, and ensures reliable evaluation of circuit breaker performance. The system can be applied in electrical testing laboratories, manufacturing industries, and power distribution networks where accurate and safe testing of protection devices is required.

2. Literature Review

Testing and evaluation of Miniature Circuit Breakers (MCBs) are essential to ensure the safety and reliability of electrical distribution systems. Several studies and testing systems have been developed to analyze the performance of circuit breakers under fault conditions such as overload and short circuits. Traditional testing methods generally use manual primary current injection systems to generate high current and observe the tripping characteristics of circuit breakers. Although these systems are widely used, they require skilled operators and may involve safety risks during high-current testing. Recent research focuses on improving circuit breaker testing through automation and digital monitoring. Modern testing equipment uses advanced sensors and control units to measure voltage, current, and tripping time accurately. Automated test systems help reduce human intervention and improve the consistency and repeatability of test results. Some studies also highlight the use of data acquisition systems to record electrical parameters and analyze the performance of protection devices. In addition, the integration of Internet of Things (IoT) technology has been explored in electrical monitoring systems to enable real-time data collection and remote monitoring.

Intelligent monitoring systems can detect abnormal conditions and provide alerts, improving system reliability and maintenance planning. Despite these advancements, many existing systems are expensive and complex, limiting their accessibility for smaller laboratories and industries. Therefore, there is a need for a cost-effective and automated high-current short-circuit testing system that ensures accurate measurements, improved safety, and efficient performance evaluation of Miniature Circuit Breakers.

3. Methodology

3.1 Problem Identification and Literature Study

The research begins with identifying the challenges involved in testing Miniature Circuit Breakers (MCBs), especially in high-current short-circuit conditions. Traditional testing methods often involve manual operation, which may lead to safety risks, inaccurate measurements, and longer testing time. A detailed literature review is conducted using research papers, technical reports, and international standards related to circuit breaker testing. This study helps in understanding the limitations of existing systems and highlights the need for an automated, accurate, and safe testing solution.

3.2 System Design and Development

Based on the analysis, the overall architecture of the automated testing system is designed. The system includes major components such as a high-current generation unit, voltage and current sensing devices, a control unit, and a monitoring interface. The design focuses on creating a stable current source capable of generating short-circuit conditions while maintaining measurement accuracy and operational safety. Proper insulation and protection mechanisms are also considered during the design stage.

3.3 Hardware Implementation

In this phase, the required hardware components are selected and assembled to build the prototype system. Components such as current sensors, voltage sensors, relays, switching devices, and microcontroller-based control units are integrated. These components work together to generate the required test current and measure the electrical parameters during the testing process.

3.4 Automation and Data Monitoring

The system is programmed to automate the testing process and reduce human intervention. During testing, voltage and current values are continuously monitored using sensors. The data are recorded and stored for analysis, allowing operators to observe the tripping behavior and performance of the MCB. Monitoring features help in identifying abnormal conditions and ensuring safe operation.

3.5 Testing and Performance Evaluation

The final stage involves testing the developed system under various simulated fault conditions. Different levels of current are applied to analyze the tripping characteristics of the MCB. The results obtained from the tests are compared with expected performance standards to evaluate the accuracy, reliability, and effectiveness of the proposed automated testing system.

4. Existing System

Currently, testing of Miniature Circuit Breakers (MCBs) is mainly carried out using conventional primary current injection testing systems and manual testing setups. In these systems, a high current is injected directly into the circuit breaker to simulate overload or short-circuit conditions and evaluate its tripping performance. The injected current allows engineers to measure parameters such as tripping time, current rating, and overall operational behavior of the breaker. One commonly used device is the primary injection test kit, which generates controlled high current using a transformer and supplies it to the circuit breaker under test.

This method helps verify whether the protection system operates correctly at the specified current level and time characteristics. However, existing systems have several limitations. Most testing setups require manual operation and skilled technicians, which increases the possibility of human error and safety risks during high-current testing. The equipment is often bulky, expensive, and time-consuming, making it difficult to use in small laboratories or industries. Additionally, many traditional systems lack advanced features such as automatic control, real-time monitoring, and remote data logging. Due to these limitations, there is a growing need for an automated and intelligent testing system that improves accuracy, reduces human intervention, and enhances safety while performing high-current short-circuit tests for MCBs.

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5. Proposed System

The proposed system is an Automated High-Current Short-Circuit Test System for Miniature Circuit Breakers (MCBs) developed to improve the efficiency, safety, and accuracy of circuit breaker testing. The main objective of the system is to simulate short-circuit conditions and evaluate the tripping performance of MCBs in a controlled and automated environment. Since MCBs are essential for protecting electrical circuits from overload and short-circuit faults, proper testing is necessary to ensure their reliability and performance.

The system is designed with several important components, including a high-current generation unit, voltage and current sensors, control unit, and monitoring system. The high-current generation unit produces the required current to create fault conditions during testing. Voltage and current sensors are used to continuously monitor electrical parameters throughout the testing process. These sensors provide accurate measurements that help in analyzing the behavior of the MCB during fault conditions.

A microcontroller or automated control unit manages the entire testing process. It automatically initiates the test, controls the current flow, and records important parameters such as tripping current and tripping time. The system also includes a data logging and monitoring feature, which stores the test results for future analysis and evaluation. In addition, the proposed system supports real-time monitoring and smart notifications, allowing operators to track the testing process and receive alerts if abnormal conditions occur. By automating the testing procedure, the system reduces manual effort, improves measurement accuracy, and enhances operator safety. This automated testing solution can be effectively used in electrical testing laboratories, industries, and power distribution systems where reliable circuit protection testing is required.

6. Block Diagram

The block diagram of the Automated High-Current Short-Circuit Test System for MCB represents the overall structure and operation of the system in Figure1. It consists of several important blocks such as the power supply unit, voltage and current sensing unit, signal conditioning circuit, microcontroller unit, fluctuation detection module, automatic MCB control, data logging and analysis system, and user notification module. Each block plays a significant role in the operation and monitoring of the circuit breaker testing process. The first block in the system is the power supply unit. This unit provides the required electrical power to all the components of the system. The main AC supply is converted into a suitable DC voltage using a transformer, rectifier, filter, and voltage regulator. This regulated voltage is necessary for operating the microcontroller, sensors, and other electronic components safely and efficiently. The signals from the sensors are passed through a signal conditioning circuit. This block ensures that the signals from the sensors are properly filtered, amplified, and adjusted to suitable levels for the microcontroller.

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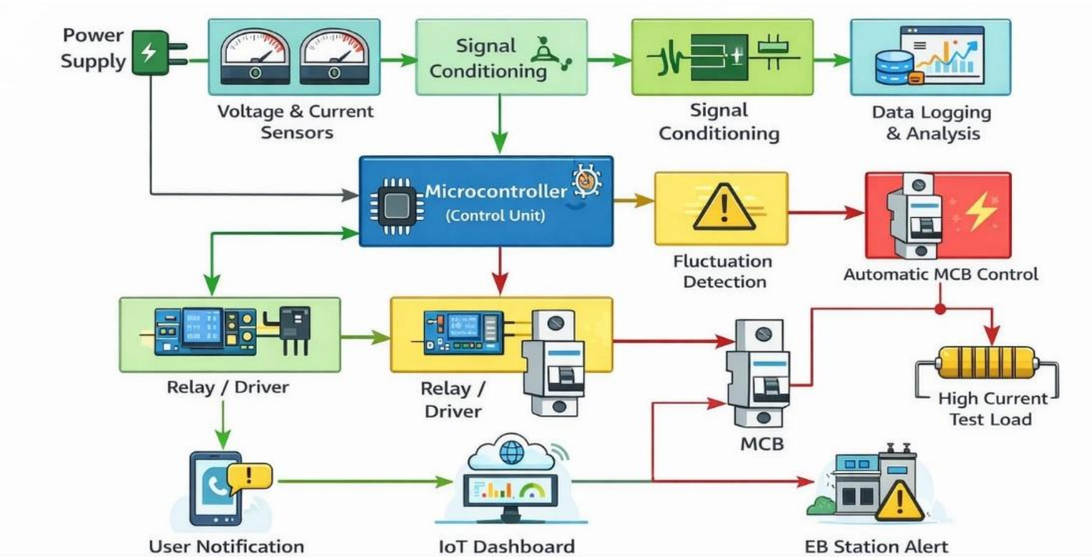

Figure 1: System Architecture

Signal conditioning improves accuracy and removes unwanted noise from the measured data. The microcontroller unit acts as the brain of the entire system. It receives input data from the voltage and current sensors, processes the information, and controls the operation of the system. The microcontroller analyzes the electrical parameters and identifies any fluctuations or fault conditions. Based on the analysis, it decides whether to initiate the testing process or activate protection mechanisms. Another important block is the fluctuation detection module. This module continuously checks for abnormal voltage or current variations in the circuit. If any unusual condition such as overcurrent or short circuit is detected, the system immediately responds to prevent damage to the equipment. The automatic MCB control block is responsible for operating the MCB during the testing process. Using relays or switching circuits controlled by the microcontroller, the system can simulate fault conditions by allowing high current to flow through the MCB. If the MCB is functioning properly, it will automatically trip and disconnect the circuit, thereby confirming its protective capability. The system also includes a data logging and analysis block. This unit records important parameters such as voltage levels, current values, and tripping time of the MCB. The collected data can be used for analyzing the performance and reliability of the circuit breaker. Proper data analysis helps in improving the design and maintenance of electrical protection systems. Finally, the user notification and monitoring block provides real-time information to the user.

The system can display the results through an LCD display or transmit them to an IoT dashboard. In addition, notifications can be sent through SMS or mobile applications to inform users or technicians about the testing status and any detected faults. Thus, the block diagram illustrates how different functional units work together to create an automated system for testing and monitoring the performance of miniature circuit breakers efficiently and accurately.

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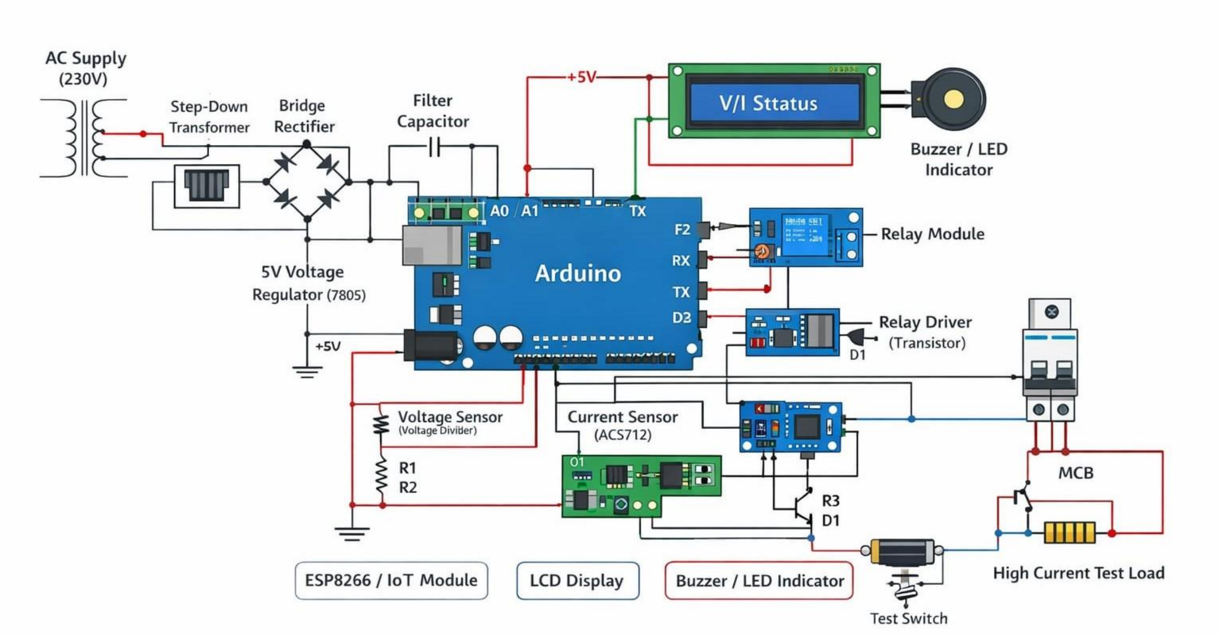

Figure 2: Circuit Diagram of Automated High-Current Short-Circuit Test System for MCB

7. Circuit Diagram

The circuit diagram of the Automated High-Current Short-Circuit Test System for MCB consists of several main components such as the power supply unit, microcontroller, sensors, relay driver circuit, and the MCB testing section in Figure 2. Initially, the 230V AC supply is converted into a lower DC voltage using a step-down transformer, rectifier, filter capacitor, and voltage regulator to provide a stable power supply for the electronic components. The voltage and current sensors are connected to the circuit to continuously measure the electrical parameters. These sensors send the measured signals to the microcontroller, which acts as the main control unit of the system. The microcontroller processes the data and detects any abnormal conditions such as overload or short circuit. Based on this analysis, the microcontroller controls the relay driver circuit to activate the testing process. When the relay is switched on, a controlled high current flows through the MCB and the test load to simulate a short-circuit condition. If the current exceeds the safe limit, the MCB automatically trips to protect the circuit. The system records and displays the test results, ensuring accurate and efficient testing of the circuit breaker.

8. Result And Discussion

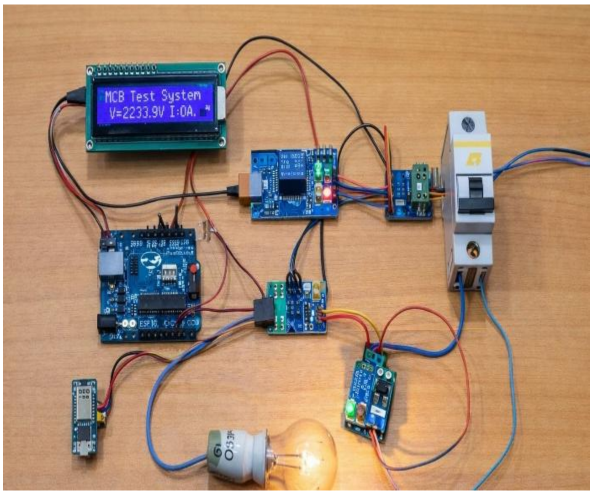

Figure 3: Hardware Implementation

The Automated High-Current Short-Circuit Test System for MCB was successfully designed and evaluated to analyze the performance of miniature circuit breakers under fault conditions in Figure 3. The system was developed using sensors, a microcontroller, relay circuits, and monitoring modules to automate the testing process. During the operation, the voltage and current sensors continuously monitored the electrical parameters of the circuit and sent the measured data to the microcontroller for analysis. When the testing process was initiated, the system created a controlled high-current condition to simulate overload or short-circuit faults. The microcontroller compared the measured current values with predefined threshold limits. If the current exceeded the safe limit, the MCB automatically tripped and disconnected the circuit.

This confirmed the proper functioning of the circuit breaker in protecting the electrical system. The system was able to accurately detect the tripping condition and record the voltage, current, and trip status of the MCB. The results were displayed through the monitoring system, allowing the user to observe the testing process in real time. The automated system reduced manual effort and minimized the chances of human error during testing. In addition, the system demonstrated stable performance during repeated testing cycles and maintained accurate measurement of electrical parameters. The collected data helped in evaluating the reliability and response time of the MCB under different load conditions. This automated approach also improved testing efficiency and ensured safer operation compared to traditional manual testing methods. The developed system demonstrated reliable performance in monitoring electrical parameters and evaluating the protective capability of MCBs. It also ensured safer and faster testing compared to traditional manual testing methods. Overall, the proposed automated testing system proved to be an efficient solution for analyzing the reliability and performance of miniature circuit breakers used in electrical distribution systems.

9. Conclusion

The Automated High-Current Short-Circuit Test System for MCB was successfully designed to improve the testing process of miniature circuit breakers in electrical systems. The system integrates sensors, a microcontroller, relay circuits, and monitoring modules to automate the detection and testing of fault conditions such as overload and short circuits. By continuously monitoring voltage and current values, the system is able to identify abnormal electrical conditions and initiate the testing process efficiently During the testing operation, a controlled high-current condition is created to simulate a short-circuit fault. If the current exceeds the specified limit, the MCB automatically trips and disconnects the circuit, thereby protecting the system from potential damage. The system records important parameters such as voltage, current, and tripping status, which helps in analyzing the performance and reliability of the circuit breaker. The results can be displayed through monitoring devices, allowing users to easily observe the testing process The implementation of automation in the testing system reduces the need for manual intervention and minimizes human error. It also improves the accuracy, safety, and efficiency of the testing procedure compared to traditional manual methods. The integration of monitoring and notification features further enhances the

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usability of the system by providing real-time information about the circuit condition.

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