



COMPARATIVE ANALYSIS OF FUSE, TYPE B, TYPE C, TYPE D MCBS, AND ELCB USING REAL-TIME MONITORING

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ABSTRACT :-

This project presents a comparative analysis of five electrical protection devices: Fuse, Type B MCB, Type C MCB, Type D MCB, and ELCB using a real-time monitoring system. The main objective is to compare their performance under different electrical fault conditions such as overload, short circuit, and earth leakage. The system continuously monitors important electrical parameters such as current and voltage and records the response of each protection device. The devices are evaluated based on their tripping characteristics, response time, and overall protection efficiency. A Fuse provides simple and economical protection, while different MCB types are suitable for different load characteristics. ELCB provides protection against earth-leakage faults. By comparing these devices under similar conditions, the project helps determine the most suitable protection device for residential, commercial, and industrial applications. This study aims to improve electrical safety, reduce equipment damage, provide reliable fault protection, and enhance the overall reliability of electrical systems.

Key Words: Fuse, MCB, ELCB,

INTRODUCTION :

Electrical protection devices are essential for protecting electrical circuits, equipment, wiring, and users from abnormal conditions such as overload, short circuit, and earth leakage. Different protection devices operate according to different characteristics and provide different levels of protection. In this project, a Fuse, Type B MCB, Type C MCB, Type D MCB, and ELCB are studied and compared under different operating and fault conditions. The main purpose is to understand their working principles, tripping behavior, response time, and protection performance. A real-time monitoring system is used to measure electrical parameters such as voltage, current, leakage current, and tripping response. The measured values are processed and displayed for easy observation and comparison. This practical analysis helps determine the advantages, limitations, and suitable applications of each protection device. The project provides a better understanding of electrical safety and reliable protection in residential, commercial, and industrial electrical systems.

HARDWARE :

Block diagram : Below is the given block diagram of the prototype design where AC supply is connected to protection devices, followed by sensing, data processing, and comparative analysis, with the results displayed on the LCD and indicated through alarm/LED .

BLOCK DIAGRAM

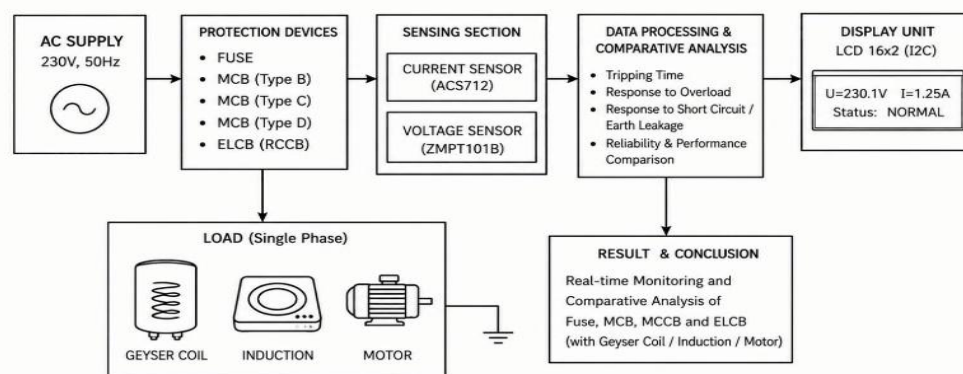


Figure: Block Diagram

Fuse: A fuse is a simple and widely used electrical protection device that protects an electrical circuit from excessive current. It contains a metallic element designed to melt when the current flowing through it exceeds its rated value. When an overload or short circuit occurs, the excessive current produces heat in the fuse element, causing it to melt and disconnect the circuit. In this project, the fuse is tested under different load conditions to study its protection performance and response behavior. Glass tube or HRC fuses with suitable ratings can be used in the experimental setup. The major advantage of a fuse is its simple construction, low cost, and reliable fault interruption. However, after operation, the fuse must be replaced before the circuit can be used again. The project compares the fuse with different types of MCBs and ELCB based on response time, protection characteristics, and performance under different fault conditions.

Type B MCB : A Type B Miniature Circuit Breaker (MCB) is an electrical protection device mainly used for circuits having relatively low inrush current. It provides protection against overload and short-circuit conditions by automatically disconnecting the supply when the current exceeds the permissible level. Type B MCBs are generally suitable for domestic circuits and applications such as lighting and resistive loads. In this project, the Type B MCB is tested under different load conditions to study its tripping behavior and response time. The measured electrical parameters are monitored using sensors and compared with the performance of Fuse, Type C MCB, Type D MCB, and ELCB. The Type B MCB has the advantage of being reusable because it can be reset after tripping instead of being replaced like a fuse. Its performance is analyzed to understand its suitability for low-inrush-current applications. The comparison helps determine how effectively Type B MCB provides protection under different fault conditions.

Type C MCB : A Type C Miniature Circuit Breaker is designed for electrical circuits where moderate inrush currents can occur during equipment operation. It provides protection against overload and short-circuit faults and is commonly suitable for commercial and light industrial applications. Examples include small motors and fluorescent lighting systems, where the starting current may be higher than the normal operating current. In this project, the Type C MCB is connected to the test circuit and its behavior is observed under different load and fault conditions. Voltage and current values are measured using suitable sensors and monitored in real time. The tripping response and protection performance of the Type C MCB are then compared with those of Type B and Type D MCBs, Fuse, and ELCB. This comparison helps identify the differences in operating characteristics among the protection devices. The study provides practical information about the suitability of Type C MCB for circuits containing loads with moderate starting or inrush current.

Type D MCB : A Type D Miniature Circuit Breaker is intended for circuits containing loads that can produce high inrush currents during starting. It is suitable for heavy industrial applications such as transformers, large induction motors, and welding equipment. The Type D MCB provides protection against overload and short-circuit conditions while allowing temporary high starting currents without unnecessary tripping. In this project, the Type D MCB is tested with suitable loads to analyze its tripping behavior, response time, and overall protection performance. The current and voltage are monitored using sensors, and the collected values are processed for comparative analysis. Its performance is compared with Type B and Type C MCBs, Fuse, and ELCB under different operating conditions. This comparison helps demonstrate how different MCB characteristics affect their suitability for various electrical loads. The study is useful for understanding why selecting the correct MCB type is important for achieving reliable protection without unwanted tripping in industrial circuits.

ELCB : An ELCB, represented in the project as an ELCB protection device, is used to provide protection against earth-leakage faults. Unlike conventional overload protection devices, its main function is to detect leakage or residual current and disconnect the circuit when the leakage exceeds the specified sensitivity. In the proposed project, an ELCB/RCCB with a suitable current rating and leakage sensitivity is tested under different conditions. The device monitors the difference between the currents flowing through the circuit conductors and trips when an abnormal leakage current is detected. This helps reduce the risk of electric shock and provides additional protection against earth faults. The performance of the ELCB is compared with Fuse and Type B, C, and D MCBs. The project focuses on parameters such as tripping response, leakage current, and overall protection behavior. This practical comparison helps explain the different roles of overcurrent protection and earth-leakage protection in an electrical installation.

ACS712 Current Sensor : The ACS712 is a current sensor module used in the project to measure the electrical current flowing through the test circuit. It can measure AC as well as DC current and provides an analog output that can be processed by a microcontroller. In the proposed system, the sensor continuously monitors the current flowing through the selected protection device and load. The measured current information is useful for identifying normal operating conditions, overload conditions, and changes occurring during fault events. The sensor output is supplied to the monitoring system, where the electrical data can be processed and displayed. The project specifies an ACS712 module with a range of 0 to 30 A AC/DC and an output sensitivity of 66 mV/A. Real-time current measurement allows the performance of Fuse, Type B, Type C, Type D MCBs, and ELCB to be compared more effectively. The sensor therefore plays an important role in collecting electrical parameters required for experimental analysis.

ZMPT101B Voltage Sensor : The ZMPT101B is a voltage sensor module used to measure AC voltage safely in the proposed monitoring system. It provides an isolated and scaled signal that can be given to the microcontroller for measurement and analysis. In this project, the ZMPT101B is used to monitor the AC supply voltage during normal operation and different fault or load conditions. The measured voltage helps in observing voltage stability and identifying changes that may occur during testing. According to the project component details, the ZMPT101B module is designed for an input range of 0–250 V AC and provides an analog output suitable for monitoring. The voltage measurement is combined with current measurement from the ACS712 sensor to understand the electrical behavior of the circuit. The collected voltage data can be processed along with current, tripping time, and other parameters. This makes the voltage sensor an important part of the real-time monitoring and comparative analysis system.

Test Load Bank : The test load bank is used to create controlled electrical loading conditions for evaluating the performance of different protection devices. In this project, resistive and inductive loads can be used to draw controlled current from the supply. Examples include bulbs, heaters, and

small motors. The load is varied to simulate normal operating conditions as well as overload conditions. According to the project component details, the test load can be variable up to approximately 2 kW. During testing, the selected Fuse, MCB, or ELCB is connected with the load, and electrical parameters are measured using sensors. The response of each protection device is then recorded and compared. Using different types of loads is important because electrical devices may behave differently depending on the current characteristics and starting conditions. The load bank therefore provides a controlled environment for studying tripping behavior, response time, and protection performance under practical operating conditions.

Real-Time Monitoring System : The real-time monitoring system is the main feature that allows electrical parameters and protection-device behavior to be observed during testing. The system measures parameters such as voltage, current, leakage current, and tripping response. Sensors such as ACS712 and ZMPT101B provide electrical measurements to the monitoring section. These values can be processed and observed while different protection devices are operating under various load and fault conditions. Real-time monitoring makes it possible to identify changes in electrical parameters before and during a protection-device trip. The collected information can then be used for comparative analysis of Fuse, Type B, Type C, Type D MCBs, and ELCB. The system also helps record or display device status and trip events. This approach provides a practical method for understanding the actual behavior of protection devices instead of depending only on theoretical characteristics. The project therefore uses real-time monitoring to improve the accuracy and usefulness of the comparative study.

LCD Display : A 16×2 LCD with an I2C module is used as the local display unit in the proposed project. Its main purpose is to present important electrical and system information in an easy-to-read format. During testing, parameters such as current, voltage, protection-device status, and trip events can be displayed on the LCD. This provides immediate information to the operator without requiring a separate computer or monitoring screen. The I2C interface also helps reduce the number of microcontroller pins required for communication with the display. In the project, the LCD forms an important part of the real-time monitoring system because it allows measured values and device conditions to be observed directly. When a protection device operates during a fault or overload condition, the corresponding status can be shown on the display. This makes the experimental setup more user-friendly and helps in recording observations during comparative testing of the Fuse, MCBs, and ELCB.

Comparative Analysis : Comparative analysis is the main objective of this project. The performance of Fuse, Type B MCB, Type C MCB, Type D MCB, and ELCB is studied under different load and fault conditions. The comparison focuses on important parameters such as tripping characteristics, response time, overload protection, short-circuit protection, earth-leakage protection, and overall efficiency. Real-time monitoring is used to collect voltage, current, leakage current, and tripping-response information during the experiments. The collected data provides a practical basis for comparing the behavior of each protection device. Type B, C, a D MCBs have different operating characteristics and are therefore suitable for different types of loads. Similarly, an ELCB/RCCB focuses mainly on leakage-current protection, while a fuse provides sacrificial overcurrent protection. By analyzing these differences, the project aims to identify the most suitable protection device for particular electrical applications. The final comparison can support better protection-device selection for residential, commercial, and industrial systems.

Data Processing and Analysis : Data processing is used to convert the electrical measurements obtained from the sensors into useful information for comparison. During the experiment, voltage and current values are continuously measured, while the behavior of the protection device is observed during different load and fault conditions. The measured data can be used to calculate important electrical parameters such as current, power, and energy. The project specifies the relationships $I = V/R$, $P = VI$, and $E = Pt$ for parameter calculations. Tripping or response time is also considered for comparing the protection devices. After measurement, the values can be organized according to the tested device and operating condition. This allows the performance of Fuse, Type B, Type C, Type D MCBs, and ELCB to be evaluated systematically. Data processing therefore helps convert raw sensor measurements into meaningful results. The analysis provides a clear basis for determining differences in protection performance and response behavior.

Variable Autotransfor : A variable autotransformer is used in the experimental setup to provide an adjustable AC supply for controlled testing. According to the project component details, the autotransformer accepts a 230 V AC, 50 Hz input and provides an adjustable output from 0 to 270 V AC with a current capability of up to 10 A. The main purpose of using this component is to safely vary the supply voltage during experiments and create controlled electrical operating conditions. By adjusting the output voltage, different load conditions can be applied to the protection devices. This helps in studying their response and behavior without making uncontrolled changes to the supply. The variable autotransformer is particularly useful during testing because it allows gradual adjustment of electrical conditions. It forms part of the input and testing section of the project and supports controlled experimentation with the Fuse, Type B, Type C, Type D MCBs, and ELCB.

Overall Methodology : The methodology of the project consists of connecting and testing Fuse, Type B, Type C, Type D MCBs, and ELCB under different load and fault conditions. The electrical supply is connected to the selected protection device and then to the test load. Sensors are used to measure important parameters such as current and voltage. During the experiment, the protection device is subjected to controlled operating conditions and its response is observed. The sensing section provides measured electrical values to the monitoring and processing system. These values are displayed or recorded for further analysis. The tripping behavior and response time of each protection device are then compared. The project uses mathematical calculations such as current, power, energy, and response-time comparison to support the analysis. Finally, the collected results are used to determine the relative protection performance and suitable applications of each device. This hardware-based methodology combines practical testing with real-time monitoring for a systematic comparative study.

COMPONENTS :

Component Name	Specific Model / Part	Standard Specification	Ratings /	Function in the Project

AC POWER SUPPLY / VARIAC	Variable Autotransformer	Input: 230V AC, 50Hz; Output: 0–270V AC, 10A	Supplies adjustable AC voltage to safely simulate and control overload or short-circuit conditions during testing.
FUSE	Glass Tube / HRC Fuse	6A / 10A, 250V AC	Provides sacrificial thermal protection and breaks the circuit during an overload.
TYPE B MCB	Miniature Circuit Breaker	6A / 10A, 230V; Magnetic trip at $3-5 \times I_n$	Provides fast protection for domestic circuits with low inrush currents.
TYPE C MCB	Miniature Circuit Breaker	6A / 10A, 230V; Magnetic trip at $5-10 \times I_n$	Protects commercial and light-industrial circuits with moderate inrush currents.
TYPE D MCB	Miniature Circuit Breaker	6A / 10A, 230V; Magnetic trip at $10-20 \times I_n$	Handles heavy industrial loads with high inrush currents, such as motors and transformers.
ELCB	Earth Leakage Circuit Breaker	25A, 30mA sensitivity, 230V AC	Detects earth leakage current and trips the circuit to provide protection against electric shock.
CURRENT SENSOR	ACS712 Module	0–30A AC/DC; Output: 66mV/A	Measures the current flowing through the circuit and sends data to the microcontroller.
VOLTAGE SENSOR	ZMPT101B Module	Input: 0–250V AC; Output: Analog 0–5V	Steps down and measures AC mains voltage for monitoring voltage variations and faults.
LOCAL DISPLAY	16×2 LCD with I2C Module	Operating Voltage: 5V DC	Displays real-time current, voltage, device status, and trip-event information locally.
TEST LOAD BANK	Resistive / Inductive Load	Variable up to 2kW; bulbs, heaters, small motors	Provides controllable loads to test the thermal and magnetic tripping characteristics of each protective device.

Table of Tripping Behaviour :

Sr. No.	Protection Device	Voltage (V)	Current (A)	Tripping Time	Tripping Behaviour	Type of Load
1	Type B	225 V	17.0 A	5 s	Yes	Geyser coil
2	Type C	282 V	17.3 A	10 s	Yes	Induction / Geyser coil
3	Type D	243 V	Motor (1HP) Instant	Instant moment	Yes	Motor
4	ELCB	240 V	—	Instant moment	Yes	Created short circuited inside

RESULT:-

The comparative analysis of the **Fuse, Type B, Type C, Type D MCBs, and ELCB** was successfully carried out using real-time monitoring. The devices showed different tripping characteristics according to the type of fault and load. Type B, C, and D MCBs provided protection with different tripping responses, while the ELCB responded quickly to earth-leakage/short-circuit conditions. The experiment demonstrated that selecting the

appropriate protection device according to the load and fault condition is important for electrical safety and reliable operation.



CONCLUSION :

The project focuses on the comparative study of Fuse, Type B, Type C, Type D MCBs, and ELCB using a real-time monitoring system. Each protection device has different operating characteristics and is suitable for different electrical applications. The project measures electrical parameters such as voltage, current, leakage current, and tripping response under different load and fault conditions. Real-time monitoring provides useful information about the actual behavior of the protection devices during testing. The collected data can be used to compare response time, tripping characteristics, and protection performance. The study helps understand the differences between conventional fuse protection, different MCB characteristics, and earth-leakage protection provided by ELCB/RCCB. Based on the comparative results, the most suitable protection device can be identified according to the application and load requirements. Overall, the project aims to improve understanding of electrical protection and support safer and more reliable electrical systems.

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