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Ultra Fast Circuit Breaker

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Abstract:- Ensuring the longevity and safety of electronic devices is crucial in the field of electrical engineering. Since they run on extremely low voltage, electronic devices—which are widely used in both home and commercial settings—are vulnerable to a number of risks, including overloading, short circuiting, and surging. It is therefore essential to put in place strong preventative measures in order to guard against future harm and guarantee continuous functioning. The design and construction of an Ultra Fast Circuit Breaker (UFCB) intended specifically for home and industrial use are presented in this study. The UFCB is designed to reduce the hazards associated with electrical problems by offering quick and dependable protection against voltage surges, overcurrent situations, and short circuits. Careful attention to detail was required during the design and execution phases of the UFCB's development. The UFCB achieves unmatched levels of reactivity and efficiency in halting electrical currents when abnormal conditions are recognized by utilizing state-of-the-art electronic components and technologies. The UFCB's strong design to resist challenging working conditions, high sensitivity to fault conditions, and ultra-fast tripping capabilities are some of its key features. Moreover, the UFCB has advanced diagnostics and monitoring features that allow proactive defect identification and real-time status updates. The implementation of the UFCB presents numerous advantages for industries and consumers alike. Economically, it lessens the possibility of expensive equipment damage and downtime due to electrical malfunctions, which results in significant cost savings on repairs and replacements. Furthermore, by reducing the amount of time needed for troubleshooting and system restoration, the UFCB improves operational efficiency, which raises productivity and overall competitiveness.

Keywords:- *Choke Resistor, Optocoupler, Relay, Overload, and Over-Current Protection in an Ultrafast Circuit Breaker.*

I. INTRODUCTION

Fuse use, which is often connected to the extension power supply or at the end of the appliance's socket, is a common way to safeguard electrical, mechanical, and other types of energy equipment from overload or short circuit of voltage in an electrical circuit. Regarding the progress of appliance safety, bimetallic strips are utilized to improve circuit breakage, and circuit breakers and surge protectors are employed to properly safeguard the appliances. Industries use electric circuit breakers in a variety of sizes based on the needs.

One of the most significant energy sources in the world, electricity has been used for millennia and will continue to be used for a very long time until other energy sources are produced. Around the world, people use it for their own personal enjoyment, businesses use it to run their machinery, homes and workplaces use it to power appliances and electronic devices, and most significantly, it is utilized in energy conversion. Most industrial electrically driven machines won't run or function at all without electricity. An element that has impeded and ruined the majority of our appliances

Energy must be managed and preserved in order to be used whenever feasible. It is necessary for electrical energy to always be accessible for usage. In most developing nations (particularly Nigeria), the distribution of power and equality have been hampered by a lack of effective, high-quality control and conservation measures.

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A. Historical Background of Circuit Breaker

The circuit breaker was created more than a century ago. Thomas Edison originally characterized it as a fuse used in his commercial power distribution in 1900. The circuit breaker was first created to guard against overload and short circuits in the lighting circuit wiring (Isreal, 1986). The development of general technology coincided with the advancement of circuit breaker technology. Its advancements include the contemporary micro circuit breakers that resemble those in use today. Brown and Boveri received a patent for it more than ninety years ago (1924). As time went on, technological breakthroughs produced the need for a variety of new types. For example, Stotz invented the thermal magnetic breaker, which is still in use today. The development of circuit breaker technology has led to its shrinking, which has made devices with both basic and complicated electrical circuits, appliances, and electronic designs easily portable and compact in order to meet the necessary requirements for electronics compactness. Household power would not be feasible without circuit breakers (or fuses, as an alternative) due to the risk of fires and other chaos caused by basic wiring issues and device malfunctions (Harris, 2015). An electrical circuit breaker is a device that detects an overload and short circuit state before cutting the circuit to safeguard the system or circuit from damage or breakdown, according to Mohankumar (2013). According to D. Mohankumar (2013), this circuit is perfect for safeguarding continuous power supplies like inverters. Circuit breakers come in a range of sizes, from tiny protectors for single home appliances to massive switch gear for high- voltage circuits. Both D.C. and A.C. current fault interruption is accomplished by them .As stated by Santoso (2012), "Solid state switches, electromechanical circuit breakers (EMCBs), and their combination in DC systems are used in existing and planned ways for halting DC fault current.

B. Ultra Fast Electrical Circuit Breaker

A major advancement in circuit protection technology is the Ultra Fast Circuit Breaker (UFCB). The UFCB uses a more advanced method than traditional circuit breakers, like the tiny circuit breaker, which relies on the thermal characteristics of a bimetallic strip to trip off in the event of overloads or short circuits. The UFCB achieves ultra-fast tripping by utilizing advanced components such as comparators, microcontrollers, and customized series elements, rather than depending exclusively on temperature-based. Comparators, which allow for accurate monitoring and comparison of electrical properties inside the circuit, are essential to the UFCB's operation. These comparators allow for quick decisions about circuit interruption by continuously assessing the electrical conditions and comparing them to predetermined criteria.

The UFCB also includes series components that are tailored to the particular needs of the appliances or circuits it protects. These series components are carefully chosen and set up to maximize compatibility and performance, significantly boosting the UFCB's dependability and efficacy in a range of applications. Because of its customized approach to circuit protection, the UFCB is a favored option for both residential and commercial installations, ensuring exceptional performance in a variety of settings.

II. METHODOLOGY

The methods involves are summarized in the block diagram of figure 1.

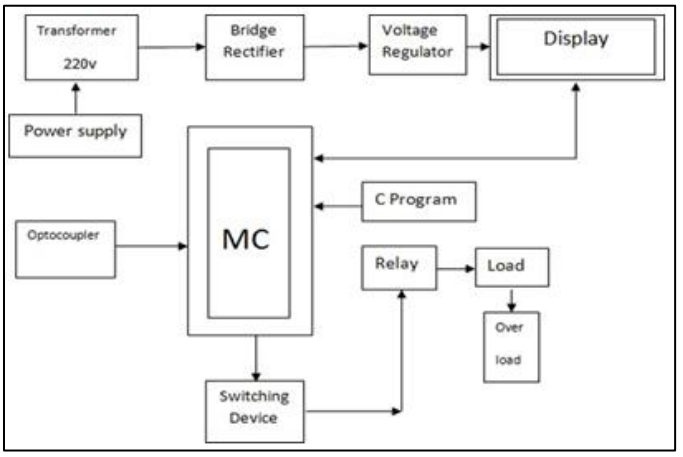

Fig 1: Block diagram of the operation processes and design methods of the UCB

The following are the five main sections of the Ultra Fast Circuit Breaker:

- Section for Power Supply;
- Comparator;
- Microcontroller;
- Relay Tripping;
- Output Section

The microcontroller and opto-coupler are connected to the voltage regulator, bridge rectifiers, 2200µF and 470µF capacitors, 220/12V transformers, and 500mA transformers. These components are utilized to monitor and control the circuit status at no load, load, and over load. One end of the load is linked to the relay, while the other end travels down the life wire (supply) to the comparator circuit. The 220/12V, 300mA transformer powers the circuit, and after that, the voltage regulator, bridge rectifier, and optocoupler provide the required 5V to the microcontroller and optocoupler. Additionally, the LCD is powered by 5V, and the contrast and backlighting are adjusted. using a variable resistor in the pin-1–3 range. The LCD shows system information and indicates when the system is prepared to be loaded.

As soon as a single 60W light is loaded, the LCD indicates "normal loading" for the UFCB. Here, the system functions as intended up until the addition of the second 60-watt lamp. The microcontroller receives a signal from the optocoupler. The buzzer is instantaneously activated when the microcontroller, in less than a second, sends an electrical signal to the relay, actuating the trigger from usually closed to normally open. The two lamps are turned off by the system, and an overload condition is shown on the LCD. The circuit was put through the following tests in order to evaluate its overall performance following the application of a clear plastic casing:

- Initial startup and No-Load test
- Test of load
- The overload test

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III. RESULTS AND DISCUSSION

In reaction to overcurrent or overload situations, the tripping circuit, when combined with a timed relay circuit managed by a microcontroller, showed remarkable performance in turning the system loads on and off. The timed relay circuit efficiently started the required shutdown procedure to shield the system from possible damage brought on by electrical faults in just 1µ seconds, which is a phenomenal response time. Furthermore, the addition of a buzzer alert guaranteed timely attention to the tripping process by offering a dependable indication of overload conditions. The reset switch made it easier to reconnect individual loads after the overload was fixed. The tripping mechanism quickly detached the system loads. The tripping circuit is efficient and user-friendly, as measured outcomes confirmed the system's functionality even more. 220V (A.C.) power was used, together with a 4.7 ohm choke resistor. The voltage of the microcontroller was 4.93V when it was tested between VCC and GND, suggesting stable operation within the intended range. In a similar vein, the LCD voltage, which was recorded between pin VCC and GND, was steady at 4.91V, confirming the display module's stable power supply. Additionally, voltage readings of the lamps showed that lamp 1 was 2.13V and lamp 2 was 3.15V, with a 1.03V voltage differential between them. These measurements show that the associated loads are receiving electricity in an appropriate manner, guaranteeing balanced system performance. Notably, it was found that the system's tripping time and subsequent shutdown in reaction to overcurrent situations happened in about Finally, the thorough analysis of the tripping circuit produced positive findings, confirming its efficacy in protecting against overload and overcurrent situations. Its accurate control, quick reaction times, and trustworthy indication methods highlight the system's dependability and efficiency, making it an invaluable tool for maintaining the longevity and integrity of electrical systems in a variety of applications.

IV. CONCLUSIONS

To sum up, the investigation into different kinds of circuit breakers has highlighted the exceptional advantages provided by the Ultra Fast Circuit Breaker (UFCB) as compared to other varieties. The UFCB is unique in that it protects electrical systems and electronic equipment better than fuses, low voltage circuit breakers, medium voltage circuit breakers, micro circuit breakers, oil circuit breakers, and other types of breakers. With the help of advanced parts like comparators and microcontrollers, the UFCB's fast tripping mechanism protects delicate equipment from damage by responding quickly to overload and overcurrent situations. Compared to traditional circuit breakers, which may have longer reaction times and less accuracy in fault identification, this incredibly quick response time is a big benefit. Furthermore, the UFCB's dependability and adaptability make it a priceless asset in a variety of contexts, including homes, workplaces, and industrial settings where a steady source of power is essential. The UFCB improves the stability and efficiency of electrical systems, which leads to increased production and operational continuity. It does this by offering strong protection against electrical disturbances. Moreover, a larger percentage of loads can be placed on higher-rated generators thanks to the UFCB's interoperability with them, which maximizes resource efficiency and increases the capacity of electrical infrastructure. Because of its scalability, the UFCB can adjust to changing power needs and meet the rising demands of contemporary applications.

Essentially, the UFCB is a circuit protection technological revolution that provides unparalleled dependability, effectiveness, and adaptability. With electronics continuing to spur innovation in electrical engineering, the UFCB is well- positioned to be a key player in maintaining the robustness and integrity of electrical systems in a variety of contexts. It is a mainstay of the contemporary electrical infrastructure, ready to fulfill the changing demands of society for many years to come thanks to its extensive applicability and track record of reliability.

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