Transformer Safety Device

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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, over current 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. Here when there is over load then supply of over load is automatically cut.

Keywords: **Current sensor module, Overload, Arduino Uno, 2*16 LCD, relay, switch**

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.

For this, a battery-operated vehicle is made using a gear motor. A coil is placed on the vehicle to convert electromagnetic waves into electrical energy. A bridge rectifier circuit is used to convert AC signals into DC signals, and this DC signal is fed to the battery for charging. On the road, an optics module is used to detect the vehicle. A coil is used to transmit electromagnetic waves obtained from the electronic circuit. Arduino Uno is used to interface the battery with a 2*16 LCD. A software program is installed in Arduino Uno, enabling the charging voltage to be displayed on the LCD. In this system, there is no wire connection between the power transmitter and receiver system.

II. LITERATURE REVIEW

Transformers are critical components in electrical power systems, and their protection from overload conditions is essential to ensure operational reliability and prevent equipment failure. Overload conditions can lead to excessive heating, insulation breakdown, and ultimately transformer failure. Therefore, researchers and engineers have focused on developing safety devices and systems capable of detecting and responding to overloads effectively.

Traditional protection methods such as fuses, circuit breakers, and thermal relays have been widely used. These devices are typically simple and low-cost, but they often lack precision and adaptability.

Fuses and circuit breakers can disconnect the transformer from the load during overcurrent situations, but they may not respond quickly enough to transient or evolving overloads. Similarly, thermal relays can offer protection by responding to temperature changes, but they usually operate with a time delay and do not provide real-time monitoring capabilities.

To overcome the limitations of conventional protection techniques, modern transformer safety systems have increasingly adopted microcontroller-based solutions. Microcontrollers such as Arduino, PIC, and ARM are used to continuously monitor current and temperature parameters through sensors like current transformers (CTs) and thermistors. These systems can provide more accurate detection of overload conditions and enable automatic disconnection of the transformer via relay modules when critical thresholds are exceeded. Recent literature highlights the use of digital displays (LCDs), data logging, and user alerts as part of integrated protection solutions.

For instance, Patel et al. presented a microcontroller-based transformer protection system that continuously monitored load current and initiated shutdown during overloads. Similarly, IoT-based systems have been explored to enable remote monitoring and control, allowing users to track transformer conditions and receive real-time alerts. These advancements enhance operational safety and facilitate predictive maintenance.

In addition to microcontroller and IoT approaches, research has explored the application of artificial intelligence for transformer overload prediction. algorithms can analyze historical load and temperature data to forecast potential overload scenarios, allowing preemptive corrective actions. Although still emerging, based systems represent a promising direction for future transformer protection technologies.

Overall, the trend in literature points toward the development of intelligent, automated, and connected transformer safety devices that provide faster, more accurate, and more reliable overload protection than traditional methods.

III. OBJECTIVES

With increasing electricity demands, transformers are under constant pressure, making preventive protection more important than ever. Studies indicate that a significant percentage of transformer failures are linked to overloading, highlighting the urgent need for intelligent safety mechanisms. In high-demand areas, such as urban power grids, manufacturing industries, and agricultural operations, a single transformer failure can disrupt an entire system, leading to: 1. Financial losses due to equipment damage and production halts. 2. Increased operational risks for industries dependent on stable power supply. 3. Frequent power outages, affecting thousands of consumers. 4. Higher maintenance costs due to repeated transformer failures.

IV. PROBLEM STATEMENT

The current dependence of electric vehicles (EVs) on wired charging infrastructure presents significant limitations, hindering their widespread adoption. These limitations include limited charging availability, long charging times, and the inconvenience of physically connecting a charging cable. Wireless power transfer (WPT) technology offers a promising solution to these challenges by enabling EVs to be charged automatically and seamlessly while parked or even in motion. However, further research and development are needed to

overcome technical challenges such as efficiency losses, safety concerns, and cost reduction to make WPT systems universally available and economically viable for mass EV adoption. By addressing these challenges, WPT can revolutionize the EV industry, leading to a more convenient, efficient, and sustainable transportation future.
By implementing automated transformer protection, power systems can be made more resilient, cost-efficient, and future-ready.

V. PROPOSED SYSTEMS

The controller gathers the necessary parameters using a variety of sensors. For any technical processes, the processing unit's digital LCD module display shows relevant parameter data at the industries. The controller detects an overload condition and excessive current flowing through the internal windings, which could cause the associated unit to malfunction. In a similar manner, the Arduino Uno microcontroller is configured to continuously monitor the transformer and update the settings at a predetermined period. Through the ADC transmitter attached to the Arduino controller unit, the parameter values sensed by the Arduino-Uno microcontroller at specific intervals are sent. The relay uses the current supply for opening or closing switch contacts. Usually, this can be done through a coil to magnetize the switch contacts & drags them jointly once activated. A spring drives them separately once the coil is not strengthened.

By using this system, there are mainly two benefits, the first one is, the required current for activating the relay is less as compared to the current used by relay contacts for switching. The other benefit is, both the contacts & the coil are isolated galvanically, which means there is no electrical connection among them.

VI. METHODOLOGY

Identify Safety Parameters:
Determine which parameters you need to monitor for transformer safety. This typically includes temperature, current, and possibly voltage.
Select Sensors:
Choose appropriate sensors to measure the identified parameters. For temperature, you might use a thermo couple or a temperature sensor like the DS18B20. For current measurement, you might use a current sensor like the ACS712. Voltage can be measured using a voltage divider circuit.

Arduino Setup:
Set up your Arduino board. Connect the sensors to the appropriate pins on the Arduino. Ensure you have proper power and ground connections. Arduino Uno AT328 is used for work as a digital controller. Arduino UnoAT328 is an AVR based upon microcontroller board.

In This system one of the C language the microcontroller will used to perform operation, it has to the original program code signal converted into a hexadecimal format. During this process some errors and warnings may occurs. If there are no errors and warnings are occurred then run the program, the system will performs all the given tasks and behaves as per expected the software developed. If it is not behaves then whole procedure is repeated again.

Code Development:
Write the Arduino code to read data from the sensors and perform safety checks. This involves reading sensor values, comparing them to safe thresholds, and triggering actions if thresholds are exceeded. Ensure your code is efficient and properly commented for future reference. It has AT mega 328 microcontroller and other on board peripherals including 16 MHz crystal Programming is done using in C language.

Safety Logic:
Implement safety logic in your code. For example, if the temperature exceeds a certain threshold, you might activate a relay to disconnect power to the transformer. Similarly, if current or voltage exceeds safe limits, appropriate actions should be taken.

Testing and Calibration:
Test your setup extensively to ensure it works as expected. Calibrate your sensors if necessary to ensure accurate readings. Enclosure and Mounting: Once everything is working correctly, enclose the Arduino and related circuitry in a suitable enclosure. Ensure proper mounting within the transformer setup, considering factors like heat dissipation and accessibility for maintenance.

Monitoring and Maintenance:
Regularly monitor the system to ensure it continues to operate safely. Perform maintenance as necessary, such as recalibration of sensors or updating the code for improved functionality.

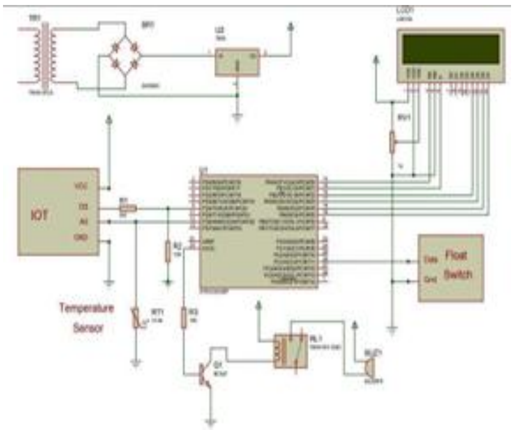

Figure 1: Circuit Diagram

VII. COMPONENTS

Arduino Uno:
Arduino uno is microcontroller based on ATMEGA-328P. it works with a mini-USB cable. It's a small sized one. operating voltage is 5V, with an input Voltage version of 7 to 12 V. It has 14 virtual pins, eight analog pins, 2 reset pins & 6 electricity pins.

Node MCU:
Node MCU is an open supply IoT platform. It includes wireless rewire which runs at the ESP866 Wi-Fi module SoC from Espressif device, and hardware that is based at the ESP-12 module. This is a single board microcontroller. The operating system is XTOS that is V3 and its primarily based-on ESP-12E. As Arduino.cc began developing new MCU boards based on non-AVR processors like the ARM/SAM MCU and used in the Arduino Due, they needed to modify the Arduino IDE so that it would be relatively easy to change the IDE to support alternate tool chains to allow Arduino C/C++ to be compiled down to these new processors. They did this with the introduction of the Board Manager and the SAM Core. A "core" is the collection of software components required by the Board Manager and the Arduino IDE to compile an Arduino C/C++ source file down to the target MCU's machine language.

Figure 2: Node MCU

Some creative ESP8266 enthusiasts have developed an Arduino core for the ESP8266 WiFi SoC that is available at the GitHub ESP8266 Core webpage.
This is what is popularly called the "ESP8266 Core for the Arduino IDE" and it has become one of the leading software development platforms for the various ESP8266 based modules and development boards, including NodeMCUs. For more information on all things ESP8266, check out the ESP8266 Community Forum on GitHu.

IOT Technology:
IoT is an interconnection of many physical gadgets with the help of the internet. The controlling and monitoring of any physical tool or parameters are viable with the help of IoT generation.

Temperature Sensor (NTC-10K):
NTC (Negative Temperature Coefficient) thermistor is a semiconductor crafted from metal oxides. It reveals an electrical resistance that has a very predictable exchange with temperature.
The resistance varies drastically with temperature, greater so than in popular resistors. they are extraordinarily sensitive to temperature change, very correct and interchangeable. they have an extensive temperature envelope and may be hermetically sealed to be used in humid environments.NTC (Negative temperature coefficient) thermistor is a semiconductor made from metallic oxides.

Figure 3: Temperature Sensor

It exhibits an electrical resistance that has a very predictable change with temperature. The resistance varies significantly with temperature, more so than in standard resistors. They are extremely sensitive to temperature change, very accurate and interchangeable. They have a wide temperature envelope and can be hermetically sealed for use in humid environments.

Oil Level Sensor:
The float transfer is a form of stage sensor, a tool used to come across the volume of oil inner a

transformer tank. The transfer is used as an indicator, an alarm, or to govern the oil stage of the transformer. wherein the switch detects the rising level of oil within the transformer tank and energizes an electrical pump which then pumps liquid out till the extent of the liquid has been substantially decreased, at which aspect the pump is switched off again. flow switches are often adjustable and might embody huge hysteresis. that is, the switch's "turn on" issue may be plenty higher than the "near off" element.

Voltage Regulator:

The voltage supply in a circuit might also have fluctuation and might no longer offer the constant voltage output. Voltage regulator (LM7805) is used to keep a constant out voltage of +5V.it's far a member of 78xx series of consistent linear voltage regulator ICs.

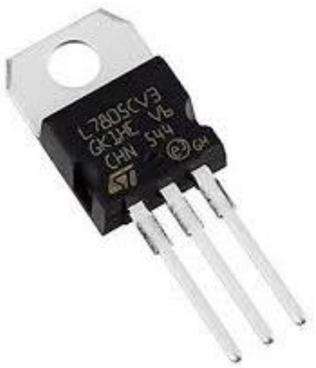

Figure 4: LM378

The voltage of +12 volt is carried out to the enter & it gives out +five volt of output which is the requirement of microcontroller, liquid crystal display and numerous distinctive gadgets used in the project.

Current Sensor Module:

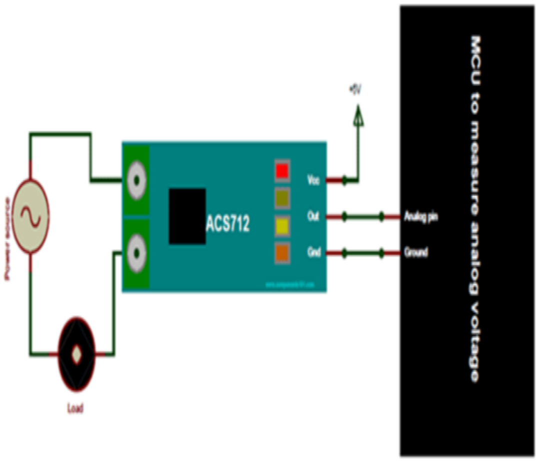

Figure 5: Current Sensor Module

The ACS712 Module uses the famous ACS712 IC to measure current using the Hall Effect principle. The module gets its name from the IC (ACS712) used in the module, so for you final products use the IC directly instead of the module. These ACS712 module can measure current AC or DC current ranging from +5A to -5A, +20A to -20A and +30A to -30A. You have to select the right range for your project since you have to trade off accuracy for higher range modules. This modules outputs Analog voltage (0-5V) based on the current flowing through the wire; hence it is very easy module to measure current using a microcontroller for you project, then this module might be the right choice for you.

VIII. MERITS AND DEMERITS

7.1 Merits

1. Transformer Protection:

Prevents damage to transformers by disconnecting the load during unsafe conditions (overload/underload).

2. Automatic Operation:

The system operates automatically without the need for manual intervention, improving reliability and safety.

3. Real-Time Monitoring:

Current sensors provide live monitoring, and the LCD displays current and system status for quick diagnostics.

4. Cost-Effective:

Uses affordable components like Arduino, relays, and current sensors, making it suitable for small-scale or educational applications.

5. Improves System Lifespan:

Reduces wear and tear on transformers by avoiding stress due to extreme load conditions.

6. Easy to Implement:

Simple circuit design with easily available components makes the system easy to assemble and maintain.

Demerits

1. Limited to Pre-Set Thresholds:

The system only works within predefined current limits and may not adapt to changing load conditions without reprogramming.

2. Sensor Accuracy Dependence:

The accuracy of overload/underload detection depends on the current sensor's precision and calibration.

3. No Voltage Monitoring:

This design monitors only current; it does not protect against voltage fluctuations or phase imbalances.

4. No Communication Capability:

Basic models lack remote communication (e.g., SMS, IoT) to alert users remotely in case of faults.

5. Relay Limitations:

Relays used may have current rating limits and are not suitable for high-power industrial transformers without proper isolation or contactors.

IX. CONCLUSION

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

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