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Design and Construction of Internet of Things Password-Based Circuit Breaker

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***Abstract* – The circuit breaker is an absolutely essential device in this modern time. It is one of the most convenient safety mechanisms used. Whenever electrical wirings in a building have an over current flowing through them, the circuit breaker interrupts the passage by shutting down the circuit, thereby preventing fire outbreaks and other casualties that occur as a result of over current. This project work focuses mainly on the domestic use of the circuit breaker. In this project, the circuit breaker is combined with password for protection, a microcontroller and an Internet of Things (IoT) Global System for Mobile-communication (GSM) module which enables It to interact (send or receive information) with another device via the internet and can also send a Short Message Service (SMS) to a receiver with the help of the GSM module. With this device, the safety of electrical installations is guaranteed, because the password of the circuit breaker installed on the power supply of the building is given to the inhabitants, who can control it physically by using the keypad or can control it remotely using the internet. The IoT-GSM module sends a text message to the phone numbers programmed into the microcontroller anytime the circuit breaker trips off.**

Keywords-Circuit breakers, Atmega328p-pu, GSM module, Internet of Things, Password, Keypad

I. INTRODUCTION

There has been a continuous rise in mobile computing and its applicable domains. People now want to control everything without moving an inch from home or place of comfort and this is made possible through embedded systems or the internet. Nowadays, electrical accidents occur at home, office and on different kinds of electrical installations [1]. This is why circuit breakers are used in different kinds of electrical installations. A circuit breaker is an automatically operated electrical switch, designed to protect an electrical circuit from damage caused by short circuit or overload [2]. Its basic function is to detect a fault condition and interrupt the flow of current [2][3]. The inclusion of circuit breakers in a electrical connection helps to secure the connection, and its components which in turn ensures the safety and wellbeing of the users of the electrical connection. A circuit breaker can be reset (either manually or automatically) to resume normal operation [2]. In order to enhance the security architecture of the circuit breaker, password is attached to it, which can be entered with the help of a keypad [4] or the interaction through the internet with the help of the SIM module and the inclusion of Internet of Things (IoT). Internet of Things (IoT) is a system of interrelated computing devices, mechanical and digital machines, objects or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interactions [5][6]. It is also the extension of internet connectivity into physical devices and everyday object. The inclusion of the internet to the password-based circuit breaker makes it more sophisticated and trustworthy to be used domestically and commercially [5][7][8].

This project provides a password-based circuit breaker system using Internet of Things. The IoT based circuit breaker is a system with high response time, which uses the interconnection network to control electrical loads. The main component used in the circuit is the microcontroller. The circuit also uses a wifi module which is paired with the Atmega328p-pu microcontroller [9] locally to connect to the internet. It is equipped with a liquid crystal display (LCD) [10], which shows the password as it is being keyed in and the working condition of the system (either ON or OFF). It also has a keypad used in keying in the password. The password which is entered is compared with the predefined password. If the entered password is correct, then the corresponding electrical line is turned ON or OFF.

The damage of components of a circuit and the electrical appliances in the home due to high voltage is alarming [11]. Some of these component's damage with great sounds that constitute noise pollution and some emit poisonous gases when they damage, which is also hazardous to the health of the people living around [11][12]. Thus, the effective mitigation of these accidents and hazards has led to the quest and demand for a circuit breaker and mostly a password-based circuit breaker that uses internet for effective operation and interaction.

Previous works have been done on adding passwords to circuit breaker constructions/installations [13]. However, these works have been limited by the fact that in order to control the circuit breaker through the password, the operator

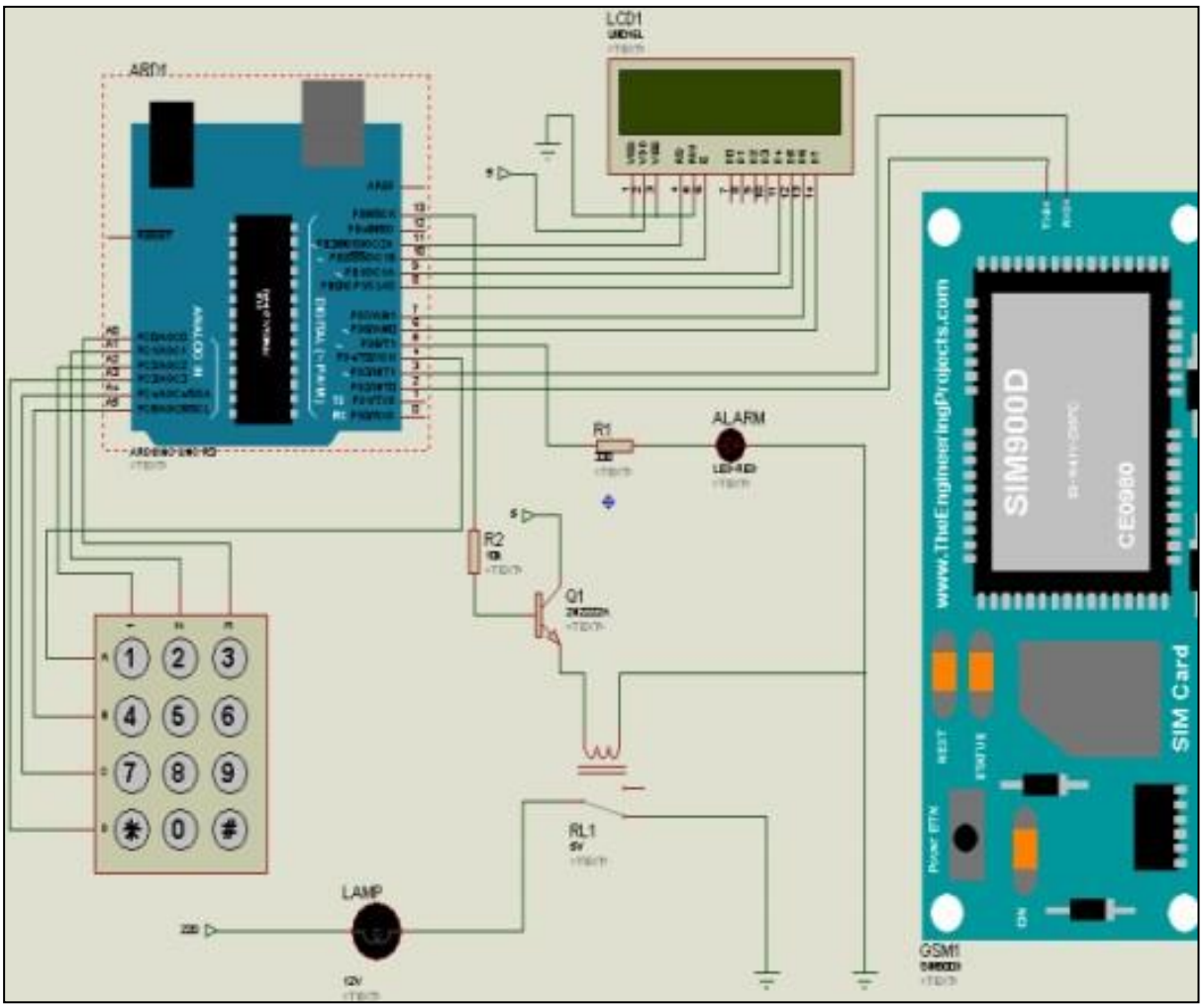
needs to be present and close in order to key in the password. This present work/project addresses this previous limitation by the inclusion of Internet of Things (IoT) to the already known/constructed password-based circuit breakers. The inclusion of the Internet of Things makes it possible for the operator to control the circuit breaker from anywhere in the world at convenience provided he/she can lay his/her hand on any device that can connect to the internet.

II. METHODOLOGY

This project makes use of components like: microcontroller (Atmega 328p-pu), relays, keypad, liquid crystal display (LCD) screen, buzzer, light emitting diode (LED), GSM module etc. These components are assembled as in the circuit diagram in Fig. 1 below to give the desired product.

The microcontroller serves as the brain of this circuit [14]. It coordinates the activities of the other components in order to achieve the desired objectives. The microcontroller compares the incoming power with the calibrated threshold of the circuit breaker. If there is an overload, it sends a signal to the relay (which acts as the switch) of the circuit breaker to automatically turn off. After the circuit is turned off, the microcontroller sends a signal to the GSM module and the GSM module with the help of the sim card sends an SMS to the phone numbers of the operators programmed into the microcontroller. When the circuit is turned off, the buzzer starts beeping and the LED starts blinking. All of these components are interconnected and mostly connected to the microcontroller to achieve the desired objective. The system is simulated using a Proteus simulation software [15]. Services like Multimedia Messaging Service (MMS), SMS service, Fax service etc. [16].

Figure 1. The system circuit diagram of the Internet of Things password-based circuit breaker.

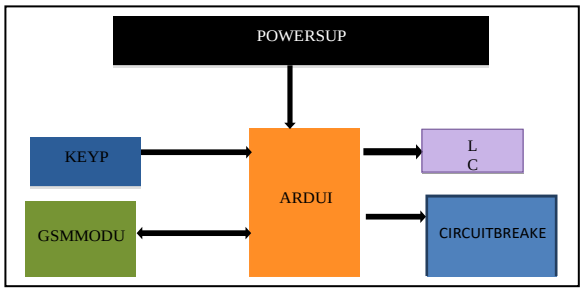


III. THEORY AND CALCULATION

In this work, a circuit breaker with voltage rating of 240Volts (V) and current rating of 30Amperes (A) was used. This circuit breaker has a threshold power detection sensitivity of 7200Watts, and has a functioning tolerance of – 2% to +2%. This means that it can carry a load within the range of 7056 – 7344Watts, which if exceeded the circuit breaker trips off and remains in the off state until being turned on manually by the physical or remote imputation of the password. The circuit breaker is calibrated in Watts which is also the unit of power. Atmega328p-pu, is used to perform processing and control operations. The micro-controller is connected to the other components as shown in Fig. 2. It does the comparison

operation. If the Atmega328p-pu determines that the incoming power is too high i.e. above 7344Watts, or too low i.e. below 7056Watts, it activates the circuit breaker to trip off and the GSM module to send an SMS. The Atmega328p-pu communicates with the GSM module using the Attention (AT) cellular command. AT command with a GSM/GPRS (General Packet Radio Service) MODEM or mobile phone can be used to access.

Figure 2. Circuit block diagram of the internet of things password-based circuit breaker showing the interconnection between the microcontroller and the other devices.



A. GSM Module

The GSM module or GPRS module as shown in Fig. 3 is a chip or circuit that will be used to establish communication between a mobile device or a computing machine and a GSM or GPRS system [17][18][19]. The phone numbers of the authorized personnel are programmed into the microcontroller. It functions with a voltage ranging from 3-3.9V. The GSM module is interfaced with the microcontroller through the AT cellular command. Each ATmega328p-pu microcontroller pin emits 5volts. As a result of the difference in voltage between the GSM module and the microcontroller, a limiting resistor is connected in series with a Zener diode to step down the 5V coming from the microcontroller to a maximum of 3.9V required to power a GSM module.

The Zener diode and the limiting resistor values can be gotten from the equation below;

$$R = (VS - VZ)/IZ \quad (1)$$

Where R = Limiting resistance

VS = Micro controller pin voltage

VZ = Voltage drop across Zener diode

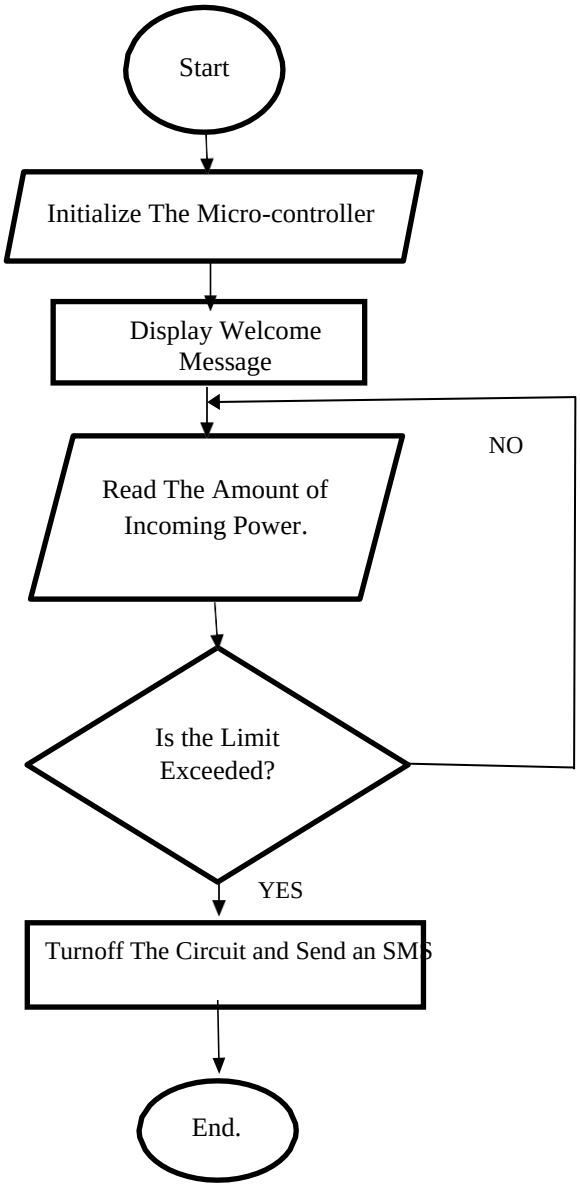
IZ = Current through Zener diode

Figure 3. SIM900A GSM module showing the pins for connection.

B. Circuit Breaker

There are various sizes and capacities of circuit breakers.

Figure 3. System Flow Chart.



The choice of each depends on the load it is to carry or the load at which it is meant to trip at. Nigeria's least voltage distribution is 240V and so can't use the same circuit breaker size as USA whose minimum voltage distribution is 120V [20]. In order to

know which circuit breaker to use, look for the amperage, voltage, frequency and temperature notation which are usually indicated on the breaker switch. The amperage, voltage and temperature notations for the low voltage lines are lower than that of the high voltage lines, but both can have the same frequency rating. For example, if a person wants to install a circuit breaker in a domestic building which uses 240Volts and 30Amperes, the circuit breaker to be used will be selected by multiplying the voltage and amperage and allowing a workability tolerance and detection sensitivity of –2% to +2% in order to get the correct power rating. Which is 240*30 = 7200Watts and considering the workability tolerance of –2% to +2%, it means that the circuit breaker can function effectively at a power range of 7056 to7344Watts, which If the power should go below or beyond, it will trip off.

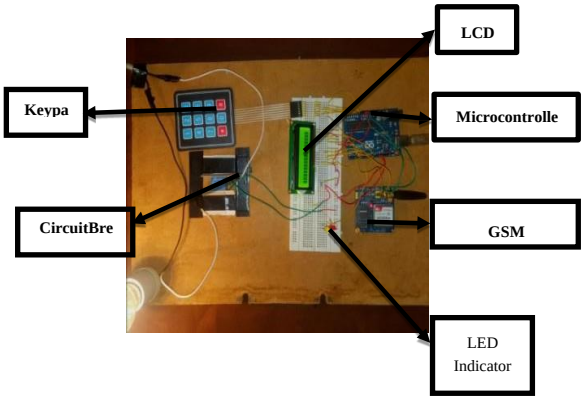
IV. System Implementation, Results And Discussions

The system is built on a small board as shown in Fig. 4 but can still be built into a small reinforced plastic box for portability. It has a power outlet which is to be used to connect it to the power source of the building and an LCD to display the password and working status (ON/OFF).

Figure 4: The practical circuit in normal condition.

An ideal amount of voltage (120– 240Volts) and current (20 – 30Amperes) is allowed into our residential homes. This amount should not be exceeded for effective functioning of the household connections and appliances. When this rate of power is exceeded, the micro controller signals the circuit breaker to trip off and the GSM module to send an SMS to the phone numbers programmed into the microcontroller. The circuit remains tripped off until it is manually turned on by the physical imputation of the password or by the remote imputation using the internet. The implementation of this circuit breaker in our homes helps to save our homes, electrical appliances and electrical installations from damages resulting from surges in power, short circuits and also makes it easy for the housekeeper to control his home from anywhere he is at his convenience with the help of the internet.

Figure 4. The practical circuit in normal condition.



Some tests were conducted in a residential building on different days and times. Some of the results are shown in Table1 below.

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Some tests were conducted in a residential building on different days and times. Some of the results are shown in Table I below.

TABLE I. RESULTS SHOWING THE ACCURACY OF THE INTERNET OF THINGS PASSWORD BASED CIRCUIT BREAKER IN DIFFERENT TEST CONDITIONS

Threshold Circuit Breaker Rating (W)	Measured Incoming/functional Power (W)	Is Incoming/functional Power Exceeded?	Date	Time
7200	7100	No	17/02/2021	11:00am
7200	7500	Yes	17/02/2021	5:00pm
7200	8200	Yes	25/02/2021	3:00pm
7200	7320	No	10/03/2021	9:00am

Table I above shows that in the residential building where the IoT password-based circuit breaker is connected, the days the circuit breaker tripped off were the days the incoming power exceeded or went below the threshold or allowable power of the circuit, and inversely the days it did not trip off were the days the incoming power did not exceed or go below the threshold or functional capacity of the circuit breaker.

The data shown in the table above were obtained manually by the home maintenance personnel with the help of a power meter.

CONCLUSION

This paper has highlighted the numerous benefits of using a circuit breaker with password protection and internet access in our homes. It has also pointed out the human, appliances and installations safety in its use. As a result, it has shown a methodology for the development of an Internet of Things Password Based Circuit Breaker. This system uses such major components as the GSM module, Atmega328p-pu and the circuit breaker in the design. It is capable of tripping off an electrical connection and sending a mobile text message. The main feature of this system is the immediate tripping of the line to protect electrical installations and to send an immediate text

while making some cautious sounds through the buzzer and a visible indication through the LED. Due to its accuracy, it is expected that a wide deployment of this system in residential homes will result in a marked reduction in fire outbreaks, electrical accidents and destruction of electrical gadgets. This in turn brings about the safety of life and properties which brings about huge economical savings, components as the GSM module, Atmega328p-pu and the circuit breaker in the design. It is capable of tripping off an electrical connection and sending a mobile text message. The main feature of this system is the immediate tripping of the line to protect electrical installations and to send an immediate text while making some cautious sounds through the buzzer and a visible indication through the LED. Due to its accuracy, it is expected that a wide deployment of this system in residential homes will result in a marked reduction in fire outbreaks, electrical accidents and destruction of electrical gadgets. This in turn brings about the safety of life and properties which brings about huge economical savings.

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