IOT BASED CIRCUIT BREAKER

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Abstract

Iot circuit breakers are brought into use due to the slow reaction time of conventional circuit breaker such as MCBs (miniature circuit breaker) to trip which causes fatal damage to property as well as human life. In a perfect world, it would be necessary to have a device that can quickly, preferably instantaneously turn off the power, especially for delicate and fragile electrical and electronic devices in case of a fault by interfacing with the web through a wifi module and a little PC called Atmega328p which can rapidly control and to continuously monitor the system

Keywords—*circuit breaker, IOT Arduino, ThingSpeaks*

I.Introduction

Modern electrical systems need circuit breakers because they protect and regulate the flow of electricity. They must function consistently because if they malfunction, the electrical system could sustain serious harm and suffer financial losses, injuries, or even fatalities. Due to the numerous mechanical and electrical components present, circuit breakers are stressed during operation. They have to deal with good or bad power and take part in techniques to prevent electrical arcs. Circuit breakers age with time and frequent use, which raises questions regarding their operational dependability

Preventive maintenance is frequently performed to ensure that circuit breakers operate dependably. The circuit breakers are turned off during this maintenance, and vital readings, including trip coil current, close coil current, and spring charging motor current, are taken using specialized diagnostic tools.

The operational mechanism, spring charging motor, fixed contact, moving contact, tripping coil, closure coil, and other components of the circuit breaker are also visually inspected and cleaned to make sure they are in good shape.

Even if the circuit breaker is in good condition, this method necessitates removing it from service, increasing the amount of downtime for the system. Additionally, using specialized diagnostic tools raises the expense of maintaining the circuit breakers the fact that circuit breakers control method is reliant on hardwired logic is another significant problem with them.

This limits the integration of Internet of Things (IoT) technologies and expands the control and metering cabinet of the circuit breaker. As a result, it becomes difficult to make the necessary adjustments to the circuit breaker's control circuit. Additionally, the absence of IoT technology hinders the capacity to quickly make educated judgments by preventing access to real-time data from the circuit breakers. Moreover, because IoT technology is not incorporated, accessing real-time data from the circuit breakers is not possible, which limits the ability to make informed decisions promptly.

Using proprietary solutions like Remote Terminal Units and SCADA (Supervisory Control and Data Acquisition) is one option to solve this problem. However, there are issues with these proprietary systems' cost-effectiveness and post-sale support. Additionally, because consumers cannot view the backend implementation of such proprietary systems, the security and dependability of crucial applications become concerning. Iran's experience with the dangerous computer worm "Stuxnet" has brought attention to the dangers of such closed networks. The programmable logic controllers (PLCs) used in industrial operations were the target of Stuxnet, which was identified in 2010. It targeted Siemens Step7 software and infected Windows-based systems. According to reports, Stuxnet infiltrated Iran's PLCs, gathered data, and broke centrifuges.

Stuxnet's design and architecture make it a potentially useful platform for attacking contemporary SCADA and PLC systems used in factories and power plants because they are not restricted to a particular industry. Stuxnet infected more than 200,000 computers and physically harmed 1,000 devices, severely harming Iran's nuclear centrifuges.

It's crucial to establish an open and user-controlled development environment in order to prevent such accidents. This would reduce the danger of cyberattacks and increase overall reliability by enabling better transparency, security, and control over crucial industrial systems.

In this paper, an open source Arduino Mega 2560 embedded microcontroller is used to construct a monitoring and control system for a standard circuit breaker. Ethernet Shield is also used to integrate the Internet of Things. Monitoring is done for characteristics related to circuit breakers, including load current, trip coil current, close coil current, spring charging motor current, number of closing operations, number of tripping operations, etc. The monitored data is posted to the "ThingSpeaks" Internet of Things platform so that circuit breaker data is instantly accessible for wise decision-making. Circuit breaker health is assessed using monitored criteria in order to guarantee its dependable performance and identify any maintenance or replacement requirements

The goal of this paper is to provide automated circuit breaker monitoring and control systems that instantly assess the mechanical and electrical health of a circuit breaker. As-needed maintenance is replacing time-based maintenance in the maintenance paradigm. The advantage of this change is that it keeps the circuit breakers performing as they should while cutting down on total maintenance expenses and unneeded downtime. Additionally, the usage of an open source platform removes any worries about the security and dependability of a safety-related or strategic application because the user has total access to and control over the implementation's complete source code.

II. BLOCK DIAGRAM

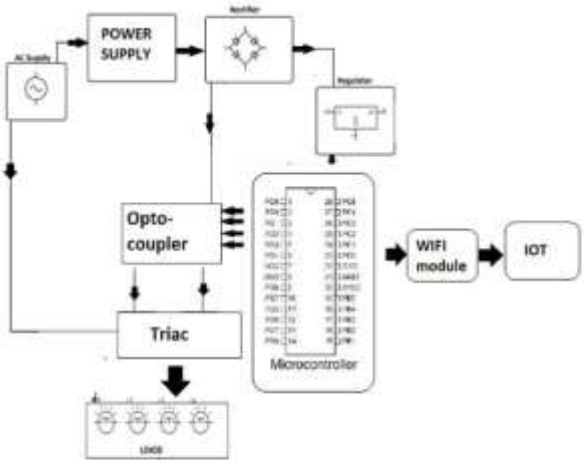


Fig 1: Block diagram of Iot circuit breaker

The block diagram of Iot C.B is shown in fig1. To connect to the internet, this system combines an Atmega328p microprocessor with a Wi-Fi module. Additionally, it contains an LCD screen that displays the status of every connected load in the system, including whether it is on or off. The system can be accessed remotely by a user or administrator using a web device and the "ThingSpeaks" network. They must enter a password in order to access the system for enhanced security. The user can control the linked loads' state (on or off) through the ThingSpeaks interface from any location in the world. This system has an advantage over other circuit breakers since it connects the administrator and loads through the faster internet. Additionally, it uses circuit-breaking technology based on semiconductors, which is quicker than relays and more successful at reducing industrial-setting accidental events like shocks caused by electricity.

III. COMPONENTS

S.NO	Components	Quantity
1	Microcontroller (eg.ESP32)	1
2	Wifi module(eg.ESP8266)	1
3	Relay	1-2
4	Transistors	2-4
5	Diodes	2-4
6	Resistors	5-10
7	Capacitors	5-10
8	Inductor\Transformer	1
9	Voltage regulator	1
10	LCD Display	1
11	Pushbuttons\switches	1-3
12	LEDs	3-5
13	PCB(printed circuit breaker)	1

a. ATMEGA

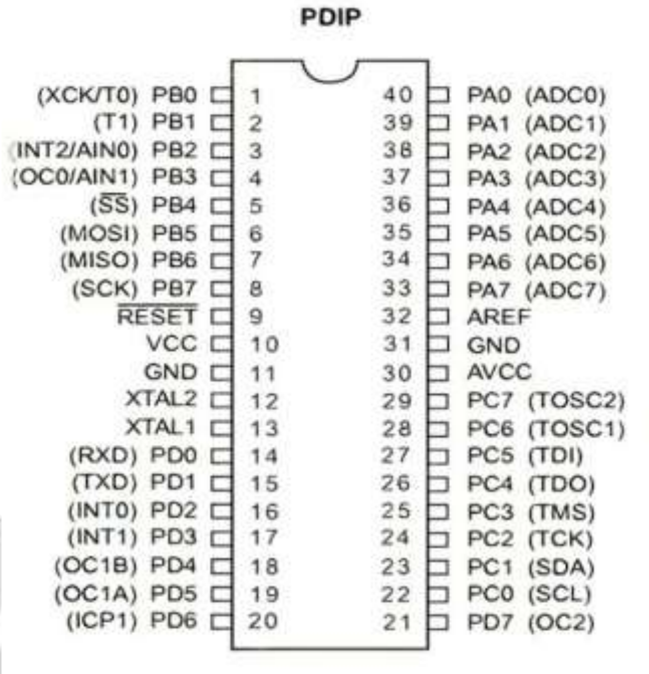


Fig2: The figure shown above is an Atmega

- Port A(PA7-PA0) : The analog inputs on Port A are used by the A/D converter. Along with that, it functions as an 8-bit bidirectional I/O port when the inbuilt A/D converter is not in use.
- Port B(PB7-PB0) and Port (PD7-PD0):These all are 8-bit bidirectional I/O ports . Their output buffers feature excellent source and sink capabilities and symmetrical drive characteristics. If the pull-up resistors are employed, these are pulled low and used as inputs. Additionally, it offers several unique ATmega32 functional characteristics.
- Port C(PC7-PC0): Port C also an 8-bit bidirectional I/O port . The pull-up resistors on pins PC2 (TCK), PC3 (TMS), and PC5 (TDI) will turn on if the Joint Test Action Group (JTAG) interface is engaged.
- Vcc : Atmega Input voltage supply GND : Ground terminal
- RESET : It is a RESET pin that is used to reset the ATmega32 microcontroller to its default setting. The RESET pin must be elevated for two machine rotations at the beginning of an application.
- XTAL1 : It serves as an input to both the operating circuit of the internal clock and the inverting oscillator amplifier and XTAL2:Inverting oscillator amplifier output.
- AVcc : It serves as the supply voltage pin for Port A and the A/D converter. It must be connected to the Vcc supply.
- AREF : For the analog to digital converter, AREF serves as the analog signal reference pin

b. Wifi module

Fig3: The figure shown above is of a wifi module

- In an Internet of Things-based circuit breaker project, the WiFi module functions as the circuit breaker's "internet connection." It enables wireless communication between the circuit breaker and a centralized control system. This system, which is frequently referred to as the "IoT platform," functions as a sizable brain that remotely maintains and controls numerous devices.
- The WiFi module enables the circuit breaker to wirelessly transmit vital information. The status of the circuit breaker, how much electricity it is consuming, and other significant facts are all included in this information. Since all of this data is transmitted in real-time to the IoT platform, it is constantly current.
- Even while you're not at home, you can use your phone or computer to check on the circuit breaker thanks to the WiFi module. This is comparable to being able to observe the performance of the circuit breaker from a distance.
- The WiFi module also enables communication between the circuit breaker and other smart home appliances. For instance, it can collaborate with smart lighting or thermostats to make your house even smarter and more effective.
- The WiFi module can warn the IoT platform if something goes wrong with the circuit breaker. Similar to a warning sign, this lets you know if a situation requires your attention.
- For the circuit breaker to be a member of the IoT, the WiFi module is necessary. It enables the circuit breaker to be a smart, networked device, which has a number of advantages like remote control, data analysis, and making your house smarter

c. LCD

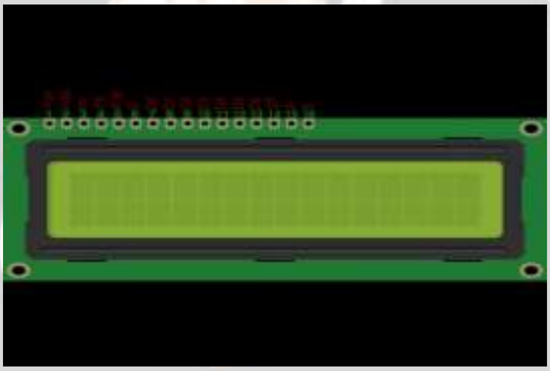


Fig4: The figure shown above is of a LCD

- The LCD display of an IoT-based circuit breaker functions as a miniature screen that displays vital data on the circuit breaker's operation. It serves as a local control panel and offers real-time notifications on topics such as how much electricity is being consumed and any other issues.
- Users can adjust the settings of the circuit breaker and view the current state of the device on the LCD display. Additionally, it issues alerts when something odd or problematic occurs.
- It is more convenient to use the circuit breaker without relying solely on remote control over the internet thanks to the LCD display, which enables users to directly interact with the device

d. Crystal oscillator

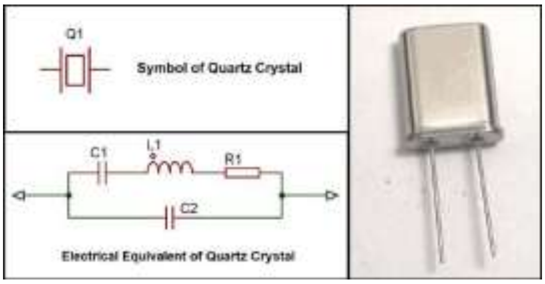


Fig5: The figure shown above is of a crystal oscilator

- The crystal oscillator functions as a little clock in an IoT-based circuit breaker to ensure that everything operates as intended.

- It keeps track of the time, ensuring that every component of the circuit breaker is aware of the precise time so that they can cooperate and perform without misunderstanding.
- When the circuit breaker communicates with other devices or the main IoT system, the crystal oscillator also aids in the accurate sending and receiving of information. It guarantees that messages are sent at the appropriate moment.
- The circuit breaker occasionally needs to wait a short period before acting. The crystal oscillator assists in precise measurement of these waiting durations. It aids in power management, increasing the circuit breaker's efficiency.
- The crystal oscillator serves as a reliable guide for other components of the circuit breaker, ensuring that everything remains steady and reliable.
- In simpler terms, the crystal oscillator acts as the circuit breakers timekeeper, making sure that everything takes place at the appropriate times and in the proper sequences to ensure that it operates smoothly and consistently
- They support and hold sensors, microcontrollers, and other electronic components on the board.

e. Transistors

Fig6: The figure shown above is of a Transistor

- In an IoT-based circuit breaker, transistors act as small switches and decision-makers. They manage the electrical current flow, turning it on and off as necessary. Transistors also assist in controlling the circuit's current flow, preventing overloads and short circuit
- They employ sensors to measure variables such as current, voltage, temperature, or humidity and ensure that the circuit breaker can comprehend and make use of this data. Transistors can also strengthen weak signals to enable correct processing by the circuit breaker.
- Transistors facilitate communication between the circuit breaker and various Iot platforms and other devices. They are essential to the circuit breaker's brain because they ensure that it follows directions and operates properly.
- In order to improve the energy efficiency of the circuit breaker and control its power consumption, transistors are also utilized in power electronics.
- The circuit breaker is intelligent and effective at protecting electrical systems thanks to the transistors that enable it to control power, make judgments, and communicate with the outside world.

f. PCB(Printed circuit breaker)

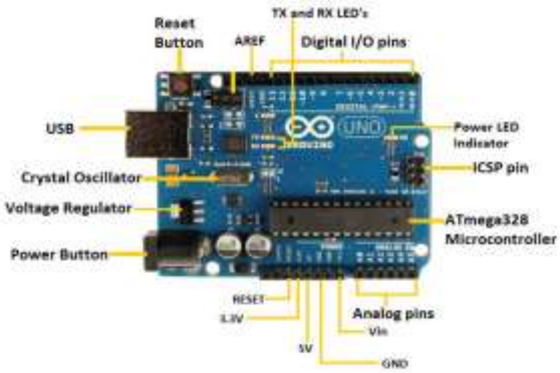


Fig7: The figure shown above is of a PCB

- They support and hold sensors, microcontrollers, and other electronic components on the board
- These components connect with one another through the pathways in PCBs

- PCBs helps in the circuit breakers organization and compactness
- They guarantee accurate and dependable data and power signal transmission.
- PCBs are made to be reliable and long-lasting for repeated use.
- They include WiFi and other communication components in the integration of the circuit breaker with the IoT system.
- PCBs can be modified to meet the unique requirements of the project.
- They improve the effectiveness and efficiency of the manufacturing process.
- Because they have a clear layout, PCBs make maintenance and troubleshooting simpler
- PCBs act as the IoT-based circuit breaker's backbone. They keep everything connected, hold everything together, and guarantee that everything functions properly

g. Regulator and Rectifier

- The rectifier and regulator are crucial components of an IoT-based circuit breaker for controlling the power supply.
- The rectifier changes the main supply's electrical power into the precise kind of electricity that the circuit breaker needs to function effectively.
- The regulator ensures that this power is maintained at a constant and secure level, eliminating any dangerous fluctuations that can damage the electronic components of the circuit breaker.
- In order for the circuit breaker to operate correctly and safely within the IoT system, the rectifier and regulator work together to make sure it receives a stable and dependable power supply.

h. Resistor

Fig8: The figure shown above is of a resistor

- A resistor is a passive two-terminal electrical component used in circuits to implement electrical resistance. Resistor use in electronic circuits includes lowering current flow, adjusting signal levels, dividing voltages, biasing active devices, and terminating transmission lines.

i. Capacitor

Fig9: The figure shown above is of a capacitor

- A two-terminal electrical device known as a capacitor is capable of storing energy in the form of an electric charge. It is made up of two electrical conductors that are spaced apart by a certain distance. The space maybe filled with vaccum or an insulating material called as a dielectric.

j. Relay

Fig10: The figure shown above is of a relay

- A relay is a switch that is activated electrically and is used to regulate the current flow in an electronic circuit. A low-power signal can control a high-power device by employing a tiny amount of current to control a greater current.
- Relays are frequently employed in electronic circuits for a number of functions, including switching high currents or voltages, supplying electrical isolation between two circuits, controlling event timing, and shielding delicate components from high voltages. Relays, for instance, can be used in a lighting circuit to control a light's on/off function or in a motor control circuit to turn the power to the motor on and off.

k. load

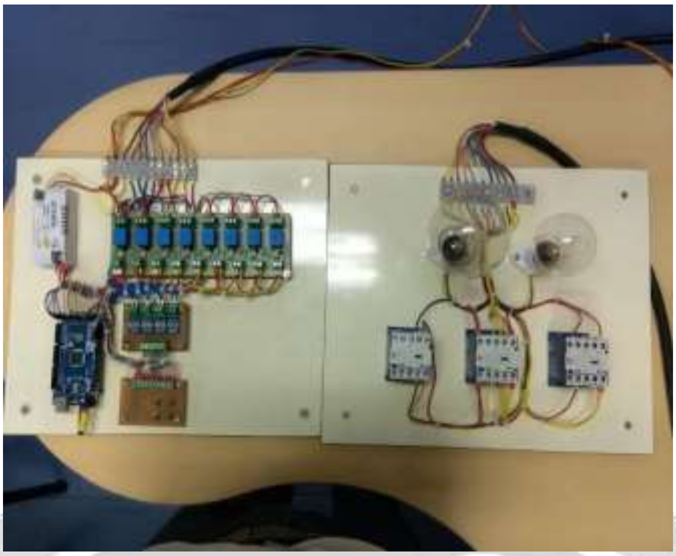
- To test the operation of the iot based circuit breaker a load is connect to the circuit. The load maybe a light or lights. The connected load is supplied by power through circuit breaker and the current flow, amount of load connected is displayed in LCD. Through ThingSpeak the control and maintenance of load is done.

IV. Code

```
#include "ThingSpeak.h"
#if defined(ARDUINO_ARCH_ESP8266) ||
defined(ARDUINO_ARCH_ESP32)
#error "EPS8266 and ESP32 are not compatible with
this example."
#endif
#if !defined(USE_WIFI101_SHIELD) &&
!defined(USE_ETHERNET_SHIELD) &&
!defined(ARDUINO_SAMD_MKR1000) &&
!defined(ARDUINO_AVR_YUN)
#error "Uncomment the #define for either
USE_WIFI101_SHIELD or USE_ETHERNET_SHIELD"
#endif
#if defined(ARDUINO_AVR_YUN)
#include "YunClient.h"
YunClient client;
#else
#if defined(USE_WIFI101_SHIELD) ||
defined(ARDUINO_SAMD_MKR1000)
// Use WiFi
#include <SPI.h>
#include <WiFi101.h>
char ssid[] = "<YOURNETWORK>"; // your
network SSID (name)
char pass[] = "<YOURPASSWORD>"; // your
network password
int status = WL_IDLE_STATUS;
WiFiClient client;
#elif defined(USE_ETHERNET_SHIELD)
// Use wired ethernet shield
#include <SPI.h>
```

```
#include <Ethernet.h>
byte mac[] = { 0xDE, 0xAD, 0xBE, 0xEF, 0xFE,
0xED};
EthernetClient client;
#endif
#endif
#ifdef ARDUINO_ARCH_AVR
// On Arduino: 0 - 1023 maps to 0 - 5 volts
#define VOLTAGE_MAX 5.0
#define VOLTAGE_MAXCOUNTS 1023.0
#elif ARDUINO_SAMD_MKR1000
// On MKR1000: 0 - 1023 maps to 0 - 3.3 volts
#define VOLTAGE_MAX 3.3
#define VOLTAGE_MAXCOUNTS 1023.0
#elif ARDUINO_SAM_DUE
    // On Due: 0 - 1023 maps to 0 - 3.3 volts
#define VOLTAGE_MAX 3.3
#define VOLTAGE_MAXCOUNTS 1023.0
#endif
unsigned long myChannelNumber = 31461;
const char * myWriteAPIKey =
"LD79EOAAWRVYF04Y";
void setup()
{
#ifdef ARDUINO_AVR_YUN
Bridge.begin();
#else
#if defined(USE_WIFI101_SHIELD) ||
defined(ARDUINO_SAMD_MKR1000)
WiFi.begin(ssid, pass);
#else
Ethernet.begin(mac);
#endif
#endif
ThingSpeak.begin(client);
}
void loop()
{
// Read the input on each pin, convert the reading, and set
each field to be sent to ThingSpeak.
// On Uno,Mega,Yun: 0 - 1023 maps to 0 - 5 volts
// On MKR1000,Due: 0 - 4095 maps to 0 - 3.3 volts
float pinVoltage = analogRead(A0) * (VOLTAGE_MAX
/ VOLTAGE_MAXCOUNTS);
ThingSpeak.setField(1,pinVoltage);
// Write the fields that you've set all at once.
ThingSpeak.writeFields(myChannelNumber,
myWriteAPIKey);
delay(20000); // ThingSpeak will only accept updates
every 15 seconds.
}
```

V. Experimental setup of IOT based circuit breaker



a. Operation of iot based circuit breaker

- It is equipped with sensors that continuously track electrical factors like voltage and current.
- The circuit breaker's central control unit receives the data from the sensors.
- Wi-Fi or other technologies can be used to link the circuit breaker to the internet. Here ThingSpeak platform is used.
- Even from a distance, users can operate the circuit breaker using their computers or smartphones or ThingSpeak platform.
- The electrical data and state of the circuit breaker are continuously monitored by the central control unit.
- The ThingSpeak notifies users if there are any issues, such as overloads or short circuits Based on the information it receives, the circuit breaker may make wise decisions and, if necessary, shut off the electricity.
- Remote system updates are available to provide new features and address issues.
- In simple terms, an IoT-based circuit breaker makes electrical systems safer, more effective, and simpler to handle from anywhere by using sensors and an internet connection to give remote management, real-time monitoring, and intelligent protection

VI. Applicatons

1. Smart Homes
2. Industrial Automation
3. Smart Grids
4. Data centers
5. Electric vehicles
6. Telecommunications
7. Healthcare facilities
8. Safety and security systems
9. Resilience and Disaster Management

VII. Results

The Iot based circuit breaker experimental setup is shown in figure. The load connected to the circuit is displayed in LCD display. When the overload or over current is flowing in the circuit then the user can be informed by the ThingSpeak platform through cloud network. The user can control the load connected to the circuit from anywhere through internet. Then the circuit breaker will automatically operate according to the user's instructions.

VIII. Conclusion

These days, equipment control and protection are of utmost importance. We employ fast responding circuit breakers to prevent electrical failure because of their exceptional precision in fault detection and cutoff time, as well as their smooth functioning compared to conventional type. Extensive tests performed after building the required circuit produced positive outcomes. Electronic circuit breakers have shown to be a very beneficial circuit for sensitive loads. The key benefit of this circuit is that it trips more quickly overall than a traditional circuit breaker. The test is a success and uses less energy.