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Monitoring And Control Of Single-Phase Electrical Systems Using Iot Based Microcontroller

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Abstract: In major power systems, the internet of things (IoT) significantly affects raising the quality and efficiency of electricity. Using a unique approach, smart voltage and current monitoring systems have been developed. The integrated design measures voltage and current sensor findings and transmits the processed data to an Android phone using an Arduino Uno microcontroller and a Wi-Fi module. The global systems for mobile communication WI-FI module is necessary for communication. An Android app can be used to alert users via email or text message when something goes wrong and assist them in taking the appropriate action. Logical programming strategies in Arduino allow for easy load times and remote device monitoring and control. This gadget monitors and safeguards the voltage, current, and temperature of a single-phase system. Inadequate monitoring and control can result in equipment failure caused by overloading, overheating, and high input voltage. An electromagnetic relay is triggered to shut down the entire device if any of these values exceed the limit. This relay is activated when the parameters exceed the predetermined threshold levels. In addition, the relay serves as a circuit breaker, cutting off the main power supply. This device provides protection and monitoring for the voltage, current, and temperature of a single-phase system. When equipment is not adequately monitored and managed, it can malfunction due to overloading, overheating, and high input voltage. An electromagnetic relay is triggered to isolate the entire unit in the event that any of these values exceed the threshold. This relay is turned on when the parameters exceed the predetermined threshold levels. Additionally, the relay shuts off the primary power source by acting as a circuit breaker.

Index Terms-IoT-based monitoring, Single-Phase electrical system, microcontroller control, Real Time Acquisition.

I. INTRODUCTION

The 'Monitoring and controlling of substations using internet of things (IoT)' project proposes a revolutionary architecture for constructing a microcontroller-based system. A single-phase system's voltage, current, and temperature are all monitored and protected by this device. Overloading, overheating, and high input voltage can all lead to equipment failure if they aren't properly monitored and controlled. In the event that any of these values surpass the limit, an electromagnetic relay is activated to shut down the whole unit. When the parameters surpass the preset threshold values, this relay is triggered. The relay also functions as a circuit breaker, shutting down the main power source. The global systems for mobile communication Wi Fi module are used to communicate real-time electrical parameters through the short message service. The 'Monitoring and controlling of substations using internet of things (IoT)' project proposes a revolutionary architecture for building a microcontroller-based system. This device monitors and protects the voltage, current, and temperature of a single-phase system. In the event that any of these values surpass the limit, an electromagnetic relay is activated to shut down the entire unit. When the parameters surpass the preset threshold values, this relay is triggered. The system notifies the authorised person via SMS when the parameters (temperature, voltage, and current) exceed the predetermined limits. Transformers reduce the voltage, and distribution networks then transfer the electricity to final users. Distribution substations take power from the transmission grid and reduce its voltage to less than 10 kV. They then use smaller distribution lines to distribute the power to industrial, commercial, and residential consumers. Ensuring clients receive safe power is made possible by system control and monitoring. The system is composed of a number of electronic parts, including relays, circuit breakers, and transformers. Failures stemming from internal insulation degradation or leaks in transformer fluid cause overheating. A laborious and imprecise approach to system validation that is still in use today involves calling When the voltage, current, and temperature exceed the predetermined thresholds, the system notifies the authorised person via SMS. Transformers are used to reduce the voltage, and distribution networks are used to distribute the energy to final consumers. Before being distributed to commercial, residential, and industrial clients via smaller distribution lines, distribution substations take power from the transmission grid and scale it down to less than 10kV. Ensuring that clients receive safe power is facilitated by system control and

monitoring. Transformers, circuit breakers, relays, and other electronic parts are among the many parts that make up the system. Degradation of internal insulation or leaks in transformer fluid can cause overheating and subsequent breakdowns.

II. BLOCK DIAGRAM

The transformer takes an input voltage of 230V AC and converts it to 12–14V AC. The rectifier circuit is then fed the voltage, which converts the AC voltage to DC voltage; as a result, the rectifier output will be 12V DC. Consequently, a 12V input voltage is given to the buzzer and relay. An Arduino is supplied with a steady 5V DC supply. The output ripples are eliminated by using a filter circuit, which is provided by the IC-7812 and 7805, which provide constant 12V DC and 5V DC. This project uses a digital humidity and temperature (DHT) sensor to detect temperature. It displays voltage, current, and frequency in addition to sending an SMS to an authorised person if temperature rises above a predetermined threshold. To convert 12–14V AC, a transformer receives an input voltage of 230V AC. The rectifier circuit, which transforms AC voltage into DC voltage, is then fed the voltage; as a result, the rectifier output will be 12V DC. For this reason, the buzzer and relay are given an input voltage of 12V. an Arduino with a steady 5V DC supply. Ripples from the output are removed by filtering the circuit, which is provided by IC-7812 and 7805, which provide constant 12V DC and 5V DC. In this project, the temperature is measured using a digital humidity and temperature (DHT) sensor. It displays voltage, current, and frequency in addition to the temperature and, if the temperature rises above a predetermined point, sends an SMS to an authorised person via Wi-Fi. An Arduino is provided with a steady 5V DC supply. The filter circuit is utilised to eliminate ripples from the output, while the IC-7812 and 7805 provide steady 12V DC and 5V DC. The temperature in this project is measured using a digital humidity and temperature (DHT) sensor, which also displays voltage, current, and frequency. If the temperature rises above a predetermined point, an SMS is sent via Wi-Fi to an authorised recipient.

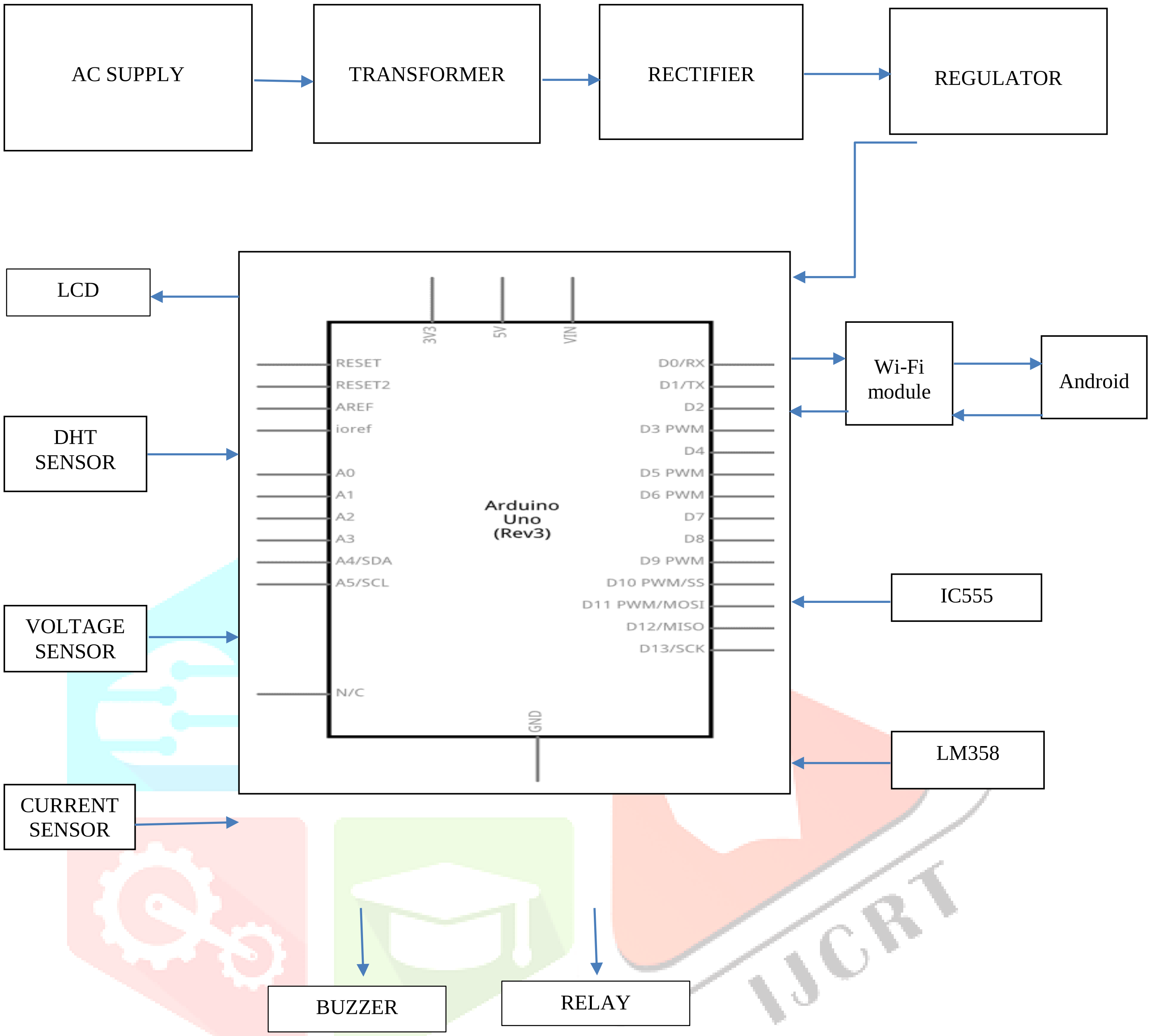


Figure 1: Block diagram of single-phase monitoring system using IoT

A microcontroller is crucial to this study project. Every piece of hardware needs to be connected in line with the block diagram. The programming will also be modified in accordance with user requirements. Fundamentals of block diagram operation The following are described under various load ON/OFF scenarios shown in Figure 1: i) When an SMS is sent to a Wi-Fi module with a load on, the relay turns on and the SMS is sent to the designated recipient; ii) When an SMS is sent to a Wi-Fi module with a load off, the relay turns off and the SMS is sent to the designated recipient with an off; and iii) When a "STATE" SMS is sent to a Wi-Fi module, it transmits all of the parameter values, including temperature, voltage, current, and frequency, along with the current state.

III. Hardware Requirements

Hardware components for using the Internet of Things to get the real results of research on a single-phase monitoring system We need components in order to implement hardware setup. Potentiometer, Arduino Uno, DHT sensor, IC 555, LM358 IC, transformer, diodes, voltage regulator, resistors, capacitors, LCD, relay, buzzer, and LEDs are some of the components used. These essential components enable tasks to be completed more quickly and conveniently. Hardware components are connected and operate well based on the block diagram. In order to create the actual model, this study work used lesser weight components. It will therefore be lightweight and simple to replace or repair. The cost, size, and quality of the components must all be considered while choosing hardware.

IV. Arduino

Software for creating free and open-source electronic projects can be obtained via Arduino, as seen in Figure 2. Write computer code and upload it to the actual board using an integrated development environment (IDE) that runs on your PC. Arduino boards have the ability to receive inputs, such as a light on sensor, a finger on button, or a message, and convert them to outputs, such as turning on an LED or starting a motor. Users will be able to design interactive electrical items with it. Arduino programming language is utilize based on wiring. Additionally, Arduino software was used for processing. By delivering a set of instructions to the microcontroller on the board, you can instruct your board on what to do. It is reasonably priced and simple to use.

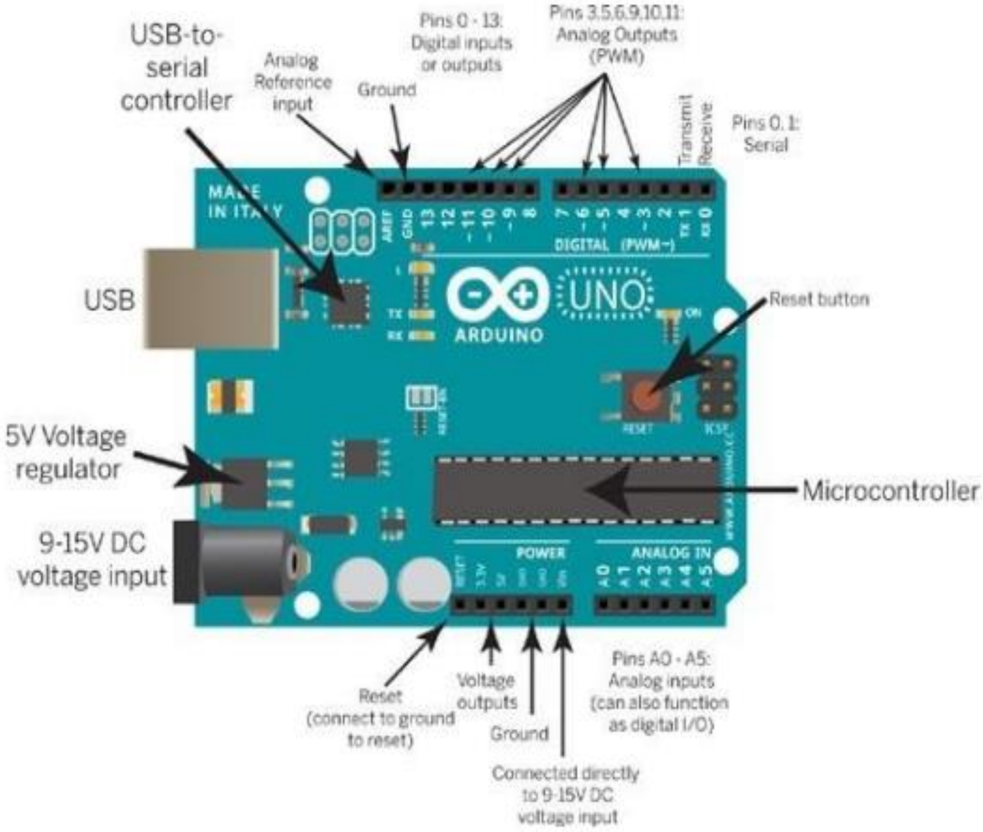


Figure 2: Arduino Uno module

V. Wi-Fi Module

Using Wi-Fi technology, a Wi-Fi module unifies all the parts required for wireless connection. Typically, it is made up of a memory, support circuitry, microcontroller or CPU, system-on-chip (SoC) or module with a Wi-Fi radio transceiver. A Wi-Fi module combines all the parts required for Wi-Fi technology-based wireless communication. A system-on-chip (SoC) or module with a memory, support circuitry, microcontroller or CPU, and Wi-Fi radio transceiver are usually its components. Wi-Fi technology allows for wireless communication, and a Wi-Fi module integrates all the components required. A Wi-Fi radio transceiver, memory, a microcontroller or CPU, and support circuitry are usually found in a system-on-chip (SoC) or module. Utilising Wi-Fi technology, a Wi-Fi module unifies all the parts required for wireless communication. It usually consists of a memory, support circuitry, microcontroller or CPU, system-on-chip (SoC) or module with a Wi-Fi radio transceiver.

VI. Relay

The fundamental parts of an electromagnetic relay are wire coils wound around a soft iron core, a movable iron armature, a low-resistance channel for magnetic flux, and one or more contact sets. The armature is mechanically coupled to one or more sets of movable contact points and is hinged to the yoke. When the spring holds the relay in place, it deactivates, creating an air gap in the magnetic circuit. The first set of contacts on the relay is closed and the second set is open while it is in this state. Depending on what they are used for, other relays could have more or fewer connections. In the example, a wire connects the relay's yoke to the armature. This guarantees the motion of the armature. What makes an electromagnetic relay work are wire coils wound around a soft iron core, a low-resistance channel for magnetic flux, a moving iron armature, and one or more contact sets. One or more sets of movable contact points are mechanically coupled to the armature, which is hinged to the yoke. The relay deactivates because of the spring keeping it in place, creating an air gap in the magnetic circuit. First set of contacts is closed and second set is open when the relay is in this state. According to their intended use, other relays might have more or fewer connections. The relay's yoke and armature are connected by a wire in this example. Thus, the armature's motion is guaranteed. The main parts of an electromagnetic relay are wire coils wound around a soft iron core, a movable iron armature, a low-resistance channel for magnetic flux, and one or more contact sets. The armature is mechanically coupled to one or more sets of movable contact points and is hinged to the yoke. The relay is held in place by a spring, which causes it to deactivate, creating an air gap in the magnetic circuit. The first set of contacts on the relay is closed and the second set is open when it is in this condition. Depending on what they are used for, other relays may have more or fewer connections. In the example, the armature and the relay's yoke are connected via a wire. This guarantees that the armature is in motion. A diode functions as a dielectric to dissipate any ensuing voltage spike that could otherwise harm semiconductor circuit components when the coil is deactivated if it is put across the coil when it is charged with direct current. Such diodes were rarely employed before transistors became widely utilised as relay drivers, but their use quickly spread because early germanium transistors were easily destroyed by this surge.

VII. DHT Sensor

The air becomes less humid as the amount of water vapour in the atmosphere rises. The air's humidity level has an impact on biological, chemical, and physical processes. Humidity in industrial environments can have a big impact on worker health and safety as well as product cost. Temperature of Humidity measurement is used to determine how much moisture is present in the gas, which may be pure gas, nitrogen, argon, or water vapour. The sensor DHT11 is capable of measuring temperature and humidity [16]. The DHT11 is a low-cost digital temperature and humidity sensor that may be purchased on eBay. If a microcontroller like the Arduino or Raspberry Pi is connected to this sensor, temperature and humidity can be tracked in real time. The air gets less humid when there is more water vapour in the atmosphere. The humidity level in the atmosphere has an impact on biological, chemical, and physical processes. Humidity may have a major impact on industrial settings' product prices as well as the health and safety of employees. Level of Humidity Whether the gas is pure gas, nitrogen, argon, or water vapour, measurement is performed to determine how much moisture is present. A temperature and humidity sensor called DHT11 is available The amount of water vapour in the air is measured as humidity. Air humidity has an impact on a number of physical, chemical, and biological processes. Humidity in industrial settings can have an impact on worker health and safety as well as the cost of the products. Therefore, humidity measurement is crucial in the semiconductor and control system industries. The quantity of moisture in a gas, which may consist of a mixture of water vapour, nitrogen, argon, or pure gas, etc., is determined by measuring its humidity. Based on their measurement units, there are two types of humidity sensors. A relative humidity sensor and an absolute humidity sensor are what they are. The digital temperature and humidity sensor DHT11 is used in Figure 3.

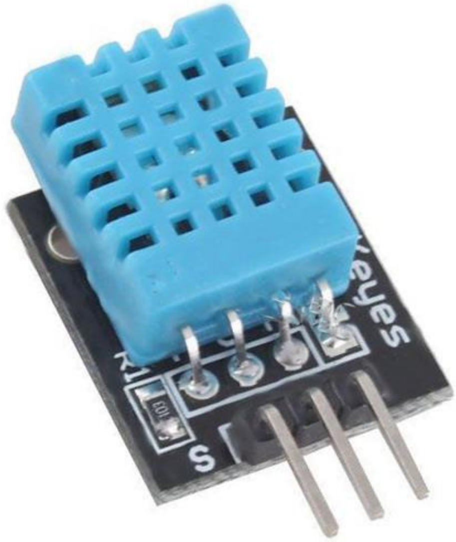
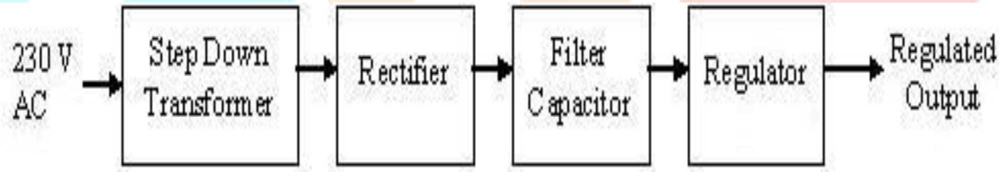


Figure 3: DHT Sensor

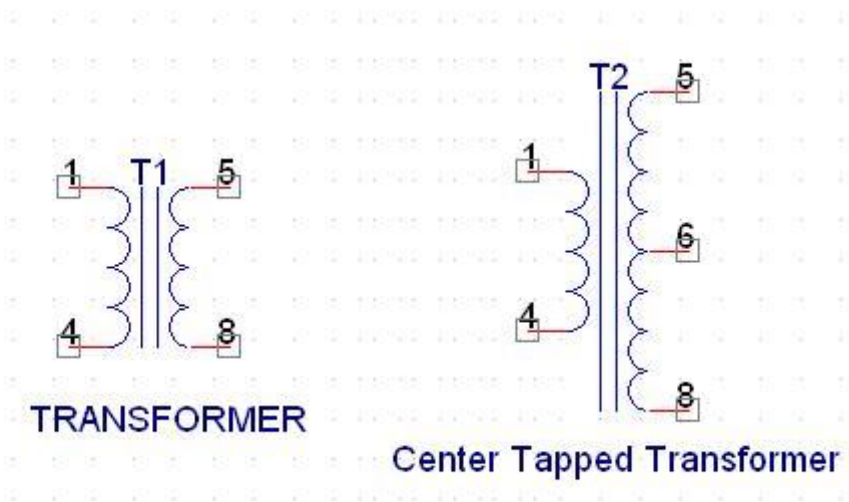
1.1 Power Supply

Every digital circuit needs a power source that is controlled. We will discover how to obtain a controlled positive supply from the main supply in this post**.**



1.2 Transformer

The primary and secondary coils, usually referred to as "WINDINGS," make up a transformer. Through electrical wires that are inductively coupled, or CORE, they are connected to one another. Alternating voltage is induced in the secondary coil by a change in the magnetic field in the core, which is caused by a change in the primary current. A load will cause an alternating current to flow through it if it is applied to the secondary. In a perfect scenario, the magnetic field would carry all of the energy from the primary circuit to the secondary circuit.



$$P_{primary} = P_{secondary}$$

So

$$I_p V_p = I_s V_s$$

The number of turns in both the primary and secondary of the transformer determines its secondary voltage.

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

1.3 Rectifier

It is far more efficient than a half-wave rectifier and, because it doesn't require a center-tapped transformer, is also far less expensive than a full-wave rectifier because, as its name implies, it converts the entire wave, or both the positive and negative half cycles, into DC.The four diodes that make up a full bridge wave rectifier are D1, D2, D3, and D4. Diodes D1 and D4 conduct during the positive half cycle, whereas diodes D2 and D3 conduct during the negative half cycle. As a result, the diodes continuously swap the transformer connections, resulting in positive half cycles in the output.

1.4 Buzzer

Is a mechanical, electromechanical, or electronic audio signalling device. Buzzers and beepers are frequently used for timers, alarms, and user input confirmation, such as mouse clicks and keystrokes.

1.5 LCD Module

With an LCD module, interactive messages can be shown. We look at a clever two-line, 16-character LCD display that is interfaced with the controllers. The display's handshaking protocol is displayed as follows. While pins D0 through D7 represent the data lines, pins RS, RW, and EN represent the control pins, and the other pins supply +5V, -5V, and GND. where EN is the Enable pin, RW is the Read Write, and RS is the Register Select. We use an LCD module to display interactive messages. We look at a clever two-line LCD display with 16 characters per line that is interfaced with the controllers. The display's handshaking protocol looks like this. The remaining pins are +5V, -5V, and GND to give power, while the D0 to D7th bit represents the data lines. The RS, RW, and EN pins are the control pins. where RW stands for read write, EN for enable pin, and RS for register select. Two internal byte-wide registers are present in the display: one for commands (RS=0) and the other for characters that will be shown (RS=1). Additionally, it has a user-programmable RAM section called the character RAM, which may be used to create any character that can be produced with a dot matrix. The hex command byte 80 will be used to indicate that the display RAM address 00h will be used in order to differentiate between these two data sections.The command or data type is provided by port 1, and the read/write levels and register select are provided by ports 3.2 to 3.4.

An electromagnetic switch known as a "Single Pole Double Throw Relay" (Figure 1) is made up of a coil (terminals 85 & 86), one common terminal (30), one generally closed terminal (87a), and one normally open terminal (87).

Both the normally closed terminal (87a) and the common terminal (30) of an SPDT relay (Figure 1) are continuous while the coil is at rest, or not energised. Both the normally open terminal (87) and the common terminal (30) are continuous when the coil is energised.

2.1 Prototype Model

There are various processes involved in designing a prototype that uses Internet of Things (IoT)-based microcontrollers to monitor and regulate a single-phase electrical system. This is a general overview of how you could about working on this project Figure 4

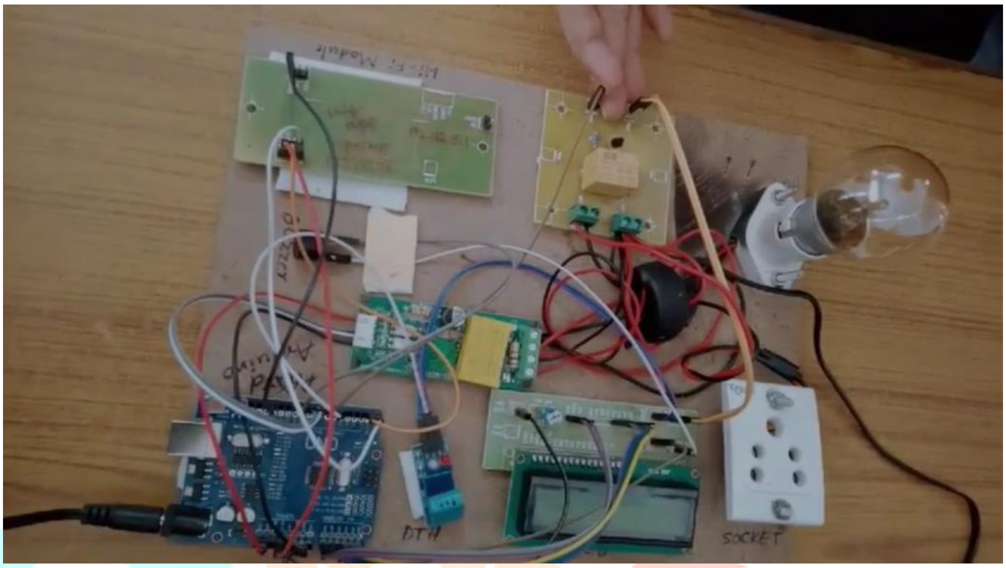


Figure 4 Hardware kit to monitor and Control single phase system using IoT

2.2 Parts Required

Microcontroller: Select an IoT-capable microcontroller board, such as the ESP32/ESP8266, Arduino, or Raspberry Pi.
Sensors: current and voltage sensors, which measure current and voltage, respectively. If necessary, temperature sensors may also be used.
Relays: Used to regulate appliances and gadgets.
IoT connectivity is provided by the WiFi/Bluetooth module.
Power Supply: To supply energy to the sensors and microprocessor.
Display Unit: An optional component used to show data in real time.
Required Elements:
Small-scale controller: Select an Arduino, Raspberry Pi, or ESP32/ESP8266 microcontroller board, or any other IoT-compatible board.The sensors are the voltage and current sensors (which measure voltage and current, respectively), and if necessary, temperature sensors.
microcontroller: Select a microcontroller board that is compatible with the Internet of Things, such as an Arduino, Raspberry Pi, or ESP32/ESP8266.
Sensors: Current and voltage sensors, which measure current and voltage, respectively. If necessary, temperature sensors may also be used.

System Architecture

Recognise the prerequisites: Which parameters—voltage, current, power, etc.—do you wish to keep an eye on? Which gadgets are you hoping to manage?
Create the circuit: Make a schematic that illustrates the connections between the microcontroller, sensors, relays, and power supply in Figure 5.

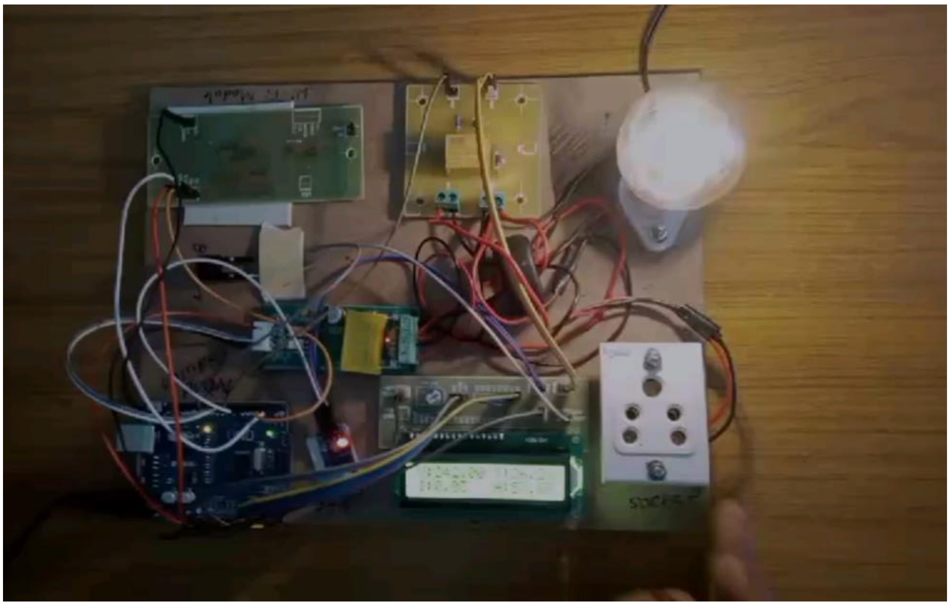


Figure 5 Kit to monitor and control single phase system using IoT

2.3 Test cases

In this instance, the user entered "3" into the system, and the result is shown on the virtual terminal. The system will go into automatic mode of operation upon receiving input 3 [22]–[24].
Case (i): in a typical setting. When every parameter in this manner of operation is below threshold value or the system is functioning properly, the system immediately activates the relay and deactivates the buzzer. A lower LED-RED (buzzer) switched OFF signifies that everything is fine with the system.
This is indicated as follows: D1 (relay): turn ON; D2 (buzzer): switch OFF. Relay is turned ON in this scenario.
Case (ii): in an unusual setting. In this mode of operation, the microcontroller automatically turns on the buzzer and switches off the relay when the parameters are above the threshold value or the system is in an abnormal state. When the lower LED-RED (buzzer) is activated, it signifies an anomalous state. This state is represented as follows: D1 (relay): turned OFF, D2 (buzzer): turned ON. Relay is switched OFF and buzzer is turned ON. Thus, the system's condition can be ascertained by looking at the buzzer's state as follows:
When the D2 buzzer is off, the system is in a healthy state (NV, NC, NT, NF), and when it is on, the system has entered an abnormal state (UV or OV, UF or OF, OC, OT).

2.4 Hardware Configuration

Link the microcontroller and sensors together: Current sensors are used to monitor current flow while voltage sensors are used to detect voltage across a phase.
Relays can be connected to a microcontroller to enable remote device control.
Make that every component has the right power supply.

2.5 Software Engineering

Create the microcontroller's firmware: Use the Raspberry Pi OS, Arduino IDE, or other comparable platforms.
Put code in place to read sensor data: Check the voltage, current, and any other pertinent information.
Put control logic into practice: Determine when to switch gadgets on based on the readings.

VIII. RESULT AND DISCUSSION

As a result, a Wi-Fi-based monitoring system was created, successfully tested under a variety of scenarios (over voltage, under voltage, over frequency, under frequency, over current, and over temperature), and it notifies the end user when parameters rise above a threshold value. Through the use of a Wi-Fi module, the prototype model notifies the end user under a variety of abnormal situations, including overvoltage, undervoltage, overfrequency, normal temperature, and overtemperature. Using "PROTEUS-software," a simulation model has been created to track the substation's voltage, current, frequency, and temperature. The model can be operated manually or automatically and notifies the user via a virtual interface.

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