

IoT Based Transformer Load Monitoring and Controlling With Alerting System Using Arduino Nano and GSM

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Abstract- The goal of this paper is to collect remote electrical data such as voltage and current and broadcast these real-time values via the network, coupled with the temperature at the power plant. This system will also safeguard the electrical circuits by using a relay. When the electrical parameters surpass the specified levels, this relay is actuated. This technology can continually update the real-time electrical parameters. This system may be programmed to transmit alarms when the relay trips or when the voltage or current exceeds predetermined limitations. It also has a cooling system (Cooling Fan). When the temperature of the transformer exceeds the prescribed limit, this cooling fan activates and blows cold air, bringing the temperature down to normal. This system makes use of an Arduino, and because this is a prototype of the planned idea, we have utilized an Arduino Nano for demonstration purposes. The Arduino can effectively communicate with the many sensors in use.

Keywords: Arduino Nano, GSM900A, 4-Channel Relay, Wi-Fi module, Internet of Things (IOT), Cooling Fan, Thing speak, LCD display, Alerting System.

1. INTRODUCTION

The word "Power" refers to all electrical, electronic, and other equipment in existence throughout the world. So, we can conclude that a major source of energy in daily living is electricity. "How is power produced?" and "How is it distributed globally." Electricity is produced by a variety of power plants, including thermal and renewable ones. Three methods—generation, transmission, and distribution are used to generate and distribute power around the globe. We will talk about the distribution system in this project. Most of the distribution system is made up of transformers. These transformers are used to distribute the transmitted power to different loads by stepping down or stepping up the power. However, these transformers are unable to monitor continually, which could shorten their lifespan. We may encounter a variety of conditions, such as transformers blasting, high and low voltages, etc., which results in power outages and may harm the transformers. A person who is near a transformer may occasionally receive an electric shock from the flow of various currents in the windings, which can be fatal. Monitoring and controlling substations is a critical task in this era of automation to provide safe electricity to consumers. The substation plays an important role in ensuring the reliability and quality of an electric power transmission system. The substation contains various electrical and electronic components such as transformers, breakers, and relays. Overheating can cause transformer fluid leakage or internal insulation breakdown. The old method requires manual system testing on a regular and imprecise basis. We took on

this endeavor to prevent these damages and human casualties. With this project, we can continuously keep an eye on the real-time values and manage the risks associated with the health of the transformer. Today, IoT (Internet of Things) technology is growing more popular. It is the combination of tiny and intelligent items with computational capability. Wi-Fi, Bluetooth, and sensors are examples of pre-existing technology. In the interim, several hardware and software platforms have been developed to enable the creation and usage of IoT-based devices and services. Electricity distribution firms strive to maximize earnings by guaranteeing a consistent and dependable power supply. Transformers, substation transformers and high voltage lines are the fundamental components of electricity distribution. Monitoring and regulating substations is an important responsibility in the automation era to keep customers safe.

2. LITERATURE REVIEW

The suggested project controls the substation with the help of the necessary components to ensure that it can be remotely managed and overseen to reduce the severity of incursion. The microcontroller can integrate and play a part in accordance with the sensors installed at the substation. Electrical characteristics such as current, voltage, and the rated value may be regularly compared to prevent future damage to the power delivery system and control transformer caused by overkill, short trip deficiency, surge voltage, and outpourings. This reduces the number of people working at the substation and saves a lot of time. In this way, the substation's data collection and operational efficiency are likely to improve.[1]

This framework proposes methods for measuring temperature, current, voltage. It reads temperature, current, voltage from sensors in a single-phase power system using Arduino. The computed data is then sent to the IoT application and LoRa handling system. When an error occurs, the burden is switched off and then turned back on until the error is corrected. A LoRa handling machine is used. The IoT server monitors these variables using the IoT module.[2]

With the adoption of the notion of an interconnected power system, the role of the substation has grown in importance. Depending on the kind of substation, the transmission system links the generating station to the distributor or the end customer. In each substation, activities such as transmission line switching, parameter measurement, defect detection, and historical data storage are carried out. Before, all tasks were performed manually; however, as system complexity grows, the function of the substation becomes increasingly important, and we must transition to the use of IEDs and automation. Substation activities may be roughly classified into three categories: supervision, control, and data collecting.[3]

The goal of this project is to create a system that will track and control the substation using a wireless technology known as IoT. An IOT module provides the communication interface. With the IOT module, data is upgraded to the server. A 16x2 LCD is also available for observing system status. This project makes use of a 5V,

500mA power source. For uncontrolled 12V DC, three terminal voltage regulators are utilized for voltage control. The bridge type full wave rectifier rectifies the AC output of the secondary 230/12V step-down transformer.[4]

The 'Substation Monitoring System' project provides a unique concept for developing a system based on a microcontroller. The goal is to continually monitor the electrical characteristics and so protect the distribution transformer from burning due to limits such as overload, overheating, and input excessive voltage. If any of these numbers exceed the limit, the entire unit is shut off by activating a Relay. When the parameters surpass the specified limitations, the system sends an SMS warning to the authorized individual. And the personnel at the substation will manually resolve the problem being faced at the substation. [5]. The objective of this project is to gather remote electrical data, such as voltage, current, and frequency, and broadcast these real-time values through the GSM network. This project will also protect the electrical circuits by using an Electromagnetic Relay[6]. When the electrical parameters (current, voltage, temperature) surpass the specified values, this Relay is triggered. The Relay may be used to activate a Circuit Breaker, which will turn off the main power supply and isolates the load. To read the distant electrical characteristics, the user can send commands in the form of SMS messages[7].

3. PROPOSED SYSTEM BLOCK DIAGRAM

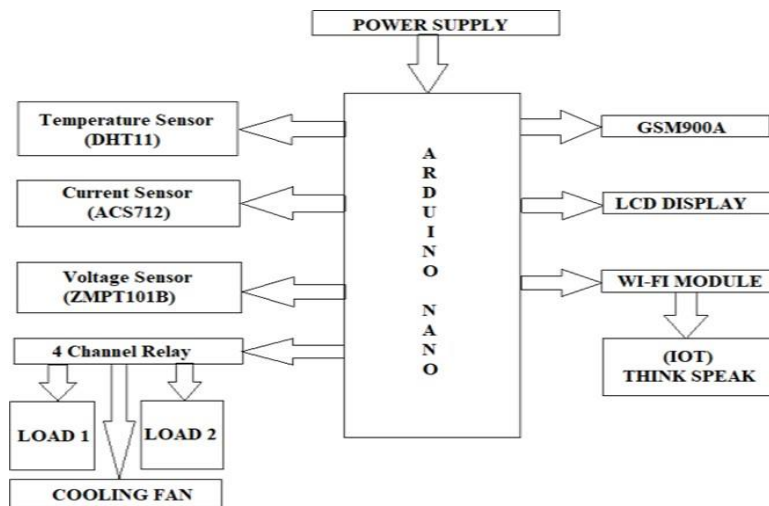


Fig 1. Block Diagram

The flow structure displays the three-stage electrical architecture, which includes the stage as a microcontroller to use the voltage and flow from the sensor. It then purposely delivers the results to the screen remotely using another Android application.

Monitoring a substation is not an easy task for a regular employee. It is a difficult and dangerous duty. Maintaining the transformer parameters is not a simple task. There have been numerous incidents involving transformer blasting, external faults,

overcurrent faults, and the loss of life. In this light, we can say that this job is extremely risky and dangerous. As a result, we took on this project to address all these issues while also ensuring supply continuity. Our plan is to continuously monitor the transformer's electrical parameters such as voltage, current, and temperature, and to isolate the transformer and other equipment by controlling in the event of a fault. We used an Arduino Nano, a Wi-Fi module, a GSM900A, sensors, relays, a buzzer, think peak, and other components to complete this project. When the Arduino detects abnormal conditions, it sends a signal to the relay and the GSM module. This relay detects the signal and trips the circuit, activating the buzzer, and sending the text message to the personnel. The Wi-Fi module is linked to the think speak app, which monitors and stores the electrical parameters of the transformer. This way, we can reduce damage and loss of life while also increasing the life of the transformer and ensuring power continuity.

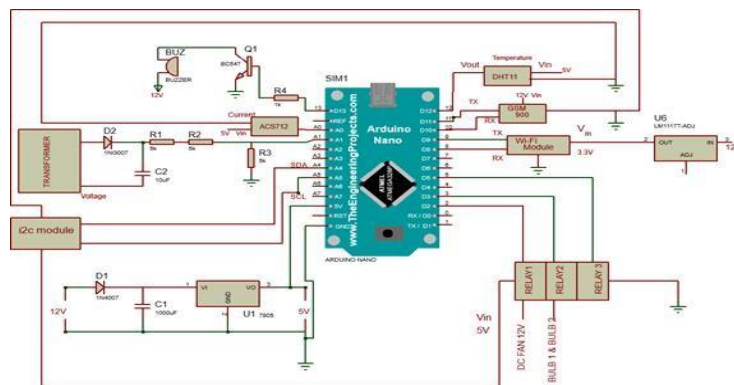


Fig 2. Circuit Diagram

Connection Description & Working Principle

In this work, we use an Arduino Nano as a microcontroller that can control and operate based on the conditions. An Arduino Nano has 30 pins, 14 of which are digital (D0 - D13), 8 of which are analogue (A0 - A7), and the remaining 8 are input, reference, ground, reset, RX, TX. We use both digital and analogue pins in this project. The Arduino Nano's input pin is first connected to a 7805 voltage regulator, followed by a 1N4007 diode and a capacitor with a capacitance of 1000uF. The nano's ground pin is connected to the ground terminal. The relay is connected to digital pins D2, D3, and D4. D8 and D9 pins are connected to the Wi-Fi module's RX and TX pins. The Wi-Fi module's input pin is connected to an LM117 voltage adjuster. D10 and D11 pins are connected to the GSM900A module's RX and TX. The GSM900A module's input pin is coupled to a 12v power source. The D12 pin is connected to the DHT11 temperature sensor. The D13 pin is connected to a resistor, which is followed by a BC547 transistor and a 12v buzzer. The analogue pin A0 is connected to the current sensor, while the input pin is linked to the power source. A1 pin is connected to the transformer, along with a 1N4007 diode, three 5kohm resistors, and a 10uF capacitor. The A4 and A5 pins are connected to the SDA and

SCL pins of the IC2 module.

Monitoring and managing transformers under various abnormal situations is a demanding task. There are several incidents that result in power outages, overvoltage, and even human fatality. All these scenarios are considered, and we decide to create a project to address all of them. In our project, we utilise an Arduino Nano as a microcontroller that runs according to the circumstances provided and can also connect with other devices and commands to send information about the state. Simply said, the "Arduino Nano" is the project's heart. The nano receives the appropriate supply voltage through a 7805 voltage regulator, which controls the input voltage supply from the transformer. The current sensor (ACS712) is attached to the nano, and it detects the amount of current flowing through the load and sends this information to the nano. The temperature sensor (DHT11) is linked to the nano, which measures the temperature of the transformer and sends the data to it. The wi-fi module (ESPO1) is linked to the nano, and it records the voltage, current, and temperature information graphically and uploads them to the cloud. The GSM module (GSM900A) is linked to the nano and transmits text messages when an abnormal situation occurs. The relays are linked to the loads, and a 12V DC fan is also linked to the relay. It also has a buzzer, which begins to ring when the relay trips the circuit.

When power is applied to the nano, it functions in such a manner that if the voltage or current across the load exceeds the specified levels, the nano detects the abnormal state and sends a trip signal to the relay. The relay detects the trip signal and trips the circuit, activating the buzzer and causing the buzz noise to begin. Moreover, the GSM module detects the trip signal and sends a text message indicating its status. This relay regulates itself by continually checking the voltage and current values unless they go outside of a specified range. Similarly, anytime the transformer temperature exceeds the predefined value, the nano detects the abnormal condition and sends a trip signal to the relay, while GSM sends a text message to workers informing them of its status. The relay detects the trip signal and activates a 12V DC fan located across the transformer. This fan blows up and cools the temperature of the transformer.

4. PROTOTYPE IMPLEMENTATION AND RESULTS

Normal Condition: The transformer voltage, load voltage, load current, and transformer temperature are all between the present values in this circumstance. As a result, no aberrant condition occurred. This project is primarily dependent on the monitoring and management of a transformer, as well as an alerting system in the event of an unexpected situation. The transformer is monitored in two ways: the first is through an LCD display that continuously monitors the transformer parameters, and the second is through a Wi-Fi module that uploads the transformer data to the cloud as a graphical representation.

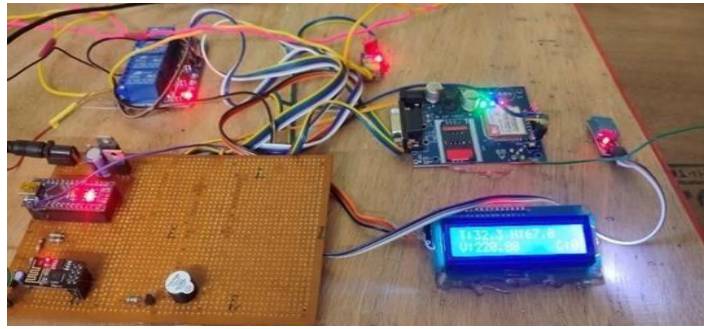


Fig 3. Normal Condition

There are four abnormal conditions in which the relay trips the circuit and isolates the load. They are: 1. Under Voltage: When the transformer voltage falls below a pre-defined level, the relay trips the circuit, and the LCD indicates the type of problem detected.

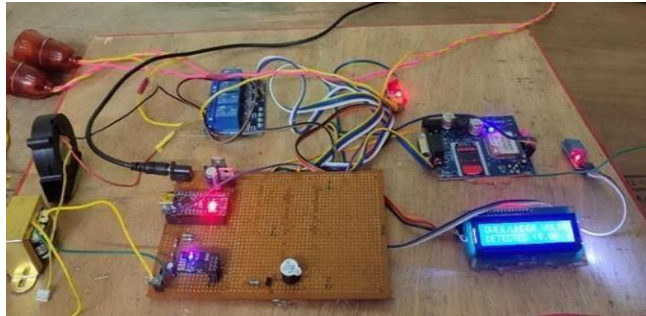


Fig 4. Under Voltage

Overload: When the load voltage or load current exceeds the pre-defined value, the relay trips the circuit, and the LCD indicates the kind of problem detected.

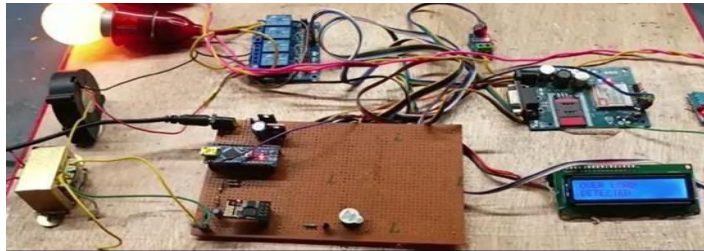


Fig 5. Overload=

Over Temperature: When the temperature of the transformer exceeds a certain value, the relay trips the circuit, the LCD displays the type of problem detected, and the cooling fan cools the transformer.

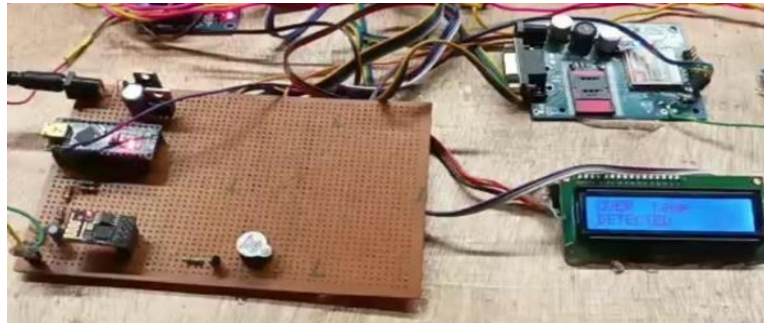


Fig 6. Over Temperature

As previously stated, the Wi-Fi module continuously monitors all parameters for a period of 5 minutes, and the observed results are saved in a graphical form. There are 3 types of individual graphical representation

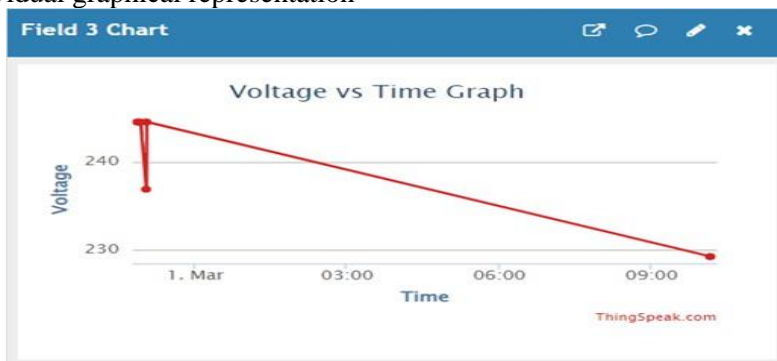


Fig 7. Voltage vs Time

The Fig 7. represents the change of voltage for change in the time. It continuously updates the values for every period of 5minutes.

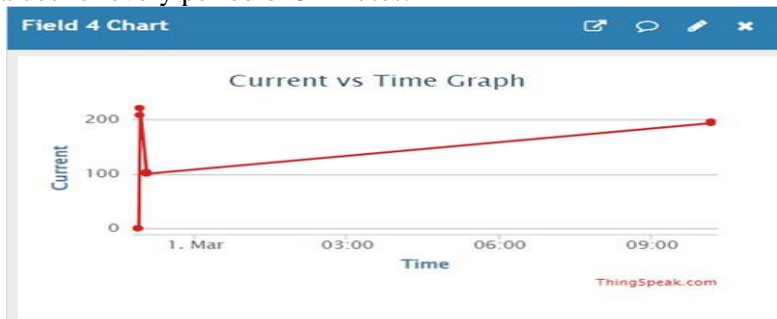


Fig 8. Current vs Time

The Fig 8. represents the change of current for change in the time. It continuously updates the values for every period of 5minutes

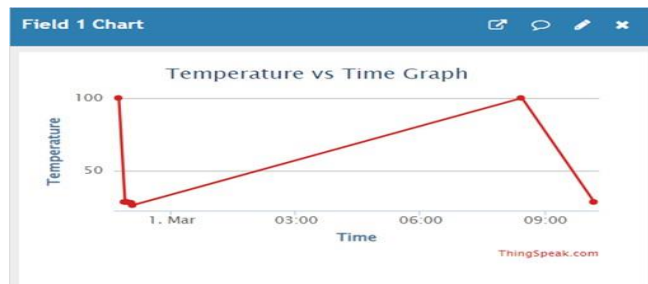


Fig 10. Temperature vs Time

. Table 1. Results & Observations

S. No	Voltage(V)	Current (A)	Temperature (°C)	Type of Condition	Type of Action
1	0V	0A	25°C	Under Voltage	Buzzer ON, Relay Tripped
2	230V	0A	25°C	-	-
3	$\geq 245V$	$\geq 3A$	25°C	Overload	Buzzer ON, Relay Tripped
4	230V	2A	$\geq 25^\circ C$	Over Temperature	CoolingFan ON

CONCLUSION

Monitoring a transformer and ensuring uninterrupted power supply is a difficult task. There are numerous examples, such as current shocks, power outages, and transformer blasting. Overcoming all these abnormal conditions is a critical task for continuous supply. This project makes it possible because we continuously monitor the state of the transformer and initiate automatic control whenever an abnormal condition occurs. This allows us to overcome many disadvantages.

REFERENCES

- [1] Malini T, Aadithiya T, Abbiram V M, Deeraj Kumar M, Ravishankar G, "IoT and LORA Based Substation Monitoring and Control System" 2021 6th International Conference on Communication and Electronics Systems (ICCES) published by IEEE.
- [2] N Loganathan, J Prasanth, R Shankara Saravanan, V Jayasuriya, S Karthikeyan, "Smart Substation Monitoring and Control" 2022 7th International Conference on Advanced Computing & Communication Systems (ICACCS), published by IEEE.
- [3] Dharita Patel, Keval Chauhan, Ankit Bhut, Jaimin Brahmabhatt, Sgar Dalia, "Substation Automation using PLC and SCADA" Journal of Emerging Technologies and Innovative Research (JETIR), Vol 5, Issue 11, November/2018, ISSN-2349-5162.
- [4] Amol Ram Kate, Girish Baban Dongare, Krishana Maroti Janwade, Payal Burande, and Narendra P.Zinjad's "Substation Monitoring System" International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321- 9653; IC Value: 45.98; SJ Impact Factor: 6.887 Volume 6 Issue V May-2018.
- [5] Amol Ram Kate, Girish Baban Dongare, Krishana Maroti Janwade, Payal Burande, and Narendra P. Zinjad's "Substation Monitoring System" International Journal for Research in Applied Science & Engineering Technology (IJRASET) ISSN: 2321- 9653; IC Value: 45.98; SJ Impact Factor: 7.429 Volume 8 Issue IX Sep-2023.
- [6] Kareem, Husam, and Dmitriy Dunaev. "The Working Principles of ESP32 and Analytical Comparison of using Low- Cost Microcontroller Modules in Embedded Systems Design." In 2021 4th International Conference on Circuits, Systems and Simulation (ICCSS), pp. 130-135. IEEE, 2024.
- [7] Nascimento, Jamile P., Nubia SD Brito, and Benemar A. Souza. "An adaptive overcurrent protection system applied to distribution systems." Computers & Electrical Engineering, vol. 81, pp.106545, 2022.