



Transformer Parameters Tracked in Real Time Internet of Things (IoT)

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Abstract—

In electrical power systems, a transformer plays a crucial role. Consistent power transmission to consumers is ensured by its dependable functioning. The transformer's real-time health monitoring system extends its life and avoids problems. Using sensors and the Internet of Things (IoT), this article demonstrates how to monitor temperature, load voltage, current, and oil level in real time. Using Arduino UNO, the gathered data were processed. The data is sent to the thingSpeak platform so it may be analyzed. The GSM module notifies a designated individual and sounds an alarm via buzzer when the detected data over the reference limit. The prototype model has confirmed the system's performance. An early warning of the transformer's unusual behavior is provided by the suggested system. This may be useful for reducing unscheduled outages and scheduling preventative maintenance. Transformer real-time monitoring, Arduino, and the Internet of Things (IoT) are all relevant terms.

I. INTRODUCTION

The structural significance of the electrical transformer is brought to light by the electrical power system. The generating, transmission, and distribution portions make up the core framework. When it comes to distributing power, the transformer is crucial. In India, it is supplied to homes, businesses, and industries at 33kV, 11kV, and 440V. Overload, insulation failure, and oil leakage are the causes of the transformer's failure. When the transformer breaks down, it cuts electricity and shortens its lifespan [1]. Therefore, it is necessary to conduct transformer condition monitoring in order to resolve problems with failure and enhance system dependability. Figure 1 shows the primary transformers of the electricity system. Due to the low voltage (11 kV and 33 kV) utilized to produce power in India, a step-up transformer is installed at the producing station in order to decrease transmission network losses. The distribution substation uses a step-down transformer to lower the voltage that may be provided to commercial and

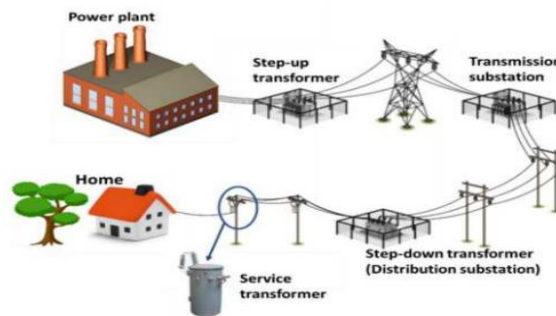


Fig. 1. Structure of electrical power system.

industrial clients. A service transformer is used to provide power to residential clients. It becomes difficult to keep track of the vast number of service transformers. In order to prolong the life of transformers and keep them free of problems, it is crucial to have a system that can remotely monitor their health and plan for preventative maintenance.

A transformer health monitoring system should be put in place to examine crucial sections on a regular basis in order to anticipate unanticipated issues. There are two approaches of tracking a patient's condition:

1. Offline Monitoring
2. Online Monitoring

The first method of monitoring requires turning off the supply, which is important for the usual schedule. The second method, on the other hand, does not need turning off the supply. Transformer health may be monitored online with the use of Internet of Things (IoT) technology. The use of an ESP-32 and a Raspberry Pi as controllers allowed for the real-time monitoring of oil level, voltage, current, and temperature in [2, 3]. Because of their high-end nature, these controllers demand expert-level understanding. The use of silica gel temperature, humidity, and color for transformer breather health monitoring is shown in [4]. The Internet of Things (IoT) relies on sensors to gather data in real-time and transmit it to the controller. The use of the internet of things (IoT) in conjunction with Arduino and Raspberry Pi to track transformer health is detailed in a recent research study [5]. In this study, the author applies the fishbone problem-solving technique to identify the primary cause of failure. [6] presents the use of LoRa technology for the monitoring of transformer vibration and noise using the Internet of Things. The author used a model predictive control method to foretell impending failures caused by anomalous vibration and sound. It is possible to anticipate transformer failure with the help of a number of preventative measures. In [7], the author lays forth a plan to use the Internet of Things to collect data about transformers in real time. Data in this system is sent via the TCP/IP protocol. The author set up a system to receive error indicators via messages and LED displays. This system routinely uses the Android device to check parameters such as voltage, current, and temperature. The Internet of Things (IoT) is used by the author to monitor the status of distribution transformers [8]. Due of their abundance, distribution transformers are notoriously difficult to manually monitor. Therefore, the author suggested a GSM-based automated embedded system. The validation of notifications sent to authorized individuals via the GSM module was accomplished in [9] using MQTT protocols. The temperature, voltage, current, and oil level of the transformer are monitored in real-time using an Arduino and a number of sensors, as shown in [10]. After the system was set up, the display showed health metrics. A communication device might be used for remote monitoring. Extensive usage of the ADC0808 to digitize detected analog data [11]. For this system, 8051 microcontrollers were used.

We employed the TCP IP protocol, which is based on Wi-Fi, to transmit the observed data. In [12], the author showed how to analyze dissolved gases and monitor transformer characteristics in real-time. Using the health index, this research may assist estimate how long a transformer will last. [13] demonstrates transformer load-sharing over the Internet of Things. A number of sensors keep tabs on the Blynk IoT platform's characteristics in real time. In this work, we show how the main and backup transformers may share load. The use of ultrasonic and DHT11 humidity sensors for substation transformer health monitoring is described in [14]. To what extent are oil level, temperature, voltage, and current monitored? If the transformer needs maintenance, this system will notify you in a timely manner. It has been noted in the aforementioned research that employing IoT technology successfully allows for real-time monitoring of the transformer. Because of its simplicity and extensive capabilities, an Arduino controller board is ideal for this application's sensor and communication device interfacing needs. In Figure 2, we can see the distribution transformer in its most basic form. Those five variables—heat, voltage, current, oil level, and humidity—stand out as the most important ones to keep an eye on. Providing a reliable method for monitoring transformer data in real-time is the primary contribution of this study. With the use of several protocols, including the GSM model, Buzzer, LCD, and web platform, this article covers every potential manner of data transfer. Here is how the remainder of the paper is structured. The methods and parts that make up the suggested system are detailed in Section II. Explanation of the system's prototype model findings was provided in Section III. In Section IV, we outline the shortcomings of the suggested approach, and in Section V, we draw a conclusion.

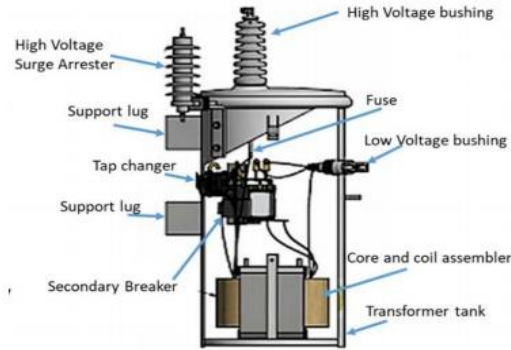


Fig. 2 Parts of Transformer.

Here we will go over some of the most crucial transformer metrics that should be monitored in conjunction with the sensors. It further emphasizes the suggested system's working premise. Section A. Crucial Transformer Parameters
The following parameters for monitoring have been determined from the literature:

- Temperature
- Oil level
- Load voltage and current
- Humidity

The transformer's top oil temperature (TOT) characterizes its thermal condition. You can't get a straight reading on TOT. Equation (1) provides the formula for its calculation based on the IEEE thermal model. Voltage, current, and room temperature are the inputs needed by this thermal model. Therefore, a temperature sensor is required to determine the surrounding temperature.

$$\Delta\theta_{TO} = \Delta\theta_{TOR} \left(\frac{K^n}{1 + \frac{K^n}{R}} \right) \quad (1)$$

Where,

$\Delta\theta_{TO}$ - top oil temperature rise over ambient temperature

$\Delta\theta_{TOR}$ - rated top oil temperature rise

K - ratio of the load current to the rated current.

R - ratio of rated load losses to no-load losses.

n – exponent (0.9)

The electrical resistance of a temperature sensor fluctuates as a function of temperature. Both NTC and PTC varieties are available. The resistance in NTC drops as the temperature goes up, however with PTC it goes up as the temperature goes up. The suggested setup makes use of a DHT11 sensor. The temperature measurement range of this sensor is 0 to 50 0C. Humidity readings, which may be anywhere from 20% to 80%, are also captured by this device. The DHT11 sensor's physical hardware is seen in Figure 3.

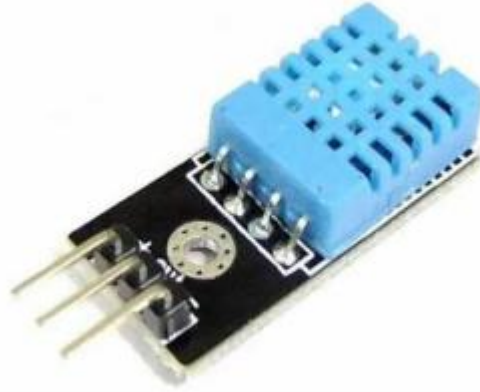


Fig. 3 Temperature & Humidity sensor.

Protecting the transformer from various problems that might arise from overload circumstances is another key element to consider. Voltage and current are the inputs that determine it, thus keeping an eye on those metrics is essential. Current transformers (CT) and potential transformers (PT) are used to measure voltage and current, respectively. In order to measure current, this system makes use of an ACS712 sensor. Figure 4 shows the present sensor. A current of up to 5A may be detected by this sensor. A float sensor was used to monitor the transformer's oil level.

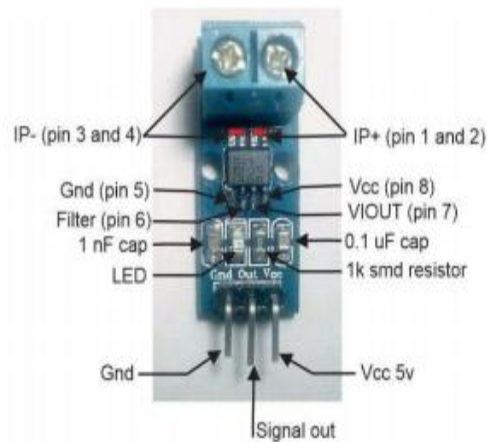


Fig. 4 Current sensor.

B. Output peripherals

The results show that output devices have their advantages and disadvantages. Therefore, the following output peripherals are taken into account in the system that is being proposed:

- 16*2 LCD
- Buzzer
- GSM model
- ThingSpeak Cloud

Figure 5 shows the SIM900A GSM module that would be used in the suggested setup. In addition to a SMA antenna, it can communicate via an RS232 interface. The device operates at a baud rate of 1200 MHz and requires a 12 V power source. A notification about abnormal circumstances is shown by the LCD when utilized with the I2C

converter in this case. I2C enables lower pin count and circuit flexibility. Not only that, but the buzzer type used in this system is straightforward to interface with Arduino and operates on a 3.3 V to 5 V supply.



Fig. 5 GSM Module.

C. Proposed system

Here we can see the suggested real-time monitoring system in action: Table 6. Controllers are the central processing units of IoT systems. Here, data is processed by Arduino and shown on an LCD. Another feature of the GSM model is the ability to detect abnormal conditions and alert authorized individuals to them. The thinkScript cloud allows for the monitoring of data in real-time.

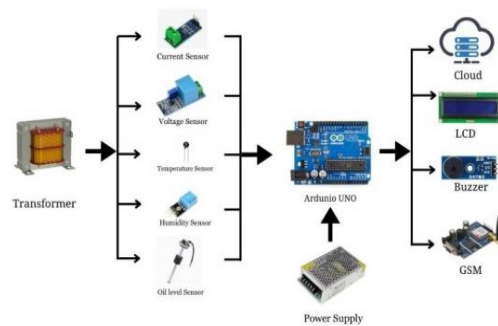


Fig. 6 Block diagram of Proposed system.

Figure 7 shows the algorithm of the suggested system. The properties of the transformer are monitored by a number of sensors. This can only be accomplished when all the sensors have been initialized. The data is processed by a controller once it has been sensed. An Arduino Uno is used for data processing in this system. Both the thinkSprit website and a 16*2 LCD display the data in real-time. The GSM module will provide an alert if the data goes above the predetermined limits. The buzzer adds to that by making a sound as well.

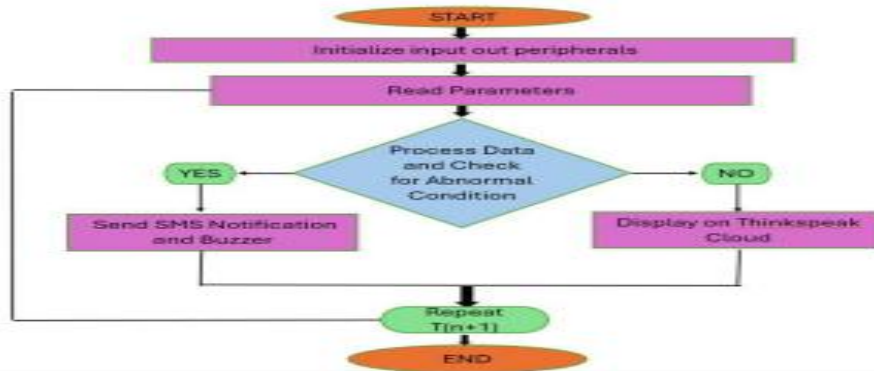


Fig. 7 System performance flow.

A popular microcontroller board based on the ATmega328P, the Arduino Uno is essential to the creation of many projects and research. Figure 8 illustrates it. It has a reset button for starting the microcontroller and a USB connector for communicating and programming. To provide a constant power source, the board has a voltage regulator. It is simple to interact with sensors and actuators because to its fourteen digital input/output pins, six of which provide pulse width modulation (PWM) output and six analog input pins. Also, low-level firmware upgrades are possible via the ICSP (In-Circuit Serial Programming) header. An external reference voltage may be set for the analog inputs via the AREF pin, which improves the accuracy of data gathering. The stability-enhancing board may be powered by an external source or a USB connection, and it comes with built-in power regulation. Onboard LEDs show power status and data transmission activities, while a crystal oscillator provides the clock signal needed for precise timing operations. With its user-friendly hardware and software, Arduino is an open-source electronics platform. Arduino is a free and open-source electronics platform that uses user-friendly software and hardware. This is accomplished by using the Arduino IDE and the Arduino programming language.

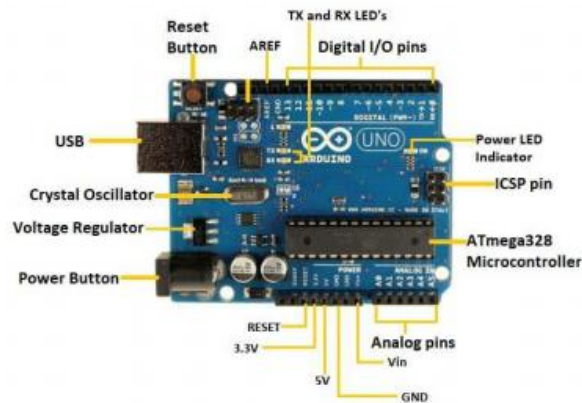


Fig. 8 Arunio Uno.

By keeping an eye on critical metrics, the system is able to do predictive maintenance, which in turn reduces downtime and prevents transformer failures. Transformer operation may be optimized for maximum efficiency by keeping an eye on the power factor and other factors. More versatility and ease are brought forth by the option to remotely monitor the transformer. By analyzing the obtained data, trends and patterns may be found, which opens the door to even more optimization and improvements.

III. RESULT & DISCUSSION

As you can see in Figure 9, the suggested system has a functional prototype. Greater dependability and substantial cost savings are achieved via the use of transformer health monitoring, which helps to detect and diagnose unexpected conditions before to any major breakdown. From any location, we can detect whether the transformer is acting abnormally. To keep an eye on the transformer, no one is required. The website is set up to automatically update any details about the transformer.

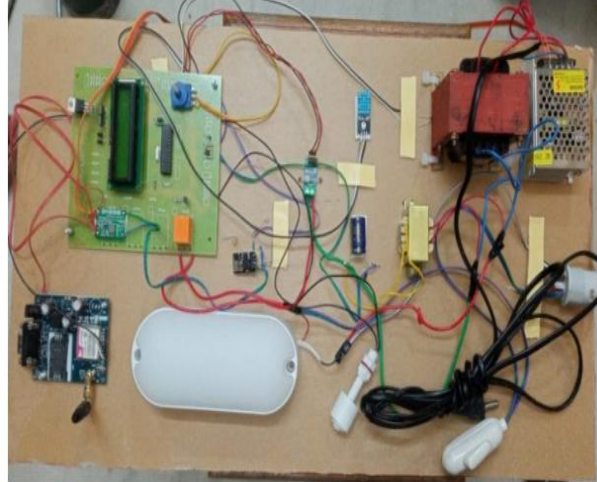


Fig. 9 Hardware of a prototype model.

The data that is detected is continually recorded on the platform called Thingspeak. Figure 10 displays the voltage fluctuation observed by PT, whereas Figure 11 shows the real-time current sensed by CT. Time is shown on the X-axis, while voltage and current are shown on the Y-axis. Anywhere from zero to two hundred and fifty volts is possible. Beginning at around 225 volts, the voltage temporarily peaks at 275 volts before plummeting to 30 volts. After a slow start, it reaches 250 at 14:00 and stays there for the most part, though it does dip somewhat towards the very end. At around 13:30, the transformer's voltage dropped significantly, then gradually increased and stabilized.



Fig. 10 Real-time transformer voltage



Fig. 11 Real-time transformer current

Figures 12 and 13 display the current humidity and temperature, respectively. It is noted that the transformer went through considerable temperature swings, reaching a maximum of 250 0C. At 30 0C, it becomes steady, indicating that the transformer is consistently and reliably operating. The transformer's humidity might be anything from 70% to 80%.



Fig. 12 Real-time ambient temperature



Fig. 13 Real-time humidity of the transformer

The suggested technique is dependable since it precisely measures all parameters. The behavior of the transformer is examined using the acquired data.

IV. LIMITATIONS & FUTURE SCOPE

The scope and constraints of the proposed system are laid forth in this section. B. Restrictions
 What follows is an explanation of the three main drawbacks of the proposed system: • Data transmission: It is very necessary to transmit data continuously in real-time monitoring. The suggested system had data interruptions due to inadequate connection and limited capacity. • Accuracy of the sensors: The sensors are crucial to this system. Because of power outages, their precision is compromised. • The difficulty and expense of integration: this problem arises due to the usage of an outdated transformer. The system's starting price goes up when sensors are included. Section B. Prospects for the Future In order to overcome all of these restrictions, the following are some possible developments in the realm of real-time transformer monitoring utilizing IoT: AI and ML (artificial intelligence and machine learning) may aid in data processing and provide reliable findings in the analysis phase. • Sensor precision: The suggested system may make use of industrial sensors to enhance the precision of the input data. Lastly, to further reduce dormancy and improve the monitoring system's overall efficiency, it may be investigated if advanced computing could be used to allow real-time data processing and decision making.

V. CONCLUSION

Keeping tabs on transformer settings in real time has never been easier than with the suggested technique. Using cutting-edge sensors and Internet of Things technologies, we can monitor oil level, temperature, voltage, and current in real-time. To lessen the likelihood of transformer failures, the suggested approach allows for early identification of any problems, which in turn allows for proactive maintenance. In conjunction with the GSM model, the thingSpeak tool's efficacy in real-time monitoring has been shown. Electricity grids will remain efficient and stable if smart monitoring methods like these are used. To further improve the system's accuracy and responsiveness, future study might investigate adding more factors and using more advanced prediction models.

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