ISSN: 2583-6129
DOI: 10.55041/ISJEM01575

IOT Based Transformer Health Monitoring and Theft Detection

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Abstract

The electrical power distribution systems are supposed to be reliable to ensure continuous power supply to the consumers. The distribution transformer plays a pivotal role for this. Hence the health and working status of the distribution transformer shall be known to the administration authorities. This also helps to determine the requirements of preventive maintenance. In addition to this, the electricity theft is a headache for distribution companies which leads to the financial loss. The companies have come up with antitheft laws and legal actions against electricity theft. However the electricity theft detection in practice is a manual procedure. This paper presents an IoT based technique for transformer health monitoring and electricity theft detection at a distribution transformer. The health detection is carried out to detect the working efficiency with current, voltage and temperature sensors and electricity theft detection is carried out by measuring the transformer secondary current and comparing it with the sum of all the consumers load current. The practical implementation results are discussed in this paper for a prototype model.

Keywords: IoT, Transformer Health Monitoring, Theft Detection, distribution

1. Introduction

Distribution transformers can get overloaded and not frequently inspected for operating temperature, oil level, moisture content produced in the transformer cooling medium, KVA demand. These behaviours typically result in abrupt transformer failures and significant system damage. The researchers plan to create an IoT-based distribution transformer monitoring system that is completely human machine interface capable and does not require human intervention during operation in order to lessen the frequency of transformer breakdowns caused by a lack of monitoring. Since the sensors offer real-time information on the essential states of the transformer, the information provided by the system will be correct [1]. There is intense competition among distribution providers to offer affordable, dependable

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power. According to estimates, transformer replacement and maintenance are costly activities for all businesses [2].

The main reasons why a transformer's health deteriorates include issues like overheating and inadequate heating. To monitor and regulate the entire transformer in an effective and dependable manner, it is important to collect data from the transformer [3]. Due to unforeseen faults that may arise, the safe and healthy operation of transformers in electrical distribution is crucial [4]. Thus, precise fault detection and transformer health monitoring are helpful in minimising equipment damage and its negative effects on the financial loss and dependability of electric power systems. Transformers that are monitored for issues early on may be spared costly maintenance and a shorter lifespan. By using this technique, it is possible to monitor the transformer's condition on a regular basis and take the necessary actions to guarantee that it is maintained correctly [5].

Internet of Things based monitoring systems have been available for a while and are mostly used in industry to track critical performance from remote places [6]. It will enable the transformer's functions, lengthen its lifespan, and offer helpful information on the distribution transformer's condition. After processing, the output data is kept in a database so that mobile applications may be used to see the report. Consequently, different kinds of data from sensors are gathered and analysed over time by an online measuring device [7].

An Internet-based solution (IoT) was presented to enhance distribution transformer control through voltage and current power, oil temperature, file temperature, and silica gel condition using various sensors and Lora WAN technology. Low-power networks like Lora WAN enable two-way Internet traffic (IoT), including massive networks with tens of millions of devices [8].

Apart from the health monitoring of transformer, electricity theft is another headache for electricity distribution companies and a significant attention is being given to this as it leads to direct revenue loss. Energy theft is the illegal use of power or the use of electricity without the electricity board's consent. There are several ways to steal energy, some of which are easy and others of which are hard. It covers things like physically blocking the path, linking up the service lines, tampering with metres, etc. Inverting a metre might also indicate lower power use. The government loses money as a result, and consumers are impacted.In India, one of the main issues is energy theft. Five to ten percent of the power sent is lost during transmission. If this amount of power is lost above what is allowed, energy theft is suspected. Thus, the rates of the power tariff are impacted by energy theft [9].

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Prepaid electricity systems have been adopted to ensure cost-effective operation and prevent issues such as overbilling and metre manipulation. In this case, the customer must buy the units, and they will receive a warning if any of the units are used. The system's drawbacks include restricted power consumption and the consumer's requirement to know the number of units needed, which might change on a frequent basis [10]. Unbalanced load sharing causes energy theft, which lowers efficiency. This is one of the effects that leads to frequent tripping, which damages household equipment [11].

2. Implementation of Health Monitoring and Theft Detection System

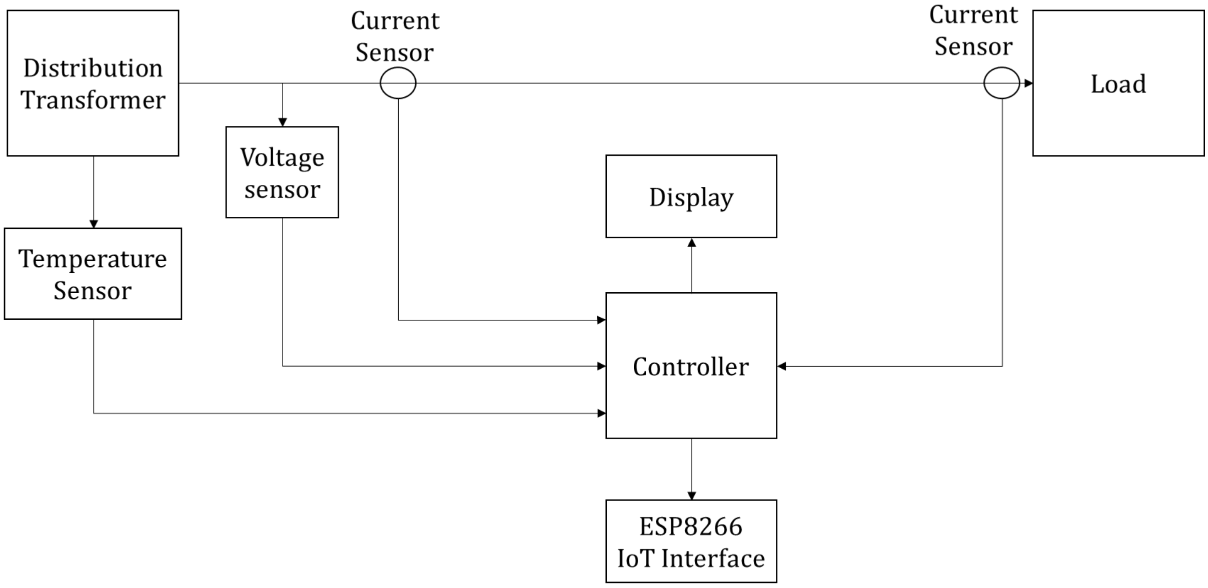

Figure 1: IoT Based transformer health monitoring and theft detection system

The block diagram of IoT based transformer health monitoring and theft detection system is shown in figure 1. The specifications of the prototype model for IoT based distribution transformer health monitoring are mentioned in table 1. In the implemented prototype model, the controller used is Arduino Uno and for providing the interface with IoT, Node MCU is used and programmed to send the data to IoT Channel at an interval of 15 seconds.

International Scientific Journal of Engineering and Management
Volume: 03 Issue: 04 | April – 2024
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata
ISSN: 2583-6129
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Table 1: Specifications of proto type model

Transformer	230/ 24V, 5A single phase transformer
Voltage sensor	ZMPT101b
Current sensor	ACS712
Temperature sensor	MLX90614
Controller	Arduino Uno
IoT Interface	Node MCU
Thing Speak Channel	https://thingspeak.com/channels/2496324

The system consists of distribution transformer equipped with sensors for monitoring temperature, voltage and current. The controller constantly tracks the data of transformer core temperature, voltage and current. By measuring the transformer current, the knowledge about the load on transformer can be obtained and overload condition of the transformer can be tracked. The transformer core temperature rises with increase in transformer losses which typically occurs at overload and abrupt loading of transformer. The voltage output of transformer is monitored to ensure that the transformer meets the voltage regulation requirements and the voltage level falls within the regulation range. The IoT interface with node MCU sends the voltage, current and temperature data to the Thing Speak IoT cloud platform. There the data logging takes continuously at an interval of every 15 seconds and the data is also retained for analysis purpose. The users and administration authorities can take this data in terms of excel sheet which is useful for analysing the loading pattern of the transformer through the day, week, month and year.

In case of the overload, rise in temperature and fall or rise in transformer voltage and alarm is raised locally and on IoT platform for the necessary intervention and corrective actions to be initiated by the monitoring authority.

In case of the electricity theft detection. The transformer secondary current is measured and also the individual load currents are measured. The positive difference between the transformer's secondary current and the summation of the individual load currents is an indicative of the electricity theft occurrence. The photograph of the developed prototype model is shown in figure 2.

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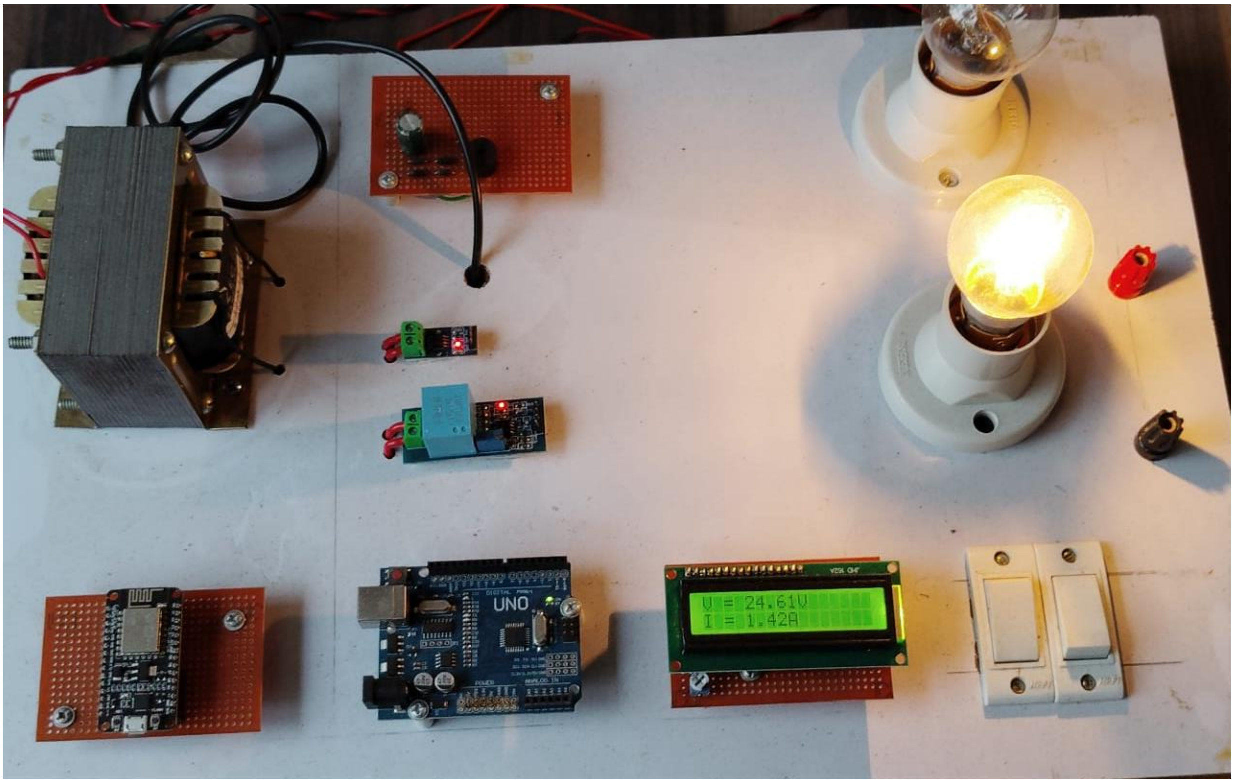

Figure 2: Photograph of the prototype model of transformer health monitoring and theft detection

3. Results

The transformer health monitoring and theft detection system is set into execution and the IoT data on the Thing Speak platform is monitored. The screenshots of the data of IoT channel fields for voltage, current and temperature are shown in figure 3, figure 4 and figure 5 respectively.

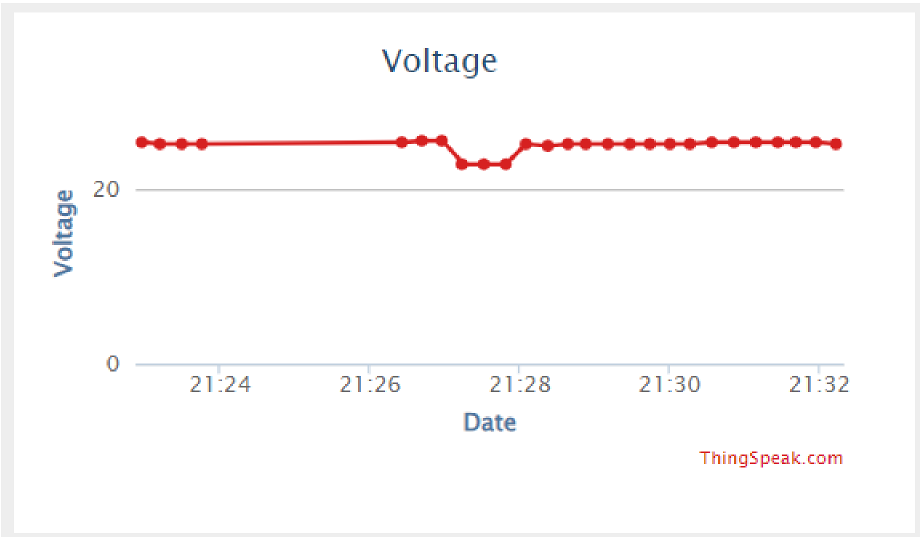

Figure 3: Voltage data on Thing Speak IoT

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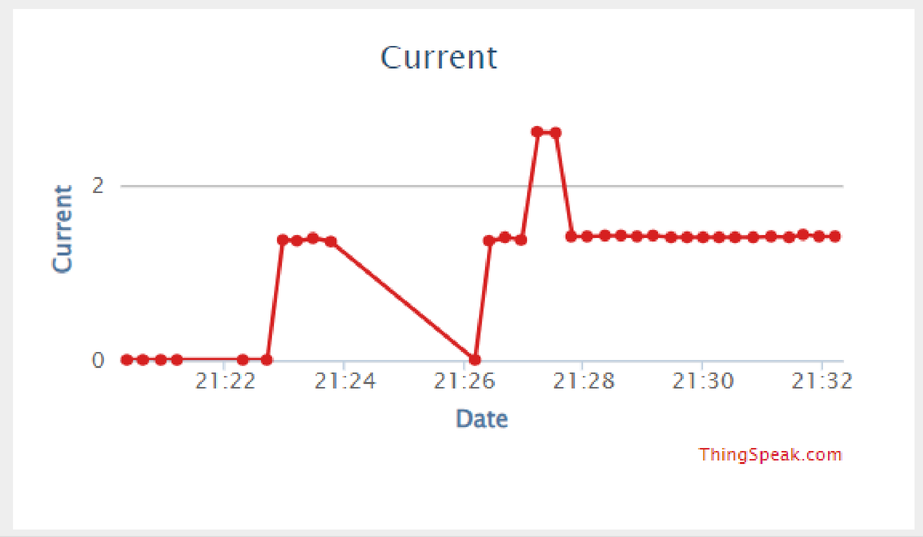

Figure 4: Current data on Thing Speak IoT

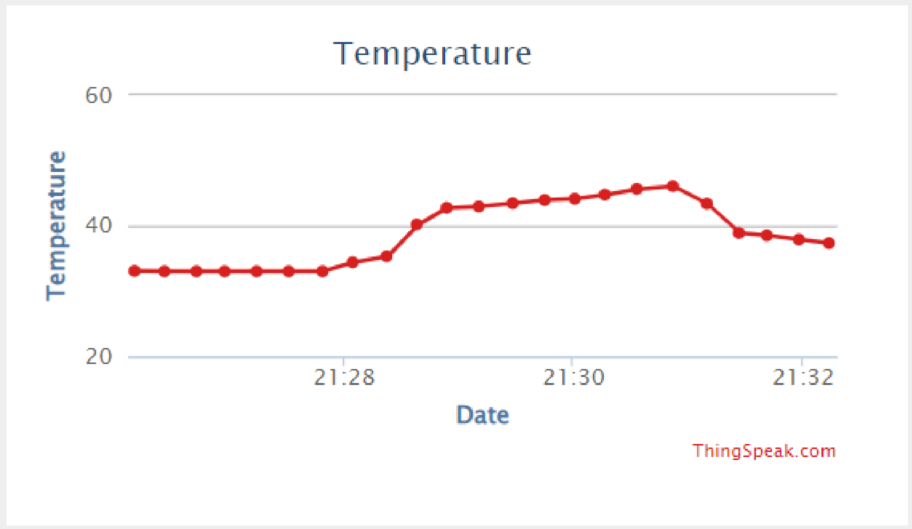

Figure 5: Transformer core temperature data on Thing Speak IoT

When the difference between the transformer current and load current is non zero, the LCD display shows the indication of theft detection and the buzzer alarm is activated. Thus the theft detection alarm is given locally. On the IoT platforms, the indications for electricity theft, voltage fault in terms of overvoltage or under voltage, overload and over temperature are given as seen in figure 6.

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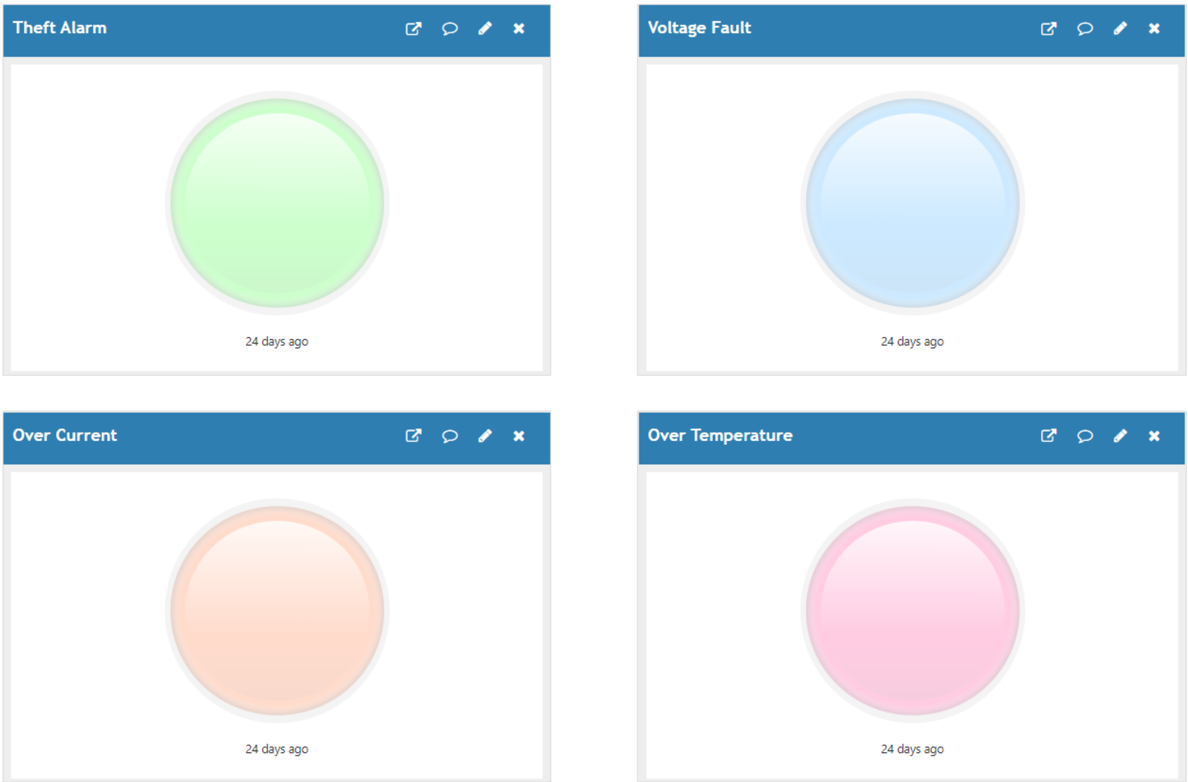

Figure 6: Fault indications on IoT for theft, voltage, current and temperature

4. Conclusion

This paper presents an IoT-based transformer health monitoring and theft detection system that offers significant advantages over traditional methods. Continuous monitoring of critical parameters like temperature, voltage and current allows for early detection of potential problems, preventing catastrophic failures and downtime. By remotely collecting and analysing data, the system enables better planning of maintenance schedules and resource allocation. Early detection of issues helps prevent costly repairs and replacements, while also minimizing power outages and associated revenue losses. The collected data provides valuable insights into transformer health, enabling informed decisions about maintenance, upgrades, and grid management. The current sensing based technique of electricity theft detection can detect the occurrence of electricity theft at distribution transformer. This can be further explored by dividing the actual distribution area into number of plots and be implemented on the basis of subareas monitoring.

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