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Analysis of Distribution Transformer Physiological and Electrical Fault Detection - A Smart Grid Application

Manohar B S[1], Spandana Shashikumar[2], Pruthviraj N[3], Santosh Bati[4], Suhas Gowda C R[5], Varun S P[6]

[1,2,3,4,5,6] Department of electronics and communication, JSSATE Bengaluru, India
Email: [1]manoharbs@jssateb.ac.in, [2]spandana.shashikumar@gmail.com, [3]pruthvirajn.1js17ec081@gmail.com, [4]santoshbati.1js17ec092@gmail.com, [5]suhas.cr2k@gmail.com, [6]varuns.1js17ec121@gmail.com

**Corresponding author's E-mail: manoharbs@jssateb.ac.in*

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Abstract

Power grids transport electricity from the point of generation to the market. Power conversion from HV to LV and vice versa occurs in grids, also known as substations. These substations or power grids can be accessible or situated in remote locations. Transformers are used to convert power; they are an essential part of transmission and distribution networks. The method of grid monitoring and maintenance is essentially a very monotonous one. Monitoring the health of the transformers to maintain an uninterrupted power supply to the customers is difficult in such circumstances. Overvoltage, load currents, oil temperature, transformer oil level, and other parameters are monitored. The condition of the distribution transformer's is evaluated in this article using real-time data from the transformer and specific sensors connected to Raspberry pi and artificial neural networks, are used to analyse the situation and make decisions regarding the health of the transformer. A model has been proposed for continuous monitoring consistent vigilance and swift actions against any faulty situations.

Keywords: *Distribution Transformer, Artificial Neural Network (ANN), IOT, GSM Module, Raspberry pi, Sensors.*

1. Introduction

Power system comprises generation, transmission and distribution system. The power plant generates power that is either step-up or step-down for transmission via a transformer [7]. Transmission lines transport power to various substations. The power is routed through the substation to the distribution transformer, which reduces the voltage to the desired normal consumer ratings.

Power being a fourth basic necessity of mankind, plays a significant role in our daily lives. In today's world, a power delivery utility's primary mission is to provide a reliable power supply at the lowest possible expense and benefit [2]-[5].

Distribution transformers play an important role in an electrical power system by serving commercial and domestic load requirements [3]-[10]. A transformer is a basic electro-magnetic passive electrical system that employs Faraday's law of induction to transfer electrical energy from one value to another. In a circuit, it swaps voltage for current while having no effect on overall electrical power [14]. It accomplishes this by transforming high-voltage power with a restricted current to low-voltage power with a huge current and contrarily. At full load, typical transformer efficiencies range between 96 and 97 percent, with extremely large capacity transformers reaching 99 percent. Transformers have a relatively low cost per KVA output when compared to other electrical machines [9]. Since there are no teeth, openings, or revolving bits, insulating transformers for very high voltages is easy, and the windings can be immersed in oil.

The failure of transformer mainly occurs due to leakage of oil, overloading and unbalanced load [1]-[11]. These are the prominent problems for Transformer failure, majorly in remote rural areas. Monitoring parameters such as current, voltage, and oil temperature and level can help to prevent distribution transformer failure. This has become a difficult task for manual measurement for every single transformer [4].

IOT refers to a broad variety of "things" that are attached to the internet in order to exchange data with other things – IOT software, connected computers, manufacturing robots, and so on. Built-in sensors in Internet-connected devices gather data and, in some cases, operate on it. Example: A smart house that automatically adjusts heating and lighting to a smart grid that scans industrial machines and facilities for problems and then automatically manages to prevent errors [6].

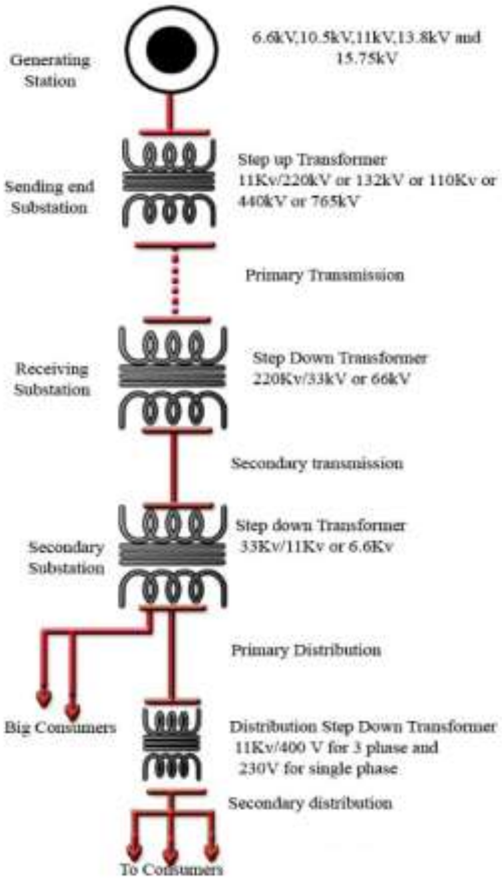

Fig a

Internet of Things (IOT) contributes to the Smart Grid by means of smart metering and other applications. Securing the distribution transformer from different faults due to the connected loads are to be detected by using IOT and the set of sensor data [7]-[8]. Understanding a Transformer's Loading Pattern and, if appropriate, the causes for transformer overloading over time can be aided through data analysis for different parameters obtained by IOT technology. The research would also help in the detection of impending transformer faults and, as a result, transformer preventive maintenance [12]-[13].

Table: Below table represents the real time data of faulty transformer.

DTC No	Fault Location	Capacity	Date of fault	Time of fault	Restoration Time	Replaced DTC No	Replaced Capacity
557	Krishnagarden	100KVA	25/04/2020	2:30pm	5:00pm	558	250KVA
69	BDA, BSK 6th Stage	100KVA	28/04/2020	10:30am	12:30pm	267	250KVA
657	Kengeri Police Station	100KVA	24/05/2020	7:40am	11:10am	20	250KVA
416	Shridharagudda	100KVA	26/05/2020	8:30am	11:00am	51	100KVA
516	Krishnagarden	250KVA	14/05/2020	6:30pm	9:00pm	515	250KVA

Table a

LITERATURE SURVEY

[1] A Remote Terminal Unit (RTU) and a control unit are the two systems used in this project. Using the PIC 18F4550, RTU analyses current, temperature, oil level increase and fall, vibration, and

humidity. If an abnormality happens, the device sends out alert messages to cell phones and saves the data in the system memory via ADC. The monitoring node receives all of the parameter values via GPRS. The buzzer on the remote terminal device will sound, and an LCD panel will display emergency information. The buzzer on the remote terminal device will sound, and an LCD panel will display emergency information.

[2] The author explains the design and construction of a mobile embedded computer that uses an on-line measuring system consisted of a single chip Arduino microcontroller and sensors to estimate load currents, over voltage, transformer oil level, and oil temperature. The sensor data is analysed and kept in the device's memory. To search for irregular conditions, the system is programmed with some predefined instructions. Via serial communication, information is automatically updated on the internet.

[3] This paper's author suggests a fuzzy logic approach for measuring and diagnosing distribution transformer conditions. The proposed scheme would aid in the detection of internal delivery transformer faults as well as the diagnosis of faults using a set of parameters. The health of the transformer is tracked based on the O/P of these parameters, and decisions are made about whether to keep it operational or call it in for repairs.

[4] Using monitoring software, the WIFI module and the ARDUINO circuit designed with PROTEUS software are related. Temperature, oil level, voltage, current, and other parameters are monitored using an ARDUINO Microcontroller board. Installing server modules at all distribution transformers to capture and archive transformer parameter info on a regular basis in a software programme.

[5] The installed system is connected to a distribution transformer, and it may capture and transmit data regarding unusual operating parameters to a mobile device over a GSM network, according to this study. The time it took to react to the SMS message varied between 2 and 10 seconds due to public GSM network traffic.

[6] The work primarily focuses on obtaining real-time data from a transformer through IOT. The transformer's temperature, voltage, and current are measured using accurate sensors. ADC 0808 multiplexes these three analogue values and connects them to a programmable microcontroller from the 8051 series. The data is transferred immediately to the WiFi module through TCP IP protocol to a specific IP address, where it is presented as a real-time chart in any web-connected device.

[7] This paper introduces an implementation that uses the internet to obtain the real-time state of a distribution transformer, thus implementing IOT. The proposed device monitors voltage, current, and temperature in real time using a potential transformer, current sensor, and temperature sensor. This data is sent to a remote server, where it can be tracked and appropriate action taken to prevent an interruption of electricity supply.

[8GSM-based distribution transformer monitoring is more convenient and efficient than manual monitoring because it is impossible to manually follow the oil level, temperature increase, load current, voltage, and theft. When the transformer fails, the GSM module sends a message to the cell phone. We can get the machine back up and running in a shorter amount of time. Regularly monitoring the transformer's health is not only cost-effective, but it also increases its efficiency.

[9] In this paper, a microcontroller-based device is developed that can track over-current, over-voltage, transformer temperature, and transformer oil level. To pass data from one stage to another, the ESP8266 modules are used. Data transmission has a time interval of less than a second between the transmitter and receiver. The distribution transformer is extremely stable and effective thanks to this method.

[10] The online management system coordinates a Wi-Fi modem, an autonomous single chip microcontroller, and a number of sensors. The ADC of the installed system is used to record voltage, current, and temperature. The collected variables are prepared & stored in framework memory, which Lab VIEW can reach at any time.

[11] The design and development of a microcontroller-based device capable of wirelessly detecting the voltage, current, and temperature of a distribution transformer. The developed product uses XBEE modules to transport data from one step to the next. Where some abnormality is detected, prompt steps should be taken to avert a transformer malfunction that may be catastrophic. This increases fault prediction speed and, as a result, reduces transformer downtime.

[12] Transformer parameters such as temperature, current, voltage, and oil level are monitored. TCP / IP protocol will be used to send these data over the internet. In the event of a power outage, the user will receive an alert message via the GSM module. It also has a one-of-a-kind feature that detects phase

failure. If any phase develops a flaw, an LED on the development board will indicate it. In an android application, these parameters will be displayed.

[13] The Arduino microcontroller synchronises the GSM and IOT. The Arduino UNO microcontroller is a high-speed, low-cost, high-accuracy system that can be programmed to continuously track the transformer with an LCD screen module display. The parameters information is displayed in the LCD module, such as voltage, current, and temperature, and this information is sent to the user via the GSM sim 800 module.

Table: Analysis of the Health Condition Monitoring of Distribution Transformer.

Ref. No	OBJECTIVE	AUTHORS	YEAR	OBSERVATION
1	The Internet of Things is being used to monitor distribution transformers (IOT)	Rohit R. Pawar, Piyanka A. Wagh, Dr. S.Deosarkar	2017	GSM/GPRS module and PIC 18F455is Microcontroller are used in this framework.
2	Real Time Transformer Health Monitoring System using IOT Technology	V. Sanjeeya, E. Ramyashankari, M. Sakthi Kannan, A. Vidhya	2018	IoT system with Arduino microcontroller and sensors on a single chip The sensor output values are processed and saved in the device memory.
3	Health Index Based Condition Monitoring of Distribution Transformer	Gajanan Jaiswal, Makarand Sudhakar Ballal, D. Tutakne	2016	This paper explains how to use Fuzzy Logic to track and diagnose the status of a Distribution Transformer.
4	Distribution Transformer Monitoring System Using Internet of Things (IOT)	Ms. Varsha Petkar, Prof. Sachin Wadhankar, Mrs. Meera Joshi	2019	Arduino Microcontroller board is used to Monitor the parameters like temperature, oil level, etc.
5	GSM and IoT-based real-time transformer health monitoring system	M. Sudalaimani, P. LakshmiPriya, J. Pooja, M. Vigneshwari	2019	The GSM modem is replaced by a standalone single chip Microcontroller and sensor bundles in the device.
6	IoT-based real-time transformer health monitoring system	D. Sarathkumar, Uvaraj.M, Kalaiselvi A Kabilesh Kumar C V,	2018	In multiplexing mode, the analogue values of the Transformer are taken and connected to the Microcontroller via an ADC before being sent to a Wi-Fi module.
7	Transformer Health Monitoring System Using Internet of Things	Divyank Srivastava, M.M. Tripathi	2018	The results of this module are shown on the on-board LCD as well as on the internet via the GSM module.
8	Transformer Monitoring And Controlling with GSM Based System	Mr. Namrata, S. Kumbhar, Ms. Shital S. Patil Ms. V. A. Patil	2017	Arduino controller is used to develop a system for Monitoring Distribution Transformer and GSM module sends SMS to operator.
9	Transformers Monitoring using Arduino	Tejas Patil, Onkar Sakpal, Omkar Tupe, Saurabh Tiwari	2020	It is Microcontroller based system. The ESP8266 module is employed to transfer data from one point to a different.
10	Analysis of Distribution Transformer Health Monitoring and	Mohammad Riyaz, Ravi Agarwal, Sanjiv Kumar	2018	A Wireless-Fidelity (Wi-Fi) modem, an independent single-chip microcontroller, and a

	Protection using Arduino			range of sensors are all coordinated by the online monitoring system.
11	Transformer Wireless Monitoring System using Arduino/XBEE	Amevi Acakpovi, Issah Babatunde Majeed, Chiedozie Odazie, George Eduful, Nana Yaw Asabere	2019	An Arduino board and an XBEE module used to monitor Voltage, Current, and Tempareture on a Power Transformer.
12	Transformer Health Monitoring System using IOT and GSM	Ammuthaelakkiya. K, Kavipriya. N, Kayalvizhi. J, Renukadevi. R, L. V. Revathi	2019	For continuous monitoring of transformer parameters in order to detect faults, an embedded mobile and IOT framework was developed and implemented.
13	Industrial Protection of Transformer using Arduino with GSM and IOT System	Manishay. Nikwade, Prof. Sumera Ali, Dr. Ulhas B. Shinde	2020	The system operates with GSM module based hardware and Arduino based control system is used for fault identification.

Table b

PROPOSED SYSTEM

The proposed system is about acquiring real time status of Transformer health parameters. Parameters acquired with a current sensor, voltage sensor, oil level sensor and temperature sensor can be used to assess physiological and electrical faults. Analog to Digital Converter ADC connects these sensors to the Raspberry Pi processor.

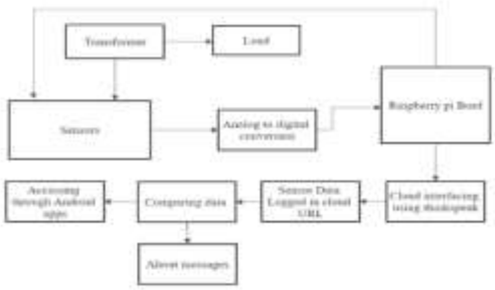

Fig b: Block diagram of proposed model

The ADC collects real-time data from the sensor, which is then transmitted to the Raspberry Pi through the Serial Peripheral Interface (SPI). The obtained voltage and current values are used to locate faults such as sag and swell. The temperature sensor, on the other hand, measures the temperature of the transformer body. The amount of coolant in the tank is measured and addressed. The real time data of all the sensors are uploaded to cloud. The data stored in cloud can be accessed and fault condition is detected using artificial neural networks. The notification to the operator is sent through the mobile app, mail and message. The responsible authority can access information on any power failure or maintenance. The live tracking of these all parameters can be done using IOT technology from anywhere around the world.

2. Materials And Methods

Fig c: Flow chart of proposed model

Objectives

1. The physiological faults like the temperature and coolant level in the coolant tank is to be continuously observed for un-interrupted power supply to the residential loads.

2. Maintaining the voltage level to be in the acceptable range is of prime importance whether it increases or reduces. Sag and swell in the voltage levels needs to be found by the controller.

3. Voltage sensor, Current Sensor, temperature and level sensors are used along with Raspberry Pi to obtain the fault detection.

4. Fault detected is intimated to the operator through the messages and mails.

4. Conclusion

Because it's very difficult to manually track all of the critical parameters all of the time, IoT-based distribution transformer monitoring is more efficient and accurate than manual monitoring. The transmission of real-time data from the distribution transformer to the IOT network is of particular importance. The main benefit is continuous distribution transformer monitoring and timely warnings to ensure rapid rectification of the abnormality, reducing the difficulty of distribution network troubleshooting and assisting in providing continuous power supply to customers. The IOT based framework will result in receiving alerts for any violation of the predefined conditions, so that it will be easier to pinpoint the fault which prevents dangerous failures in the distribution transformers.

Referring to table a it is noted that the time gap between fault detection and restoration is around 3-4 hours whereas our designed system minimizes this time gap and improves the fault detection and restoration process and makes it more efficient.

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