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An intelligent system to detect faults and condition monitoring in transformers

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Abstract
Operating power transformers frequently experience winding deformation as a result of different internal and external factors. Because of the democratic nature of winding deformations, it is important that they be identified and repaired as soon as they appear. Analyses of frequency response that are conducted offline is currently the only effective method for finding these issues. This study presents a method for monitoring voltage and current levels within a transformer in real time to detect approaching winding deformations. The live state of the transformer can be checked using this approach utilizing inexpensive and easily accessible sensors.

Keywords: Transformers, faults, transformer fuzzy logic, fault detection, sensors

1. Introduction
A system for supplying electricity is made up of a producing station, transmission lines, and distribution network. Three-phase alternators running in parallel produce electricity at generating stations. An interconnected network of electric grids is utilized to carry the power from the point of generation to the final consumer. High-voltage transmission lines, distribution lines, and a countable number of producing stations make up the electric grid network. Aware that the power loss experience will be greater when low-voltage power is transmitted over a long distance.

The voltage sensing unit and the current sensing unit are the system's two primary input components. Both of these devices continually check the voltage and current levels of the transformer. These devices transmit their output values to a microcontroller, which compares them to a set of values. It is also critical to keep an eye on the transformer's condition. To do this, many sensors are integrated with the controller to monitor the live state of a transformer. A temperature sensor measures the amount of heat produced in a transformer, an oil sensor measures the amount of insulating oil, and a smoke sensor measures the number of gases produced in a transformer.

2. Related works
Early defect identification can help prevent transformer failure since they are crucial parts of electrical power networks. The bulk of failures in a transformer is caused by inter-turn faults. Thus, this study presents an efficient search coil-based method to identify inter-turn faults. These induced voltage searching coils may be utilised to investigate the possibility of any impending faults and to assess the symmetrical nature of the leakage flux pattern. This technique can also be used to locate faults. This article also provides design estimations for the 1kVA, 440/440, Delta-Star distribution substation which was the topic of the research and was found by K. Kamal Sandeep, Lokesh Y. Sonwane, and Pramil Wakchaure in [1] was cited in this article.

Although there is a link among dissolved gas analysis (DGA) in transformer oil and immature faults, the reasons for this association are not well understood, despite the fact that this correlation does exist. There are many methods to evaluate DGA data; Some standards apply individual gas restrictions, while others employ key gas ratios or ratios of essential gases (such as Rogers). In order to "take care of" each fault-specific transformer, this work has addressed how everyone may face the hurdles in actual scenarios and offers expertise garnered from using DGA diagnostic procedures. This is distinct from the many articles on the topic that have been provided About the several ways that DGA interpretation may be done that are at the disposal for the early discovery of flaws.

One important lesson to remember is that the DGA signature is effective at identifying a variety of transformer faults that are just beginning to manifest themselves when properly applied. When a transformer should be taken out of service for the purposes of repair or replacement; (2) Understanding the strengths and weaknesses of the transformer design, along with knowledge of previous operations and maintenance; and (3) Applying this practical knowledge to reduce the chance of malfunction and the requirement for maintenance. John Lapworth, Richard Josebury, Andrew Roxborough, Hongzhi Ding, Richard Heywood, and Elaine McCulloch all spoke about this in [2].

In the current electric power system, the power transmission and transformation devices' defect detection systems use a signal feedback mechanism. Numerous pieces of equipment are under the supervision of each monitor station. Workers are given fault information by having it shown on the screen. Important defect information will be lost due to the high rate of prompt message refreshes and the protracted decision-making process.

This provided a solution to the problem by building a transformer fault detection system utilising a rule-based programming technique. The system was based on the defective identification of the transformer during the distribution and converting of electric power. This technology can aid employees in fault information analysis and corresponding action. It created a business rules management system to enable users to autonomously maintain business rules bases. This research demonstrates that a rule-based technique may be used for fault identification and significantly lessens worker load. Users are capable of autonomously maintaining the rule base, as shown by the creation of a rule administration system. According to Tao Guo, Gang Zhang, and Jiejun Liu's assertions in [3], if the system creates an accurate description of conflicts in the rule base, it will be able to readily identify the existence of conflict rules.

One of the most common failures in transformers is an inter-turn winding fault, which, if not promptly identified, can progress to a significant fault and do the transformer serious harm. The implications of leakage flux variation under the circumstances of an inter-turn winding failure are investigated in this work. The behaviour of the transformer with inter-turn winding faults is examined using such a time-stepping finite element simulation of a three-phase transformers with real dimensions (TSFEM).

Four search coils are mounted on the transformer's HV windings for the experimental measurement of leakage flux, and their frequency spectra are analyzed. For various inter-turn fault and transformer operation scenarios, search coil signature analysis is retrieved. The findings show that leakage flux analysis is a useful and reliable technique for identifying transformer inter-turn problems. M. Milad Hosseini Ahmadi, Salman Hajiaghasi, Z. Rafiee, and Ahmad Selemnia provided an explanation for this in [4].

Short circuit failures between turns are one of the main reasons power transformers fail. Electricity engineers face a difficult challenge in trying to find these defects at an early stage. These developing faults would become more serious defects that would cause harm to the transformer if they were not discovered when they were first present. In this study, MATLAB/SIMULINK software is used to create a simulation of a 100 MVA, 138/13.8 KV multi-winding power converter in a power system.

The principal and secondary sides of an inter transformer are short circuited in order to measure the terminal current at various turn percentages, including 1%, 3%, 5%, 10%, 15%, and 25%. When a fault (inter-turn fault) occurs, the terminal current changes very little. Negative sequence currents may be recovered and go through considerable alterations when a symmetrical component technique is used. The percentage changes in the magnitudes of negative sequence currents and their related phase shifts that occur in the transformer over the course of the fault incidence period are calculated with the use of fuzzy logic. This is done so that the results may be more accurate.

In this particular instance, fuzzy logic is used in order to both monitor the condition of the transformer and boost the sensitivity of the recommended scheme. As inputs, fuzzy logic receives the values for the variables %MAG and PS. The inputs are each given one of three membership functions—low, medium, and high—based on the data that was obtained. In light of the understanding provided by the system behaviour, nine fuzzy rules are used to construct a fuzzy inference engine. Here, the centroid calculation approach is used to carry out the defuzzification process. The Transformer condition output variable has three possible values: "incipient fault," "minor fault," and "severe fault." M. Sushama and K. Ramesh revealed this in [5].

3. Existing system

According to the statistics, the most common cause of failure for the current fleet of power transformers situated all over the world is winding distortion. The power transformer needs to be disconnected before testing can begin in order to make use of the current traditional technique for identifying transformer winding deformations. These methods include sweep frequency response analysis (SFRA), short-circuit impedance (SCI), and low-voltage impulse testing (LVI). The key difference between the approach that has been presented and others is that the V-I technique can be executed online and does not call for any specialised equipment or sensors since it makes use of the metering devices that are already integrated into the power transformer.

4. Proposed system

The proposed methodology measures the voltage and current in the transformer continuously. These units send their output values to a microcontroller, which compares them to a specified range of values. Through the Internet of Things, the central monitoring unit is updated with both the output values and the comparison result (IoT). A warning will be issued in the central unit if the output values slightly exceed the predetermined range monitoring the transformer's condition is also crucial.

In order to process, a few sensors are built into the controller to track the transformer's live status. A temperature sensor measures how much heat is created in a transformer, an oil sensor measures how much insulation oil is present, and a smoke sensor measures how often gas is produced in a transformer.

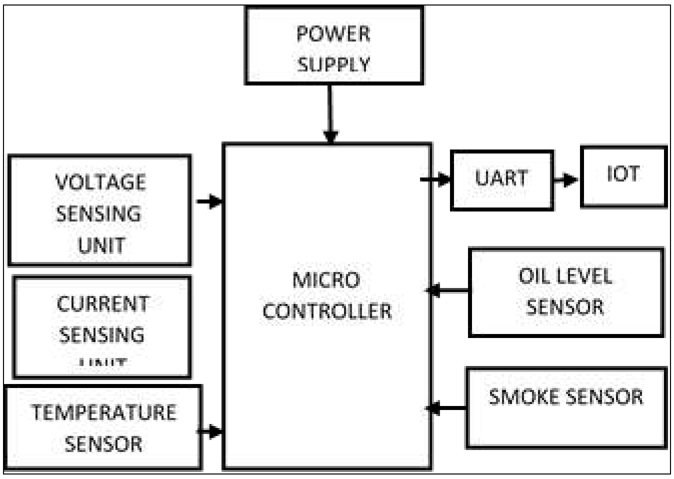

Fig 1: Block Diagram of Transformer monitoring system

Microcontroller: The affordable ESP32 System on Chip (SoC) Microcontroller is made available by Espressif Systems, the same firm that was responsible for the development of the well-known ESP8266 SoC. The 32-bit Xtensa LX6 Microprocessor from Tensilica may potentially take the role of the ESP8266 System-on-a-Chip (SoC). This processor also has built-in support for Wi-Fi and Bluetooth. There is a choice between a single-core and a dual-core model of it.

Temperature sensor: The accurate IC temperature sensor LM35 has an output that is proportional to the temperature of the surrounding environment (in 0C). Because the sensor circuitry is hermetically sealed, it is protected from oxidation and any other processes that may affect it. When compared to a thermistor, the LM35 is capable of providing a more precise reading of the current temperature. Furthermore, it has very little self-heating and boosts the temperature of still air by no more than 0.1 C. The component may be powered by a single supply or by both positive and negative sources simultaneously. Due to the fact that it draws less than 60 microamperes from the supply, the LM35 device has an exceptionally low level of self-heating, which registers at less than 0.1 degrees Celsius even when the air around it is motionless. The LM35 device can function in temperatures ranging from 55 degrees Celsius to 150 degrees Celsius [7].

DC voltage sensor: In addition, it has a very low capacity for self-heating and contributes no more than 0.1 degree Celsius to the increase in temperature of the air around it. The component may be composed of a single supply or by both positive and negative sources simultaneously. Due to the fact that it draws less than 60 microamperes from the supply, the LM35 device has an exceptionally low level of self-heating, which registers at less than 0.1 degrees Celsius even when the air around it is motionless. The LM35 device can function in temperatures ranging from 55 degrees Celsius to 150 degrees Celsius [7]. It's possible that the primary connection is built right inside the sensor. Insulation against galvanic current between the main and secondary circuits as well as pulsing voltage [8]. When a voltage that is more than the limit is detected, the voltage detector will provide an alert. The inclusion of a microprocessor in the Voltage Sensors results in significant enhancements to the accuracy, precision, and reliability of the data provided by the sensors. They are sent to you already calibrated, and the calibration that has been saved (in Volts) is instantly imported whenever you attach the Voltage Sensor.

Current sensor: The component consists of a linear Hall sensor circuit that is precise, has a low offset, and has a copper conduction channel that is positioned in close proximity to the surface of the die. Additionally, the component has an exact offset value. The central Process IC derives an approximation of the proportional voltage from the magnetic field that is produced as a result of the applied electricity moving across this copper conduction line. The accuracy of the device is improved by the closeness of the magnet signal to the Hall transducer. The precise and proportional voltage is produced using a limited, chopper-stabilized BiCMOS Hall IC that is optimised for reliability after packing. The output of the gadget will be shown. a positive slope indicates that a rising current is capable of passing through all of the principal copper current flowing pathways that are utilised for current sensing.

GAS sensor: The MQ-8 gas sensor, a measuring electrode, a heater, and a sensitive layer for tin dioxide (SnO2) are all connected to one another by a crust made of a plastic and stainless steel netThe MQ-8 gas sensor is extremely susceptible to hydrogen gas despite its anti-interference qualities and the fact that it is particularly sensitive to hydrogen gas [6]. There are six pins on the wrapped MQ-8, two of which are utilised to provide heating current and the other four are used to collect signals. The MQ-8 gas module is installed on a PCB board that runs on a voltage of 5VDC and has an operational voltage. Both analogue and digital methods may be used to get the sensor's output values.

Oil level sensor: The use of level sensors allows for the detection of a wide variety of flowing materials, including liquids, slurries, granular solids, and powders. The thing that is going to be measured can be in its natural condition, or it might be contained in something. Both continuous and point value measurements are viable options for level assessment. Continuous-level sensors detect the degree of a system based on the tolerance that is defined and calculate the precise concentration of a chemical at a specific point [9]. While continuous-level sensors are capable of recognizing levels that are much above or below the sensing point, point-level sensors can simply show if the substance is above or below the detecting point. It is extremely crucial to choose a kind of sensor that is suited for the application and meets the requirements.

16×2 LCD: This LCD was developed specifically for use with E-blocks. It is a single 9-way D-type connection that is attached to an alphanumeric LCD that has 16 characters over two lines. Because of this, it is possible to connect the device to the majority of the E-I/O Block's ports. The LCD needs the data to be in a serial format, which is described in more depth in the user guide that can be found below. In addition, the display calls for a power source that is 5V. Either the E-blocks Multi programmer or a 5V fixed regulated power supply is ideal for generating the 5V that is required. The 16 x 2 smart alphanumeric dot matrix panels are capable of displaying a wide variety of letters and symbols, totaling 224 in total.

IoT: The term "Internet of things" (IoT) refers to a network that is made up of everyday objects that have been modified with electronics, software, sensors, and network connections in order to make it simpler for data to be sent between the objects in the network. Lantern glows, home appliances, flower pots, smartwatches, fans, planes, trains, vehicles, and anything else in your surroundings may all be controlled by a small networked computer if it is linked to the item. This allows information to be sent to and from the thing. It may be used to either take input (particularly control of an object) or to collect and create informative output (usually object status or other sensory data) [10].

5. Conclusion

The model was developed in such a manner as to provide a solution to the issues that were being experienced by the customer. By using such an approach, it is simple to identify the issue and find a solution to it. It has a very high level of dependability, can determine where the problem is in a three-phase transmission line, and is also designed to store data. It operates in real time, allowing us to keep track of all datasheets and ward against any issues with the transmission line in the future.

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