Monitoring and Controlling Of Distribution Transformer via Wireless Sensor Networks for Power Transformer Asset Management

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Abstract— Distribution transformers are one of the most important equipment in power network. Because of, the large number of transformers distributed over a wide area in power electric systems, the data acquisition and condition monitoring is a important issue. Here transformers are damaged due to the oil damage. Oil damage is depends on different parameters and environmental conditions. Now in this system we are concentrating on temperature of transformer and oil tank level. In this system temperature and oil level monitoring and control action is performed based on the AVR microcontroller. After interfacing the required components user has to develop one application program in embedded-c. Here controller is continuously reading the temperature and oil level, and display on the LCD and PC via ZigBee transceiver along with the set point. Hence the chance of damage can be prevented. This will result in high efficiency and long life of transformer, more than that the safety and reliability of the electrical power system will ensure.

Keyword:Asset management, power transformer, insulation, fault analysis.

I. INTRODUCTION

Transformer plays important role in power transmission network. There are different kinds of transformers such as two winding or three winding electric power transformers, auto transformers, regulating transformers, earthing transformers etc. so the protection of transformer is a necessary thing. In order to maintain the proper working of transformer, the transformer should be provided by supporting conditions and parameters like discharge capacity, insulation etc. The main objective of the project is to protect the transformer from any kind of damage and at critical situations the automatic shutting of transformer. Additionally the oil level of the transformer will be monitored online and during insufficiency period the oil will be filled automatically. Power transformer is one of the most important assets in an electricity grid. During its operation, a power transformer is subjected to thermal, mechanical, and electrical stresses, which can eventually deteriorate the transformer and cause the failure of the whole unit. Moreover, electrical utilities around the world are currently facing an increasingly aged population of power transformers in their grids. To ensure reliable operation of a transformer, its health condition must be continuously monitored and evaluated for appropriate asset management decisions [1]–[4].A variety of measurements has been adopted in utilities for condition monitoring and assessment of power transformers [5]–[10]. Transformer is the key equipment in power system, to ensure its safe and stable operation is important. Transformers either raise a voltage to decrease losses, or decreases voltage to a safe level. "Monitoring" is here defined as on-line collection of data and includes sensor development, measurement techniques for on-line applications. It is very difficult and expensive to construct the communication wires to monitor and control each distribution transformer station. Here ZigBee is used for communicating the monitored parameters. The failures of transformers in service are broadly due to temperature rise, low oil levels, over load, poor quality of LT cables, and improper installation and maintenance. Out of these factors temperature rise low oil levels and over load, need continuous monitoring to save transformer life.

Due to the complexity of a transformer's structure and its degradation mechanism, interpreting the measurement data obtained from the above techniques and subsequently evaluating the

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transformer's condition is a challenging task, especially for nonexperts. Therefore, there is a necessity to investigate intelligent techniques and their applications for automatically analysing measurement data and have been reported in [11]–[15]. For example, numerous artificial neural networks (ANNs), neural-fuzzy systems, and evolutionary algorithms have been applied for diagnosing transformer incipient faults using DGA measurement data [11]–[13]. Recently, intelligent algorithms have also been applied to compute health index for a transformer to provide an indication of the status of its insulation system [14]–[16]. Nevertheless, the above techniques scattered over different aspects of interpreting measurement data and making faults diagnosis; there is still lack of a common framework, within which different intelligent algorithms can be effectively deployed and executed to fulfil the tasks of performing sensor-based transformer condition monitoring and assessment.

II. BLOCK DIAGRAM DESCRIPTION

The proposed system described with the help of a block diagram and its flow of operation. Transformers plays a crucial role in the power distribution network and any failure creates disruption of power supply to consumers and the extent of effect depends upon the rating of transformers. With the increase in the market competition, it has been observed that the safety margins of the distribution transforms have been brought down to bare minimum, just sufficient to satisfy standard specification and ideal loading conditions. As a result users have been put to constrain of running the plant within the specified capacity throughout the year.

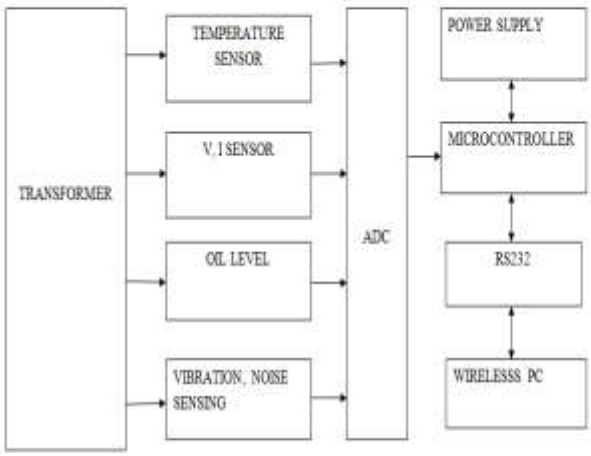

Fig.1.Block Diagram

In this system temperature and viscosity monitoring and control action is performed based on the AVR microcontroller. After interfacing the required components user has to develop one application program in embedded-c. Here controller is continuously reading the temperature and viscosity, and display on the LCD along with the set point. Set point is saved in the external memory. If current value is crossing the set point then one alert message is sent to the control room via ZigBee transceiver which is mentioned in application program. If user wants to change the set point he has to send one predefined message format to the ZigBee which is placed in the transformer section. Then controller is reading that message and if it is in the valid format then it is updated to the external memory. Now control action is based on the new set point. Here set point is saved in the external memory so even power is gone set point will not change. From the block diagram it can be seen that the transformer is connected with the four sensors like temperature sensor, voltage and current sensor, oil level sensor and vibration or noise sensor. The sensor characteristics are given in the module description given below. The sensors will be directly given to the ADC for analog to digital conversion. The microcontroller used here is ATMEGA 8A and interface is RS232. Zigbee is used for the communication purpose.

2.1 TEMPERATURE SENSOR

These sensors use a solid-state technique to determine the temperature. That is to say, they don't use mercury (like old thermometers), bimetallic strips (like in some home thermometers or stoves), nor do they use thermistors (temperature sensitive resistors). Instead, they use the fact as temperature increases, the voltage across a diode increases at a known rate. Technically, this is actually the voltage drop between the base and emitter of a transistor. By precisely amplifying the voltage change, it is easy to generate an analog signal that is directly proportional to temperature. There have been some improvements on the technique but, essentially that is how temperature is measured. Because these sensors have no moving parts, they are precise, never wear out, don't need calibration, work under many environmental conditions, and are consistent between sensors and readings. Moreover they are very inexpensive and quite easy to use.

2.2 OIL LEVEL SENSOR

All oil immersed distribution andelectrical power transformers are provided with expansion vessel which is known as conservator of transformer. This vessel takes care of oil expansion due to temperature rise. When transformer insulating oil is expanded, the oil level in the conservator tank goes up. Again when oil volume is reduced due to fall in oil temperature, the oil level in the conservator goes down. But it is essential to maintain a minimum oil level in the conservator tank of transformer even at lowest possible temperature. All large electrical power transformers are therefore provided with an oil level indicator or oil gauge. In conventional conservator tank, a light weight hollow ball or drum floats on the transformer insulating oil. The float arm is attached with bevel gear as we already explained during the discussion on the construction of magnetic oil gauge. Naturally the position of the float goes up and down depending upon the oil level in the conservator and consequently the alignment of floatarm changes. Consequently, the bevel gear rotates. This movement of bevel gear is transmitted to the pointer outside the conservator, as this pointer is magnetically coupled with the bevel gear. The pointer of magnetic oil level indicator is also incorporated with a mercury switch. So it is need not say, when oil level in the conservator goes up and down, the pointer moves on the MOG dial to indicate the actual level of

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transformer insulating oil in conservator tank. As the alignment of mercury switch changes along with the pointer, this switch closes and actuates an audible alarm when pointer reaches near empty position on the dial of magnetic oil gauge. This event alerts us for topping up oil in electrical power transformer.

III. SIMULATION CIRCUIT AND RESULTS

The work is done in MATLAB Version 7.12.0(R2011a). The Image processing toolbox is made use of for the work.MATLAB (matrix laboratory) is a paradigm numerical environment and fourth-generation programming language. A proprietary programming language developed by Math Works, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs.

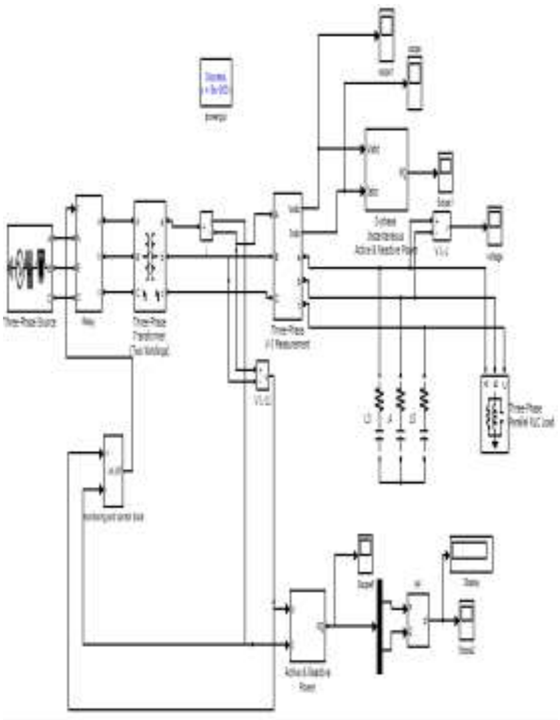

Fig.2.Simulation circuit diagram of transformer monitoring

The simulation circuit of the monitoring of the transformer is shown below. The diagram shows the working of transformer which is connected with the three phase supply. Here the transformer is monitored with the help of the monitoring and control block. Here the temperature, oil level, vibration sensor blocks are given with the fault values and one threshold value is given. When the simulation is run the output will show with the on condition and off condition that indicates at fault condition the voltage will be tripped automatically.

In this circuit number of scopes can be seen, of which the scopes for current and voltage is present, the voltage response and current response for the input that given in monitoring and control block will be gained by running this scopes. The monitoring and control block in the simulation diagram of transformer monitoring is shown below:

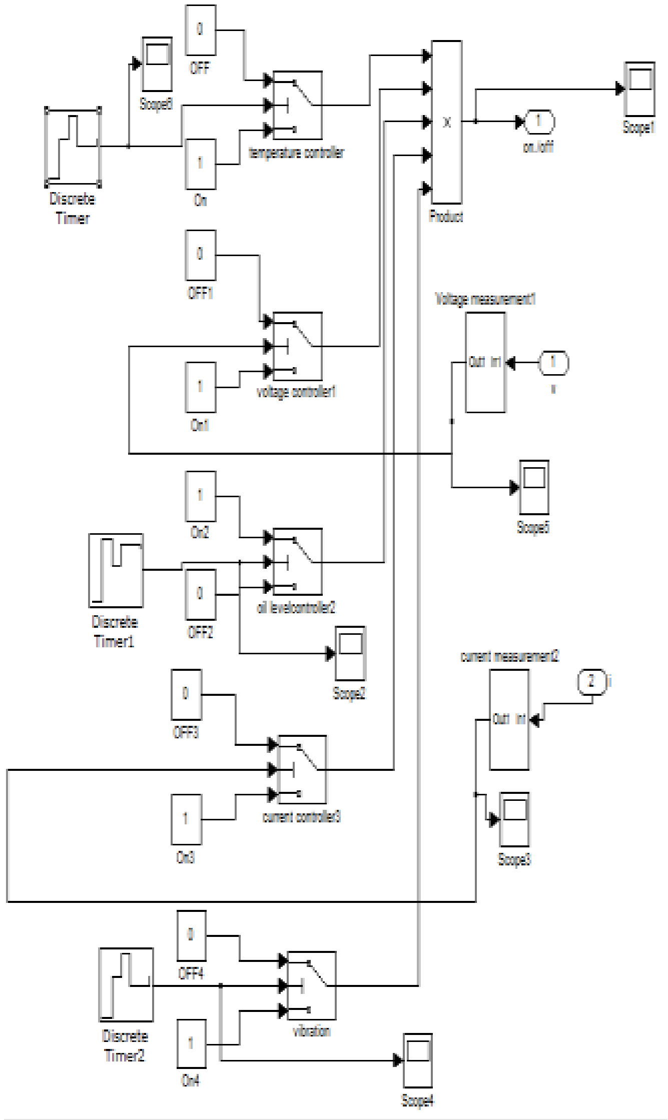

Fig.3. Monitoring and control block diagram

In this monitoring and control block diagram, the blocks for temperature monitoring, oil level monitoring, vibration monitoring are present. For each blocks the threshold value is given. If the input values taken by the discrete timer is against condition of temperature block or any other block the voltage will be tripped automatically. The output waveform for blocks and the output waveform for voltage response and current response are given below:

3.1 SIMULATION RESULTS

The output waveform of the proposed simulation circuit diagram is shown below. The output waveform of temperature response is shown below in which the threshold value given is 75 degree Celsius. The input values given are 75 degree Celsius, 120 degree Celsius and 55 degree Celsius. So, during values crossing threshold value the voltage will be tripped.

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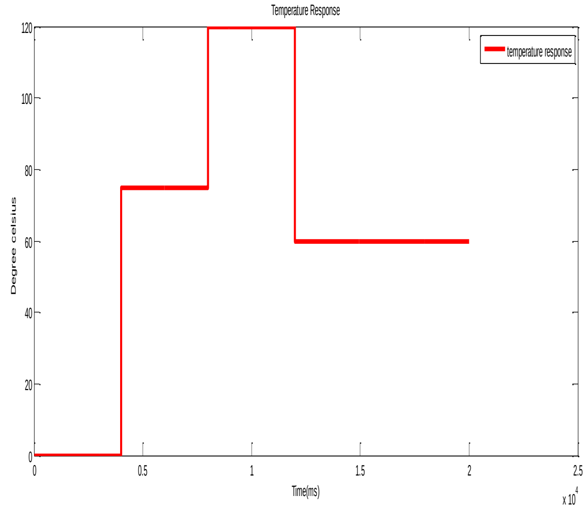

Fig.4. Output waveform of Temperature response

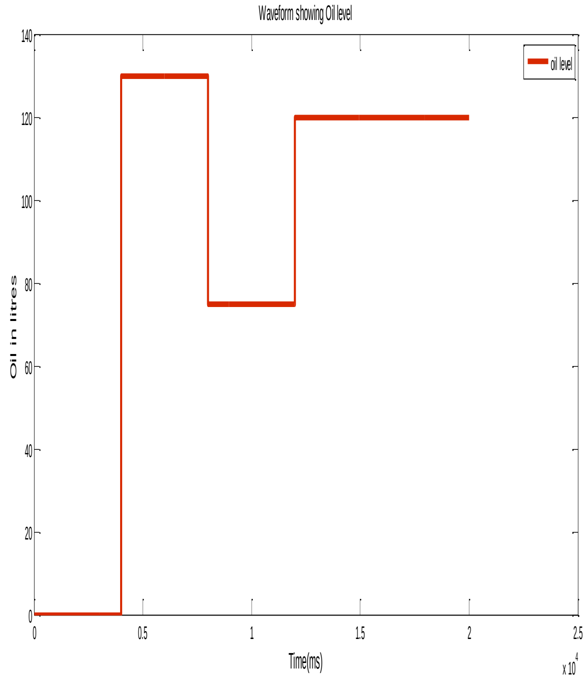

Fig.5. Output waveform of oil level

Figure 6.4 shows the output waveform of the oil level in litres. The threshold value for the oil level is given 110 litres. The input values set in discrete values are 130 litres, 90 litres, 120 litres. Whenever the input values cross the threshold value, the voltage will be tripped. Here the time will be given in milliseconds. One of the main causes of transformer failure is the oil damage and its insufficiency. So the oil level should be monitored for the proper working of the transformer. Here the distribution transformer working is taking into account. Other than the transformer oil level, the vibration and the temperature is monitoring.

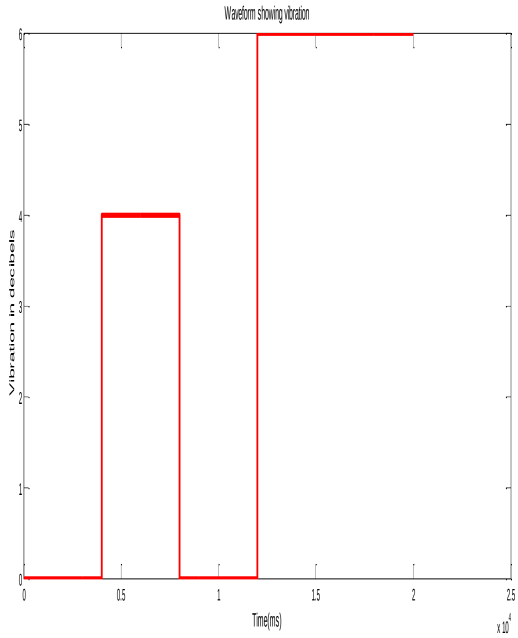

Fig.6. Output waveform of vibration sensor

Figure 6.5 shows the output waveform of the vibration sensor. The knocking effect problem may damage the transformer. This will be prevented by this sensor. Here the value will be given in decibel. As same as the temperature monitoring and oil level monitoring the vibration sensor also functioning.

Voltage and Current Response

The voltage and current response of the above sensors operation is shown below. The waveform shows the voltage and current will be tripped during the abnormal values means, the values cross the threshold value.The threshold values of any of the oil level indicator, vibration sensor, temperature sensor is crossed the voltage and current response will be affected. During this deviation occurring time the voltage and current waveform will be tripped. The voltage and current response is shown in fig 7 and fig 8.

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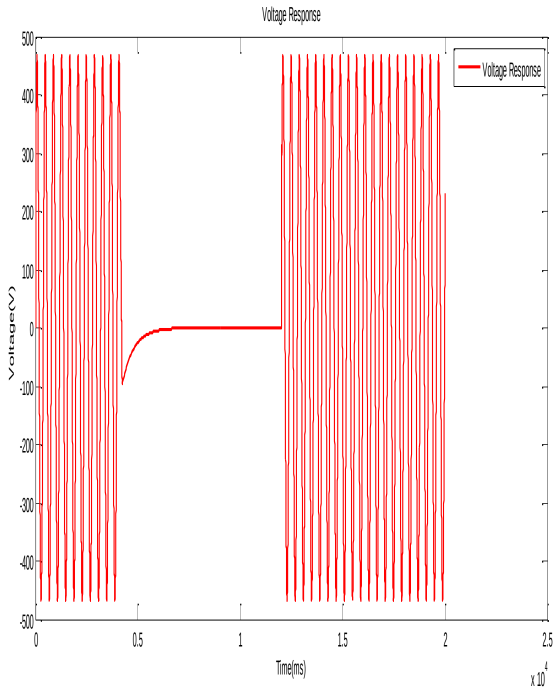

Fig.7.Output waveform of voltage response

The output waveform of voltage response is shown above. From the output waveform it is clear that the voltage passes during the given input value which obeys the threshold value. Similarly the voltage trips during the critical values. As the output waveform of temperature response, the response of oil level controller, vibration controller can be taken. The resultant voltage response of the oil level controller and vibration controller is as same as the temperature sensor voltage response shown below. The output waveform of the current response is shown below.

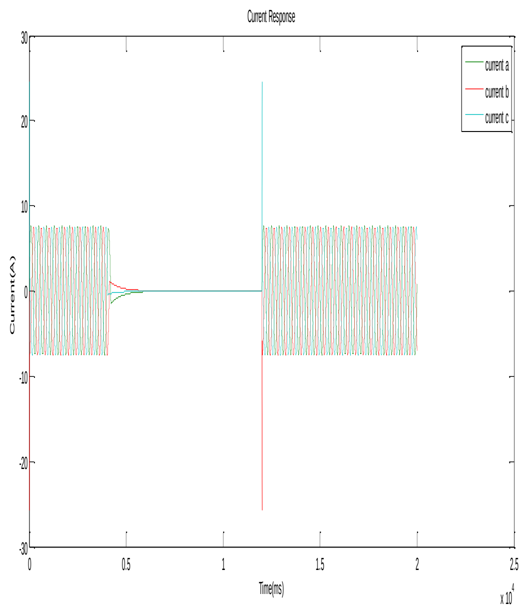

Fig.8. Current response output waveform

The output waveform of current response is shown above. The waveform shows the three phases current like phase a, phase b and phase c. The line current is shown here so the waveform is from negative value to positive value. As the voltage response the current response can be analyzed. When the input value limit to the threshold value the current will be passed and otherwise current will not pass.

IV. CONCLUSION

With modern technology it is possible to monitor a large number of parameters of distributed transformer at a relatively high cost. The challenge is to balance the functions of the monitoring system and its cost and reliability. In order to get effective transformer monitoring system to a moderate cost, it is necessary to focus on a few key parameters. WDTMS is able to record and send abnormal parameters of a transformer to concerned office. It works on ZigBee technology that supports multiple network topologies such as point-to-point, point-to-multipoint and mesh networks. It has low duty cycle – provides long battery life.

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BIOGRAPHIES

Mrs.R.Dheivanai received her Master Degree in the application of Power electronics and drives from Anna University Chennai and also received her MBA Degree from Periyar University. Her area of interest includes High Voltage, Power System and Machines. Currently she is pursuing Ph.D in Anna university Chennai and also she is working as an Assistant Professor in the department of Electrical and Electronics Engineering at Vivekanadha Institute ofEngineering and Technology for Women, Tamil Nadu, India.

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