IoT Based Real Time Distribution Transformer Parameter Monitoring and Protection System

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Abstract: Transformers are one of the most significant equipment in a power system. If there is any fault in the transformer it negatively affects the balance of a power system. The faults are primarily due to improper cooling and overloading. The primary aim is the real time monitoring of the health conditions of the distribution transformer using IoT technology. The key parameters such as voltage, current, temperature, frequency and oil level of a transformer will be monitored, processed and updated in servers using Wi-Fi module. For this implementation, sensors are employed which are interfaced with Atmega328 microcontroller. The parameters can be sent to IoT cloud using ESP8266 Wi-Fi module and accessed from anyplace around the globe using IoT technology. This aids in detecting problem before failure and also prevents the failure of the transformer without physical or human monitoring. Using this project, we will be able to screen the different parameters of distribution transformer locally using 16X2 LCD display and remote location monitoring using IoT cloud services. Blynk application is used to access the sensor data on android or iOS phone at anyplace across the world.

IndexTerms **- Real Time monitoring, Distribution Transformer, Android application, Sensor, IoT technology, Wi-Fi module.**

1.INTRODUCTION

1.1 Background

Earlier there was no testing or health monitoring system implemented for transformers. Transformer health was checked generally by the technician or operator periodically or whenever any fault was reported. So he couldn't track the occasional overloads which in turn lead to heating of transformer. Also it was a time-consuming process and chances of error were more. All these operations were manually handled for all transformers and gradually with the advancement of technology, new design and system came into picture. In these systems also the remote monitoring was not possible. The monitoring was possible through LCD display at the transformer location. Few years later GSM was introduced in the system, but GSM also had lots of drawbacks. Gradually online monitoring system were developed which consists of sensors, microcontroller which acted as the main processor, some embedded systems etc. Sensors are employed on transformer, which reads and measures the parameters of the distribution transformer and subsequently the parameters are converted into digital information by the microcontroller. This microcontroller is also fixed at the transformer. It acquires, processes, displays, transmits the parameters to the IOT server through Wi-Fi module. With this system it is possible to get information about transformer health from any place

1.2 Factors affecting normal working conditions of transformer

The significant faults occurring in a transformer are current, voltage, temperature rise, oil level, frequency fault etc. mainly due to improper maintenance, insufficient cooling and overloading.

- Over Current / Over Load fault
- Over Voltage and under Voltage fault
- Temperature fault
- Oil level fault
- Output Frequency fault

1.3 Need of IoT

IoT works by connecting physical devices over the Internet for the purpose of exchanging and connecting data with the other devices and systems. Day by day technology is getting improved and so everything is getting smart. It's also very useful in various embedded or electronics device. Because of all these reasons the internet of things is the most suitable choice for our project. With help of this system we will able to get the data from the distribution transformers in the area or the ones which has to be monitored at a common place. This system saves time, effort, man power and mainly the destruction of transformer since it prevents the fault before it occurs. IoT is the future technology. To make more advance IoT application there are many functions that can be added or can be utilized in various application. Many companies like IBM, Dell, Intel, Lenovo, Hewlett etc. are providing the server space for IoT. Thinkspeak, Blynk are the very popular IoT application for monitoring parameters on any android or iOS system. With help of this we can access the project data from anywhere in the world.

2. PROBLEM STATEMENT AND PROPOSED METHODOLOGY

2.1 Statement of the problem

Transformer is an electromagnetic static device which convert the voltage from one level to other level without change in frequency. The transformers role is very vital in power system. If the Distribution Transformers are operated under normal rated conditions they have a long life. If they are overloaded their life essentially comes down. If severe fault occurs, sometimes it may be necessary to replace the transformer since onsite repair may not be possible. This process will take time and also handful of technicians are required to disconnect, as the transformer is very heavy device. During this time there is interruption of supply to the customers connected, if spare healthy transformers are not available to replace and repair of the same is needed. Also manually, it's very difficult to observe a number of transformers simultaneously by using a common system. One more main drawback is the transformer may be working under normal condition during the manual inspection and may be prone to occasional overloads which is left unrecorded. To defeat these flaws, an on line screening system is very much needed that can prevent failures and protect transformers which are one of the key equipment in transmission and distribution system.

2.2 Methodology

The main idea used here is to establish connection between different physical devices over internet so as to convey the correct data to right individual or thing and to notify the concerned person, at the right time to take right action before breakdown or failure of the transformer occurs. Here all the parameters are monitored in a single system. It is completely automated and human interface is not needed.

In this real-time screening system sensors are employed to monitor all operating parameters of the distribution transformer and notify the concerned person about any deviation from the normal value and send the same to monitoring point or server at the same time. In the meantime, the relay operates if the value exceeds the set value thereby disconnecting the transformer before failure occurs thereby providing protection. Online screening of basic parameters of distribution transformers that gives valuable data about the wellbeing of transformers which will help the ideal utilization of transformers. It will likewise aid in detecting issues before any damage or crash which brings about a huge cost saving, more reliability and quality of supply.

3. IoT BASED REAL TIME DISTRIBUTION TRANSFORMER PAPAMETER MEASUREMENT SYSTEM

3.1 Design and Development

This distribution transformer parameter monitoring and measurement system project is about obtaining real time values of transformer to track the wellbeing of the device. Temperature, current, voltage, oil level and frequency of transformers are monitored and sent over internet IOT cloud service. These variables can be read and accessed using IOT technology from any place around the globe. The system designed is reasonably priced. The concerned person or operator/ authority can obtain data regarding any maintenance requirement or detect any failure that may occur.

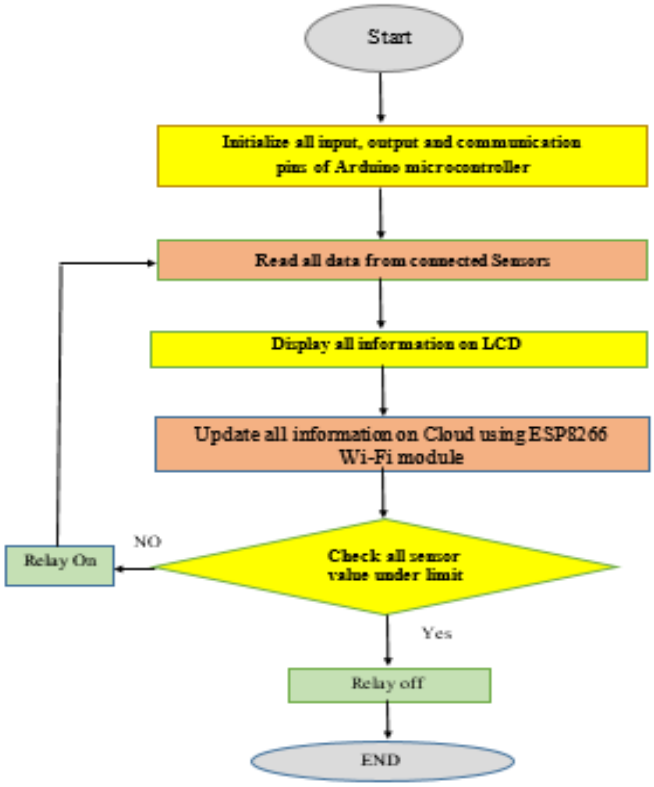
This system presents a better strategy for transformer variable checking utilizing IOT cloud for monitoring the transformer health. The sensors are employed on the transformer for gathering the information of transformer wellbeing, for example, voltage, current temperature, oil level and frequency. Sensors are interfaced to Arduino microcontroller, which processes the data and displays it on the LCD that is interfaced to it for local monitoring of all these parameters. These data are also sent to an IOT server, using ESP8266 Wi-Fi module. These data can be accessed using Blynk app over the internet. Thus, with the system obtaining the real time data and monitoring of the transformer health parameters are executable.

3.2 Algorithm

Proposed system algorithm

- Initialization of all the GPIO pin of microcontroller.
- Set the pin configuration according to code setup
- Connect with IOT server.
- Read all the defined pin value from particular pin.
- Process data after receiving from different sensors.
- Display data on LCD Display.
- Update all information on IOT cloud.
- Relay operates in case any fault observed.
- Continue same operation in LOOP.

3.3 Flow Chart



4. Working Mechanism

4.1 Hardware Implementation

We are using Arduino Uno microcontroller for this implementation of project. In this system proposed, Real-Time value and parameter acquisition, a Voltage sensor, oil level sensor, Current sensor, frequency sensor and temperature sensor are employed for screening the values of voltage, oil level, Current, frequency and temperature respectively. Data of the transformer are then sent to a IOT server for easy access from anyplace in the globe. All these sensor value are processed in Programmable Microcontroller Arduino. After this data will be displayed the on LCD. The values acquired are then sent directly under TCP IP Protocol via a Wi-Fi Module to a committed server address that displays the data in real time in any android or iOS mobile phone or lap top with internet for display. One relay is connected with microcontroller for cut off supply in case of any fault like overvoltage, reduction of oil level, over temperature and over current. Then microcontroller will send notification to the Blynk app via Wi-Fi Module and values are revised or updated in the server and relay will operate in that case.

Various components used in Hardware Implementation are as follows:

1)**ZMCT103C Current Sensor Module**

This module is designed using the ZMCT series of high-precision micro CT and high-precision operational amplifier circuits to measure more accurate sampling and proper signal compensation

2)Voltage Sensor Circuit

The voltage sensor designed for Arduino is an analog sensor which is voltage divider. Voltage measured using this voltage divider is given to analog pin of Arduino which then converts it into digital value. This potential divider circuit is composed of two resistors in series which will divide the input voltage to bring it within the range of the Arduino analog inputs.

3)**Oil Level Ultrasonic Sensor**

The oil sensor used is an ultrasonic level sensor. The level transmitter is mounted on the head of the tank. It sends an ultrasonic pulse down in to the tank. This pulse, which travels at the speed of sound, once reaches the oil level is reflected back to the same sensor. To measure the liquid level, the time delay between the transmitted and received echo signal is calculated by on-board microprocessor using the formula of this sensor.

4)**Temperature Sensor**

The sensor used is LM35. LM35 is analog sensor. When temperature changes the output of the sensor varies proportionally with temperature. This sensor has three terminals and has the ability to measure temperature from -55^0 Celsius to $+150^0$ C. For each degree increase in temperature the LM35 voltage output increases by 10mV. It can work with an input voltage of 5V to 12V and a current of around 60 micro Ampere.

5) **Frequency Sensor**

Frequency sensor is a digital sensor. Bridge rectifier, opto coupler, resisters are some of the components in the circuit. The frequency, of the sinusoidal or alternating signal that has to be measured is applied to the input of bridge rectifier. Care should be taken that the amplitude of the alternating signal applied should not overreach the forward diode current rating of the opto coupler for a fixed value of the series resistance.

6) Microcontroller

The Atmega328 controller used in the system proposed is Arduino Uno which is an open source electronics platform. It provides a more economical as well as a flexible platform for programming and in addition controlling of various devices connected to it. This model has an USB interface. Fourteen General purpose input output digital ports, six analogy input pins. Out of these fourteen ports six ports are meant for PWM output.

Fig 6 **Arduino Uno Board**

The board can be connected to the PC via USB data cable. The program code written on the computer utilizing IDE software can be transferred to the Uno. This software is exclusively developed for programming controller. The power supply to the board can be given by the battery or AC to DC adapter in addition to USB. Arduino Uno is one of the most used model of Atmega328 eight bit AVR microcontroller. C and C++ are more commonly utilized programming languages.

7)ESP8266 Wi-Fi Module:

ESP8266 is a compact, cost effective and powerful Wi-Fi module which gives Wi-Fi connectivity to the Arduino in our project. It has a highly integrated TCP IP protocol stack that gives Arduino access to Wi-Fi network. The above module is pre-programmed with AT order set.ESP-01, ESP-03 was initially used as Arduino Wi-Fi module.

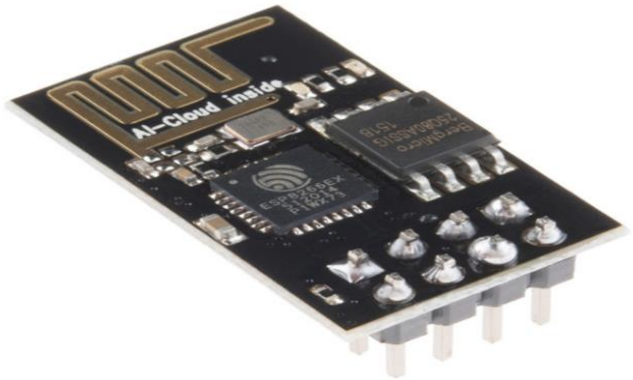


Fig 7 **ESP8266 Wi-Fi Module**

8 Arduino connection to ESP8266

Power supply to the module is provided by the 3v3 pin of Arduino board. That is 3.3 V supply is given for the module. The reset pin is grounded, then microcontroller works as a USB to serial connector, to talk to ESP8266. The receive data pin of ESP is coupled to receive data pin RXD of Uno control1er. The transmit data pin of module is coupled to transmit data pin TXD of control1er. Normally, when communication between two devices is required the transmit pins connected to the receive pin but since communication between controller and ESP module is not required here, and computer can talk to ESP through controller. After all, chip power down is given supply to enable working. The module has 2 General purpose input output pin 0,2 as shown.

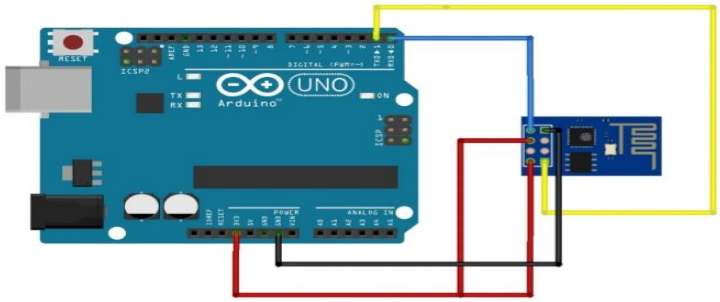


Fig 5 **Arduino connection to ESP8266**

5 Software Requirements

5.l Arduino IDE

It is an open source programming software that is basically utilized for composing and compiling the code into the contro1ler module. In this software compilation of the code is too easy. As we are using Arduino microcontroller in our project for writing the code and uploading code in microcontroller the above software is used.

It contains a text editor for writing program, a message area, a too1bar with buttons for general functions, a text conso1e and a bunch of menus. It interfaces with the controller hardware to upload programs and to interact with them. This software supports both C and C++ languages.

5.2 Blynk Application

Blynk is an open source IoT application. This app helps in storing, visualizing as well as analyzing the information which is sent by Wi-Fi module. There is a Blynk channel where the data sent is stored. Remote control of the hardware is also possible using this app. Sending, processing and data access as and when needed are the provisions given this blynk app. The data is sent to blynk using TCP IP or HTTP protocol. Data can be accessed on the android or iOS phone by using the blynk app.

6. SYSTEM IMPLEMENTATION

6.1 Block Diagram and its working

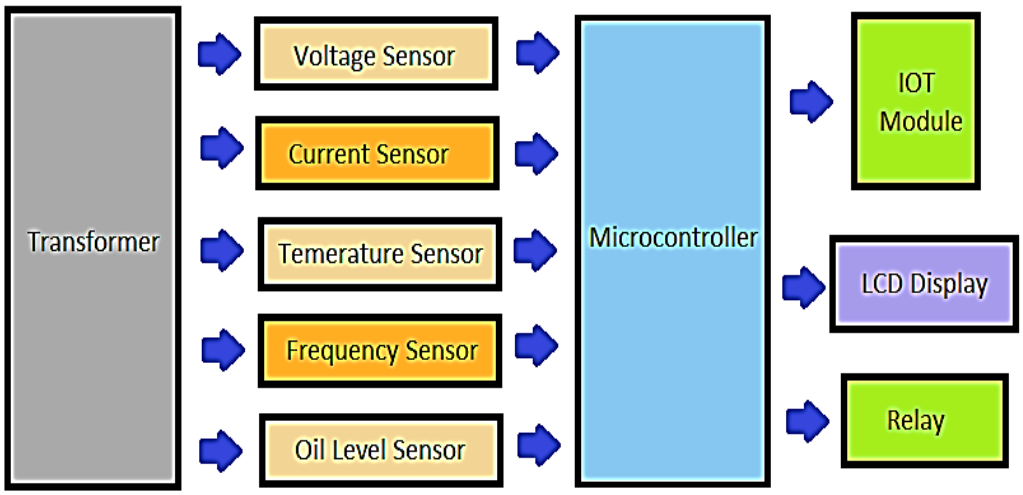


Fig. 6.1 **Block Diagram of System Implemented**

In this project we are implementing using atmega328 microcontroller. Voltage sensor we are making using voltage divider circuit. And this will be connected with analog pin of microcontroller. Current sensor we are using ZMCT103C Sensor. This sensor interfaced with analog pin of microcontroller. Oil level we are measuring using ultrasonic sensor and this ultrasonic need two digital pin of microcontroller for this operation. LCD display we are using 16X2 model and it required the 6-digital pin for share the data from microcontroller to LCD Display. Temperature we are measuring using LM35 sensor for this implementation. This sensor will be connected with analog pin of microcontroller. Frequency measurement we are opto coupler circuit for it. And this will be interfaced with digital pin of microcontroller. Esp8266 Wi-Fi module is utilized for IOT service. This module need TX and RX serial communication pin for working operation. We are interfacing it with microcontroller TX and RX pin. All these sensors will read the health status from transformer and will pass this value to microcontroller. After this data is processed by the microcontroller and will be shown on LCD and will update on IOT cloud with help of Esp8266 Wi-Fi module and user will able to access this data using Blynk app on android or iOS phone from anywhere across the world location.

6.2 Complete Hardware Circuit of the project

The complete hardware circuit after assembling the components listed above:

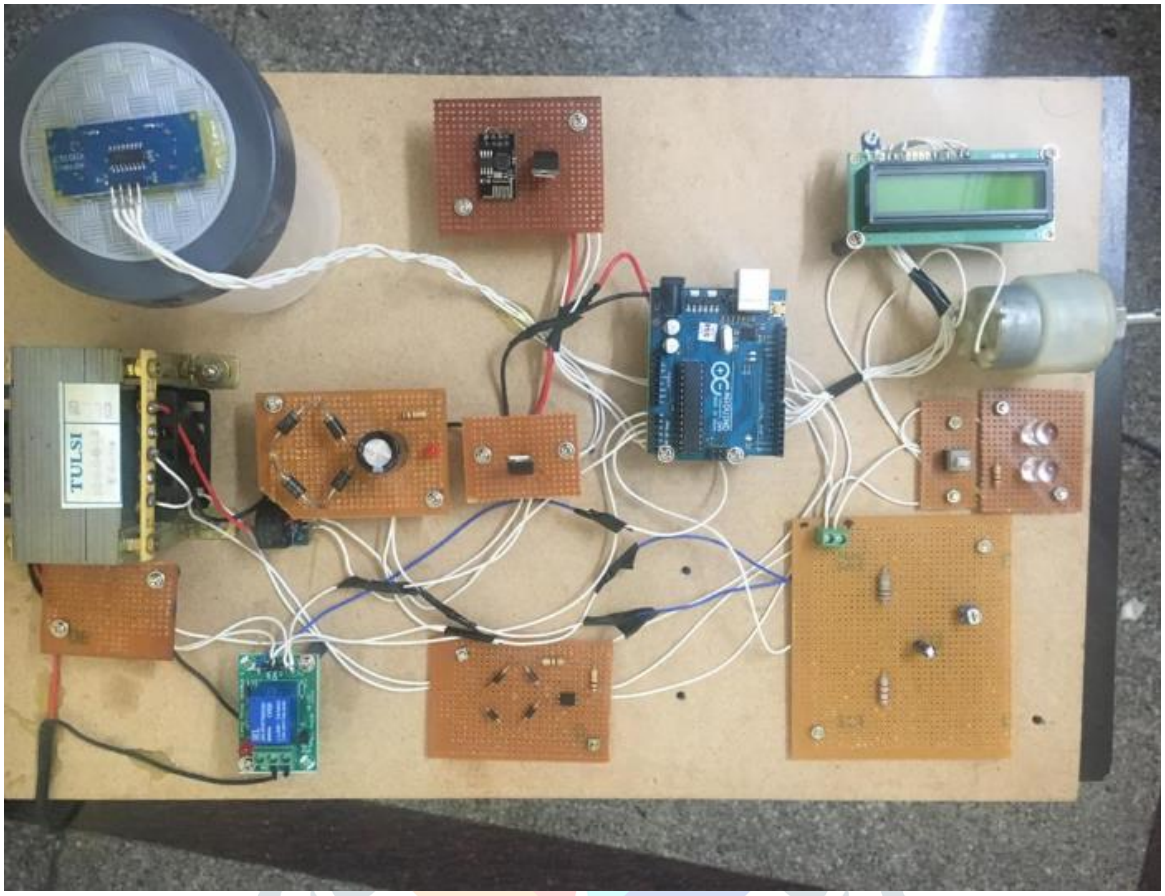


Fig. 6.2 **Complete Hardware Circuit**

7. Results and Discussion

The results of the proposed method have indicated that the system works appropriately with exactness and sensitivity. Transformer Health screening will assist in detecting or diagnosing unexpected circumstances before any life threatening failure occurs and operator can get this data which results in improving reliability, quality of supply and significant amount savings in maintenance. This system also will save the man power and we will able to monitor a number of transformers simultaneously. If any anomalies are sensed in a transformer, information regarding it can be known from anyplace across the world. For safety and protection, we use a relay automatic switch for disconnection of the transformer. No operator is needed to screen the transformer as before. Information regarding the variables of transformer are naturally refreshed periodically in IOT cloud service successfully and below mentioned are the result images of LCD Display for all sensors and alerts on Blynk app.

7.1 Case 1: Over Load / Over Current

Over Current is basically due to over loads connected on the secondary of transformer. In this system proposed the sensor measures the current and if the system detects overcurrent that is, current flowing through the load circuit is greater than normal set value then the system is overloaded. In that case Current sensor result is as shown on LCD for the sake of local display. Details are automatically updated to server using IOT and notification is sent to the concerned engineer or operator through Blynk app as shown below.

Fig 7.1(a) Current Sensor Output on LCD

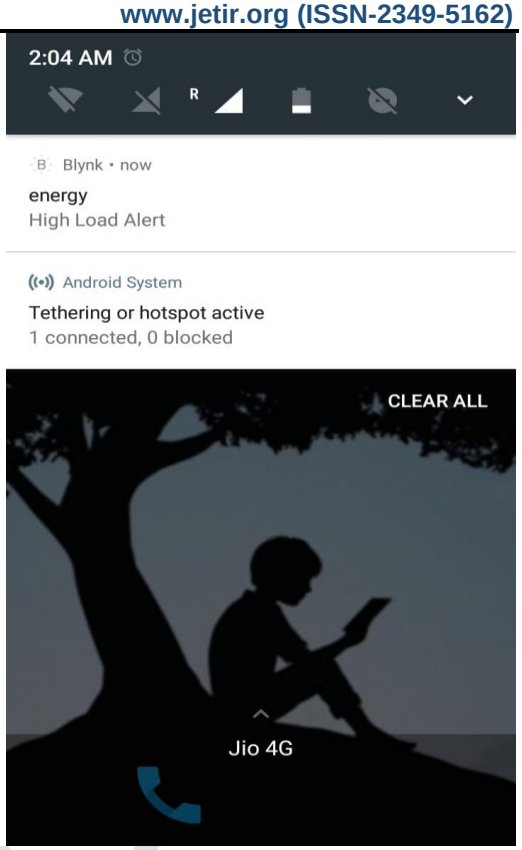


Fig 7.1(b) High load alert notification

7.2 Case 2: Over Voltage/ Under Voltage

Over Voltage are mainly due to light load or sudden interruption of the load that is connected. It may also be due to large imbalance in the three phase transformer due to unbalanced load. Lightning discharge or switching actions can also cause OV. Under voltage may be due to increase in load.

When the sensor measures and the proposed system detects the voltage in system is high or low than normal set value (>250V, < 220V). In that case Voltage sensor result is as shown on LCD for the sake of local display. Details are automatically updated to server using IOT and notification is sent to the concerned engineer or operator through Blynk app as shown below. This helps in taking corrective action or self-protection as stated above in Case1

Fig7.2(a)Voltage Sensor Output on LCD

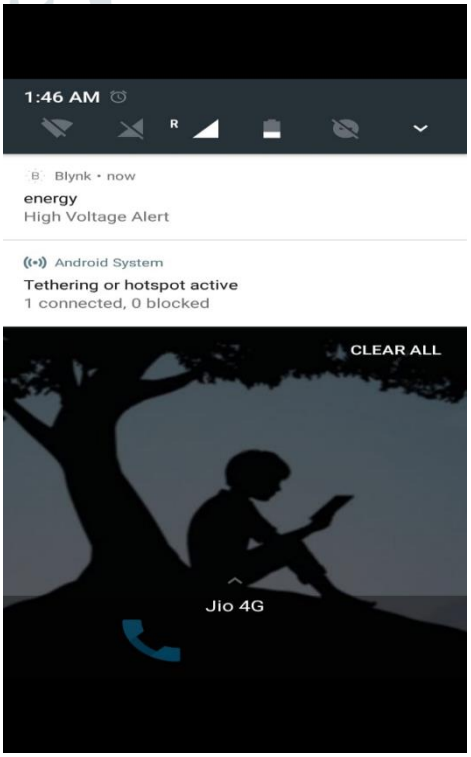


Fig 7.2(b) High Voltage alert notification

7.3 Case 3: Temperature Rise

Temperature Rise may be due to overload (over current) which cause heating of transformer winding thereby transformer oil heating. Thereby causing a rise in temperature which causes degradation of insulating oil, loose mechanical strength, char or even catch fire. When the sensor measures and the proposed system detects the temperature in system is high than normal set value (40 deg C) then sensor result is as shown on LCD for the sake of local display. Details are automatically updated to server using IOT

and notification is sent to the concerned engineer or operator through Blynk app as shown below. This helps in taking corrective action or self-protection as stated above in Case1.

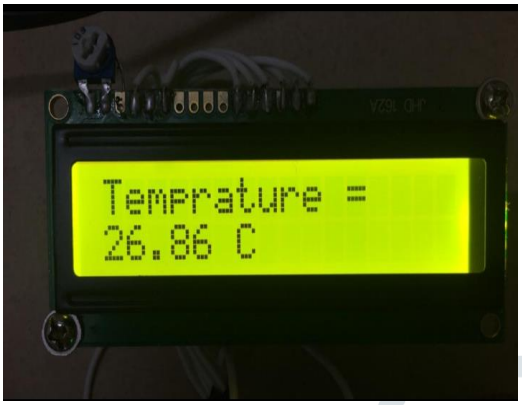


Fig 7.3 (a) Temperature Sensor Output

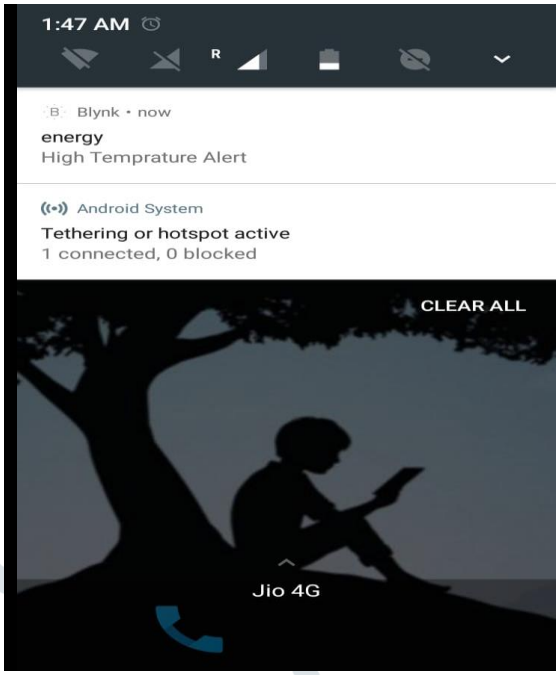


Fig 7.3 (b) High Temperature alert notification

7.4 Case 4: Decrease in Oil Level

The main function of insulating oil is to provide cooling and insulation. Decrease in Oil Level is mainly due to leakage and aging. When the sensor measures and the proposed system detects the oil level in the system is lower than normal set value (say 4). In that case Level sensor result is as shown on LCD for the sake of local display. Details are automatically updated to server using IOT and notification is sent to the concerned engineer or operator through Blynk app as shown below. This helps in taking corrective action or self-protection as stated above in Case1

Fig 7.4 (a) Oil Sensor Output on LCD

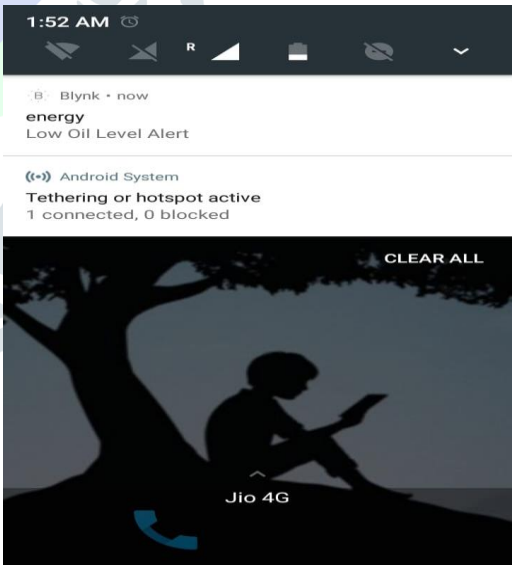


Fig 7.4 (b) Low Oil level alert notification

7.5 Case 5: High / Low Frequency

In India the frequency is 50 Hz and so all the equipment's or devices are designed for this frequency. When the sensor measures and the proposed system detects a higher or lower frequency than the normal set value (45< f > 55). In that case frequency sensor result is as shown on LCD for the sake of local display. Details are automatically updated to server using IOT and notification is sent to the concerned engineer or operator through Blynk app as shown below. This helps in taking corrective action or self-protection as stated above in Case1.

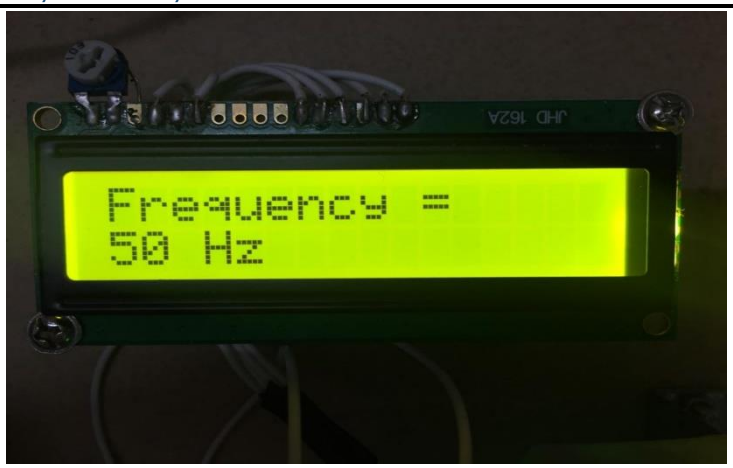


Fig 7.5 Frequency Sensor Output

7.6 DATA ACCESS OF ALL TRANSFORMER PARAMETERS ON BLYNK APP

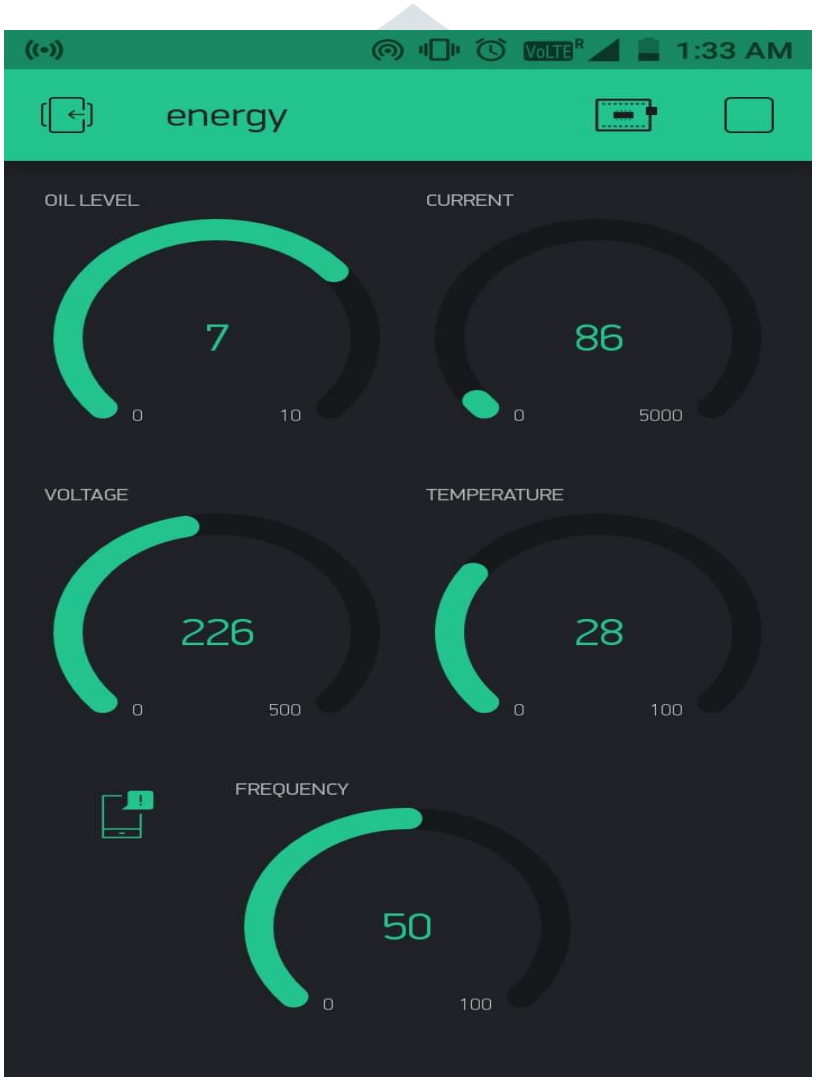


Fig. 7.6 Overall Data Accessed on Blynk

Table 7.7: Tabulation of Results

CASES	Specified Range	Notification on App
Case1: Over Load	Current > 200mA	Over load alert
Case2: Over Voltage Under Voltage	Voltage > 250V Voltage < 220V	Over Voltage alert Under Voltage alert
Case3 : Temperature Rise	Temp > 40^0 C	Temperature Rise alert
Case 4: Decrease in Oil Level	Oil Level < 4	Low oil level alert
Case5: Output Frequency Fault	f < 45, f >55	Output Frequency fault alert

8 CONCLUSIONS AND FUTURE SCOPE

8.1 Conclusions

Transformers are indeed one of the expensive device in power system. So an IOT based system for transformer parameter monitoring of distribution transformer was structured, actualized and tried. It is very helpful when contrasted with manual observing and furthermore it is reliable as it is impossible to screen the parameters like oil level, temperature rise, voltage, current locally. A server module is added to this system to refresh the parameter data that is sensed by the sensors periodically for remote monitoring and displayed on LCD as well for monitoring locally. When notified the operator or the concerned person can immediately take preventive action to avoid catastrophic failure of the power system. Because of this the recovery time can be reduced and prevention of faults is possible thereby improving reliability. There is no requirement of many skilled technician as in the manual system.

8.2 Future Scope

More parameters of distribution transformer can be added. In future we can also interface with touch LCD screen for various function and features. In future we can also add battery bank in this system so with that it will able to upload information even if the main power fails.

This system of real time monitoring can also be extended to other transmission and distribution components like transmission lines by using wireless sensors on relays of these lines, resistance temperature detectors of generators and other significant components of power system and by sending and monitoring these data through IOT which aids in making our system healthier and reliable.

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