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Design and Implementation of Transformer Health Monitoring using IOT

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ABSTRACT

Health monitoring of electrical equipment using IOT may help to replace the equipment before failure and continuity of the power will not be disturbed. This paper presents an implementation of this concept which acquires the real-time condition of the distribution transformer remotely with the use of internet implementing IOT. The proposed health monitoring system works in real time and uses temperature-sensor, potential transformer and current transformer for monitoring temperature, voltage and current of the distribution transformer and send these, information to a remote server where it can be monitored and necessary action may be taken to avoid the outage of the electricity supply. The proposed system has been implemented in Laboratory and tested. The data collected are validated and it has been found that the proposed system is working satisfactorily.

Keywords—Internet of things, Health monitoring system, Distribution transformers, GSM, Microcontroller, Sensor.

INTRODUCTION

A distribution transformer is a step-down transformer which delivers power to the users which can be used in houses or industries, etc. Various predicaments can be faced by distribution transformers if their health is not monitored periodically. The operating parameters such as temperature, voltage and current of a distribution transformer are vital measurement criterion which can tell about the health of the transformer. The operating condition depends on several factors such as overloading, loss of supply etc. Life of a transformer is proportional to its health. Better the health of a transformer, longer the life. Issues such as overburden and inadequate heating of a transformer are the main reasons of deterioration of a transformer's health. Earlier the health monitoring system was not much prevalent in the distribution network and the faults could only be detected after a complete blackout. It caused major penalties for the distribution system as large number of losses were incurred. Therefore, there was a foremost need for a reliable health monitoring system which would help in creating preventive measures beforehand. The present health monitoring systems pose a few concerns which are listed below: (i) Common systems for transformer measurements merely identify a single transformer parameter. Even if some systems are able to detect multiple parameters, the time consumed in the testing is too lengthy and hence slow speed is attained. (ii) Detection system is erratic. The performance of the detection system is less accurate. Slower detection of the faults is present and it is unreliable and unstable (iii) The monitoringsystem is unable to observe all the user data of transformers to decrease costs. As per the abovementioned requirements, we need a monitoring system to analyse real time data associated with the distribution transformer to characterize various operating parameters and further provide the information to the monitoring centre in requisite time. This is when Internet of Things (IOT) comes into picture. It helps to invigilate the data online of the key functional factors of the distribution transformers which grants constructive data about the health of distribution-transformers which in turn will facilitate the services to use their transformers in a best possible way and increase the life of a transformer. IOT helps in identifying the problems beforehand i.e. Before the occurrence of any failed mechanism which facilitates cost effective solutions and hence less penalty. IOT serves greater reliability and stability than other conventional systems.

BLOCK DIAGRAM

The fig.1 represented by a block diagram suggests it is essential that the device being used for invigilating (monitoring) be housed nearby the transformer itself. The blocks represented in the block diagram evaluate different parameters communicating the health of the transformer. Furthermore, the proposed system provides us with a health monitoring system of the distribution transformer which presents us with the data regarding various parameters of the transformer. Additionally, three sensors have been used in the proposed system, namely, voltage sensor, a current sensor, and temperature sensor. For the use of PIC microcontroller, a power supply for supplying power has been used, a Wi-fi modem for internet connectivity has been used and several sensors has been used. Fig.1 shows the different modules used in the proposed model. The data received by the IOT is sensed by the sensors incorporated and displayed on the LCD screen. Furthermore, at the same time, data is also being sent to the user on a given server or on the cellphone via Wi-fi connection. The advantage of having such a system is that if estimation of an unprotected system is made by IOT, system failure can be prevented. The proposed system comprises the following module:

A. Power Supply

As per the standard process we need 5V power supply for our proposed model, in which we have used a bridge rectifier, capacitors and a 7805-voltage regulator. Here we have used a 230/12V transformer to convert the power supply to its desirable value, i.e.,12V. A bridge rectifier is connected after a 230/12V transformer which convert the 12V AC to DC, then a 1000μf capacitor is connected in parallel to filter out the ripples from there we give a connection to our GSM module then a 7805 regulator is connected after that two 100μf capacitors are connected which gives a pure 5V dc to give in whole circuit.

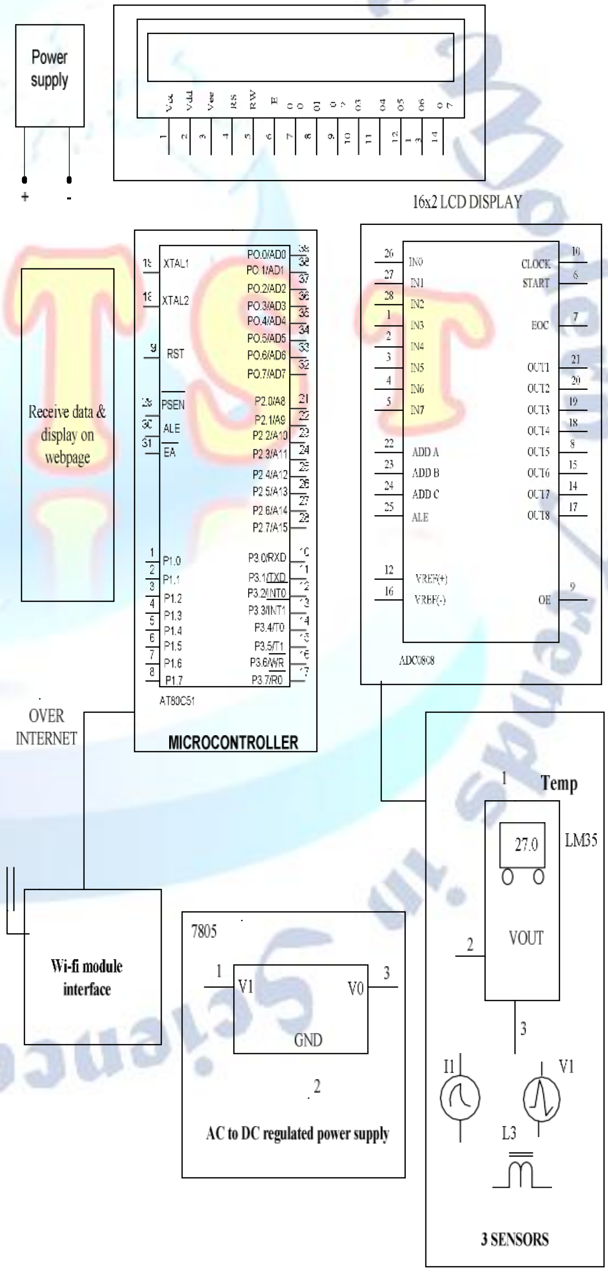

Fig.1: Block Diagram of proposed model

B. LCD Module

One of the commonly used devices connected to a PIC microcontroller is an LCD module. Some common LCDs which can be used with the PIC microcontroller for implementation of any kind of hardware projects are 16x2 type and 20x2 type display LCD, means it can show 16 characters in each line, and 20 characters in each line (both can show output in two line).

C. PIC-Microcontroller 18F4520

PIC-microcontroller was made by Microchip-Technology in 1993.Acronym of PIC is Peripheral Interface Controller. The performance of these microcontrollers is steadfast and they can implement a program very easily compared with other microcontroller of same categories. PIC-microcontrollers are widely used because of their effortless programming, wide obtainability, easily connection with other peripherals, cheapness, large client network and serial-programming ability (reprogramming along with flash-memory), etc. In 2000, Microchip-technology present the PIC18 microcontroller which is distinct from the 17 series, which become very popular and fast selling microcontroller in the market, with a huge number of PIC-microcontroller-17 deviations presently in production. In compare to earlier microcontroller, which mainly used assembly language for programming, Now C has become the major programming language.

D. GSM Module

In the village areas, GSM delivers an ultimate communication network by using the web of mobile communication network. With the use of GSM technology, we can transmit data with high efficiency, suitability and with low cost. Through GSM the monitoring of distribution-transformer health can be done easily. We used 2.4 GHz GSM module which is a very precise, accurate and high-speed data transfer can be achieved. Its works with the baud rates 9600, 19200.etc. It is a transceiver part through which information can be simultaneously transmitted and received. It should be connected to any TTL/CMOS logic serial RXD and TXD lines and can support Baud-rate of 9600bps, 19200bps, 38400bps and 57600bps. It can also work with 4 different RF.

E. Regulator

The used voltage regulator L7800 series is a three-terminal regulator, which is available in D2PAK packages and multiple no of output voltage, because of that we can used it in different and wide number of applications. With these regulators local-on card regulation can be achieved, removing the error occur due to single-point regulation.[14] Each regulator type can used in internal current limiting, thermal shut-down and protection of the network, making it fundamentally enduring. If suitable heat-sinking is offered, they can give over 1A output current. While these devices used as primarily voltage regulator, these can also be used with external hardware circuit for getting constant voltage and desirable current.

F. LM 35 Temperature Sensor

LM35 sensors are used for sensing the temperature and an IC ADC0808 is used to convert the data into digital form. LM35 sensor consist of 3 pin's i.e., VCC, GND and output pin. When LM35 is heated the voltage at output pin increases, it is connected to the analog to digital convertor IC (ADC). This LM35 series sensors are more accurate integrated-circuit temperature sensors, because there output voltage is directly proportional (linear) to Celsius temperature scale. Thus LM35 are more advantageous than other standard linear temperature sensors which are calibrated in kelvin, due to this there is no need to minus a large voltage value from its output to convert in centigrade value. The LM35 don't entail any external regulation to deliver distinctive precision of ±1⁄4˚C at room temperature and ±3⁄4˚C0ver a full(−55 to +150˚C) temperature range.

G. Voltage Sensor

A voltage sensor is nothing but a potential transformer. Voltage sensors sense the voltage of an output terminal and gives a signa1 directly proportional to it. The sent signal can be in the form of analog current or voltage, which can be converted into a digital output using ADC [15]. The output produced is employed to exhibit the precise voltage by a suitable measuring device or it can be saved for further analytical purpose in the database for controlling of different variables.

H. Current Sensor

A current sensor is equivalent to a current transformer. Current sensors sense the current in an external load and gives a signal directly proportional to it. The produced output could be analog voltage Or current which can be converted into digital form using ADC. The produced signal is utilized to display the measured current using a suitable measuring device [15]. Value obtain from current sensors can be saved for further analytical purpose in the database for controlling of different variables. The output of current sensor can be in the form of various quantities such as:

DC input, a tripping output like in a relay, which replicates the value of the sensed current digital output, which tripped when the sensed current surpasses a certain pickup value.

CONNECTIONS AND DESIGNING

The connection of LCD, microcontroller, temperature sensor, current transformer and potential transformer are as follows:

We connect a 16x2 LCD which is having 16 pins, 1st pin is connected to ground, 2nd to 5v supply, 3rd is connected with 2 resistors value 1kΩ and 10kΩ through 5v supply, this pin is used to adjust the contrast, 4th pin is Rs pin, 5th is data read/write, 6th is data enable pin and these 3 goes to 27,28,29th pin of microcontroller. 7th to 14th pins are data pins and connected to 33th to 40th pins of microcontroller, 15th pin is again used for brightness adjustment, connected to 5v supply and the last 16th pin is grounded.

33th to 40th pins are data pins which is connected to 7th to 14th pin of 16x2 LCD, 27th 28th 29th pins are Rs, RD/WR, End pins connected to 4th 5th 6th pin of 16x2 LCD, 11th and 32th pins are power pin connected to 5v supply and 12th and 31th pins are used for grounding.

There is a .1μf capacitor is connected between pin 12 and 32. 1st pin is used to reset the microcontroller connected to 5v supply through a 10kμ resistor and a switch. 13th and 14th pins are used to connect the crystal oscillator of 11.0592MHZ frequency, 22pf capacitor are connected to both the pins. 15th 16th 17th 18th pins are used to enter the mobile no on which we have to send the transformer health data, each is connected to 5v supply through a 10kΩ ladder resistor network and a switch. Pins 19th 20th 21th and 22nd are connected to 4 LED to send some data from the remote center to our GSM module and the LED glow according to the message, pins 25th and 26th are transmitter and receiver pins connected to 11th and 12th pins of max 232, microcontroller works on RS232 level, 5V TTL logic.

MAX 232 is used for level conversion because as all the system works on 5V supply but our GSM module works on +10V,+12V, +18V supply so MAX 232 convert +5V to +12V, its 11th and 12th pins are connected to 25th and 26th pins of microcontroller. 16th pin is connected to +5V supply and 15th pin to ground, there is .1μf capacitor connected between these two pins. There is 10μf capacitor connected between 1st -3th pin and 4th – 5th pin, similarly pin 2 is connected to 5v supply through 10μf capacitor and pin 6th to ground through 10μf capacitor.

GSM module (SIM 900) also works on RS232 level its pin 3 is receiver pin which receive the signals from 14th pin of MAX 232 and its 2 pin is transmitter pin which transmit data to pin 13th of MAX 232.

The 12V ac coming from 220/12V transformer is converted to 12V DC through 4 diode (1N4007) bridge converter then a 100μf capacitor is connected in parallel to eliminate the ripple content then 3, 10kΩ resistors are connected in series with a 6.5kΩ resistor and 4.7kΩ variable resistor in parallel. This variable resistance is connected to limit the output to 5V, then this circuit output goes to pin 3rd of ADC.

A phase and neutral wire go to load from which a C.T is connected to load wire from which a diode (1N4148) is connected, a 10kΩ resistor and a 100μf capacitor are connected in parallel, one 83kΩ resistor is connected in series then a 6.8kΩ resistor along with 4.7kΩ variable resistor is connected in parallel to limit the output current, then this circuit output is goes to pin 4 of ADC. There is an analog temperature sensor i.e., LM35 which can sense 10mV/o, its 1st pin is connected to 5V supply and 3rd pin to ground. 2nd pin is goes to pin 2 of ADC.

For designing a PCB layout, we use DIP TRACE software. In this software, for creating a 16, 32 or 40 DIP pin we use pattern template. The toolbox is used to select various components. The selected component is held and dragged into the workspace. The wired network of desired width is used to connect the components in the workspace. We can use pin manager for connection of microcontroller pins with other components. We have Design manager on the left side of our workspace from which properties of selected object or function can be modified. Parameters in this panel change, depending on the selection (component, net, bus etc.). If several objects are chosen, we will see only common parameters for all of them. The schematic diagram of our PCB layout is shown in fig.2.

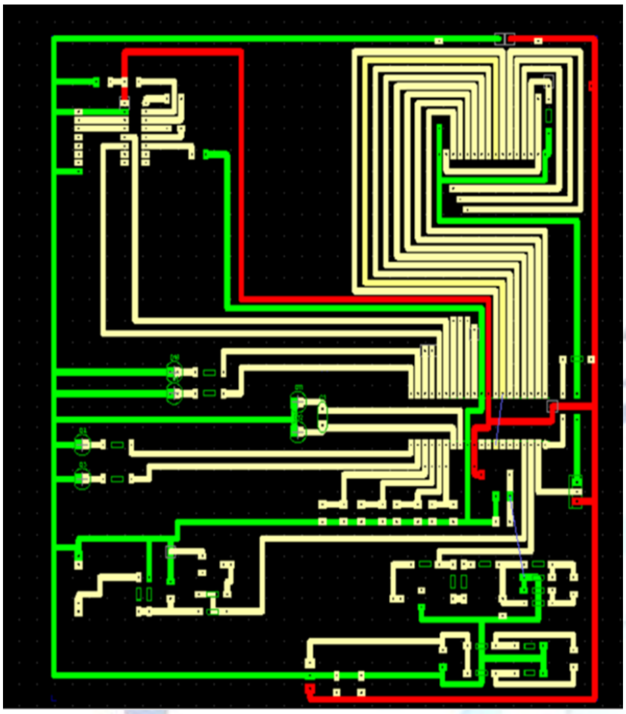

Fig.2: PCB Layout

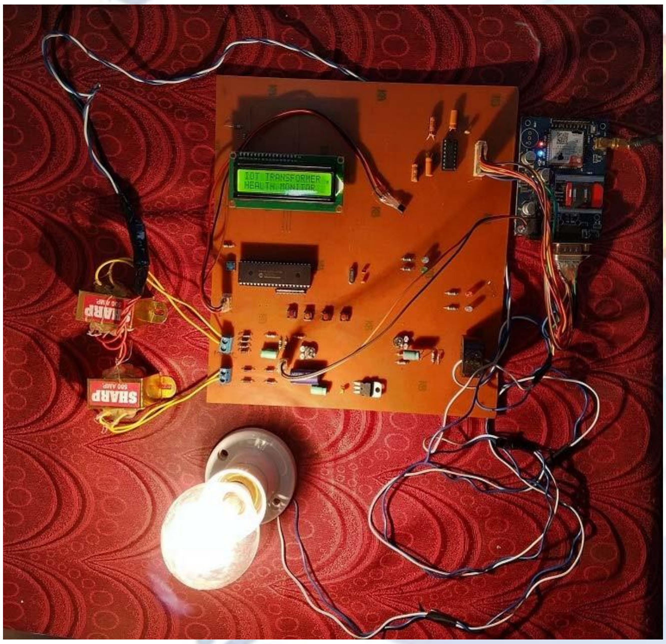

Fig: 3 Actual hardware Model

RESULTS

On the 16x2 LCD, transformer current, voltage and temperature were observed after 7 initialization pulses. After the next 9 pulses the data was sent to the IOT servers on which the health was monitored and necessary actions were taken.

On the IOT servers, three parameters can be viewed i.e., temperature, voltage and current as seen in fig.3, fig.4 and fig.5 respectively. The data entries can also be viewed on the IOT server on JSON file type as shown in fig.6.

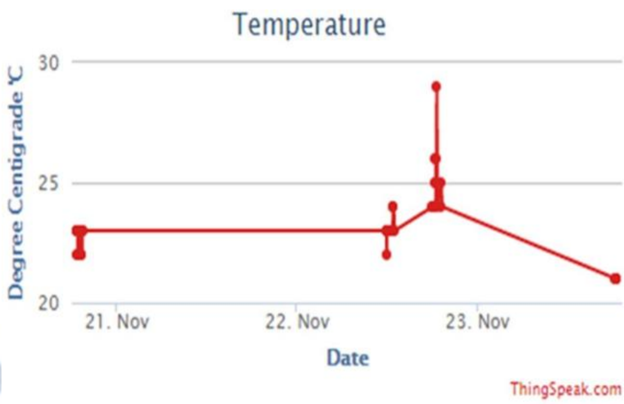

Fig.4: Transformer Temperature

Fig.5: Load current

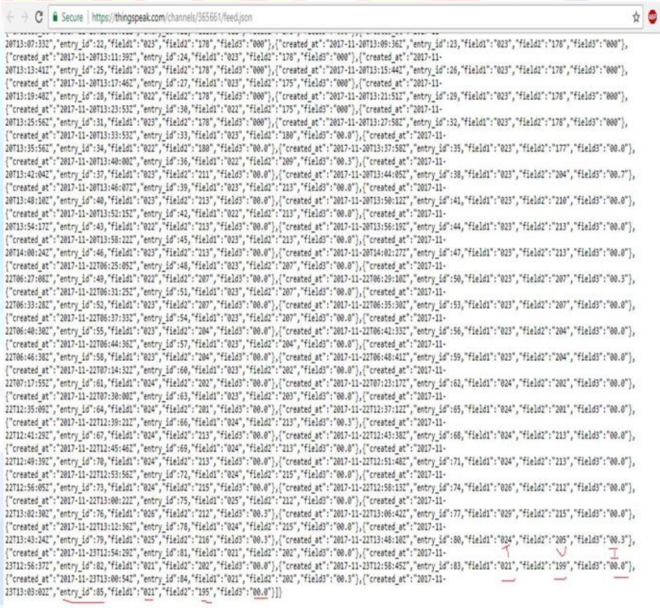

Fig: 6 Real Time Data on IOT Server

CONCLUSION

The IOT wireless open typical technology is beingdesignated in this paper as the energy management and efficiency technology of choice. Employing the system for real time monitoring of power line with an open standard such as IOT helps to keep costs down and condensed power consumption. We can observe from this project that sensors can be employed to conventional as well as smart grid for monitoring of different parameter of the grid. It can be concluded that our model showing results on internet through GSM module as well as on the on-board LCD. Using IOT for monitoring different parameter of distribution transformer, human labor will be minimized and we can also save the data for forecasting as well as for any electricity theft. With the use of IOT our power system would become more accurate and reliable. The advantage of using GSM based monitoring over manual monitoring is that there is no need for an operator to note down the variables after every minute because with the use of IOT the data can be stored with every 90 second After we found out any abnormality in the system, necessary action can be taken instantly and any catastrophic failure can be prevented.

In the same way we can implement wireless sensors on relays of transmission line, RTD of generators and different power system component, and send their data through GSM on internet making our power system network healthy and reliable.

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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