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Condition Monitoring of Distribution Transformer Using Internet of Things (IoT)

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Abstract: ***Transformers are used for electricity distribution and transmission which reduces the primary voltage to the utilization voltage for customer use. As distribution transformers are very costlier in electrical industry therefore this paper presents the system which monitor different parameters of distribution transformer. There are two units which are remote terminal unit (RTU) and monitoring unit. Remote terminal unit consist of analyzing parameters such as current, temperature , rise and fall in oil level, vibration and humidity with the help of PIC 18F4550. All monitoring parameters are processed and if any abnormality occurs, the system sends Alert messages to the mobile phones and recorded in system memory through (ADC) analog to digital converter. All parameters values are send to monitoring node through GPRS. If any emergency condition occurs immediately message send to the corresponding engineer through GSM and similarly on webpage we can get alert about it through GPRS. Near remote terminal unit buzzer will beep and LCD gives notification about emergency condition. An engineer at transformer cannot continuously keep an eye on transformer therefore given proposed system does communication with us at emergency conditions of distribution transformer through GSM/ GPRS module.***

Keywords: Distribution transformer; PIC microcontroller; GSM/GPRS module ;current; temperature; oil level; vibration; humidity; Remote terminal Unit (RTU); Monitoring Unit

1. Introduction

The main backbone for any power distribution network is distribution transformer. In this paper we are developing on-line monitoring system which has many advantages such as information gathering, better management, condition assessment and decision making for engineers [2]. Main function of distribution transformer is to convert high AC voltage to low. Life of distribution transformer is dependent on the rated conditions. If transformer is working with normal conditions then it has long life and becomes less if they are overloaded. Overloading of distribution transformer reduces system reliability[9-10]. Now days, Distribution transformers are monitored manually for maintenance and recording parameter values. There are some faults in manual testing which are caused by oil and windings .This proposed system overcomes all disadvantages of manual testing and improves life of transformer. Graphical representation of all the parameters give complete idea of working of transformer to engineer.

Technology of GPRS

GPRS has full form as general packet radio service. This technology is a packet-switching technology which transfers data through cellular networks. This technology used by data communications, mobile internet, MMS. Speed of GPRS is 115 kbps and it is also called as 2.5G. The GPRS and GSM parameters of the system operate separately. The GSM & GPRS technology is used for voice calls, while GPRS data results voice and data can be sent and received simultaneously. Services provided by GPRS & Internet are same means GPRS and internet are analogues to each other. Mobility, immediacy and localization are characteristics of GPRS [1].

2. Literature Review

Buyung Sofiarto Munir monitored only vibrations of transformer with two methods which are Fast Fourier Transform (FFT) and Hilbert Huang Transform (HHT) for finding discrete fourier transform and converting vibration signal into small intrinsic mode functions respectively [3]. Second way for monitoring health of transformer is widespread technique that is Neural network. This technique gives relation between gases in transformer oil which are dissolved and improve reliability and accuracy of health of transformer [4]. D S Suresh have used PLC and SCADA system for monitoring of transformer and GSM technology for sending parameters values and emergency condition through SMS[5-12]. From the above review, it is finally concluded that there are some faults in above systems but by using proposed Microcontroller based approach we can enhance it to better extend. Given proposed system monitor all the major parameters and display it on webpage having network IP address 172.16.3.57 with GPRS technology with SMS alert usingGSM.

3. Overall System Design

The system design consists of twoparts:

1) Hardware Design

Figure one shows Distribution transformer condition monitoring hardware setup of computer aided design using 3D modeling. PIC 18F4550 Microcontroller with different sensors such as current sensor, temperature sensor, oil level sensor, vibration sensor, humidity sensor comes in hardware design as input devices at Remote Terminal Unit (RTU)[6]. After getting all parameter values from microcontroller are displayed on liquid crystal display and similarly on web page.

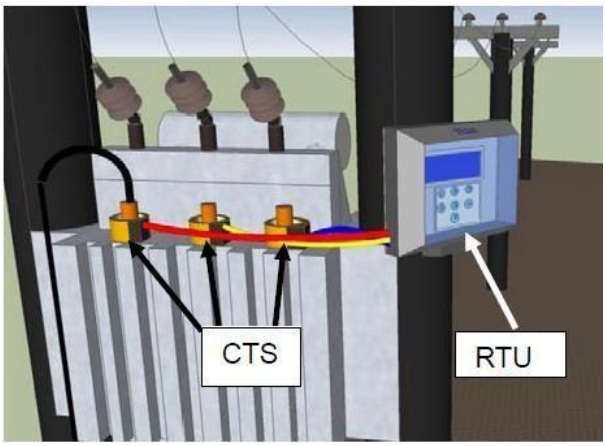

Figure 1: Distribution transformer condition monitoring hardware set up CAD design

GSM/GPRS module sends all parameter values to webpage as online interface to engineers. If any emergency condition occurs like overvoltage, overcurrent, rise and fall of oil level, increased temperature range, abnormality in vibrations and change in humidity affects the transformer life, so we are informing engineers by giving notification by SMS through GSM, as well as displaying on LCD with buzzer sound at Remote Terminal Unit (RTU)[15]. At monitoring node whole system can be accessed by webpage. The proposed system is discussed below:

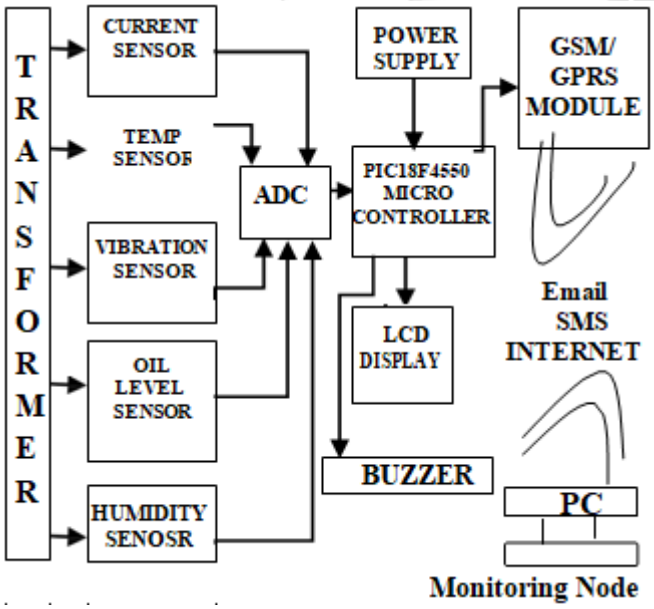

Figure 2: Block diagram of distribution transformer monitoring system

Brief introduction about components is given below.

2) Temperature Sensor

LM35 measures temperature of windings for distribution transformer. As temperature sensor is integrated circuit sensor which gives analog output[14]. Voltage increases whenever temperature rises. Actually sensor records any voltage drop between the transistor base and emitter. This voltage is then amplified and gives analogue signal that is proportional to the temperature.

3) Oil Level Sensor

In given proposed system we are placing oil level sensor at the tank of transformer. Level of oil is measured with float. Float tells us the oil level and accordingly we get analog output voltage[7]. This output voltage has given to ADC of microcontroller.

4) Current Measuring Circuit

Current of the transformer is calculated by ratio of current of primary winding to secondary winding. In this project the CT with output 5 Ampere has been preferred with ratio 1000:5. There are numbers of dedicated current IC's exist which translate the current sensed into a voltage directly appropriate for the analog input of the PIC18f4550. Current sensor is used here is ACS712, 5 Ampere. According to datasheet of ACS712, 5 A the sensitivity is 185mV/A. The ACS712 produces an output of 2.5V for 0A current through the current sensor [13].

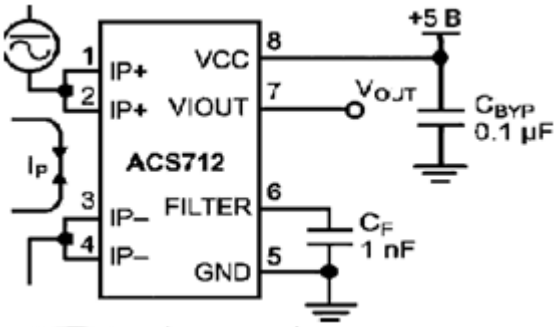

Figure 3: ACS712 IC with basic connections.

5) Humidity Sensor

Relative humidity is sensed by humidity sensor, means it measures both air temperature and moisture. Relative humidity is measured in percentage, which is the ratio of moisture present time to the total amount of moisture present in air, at that temperature can hold. It works on the basis of changes in temperature or changing electrical currents in air.

6) Vibration Sensor

Displacement, velocity and acceleration are three parameters are used for detection of vibrations. Vibration switch SW-420 is used for detection of vibrations with LM393 comparator. Previously Vibration switch is considered as vibration sensor as it has high sensitivity.

7) GSM/GPRS Module

Figure 4: GSM/GPRS Module

SIM808 has GSM and GPRS both functions therefore it sends message as well as uses mobile data for communication. GSM sends message or SMS but we have to insert SIM card from wireless carrier into GSM/GPRS module [11]. After inserting SIM card we can control module by sending instructions which are AT commands. AT

command such as +CMGS, +CMSS, +CMGW, +CMGD, +CMGC, +CMMS are used for sending message, sending message from storage, writing message to memory, deleting messages, sending command and more messages to send respectively[8]. GPRS does connection to TCP/IP protocol. GSM/GPRS module is first interface with RS-232 cable. GPRS connects to internet with HTTP. The module accessed with AT commands through TCP/IP stack[1]. For low bandwidth networks it becomes handy for data logging. GPRS also uses AT commands such as AT+CGATT=1,AT+CGDCONT=1,"IP","CMNET",AT*E2IPA=1, ATD*99***1# return CONNECT and many more.

8) Software Design

The software is responsible for managing the PIC microcontroller & devices are connected to it.

9) DatabaseManagement

Database for transformer is created due to tworeasons:

- If engineer wants to refer previous data which is stored at database of transformer then he can get the idea about transformer condition.
- Engineer cannot continuously keep an eye on transformer conditions therefore previous data is stored in database as data is updated periodically on webpage.

The database was linked with monitoring node using MySQL connector for data storage and update. Database software is designed using MySQL C# programming language and Microsoft visual studio with MySQL database[6].

10) ApplicationDevelopment

Now days everywhere internet is used and becoming a communication network to people. We are taking private IP address 172.16.3.57 and displaying webpage using GPRS. Therefore in given proposed system we are making communication between transformer and people through webpage. For design of webpage there are different languages can be used. All web pages that we see on the Internet use HTML to format its pages for display in a web browser. In given proposed system, HTML language is used to create webpage. Hypertext Markup Language gives content structure and meaning which defines content as, for example, Cascading Style Sheets, headings, paragraphs. Elements, tags, and attributes are three common HTML terms. Elements define the content and structure of objects within a page. Tag is defined as elements surrounded by less than and greater than brackets. Additional information about an element is provided by properties called as Attributes. There are three types of ID attributes. They are class, src and href attributes which specifies an element, for embeddable content and a linked resource of hyperlink reference. HTML page generated first in text document and then it is saved by html extension. Structure of HTML requires a defined format and they include tags such as <!DOCTYPE html>, <html>, <head> and<body>, <!DOCTYPE html> for specifying version of HTML. <head> inside <html> identifies the top of the document, including any metadata. All the content or information comes in <body>. Figure.5. shows webpage for given proposed system.

Algorithm of Proposed System

1) Start
2) Initialize proposed system with buttonswitch.
3) All sensors such as current sensor, temperature sensor, oil level sensor, vibration sensor and humidity sensor take the reading from thetransformer.
4) All analog values are sent to ADC to convertthem into digital.
5) Digital values are passed to PIC 18F4550 microcontroller.
6) PIC 18F4550 display these values onLCD.
7) Microcontroller sends these values onwebpage having 172.16.3.57 IPaddress.
8) If any emergency condition occurs then immediately SMS is sent to engineers present over there through GSM.
9) Buzzer beeps for indication at RTUside.
10) Webpage Valued box will blow red to alertonline.
11) All the data values are saved in databaseperiodically.
12) End.

4. Tests & Results

After testing of proposed system, it provides following results:

1) Current > 10A = CurrentFault
2) Temperature > 40^0c = temperaturefault
3) Oil Level < 30 ML = Oil Levelfault
4) Vibration > Normal Transformer Vibrations= VibrationFault
5) Humidity > 25% = HumidityFault

Therefore any abnormality condition occurred in above rated condition, this changes shown in the LCD at RTU side, Also same data monitored at monitoring node sent via GSM/GPRS system on webpage. All above results for normal conditions of parameters are displayed on webpage which is shown in below figure.5.

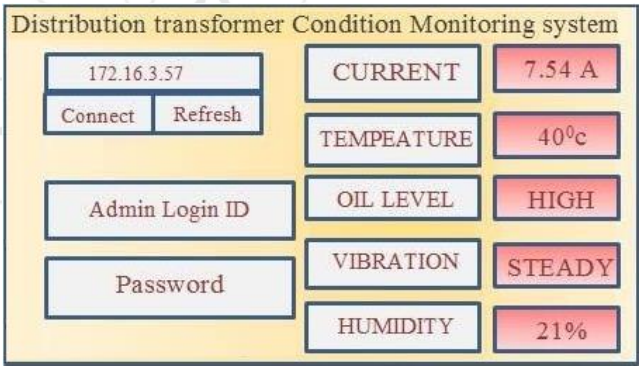

Figure 5: Distribution transformer condition monitoring system displaying on webpage.

If abnormality conditions occur then automatically values box for particular condition will glow red for showing alert. Figure 6 shows graphical representation for oil level of transformer.

5. Future Work

In future work we can develop database of all parameters of distribution transformer which are placed at different places. We can get all information by placing the proposed system

modules at every transformer. We can send the data through Wifi module and also through Ethernet shield. With Ethernet shield we can make remote terminal unit as a server and store data on webpage or website. Wifimodule connect to nearby network and send information to monitoring node.

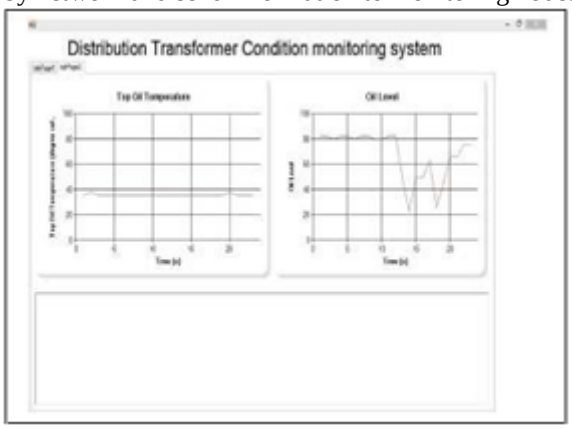

Figure 6: Graphical representation for oil level of transformer

Similarly we can see graphical representation of current, temperature, vibration and humidity on webpage. Therefore proposed system is beneficial to engineers and we can prevent transformer from faults.

6. Conclusion

All disadvantages of manual monitoring of distribution transformer are overcome by given proposed system. Main disadvantages of manual monitoring such as overheating and overloading are prevented through given system. This system designed with GSM/GPRS module and PIC 18F4550 microcontroller. GPRS is used for online monitoring of parameters of distribution transformer which can also be used in rural areas. There are four ways which are used in the proposed system to alert about emergency conditions to the engineers so we can increase the life of transformer.

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