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Monitoring and Controlling of Distribution Transformer Using GSM Module (AVR Microcontroller Based)

Abdurrahman Shu'Aibu Hassan

Department of Electrical Engineering, Sharda University, G.Noida, (India)

ABSTRACT

This paper is about design and implementation of a mobile embedded system to monitor and record key parameters of a distribution transformer like load current, oil level and ambient temperature. The idea of on-line monitoring system integrates a global service mobile (GSM) Modem before any catastrophic, with a standalone single chip microcontroller and different sensor. It is installed at the distribution transformer site and above parameters are recorded using the analog to digital converter (ADC)of the embedded system. The obtained parameter are processed and recorded in the system memory.if any abnormality or an emergency situation occurs the system sends SMS (short message service) messages to the mobile phone containing information about the abnormality according to some predefined instructions programmed in the microcontroller. This mobile system will help the transformers to operate smoothly and identify problems failure.

Keywords: Transformer, Microcontroller, Mobile (GSM), Digital Converter (ADC)

I. INTRODUCTION

In power systems, distribution transformer is electrical equipment which distributes power to the low-voltage users directly, and its operation condition is an important component of the entire distribution network operation. Operation of distribution transformer under rated condition(as per specification in their nameplate) guarantees their long life .However, their life is significantly reduced if they are subjected to overloading, resulting in unexpected failures and loss of supply to a large number of customers thus effecting system reliability. Overloading and ineffective cooling of transformers are the major causes of failure in distribution transformers. The monitoring devices or systems which are presently used for monitoring distribution transformer havingnumbers and deficiencies. Few of them are mentioned below.

(1) Ordinary transformer measurement system generally detects a single transformer parameter, such as power, current, voltage, and phase. While some ways could detect multi-parameter, the time of acquisition and operation parameters is too long, and testing speed is not fast enough.

(2) Detection system itself is not reliable. The main performance is the device itself instability, poor anti-jamming capability, low measurement accuracy of the data, or even state monitoring system should is no effect.

(3) Timely detection data will not be sent to monitoring centres in time, which cannot judge distribution transformers three-phase equilibrium.

(4) A monitoring system can only monitor the operation state or guard against steal the power, and is not able to monitor all useful data of distribution transformers to reduce costs.

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(5) Many monitoring systems use power carrier communication to send data, but the power carrier communication has some disadvantages: serious frequency interference, with the increase in distance the signal attenuation serious, load changes brought about large electrical noise. So if use power carrier communication to send data, the real-time data transmission, reliability cannot be guaranteed. According to the above requirements, we need a distribution transformer real-time monitoring system to detect all operating parameters operation, and send to the monitoring centre in time. It leads to online monitoring of key operational parameters of distribution transformers which can provide useful information about the health of transformers which will help the utilities to optimally use their transformers and keep the asset in operation for a longer period. This will help to identify problems before any serious failure which leads to a significant cost savings and greater reliability. Widespread use of mobile networks and GSM devices such GSM modems and their decreasing costs have made them an attractive option not only for voice media but for other wide area network applications.

Therefore a proposed solution is chosen to develop a microcontroller based transformer overload protection prototype because the microprocessors based relays provides greater flexibility, more adjustable characteristics, increased range of setting, high accuracy, reduced size, and lower costs, along with many ancillary functions, such as control logic, event recording, fault location data, remote setting, self-monitoring and checking, etc.(Blackburn,2006).

II. SYSTEM DESIGN:

2.0 Interfacing module scheme

The figure below shows the block diagram of the system

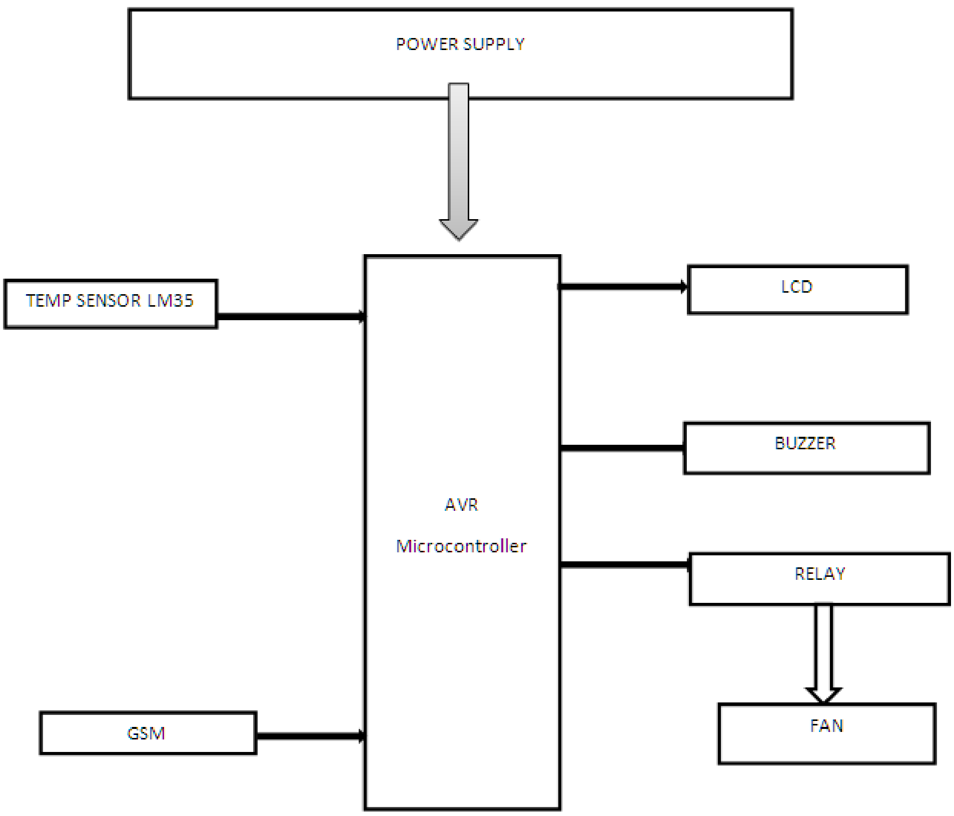

Figure 2.0

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At the primary side of the 230:160VAC transformer, a step down 230-12VAC transformer is rectified to a pure 5VDC and feed into the ADC pin of the microcontroller for monitoring the voltage of the transformer.

At the secondary side of the transformer, a current sensor is connected in series between the load and the transformer secondary terminal for sensing, the load current, output of the current sensor is then feed to the microcontroller ADC pin for monitoring. The LCD is used to display the transformer voltage, current and temperature, similarly the personal computer is used to display the transformer parameters for monitoring purpose. While monitoring the transformer parameters, whenever the load current exceeds the transformer rated current, the microcontroller detects an overcurrent faults and it sends a trip signal to the overcurrent relay, thereby protecting the transformer from blowing off. Moreover, when the autotransformer secondary is varied above the specific limit, the microcontroller detects an overvoltage faults and it sends a trip signal to the overvoltage protective relay, thereby protecting the transformer and the loads from blowing off.

2.1 COMPONENT DETAILS

Based on the various reviews conducted on transformer protection and the above block diagram which was conceived out of those literature reviews conducted, Numbers of components are required in developing the protection system.

2.2 MICROCONTROLLER

The microcontroller is required to serve the purpose monitoring the transformer information such as temperature, voltage and current through the LCDdisplay, personal Gsm module and triggering the relay when there is any fault. Modern power networks require faster, more accurate and reliable protective schemes. Microcontroller-based protective schemes are capable of fulfilling these requirements. They are superior to electromagnetic and static relays. These schemes have more flexibility due to their programmable approach when compared with the static relays which have hardwired circuitry. Therefore in order to achieve this task the ATmega16 microcontroller was chosen because of its suitability for this project such as speed, power consumption, universal synchronous asynchronous receiver transmitter (USART) functionality, in builtADC, and amount of RAM and ROM on the chip. The ATmega16 is a low-power CMOS 8-bit microcontroller based on theAVR enhanced RISC architecture. It has a High Endurance Non-volatile Memory segments such as 32K Bytes of In-System Self-programmable Flash program memory,1024 Bytes EEPROM, 2K Byte Internal SRAM, write/erase Cycles: 10,000Flash/100,000 EEPROM [4]-[5].

The ATmega32 microcontroller I/O pins are 40 in number, and most of them can be used as I/O pins. The input/output pinsserves the purpose of connecting the ADC

chip, LED, LCD display, alarm buzzer and in this case the port A, pin one, two and three were used to take care of ADC input since we are using three different analogue signals ne for the voltage transformer other for the current transformer and finally for the temperature sensor.

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2.3 FLOW CHART OF THE SYSTEM

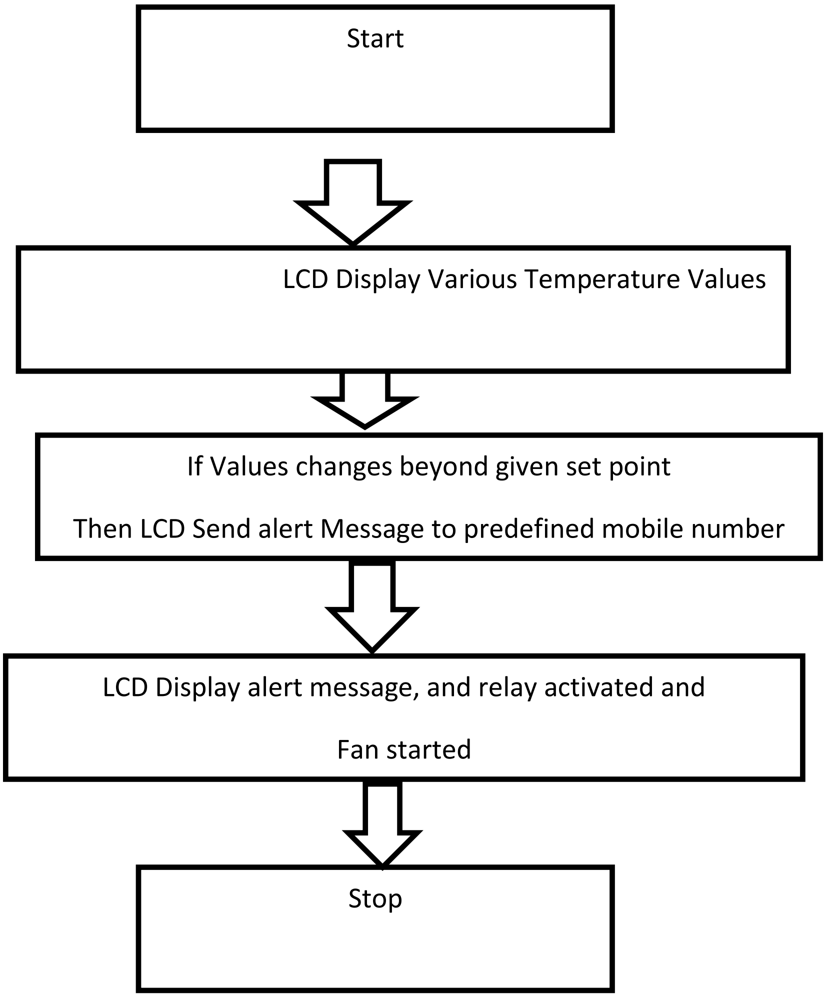

Figure 2.3

The Diagram above explain the details of the flow chart of the system design, initial reads the start and Display the various values of the temperature on the Led ,if the current set value of the temperature is crossing the set value, it activate the relay and the buzzer alarm starts blowing and the fans turn on.

An alert Message is send to the predefined defined number defines on the microcontroller program so that necessary action is taken.

2.4 VOLTAGE TRANSFORMER

The 230VAC:12VAC step down voltage transformer is used to measure the load voltage. The voltage transformer will pass through rectification process before fed to The ADC.

$$\frac{N1}{N2} = \frac{I2}{I1} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots 1$$

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$$\frac{N1}{N2} = \frac{E1}{E2}$$

$$\therefore \frac{E1}{E2} = \frac{I2}{I1}$$

$$\frac{240}{160} = \frac{1}{I1}$$

The above calculation shows that the step down transformer has step up the
primary current from 0.667 to 1A at the secondary

2.5 OVER VOLTAGE PROTECTION CIRCUIT DESIGN CALCULATIONS.

The secondary voltage of the transformer is 160VAC and connected to a
bridge rectifier, therefore the DC output is approximately:

$$Vdc \times \sqrt{2} - (2 \times 0.7) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

$$Vdc = 12 \times \sqrt{2} - 1.4 = 15.57$$

From equation 3, the VAC is the RMS transformer voltage and the 0.7V is the
voltage drop across the rectifier. As there are two diodes conducting for each half cycle, therefore there will be two rectifier voltage.

2.6 RELAY

The relay is an electrically controllable switch widely used in industrial controls, automobiles, and appliances. It allows the isolation of two separate sections of a system with two different voltage sources. For example, a +5V system can be isolated from a 120V system by placing a relay in between them. One such relay is called an electromechanical or electromagnetic relay EMR as shown in figure 3.4. The EMRs have three components: the coil, spring and contacts. In Figure 3.4, a digital +5V can control a 230Vac lamp without any physical contact between them. When current flows through the coil, a magnetic field is created around the coil (the coil is energized), which causes the armature to be attracted to the coil. The armature's contact acts like a switch and closes or opens the circuit. The relay serves as the protective device of the entire system. The relay receives trip signal from the microcontroller and thereby cutting the transformer primary from the input ac source hence protecting the transformer [13]-[14]-[15]-[16].

2.7 RELAY DRIVE CIRCUIT

Microcontroller pins lack sufficient current to drive a relay. While the 6volts relay's coil needs around 12mA to be energized, the current is obtained by the V/R expression. For example, if the coil is 6VDC and the coil resistance is 500Ω, a minimum of 12mA (6V/500Ω = 12mA) is need to energize the relay while the microcontroller's pin can provide a maximum of 1-2mA current, therefore a transistor was used as relay driver which is placed between the microcontroller and the relay as shown in figure 2.6.

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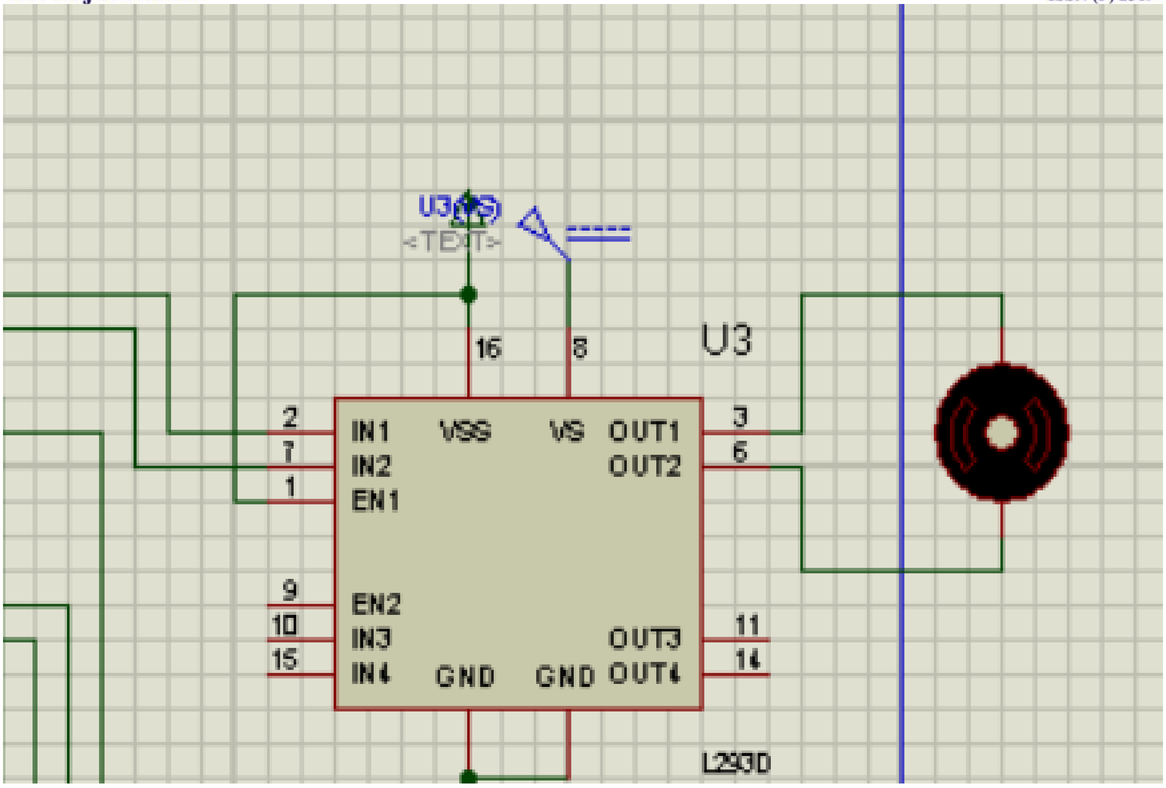

Figure 2.7 shows relay driver circuit

2.8Cut-off condition

A transistor is said to be in cut-off region when the base emitter BE junction is not forward-biased. When is near zero, approaches zero in a nonlinear manner, this is known as a cut-off region of operation. In this case the transistor acts as an open or off switch.

2.9 Saturation condition

The transistor is said to be in a saturated condition when the BE base emitter junction is in forward biased, and there is an enough base current to produce high
collector current. In this case the transistor is said to be closed or on. Saturation:

$Vbe = 0.7v, Ib > 0A,$

2

III. RESULTS AND DISCUSSIONS

3.1 Results

Nameplate rating of Distribution Transformer:

KVA rating: 500

Cooling type: oil natural

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Voltage rating:

HV: 11KV

LV: 0.4KV

Current rating:

HV: 26.24A

LV: 666.70A 40

Impedance voltage: 3.92%

Vector Group: Dy11

Maximum Temperature Rise in oil: 45 deg.C

We need to monitor voltage and currents in phase.

Under normal condition

Ia=121.4A Vab=442.0V

Ib=108.8A Vbc=437.2V

Ic=138.5A Vca=440.3V

Taking the data of previous fault condition

Instantaneous load current in phases

Ia=318.6A

Ib=294.4A

Ic=333.1A

These currents of high magnitudes can't be fed directly to our designed system. It needs to be scaled down. For this purpose current transformer and potential transformer can be used in practice. The current and voltage after being scaled down is fed to microprocessor based system where it compares it with the reference value and take consequent action.

Regarding taking reference value, we have to take account the normal current, turn ratio of CT and PT, accuracy and associated errors. Comparing suchsituation using potentiometer. We will vary the voltage and current in different phases.

The reference voltage is 2.44

By varying the potentiometer we change the voltage of phase 3 to 3.1

It is more than the reference voltage…

So the system will send message.

The following displays are obtained during the operation

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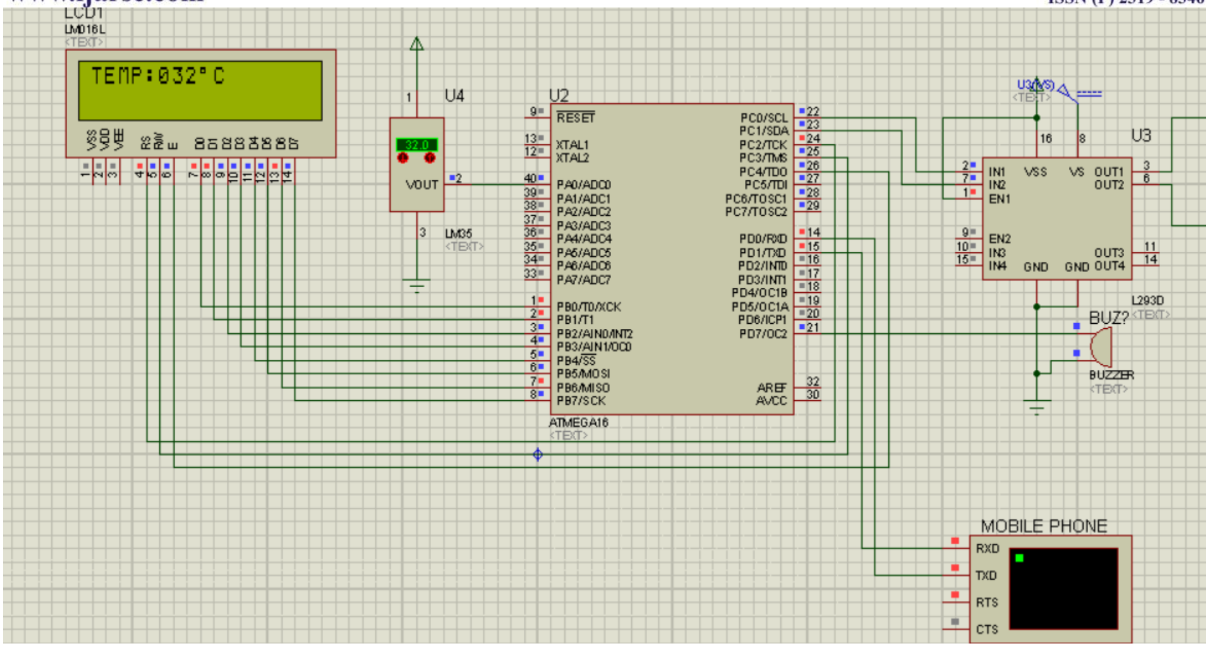

Figure 3.1

IV. SUMMARY AND CONCLUSION

The GSM based monitoring of distribution transformer is quite useful as compared to manual monitoring and also it is reliable as it is not possible to monitor always the oil level, oil temperature rise, ambient temperature rise, load current manually. After receiving of message of any abnormality we can take action immediately to prevent any catastrophic failures of distribution transformers. In a distribution network there are many distribution transformers and associating each transformer with such system, we can easily figure out whichof Transformer is undergoing fault from the message sent to mobile. We don't need to check all transformers and corresponding phase currents and voltages and thus we can recover the system in less time. The time for receiving messages may vary due to the public GSM network traffic but still then it is effective than manual monitoring.

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