GSM Based Condition Monitoring of Transformer

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Abstract—In normal ways all the Industrial or Electrical machineries are controlled by the manual operation. Hence there is step by step progress but most of the time there is not actually instant cooperation between system and operator in case of emergency or fault type situation. Therefore we are designing a system where there exits communication between system and operator. For this we are using Transformer, microcontroller, logic level converter and GSM i.e. global system for mobile communication modem. This GSM modem helps to monitor transformer health by sending message to the system. As we know, transformer is a major component of power system and its correct functioning is vital to system operations. To reduce the risk of unexpected failure and the ensuring unscheduled outage, on-line monitoring has become the common practice to assess continuously the condition of the transformer. This paper presents design and implementation of a mobile embedded system to monitor and record key operation of a distribution transformer like overvoltage, over current, temperatures, fall of oil level. Also it is important to keep an eye on transformer health when operator is not present actually at transformer site so we are introducing system named as two way communication systems between transformer and operator through GSM modem where person can ask any related parameter value of transformer health by sending message to the system. This system is designed to send SMS alerts whenever related parameter value exceeds the predefined limits.

Keywords: Power system faults, transformer conditioning monitoring, GSM technology, micro controller

I. INTRODUCTION

In the expanding world the demand of electricity is increasing day by day. The power utilities are making continuous efforts to reduce the gap between supply and demand. The effect of various faults in power system leads to unplanned outages in power system, which makes the situation still worse. Powers transformers are the heart of power system. They are the key apparatus in power system. Any fault on transformer leads to unnecessary outages and huge loss to electric utility. For proper and reliable operation of transformer, continuous condition monitoring is required.

Transformer is a high efficient static electrical device used for power transfer from one voltage level to the other and plays the vital role in electrical transmission and distribution system. From the day of this equipment in service, different stresses like electrical, mechanical, chemical, and environmental factors affect the condition of the transformer. At the initial stage, degradation of insulation quality occurs slowly. But this deterioration multiplies in due course of time and leads to final failure of the transformer. So, to overcome this situation, continuous monitoring of the condition and preventive measures is required for correct maintenance of the transformer.

Distribution transformers have a long service life if they are operated under good and rated conditions. However, their life is significantly reduced if they are overloaded, 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.

Distribution transformers are currently monitored manually where a person periodically visits a transformer site for maintenance and records parameter of importance. This type of monitoring cannot provide information about occasional overloads and overheating of transformer oil and windings. All these factors can significantly reduce transformer life. Our system is designed based upon online monitoring of key operational parameters of distribution transformers 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 paper presents the design and development of an automatic real time monitoring system consisting of PIC micro controller, sensors and GSM modem.

II. TRANSFORMER FAULT ANALYSIS

A. Over load

Over current is the current flowing through the transformer resulting from faults on the power system. Fault currents that do not include ground are generally in excess of four times full-load current; fault currents that include ground can be below the full-load current depending on the system grounding method. Over current conditions are typically short in duration (less than two seconds) because protection relays usually operate to isolate the faults from the power system. Overload, by contrast, is current drawn by load, a load current in excess of the transformer name-plate rating. In summary, loading large power transformers beyond nameplate ratings can result in reduced dielectric integrity, thermal runaway condition (extreme case) of the contacts of the tap changer, and reduced mechanical strength in insulation of conductors and the transformer structure. Three factors, namely water, oxygen, and heat, determine the insulation life of a transformer. Filters and other oil preservation systems control the water and oxygen content in the insulation, but heat is essentially a function of the ambient temperature and the load current. Current increases
the hottest-spot temperature (and the oil temperature), and there by decreases the insulation life span.

B. Over Temperature

Excessive load current alone may not result in damage to the transformer if the absolute temperature of the windings and transformer oil remains within specified limits. Transformer ratings are based on a 24-hour average ambient temperature of 30°C (86°F). Due to overload and under voltage, temperature of oil increases which causes failure of insulation of transformer winding.

C. Over Excitation

The flux in the transformer core is directly proportional to the applied voltage and inversely proportional to the frequency. Over excitation can occur when the per-unit ratio of voltage to frequency (Volts/Hz) exceeds 1.05 p.u. at full load and 1.10 p.u. at no load. An increase in transformer terminal voltage or a decrease in frequency will result in an increase in the flux. Over excitation results in excess flux, which causes transformer heating and increases exciting current, noise, and vibration.

D. Oil Level Fault

Oil mainly used in transformer for two purposes one is for cooling of transformer and another use is for insulation purpose. When temperature of transformer goes high, oil level in transformer tank decreases due to heating effect. For normal operation of transformer oil level should maintain at required level. If oil level decreases beyond required level, it affect cooling and insulation of the transformer.

III. COMPONENTS USED FOR THE DESIGN OF CONDITION MONITORING OF THE TRANSFORMER

A. PIC16F877A MICROCONTROLLER

This is one of the most advanced microcontrollers from Microchip. This controller is widely used for experimental and modern applications because of its low price, wide range of applications, high quality, and ease of availability. It is ideal for applications such as machine control applications, measurement devices, study purpose, and so on. The PIC16F877A features all the components which modern microcontrollers normally have.

General features

1) All single-cycle instructions except for program branches, which are two-cycle
2) Operating Speed: DC-20 MHZ clock input DC- 200 ns instruction cycle.
3) Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory.
4) Fully static design.
5) Wide operating voltage range (2.0 – 5.56) volts.
6) High sink/source current (25mA).
7) Commercial, industrial and extended temperature ranges.
8) Low power consumption.

B. Power supply

The power supply circuit is shown in the fig 1. It has been designed to generate a regulated 5V DC and 12V DC from the mains 230V AC. A step down transformer is used to convert 230V AC to 9V AC. The output from the secondary is then applied to the bridge rectifiers IN4007, which converts the sinusoidal input into full wave rectified output. The filter capacitor at the output of the bridge rectifier is charged to the peak value of the rectified output voltage whenever the diodes are forward biased. Since the diodes are forward biased during entire positive and negative half cycle of the input waveform, the voltage across the filter capacitor is a pulsating DC that is a combination of DC and a ripple voltage. From the pulsating DC voltage, a regulated DC voltage is extracted by the regulator IC. The 7805 is an IC which output the +5v regulated voltage and can deliver output current in excess of 1.0A.

Fig 1. power supply circuit

1) Step Down Transformer

It is a device for stepping down voltage from 230V to 15V. The transformer for 5V supply is 0-9V and transformer for 12V supply is 0-15V.

2) Bridge Rectifier

The bridge rectifier converts ac voltage to dc voltage. The advantages of bridge rectifier are The center tap of the transformer secondary is eliminated. It provides output twice that of center taps circuits for the same secondary voltage. The peak inverse voltage is one half of the center tapped circuits.

C. Voltage Regulator (LM7805)

The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. Voltage regulator (LM7805) is used to maintain a constant out voltage of +5v. It is a member of 78xx series of fixed linear voltage regulator ICs. The 7800 series of the three terminal positive voltage regulators are monolithic integrated circuits designed for fixed voltage regulator for a wide variety of applications including local regulators. It is available in seven fixed output voltage options from +5V to +24V DC.

The voltage source in a circuit may have fluctuations and would not give the fixed voltage output. It is a three terminal device. The voltage of +12V is applied to the input and it gives out +5v of output which is the requirement of microcontroller. LCD display(16*2),MAX232 and various other devices used in this project.

Features of IC 7805

• Output current in excess of 1A.
• No external components required.
• Internal thermal overload protection.
• Internal short circuit current limiting.
• Package in plastic case.
D. Potential Transformer

Potential transformers are used for measuring voltage in electrical power systems, and for power system protection and control. When a voltage is too large to be conveniently used by an instrument, it can be scaled down to a standardized, low value. Potential transformers isolate measurement, protection and control circuitry from the high voltages present on the circuits being measured or controlled.

Two voltage transformers are used to measure the input voltage and output voltage. One is connected in parallel to the primary of the transformer under test and from there to directly to (RA0) port of the microcontroller and second is connected in parallel to the secondary of the transformer to (RA2) port of the microcontroller.

E. Current Transformer

Instrument transformers are used for measuring current in electrical power systems, and for power system protection and control. Where a current is too large to be conveniently used by an instrument, it can be scaled down to a standardized, low value. Instrument transformers isolate measurement, protection and control circuitry from the high voltages present on the circuits being measured or controlled.

A current transformer is a transformer designed to provide a current in its secondary coil proportional to the current flowing in its primary coil. Current instrument transformers are designed to have predictable characteristics on overloads.

Two Current Transformers are used to measure the input current and output current. One is connected in series to the primary of the transformer under test and from there to directly to (RA4) port of the microcontroller and second is connected in series to the secondary of the transformer to (RA3) port of the microcontroller.

F. Temperature sensor

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

LM35 is directly connected to the analog ports of the PIC Microcontroller (RA1), which directly give the temperature of the winding. As second connection of the temperature sensor is to the winding of the transformer.

G. Ultrasonic oil level detector

Ultrasonic oil level sensor is used for oil level measurement in the transformer. When temperature of transformer goes high, oil level in transformer tank decreases due to heating effect. For normal operation of transformer oil level should maintain at required level. If oil level decreases beyond required level, it affect cooling and insulation of the transformer.

Here an ultrasonic oil level detector is used to measure the level of oil, which is placed at the top of the tank in which transformer under test is placed. It is directly connected (RC7) port of the microcontroller.

I) Application:

Fuel tank level sensor can measure changing level of any liquid (diesel, gasoline, water, liquefied gas, milk etc.) in moving and fixed tanks (vehicles fuel tanks, fuel tank tracks, railway tank cars, industrial tanks and liquid storages). The measurements are provided through the tank bottom so no damage and drilling of the tank are needed.

IV. DESIGN OF MICROCONTROLLER BASED TRANSFORMER HEALTH CONDITION MONITORING KIT

Fig. 2: Basic block diagram

Fig. 3: Circuit diagram for GSM based Conditioning Monitoring
The Fig. 2 shows the basic block diagram for online monitoring the condition of the transformer using microcontroller, sensor, and GSM modem

Fig 3 Shows the design of the circuit for monitoring the condition of transformer using GSM(Global System for Mobile Communication)

V. CIRCUIT DIAGRAM DESCRIPTION

The proposed circuit diagram is used for monitoring of transformer parameter like voltage, current, oil level, temperature of the windings based on microcontroller. The monitored output will be displayed on a display screen (size 16x2) through wireless communication network. Monitored outputs are compared with the rated values of the transformer and microcontroller is programmed in such a way when the monitored values exceed the rated values it displays it on the screen and at the same time alarm rings. The microcontroller is programmed in such a manner so as to continuously scan the transformer and update the parameters at a particular time interval.

Since the input voltage to the microcontroller is 5V the voltage and current from the transformer are step down and rectified by voltage transformer (230/12V) and current Transformers, the temperature of the winding are sensed by the temperature sensors (LM35). The ultra-sonic oil level detector is used to detect the level of oil. These values are given as inputs to the microcontroller which as a built in ADC. Which converts the analog signal to digital to be compatible with microcontroller. And when any of the above condition violate there is an alarm and corresponding fault values are indicated on the display screen and message is sent to corresponding mobile user about the fault condition.

To interface the microcontroller with the GSM module as both work on different level. Microcontroller works on TTL logic and GSM works on RS232 logic. MAX232 is used which can interpret both the logic. It is a dual driver and receiver. In between MAX232 and GSM module there is a (DB9) socket.

By knowing about the fault value/condition the operator can quickly repair the fault condition and avoid the catastrophic failure. So to avoid damaged to the transformer. Even the receiver can send the msg to the GSM asking about the condition of different parameter and the GSM modem will reply to the condition of the transformer through MSG as it is a 2 way GSM modem.

This way to sending and receiving message based communication is easy and fast and is even reliable. It is also cost effective compared to other methods of online monitoring of transformer. As transformer is the most costly equipment of the power system so its online conditioning monitoring is very important in order to avoid large catastrophic failure and also to avoid large expenses that can be caused by replacing of the transformer.

VI. CONCLUSION

We have design a circuit for online monitoring the condition of transformer. The instrument value taken in the circuit is calculated on theory basis and may differ sightly when implemented on the hardware. In the circuit diagram the microcontroller will receive the input analog signals and will convert into digital signals in the microcontroller and the result of transformer condition will be displayed on the display screen. Initially the rated value of the transformer will be set and if any of values reaches above that value then the alarm will ring and at that same time the msg will be sent to the mobile user whose number is feed into the GSM modem.

By knowing the values of the violating the parameter the operator can take necessary step, so as to avoid the damage to the equipment. Thus this is the convinent way of avoiding the catastrophic failure and the damage to the equipment and to save the cost of replacing the transformer.

Use of GSM technique provides speed of communication with distance independanty also it enables bidirectional communication as a message.

REFERENCES


