Transformer Health Monitoring and Control through Arduino

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 transformers have some problems and deficiencies. Few of them are mentioned below.

1) Ordinary transformer measurement system generally detects a single transformer parameter, such as power, current, voltage. 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 be 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.

5) Against steal the power, and is not able to monitor all useful data of distribution transformers to reduce costs.

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 application.

II. TRANSFORMER FAULT ANALYSIS

A power transformer consists of a set of windings around a magnetic core. The windings are insulated from each other and the core. Operational stresses can cause failure of the transformer winding, insulation, and core. The power transformer windings and...
magnetic core are subject to a number of different forces during operation:

1. Expansion and contraction caused by thermal cycling
2. Vibration caused by flux in the core changing direction
3. Localized heating caused by eddy currents in parts of the winding, induced by magnetic flux
4. Impact forces caused by fault currents.
5. Thermal heating caused by overloading.

These operating limits only considered the thermal effects of transformer overload. Later, the capability limit was changed to include the mechanical effect of higher fault currents through the transformer. Power transformer faults produce physical forces that cause insulation wear. These effects are cumulative and should be considered over the life of the transformer. The following discussion highlights on different capability limits of transformer.

2.1 Over Load
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 nameplate 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 thereby decreases the insulation life span.

2.2 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 over voltage and over current, temperature of oil increases which causes failure of insulation of transformer winding.

2.3 Over/Under Voltage
The flux in the transformer core is directly proportional to the applied voltage and inversely proportional to the frequency. Over voltage 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.

2.4 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 affects cooling and insulation of the transformer.

III. THE ARDUINO MEGA 2560
It is a microcontroller board based on the AT-Mega 2560 (datasheet). It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila.

Schematic & Reference Design EAGLE files: arduino-mega2560-reference-design.zip

Schematic: arduino-mega2560-schematic

Summary
Microcontroller ATmega2560
Operating Voltage 5V
Input Voltage (recommended) 7-12V
Input Voltage (limits) 6-20V
Digital I/O Pins 54 (of which 14 provide PWM output)
Analog Input Pins 16
DC Current per I/O Pin 40 ma
DC Current for 3.3V Pin 50 ma
Flash Memory 256 KB of which 8 KB used by bootloader
SRAM 8 KB
EEPROM 4 KB
Clock Speed 16 MHz

Power The Arduino Mega can be powered via the USB connection or with an external power supply. The power source is selected automatically.
IV. DESIGN OF ARDUINO BASED TRANSFORMER HEALTH CONDITION MONITORING KIT

It consist of current transformer, power transformer, thermister, oil sensor, Arduino, LCD display, GSM modem and relay. Normally in transformer, failure occurs due to voltage and current fluctuation, overheating, change in oil level etc. In this project, to sense these fault we have used current and power transformer, temperature sensor, oil sensor respectively. All these sensors are connected Arduino, GSM model and LCD respectively. When fault occurs due to above any reason then change in ratings will be shown on LCD and quick SMS will go to control room via GSM modem. A brief discussion about components used is as given below Sensors play a vital role in effective implementation of the project. As we are interested in monitoring over current, over temperature and oil level following sensors are selected and suitable designed with respect to prevailing conditions of power system and rating of transformer to be protected.

4.1 Current and Voltage Transformer
Current or potential transformer are necessary for isolating the protection & control. The behaviour of current and voltage transformer during and after the occurrence of fault is critical in electrical protection since error in signal from transformer can cause mal operation of the relays.

4.2 Oil Level Sensor
Oil level sensor is float connected angular potentiometer. Float is immersed in oil and its mechanical output is given to angular potentiometer. When there is any mechanical movement of float, there is voltage generation corresponding to mechanical movement of float. That voltage is used for oil level monitoring.

4.3 Temperature Sensors LM35
4.3.1 Feature
Calibrated directly in °Celsius (Centigrade)

4.3.2 Applications
The LM35 can be applied easily in the same way as other Integrated- circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.01°C of the surface temperature.

This presumes that the ambient air temperature is almost the same as the surface temperature; if the air temperature were much higher or lower than the surface temperature the actual temperature of the LM35 die would be at an intermediate temperature between the surface temperature and the air temperature. This is especially true for the TO-92 plastic package, where the copper leads are the principal thermal path to carry heat into the device, so its temperature might be closer to the air temperature than to the surface temperature.

To minimize this problem, be sure that the wiring to the LM35, as it leaves the device, is held at the same temperature as the surface of interest. The easiest way to do this is to cover up these wires with a bead of epoxy which will insure that the leads and wires are all at the same temperature as the surface, and that the LM35 die’s temperature will not be affected by the air temperature.

CASE STUDY

This system is totally independent i.e. having separate power supply to operate this total circuitry which is nothing but battery supplied.

This system can sustain over up-to 66 kV range. Over these voltages there is some restriction about CT and PT ratio. As the ratio increases, change in output i.e. secondary output has large change which cannot directly proportional to input quantity.

Limit range of voltage level such as minimum and maximum can set which is in our hand so that we can decide the range of voltages.

Similarly we can set the maximum limit of current so that crossed limit is abnormal current range.

Even having single line taking large current than other lines and set limit will also takes as faulty condition.

We also have the oil level detector having full and low indication. It indicates that whenever the

Transformer Health Monitoring and Control through Arduino

61
oil inside of transformer goes low or particular set limit it will give indication.

✓ We attached temperature detector too for checking the condition of transformer overall body temperature. Even that sensor can act like temperature sensor of oil inside of transformer where it is inserted in oil of transformer.

✓ This system can be also used in Transmission Line, and Three Phase Induction Motor. Only exception is oil level sensor and temperature sensor, we can take it as neutral in those above cases.

✓ If any abnormal condition occur mentioned above, it will give indication through buzzer and will cut the system supply or load through line and inform us through GSM message which fault occurs on system

RESULT

Fault No.1- Voltage level
When device detects low voltage or high voltage (set values), it will send the message to set number that “Transformer no.--- Low/High Voltage Occur”; also it will trigger circuit breaker for cut off supply.

Fault No. 2- Over Load
When device detects current flowing through system high then it assumed that system is overloaded. After detect overloading device send message “Transformer No. --- Overload Occur”, and will break system through line by opening circuit breaker.

Fault No.3- Oil Level
In this system in transformer oil level is low or high it sense the by using float sensor it gives the massage through GSM by mobile.

Fault No.4- Temperature
Ambient temperature of Transformer is high or it will be increase it sense through the sensor LM-35 and gives msg. Through GSM by mobile.

CONCLUSION

Transformers are among the most generic and expensive piece of equipment of the transmission and distribution system. Regular monitoring health condition of transformer not only is economical also adds to increased reliability. In the past, maintenance of transformers was done based on a pre-determined schedule. With the advancement of communication technology now it is possible to receive fault information of transformer through GSM technology remotely to the operator and authorities so one can able to take possible solution before converting fault in to fatal situation.

Depending upon fault analysis a prototype model of microcontroller based transformer health monitoring kit is developed in laboratory. Using digital controller analysis results are regularly updated. During abnormal conditions exceeding specified limits information is immediately communicated through GSM technology to the operator and also to concerned authority for possible remedial action.

This type of remote observation of health condition of transformer not only increases the life of transformer but also increases mean down time of transformer there by increased reliability and decreased cost of power system operations.

REFERENCES


