Monitoring and Protection of Transformer design using IoT

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Abstract— ***The system is very useful in the manufacturing industries where the transformer is used for powering the machineries. The objective of this project is to monitor and protect if the transformer parameters such as primary and secondary voltage and temperature level are exceed above the normal value. When load voltage is above the rated voltage, the transformer windings are spoiled some time the transformer may burst. So this is designed to protect the transformer if any one parameter such as primary voltage, secondary voltage, current and temperature range exceed the normal value. If any emergency or aberrant conditions occur the system sends information through SMS to the mobile phones, by using GSM Modem.***

In this work we are going to monitor the voltage, current and temperature. Voltage to the load is measured with the help of a voltage sensor. Current consumed by the load is measured with the help of a current transformer. Then the rectified output will be given to the micro controller through an analog to digital converter. Analog to digital converter convert the input analog signal to corresponding digital signal which is given to microcontroller.

Temperature sensor is used to monitor temperature level in the transformer. The temperature sensor output is given to microcontroller through amplifier. As temperature reaches to threshold value set in system, a fan would turn on for the cooling of the heated transformer. Then the micro controller will receive above mentioned parameter and displayed on the LCD display which equal to monitored parameters. The microcontroller compares the set values with normal values. If anyone value is exceeding above the normal value, the microcontroller activates the relay driver circuit to trip the incoming power to the transformers. Buzzer is used to provide the alarm in abnormal condition.

Keywords— GSM; Transformer health monitoring; Microcontroller; Transformer faults, protection.

1. INTRODUCTION

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 co-operation 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, analog to digital converter. As we know Distribution 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 ensuing unscheduled outage, on-line monitoring has become the common practice to assess continuously the condition of the transformer with. This work presents design and implementation of a system to monitor and record key operation of a distribution transformer like overvoltage, over current, temperatures, rise or fall of oil level. Sensors, including a Temperature Detector, current sensor and voltage sensor according to manufacturers' specifications are calibrated and tested by power distribution monitoring offices. The system is installed at the distribution transformer site and by measuring above parameters it will help the utilities to optimally utilize transformers and identify problems before any catastrophic failure.

With the increasing loads, voltages and short-circuit duty in distribution system, over current protection has become more important today. The ability of protection system is demanded not only for economic reason but also consumers just expect 'reliable' service. In a Power System Protection, the system engineer would need to a device that can monitor current, voltage, frequency and in some case over power in the system. Thus a device called Protective Relay is created to serve the purpose. The protective relay is most often relay coupled with Circuit Breaker such that it can isolate the abnormal condition in the system. In the interest of reliable and effective protection, some designers of power distribution/power controllers select relay as opposed to electro-magnetic circuit breakers as a method of circuit protection.

However, a rare fault may be very dangerous unless the transformer is quickly disconnected from the system. This necessitates adequate automatic protection for transformers against possible faults. Small capacity transformers are provided with series fuses for protection against overloading and earth faults. No circuit breakers are provided. i.e no automatic protection is given. However, the probability of faults on power transformers is more and hence automatic protection is necessary. A fault which occurs beyond the protection zone of the transformer, but fed through the transformer is known as "Through faults". A unit protection of transformer should not operate for through faults. The overload relaying may be provided to operate with a time lag to provide back-up protection. Internal faults are those in the protected zone of the transformer. These faults can be between phase to phase and phase to ground. Generally, they occur due to a failure of insulation due to temperature rise. Incipient faults are initially minor causing gradual damage. These faults grow into serious faults. Incipient faults include loose connection in conducting path, sparking, small arcing etc.

The main objectives are to prevent forced outages, indicate acceptable overload, assess the remaining insulation-life and reduce maintenance costs. To achieve these goals, the monitoring system manufacturers must follow strategies, which are in line with the interests of transformer owners. Transformer is the key equipment in power system, to ensure its safe and stable operation is important.

Distribution transformer is a critical equipment in power system operation which distributes power to the low-voltage users directly. Operation of distribution transformer under rated condition (as per specification in their nameplate) guarantees their long life. However, their life span and reliability is significantly reduced if they are subjected to overloading, resulting in unexpected failures and loss of supply to a large number of customers thus affecting system reliability. Overloading and ineffective cooling of transformers are the major causes of failure in distribution transformers. Therefore, monitoring of key parameters are necessary for evaluating the performance of the distribution transformer and also helpful to avoid or reduce disruption due to sudden unexpected failures. Monitoring in the context of this research entails remote collection of data and include sensor development, measurement techniques for real-time application.

Transformers either raise a voltage to decrease losses, or decreases voltage to a safe level. "Monitoring" is here defined as on-line collection of data and includes sensor development, measurement techniques for online applications. It is very difficult and expensive to construct the communication wires to monitor and control each distribution transformer station. Here GSM is used for communicating the monitored parameters. The failures of transformers in service are broadly due to: Over Load condition temperature rise, low oil levels, over load, Earth grounding, and improper installation and maintenance. Out of these factors temperature rise, and over load, need continuous monitoring to save transformer life. A distributed transformer networks remote monitoring system increases the reliability of distribution network, by monitoring critical information such as temperature, current and voltage of the transformer. Data are collected continuously. Monitoring the transformers for problems before they occur can prevent faults that are costly to fix and result in a loss of service life.

2. METHODOLOGY

Transformer can be a part of a set of equipment designed for reducing & increasing the current and electrical power. Transformer can be key inside land area as a result it be important during broadcast and allocation set of connections. The normal scheme in the direction of provide by means of a protect rearing used for the transformer which be distribute command in the direction of assured area since redundant contiguous. The transformer confined through graceful the transformer on or after the leading make available by means of microcontroller based relay. In irregularity situation in distribution transformer is attain pole away from each other by way of incongruity within limits similar, short circuit, snaking high temperature, oil temperature, ambient heat, bushing issue, load current issues, winding issues. As a result we are operate by way of inner issues. Consequent The normal scheme in the direction of provide by means of a protect rearing used for the transformer which be distribute command in the direction of assured area since redundant contiguous. The transformer confined through graceful the transformer on or after the leading make available by means of microcontroller based relay. In irregularity situation in distribution transformer is attain pole away from each other by way of incongruity within limits similar, short circuit, snaking high temperature, oil temperature, ambient heat, bushing issue, load current issues, winding issues. as a result we are operate by way of inner issues. consequent protection approach used for transformer is included in this expansion work.

1) Primary safeguard of transformer
2) Over-current shelter (back-up protection)
3) Over-load or persistent load security by sensing oil hotness.

This system is a presentation of the design implementation of Real Time Transformer Health Monitoring System (THMS). Cost effectiveness and remote location will be given priority to this project. In case of software driven system total system requires lot of connection and apparatus and technically skilled personnel. Fault information will available only in control room.

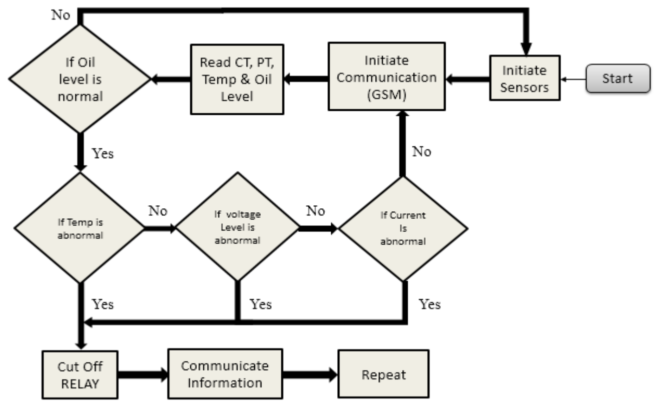

Fig. 1: Flow chart

3. SYSTEM OVERVIEW

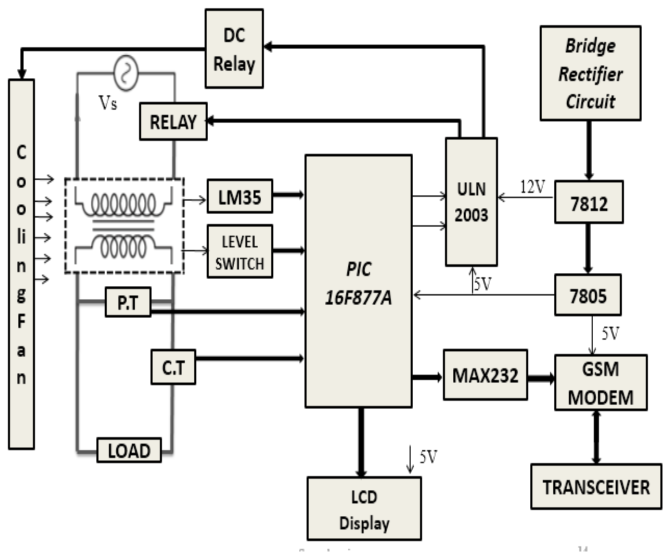

Fig. 2 : Block Diagram

Every circuit needs a source to give energy to that circuit. The Source wills a particular voltage and load current ratings. The following is a circuit diagram of a power supply. We need a constant low voltage regulated power supply of +5V, providing input voltages to the microcontroller RS232, LM311 and LCD display which requires 5 volts supply.

The transformer works on the principle of faradays law of electromagnetic inductions. Transformer is in its simplest form.

A resistor is an electric component. It has a known value of resistance. It is especially designed to introduce a desired amount of resistance in a circuit. A resistor is used either to control the flow of current or to produce a voltage drop.

Capacitor is an electrical device used for storing electrical energy. The stored electrical energy is the form of a current in to the circuits which the capacitor form a part.

A voltage regulator is an electronic circuit that provides a stable DC voltage independent of the load current, temperature and AC line voltage variations.

The PIC16F family of devices is CMOS (Complementary Metal Oxide Semiconductor). CMOS technology offers a number of advantages over other technologies. For example, CMOS circuits consume very little power, operate over quite a wide voltage range and are quite forgiving of bad layout and electrical noise. One of the most useful features of a PIC microcontroller is that you can re-program them as they use flash memory. You can also use the ICSP serial interface built into each PIC Microcontroller for programming and even do programming while it's still plugged into the circuit. You can either program a PIC microcontroller using assembler or a high level language and I recommend using a high level language such as C as it is much easier to use (after an initial learning curve). Once you have learned the high level language you are not forced to use the same processor e.g. you could go to an AVR or Dallas microcontroller and still use the same high level language.

It is easy to interface with a micro-controller because of an embedded controller (the black blob on the back of the board).This controller is standard across many displays which means many micro-controllers have libraries that make displaying messages as easy as a single line of code.

A current sensor is used for measurement of alternating electric currents. When current in a circuit is too high to apply directly to measuring instruments, a current transformer produces a reduced current accurately proportional to the current in the circuit, which can be conveniently connected to measuring and recording instruments.

Potential transformers are also known as voltage transformers and they are basically step down transformers with extremely accurate turns ratio. Potential transformers step down the voltage of high magnitude to a lower voltage which can be measured with standard measuring instrument. These transformers have large number of primary turns and smaller number of secondary turns.

LM 35 used as temperature sensor which also provides an ADC output as voltage varies 10mV for every degree Celsius change of temperature. Equation to measure temperature in Celsius unit,

$$\text{Temp} = \text{output\_voltage}/0.01$$

Level sensors detect the level of liquids and other fluids and fluidized solids, including slurries, granular materials, and powders that exhibit an upper free surface. Substances that flow become essentially horizontal in their containers (or other physical boundaries) because of gravity whereas most bulk solids pile at an angle of repose to a peak.

A relay is an electrical switch that opens and closes under control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts.

GSM is an open and digital cellular technology used for transmitting mobile voice and data services operates at the 850MHz, 900MHz, 1800MHz and 1900MHz frequency bands. GSM system was developed as a digital system using time division multiple access (TDMA) technique for communication purpose. A GSM digitizes and reduces the data, then sends it down through a channel with two different streams of client data, each in its own particular time slot. The digital system has an ability to carry 64 kbps to 120 Mbps of data rates.

4. OPERATION

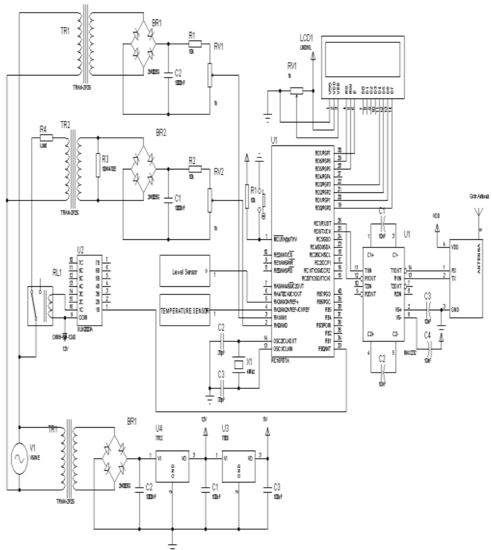

Fig. 3 : Circuit Diagram

When AC is applied to the primary winding of the power transformer it can either be stepped down or up depending on the value of DC needed. In our circuit the transformer of 230v/15v is used to perform the step down operation where a 230V AC appears as 15V AC across the secondary winding. In the power supply unit, rectification is normally achieved using a solid-state diode. Diode has the property that will let the electron flow easily in one direction at proper biasing condition. As AC is applied to the diode, electrons only flow when the anode and cathode is negative. Reversing the polarity of voltage will not permit electron flow. A commonly used circuit for supplying large amounts of DC power is the bridge rectifier. A bridge rectifier of four diodes (4*IN4007) is used to achieve full wave rectification. Two diodes will conduct during the negative cycle and the other two will conduct during the positive half cycle. The DC voltage appearing across the output terminals of the bridge rectifier will be somewhat less than 90% of the applied RMS value. Filter circuits, which usually capacitor is acting as a surge arrester always follow the rectifier unit. This capacitor is also called as a decoupling capacitor or a bypassing capacitor, is used not only to ‘short’ the ripple with frequency of 120Hz to ground but also to leave the frequency of the DC to appear at the output. The voltage regulators play an important role in any power supply unit. The primary purpose of a regulator is to aid the rectifier and filter circuit in providing a constant DC voltage to the device. Power supplies without regulators have an inherent problem of changing DC voltage values due to variations in the load or due to fluctuations in the AC liner voltage. With a regulator connected to the DC output, the voltage can be maintained within a close tolerant region of the desired output. The regulators IC7812 and 7805 are used to provide the +12v and +5v to the circuit.

PIC16F877A is a 40 Pin DIP pack IC with 33 I/O pins. Out of which 9 pins can be used either as Digital I/O pins or Analog Input pins. The micro controller is having 5 ports Port A, Port B, Port C, Port D and Port E. Here Port A consists of 6Pins and can be used as Analog Pins and Digital Pins, in the same way Port E consists of 3Pins all of them can either be used as Analog Pins or Digital Pins. The Port pins of Port D are connected to LCD pins. RD0 to RD3 pins are data pins and RD5 to RD7 pins are control pins. The Pins 13 and 14 are connected to Oscillators. This Oscillator provides required clock reference for the PIC microcontroller. Either Pins 11 and 12 or 31 and 32 can be used as power supply pins. The 5v supply is given to the 11th and 32 pin and GND is connected to the 12th and 31th pin of microcontroller. Pins 25 and 26 of Port C are used for serial Port communications; these pins are interfaced with MAX232 for PC based communications. Pins 39 and 40 are used for In-Circuit Debugger Operations, with which the hex code is downloaded to the Chip. Pin 33 is used as external Interrupt Pin. Pin 1 is used as Reset Pin. This Pin is connected to Vcc through a resistor.

The LCD we have used in this project is HD1234. This is an alphanumeric type of LCD with 16 pins. Of which Pins 7 to 14 are used as data pins, 11 to 14 pins are connected to 2-5th pin of the microcontroller. There are 3 control pins RS (Pin-4), RW (Pin-5) and EN (Pin-6). The RS pin is connected to the 7th Pin of micro controller. The RW pin is usually grounded. The RW is connected to 28th Pin. The EN pin is connected 6th pin. The LCD has two Rows and 16 Columns. The LCD is powered up with 5V supply connected to Pins 1(GND) and 2(Vcc). The Pin 3 is connected to Vcc through a Potentiometer. The potentiometer is used to adjust the contrast level. Here in our project we use the PIC controller in 4-bit mode. Here only 4 data pins are connected and are used as Data Port.

Voltage sensor is used a step-down transformers in general, which senses the voltage. Output from the sensor is in the form of voltage, sinusoidal wave-shaped. From voltage transformer to convert the voltage into 220 volt and 12 volt signal directed with full direct waves. Voltage calibration is done by placing a variable resistor 10k so that the resulting voltage can be adjusted, on the other end of the series capacitor installed a filter to produce a pure DC voltage against compatible voltage needed by the ADC. The voltage sensor output is connected to the A1 of the Arduino.

Current sensor circuit consists of rectifier and gain OP-AMP circuit. The second op-amp is used as a comparator which detects a voltage rise greater than the diode drop. Voltage calibration is done by placing a resistor so that the resulting voltage can be adjusted, on the other end of the series capacitor installed a filter to produce a pure DC voltage against compatible voltage needed by the ADC. The current sensor output is connected to the A2 pin of arduino.

A temperature sensor LM35 is interfaced to the ADC port of PIC16F877A microcontroller. The output voltage from the LM35 is linearly proportional to the measuring temperature. The internal ADC converts the output voltages from the LM35 into digital signals, which correspond to the measured temperature. The Three pins are VCC, Output and Ground. The output voltage of the LM35 increases by 10 mV per 1° rise in temperature. This LM35 can measure temperature ranging from -55°C to 150°C.The 5V supply is given to the 1st pin and GND is given to the 3rd pin of LM35. The 2nd pin (output) of LM35 is connected to the A0 pin of Arduino.

The relays are connected to microcontroller through ULN2003 relay driver IC. The ULN2003 has 16 pins. The 9th pin of ULN2003 is Vcc and 8th pin of the ULN2003 is GND. The 12V supply is given to the 9th pin of the ULN2003. The ULN2003 has 7 input pins (1-7) and 7 output pins (10-16). The ULN consists of Darlington arrays. The 1st and 2nd pin of ULN2003 is connected to the 8 and 9th pin of the Arduino microcontroller. The 15 and 16th pin of the ULN2003 is connected to the relay, which drives the relay and the relay which drives the DC fan.

The Max-232 can simultaneously be interfaced with two channels. This is a 16-pin DIP pack IC. The pin 1st pin of arduino microcontroller is connected to pin 11 of the Max-232. The pin 0th pin of arduino microcontroller is connected to pin 12 of the Max-232. The AT commands are sent by the HyperTerminal to the GSM module. The Information Response and/or Result Codes are received at the microcontroller and retransmitted to the HyperTerminal by the controller. A GSM module has an RS232 interface for serial communication with an external peripheral. The Pin 14 of Max-232 is connected to Rx pin of the GSM. The Pin 13 of Max-232 is connected to Tx pin of the GSM

5. CONCLUSION

The project “DISTRIBUTION TRANSFORMER PROTECTION BY USING GSM MODEM” has been completed successfully and the output results are verified. The results are in line with the expected output. The project has been checked with both software and hardware testing tools. In this work “LCD, Arduino, current sensor, voltage sensor, temperature sensor, GSM and relay” are chosen are proved to be more appropriate for the intended application. The project is having enough avenues for future enhancement. The project is a prototype model that fulfills all the logical requirements. The project with minimal improvements can be directly applicable for real time applications. Thus the project contributes a significant step forward in the field of “ADVANCED CONSUMER APPLICATION”, and further paves a road path towards faster development s in the same field. The project is further adaptive towards continuous performance and peripheral up gradations. This work can be applied to variety of industrial and commercial applications.

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