Centralized Transformer Monitoring using GPRS

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ABSTRACT— ***In order to provide effective and wireless supervision based on newest technology, a monitoring and control systems for transformers utilizing the GPRS system is introduced here. The voltage in the three phase lines that comes to the transformer may drop or cut-off if there is any problem in the power line. Also if the transformer develops any error internally, the temperature in the transformer rises. Here a system is developed that can be fitted in the transformers to monitor the power line faults and internal errors. This device monitors the power lines, reads the values and calculates parameters like true RMS voltage and RMS current. The device detects high voltage, low voltage and short circuit in power line. Also it checks overheat and liquid level of the transformer. It also has a dedicated microcontroller to control the operation.***

Keywords— GPRS, Microcontroller, Transformer Monitoring

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1. INTRODUCTION

Electricity or power supply has become one of the basic requirements of mankind. Failure in power supply thus causes difficulties to common man and huge losses to industries. The delay in repairing the faults in power lines happens due to the non-availability of fault information at the control station or electrical office. This work attempts to develop a device that monitors the fault in three-phase lines (R, Y and B) connected to the transformers. The fault detected in the line or transformer is informed to the control station using the power line transmission. Hence the recent trends in the modern power sector are to modernize the age old grids to smart grid which is an emerging area in the modern power sector.

Transformers serve as a hub for collection and distribution of energy changing the voltage level at different locations of the Grid. They are a key component of the Smart Grid, loosely defined as an automated, widely distributed energy delivery network, characterized by a two-way flow of electricity and information and able to monitor everything from power plants to customer preferences to individual appliances. Recently monitoring transformers has taken a great leap forward, as energy production sites seek solutions to lower maintenance costs. Modern energy networks are vast. The rising need for electricity and client demands from suppliers make the matter of supervising their efficient, effective, and stable functioning a priority. Transformers are found at large distances from each other. Utilizing conduit technology is costly and unpractical in this instance. In order to provide effective and wireless supervision based on the newest technology, a monitoring and control system for transformers utilizing the GPRS is introduced here.

The smart grid technology incorporates information technology and communicates technology into every aspect of electricity generation, transmission, distribution and consumption in order to minimize environmental impacts .This helps in improving the reliability, service efficiency and reduces cost. Also the asset modernization is an important element of smart grid. It is a fundamental re-engineering of electricity architecture. It encompasses a basket of technologies which are helping utilities to transform from their age old grids. Efficient transmission, quick restoration, better quality and reliability of supply, reduced costs, reduced peak demand, competitive electricity market and improved grid security are some of the benefits of smart grid technology.

Power distribution automation function is to deliver electricity in a stable and efficient manner to the consumers. Power utilities are adopting computer aided monitoring, control and management of electric power distribution system to provide better services to consumers. The Institute of Electrical and Electronics Engineers (IEEE) has defined

Distribution Automation System (DAS) as a "system that enables an electric utility to remotely monitor, coordinate and operate distribution components in a real time mode from remote locations.

Power distribution circuits can experience various faults that disrupt service to consumers of electricity. The delay in repairing is due to lack of fault information at the electricity office. Presently there is no fault indication mechanism in the rural networks. The authorities have to wait for the information from the consumers. As power transmission or distribution circuit extent over large distances, repair crews must patrol the entire line section. Locating faults is thus presently time consuming and expensive. Therefore a need remains in the industry for an efficient, effective and low cost fault monitoring system. Here the aim is to develop a practical cost effective system that monitors the three phase lines and internal errors in the transformers connected to them, using the microcontroller P89V51RD2.

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2. TRANSFORMER MONITORING

Transformer is a device that transfers electrical energy from one circuit to another through inductively coupled conductors-the transformer winding. A varying current in the primary winding creates a varying magnetic flux in the transformer's core, and thus a varying magnetic field through the secondary winding, this effect is called mutual induction.

2.1 Transformers

Transformers are manufactured using modern techniques of production under rigid quality control at every stage of manufacture. Usually special non-aging CRGO silicon steel laminations are used for the cores. The core laminations are interleaved clamped and taped to reduce vibration and noise as well as to provide excellent mechanical strength. Eddy current losses are reduced by coating the laminations with suitable insulation. The cores are effectively earthed. Cores are wound with electrolyte, high conductivity paper covered aluminum or copper conductors. Spiral disc and cross over types of windings are used giving due consideration to the thermal, electrical and mechanical aspects. Strong self-supporting coils are made by anchoring the turns using tapes. Adequate horizontal and vertical ducts are provided to ensure that the temperature gradient between the windings and oil do not exceed the limits and no hot spots developed. Tappings are normally provided in HV windings.LV winding is placed next to the core and HV winding is placed concentrically around the LV winding. Press board and Kraft paper are used for insulation. The transformer tanks are made of mild steel sheets and plates of adequate thickness. They are pressure tested to make it leak proof.

Distribution transformer is used to convert electrical energy of higher voltage to a lower voltage with frequency identical before and after the transformation. Application of this is mainly within suburban areas, public authorities and industrial customers. With given secondary voltage, distribution transformer is usually the last in the chain of electrical energy supply to households and industrial enterprises. Main parts in the distribution transformer are coils, magnetic core and tank.

2.2 Causes of Transformer Failure

The different failures that can occur in a transformer are:

i. *Over voltage*

Each winding of the transformer will be assigned a value of highest voltage of a system to which the winding may be connected with respect to its insulation. The line surge is the major cause for all types of transformer failure. This category includes switching surges, voltage spikes, line fault and other transmission and distribution abnormalities. This significant portion in transformer losses indicates that more attention should be given to provide surge protection or testing the adequacy of existing surge protection.

ii. *Over current*

The fault current of a power transformer depends on transformer rating per unit impedance of the transformer, line/phase voltage. The following formula can be used to find the fault current on the secondary side of a transformer,
Fault current=Transformer Rating/ (per unit impedance × phase voltage)

iii. *High Temperature*

The temperature rise can cause deterioration of insulation. At the winding hotspot temperature of 98 degree Celsius, insulation deterioration occurs at normal rate. In a temperature zone extending up to 140 degree Celsius, the rate of deterioration increase exponentially with temperature. Temperature rise is the prime cause of the of the insulation failure and thereby the failure of the transformer.

Methods to Overcome Failure

Several methods are adopted for the transformer protection, some of the common methods are: 1) over current protection can be achieved by providing fuses, on both primary and secondary sides of the transformer. 2) For over voltage protection lightning arrestors can be provided on both sides of the transformer. 3)Reduction in oil level can be controlled beyond exceeding the permanent limits by providing sufficient volume of reserve oil in an additional tank. 4) Failure due to rise in temperature can also be avoided by providing a better cooling facility at that time. One method is to operate a cooling fan.

The first two methods are already employed in the distribution level of lower system. In case of overvoltage protection, lightning arrestor is provided only on the primary side as it is uneconomical to be provided also on the secondary. The next two are uneconomical to adopt in a distribution transformer. The last method mentioned is usual employed in the protection scheme of power transformers as it is economical and can be easily employed in the transformer system.

2.3 Transformer Monitoring System

TMS is primarily health monitoring of the equipment that can acquire, process, analyze and communicates the critical parameters to centralized data center for analysis and visualization of widespread distribution transformers and power transformers in electrical network. Transformer Monitoring System increases the reliability of distribution network. Not only the conventional technical data, such as current, voltage etc. but also other critical information such as moisture, oil temperature, oil level etc. of transformers, are required by the operators to ensure reliable power delivery and to assist the day to day decision making activities.

On Line Dissolved Gas Analysis, hot spot and tan delta of bushing for power transformer helps to monitor the health of transformer and more important loading of the transformer can be accurately controlled. Transformer monitoring requires the integration of sensors, data management and analysis to turn sensor data into useful knowledge and then an overlay of software applications to turn knowledge into actionable information. Features of TMS are:

1) Advanced detection of abnormal conditions.

2) Easily installed on new transformers from any manufacturer utilizing existing sensors.

3) Automatically detects bad sensor data to avoid false diagnosis.

4) Supports fiber optics and wireless based communication mediums.

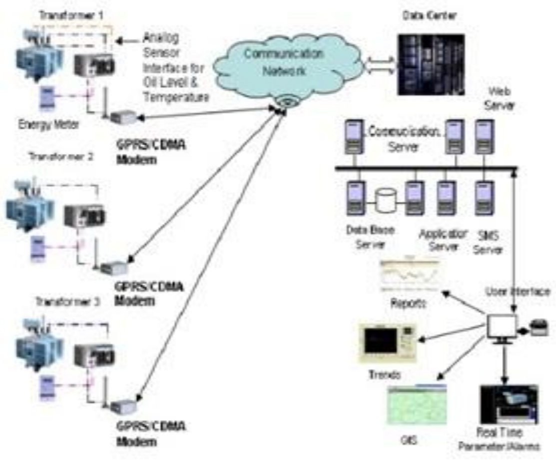

Figure 1: Transformer Monitoring System

2.4 Work Overview

Each transformer has its own identification number and has a controlling device attached to it. The microcontroller based embedded system monitors the power lines. The voltage in the three lines is sensed by the system in frequent intervals. The temperature is also sensed and compared with the safe level. If a drop or error comes in the lines the system sends the data to the controlling station. The values along with the transformer-id are transmitted to the controlling station with the help of GPRS transmission.

The communication between the module and the control station module is established using GPRS. Highly cost effective and secure design of this network ensures outstanding advantages over transmission used in the past. The controller station has a GPRS receiver system that receives the fault messages and displays it. This module indicates the message along with the ID of the transformers and the error found. The hardware part consists of a transmitter section and receiver section. The figure 2 represents the block diagram of the transmitter which contains the microcontroller, LCD, inputs from the transformer, GPRS module and ADC. Here the microcontroller, the main part of the transmitter used is P89V51RD2, is used for generating 120 kHz PWM to transmit information over 50 Hz power lines. Zero crossing detectors is used to detect the time at which the wave of AC power line crosses zero value for sending the data at that time. It is connected to AC main line and to the external interrupt pin of the microcontroller. High pass filter is used to block the low frequency component and will allow passing the high frequency component. Here it is designed in such a way that it allows the 120 kHz signal to be safely coupled to the 50Hz power line.

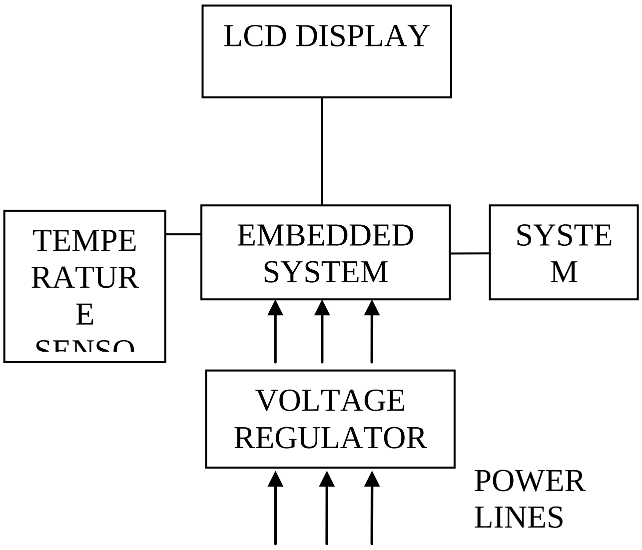

Figure 2: Block Diagram of Transmitter

Basic elements used in Centralized transformer monitoring using GPRS are P89V51RD2 microcontroller RS232, MAX232, GPRS/GSM module, temperature sensor, voltage regulator, transformer etc. which is elaborated in figure 3 explaining the block diagram of the work.
A temperature sensor is fixed on the body of the transformer, which is to be monitored. The sensor produces weak current signal, proportional to the temperature. This current signal is amplified and converted from analog voltage to digital by the ADC. The ADC gives the binary output to the microcontroller. The microcontroller monitors the temperature value and when the temperature of the transformer exceeds the threshold value, the microcontroller senses this logic signal and switch ON the cooling fan waits for few minutes. If the temperature is not become low with in this period, then the controller sends information to the electricity board via GPRS. It also activates its buzzer.

The gas sensor and the oil level sensor integrated to the system monitors the gas presence and oil level in the transformer and informs the microcontroller. The microcontroller via the GPRS Module updates the status. The microcontroller monitors the current usage of the load via current transformer. If the load tries to take the current higher than the particular value, then the microcontroller cuts the supply to the transformer with the help of a relay.

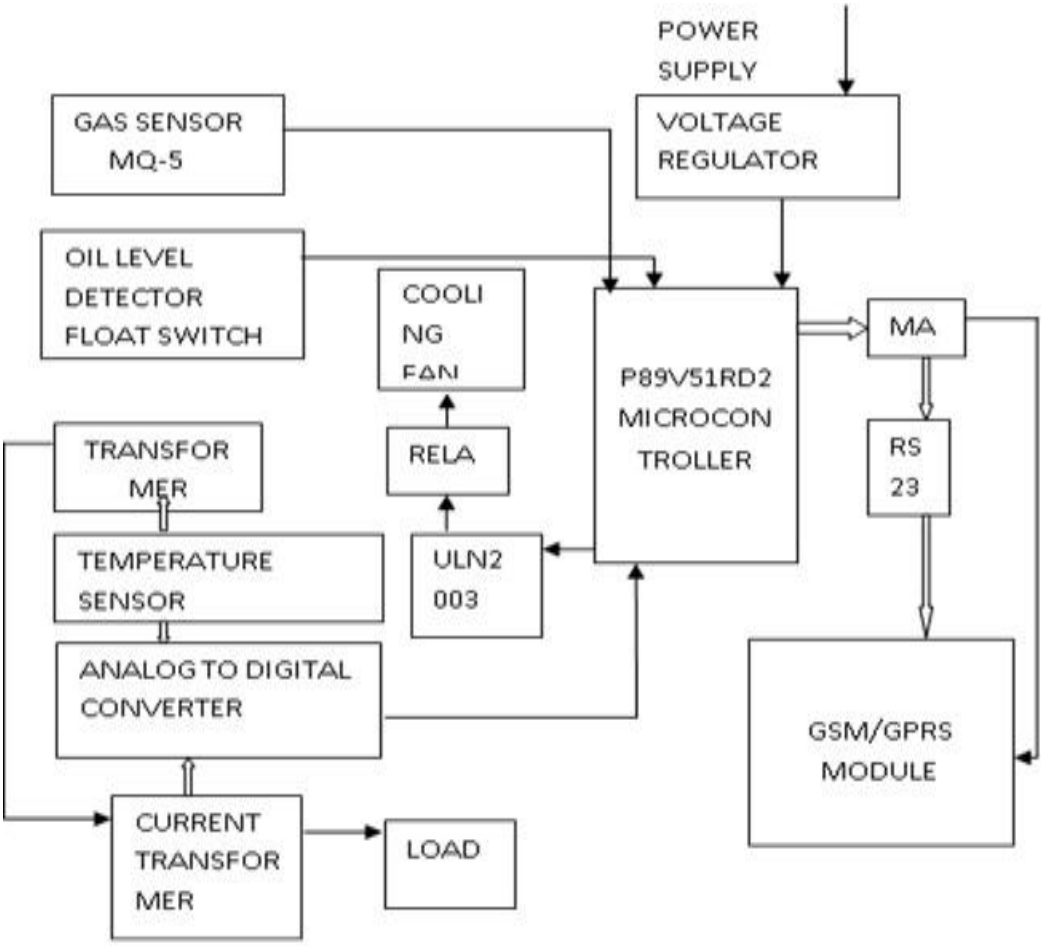

Figure 3: Overall Block Diagram

P89V51RD2 Microcontroller

A microcontroller can be compared to a small stand-alone computer; it is a very powerful device, which is capable of executing a series of pre-programmed tasks and interacting with other hardware devices. It is a tiny integrated circuit whose size and wait is usually negligible, so it is becoming the perfect controller for robots or any machines requiring some kind of intelligent automation. The microcontroller used here is P89V51RD2 and has the features like CMOS 8 bit microcontroller, 6 kilobytes flash programmable and erasable read only memory, 1KB internal RAM, Three 16-bit Timers/Counters etc. Being packed in a tiny integrated circuit (IC) whose size and weight is usually negligible, it is becoming the perfect controller for robots or any machines requiring some kind of intelligent automation. A single microcontroller can be sufficient to control a small mobile robot, an automatic washer machine or a security system.

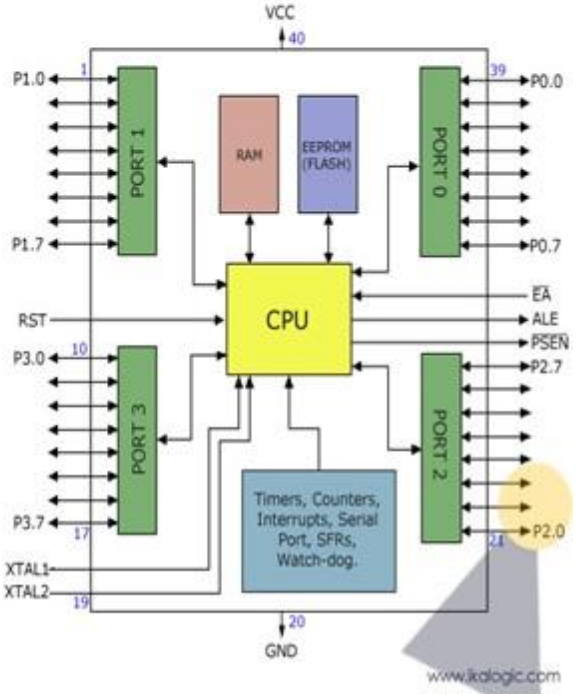

Figure 4: Block Diagram of P89V51RD2

Any microcontroller contains a memory to store the program to be executed, and a number of input/output lines that can be used to interact with other devices, like reading the state of a sensor or controlling a motor.

The microcontroller used is P89V51RD2. The features of this µcontroller are as follows:

- CMOS 8-bit microcontroller
- 6K bytes Flash programmable and erasable read only
- 1KB internal RAM
- Fully Static Operation: 0 Hz to 24 MHz
- Three-level Program Memory Lock
- 32 Programmable I/O Lines
- Three 16-bit Timer/Counters
- Six Interrupt Sources
- Programmable Serial Channel
- Low-power Idle and Power-down Modes

General Packet Radio Service(GPRS)

It is a packet based data bearer service for wireless communication services that is delivered as a network overlay for GSM,TDMA, and CDMA networks.GPRS applies a packet radio principle to transfer user data packets in an efficient way between GSM mobile stations and external packet data networks.Packet switching is where data is split into packets that are transmitted seperately and then reassembled at the receiving end.GPRS supports the world's leading packet based internet communication protocols,Internet Protocol(IP) and X.25,a protocol that is used mainly in Europe

The circuit diagram of the work is elaborated in the following figure 5.

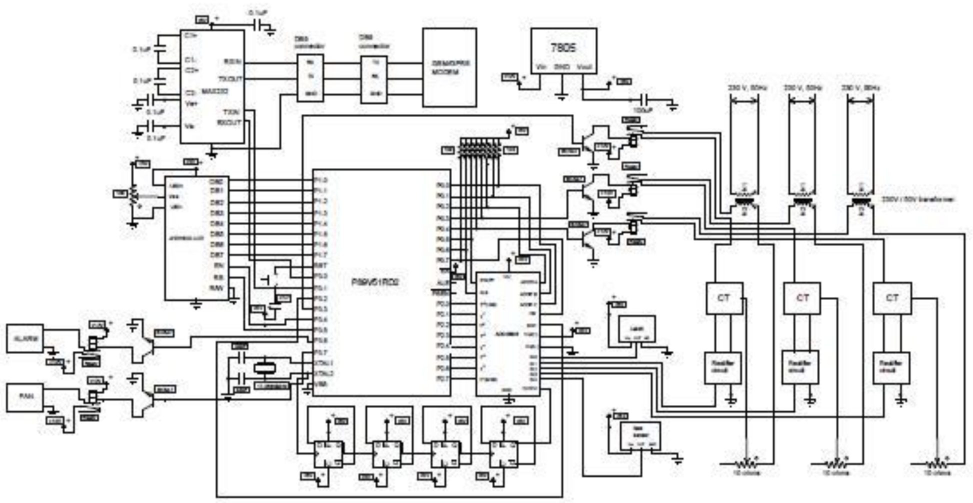

Figure 5: Circuit Diagram

ACKNOWLEDGEMENT

The preferred spelling of the word "acknowledgement" in America is without an "e" after the "g". Avoid the stilted expression, "One of us (R. B. G.) thanks . . ." Instead, try "R. B. G. thanks".

3 REFERENCES

List and number all bibliographical references in 10-point Times New Roman, single-spaced, at the end of your paper. For example, [1] is for a journal paper, [2] is for a book and [3] is for a conference (symposium) paper.

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