A COMPACT WIRELESS REMOTE MONITORING AND CONTROL SYSTEM USING EMBEDDED AND GSM TECHNOLOGY

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Abstract— In many areas remote monitoring has been implemented. The application to a single phase energy efficient switchable distribution transformer is introduces in this paper. For the compact remote condition monitoring of the transformer a designed embedded system and embedded Ethernet have been implemented. The embedded system will do the acquisition of voltages, currents and temperatures, it controls the switching devices that connect the tapings of the transformer, and then process the acquired data. Embedded Ethernet will do the client server applications and the remote monitoring is achieved through GSM. As part of the software development some protocols were developed. Experimentation was done by applying remote monitoring to the system connected to the single phase variable supply voltage and load. A result of this experimentation was sent to the computer through GSM.

Keywords— **remote monitoring, switchable transformer**

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I. INTRODUCTION

The general area of remote monitoring of computer systems encompasses abroad spectrum of mechanisms for a wide variety of purposes. In this report, the discussion is restricted to monitoring systems or studies where a mechanism is used to measure or observe the performance of a computer system and that mechanism can be controlled by another device or a human from some geographically distinct location. In most cases, it is expected that the monitoring device itself is designed to collect data about the host system, perform at least preliminary filtering of the raw data, and then either store the filtered data for retrieval by the central controller or immediately transmit the filtered data to the central monitor controller. The nomenclature used for the various constituents. The host system is the installation being monitored• A monitor that is local to the host is referred to as the remote monitor. The remote monitor is ultimately controlled from a central monitor controller.

This classification of remote monitors admits such approaches as; those implemented purely in software which can be interrogated from an external terminal. Programmable hardware monitors, hardware monitors distributed over different portions of the host machine, hybrid monitors, monitors used in distributed computer networks, fault diagnosis monitors, and extended consoles for a computer system. Each of these categories will be discussed in detail in a later section of this report. The classification excludes class ic hardware monitors that require plug board alterations to change the logical combination of probe signals. It also excludes pure software-implemented monitors which use the normal operating system facilities for "triggering," reporting and recording.

Remote monitors are being used in a number of ways that earlier, locally controlled monitors were not used. Remote performance monitor facilities are frequently divided into a number of remote data gathering mechanisms plus a single, shared facility to analyse data and prepare reports; the Test data facilities are examples of this type. Distributed monitors, perhaps best exemplified by the partner package for Control Data 6000 series machines, are also frequently used for performance measurements; the idea here is to dedicate certain hardware facilities of the host system to the measurement function. Prograll1llable hardware monitors are merely a refinement of earlier hardware monitors, and also are primarily used for performance measurement.

A new area for which remotely controlled monitors might be employed is that of performance assurance and safeguard studies. The goal is to monitor the workload of a computer system in order to either assure a given level of performance. or to assure that a computer system is not being used for tasks that were not intended to be executed on that system. Although it would be satisfying to be able to monitor a processor's program counter to determine what program the processor is executing , this is obviously impossible in the general case. The remote monitoring system for the switchable transformer is however quite unique because it includes measurements of switching devices' temperature. Moreover, the system is useful not only in monitoring the parameters of the transformer(such as voltages and currents) but also in controlling the switching devices and performing switching at appropriate timings. A compact monitoring system was considered to be developed for this purpose as it requires less power and space and it is portable. To perform remote monitoring, a client/server system was implemented by using some embedded Ethernet boards.

II. RELATED WORK

Transformer CM is concerned with the application and development of special purpose equipment/methods that are involved in monitoring a condition of a parameter in a transformer and its data acquisition while CA means the development of new techniques for analysing this data to both predict the trends of the monitored transformer and evaluate its current performance. CM focuses mainly on the detection of incipient faults inside the transformer that are created from the gradual deterioration. Some of these incipient faults may be detected during routine maintenance; however, other faults may cause numerous problems before the routine maintenance cycle. As a result, the ability to have detailed information on the state-of-health of the transformer prior to carrying out maintenance work was unavailable. Also, the diagnosis of many incipient faults in the transformer was, in many cases, unavailable especially with those faults occurring after the routine maintenance cycle. The CM has multiple benefits: it reduces the maintenance costs due to its ability to detect faults early, limits the probability of complete failures, and identifies the root causes of the failure. On the other hand, there are some obstacles during the realization of the CM techniques such as extra added cost to the system due to the added monitoring and communication equipment, increase in the complexity of the control and

communication system, need for newand high speed processing systems for data processing and decision making, and need for suitable memory storage for data base knowledge.In order to have information about the state-of-health of the transformer, the monitored data and the incipient faults detected by the CM system should be analyzed to assess the transformer condition. This assessment is done using the CA of the transformer. Transformer CM can be divided into five main categories: monitoring the hot spot temperature, monitoring the vibration of the wall and winding, monitoring the dissolved gases in the transformer oil, monitoring the partial discharges (PDs) in the solid and liquid insulations of the transformer, and monitoring the winding movement and deformations. In order to have a meaning of these monitored parameters, the monitored data should be analysed to assess the condition of the transformer. Each CM data category canbe assessed using certain CA technique. Fig. 2 shows the main categories of transformer CM and the corresponding CA techniques.In the following sub-sections, each CA technique will be discussed separately.

A. *Condition assessment by thermal analysis*

Thermal analysis of the transformers can provide useful information about its condition and can be used to detect the inception of any fault. Most of the faults cause change in the thermal behaviour of the transformer. Abnormal conditions can be detected by analysing the HST. The most famous abnormal condition of the transformer that can be detected by thermal analysis is the overload. Transformer life is affected greatly for a continuous maximum HST more than 110◦. Predicting the HST can be done by two techniques. The first technique uses the artificial intelligence techniques such as Artificial Neural Network (ANN) to predict the HST. The second technique develops a thermal model to predict the thermal behaviour of the transformer.

B. Condition assessment by vibration analysis

The usage of the vibration signals in assessing the transformer health is a relatively new technique compared with other methods of transformer CA. The transformer vibration consists of core vibrations, winding vibrations, and on load tap changer vibrations. These generated vibrations propagate through the transformer oil until they reach the transformer walls, at which they can be collected via vibration sensors. The health condition of the core and windings can be

assessed using the vibration signature of transformer tank. Vibration analysis is a very powerful tool for assessing the health of the on load tap changer.

C. Condition assessment by partial discharge analysis

PDs occur when the electric field strength exceeds dielectric breakdown strength of a certain localized area, in which an electrical discharge or discharges partially bridge the insulation between conductors. The dielectric properties of the insulation may be severely affected if subjected to consistent PD activity over long periods of time. This may lead to complete failure if the PD activity remains untreated. PD can be detected and measured using piezo-electric sensors, optical fiber sensors, and Ultra High frequency (UHF) sensors . On site PD measurement is often affected by strong coupled electromagnetic interference that increases the difficulty of extracting PD signals without noise. The most common methods for PD de-noising are the usage of the Wavelet Transform , the gating method, and the directional sensing. PD measurement was used extensively for the condition assessment of the transformer insulation due to the fact that large numbers of insulation problems start with PD activity.

D. Condition assessment by dissolved gas analysis (DGA)

All transformers generate different gases at normal operating temperatures. Nevertheless, the concentration of these gases increases in the presence of an abnormality (fault) such as thermal, partial discharge, and arcing faults. During internal faults,oil produces gases such as hydrogen (H2), methane (CH4), acetylene (C2H2), ethylene (C2H4), and ethane (C2H6), while cellulose produces methane (CH4), hydrogen (H2), carbon monoxide (CO), and carbon dioxide (CO2). Each fault type produces certain gases from the above-mentioned gases [20]. Analysing transformer oil for these key gases by chromatography helps to know the fault type,and location [20,21]. Also, laboratories may rely upon defined critical levels of gases, rates of increase in gas level (on a year-by-year basis), or one of the ratio methodologies such as Rogers or Dornenberg ratios [20,22,23] to asses the condition of oil. However,

III. SYSTEM ARCHITECTURE

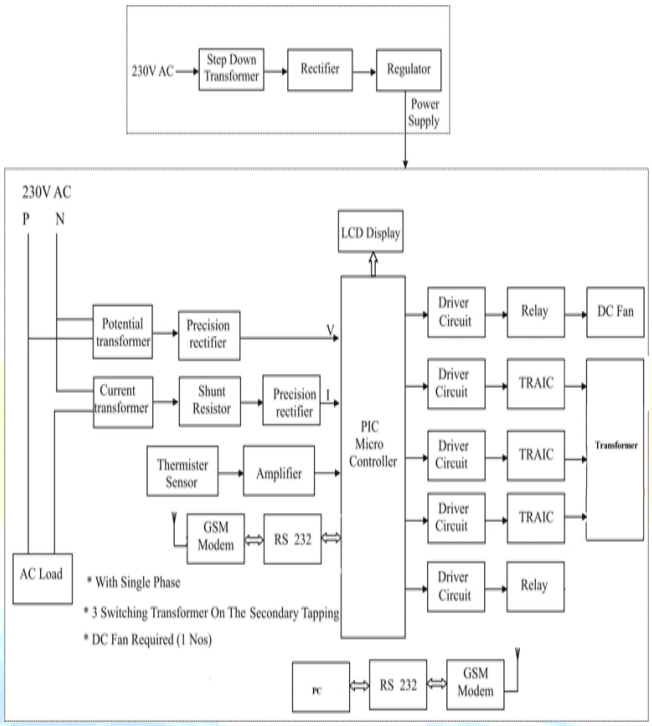

Fig.1 architecture of the whole system

Fig.1 shows the architecture of the whole system for remote monitoring of the transformer. The architecture of the whole system for remote monitoring of the transformer contains a single phase energy-efficient switchable distribution transformer with its switching devices, three-phase variable power supply and load, an embedded system, embedded Ethernet units, and a computer. The embedded system is made up of some modules to acquire as well as to control the parameters of the transformer and developed using a modular approach. Voltage regulators comprise a class of widely used ICs. Regulator IC units contain the circuitry for reference source, comparator amplifier, control device, and overload protection all in a single IC. Although the internal construction of the IC is somewhat different from that described for discrete voltage regulator circuits, the external operation is much the same. IC units provide regulation of either a fixed positive voltage, a fixed negative voltage, or an adjustably set voltage

The current measurement circuit is designed to monitor the supply current. The supply current that has to monitor is step down by the current transformer. The step down current is converted by the voltage with the help of shunt resistor. Then the converted voltage is rectified

by the precision rectifier. The precision rectifier is a configuration obtained with an operational amplifier in order to have a circuit behaving like an ideal diode or rectifier.

A GSM modem is a specialized type of modem which accepts a SIM card, and operates over a subscription to a mobile operator, just like a mobile phone. From the mobile operator perspective, a GSM modem looks just like a mobile phone. When a GSM modem is connected to a computer, this allows the computer to use the GSM modem to communicate over the mobile network. While these GSM modems are most frequently used to provide mobile internet connectivity, many of them can also be used for sending and receiving SMS and MMS messages.

Liquid crystal displays (LCDs) have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal .An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle. One each polarisers are pasted outside the two glass panels. These polarisers would rotate the light rays passing through them to a definite angle, in a particular direction. When the LCD is in the off state, light rays are rotated by the two polarisers and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction.

The microcontroller that has been used for this project is from PIC series. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques. Various microcontrollers offer different kinds of memories. EEPROM, EPROM, FLASH etc. are some of the memories of which FLASH is the most recently developed.

A thermistor is a type of resistor used to measure temperature changes, relying on the change in its resistance with changing temperature. Thermistor is a combination of the words thermal and resistor. The Thermistor was first invented by Samuel Ruben in 1930, and has U.S. Patent #2,021,491.

If we assume that the relationship between resistance and temperature is linear (i.e. we make a first-order approximation), then we can say that:

$\Delta R = k\Delta T$

Where

ΔR = change in resistance

ΔT = change in temperature

sk = first-order temperature coefficient of resistance

Thermistors can be classified into two types depending on the sign of k. If k is positive, the resistance increases with increasing temperature, and the device is called a positive temperature coefficient (PTC) thermistor, Posistor. If k is negative, the resistance decreases with increasing temperature, and the device is called a negative temperature coefficient (NTC) thermistor.

IV MEASUREMENTS

Transformer to single-phase supply voltage and variable load.

Four alternative configurations were implemented to perform remote monitoring and control while the transformer was on. Results of the experimentations by using LAN in the school revealed that the system could work properly with all of these configurations. For instance, the embedded Ethernet as a server could serve client applications in either the embedded Ethernet or computers. The embedded Ethernet application for clients could also be implemented to perform monitoring and control when a computer (instead of embedded Ethernet) was used a server. The most compact system could be achieved by implementing the embedded Ethernet as the client and server modules. The display shows parameters of the transformer on all phases such as RMS voltages, RMS currents, powers, efficiency, and temperatures. Furthermore, winding configurations (whether in series or in parallel) as well as their modes are also shown. Users need to choose the next page of the display using the keypad to view other parameters or waveforms of voltages and currents. The text on the bottom of the display shows useful tips for

users in relation to the current display. The client application for computers however provides easiness in displaying, controlling, and recording parameters of the transformer. This application also uses a TCP connection to accomplish communication in zone 3. The connection was made by first entering the IP address of the server and the port. Once connected, this application automatically made repetitive requests of parameters from the server.

IV. APPLICATION

Here we use GSM technology for long distance communication for monitoring the temperature and other details Using GSM we can send the results of the processor to different control areas. Here increase in traffic will not affect the performance of the network. When voltage varies, the TRIAC should be switched for regulating the output. One RELAY is used to drive the DC fan when the temperature exceeds the threshold value. Another RELAY is used to shutdown the primary connection in the case of overload. The GSM modem is used to transmit the fault occurrences and also when the system restored to normal. The value of the voltage and current are displayed using LCD. This will solve the drawbacks of the LAN system in the proposed system.

VI. CONCLUSION

The remote monitoring system that had been developed was very useful in understanding conditions of the transformer. It also enables operators to monitor the parameters away from the transformer. The result of the experimentations showed that the system could handle remote monitoring control tasks for the single phase switchable transformer. The system may contain either embedded Ethernet units or computers or a combination of them. The use of embedded Ethernet units as a client and a server however provides the most compact system. This system is easy to operate, to maintain, and to reproduce massively with low cost for applications in the fields.

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