Nigerian Journal of Technology (NIJOTECH)
Vol. 33. No. 3, July 2014, pp. 331 – 336

ISSN: 1115-8443
www.nijotech.com
http://dx.doi.org/10.4314/njt.v33i3.10

DESIGN AND IMPLEMENTATION OF GSM BASED TRANSFORMER PHASE MONITORING SYSTEM

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ABSTRACT
In electric power distribution, transformers used in the process of distributing electric power to the final consumers which include industries and residents stand chances to fail due to overloading. Most often, fuses are the major components that fail in other to protect the transformer from severe damage. In situation like this it is deemed necessary for electric distribution company personnel to be notified of such failure as a smart response in other to bring a quick power restoration to the community or area affected. In this work, the design and implementation of a transformer phase monitoring system, which continuously check for blown fuses on each phases of the distribution transformer was carried out. The system promptly reports any transformer with blown J&P fuse via a preprogrammed SMS which will state the location of the transformer and the open phase. This system consists of "blown fuse circuit detectors" each connected across the fuse of each phase of the transformer. The detector was designed around an optocoupler and an Operational Amplifier (LM324) functioned to detect an open fuse. PIC16F876A was used under a program written in mikrobasic to process the output of the "blown fuse detectors". If any open fuse was detected, it generates control signal to a SMS control unit consisting of a SAGEM mobile phone and an 8051 microcontroller. The SMS control unit sends an SMS to the distribution company as a failure notification, using AT commands over RS232 serial interface of the system. The system was designed and tested and it was found to work satisfactorily.

Keywords: *Opt-coupler, AT-Command, Serial Interface, Telemetry*

1. INTRODUCTION
Utility providers has been incapable of providing minimum acceptable international standards of electricity service in the past three decades [1]. One of such standards is that the voltage at the consumer premises should lie within some acceptable limits. There are many reasons for low voltage, one of such reasons is the failure in transformer phase(s). Most failures in transformers phases are as a result of overloading [2]. Therefore, faulty transformers phase(s) require a quick restoration to its functioning state to protect the functioning phase(s) of the transformers from unnecessary overloading and to reduce the incidences of unresolved failed phases. Therefore, methods should be investigated to facilitate a quick notification of a faulty transformer phase(s) to the electricity distribution company. Presently, failed transformer phase(s) have to be reported by people from that community to a local office of the electric power distribution company to ensure restoration of the failed phase(s) which may take a whole lot of time.

In this paper the methods that facilitate a quick notification on transformer phase failure were looked into. The best method is to implementing a remote notification system that is capable of sending notification automatically whenever a fault detected. This process is described as telemetry.

Telemetry is a technique used in transmitting and receiving information or data over a medium. The information can be measurements, such as voltage, speed or flow. These data are transmitted to another location through a medium such as cable, telephone or radio. Information may come from multiple locations [3]. The telemetry system is designed such the base station is capable of addressing different remote location. Figure 1 describes the basic component of a telemetry system.

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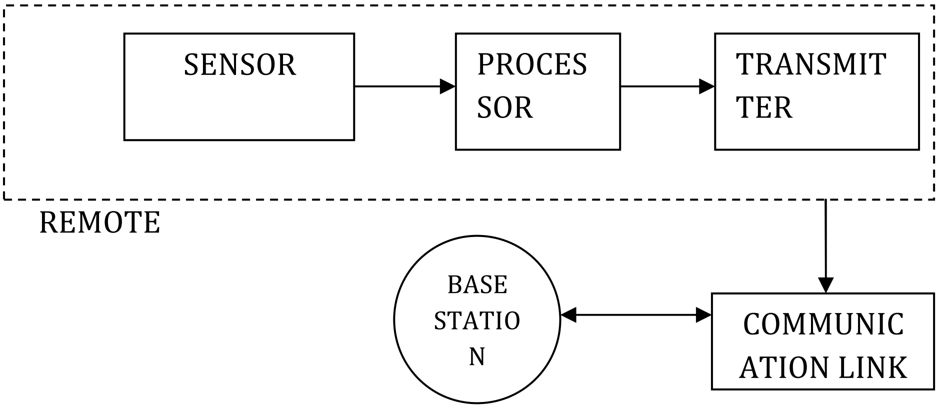

Figure 1: Basic component of a telemetry system

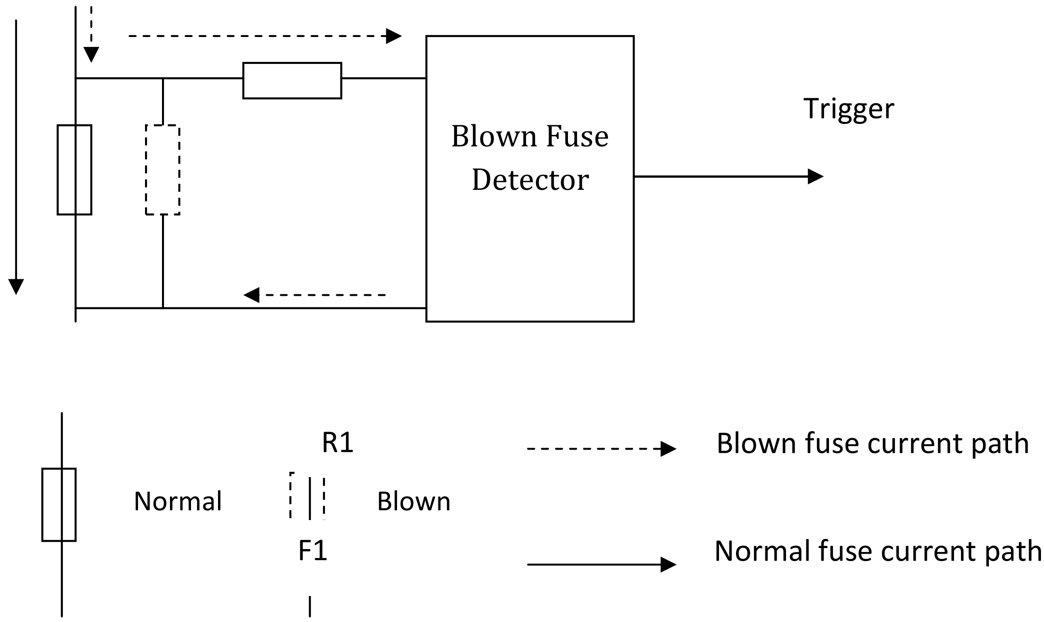

Figure 2: Descriptive Diagram of a blown fuse detector.

This majorly consists of a Sensing and acquisition device, onboard processor, a data transmission link and a base station where reports are sent to. Compared to wired telemetry, wireless telemetry has several advantages such as improved mobility, simple installation, easier extension and reconfiguration [4].

2. PRINCIPLES OF OPERATION OF THE PHASE MONITORING SYSTEM

In this paper, we present a method of detecting failed phases in a distribution transformer and also implement a necessary means of notifying the power distribution office of an open fuse. In this wise we designed an open fuse detector, which is connected across the fuse of a phase of the transformer. The detector was designed using an optocoupler, Operational Amplifier and a D type flip-flop (CD4013). It works with the principle of current flowing through the lowest resistance. As described in the Figure 2, a blown fuse would make current to flow through the optocoupler causing the necessary trigger signal of a blown fuse detector to go high.

The flow chart of the system is shown in Fig. 3.

PIC16F876A microcontroller which is the system control unit was used to process the generated triggered signal from the blown fuse detector when a fuse is blown. On the occurrence of any fuse blown, the system control unit generates corresponding signals to a SMS control unit. The SMS control unit comprises of a mobile phone that can accept AT commands over an available interface, most often a serial Interface. This unit is controlled by another microcontroller 8051 which possesses all necessary AT command to send SMS.

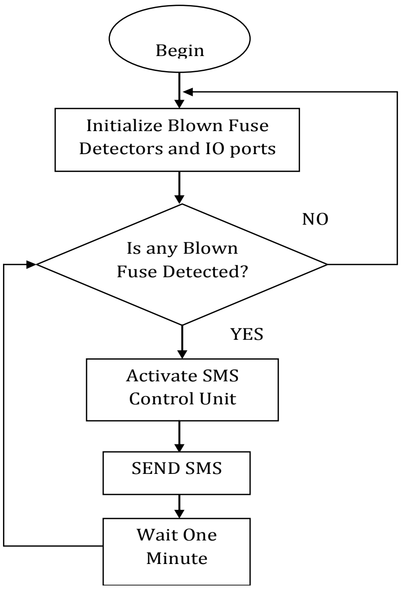

Fig. 3: Flowchart Diagram of GSM Based Transformer Monitoring System.

On the reception of a trigger from the system control unit, procedures in the program running inside the 8051 microcontroller executes the AT command to send a short message service message (SMS message) to the power distribution operators station. This set of AT command for sending SMS may be summarized as:

AT+CMGF=<n> used to change message format, text (ASCII values) or hex (numbers only). For text AT+CMGF=1; for Hex AT+CMGF=0. We used AT+CMGF=1;

AT+CMGS=<number><message>. This command is used to send message to the number [5].

3. THE DESIGN OF GSM BASED TRANSFORMER SWITCHING AND PHASE MONITORING SYSTEM

The block diagram of the GSM based transformer phase monitoring system is presented in Fig. 4.

It is designed to monitor two transformers, for simplicity. Figure 4 consists of power supply unit, blown fuse detector units, system controller unit and an SMS controller unit. The systems controller unit processes inputs from all its peripherals, and sends a signal to the SMS controller unit which in turn sends a programmed SMS to the system operators to either report fault or indicate that a particular transformer phase is blown.

3.1 Power Supply Unit

The circuit diagram for the power supply unit is shown in Figure 5. DC power supply to the entire circuit is from the rechargeable 12V, 4.7AH lead acid battery. This battery is charged from the rectified output voltage from the mains.

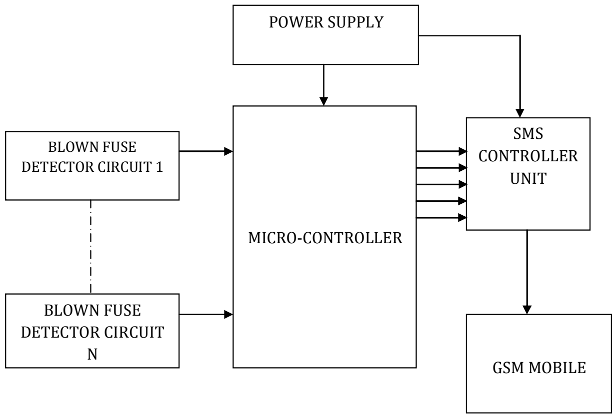

Figure 4: Block Diagram of GSM based transformer phase monitoring system

The rectifier circuit is implemented with a combination of 220/15V transformer (TR1), full wave bridge rectifier BR_3 (G25B20 1C), and an RC filter circuit as shown in figure 5. U3 is a 7805 1C voltage regulator; this maintains part of the battery output at 5v required as V_{cc} for the microcontroller circuits.

3.2 Blown Fuse Detector Circuit

The circuit diagram for the blown fuse detector is shown in fig 6. The circuit monitors the Johnson and Phillips (J&P) fuses in each of the phase. The input terminals of the circuit are connected across the fuse in each phase, the circuit generate a logic 1 (5V) when it detects a blown fuse, it then sends a signal to the microcontroller for processing. As shown in fig. 6, the circuit consist of a PC123 optocoupler, (U4), an LM324 operational amplifier and a D flip flop among other components.

When light from the LED falls on the base of the transistor in the optocoupler, the transistor saturates and voltage is dropped across pull down resistor R_8. This drop is compared with V_{ref} (1.5V) in the comparator circuit of U4 (LM324). For U4 to saturate, V_{R8} must be greater or equal to V_{ref}; Setting V_{R8} at 3V,

$$R_8 = \frac{V_{R8}}{I_3} = \frac{5}{I_3} \qquad (1)$$

where I_3 is the emitter current of the transistor at saturation I_{sat} = 2 mA [6]. Therefore $R_8 = 3/\ 2X10^{-3} = 1500\ \Omega$

A standard resistor of 1kΩ is chosen as R_8 so as to adequately limit the current flowing through the OPamp and ensure U4 saturates whenever current flows through the optocoupler. Hence when V_{R8} is greater than V_{ref}, voltage comparator U4 switches to positive saturation. RV2 is a potentiometer used to set V_{ref} at 1.5 V. The output of the voltage comparator is fed to the clock of the D flip flop through a low pass filter (R_9 and C_9). A high clock input in the flip flop is interpreted by the microcontroller as a blown fuse.

3.3 Systems Controller Unit

The system is built on the PIC16F876A microcontroller. This unit continuously analyzes signals from the various detector circuits (blown fuse detector). It sends a high logic signal to the SMS controller unit when it receives a high signal for the detector circuits. The signal from the microcontroller also drives the LED indicators D7, D8 and D9 which shows the status of the transformers and their J&P fuses. Fig. 6 shows the circuit diagram of the system control unit.

The P1C16F876A microcontroller has three Input/output (I/O) ports [7]. These are ports where peripheral devices are connected [8]. These are port A, B and port C. In Fig 6, port A and B is configured as output ports, while port C is configured input port. The output of the various detector circuits is used as signal input to the microcontroller at port C. The PIC16F876A microcontroller is operated with a 4MHz crystal oscillator. Resistors R14, R15, and R16 are pull down resistors of the same rating to drive the LEDs by limiting the current flow. Port A.0 (pin 2) is used as reset signal for the flip flops in the detector circuit. The 8-bit signal at Port B (output port), is used as driver for the SMS controller unit. The PIC16F876A microcontroller was programmed in Basic language.

3.4 SMS Controller Unit

Shown in Figure 8 is the SMS controller unit. This unit receives signal from the systems controller and send the appropriate dialing codes to the mobile phone. This code enables the mobile phone to automatically send programmed SMS to alert managers of the system about the status of the network.

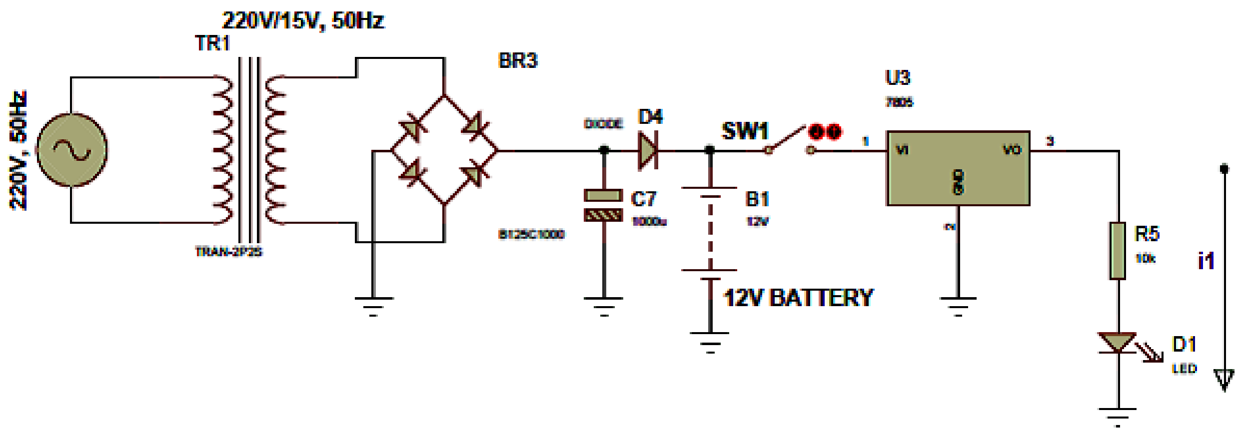

Figure 5: Power Supply Unit

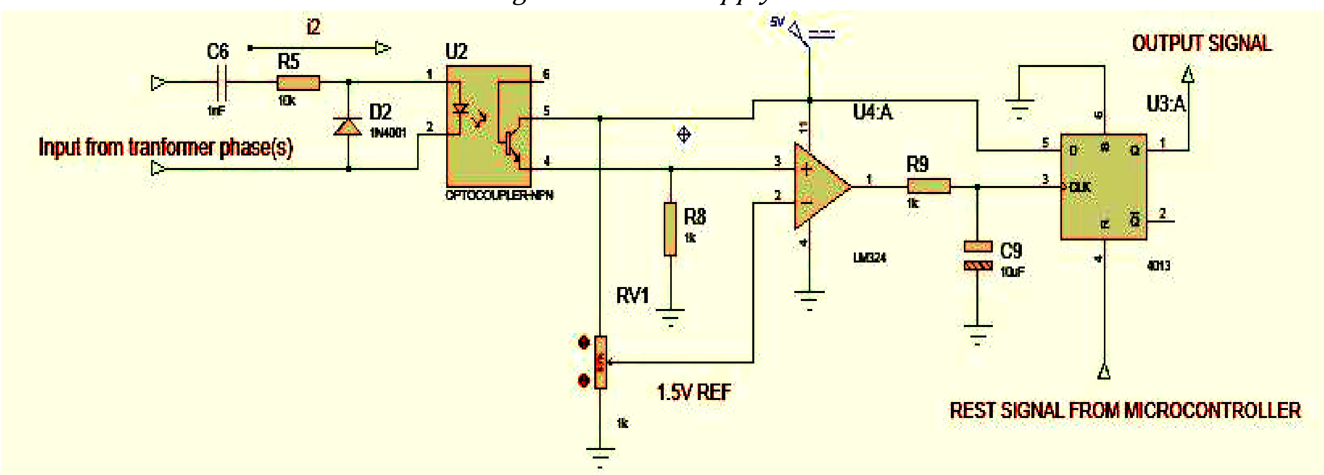

Figure 6: Blown Fuse Detector Circuit.

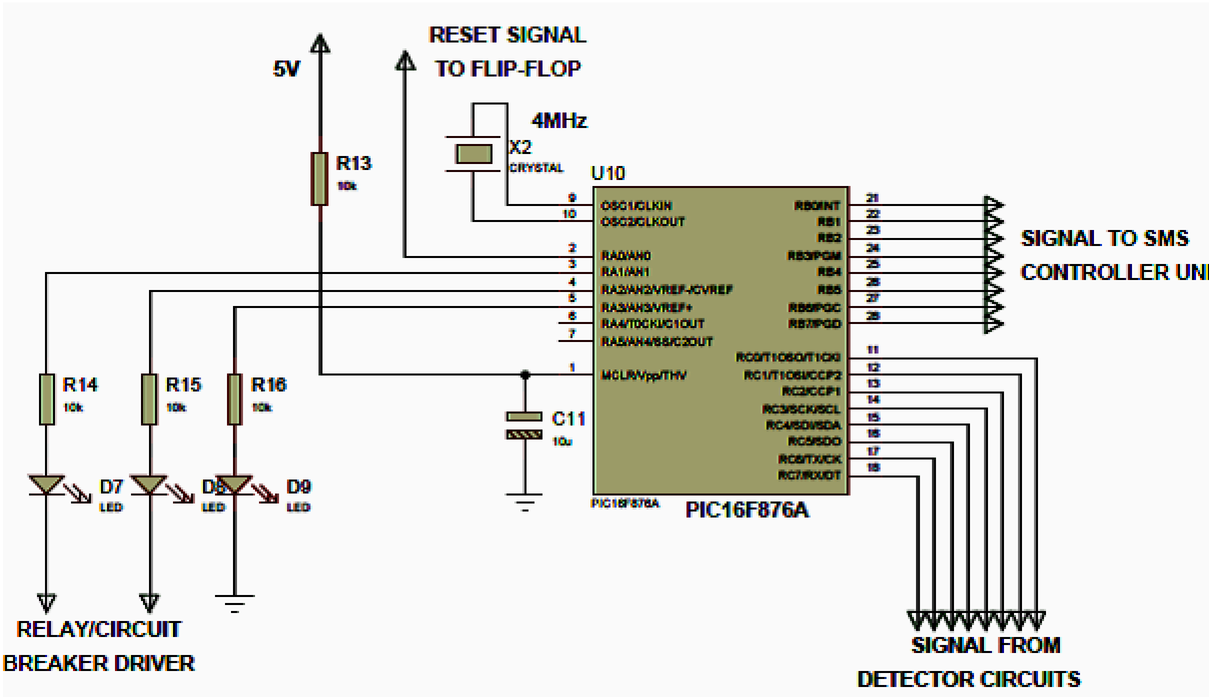

Figure 7: Systems Controller Unit.

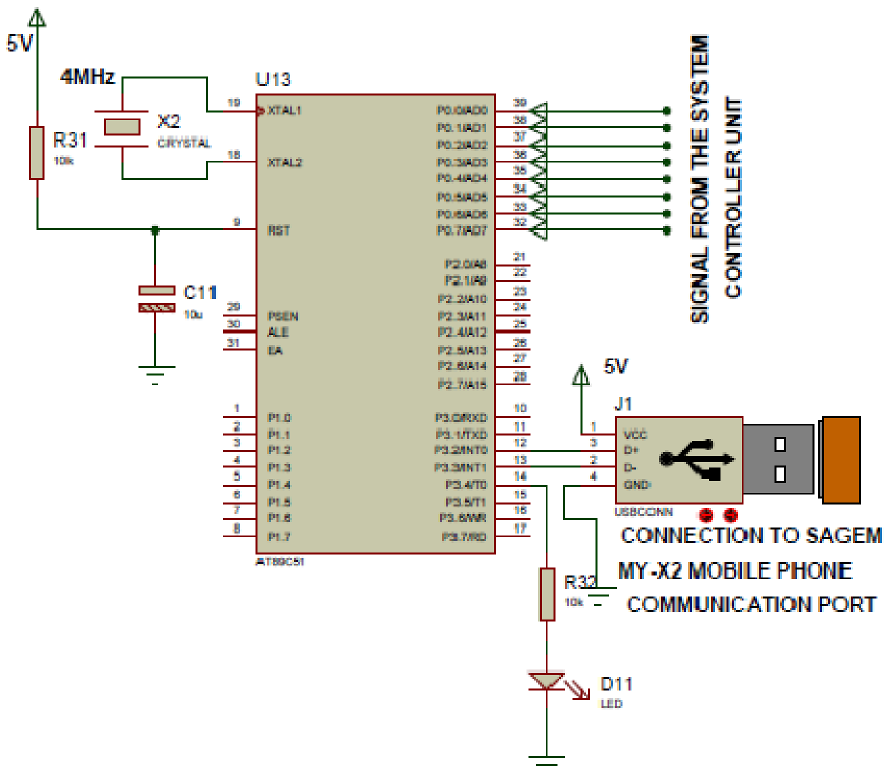

Figure 8: SMS controller Unit.

The circuit is implemented with an ATMEL89C52 microcontroller. Input to the microcontroller is at port 0 [9]. Its output is interfaced with the mobile phone at port 3. Communication between the microcontroller and the mobile phone is enhanced through AT- commands. (Attention command) at port 3.2 and port 3.3 which utilizes the serial port module of the microcontroller. The eight signals at port 0 correspond to eight different SMS. When a 1 appears at any of the inputs at port 0, the microcontroller sends a signal to the mobile phone and a text message is sent. The entire circuit was simulated on lab center proteus 8.0 and it was found to have worked satisfactorily

3.5 Principle of Operation of the Designed Circuit.

DC power supply to the entire circuit is from the rechargeable 12V, 4.7AH lead acid battery. This battery is charged from the rectified output voltage from the mains. The rectifier circuit is implemented with a combination of 220/15V transformer (TR_3), full wave bridge rectifier (G25B20 1C), and an RC filter circuit. The 7805 IC voltage regulator maintains part of the battery output at 5V required as V_{cc} for the microcontroller circuits.

The blown fuse circuit monitors the Johnson and Phillips (J&P) fuses in each of the phases. When a fuse is blown, the detector circuit provides an alternative path for current to flow through. This current, flows through the LED in the optocoupler, causing it to glow and in essence switches on the phototransistor also present in the optocoupler.

For U5 to saturate, V_{R8} must be greater or equal to V_{ref} Hence when V_{R8} is greater than Vre_f, voltage comparator U5 switches to positive saturation and outputs 5V. The output of the voltage comparator is fed to the clock input of the D flip flop through a low pass filter (R_9 and C_9). A high clock input in the flip flop is interpreted by the PIC16F876A microcontroller as a blown fuse.

The systems controller unit built on the PIC16F876A microcontroller continuously analyzes signals from the various detector circuits (blown fuse detector). It sends a high logic signal to the SMS controller when it receives a high signal from any of the detector circuits.

The SMS controller unit built on the ATMEL89C52 microcontroller receives signal from the systems controller and send the appropriate stored SMS AT commands to the mobile phone. This command enables the mobile phone to automatically send programmed SMS to alert managers of the system of a blown fuse.

4. CONCLUSION

In this paper we developed a GSM based Transformer Phase Monitoring system, to facilitate a seamless notification to power Distribution Company of blown fuses in a transformer phases. The solution was built around PIC16F867A as the main system control unit, and blown fuse detector was also implemented along with SMS control unit.

Utility providers should adopt this method for seamless reporting of blown J&P fuses as this would enhance prompt rectification of such faults and reduce down time associated with troubleshooting.

5. REFERENCES

[1] Ugwu, H. U. And Nwankwojike, B. N, Ogbonnaya E. J and Ekoi, E. J. 2012, “Energy and Economic losses due to constant power outages in Nigeria”, *Nigerian Journal of Technology,* Vol. 31, No. 2, 181 – 188.

[2] Al-hamad, D and Buruncuk, K.. 2009, *“Implementation methods to eliminate overload power system problem”*, Unpublished M. Sc. Disertation, Department of Electrical Engineering, Near East University, Nicosia, Turkish Republic of Northern Cyprus.

[3] Mullaney, J. *“Introduction to SCADA and Telemetry*” MSE Technology Applications, Inc. Tetragenics Division. Available at www.tetragenics.com, accessed on 25/03/2014.

[4] Kamal,N.,Ismail,S. S. Abd-ElKader, H. and Sharaf, M., 2012. “Telemetry Over SMS-Based GSM Wireless Communication System” *International Journal of Engineering and Advanced Technology (IJEAT),* Volume 2.

[5] Quectel Inc., 2012. “M95 AT command set” Quectel Wireless Solutions Co. Ltd, available at www.quectel.com, accessed on 25/03/2014.

[6] SHARP Corporation, 2003 "*PC123 Series"*, Sheet No.: D2-A02902EN

[7] Microchip Technology Inc., 2010."PIC16F87XA datasheet"

[8] Orukpe, P. E. and Adesemowo A, 2012, “Digital control of external devices through the parallel port of a computer using Visual basic, *Nigerian Journal of Technology,* Vol. 31, No. 3, pp. 261 – 267.

[9] Atmel Corporation, 2000. "AT89C52 datasheet"