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DESIGN AND ANALYSIS OF FEEDER PILLAR FAULT FUSE DETECTION WITH SMS REPORTING

P.U.Okorie[1], A.M.S. Tekanyi[2] & A.L. Ango[3]
[1,3]Department of Electrical Engineering, Ahmadu Bello University, Zaria.
[2]Department of Electronics & Telecomm. Engineering, ABU Zaria.
[1]patrickubeokorie@yahoo.com, [2]amtekanyi@abu.edu.ng

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ABSTRACT

This paper present a system of monitoring the distribution feeder pillar to determine if the Johnson & Phillips (J&P) fuse is blown or not. Blown fuses are common with distribution feeder to protect the feeder pillar itself from being faulty. However, this fault should be promptly reported and localized so that power can be quickly restored to the phase. This designed of the fuse fault in a feeder is done in such a way that give the location of the failure after fault has occurred will be easy such that after fault is cleared. Also, the system is designed in such a way that there will be easy discrimination. After the source, the bus bar is connected next, then the contactor controlled by a switch. The phase monitor indicates the sequence of the three lines of the source. If the system detects a fault, the PIC16F877A microcontroller will activate the SIMCOM_900 GSM module, to send a pre-programmed message indicating the location of the fault to the utility provider. All these components are used to achieve the purpose of the feeder pillar analysis that is to ensure the availability of an appropriate protection.

1. INTRODUCTION

A feeder pillar (also known as a power box, distribution pillar or feeder pillar box) is a cabinet used to house electrical equipment. In electrical power distribution, feeder is voltage power line transferring power from a distribution substation to the distribution transformers, in turn carries power from a transformer or switch gear to a distribution panel. A feeder pillar is essential in a power system distribution network to distribute electric power (three-phase, 415V AC) from a step-down transformer to the low-tension (LT) lines for the consumers. A default feeder pillar consists of a panel which embodies all other sub-units of the feeder pillar, bus-bars which connected the incoming and outgoing lines, An ammeter which records the voltage across the bus-bars, the fuse holders holds the fuses, high-rupturing-capacity fuses for making contact and for protection purposes, This set up, which protect the transformer from direct faults and the feeder pillar to the 415V LT lines, protecting the bus-bars (incoming and outgoing circuit).

Similar work was carried out by [1], the paper described the design and implementation of an "Automatic method of protecting transformer as an alternative to the fuse protection technique". This work is proposal an alternative, effective, efficient and more reliable method of protecting fault from power transformer which may arose as a result of overload, high temperature or a high input voltage. Generally, fault may occur in transformers due to the stated reasons above.

This paper present design and analyses of microcontroller based feeder pillar faulty fuse position detection through SMS.

AC Power supply in Nigeria is a great challenge today. With the advent of microcontrollers, protection of transformers is greatly achieved with degree of accuracy. The system provides effective and efficient methods which are currently in are use. The benefits of this system over the traditional methods are that it has fast response, better isolation and accurate detection of the fault. This system overcomes the other drawbacks in the existing systems such as maintenance and response time. Egwaile and Bello, (2014) design and implementation of GSM based transformer phase monitoring system: In their paper, presented 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. Ahmed, **(**2017) on a Fault sensing in a remote transformer using GSM & automatic on/off of street lamps from his study. In [1], Automatic method of protecting transformer using pic microcontroller as an alternative to the fuse protection technique. Three Phase Sensing and Power Supply Unit, while the regulator IC 7805 attached across the filter capacitor for supply the regulated voltage +5V [2]. There are several types of faults in the distribution system. However, faults associated with the distribution feeder pillar are a major source of downtime in power supply. Some of these faults are phase fault such as single phase to ground fault, two phase to ground fault, phase to phase fault, three phase fault [3], [4] and [5]. In order to guarantee stable power supply, feeder pillar should be monitored continuously. Some of the parameters that can be monitored are load currents, under-voltage, overvoltage, oil level, oil aging, overload, frequency, winding temperature, ambient temperature, power factor, active power and fuse status [6], [7]&[8] The subsequent sections present the design and analysis procedure, results and discussion then the final section draw the conclusion.

2. SYSTEM DESIGN

This section described the design of the various circuits involve in the study by calculating their required values for this analysis.

This unit serve to sense the three phase mains from utility power and supply to the input of microcontroller across ADC channels (RA0, RA1 and RA2). The following components connected together to form a power supply circuit.

i) Stepped down transformer 220v-12V at 500mA.
ii) Bridge rectifier using diode.
iii) Electrolytic capacitor as a filter.

2.1 System Design

The following components were selected for the analysis and design as follows:

2.1.1 Transformer Selection

In considering transformer selection, the maximum and minimum values of operating voltage and current are important. The supply from mains considered for this study is 220V-240V at 50 Hz. To calculate the power relating to the transformer to be used, the maximum current that will flow in the system at full load was estimated as shown in Table 1 after specified the current rating from datasheet in internet. Hence current rating of transformer selected is

500mA. The chosen transformer is 12V, 500mA.

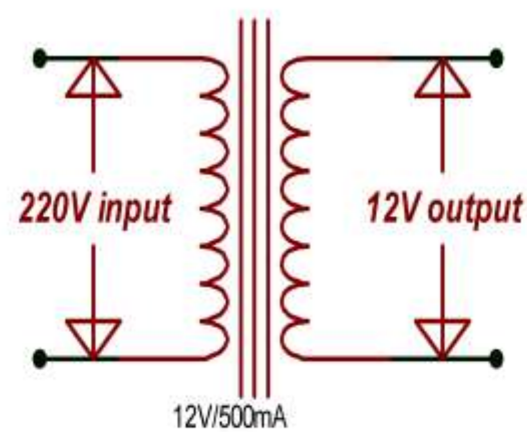

Figure 1: Selected Transformer

Table1: Current Estimation of the system

Components	Quantity	Max current consumption (mA)	Total max current consumption (mA)
16F877A	1	25	25
GSM MODULE	1	25	25
LCD	1	5	5

2.1. 2 Rectifier Selection

When selecting a rectifier, the peak inverse voltage (PIV) is considered. The PIV is the maximum voltage that occurs across the rectifying diode in the reverse direction.

$$PIV = 2Vmax \qquad (1)$$

From the transformer secondary:

$$Vrms = 12V$$

Root mean square voltage from secondary terminal of transformer

$$Vmax = Vrmsx\sqrt{2} \qquad (2)$$

V_{max} is the maximum voltage occur at the rectifier

From eqn. (2) to calculate the maximum voltage

$$Vmax = 12 \times \sqrt{2} = 16.97V$$

$From\ eqn\ (1)$

$$PIV = 2 \times 16.97 = 33.9V$$

The peak value of current that the diode must be able to pass safely with resistance load is I_{peak}.

$$Ipeak = {}^{\pi}/_{2} \times Idc$$

$$= {}^{\pi}/_{2} \times 293.4 \times 10^{-3}$$

$$= 0.46A$$

Hence IN4001 was selected 2A/50V from data sheet, The basic circuit of full wave rectifier is shown in Figure 2

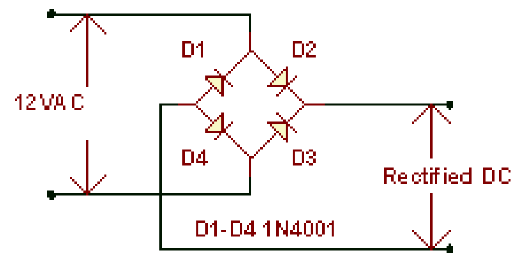

Figure 2 Rectifier circuit

2.1.3 Filter Capacitor

Using a ripple factor of 4% for high current

$$\alpha = \frac{1}{4\sqrt{3}\,CFRl} \qquad (3)$$

To find the value of the capacitor,

F = 2x50Hz

$$Rl = \frac{12}{293.4 \times 10^{-3}} \qquad (4)$$

$$= 40.9\Omega$$

$$C = \frac{1}{4 \times \sqrt{3} \times 0.04 \times 50 \times 40.9} \qquad (5)$$

$$= 1764.5\mu F$$

The **s**tandard value of 2200µF was selected.

The voltage across the capacitor V_c is given as:

$$Vc = Vdc - diode\ drop \qquad (6)$$

Diode drop = 0.7V (silicon material)

For a full wave rectifier the two diode drops = 0.7×2 = 1.4V

During first duty cycle D_1 and D_3 conduct while D_2 and D_4 off. Similarly for the second duty cycle D_2 and D_4 conduct while D_1 and D_3 off. Therefore the Vdc is [9]-[10].

$$Vdc = {}^{2}/_{\pi} \times Vmax \qquad (7)$$

$$V_{dc} = \frac{2}{\pi} \times 16.95$$

$$Vdc = 10.8V$$

From eqn. (6)

$$Vc = Vdc - diode\ drop$$

$$Vc = 10.8 - 1.4 = 9.4$$

The rating voltage across the capacitor a standard value of 2200µF/25V was selected.

The zener diode serves to regulate a dc input to the PIC16F84A at +5V constant.

The general circuit of power supply unit shown in Figure 3

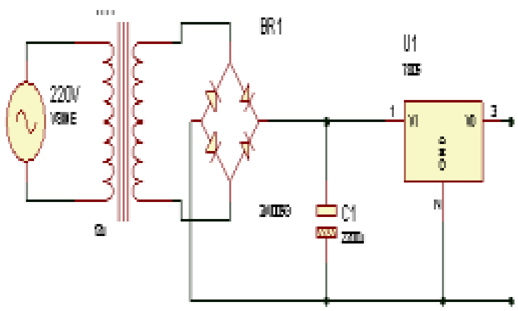

Figure 3 Power supply circuit

2.3 Microcontroller Unit

The PIC16F877A serves as a brain of the system, where the 16F877A program by develop C-language into a machine codes. The machine code was burnt using serial port programmer and computer as PIC16F877A to be workable.

The two steps carried out to achieved this unit are as follow:

i) Program development.
ii) Develop circuit to embedded PIC16F877A

2.3.1 Program Development

The program consists of several subroutines which were called to execute certain function shown in appendix. The most important subroutines include: the initialization routine, the main program and the delay. The main programs call each subroutine in an order. It initialed the display the ac voltage, inverter ac voltage etc.

The Software Part were used for the programming and the MICROC PRO for PIC compiler was used for developing C- language and debug into machine codes, which involved the following step:

1. *Source files Create study file and add.* In the menu bar, click study→ studyWizard. The study wizard dialogue box appears. Click 'Next.' In 'Next' window, select the device as PIC16F877A from the drop-down menu. Click 'Next' and select 'PASM' suite from the drop down menu. Click 'Next,' name your study file as 'gen' and specify its location. The file is automatically saved with 'gen.mcp' extension. Click 'Next' and add source files energy_saver.asm to your project. If you want to create the source files on your own, you can skip the above step. Click Next→ Finish button. Now your study is created and the source files are added to your study.

2. *Configure the system.* To configure features like type of oscillator and WDT, click 'Configure' menu and then click 'Configuration Bits.' In the configuration bits window, select the type of oscillator as XT, and disable all other features like watchdog timer, power-up timer and brownout detect.

3. *Compile the program.* To compile the software, click 'Build' option in 'program' menu. The software is compiled and 'Build Successful' message appears in the output window. After successful compilation of the program, the file phase.hex is generated.

2.3.2 SMS Reporting Unit

This unit sends SMS to the control room of the utility power company of the fuse failure in the feeder pillar. For sending message using a GSM Module named SIMCOM_900. GSM Module SIM900 with SIM-card holder, RS232 interfaces. The interface GSM Module with microcontroller directly through wires.

GSM Module works with AT COMMANDS. AT commands are used to control MODEMs. AT is the abbreviation for Attention.

AT commands with a GSM/GPRS MODEM or mobile phone can be used to access following information and services:

```
char mode_text[]="AT+CMGF=1\r\n";
char AT[]="AT\r\n";
char
mobile_no[]="AT+CMGS=\"+2348031988214\"\r\n";
char terminator=0x1A;
char text1[]="Red phase fuse fault at kabuga";
```

The basic circuit of SMS reporting unit is shown in Figure 4

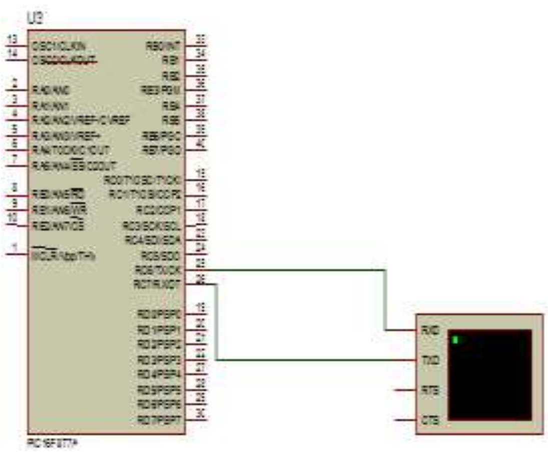

Figure 4 SMS Reporting Unit

2.3.3 Display Unit

The LCD used for displaying the performance of the system, voltage, ac voltage etc

The main purpose of the 4-bit LCD mode is to save valuable I/O pins of the microcontroller. Only 4 higher bits (D4-D7) are used for communication, while others may be left unconnected. Each piece of data is sent to the LCD in two steps- four higher bits are sent first (normally through the lines D4-D7), then four lower bits. Initialization enables the LCD to link and interpret received bits correctly.

LCD INTIALISE

```
/* In mikroC for PIC, it is sufficient to write only one function to perform all
  described operations for LCD initialization. */
Lcd_Init(); // Initialize LCD
Lcd_cmd(_lcd_clear);
```

The basic circuit of display unit is shown in Figure 5 and Figure 6 present the complete circuit of the proposed system which comprises of three main units.

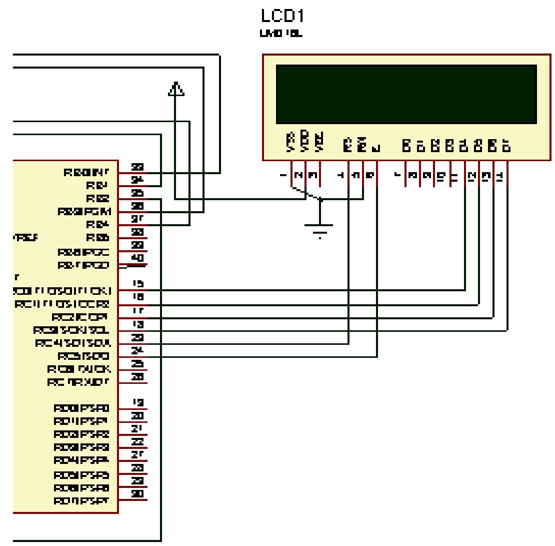

Figure 5 Display unit

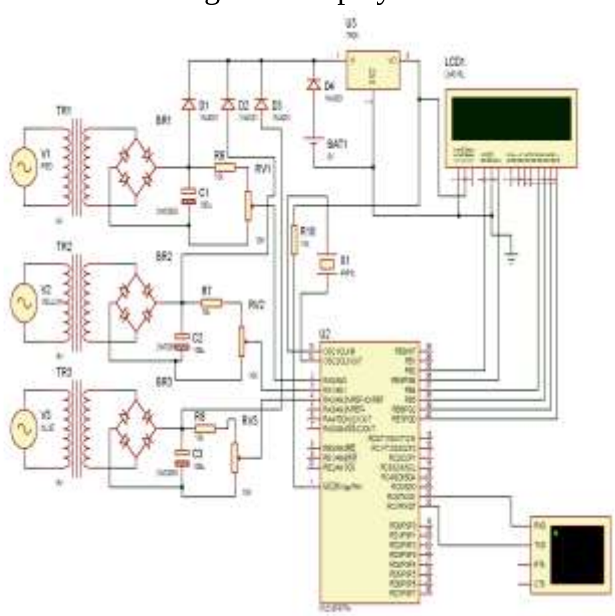

Figure 6 Circuit of Feeder Pillar Fault Fuse Detection with SMS Report

3. RESULTS AND DISCUSSION

This section describes the process of construction and the components used in designing the circuit. It also gives the detail discussions of the result, testing of the circuit and the system casing.

3.1 Circuit Components Assembly

There are three stages involved in the assembling of the circuit components. They are;

i. Testing of components; each component is tested before placing them on Vero board and are all found functioning well as expected.
ii. Arrangement of the components at the right location on the vero board.
iii. Soldering the components firmly on the vero board and testing the whole circuit to confirm whether it yields the desired result. Components are fixed firmly and their continuity as well as their polarity is tested.

3.2 Simulation

The program was written in the Micro C integrated development environment and debugged from C language into machine code (hex-file). It is then simulated in the PROTEUS ISIS professional and tested. The program was found to be working successfully with some minor errors which were corrected before the completion of the system. The procedure of simulation is shown in Figure 7.

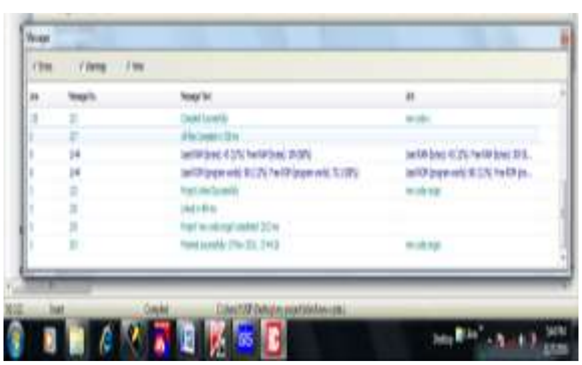

Figure 7 Simulation

3.3 Loading and Burning the Program

The written debugged program (hex-file) was burnt into the PIC16F877A using k150 programmer adaptor which interfaces winpicpgm_V1021 software installed in the PIC. After burning the program, it was tested on a testing board and found working perfectly. The of debugging program is shown in Figure 8 and the simulation code are presented in Appendix.

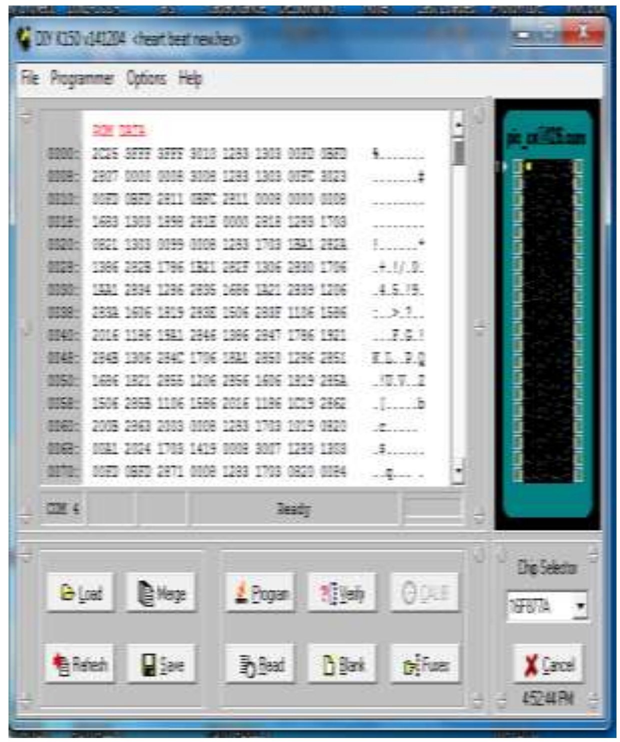

Figure. 8 Debugging Diagram.

Components were installed on the top side of the vero board unless indicated, the top legends shows where each component goes. The leads pass through the corresponding holes in the board and are soldered on the foil side.

3.4 Assembling and System Packaging

The system components were first of all mounted on a bread board and found working successfully. The complete system is designed using ISIS and ARES PCB design software packages. The PCB layout and the implemented PCB are shown in Figure 9.

Figure 9 System Package and Assembling.

The complete circuit was built and tested for a long period of time and was found working perfectly and meet up the design specification. Circuit simulation and components test were performed in computer and vero board respectively. Some testing devices used are, digital multi-meter and computer. The main supply (9V DC) was connected to the circuit to c0nfirm that there is no short circuit, open circuit and dry joints in the circuit.

After testing the whole system it was found working satisfactorily which proved to be in line with the design procedure and high reliability. Table 2 present the result of the system.

Table 2 Results of the System

Descriptions	Red	Yellow	Blue	GSM status
Readings	160-260	160-260	160-260	Normal
Readings	160< & >260	160< & >260	160< & >260	Sent SMS

The result obtained from the table 2 was analyzed by comparing the results obtained with the required circuit standard result. It was observed to be in line with the scope of the study.

4. CONCLUSION

In a fuse SMS fault detection which detects the presence of fuse failed on particular conditions was successfully designed and analysed according to result obtained. The study focused on the designing and analyzing of a device for monitoring and detecting fault, fuse conditions on the power distribution substation (feeder pillar) by integrating and initializing SMS report. The design goals were successfully achieved and the test results confirm the system functionality and its accuracy in detecting and promptly reporting the prevailing fault conditions to the utility control room. The system has been designed using the desired specifications of the standard electronics components and each unit was tested separately and later the whole system was tested.

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