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A New Approach to monitor Condition of Transformers incipient fault diagnosis based on GSM & XBEE

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***Abstract* - The microcontroller has been recognized as a general purpose building block for intelligent digital system. A microcontroller is a microprocessor system build on a single chip. Major features of PIC 16f877A microcontroller are 16 bit CPU optimized for control applications, Extensive Boolean processing capabilities, On-Chip Flash program memory, On-Chip data RAM, Bi-directional and Individual Addressable Input and Output Lines, Multiple 16-Bit Timer or Counter, Full Duplex UART, Multiple Source/Vector/Priority Interrupt structure, On-Chip Oscillator and Clock circuitry, On-Chip EEPROM, SPI Serial Bus Interface, Watch Dog Timer. In this project, we are using one Temperature sensor, Microcontroller PIC16F877A, LCD for displaying the faults and parameters, GSM Board and XBEE used to send the fault message to electricity board. In this project, we are using one Temperature sensor, ADC, Microcontroller 8051, LCD for displaying the faults and parameters, GSM board used to send the fault message to electricity board. By using this project, we can detect the multiple faults of three phase transmission lines one can monitor the Temperature, Voltage, Current by means of GSM modem by sending message.**

***Keywords*- Microcontroller, Transformer, fault detection and diagnosis, LCD, GSM, XBEE**

I. INTRODUCTION

Automation in Embedded System plays a major role in various applications. Automation reduces human effect and saves lot of time. This paper is based on automation and transformers which mainly uses GSM and XBEE to transmit the status of the Transformer via message. A transformer cannot operate with direct current; although, when it is connected to a DC source, a transformer typically produces a short output pulse as the current rises. A **transformer** is an electrical device that transfers energy between two circuits through electromagnetic induction. A transformer may be used as a safe and efficient voltage converter to change the AC voltage at its input to a higher or lower voltage at its output. Other uses include current conversion, isolation with or without changing voltage and impedance conversion. A transformer cannot operate with direct current; although, when it is connected to a DC source, a transformer typically produces a short output pulse as the current rises. A transformer is an electrical device that transfers energy between two circuits.

A transformer most commonly consists of two windings of wire that are wound around a common core to provide tight electromagnetic coupling between the windings. The functioning of a transformer is based on two principles of the laws of electromagnetic induction: An electric current through a conductor, such as a wire, produces a magnetic field surrounding the wire, and a changing magnetic field in the vicinity of a wire induces a voltage across the ends of that wire. The magnetic field excited in the primary coil gives rise to self-induction as well as mutual induction between coils. This self-induction counters the excited field to such a degree that the resulting current through the primary winding is very small when no load draws power from the secondary winding. The physical principles of the inductive behavior of the transformer are most readily understood and formalized when making some assumptions to construct a simple model which is called the *ideal transformer*.

Applications

This transformers will perform voltage conversion; isolation protection; and impedance matching. In terms of voltage conversion, transformers can step-up voltage/step-down current from generators to high-voltage transmission lines, and step-down voltage/step-up current to local distribution circuits or industrial customers. The step-up transformer is used to increase the secondary voltage relative to the primary voltage, whereas the step-down transformer is used to decrease the secondary voltage relative to the primary voltage. Transformers range in size from thumbnail-sized used in microphones to units weighing hundreds of tons interconnecting the power grid. A broad range of transformer designs are used in electronic and electric power applications, including miniature, audio, isolation, high-frequency, power conversion transformers, etc.

External Faults in Power Transformer

External Short - Circuit of Power Transformer The short - circuit may occur in two or three phases of electrical power system. The level of fault current is always high enough. It depends upon the voltage which has been short - circuited and upon the impedance of the circuit up to the fault point. The copper loss of the fault feeding transformer is abruptly increased. This increasing copper loss causes internal heating in the transformer. Large fault current also produces severe mechanical stresses in the transformer. The maximum mechanical stresses occur during first cycle of symmetrical fault current.

High Voltage Disturbance in Power Transformer

High Voltage Disturbance in Power Transformer is of two kinds,
(1) Transient Surge Voltage
(2) Power Frequency over Voltage
High voltage and high frequency surge may arise in the power system due to any of the following causes,
(a) Arcing ground if neutral point is isolated
(b) Switching operation of different electrical equipment.
(c) Atmospheric Lightening Impulse.
Whatever may be the causes of surge voltage, it is after all a traveling wave having high and steep wave form and also having high frequency. This wave travels in the electrical power system network, upon reaching in the power transformer; it causes breakdown the insulation between turns adjacent to line terminal, which may create short circuit between turns.

Internal Faults in Power Transformer

The principle faults which occurs inside a power transformer are categorized as,
(1) Insulation breakdown between winding and earth
(2) Insulation breakdown in between different phases
(3) Insulation breakdown in between adjacent turns i.e. inter - turn fault
(4) Transformer core fault

Internal Earth Faults in Power Transformer

Internal Earth Faults in a Star Connected Winding with Neutral Point Earthed through an Impedance In this case the fault current is dependent on the value of earthing impedance and is also proportional to the distance of the fault point from neutral point as the voltage at the point depends upon, the number of winding turns come under across neutral and fault point. If the distance between fault point and neutral point is more, the number of turns come under this distance is also more, hence voltage across the neutral point and fault point is high which causes higher fault current. So, in few words it can be said that, the value of fault current depends on the value of earthing impedance as well as the distance between the faulty point and neutral point. The fault current also depends up on leakage reactance of the portion of the winding across the fault point and neutral. But compared to the earthing impedance, it is very low and it is obviously ignored as it comes in series with comparatively much higher earthing impedance.

Internal Earth Faults in a Star Connected Winding with Neutral Point Solidly Earthed

In this case, earthing impedance is ideally zero. The fault current is dependent up on leakage reactance of the portion of winding comes across faulty point and neutral point of transformer. The fault current is also dependent on the distance between neutral point and fault point in the transformer. As said in previous case the voltage across these two points depends upon the number of winding turn comes across faulty point and neutral point. So in star connected winding with neutral point solidly earthed, the fault current depends upon two main factors, first the leakage reactance of the winding comes across faulty point and neutral point and secondly the distance between faulty point and neutral point. But the leakage reactance of the winding varies in complex manner with position of the fault in the winding. It is seen that the reactance decreases very rapidly for fault point approaching the neutral and hence the fault current is highest for the fault near the neutral end. So at this point, the voltage available for fault current is low and at the same time the reactance opposes the fault current is also low, hence the value of fault current is high enough. Again at fault point away from the neutral point, the voltage available for fault current is high but at the same time reactance offered by the winding portion between fault point and neutral point is high. It can be noticed that the fault current stays a very high level throughout the winding. In other word, the fault current maintains a very high magnitude irrelevant to the position of the fault on winding.

Internal Phase to Phase Faults in Power Transformer

Phase to phase fault in the transformer are rare. If such a fault does occur, it will give rise to substantial current to operate instantaneous over current relay on the primary side as well as the differential relay.

Inter Turns Fault in Power Transformer

Power Transformer connected with electrical extra high voltage transmission system, is very likely to be subjected to high magnitude, steep fronted and high frequency impulse voltage due to lightening surge on the transmission line. The voltage stresses between winding turns become so large, it cannot sustain the stress and causing insulation failure between inter - turns in some points. Also LV winding is stressed because of the transferred surge voltage. Very large number of Power Transformer failure arises from fault between turns. Inter turn fault may also be occurred due to mechanical forces between turns originated by external short circuit.

Core Fault in Power Transformer

In any portion of the core lamination is damaged, or lamination of the core is bridged by any conducting material cause’s sufficient eddy current to flow, hence, this part of the core becomes over heated. Sometimes, insulation of bolts (Used for tightening the core lamination together) fails which also permits sufficient eddy current to flow through the bolt and causing overheating. This insulation failure in lamination and core bolts causes severe local heating. Although these local heating, causes additional core loss but cannot create any noticeable change in input and output electric current in the transformer, hence these faults cannot be detected by normal electrical protection scheme. This is desirable to detect the local over heating condition of the transformer core before any major fault occurs. Excessive over heating leads to breakdown of transformer insulating oil with evolution of gases. These gases are accumulated in Buchholz relay and actuating Buchholz Alarm.

In this particular project we are detecting three transformer faults, those are

- Overvoltage fault
- High current fault
- oil leakage detection

Over voltage detection:

In this project we are using a transformer with multiple tapings. Each tapings will be connected to the relays. When a particular relay switches on the microcontroller will sense it, and checks if it is more than the required value of the voltage. Using different tapings the voltages are and voltage level is checked. If the overvoltage has been detected the microcontroller will send a message through GSM module stating that Overvoltage fault has been occurred in the transformer.

High current detection:

Here different loads are connected to relays. With switching a particular relay different values of loads will be selected. Higher load draws higher current. Hence after selecting the higher load the current will be checked. And if the high current has been detected the microcontroller will send a message through GSM module stating that high current fault has been occurred in the transformer.

Oil leakage detection:

Here a floating switch is been used and when oil level decreases below a certain level then it will send a signal to microcontroller. And microcontroller will send a message through GSM module stating that oil leakage fault has been occurred in the transformer.

II. EXISTING SYSTEMS

Generally when a fault occurs in transmission line, unless it is severe it is unseen. But gradually these minor faults can lead to damage of transformer and can turn havoc to human life. It may also initiate fire. Present day in India, we do not have a system in hand that would let us know in real time once a fault occurs. Matter of concern is that since we do not have a real time system, this leads to damage of the underlying equipment's connected and turns out to be a threat to human around. In order to avoid such incidents to the maximum extent, maintenance or checking of the transmission lines are generally carried out on a frequent basis. This leads to increased manpower requirement. The fact remains that the real intention of this is not met as many a times line failure may be due to rain, toppling of trees which cannot be predicted. Like in Western Ghats where the transmission lines are usually drawn amidst the forest and places like Chirapunjee where massive rainfall almost sets everything standstill. It is necessary to understand the gravity and after effects of a line failure. To overcome these, we are proposing a GSM based transmission line fault detection System. Whenever the preset threshold is crossed, the microcontroller instantly initiates a message to be sent to the area lineman and the Control Station stating the exact pole to pole location. This helps us to realize a almost real time system. The real intention of detecting fault in real time and protecting the transformer at the earliest is realized. It is important to note that transformers are very costly. An 11KV transformer on an average costs 3000 US$. So here we are designing a cost effective and fast response system aiding in improving safety.

III. FAULTS

In an electric power system, a fault is any abnormal flow of electric current. For example a short circuit is a fault in which current flow by passes the normal load. An open circuit fault occurs if a circuit is interrupted by some failure. In three phase systems, a fault may involve one or more phases and ground, or may occur only between phases. In a "ground fault" or "earth fault", current flows into the earth. The prospective short circuit current of a fault can be calculated for power systems. In power systems, protective devices detect fault conditions and operate circuit breakers and other devices to limit the loss of service due to a failure. In a poly phase system, a fault may affect all phases equally which is a "symmetrical fault". If only some phases are affected, the "asymmetrical fault" requires use of methods such as symmetrical components for analysis, since the simplifying assumption of equal current magnitude in all phases no longer applicable. .In this particular project we are detecting three transformer faults, those are Overvoltage fault, High current fault and Oil leakage detection [2].

IV. BLOCK DIAGRAM OF MULTIPLE FAULT DETECTION

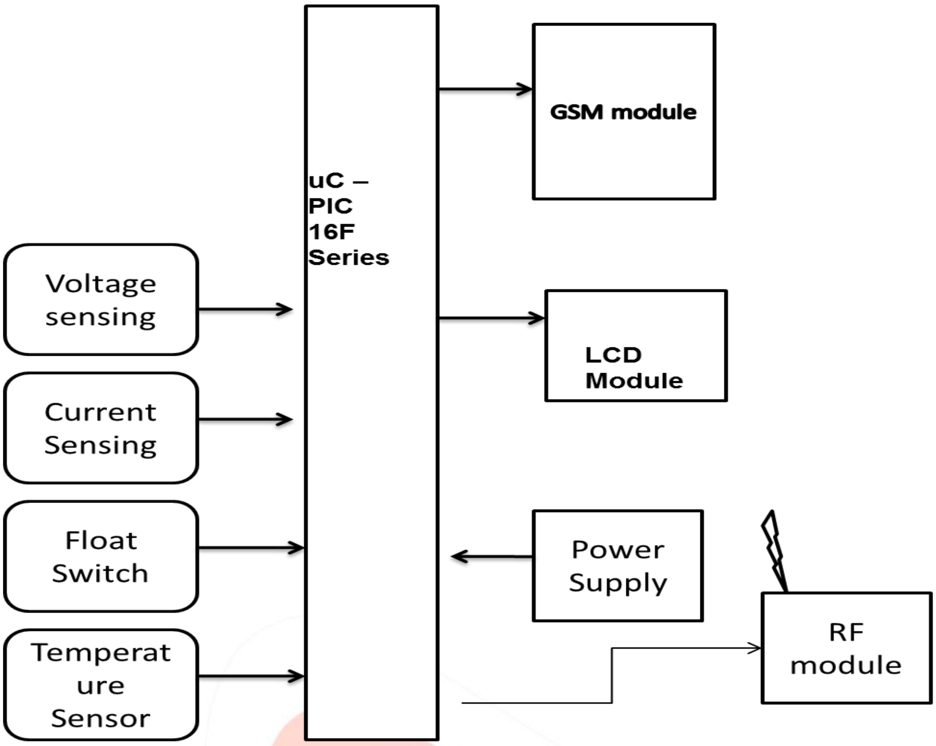

Fig 1 TRANSMITTER

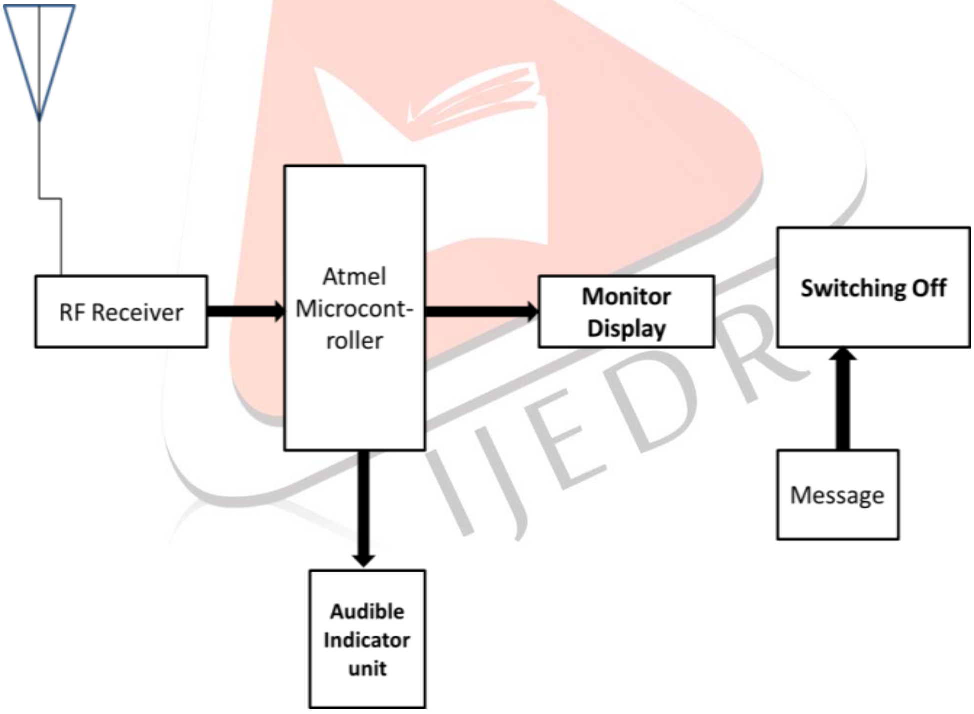

Fig 2 RECEIVER

A. MICROCONTROLLER

In this project work the micro-controller is plays major role. Micro-controllers were originally used as components in complicated process-control systems. However, because of their small size and low price, Micro-controllers are now also being used in regulators for individual control loops. In several areas Micro-controllers are now outperforming their analog counterparts and are cheaper as well.

B. POWER SUPPY

A variable regulated power supply, also called a variable bench power supply, is one where you can continuously adjust the output voltage to your requirements. This type of regulation is ideal for having a simple variable bench power supply. While a dedicated supply is quite handy e.g. 5V or 12V, it's much handier to have a variable supply on hand, especially for testing. Most digital logic circuits and processors need a 5 volt power supply. To use these parts we need to build a regulated 5 volt source. Usually you start with an unregulated power supply ranging from 9 volts to 24 volts DC (A 12 volt power supply is included with the Beginner Kit and the Microcontroller Beginner Kit.). To make a 5 volt power supply, we use a LM7805 voltage regulator IC.

C. SENSORS

This part of the system consists of temperature sensor. These sensors sense various parameters- of temperature and then sent to the Analog to Digital Converter.

D. ADC

This device will convert the analog values into digital format and fetches to the microcontroller. PIC 16f has inbuilt ADC else we would use additional ADC if the values received are not proper.

E. LCD

How to interface 16x2 LCD with PIC microcontroller**.** It is very important to keep a track of the working of almost all the automated and semi-automated devices, be it a washing machine, an autonomous robot or anything else. This is achieved by displaying their status on a small display module. LCD (Liquid Crystal Display) screen is such a display module and a 16x2 LCD module is very commonly used. These modules are replacing seven segments and other multi segment LEDs for these purposes. The reasons being: LCDs are economical, easily programmable, have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on. LCD can be easily interfaced with a microcontroller to display a message or status of a device. This topic explains the basics of a 16x2 LCD and how it can be interfaced with PIC16F877A to display a character. A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers.

1. Command/Instruction Register - stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing, clearing the screen, setting the cursor position, controlling display etc.
2. Data Register - stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

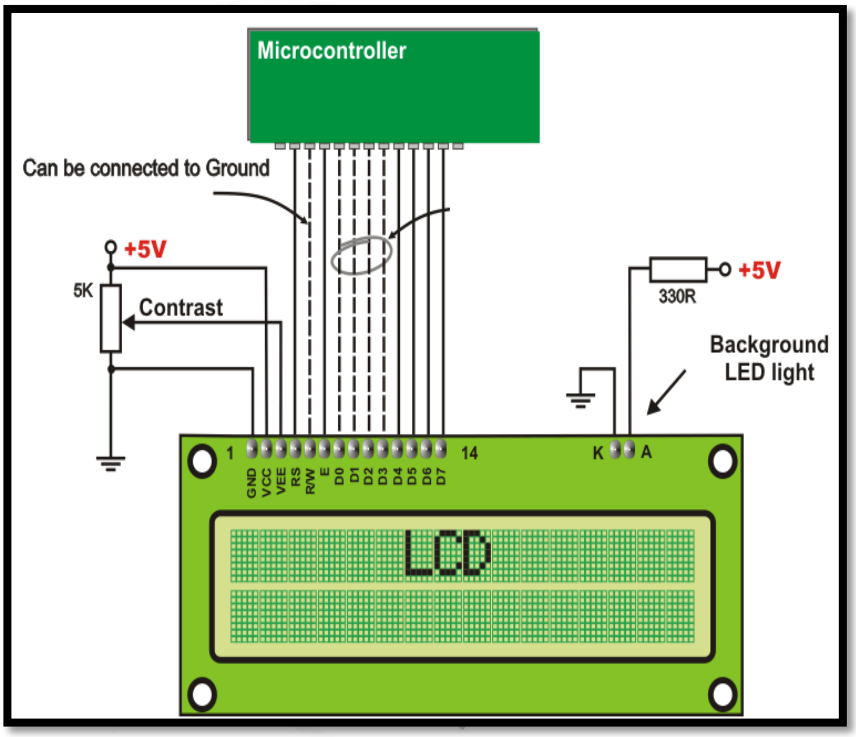

Fig 3 LCD DISPLAY

Pin No:	Name	Function
1	VSS	This pin must be connected to the ground
2	VCC	Positive supply voltage pin (5V DC)
3	VEE	Contrast adjustment
4	RS	Register selection
5	R/W	Read or write
6	E	Enable
7	DB0	Data
8	DB1	Data
9	DB2	Data
10	DB3	Data
11	DB4	Data
12	DB5	Data
13	DB6	Data
14	DB7	Data
15	LED+	Back light LED+
16	LED-	Back light LED-

Table 1 Pin Discription

VEE pin is meant for adjusting the contrast of the LCD display and the contrast can be adjusted by varying the voltage at this pin. This is done by connecting one end of a POT to the VCC (5V), other end to the Ground and connecting the center terminal (wiper) of the POT to the VEE pin. See the circuit diagram for better understanding.

The JHD162A has two built in registers namely data register and command register. Data register is for placing the data to be displayed and the command register is to place the commands. The 16×2 LCD module has a set of commands each meant for doing a particular job with the display. We will discuss in detail about the commands later.

High logic at the RS pin will select the data register and Low logic at the RS pin will select the command register. If we make the RS pin high and the put a data in the 8 bit data line (DB0 to DB7) , the LCD module will recognize it as a data to be displayed . If we make RS pin low and put a data on the data line, the module will recognize it as a command. R/W pin is meant for selecting between read and write modes. High level at this pin enables read mode and low level at this pin enables write mode. E pin is for enabling the module. A high to low transition at this pin will enable the module. DB0 to DB7 are the data pins. The data to be displayed and the command instructions are placed on these pins. LED+ is the anode of the back light LED and this pin must be connected to VCC through a suitable series current limiting resistor. LED- is the cathode of the back light LED and this pin must be connected to the ground.

V. PIN DETAILS

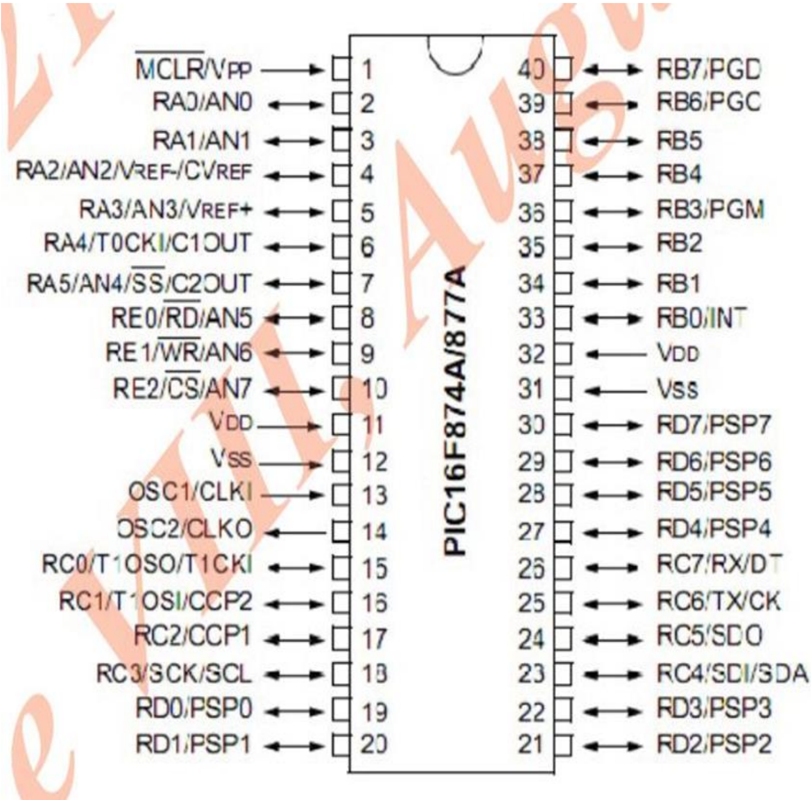

Fig 4 PIC16F877A pin diagram

Only 35 single-word instructions to learn, all single-cycle instructions except for program branches, which are two-cycle. Operating speed: DC – 20 MHz clock input DC – 200 ns instruction cycle, Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM),Up to 256 x 8 bytes of EEPROM Data Memory.

Peripheral Features

Timer0: 8-bit timer/counter with 8-bit pre scaler, Timer1: 16-bit timer/counter with pre scaler can be incremented during Sleep via external crystal/clock, Timer2: 8-bit timer/counter with 8-bit period register, pre scaler and post scaler. Two Capture, Compare, PWM modules, Capture is 16-bit, max resolution is 12.5 ns, Compare is 16-bit, max resolution is 200 ns, PWM max. resolution is 10-bit, Synchronous Serial Port (SSP) with SPI™(Master mode) and I2C™ (Master/Slave), Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection, Parallel Slave Port (PSP) – 8 bits wide with external RD, WR and CS controls (40/44-pin only), Brown-out detection circuitry for Brown-out Reset (BOR).

VI. TECHNICAL DETAILS

Global System for Mobile communications is the most popular standard for mobile phones in the world. Its promoter, the GSM Association, estimate that 82% of the global mobile market uses the standard. GSM is used by over 2 billion people across more than 212 countries and territories. Its ubiquity makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world.

GSM has used a variety of voice codec's to squeeze 3.1 kHz audio into between 5.6 and 13 Kbit/s. Originally, two codec's, named after the types of data channel they were allocated, were used, called Half Rate (5.6 Kbit/s) and Full Rate (13 Kbit/s). These used a system based upon linear predictive coding (LPC). In additional to being efficient with bit rates, these codec's also made it easier to identify more important parts of the audio, allowing the air interface layer to prioritize and better protect these parts of the signal. There five different cell sizes in a GSM network-macro, micro, Pico, femto and umbrella cells. The coverage area of each cell varies according to the implementation environment. Macro cells can be regarded as cells where the base station antenna is installed on a mast or a building above average roof top level. Micro cells are cells whose antenna height is under average roof top level; they are typically used in urban areas. Pico cells are small cells whose coverage diameter is a few dozen meters; they are mainly used indoors. Femto cells are cells designed for use in residential or small business environments and connect to the service provider's network via a broadband internet connection. Umbrella cells are used to cover shadowed regions of smaller cells and fill in gaps in coverage between those cells. Cell horizontal radius varies depending on antenna height, antenna gain and propagation conditions from a couple of hundred meters to several tens of kilometers. The longest distance the GSM specification supports in practical use is 35 kilometers Indoor coverage is also supported by GSM and may be achieved by using an indoor Pico cell base station, or an indoor repeater with distributed indoor antennas fed through power splitters, to deliver the radio signals from an antenna outdoors to the separate indoor distributed antenna system. These are typically deployed when a lot of call capacity is needed indoors, for example in shopping centers or airports.

VII. SUBSCRIBER IDENTITY MODULE

One of the key features of GSM is the Subscriber Identity Module (SIM), commonly known as a SIM card. The SIM is a detachable smart care containing the user's subscription information and phonebook. This allows the user to retain his or her information after switching handsets. Alternatively, the user can also change operators while retaining the handset simply by changing the SIM. Some operators will block this by allowing the phone to use only a single SIM, or only a SIM issued by them; this practice is known as SIM locking, and is illegal in some countries. A subscriber can usually contact the provider to remove the lock for a fee, utilize private services to remove the lock, to make use of ample software and websites available on the Internet to unlock the handset themselves. While most web sites offer the unlocking for a fee, some do it for free.

Working of GSM Modem

A GSM modem is a wireless modem that works with GSM wireless networks. A wireless modem is similar to a dial-up modem. The main difference is that a wireless modem transmits data through a wireless network whereas a dial-up modem transmits data through a copper telephone line. Most mobile phones can be used as a wireless modem. To send SMS messages, first place a valid SIM card into a GSM modem, which is then connected to microcontroller by RS 232 cable. After connecting a GSM modem to a microcontroller, you can control the GSM modem by sending instructions to it.

XBEE

XBEE work together to monitor three parameters of a generator transformer and send this data to remote location. All of the monitored sensor value are then sent in a sequential order according to multiplexing frequency obtain from ADC from microcontroller. It sends these parameters to the XBEE module that operates at 2 GHz in order to send over the data. A Microcontroller interface system is used as the receiver that is used to receive the real time data along with error signals transmitted for desired relay, required for displaying output on an LCD display.

VIII. CONCLUSION

Here, in this project we have designed a GSM based transmission line monitoring and indication system that sends information of the same to electricity board via SMS.

IX. FUTURE SCOPE:

The project is designed to send in an alert message as soon as there is a fault. In this model, we predict the place of fault using the distance from pole to pole. In future we can have a GPS attached to it that would exactly send the location in terms of longitude and latitude.

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