LIST OF FIGURES

Fig 1.1	Block Diagram of GSM Based Fault Indication System for Transformer	1
Fig 2.1	Transformer	2
Fig 2.2	Transformer Core & Its Winding	3
Fig 2.3	Windings	4
Fig 2.4	Shell Type Lamination	5
Fig 2.5	Bridge Rectifier Operation	8
Fig 3.1	ASC712 Module & Its Pin Diagram	12
Fig 3.2	LM35 IC	14
Fig 3.3	SW420 Vibration Sensor Module	15
Fig 3.4	Vibration Sensor Roller	15
Fig 3.5	Pin Diagram of PIC16F887	16
Fig 3.6	GSM Module	18
Fig 4.1	Flow Chart	21
Fig 4.2	Room temperature reading	22
Fig 4.3	Increasing temperature using soldering iron	22
Fig 4.4	Under increased temperature condition	23
Fig 4.5	Voltage under 3V	23
Fig 4.6	Varying resistance to increase voltage	24
Fig 4.7	Over Voltage detected	24
Fig 4.8	Vibrating SW-420 sensor	25
Fig 4.9	Vibration detected and indicated on HyperTerminal	25
Fig 4.10	Measuring current drawn by DC motors using ACS712	26
Fig 4.11	Current measured and observed on HyperTerminal	26
Fig 4.12	Voltage and Temperature above threshold value	27
Fig 4.13	Current above threshold and Vibration detected	27
Fig 4.14	Screenshot of SMS received when fault detected	28

LIST OF TABLES

3.1 Sensors for Different Transformer's Parameter 11

CHAPTER 1

PROBLEM DEFINITION & DESIGN SPECIFICATION

Instumentation transformer is a key part of measuring voltage and current precisely flowing through it. There are roughly 3 cases of transformer fail on regular basis. The demand for electrical energy is ever increasing. Today over 21% of the total electrical energy generated in India is lost in transmission (4-6%) and distribution (15-18%). The electrical power deficit in the country is currently about 18%. Clearly, the measurements of the voltage and current are very necessary. It is also very important to reduce the loses while measuring. It is possible to bring down the distribution losses to a 6-8 % level in India with the help of automation in the monitoring of transformers which will enable better monitoring and control. So, we need transformer automation to improve power quality, for energy cost reduction and to improve reliability.

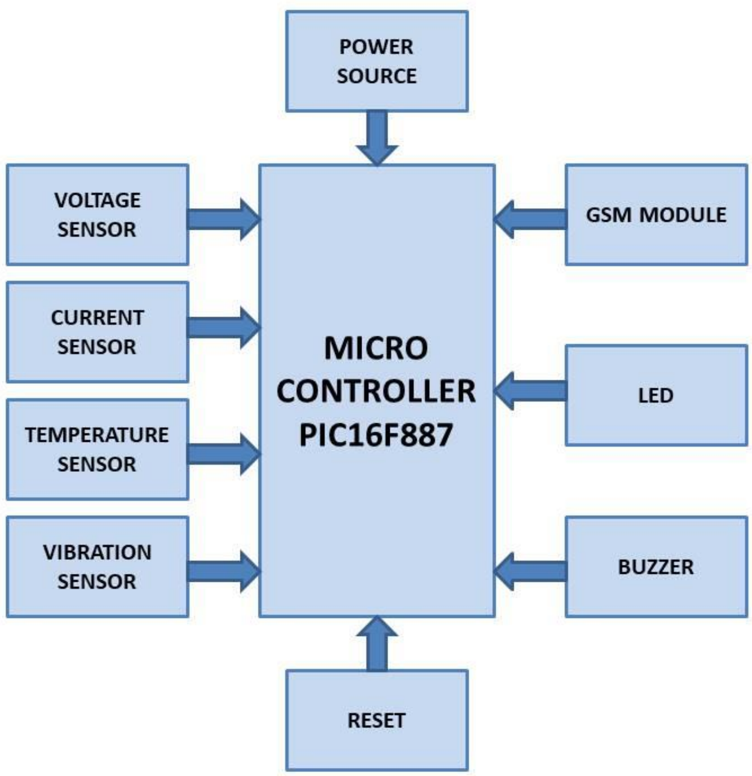

Fig 1.1 Block Diagram of GSM Based Fault Indication System for Transformer

BASIC THEORY

2.1 Transformer Basics

Fig. 2.1: Transformer

A transformer (Fig.2.1) is a static piece of apparatus by means of which an electrical power is transferred from one alternating current circuit to another electrical circuit. There is no electrical contact between the low and high winding. The desire change in voltage or current without any change in frequency.

2.1.1 Structure

The transformer two inductive coils, these are electrical separated but linked through a common magnetic current circuit. These two coils have a high mutual induction. One of the two coils is connected of alternating voltage this coil in which electrical energy is fed with the help of source called primary winding (P) shown in Fig. 2.2. The other winding is connected to a load the electrical energy is transformed to this winding drawn out to the load this winding is called secondary winding(S) shown in Fig 2.2. The primary and secondary coil wound on a ferromagnetic metal core. The function of the core is to transfer the changing magnetic flux from the primary coil to the secondary coil. The primary has N1 no of turns and the secondary has N2 no of turns of turn's plays major important role in the function of transformer.

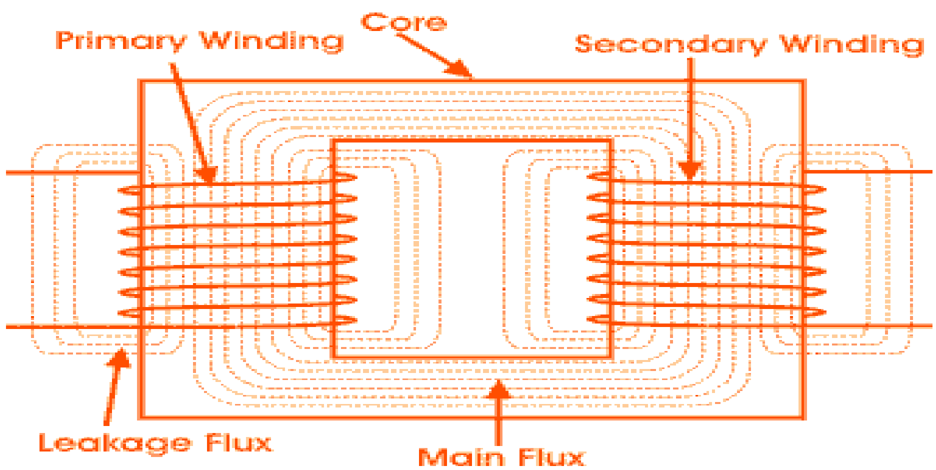

Fig 2.2: Transformer Core & Its Winding

2.1.2 Working

The transformer works in the principle of mutual induction. When the alternating current flows in the primary coils, a changing magnetic flux is generated around the primary coil. The changing magnetic flux is transferred to the secondary coil through the iron core. The changing magnetic flux is cut by the secondary coil, hence induces an E.M.F in the secondary coil. Now if load is connected to a secondary winding, this E.M.F drives a current through it. The magnitude of the output voltage can be controlled by the ratio of the no. of primary coil and secondary coil.

2.1.3 Construction

These are two basic of transformer construction (i) Magnetic core (ii) Windings or coils. The core of transformer either square or rectangular type in size. It is further divided into two parts vertical and horizontal. The vertical portion on which coils are wounds called limb while horizontal portion is called yoke. Core is made of laminated core type constructions, eddy current losses get minimize. Generally high grade silicon steel laminations (0.3 to 0.5mm) are used.

2.1.4 Winding

Conducting material is used in the winding of the transformer. The coils are used to wound on the limbs and insulated from each other. The two different windings are wounds on two different limbs. The leakage flux increases which affects the performance and efficiency of transformer. To reduce the leakage flux it is necessary that the windings should be very close to each other as shown in Fig. 2.3 to have high mutual induction.

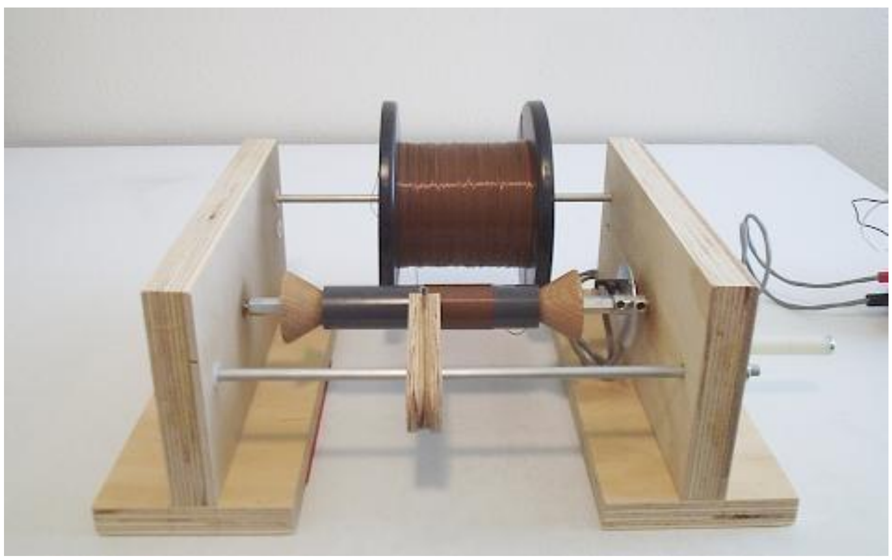

Fig 2.3: Windings

2.1.5 Shell Type Transformer Construction

The winding is wound on central limbs. For the cell type each high voltage winding lie between two voltage portions sandwiching the high voltage winding as shown in Fig. 2.4. Sub division of windings reduces the leakage flux. Greater the number of sub division lesser the reactance. This type of construction is used for high voltage.

Fig 2.4: Shell Type Lamination

2.1.6 Losses in Transformer

In the transformer there are major three losses Copper loss, Hysteresis loss and Eddy current loss. Its description is given below.

Copper Loss

It is due to power wasted in the form of I2R due to resistance of primary and secondary. The magnitude of copper losses depends upon the current flowing through these coils.

Hysteresis Loss

During magnetization and demagnetization, due to hysteresis affect some energy losses in the core called hysteresis loss.

Eddy Current Loss

The leakage magnetic flux generates the E.M.F in the core produces current is called of eddy current loss.

2.1.7 Instrument Transformer

Instrument transformers are high accuracy class electrical devices used to isolate or transform voltage or current levels. The most common usage of instrument transformers is to operate instruments or metering from high voltage or high current circuits, safely isolating secondary control circuitry from the high voltages or currents. The primary winding of the transformer is connected to the high voltage or high current circuit, and the meter or relay is connected to the secondary circuit.

Types of Instrument Transformer

Current Transformer

Current transformers (CT) are a series connected type of instrument transformer. They are designed to present negligible load to the supply being measured and have an accurate current ratio and phase relationship to enable accurate secondary connected metering.

Potential Transformer

Potential transformers (PT), are a parallel connected type of instrument transformer. They are designed to present negligible load to the supply being measured and have an accurate voltage ratio and phase relationship to enable accurate secondary connected metering.

2.1.8 Faults occurring in transformer

Core Saturation

Ferromagnetic materials cannot support infinite magnetic flux densities: they tend to saturate at a certain level (dictated by the material and core dimensions), meaning that further increases in magnetic field force (mmf) do not result in proportional increases in magnetic field flux (Φ).

So, if a transformer's primary winding is overloaded from excessive applied voltage, the core flux may reach saturation levels during peak moments of the AC sinewave cycle and the voltage induced in the secondary winding will no longer match the wave-shape as the voltage powering the primary coil

Noise

Transformer noise is caused by a phenomenon which causes a piece of magnetic sheet steel to extend itself when magnetized. When the magnetization is taken away, it goes back to its original condition. This phenomenon is scientifically referred to as magnetostriction. A transformer is magnetically excited by an alternating voltage and current so that it becomes extended and contracted twice during a full cycle of magnetization. So, as the voltage and current increases the humming of transformer also increases therefore, the voltage and current levels should be maintained so that the core does not get saturated.

The magnetization of any given point on the sheet varies, so the extension and contraction is not uniform. A transformer core is made from many sheets of special steel to reduce losses and moderate the ensuing heating effect. The extensions and contractions are taking place erratically all over a sheet and each sheet is behaving erratically with respect to each other. These extensions are very minute and therefore not normally visible to the naked eye. However, they are sufficient to cause a vibration, and consequently noise. Applying voltage to a transformer produces a magnetic flux, or magnetic lines of force in the core. The degree of flux determines the amount of magnetostriction and hence, the noise level.

2.1.9 Application & Uses

The transformer used in television and photocopy machines. The transmission and distribution of alternating power is possible by transformer. Simple camera flash uses fly back transformer. Signal and audio transformer is used as couple in amplifier.

2.2 230V to 9V Potential Transformer

We used 440V to 230V step down distribution transformer; its output voltage is 230V. These voltages can’t be fed directly to our designed system. So we need to be scaled down. For this purpose we use potential transformer can be used in practice.

The major specifications of the transformer in use are as follows:

Output Voltage: 12 V

Output Current: 1 A

2.3 Bridge Rectifier

A Bridge rectifier is an Alternating Current (AC) to Direct Current (DC) converter that rectifies mains AC input to DC output. Bridge Rectifiers are widely used in power supplies that provide necessary DC voltage for the electronic components or devices. They can be constructed with four or more diodes or any other controlled solid state switches. Depending on the load current requirements, a proper bridge rectifier is selected. Components' ratings and specifications, breakdown voltage, temperature ranges, transient current rating, forward current rating, mounting requirements and other considerations are taken into account while selecting a rectifier power supply for an appropriate electronic circuit's application.

2.3.1 Operation

As we discussed above, a single-phase bridge rectifier consists of four diodes and this configuration is connected across the load. For understanding the bridge rectifier's working principle, we have to consider the below circuit for demonstration purpose.

During the Positive half cycle of the input AC waveform diodes D1 and D2 are forward biased and D3 and D4 are reverse biased. When the voltage, more than the threshold level of the diodes D1 and D2, starts conducting – the load current starts flowing through it, as shown as red lines path in the diagram below.

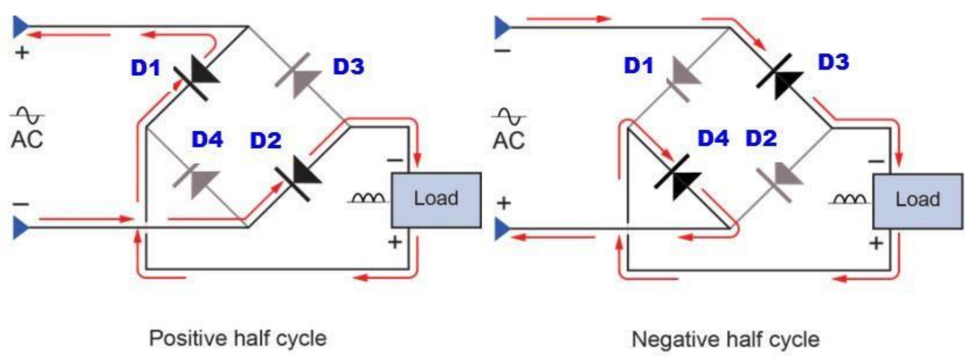

Fig 2.6: Bridge Rectifier Operation

During the negative half cycle of the input AC waveform, the diodes D3 and D4 are forward biased, and D1 and D2 are reverse biased. Load current starts flowing through the D3 and D4 diodes when these diodes starts conducting as shown in the Fig. 2.6.

We can observe that in both the cases, the load current direction is same, i.e., up to down as shown in the figure – so unidirectional, which means DC current. Thus, by the usage of a bridge rectifier, the input AC current is converted into a DC current. The output at the load with this bridge wave rectifier is pulsating in nature, but for producing a pure DC requires additional filter like capacitor. The same operation is applicable for different bridge rectifiers, but in case of controlled rectifiers thyristors triggering is necessary to drive the current to load.

2.3.2 Application & Uses

The primary application of bridge rectifiers is to transform an AC supply into DC power. All electronic devices require direct current, so bridge rectifiers are used inside the power supplies of almost all electronic equipment. Bridge rectifiers are also used for detecting the amplitude of modulated radio signals. The signal may be amplified before it is detected. If it is not, then a very low voltage drop diode or a diode biased with a fixed voltage must be used. Rectifiers are also used to supply polarized voltage for welding applications. Control of the output current is required in such circuits, and this may be achieved by replacing some of the diodes in a bridge rectifier with thyristors, which are diodes whose voltage output can be regulated by switching on and off with phase fired controllers.

CHAPTER 3
HARDWARE AND SOFTWARE DESIGN DETAILS

3.1 Hardware Implementation

This chapter explains regarding the Hardware Implementation of the project.it tells about the design and working of the design with the help of circuit diagram and explanation of circuit diagram in detail. It explains the features, programming and serial communication of PIC16F887. It also explains the different module used in this project.

3.1.1Interfacing Module Scheme

The above scheme depicts the sequence of methodologies followed in the monitoring and detection of fault of transformer via GSM technology.

- First sensors which are installed at the transformer site sense the various parameters of transformers and convert into analog signal to be processed in a signal conditioning circuit.
- Next the analog signal is passed through PIC16F887. It is used to read the parameters, built-in program memory is used to host the embedded software algorithm that takes care of the parameters acquisition, processing, transmitting and receiving.
- The GSM modem is interfaced with the PIC16F887 through connecting wires by which it sends SMS message indicating about various transformer parameters failure.

3.1.2 Sensors

Sensors are installed on transformer site which reads and measures the physical quantity from the transformer and then it converts it into the analog signal. Sensors are used for sensing load current, voltage, temperature, vibration. A sensor is a device which receives and responds to a signal when touched. A multitude of different measurable variables can be collected for online monitoring. However, it is very rarely useful to use the entire spectrum.

Therefore, sensor technology must be adjusted to the specific requirements of a particular transformer depending on their age and condition.

Following general set-up of sensors for example is proposed for the use at a Transformer:

Table 3.1: Sensors for Different Transformer's Parameter

SR No.	Parameter	Sensor
1	Phase Voltage	Built in ADC
2	Phase Current	ACS712 Current Sensor Module (5 Ampere)
3	Temperature	LM35
4	Humming	SW420 Vibration Sensor Module

Voltage Sensor

The PIC analog input is limited to a 5V DC input. If we wish to measure higher voltage, we will need to resort to another means. We have used 750ohm resistance connected in series with 1000 ohm resistance trim pot to do so.

Inputs

- **GND:** We connect the gnd of signal to the gnd of controller.
- **ANALOG INPUT:** We connect the analog input to analog pin (A0) of controller

Measurement of Voltage Using ADC

There are certain steps to initialize the ADC of the controller. They are listed below:

- Configure Port:
  - Disable pin output driver (See TRIS register)
  - Configure pin as analog
- Configure the ADC module:
  - Select ADC conversion clock
  - Configure voltage reference
  - Select ADC input channel
  - Select result format
  - Turn on ADC module

- Configure ADC interrupt (optional):
    - Clear ADC interrupt flag
    - Enable ADC interrupt
    - Enable peripheral interrupt
    - Enable global interrupt
- Wait the required acquisition time
- Start conversion by setting the GO/DONE bit.
- Wait for ADC conversion to complete by one of the following:
    - Polling the GO/DONE bit
    - Waiting for the ADC interrupt (interrupts enabled)
- Read ADC Result
- Clear the ADC interrupts flag (required if interrupt is enabled).

Current Sensor

Here, to measure current we are using IC ACS712 Current Sensor module as shown in Fig. 3.1. The ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switch mode power supplies and over-current fault protection. The device consists of a precise, low-offset, linear Hall circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which the Hall IC converts into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer.

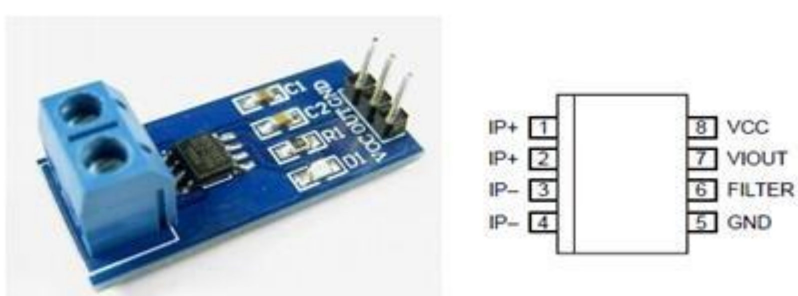

Fig. 3.1 ASC712 Module & Its Pin Diagram

A precise, proportional voltage is provided by the low-offset, Chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy after packaging. The output of the device has a positive slope (>VIOUT (Q)) when an increasing current flows through the primary copper conduction path (from pins 1 and 2, to pins 3 and 4), which is the path used for current sampling. The internal resistance of this conductive path is 1.2mΩ typical, providing low power loss. The thickness of the copper conductor allows survival of the device at up to 5× over-current conditions. The ACS712 is provided in a small, surface mount SOIC8 package. The lead-frame is plated with 100% matte tin, which is compatible with standard lead (Pb) free printed circuit board assembly processes. Internally, the device is Pb-free, except for flip-chip high-temperature
Pb-based solder balls, currently exempt from RoHS.

Features and Benefits

- Low noise analog signal path
- Device bandwidth is set via the new FILTER pin
- 5µs output rise time in response to step input current
- 80 kHz bandwidth
- Total output error 1.5% at TA=25ºC
- 1.2mΩ internal conductor resistance
- 5.0V single supply operation
- 66 to 185 mV/A output sensitivity
- Output voltage proportional to AC or DC currents

Formula of Current Sensor

Iout = Vout(from sensor)/185mV per Amp

Temperature Sensor

As we all know what a temperature sensor does. In simple words these are devices used to measure the temperature or heat of a medium. There are various types of temperature sensor such as thermistor, RTD, thermocouple and IC Sensor but we will here focus on integrated circuit (IC) temperature sensor i.e. LM35 shown in Fig. 3.2.

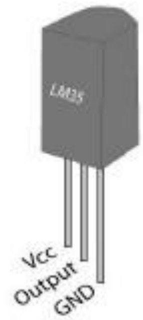

Fig. 3.2 LM35 IC

LM35 is a precision IC temperature sensor with its output proportional to the temperature (inºC).The sensor circuitry is sealed and therefore it is not subjected to oxidation and other processes. With LM35, temperature can be measured more accurately than with a thermistor. It also possess low self-heating and does not cause more than 0.1ºC temperature rise in still air. The operating temperature range is from 55°C to 150°C.The output voltage varies by 10mV in response to every ºC rise/fall in ambient temperature, i.e. its scale factor is 0.01V/ºC.

Measurement of Temperature

Simply make the connections with the micro-controller being used. The analog voltage is independent of the power supply. Formula to calculate the temperature from the output (Vout) of the LM35:-

Temp in °C = (Vout in mV) / 10

Vibration Sensor

The Vibration module as shown in Fig3.3 is based on the vibration sensor SW-420 and Comparator LM393 to detect if there is any vibration that beyond the threshold. The threshold can be adjusted by the on-board potentiometer. Single-roller type full induction trigger switch. When no vibration or tilt, the product is ON conduction state, and in the steady state, when a vibration or tilt, the switch will be rendered instantly disconnect the conductive resistance increases, generating a current pulse signal, thereby triggering circuit.

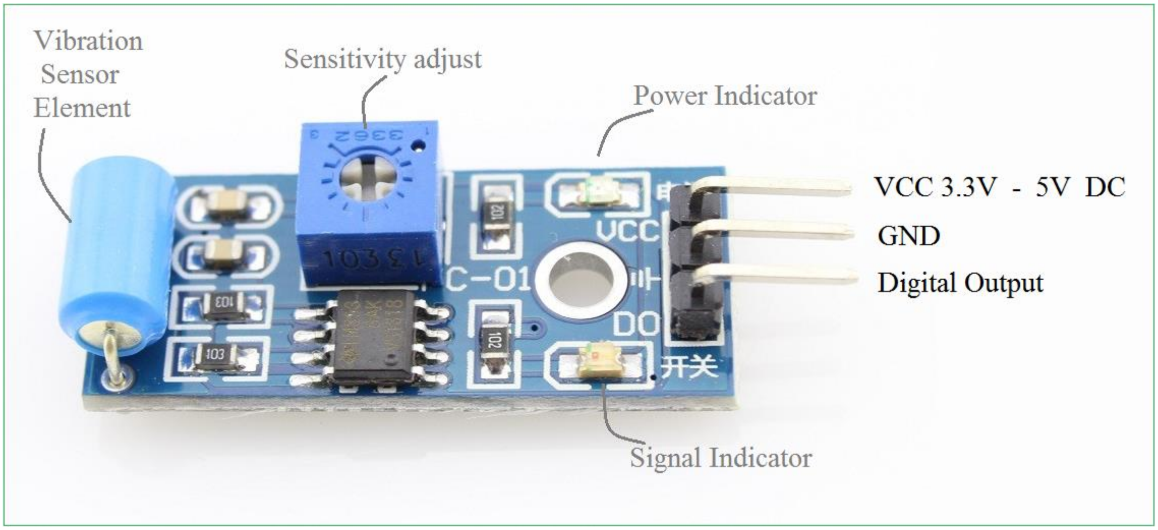

Fig3.3: SW420 Vibration Sensor Module

Principle

Usually at any angle switch is ON state, by the vibration or movement, the rollers of the conduction current as shown in Fig 3.4 in the switch will produce a movement or vibration, causing the current through the disconnect or the rise of the resistance and trigger circuit. The characteristics of this switch is usually general in the conduction state briefly disconnected resistant to vibration, so it's high sensitivity can be set as per the requirements of user.

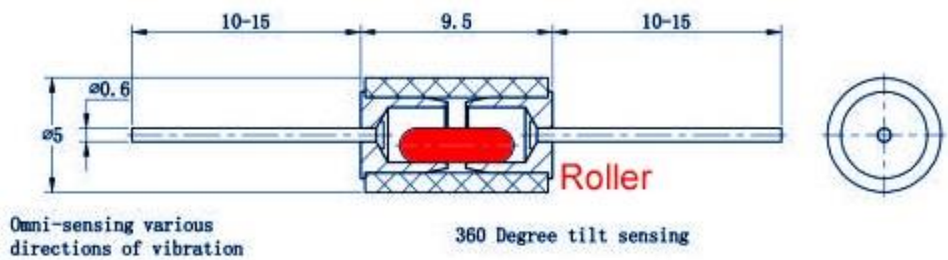

Fig3.4: Vibration Sensor Roller

INPUT

- **GND:** Connect to GND of controller
- **VCC:** Connect to +5V DC of power supply

OUTPUT

- **DQ:** Connect to port pin of controller

3.2 PIC16F887

PIC (Peripheral Interface Controller) is the microcontroller manufactured by Microchip. It very powerful and power efficient controller. Below is the pin diagram of controller.

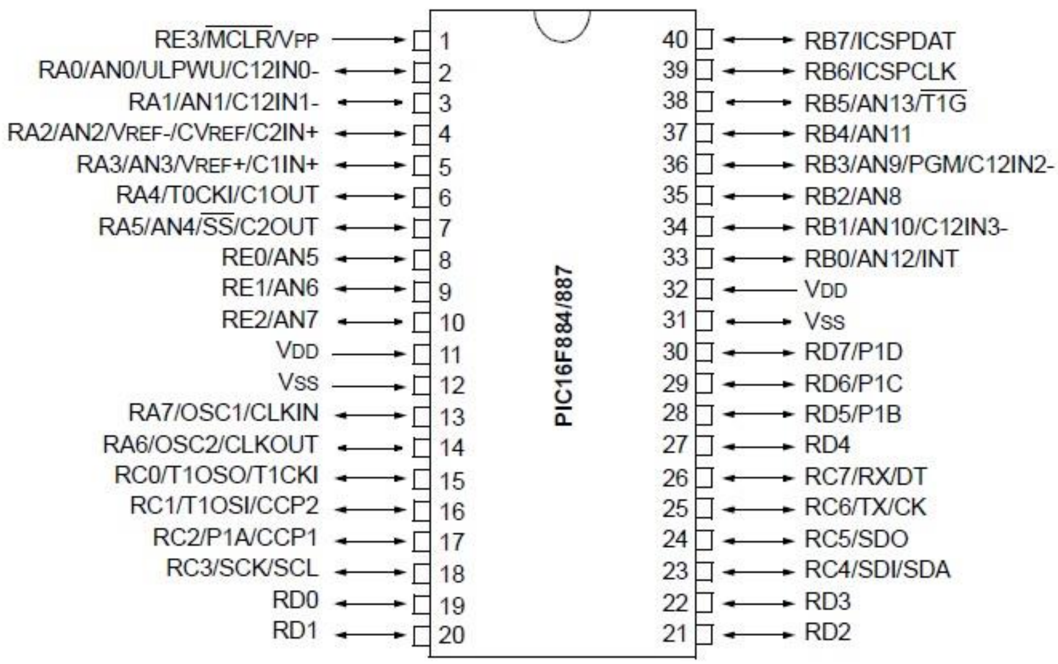

Fig 3.5: Pin Diagram of PIC16F887

Following are the features of PIC16F887:

- RISC architecture
    - Only 35 instructions to learn
    - All single-cycle instructions except branches
- Operating frequency 0-20 MHz
- Precision internal oscillator
    - Software selectable frequency range of 8MHz to 31KHz
    - Power supply voltage 2.0-5.5V
    - Consumption: 220uA (2.0V, 4MHz), 11uA (2.0 V, 32 KHz), 50nA (standby mode)
- Power-Saving Sleep Mode
- Brown-out Reset (BOR) with software control option

- 35 input/output pin
- 8K ROM memory in FLASH technology
    - Chip can be reprogrammed up to 100.000 times
- 256 bytes EEPROM memory
    - Data can be written more than 1.000.000 times
- 368 bytes RAM memory
- A/D converter:
    - 14-channels
    - 10-bit resolution
- 3 independent timers/counters
- Watch-dog timer
- Analogue comparator module with
    - Two analogue comparators
    - Fixed voltage reference (0.6V)
    - Programmable on-chip voltage reference
- Enhanced USART module
    - Supports RS-485, RS-232 and LIN2.0
    - Auto-Baud Detect
- Master Synchronous Serial Port (MSSP)
- supports SPI and I2C mode

3.3 GSM MODULE

A GSM modem is a wireless modem that works with a GSM wireless network as shown in Fig.3.8. A wireless modem is like dial-up modem. The basic difference between them is the dial-up modem sends and receives data through a fixed telephone line while the wireless modem sends and receives data through waves. Like a GSM mobile phone, a GSM modem also requires a SIM card from wireless carrier to operate. SIM 900 is Fixed Cellular Terminal (FCT) used for data application. It is compact and portable terminals which satisfy various data communication over GSM. It also can be connected to computer with a standard RS232 serial port. The GSM/GPRS modem is having internal TCP/IP stack to enable you to connect with internet via GPRS. SIM 900 offers features like Short Message Services (SMS), Data Services (sending and receiving data files), voice call, FAX services and data files connectivity through wire is not available or not possible.

Fig3.6: GSM Module

The SIM 900 is very easy to set up. It also finds its application in IT companies, Banks, Financial Institution, Service providers, Far away Project Sites and other business establishment. SIM 900 designed for global market is a Dual band GSM/GPRS engine works on the frequencies 900/1800 MHz

We can use AT Commands for getting information in SIM card. The SIM interface support the operation of GSM phase 1 specification and also supports the operation of the new GSM phase 2 and specification for fast 64kbps SIM (intended to use having a SIM application Tool-Kit). Both the 1.8V and 3.0V SIM Cards are supported.

AT commands are used by the computers to control modems. Both the GSM modems and dial-up modems support a fixed set of standard AT commands. GSM modem can be used like a dial- up modem. Apart from the standard AT commands, GSM modems also support an extended set of AT commands. This extended AT commands are defined in the GSM standards. With the extended AT commands, several things are done like as given below.

- To read, write and delete SMS messages.
- To send SMS messages

- To monitor signal strength
- To monitor the charging status charge level of the battery.
- Reading, writing and searching phone book entries.
- Get the data from http server and also post the data to an http server.

AT commands are the instructions used for controlling a modem. AT stands for Attention. Each and every command line starts with “AT” or “at”. Because of this modem commands are called AT commands. Many of the commands are also used for controlling wired dial-up modems. These are supported by GSM/GPRS modems and mobile phones. Apart from this common set, GSM/GPRS modems and mobile phones also support an AT command sets which are specific to the GSM technology, which also includes SMS-related commands.

- Basic commands are AT commands that do not start with “+”. For example, D (Dial), A (Answer), H (Hook control) and O (Return to online data state) are basic commands.
- Extended commands are AT commands that start with “+”. All GSM AT commands are extended commands. For example, +CMGS (send SMS message), +CMSS (send SMS message from storage), +CMGL (list SMS message) and +CMGR (read SMS messages) + HTTPINIT (HTTP initialization) are extended commands.

3.4 Software Implementation

This chapter describes about the software implementation of the project. This discuss about the programming and the software tools used and how output is obtained by programming.

3.4.1 Software Tools

In our project we have use many software for different purpose like VSM Studio for Programming , Hyperterminal for observing output on computer , AT Command Tester V28 for GSM command testing,PICPgm Programmer for burning hex file on the controller chip. Software Description is given below.

VSM Studio

The VSM Studio IDE is a free development tool. It is developed by Labcenter .It is lightweight and powerful software with its primary purpose to link firmware development with simulation and debugging in Proteus VSM.

Steps to implement an embedded C code are shown in Appendix C.

HyperTerminal Private Edition

HyperTerminal Private Edition (HTPE) is our award winning windows terminal emulation program capable of connecting to systems through TCP/IP Networks, Dial-Up Modems, and COM ports.

Features of HyperTerminal:

- Use a TCP/IP network to connect to systems on the Internet or your network using Telnet or Secure Shell (SSH)
- Use a Dial-Up modem to dial into modem based systems
- Talk directly to many different types of devices using RS232 serial COM ports.
- Emulate many different termal types including ANSI, ANSIW, VT100, VT100J, VT52, VT220, VT320, TTY, Minitel, and ViewData
- Transfer files with Xmodem, Ymodem, Zmodem, and Kermit.

Steps to set up HyperTerminal on PC are given in Appendix D.

PICPgm Programmer

The PICPgm Development Programmer Software is a free and simple In-System-Development Programmer Software for the Microchip PIC microcontrollers. The programmer software is available with a Graphical User Interface (GUI) and a Command Line interface. The programmer software runs on Windows 98/ME/2k/XP/Vista/7/8/10 (including 64 bit Windows versions), Linux on PC and ARM hardware (e.g. Raspberry Pi, Banana Pi) and MacOS X (command line version only, experimental). PICPgm supports a lot of different programmes which can be connected to the PC via the centronics port (printer port), serial COM port or USB.
Steps to burn a hex file on PIC16F series controller is given in Appendix E.

DipTrace

DipTrace is an EDA/CAD software for creating schematic diagrams and printed circuit boards. DipTrace has 4 modules: schematic capture editor, PCB layout editor with built-in shape-based autorouter and 3D-preview & export, component editor, and pattern editor.

Circuit Diagram of Project in Appendix B.

CHAPTER 4

TESTING AND RESULTS

4.1 FLOW CHART

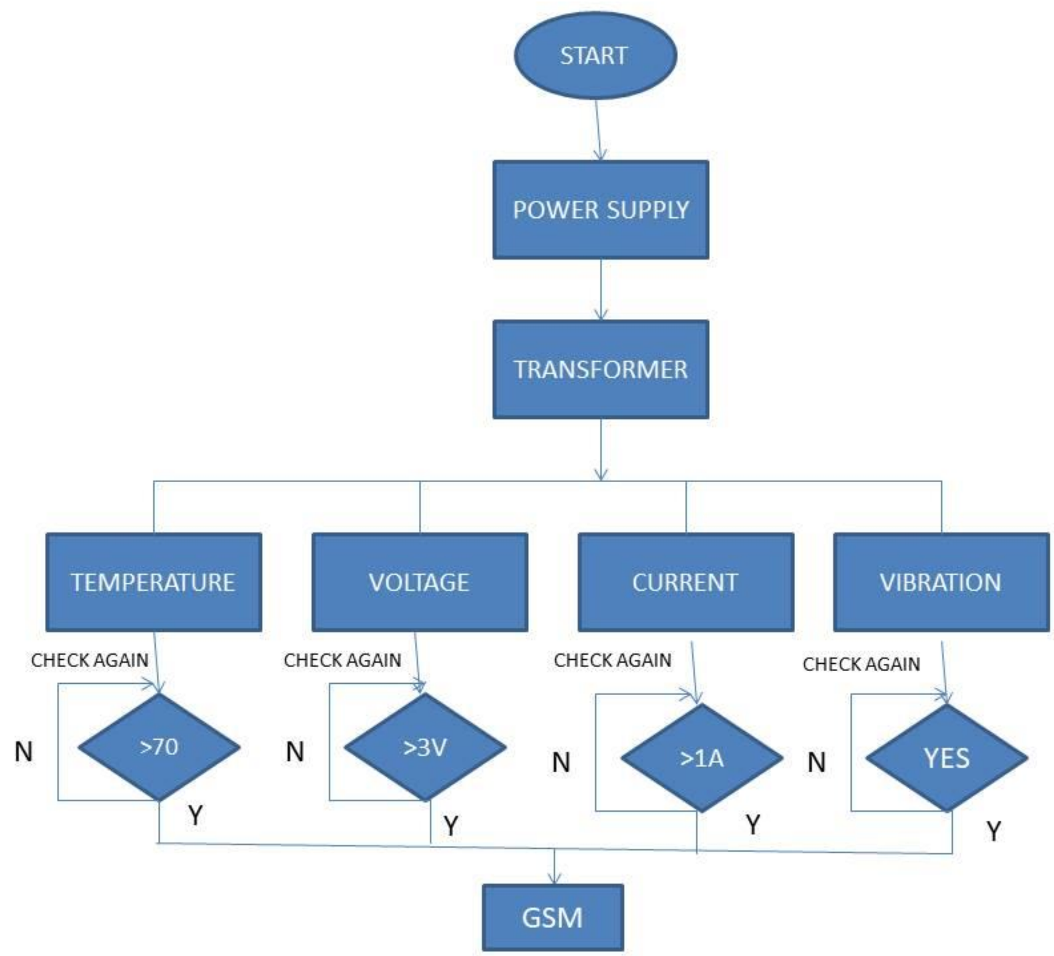

Fig 4.1: Flow chart

4.2 Test Analysis of temperature sensor

Case 1: Under normal condition

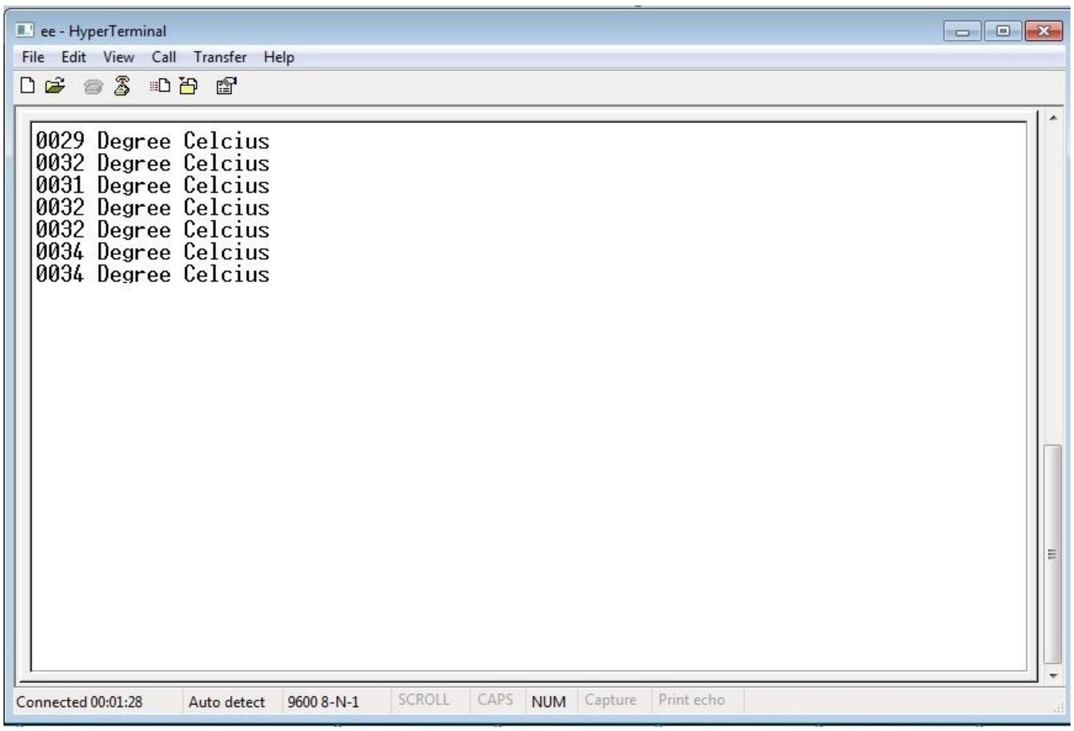

Fig4.2: Room temperature reading

Case 2: Under increased temperature condition

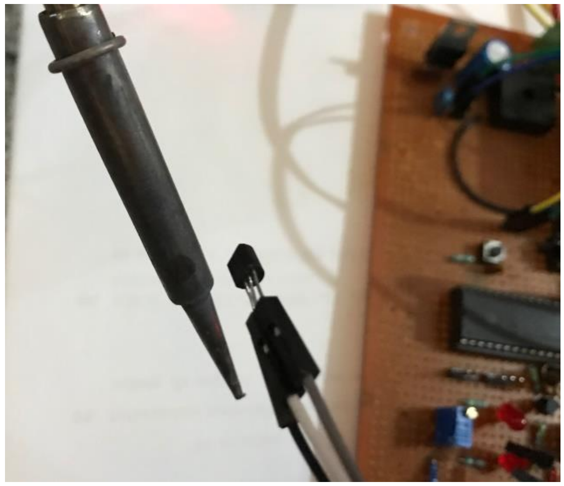

Fig4.3: Increasing temperature using soldering iron

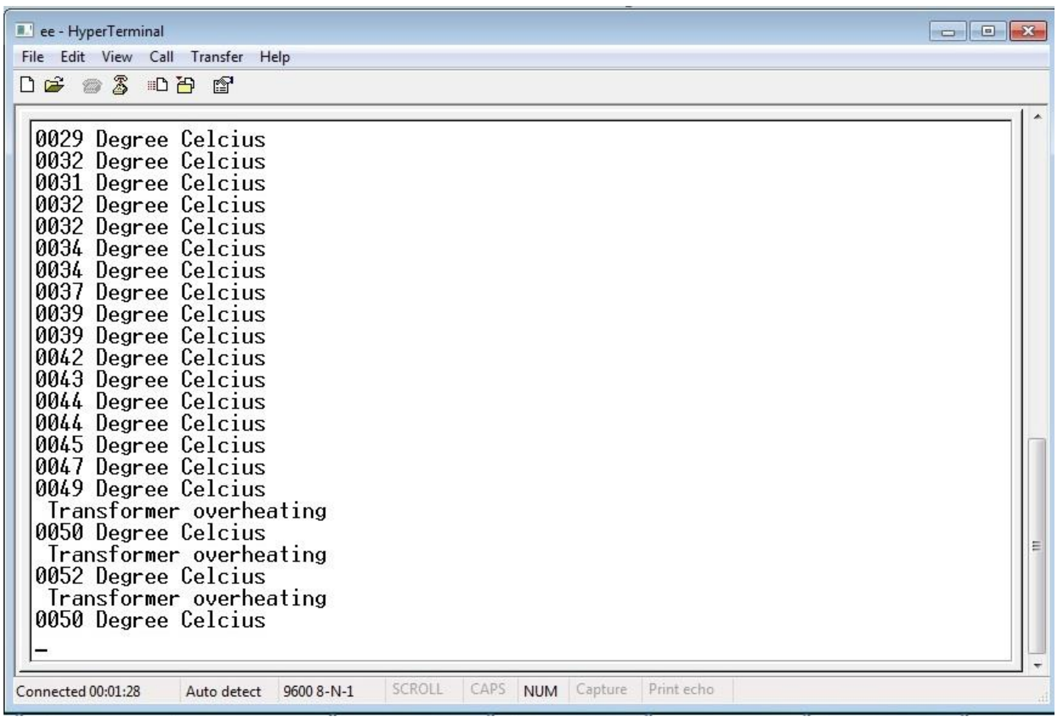

Fig 4.4: Under increased temperature condition

4.2 Test analysis of voltage detection

Case 1: When voltage below 3V

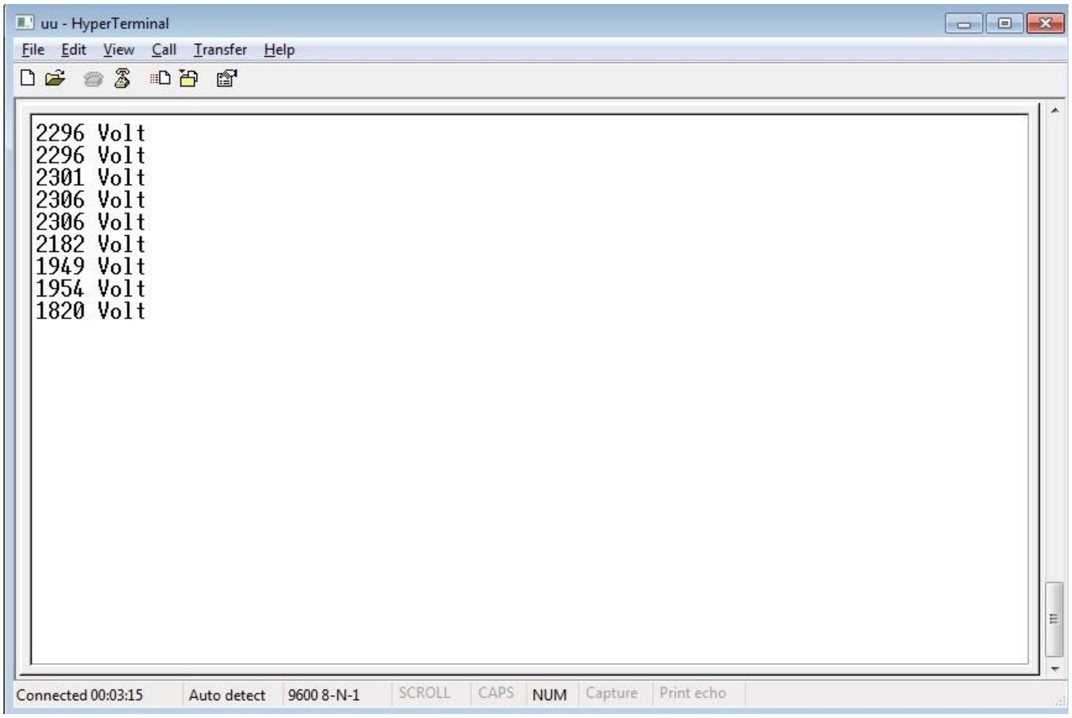

Fig4.5: Voltage under 3V

Case 2: When voltage is above 3V by varying the resistance using trim pot

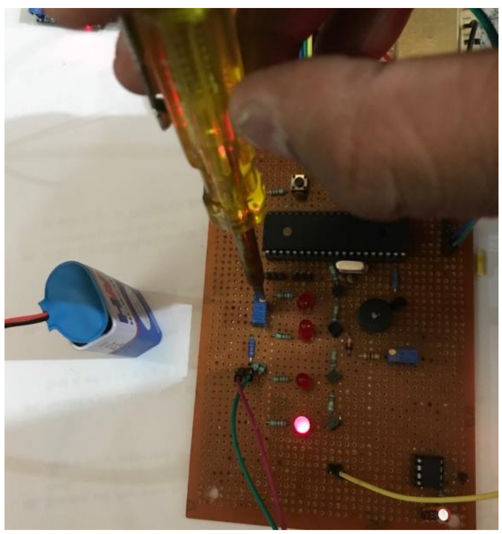

Fig 4.6: Varying resistance to increase voltage

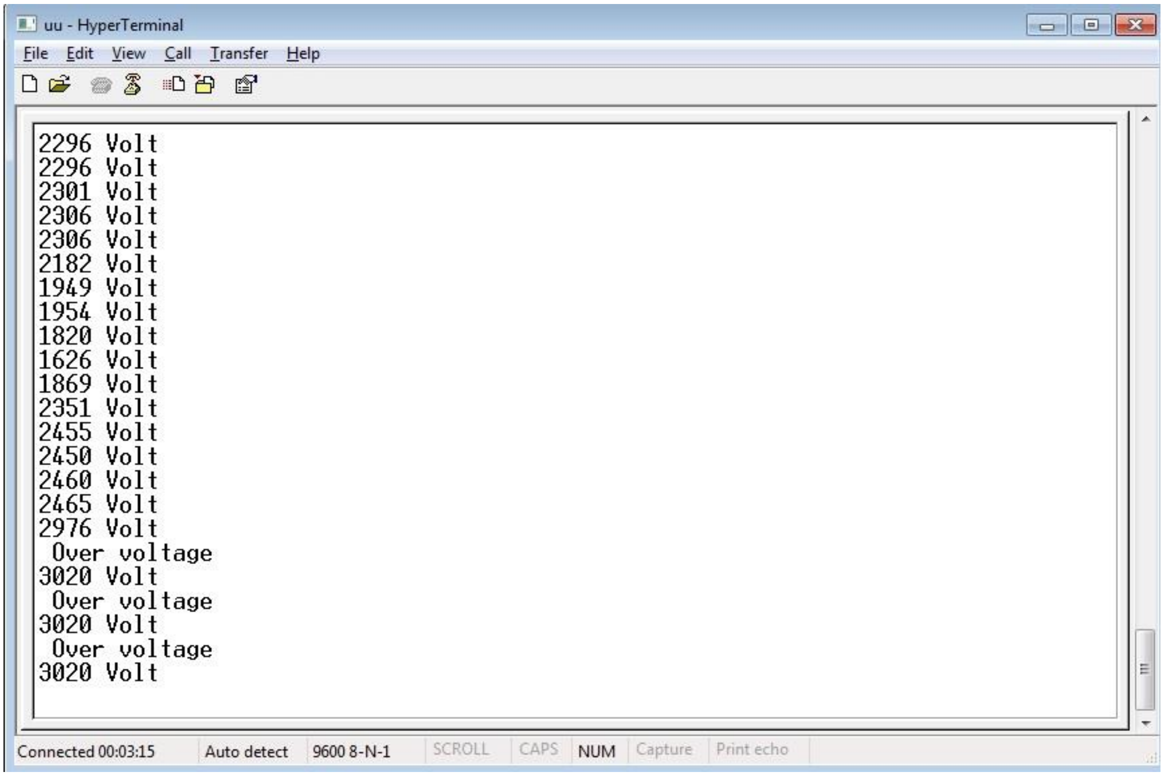

Fig 4.7: Over Voltage detected

4.3 Test analysis of vibration sensor (SW-420)

Case: When vibration is detected

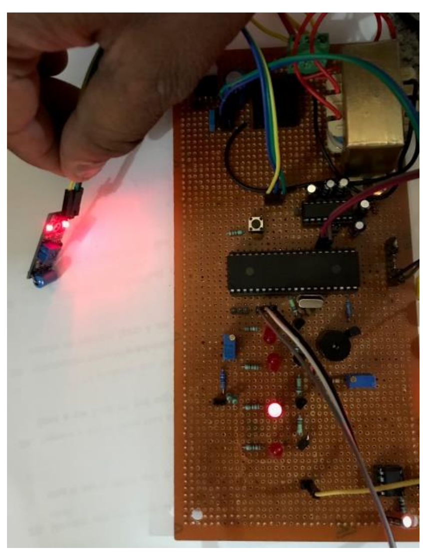

Fig4.8: Vibrating SW-420 sensor

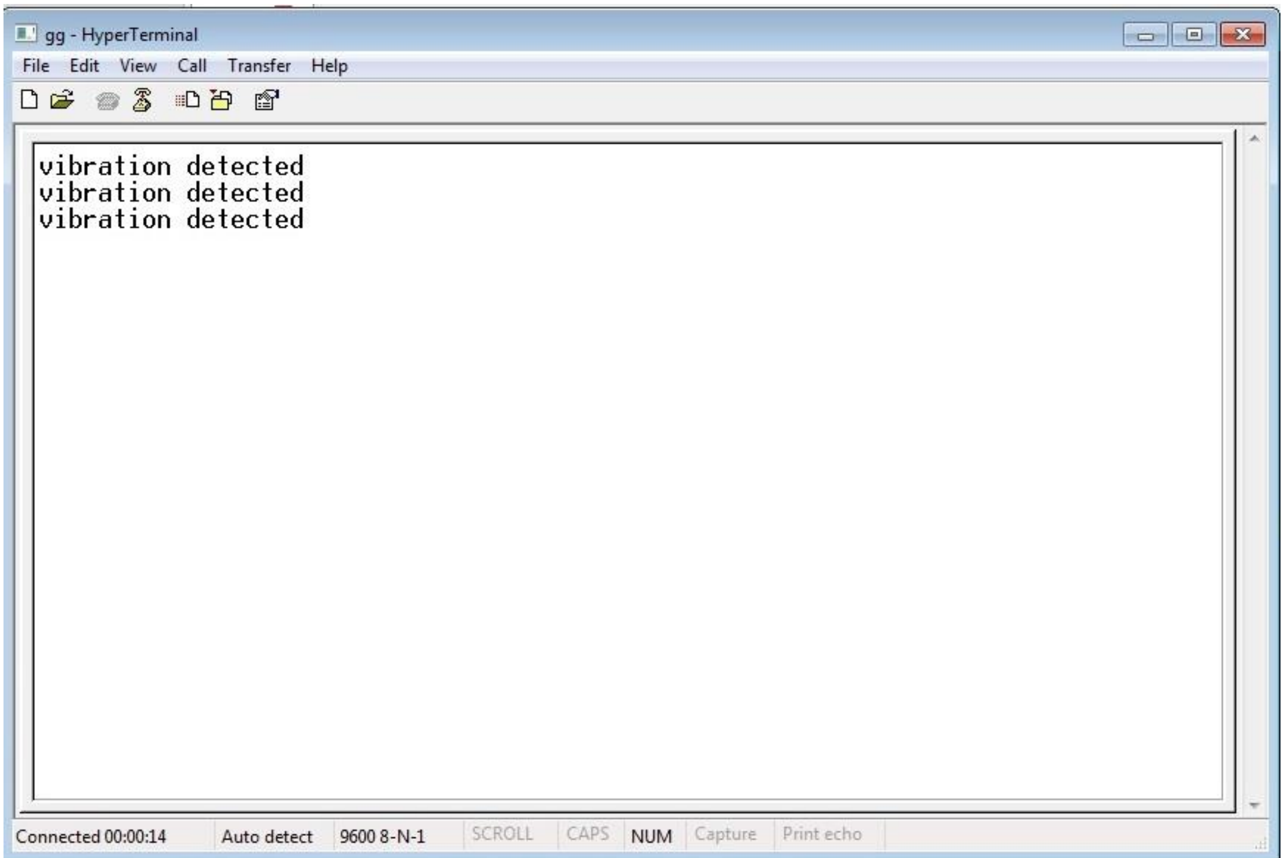

Fig 4.9: Vibration detected and indicated on HyperTerminal

4.4 Test analysis of current sensor (ACS712)

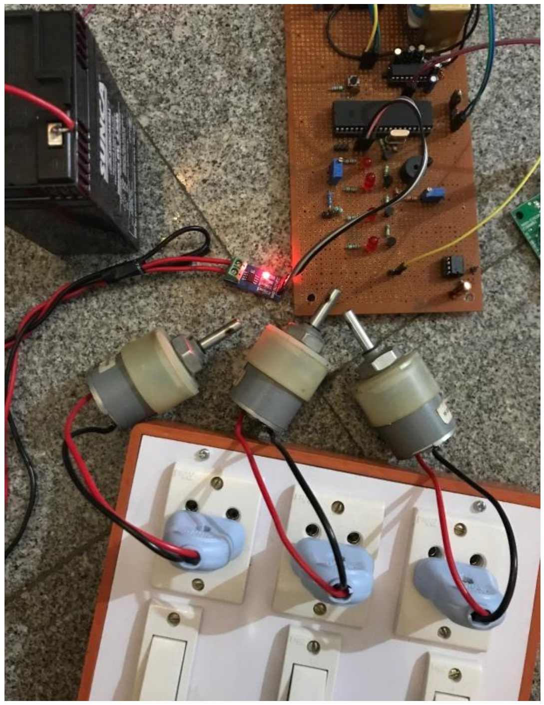

Fig 4.10: Measuring current drawn by DC motors using ACS712

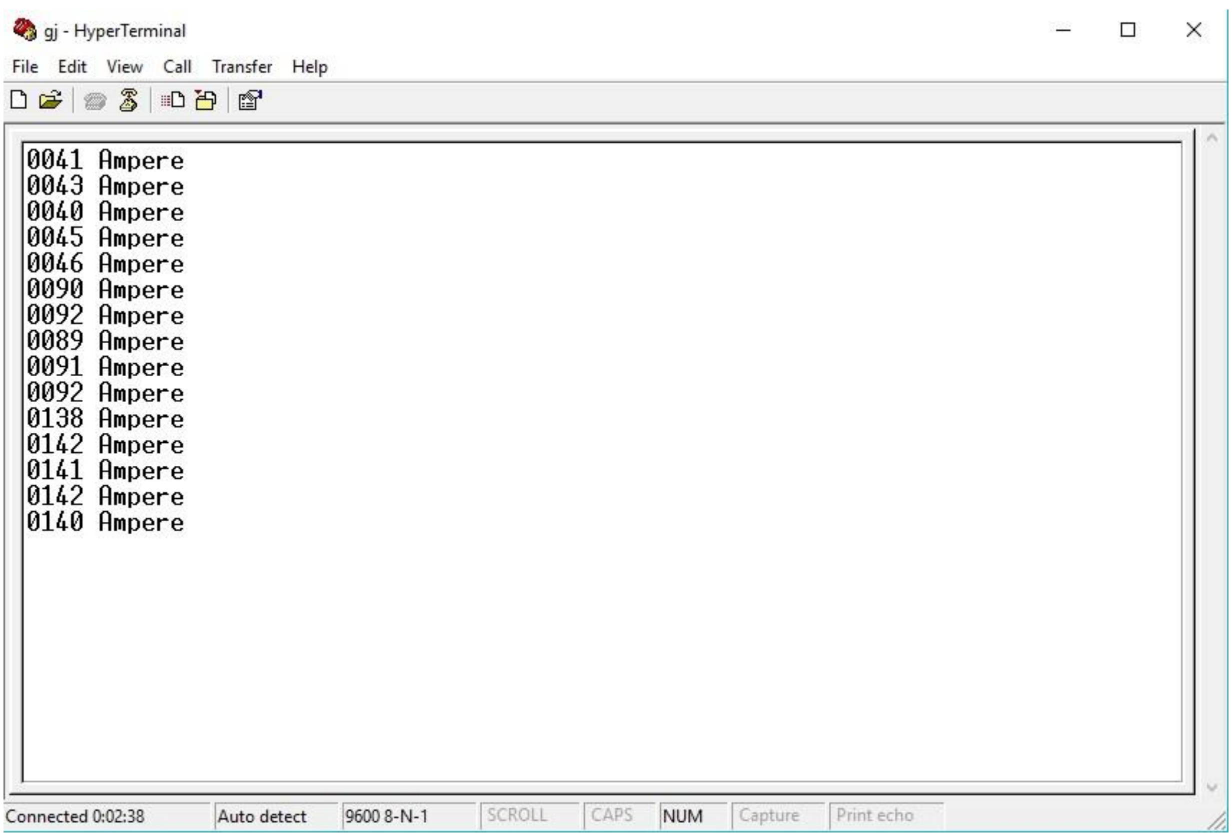

Fig 4.11: Current measured and observed on HyperTerminal

4.5 Test analysis after merging all the sensors along with GSM module

Case: All the parameters are forced to be abnormal and indicated via SMS

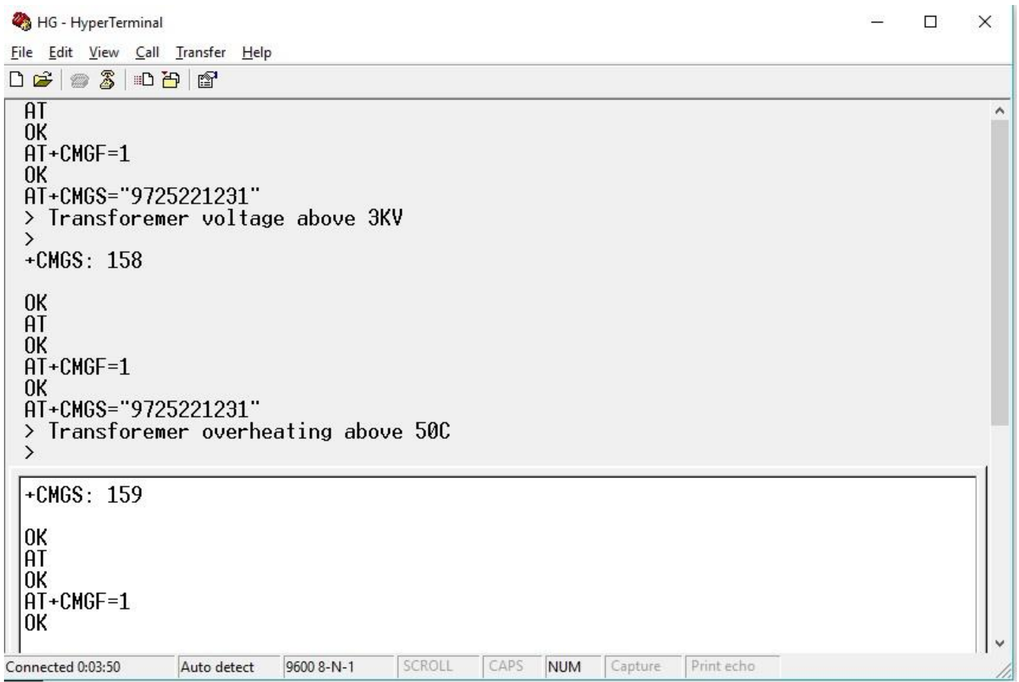

Fig 4.12: Voltage and Temperature above threshold value

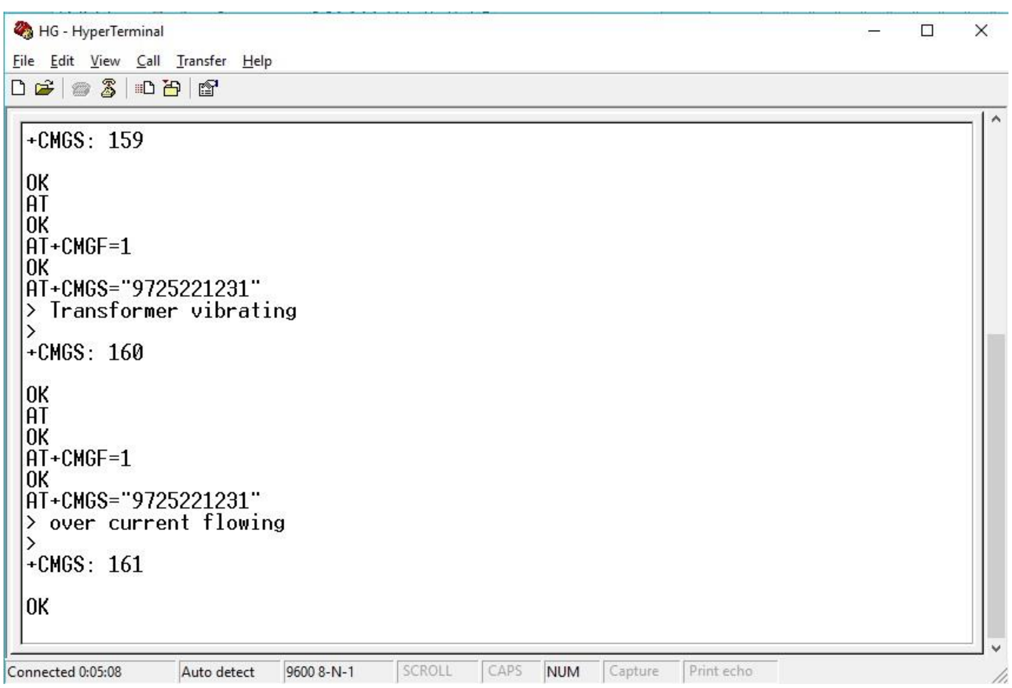

Fig 4.13: Current above threshold and Vibration detected

Fig4.14: Screenshot of SMS received when fault detected

APPENDIX A

ABBREVATION

AC	Alternating Current
DC	Direct Current
GPRS	General Packet Radio Service
GPS	Global Positioning System
GSM	Global System for Mobile Communication
IOT	Internet of Things
SMS	Short Message Service
UART	Universal Asynchronous receiver transmitter

APPENDIX B

CIRCUIT DIAGRAM

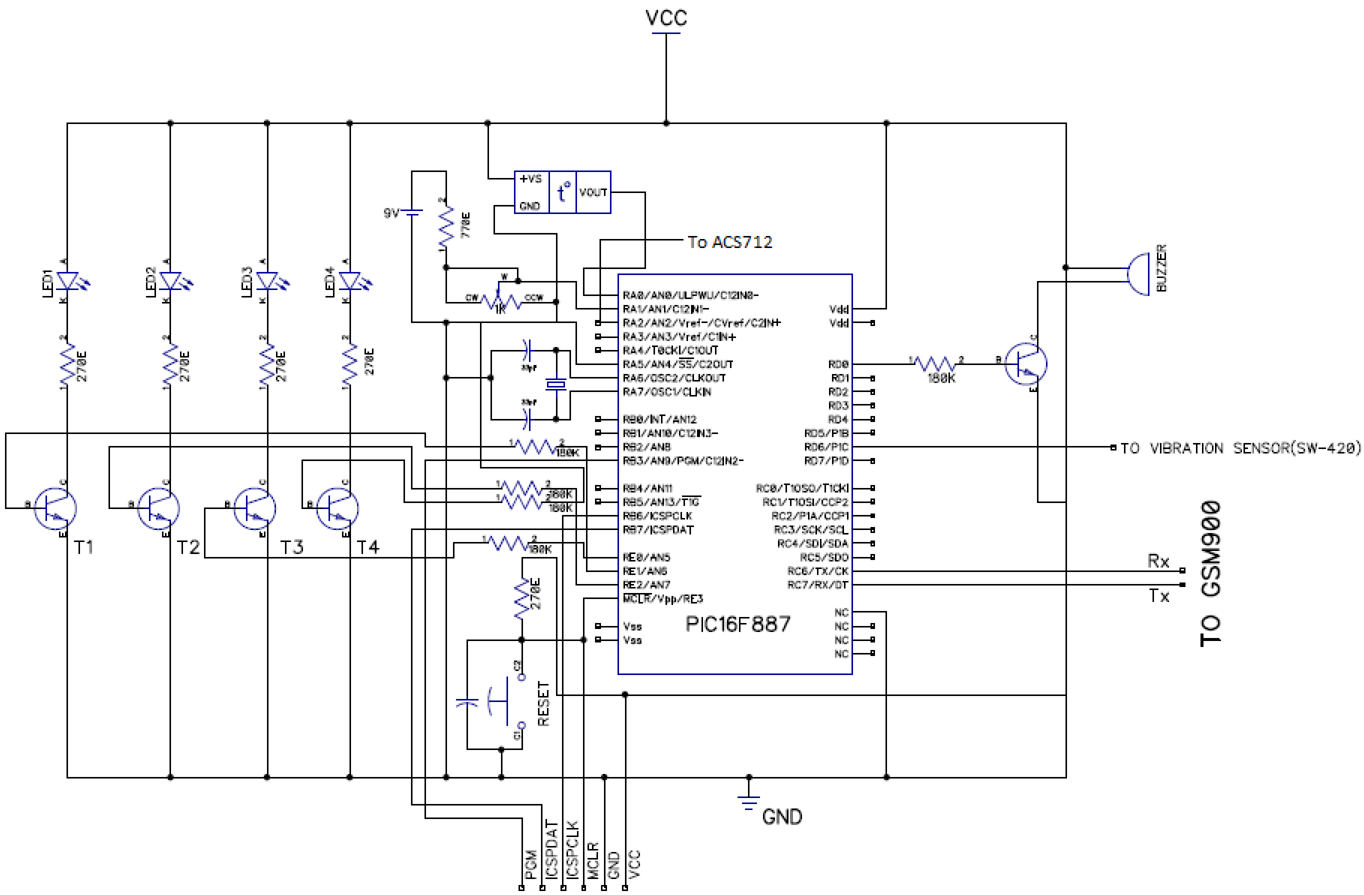

Fig 1: Circuit Diagram

APPENDIX C

Steps to compile an embedded C code in VSM Studio

1. Open VSM Studio

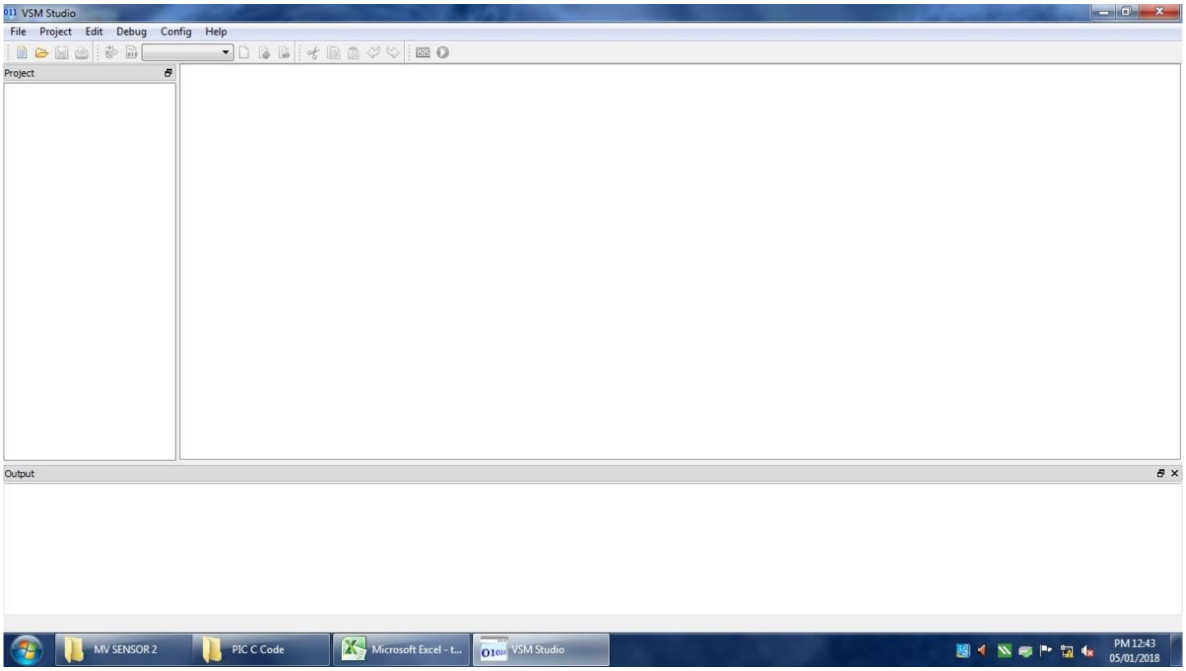

Fig 1: Open VSM Studio

2. Go to File and click on New Project

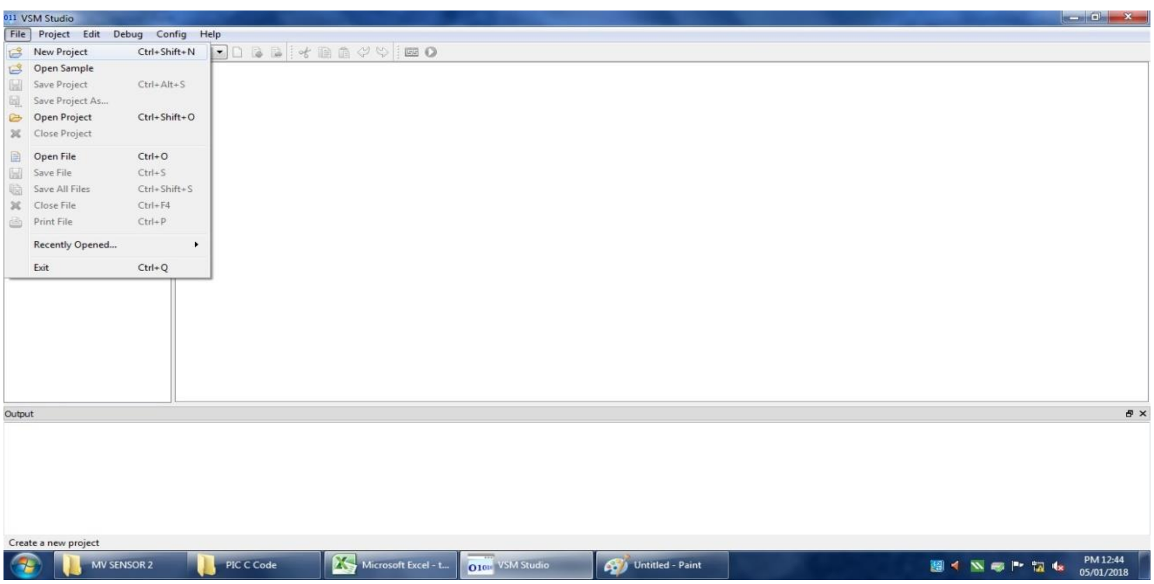

Fig 2: Creating New Project

3. Select None and then press Next

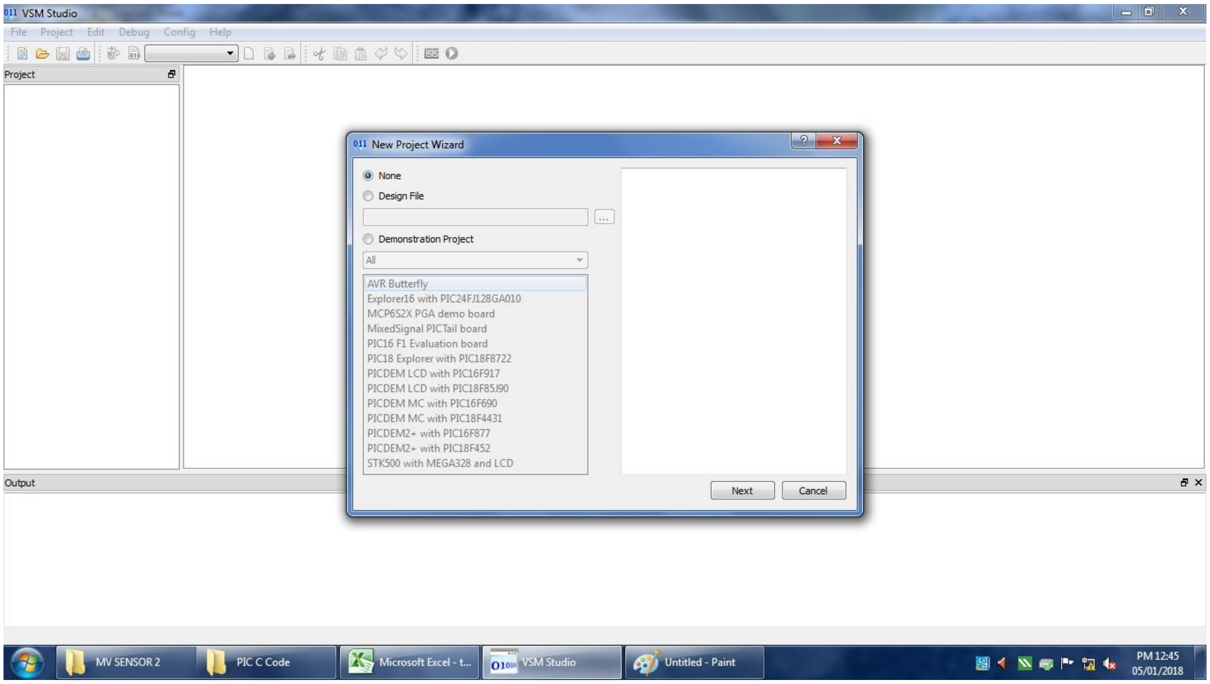

Fig 3: New Project Wizard Setup

4. Enter the of path and Project name

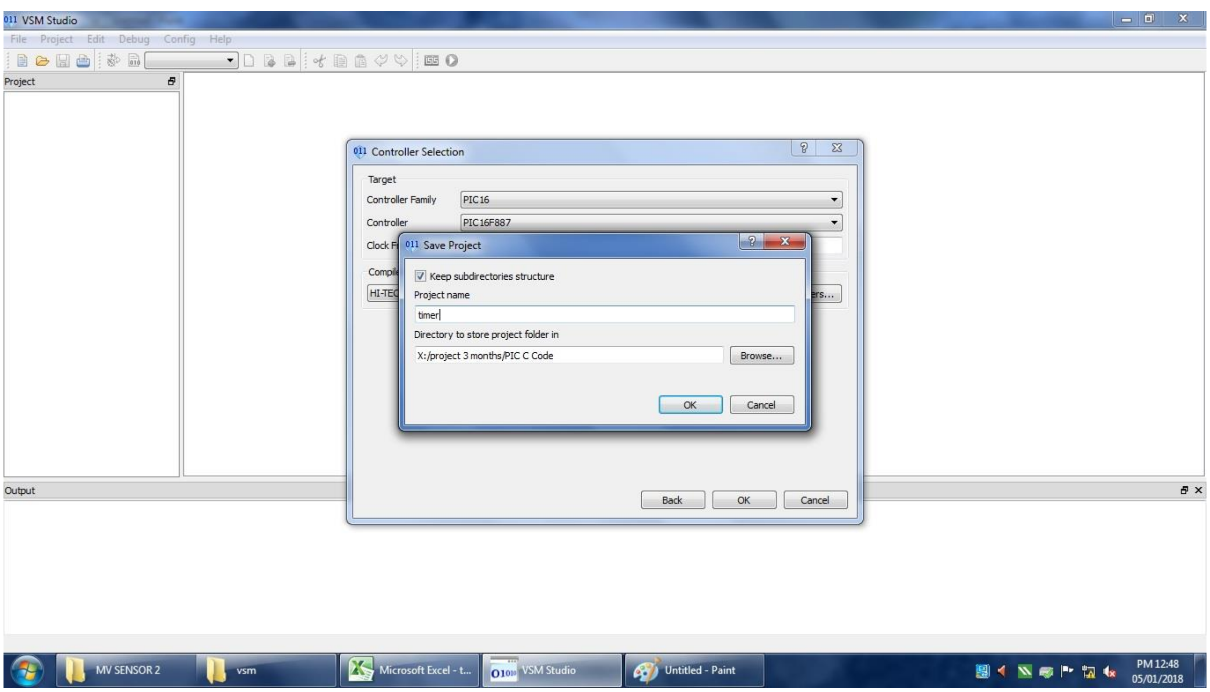

Fig 4: Project Name and Path

5. Click on File and then select Add New File

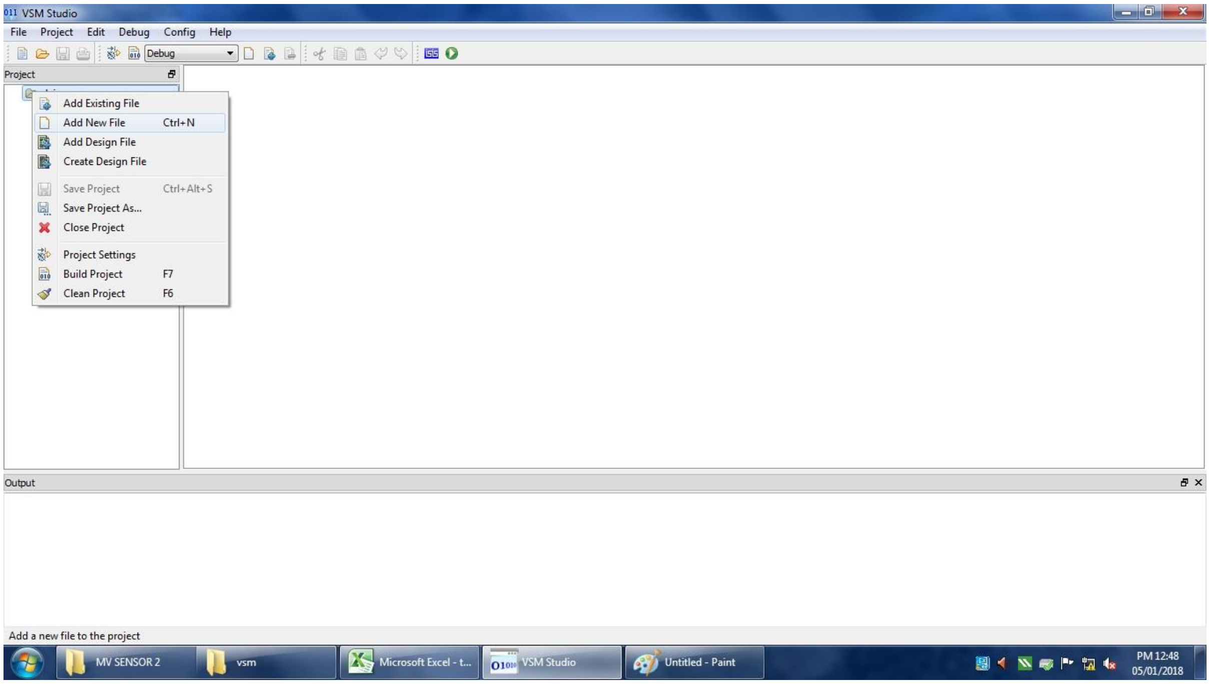

Fig 5: Adding New File to Project

6. Add filename.c and save the file

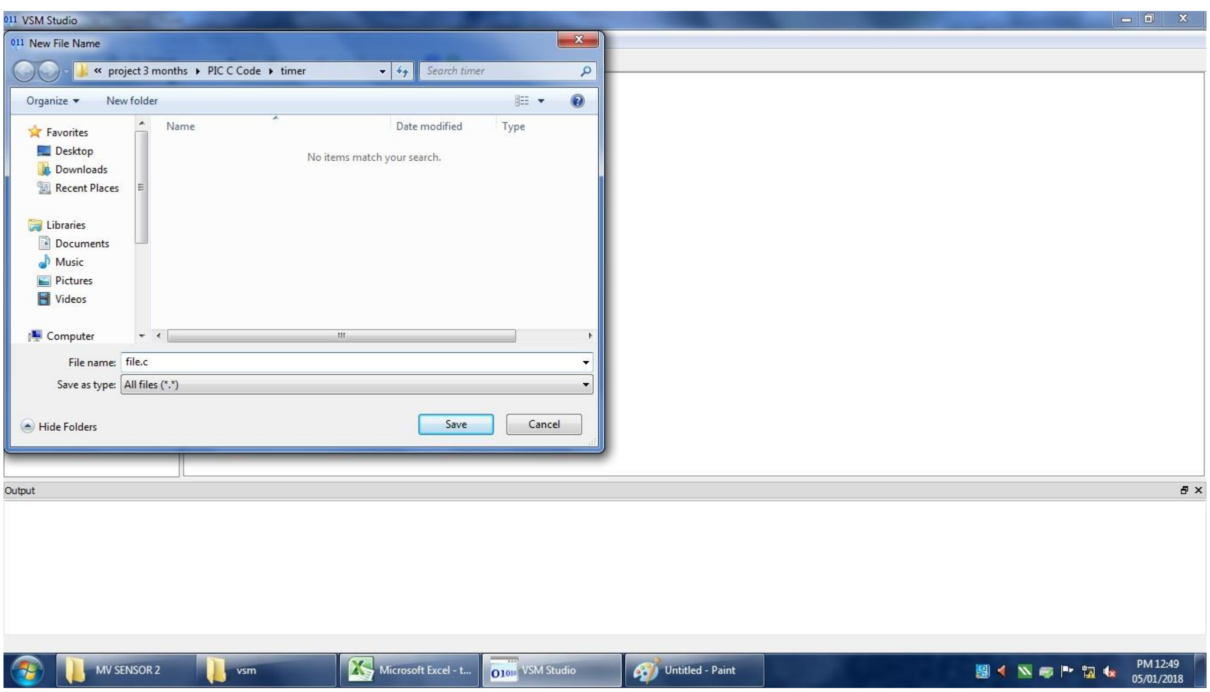

Fig 6 : Adding C File

7. Write C Code and Save the File

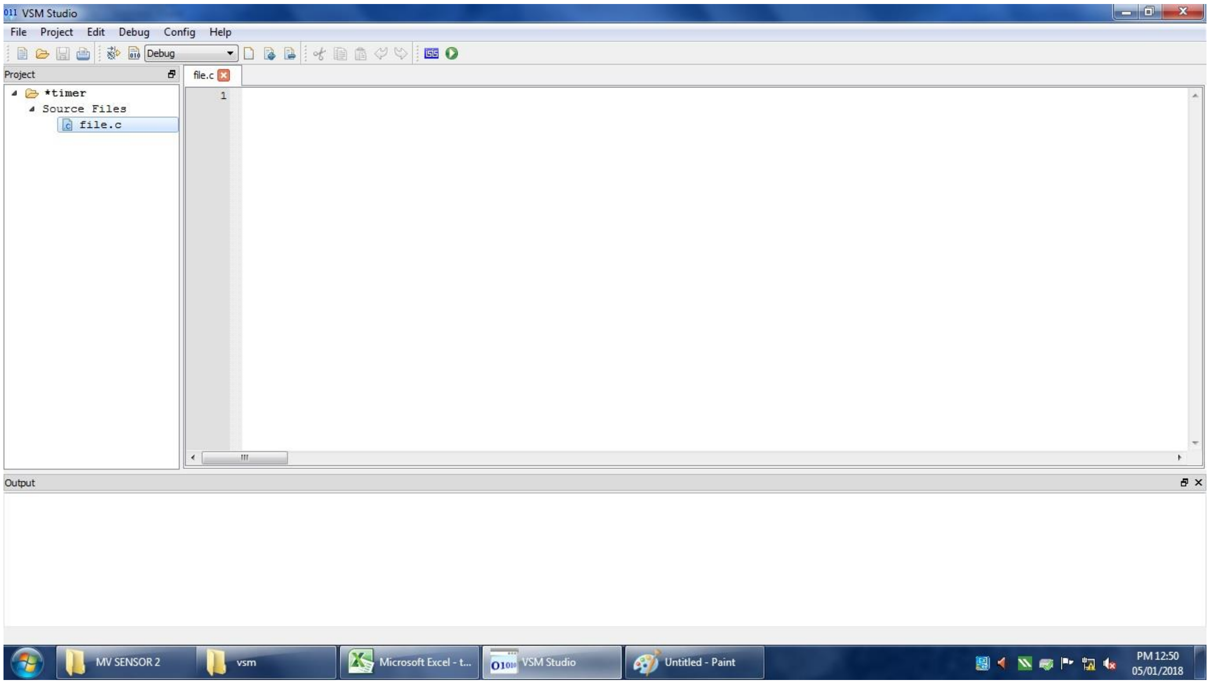

Fig 7: C Code window

8. Build Project

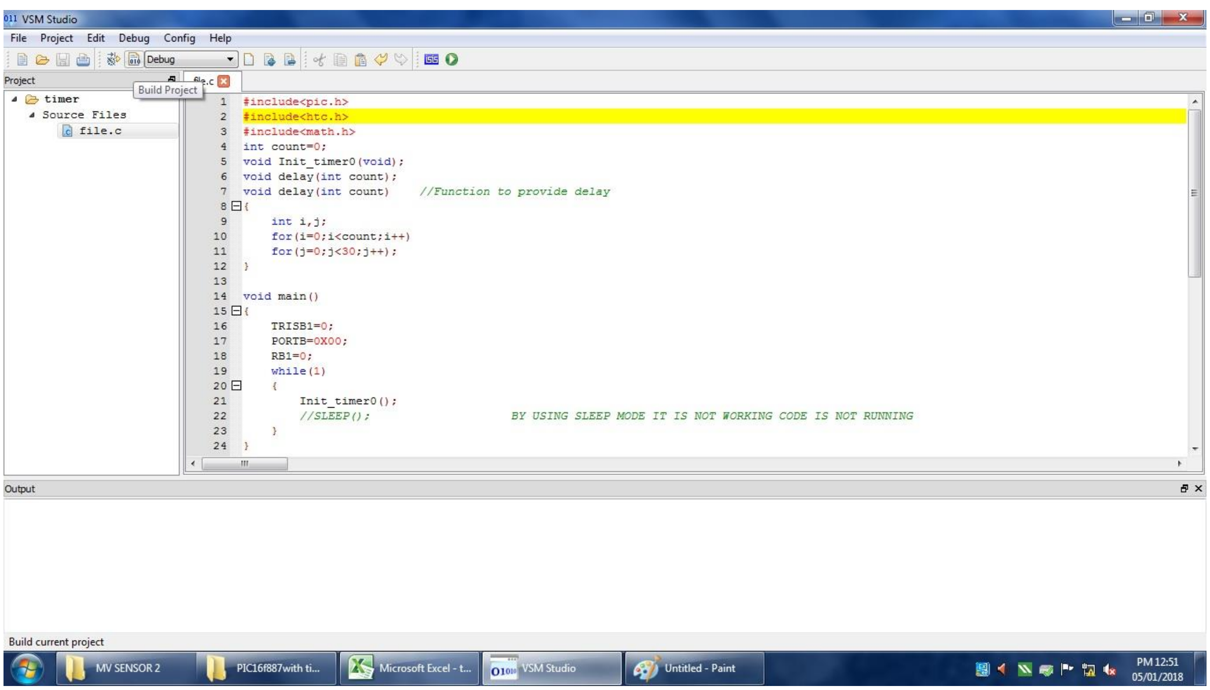

Fig 8: Build Project

APPENDIX D

Steps to setup HyperTerminal in PC

1. Open HyperTerminal application and give a name to connection

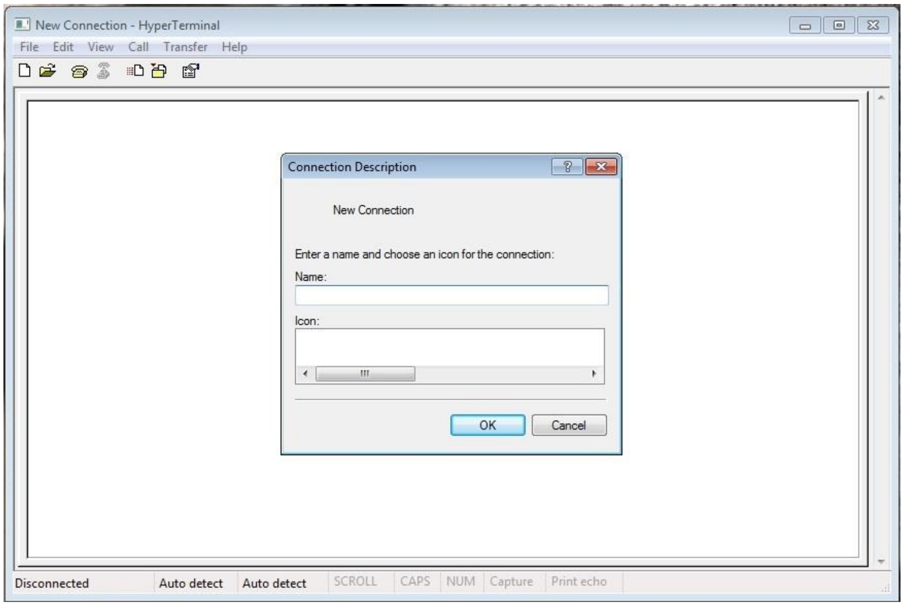

Fig 1: HyperTerminal window

2. Select the COM Port

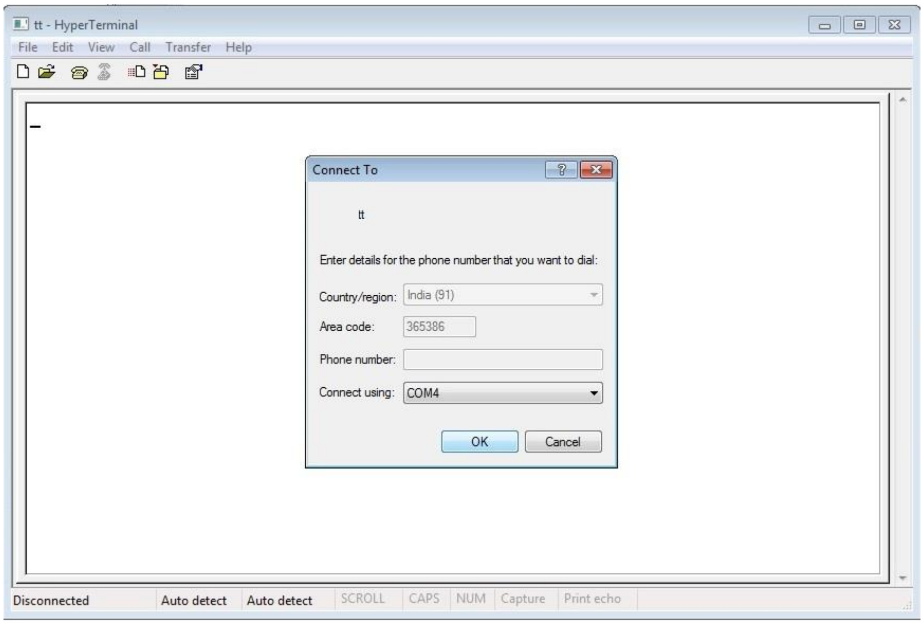

Fig 2: COM Port Selection

3. Specify baud rate, number of bits and stop bits.

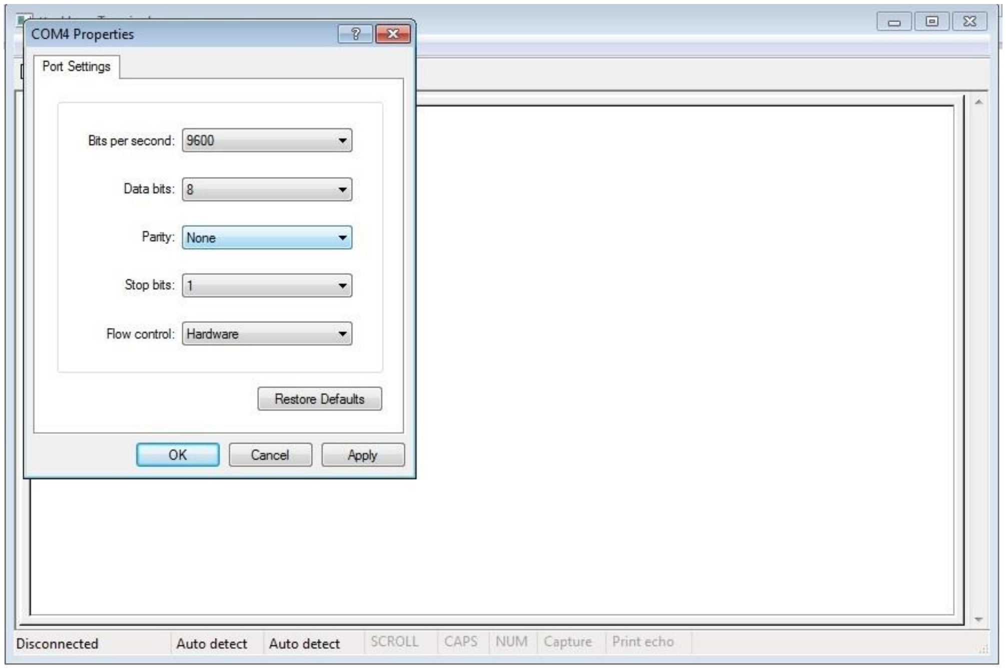

Fig 3: Configuration window

4. Connection is established and now monitor the received data.

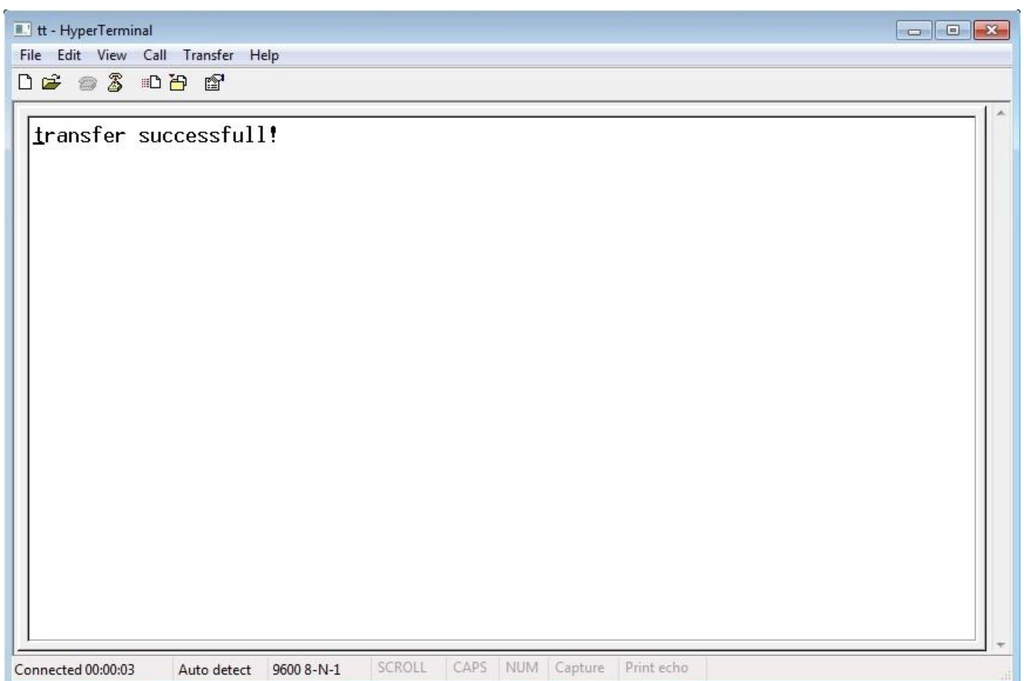

Fig 4: Rx data window

APPENDIX E

Steps to burn a hex file on PIC controller chip

1. Open PICPgm Development Programmer and select the .hex file to be programmed using the ‘Browse’ button.

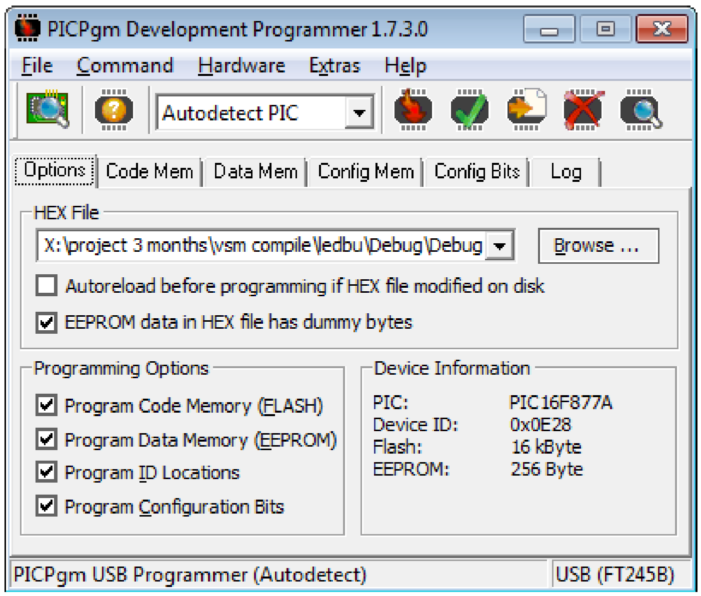

Fig 1: Select .hex file

2. Select ‘Config Bits’ and make the necessary changes as shown in snap.

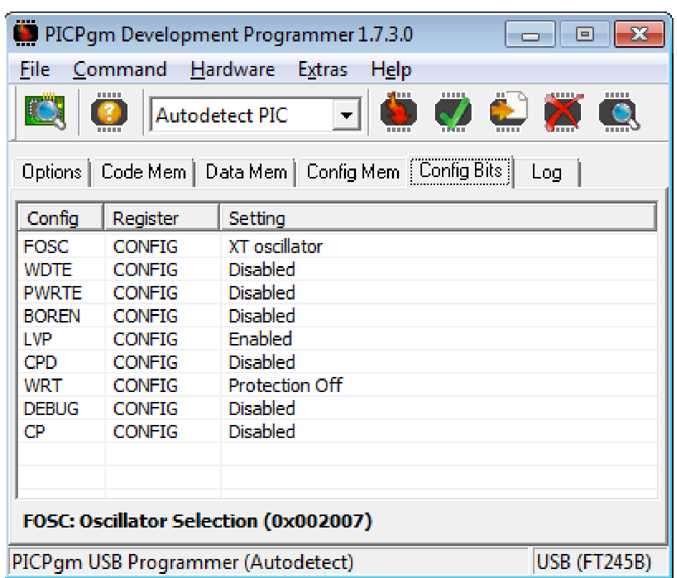

Fig 2: Config Bits Menu and changes in it

3. Select the ‘Program PIC’() to burn the program on the microcontroller

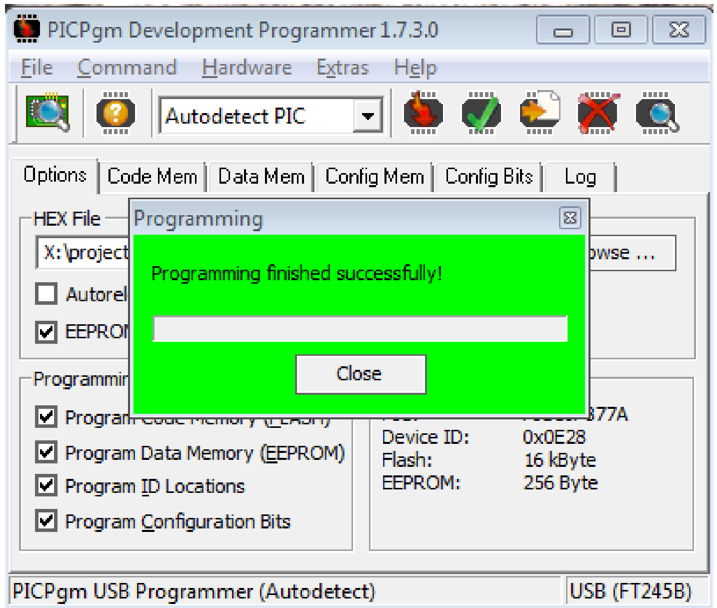

Fig 8: Programming PIC successful

APPENDIX F

Basic AT commands for GSM Module

Table: Basic AT commands

AT COMMAND	USE
ATA	Answer an incoming call
ATD	Originate a call
ATE	Set command EACHO mode
ATH	Disconnect existing connection
AT+CMGF=1	Set GSM module to text mode
AT+CMGS	Send SMS to a mobile
AT+CPIN?	Check if SIM is inserted