WIRELESS SENSOR NETWORK IN UNHEALTHY ENVIRONMENT

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(Electronics Engineering)

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CERTIFICATE

This is to certify that the work contained in this report titled "**WIRELESS SENSOR NETWORK IN UNHEALTHY ENVIRONMENT**" has been carried out by **AKASH SRIVASTAVA & JATIN KUMAR KHILRANI** under my/our supervision and has not been submitted elsewhere for a degree.

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Akash Srivastava
Jatin Kumar Khilrani

ABSTRACT

The objective of the present work is to obtain real time environmental data from sensor devices such as temperature sensor, LDR sensor and smoke/flammable gas detector sensor and transmitting it wirelessly over the ZigBee network to the control room setup independently at a remote location. This system can be used for the surveillance purpose in various locations at extreme environments and hasty situations in order to make a quick decision about the situation arise for a distant location without any human interference. This system can be useful in doing survey for extreme conditions, adverse climates and for long hours without fail.

Survey has a great importance in every aspect like security surveillance, detection and of great military importance. The prototype here is able to do wireless survey over a 50meter radius with a streamline flow of data to the control room. In order to insure its compatibility, range inspection and data flow accuracy or the prototype, detailed convergence study have been performed. Results came out are also compared with present technology and open literature.

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1.7 Objective

According to Moore's Law, for every two years the number of transistors doubles, making the system more efficient and more powerful. With the same rate the computing capacity of microprocessor are becoming smaller and cheaper. While silicon scaling increases on, the same type semiconductor chip is used for manufacturing the micro level mechanical structures for different sensors. In the MEMS technology, themanufacturing of temperature sensors, accelerometer, and radio frequency components are availablein small size that directly fit on the head of a pin. These three hardware components e.g. microprocessors, sensors, and low-power RF--make up a wireless sensor node.

Now a days it's been an efficient system as implementation of wireless sensor network plays a vital role that connect the physical world to the virtual world by sensor network. By making a large network of small senor nodes, we can obtain sensor's data in our system for monitoring and analyzing which is very easy than that we used to get through conventional process. In future as the technology goes more advance in micro fabrication, the size of chip becomes smaller and also drop the price of making the sensor, increasing use of wireless sensor networks are expected with the network connecting to large numbers of motes.

1.1 Applications

Battle field surveillance, Tracking of enemy activities, Analyzing the environment , Spying, Secured Systems, Surveillance, Fault detection in large bridges and tall structures, Detecting environmental conditions like temperature, movement of air, sounds, lights, radiation, vibration, smoke, gases etc., Habitat monitoring, Air pollution monitoring, Forecasting system , Disaster relief management, Soil moisture monitoring, Home/Office applications, Body area network, Vehicular Network, Human health care monitoring, etc.

1.2Features of WSN

1. Easily Place able: It can be deployed (or dropped from plane or spread over an area) . It can be placed without any hindrance at the required place.

2. Longer Range: Network of small sensors it can be distributed over a larger range (than can be done with a macro-sensor) .
3. Fault Tolerant: In case of non-working of any node the entire system will not get affected.

4. Mobility: It is easily mobile and can be relocated to any place.
5. Attribute Based Addressing: Clustering is done based on physical parameters in which WSN can be grouped together.
6. Location awareness: It is required to know the location of nodes for proper collection of data.
7. Immediate reaction to environment changes: It has high sensitivity and low delay.
8. Query Handling: Principle of acknowledgement is also followed whenever a user asks any questions form the nodes.

1.3Design Issues

1. *Fault tolerance:* In case of non-working of any node due to physical damage or inappropriate power supply the mac and routing protocols search for alternatives links for data collection.

2. *Connectivity:* All the sensor networks are wirelessly connected so that they are not completely isolated.
3. *Transmission media:* The transmission media causes problems in the working of sensor networks so they should be designed properly such as the bandwidth requirements should be met.

1.4Classifications of WSNs:

1. Proactive Networks: The sensors and transmitters of these networks switch on automatically and sends the data to the desired locations.

2. Reactive Networks: This network works in real time and sends the data with almost no time delay.
3. Hybrid Networks: Proactive and reactive networks combine together to form the hybrid networks such that the data is collected automatically and with no delay.

1.5 Background:-

With the advancement of science and technology, a wireless sensor network (WSN) are the networks which are used to measure the environmental conditions such as temperature, light, smoke, gas etc. and to cooperatively pass their data through the network to a main location. It actually an integration of sensor nodes in a single network. The network can be branched either by star topology, mesh topology or any other network topologies. It is provided with a band with asset of protocols such as ZigBee that can communicate error free with low power capability. The main server is a server that has all individual data of nodes and it analyses the data graphically. After analysis the information is predicted.

WSN consists of different nodes and nodes can vary from a few to several hundreds or even thousands, where every node is connected to one (or sometimes several) sensors. The different parts of a sensor network are: A radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, and battery is a type of source for the electronics circuits. The variations in sensor nodes is of size and cost. These constraints resulting an influences in resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can be varied from a star to multi hop wireless mesh network. Routing is defined as the technique used for propagation of signals among various nodes.

The direct applications of wireless sensor network technology is in remote monitoring in low frequency data bursts. For example, a plant of chemical generation could be easily monitored for leaks by hundreds of sensors that automatically forma wireless interconnection network and immediately report the detection of any chemical leaks. As referred to Wireless Sensor Networks they can be easily used to control actuators and any embedded devices.

Along with the reduced installation cost there are many advantages to use wireless sensor networks. The wireless sensor networks can adapt to changing environments. As we change the network topology the adaption environments can be changed. Let us take an example of an embedded system performing monitoring of leakage in a chemical factory can be reconfigured into a network designed to localizing the source of the leak and can track the diffusion of the leaked poisonous gases. The networks can direct workers to the safest path for an emergency failure.

Wireless sensor nodes do not need to communicate directly with the nearest high-power control tower or base station, but only with their local peers. We suggest not to rely on individual infrastructure each sensor or actuators are a part of overall infrastructure. Peer-to-peer networking protocols provide a mesh-like interconnect to shuttle data between the thousands of tiny embedded devices in a multi-hop fashion. The flexible mesh architectures envisioned dynamically adapt to support introduction of new nodes or expand to cover a larger geographic region. A system must have the ability to automatically compensate for wireless node failures.

1.6Wireless network

ZigBee technology is developed for means of two-way wireless communications which is based on protocol that meets the required specifications of very low power consumption and low cost. Protocol features includes:-

- Topology (Master / Slave)
- Automatic network configuration
- Addressing
- Maximum 254 network nodes
- TDMA slots can be allocated
- Complete transfer of packets
- Data rate of 20 kbps at 868 MHz, 40 Kbps at 915Mhz and 250kbps at 2.4 MHz
- Definite features for Power management

The ZigBee protocol basically based on three types of frequency bands that are(2.4 GHz ISM worldwide, 915MHz USA ISM band and 868 MHz – Europe. As ZigBee network is more efficient than another network such as Bluetooth network in terms of that ZigBee's range is more than Bluetooth range and in ZigBee network, more no. of nodes are connected than Bluetooth network. Overall ZigBee network is well and good in all sense.

1.7Objective of the Thesis

The primary objective of the work is to design and develop a wireless sensor network which can be used for the surveillance purpose of environmental changes and transmits all the sensor's data to the base station via ZigBee protocol (802.15.4) within the radius of 1km of the network.

In the control room, the data received by ZigBee will be sent to the PC with the help of FTDI module and observed in the XCTU software in PC as well as in mobile. After that this reading will be continuously observed and if according to environmental changes, any problem may occur then it will accordingly take decision and control all nodes accordingly. The application of this system will be made in various locations as discussed earlier.

In the upcoming chapter we will discuss the methodology for the development of the hardware for the system followed by the analysis and software development phase of the overall system with the ZigBee Network Protocol.

Chapter no. 2:- Literature Review

2.1 History

The evolution of semiconductor technology, networking and material science combines the development of new type of sensor networks which are wireless. The first wireless sensor network was used by the United States military in 1950. It was a sound surveillance system (SOSUS) to detect and track the soviet submarines. The sensor deployed is submarine acoustic sensors-hydrophones. They are distributed in Atlantic and pacific oceans for monitoring undersea wildlife and volcanic activity. The DRPA-United States Advance Research Projects Agency started the distributed sensor network program in the year 1980. Industrial use of WSN started after 2002 with the development of ZigBee alliance.

Wireless Sensor Networks consists of sensor nodes. A Sensor node detects the physical environment changes such as temperature, vibration, movement of an object etc. into layman form that is understood by users. A wireless Sensor board consist of RF module, microcontroller, power supply unit and the actual sensor. These components makes it a single device i.e. sensor node.

2.2 Research Projects and Papers on Wireless sensor network

2.2.1-[R5] In the paper, they discuss their work is to make an efficient multipath geographic routing algorithm for wireless sensor network. They proposed a method to determine near-optimal multiple disjoint paths from base node to the sink to gain efficiency of the network.

2.2.2-[R7] In their paper, they proposed a wireless sensor network system prototype is used for water quality monitoring at Lake Victoria Basin. Through the real time network, they detect water temperature, dissolved oxygen, pH and electrical conductivity and transmit to the web-based portal and mobile phone platforms.

2.2.3[R6]In their paper, they establish a WSN based on ZigBee protocol with a piezo resistive pressure sensor to determine water levels in closed tanks and aquaculture systems. In this an AVR microcontroller is used for interfacing RF devices and sensors in idle and power down mode to make it efficient.

2.2.4-[R8] In their paper, they use the features and technology of WSNs to establish temperature monitoring system in a real time to prevent fire and other accidents. All the real time data is transmitted to the central computer system and displayed at hyper terminal.

2.2.4-[R9] In their paper, they develop a WSNs with Geo-physical sensors for detection, monitoring and controlling the Landslides problems in hilly areas. The sensor's data is taken out and according to that accurate measures will be taken.

2.2.5-[R10]In their paper, designing a prototype of system for wireless video streaming in ISM band making the system power efficient and of less cost. By using the ZigBee wireless sensor network, it is very easy to transmit data i.e. JPEG pictures from serial digital camera and can be used for monitoring at defense area for perimeter control.

2.2.6-[R11] In their paper, they survey a review of the available solutions to support wireless sensor network environmental monitoring applications. Environmental monitoring is done by small mo. Of nodes with high precision sensors. Data are collected and analysis is done on it.

Inthe next chapter there is a description of hardware implementation using selected devices. Hardware implementation concerns with the integration of the devices on the PCB, which gave a physical realization for the Wireless transmitter Module of the Wireless sensor network.

Chapter 3

HARDWARE DEVELOPMENT

1. Node Section
2. Base Station Section

This chapter presents the hardware development of the Wireless sensor network system phase by phase. This will give the detailed idea on how this system working in any undefined environmental conditions .The Hardware implementation means making the schematic according to the applications and specification, testing the design on the breadboard by connecting various sensors to obtain the required design that meets the objective of the project, making the PCB layout of the schematic and then PCB board is fabricated and testing the desired hardware.

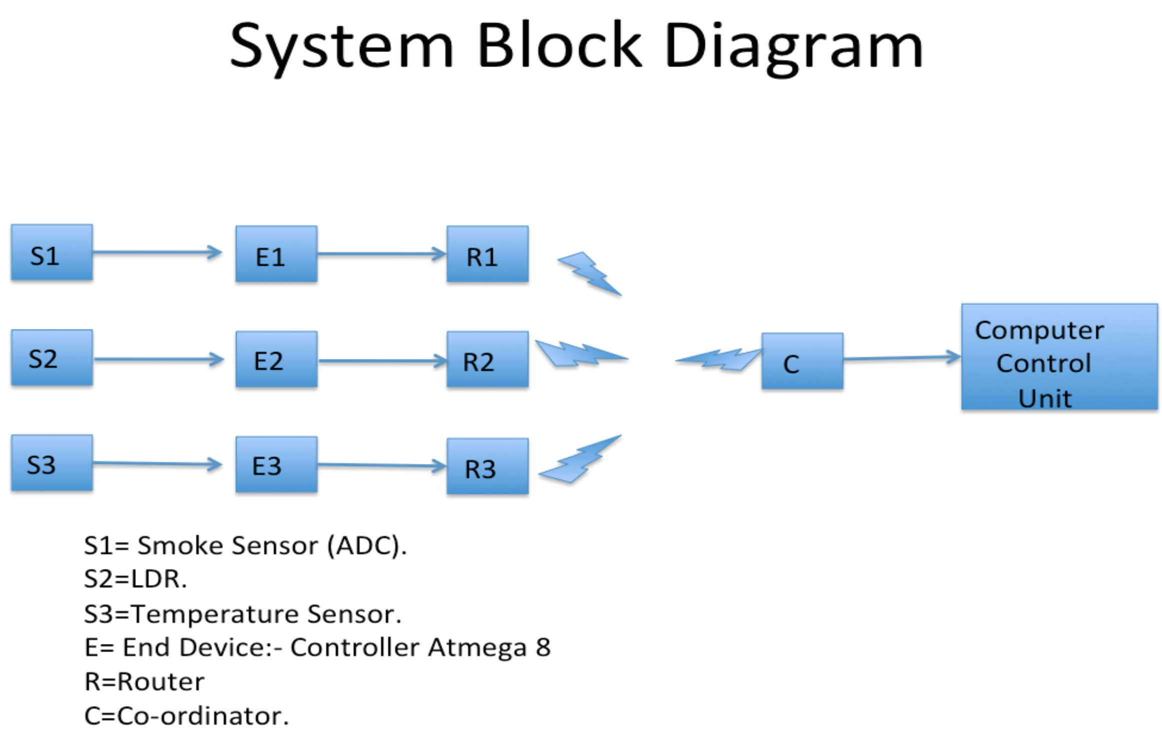


Fig.3:-System block diagram

3.1 Node Section

3.1.1 Block Diagram of Node Section

This section transmits the data from the sensor node device to the coordinator and to the computer system. The block diagram of the End Device Section is shown following

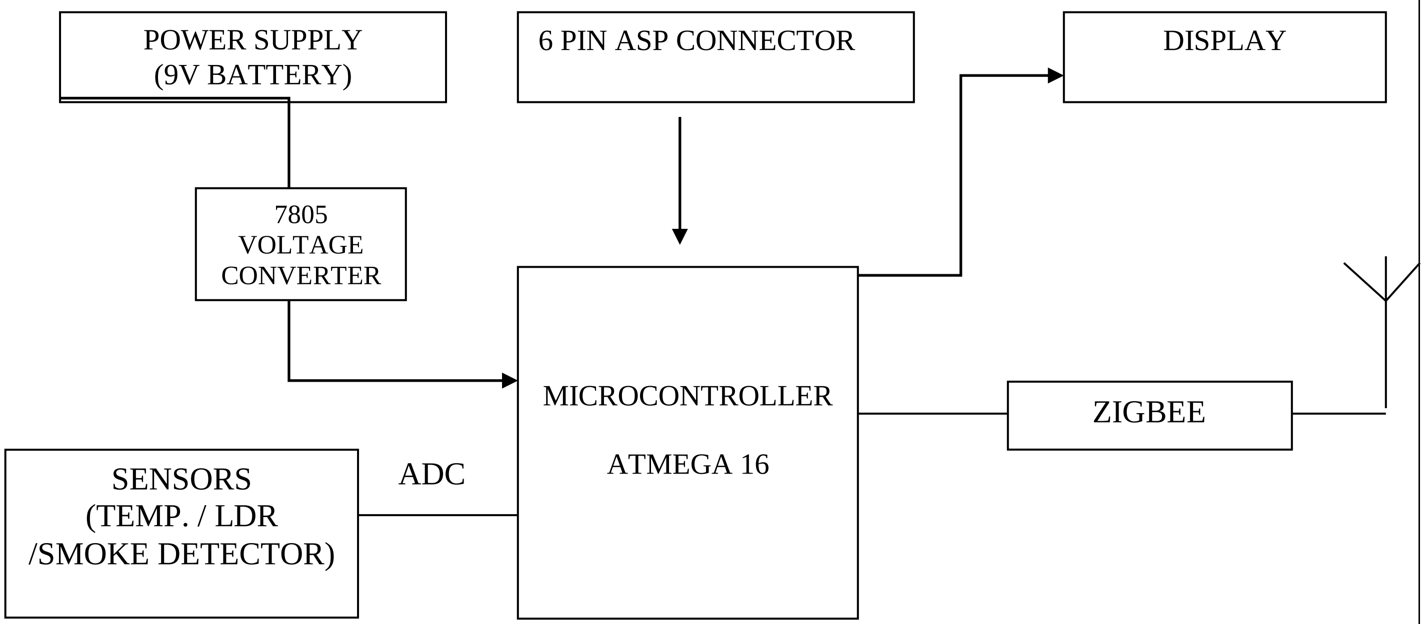


Fig3.1.1: - Block Diagram of data transmitter section of the End device section

The basic components of the transmitter section shown are:-

i. Microcontroller Atmel ATmega 16
ii. ZigBee module
iii. 16*2 LCD
iv. 9V Battery
v. 7805 Voltage converter
vi. ASP programmer
vii. Sensors (Temperature sensor, LDR, Smoke detector)

3.1.2 ZigBee (Transceiver unit)

The WSN establish the communication between each node and also to the main station wirelessly. For wireless network WSN needs a sensor's data transmitter at sensor node and a receiver system at coordinator end. In market, there are different types of transceivers module available and based on the main features like type of modulation, range, operating voltage, throughput, Transmitted power, current in receiving/transmitting mode etc. Mainly the following standards for wireless connectivity are used such as Bluetooth, Wi-Fi and ZigBee can be considered for wireless applicayion.

WIRELESS CONECTIVITY TECHNIQUES			
	Bluetooth	**ZigBee**	**Wi-Fi 802.11**
Data Rate	1 Mbit/s	20, 40, and 250 Kbits/s	11 and 54 Mbits/s
Range	10 m	10 to 100 m	Up to 100m
Networking topology	Ad-hoc, small networks	Ad-hoc, peer to peer, star, or mesh	Point to hub
Frequency	2.4 GHz	868 MHz(Europe), 900 to 928 MHz (North America), 2.4 GHz (worldwide)	2.4 and 5 GHz
Power consumption	Low	Very low	High

Table no. 3.1.2: - Comparison between Bluetooth, ZigBee and Wi-Fi.

3.1.2.1 Comparison of ZigBee with Wi-Fi Devices

Wi-Fi comes under the IEEE 802.11.x standard. The "x" gets replaced by a, b, g, n etc. on the basis of various version of its protocol of Wi-Fi. ZigBee comes under 802.15.4 IEEE standard. The idea for Wi-Fi came out as another choice to ease work of cashier machines in the year 1985. A community to standardize was built in the year 1990 which launched the standard in the year 1997.On the other hand, idea was ZigBee was conceived in the year 1999, when it was found that for some long running applications, Wi-Fi and Bluetooth were not prepared. It was launched in the year 2004. Wi-Fi is mainly work at 2.4GHz, 5GHz, after the recent developments the Wi-Fi is working at 60GHz frequency. ZigBee works at 900-928 MHz and also at 2.4GHz. Besides in some European countries ZigBee protocol has a specific frequency of 868MHz. Wi-Fi networks is much faster than ZigBee networks in terms of data transfer. Wi-Fi networks defined under 802.11b standard have maximum data transfer rate of 11Mbps while a and c versions of Wi-Fi have 54Mbps of maximum data transfer rate. Maximum data rate in ZigBee networks is only 250kbps, which is lower than the lowest Wi-Fi offers. Wi-Fi, though now having a low power version over the horizon, has not been yet known as a power efficient network. In general, ZigBee based networks consume 1/4th of the power consumed by Wi-Fi networks. In a standard point to point network, two stations can communicate with each other. A Wi-Fi router is also needed in some places where one needs to connect multiple devices to each other and/or wants to connect to the internet. In ZigBee, the network elements can be broadly classified into three types: ZigBee coordinator, ZigBee end router, ZigBee end device. A single Wi-Fi based network can establish a network size of maximum 2007 nodes whereas ZigBee based networks can establish a network of 65,000 nodes. Wi-Fi is mainly preferred for internet connection based network. Wi-Fi can be used for data exchange between a computer and modem, streaming music and videos on a television through a Wi-Fi enabled computer or media device. ZigBee protocol is mostly used in the wireless sensor based networks such as those in industrial automation system, home automation systems or industrial machinery coordination systems.

3.1.2.2 Comparison of ZigBee with Bluetooth

Bluetooth protocols not used for long period applications owing to power consumption limitations. Hence, for tiny gadgets that run on battery or restricted power supply, a replacement wireless knowledge transfer protocol was required that might manage operating with low power consumption. To satisfy these necessities, a protocol named ZigBee was proclaimed simply at the time once Bluetooth was obtaining standard i.e. in 1999. However, ZigBee caught attention for industrial applications around 2005. Bluetooth, although not underneath IEEE currently, was outlined underneath 802.15.1 normal whereas ZigBee is outlined underneath IEEE 802.15.4 standard. Bluetooth based mostly} channel consume bandwidths up to 1MHz whereas ZigBee based networks consume bandwidths of zero.3MHz, 0.6 MHz and a couple of MHz relying upon the frequency at that networks square measure human activity. ZigBee has been designed to speak underneath Personal space Network whereas Bluetooth primarily based communication serves for Wide PAN (WPAN). In Bluetooth, up to eight cell nodes will be connected to every alternative whereas in ZigBee over sixty five thousand cell nodes will be connected along. Bluetooth primarily based networks will exist up to 10m, whereas Wi-Fi based mostly} networks will exist from 10-100meters Bluetooth based networks have most knowledge transfer rates of up to 1Mbps whereas in ZigBee, knowledge transfer rates square measure up to 250Kbps. Bluetooth may be a protocol famous for exchanging most varieties of knowledge like text, multimedia. Usually, ZigBee devices square measure two.5-3 times additional economical than those acting at Bluetooth. Bluetooth primarily based applications square measure primarily in laptop peripherals like wireless keyboards, mouse, headsets etc. Also, some wireless remotes or gesture controlled gadgets use Bluetooth to exchange knowledge.

3.1.3 AVR Microcontroller (Data Processing Unit)

A Microcontroller could be a miniature laptop. It’s associate Integrated Chip (IC) that incorporates a central process Unit (CPU), Random Access Memory (RAM), scan solely Memory (ROM) and alternative parts that are gift during a laptop. It’s been utilized in WSN as s process unit. The top device is predicted to speak with organizer device by causing the processed sensing element knowledge done by microcontroller.

3.1.3.1 How to choose a Microcontroller

For a controlling the system, the main role plays is a microcontroller and it is somewhat difficult for choosing a microcontroller having same type of specifications. In Digi-Key, it's searched about 16000 different microcontroller. Which one we should choose. It's upon the individual that which microcontroller would choose based on his learning experience. For implementing WSN system, commercially available microcontrollers are as follows

Characteristics	Atmel AT91 M 42800 a	MC68HC 05PV8A	EM6603	Atmega16	DS80C310	AT89C52
Bits	16/32	8	4	8	8	8
RAM	8KB	192B	96*4B	512 bytes	256 B	2K
ADC	0	8 bit	0	10 bit	0	0
Timers	6	1	1	2/8bit,1/16bit	3	3
Operating voltage	2.7 – 3.6V	3.3 – 5.0 V	1.2 – 3.6 V	4.5 – 5.5V	4.5 – 5.5V	3 – 6.6 V
Power Active		16mA@ 1.6Mhz	1.8uA@3 2Khz	1.1mA@1Mh z	30mA	
Power Idle Mode		4mA@1. 6Mhz	0.35uA	0.35mA	1.5mA	
Power down Mode		50uA@1 .6Mhz	0.1uA	0.1uA	1uA	100uA

Table no. 3.1.3.1:- Shows a comparison of microcontrollers

3.1.3.2 ATmega 16:-

The ATmega16 is a product from Atmel Corporation which is generally on based on 8- bit microcontroller with RISC architecture. Another advantage is it is low-power. Internally it is having frequency of 1 MHz as by executing powerful instructions in one clock cycle.

Features:-

- Low-power consumption.
- 131 Powerful Instructions in one cycle
- 32 GPIO pins
- Maximum frequency can be 16 MHz
- 512 Bytes EEPROM
- 32 Programmable I/O Lines
- Operate at 4.5V - 5.5V
- 8-channel, 10-bit ADC
- Four PWM Channels Programmable Serial USART
- Master/Slave SPI Serial Interface

Fig.3.1.3.1:- ATmega 16

Pin Description of ATmega 16

- **Port A (PA7...PA0)**
  - Main feature of Port A is the Analog to Digital Converter.
  - It can also be used as 8-bit normal I/O port, but if ADC is not initialized.
  - Internal pull ups can be set.
  - If no clock pulse is given and reset is active then it is in tristate.

- **Port B (PB7...PB0)**
  - Port B has 8-bit I/O Port that can have both sink and source capability.
  - As inputs, pins are externally pulled low and provide current when pull-ups are set.
  - If no clock pulse is given and reset is active then it is in tristate.

- **Port C (PC7...PC0)**
  - Port C has 8-bit I/O Port that can have both sink and source capability.
  - As inputs, pins are externally pulled low and provide current when pull-ups are set.
  - If no clock pulse is given and reset is active then it is in tristate.
  - If the JTAG is enabled, the pull-ups on pins PC5, PC3 and PC2 will get activated even when reset occurs.

- **PORT D (PD7...PD0)**
  - Port D has 8-bit I/O Port that can have both sink and source capability.
  - As inputs, pins are externally pulled low and provide current when pull-ups are set.
  - If no clock pulse is given and reset is active then it is in tristate.

- **RESET**
  - Reset the Input and the microcontroller.
  - Low logic on reset pin for some delay time will generate reset without any clock pulse

- **XTAL1**

  For the connection of external crystal oscillator pin 1.

- **XTAL2**

  For the connection of external oscillator pin2.

- **AVCC**
  - AVCC will provide the power to PORT A and its secondary function ADC
  - Must be connected to +5V, either the internal ADC not used or not.
  - If the ADC is used, a filter capacitor is used between VCC and GND.

- **AREF**

  Reference voltage is provided to the ADC by AREF pin.

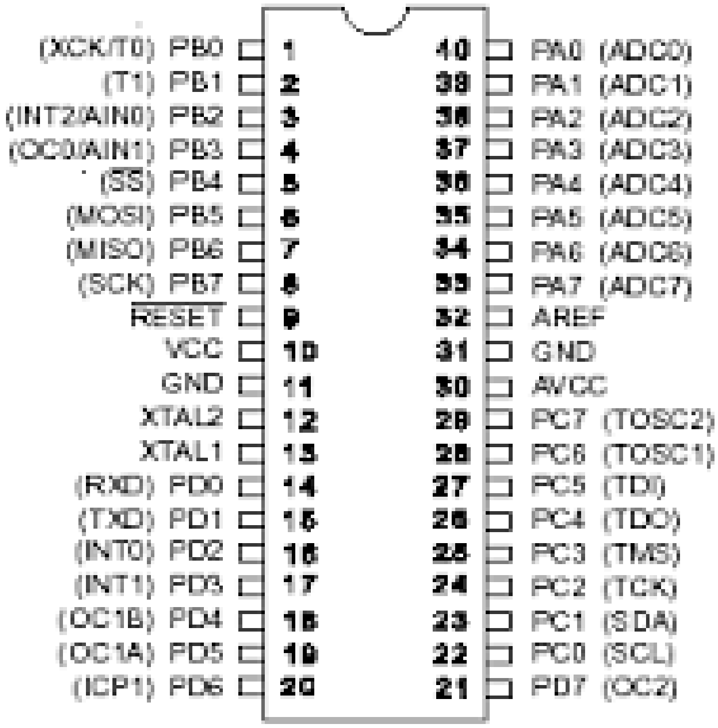


Fig3.1.3.2:- Pin Description of ATmega 16

As discussed above about the different types of microcontrollers like Motorola's controller, Dallas's controller and Texas Instrument's controller are having different industrial application subject based on their sizes according to industrial infrastructure. Another thing that we have to keep in mind related to proof-of-concept model availability that plays an essential role in choosing the microcontroller. Atmel's AVR series microcontroller are mostly popular in small embedded projects and can be used for WSN system. ATmega has been selected in the present work on account of its low cost and great features.

3.1.4 Temperature Sensor (LM35)

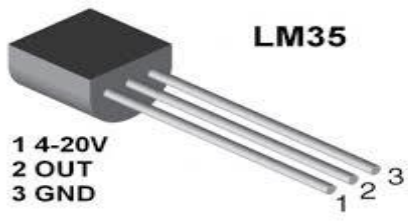


Fig.3.1.4.1:- Temperature Sensor (LM35)

The LM35 series are precise temperature detection devices with an analog output voltage which is proportional to the temperature in Celsius. As the LM35 device takes only 60 µA from the supply, it has very low self-heating of less than 0.1°C in still air.

- **Features**
  - Directly gives reading in Celsius (Centigrade).
  - Linear factor of sensor is + 10-mV/°C
  - Gives temperature range of −55°C to 150°C
  - Operates between 4 V to 30 V
  - Less than 60-µA.

- **LM35 Transfer Function**

  Relation between sensor's voltage and temperature is given as follows

VOUT = 10 mv/°F × T

Where • VOUT is the LM35 output voltage

• T is the temperature in °C

In LM35, an analog output directly proportional to temperature.

- **Basic Centigrade Temperature Sensor**

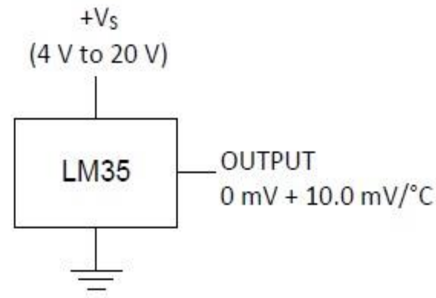


Fig.3.1.4.2: - Basic Temperature Sensor

- **Design Requirements**

PARAMETER	VALUE
Accuracy at 25°C	±0.5°C
Accuracy from –55 °C to 150°C	±1°C
Temperature Slope	10 mV/°C

Table no. 3.1.4: - Design Parameters of temperature sensor

3.1.5 LDR Sensor:-

A LDR Sensor is a photo resistor that is controlled by light. The resistance of a LDR decreases with increasing incident light intensity. A LDR can be used in light-sensitive detector circuits.

Fig.3.1.5: - LDR Sensor

LDR varies from a resistance of mega-ohms to few hundred ohms in the presence of light. It behaves like a sensor, since output voltage varies with its internal resistance.

3.1.6 Combustible Gas Sensor

Combustible Gas sensor mainly used in detecting of LPG, iso-butane, propane, LNG combustible gases from any leakage of an instrument. This sensor does not detect fumes of cooking and cigarette smoke. This is a commercial instrument used in offices, factories etc.

- **Features:-**
  - Gives analog output
  - Interface - ADC
  - High sensitivity to LPG, iso-butane, propane
  - Quick result
  - Stable performance and long life

Fig.3.1.6: - Combustible Gas Sensor

- **Applications:-**
  - Smoke detection system
  - Fire detection unit
  - Gas leak indicator

Pin outs

#	Pin	Details
1.	GND	Ground
2.	A.OUT	Analog Output
3.	+5 V	+5 V supply

Table no.3.1.6.2:- Pin outs of Combustible gas sensor

During the start-up of the sensor, the sensor requires around 10 minutes for heating up. After 10 mins, the accurate reading will be available. The sensor requires exact 5V to operate. During the heating up of the sensor, its voltage varies from 4.5V to 0.5V.

- **Sensitivity**

  Typical Sensitivity Characteristics of sensor for several gases in their
  - RL = 10K Ohm
  - Ro = Sensor resistance
  - Rs = Sensor resistance at various concentrations of gases

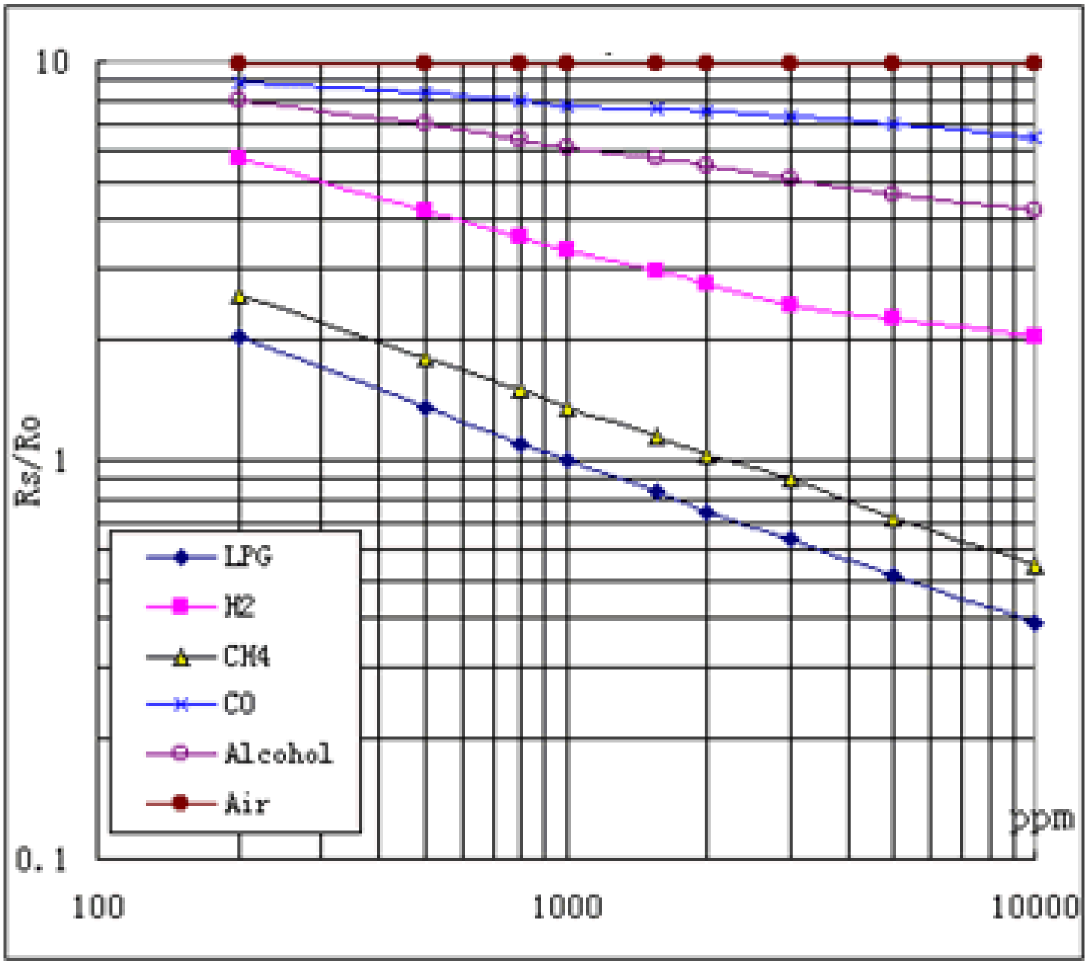


Fig.3.1.6.1: - Relation between PPM and Rs/Ro

- **Deriving Gas concentration from Output Voltage**

Here is a the equation which convert analog output to PPM gas concentration

PPM = Analog Voltage in mV x 2

PPM:	**200**	**300**	**500**	**1000**	**2000**	**3000**	**5000**	**9000**	**10000**
Voltage (mV)	100	150	250	500	1000	1500	2500	4500	5000

Table no.3.1.6.3:- Output Voltage related to Conc. of Combustible gas sensor

3.1.7 Xbee Explorer USB, CP2102 based

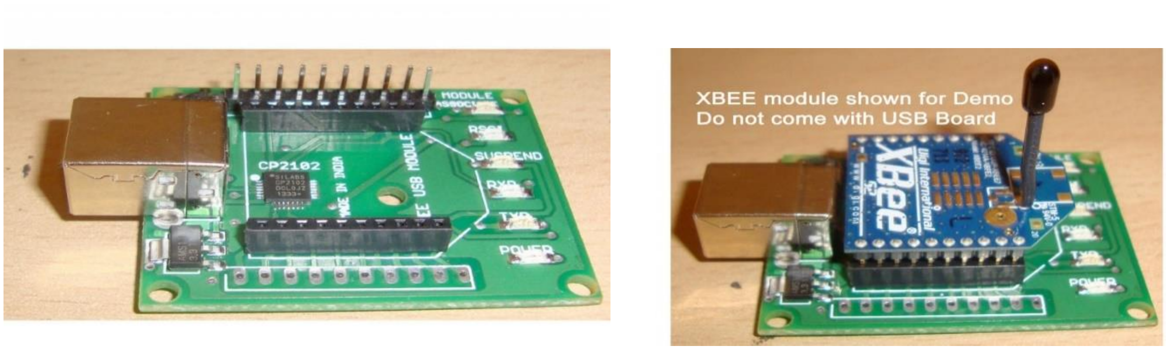


Figure- 3.1.7 Xbee Explorer USB Device

Xbee Explorer USB made simple to interface the Xbee module to USB from serial base unit. This device is compatible to all series of Xbee modules. Attach the Xbee module with the Xbee Explorer and with a USB cable, we canuse both the serial and programming pins on the Xbee unit with the help of X-CTU software. The RXD and TXD pins of Xbee Explorer are connected to the MCU. The Xbee Explorer Device has inbuilt FTDI which make communication between PC and MCU.

3.18 ZigBee Device

Figure- A1.2 ZigBee Device

Digi Xbee 802.15.4 Xbee modules provides communication for sending a packet of data. These modules can communicate peer to peer or in a mesh network.

Key features:

- Maximum exterior range is up to 90m.
- Interior range in operating device is up to 30m.
- Data rate up to 250 kbps

- 2.4 GHz frequency band

3.2 Base Station Section

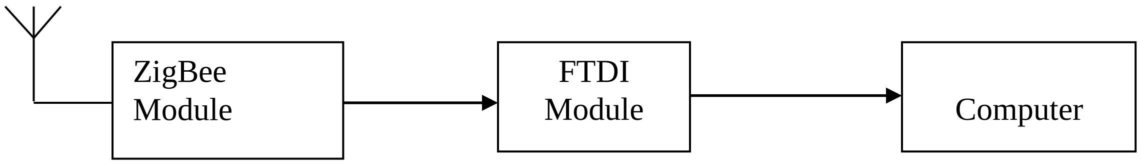


Fig.3.2: - Block Diagram of Base station Section

In this Base Station, Sensor's data is received by the coordinator ZigBee module from different nodes. The FTDI module build a bridge between the ZigBee and the Computer, so that data is transferred to the computer. In computer, the XCTU Software will show all the Sensor's data continuously and can be observed. The obtained data is then received in another software in which it gives sensor's data in word document form. That document is sorted and compared in MS. Excel.

Chapter 4

COMPONENT INTERFACING WITH MODULES

4.1 Interfacing of LCD with Microcontroller

4.2 Interfacing of Temperature sensor with Microcontroller

4.3Interfacing of Combustible Gas sensor with Microcontroller

4.4 Interfacing of LDR with Microcontroller

In this section we will discuss the method adopted step by step in the course of developing the WSN. First of all we will discuss the interfacing of different modules with the microcontroller and the supply. Interfacing is the interaction between two components so that it can make a complete system to fulfil a particular purpose. In WSN system there are various modules interfaced such as Microcontroller, LCD, Xbee, Temperature sensor, LDR sensor and Combustible Gas sensor hence interfacing circuits, pinouts are discussed later on this chapter.

4.1 Interfacing the LCD with the Microcontroller

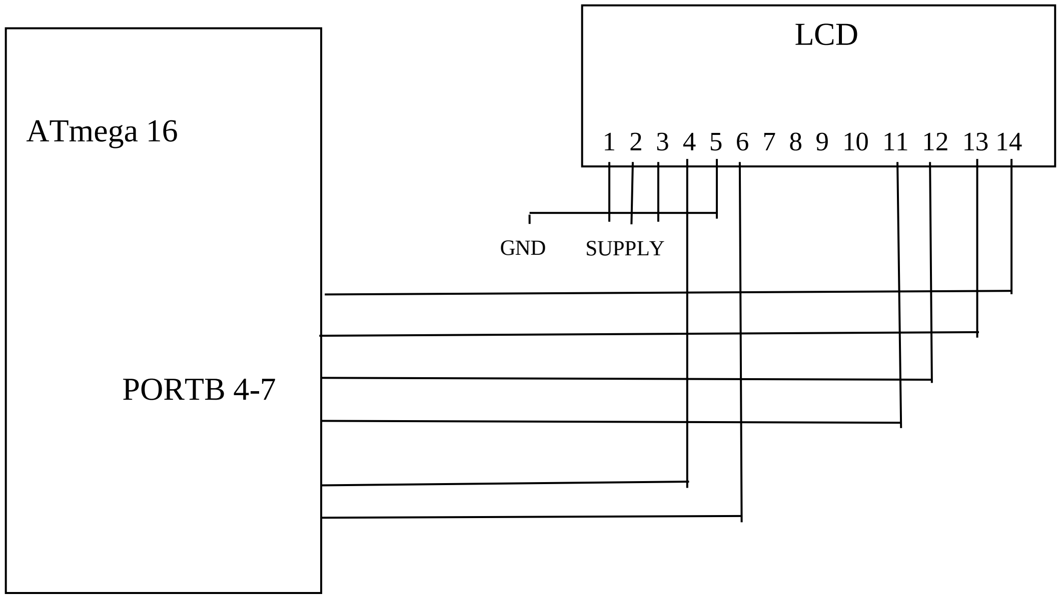


Fig.4.1 Interfacing of LCD with Microcontroller

The interface between the ATmega 16 and the LCD can be accomplished directly with 7 pins that needed to be connected:-

D7, D6, D5, D4 pins from LCD needs to be connected to the Port B (4-7) and E, RS pins are connected to Port C (0 & 1)

4.2 Interfacing the Temperature sensor with the Microcontroller

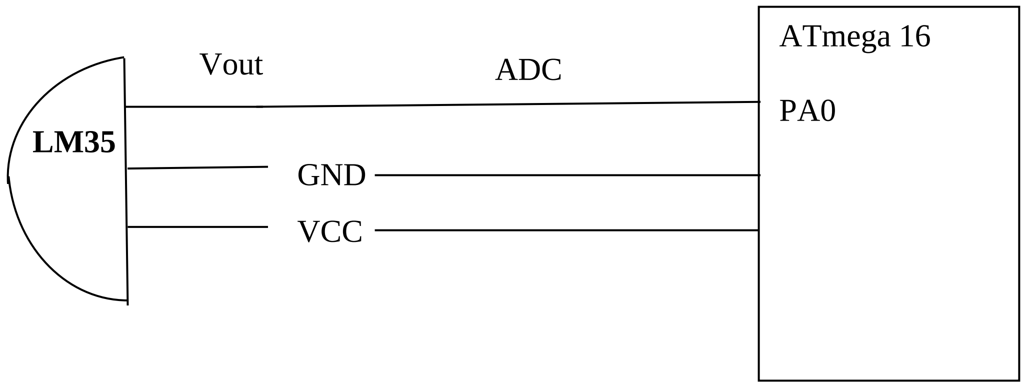
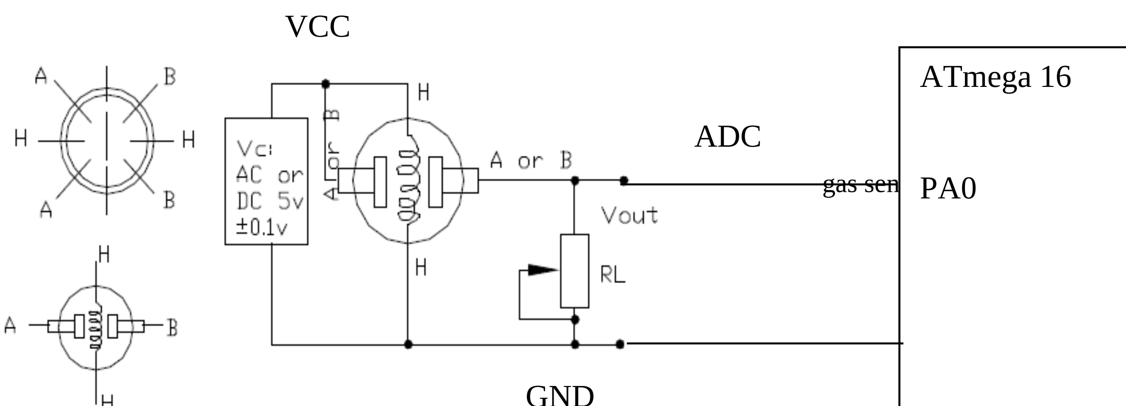


Fig. 4.2:- Interfacing the Temperature sensor with the Microcontroller

The interface between the ATmega 16 of Node 1 and the LM35 can be accomplished directly with pins that needed to be connected:-

The Vout Pin of the LM35 Sensor is connected to the PORT A of 0^{th} pin via ADC interface.

4.3 Interfacing the Combustible gas sensor with the Microcontroller



the Combustible gas sen ntroller

Rs = 3KΩ – 30 KΩ

RL = 10KΩ Pot

The interface between the ATmega 16 of Node 2 and the Combustible gas sensor can be accomplished directly with pins that needed to be connected:-

The Vout Pin of the Combustible gas sensor circuit is connected to the PORT A of 0^{th} pin via ADC interface.

If the Rl value change then it will detect another gas which is mentioned in its datasheet.

4.4 Interfacing the LDR Sensor with the Microcontroller

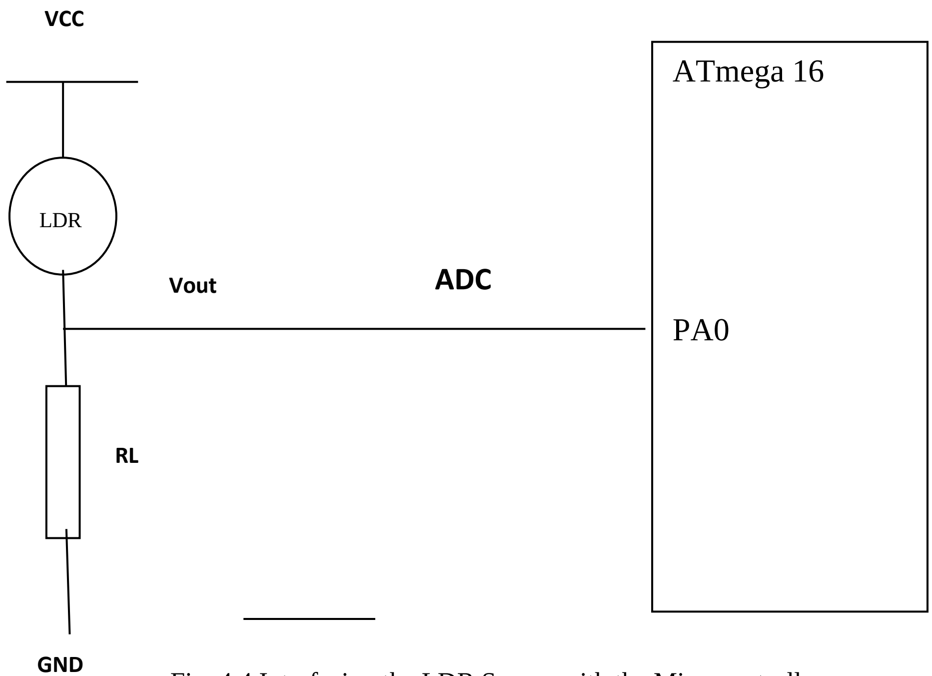


Fig. 4.4 Interfacing the LDR Sensor with the Microcontroller

RL = 10KΩ

The interface between the ATmega 16 of Node 3 and the LDR can be accomplished directly with pins that needed to be connected:-

The Vout Pin of the Combustible gas sensor circuit is connected to the PORT A of 0^{th} pin via ADC interface.

4.5 Schematic of ATmega 16 PCB

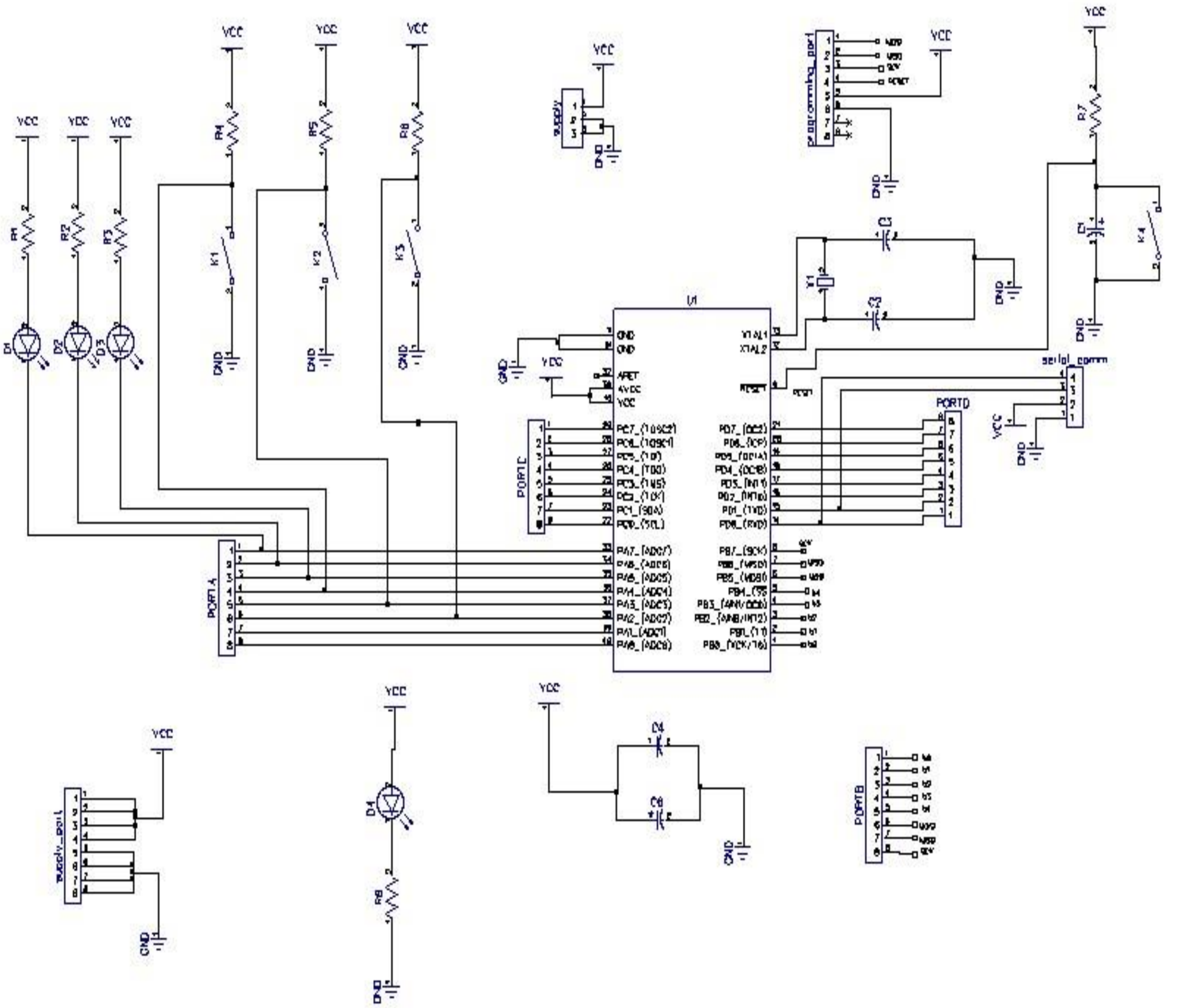


Fig. 4.5 Schematic of ATmega 16 PCB

4.6 Back Side of Main board PCB

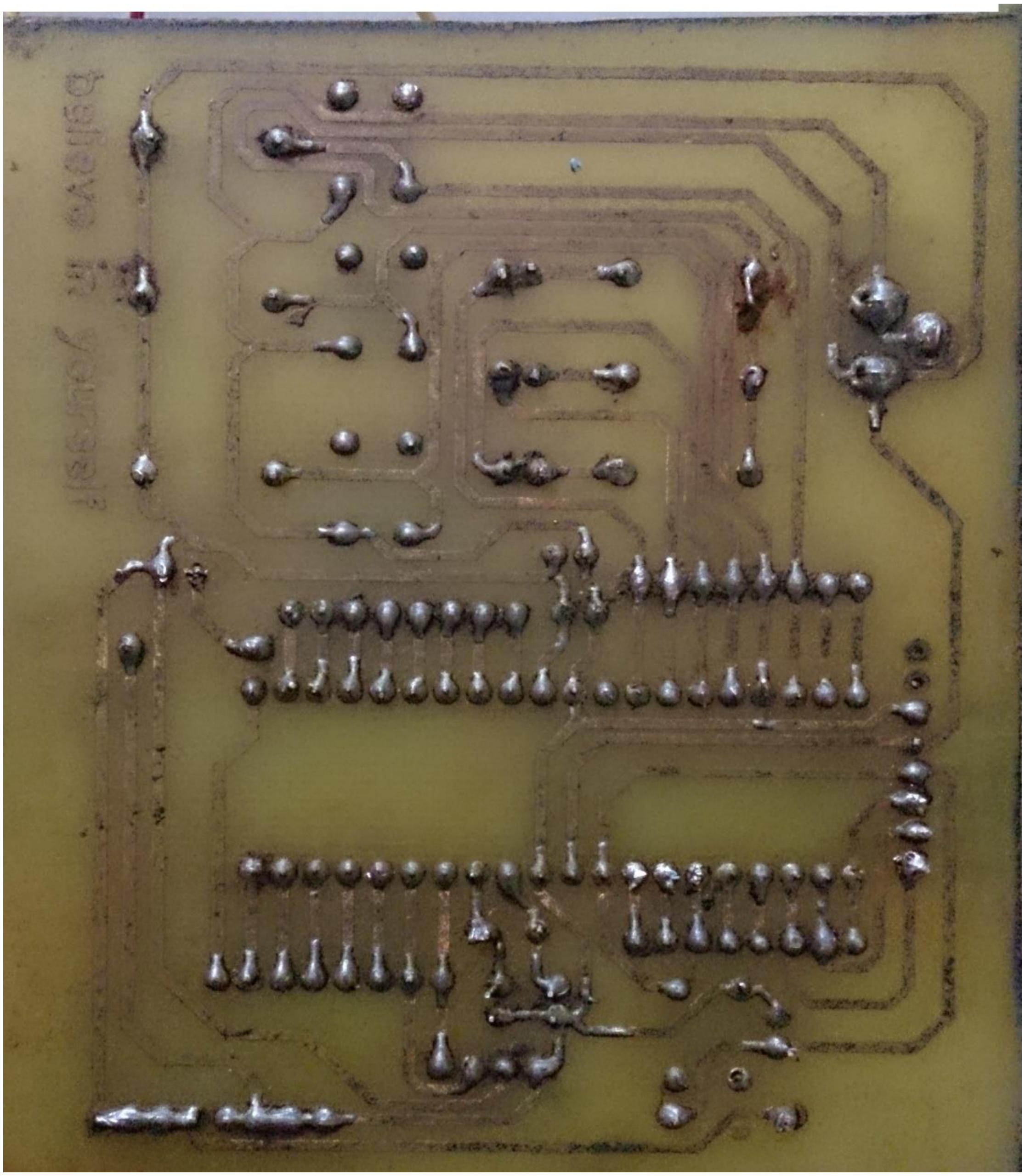


Fig. 4.6:-The Back side of MCU Development Board

4.7The MCU Development Board

The MCU used is Atmega16L. It is an 8 bit microcontroller with 16Kb in-system programmable flash. Following is the pin configuration of ATmega16L:-

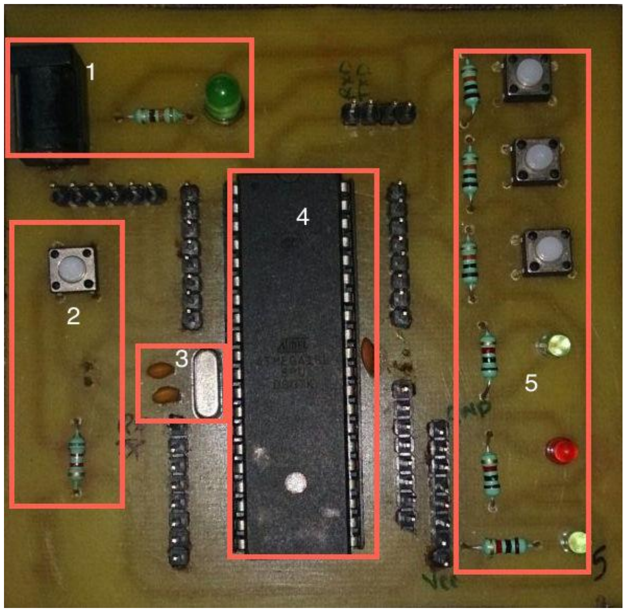


Fig. 4.7:-The MCU Development Board

1-Power Section: - The supply jack is connected to Battery terminals via 7805 Linear Regulator. A Led connected to the section for power indication.

2- Reset: – The Reset button is used to reset the MCU as the reset pin of MCU is active low pin. So it is kept high.

3- Crystal – 8MHz Crystal gives external clock to the MCU. The bypass capacitors are attached in Series with the crystal for proper functioning.

4-ATmega16 MCU – MCU is connected with 40 pin base. The 4 ports are given out for GPIO connectivity.

5- Switch and LED connection- The Switch is connected to PB3-5 and the LED from PB1-3. It is used as a user interface for debugging.

CHAPTER 5

SOFTWARE DEVELOPMENT

5.1 Development Stages

The designing and development of WSN system. Involves the cycle of the programming stages of the MCU to achieve the required goal of our WSN application system. Firstly according to the application, code had been written and then compiling and burning process has been done.

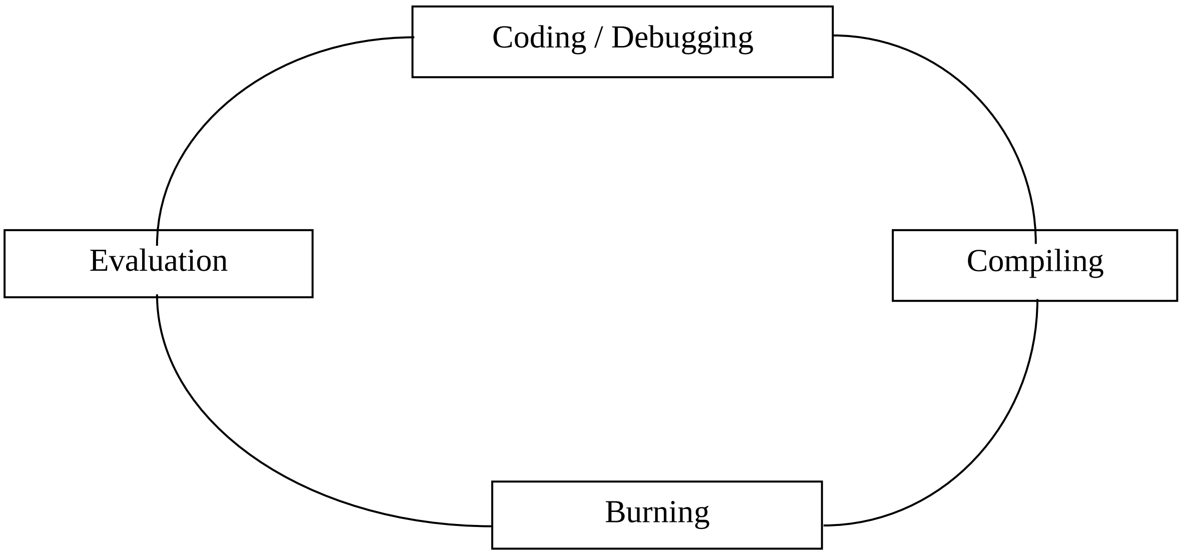


Fig.5.1: -Stages of Software Developments

5.2 Coding / Debugging

Programming and problem solving for any high level language is not so tedious as well as fast to do. For programming the microcontrollers we have used the the WinAVR software which was installed in our laptops. All the programming of our project was written in C language however inline assembly could be used. The ATMEL series of microprocessors are easily programmable by the. WinAVR software development tool which is as open source software. The compiler for C and C++ are GNU GCC. WinAVR contains all the tools for developing on the AVR. The debugger for the WIN AVR is AVR-GDB. For testing the microcontroller the test source code has also been written in c language. The XCTU software setting on COM port of PC Xbee module has been checked. The ZigBee module collects the sensor data very fast and displays it on the monitor with the help of a coordinator device.

Step By Step coding of WSN program are shown in figures using AVR Studio5.0 Software.

Step- 1:- Open the Atmel AVR studio 5 and make a new project.

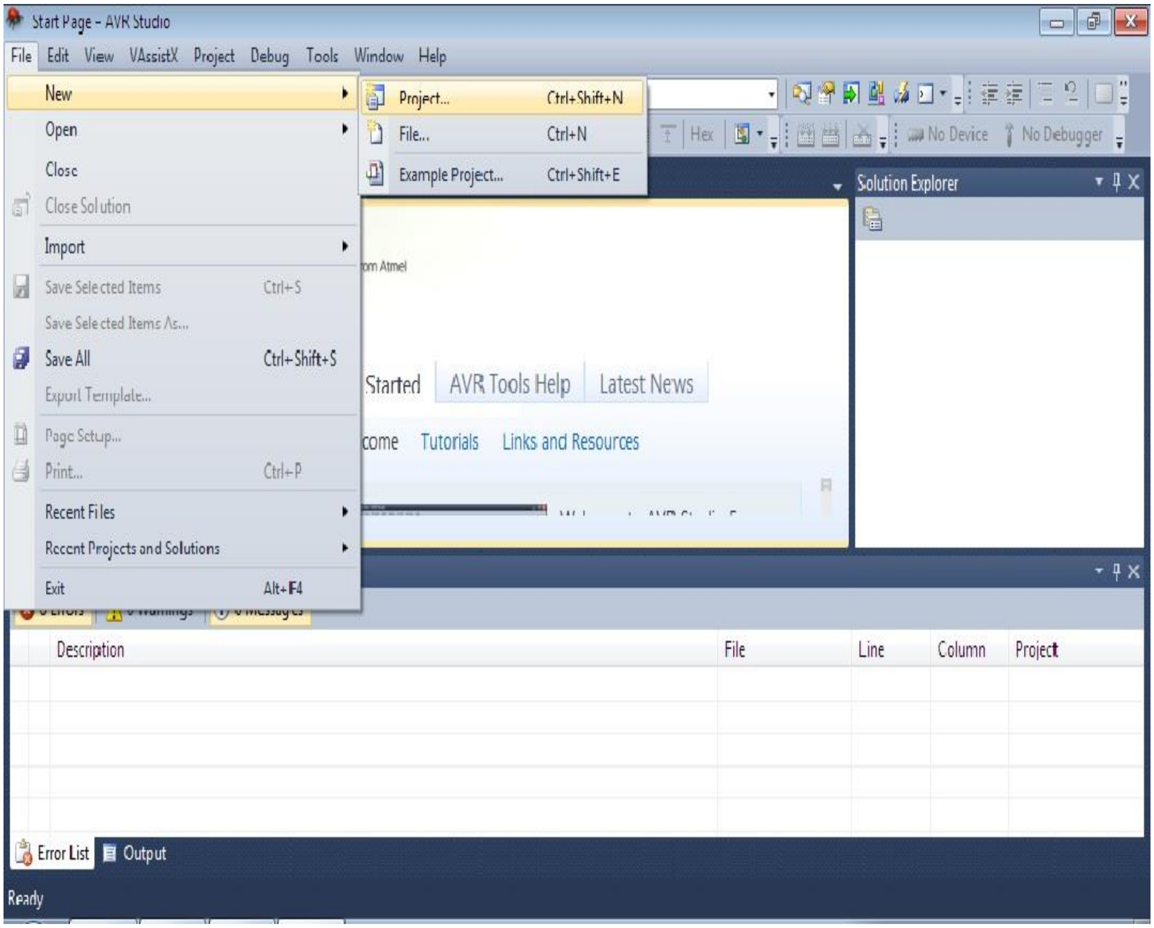


Fig.5.2.1: - Step 1 Coding / Decoding

Step -2:-Select the C Executable Project AVRGCC.

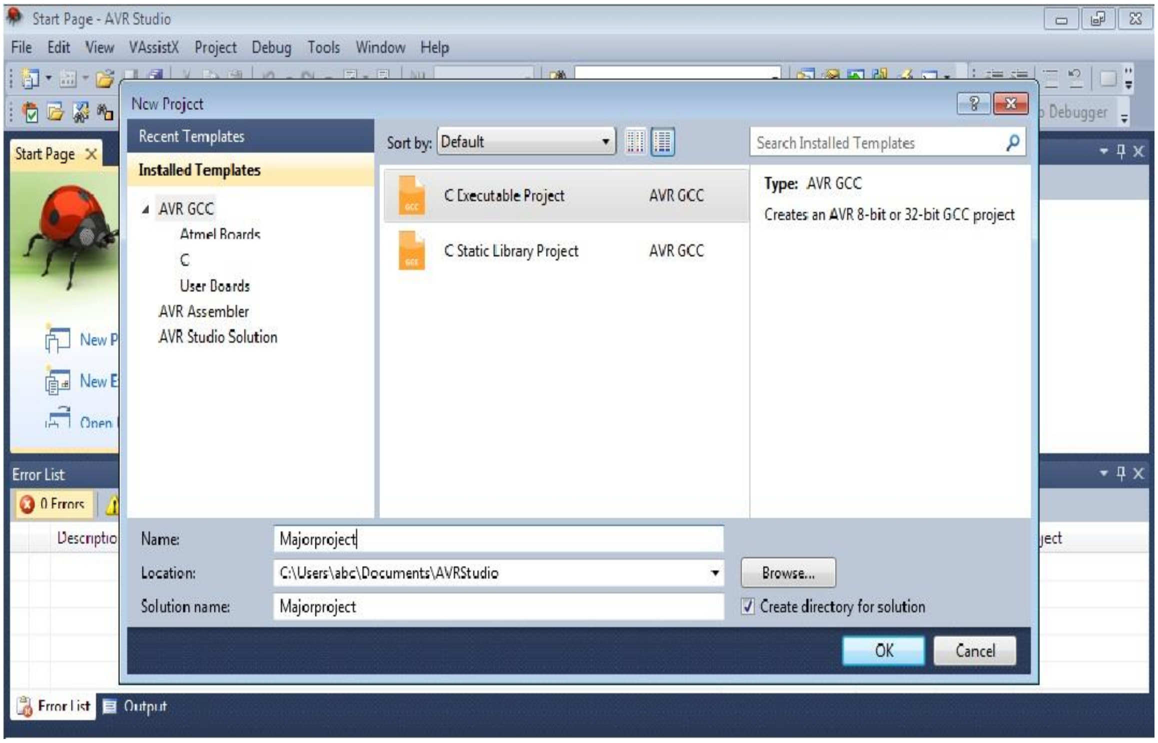


Fig.5.2.2: - Step 2 Coding / Decoding

Step- 3:- Select the ATmega 16 MCU device.

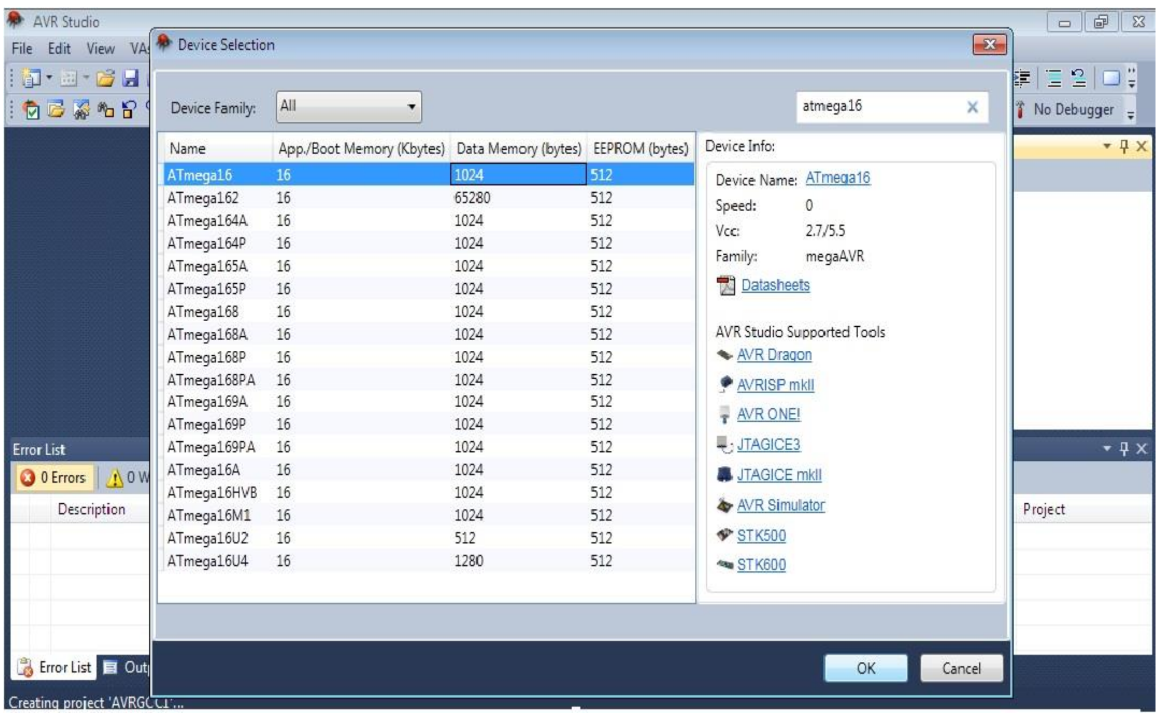


Fig.5.2.3: - Step 3 Coding / Decoding

Step-4:- Add Majorproject Source file and Header file.

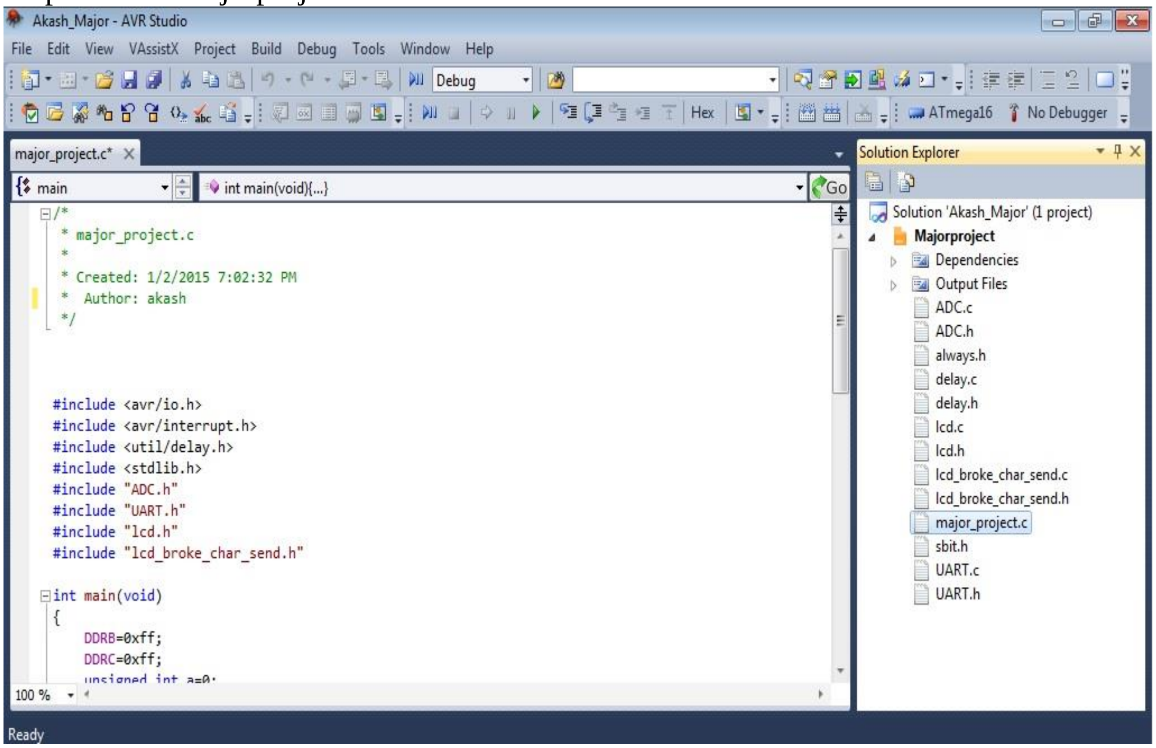


Fig.5.2.4: - Step 4 Coding / Decoding

Step-5:- Set the MCU at 8MHz frequency.

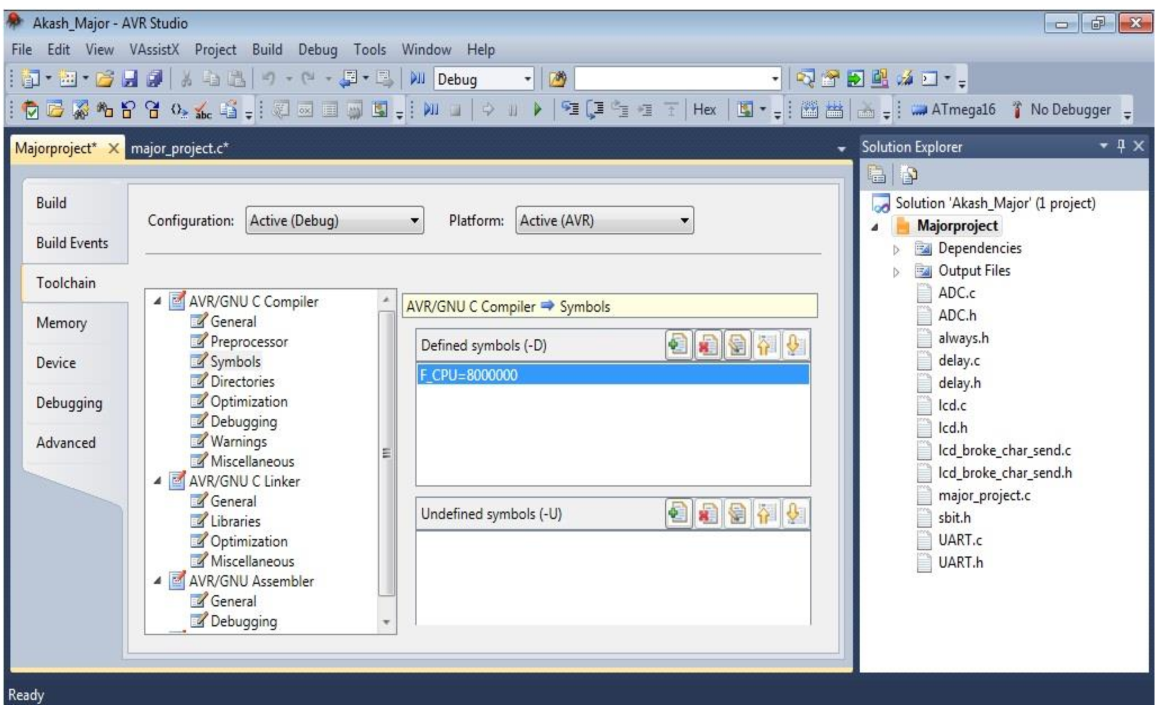


Fig.5.2.5: - Step 5 Coding / Decoding

5.3 Compiling

The compilation of the C program converts it into machine language file (.hex). The microcontroller only understand program code and it changes into the hexadecimal format. During this step, some warnings about eventual errors / mistakes occurs in the program will be shown.

After writing the code in AVR Studio5, Click on build button for compilation and generation of Hex file of the respected code. After the Build process, if the code has error then it shows all the lines that contains error otherwise it shows Build succeeded.

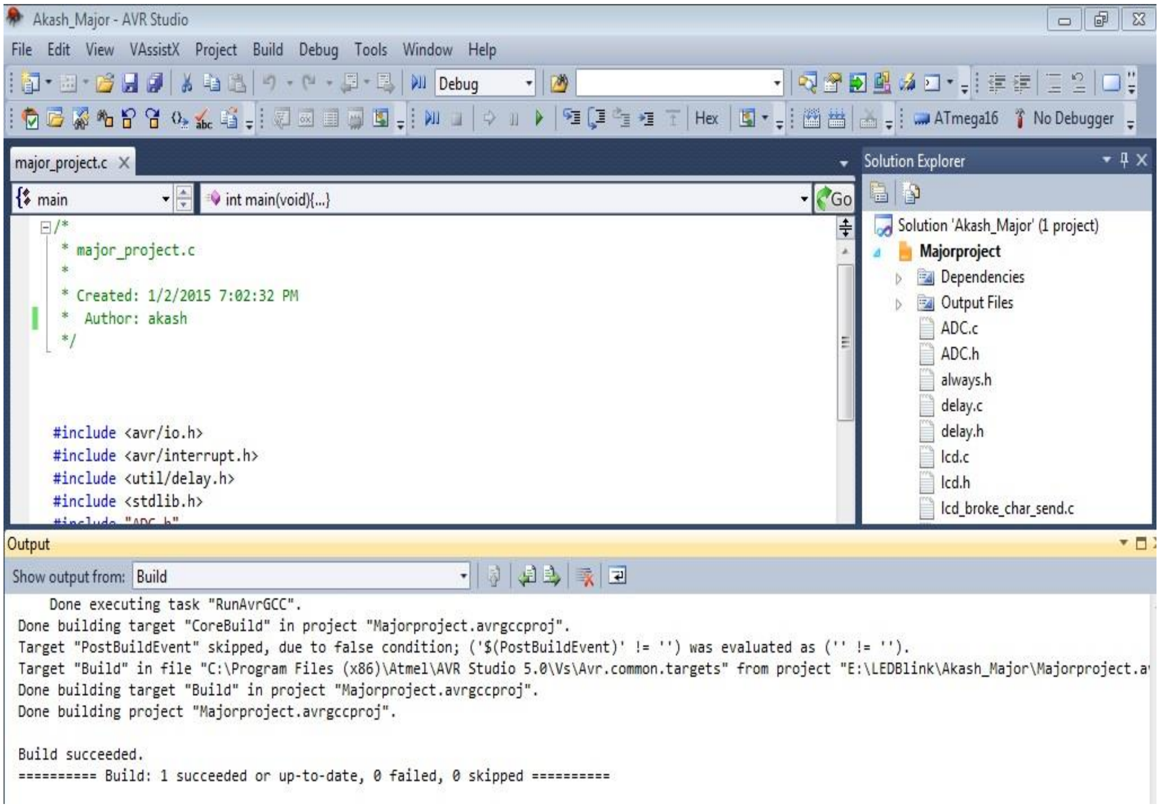


Fig.5.3:- Compilation of code

5.4 Burning

Burning the machine language (hex) file is a very important step in the programming. In the present work the AVR ASP programmer has been used to burn the machine language file into the microcontroller's program memory. The programmer communicate with the MCU through the SPI mode i.e. through the MISO and MOSI pins of the MCU and it connected serially to the PC.

Fig.5.4.1: - AVR ASP Programmer

The extreme burner Software load the respective Hex file and write it to the Atmega16 MCU with the help of AVR ASP programmer.

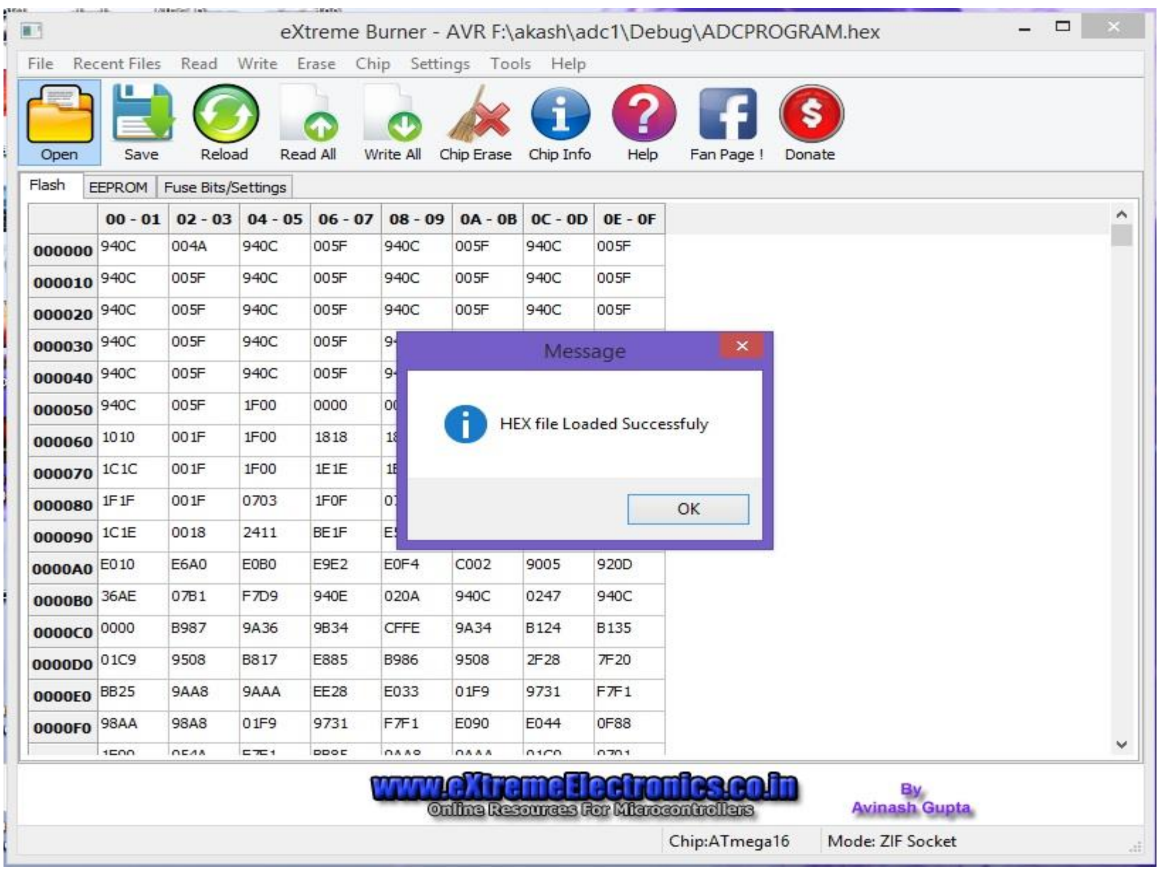


Fig.5.4.2: - Burning of hex file

5.5 Xbee Configuration through XCTU Software

Step 1 Configuration

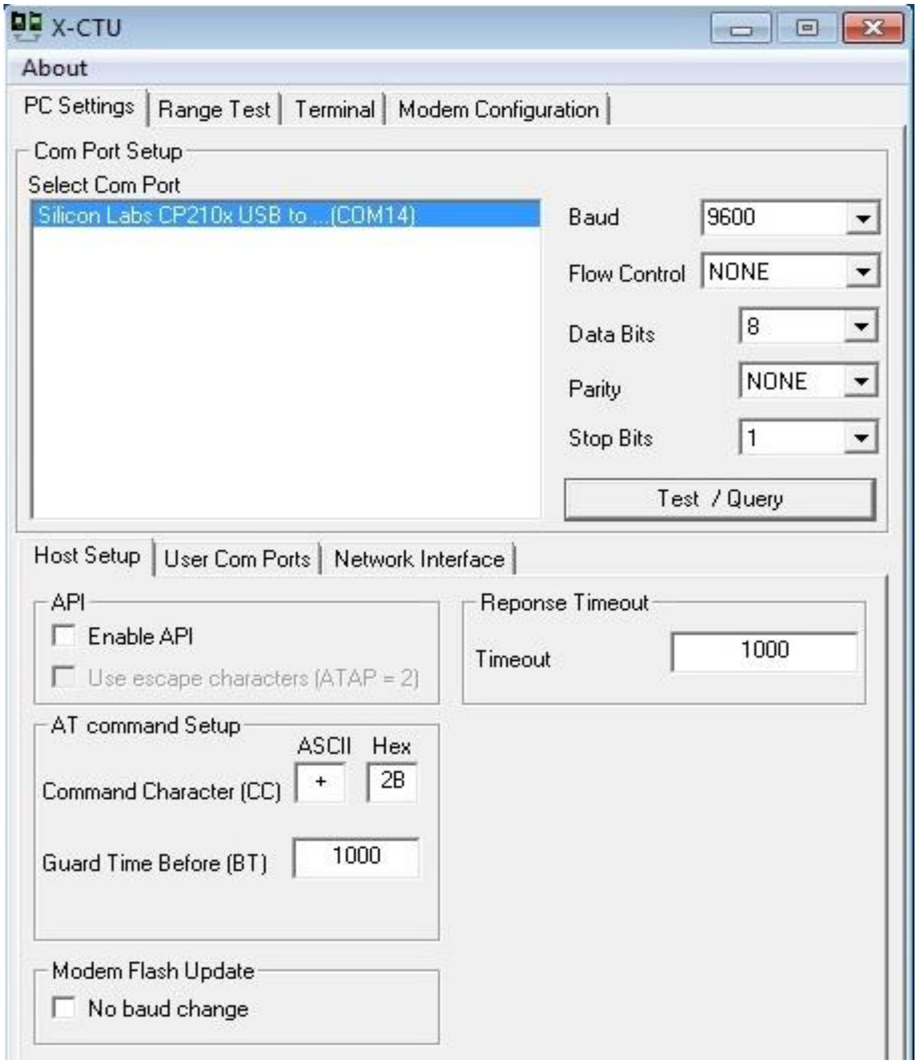


Fig. 5.5.1:-Xbee Configuration Step1

The main window of XCTU software has a row of tabs on the top. The main tabs has a modem configuration menu that is used for programming the Xbee module.

Range Test is mainly used to check the Xbee communication range at different locations. A range may be vary according to the materials that it has to transmit through. In plane area, Line of sight range of devices will vary when the same device is placed inside the rooms. The Terminal window shows the serial communication of Xbee module.

Step 2 PC settings

Mainly we set the Xbee device at 9600 baud rate. The following setting will be done as No flow control, data bits is 8, no parity and with 1 stop bit. Before doing the modem configuration click on the Test/Query button for checking the successfully connection. If test failed then, press the reset button available on the Xbee USB interface module.

Step 3 – Modem Configuration

After the proper settings in PC settings, click over to the Modem Configuration. let's focus on Modem Parameters, and Firmware.

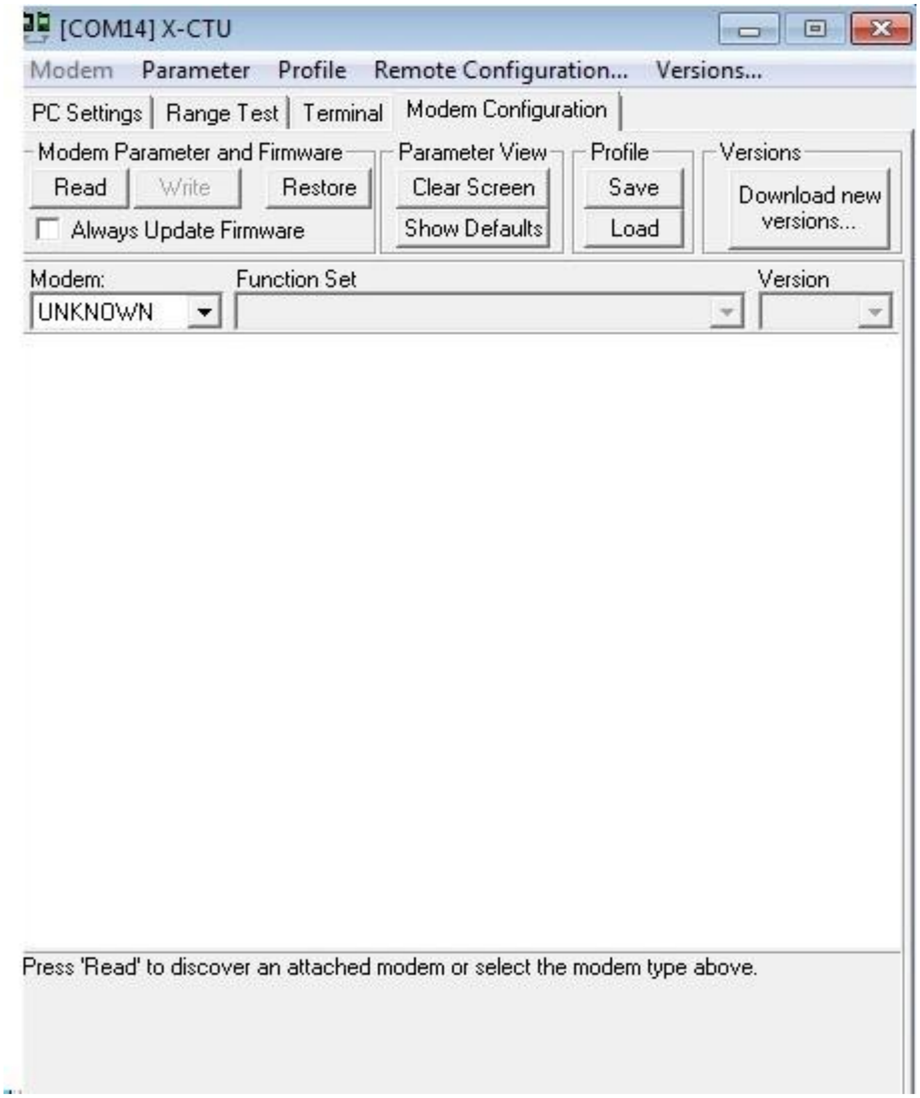


Fig. 5.5.2:-Xbee Configuration Step2

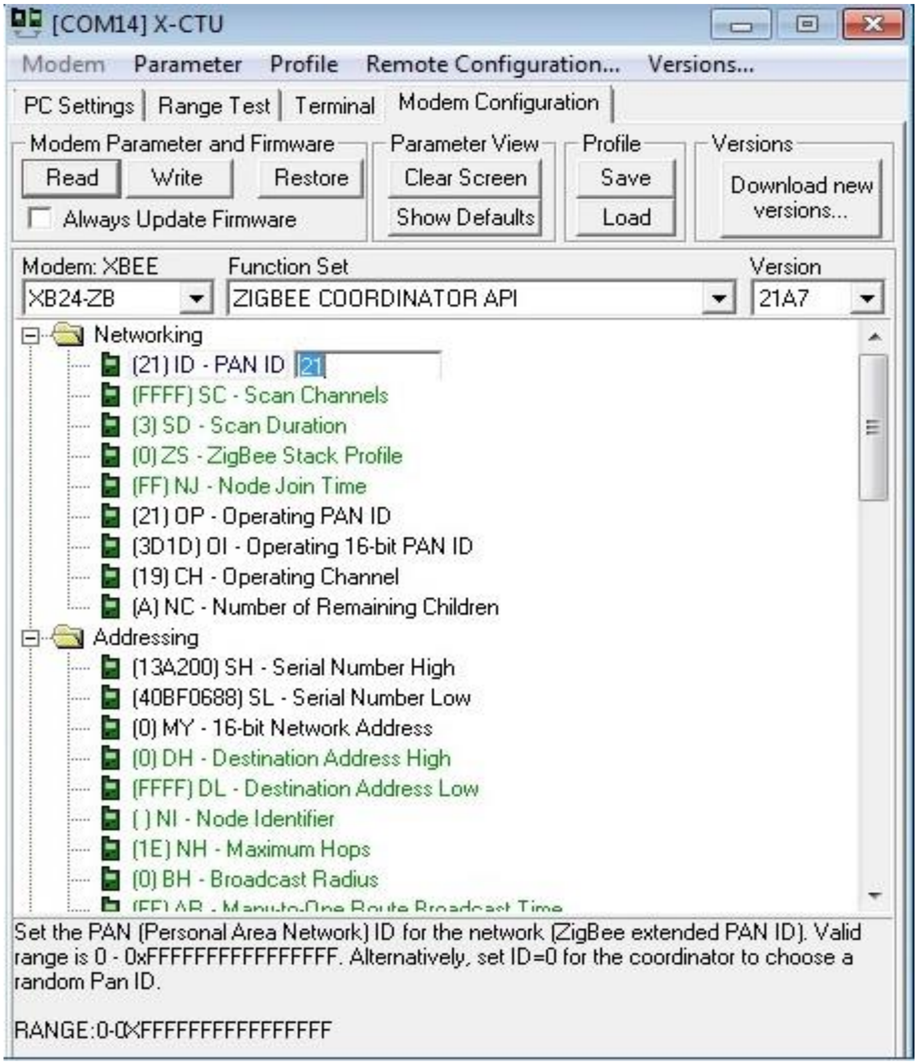


Fig. 5.5.3:-Xbee Configuration Step3

To start, click Read. This should change the blank box to a list of options.

Set the Xbee to the required function set i.e. Xbee to be work as coordinator, set it to ZIGBEE COORDINATOR API and for end device, set it to ZIGBEE ROUTER AT Click on the ID, and type in your channel of choice. Set all of your Xbee to the same channel and with the same PAN ID. After the adjustments, simply click the Write button. It should take a moment, but if everything goes well, it should say,

Getting modem type.... OK

Modem's firmware not updated

Setting AT parameters... OK

Write parameters.... Complete

As from the above configuration steps, we set the ZigBee i.e. attached to computer system is Coordinator API mode and at the nodes side we set that ZigBee as Router AT mode. These two modes are generally used in Wireless sensor network. The most point in ZigBee is the PAN id which is like a password. Those nodes which are having the same PAN id are accessible in network i.e. in a particular network all nodes should have same PAN id including the Coordinator.

- **API mode (Application Programming Interface)**

Automatic generation of data from ZigBee without waiting for user commands.

Following Functions:-

1-View:

a- Received Signal Strength Indication.

b- Source Address- on packet to packet

2-Receive: Acknowledge bit on every transmitted packet.

3-Transmit: data to multiple destination without entering command mode

Multiple Input====➔Xbee identify the destination addr====➔multiple outputs

- **AT mode**

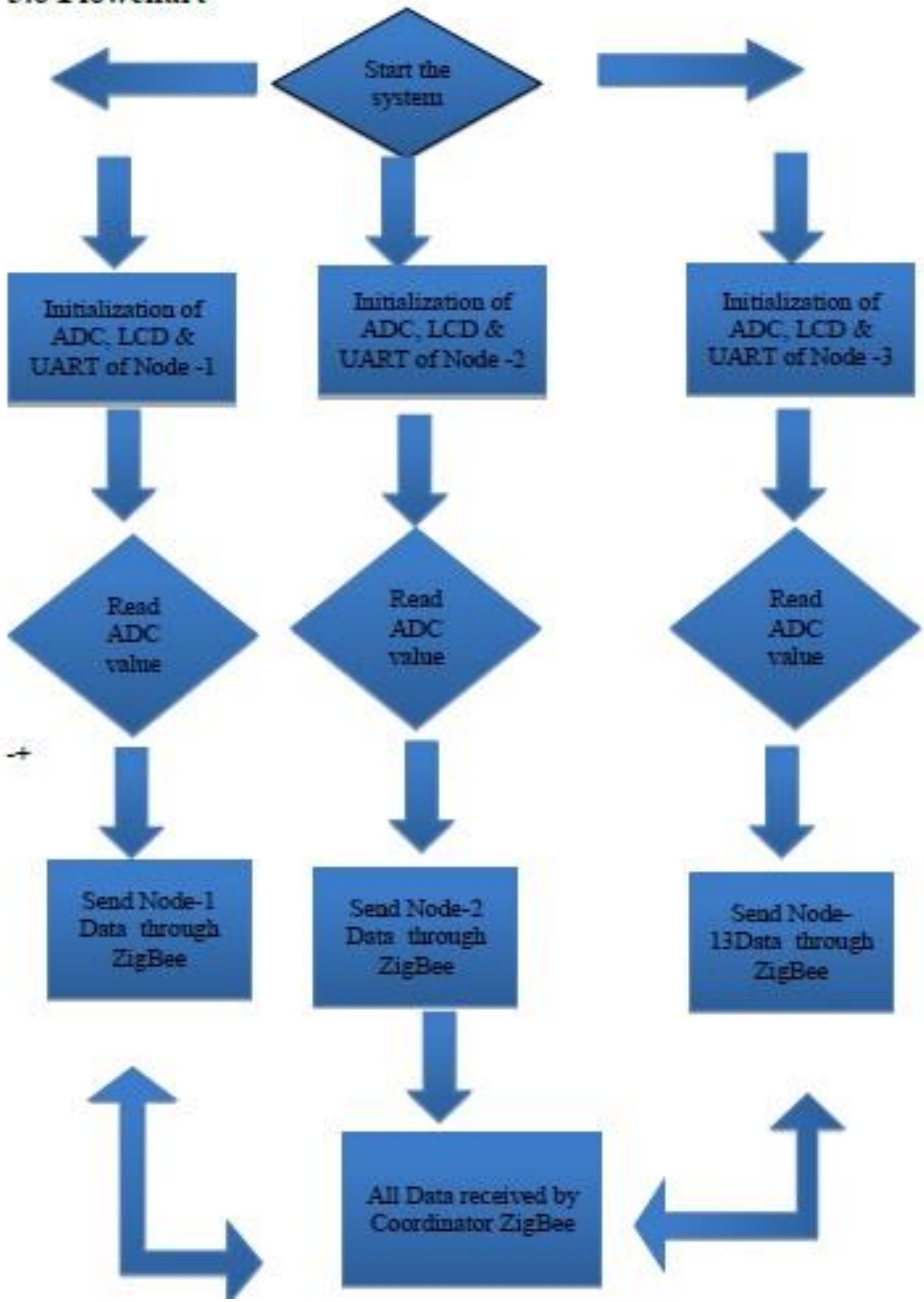
It is also known as transparent mode where user specifies AT commands in command mode then sending it to UART port. Useful in point to point communication.

Data=(point 1)========➔ Xbee-buffer and make packet==➔Remote Module User AT Command===➔ (Takes Time) (point 2)

- **API format for Remote AT Command Request**

Data bit	Example	Description
0	0x7e	Start byte – Indicates beginning of data frame
2	0x00	Length – Number of bytes (Checksum Byte# – 1 – 2)
3	0x10	
4	0x17	Frame type - 0x17 means this is a AT command Request
5	0x52	Frame ID – Command sequence number
6	0x00	64-bit Destination Address (Serial Number)
7	0x13	MSB is byte 5, LSB is byte 12
8	0xA2	
9	0x00	0x0000000000000000 = Coordinator
10	0x40	0x000000000000FFFF = Broadcast
11	0x77	
12	0x9C	
13	0x49	
14	0xFF	Destination Network Address
15	0xFE	(Set to 0xFFFE to send a broadcast)
16	0x02	Remote command options (set to 0x02 to apply changes)
17	0x44(D)	AT Command Name (Two ASCII characters)
18	0x02 (2)	
19	0x04	Command Parameter (queries if not present)
19	0XF5	Checksum

5.6 Flowchart



Chapter 6

Results & Observations

After connecting the ZigBee to all nodes, start the system. Now we get all sensor's data from node 1, 2, 3 without any interference and easily monitored on the XCTU software.

- **LDR Sensor data received at XCTU Software**

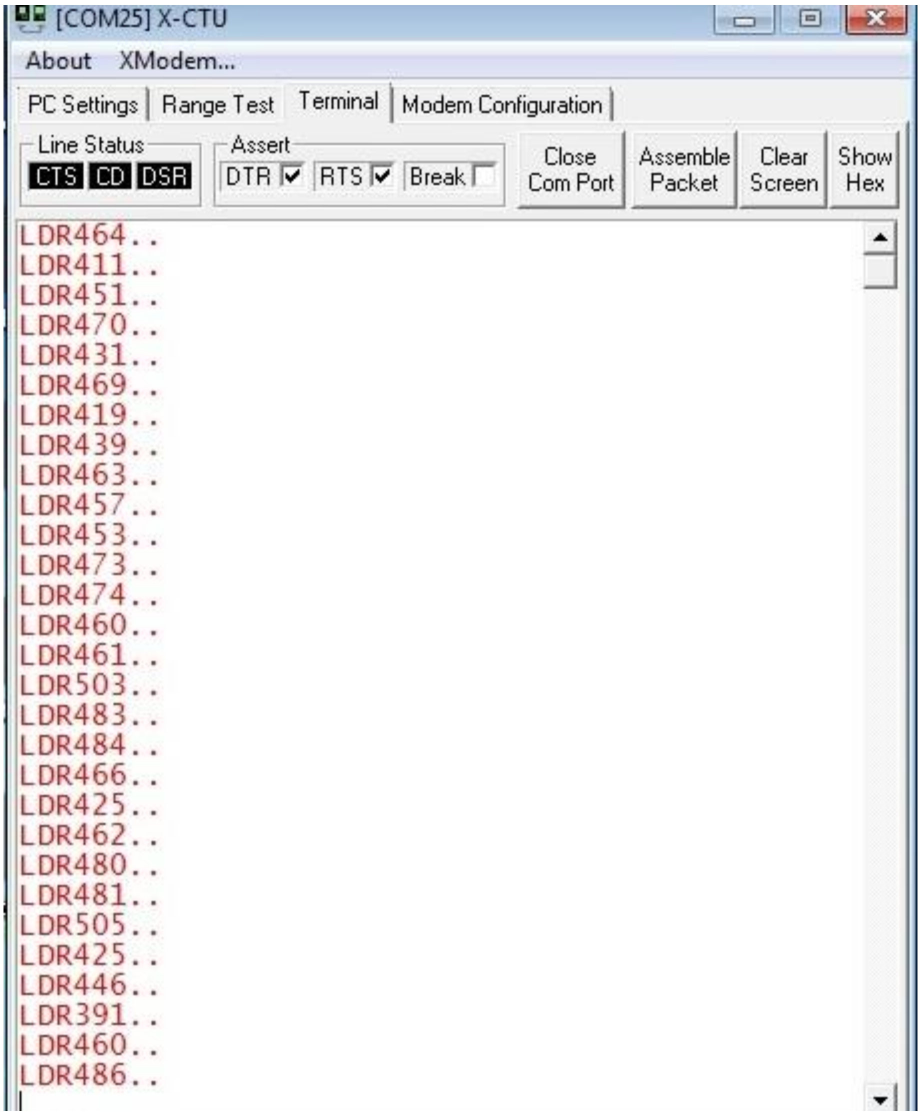


Fig.6.1:- LDR Sensor data

- **Temperature Sensor data received at XCTU software**

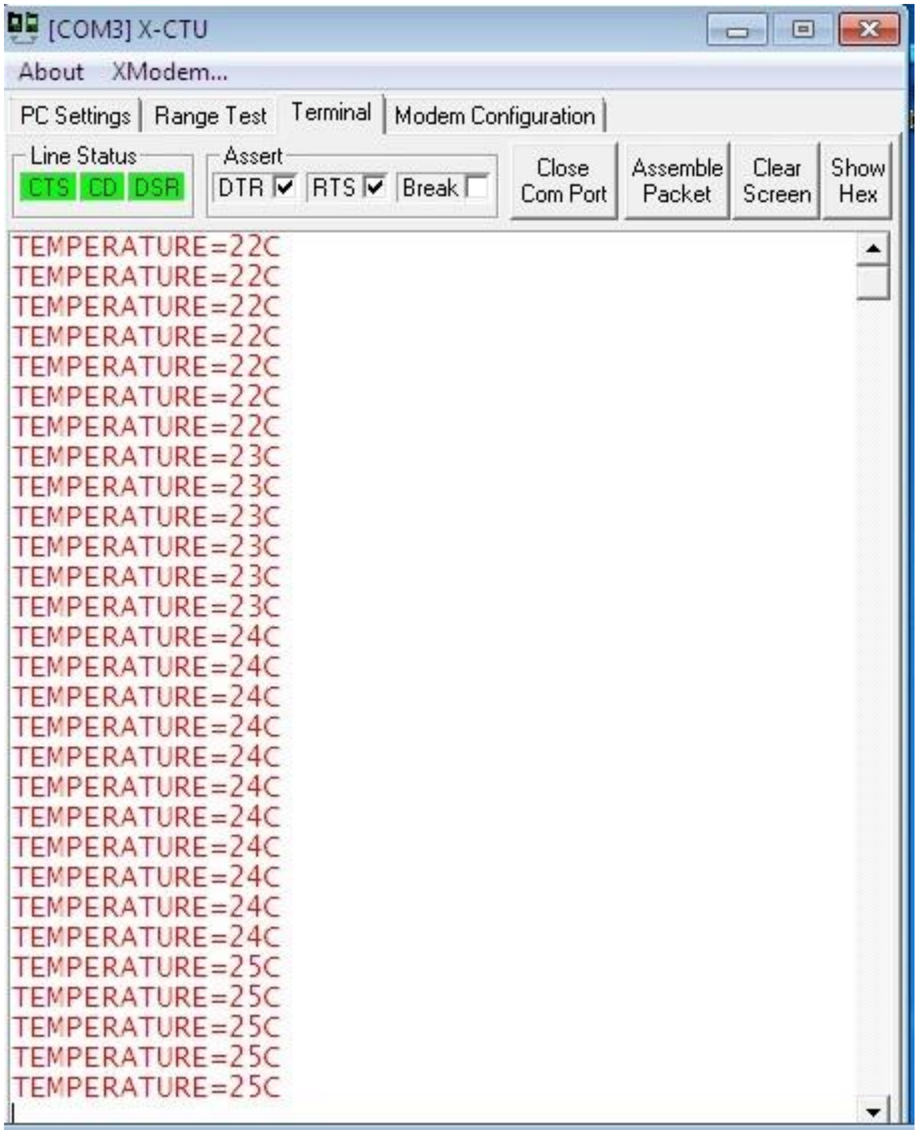


Fig.6.2:-Temperature Sensor data

- **Combined Data received at the XCTU Software**

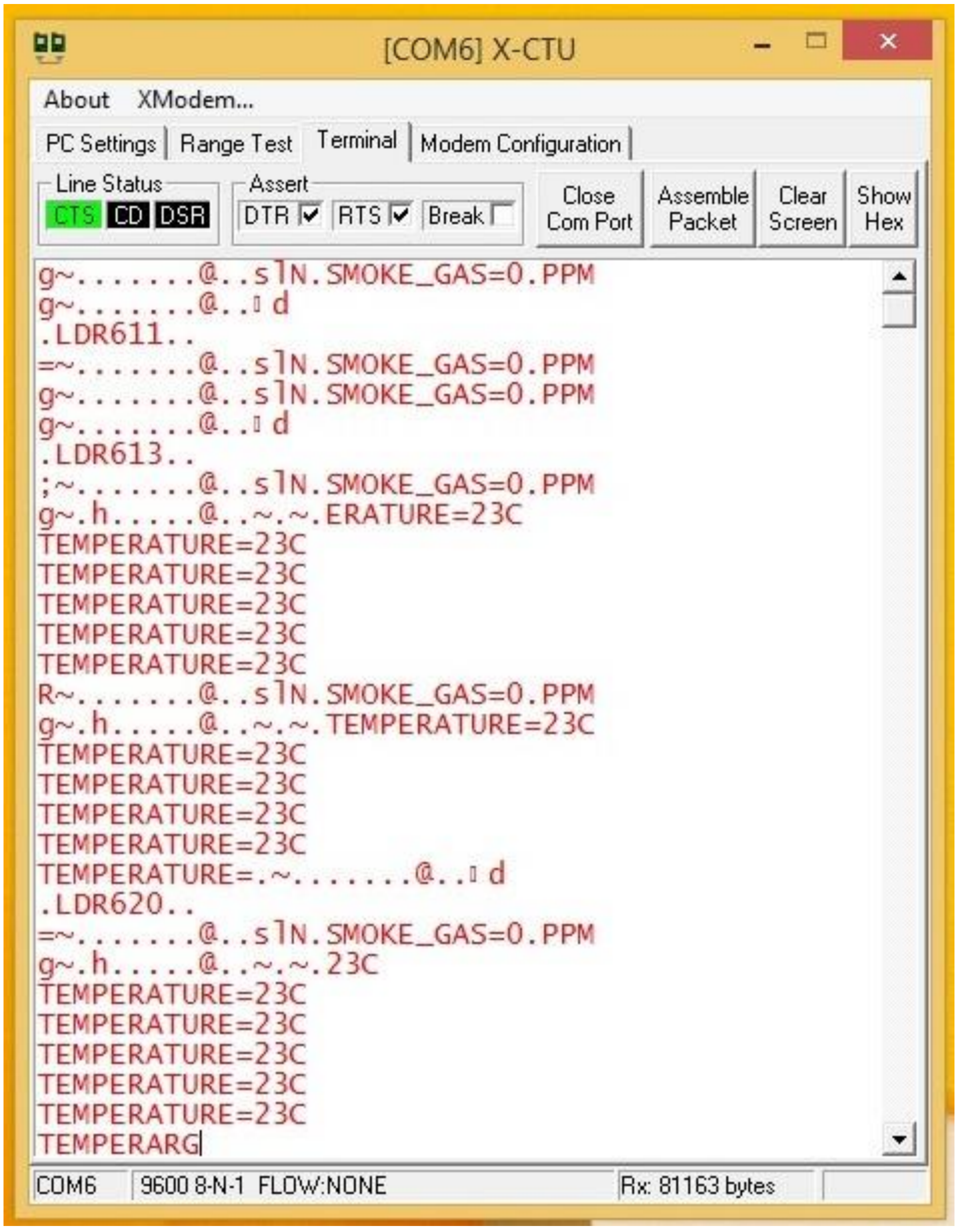


Fig.6.3:-Combined all Sensor's data

From the XCTU, we observe the real time data of all nodes placed at any place and if any environmental problem occurs, we can take actions according to it.

Chapter 7

CONCLUSIONS AND SUGGESTIONS

7.1 Conclusion:-

The project we have done can be designed by using any of the microcontrollers. The power consumption at individual nodes is quite high thus it is a drawback of our project. This drawback can be overcome if the nodes are kept in standby mode at times when it is not required to sense anything. This will surely result in low battery consumption and great battery life The system we have designed have zero interference and the code length is also appropriate if compared to other systems Many features of the microcontroller are not used thus requiring even lesser power.

7.2 Suggestions for future work:-

Size

The size of any development board immensely contributes to the power consumed by the system .In order to reduce the power consumed and to get a larger battery life we can obviously remove the unnecessary functional blocks which are just consuming power and not doing any task .Proper investigation can be done in this context such tat energy is saved to a great extent**.**

Wireless Transmission

The Module used in this project has a range of around 30m in closed space and around 100 m in open space which can used be used for monitoring small range applications but for applications requiring longer transmission range some other trans receiver module can be used such that the data is not lost in the way. An application such as underwater monitoring requires a radio with long range.

Power Consumption

The system designed by us primarily monitors the motion in a prohibited environment. To save significant amount of power the data can be collected at proper time intervals which will automatically reduce the power consumed.

The Power consumed by the slave nodes is quite high keeping in mind that it is a battery-powered system. The world is now leading towards miniaturization of devices which will obviously require small power resources. Thus, it is of utmost importance to lower down the levels of power consumption. The use of low power devices like LMC6464 micro-power op-amp, consuming only around 20uA current per amplifier, is advised. A very low power instrumentation amplifier can be implemented with three of the four amplifiers on the LMC6464 and it is suggested that this should be tried. There should be proper power management for the features present on the micro-controller and Trans receivers and the possible sharing of crystal between Trans receiver should be done.

PC Software

The coding of this system is done in C language however this type of coding is a bit slower and a little power consuming when compared to writing a program in assembler language. An assembler level language is even faster when compared to the high level language almost 2-29 times faster More functionality can be added to this system such as if the slave sensor starts transmission only if it gets a certain character to start transmission.

7.3 Applications

Military Applications

- To monitor the environment for any kind of friendly man force or arms.
- Monitoring the battlefield
- Keeping a check on the external opposing army approaching towards personal territory.
- Targeting
- To assess any kind of damage caused due to warfare.
- The system offers analyzing any kind of biological or nuclear attack.

Environmental Applications

- This project is helpful in monitoring fire in forests.
- Bio-complexity mapping of environment
- Flood detection
- To find lands most suitable to agriculture
- To measure the extent up to which Air and water pollution exists in the world.

Health Applications

- Tele monitoring of human physiological data

- To track the movement of any person inside a hospital.
- To keep a check on the drug quantity in a hospital

Home and Office Applications

- Making Homes and offices completely automated
- Intelligent environment which includes automatic turning on of an A.C. when we are about to reach home.

Automotive Applications

- In automotive parts lots of concealed wiring is required. This project aims to reduce the concept of wiring
- Sensing of data can be done for moving parts
- Easy testing of vehicles
- The conditions can be easily measured even at the smallest parts

Other Commercial Applications

- Environmental control in office buildings
- Interactive museums
- Detecting and monitoring car thefts
- Managing inventory control
- Ease of tracking of vehicles increases with this system

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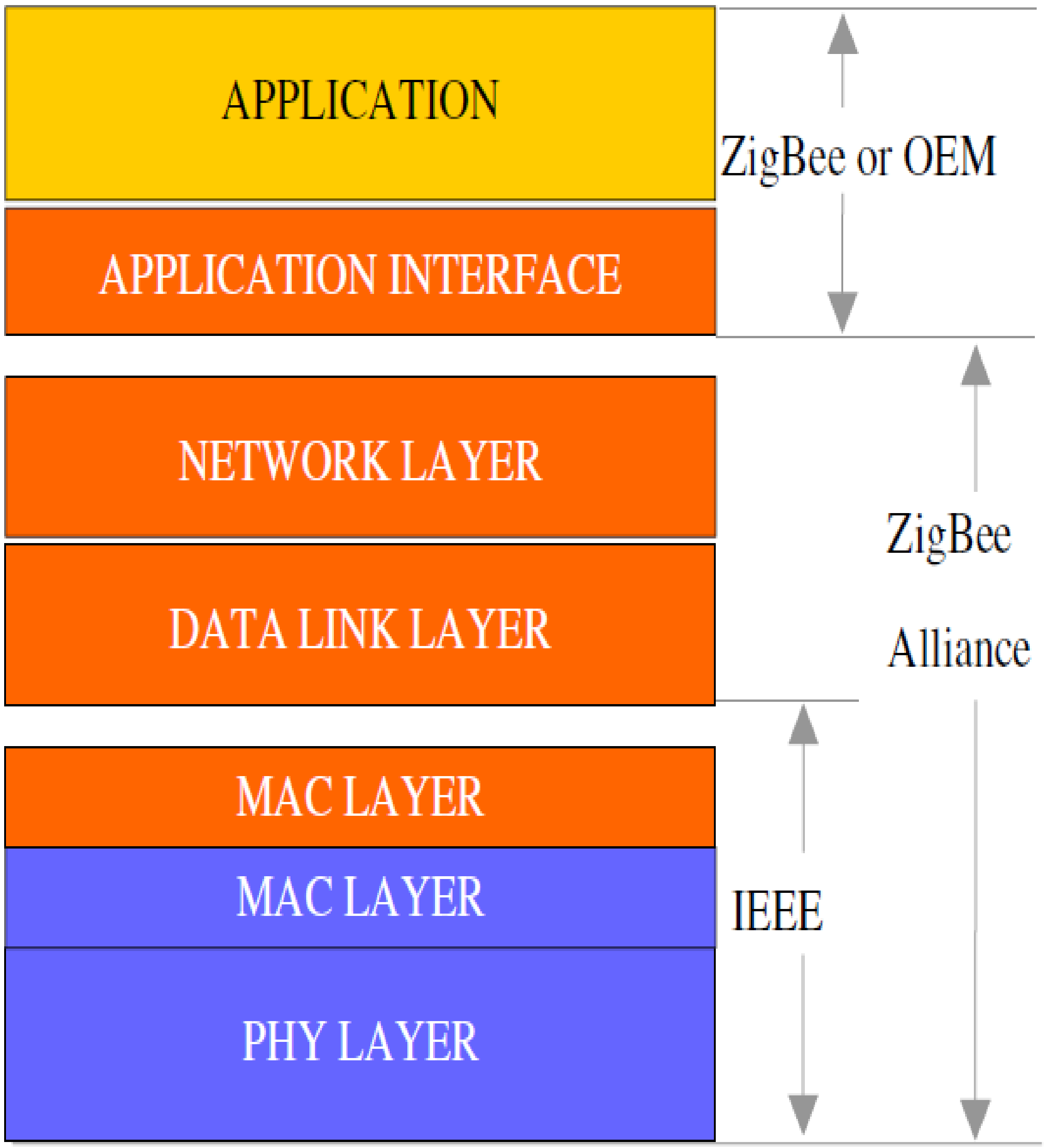
Appendix 1

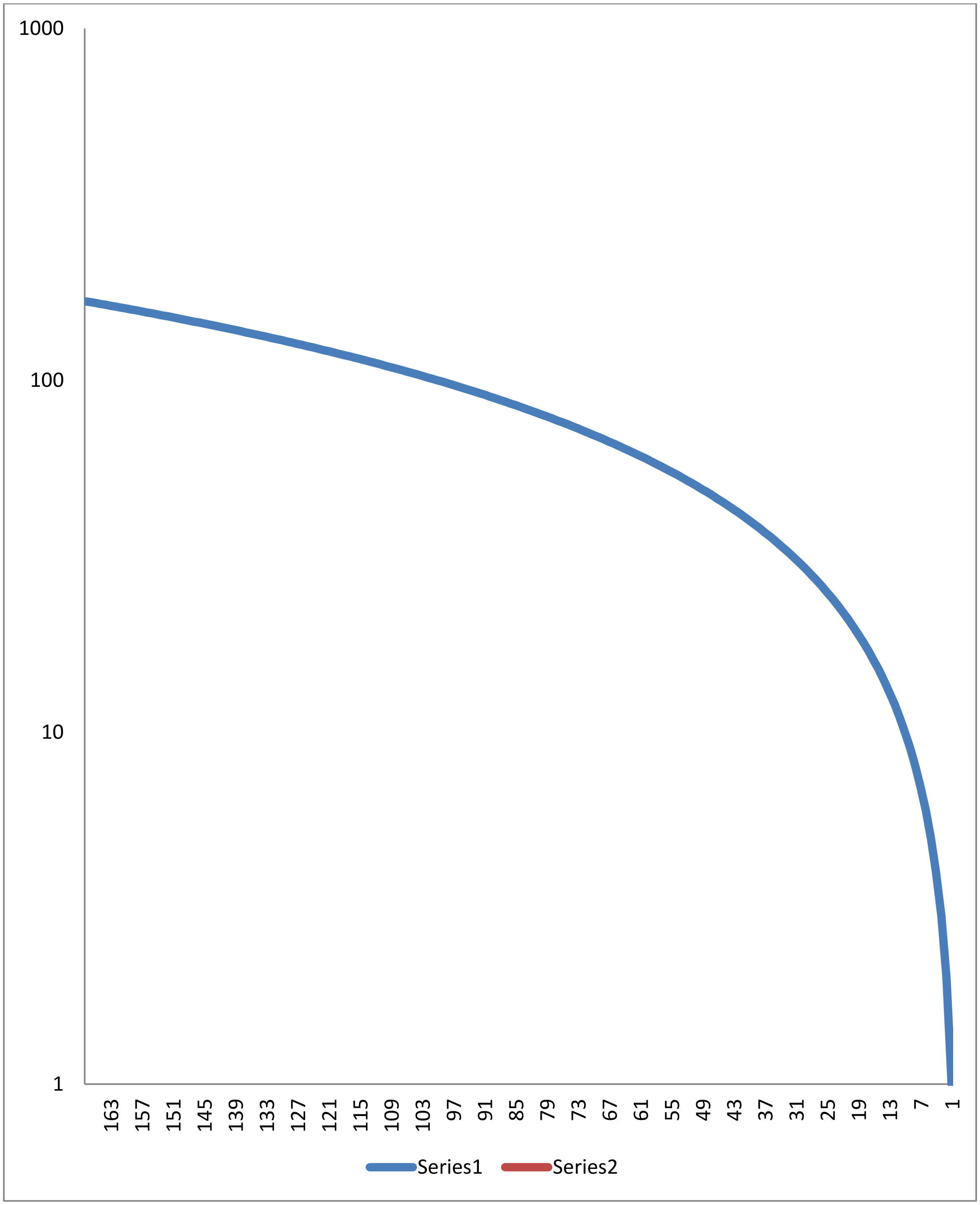
The Sample Code of LDR Sensor Node

```
#include <avr/io.h>
#include <avr/interrupt.h>
#include <util/delay.h>
#include <stdlib.h>
#include "ADC.h"
#include "UART.h"
#include "lcd.h"
#include "lcd_broke_char_send.h"

int main(void)
{
     DDRB=0xff;
     DDRC=0x00;
     unsignedint a=0;
     int temp;
     _delay_ms(50);
     InitADC();
     _delay_ms(50);
     UART_int();
     lcd_init();
while(1)
    {
          a=ReadADC(0);
          temp = a;
          lcd_clear();
          _delay_ms(100);
          lcd_to_number(temp);
          send(temp);
          _delay_ms(400);

    }
}
```

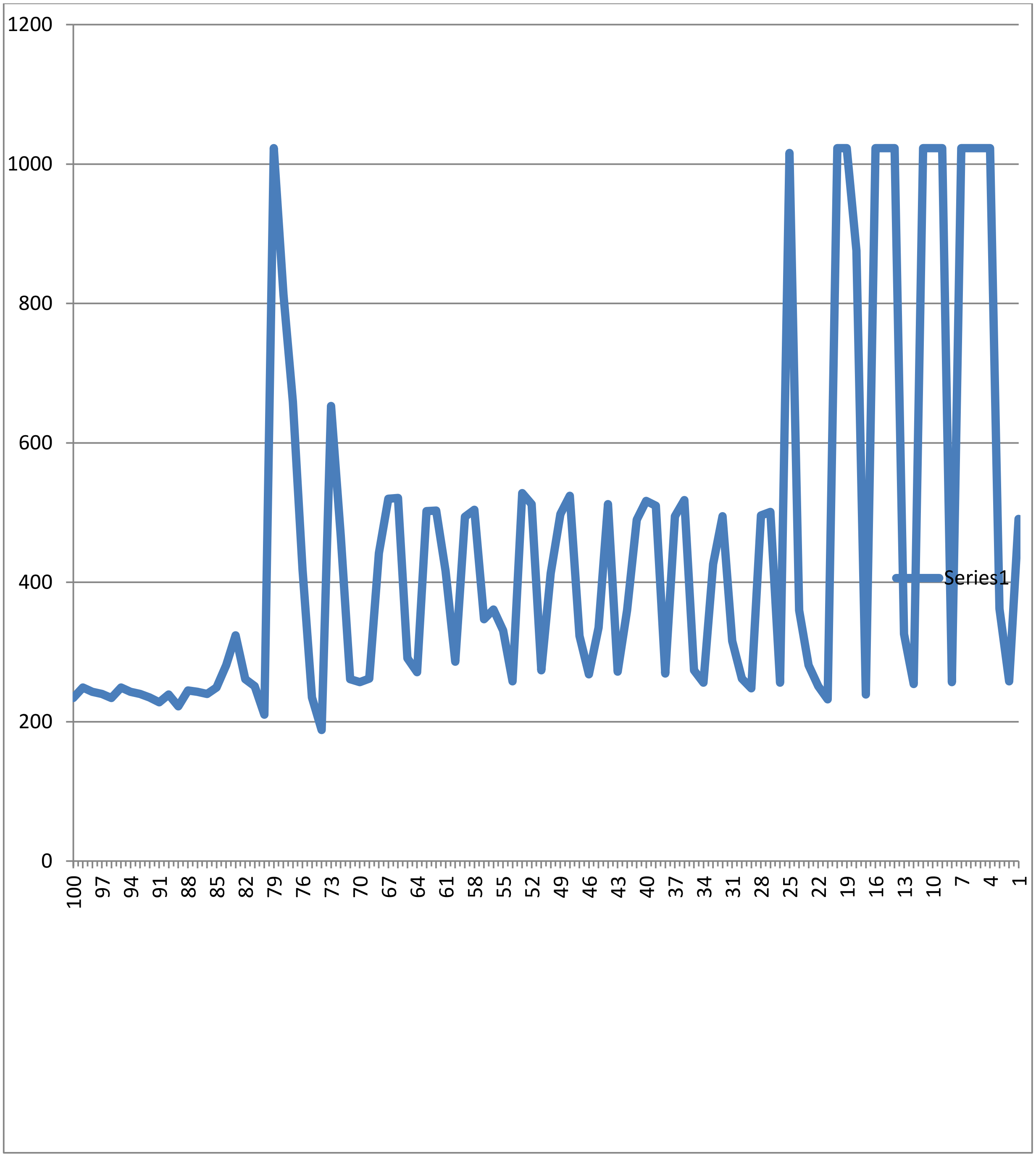
Appendix 2


APPLICATION
APPLICATION INTERFACE
NETWORK LAYER
DATA LINK LAYER
MAC LAYER
MAC LAYER
PHY LAYER
ZigBee or OEM
ZigBee
Alliance
IEEE

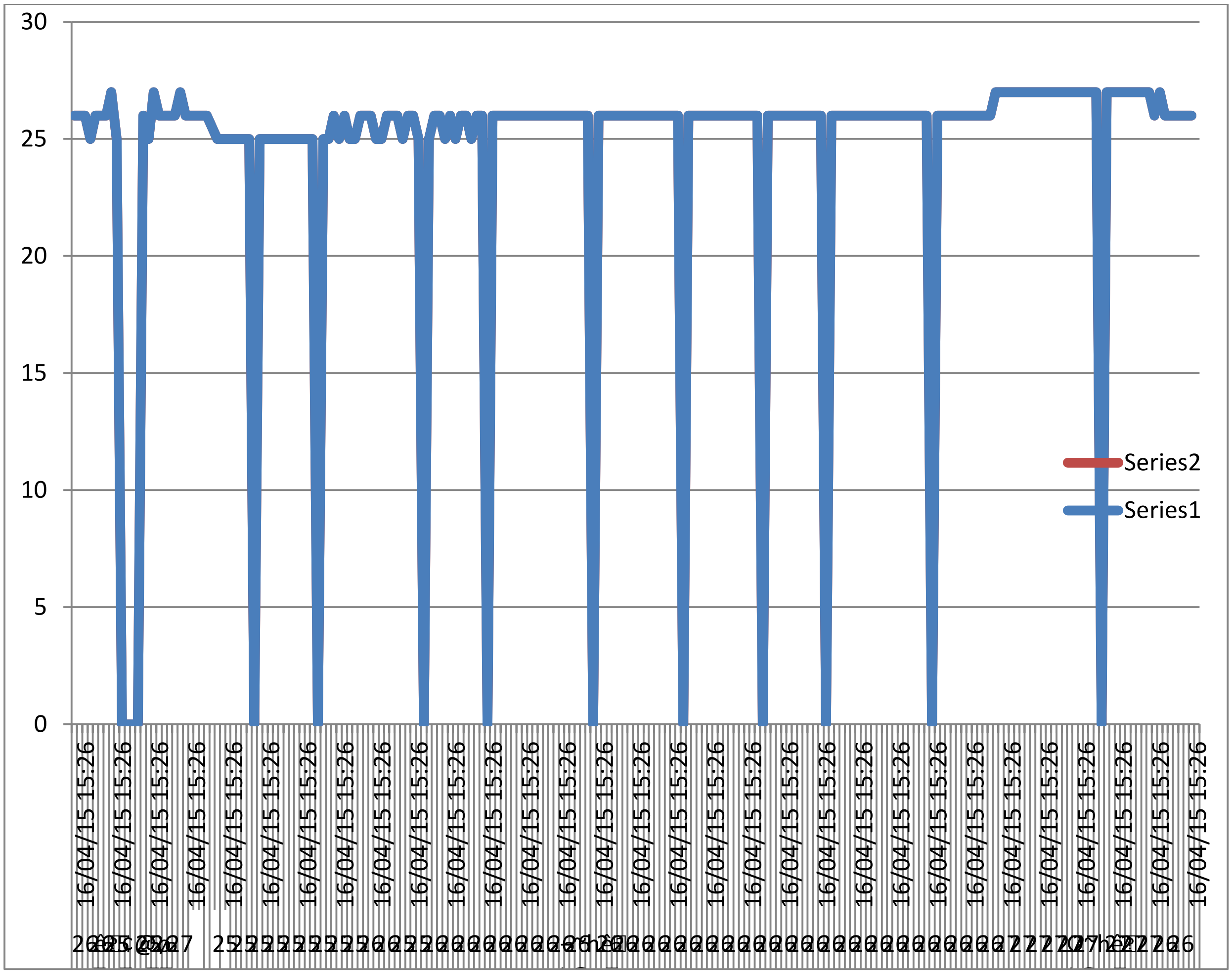
Appendix-3



A.fig. 3.1:- Graph plot of Smoke Detector senor’s data



A.fig. 3.2:- Graph plot of LDR senor's data



A.fig. 3.3:- Graph plot of Temperature Sensor's data