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A Wireless Sensor Network for Cargo Chain Monitoring

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Abstract

The Global trade is strongly growing nowadays due to globalization. The use of containers has significantly increased and bringing the change in the shape of the world economy. Monitoring every single container is a big challenge for port industries. This paper describes the cargo monitoring system based on WSN. It describes the data storage method,cargo tracking system along with the temperature and gas sensors to improve the shipping of goods without being damaged. The temperature of a cargo container is monitors and if it increases the threshold value, automatically a signal will be generated and it will be stored in a memory card. Through zigbee the present location will also be transmitted and we are using an RF that is used to detect the border of any country, if the border is crossed it will be indicated in the LCD and transmitted through zigbee. The presentlocation and container details will be transmitted at each interval.

Index terms – Cold Chain, WSN,Sensor node.

I. INTRODUCTION

Wireless technology has expanded the limits of our world. Through this innovation, people have been given freedom to work away from their desks or even outside. The new found freedom that people are beginning to enjoy with their computers has started making the world of technology and nature blend. WSN are the next stage of this technology. Although a new technology, the applications have been varied and promise to be even more varied. These networks are collections of small devices, known as nodes, with limited computational power.

Wireless Sensor Networks have been used to enable better data collection in scientific studies, create effective strategic military defences, pinpoint the origin of a gunshot, and monitor factory machinery. All of these uses depend on the ability to collect data such as vibration, moisture, temperature, and more, as well as the ability to communicate with each other.

A wireless sensor network (WSN) is a combination of various autonomous sensors to measure temperature, sound, pressure, etc. and these data are transferred through a network in a single location. The modern networks are bi-directional and enables control of sensor activity.

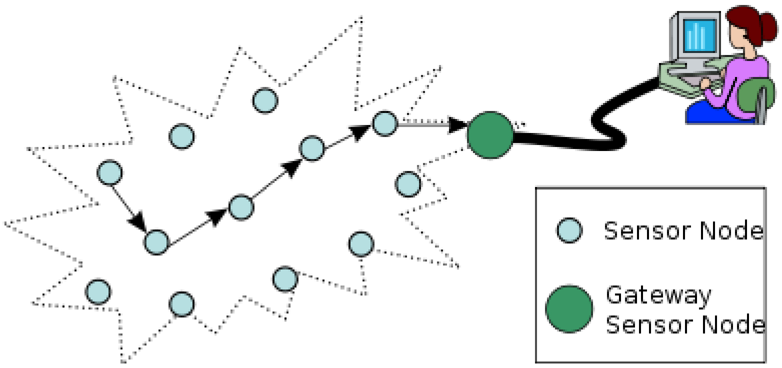

Fig1.1 working of WSN

The WSN is built of few to several hundreds or even thousands of "nodes". All nodes are connected to one or more sensors. Every sensor network node has different parts like a radio transceiver with an internal antenna, connection to an external antenna or a microcontroller or an electronic circuit for interfacing with the sensors and an energy source such as battery or a consolidated form of energy harvesting. Past uses and potential applications will be touched upon briefly to further illustrate the faculty of these machines. The introduction of these collections of computing devices has brought forth changes in factory safety, data collection, and military.

The scope of the work is to provide the security for companies while shipping cargo containers from practical issues like misuse of the operator's information to endanger supply chains, tampering with goods, and unauthorized access or entry of vehicle, persons or goods to the premises and/or close to the loading and shipping area, incomplete control over the flow of goods and the scope for maintaining higher security levels will be carried out in different stages.

II. RELATED WORKS

In thissections, some of the existing works related to Wireless Sensor Networks (WSN) are provided. Valentina Casola et al(2002) proposed in his paper that the main advantage of WSN is that it can monitor freight train transporting hazardous materials and the sensors can interact through security platforms in order to share different information.

L. Ruiz-Garcia et al (2007) provided that perishable food items that can lose water and condenses eventually due to weather conditions are monitored with the deployment of temperature and humidity sensors in the WSN architecture and proved that it will improve the food condition while transportation.

Joseph Polastre et al(2002) made a study of sensor data for predicting system operation and network failures. Myo Min Aung et al(2012) explained about Quality monitoring and dynamic pricing based on temperature measurement.

A. Problem description

Monitoring with the help of temperature sensor alone will not help in quality monitoring, as the humidity also plays an important role in perishing the food item. Humidity sensor also must be included for better monitoring of the food items until it reaches the customer.

1. While monitoring habitat the computer scientist must work closely with biologists to create a system that produces useful data leveraging sensor network research for robustness and predictable operation, if that's not done then there might be lack of accuracy in the reading of the values.
2. As the door opening and closing is not being monitored so if in any case the door has been kept open for long duration of time then there is increase in temperature which will ultimately result in degradation of fruits and vegetables, causing loss of economy.
3. Very few parameters have been used to monitor the freight train which could lack in protection of the objects used. For example, if any gaseous material is being transported then there should be installation of gas sensor on the hardware board.

B. *Performance Improvement:*

The performance of the system can be improved by the implementation of advanced network topologies, such as point-to-multipoint, peer-to-peer and mesh, improving the reliability and robustness of the system.For every component (sensors, microcontrollers and radiofrequency devices) performance optimization is important to consume less power as possible while still meeting the requirements of the application in terms of data throughput, latency and reliabilityas possible while still meeting the requirements of the application in terms of data throughput, latency and reliability

Many kinds of products have to be handled under controlled environmental quantities, such as temperature, humidity, vibrations, and exposure to light. Among these parameters, the temperature is usually a major concern due to its huge variety of effects. For example, if the temperature of some chilled foods exceeds specific limits, a great decrease in quality and increase in the risk of food poisoning.

The limits can be quite strict for chilled products with a storage temperature near 0 ◦C, where a rise in temperature of just a few degrees could cause microbial growth.The situation is more serious in the case of pharmaceutical products since an uncontrolled change in the temperature,even for short time intervals, could cancel the effectiveness of the product or even make it dangerous.The chain that brings the temperature-sensitive products from the factory to the consumer through an uninterrupted series of steps under a controlled temperature is usually known as cold chain.The goods follow complex logistic paths along cold chain,and the final distribution often requires the use of refrigerated vehicles.

The temperature is easily controlled and monitored in the factories. The refrigerated vehicles have crucial point in the whole chain since the products may undergo transient conditions during the loading operations or even during the whole transport process with great risk to the integrity of the goods. Some thermal requirements have to satisfy by the refrigerated vehicles, which are mainly related to the insulation and refrigeration capabilities. Product integrity assurance is not there because of the Unpredictable conditions that may occur during the transportation and that could cause a significant change in the product temperature. To verifying the real integrity of the coldchain consists of monitoring the temperature of the products during their distribution.

However, this task is not simple since the products are often packed in small containers that cannot individually be monitored due to both the cost and the logistical problems. In this paper, the problems related to cold chain assurance and propose a measuring system that is suitable for this task is analysed.

C. Measurement Issues

Most delivery companies transport temperature-sensitive goods by using specialized vehicles, such as adiabatic boxes, and by monitoring air temperature inside these vehicles by means of either data loggers or smart sensors. Unfortunately, in the presence of perturbations, air temperature is not representative of all the products due to the temperature gradients within the vehicle and the different thermal behaviour of the different goods, which is related to their nature and packing.

D. Limitations

An effective monitoring could, therefore, be performed by taking such phenomena into account by using a suitable thermal model.

Alternative way of monitoring the cold-chain integrity consists of measuring the temperature of the delivered products, although a series of constraints has to be taken into account.

1. The measuring system cannot make use of wires since each sensor should be able to move independent of the others and the system itself should not interfere with the distribution process.
2. Each sensor has to meet the requirements imposed by the local regulations in terms of uncertainty and resolution .Each sensor has to be cheap, thus making the recovery of the sensors unnecessary.
3. The measuring system has to be able to manage a dynamic configuration of the sensors since some monitored products can be unloaded from the vehicle during the delivery.
4. The measuring system must be able to quickly estimate the status of the cold chain, highlighting whether the chain is at risk or has been compromised.

Such constraints have stimulated to consider that one solution for the considered problem could be the employment of a wireless sensor network (WSN), which employs sensor nodes that are configured to monitor the temperature of the delivered products.

III. CARGO CHAIN MONITORING SYSTEM

The progress in machine-to-machine communication technique and wireless sensor networks provides a differentiating factor for companies.From the starting point to the destination pointthe cargo can be located and tracked and can also measure its transportation conditions throughout the entire journey. The presence of large amount of moisture in the container and the goods are opened along the journey and there should be variations in temperature,knowledge about how, where, and when it occurred.

A wireless sensor network consists of various autonomous sensors to measure temperature, sound, pressure, etc. The data is passed together to the main location. The modern networks are bi-directional, and it enables the control of sensor activity.

A. Aim of the proposed system

The purpose of the proposed system is to provide the security for companies while shipping cargo containers from practical issues like tampering with goods, shipping goods to the customer without being damaged. Keeping away the unwanted materials from the gaseous material is one more issue to look at, which might cause explosion after coming in contact with that gaseous material, so for that gas sensor is included which will detect the presence of gases around and trigger a message to the operator in charge, reacting to which, will keep the ship safe from explosion.

It also provides provide security for companies while shipping cargo containers from practical issues like misuse of the operator’s information to endanger supply chains, tampering with goods, and unauthorized access or entry of vehicle, persons or goods to the premises and/or close to the loading and shipping area, incomplete control over the flow of goods and the scope for maintaining higher security levels will be carried out in different stages.

B. Hardware Implementation

The block diagram indicates the hardware implementation of base station (Fig 3.1),node 1 (Fig 3.2) and node 2 (Fig 3.3) is provided below.

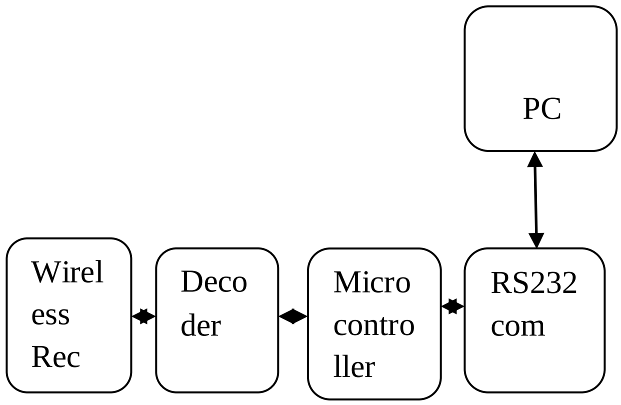

Fig 3.1 Base Station

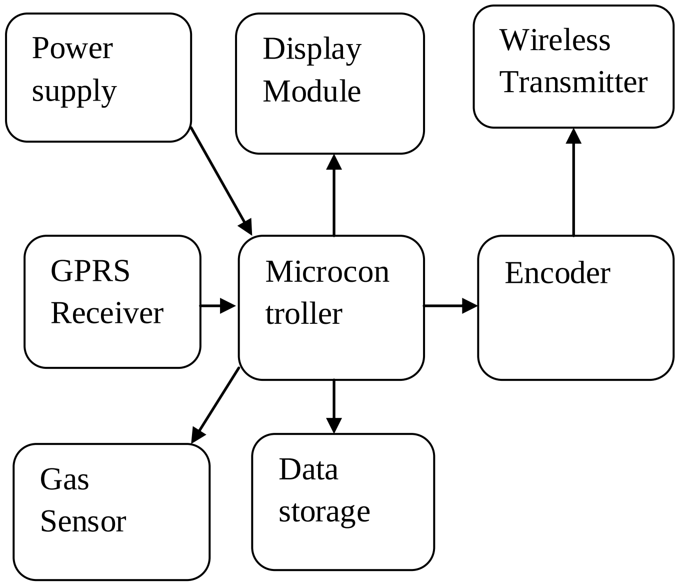

Fig 3.2 Node 1

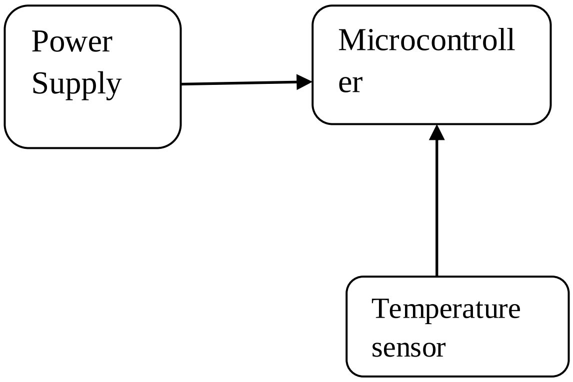

Fig 3.3 Node 2

Node 1 contains Power supply,GPRSunit,Gas sensor,data storage,Microcontroller,Display,Wirelesstransmitter and Encoder unit.The main function of Node 1 is to sense the gaseous level inside the container as well as the present location of the cargo container.

Node 2 contains Power supply,Microcontroller and temperature sensor.It is used to detect the temperature inside the container.

C. Circuit Description

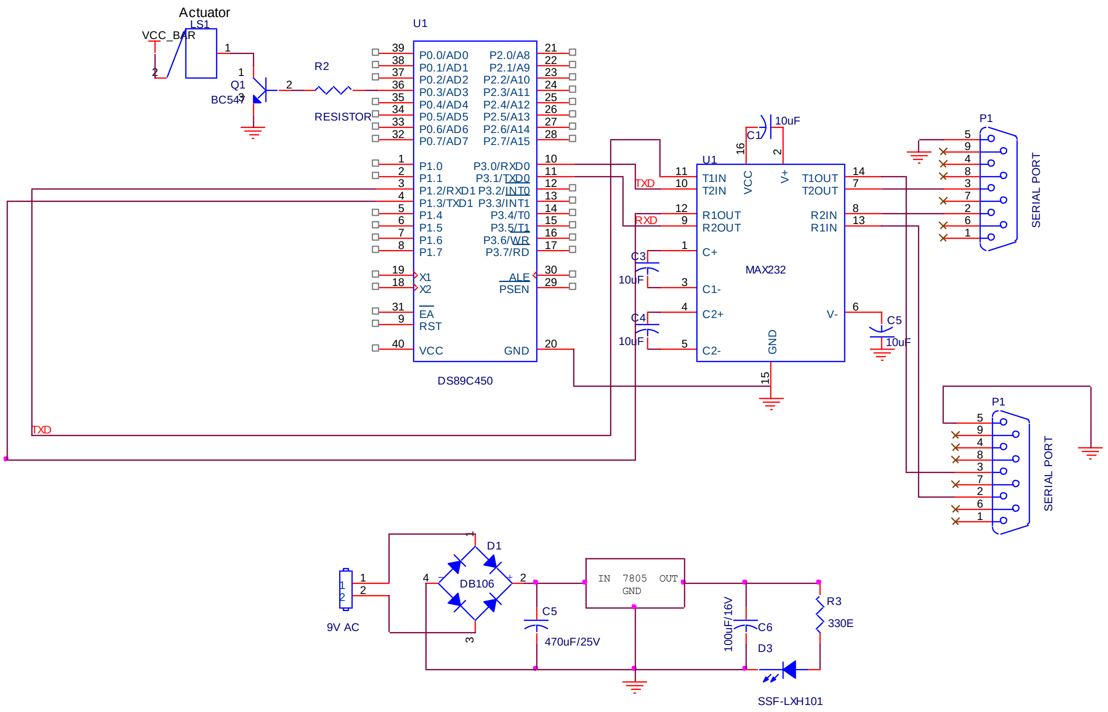

Fig 3.4 circuit diagram

1) Power Supply Unit:

The transformer steps down the 220v AC voltage to the desired dc voltage output .The rectifier gives arectified voltage that is initially filtered by a simple capacitor filter to produce a DC voltage. This resulting dc voltage usually some ripple or AC voltage variation.

2) Microcontroller Unit:

It contains four ports(0-3).In this port 0 is an external port and other three ports are internal ports. The devices like motor, alarm devices etc. are connected to the port 0.

3) Serial communication unit:

The serial communication unit contains MAX 232 IC and two serial ports. One serial port connects the GSM module and another port connects the GPS module.

In Serial communication the one bit data is transmitted and received simultaneously.The function of serial port is the conversion of byte to stream of ones and zeros and vice versa.Universal Asynchronous Receiver/Transmitter (UART) is present in the serial port.

4) Bridge rectifier:

Bridge rectifier consists of four individual diodes D1, D2, D3 and D4.During the positive half cycle the diodes D1 and D4 are forward biased and the diodes D2 and D3 are reverse biased. The current flows through load resistor.

During the negative half cycle the diodes D2and D3 are forward biased and the diodes D1 and D4 are reverse biased. The current flows through the load resistor.

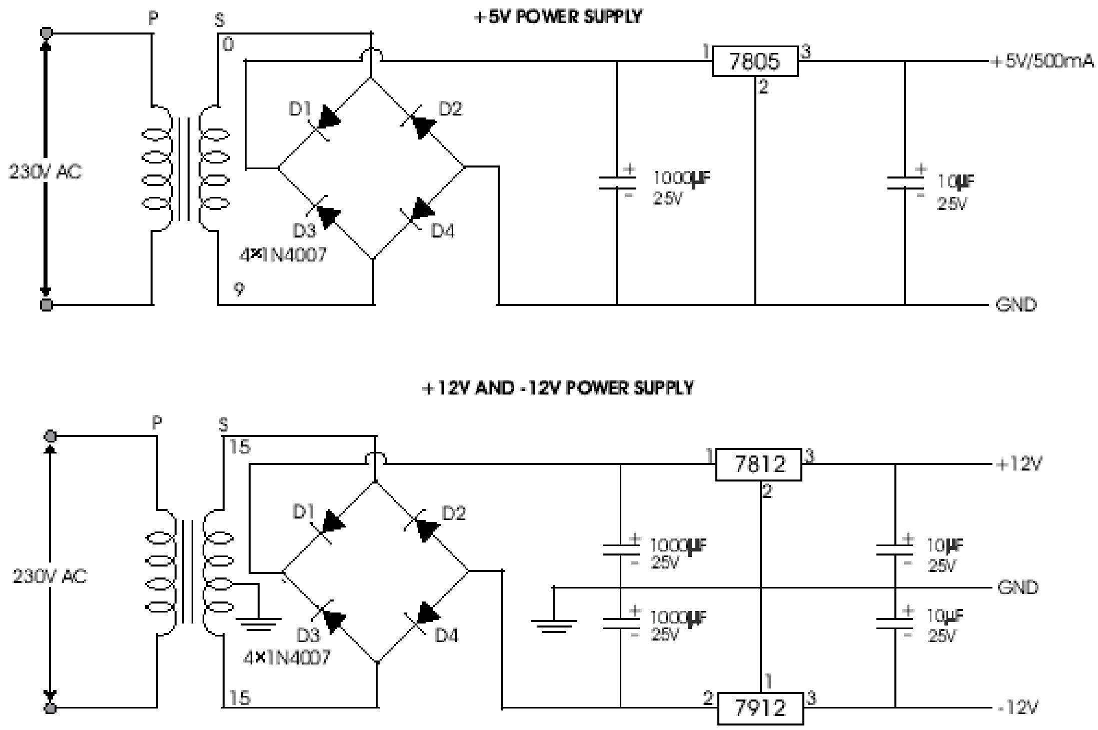

Fig.3.5. Circuit Diagram of Power Supply

During both half cycles of the applied voltage the current flows through the load resistor.So this bridge rectifier is known as a full-wave rectifier.

The advantages of a bridge rectifier is

1) When comparing with conventional full wave rectifier it produces twice the voltage
2) It does not require centre tapped transformer

H. ICVoltage regulator:
Regulator IC contains different units like reference source, comparator amplifier, and control device in a single IC. It provide regulation to a fixed positive voltage or negative voltage or to an adjustable voltage. The regulator operating current is ranging from 100mA to 10A.Corresponding power ratings from milli watts to tens of watts.

IV. GPS Module:
The Global Positioning System (GPS) consists of three units:
- The space segment
- The control segment
- The user segment

A. Space segment:
It consists of 28 operational satellites revolving around the Earth on 6 different Orbital planes. Any one satellite completes its orbit in around 12 hours. A satellite will be at its initial starting position after 24 hours approximately because of Earth’s rotation.

B. Control segments:
It consists of a Master Control Station. It has five monitor stations and three ground control stations.

The most important functions of the control segment are:
- To measure the movement of the satellites and compute the orbital data
- Observe the satellite clocks and intimate their behavior
- Provide synchronization to on board satellite time
- To relay the approximate orbital data of all satellites
- To convey other informations like satellite health, clock errors etc.

C. User segment:
The transmitted signals will reach the receiver nearly within 67 milli seconds.The transit time depends on the distance between the satellites and the user. In the receiver four different signals are generated. It has the same structure as those received from the 4 satellites.

V. SOFTWARE TOOLS USED FOR DEVELOPING THE SYSTEM.
A. *Keil C*:
Keil C is one of the high level language used for 8051 compilation.When compared with other compilers it is very efficient.Once we know about the 8085 assembly language instructions we can write easily program in Keil C.

B. ***Flash magic:***

Entry into the ISP mode microcontroller devices can be controlled by Flash Magic. It is done by the usage of COM port handshaking signals to control the device.The pins like Reset, PSEN and VCC etc are controlled by handshaking signals

C. ***Orcad:***

Orcad is a design tool for electronic circuit design.Capture is used for design circuit in schematic form. The tool for designing the physical layout of components and circuits on a Printed circuit board is Layout. The design flow diagram is given below:

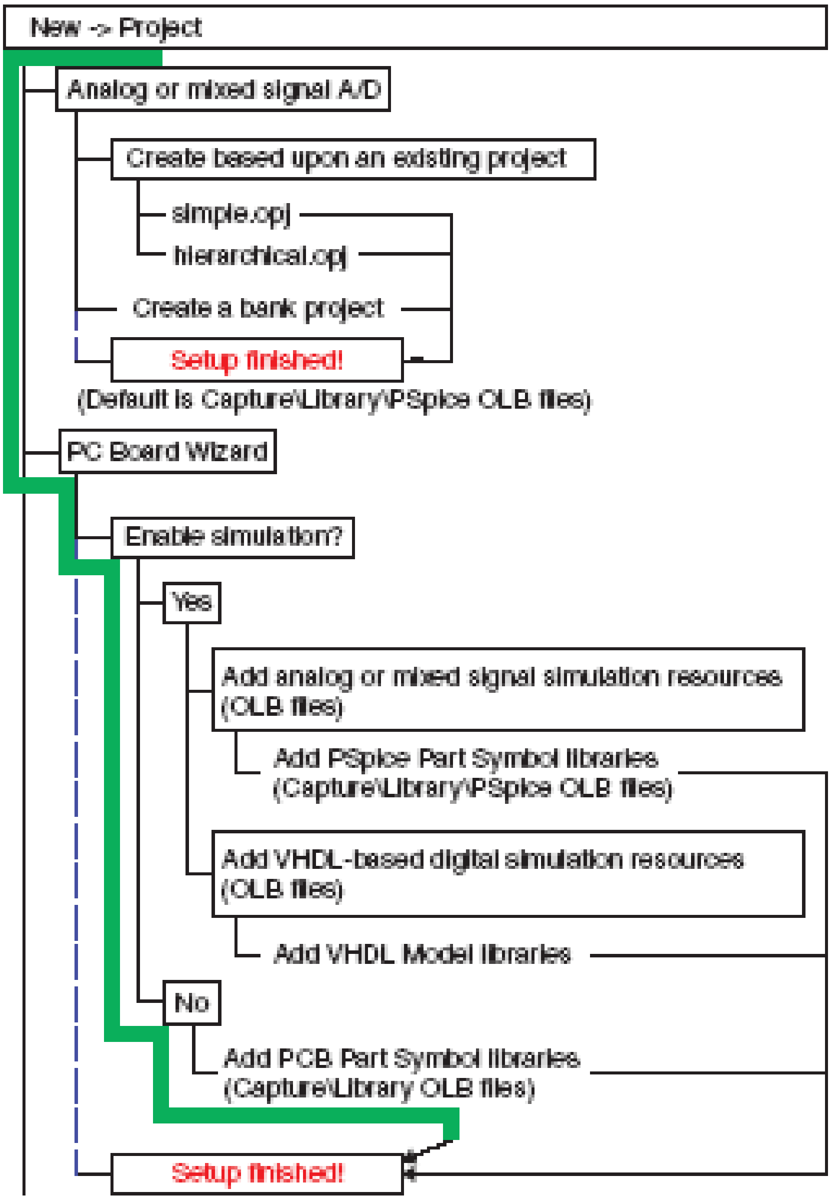

Fig 4.2Orcad design

D. EMBEDDED PRODUCT DEVELOPMENT LIFE CYCLE

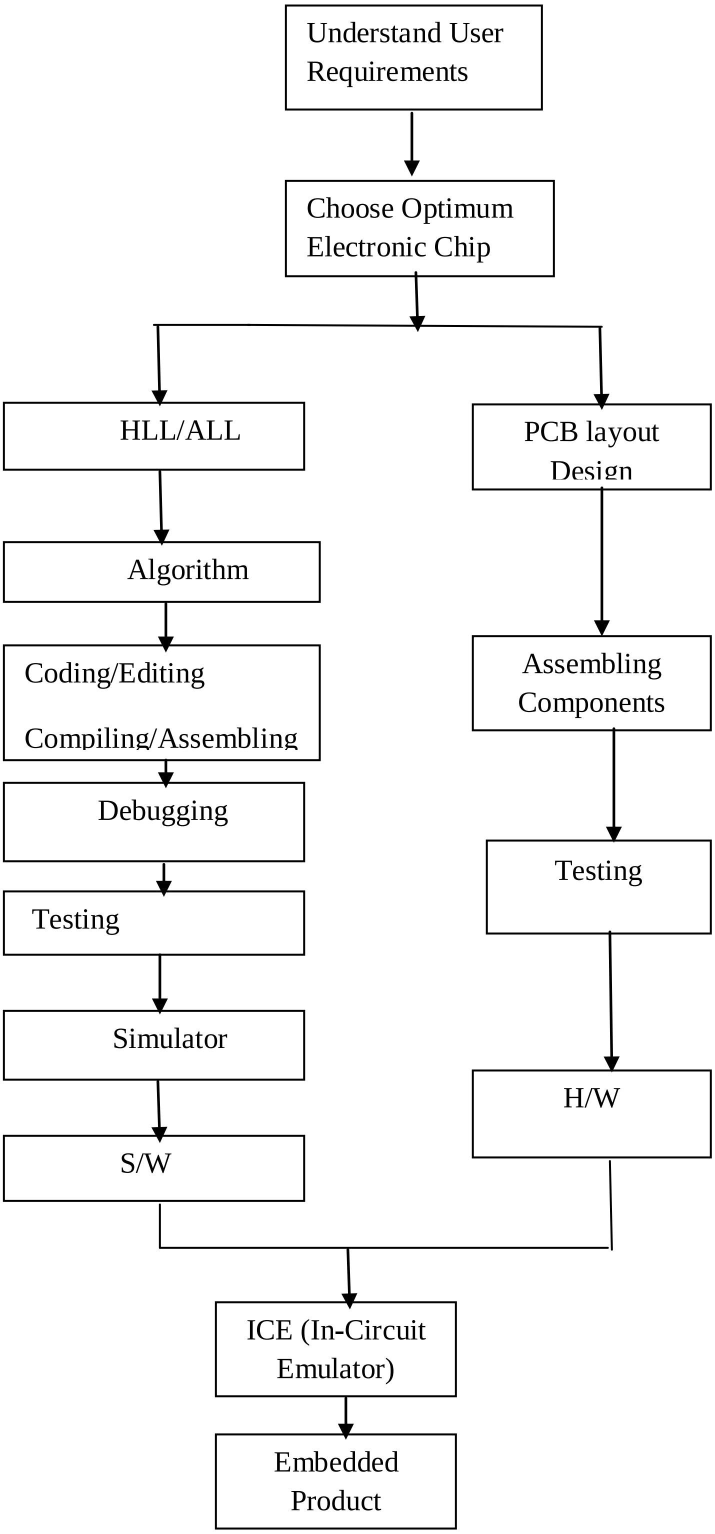

Fig 4.3Embedded Product Development Life Cycle

V. RESULT ANALYSIS

A. PerformanceAnalysis

When the proposed architecture was put for tests at various levels, it showed different results. The results were obtained under diverse circumstances. Some of the tests that were performed are listed below. Preliminary tests were performed to test the effectiveness of the system.

B. Device Characterization

When all the devices are set in position, power supply is given to them. To check whether all the devices are properly functioning, base station i.e., the zigbee module is connected with pc at one end. The other two zigbees are kept at different position where signal can be reached, and then by opening micro c software in the system we can find that all the devices are functioning properly by sending message to each other at different time intervals. The base station zigbee receives the messages from the other two zigbees that are kept at other locations. Now to check GPS system, we kept the GPS module outside the window for better signal strength after which we obtained the longitude and latitude values of that particular location.

While measuring the temperature of food items the environment plays a major role in it, because when an item is kept in the refrigerator and sudden change in climate might cause the temperature to rise or to drop, other than that there will also be change in humidity level which is a big cause for concern.

C. Report Analysis

We have taken some of the working screen shots of the system to get to know that system is working well. Not only that but also we have included few results to display, these are shown in the figure below , in which one of the windowshows the device functioning and other displays few results.Advantages of WSN for cargo operations are

- Continuous tracking of goods throughout the transportation chain.
- Monitoring of unexpected container openings.
- Observing of transport conditions.
- Detection of storage incompatibilities.

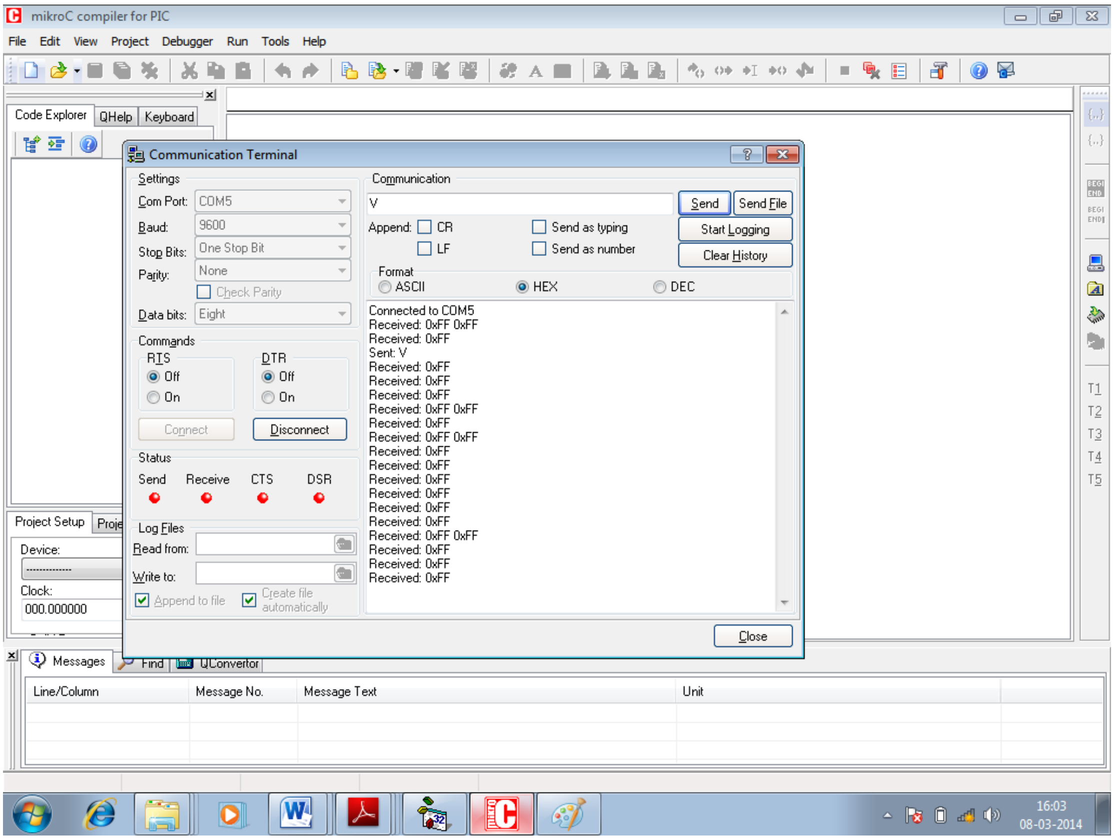

Fig.5.1 Devicetesting

Cold-chain problems have been discussed in this paper, and a measuring system that is conceived for the monitoring of the temperature-sensitive products during their distribution has been proposed. This system, which is essentially a WSN, consists of a base station and several nodes that are able to carry out measurements of the air and the temperature inside the monitored products; the measuring nodes receive the configuration commands and send the acquired data to the base station through an RF communication channel. The scope of this project is far more than we think, as there is a great potential for growth in this region. Our future work could include some more modifications and this will help the cargo chain owners to transport the goods more safely and without being damaged from unexpected errors.

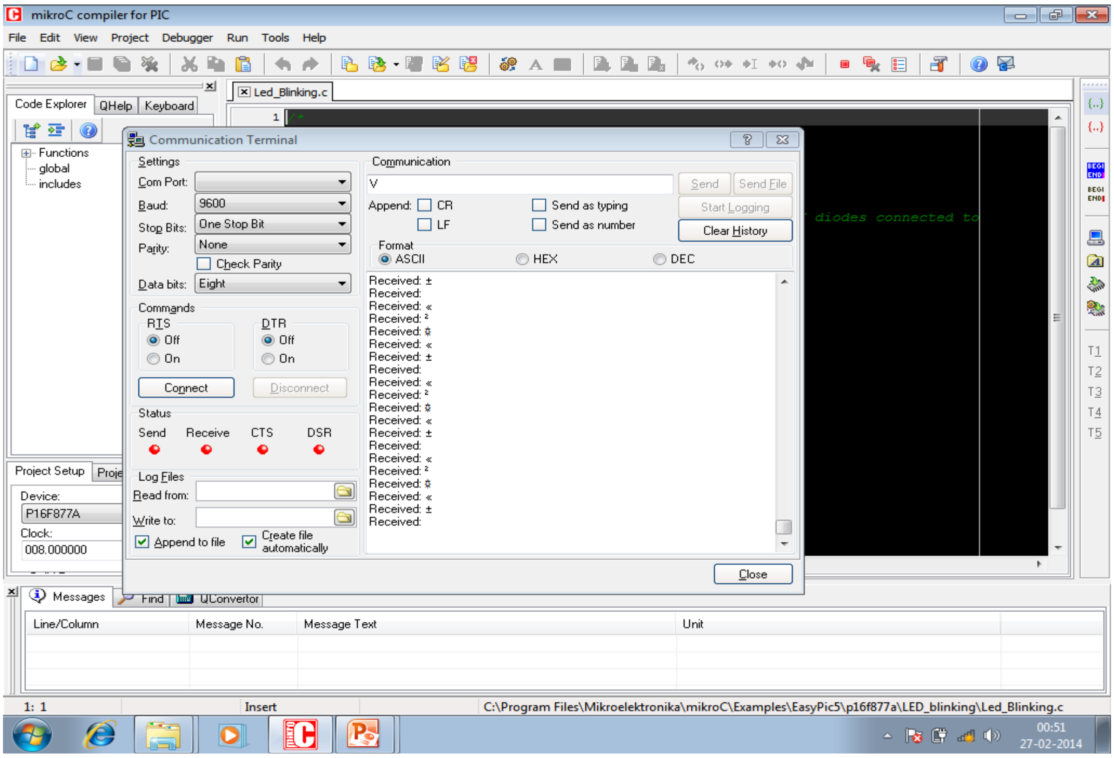

Fig.5.2 mikroC compiler output for PIC

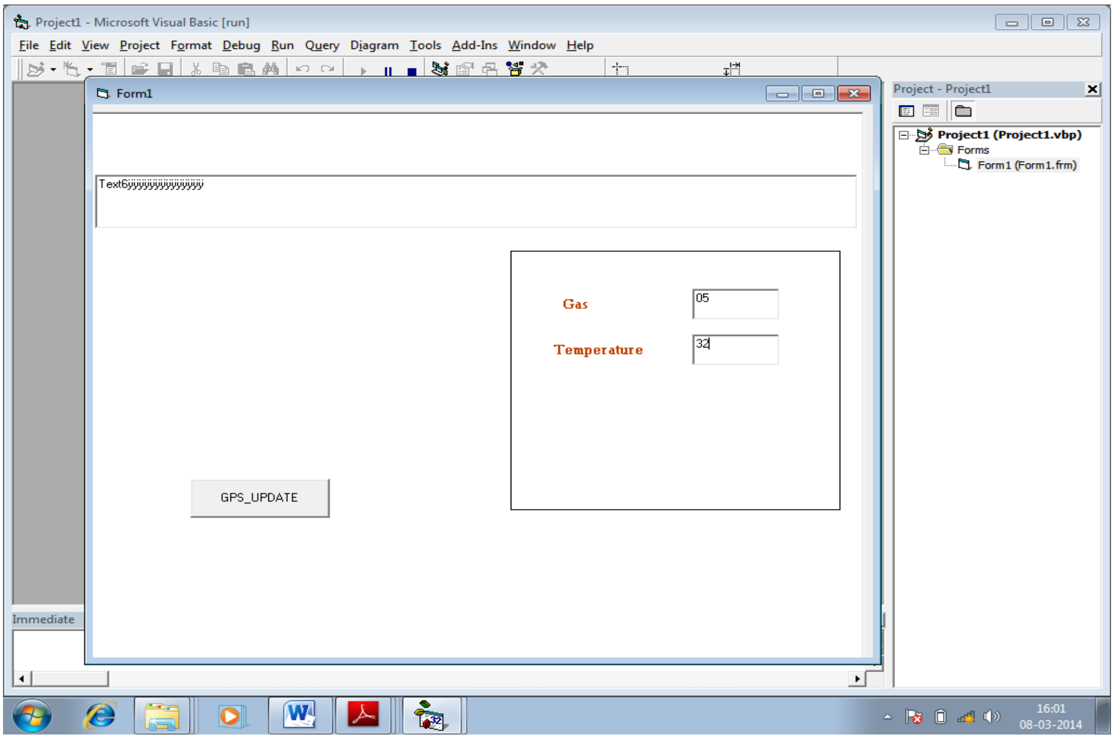

Fig.5.3Resultwindow

VI. CONCLUSION

This paperhelped has to gain knowledge about the WSN networks and how theycanbeuseful for cargo tracking system, alsowelearned about the variousins and outs about the fleet management system whichhelped us to solvesome of the issues faced by them. Finally, wecanconcludethat in cargo industries while transportation, consideringthatwe have to shipsome of the items which are to bedealtwith the measurement of temperature and some explosive materialssuch as gases are to bekeptawayfromsome of the unwantedmaterials are monitored by our system. Our system isdesigned to do all thistaskefficiently and providebetter solutions to the cargo industries whichwill help themlowermanpower and increase the economy of the industries. This data permitsproducers, packinghouseoperators, and commercial cooleroperators to improve post harvestcooling and storage conditions for freshproducts.Itfeatures the possibility to correct cold chainundesirable situations, like high temperatures and lowmoisturelevels.

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