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Home Security using Embedded Controlled Sensor Network

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Abstract —This Embedded controlled detector network is that the technology needs to implement environmental solutions effectively. Many researchers are creating makes an attempt to develop the embedded controlled device network. ARM primarily based microcontroller and wireless sensors want to management the assorted devices and to watch the knowledge concerning the atmosphere exploitation. In the proposed system ARM based microcontroller and wireless sensors are used to control the various devices and to monitor the information regarding the environment using Zigbee and GSM technologies.

Keywords- **ARM7micro-controller, Home security, GSM modem, wireless sensor network, zigbee.**

I. INTRODUCTION

1.1 General

Environment monitoring and device control allows new level of comfort in homes and it can also manage the energy consumption efficiently which in turns promotes the saving. Remote controlling of the devices offers many advantages to senior citizens and people with disabilities which helps them in being more autonomous and increasing quality of life. In addition to remote control, monitoring carbon dioxide, LPG gas leakage and fire detection in homes is also a major concern. There is a drastic increase use of vehicles in these days which produce carbon dioxide and loud noise this affected the human health. Considering the sensitivity of fire accidents, the Bureau has also collected data on fire accidents according to places of occurrence. A total of 20,377 cases of fire accidents were reported in the country during 2014, which caused 1,889 persons injured and 19,513 deaths. The cause-wise analysis of fire accidents revealed that 18.3% of 20,377 fire accidents were reported in residential/dwelling buildings. The aim of this project is to protect people and property by generating an alarm earlier by sensing the environmental conditions.

1.2 Effect of carbon dioxide on human health

The low and high level of carbon dioxide in the air affects the human health.
Carbon dioxide in its gas form is an asphyxiate, which cuts off the oxygen supply for breathing, especially in confined spaces. Exposure to concentrations of 10 percent or more of carbon dioxide can cause death, unconsciousness, or convulsions. Exposure may damage a developing fetus. Exposure to lower concentrations of carbon dioxide can cause hyperventilation, vision damage, lung congestion, central nervous system injury, abrupt muscle contractions, elevated blood pressure, and shortness of breath. Exposure can also cause dizziness, headache, sweating, fatigue, numbness and tingling of extremities, memory loss, nausea, vomiting, depression, confusion, skin and eye burns, and ringing in the ears.

1.3 Effect of Harmful Noise on Human Health

Loud noise can be very damaging to hearing. Both the level of noise and the length of time you listen to the noise can put you at risk for noise-induced hearing loss. Sounds that are louder than 85 dB can cause permanent hearing loss. The hearing system can be injured not only by a loud blast or explosion but also by prolonged exposure to high noise levels. When a sudden, extremely loud sound, such as an explosion, a gunshot, or a firecracker close to

the ear, damages any of the structures in the ear and produces an immediate, severe, and often permanent hearing loss. This type of injury often requires immediate medical attention.

Loud noise can also cause other physical problems, such as:

- High blood pressure
- Increased or abnormal heart rate
- Upset stomach
- Insomnia or difficulty sleeping (even after the noise stops)

1.4 Major Causes of Fires

1.4.1 Electrical Wiring, Electrical Outlets and Faulty Wiring

Whether it's in an electrical outlet or a short in the wall, many fires are caused by electrical wiring. Older homes are particularly susceptible, as they were not wired for the many, many appliances that we have filled our homes with. Many homes that were built in the 50′s -70′s have aluminum wiring that gets very hot and increases the chance of fire.

1.4.2 Appliances

Lamps, toasters and even baby monitors can short out. Be particularly careful with older appliances and extension cords. Even new appliances can be the source of a home fire. To be safe, appliances should be unplugged when not in use. Unfortunately, not all appliances can be unplugged, leaving your home at risk 24 hours a day.

1.4.3 Heating

Heating is another major cause of residential fire deaths. This is especially true in southeastern states and among wood stove users in the north.

1.5 Harmful Effects of LPG Leakage on Humans

LPG is a highly combustible substance and quickly forms explosive air - hydrocarbon mixture when subjected to atmospheric conditions. Since LPG has low flash point, leakages that may form can cause severe fire and/or explosions. LPG vapor is heavier than air. It can move away from its source with density difference and air movement, and accumulate in low code areas in open air, and lower floors in houses. Liquid leakages that may form in LPG systems can create combustible and explosive gas mixtures in large volumes (approximately, 1 unit volume LPG (liquid) forms 250 unit volumes of gas). LPG liquid forms cold burns when contacted with skin or eye. Inhaling of LPG vapor can cause irritation in nose and throat, headache and nausea, vomiting, dizziness and loss of consciousness. LPG vapor can cause fainting and choking in closed or poorly ventilated environments.

1.6 Overview of Wireless Technology

Wireless sensor network (WSN) is a group of sensors for monitoring and recording the physical conditions of the environment and organizing the collected data at a central location. WSNs measure environmental conditions like temperature, sound, pollution levels, humidity, wind speed and direction, pressure, etc. In the twenty first century, there is revolution of the sensor networks which have also come up with various applications like surveillance, traffic control, environmental and wildlife monitoring, agricultural application, home automation and industrial process control [1].

Embedded controlled sensor networks (ECSN) are mainly designed to be application- specific so that the minimum energy consumption is as the battery-powered nodes demand life-time of several months or even a few years. The available technologies are Bluetooth, Wi-Fi, Wi-Max, wireless mobile Ad-hoc network (WMANET), UMB, wireless HART, Bluetooth and ZigBee. Embedded sensor networks are formed by communicating over wireless links without using a fixed networked infrastructure controlled by microcontroller. Environment monitoring and device control allows new level of comfort in homes and it can also manage the energy consumption efficiently

which in turns promotes the saving. Remote controlling of the devices offers many advantages to senior citizens and people with disabilities which helps them in being more autonomous and increasing quality of life.

II. METHODOLOGY

2.1 System Architecture

The main aim of this paper is to protect people and property by generating an alarm earlier by sensing the environmental conditions. In this system, we have designed one master module which consists of arm7 microcontroller, GSM module and Zigbee module. The slave module is designed using AVR microcontroller, Zigbee module with different sensors. Slave module collects the information about different environmental parameters such as Humidity, Smoke, Carbon dioxide, Harmful noise and LPG gas concentration in air with the help of sensors. When smoke is detected or when LPG gas leakage is detected, the slave module will send encoded alarm signal to the master module through the wireless sensor network established in home. Once the master module receives alarm signal, it will send alarm short message to the house owner mobile phone through the GSM module by using AT commands and as well as control the respective devices. Here the serial communication interface UART is used for the communication between the microcontroller, GSM and zigbee module. The RS232 communication standard is used for the electrical signal characteristics such as voltage levels. This communication enables point to point data transfer. A high performance 16/32 bit microcontroller unit is used to process and store real time signal from various sensor

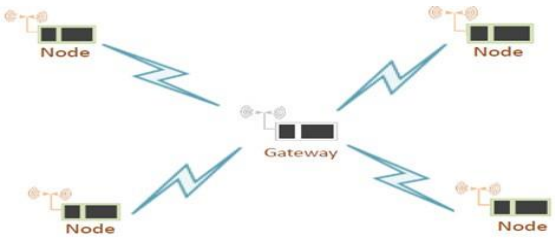

Figure 1: System Architecture

2.2 Block Diagram of the System

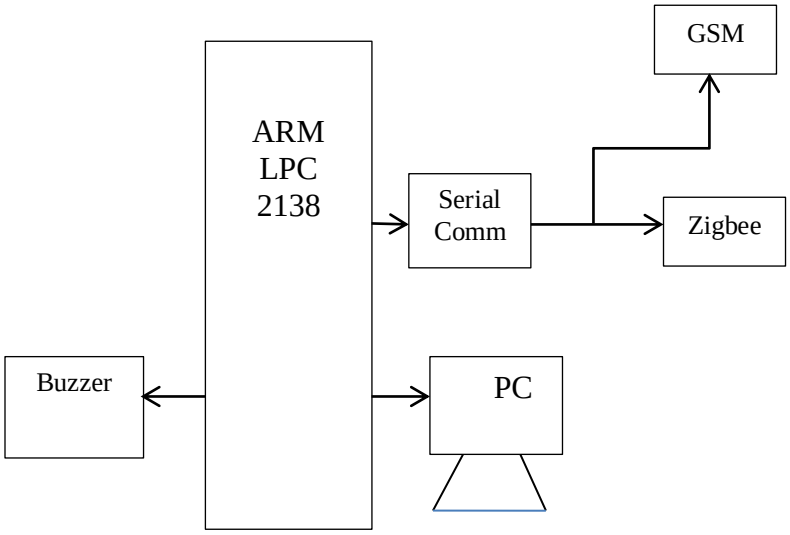

Figure 2: Block diagram of Master Module

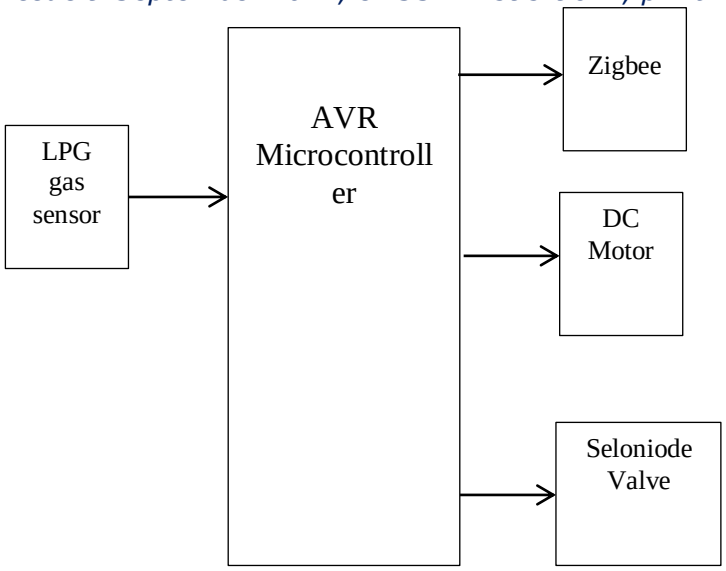

Figure 3: Block diagram of slave Module 1

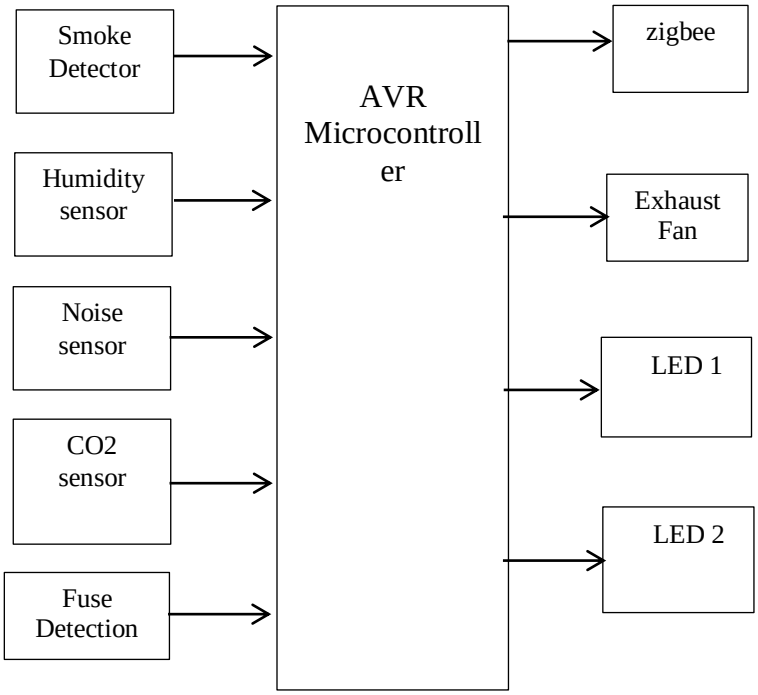

Figure 4: Block diagram of slave Module 2

The basic block diagram of Home Security system is shown in above figures. Hardware framework for Home Security system consists of one Master module which consists of GSM and Zigbee modules. One Slave modules consist of LPG gas sensor, DC motor which is used to open the window of kitchen, solenoid valve which is used to block the gas pipe. Another Slave module consist of different sensors such as Smoke detector as a fire sensor, Humidity sensor, Carbon dioxide sensor, Noise sensor to monitor the environmental parameters like humidity, noise and harmful gases.

2.3 Gas Sensor

A gas sensor is a technological device that detects or senses a signal, physical condition and chemical compounds. Gas sensor is a subclass of chemical sensor. Gas sensor measures the concentration of gas in its vicinity. Here we are using MQ-6 gas sensor. It has high sensitivity to propane, butane, LPG and natural gas. The sensitive material of MQ-6 sensor is SnO2. It has lower conductivity in clean air. When the target combustible gas exist, the sensors conductivity is higher along with the gas concentration rising. In combustible gas sensor the electrical resistance of most metals will increase with temperature. The combustible gas sensor consists of little more than a coil of platinum wire which is electrically heated. When gases are combust on the surface, some of the heat of combustion is transferred to the wire coil. The increase in coil temperature is reflected as an increase in electrical resistance.

Figure 5: Gas Sensor MQ-6

2.4 Humidity Sensor

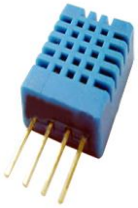

Figure 6: Humidity Sensor

Humidity is the presence of water in air. The amount of water vapor in air can affect human comfort as well as many manufacturing processes in industries. The presence of water vapor also influences various physical, chemical, and biological processes. Humidity measurement in industries is critical because it may affect the business cost of the product and the health and safety of the personnel. Hence, humidity sensing is very important, especially in the control systems for industrial processes and human comfort. Controlling or monitoring humidity is of paramount importance in many industrial & domestic applications. In semiconductor industry, humidity or moisture levels needs to be properly controlled & monitored during wafer processing. In medical applications, humidity control is required for respiratory equipment's, sterilizers, incubators, pharmaceutical processing, and biological products. Humidity control is also necessary in chemical gas purification, dryers, ovens, film desiccation, paper and textile production, and food processing. In agriculture, measurement of humidity is important for plantation protection (dew prevention), soil moisture monitoring, etc. For domestic applications, humidity control is required for living environment in buildings, cooking control for microwave ovens, etc. In all such applications and many others, humidity sensors are employed to provide an indication of the moisture levels in the environment.

2.5 Noise Sensor

This is an updated version of the Analog Sound Sensor. Analog Sound Sensor is typically used in detecting the loudness in ambient, the Arduino can collect its output signal and actuate accordingly. This sensor works best with our sound analyzer module. As one of our new version of breakout boards, we have improved the analog sound sensor in below:

Figure 7: Noise Sensor

2.6 Smoke Sensor

Figure 10: Smoke Sensor

The MQ-2 smoke sensor is sensitive to smoke. Sensitive material of MQ-2 gas sensor is SnO2, which with lower conductivity in clean air. When the target combustible gas exist, the sensor's conductivity is higher along with the gas concentration rising.

2.7 Co2 Sensor

Figure 11: CO2 Sensor

Sensitive material of MQ-7 gas sensor is SnO2. Which with lower conductivity in clean air. It make detection by method of cycle high and low temperature, and detect CO when low temperature (heated by 1.5V). The sensor's conductivity is higher along with the gas concentration rising. When high temperature (heated by 5.0V), it cleans the other gases adsorbed under low temperature. Please use simple electro circuit, Convert change of conductivity to correspond output signal of gas concentration.

2.8 ARM Processor

LPC2138 microcontrollers are based on a 16-bit/32-bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combine microcontroller with embedded high speed flash memory ranging from 32 kB to 512 kB. A 128-bit wide memory interface and unique accelerator architecture enable 32-bit code execution at the maximum clock rate. For critical code size applications, the alternative 16-bit Thumb mode reduces code by more than 30 % with minimal performance penalty. Due to their tiny size and low power consumption, LPC2141/42/44/46/48 are ideal for applications where miniaturization is a key requirement, such as access control and point-of-sale. Serial communications interfaces ranging from a USB 2.0 Full-speed device, multiple UARTs, SPI, SSP to I2C-bus and on-chip SRAM of 8 kB up to 40 kB, make these devices very well suited for communication gateways and protocol converters, soft modems, voice recognition and low end imaging, providing both large buffer size and high processing power. Various 32-bit timers, single or dual 10-bit ADC(s), 10-bit DAC, PWM channels and 45 fast GPIO lines with up to nine edge or level sensitive external interrupt pins make these microcontrollers suitable for industrial control and medical systems.

2.9 AVR Microcontroller

The AVR is a Modified Harvard architecture 8-bit RISC single chip microcontroller (µC) which was developed by Atmel in 1996. The AVR was one of the first microcontroller families to use on-chip flash memory for program storage, as opposed to One-Time Programmable ROM, EPROM, or EEPROM used by other microcontrollers at the time. AVRs have been used in various automotive applications such as security, safety, power train and entertainment systems. Atmel has recently launched a new publication "Atmel Automotive Compilation" to help developers with automotive applications. With Atmega16 cannot require pull-up registers whereas 8051 required pull-up resistors and such components that are required by 8051 to at least run properly in the first place. Atmega16 has better RISC instruction set, most of them being single cycle execution thus faster code execution, while 8051 still supports slower CISC which require multiple machine cycles for execution.Atmega16 has loads of on-chip peripherals like timers(both 8 and 16 bits), 8-channel 10 bit ADCs, I2C bus, SPI bus, UART interface, watchdog timer, whereas original 8051 only has 2 timers plus UART and better variants like RD2 only has SPI added.Atmega16 has higher code memory and RAM as compare to 8051. Atmega16 is simple to program and supporting programming hardware is also easy to learn and use. One big difference is the AVR is much faster. It executes most instructions in a single clock cycle, as against 12 for a standard 8051 or 6 for one of the high speed variants.

2.10 Global System For Mobile

GSM stands for **G**lobal **S**ystem for **M**obile Communication. It is a digital cellular technology used for transmitting mobile voice and data services. GSM (Global System for Mobile communication) is a digital mobile telephony system that is widely used in Europe and other parts of the world. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band.

2.11 Zigbee

Zigbee operates in the industrial, scientific and medical (ISM) radio bands; 868 MHz in Europe, 915 MHz in the USA and Australia, and 2.4GHz in worldwide. Data transmission rates vary from 20 to 900 kilobits/second. ZigBee is an open global standard for wireless technology and operates on the IEEE 802.15.4 specification designed to use low-power digital radio signals for personal area networks. ZigBee can automatically establish its network. It supports up to 65,000 nodes connected in a network. Zigbee is a wireless networking standard that is aimed at remote control and sensor applications which is suitable for operation in harsh radio environments and in isolated locations. It builds on IEEE standard 802.15.4 which defines the physical and MAC layers. Above this, Zigbee defines the application and security layer specifications enabling interoperability between products from different manufacturers. In this way Zigbee is a superset of the 802.15.4 specification.

III. Hardware Implementation

The main objective of this work is to reduce the human death and protect property due to fire by generating an alarm earlier by sensing the environmental conditions. It is also monitor CO2 gas, environmental noise, humidity and LPG gas which are harmful to human health. Remote monitoring and control gives new level of home security and comfort to senior citizens and people with disability.

3.1 Working

The system consists of one master node and two slave nodes. The wireless system design for Home security and environmental monitoring is mainly based on ARM and GSM. Master node consist of ARM7 micro-controller, GSM module, Zigbee module, Buzzer and serial port to USB converter. Master node monitor and collect the information from slave nodes. Zigbee module is used for short distance communication between master and slave nodes and GSM is used for long distance communication to transmit the alert message on owner's mobile phone.

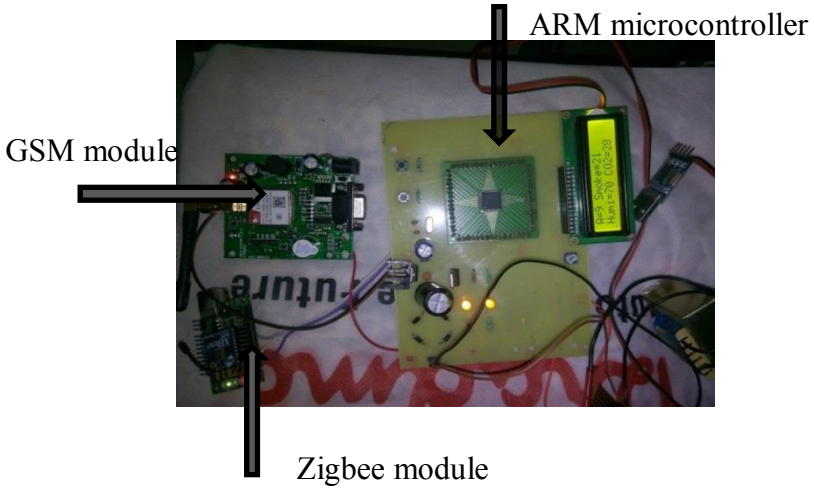

Figure 12: Working model of Master node

Slave node -1 consists of AVR microcontroller, LPG gas sensor, DC motor and solenoid valve. LPG gas sensor is used for gas leakage detection. When gas leakage is detected by sensor DC motor is turn ON which is used to open the window and solenoid valve is used to block the LPG gas pipe to prevent gas leakage from pipe. As soon as gas leakage is detected AVR microcontroller transmits signals via ZigBee to master node (ARM 7). When master node receive signal, it send 'LPG Leakage' alert message on mobile phone via GSM.

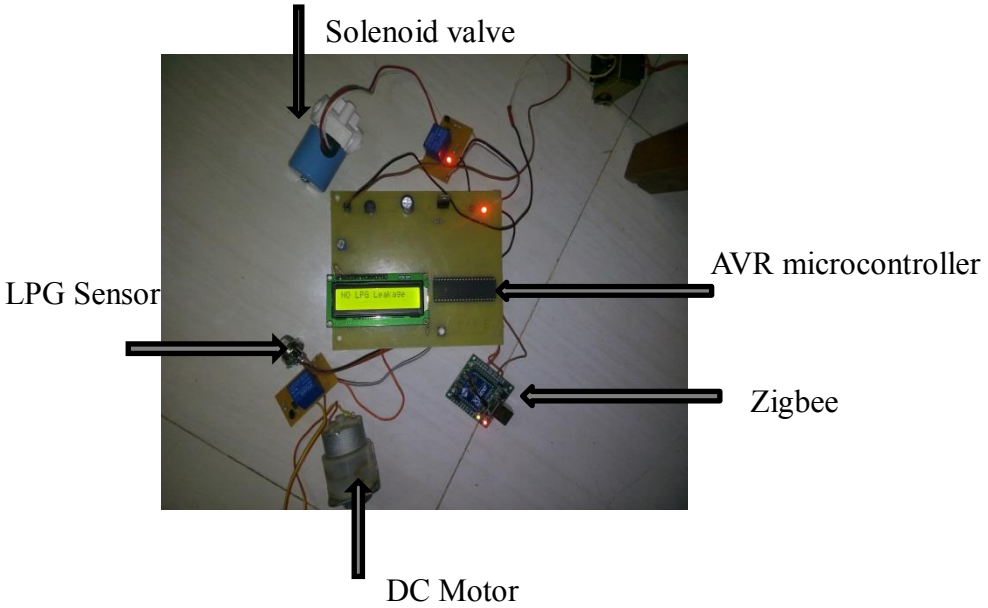

Figure 13: Working model of Slave node 1

Slave node-2 consists of AVR microcontroller, smoke detector, humidity sensor, noise sensor, CO2 sensor. When humidity in air increases it is detected by humidity sensor, Exhaust fan will be turn ON. When environmental

noise exceeds its appropriate value it is detected by noise sensor AVR transmit signal to master node. When master node receive signal, it send 'High Noise' alert message on mobile phone via GSM.

When smoke is detected by smoke detector then AVR microcontroller checks the status of fuse. If fuse is blown LED 1 is turn ON otherwise LED 2 is turn ON. Also AVR transmit signal to master node. When master node receive signal, it send 'Fire Detected' alert message on mobile phone via GSM and an alarm is generated by master node.

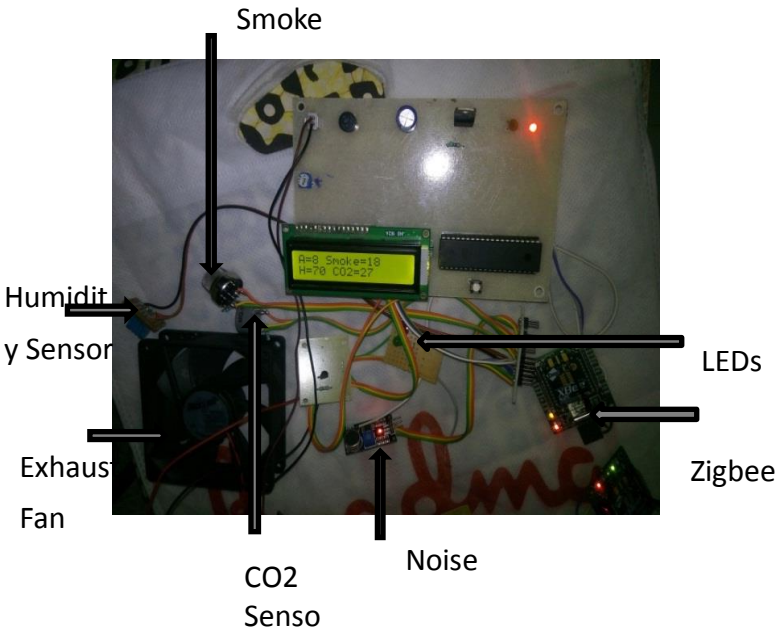

Figure 14: Working model of Slave node 2

The level of the toxic gas CO2 is continuously sensed by the sensor. The level is displayed on the LCD display continuously for each and every second and AVR transmit signal to master node. When the level of the toxic gas CO2 exceeds the normal level then an alarm is generated by master node. Master node is connected to PC where we can monitor the level of the toxic gas CO2 continuously and stored database on PC.

IV. RESULTS

The mobile number of the user should be included in the software programming in order to receive the accident location values from the GSM modem. The snapshot indicates the message alerts of Fire detection, High noise detection and LPG gas leakage detection.

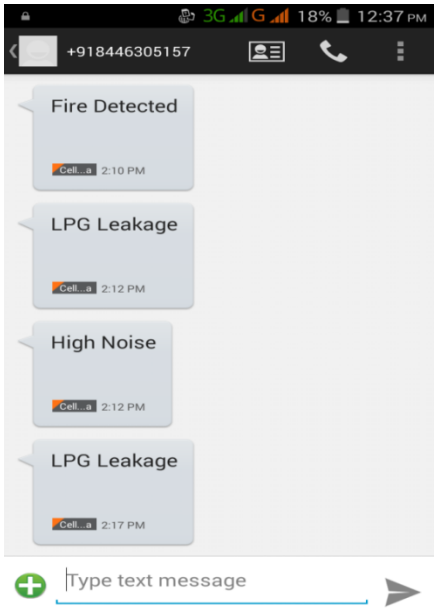

Figure 15: Snapshot of Fire, Noise and LPG gas leakage detection message

The level of the toxic gas CO2 is continuously sensed by the sensor. The level is displayed in the LCD continuously for each and every second. When the level of the toxic gas CO2 exceeds the normal level, then the microcontroller proceeds with an alarm.

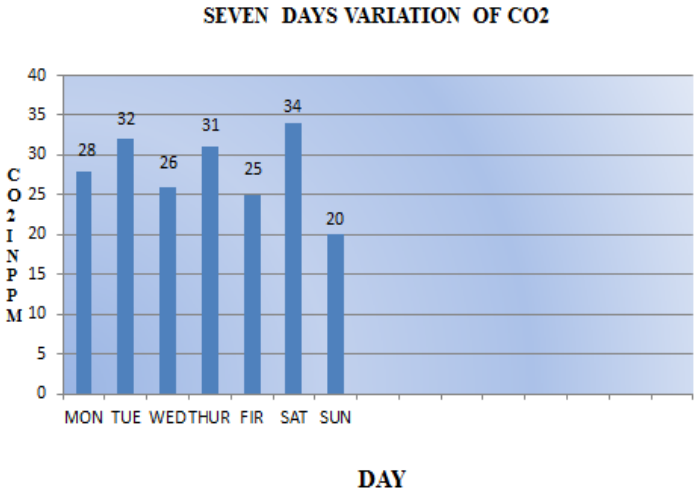

Figure 16: Graph of seven days variation of CO2.

We can also store database of CO2 on PC which is imported from Matlab to Microsoft Excel. So we can analysis CO2 concentration in air for each and every second. Above graph show the result of CO2 variation in seven days.

V. CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

This paper demonstrates designing of embedded controlled sensor networks used for controlling the home devices as well as monitoring the environmental parameters. The features of GSM and Zigbee are explored to design the system for long distance as well as short distance. Embedded controlled sensor networks have proven themselves to be a reliable solution in providing remote control and sensing for indoor environmental monitoring systems. The commercial sensors had been integrated with the system to monitor and compute the level of existence of CO2 gas, LPG Gas, Smoke detector, noise and humidity in atmosphere using information and communication technologies. This paper demonstrates designing of embedded controlled sensing element networks used for controlling the home devices as well as monitoring the environmental parameters. The features of Zigbee are explored to design the system for long distance as well as short distance. Embedded controlled sensor networks have proven themselves to be a reliable solution in providing remote control and sensing for indoor environmental monitoring systems. Three commercial sensors had been integrated with the system to monitor and compute the level of existence of CO gas, noise and humidity in atmosphere using information and communication technologies.

5.2 Future Scope

In future we can collect the database of all the sensors on PC and continuously monitor it. We can also use both Smoke detector and Temperature detector as fire sensors as per our requirement, such as temperature detectors are generally used in storage rooms where chemicals, fuels and other properties are stored.

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