CALICUT UNIVERSITY

INSTITUTE OF ENGINEERING AND TECHNOLOGY

THENHIPALAM

Project Report On

PULMONARY EDEMA MONITORING SYSTEM

Done by

JAFIS P C
(IEALEEC031)

Under the guidance of

Mr. RATHEESH C

(ASST.PROFESSOR, ECE DEPT.)

DEPARTMENT OF ELECTRONICS&COMMUNICATION ENGINEERING

2014-2015

CALICUT UNIVERSITY

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Certificate

Certified that the Project report entitled

PULMONARY EDEMA MONITORING SYSTEM

is a bonafide work carried out by

JAFIS P C

in partial fulfilment of Project of Eighth Semester in
Electronics and communication Engineering
under
University of Calicut
during the year 2014-2015.

It is certified that the Project report has been approved as it satisfies the academic requirements as prescribed for the

Bachelor of Technology Degree

Faculty member in charge ***Head of the Department***

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CERTIFICATE

This is to certify that it is a bonafide Project Report done by Jafis P C, Register No. IEALEEC031 of Eighth Semester B.Tech, Electronics And Communication Engineering on the title 'Pulmonary Edema Monitoring System' submitted for Calicut University Institute of Engineering and Technology, affiliated to Calicut University in partial fulfilment of requirement for the B.Tech Degree.

PROJECT CO-ORDINATOR ***HEAD OF THE DEPARTMENT***

Place :

Date :

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I express my sincere thanks to the great Almighty for being with me from the beginning till the completion of my project.

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ABSTRACT

Pulmonary edema is the state of fluid accumulation in the air spaces and parenchyma of the lungs which leads to impaired gas exchange and causes respiratory failure. The present diagnosis methods for this are not so accurate and not always applicable to different subjects. The pulmonary edema monitoring system (PEMS) is a non-invasive and robust diagnostic device for the continuous monitoring and detection of pulmonary edema. The system employs placing 3 EMG electrodes on the human chest and analyses the respiratory muscle activities thus giving indications about the working condition of the lungs and detect lung irregularities, if any. Specifically, the electrodes pick up bio signals associated with the lung diaphragm muscle, amplify it, and converted to digital form for analysis and transmission. A threshold value will be set in the analysing device which compares the measured value with the threshold and indicate whether the subject suffers from pulmonary edema or not. Concurrently, a medical sensing body area network (MS-BAN) is employed using Zigbee to provide remote monitoring of subjects. Additionally, pressure and temperature sensors are also added to the system.

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LIST OF ABBREVIATIONS

PEMS	PULMONARY EDEMA MONITORING SYSTEM
ECG	ELECTRO CARDIO GRAM
EEG	ELECTRO ENCEPHALO GRAM
EMG	ELECTRO MYO GRAM
HAPE	HIGH ALTITUDE PULMONARY EDEMA
LED	LIGHT EMITTING DIODE
BNP	B-TYPE NATRIURETIC PEPTIDE
PIC	PERIPHERAL INTERFACE CONTROLLER
LCD	LIQUID CRYSTAL DISPLAY
ADC	ANALOG TO DIGITAL CONVERTER
IC	INTEGRATED CIRCUIT
ROM	READ ONLY MEMORY
RAM	RANDOM ACCESS MEMORY
BAN	BODY AREA NETWORK
I/O	INPUT/OUTPUT
RISC	REDUCED INSTRUCTION SET COMMAND
CMOS	COMPLEMENTARY METAL OXIDE SEMICONDUCTOR
DTE	DATA TERMINAL EQUIPMENT
DCE	DATA CIRCUIT TERMINATING EQUIPMENT
EEPROM	ELECTRICALLY ERASABLE PROGRAMMABLE READ ONLY MEMORY
CPU	CENTRAL PROCESSING UNIT
NTC	NEGATIVE TEMPERATURE COEFFICENT
PTC	POSITIVE TEMPERATURE COEFFICIENT
ASCII	AMERICAN STANDARD CODE FOR INFORMATION INTERCHANGE

CHAPTER 1

INTRODUCTION

Recent developments in the electronics and communication fields initiated a new era in the medical field as in the case of disease diagnosis, real time monitoring of patients, drug control inside body, various medical equipments, surgeries, etc. As a result the efforts of a physician is reduced considerably and the efficiency is increased which resulted in a medical evolution.

In this project a new biomedical equipment introduced which is capable of monitoring patients remotely through a wireless network. The system detects a condition called Pulmonary edema, a state of fluid accumulation inside the lungs which leads to difficulties in breathing and gas exchange. The equipment, Pulmonary Edema Monitoring System (PEMS) basically capable of continuously monitoring the patient and wirelessly transferring the corresponding data to a computer in real time. It monitors the activity of the respiratory muscles via a set of skin electrodes and determines the edema condition. A model for pressure and temperature sensing is also included in the system for showing its functional capabilities.

1.1 WORKING OF THE LUNGS

Lungs are the respiratory organs of complex structured organisms such as birds and animals including human beings. It intake air through inspiration and expel air through expiration. Lungs are located at thoracic cavity, below the rib cage and above the diaphragm muscle. This muscle along with a set of muscles associated with the ribs (intercostal muscles) help in respiration process. Inspiration occurs when the diaphragm muscle contract and intercostal muscle expand which increases the thoracic cavity volume which in turn reduces the air pressure inside the body. So the outside air easily in taken. To expel the air the diaphragm muscle expands and intercostal muscle contract which reduces the thoracic volume and in turn forces the air to go out .

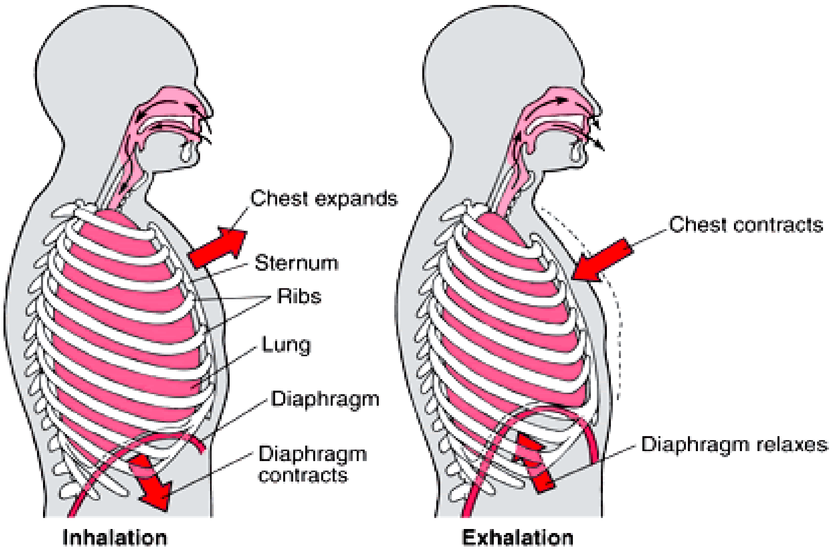

Fig. 1.1 Breathing process

The exchange of gases between blood and air occurs at alveoli, tiny air sacs with minute blood vessels (capillaries) inside the lungs. CO_2 rich blood is pumped to the alveoli by the heart through pulmonary artery. The CO_2 is removed from blood and O_2 is supplied to it through diffusion process. The oxygenated blood flows to heart through pulmonary vein and the CO_2 goes out through expiration. This is the respiration process. It is shown in the below figure.

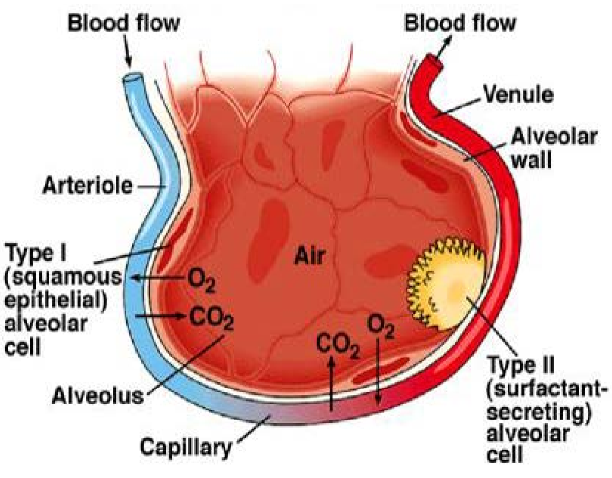

Fig. 1.2 Gas exchange in alveoli

Due to any internal or external factors the breathing and gas exchange becomes difficult for an individual. It may be due to lung injuries, viral infections, altitude problems, Heart problems , Brain problems , etc. So the person takes more effort to breath air.

1.2 PULMONARY EDEMA

Pulmonary edema is the state of fluid accumulation (mostly blood) in the air spaces (alveoli) and parenchyma of the lungs which leads to impaired gas exchange and may cause respiratory failure. It is due to either failure of the heart to adequately remove blood from the pulmonary circulation or an injury to the lung parenchyma or vasculature of the lung. The first condition is called cardiogenic pulmonary edema because it occurs due to problems of heart. It includes high blood pressure, Cardiomyopathy, coronary artery disease and Heart valve problems.

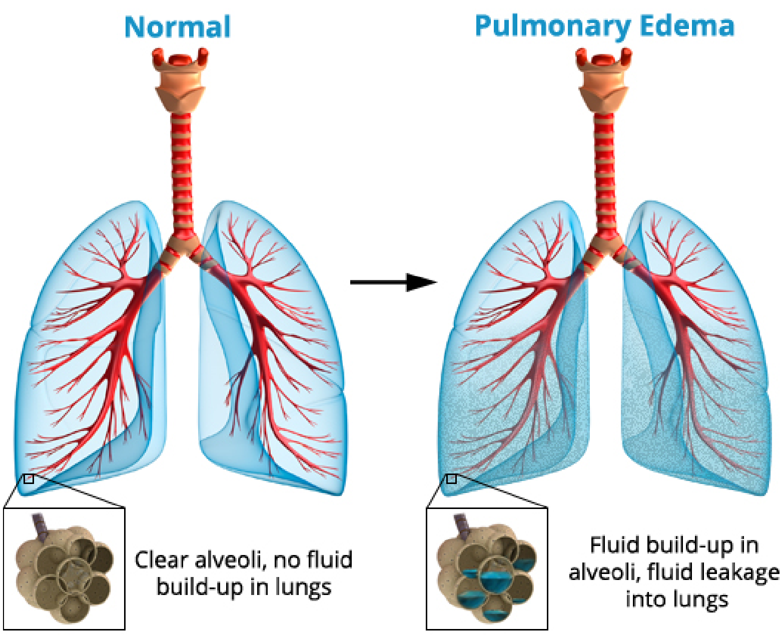

Fig. 1.3 Pulmonary edema

The other factors causing edema are viral infections, certain diseases, Altitude variation, Nervous system problems, Inhaling of toxins and pulmonary embolism. The edema due to these factors other is called non cardiogenic pulmonary edema. The symptoms are breathing difficulty, coughing up blood, excessive sweating, anxiety, sleeplessness and pale skin. If untreated it can lead to respiratory distress, cardiac arrest and death.

A person who suffers from pulmonary edema condition have to breath with effort for satisfying the oxygen requirement of body. So accordingly his respiration muscle activity will be high compared to a normal one.

1.3 EXISTING DIAGNOSTIC METHODS

Because pulmonary edema requires prompt treatment, the person will initially be diagnosed on the basis of the symptoms and a physical exam, electrocardiogram and chest X-ray. Once the condition is more stable, the doctor will ask about the medical history, especially whether the person have ever had cardiovascular or lung disease. Tests that may be done to diagnose pulmonary edema or to determine why the person developed fluid in the lungs are described below

1.3.1 Chest X-ray

A chest X-ray will likely be the first test that have done to confirm the diagnosis of pulmonary edema and exclude other possible causes of the shortness of breath. The X-ray images of the lungs is taken and compares with a normal one. Usually, the X-ray shows the fluid filled alveoli as white shades or spots, as shown in figure.

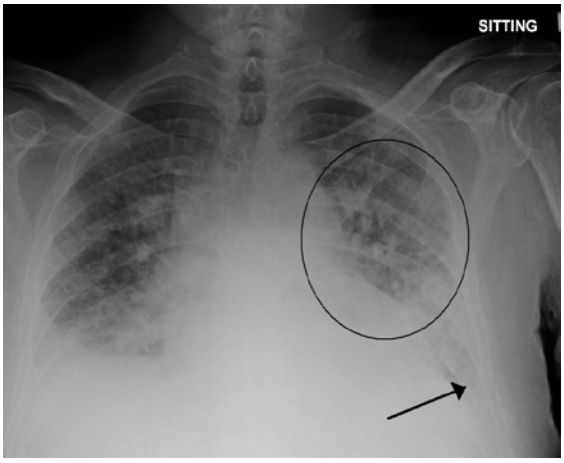

Fig. 1.4 X-ray image of Lungs

1.3.2 Pulse Oximetry

In pulse oximetry, a sensor attached to the finger or ear uses light to determine how much oxygen is in the blood. It has a light transmitter at one end and a photo detector at other end. Light emitting diodes (LEDs) are used as the light source. The light is passed through the finger tip or ear from the LED to the detector. As arterial pulsation fill the capillary bed, the changes in volume of the vessels modify the absorption, reflection, and scattering of the light. In addition to the light sensor a filter is required to restrict the sensitivity of the sensor to the near infrared region so that changes in blood O_2 content that are prominent in the visible light region will not cause changes in sensitivity.

Fig. 1.5 Pulse oximetry device

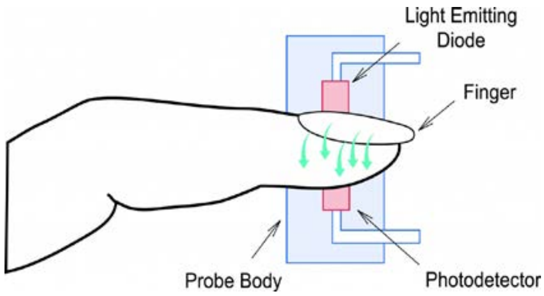

Fig. 1.6 Working principle

1.3.3 Blood Tests

In this the blood is drawn, usually from an artery in the wrist, so that it can be checked for the amount of oxygen and carbon dioxide it contains (arterial blood gas concentrations). The blood may also be checked for levels of a substance called B type natriuretic peptide (BNP). Increased levels of BNP may indicate that the pulmonary edema is caused by a heart condition. Other blood tests may be done including tests of the kidney function, thyroid function and blood count as well as tests to exclude a heart attack as the cause of the pulmonary edema.

1.3.4 Electrocardiogram (ECG)

This non invasive test can reveal a wide range of information about the heart. During an ECG, patches attached to the skin receive electrical impulses from the heart. These are recorded in the form of waves on graph paper or a monitor. The wave patterns show the heart rate and rhythm and whether areas of the heart show diminished blood flow.

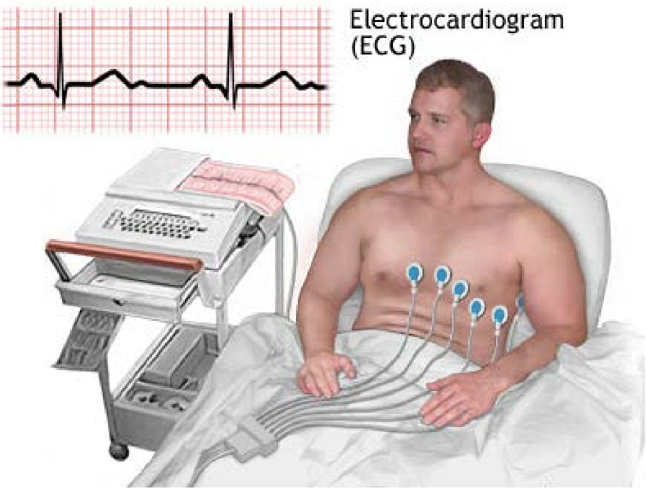

Fig. 1.7 ECG measurement

1.3.5 Echocardiogram

An echocardiogram is a non invasive test that uses a wand shaped device called a transducer to generate high frequency sound waves that are reflected from the tissues of the heart. The sound waves are then sent to a machine that uses them to compose images of the heart on a monitor. The test can help diagnose a number of heart problems, including heart valve problems, abnormal motions of the ventricular walls, fluid around the heart (pericardial effusion) and congenital heart defects. It can also show areas of diminished blood flow in the heart and if the heart pumps blood effectively when it beats. It can also estimate if there's increased pressure in the right side of the heart and increased pressure in the pulmonary arteries.

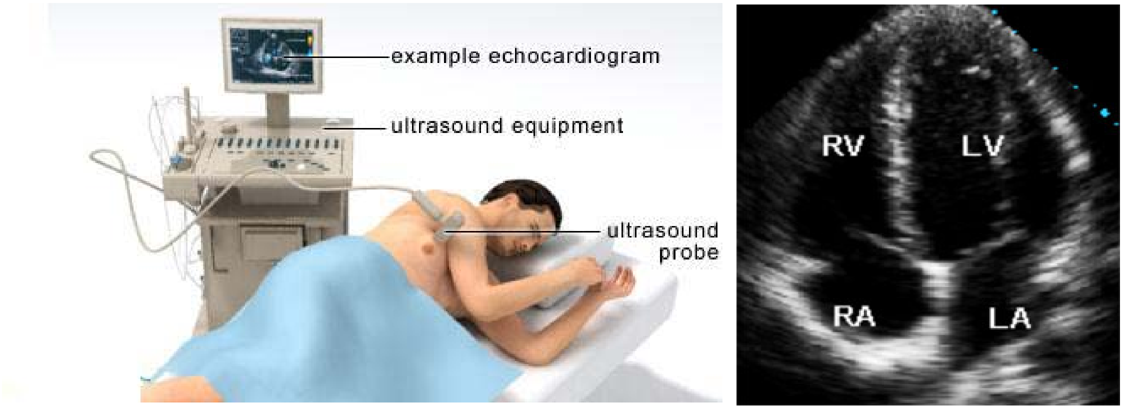

Fig. 1.8 Echocardiogram of heart

1.3.6 Cardiac Catheterization

If tests such as an ECG or echocardiography don't uncover the cause of the pulmonary edema, or the person also have chest pain, the doctor may suggest cardiac catheterization and coronary angiogram. During cardiac catheterization, a doctor inserts a long, thin catheter in an artery or vein in the groin, neck or arm and threads it through the blood vessels to the heart using X-ray imaging. Doctors then inject dye into the blood vessels of the heart to make them visible under X-ray imaging (coronary angiogram). Cardiac catheterization is used to measure the pressure in the heart chambers by inflating and deflating a balloon attached to the catheter and taking the readings by a pressure sensor. Also the doctor can measure nutrient contents of blood or even take blood samples for testing

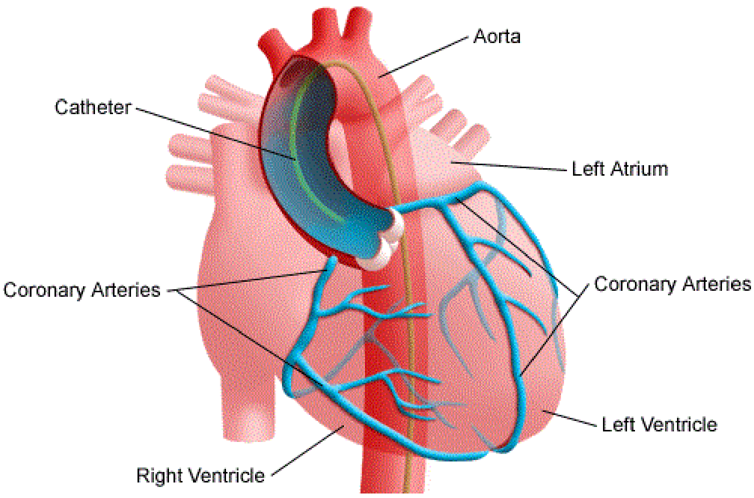

Fig. 1.9 Cardiac catheterization

1.4 LIMITATIONS OF EXISTING SYSTEMS

The current diagnostic methods of pulmonary edema have some limitations. From the above listed methods only the Chest X-ray is the one which applied directly on lungs. Other tests such as ECG , Echocardiogram, Catheterization and Blood tests are employed for finding the cause of pulmonary edema such as heart irregularities. Most of these techniques cannot be applied to detect non cardiogenic pulmonary edema because in that case edema occurs due various external factors such as lung injury , blood clots , viral infections , altitude variations , etc. In that case the heart functions normally without any problems.

Invasive methods such as Catheterization cannot be applied on various subjects such as children and adults because it requires inserting the diagnosing equipment inside the body through blood vessel or by any other means. It is difficult to perform and requires more time and extra care. Catheterization is usually performed at operation theatre after sedating the patients. So an easy diagnosis is basically not possible. Calculating the amount of Oxygen in the blood is promising but the variations can occur due to many other factors apart from pulmonary edema. The pulse oximetry test described above is sensitive to the finger movement.

The chest X-ray is the best diagnostic method in present day because it provides clear images of the lung which can indicate irregularities. But the technique has a demerit that it cannot be used for continuous monitoring of lungs because the radiations from the equipment causes Cancer.

CHAPTER 2
LITERATURE REVIEW

2.1 PROPOSED METHODOLOGY

From the above paragraphs it is understood that there are some of limitations in the current diagnosis methods for pulmonary edema. So in this project a solution for the above is proposed, which is the monitoring of respiratory muscle activities for determining lung irregularities. It is done by means of non invasive electromyography (EMG) technique. pulmonary edema can be detected and monitored by employing this technique. The major advantage of this technique is that it is a non invasive methodology which does not require 'anything' to be inserted into the body. So it can be safely applied to children and adults. The technique employs a set of EMG surface electrodes which are placed on the chest , above the diaphragm and intercostal muscle areas of the skin. They picks up the electric signals (bio potentials) associated with the muscles.

2.1.1 Electromyogram

Electromyogram or EMG is the bio potential associated with the muscle fibers. These ionic potentials can give the details about the muscle activity. It can be converted into electric potential by using electrodes. These potentials may be measured at the surface of the body using surface electrodes near a muscle of interest or directly from the muscle by penetrating the skin with needle electrode.

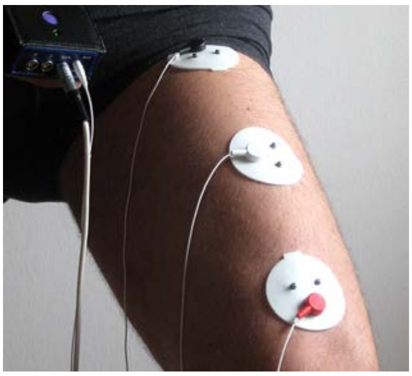

Fig. 2.1 EMG measurement from leg

Most of the EMG measurements are intended to obtain an indication of the amount of activity of a given muscle, or group of muscles, rather than of an individual muscle fiber, the pattern is usually a summation of the individual action potentials from the fibers constituting the muscle or muscle being measured. The action potential of a given muscle has a fixed magnitude, regardless of the intensity of the stimulus that generates the response. Thus, in a muscle, the intensity with which the muscle acts does not increase the net height of the action potential pulse but does increase the rate with which each muscle fiber fires and the number of fibers that are activated at any given time.

Because these action potentials occur in both positive and negative polarities at a given pair of electrodes, they sometimes add and sometimes cancel. Thus the EMG waveform appears very much like a random noise waveform, with the energy of the signal a function of the amount of muscle activity and electrode placement.

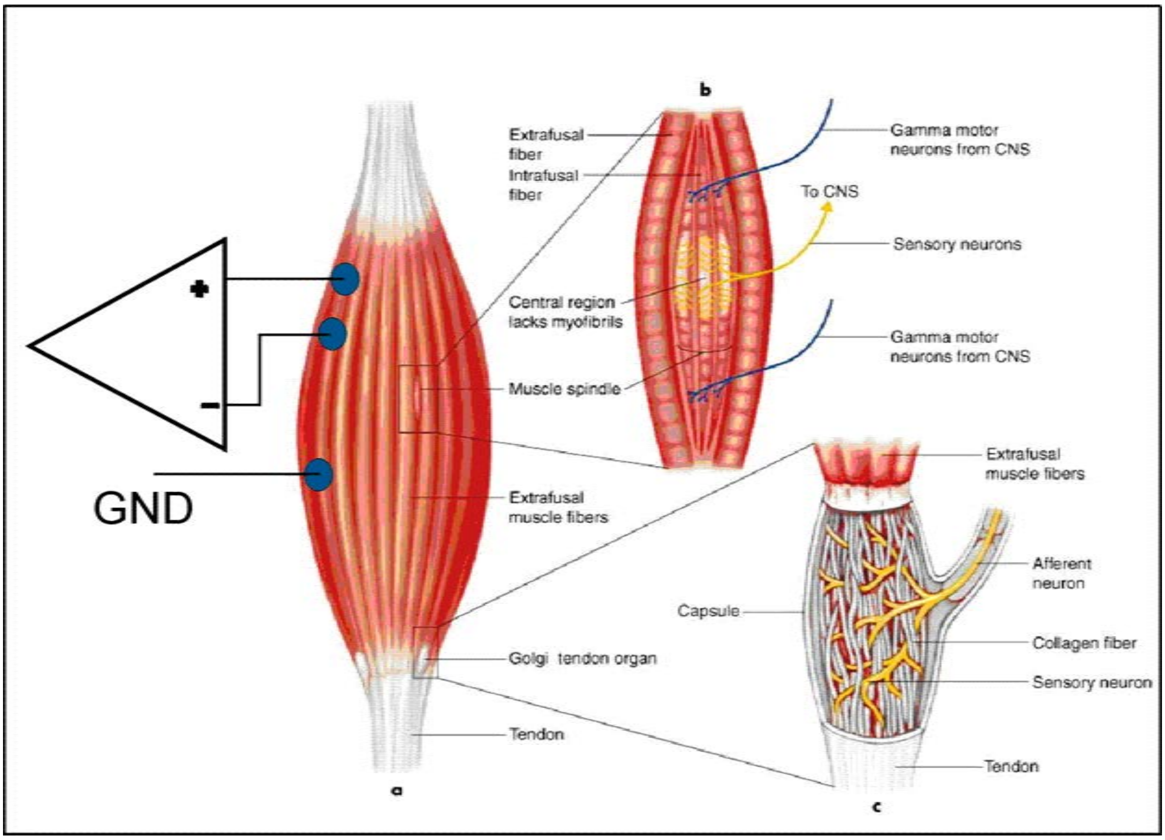

Fig. 2.2 EMG measurement from Muscle fiber

2.1.2 EMG From Respiratory Muscles

As in the case of lung muscles (diaphragm and intercostal) their EMG values indirectly indicates the activity of the lungs. For a healthy person the EMG values will be normal because he inhales and exhales air at normal rates. But for subjects with pulmonary edema requires more effort to breath to meet the body requirement. For that the diaphragm and intercostal muscle needed work harder and produce higher levels of EMG values. So by analysing the EMG signals from these lung muscles one can differentiate between a healthy and unhealthy persons.

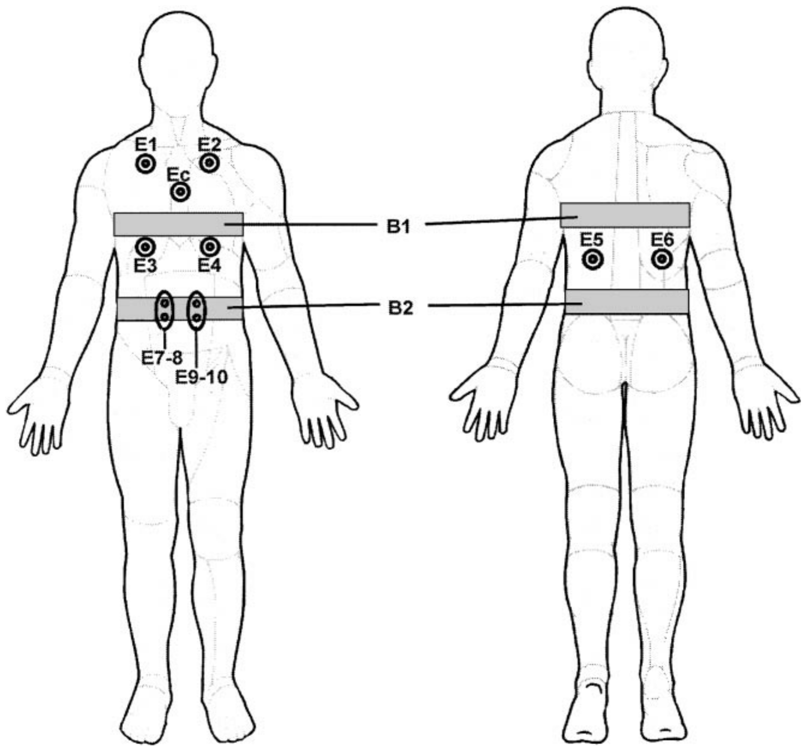

Fig. 2.3 Respiratory muscle monitoring

The above figure shows an example for monitoring of lung muscle activity. The corresponding EMG signal are shown below .The typical value of EMG for diaphragm ranges from 5 to 20uV and EMG for intercostal muscle ranges from 2-8uV. The frequency of EMG signals usually varies between few hertz to maximum of 500Hz for various muscle fibers. For the respiratory muscles it ranges from few hertz to 150Hz. The EMG signals are equivalent to noise like waveforms. The plotted waveforms are filtered and averaged ones which gives clear waveforms.

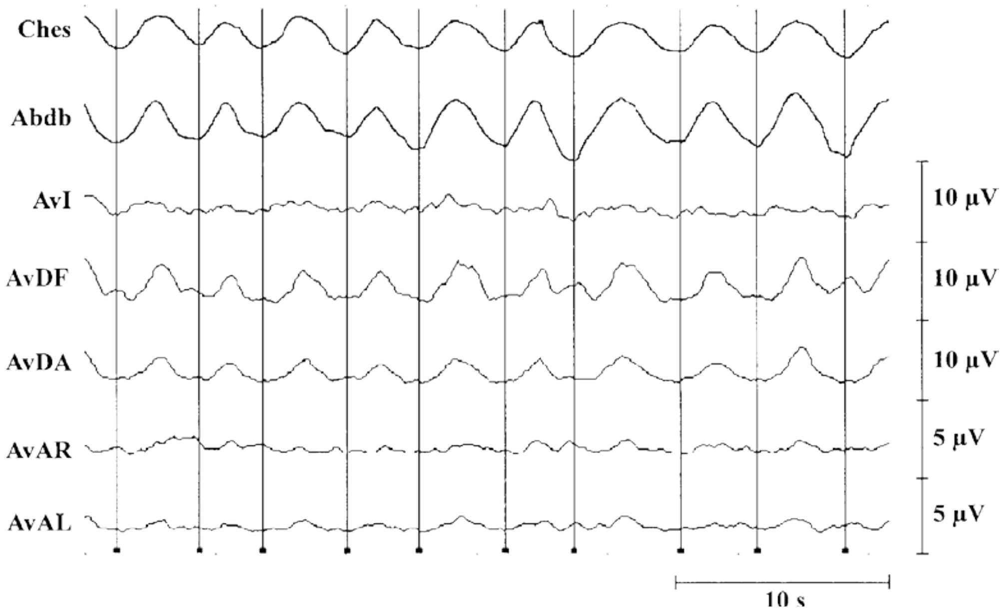

Fig. 2.4 EMG signal from various part of the chest

ches	: Chest
abdb	: Abdomen
I	: Intercostal
DF	: Dorsal Diaphragm
DA	: Ventral Diaphragm
AR	: Right Abdomen
AL	: Left Abdomen
*Av	: Averaged value

CHAPTER 3
OBJECTIVE AND SCOPE

Pulmonary Edema monitoring system (PEMS) is an adequate lung monitoring system which can continuously monitor the activity of lungs. It can detect the pulmonary edema condition of the lungs by analysing the EMG signals associated with the diaphragm and intercostal muscles. If a person suffer from pulmonary edema , his or her EMG signals will be higher compared to normal levels, because he or she takes more effort for breathing to meet the bodies requirement. The system records the EMG value obtained from the test subjects digitally and compares it with a threshold value. If it is higher the subject suffers from pulmonary edema. Otherwise the test subject is normal.

The obtained result can be transmitted via Zigbee wireless technology to nearby mobile or computing devices. So the patient can be monitored wirelessly. A LCD display is integrated for the quick access of diagnosis result. Additional sensors such as temperature sensors, pressure sensors, etc. can be integrated in to the system to make it more functional. As it comes with a wireless body area network (BAN) it provides remote patient monitoring capabilities. In the current system a temperature sensor and a pressure sensor are added. An alarm circuit is also added to warn critical conditions of the subject. The whole system is controlled and coordinated by a dedicated microcontroller.

The PEMS is a biomedical equipment which can continuously monitor the activity of lung muscles and other body parameters, such as body temperature, and transmits the results wirelessly to computer device. Apart from the current diagnosis systems the PEMS can be applied on children and adults without causing them any discomfort or trouble because it is a non invasive system.

CHAPTER 4

BLOCK DIAGRAM

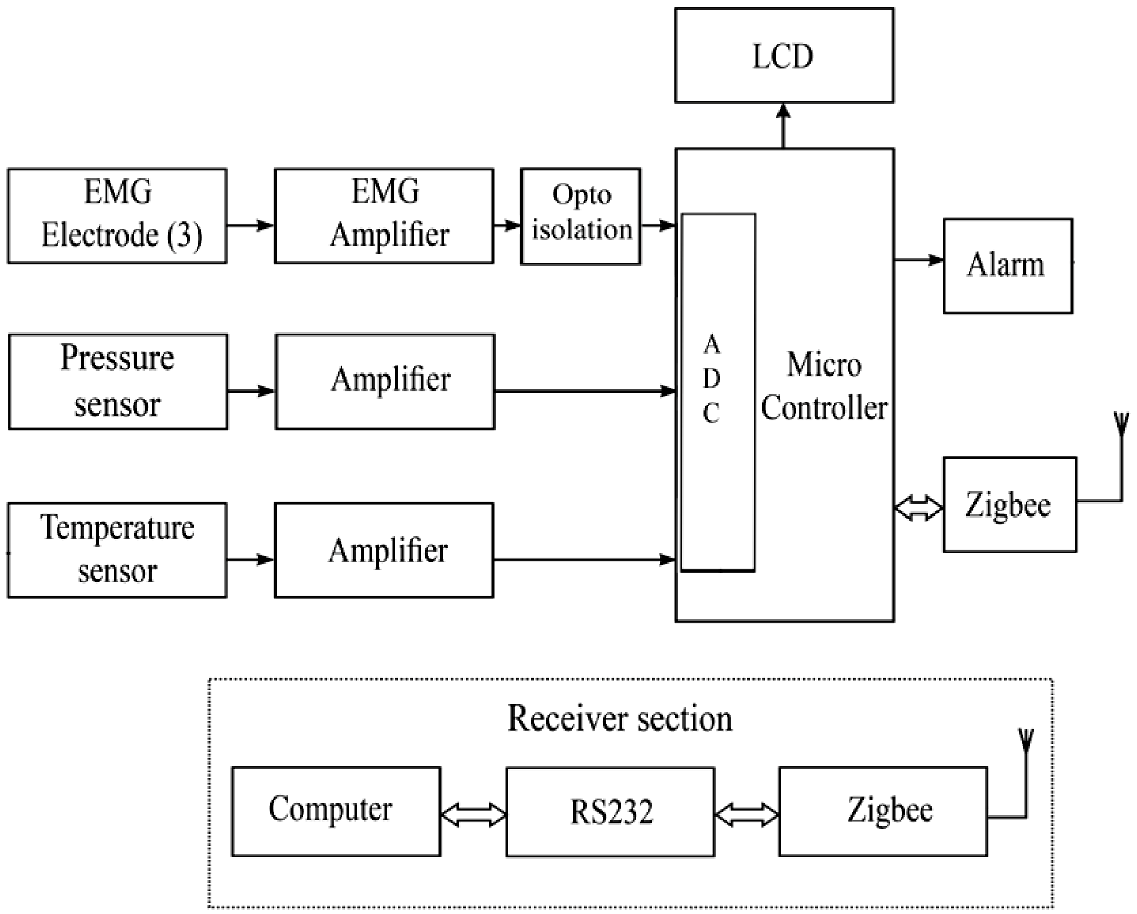

Fig. 4.1 PEMS block diagram

4.1 BLOCK DIAGRAM DESCRIPTION

The above block diagram shows the major components of a pulmonary edema monitoring system. It consist of a set of EMG electrodes , EMG amplifier unit, Temperature sensor, pressure sensor and amplifier, Microcontroller with analog to digital converter (ADC), Alarm network, Liquid crystal display (LCD), Zigbee wireless module and a computer. The brief description of each component is explained below.

4.1.1 Electromyogram Sensor and Amplifier

The EMG network of the pulmonary edema monitoring system consist of a set of three EMG electrodes (sensors) and a EMG amplifier unit. The 3 electrodes are placed on the three different regions of the chest, located above the diaphragm and inter costal muscles. Dry skin electrodes are used here which does not required gels at the body contacts. They picks up the EMG signals from the corresponding muscle continuously. They converts the weak bio signals in to electrical signals which is then amplified by a series of amplifiers. The sensor output is in terms of micro volts. So we have to amplify the signal to required power level sufficient of driving ADC.

4.1.2 Optical Isolation

In electronics, an opto isolator (or optical isolator, opto coupler or photo coupler) is a device that uses a short optical transmission path to transfer a signal between elements of a circuit, typically a transmitter and a receiver, while keeping them electrically isolate since the signal goes from an electrical signal to an optical signal back to an electrical signal, electrical contact along the path is broken.

A common implementation involves an LED and a light sensor, separated so that light may travel across a barrier but electrical current may not. When an electrical signal is applied to the input of the opto isolator, its LED lights, its light sensor then activates, and a corresponding electrical signal is generated at the output. Unlike a transformer, the opto isolator allows for DC coupling and generally provides significant protection from serious overvoltage conditions in one circuit affecting the other.

4.1.3 Temperature Sensor and Amplifier

Temperature sensor is employed for demonstrating measuring of temperature during the analysis of EMG of Lung muscles. A thermistor is used for this purpose. Thermistor is nothing but temperature sensitive resistor. There are two type of thermistor available such as positive temperature coefficient and negative temperature coefficient. Here a negative temperature coefficient in which the resistance value is decreased when the temperature is increased. The obtained weak signals from the temperature sensor is also amplified to required power by an amplifier.

4.1.4 Pressure Sensor and Amplifier

A pressure sensor is attached for demonstrating the pressure sensing process. A silicon piezo resistive pressure sensor is used for this purpose. It provide a accurate linear voltage output directly proportional to the applied pressure. In older systems pressure readings where based on mercury tubes which is less accurate and more difficult to operate. The modern pressure sensors are very small in size, more accurate and easy to operate. Pressure sensors are used for control and monitoring of thousands of everyday applications. The output from pressure sensor is amplified to required power level for driving ADC.

4.1.5 Microcontroller

A microcontroller is a complete microprocessor system built on a single IC. Microcontrollers were developed to meet a need for microprocessors to be put into low cost products. Building a complete microprocessor system on a single chip substantially reduces the cost of building simple products, which use the microprocessor's power to implement their function, because the microprocessor is a natural way to implement many products. The microcontroller contains full implementation of a standard microprocessor, ROM, RAM, I/O, clock, timers, and also serial ports. Microcontroller also called "system on a chip" or "single chip microprocessor system" or "computer on a chip". A microcontroller is a Computer On A Chip, or, if you prefer, a single chip computer. Micro suggests that the device is small, and controller tells you that the device might be used to control objects, processes, or events. Another term to describe a microcontroller is embedded controller, because the microcontroller and its support circuits are often built into, or embedded in, the devices they control.

A microcontroller is used in the pulmonary edema monitoring system to control and co ordinate all the components used in the system; such as LCD display, Sensors, Amplifiers, Body area network, etc. Which makes the PEMS an embedded system. It also performs the conversion of analog signals from the sensor units to digital format (ADC) and the comparison with a threshold value for determining a person's condition. If the threshold is lower than measured value it confirms that the person has edema, Otherwise he is normal. The pressure and temperature readings also compared in this manner.

4.1.6 LCD Display

A Liquid crystal display (LCD) is implemented in PEMS for displaying the diagnosis result of test subjects. LCDs have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal.

When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarisers, which would result in activating / highlighting the desired characters. The LCD’s are lightweight with only a few millimetres thickness. Since the LCD’s consume less power, they are compatible with low power electronic circuits, and can be powered for long durations. The LCD’s don’t generate light and so light is needed to read the display.

4.1.7 ZigBee

ZigBee is a specification for a suite of high level communication protocols used to create personal area networks built from small, low power digital radios. ZigBee is based on an IEEE 802.15 standard. Though low powered, ZigBee devices can transmit data over long distances by passing data through intermediate devices to reach more distant ones, creating a mesh network; i.e., a network with no centralized control or high power transmitter/receiver able to reach all of the networked devices. The decentralized nature of such wireless ad hoc networks make them suitable for applications where a central node can't be relied upon.

ZigBee is used in the PEMS for creating a wireless body area network (BAN) for remote monitoring of patients or test subjects. It transmits the diagnosis result to the personal computer of a doctor or to the computer in a laboratory wirelessly. ZigBee is used in applications that require only a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 Kbit/s, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device.

4.1.8 Alarm

An alarm network is employed in PEMS for warning critical conditions of the patients or test subject. If the measured value from the sensors is greater than that of the threshold value, the alarm beeps. A buzzer or beeper is used as the alarm or signalling device. It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound.

4.1.9 RS 232 Serial Port and Computer

In telecommunications, RS-232 is a standard for serial binary data interconnection between a *DTE* (Data terminal equipment) and a *DCE* (Data Circuit-terminating Equipment). It is commonly used in computer serial ports for interfacing the computer with an external hardware. The main purpose of the RS 232 in this system is to interface the ZigBee receiver unit to a computer or group of computers for getting the diagnosis results of patients or test subjects remotely. A logic level converter circuit is associated with the RS-232 for converting the logic levels of transmitted bit from Zigbee to a compatible signal level. The intended symbol rate is 9600 symbol per sec for this project system and asynchronous communication is used. The computer displays the received details to the user.

CHAPTER 5

CIRCUIT DIAGRAM

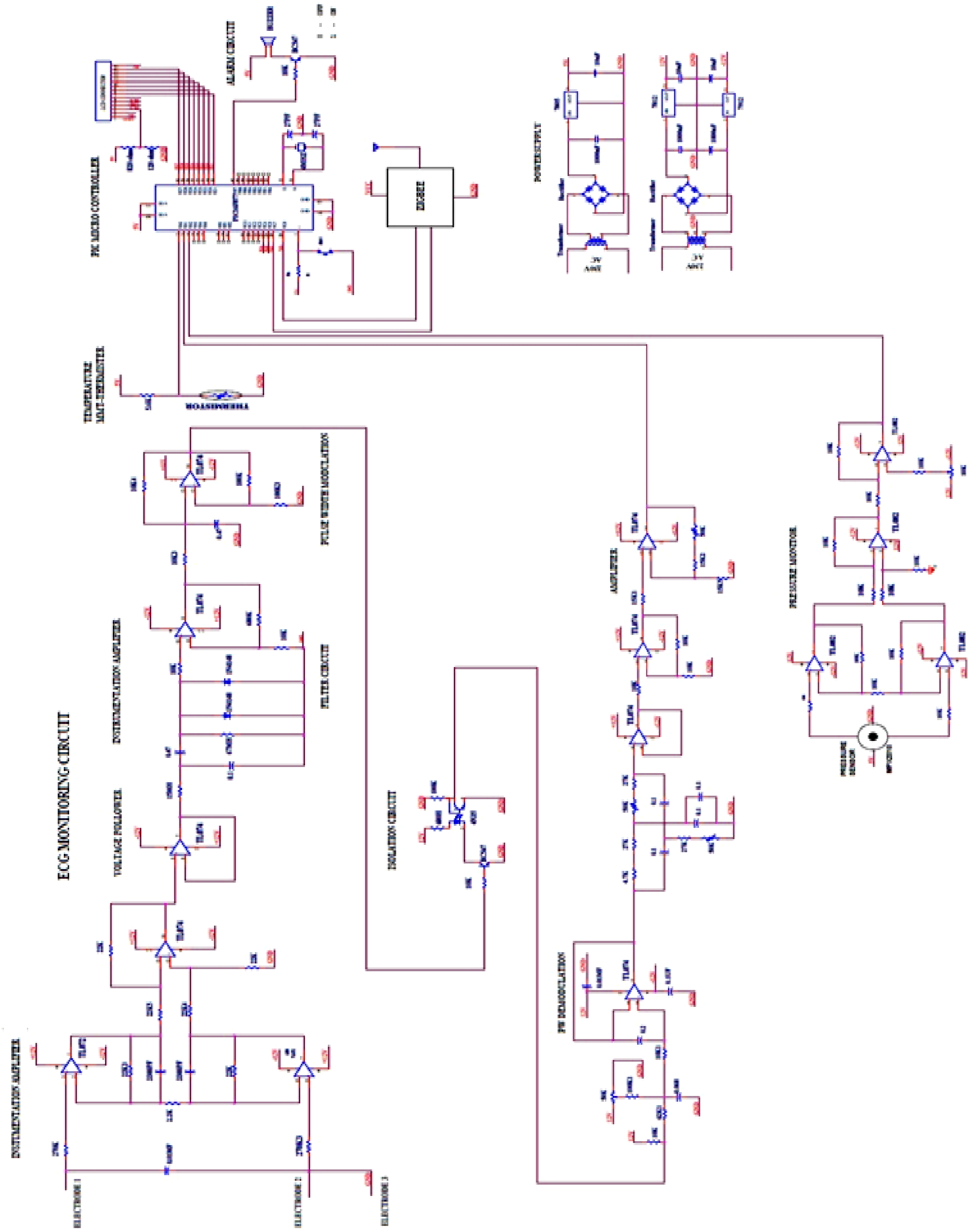

Fig.5.1 Sensor input section of PEMS

The sensor input section of the circuit includes various sections such as the power supply section, temperature monitoring section, pressure monitoring section, EMG monitoring section, isolation section, amplifier section, microcontroller, alarm section, LCD interfacing section and a Zigbee module.

5.1 EMG MONITORING CIRCUITRY

By measuring the EMG of a person, we can explain a variety of aspects of a person's condition and the possible cause of edema, if any. The EMG monitoring circuit includes the EMG electrodes, Instrumentation amplifiers, Voltage follower, Pulse Width circuit, Opto-isolation, Pulse Width demodulation circuit, Notch filter and amplifier. The three EMG electrodes are connected to the person's body(chest) and are connected to the terminals of the instrumentation amplifier.

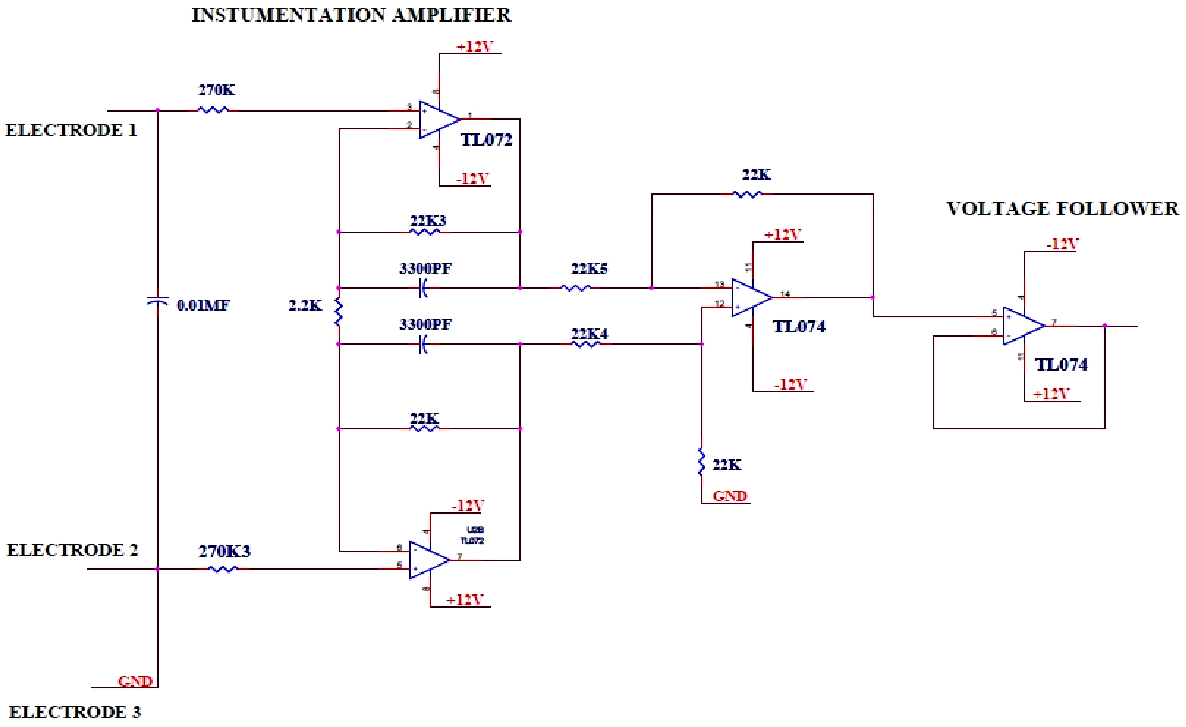

Fig.5.2 EMG amplifiers

Two of the electrodes serve as input from the respiratory muscles and the third serves as ground terminal to the instrumentation amplifier. An instrumentation amplifier is a type of differential amplifier that has been outfitted with input buffer amplifiers, which eliminate the need for input impedance matching and thus making the amplifier particularly suitable for use in measurement and test equipment. Additional characteristics include very low DC offset, low drift, low noise, very high open-loop gain, very high common-mode rejection ratio, and very high input impedances. Instrumentation amplifiers are used where great accuracy and stability of the circuit both short and long term are required. The electronic instrumentation amplifier is almost always internally composed of 3 op-amps. These are arranged so that there is one op-amp to buffer each input (+,-), and one to produce the desired output with adequate impedance matching for the function. Hence, the use of instrumentation amplifier reduces the noise by rejecting the common noise signals and provides a very high gain required by the ECG monitoring circuit.

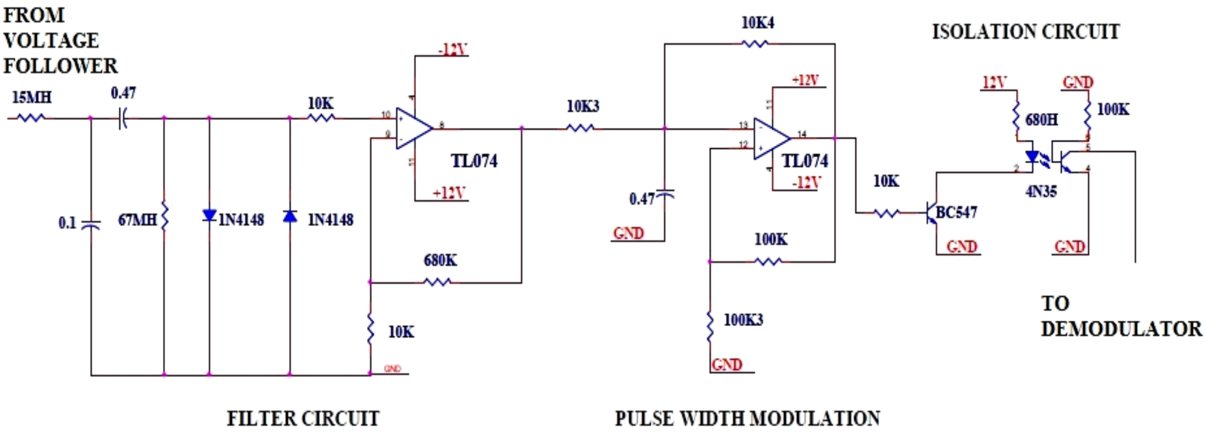

Fig.5.3 Filters and Opto isolator

The amplified difference signal outputted from the instrumentation amplifier is fed to a voltage follower circuit which reduces further noise which got amplified by the amplifier output. Then the signal is filtered to a band between 0.5Hz and 150Hz using a high pass and low pass filters respectively. It removes all the unnecessary noises which mostly caused by heart. After that the signal is again further amplified using another instrumentation amplifier and is fed to a PWM generator for driving the optical isolator circuitry.

Isolation circuits prevent leakages currents from entering the person’s body in any manner and thus to prevent shocks. Optical isolation being cheaper and cost effective method is used here. It uses a short optical transmission path to transfer a signal between elements of a circuit, typically a transmitter and a receiver, while keeping them electrically isolate since the signal goes from an electrical signal to an optical signal back to an electrical signal, electrical contact along the path is broken. When an electrical signal is applied to the input of the opto isolator, its LED lights, its light sensor then activates, and a corresponding electrical signal is generated at the output. With a photodiode as the detector, the output current is proportional to the amount of incident light supplied by the emitter.

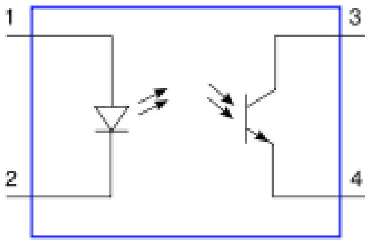

Fig.5.4 Opto isolator operation

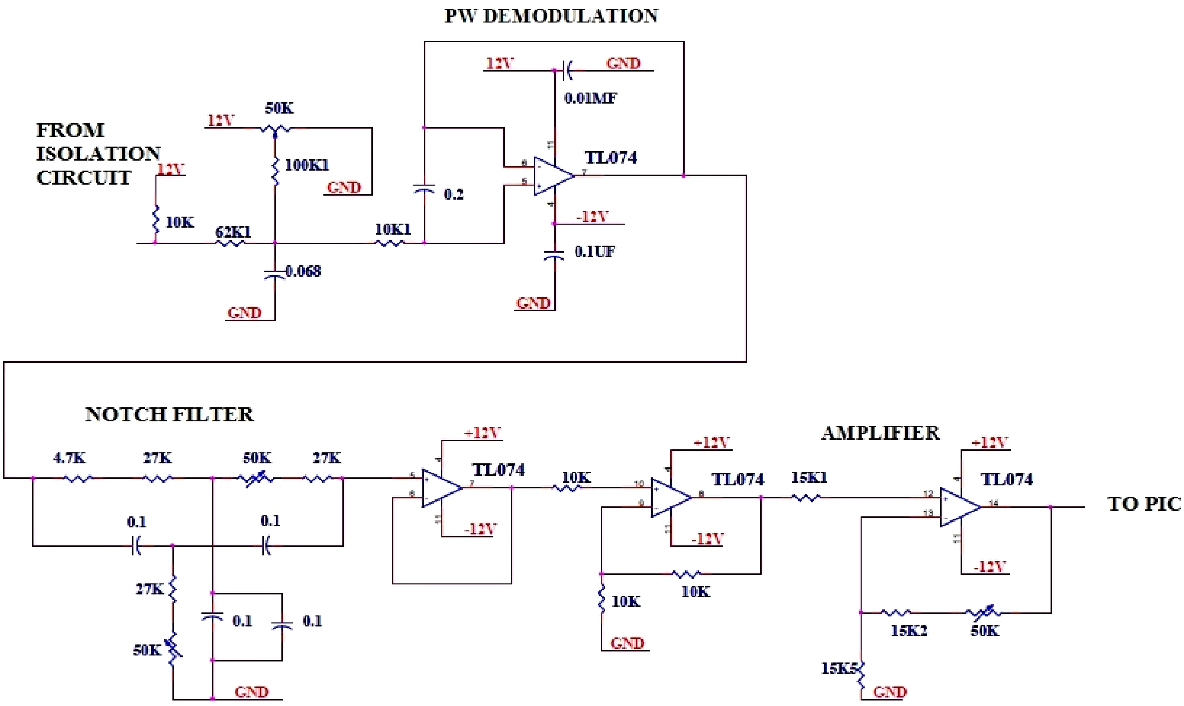

Fig.5.5 PW demodulation and amplification

The opto coupler consists of photo LED and photo transistor. The photo transistor conducting only when light rays falls on the base of the transistor. The signal to be isolated is given to base of BC547 switching transistor. Whenever the signal is high, the transistor is switched ON, so the emitter and collector terminals are shorted. Now the photo LED is conducting and light rays falls on the photo transistor. Due to that the photo transistor is conducting and shorts the emitter and collector terminal. The 7404 inverter is connected in the collector terminal. So the ground signal that is zero signals is given to inverter input and high pulse is taken from the inverter output. Now the output pulse is equal to input pulse as applied to the base of the transistor BC547 (Q1). PWM output signal is to be demodulated in order to get the original signal and hence PWM demodulation circuit is implied.

A notch filter is a band-stop filter with a narrow stopband (high Q factor). Notch filters are used in live sound and in instrument amplifier (especially amplifiers or preamplifiers for acoustic instruments such as acoustic guitar, mandolin, bass instrument amplifier, etc.) to reduce or prevent feedback, while having little noticeable effect on the rest of the frequency spectrum. Other names include 'band limit filter', 'T-notch filter', 'band-elimination filter', and 'band-rejection filter'.

Typically, the width of the stopband is less than 1 to 2 decades (that is, the highest frequency attenuated is less than 10 to 100 times the lowest frequency attenuated). In the audio band, a notch filter uses high and low frequencies that may be only semitones apart. Here the notch filter is constructed by the operational amplifier TL074. Finally noise free EMG wave is given to amplifier. Then the amplifed signal is given to PIC.

5.2 TEMPERATURE MONITOR CIRCUITRY

The temperature monitoring circuitry includes the thermistor and the voltage division circuitry for the same. Since the resistance of the thermistor varies in accordance with the temperature variation, the body temperature of the person can be found out using the value of current through the thermistor. Here we are using negative temperature co-efficient in which the resistance value is decreased when the temperature is increased. This signal is fed to the one of the ports of the microcontroller.

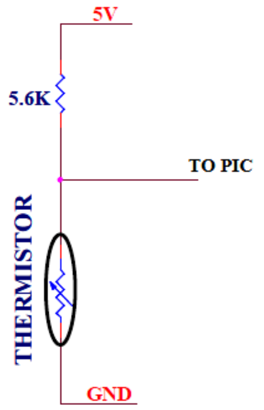

Fig.5.6 Thermistor circuit

5.3 PRESSURE MONITOR CIRCUITRY

Pressure monitoring circuitry includes the pressure sensor MPX2010, instrumentation amplifier and the inverting amplifier. The pressure sensor attached to the person generates an electrical signal corresponding to the value of blood pressure of that person. This signal being weak is fed to the instrumentation amplifier for amplification and noise reduction. Since this has no electrodes attached directly to body, it does not constitute isolation circuitry. This amplified signal is further amplified using inverting amplifier and is fed to one of the ports of the microcontroller.

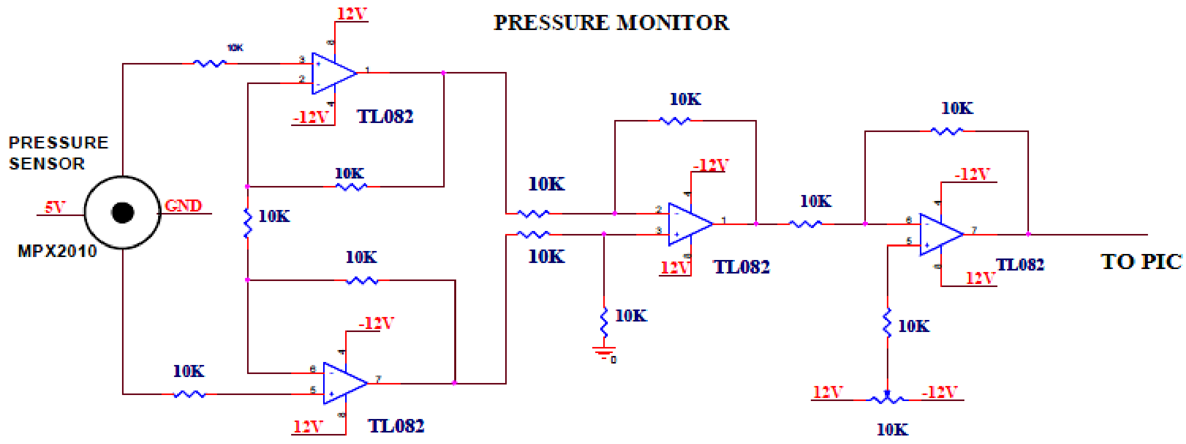

Fig.5.7 Pressure monitor

5.4 LCD INTERFACING

The LCD used here is Hitachi HD66780 which is a 16 pin IC. The 1st and 16th pins are connected to the ground. The 2nd and 15th pins are connected to the 5V supply. The third pin being the pin for the brightness adjustment of the LCD backlight is connected to the movable terminal of a potentiometer whose other two terminals is connected to 5V DC supply and ground terminals respectively. The 4th pin (i.e. register select pin) is connected to the 4th pin of the PORTC and 6th pin (i.e. the enable pin) is connected to the 6th pin of PORTC.

Here there is no LCD read required, the RW pin is set to LOW by connecting it to the ground. The data lines constitute the pins from 7 to 14.The 8 data lines are connected to the 8 pins of a PORT D. Thus the microcontroller can display whatever it want to display through the data lines after enabling the LCD by giving an active HIGH signal. When the RS signal is HIGH, Data Register writes as an internal operation and when it is LOW, Instruction Register writes as an internal operation.

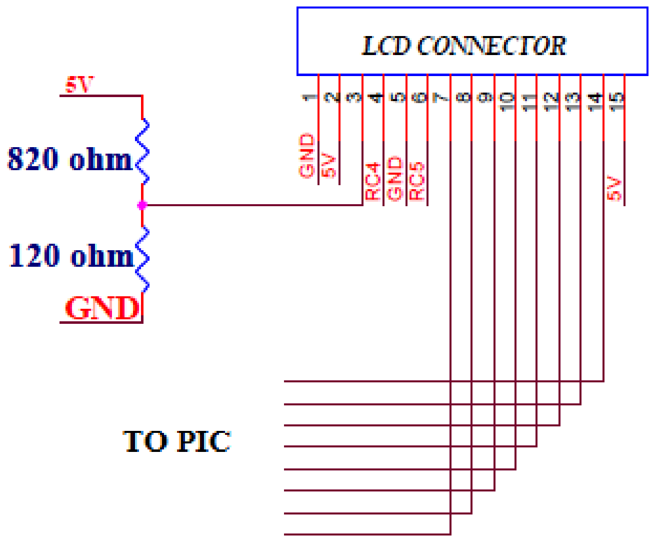

Fig.5.8 LCD interface

5.5 ALARM

Alarm circuitry mainly includes a transistor switch BC547 and the buzzer. The circuit is designed in such a manner than whenever the microcontroller sends a logical LOW signal to the port where the alarm circuitry is connected, the alarm will be set to OFF condition and vice versa.

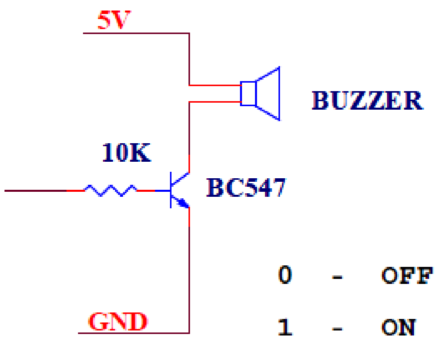

Fig.5.9 Alarm circuit

5.6 MICROCONTROLLER

The microcontroller used here is PIC 16877 which is a 40 Pin IC. The different inputs to the microcontroller are temperature monitor section output, the pressure monitor output, the EMG monitoring output, and Zigbee output. The outputs from the microcontroller include the signals for wireless transmission, alarm system, and LCD interfacing. These inputs and outputs are connected to the different ports as shown in the figure. Apart from these, the microcontroller is also provided with power supply and oscillator feeds for its efficient working. The signal received from the remote sender defines the threshold values of the various parameters measured. This is compared with the obtained results and if the obtained results exceed the thresholds, alarm is set to ON. Both the values are outputted to the LCD irrespective whether it is within or beyond the threshold but a additional message will also be displayed in the LCD if the threshold is broken. The obtained values are sent to the Zigbee through by means of PWM signals.

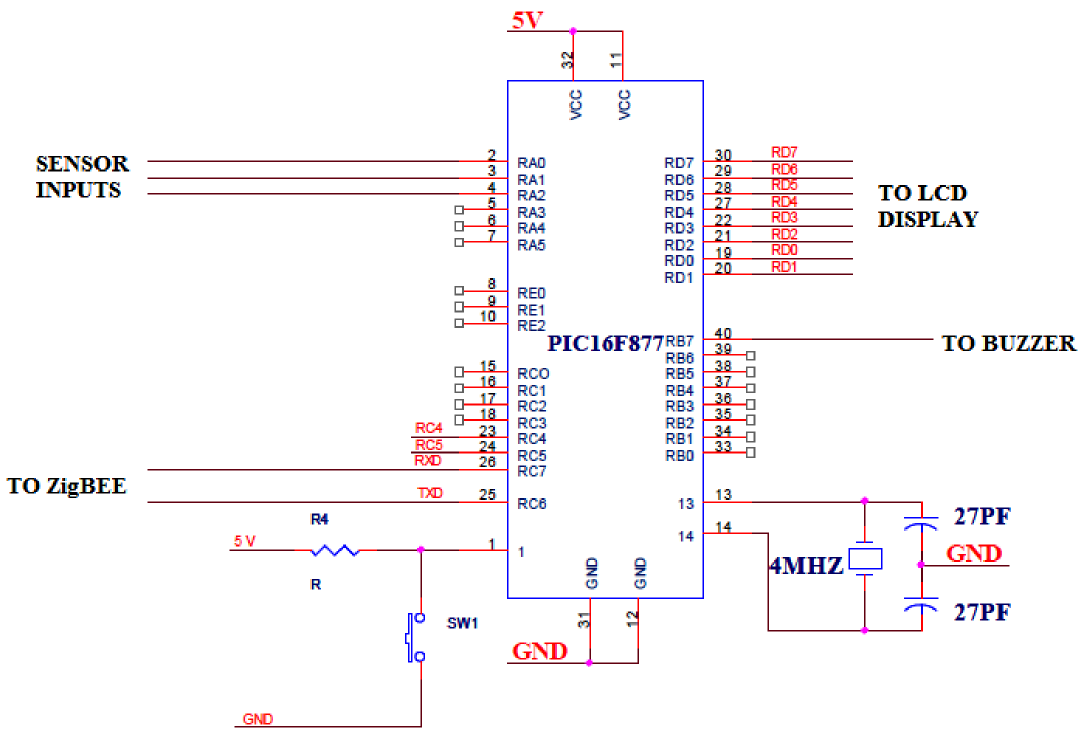

Fig.5.10 PIC interface

5.7 COMPUTER INTERFACE SECTION

The computer interface section of the system includes Zigbee module, Logic level converter, RS232 connector and the power supply section for the same. The power supply section used in the receiver side is similar to the transmitter side i.e. DC supply by converting the widely & easily available AC power supply. The receiver side only requires the 5V DC and hence only one power supply section is only required.

A Zigbee module is used at the receiver side is similar to that on transmitter side and works on the same power levels. It has two lines which are being fed to the pins of the logic level converter IC. It is also bi directional in nature. It transmits data from the PIC to the level converter. The level converter changes the voltage level for enabling serial communication. The Zigbee provides protection to the transmitted message since it uses spread spectrum modulation techniques. The message will be modulated in QPSK and transmitted at a frequency of 2.4GHz

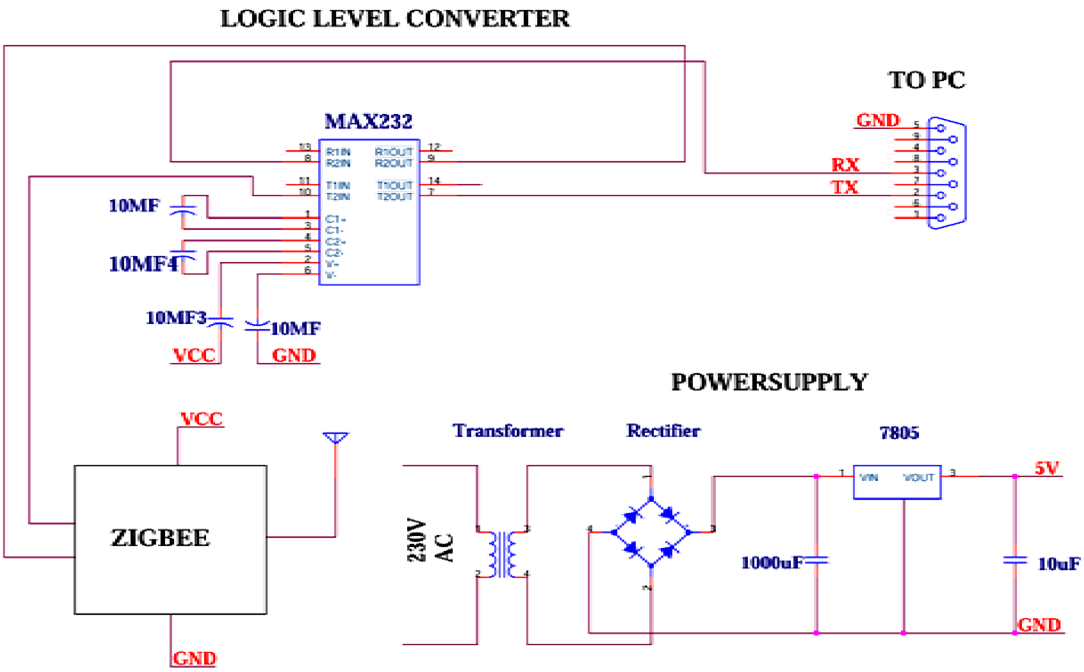

Fig. 5.11 Computer interface Section of PEMS

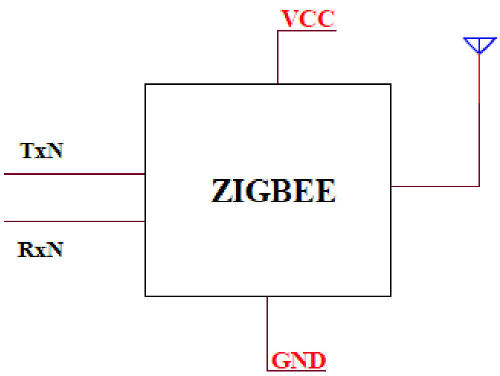

Fig. 5.12 Zigbee

The logic level converter converts the received signal from the receptor Zigbee module to a form which can be understandable for the computer as the output of the logic level converter is connected to the RS232. The logic level converter used here is MAX232. The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply EIA-232 voltage levels from a single 5-V supply. Each receiver converts EIA-232 inputs to 5-V TTL/CMOS levels. These receivers have a typical threshold of 1.3 V and a typical hysteresis of 0.5 V, and can accept ±30-V inputs. Each driver converts TTL/CMOS input levels into EIA-232 levels.

Table I. MAX232 Function

EACH DRIVER

INPUT TIN	OUTPUT TOUT
L	H
H	L

H = high level, L = low level

EACH RECEIVER

INPUT RIN	OUTPUT ROUT
L	H
H	L

H = high level, L = low level

In this circuit the Zigbee transmitter pin is connected in the MAX232 T2IN pin which converts input 5v TTL/CMOS level to RS232 level. Then T2OUT pin is connected to reviver pin of 9 pin D type serial connector which is directly connected to PC. In PC the transmitting data is given to R2IN of MAX232 through transmitting pin of 9 pin D type connector which converts the RS232 level to 5v TTL/CMOS level. The R2OUT pin is connected to receiver pin of the Zigbee. Likewise the data is transmitted and received between the Zigbee and PC vice versa. The serial communication is designed at a baud rate of 9600 symbols per second and synchronous in nature. So data can be transferred or received at same time.

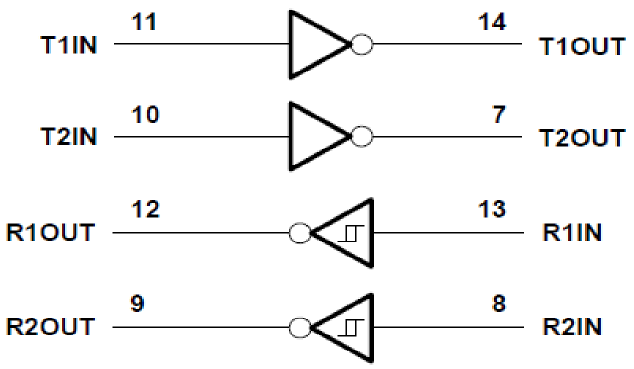

Fig. 5.13 Logic diagram

In this circuit the Zigbee transmitter pin is connected in the MAX232 T2IN pin which converts input 5v TTL/CMOS level to RS232 level. Then T2OUT pin is connected to reviver pin of 9 pin D type serial connector which is directly connected to PC. In PC the transmitting data is given to R2IN of MAX232 through transmitting pin of 9 pin D type connector which converts the RS232 level to 5v TTL/CMOS level. The R2OUT pin is connected to receiver pin of the Zigbee. Likewise the data is transmitted and received between the Zigbee and PC vice versa. The serial communication is designed at a baud rate of 9600 symbols per second and synchronous in nature. So data can be transferred or received at same time.

5.8 POWER SUPPLY SECTION

Power supply is the inevitable part of any system. Here, there are different sections within the system which requires different power ratings and voltage ratings. In order to meet up with the required level of DC voltages for the various components, it is necessary to provide DC supply either through interconnection of cells or by conversion from AC supply. Since the latter is more economically feasible and easily available, it is being used here too. The transmitter section includes components that work on three different voltage levels i.e. 5V and +12V and -12V.The receiver section includes components which work on only 5V. Such power supply sections include a step down transformer, rectifier circuit, filter circuit, voltage regulators.

The transformer used here is of step down type i.e. it converts the input AC signal of 230V into AC signal of 12V and 5V respectively. This is fed to a bridge rectifier circuitry which converts the AC to DC. One advantage of a bridge rectifier over a conventional full-wave rectifier is that with a given transformer the bridge rectifier produces a voltage output that is nearly twice that of the conventional full-wave circuit. The input to the circuit is applied to the diagonally opposite corners of the network, and the output is taken from the remaining two corners. This is fed to a filter circuit for ripple reduction.

The filter used here are of capacitor type as it is the easiest and cost efficient technique. This type of filter works on the principle of the capacitor action of charging and discharging. The ripple can be reduced by increasing the time constant of the capacitor. This is fed to a voltage regulator for obtaining the required voltage levels.

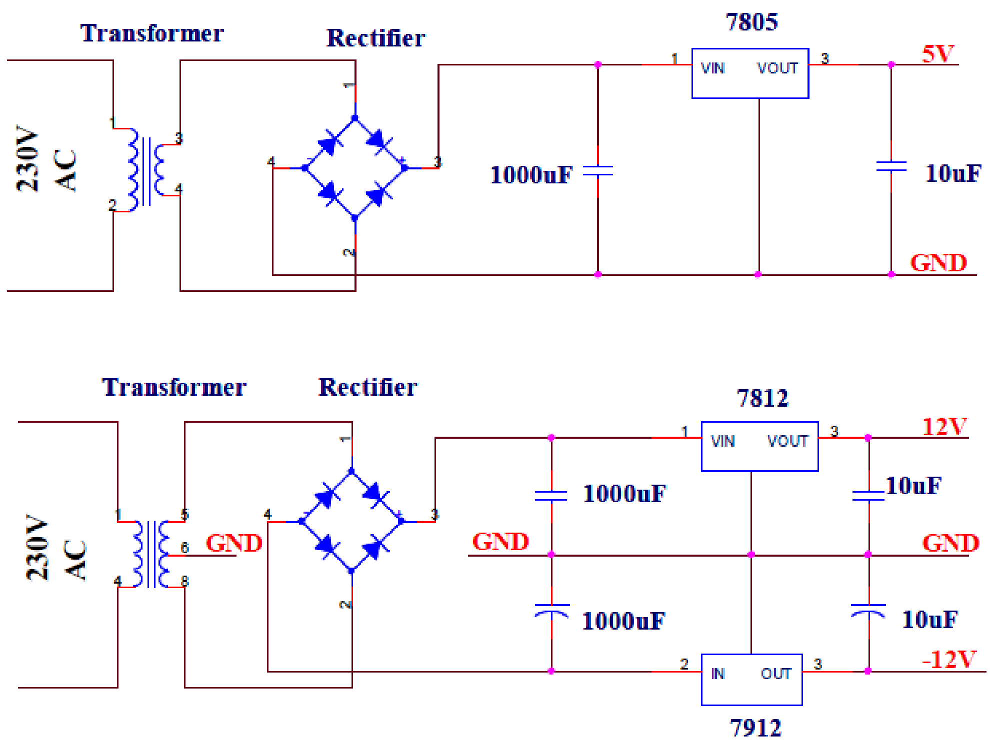

Fig. 5.14 Power supplies

The voltage regulators used here are of Integrated Circuit type where there are three leads for the IC out of which one lead is common to both input and output i.e. the ground terminal and the other two terminals for input and output. The IC's 7812 and 7912 produces voltage outputs of +12V and -12V respectively whereas the IC 7805 produces voltage output of 5V. Additional capacitor filters are also provided at both input and output terminals of the regulators for further ripple reduction and thereby to produce a more stable DC output voltage at the required levels.

CHAPTER 6
HARDWARE REQUIREMENTS

6.1 PIC 16F877

A microcontroller is a complete microprocessor system built on a single IC. Microcontrollers were developed to meet a need for microprocessors to be put into low cost products. A microcontroller is a Computer On A Chip or a single chip computer. Micro suggests that the device is small, and controller tells one that the device might be used to control objects, processes, or events. Another term to describe a microcontroller is embedded controller, because the microcontroller and its support circuits are often built into, or embedded in, the devices they control. The microcontroller contains full implementation of a standard MICROPROCESSOR, ROM, RAM, I/O, CLOCK, TIMERS, and also SERIAL PORTS. Microcontroller also called "system on a chip" or "single chip microprocessor system" or "computer on a chip".

The microcontroller that has been used for this project is from PIC series. PIC microcontroller is the first RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory. The main advantage of CMOS and RISC combination is low power consumption resulting in a very small chip size with a small pin count. The main advantage of CMOS is that it has immunity to noise than other fabrication techniques.

Various microcontrollers offer different kinds of memories. EEPROM, EPROM, FLASH etc. are some of the memories of which FLASH is the most recently developed. Technology that is used in pic16F877 is flash technology, so that data is retained even when the power is switched off. Easy Programming and Erasing are other features of PIC 16F877.

6.1.1 Core Features

- High-performance RISC CPU
- Only 35 single word instructions to learn
- All single cycle instructions except for program branches which are two cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory,
  Up to 368 x 8 bytes of Data Memory (RAM)
  Up to 256 x 8 bytes of EEPROM data memory
- Pin out compatible to the PIC16C73/74/76/77
- Interrupt capability (up to 14 internal/external
- Eight level deep hardware stack
- Direct, indirect, and relative addressing modes
- Power-on Reset (POR)
- Power-up Timer (PWRT) and Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own on-chip RC Oscillator for reliable operation
- Programmable code-protection
- Power saving SLEEP mode
- Selectable oscillator options
- Low-power, high-speed CMOS EPROM/EEPROM technology
- Fully static design
- In-Circuit Serial Programming (ICSP) via two pins
- Only single 5V source needed for programming capability
- In-Circuit Debugging via two pins
- Processor read/write access to program memory
- Wide operating voltage range: 2.5V to 5.5V
- High Sink/Source Current: 25 mA
- Commercial and Industrial temperature ranges
- Low-power consumption:

< 2mA typical @ 5V, 4 MHz

20mA typical @ 3V, 32 kHz

< 1mA typical standby current

6.1.2 Peripheral Features

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during sleep
  Via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  Capture is 16-bit, max resolution is 12.5 ns,
  Compare is 16-bit, max resolution is 200 ns,
  PWM max. Resolution is 10-bit
- 10-bit multi-channel Analog-to-Digital converter
- Synchronous Serial Port (SSP) with SPI. (Master Mode) and I2C. (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with
  9- Bit addresses detection.
- Brown-out detection circuitry for Brown-out Reset (BOR)

6.1.3 Analog to Digital Converter (ADC)

There are two types of analog to digital converter is present in this IC. We use 10-bit ADC. The ADC module can have up to eight analog inputs for a device. The analog input charges a sample and hold capacitor. The output of sample and hold capacitor is the input into the converter. The converter then generates a digital result of this analog level via successive approximation. The A/D conversion of the analog input signal results in a corresponding10-bit digital number.

The A/D module has high and low voltage reference input that is software selectable to some combination of VDD, VSS, and RA2 Or RA3.The A/D module has four registers. These registers are

A/D result high register (ADRESH)
A/D RESULT LOW REGISTER (ADRESL)
A/D CONTROL REGISTER 0 (ADCON0)
A/D CONTROL REGISTER 1 (ADCON1)

6.1.4 Architecture of PIC 16F877

The complete architecture of PIC 16F877 is shown in the fig 5.1. Table I gives details about the specifications of PIC 16F877. Fig 5.2 shows the complete pin diagram of the IC PIC 16F877.

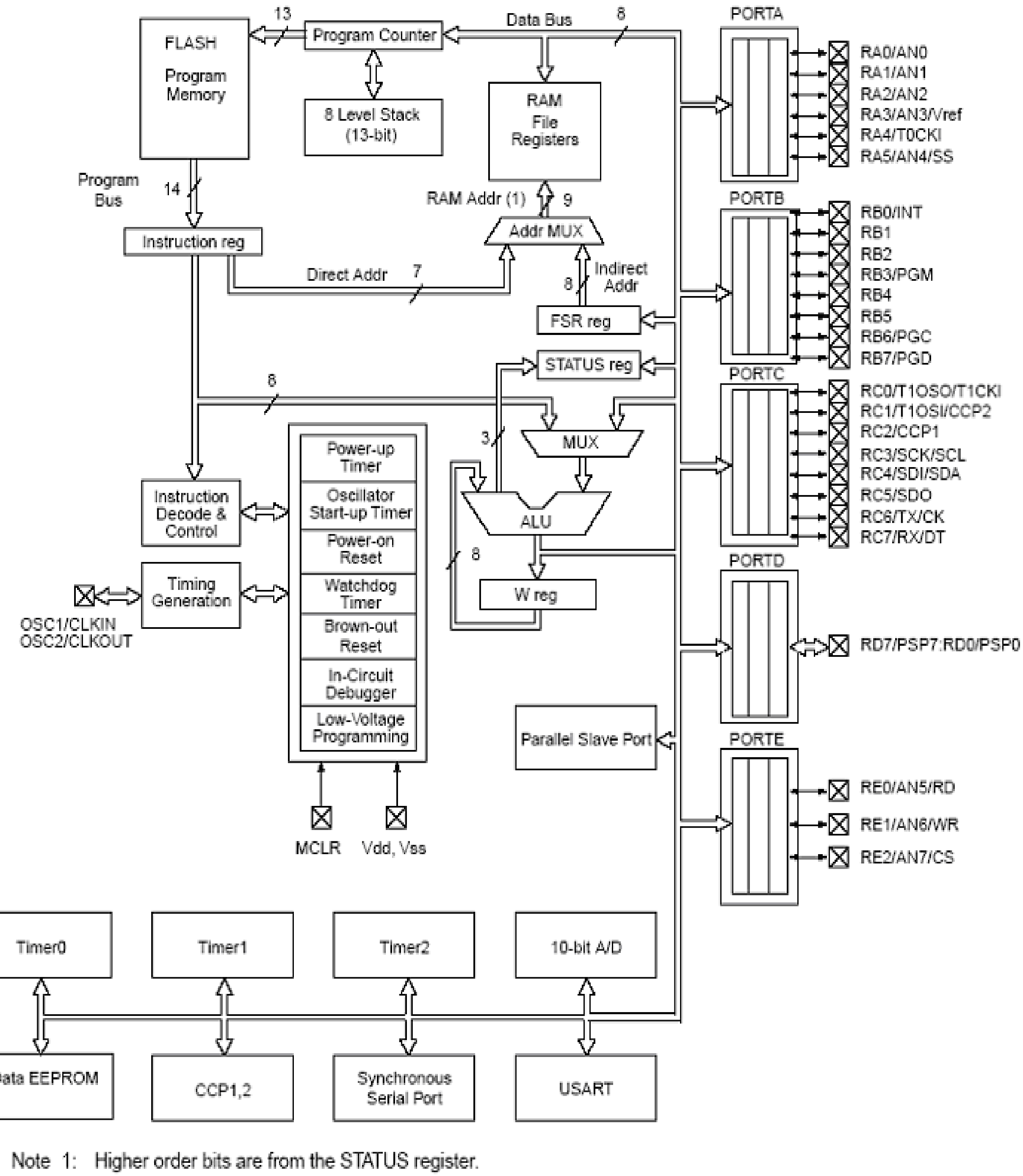

Fig. 6.1 Architecture of PIC 16F877

Table II. Specification of PIC 16F877

DEVICE	PROGRAM FLASH	DATA MEMORY	DATA EEPROM
PIC 16F877	8K	368 Bytes	256 Bytes

6.1.5 Pin Diagram of PIC 16F877

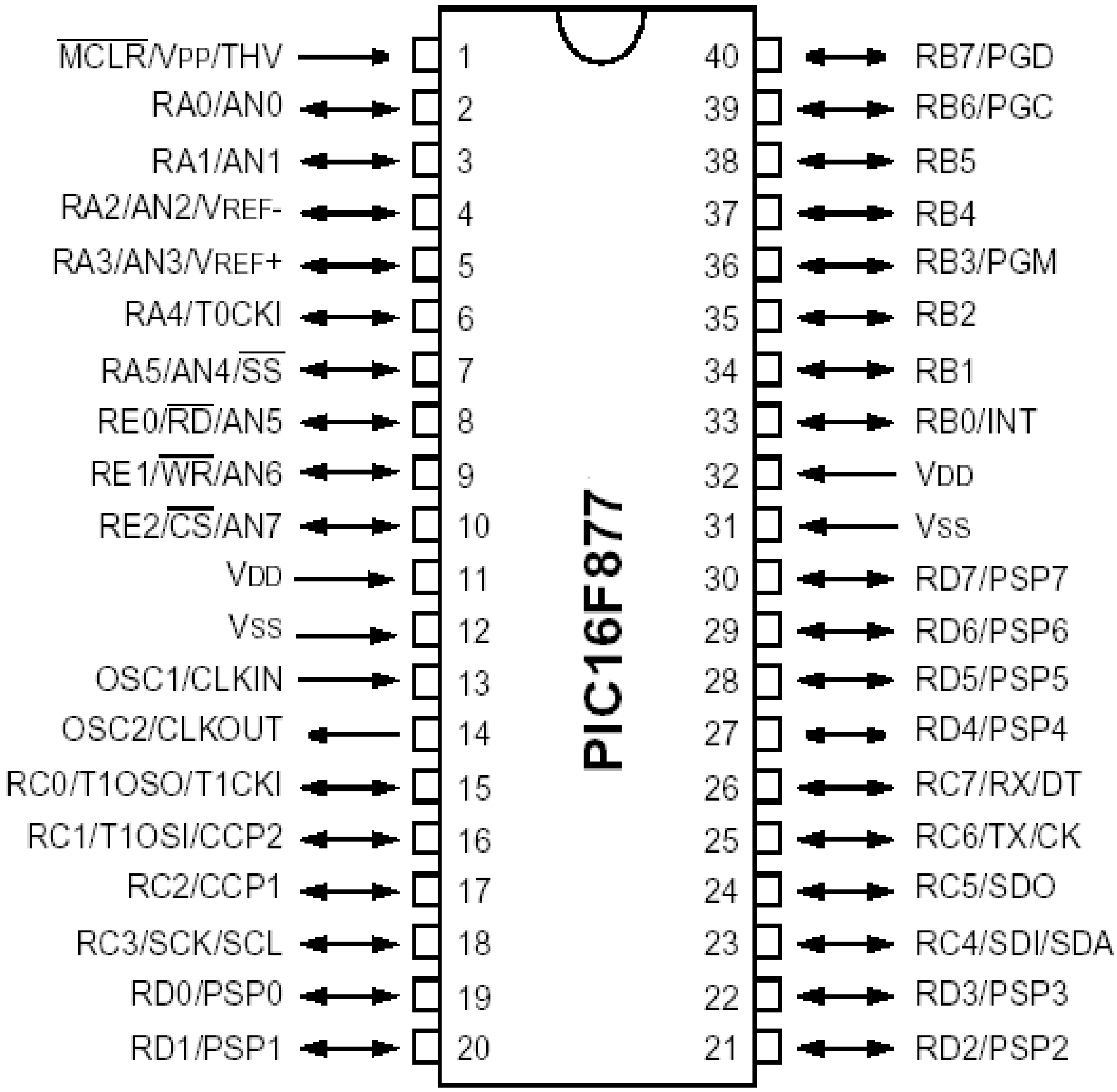

Fig. 6.2 Pin diagram of PIC 16F877

Table III. Pin description of PIC 16F877

Pin Name	DIP Pin#	PLCC Pin#	QFP Pin#	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	13	14	30	I	ST/CMOS(4)	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	14	15	31	O	—	Oscillator crystal output. Connects to crystal or resonator in crystal oscillator mode. In RC mode, OSC2 pin outputs CLKOUT which has 1/4 the frequency of OSC1, and denotes the instruction cycle rate.
$\overline{\text{MCLR}}$/VPP/THV	1	2	18	I/P	ST	Master clear (reset) input or programming voltage input or high voltage test mode control. This pin is an active low reset to the device.
						PORTA is a bi-directional I/O port.
RA0/AN0	2	3	19	I/O	TTL	RA0 can also be analog input0
RA1/AN1	3	4	20	I/O	TTL	RA1 can also be analog input1
RA2/AN2/VREF-	4	5	21	I/O	TTL	RA2 can also be analog input2 or negative analog reference voltage
RA3/AN3/VREF+	5	6	22	I/O	TTL	RA3 can also be analog input3 or positive analog reference voltage
RA4/T0CKI	6	7	23	I/O	ST	RA4 can also be the clock input to the Timer0 timer/ counter. Output is open drain type.
RA5/$\overline{\text{SS}}$/AN4	7	8	24	I/O	TTL	RA5 can also be analog input4 or the slave select for the synchronous serial port.
						PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	33	36	8	I/O	TTL/ST(1)	RB0 can also be the external interrupt pin.
RB1	34	37	9	I/O	TTL	
RB2	35	38	10	I/O	TTL	
RB3/PGM	36	39	11	I/O	TTL	RB3 can also be the low voltage programming input
RB4	37	41	14	I/O	TTL	Interrupt on change pin.
RB5	38	42	15	I/O	TTL	Interrupt on change pin.
RB6/PGC	39	43	16	I/O	TTL/ST(2)	Interrupt on change pin or In-Circuit Debugger pin. Serial programming clock.
RB7/PGD	40	44	17	I/O	TTL/ST(2)	Interrupt on change pin or In-Circuit Debugger pin. Serial programming data.
						PORTC is a bi-directional I/O port.
RC0/T1OSO/T1CKI	15	16	32	I/O	ST	RC0 can also be the Timer1 oscillator output or a Timer1 clock input.
RC1/T1OSI/CCP2	16	18	35	I/O	ST	RC1 can also be the Timer1 oscillator input or Capture2 input/Compare2 output/PWM2 output.
RC2/CCP1	17	19	36	I/O	ST	RC2 can also be the Capture1 input/Compare1 output/ PWM1 output.
RC3/SCK/SCL	18	20	37	I/O	ST	RC3 can also be the synchronous serial clock input/ output for both SPI and I2C modes.
RC4/SDI/SDA	23	25	42	I/O	ST	RC4 can also be the SPI Data In (SPI mode) or data I/O (I2C mode).
RC5/SDO	24	26	43	I/O	ST	RC5 can also be the SPI Data Out (SPI mode).
RC6/TX/CK	25	27	44	I/O	ST	RC6 can also be the USART Asynchronous Transmit or Synchronous Clock.
RC7/RX/DT	26	29	1	I/O	ST	RC7 can also be the USART Asynchronous Receive or Synchronous Data.
						PORTD is a bi-directional I/O port or parallel slave port when interfacing to a microprocessor bus.
RD0/PSP0	19	21	38	I/O	ST/TTL(3)	
RD1/PSP1	20	22	39	I/O	ST/TTL(3)	
RD2/PSP2	21	23	40	I/O	ST/TTL(3)	
RD3/PSP3	22	24	41	I/O	ST/TTL(3)	
RD4/PSP4	27	30	2	I/O	ST/TTL(3)	
RD5/PSP5	28	31	3	I/O	ST/TTL(3)	
RD6/PSP6	29	32	4	I/O	ST/TTL(3)	
RD7/PSP7	30	33	5	I/O	ST/TTL(3)	
						PORTE is a bi-directional I/O port.
RE0/$\overline{\text{RD}}$/AN5	8	9	25	I/O	ST/TTL(3)	RE0 can also be read control for the parallel slave port, or analog input5.
RE1/$\overline{\text{WR}}$/AN6	9	10	26	I/O	ST/TTL(3)	RE1 can also be write control for the parallel slave port, or analog input6.
RE2/$\overline{\text{CS}}$/AN7	10	11	27	I/O	ST/TTL(3)	RE2 can also be select control for the parallel slave port, or analog input7.
VSS	12,31	13,34	6,29	P	—	Ground reference for logic and I/O pins.
VDD	11,32	12,35	7,28	P	—	Positive supply for logic and I/O pins.
NC	—	1,17,28, 40	12,13, 33,34		—	These pins are not internally connected. These pins should be left unconnected.

6.2 SKIN ELECTRODE

Electrodes are the devices which converts ionic potentials associated with tissues into electronic potentials. As in the case of muscles the bioelectric potentials associated with them constitute the electromyogram(EMG). These potentials may be measured at the surface of the body near a muscle of interest or directly from the muscle by penetrating the skin with needle electrode.

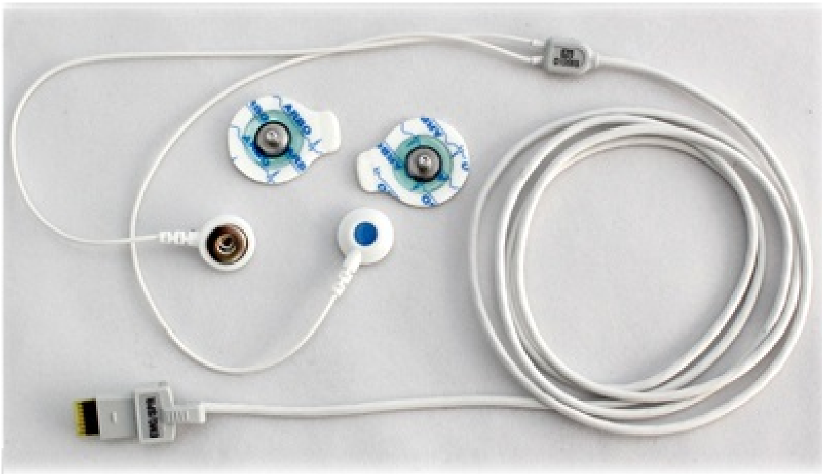

Fig. 6.3 Skin electrode and connector

Most of the EMG measurements are intended to obtain an indication of the amount of activity of a given muscle, or group of muscles, rather than of an individual muscle fiber, the pattern is usually a summation of the individual action potentials from the fibers constituting the muscle or muscle being measured. Because these action potentials occur in both positive and negative polarities at a given pair of electrodes, they sometimes add and sometimes cancel. Thus the EMG waveform appears very much like a random noise waveform, with the energy of the signal a function of the amount of muscle activity and electrode placement.

The electrodes used in this system are 3M Red dot repositionable skin electrode designed with a larger conductive area to help improve trace quality by reducing ECG artefact. They adhere securely and are repositionable allow the user to move the electrode rather than replacing with new ones. It will have a impedance of 40KΩ.The electrode is coated with Ag-AgCl.

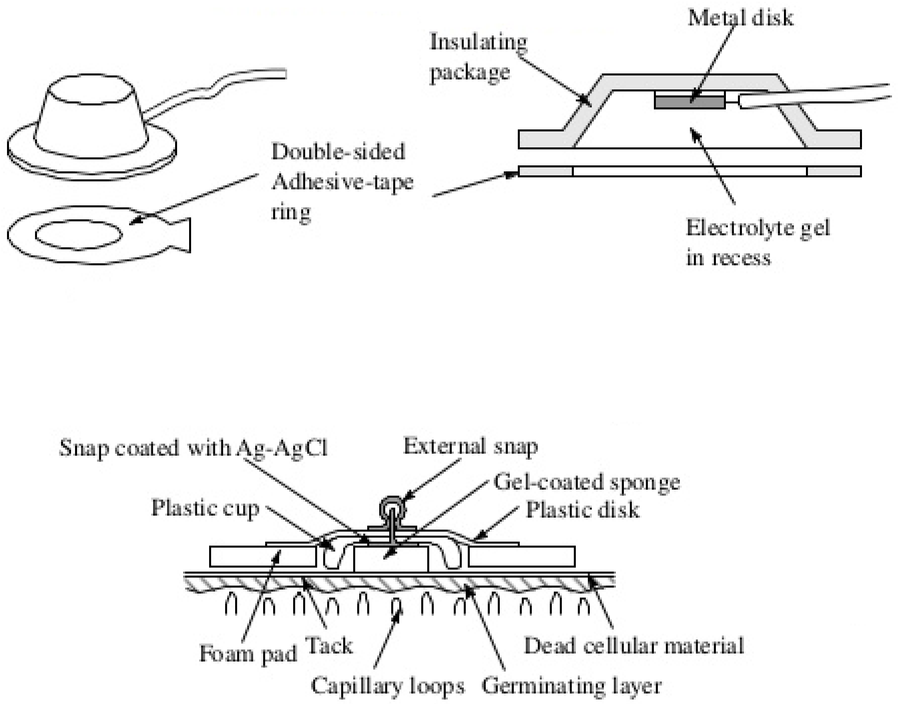

Fig. 6.4 Skin electrode structure

6.3 THERMISTOR

A thermistor is a type of resistor used to measure temperature changes, relying on the change in its resistance with changing temperature. Thermistor is a combination of the words thermal and resistor. Thermistor can be classified into two types depending on the resistance relation with temperature. If the resistance increases with increasing temperature, and the device is called a positive temperature coefficient (PTC) thermistor, Posistor. If the resistance decreases with increasing temperature, and the device is called a negative temperature coefficient (NTC) thermistor. Resistors that are not thermistors are designed to have the smallest possible *k*, so that their resistance remains almost constant over a wide temperature range.

The thermistor used in the PEMS is negative temperature co efficient in which the resistance value is decreased when the temperature is increased. It is a Epoxy coated point matched disc thermistors with .010" nickel PTFE insulated lead-wires. The operating temperature range is from -50°C to 150°C.

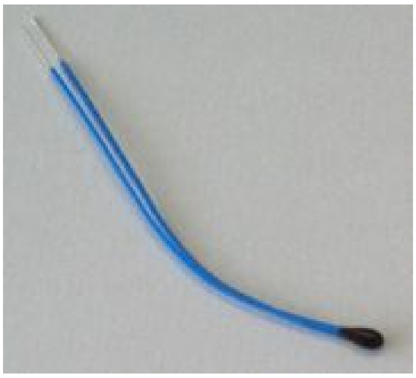

Fig. 6.5 Thermistor

6.4 PRESSURE SENSOR

A pressure sensor measures pressure, typically of gases or liquids. Pressure is an expression of the force required to stop a fluid from expanding, and is usually stated in terms of force per unit area. A pressure sensor usually acts as a transducer; it generates a signal as a function of the pressure imposed. Pressure sensors are used for control and monitoring in thousands of everyday applications. Pressure sensors can also be used to indirectly measure other variables such as fluid/gas flow, speed, water level, and altitude.

Pressure sensors can vary drastically in technology, design, performance, application suitability and cost. A conservative estimate would be that there may be over 50 technologies and at least 300 companies making pressure sensors worldwide. There is also a category of pressure sensors that are designed to measure in a dynamic mode for capturing very high speed changes in pressure. Example applications for this type of sensor would be in the measuring of combustion pressure in an engine cylinder or in a gas turbine. These sensors are commonly manufactured out of piezoelectric materials such as quartz.

The pressure sensor used here is a MPX2010 series. The MPX2010 series silicon piezo resistive pressure sensors provide a very accurate and linear voltage output directly proportional to the applied pressure. These sensors house a single monolithic silicon die with the strain gauge and thin film resistor network integrated. The sensor is laser trimmed for precise span, offset calibration and temperature compensation.

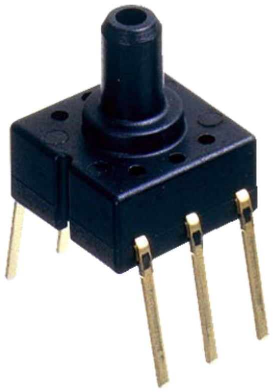

Fig.6.6 MPX2010

Features

• Temperature Compensated over 0°C to +85°C

• Ratiometric to Supply Voltage

• Differential and Gauge Options

• Available in Easy-to-Use Tape & Reel

6.5 OPTO COUPLER

In electronics, an opto-isolator (or optical isolator, opto coupler or photo coupler) is a device that uses a short optical transmission path to transfer a signal between elements of a circuit, typically a transmitter and a receiver, while keeping them electrically isolate since the signal goes from an electrical signal to an optical signal back to an electrical signal, electrical contact along the path is broken.

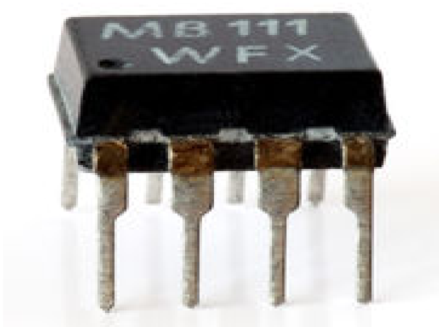

Fig.6.7 MB 111 Opto Coupler chip

A common implementation involves an LED and a light sensor, separated so that light may travel across a barrier but electrical current may not. When an electrical signal is applied to the input of the opto-isolator, its LED lights, its light sensor then activates, and a corresponding electrical signal is generated at the output. Unlike a transformer, the opto-isolator allows for DC coupling and generally provides significant protection from serious overvoltage conditions in one circuit affecting the other.

With a photodiode as the detector, the output current is proportional to the amount of incident light supplied by the emitter. The diode can be used in a photovoltaic mode or a photoconductive mode. In photovoltaic mode, the diode acts like a current source in parallel with a forward-biased diode. The output current and voltage are dependent on the load impedance and light intensity. In photoconductive mode, the diode is connected to a supply voltage, and the magnitude of the current conducted is directly proportional to the intensity of light.

6.6 LCD

Liquid crystal displays (LCDs) have materials which combine the properties of both liquids and crystals. Rather than having a melting point, they have a temperature range within which the molecules are almost as mobile as they would be in a liquid, but are grouped together in an ordered form similar to a crystal.

An LCD consists of two glass panels, with the liquid crystal material sand witched in between them. The inner surface of the glass plates are coated with transparent electrodes which define the character, symbols or patterns to be displayed polymeric layers are present in between the electrodes and the liquid crystal, which makes the liquid crystal molecules to maintain a defined orientation angle.One each polarisers are pasted outside the two glass panels. These polarisers would rotate the light rays passing through them to a definite angle, in a particular direction.

When the LCD is in the off state, light rays are rotated by the two polarisers and the liquid crystal, such that the light rays come out of the LCD without any orientation, and hence the LCD appears transparent. When sufficient voltage is applied to the electrodes, the liquid crystal molecules would be aligned in a specific direction. The light rays passing through the LCD would be rotated by the polarisers, which would result in activating / highlighting the desired characters.

The LCD's are lightweight with only a few millimeters thickness. Since the LCD's consume less power, they are compatible with low power electronic circuits, and can be powered for long durations. The LCD's don't generate light and so light is needed to read the display. By using backlighting, reading is possible in the dark. The LCD's have long life and a wide operating temperature range. Changing the display size or the layout size is relatively simple which makes the LCD's more customer friendly.

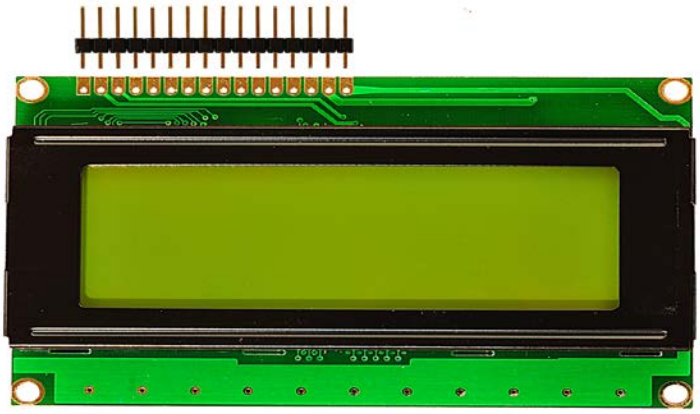

Fig. 6.8 A 16x2 LCD display

The LCDs used exclusively in watches, calculators and measuring instruments are the simple seven-segment displays, having a limited amount of numeric data. The recent advances in technology have resulted in better legibility, more information displaying capability and a wider temperature range. These have resulted in the LCDs being extensively used in telecommunications and entertainment electronics. The LCDs have even started replacing the cathode ray tubes (CRTs) used for the display of text and graphics, and also in small TV applications.

6.7 BUZZER

A buzzer or beeper is a signalling device, usually electronic, typically used in automobiles, household appliances such as a microwave oven, or game shows. It most commonly consists of a number of switches or sensors connected to a control unit that determines if and which button was pushed or a preset time has lapsed, and usually illuminates a light on the appropriate button or control panel, and sounds a warning in the form of a continuous or intermittent buzzing or beeping sound. Initially this device was based on an electromechanical system which was identical to an electric bell without the metal gong (which makes the ringing noise).

Fig. 6.9 Buzzer

Often these units were anchored to a wall or ceiling and used the ceiling or wall as a sounding board. Another implementation with some AC-connected devices was to implement a circuit to make the AC current into a noise loud enough to drive a loudspeaker and hook this circuit up to a cheap 8-ohm speaker. Nowadays, it is more popular to use a ceramic-based piezoelectric sounder like a Son alert which makes a high-pitched tone. Usually these were hooked up to "driver" circuits which varied the pitch of the sound or pulsed the sound on and off.

6.8 ZIGBEE

ZigBee is a specification for a suite of high-level communication protocols used to create personal area networks built from small, low-power digital radios. ZigBee is based on an IEEE 802.15 standard. Though low-powered, ZigBee devices can transmit data over long distances by passing data through intermediate devices to reach more distant ones, creating a mesh network; i.e., a network with no centralized control or high-power transmitter/receiver able to reach all of the networked devices. The decentralized nature of such wireless ad hoc networksmake them suitable for applications where a central node can't be relied upon.

XBee series 2 OEM RF module is used in the PEMS for creating a wireless body area network (BAN) for remote monitoring of patients or test subjects.. ZigBee is used in applications that require only a low data rate, long battery life, and secure networking. ZigBee has a defined rate of 250 Kbit/s, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device

Fig. 6.10 XBee module

The features of ZigBee is given below.

Long Range Data Integrity

- Indoor/Urban: up to 100’ (30 m)
- Outdoor line-of-sight: up to 300’ (100 m)
- Transmit Power: 1 mW (0 dBm)
- Receiver Sensitivity: -92 dBm

Advanced Networking & Security

- Retries and Acknowledgements DSSS (Direct Sequence Spread Spectrum)
- Each direct sequence channels has over 65,000 unique network addresses available
- Source/Destination Addressing Unit cast & Broadcast Communications
- Point-to-point, point-to-multipoint and peer-to-peer topologies supported

Low Power

- TX Current: 45 mA (@3.3 V)

- RX Current: 50 mA (@3.3 V)
- Power-down Current: < 10 μA

The ZigBee network layer natively supports both star and tree typical networks, and generic mesh networks. Every network must have one coordinator device, tasked with its creation, the control of its parameters and basic maintenance. Within star networks, the coordinator must be the central node. Both trees and meshes allows the use of ZigBee routers to extend communication at the network level.

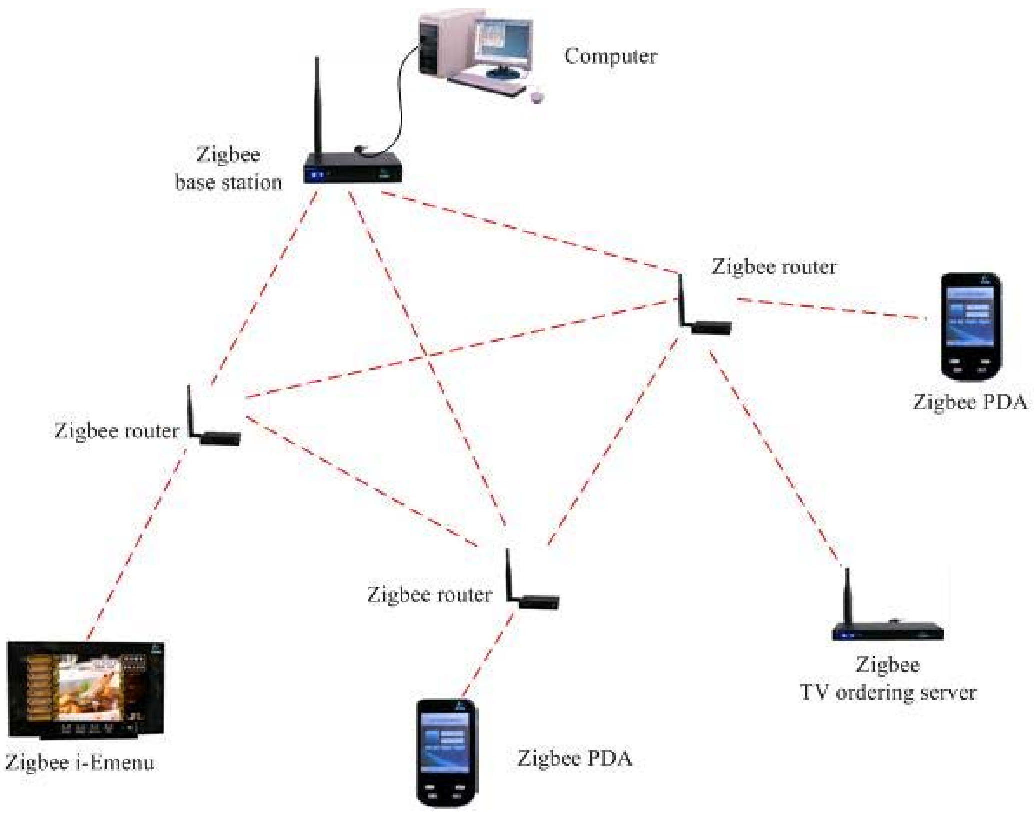

Fig. 6.11 A ZigBee network

ZigBee protocols are intended for embedded applications requiring low data rates and low power consumption. The resulting network will use very small amounts of power individual devices must have a battery life of at least two years to pass ZigBee certification.

6.9 RS232 and MAX232

In telecommunications, RS-232 is a standard for serial binary data interconnection between a *DTE* (Data terminal equipment) and a *DCE* (Data Circuit-terminating Equipment). It is commonly used in computer serial ports.

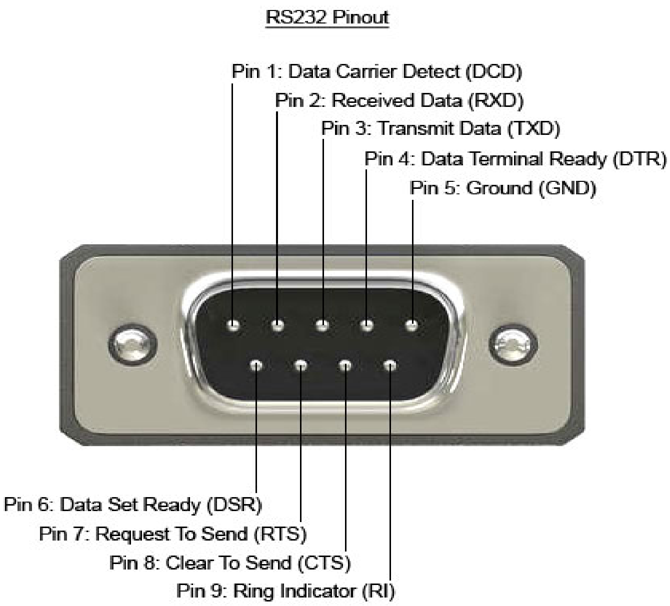

Fig. 6.12 RS 232 serial port

Scope of the Standard:

The Electronic Industries Alliance (EIA) standard RS-232-C [3] as of 1969 defines:

- Electrical signal characteristics such as voltage levels, signalling rate, timing and slew-rate of signals, voltage withstand level, short-circuit behaviour, maximum stray capacitance and cable length
- Interface mechanical characteristics, pluggable connectors and pin identification
- Functions of each circuit in the interface connector
- Standard subsets of interface circuits for selected telecom applications.

The standard does not define such elements as character encoding (for example, ASCII, Baudot or EBCDIC), or the framing of characters in the data stream (bits per character, start/stop bits, parity). The standard does not define protocols for error detection or algorithms for data compression.

The standard does not define bit rates for transmission, although the standard says it is intended for bit rates lower than 20,000 bits per second. Many modern devices can exceed this speed (38,400 and 57,600 bit/s being common, and 115,200 and 230,400 bit/s making occasional appearances) while still using RS-232 compatible signal levels.

Details of character format and transmission bit rate are controlled by the serial port hardware, often a single integrated circuit called a UART that converts data from parallel to serial form. A typical serial port includes specialized driver and receiver integrated circuits to convert between internal logic levels and RS-232 compatible signal levels.

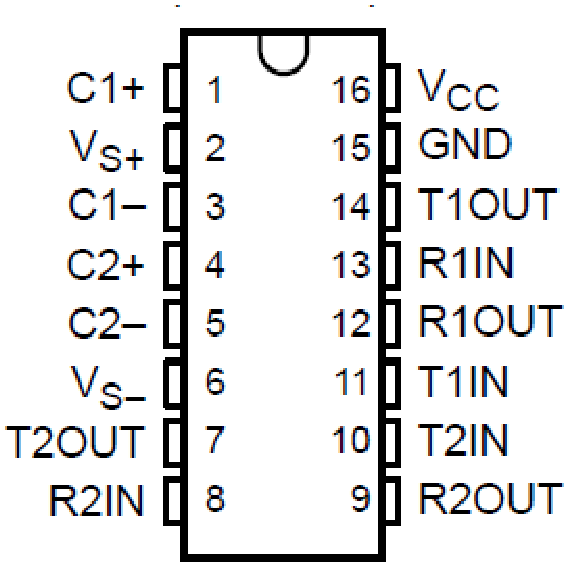

Fig. 6.13 MAX 232 IC

The MAX 232 IC used as level logic converter. The MAX232 is a dual driver/receiver that includes a capacitive voltage generator to supply EIA 232 voltage levels from a single 5v supply. Each receiver converts EIA-232 to 5v TTL/CMOS levels. Each driver converts TLL/CMOS input levels into EIA-232 levels. . It can operate up to speed of 120kbps and has only typically low supply current requirement of 8mA. The applications of MAX232 include TIA/EIA-232-F, Battery Powered Systems, Terminals, Modems, and Computers.

6.10 TL074

The TL074 series are high speed J–FET input quad operational amplifiers incorporating well matched, high voltage J–FET and bipolar transistors in a monolithic integrated circuit. The devices feature high slew rates, low input bias and offset currents, and low offset voltage temperature coefficient.

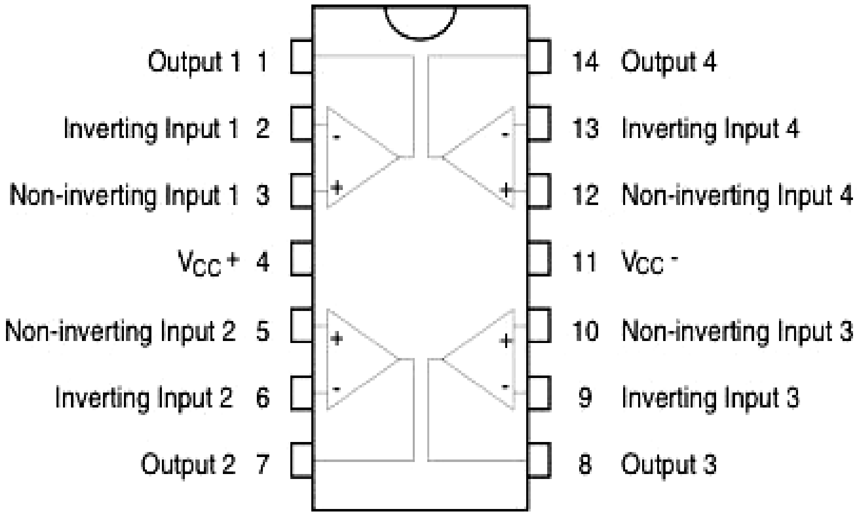

Fig. 6.14 TL074 pin diagram

Features

- low power consumption
- wide common-mode (up to vcc^{+}) and differential voltage range
- low input bias and offset current
- low noise en = 15nv//hz (typ)
- output short-circuit protection
- high input impedance J-FET input stage
- low harmonic distortion : 0.01%(typ)
- internal frequency compensation
- latch up free operation
- High slew rate : 13v/ms (typ)

6.11 TL072

The TL072 series are high speed J–FET input dual operational amplifiers incorporating well matched, high voltage J–FET and bipolar transistors in a monolithic integrated circuit. The devices feature high slew rates, low input bias and offset current, and low offset voltage temperature coefficient.

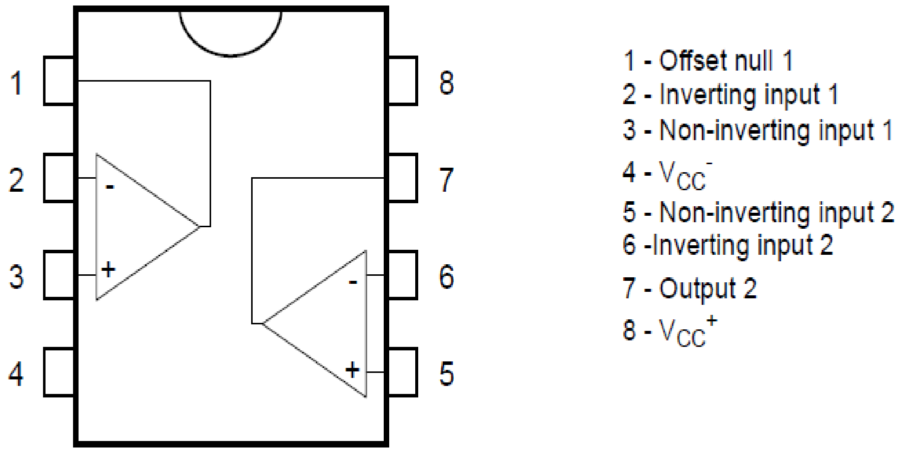

Fig. 6.15 TL072 pin diagram

Features

- Wide common-mode (up to vcc+) and differential voltage range
- Low input bias and offset current
- Low noise en = 15nv/öhz (typ)
- Output short-circuit protection
- High input impedance j–fet input stage
- Low harmonic distortion : 0.01% (typ)
- Internal frequency compensation
- Latch up free operation
- High slew rate : 16v/ms (typ)

6.12 TRANSFORMER

Transformers are AC components which transfers energy between two or more circuits based on mutual induction principle. Transformers can be classified into two based on constant potential transformations: Step Up Transformer and Step Down Transformer.

Fig. 6.16 Transformer

In case of a step up transformer, the voltage level is stepped up from that of the received voltage level and in case of step down transformer, the voltage level is lower in the transformer output when compared to the input voltage to the transformer. Various specific electrical application design specifications require different transformer types. Although they all share the basic characteristic transformer principles, they are customised in construction or electrical properties for certain installations or circuit conditions. Transformers can therefore be distinguished as autotransformer, Capacitor voltage transformer, Distribution transformer, Power transformer, Phase angle regulating transformer, Scott-T transformer, Poly phase transformer, Grounding transformer, Leakage transformer, Resonant transformer, Audio transformer, Output transformer, and Instrument transformer.

The transformer used here is of step down type i.e. it converts the input AC signal of 230V into AC signal of 12V and 5V respectively. This is fed to a bridge rectifier circuitry which converts the AC to DC.

CHAPTER 7
SOFTWARE

7.1 FLOW CHART

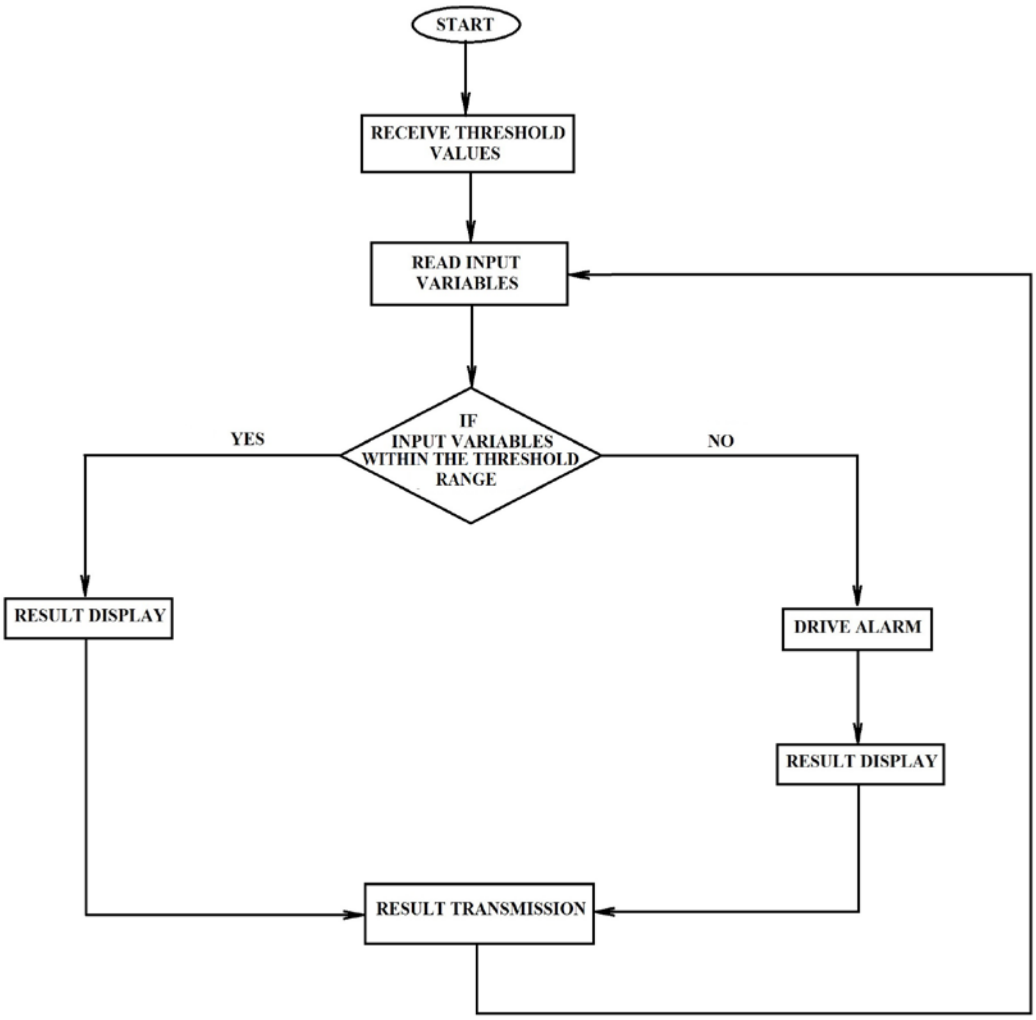

Fig.7.1 PEMS flow chart

7.2 FLOW CHART DESCRIPTION

The above figure shows the flow chart of the main events that occurs in pulmonary edema monitoring system. The system simply compares the input values from the sensors with that of a threshold value which is defined by the controller. After setting up the sensors and turning on the system, The required threshold values are wirelessly transferred from the computer to the microcontroller via Zigbee. It is taken as a interrupt by the microcontroller.

After successfully receiving the values the microcontroller reads the input from sensors and then compares them with the threshold values. The values are EMG, pressure and temperature in this case. These input values are analog in nature. So for the purpose comparison , the analog values are converted into digital format by an ADC in the microcontroller. The sampling rate of ADC is set to 1MHz and the baud rate for serial communication is 9600.

After comparing the values with that of threshold the microcontroller takes the further actions. For a typical human body, the EMG of respiratory muscles are in the range of few microvolt (approximately 5-15µV). This is amplified to a required power level prior to analog to digital conversion. The threshold value for EMG after testing some subjects is obtained in the range of 110 to 130 as the ADC output. For pressure the value can be set between 120/80 (mmHg) and temperature around 37(^{0}C) for demonstrating body pressure and temperature respectively. The set values can be changed if necessary from the computer.

If the input values are within the specified range then the result is displayed on the LCD screen. There will be no triggering of Alarm. In the mean time the results are also wirelessly transmitted to computer via Zigbee. The outputs are graphically plotted on the computer by the help of Labview software. The alarm unit becomes active only when the diagnosis results exceeds the normal condition. Also the LCD will display the respective condition, either 'High parameter' or 'Low parameter'. The whole process is repeated continuously until the reset is applied.

7.3 TOOLS USED

For the software development of pulmonary edema monitoring system two tools are used MP LAB and LabVIEW. MP LAB is used for writing and compiling the C code for implementing the embedded system using the PIC microcontroller. LabVIEW is used to display the results from the monitoring system in the computer. They are explained in detail below.

7.3.1 MPLAB IDE

MP LAB is a free integrated development environment for the development of embedded application on PIC and digital signal PIC microcontroller which is developed by micro chip technology. It supports project management, code editing, debugging and programming of Microchip 8-bit, 16-bit and 32-bit PIC microcontrollers. It is called an integrated development environment (IDE), because it provides a single integrated environment to develop code for embedded microcontrollers. An embedded system is typically a design making use of the power of a small microcontroller, like the Microchip PICmicro® microcontrollers and dsPIC® digital signal controllers. These chips have a microcontroller unit and some additional circuits on the same chip to make a small control module requiring few other external devices.

MP LAB IDE consist of several microcontrollers for creating an embedded system code. It is called as a project. All projects will have same basic steps. The first one is to select the device. The capabilities of MPLAB IDE vary according to which device is selected. That is the first thing that must be done before anything else. The MP LAB Project Wizard is used to Create a Project. In the Project Wizard one can select the language tools (compilers) such as HI-TECH Universal Tool suite. Additional files can be added to a new project such as a template file or a linker script. The template files are simple files that can be used to start a project. They have the essential sections for any source file, and have information in them that will help to write and organize the code

After that the codes can be written according to the users preference and the type of application. After saving the code it must be added as a source to the project. Then only it can be compiled. The compilation process in MP LAB is referred as 'build'. It causes the source files to be assembled and linked into machine code that can run on the selected PIC micro device. It assures that the project is set up correctly.

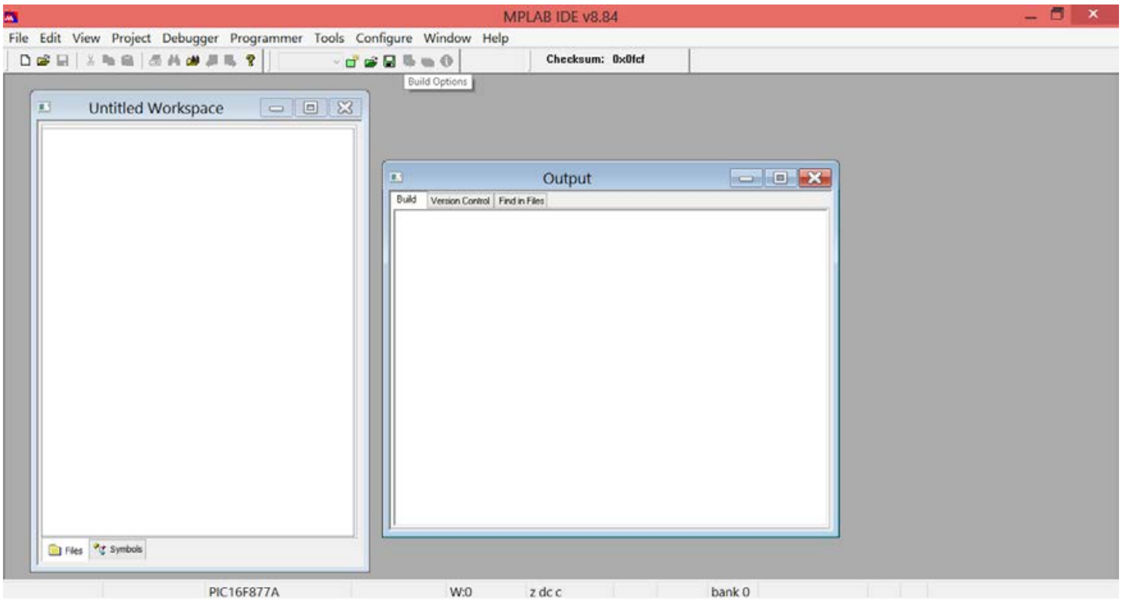

Fig.7.2 MP LAB platform

The workspace window shows all the source, header and other associated files with the project. The output window will show the entire building procedure. If the build is failed it will be displayed in output window. The MP LAB will only operate on windows platforms such as Windows 98 and above.

7.3.2 LabVIEW

LabVIEW (short for Laboratory Virtual Instrument Engineering Workbench) is a system design platform and development environment for a visual programming language from National Instruments. The graphical language is named "G". LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of platforms including Microsoft Windows, various versions of UNIX, Linux, and Mac OS X.

The programming language used in LabVIEW, also referred to as G, is a dataflow programming language. Execution is determined by the structure of a graphical block diagram (the LabVIEW source code) on which the programmer connects different function nodes by drawing wires. These wires propagate variables and any node can execute as soon as all its input data become available. Since this might be the case for multiple nodes simultaneously, G is inherently capable of parallel execution. Multi processing and multi threading hardware is automatically exploited by the built in scheduler, which multiplexes multiple OS threads over the nodes ready for execution. Graphical programming LabVIEW ties the creation of user interfaces (called front panels) into the development cycle.

LabVIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel and a connector panel. The last is used to represent the VI in the block diagrams of other, calling VIs. The front panel is built using controls and indicators. Controls are inputs which allow a user to supply information to the VI. Indicators are outputs which indicate, or display, the results based on the inputs given to the VI. The back panel, which is a block diagram, contains the graphical source code. All of the objects placed on the front panel will appear on the back panel as terminals. The back panel also contains structures and functions which perform operations on controls and supply data to indicators. The structures and functions are found on the Functions palette and can be placed on the back panel.

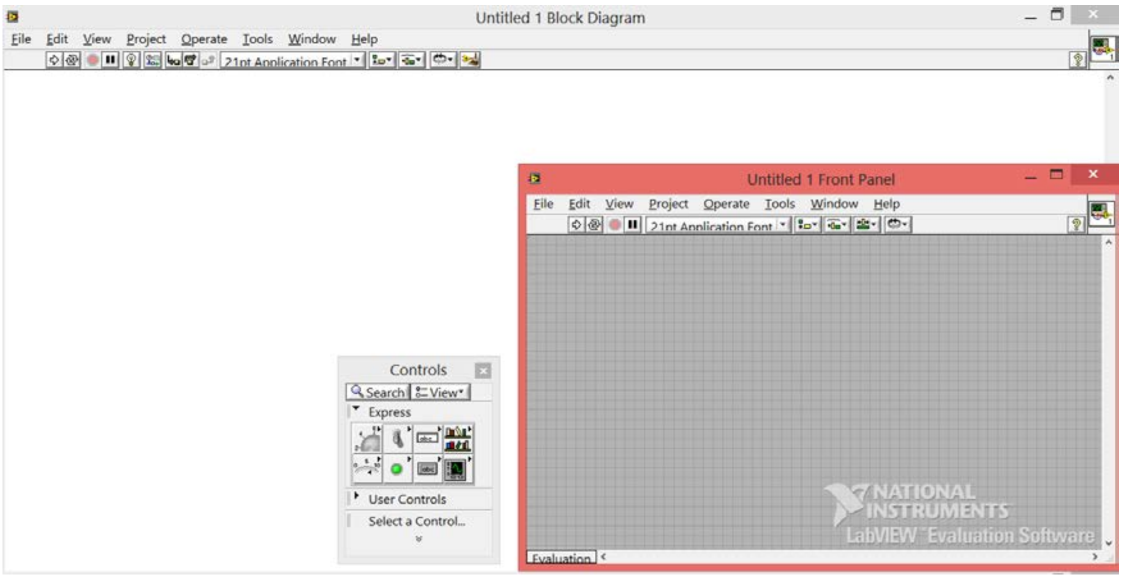

Fig.7.3 LabVIEW platform

Collectively controls, indicators, structures and functions will be referred to as nodes. Nodes are connected to one another using wires. Thus a virtual instrument can either be run as a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the given node through the connector pane. This implies each VI can be easily tested before being embedded as a subroutine into a larger program. The graphical approach also allows non programmers to build programs by dragging and dropping virtual representations of lab equipment with which they are already familiar.

LabVIEW includes extensive support for interfacing to devices, instruments, cameras, and other devices. Users interface to hardware by either writing direct bus commands (USB, GPIB, Serial) or using high level, device specific, drivers that provide native LabVIEW function nodes for controlling the device. LabVIEW includes built-in support for NI hardware platforms such as Compact DAQ and Compact RIO, with a large number of device specific blocks for such hardware, the Measurement and Automation eXplorer (MAX) and Virtual Instrument Software Architecture(VISA) toolsets.

CHAPTER 8
ADVANTAGES AND APPLICATIONS

8.1 ADVANTAGES

- The pulmonary edema monitoring system can continuously monitor the activity of respiratory muscle and other body parameters such as temperature and blood pressure.

- Since surface electrodes are used it is a non invasive system which is easy to implement for diagnosis. The additional sensors attached to the system are also non invasive type.

- It can be safely applied on children and adults because it is a non invasive system which does not require anything to be inserted into the body.

- The integrated wireless body area network make the system capable of monitoring patients remotely. The doctor need not be present in the vicinity of patient during diagnosis.

- The system can also monitor the activities other muscle groups inside human body as in the case of athletes without making any changes in hardware.

8.2 APPLICATIONS

- Monitoring the activity of respiratory muscles continuously for the detection of pulmonary edema.

- Remotely monitoring of the conditions of patients through wireless body area network and also interpreting the results on computer.

- Sensing of other body parameters such as temperature and blood pressure.

- The system can be used monitor the activities other muscle groups.

CHAPTER 9
RESULT AND DESCRIPTION

9.1 HARDWARE

The Pulmonary edema monitoring system hardware is shown below figure. It has two units: The sensor part and the computer interface part.

Fig.9.1 Sensor input section

The sensor input parts consist of 3 sets of sensors: EMG surface electrodes, thermistor and a pressure sensor and also their associated circuits such as amplifiers and filters. A 16x2 LCD display is interfaced with the PIC along with the sensor inputs. A Zigbee is implemented which act as the gateway between computer and PIC. A buzzer is connected to the PIC for warning critical conditions of patients. Two types of power supplies are used in this circuit: A 5V and a 12V supply using AC step down transformers. The 5V supply is used to power the PIC, LCD, Buzzer, Thermistor and Zigbee module. The 12V supply is used to power up the amplifiers.

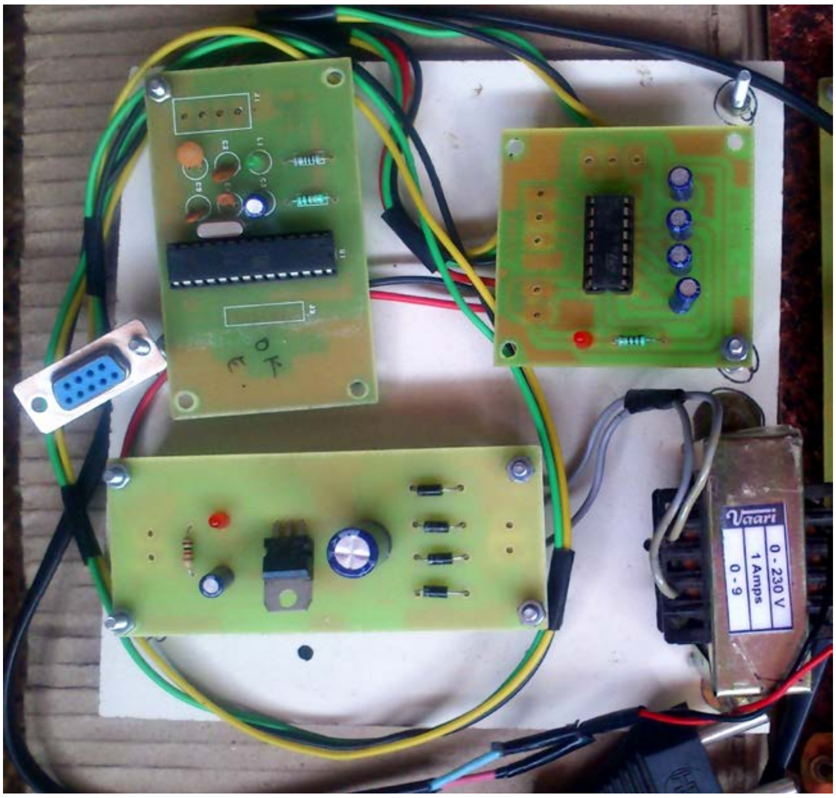

Fig.9.2 The computer interface section

The computer interface section consist of a Zigbee module and a logic level converter. This Zigbee module together with that of sensor input section forms the wireless body area network for the PEMS. It act as a gateway between the PIC and logic level converter. RS 232 serial port are used here for interfacing the system with the computer.

9.2 WORKING

The EMG electrodes and other sensors are attached to the body of test subject. The EMG electrodes are place on the chest above the respiratory muscles. The thermistor can placed at the armpit or any other suitable body part. The pressure cough is supposed to be placed around the arm. But it should be noted that only a doctor can operate it because it is complex process which requires a expert supervision. So it is not advisable to perform the actual pressure monitoring process by students. So the pressure variation can only be mimicked for demonstrating purpose. But the other two sensors does not have this issue. So they can be safely employed .

After connecting the sensors the circuit is turned on. In the mean time the computer is turned on and the result monitoring software (LabVIEW) is opened. The serial port is connected to the computer and the VISA source (Port number) is selected in the LabVIEW panel. After that click the run button on the top left corner. The status of data transmission and reception can be monitored from the left side window

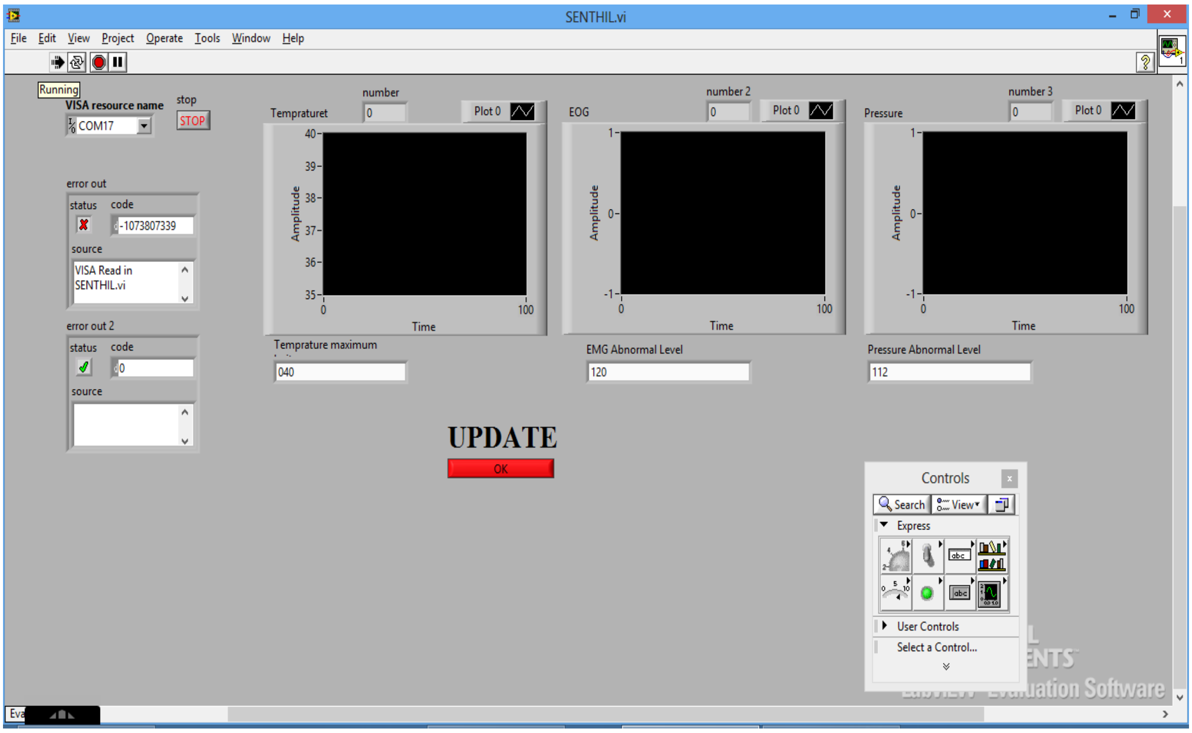

Fig.9.3 LabVIEW panel

After 15 to 30 sec of initialisation enter the required threshold values in the corresponding columns. Then click update. It will transmit the entered values in to the PIC. This feature is include for demonstrating how the system will respond to different conditions of patients. Then the LCD will display that 'set values are updated'. Now the PIC starts to compare these values with the inputs from three sensors, that is EMG, Pressure and temperature. If any one or two or all of them are abnormal the buzzer will trigger and the LCD will show which parameter is abnormal such as 'high pressure' or 'high EMG' or 'low temperature' etc. Otherwise it will only display the obtained values. In both case the results are transmitted to the computer and it is graphically plotted on the LabVIEW panel.

Fig.9.4 LCD display after setting threshold value

For example a high EMG case is shown below when the EMG threshold is set below the normal level.

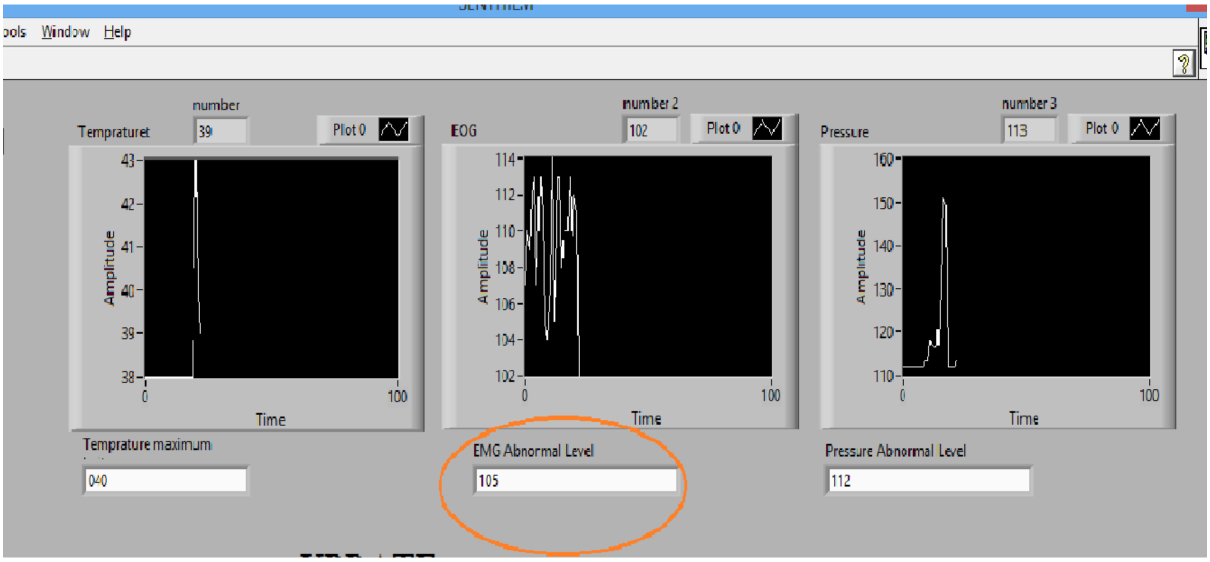

Fig.9.5 Low EMG value updated

The graphical plot of the three body parameters is shown in above figure. The encircled column shows the setting of a low EMG threshold.

Fig.9.6 LCD display for high EMG

The above figure shows a high EMG condition when the threshold is set below the normal range. The same can be observed for the other parameters too.

CHAPTER 10
CONCLUSION

The pulmonary edema monitoring system is an adequate device for wireless monitoring of Pulmonary edema patients. It is first of its kind and also a non invasive system for the diagnosis of lung irregularities by analysing EMG signals from respiratory muscles.

The current diagnosis methods for the detection of pulmonary edema suffers from various limitations. Only X-ray imaging gives a satisfactory result apart from other methods such as ECG, echocardiogram , Pulse oximetry, Catheterization. But none of them can be used for continuous, remote monitoring of patients. Also continuous exposure to X-ray causes major hazards such as Cancer. The invasive diagnosis methods such as Catheterization are difficult to use on adults and children.

In this project a new system is developed to continuously monitor respiratory muscle activities and other body parameters and transfer the results wirelessly. It is achieved by interfacing the EMG electrodes, temperature and pressure sensors and the associated units such as LCD display, Body area network and alarm with a dedicated microcontroller, the PIC16F877A. Body area network is implemented using ZigBee module which has higher range compared to Bluetooth. It also provides protection for the transmitted message from unintended users. It also enables the wireless remote monitoring of patients. The diagnosis results are displayed on LCD display and simultaneously transmitted to distant computers. An alarm is also added to warn the critical condition of patients.

The proposed system can be used in adults and children without hesitation because it is non invasive. It can also be used to monitor activities of other muscle group without any modifications in the hardware. Also the integration wireless body area network makes it a robust, future ready patient monitoring system .

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APPENDIX

C PROGRAM CODING

```
#include<pic.h>
#include<math.h>
#include<stdio.h>
#include <stdlib.h>
#include <string.h>
#include"pic_lcd8.h"
#include"pic_serial.h"
#include"pic_adc.h"

//#include"myfunctions.h"
#define _XTAL_FREQ 4000000

#define buz RB0

__CONFIG(0XFF71);

void display();

unsigned char t,ts,emg,emgs,p,ps;

char dis=1,en=0,rcv[20],r,time;

void interrupt ___()
{

        if(RCIF)
        {
                rcv[r]=RCREG;
                if(rcv[0]=='*')r++;
```

```
                else r=0;
        }

}
void main()
{
        TRISA=0xFF;
        TRISC=0x8f;
        TRISD=0x00;
        TRISB=0b11111110;
        buz=0;
        Lcd8_Init();
        Lcd8_Display(0x80,"PULMONARY EDEMA ",16);
        Lcd8_Display(0xC0,"MONITORING SYSTM",16);
   T1CON=0X00;
   Serial_Init(9600);
   Receive(1);
  /*s=EEPROM_READ(0);   __delay_ms(500);
   emgs=EEPROM_READ(1);   __delay_ms(500);
   ps=EEPROM_READ(2);   __delay_ms(500);*/

         __delay_ms(500);
        display();
        while(1)
        {



        t=Adc8_Cha(0);
        emg=Adc8_Cha(1);
        p=Adc8_Cha(2);

        if(time>5)
                {
                        printf("*%3d%3d%3d",t,emg,p);
```

```
                __delay_ms(500);
                printf("\r\n");
                time=0;
            }
            else time++;

            if(r>9)
            {
        Lcd8_Display(0x80,"SET VALUES      ",16);
        Lcd8_Display(0xC0,"       UPDATED ",16);
        __delay_ms(1000);

        char buf[5];
        strncpy(buf,rcv+1,3);ts=atoi(buf);
        strncpy(buf,rcv+4,3);emgs=atoi(buf);
        strncpy(buf,rcv+7,3);ps=atoi(buf);

        Lcd8_Display(0x80,"T   \   P   \   ",16);
        Lcd8_Display(0xC0,"EMG:   \        ",16);

        Lcd8_Decimal3(0x81,(unsigned char)ts);
        Lcd8_Decimal3(0x85,(unsigned char)t);
        Lcd8_Decimal3(0xc4,(unsigned char)emgs);
        Lcd8_Decimal3(0xc8,(unsigned char)emg);
        Lcd8_Decimal3(0x89,(unsigned char)ps);
        Lcd8_Decimal3(0x8d,(unsigned char)p);
                __delay_ms(5000);
                display();
                r=0;en=1;
            }

 if(t>ts && en)   {Lcd8_Display(0x80,"High Temprature ",16);buz=1;dis=1;}
     __delay_ms(500);
 if(t<ts-6 && en) {Lcd8_Display(0x80,"low  Temprature ",16);buz=1;dis=1;}
```

```
        __delay_ms(500);
 if(emg>emgs && en){Lcd8_Display(0x80,"High EMG Value  ",16);buz=1;dis=1;}
        __delay_ms(500);
 if(emg<(emgs-20) && en){Lcd8_Display(0x80,"LOW EMG Value
",16);buz=1;dis=1;}
        __delay_ms(500);
 if(p>ps+5 && en){Lcd8_Display(0x80,"High Pressure   ",16);buz=1;dis=1;}
        __delay_ms(500);
 if(p<ps-20 && en){Lcd8_Display(0x80,"Low  Pressure   ",16);buz=1;dis=1;}
                else
                {
                        if(dis)display(),dis=0;
                        buz=0;
                        Lcd8_Decimal3(0x84,(unsigned char)t);
                        Lcd8_Decimal3(0x8d,(unsigned char)p);
                        Lcd8_Decimal3(0xc4,(unsigned char)emg);


                }
        }
}

void display()
{
        Lcd8_Display(0x80,"TEM:       P:   ",16);
        Lcd8_Display(0xC0,"EMG:            ",16);
}

void putch(char c)
{
        while(!TXIF)
                continue;
        TXREG = c;
        return;
}
```