Design a simple apnea detection system

CHAPTER 1

1. 1 INTRODUCTION

AIM

The aim of the project is to design a simple apnea detecting system with an alarm and to classify the type of apnea identified using LabVIEW.

1. 1. 1 Normal Respiratory Event:

Respiration is the phenomenon of supplying oxygen to the tissues and removing the carbon dioxide from the tissues. External respiration is the process of exchange of gases between the lungs and atmosphere. Internal respiration is the process of gas exchange in the tissues. The balance between the absorption and excretion of these gases in blood are maintained as breathing activity. During inspiration the level of blood in oxygen increases and it decreases during exhalation. Chemoreceptors are the sensory receptors in the blood stream that senses the level of oxygen and carbon dioxide in blood , and sends signals to the brain. Then the brain allows the opening of larynx and vocal cords, followed by the expansion of ribcage and diaphragm muscles. The chest cavity enlarges to allow the inflow of oxygen into the lungs thus resulting in inhalation process. Similarly the chest cavity occludes during the process of exhalation and expels the carbon dioxide from lungs. More of oxygen inflow results in maximum tidal volume and a normal respiratory flow. Fig 1. 1 shows the normal respiratory signal with respiration rate of 12 breaths per minute.

1. 1. 2 Applications

Sleep analysis

Polygraphy

Pulmonary function

Stress test

Sports

Sudden Infant Death Syndrome (SIDS)

1. 1. 3 Respiration Signal Specifications

Amplitude – 2-200mV

Frequency waveform-0 – 150Hz

Repetition frequency- 20 cycles per minute (adults)

– 100 cycles per minute (neonates)

1. 1. 4 Respiratory Measurements

Respiration rate

Tidal volume

Apnea's

Obstructive apnea

Central apnea

Hypopnea

Tachypnea

Bradypnea

Apnea index

Also several correlations between EEG, REM sleep, apnea's, quiet sleep, non-quiet sleep and de-saturations.

1. 2 APNEA AND ITS TYPES

Apnea is the cessation of breathing during sleep which may precede the arrest of the heart and circulation in several clinical situations such as head injury, drug overdose, anesthetic complications and obstructive respiratory diseases. Apnea may also occur in premature babies during the first weeks of life because of their immature nervous system. If apnea persists for a prolonged period, brain function can be severely damaged. Therefore, patients suffering from apnea require close and constant observation of their respiratory activity. Apnea monitors are particularly useful for monitoring the respiratory activity of premature infants.

There are three types of sleep apnea. They are

1. Obstructive apnea
2. Central sleep apnea
3. Mixed or complex sleep apnea

1. 2. 1 Obstructive Sleep Apnea

Individuals with obesity due to low muscle tone and soft tissue around the airway give rise to a narrowed airway , so they are at high risk of obstructive sleep apnea. The elderly people are more likely to suffer from OSA than young people because of their food habits, smoking and alcoholic life style. Men are more typical sleep apnea sufferers when compared to women and children. The risk of OSA rises with increasing body weight, age, high cholesterol, sinus problems, and in addition, patients with diabetes have up to three times the risk of having OSA compared to others. Loudsnoring, restless sleep, and sleepiness during the daytime are some of the common symptoms of OSA. Diagnostic tests include

homeoximetryorpolysomnographyin a sleep clinic. Treatment includes CPAP apparatus that gives continuous positive airway pressure in order to expand their narrowed nasal pathway

1. 2. 2 Central Sleep Apnea

When the brain’s respiratory control centers are imbalanced during sleep, it results in pure central sleep apnea , also called as Cheyne-Stokes respiration. In this type of apnea the brain pauses to trigger the respiratory activity for about 30 seconds and triggers when it realizes that the patient suffocates for oxygen. The sleeper do not breathe for a certain period, during which there are no chest movements and no effort by the patient. Brain does not react immediately with a neurological feedback to make the respiratory rate even. There is a swing between apnea and hyperpnea in order to compensate the need for oxygen. After an apnea episode the hypoxia condition is reduced by breathing faster and absorbing more oxygen. Central sleep apnea may be due to hypertension, excess stress, and neuronal damage. In most of the cases CSA is treated with medications while some need surgery. Fig. 1. 3 shows Central Sleep Apnea.

1. 2. 3 Mixed Sleep Apnea

Mixed sleep apnea is a combination of obstructive and central sleep apnea . It is also called as complex sleep apnea. When obstructive sleep apnea syndrome is severe and longstanding, some episodes of central apnea develop during the course of sleep. Though the exact mechanism of the loss of central respiratory drive during sleep in OSA is unknown it is most commonly related to acid-base and CO2feedback malfunctions originating fromheart failure. Complex sleep apnea has been described by researchers

as a different dimension of sleep apnea. Patients with complex sleep apnea when treated with positive airway pressure for OSA was observed to exhibit persistent central sleep apnea. In sleep-disordered breathing there is a collection of diseases and symptoms relating to body mass, cardiovascular, respiratory, and occasionally, neurological dysfunction that have a synergistic effect.

1. 2. 4 Hypopnea

Hypopnea refers to a transient reduction of airflow (often while asleep) that lasts for at least 10 seconds, shallow breathing, or an abnormally low respiratory rate. Breathing that is shallower or slower than normal. Hypopnea is distinct from apnea in which there is no breathing. Hypopnea comes from the Greek roots hypo- (meaning low, under, beneath, down, below normal) and pnoe (meaning breathing). Hypopnea is less severe than apnea (which is a more complete loss of airflow). It may likewise result in a decreased amount of air movement into the lungs and can cause oxygen levels in the blood to drop. It more commonly is due to partial obstruction of the upper airway

1. 2. 5 Tachypnea

Tachypnea means elevated respiratory rate. In some situations, this might be usual, for example when climbing a flight of stairs. In disease it is indicative of problems with oxygenation. It occurs when the patient is breathing really hard to compensate for the higher than usual PCO2. When the patient is tachypneic it is important to sit him up in bed. In tachypnea the tidal volume is decreased, the minute volume may be the same because the respiratory rate is increased. Decreased tidal volume will have bad

consequences for the patient because a lot of energy is being spent on moving dead air space which does not help oxygenate the interior of lungs where gas exchange takes place.

1. 2. 6 Bradypnea

This is a slow respiratory rate which is seen in the post anesthetic or sedated patient. Bradypnea is also seen in patients who have taken overdoses of barbiturates and/or hypnotics. Bradypnea with a respiratory rate of more than ten breaths may correct itself as the patient recovers from the anaesthetic gases. Sometimes, in bradypnea, the patient compensates by increasing the tidal volume thereby the blood gases and oxygen saturation remain stable. Fig 1. 6 shows bradypnea with respiratory rate 8b/min.

1. 3 IMPEDANCE PNEUMOGRAPHY

Impedance pneumography is another practical method to monitor the breathing of the patient. The technique also enables the simultaneous monitoring of the heart rate and respiration. This has certain inherent disadvantages. One is that the placement of the electrodes is very critical and other is cardiovascular artifact. This results from the detection of movement between the electrodes because of the cardiovascular system, rather than due to respiration. Apnea monitors need to be designed to reject this artifact.

The principle of impedance pneumography is to pass a current through the chest between two electrodes, and from the resultant voltage to determine the changes in chest impedance which occur during respiration. It has been proposed that the impedance change occurring in respiration is directly

proportional to the change in volume of air contained in the thorax, and therefore reflects tidal volume.

The technique works by applying a current of approximately 10 microamperes to 1milliamperes with a frequency of 30-100 kHz to the thorax. This frequency is high enough to avoid stimulation of tissues, electrode polarization and excessively high skin impedance. The electrodes are always maintained with negligible potential difference which makes it possible to measure the impedance of a central core of thoracic tissue. Thus these impedance changes are obtained as thoracic changes that gives details about respiration. Fig 1. 7 shows the block diagram Of impedance pneumography technique.

1. 4 LABVIEW AND ITS APPLICATIONS

LabVIEW

Laboratory Virtual Instrumentation Engineering Workbench. LabVIEW is a graphical programming environment used by millions of engineers and scientists to develop sophisticated measurement, test, and control systems using intuitive graphical icons and wires that resemble a flowchart.

Biomedical Application:

Multisim Simulation with anECGAmplifier

1. Noninvasive Blood Pressure (NIBP) Analyzer
2. Analog ECGGenerator
3. Heart Rate Variability (HRV) Analyzer
4. ECG Feature Extractor
5. Online Biosignal Noise Reduction Data Logger
6. Biosignal Logger

OBJECTIVES

1. To collect the respiratory database
2. To study the apnea characteristics
3. To detect and classify apnea
4. To achieve maximum accuracy
5. To design a respiratory signal simulation system

CHAPTER 2

LITERATURE SURVEY

2. 1 RESPIRATION DATA ACQUISITION, CONVERSION AND DISPLAY SYSTEM

2. 1. 1 Methodology

1. Respiration data is acquired and converted into a series of pulses, the frequency of which is related to the respiration rate of the data measured .
2. The output pulses switch a timing device “ on” and “ off ”, and the average time of a respiration cycle is then converted and displayed as respiration rate.
3. The timing device includes a means for delaying a first output pulses before beginning the sampling period and registering a count of clock pulses for a specified number which represents the time period of a second specified number of the output pulses occurring subsequently to the first specified number of output pulses.

2. 1. 2 Conclusion

This invention relates to an acquisition unit for acquiring data relating to one or more physiological variables from a patient. Displaying the data digitally and, upon operator approval, recording the data in an internal memory.

Further, the invention relates to a data storage system responsive to data stored in an acquisition unit for a display presentation.

2. 2 METHOD AND APPARATUS FOR DETERMINING A RESPIRATIONPARAMETER IN A MEDICAL DEVICE

Shrivastav, Maneesh, Cho, Yong K., Bennett, Tommy D., Erickson, Mark K., Greenhut, Saul E., Kleckner, Karen J., Sperling, Charles P., Corey, Robert A.

2. 2. 1 Methodology

1. A pressure sensor senses pressure signals, and a signal processor, coupled to the pressure sensor, receives the sensed pressure signaland generates corresponding sample points.
2. A microprocessor continuously adjusts a breath detection threshold in response to the generated sample points to generate a current adjusted breath detection threshold.
3. Then it compares a current generated sample point to the current adjusted breath detection threshold, suspends the continuous adjusting of the breath detection threshold.
4. Then the microcontroller sets the breath detection threshold equal to the most current adjusted breath detection threshold generated prior to the suspending, and determines the respirationparameter in response to a comparing of a next generated sample point to the set breath detection threshold.

2. 2. 2 Conclusion

This invention relates to a method of acquisition of respiratory signal using pressure sensor and displays that respiration parameter using a microcontroller.

2. 3 METHOD AND APPARATUS FOR MONITORING RESPIRATION

Rymut, Russell, Slotty, Eric, Kini, Narendra

2. 3. 1 Methodology

1. The apparatus includes a piezoelectric film which converts acoustical waves generated by the patient’s respiration activity into electrical signal output.
2. The piezoelectric film sensor placed in the subject can be used to monitor the respiration of a patient by correlating the sound generated in the patient’s airway with respiratory activity.
3. Further, the data generated by the sensor may be further analyzed by a patient monitor to diagnose respiratory conditions and display it.

2. 3. 2 Conclusion

This invention relates to a method and apparatus for monitoring and quantitatively measuring the respiration of a patient , particularly, using a flexible piezoelectric film sensor.

2. 4 APNEA MONITOR

Guixian Lu

2. 4. 1 Methodology

1. 1. A conductive rubber string is used to measure the chest volume changes. It is not suitable for OSA. In that case a differential gas flow sensor is used.
2. The output of the sensors is amplified and then fed to a re-shaper.
3. 3. The re-shaper re-shapes the signal and generates pulses to trigger the counter.

4. 4. The counter triggers the alarm circuit if the count exceeds a predetermined threshold.

2. 4. 2 Conclusion

For adults one rubber string is enough. But for infants, the frequency of the body movement is measured. So an additional rubber string with motion detector is needed. The gas flow sensor is reliable and sensitive. A buzzer is used to give alarm.

2. 5 DESIGN AND IMPLEMENTATION OF A PROGRAMMABLE APNEA MONITORING SYSTEM

Mustafa Çavuşoğlu, Osman Eroğul , Ziya Telatar

2. 5. 1 Methodology

1. Respiratory signal is perceived by a thermal sensor.
2. The signal is amplified and then fed to the microcontroller.
3. The output of microcontroller is transferred to the computer and the relation between ECG and the signal is evaluated.
4. An alarm system is also provided to indicate apnea

2. 5. 2 Conclusion

The system is capable of detecting apnea, warns during the apnea and transfers the respiration signals to the computer. Finally, categorization of the apnea intervals is done to generate a real-time histogram of their frequency and duration which makes possible to investigate the relations between the EEG, ECG or other physiological signals and the respiratory patterns.

2. 6 APNEA ALARM SYSTEMS

2. 6. 1 Methodology

1. A crib or bed with piezo electric or strain gauge transducer attached to each leg is used to acquire the movement of infants.
2. Whenever the infant is breathing there is a variation in the force distibution in the foam mat, so the vertical force applied on the frame of the crib also varies, which is captured by the sensors attached to the leg of the crib.
3. These sensors convert the force into an electrical output signal and gives it to a summing amplifier to provide a summed output signal from all four legs.
4. The summed output is given to a microcontroller where it is compared with the patients physical parameters to give an alarm if there is apnea detected using a buzzer or flashing light.

2. 6. 2 Conclusion

This apparatus helps to detect apnea in infants who can be monitored even at home instead of hospitals. This alarm system is more comfortable to babies as it does not attach any sensor to infant s body. Mainly used to detect death due to apnea (‘ crib death’ or ‘ cot death’) very common in premature infants.

2. 7 APNEA MONITOR DATA SYSTEM

2. 7. 1 Methodology

1. An apnea monitoring system along with a portable data storage cartridge is presented.
2. Respiration is monitored through the electrodes located on the thoracic cavity of the patient.

3. Detected events are compared with respiration rates and when it is exceeded the signal is transmitted to audio and visual alarms indicating apnea.
4. In addition to that a poratable data storage cartridge is provided which has enough memory to store all monitored events and waveforms that can be transferred to computer.

2. 7. 2 Conclusion

This invention not only helps to monitor also contains a portable cartridge, that can be easily carried or mailed, which makes it time efficient and cost efficient method to store data. Another advantage is that the cartridge is replaceable, which provides an unlimited amount of memory space that helps in transfer of data.

2. 8 A MODEL ANALYSIS OF ARTERIAL OXYGEN DESATURATION DURING APNEA IN PRETERM INFANTS

Scott A. Sands, Bradley A. Edwards, Vanessa J. Kelly, Malcolm R. Davidson, Malcolm H. Wilkinson, Philip J. Berge

2. 8. 1 Methodology

1. Independent influence of clinically relevant cardiorespiratory fators on the desaturation of arterial oxygen during apnea is determined using a two-compartmental lung-body mathematical model which incorporated realistic oxygen stores and gas exchange dynamic
2. Analytic solutions were derived for arterial oxygen desaturation to quantify the importance of cardiorespiratory factors on arterial oxygen desaturation such as cardiac output, lung volume, metabolic oxygen

consumption, pre-apneic ventilation, blood oxygen affinity, hemoglobin content and blood volume

3. The model analysis reveals that lung volume, hemoglobin content, cardiac output, pre-apneic ventilation exerts a unique effect on arterial oxygen desaturation throughout the time-course of desaturation and metabolic oxygen consumption is uniformly influential throughout the process.
4. Infants with elvated metabolic needs and low lung volume and those with anemia, cardiac dysfunction or hypovolemia which are common in prematurity are at heightened risk of rapid and profound arterial desaturation during apnea.

2. 8. 2 Conclusion

A mathematical framework for quantifying the relative importance of key cardiorespiratory factors on the rate of arterial oxygen desaturation during apnea with particular relevance to preterm infants is provided. Each of the factors examined has a signature influence on the trajectory of desaturation, providing quantitativeinsight into the causes of rapidlydeveloping hypoxemia during apnea have been demonstrated.

2. 9 OBSTRUCTIVE SLEEP APNEA AS A RISK FACTOR FOR STROKE AND DEATH

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2. 9. 1 Methodology

1. 1. In this study patients underwent polysomnography and subsequent events like stroke and death are verified.
2. 2. The diagnosis was based on apnea-hypopnea index of the patients. Patients with apnea-hypopnea index of less than 5 served as a comparison group.
3. 3. Proportional hazards analysis was used to determine the independent effect of OSA syndrome on the outcome of stroke or death from any cause.
4. 4. The mean apnea-hypopnea index for the patient with syndrome is 35 while the same for patients in the comparison group is 2.
5. 5. After adjustment for age, sex, diabetes mellitus, smoking status, alcohol consumption status, body-mass index, hypertension, the OSA syndrome retained a statistically significant association with stroke or death.

2. 9. 2 Conclusion

The obstructive sleep apnea syndrome significantly and severely increases the chance for stroke or death from any cause. The increase for the risk of stroke or death due to OSA syndrome is independent of the other risk factors, including hypertension.

2. 10 AN ECONOMIC ANALYSIS OF CONTINUOUS POSITIVE AIRWAY PRESSURE FOR THE TREATMENT OF OBSTRUCTIVE SLEEP APNEA-HYPOPNEA SYNDROME

Helen L. A. Weatherly, Susan C. Griffin, Catriona Mc Daid, Kate H. Durée, Robert J. O. Davies, John R. Stradling, Marie E. Westwood and Mark J. Sculpher.

2. 10. 1 Methodology

1. This study reports on the cost-effectiveness of the continuous airway-pressure(CPAP) compared with the dental devices and lifestyle advice to the patient. The Markov model compared the interventions over the patient’s life expectancy.
2. The primary measure for cost-effectiveness was the incremental cost per quality adjusted life-year(QALY) gained for every patient.
3. On further analysis, CPAP was associated with higher costs and QALYs compared with dental devices and lifestyle advice.
4. The result of analysis was that the probability that CPAP is more cost-effective than dental devices or lifestyle advice at a threshold value of £20, 000 per QALY was 0. 78 for men and 0. 80 for women.

2. 10. 2 Conclusion

This model suggests that CPAP is cost-effective compared with dental devices and also the lifestyle advice for adults with moderate or severe symptomatic Obstructive Sleep Apnea -Hypopnea Syndrome are at the cost-effectiveness thresholds used by NICE. This finding is reflected in the NICE guidance.

CHAPTER 3

METHODOLOGY

3. 1 EXISTING METHODS

Several contactless methods are available for monitoring the respiration of infants. The most successful apnea monitors to-date been mattress monitors. These instruments rely for their operation on the fact that the process of breathing redistributes an infant’s weight and this is detected by some form of a pressure sensitive pad or mattress on which infant is nursed.

The mattress, in its simplest form, is a multi-compartment air bed, and in this case the weight redistribution forces air to flow from one compartment to another. The air flow is detected by the cooling effect it produces on a heated thermistor bead. Though the technique is simple, the main disadvantage with the air mattress is the short-term sensitivity variation and the double peaking effect when inspiration or expiration produces separate cooling of the thermistor.

Alternatively, a capacitance type pressure sensor in the form of a thin square pad is usually placed under or slightly above the infant’s head. Respiratory movements produce regular pressure changes on the pad and these alter the capacitance between the electrode plates incorporated in the pad. The capacitance change is measured by applying a 200 kHz signal across the electrodes and by detecting the current flow with a phase-sensitive amplifier. The disadvantage of this method is that the system is much too sensitive to people moving nearby and thus an electrically screened incubator is essential for the infant.

3. 1. 1 METHOD ADOPTED

This project is based on impedance pneumography method. Impedance pneumography is one of the practical methods to monitor the breathing of the patient. The technique also enables the simultaneous monitoring of the heart rate and respiration. This has certain inherent disadvantages. One is that the placement of the electrodes is very critical and other is cardiovascular artifact. This results from the detection of movement between the electrodes because of the cardiovascular system, rather than due to respiration. Apnea monitors need to be designed to reject this artifact.

So in this project the respiratory signal is considered to be acquired by using respiratory sensor. As there is no availability of sensor, respiratory signal is simulated using our own designed impedance pneumography technique based circuit. Then this signal is given to microcontroller where apnea is detected and it then triggers an alarm. The classification of apnea is also done using LabVIEW.

In future respiratory sensor will be designed and the respiratory signal will be acquired. Then this signal can be given to the microcontroller directly.

3. 2 RESPIRATORY SIGNAL SIMULATION

The respiratory signal simulation circuit consists of an excitation source and a constant current source circuit which gives a high frequency, low voltage and constant current signal. This constant current will be applied to the thorax of the subject. But due to the ethical issues the current is applied on the resistance circuit which acts as the thorax impedance. This circuit in turn gives a voltage signal. This voltage signal will be amplified by an instrumentation amplifier. The amplified signal will be fed to the LabVIEW for classification of normal and apnea signal and also types of apnea. Figure 3. 2. 1 shows the block diagram to simulate respiratory signal and the hardware design of the circuit

3. 2. 1 EXCITATION SOURCE

The wien bridge oscillator which produces 50kHz and 8 V peak to peak signal is used as the excitation signal. The operational amplifier used in the circuit is LF351. The Voltage gain of the amplifier must be at least 3. The input resistance of the amplifier must be high compared toRso that theRCnetwork is not overloaded and alter the required conditions. The output resistance of

the amplifier must be low so that the effect of external loading is minimized. Some method of stabilizing the amplitude of the oscillations must be provided because if the voltage gain of the amplifier is too small the desired oscillation will decay and if it is too large the waveform becomes distorted

3. 2. 2 CONSTANT CURRENT SOURCE

The constant source circuit is used to generate a 4mA constant current to be applied on the resistance circuit. CL100 and CK100 transistors are used in this circuit and these are npn and pnp paired transistors. The base emitter on voltage of these transistors is 0. 9V. The collector current can be found by using the formula,

Ic= (Vcc-Vbe)/Rc

Where

Vcc-Supply voltage

Rc-Collector Resistance

Vbe-Base emitter on voltage

3. 2. 3 PHANTOM MODEL

The model consists of four resistors of 500 ohms which mimics the thoracic resistance.

3. 3 DATA COLLECTION

To know about characteristics of normal respiration and apnea their corresponding signals were essential. So 40 respiration data sets with 100

sample values in each data set were collected from PHYSIONET - PHYSIOBANK ATM.

Among these 20 were normal data sets obtained from SLEEP HEART HEALTH STUDY POLYSOMNOGRAPHY DATABASE (SHHPSGDB) while the other 20 were apnea data sets obtained from UCD SLEEP APNEA DATABASE (UCDDB).

In Apnea data sets 10 belonged to Central Sleep Apnea and remaining 10 to Obstructive Sleep Apnea.

Each Data set contained 100 samples whose units are volts(V). They were recorded for 100seconds. So on plotting each data we get time in X-axis and volts in Y axis.

3. 4 CLASSIFICATION OF APNEA USING RESPIRATION RATE

Input data which contains 60 samples each. Normalizing of the signal by squaring the signal. Extraction of maximum peak for every 5 samples. Display of respiratory cycles. If the peak value is greater than 6V it will be counted as normal respiratory cycle. If the count is between 10 and 20 the signal will be having normal respiratory rate. If the count is less than 10 the signal will be classified as bradypnea. If the count is greater than 20 the signal will be classified as tachypnea

As the parameter of respiratory rate alone is not enough for classifying the types of apnea the statistical parameters are calculated and then signals are classified using LabVIEW.

FLOWCHART

3. 5 CLASSIFICATION OF APNEA USING STATISTICAL PARAMETERS

The signal data was imported from a spread sheet into labview using READ FROM SPREADSHEET block in labview. Then signal was plotted as a graph using WAVEFORM CHART block. The data cannot be manipulated directly so the transpose of the data is taken to find the statistical parameters using TRANSPOSE ARRAY block. Now using the STATISTICS block the signal's various parameters like arithmetic mean, median, mode, maximum peak, minimum peak, range, standard deviation variance, and rms value are found and recorded. Considering the range and mean of the signal it can be classified as its respective type. Give the upper and (or) lower limit for range and mean. Now using AND operator the signal is classified when its condition are satisfied. When the signal s range is greater than 7 and its mean is less than 0. 1 it is normal. When the signal s range is lesser than 6 and its mean is greater than 0. 21 it is abnormal. When the signal s range lies below 3. 0 it is obstructive. When the signal s range lies between 3. 1 and 6. 99 it is central.

FLOWCHART

CHAPTER 4

4. 1 RESULTS AND DISCUSSION

4. 1. 1 Hardware Results

Output from the excitation source (wein bridge oscillator) was checked in MULTISIM and then implemented using hardware. On applying the constant current to a resistance network that imitates human thoracic impedance , the current varied to a greater extent because of loading effect. The same problem will occur even when the patient is connected to the high frequency,

low voltage, constant current module. Also, due to ethical issues the constant current generated cannot be given to the patient directly. So monitoring of real time data could not be done using the hardware design. Hence , the idea of respiration signal simulation was dropped and offline data were collected from respiration databases for further classification.

4. 1. 2 Normal and Apnea Data

To know about characteristics of normal respiration and apnea their corresponding signals were essential. So 40 respiration data sets with 100 sample values in each data set were collected from PHYSIONET - PHYSIOBANK ATM. Among these 20 were normal data sets obtained from SLEEP HEART HEALTH STUDY POLYSOMNOGRAPHY DATABASE (SHHPSGDB) while the other 20 were apnea data sets obtained from UCD SLEEP APNEA DATABASE(UCDDB). The Resulting plot for each type of respiration signal is plotted below.

The following figure shows the normal respiration data plotted for 100 samples with time in x-axis and amplitude in y-axis with a maximum peak to peak voltage of 8V and 24 respiration cycles for 100seconds.

The following figure 4. 4 shows Ce