Detection of Sleep Apnea using Pressure Sensor

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Abstract - *Sleep apnea is a disorder where there are periods of pauses in breathing of obstruction in airflow during sleep, which can last from a few seconds to minutes. Sleep apnea is associated with symptoms like chronic snoring, apnea, and excessive sleepiness during daytime that causes problems in daily lives. In this paper, an implementation for detection of sleep apnea is performed based on respiration rate using pressure sensor.*

Key Words: Sleep apnea, hypopnea, pressure sensor, respiration rate, hypoxia.

1. INTRODUCTION

Obstructive Sleep apnea (OSA) is a disorder where there are periods of pauses in breathing [1]. Due to these breathing pauses, there is oxygen desaturation (hypoxia), CO2 retention, and CO retention and sleep fragmentation. Sleep apnea syndrome affects the quality of sleep, which makes us acknowledge tired far and wide the day. The common risk factors are hypertension, heart attack, stroke, diabetes and obesity. However, OSA suffers periodic goes undiagnosed as doctors to the end of time can't notice the condition from one end to the other routine visits and besides there is no family show once and for all which boot threw in one lot with diagnose the condition. So, roughly people who have OSA don't get through one head they have it as it abandoned occurs everywhere sleep [1]. Figure 1 shows the international statistics where red colour indicates the portion of people with obstructive sleep apnea, green colour shows people who got diagnosed by OSA and blue colour shows people who have been successfully treated with OSA. So from this, conclusion can be made that only few percentages of people will be treated with sleep apnea. So, prolonged sleep apnea may result in severe disorders such as hypertension, diabetes, etc.

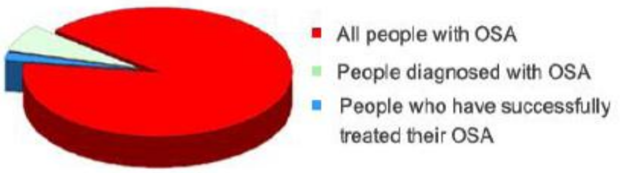

Fig -1: International Statistics showing OSA diagnosis [15]

Figure 2 shows the statistics based on gender and age where percentage of male sufferer due to sleep apnea is more when compared to female in the age group 40 and more. According to a study [1], the widespread presence of sleep apnea in male is 3.3% and in female is 1.2%.

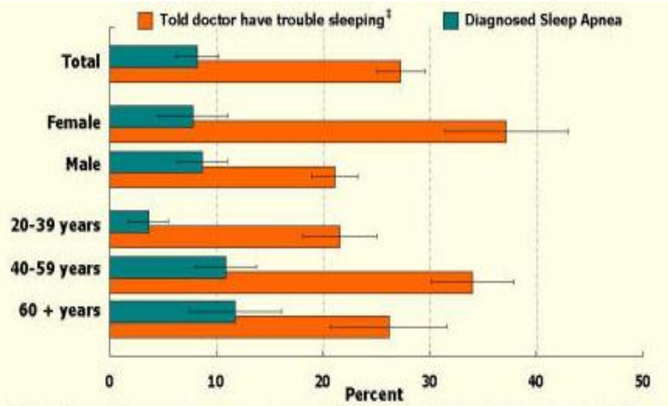

Fig -2: International Statistics showing prevalence of sleep apnea gender and age wise [16]

Sleep studies are performed in order to detect how well person sleep or how a patient body responds to sleep problems. Sleep studies may involve polysomnography test (PSG). This test involves monitoring of intellectual activity, movement of eyeball, heart rate and blood pressure. A PSG likewise records the oxygen saturation level in blood, wind stream through nose, snoring, and rise of chest. PSG tests are usually done at sleep centers or sleep labs. A polysomnogram will ordinarily record at least 12 channels requiring at least 22 wire connections to persistent. So for OSA test the patient needs to wear electrodes and experience the long haul observing for entire night at a specific wards or research facilities. This would build the mental and physiological weight and influence the rest nature of patients, along these lines affected the observing consequence of sleep apnea by implication. In spite of the fact that this technique gives an itemized examination of apnea episodes which can be for an exact medicines, it is meddling and exceptionally costly, as well as analysis must be performed disconnected from the net, once the signs are recorded overnight [2].

2. BACKGROUND

Recently, large no. of techniques have been developed for measurement of human respiratory activities and indicates obstructive sleep apnea along with other physiological signal. Vishnoukumaar Sivaji et. al. [1] have concentrated on the development of wireless sleep apnea monitor based on airflow, respiratory effort and blood oxygenation and discovered indication of sleep apnea based on the selected parameters. Lili Chen et al. [2] focused on the investigation of the impact of OSA based on RR interim on ECG sign and discrimination was done in the middle of OSA and non-OSA. Venema et al. [3] have talked about and dissected the applicable wonders between heart rate, oxygen immersion and respiratory data through assessing the in-ear beat oximeter with the intelligent PPG sensor. Tae-yang Han et al. [4] have presented a technique that gathers ECG, sound, increasing speed and introduction signal for rest apnea recognition. Jinet al. [5] has presented the strategy that utilizing MEMS pressure sensor to quantify nasal wind stream, which is the most solid parameter for sleep apnea identification.

Recent researches as discussed above have shown that apnea detection can be made without EEG signal which will lessen the measure of anodes, sensors, links and gadgets and along these lines enhance the solace and nature of the rest. Thus, a convenient with less no. of wires has been created for checking sleep apnea scenes, gaining respiratory rate utilizing pressure sensor. Further work comprises of monitoring oxygen desaturation and carbon monoxide level for sleep apnea patients.

3. IMPLEMENTATION

The Proposed sleep apnea monitor consists of three sensors, pressure sensor, photoplethesmograph sensor and gas sensor. Pressure sensor is used for measurement of respiratory rate in breaths per minute. Photoplethesmograph sensor is constructed and basically used for recording oxygen saturation level in blood given in percentage. Gas sensor is used for detection of CO level in exhaled air in parts per million. There are various types of pressure sensor such as absolute pressure sensor, gauge pressure sensor, vacuum pressure sensor and differential pressure sensor. Absolute pressure sensor measures the pressure with respect to vacuum. Gauge pressure sensor measures the pressure relative to atmospheric pressure. Vacuum pressure sensor is a sensor that measures pressure below atmospheric pressure. Differential pressure sensor is a sensor that measures the difference of the two pressures, one being the reference pressure.

Pressure sensor used for this project is a differential pressure type which is converted into vacuum pressure sensor since only one output that the expired air is required and not the difference of the two outputs. The pressure sensor used is MPX100DP which is a MEMS based sensor from Motorola. It is a piezoresistive silicon based sensor that provides linear and accurate voltage output. It highlights minimal effort, silicon shear stress strain gage, 60mV span, absolute/differential/gauge options and ±0.25% linearity. It can be used for various applications such as in robotics, pump/motor controller, medical diagnostics, pressure switching, barometers and altimeters. MPX100DP, pressure sensor sensivity is 0.6mV/kPa with a pressure range of 0-100kPa [6]. Other specification of the MPX100DP pressure sensor is shown in Table 1 and Table 2.

Table -1: Maximum Ratings of MPX100DP sensor [6]

Rating	Symbol	Value	Unit
Overpressure(8) (P1 > P2)	P_{max}	200	kPa
Burst Pressure(8) (P1 > P2)	P_{burst}	1000	kPa
Storage Temperature	T_{stg}	−40 to +125	°C
Operating Temperature	T_A	−40 to +125	°C

Table -2: Operating Characteristics of MPX100DP [6]

Characteristic	Symbol	Min	Typ	Max	Unit
Pressure Range(1)	P_{OP}	0	—	100	kPa
Supply Voltage(2)	V_S	—	3.0	6.0	Vdc
Supply Current	I_o	—	6.0	—	mAdc
Full Scale Span(3)	V_{FSS}	45	60	90	mV
Offset(4)	V_{off}	0	20	35	mV
Sensitivity	ΔV/ΔP	—	0.6	—	mV/kPa
Linearity(5)	—	−0.25	—	0.25	%V_{FSS}
Pressure Hysteresis(5) (0 to 100 kPa)	—	—	±0.1	—	%V_{FSS}
Temperature Hysteresis(5) (−40°C to +125°C)	—	—	±0.5	—	%V_{FSS}

The linear output that is the voltage produced directly proportional to the applied pressures is given by comparison: ***Vout = Voff + affectability x P*** over the working weight where range 'P' indicates applied pressure. Figure 3 shows the linearity distribution of the pressure sensor.

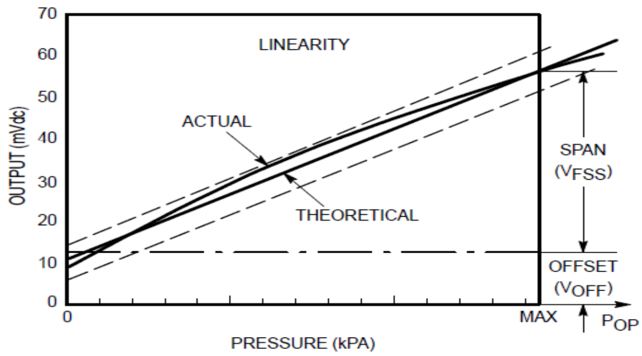

Fig -3: Linearity Specification Comparison [6]

The analog signal acquired from the pressure sensor is given to signal conditioning circuit. For signal conditioning, non-inverting operational amplifier from Philips semiconductor is used. After signal conditioning, the analog signal obtained have the gain of 821. The analog signal is given to microcontroller for converting it into digital form. The Arduino Uno board is used for implementing the same. Microcontroller is also used to develop a serial communication between amplification circuit and the Arduino board. The digital waveform is transmitted via HC-05 Bluetooth module to the system. The information is gathered over virtual COM port and the outcome is shown on MATLAB. Figure 4 demonstrates the block diagram of the proposed system.

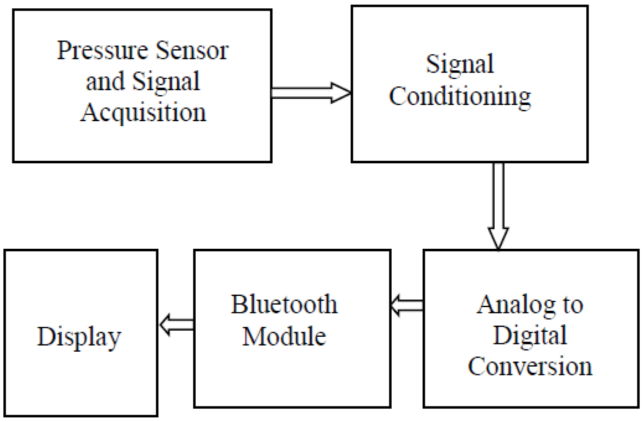

Fig -4: Block Diagram of the system

Programming code to get information from the entrance point and show the outcome was composed on MATLAB. 200 sets of data is taken at a time and an iteration count for some 150 samples is selected. A loop is given to read all the samples received. The data keeps on adding and then concatenated data is plotted. Plot is smoothened. At a time 150 samples were considered to be plotted. Threshold of three is set as reparation rate voltage will be less than 3mV. If data value is less than the threshold, then it is added to the samples data and plotted otherwise it is discarded. No. of peaks per minute is counted and respiration rate in breaths per minute is displayed.

4. EXPERIEMNT AND RESULT

For the underlying testing, a volunteer was situated on a seat and a pipe from the pressure sensor is placed near the nostril. The subject is asked to take deep breaths. This is how respiration rate has been recorded for healthy person. The signal is transferred to microcontroller at a baud rate of 9600 bits/s. The digital signal is transferred via Bluetooth module for wireless serial communication setup. The wireless transmission can be up to a distance of 200m. The entrance point was avoided as much as possible of 5m structure this setup and was associated with the PC through COM port 26 which was executing the MATLAB code for information catch and show. The testing stage included recording the respiratory rate interim over a time of 5min, as it would give enough time to record a few scenes of apnea going on for around 10s. The person was asked to simulate the episodes of sleep apnea. Figure 5 shows the respiration rate where no. of peaks denotes the no. of breaths taken in a minute.

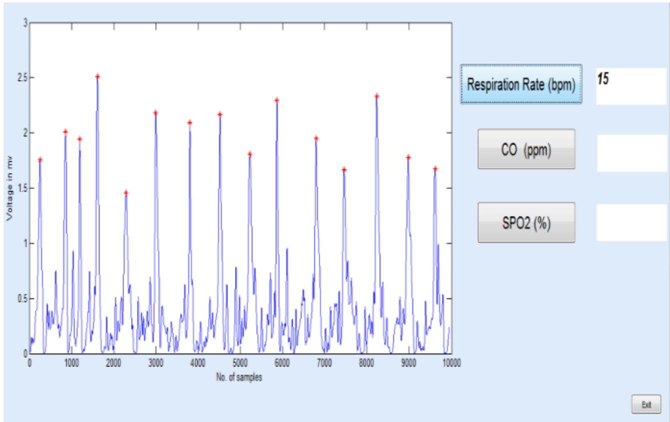

Fig -5: Normal Respiration rate acquired from female subject

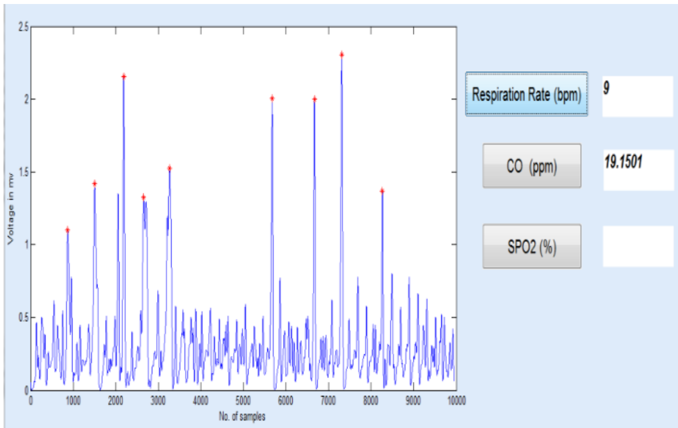

Fig -6: Simulated result of sleep apnea for Respiration rate acquired from female subject

The respiratory rate recorded for a healthy person, female, age of 26 is shown in figure 5. The no. of breaths per minute was counted to be around 15 for normal breathing. Episode of sleep apnea simulation is shown in Figure 6 where it can be noticed there is pause in breathing after 3200 samples and thus the no. of breaths per minute is reduced to 9.

5. CONCLUSION

The project shows the sleep apnea monitoring device for measurement of respiratory rate where data can be analyzed wirelessly and online. Genuine recording of respiratory parameters demonstrated that this gadget could be utilized to recognize scenes of sleep apnea. Such a system would not just free the patient to lay down with interweaved wires additionally information can be imagined on the wirelessly. Moreover, this is a portable device. Further, work is carried out to detect sleep apnea on other parameters such as oxygen desaturation level in blood and carbon monoxide level in expired air.

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