Snoring Sound and Oxygen Saturation Screening for the Detection of Sleep Apnea

Anas M. N., Member, IEEE, N. A. Fitri, Y. Yusoff.

***Abstract*— Sleep apnea disorder or sometimes called as Obstructive Sleep Apnea (OSA) usually last for at least 10 seconds and it often goes undiagnosed as it is poorly recognized by the majority of the population. The level of blood-oxygenation could be decreased during the event to the patient and this could lead to other health risk. Current practice in diagnosing this event is using Polysomnography (PSG) in sleep test. This typical PSG is used to record the biophysiological changes that occur during sleep. However, this technique have some limitations since the patient feels uncomfortable to sleep with various electrodes and wires are attached to the body and also need a dedicated room for conducting the sleep test. The blood oxygen and snoring sound are suggested to improve the current technique and assist physician to monitor and diagnose the OSA problem. Therefore, a measurement system for monitoring the blood oxygen and snoring sound and frequency is developed. Preliminary results of the developed system demonstrated the system is proven reliable, practical and provide comfortable to be used in the sleep test study.**

***Index Term*— Obstructive sleep apnea; blood oxygen; snoring sound; monitoring system**

I. INTRODUCTION

NOT all snoring is an indication of sleep apnea disorder (AD). However, if the ongoing (chronic) snoring frequent disrupts the sleep, it might a signal of AD, a potentially life-threatening condition that require medical attention. The obstruction in the upper airway partially or completely or because of the resistance in upper airway has been increased, airflow through the upper airway will be decreased; and it causes a spectrum of diseases which also known as sleep-disordered breathing. As a result, a poor sleep quality, could lead to many others side effects such as headaches, poor concentration, loss of memory, frustration, depression, and even marital discord [1]. Snoring can be produce in various locations along the airway on different people. The snoring vibration can occur at any point inside the wind tunnel, anywhere along the airway. In fact, even on the same person, snoring may be generated at different sites at different times. Wherever snore is produced, the tone and the loudness of the snore will depending on how much air is going through, how fast and forcefully the air is traveling, how much flabby tissue there is, and how much the tissue vibrates. Because there are so many causes of snoring and so many things that can make it worse, it needs an integrated program that includes all facets of the various causes and the treatments for them. Fig. 1 shows the differences between apnea and snoring airflow. The blocked airways can cause the decreasing of oxygen level in the patient's body. A normal blood oxygen level should be 96% to 100%. However, if the oxygen level is below 90%, there is high possibility that the patient has sleep apnea because of not breathing for 30 seconds or more during sleep.

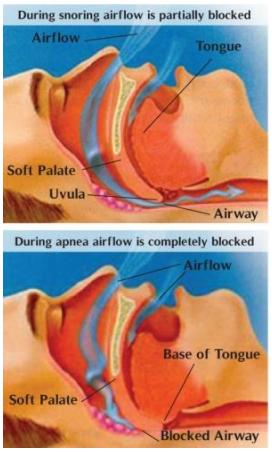

Fig. 1. Differences between apnea and snoring flow

Unfortunately, sleep apnea frequently goes undiagnosed. Specialist usually hard to locate the AD condition throughout routine visits. Likewise, there's no blood test can help diagnose the condition. Local study of the OSA in Malaysia, estimated that middle aged men and women to be 9% and 4%, respectively predominance of this syndrome. Moreover, 24% of men and 9% of women having this AD problem [2,3]. There are estimated that over the world currently around 20 million people diagnosed with this problem and many more are still undiagnosed [4].There were also many reports regarding the effects and caused of sleep apnea such as cardiovascular diseases, strokes, hypertension and many others complications [5-7]. Recent research also highlighted that OSA as a high risk factor for sudden cardiac death during the sleeping hours [7,8].

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The current method to diagnose this AD is using polysomnography (PSG). PSG is a gold standard device use in the sleep test to monitor OSA and routinely done in a dedicated sleep lab [9]. There were various electrodes and wires are attached to the patient non-invasively, at a specific body position to detect and measure different biophysiological variables simultaneously during sleep. Parameters such as air flow in and out of the lungs, level of blood oxygen, body position, brain waves (EEG), electrical activity of muscle (EMG), eye movement and many other physiological signals are monitor using these method [10-12].

Nevertheless, these methods introduce several limitations, including major discomfort due to equipment wires, tubing and also electrodes hooked to the patient. Fig. 2 shows the PSG technique in monitoring sleep apnea. These techniques also highly in cost operation, need a dedicated sleep lab to perform the test and sometimes need an operator to monitor the test session. Moreover, recently, the issues of PSG accuracy are being questioned. Several studies show that the test result do not correlate well with clinical significance. They said the result just present statistical data not the practical correlation [13-15].

Fig. 2. Polysomnography technique

Hence, this paper is aiming to the development of a monitoring device which might be able to be use in the diagnose certain conditions of sleep apnea by means of blood-oxy level and sound vibration produced during the event. The real-time monitoring and analysis, portable, compact and suit for home usage device and comfort to the patient. Moreover, the developed device is a stand-alone system, however, it also could be integrated with others established system with some configuration are needed.

II. System Design

The developed system comprises of the development board, from Olimex Ltd., USB sound converter device, piezoelectric transducer, and blood oxygen finger probe. The overall system block diagram of the developed prototype system is shown in Fig. 3.

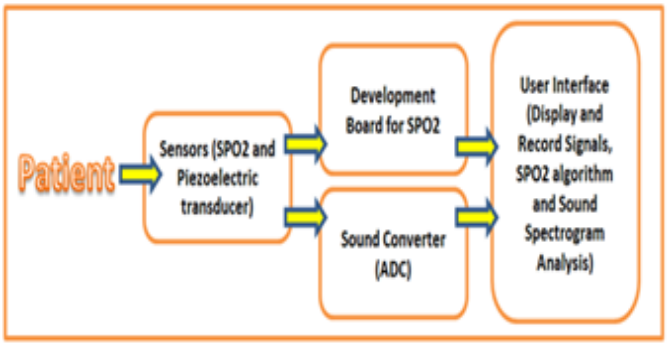

Fig. 3. Block diagram for sleep apnea monitoring system

The MOD-PULSE Olimex development board is a single-chip pulse oximeter instrument to monitor human blood oxygenation. The board is embedded with oximeter circuit measurement and process the signal using MSP430F (from Texas Instrument) microcontroller. It also calculates the heart rate and display thru LCD. The selection of this device due to its less complexity circuit and functional, compact, portable and cost-effective makes it suitable use in the sleep apnea monitoring system. The SPO2 finger probe from Nellcor use together with Olimex development board. This probe model suitable use for adult only. Fig. 4 shows the MOD-PULSE development board.

Fig. 4. MOD-PULSE development board from Olimex Ltd.

USB sound card device from Anera Technology has been used to convert the analogue sound signal to digital for further signal processing. It has maximum rate of 44 kHz of sampling mono input, with 12Mbps USB communication which suitable to convert snoring signal coming from high sensitivity omni directional piezoelectric transducer from Pro Signal. The transducer has frequency response characteristic from 15Hz to 18 kHz and sensitivity of -65dB +/-3dB @ 1 kHz/µPA which is suitable to be used in this application. The conversion of sound signal also may possibly use the built-in internal sound card on personal computer, however, the sampling rate and speed must be adequate higher for quality sampling signal.

LabVIEW software is used in the developed system as a user interface for system monitoring and platform for the signal processing. The signal from MOD-PULSE development board and USB sound card are connected to the PC via USB connection. The sound signal filtered using Butterworth band-pass filter (15Hz-15KHz) and notch filter (50Hz) to eliminate

environment and also power-line noise. The mean signal then calculated and the short-time Fourier transform (STFT) for analysis of sound frequency and amplitude spectrogram also computed. The spectrogram provides more information compared to time-domain signal's representation. Analysis of the frequency, time and amplitude on the spectrogram could help physicians determine the level of snoring severities. On the other hand, SPO2 data need to be extracted using a simple build algorithm to read from SPO2 MOD-PULSE development board. The heart rate and blood oxygenation, then will be presented in the user interface monitor. All data can be recorded with details of patient name, date and time of the sleep test. Fig. 5 shows the block diagrams of the user interface monitoring system.

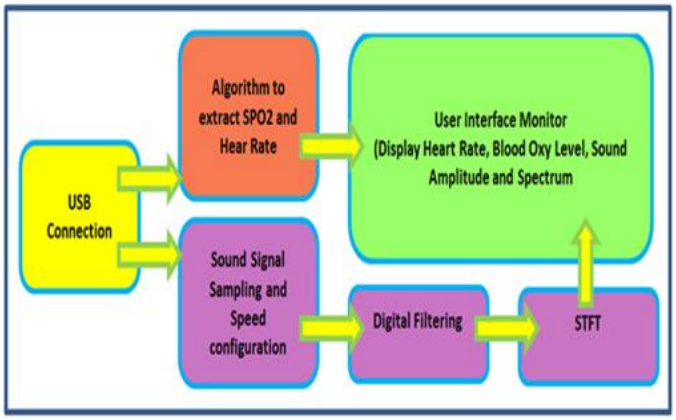

Fig. 5. Block diagram of the user interface system using LabVIEW software

The SPO2 finger probe attached to the index finger and piezoelectric transducer is attached to the patient's shirt collar or near the throat. Normally the test session took 8 to 9 hours. Data will be recorded and analyzed by a technician based on the blood-oxy level, frequency intensity, snoring frequency and amplitude. Further AD diagnosis should be conducted by specialists.

III. System Evaluation

Fig. 6 shows the user interface of the developed system. The interface included patient name and number for the record, the oxygenation, heart rate, sound signal and spectrogram with some hardware configurations. The system has been tested on 4 volunteer subjects that been identified previously with snoring problems. However, there have been no recorded of AD case to the test subjects. The testing of full night sleep test is done only one day per subject. Table 1 shows the averaged result recorded and calculated. In general, the result obtained is not yet a concrete diagnosis of sleep problem since this study is performed only one night and certain parameters such as sleeping position or posture is not recorded. Moreover, the details of diagnosis should be performed by specialist and also supported by other instruments or devices as well.

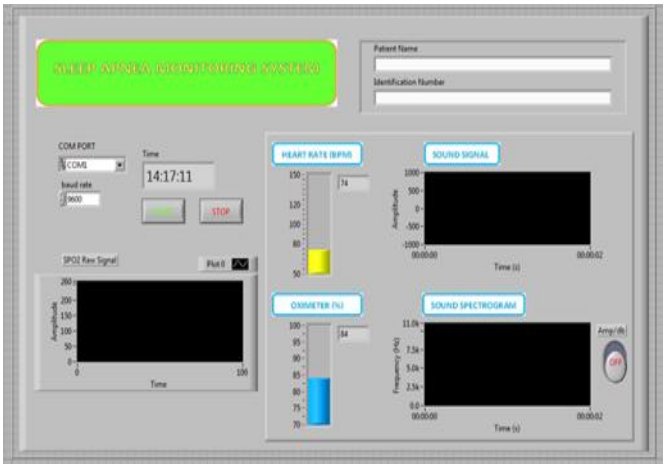

Fig. 6. The front panel of system user interface

Table 1. The calculated value of measurement parameters

Subjects	Heart Rate (bpm)	SPO2 level (%)	Snoring Level (dB)	Frequency (Hz)	Event Frequent
1	85	97	54	< 10 K	15
2	83	96	53	< 10 K	13
3	86	96	48	< 10 K	16
4	90	96	52	< 10 K	15

There are several constrain on the developed system prototype. The SPO2 signal is very sensitive and could contribute to error calculation of blood oxygenation during extremely low local perfusion. Advance intelligence signal processing is suggested to minimize this error. On the other hand, the calculation of the parameters such as event frequent and snoring level measured are still handled manually. This system is not suggested to replace the gold standard measurement practice of sleep study using polysomonography, however, there are many researchers and inventors attempts of enhancement of the current practice in monitoring and assisting in sleep study as well as managing the disorder [16-18].

IV. Conclusion

There are three types of sleep apnea disorder, namely; obstructive, central and complex sleep apnea. Whenever the symptoms of this disorder appear, there are still people unware of this problem and sometimes it could lead to others health risks. The further details of AD or OSA diagnosis is performed by a specialist using high-end approaches such as endoscopy technique. However, due to time consuming, high cost and uncertainty result in a short period of sleep study, the polysomonography is introduced. Furthermore, many sleep studies are using various method for better improvement such as using camera, wireless system and also built-in sensors in bed mattress will help to reduce thus disturbing and distressing of conventional polysomonography.

The developed prototype system could be improved its performance for example, parameters average calculate on-

line, snoring frequent occurrence and also classification to help technician or physician to get an early result conducted before further investigation of the disorder. The combination of this device and other devices could promise a better diagnosing result study specialize in the apnea disorder.

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