Ventilator Controlled Sleep Apnea Monitor for Children

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ABSTRACT

APNEA is a Greek word which means to breath. Sleep apnea is defined as a temporary pause in breathing. Sleep apnea is the absence of effective breathing and is associated with color changes (blue, gray, or dusky) and/or reduced muscle tone (turning "floppy"). Sleep apnea is a breathing disorder characterized by brief interruptions of breathing during sleep. The number of involuntary or "apneaic events" may be as high as 20 to 60 or more per hour in a nights sleep. These apneaic events or so called breathing pauses are accompanied by snoring always between apnea episodes, although not everyone who snores has this condition. When a person is awake or normal during sleep, his throat muscles keep the throat open and air flows into lungs, but if the person has sleep apnea, then enough air cannot move into lungs. Signals are been collected from the patients through sensors. The signal is processed and amplified and is been sent to the monitor. Timer is been set, it waits for the time set for receiving signals, if not alarm is been set. Which in turn turns on the ventilator automatically? This is specially done for children between it ages of 2 to 6 years

KEY WORDS: Ventilator Controlled, Monitor, Apnea.

1. INTRODUCTION

Sleep Apnea and Children: Although typically considered as an 'adult' condition, Sleep apnea affects 10% - 12% of otherwise healthy children nationwide. The majority of sleep apnea suffers range in age from 2 to 6 years and in rare instances the conditions can be seen in newborn adolescents. The survey illustrates the prevalence rate of sleep apnea and the need for awareness about this life threatening disease. The table further extrapolates the prevalence rate of sleep apnea in various countries. According to a study made by US census bureau, the table extrapolates the prevalence rate of sleep apnea in various countries.

Table.1. Prevalence rate of sleep apnea in various countries

Country	Extrapolated prevalence	Population Estimation
India	70,482,614	1,065,070,607
USA	19,433,078	293,655,405
UK	3,988,502	60,270,708
Russia	9,527,695	143,974,059
China	85,953,153	1,298,847,624
Japan	8,426,448	127,333,002
Pakistan	10,535,051	159,196,336

Types of Sleep Apnea: There are two primary types of sleep apnea and one combination.
- Obstructive sleep apnea
- Central sleep apnea
- Mixed sleep apnea.

Flow of Events Occurring during OSA:
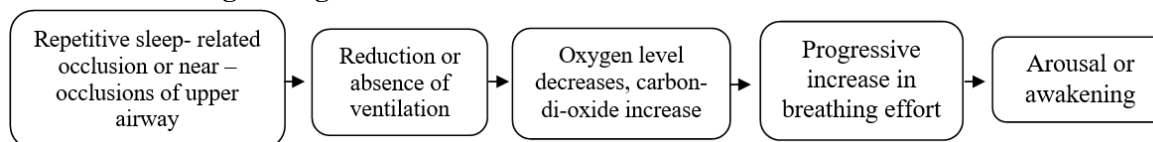
Figure.1. Flow of Events Occurring during OSA

Symptoms for Sleep Apnea: Sleep apnea occurs in all age groups and both sexes, but is more common in men.
- Loud snoring
- Excessive day time sleepiness and episodes of not breathing
- Sweating and chest pain
- Walking with an un-refreshed feeling after sleep apnea
- Feeling irritable and tired which might lead to accidents
- Morning headache
- Getting up during night to urinate
- Day time naps or activities during inappropriate times

Detection Process

Signal Processing Stage: First stage of signal processing includes

- Detection of 3 input signals, nasal respiration signal, abdominal respiration signal and ECG signals.
- Amplification of detected signals.
- Filtration of amplified signals.
- Conversion of filtered signals to digital form.

Monitoring and Analyzing Stage: The second stage of monitoring and analyzing stage includes

- Fuzzy logical analysis of processed signals along with usage of visual basic.

The output of the system is given to both the alarm and artificial ventilation system.

First Stage - Signal Processing Stage: In this biomedical project for online detection of sleep apnea, we have used three inputs. Even one input is enough but for more accuracy three input signals are used. Nasal input signal is used to detect the breathing of a person. His breathing rate is calculated using number of pulses for specific time period. Abdominal signal senses the abdominal movement of patients. Here also numbers of pulses are calculated and compared with standard values for specific time duration. ECG rating is obtained using ECG signal and compared with standard values. All the three inputs are amplified using instrumentation amplifier circuits. Amplifier circuit will differ for each input. Output obtained by nasal and abdomen is DC output, where as for ECG it is AC output. For convenience we have converted AC ECG output to DC using clamper circuit. Later multiplexer is used to merge all the three inputs and the signals are then transmitted to ADC. Analog outputs are converted to digital form and send to one port of the microcontroller. Microcontroller 8051 is used to check baud rate and to control multiplexer.

Second Stage - Monitoring And Analyzing Stage: Data obtained in the first stage is examined in second stage. In this second stage fuzzy logic concept is used and it is implemented in the visual basic which is user friendly software. RS 232 data transfer is used to match signal voltages with that of PC. Microcontroller 2051 is used to produce buzzer alarm when abdominal signals are not in normal conditions. RS 232 communication concept is used to control the voltage level of artificial ventilation system, so that it is activated with more voltage and person gets more oxygen.

Nasal respiratory signal: The sensor used to detect the nasal signal is the microphone which is a sound sensitive device that converts sound signal to electrical signal. Nasal sensor circuit have two parts.

- Microphone section
- Amplification section

In microphone section, we have used microphone along with a transistor to estimate the voltage output during breathing cycles of the patient. In amplification circuit, we have used a 555 timer in the mono stable state to obtain the pulsed wave form. Finally the output of the nasal sensor circuit is 2 to 4 volt in DC while breathing out and zero while breathing in.

The 555 timer is a highly stable device for generating accurate time delay or oscillation. A single 555 timer can provide time delay ranging from micro seconds to hours whereas counter timer can have maximum timing range of days.

The 555 timer can be used with supply voltage in the range of +5V to +18V. Because of wide range of supply voltage, the 555 timer is versatile and easy to use in various applications. The 555 timer pin diagram is as shown.
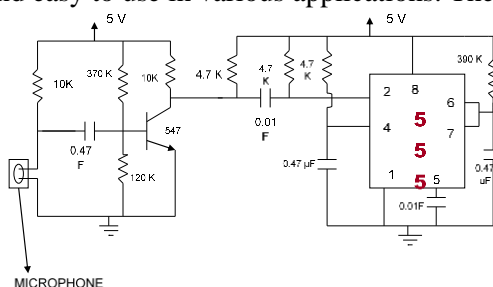
Figure.2. 555 Timer pin diagram

Abdominal respiratory signal: A contact less opto-electronic displacement transducer has been designed to sense the movement on the chest wall. The process of breathing causes subtle changes on the abdomen/chest regions. Using indigenous components, we have developed a miniature opto-electronic sensor that effectively monitors respiration rhythm.

The abdomen sensor uses MOC7811(Optoelectronic transducer) which is a combination of infrared ED TEL-8 made of GaAIAs (clear lens high power 3mm IRLED) and a phototransistor (GT1735) made of GaAsP. It consists of a Led transmitter and a transistor. Light from LED falls on the base of the transistor. When the cutoff plate comes in between the Led and the transistor the intensity of light falling on the base of the transistor varies and thus an output voltage is produced. The output voltage thus produced is indication of breath in a patient.

The sensor output is given to a NPN transistor which amplifies the sensor output and sends that to the next stage NPN transistor which acts as a switch. A LED in parallel is connected with the collector of this amplifier to

indicate continuous breathing. The signal from this is sent to the missing pulse detector. A test/ calibration rig was constructed to evaluate the transducer performance, by simulation of breathing pattern.

The resultant signal is processed by a mono-stable, averaging pump circuitry, ADC and LED digital panel meter to display the respiration rate in breathes per minutes. The mono-stable output is also used to trigger an alarm circuit if the apnea period was exceeded. When there are no breathes for apnea period of 10, 20, 30, 60, 120 seconds.

Figure.3. Digital panel meter

Data Transmission: In transmission of data, the information is grabbed from 8 bit data bus and presented to the 8 bit data bus of printer. This kind of transmission is parallel transmission. Parallel transmission is expensive with 8 bit data path.

Serial communication uses single data line and makes it much cheaper. This communication covers long distance. For serial communication, the byte of data must be converted to serial bits using a parallel in serial out shift register; then it can be transmitted over a single data line. Receiving end must have serial in parallel out shift register.

There are two methods of serial data communication

Synchronous Mode: transfers a block of data at time. There will be acknowledgment.

Asynchronous Mode: transfers a single byte at a time. There will not be acknowledgment.

Asynchronous Serial Communication: Asynchronous Serial Communication is widely used for character oriented transmission. In this each character is placed between start and stop bits. This is framing.

The rate of data transfer in serial communication is stated in bits per second bps. The number of signals changes per second is baud rate. Baud rate and bps are same when conductor wire is concerned.
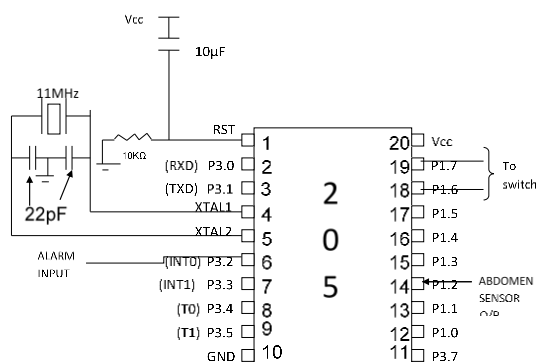
Figure.4. Asynchronous Serial Communication

Data Simulation Software: The programming software's that are used to compare the input signals and to detect the disease (either sleep apnea or respiratory disorders). Visual basic is event based simple programming software which does not need any expert knowledge to program and execute. Creating a module in VB is quite easier than any other programming software's. With small controls, we can include any components in our form (i.e.) module. VB6 which is the latest version has been used in our project. This version has many new database capabilities. The key to these new data abilities, the Explorer-like Data View window, lets you connect to one or more databases, explore their structures, look at the data they contain, and more. Likewise this version has many new features. VB programming is not case sensitive.
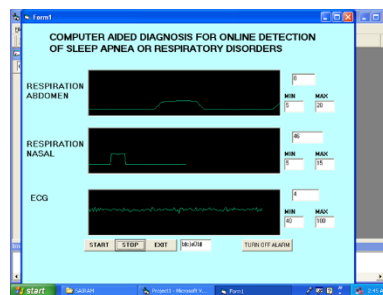
Artificial Ventilation: Ventilation of the unconscious, or, in some circumstances conscious, patient has the following aims:

• clear and control the airway
• optimize ventilation
• use airway adjuncts effectively

Obstruction in the absence of trauma or a foreign body is caused by:

• tongue
• epiglottis

In this project, voltage level of the artificial ventilation system is increased so that more oxygen is provided for the patient. For this purpose we are using RS 232 communication cables. RS 232 DB 25 pin cable is used.

Testing in Normal Patient:
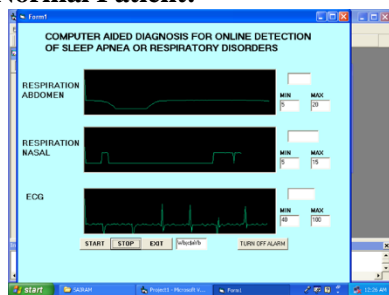
Figure.5a. Testing in Normal Patient   **Figure.5b. Testing in Normal Patient**

Testing In Respiratory Disorder Patient

Existing Techniques & Their Disadvantages: Definitive diagnostic technique is Polysomnogram (PSG).

It measures brain activity, eye movement, muscle activity, breathing, heart rate, movement of lungs and oxygen level. PSG is uncomfortable for the patient & involves considerable capital investment for healthcare system in equipment, bed space. Specialized technical support. Interpretation of test data is also complex. Time consuming. Overall cost of performing PSG is estimated to be around 1000 to 2000$.

Advantages of Cad for Online Detection of Sleep Apnea:
- Minimally intrusive.
- Usage of sensors (belts or electrodes) do not   significantly burden a patient.
- Inexpensive.
- Well suited for screening.
- Simple and can be easily implemented**.**
- Reliable detection.

Need for Diagnosing Sleep Apnea: The sleep apnea increased risk for cardiovascular patients, as they fall into aerodynamically unstable state so the online detection of sleep apnea is of great importance in giving timely medication or respiratory assistance. If the sleep apnea is recognized in time, the number of apneal breaths can be detected or even fully eliminated. If the patient has an artificially respirator then a solution can be the appropriate control of the respirator.

Sleep apnea is a serious condition which is potentially life threatening which is far more than generally understood. Early diagnosis and treatment of sleep apnea is important because it may be associated with irregular heartbeat, high blood pressure, heart attack and stroke.

Sleep apnea is common and potentially deadly disease. Depending on its severity, several health problems occur. Most commonly occurring health problems are,
- Slowing down of heart beat
- Atrio ventricular block
- Congestive heart failure
- Hypertension or high blood pressure
- Premature death in women
- Hardening of arteries

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