



Pulse Transit Time Measurement using ATmega16 Microcontroller

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Abstract— Sleep apnea detection is usually conducted in sleep laboratories. But the unavailability of laboratories and long patient waiting queue will lead to the detection more complex. In order to avoid this situation more flexible system is needed. This paper deals with the detection of sleep apnea using Atmega16 microcontroller. Here ECG and PPG signals both are simultaneously acquired from a bio kit and given to the inbuilt ADC pin of microcontroller. After ADC conversion both the peaks of ECG and PPG signals are detected. Further PTT calculation is performed and results are compared with a standard value of 250 ms to detect the sleep apnea.

Keywords— Sleep apnea , ECG, PPG, PTT, LabVIEW.

I. INTRODUCTION

Sleep apnea is a breathing disorder resulting from upper airway obstruction. Untreated sleep apnea can result in high blood pressure, heart attack and even in IQ loss. Sometimes it is hereditary. But most of the time the patient is unaware of this disorder during sleeping. Snoring is the important sign of sleep apnea. Usually sleep laboratories are conducting sleep apnea detection test. But the unavailability of sleep laboratories and long patient waiting queue results in more complex diagnosis. In order to avoid this situation a simple detecting scheme is needed. Here in this paper a simple monitoring device is used for detecting sleep apnea. Which consists of an AVR ATmega 16 microcontroller as the heart of the device and a biokit is used to acquire real time signals from the patient. ECG and PPG signals both are simultaneously acquired from the patient and given to the microcontroller. Microcontroller performs the peak detection on these signals and pulse transit time is calculated. The system consists of the real time acquisition of the ECG and PPG signals from the biokit. The first job is to detect the QRS complex from the signals. A timer starts after detecting the R peak. Detection of PPG peak results in stopping of the timer. The resultant timer value is the pulse transit time and is compared with the standard value of 250ms. Sleep apnea can be detected using several methods. It can be measured by taking the oxygen saturation content and also by taking the respiratory signals. Such a method to find out the respiratory rate is by taking the RR interval between the ECG peaks [1].

An external ADC is used for converting the analog signals to the digital samples and the results are displayed with the help of graphical user interface software Visual C++. Another method of finding sleep apnea is by using PPG signals [2]. Here the system is a wearable device and the signals are acquired from a standard SpO2 wrapped sensor. Here threshold detection scheme is used. An alarm activates the apnea crosses a particular threshold. But these two approaches are much more complex compared to this system. Another one shows a method of transmitting physiological signals via Bluetooth [3] to a distant cell phone which stores and transmit the data. Here two different algorithms are used for detecting sleep apnea. And performance is verified among 20 people. This method is not as much as simple as the one we did here. Sleep apnea can be effectively detected using the ECG and PPG sensors. An AT90S8535 microcontroller is used for the detection purpose. Two algorithms are used for detection one is slope detection and other one is moving average algorithm [5]. These two algorithms are used for the detection of peak values of ECG and PPG signals. After detecting peak values pulse transit time is calculated by turning on a timer. Another method of finding sleep apnea is by measuring the heart rate variability during sleeping [6]. A continuous pausing of respiratory flow will occur for a patient having sleep apnea and this will occur at least 600 times during night. This also accompanied by the heart rate variability. Heart rate variability is checking after finding the peaks of the ECG waveform. This is a tele-monitoring device and a microcontroller is used for this purpose. Sleep apnea can be detected by taking the thoracic and abdominal excursion signals [7]. The phase differences between two respiratory signals are calculated for detecting obstructive sleep apnea. The pulse transit time can be calculated in children for detecting sleep apnea [8]. A non breathing face mask is used for this purpose here 20 events of obstructive sleep apnea and 90 events of central apnea are detected.

II. METHODOLOGY

A. Problem Definition

In this paper the real time acquisition of ECG and PPG signals are done for the detection of sleep apnea. The signals acquired from the sensors connected to the body of the patient are transmitted to the microcontroller through biokit amplifier. The amplified signals are transmitted to the microcontroller for further detection through an in built ADC of the microcontroller. Here ATmega 16 microcontroller is used for the purpose because it is very much fit to this proposed

low cost system. ATmega 16 having an inbuilt 10 bit ADC that is needed for the conversion of the analog signals coming from the sensor. The proposed system is shown below Peak detection is done here by continuous comparison of the samples in the signals. Each incoming samples are compared with the previous samples and the greater ones are stored. The stored samples are again compared with the next samples. And the process is going on .Finally when the maximum value of ECG peak detected, a timer starts. Similar comparison is done on PPG signal also. Here after detecting peak timer stops.

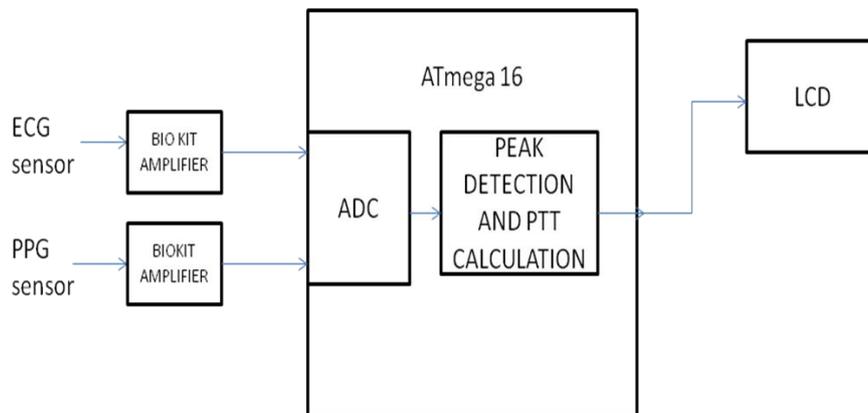


Fig 1. Block diagram

The process continues for each and every peak in the signals and the values are displayed in LCD. The incoming signals are verified using Labview for that NI DAQ is used to acquire the signals .Peak detection can also be done with threshold detection method. Usually ECG signals are subjected to baseline wanders and PPG signals affect amplitude fluctuations. A normal threshold detection method is not suitable for this condition. Sometimes the amplitude of T waves in ECG signals will be larger than the R wave so the device automatically decides it as the peak and calculates the pulse transit time value. In order to avoid that situation comparison among the samples is needed. We can also detect the negative slopes for analysis. The positive slope of the ECG signal is less affected by the cardiac rhythm disturbances so it is taken as the sign of arriving peaks. Peak detection is done here by continuous comparison of the samples in the signals. Each incoming samples are compared with the previous samples and the greater ones are stored. The stored samples again compared with the next samples and the process is going on. Finally when the maximum value of ECG peak detected, a timer starts. Similar comparison is done on PPG signal also. Here after detecting peak timer stops. The process continues for each and every peak in the signals and the values are displayed in LCD. The incoming signals are verified using Labview for that NI DAQ is used to acquire the signals .Peak detection can also be done with threshold detection method. Usually ECG signals are subjected to baseline wanders and PPG signals affect amplitude fluctuations. A normal threshold detection method is not suitable for this condition. Sometimes the amplitude of T waves in ECG signals will be larger than the R wave so the device automatically decides it as the peak and calculates the pulse transit time value. In order to avoid that situation comparison among the samples is needed. We can also detect the negative slopes for analysis. The positive slope of the ECG signal is less affected by the cardiac rhythm disturbances so it is taken as the sign of arriving peaks. The flow chart of the given system is shown in fig.3. First process is to detect the R peak. If R peak is detected then a timer is set to on for the PTT calculation .Next process is to detect the peak of PPG signal. If the peak of PPG signal is detected the timer turn off. The process continues for each and every peak. The value of PTT is displaying in LCD for verification. The signals are verified with the help of Labview software.

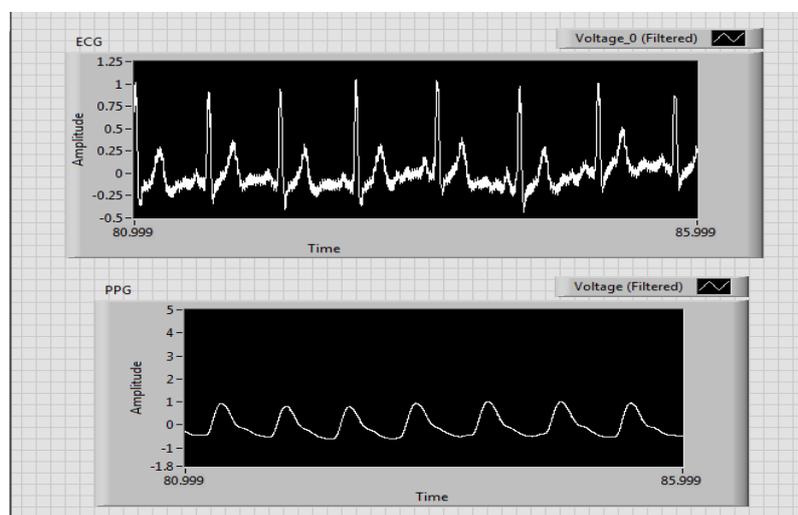


Fig 2. Wave form acquired using LabView

III. Experiments

. ECG signals are collected from the patients fingers using ring electrodes.PPG signals are collected from the tip of the finger using the PPG sensor .It consist of a red LED and a photodiode. The light from the LED pass through the fingers and the reflected light is absorbed by the photodiode. The acquired ECG and PPG signals are shown in fig.2.

A.Hardware

ECG and PPG signals are collected from the sensors are fed to the biokit amplifier the amplified signals are acquired using the NI DAQ and viewed using LabView software. These signals are again given to a microcontroller .Here ATmega 16 microcontroller is used for the rest of peak detection and pulse transit time calculation. For each peaks in the ECG and PPG the presented system calculates the pulse transit time and the values are displayed in LCD.

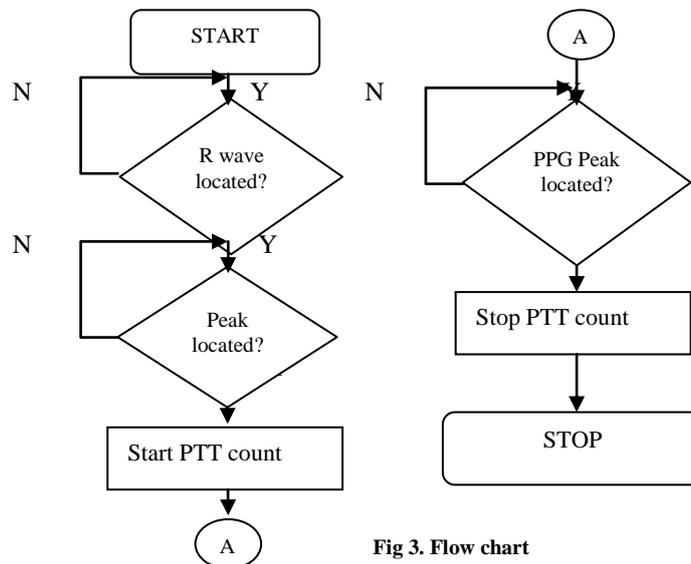


Fig 3. Flow chart

B.Results

Signal acquisition using NIDAQ was performed. The values are checked with the LCD in microcontroller. The calculation of pulse transit time was performed and the results are checked with the help of Liquid Cristal display and it is shown below. For a normal patient the values are between 230-260 ms approximately. A patient having sleep apnea , the PTT values are above 260.

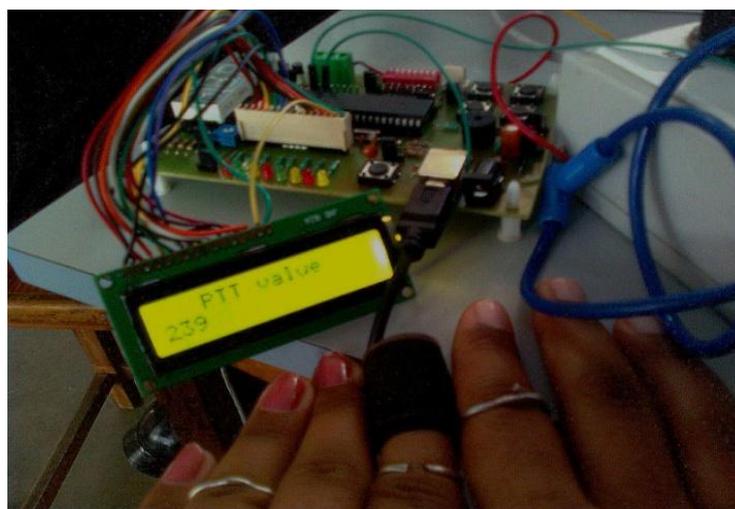


Fig 4. PTT result in LCD.

IV. CONCLUSIONS

The real time detection of sleep apnea has been effectively done using ATmega 16 microcontroller. The signals are verified with both Labview software and LCD. This system can be used as a wearable device and can transmit the values to a distant system using cell phones.

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