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Respiration Rate Measurement: A Different Approach

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Abstract

This paper presents a methodology of monitoring respiration rate by measuring change in exhale and inhale temperature. Various techniques are there for monitoring respiration rate e.g. by counting how many times chest rises and falls in one minute, using microphone which is placed either close to the respiratory airways or over the throat to observe the variation of sound, using Photoplethysmography. This project determine cost effective method for respiration rate measurement using NTC type Thermistor, amplifier circuit, Arduino (due) with result display on Arduino IDE. Measurement of respiration rate by measuring change in temperature from Thermistor which placed in patients breathing mask. Designed project consist of different hardware components and software for monitoring respiration rate with relative accuracy.

***Key Words*:** NTC Thermistor, Respiration rate, microcontroller.

1 INTRODUCTION

Respire means breathing. Respiration is an act of exchange of oxygen and carbon dioxide continuously with external environment. During respiration inhaled oxygen enters into alveoli, an air sacs present in the lungs. Surrounding the alveoli, there is an air blood barrier through which oxygen and carbon dioxide exchange takes place into the atmosphere. Respiration rate is a rate in which how many breaths a person takes in one minute or each minute. Normal respiration rate of human being is 12-16 breaths per minute [1]. When patient is in rest and sleep condition, respiration rate is measured. Measurement of respiration rate gives out the monitoring of respiration illness progress. The temperature difference between exhale and inhale is around 1-20 C and is small. Exhaled air temperature is high than inhaled air temperature [3]. There are mainly two methods for measurements of respiration rate i.e. respiration monitoring using contact type sensor and noncontact type sensor methods. Respiration rate monitoring using Radar Based and Optical Based Respiration Rate Monitoring methods are noncontact type [4 , 5]. During exhalation, output of Thermistor is less and during inhalation output of Thermistor is more.

2 Literature survey

Paper [6], Impedance pneumography is most oftently used method to measure respiration rate, this method uses the electrodes to measure changing electrical resistance of persons thorax caused by breathing. Ac current with high frequency is passed from the tissue through electrodes so the difference in potential is proportional to resistance of tissue between the voltage sensing electrodes and equivalent resistance is nothing but ratio of voltage between two electrodes and current flows through these tissues. In the paper [7], piezoelectric sensor, named polyvinylidene-fluoride (PVDF) and electrodes is placed in jacket of patient or chest belt or could be used as wearable device in which chest dilation due to respiration is measured. Voltage is generated from piezo sensor using charge amplifier and then to remove noise signal low pass filter is used so breathing signal is effectively detected by vibration due to chest movement. Paper [8], explains respiration rate measured in two ways, one is respiration rate estimated using accelerometer by capturing data and second one uses eGlasses with thermal camera to find temperature change through nostril region. The simple methodology for measurement of respiration rate with inexpensive sensor i.e. paper used in paper [9], comprises digitally printed graphite electrode with paper and flexible textile procedure mask to measure respiration rate of person by measuring how much difference in moisture absorbed by paper while exhalation and inhalation. This system displays the data on smart phone or tab and we can send this data over cloud. Paper[10], Digital respiration rate meter for monitoring respiration rate, which consist of three sections i.e. transmitter, receiver and breathing setup. Breathing setup includes displacement transducer placed in breathing mask which consist of glass tube with thermocol ball. Displacement of thermocol ball occurred up and down due to the breathing and this displacement is proportional to respiration rate. Displacement transducer cut the IR waves transmitted by transmitter section and these waves sensed by receiver section. Three digit seven segment display used to read the data.

I. SYSTEMDESCRIPTION

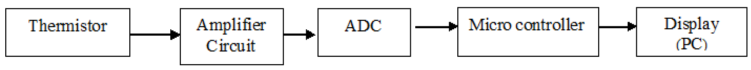

Fig.1. Block diagram of system

A. Hardware Design

Sensor

Thermistor is main sensing element in this project. Thermistor is more sensitive and cost effective device. There two are two types of Thermistor one is positive temperature coefficient (PTC), as temperature increases proportionally resistance also increases and Second is negative temperature coefficient (NTC), as temperature increases proportionally resistance decreases. NTC type Thermistor of 10K is used in this project and temperature range is -40°C to +125°C.

Amplifier circuit

Sensor measures the change in temperature through mask but output of Thermistor is very less which cannot give directly to microcontroller so amplifier circuitry is required to amplify output of Thermistor. To amplify the output from sensor amplifier circuit designed is shown below.

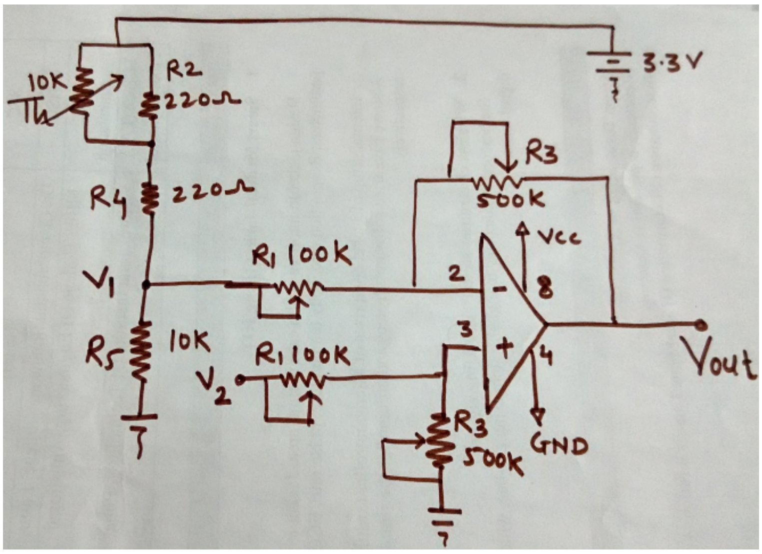

Fig.2. Aamplifier circuitry

Figure 2 shows the amplifier circuitry with amplifier LM358. Gain is adjusted by using suitable resistor value of R3 and R1 and output voltage is calculated from formula given below. To find v1 using voltage division rule,

$$V_1 = \frac{3.3 * 1oK}{(Th||R_2) + R_4 + R_5} \quad (1)$$

$$V_2 = 3.3V \quad (2)$$

From equation 1 and 2 output voltage is,

$$V_{out} = (V_2 - V_1) \quad (3)$$

Band pass filter

Change in voltage from amplifier circuit is given to band pass filter to remove dc and also high frequency noise so band pass filter is implemented in Arduino software. Exponential moving average filter used for implementation. Output of exponential moving average filter is determined as,

$$Yk = \alpha yK - 1 + (1 - \alpha)xK \quad (4)$$

Similarly,

$$EMAHIGH = (\alpha * sensorvalue) + (1 - \alpha) * valueofhighpassfilter \quad (5)$$

$$EMALOW = (\alpha * sensorvalue) + (1 - \alpha) * valueoflowpassfilter \quad (6)$$

From equation 5 & 6,

$$Bandpassfilter = EMAHIGHEMALOW \quad (7)$$

Designed band pass filter is not responding due to the very less frequency change in respiratory system hence not considered further for designing.

B. Software Design

Microcontroller

Microcontroller used in this project is to receive continuously changed output signal from temperature sensor and send continuously data for monitoring system. The microcontroller Arduino due, which is 32 bit and based on Atmel SAM3X8E ARM Cortex-M3 CPU. This runs at 3.3v,84 MHZ clock frequency.

Flowchart

Amplified voltage of voltage divider circuits using Thermistor is given to ADC of microcontroller. ADC value gives high and low values in the form of peaks. So initializing the sensor value, previous sensor value and time interval to measure respiration rate.

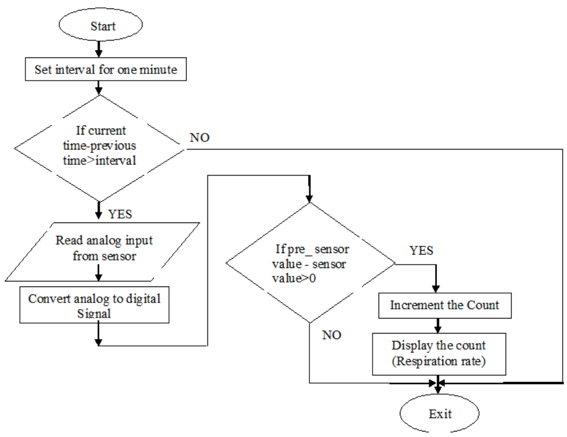

Fig.3. Flowchart of System

3 Results and Analysis

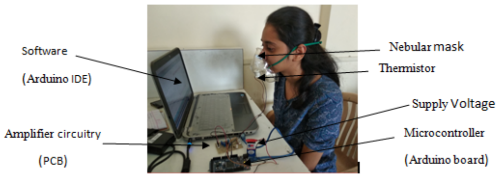

Fig.4. Experimental setup of system

Fig.4 shows experimental setup in which respiration rate is measured and its waveforms are shown in Fig.5 and 6 i.e. change in voltage on y axis with respect to time on x axis.

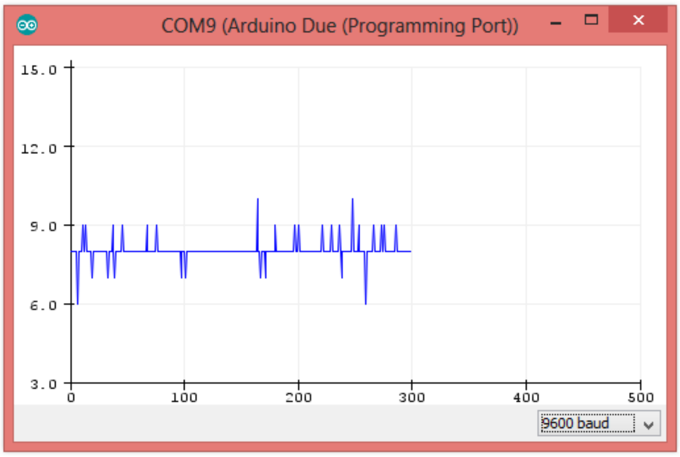

Fig.5. Respiration when person at rest condition.

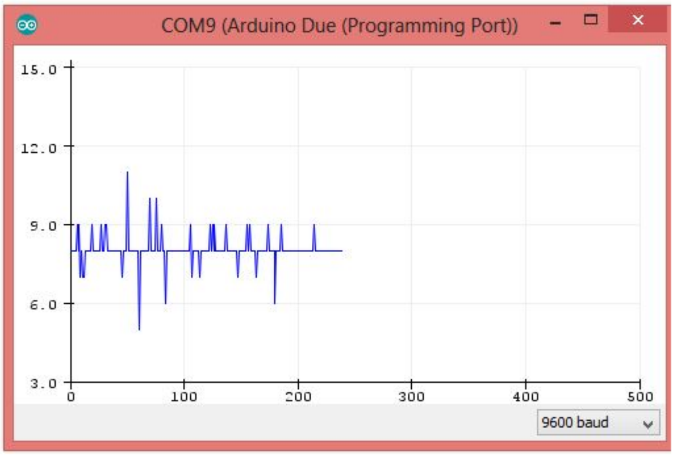

Fig.6. Respiration when person during deep

TABLE I. RESPIRATION RATE OF DIFFERENT PEOPLE

Sr.No.	Recorded Respiration Rate	Actual Respiration Rate	Age (year)
1	13	15	24
2	16	18	15
3	12	13	55
4	14	16	22
5	17	19	12
6	14	15	23

4 Conclusion

The experimental work explained in this paper provides a different technique for monitoring. Measurement with the placement of sensor in mask without heating provides a good solution to the techniques available in the medical field. Results are encouraging.

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