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Respiratory Monitor with Corrective Measure System Using Thermistor, At Mega 328 and GSM

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ABSTRACT: Thermistor based respiratory monitor is an integrated device which calculates the breathing rate of a person and takes step-wise measures in extreme conditions. It calculates the breathing rate by using a thermistor which shows variations in its output when the person breathes in or out by detecting the corresponding temperature changes. Features of this device include LCD, buzzer, stepper motor and GSM module. LCD is used to continuously display the breathing rate of the person. Buzzer is used to sound when the person has started to breathe erratically and stepper motor is used to control the oxygen supply. GSM module is used as the last step in which a message is sent to a doctor for immediate assistance. The implementation of the project includes various hardware components as well as software.

KEYWORDS: Thermistor, breathing, GSM, embedded, medical, low-resource, temperature.

I. INTRODUCTION

Commercially available biomedical devices require a stable supply of power and are very environment specific. They are also bulky and require constant supervision. Thus the need for an adaptable low-resource device becomes necessary. The project uses thermistor to give input to the system which reduces the overall cost of the system and also makes it easier to handle. [1]

To use this device, the patient needs to wear a thermistor embedded nebulizer mask. When the patient breathes through the mask, the ambient temperature of the air surrounding the thermistor varies. This corresponding variation in voltage across the thermistor is given to the amplification circuitry and further to the arduino. If the breath rate of the patient is not within the normal range, then necessary steps are taken. In this project, breath rate of the patient is displayed on a LCD every 15 seconds. If the patient has erratic breathing, then the buzzer alarms to indicate the condition of the patient. If the case continues, then the oxygen valve is adjusted to supply more oxygen to the patient. If even after the above measures, the breath rate is not normalized, then the doctor is notified about the condition of the patient using a GSM module.

II. LITERATURE SURVEY

The IEEE paper on “Low-Cost, Thermistor Based Respiration Monitor” by M. Gupta and H. Qudsi was used to build the basic idea of the project. The paper was used to understand how thermistor was used to measure the breath rate of a person with the help of an amplification circuitry. [1]

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The IJERT paper on "GSM Based Home Automation, Safety and Security System Using Android Mobile Phone" by Arijit Pal, Akanksha Singh and Bijay Rai was used to understand the interfacing of GSM module with Arduino board which was used to send SMS to a doctor in our project. [4]

III. HARDWARE DESIGN

1. Thermistor

The project uses a NTC thermistor of value 100Kohm at 25 degree Celsius. As the temperature increases, resistance of the thermistor decreases and vice versa. The varying voltage signal is then given to the amplifying circuit for further processing.

2. Arduino

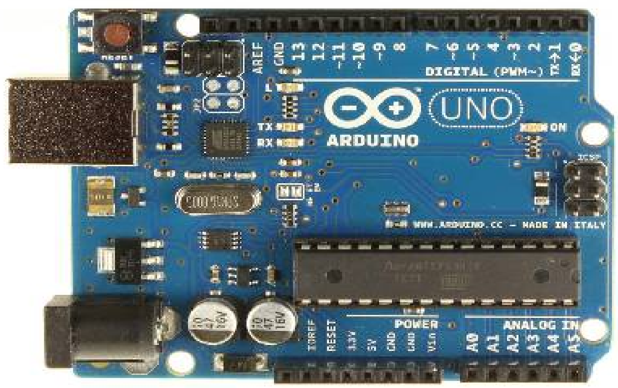

Fig. 1. Arduino UNO

Arduino provides a set of digital and analog I/O pins that can be interfaced to various other circuits. For programming the microcontrollers, the Arduino platform provides an integrated development environment (IDE) based on the Processing project, which includes support for C, C++ and Java programming languages. Arduino works at an operating voltage of 5V. It has 14 digital pins and 6 analog pins. All the circuits used in the project such as sim300, buzzer, motor, LCD and buzzer are controlled by arduino.

3. Amplification Circuitry [2]

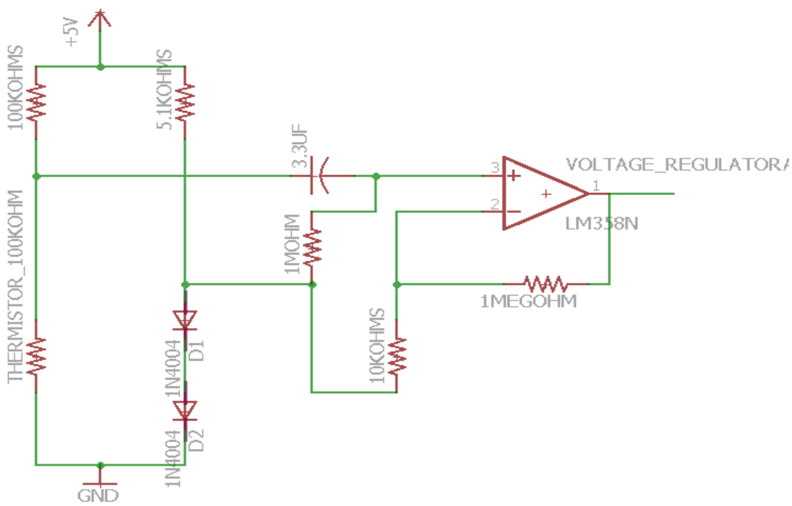

Fig. 2. Amplification circuitry

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The above circuit uses LM358 as a comparator and 100kohm thermistor is used to sense the temperature changes. The circuit amplifies the signal 100 times and the two diodes are used to provide bias of 1.4V. Amplified signal is then given to the analog pin of arduino. [3]

4. LCD

We use a 16x2 LCD display for displaying the breaths per minute of the patient which is updated after every 15 seconds. A potentiometer is used to adjust the contrast of the LCD.

5. Buzzer

A buzzer is used to indicate erratic breathing of the patient. If the patient starts breathing abnormally i.e. breaths per minute crosses the threshold values then buzzer will ring which will indicate the attendant to diagnose the patient.

6. Motor

If the patient's breaths per minute again crosses the threshold values i.e. the patient breathes abnormally again, then extra oxygen is passed through the pipe so that the patient starts breathing normally. A normal DC motor is used for this purpose.

7. GSM

Fig. 3. SIM300 module

SIM 300 is the GSM module used which operates on either 900MHz or 1800MHz of 1900MHz. A 9V battery is used to power the module. If the patient doesn't start breathing normally despite of oxygen passage then finally a GSM module (SIM 300) is used to indicate the doctor about the third erratic breathing of the patient. A message is sent to the doctor about the condition of the patient in order to take proper steps.

8. Battery

A 9V battery is used to operate the entire system.

IV. WORKING

In order to lessen the number of connecting wires in the project, an integrated board was developed. This board contains interfacing of the arduino with the LCD and the amplification circuitry. This reduced the overall cost of the system as it involved self-made arduino. The above board is very easy to use and compact in size.

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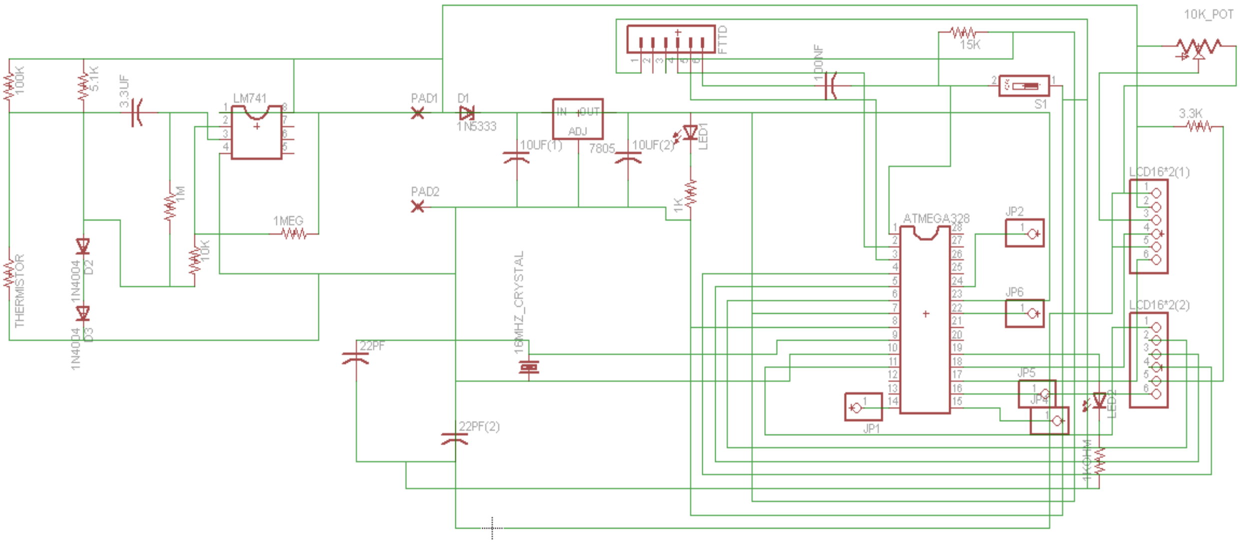

Fig. 4. Circuit diagram (schematic)

The thermistor(100k), 5.1k, 2 1meg, 10 k resistances, 3.3u, 2 diodes (D2,D3) and LM741 Op-Amp make up the sensory circuit. JP1 connector is used to connect the buzzer, JP2 connector is used to connect the motor for oxygen valve control while JP4,JP5 and JP6 are used for connection with GSM module. All the remaining connections are for the working of the Atmega328 microcontroller and connection with LCD 16*2 display.

The variations in temperature within the nebulizer mask corresponding to the breathing of the patient (temperature rise while breathing in and temperature fall while breathing out) is sensed by the thermistor fitted inside the mask and converted into subsequent variation in resistance (The thermistor is an NTC device hence rise in temperature leads to a drop in output resistance and vice-versa; this change is fed to a Wheatstone network that converts varying resistance into varying voltage levels. [1][4] This voltage is amplified and fed as an input to the microcontroller.

The microcontroller is embedded with a code that keeps a track of the patient's breathing by taking into account the three most recent voltage values that represent the current state of breathing. If the voltage level of the previous breath is the maximum out of the three i.e. current breath level, previous breath level and the breath before that; it means that the patient was previously breathing in and has now started breathing out. Conversely if the voltage level of the previous breath is the lowest out of the three; then the patient was initially breathing out and has now started breathing in. One breath involves one breath in cycle and one breath out cycle, hence a breath counter is incremented accordingly and data is recorded for a fifteen second cycle and then extrapolated to one minute.

An average healthy human being has a normal breathing rate lying between 10 to 14 breaths/minute and keeping some buffer, any breathing rate lower than 8 breaths per minute or greater than 16 breaths per minute can be abnormal and it may be possible that the patient is experiencing some discomfort in breathing. In such cases if the breathing rate is erratic for the first time an alarm is sounded to gain the attention of any available help in the near vicinity of the patient. If the breathing continues to remain abnormal in the second cycle then a motor is switched on to control the valve of the oxygen tank to ensure a surge of oxygen into the mask which might help normalize the breathing. If the breathing rate is still out of limits then an SMS is sent to a registered medical personnel or relative who can initiate a rapid response to take care of the patient or look into the patient's condition.

V. ALGORITHM AND FLOWCHART

1.All required variables like current_breath, previous_breath, breath_before_that, erratic_breath, breath_count and timer is all set to zero.

2.The current value of breathing is stored in current_breath after a delay of half a second.

3.If the value of previous breath is the highest or the lowest out of the three recorded values. The breath_count is incremented.

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4. Timer is incremented by 1.
5.If timer is less than 31 go back to step 2.
6. Multiply the breath_count by 2 to extrapolate the data to 1 minute.
7.If the breathing rate is erratic sound the alarm.
8.If erratic_breath=1 switch on the motor for 5 seconds to turn the oxygen valve.
9.If erratic_breath=2 send a message via GSM module to a medical personnel or relative, set erratic_breath to 0 and go to step 11.
10.Increment erratic_breath by 1.
11.Store current_breath value in previous_breath and previous_breath value in breath_before_that.
12. Initialize breath_count to 0 and timer to 0 and go back to step 2.

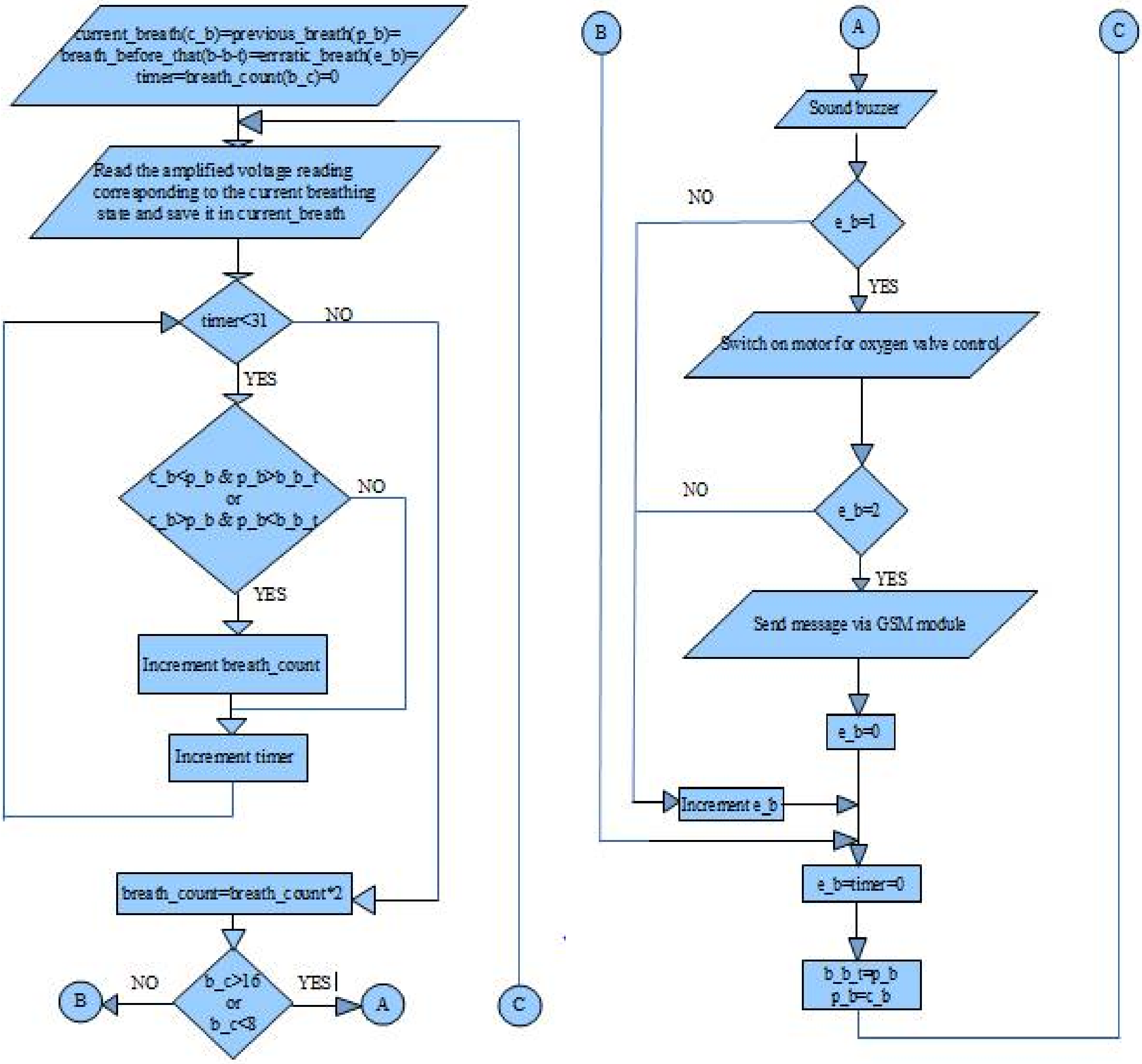

Fig. 5. Flowchart of the microcontroller program

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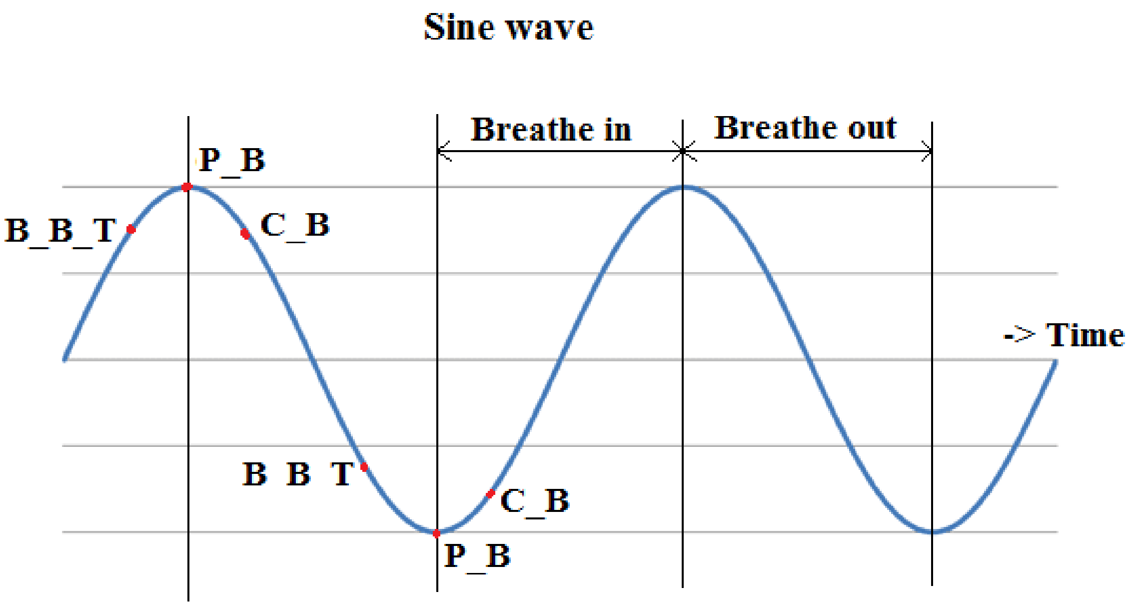

Fig. 6. Variation of output voltage with time

The amplified voltage corresponding to temperature changes picked up by the thermistor in correspondence to the patient's breathing when plotted as a graph of amplitude (on y-axis) versus time (on x-axis) replicates a sinusoidal wave. As the thermistor is a NTC(Negative Temperature Coefficient) device; the rising curves represent the 'Breath In' values while the falling curves correspond to "Breath Out'. The top of the crest is the first crossover point which denotes that the patient was inhaling and has now started exhaling while the negative peak on the trough is the point when the patient was previously exhaling and has now started inhaling.

VI. RESULTS AND OBSERVATIONS

Fig. 7. Serial monitor of arduino software

The above figure is a screenshot of the serial monitor of the arduino software. It displays the breathing pattern of the patient and displays the breath rate after every 15 seconds.

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Temperature (in Celsius)	**Thermistor resistance (in ohms)**
25	100k
36	60k
36+0.4 (breathe out)	59.43k
36-0.4 (breathe in)	61.67k

Table 1. Observation table [5][6]

The table shows change in the thermistor resistance as the patient breathes (as the temperature varies) through the mask. This change in resistance changes the output voltage of the amplification circuitry which is then given as input to the arduino board's analog pin.

VII. ADVANTAGES

1.It uses easily available components and a simple PCB that can be easily fabricated and assembled at a very low cost so that it can be made easily available and deployed in rural households or clinics in villages all over India.

2. It does not require constant monitoring by a trained professional. Any relative or any person in the vicinity can hear the beep and realize that something is wrong and that the patient requires attention.

3. The entire operation works on a 9V battery and hence when used in small hospitals or doctors in clinics in poor parts of the country; the entire monitor has low running cost, is easily portable and gives an accurate measure of the person's breathing.

4. Accurate breathing rate estimation (error within 10% of actual value) [4]

5. Can record any discrepancies in breathing in under 20 seconds of abnormal breathing by the patient.

6. Determination of whether the patient is breathing in or breathing out is done in real time depending on actual current breathing rate of the patient. There are no preset thresholds that determine the breathing and hence the monitor can be used on a range of patients from toddlers to aged people.

7. The GSM module requires power of 9V through a battery and hence this section makes the project completely portable.

VIII. DISADVANTAGES

1. To get accurate readings there is a start-up time of about 25 seconds.

2. If the thermistor is kept ideal and the circuit is switched on, then it will record garbage values from the surrounding and might sound the alarm on its own while not recording the actual breaths of a patient.

3. The range for normal and abnormal breathing is already defined in the code and can only be changed by a trained professional. Hence it is possible for eg that an athlete who has just returned from some physical exercise will be recorded as having abnormal breathing when using this respiratory monitor.

IX. APPLICATIONS

The integrated circuit can be sold to rural clinics and hospitals where capital investment is minimal and bulky heart monitors cannot be installed or made available for every patient hence can be easily substituted by low-cost and portable breathing monitors. These clinics can then use these monitors on their own or lease them out to bedridden patients in hard to access villages and the doctors can then be alerted by the message if a patient is unwell.

X. CONCLUSION

The project can measure the breath rate of the patient and take necessary actions when the breathing is abnormal. It alarms when abnormal breathing is detected for providing immediate assistance to the patient. If erratic breathing continues then the oxygen valve is adjusted for increased oxygen supply and GSM is used as last step to notify the doctor. The breath rate is updated after every 15 seconds which ensures the safety of the patient. The project proves to be very helpful in low resource environment as it works on 9V battery.

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