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Using Thermistors and GSM to Monitor Breathing and Heartbeat

Hiren Patel[1], M. Balamurugan[2]

Associate Professor[1], Student[2]

Department of Electrical and Electrical Engineering

Shah & Anchor Kutchhi Engineering College, Chembur, Mumbai, Maharashtra, India-400088

Corresponding Author's Email:- *mbalamurugan@gmail.com*

Abstract

The concerns and factors associated with health are extremely important to man and are required for his life and functional thinking. As a result, a more sophisticated system capable of tracking and documenting changes in health indicators independent of time or place must be built. This research proposes a device capable of remotely monitoring heartbeat and breathing in real time. The goal of this project is to develop and build a low-cost adaptable heartbeat and respiration rate monitor alarm system utilising GSM technology. It is intended to show the patient's pulse and breath rate on an LCD before sounding an alarm and sending an SMS to the medical expert's or health personnel's mobile phone if and only if the heartbeat and breath rate threshold value is surpassed to a maximum. As a result, this approach suggests a continuous, real-time, secure, and exact monitoring of the patient's health. Its diagnosis of the patient's health and prevention of cardiovascular disease.

Keywords: *GSM technology, cardiac rate, parameters, real-time monitoring, sensors, SMS are all examples of emergencies.*

INTRODUCTION

Cardiovascular disease is one of the leading causes of mortality in many countries, accounting for approximately 15 million fatalities annually; thus, innovative tactics are required to minimize the time between diagnosis and treatment. One such method is to monitor patients. This work includes several considerations and enhancements that were included into the device's operation in order to represent desired aspects such as cost, design complexity, size, software development, weight, lack of mobility, and so on. Many biomedical equipment [1–5] are expensive and require a constant power source to work, such as commercially available respiratory monitors [6], [10], [11]. We discovered a pressing need for low-cost, simple-to-use respiratory and cardiac monitors.

While researching several techniques of measuring respiration, we came across numerous commercial respiratory monitors [7], [12], and [13] that used various types of sensors. The most often used approach is pulse oximetry, which monitors oxygen saturation in the blood. To monitor the patient's health, we employ a pulse sensor to detect heartbeat rate and a thermistor to measure breathing rate in our suggested gadget.

We hoped to make using our thermistor-based monitor very inexpensive and straightforward. We choose to employ a nebulizer mask to ensure safety in our design. As the patient breathes through the mask, the temperature across the thermistor oscillates in lockstep with the patient's respiratory rate. The voltage across the thermistor can be used to calculate the rate of respiration indirectly. A patient's breathing rate is monitored and shown on a tiny LCD screen in breaths per minute (bpm). A piezoelectric speaker on our gadget creates two alerts to notify when a patient is not breathing and when the device's battery is going low. This article focuses on the design of a heartbeat monitor that can continuously monitor the patient's pulse rate status. This signal is analyzed by the microcontroller to determine the heartbeat frequency per minute. It subsequently sends an SMS warning about the patient's status and unexpected information to the mobile phones of medical professionals, family members, or friends of the patient.

Doctors may therefore continuously monitor and diagnose the patient's state and may recommend prior safeguards for the patients themselves. This will also alert family members to the need to care for the sufferer as soon as possible [8].

Overview of Proposed Work

A heartbeat sensor is a monitoring gadget that allows one to detect his or her heart rate in real time while also recording the patient's heart rate and breath rate. The heartbeat sensor and thermistor were linked to monitor the patient's status and collect real-time health data. These numbers are then compared to conventional threshold levels to determine whether or not the patient is in normal condition. Microcontrollers and sensors are used to continuously monitor the patient's health parameters.

In the event of an emergency, an alarm is sent to the doctor's mobile phone in the form of an SMS alert via GSM modem, indicating the doctor's requirement for an immediate visit.

Block Diagram of Proposed System

This suggested system can be readily interfaced with a computer since it is controlled by an Arduino board and a microcontroller chip. If the analogue signal from the heartbeat sensor climbs above the midpoint or falls below the midway, Arduino registers this and transmits the signal to the GSM module, as illustrated in Figure 1.

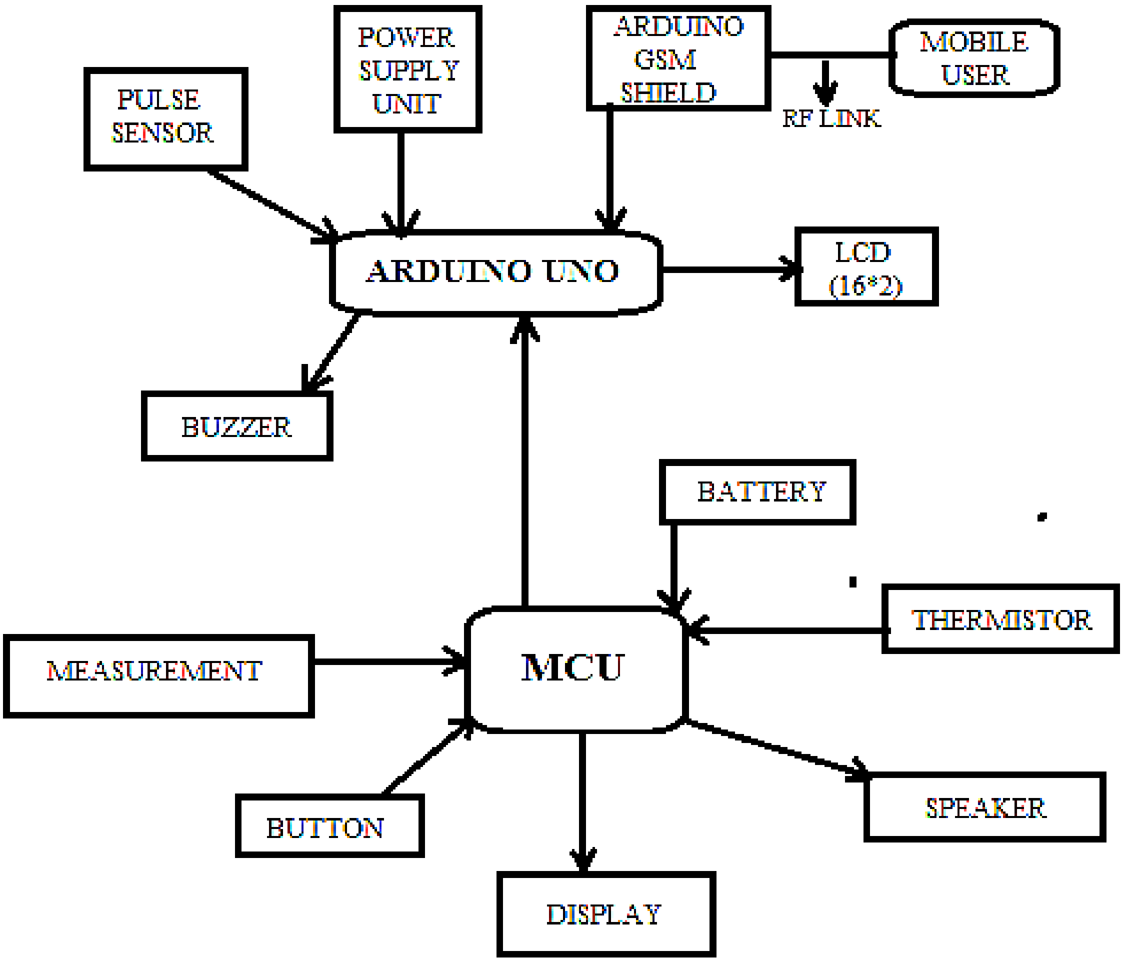

Figure 1: Block diagram

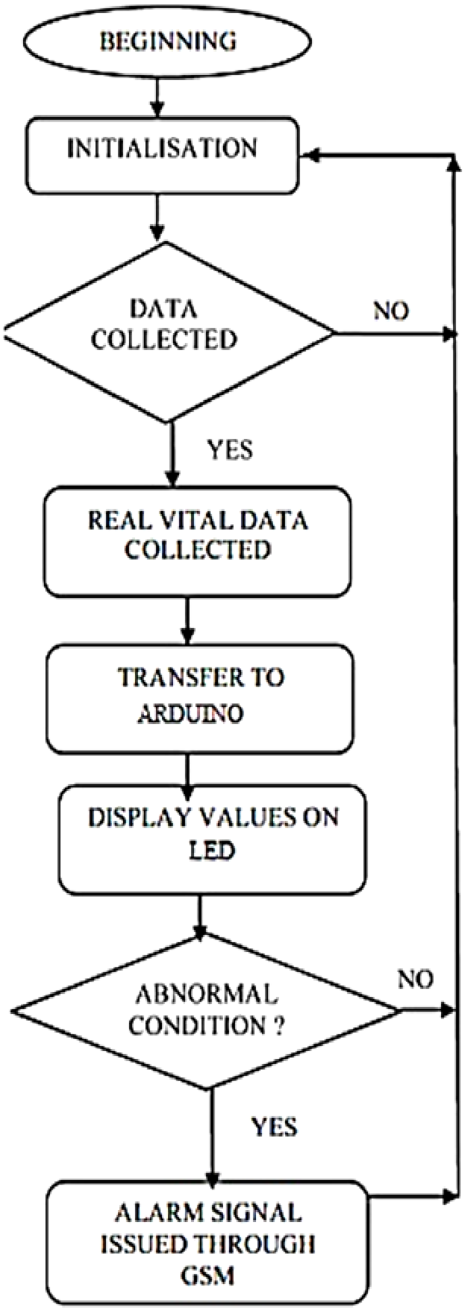

Figure 2: Flowchart for monitoring unit.

This chapter provides insights into the structure of the proposed scheme and discusses the key building blocks as well as the connectivity links of the system components. The suggested system primarily seeks to encompass an end-to-end smart health monitoring system that can easily assess the patient's cardiac rate and breath rate. Figure 2 depicts the operation of the suggested model.

IMPLEMENTATION METHODOLOGY

The designing part includes basically two sections as follows:

Hardware Used

Thermistor Amplification

During testing, we noticed that a human breathing on the thermistor caused a 10mV voltage shift. To detect a "breath" using the microcontroller, we increased this shift with an operational amplifier and a high pass filter. We chose 22 seconds as the time constant for our high pass filter, so that our operational amplifier will enhance breathing with a period shorter than 22 seconds. The difference in respiration after amplification was in the 0V range.

Capacitor Charger

The above-mentioned thermistor amplification circuit has a time limit of 22 seconds, implying that charging by the capacitor takes several minutes. Because the condenser is not fully charged, the device does not function properly throughout this charging period. A lower resistor has been added to another circuit to make the time constant for charging faster in order to lessen this charging time. When PortB4 and PortB5 are set to 5V and 0V, respectively, the capacitor begins charging through R6 (see software design for more information). R5 and R6 are both 330 in order to offer the least amount of strength. The charging time constant is thus 0.73 seconds, and the total charging time is around 6 seconds. R5 must safeguard PortB4 so that it is not affected.

Battery Monitor

We use a voltage divider and a low pass filter to measure the voltage of the 9-V battery. The voltage divider is used to convert the voltage range from 0-9 V to 0-5 V in order to protect the microcontroller pins. The low pass filter's goal is to remove any high frequency signals that may occur. The filter's time constant is 1s, and the voltage divider's resistance values are

Microcontroller

The microcontroller receives the digital signal from the Analog Comparator. Microcontrollers dynamically determine the breathing rate by counting the number of 1s and 0s during a specific time period. The Arduino was connected to the LCD using preset libraries, and the breathing rate is now shown on the LCD in terms of breaths per minute (BPM).

Arduino UNO Board

The Arduino Uno is a microcontroller board based on the ATmega328. It contains 14 digital input/output pins (including 6 for PWM outputs), 6 analogue inputs, a ceramic resonator operating at 16 MHz, a USB connection, an energy jack, an ICSP header, and a reset button. It comes with everything you need to help the microcontroller and can be connected to a USB cable laptop or powered to get started with an AC-to-DC adapter or battery.

The Arduino GSM Shield/Module

Using the wireless GPRS network, the Arduino GSM Shield allows an Arduino board to connect to the internet, make/receive phone calls, and send/receive SMS messages. There are several ways to interact with the shield using the GSM library. As with all Arduino platforms, every component of the platform–hardware, software, and documentation–is publicly accessible and open-source. As a result, the computer or microprocessor/microcontroller-based system is easily interfaced. To interact with the cellular network, the panel requires a SIM card from a network provider. The GSM shield is solely capable of transmitting data. Only 2 G data enables GPRS and SMS. Because data transport is based on GSM technology, it is not compatible with 3G or UMPS. It is not suggested to power an Arduino and the GSM shield over a USB connection since USB cannot give the sufficient current while the modern is in high usage.

The Pulse Sensor Unit

A heartbeat sensor is a monitoring gadget that measures one's heart rate in real time or records it for subsequent analysis. It provides a simple approach to investigate the core's function. The pulse sensor module has a light that aids in measuring the pulse rate. When we place our finger on the pulse sensor, the reflected light in the capillary blood vessels changes depending on the amount of blood.

During a heartbeat, the volume of the capillary blood capillaries expands significantly. This affects light reflection, and the light reflected at the time of a heartbeat will be less than at the time when there is no heartbeat (the volume inside the capillary ships will be lower during the moment when there is no heartbeat or the time interval between heartbeats, resulting in greater reflection of light). This variation in light transmission and reflection may be obtained as a pulse from the pulse sensor output. This pulse can then be set as a heartbeat count after being conditioned to evaluate heartbeat.

LCD Display Unit

LCD modules that display characters such as letters and numbers are the cheapest and easiest to use of all LCDs. They are available in a variety of sizes, which are determined by the number of rows and columns of characters they can show. Any LCD having an HD44780- or KS0066-compatible interface is Arduino-compatible. A 16x2 LCD display is a basic electronic module that is found in a variety of products and circuits. These modules are favoured over seven-segment and other multi-segment LEDs because they are less expensive and easier to programme. This LCD module has no restrictions on displaying unusual and even bespoke characters, animations, and so on. A16x2 LCD means that 16 characters may be shown per row.

There are two such lines. In this LCD, each character is shown in a 5x7 pixel matrix. This LCD has two registers: command and data. The register command saves the command instructions sent to the LCD. A command is a series of instructions sent to an LCD to do a specific task, such as initializing it, clearing its screen, establishing the location of the pointer, controlling the display, and so on. The information that will be shown on the LCD will be stored in the data register. The data is the ASCII value of the character to be shown on the LCD [9].

Software Used

The Atmega 1284p microcontroller was programmed in 15.2.0 utilising an integrated development environment (IDE) platform and the c programming language. This IDE is a software application that provides computer programmers with a comprehensive software development environment. The device passes through a number of circumstances in the main execution loop to determine whether a certain job needs to be called. Because the thermistor and sampling activities are both scheduled, the counter is reset and the press is executed if either timer count equals 0. The thermistor sampling procedure is called every second, whereas the battery sampling process is called every minute. When the "measure flag" indicates that a measurement is ready to be taken, the measurement task is called. Finally, the display task is activated when the user holds down the show button.

To recognize breathing, the absolute value of the difference between two subsequent Analog to Digital Converter samples is gathered. If this difference is less than or equal to 8, "no breath" is considered. If the difference exceeds the tolerance, the counter variable "no breath" is reset to zero, and the modulated pulse-width (PWM) signal is turned off. The tolerance for the disparity between breaths was determined through experimentation.

Because repeated samples may fall outside the tolerance range depending on how an individual is breathing, a counter is used to track the number of "no breaths" observed. After five "no breaths," the alarm goes off. Similarly, to detect a low battery, if the battery sample is less than or equal to the tolerance, a PWM signal is created, turned on for around 1 second, and then turned off. The PWM channel that generates a low-battery warning tone has a greater pre-scalar than the PWM channel that generates an alert when a patient is not breathing; hence the low-battery tone is lower in pitch. The respiration rate is estimated by comparing the times when the voltage across the thermistor passes the reference voltage. This is done in an interrupt service procedure. (ISR) that counts the number of clock cycles between two reference voltage intersections. The "measure flag" is then set, and the measure job is launched. An average difference in clock cycles is computed in the measurement assignment by taking a weighted average of the freshly measured difference and the preceding average difference. The weights of the previous average are 0.75, while the weights of the new distinction are 0.25. This weighted average is used to compute the average rate of respiration. This average difference is subsequently converted into breaths per minute in the clock's cycles. The screen assignment displaying this estimated value was taken from a previously created function library for this LCD.

The input pulse for the op-amp (LM358) series is made up of two independent, high-gain, internal frequency adjusted operational amplifiers that were designed to operate across a wide range of voltages from a single power supply and then pass it on to the microcontroller. The microcontroller contains an inbuilt timer/counter that counts all incoming pulses from the external module, calculates BPM (beats per minute), and displays the result on the LCD display. After starting the sensor device, the fingertip will be detected for 15 seconds, the pulse from the op amp circuit will be tallied using the microcontroller timer, and the final result will be shown on the LCD exhibiting status depending on the count value.

Application

It provides continuous monitoring of the patient's heartbeat over long periods of time until an uncommon scenario is detected, allowing crucial situations to be overcome. This surveillance technology provides long-term surveillance capabilities to hospital staff while reducing their effort. The integrated circuit may be offered to rural clinics and hospitals where capital investment is minimal and cardiac monitors cannot be installed or made accessible for each patient, allowing for the rapid replacement of low-cost and portable breathing monitors. The clinics may then utilize these monitors on their own or rent them out to bedridden patients in remote communities, and the physicians can be informed by the message if a patient becomes ill in the future. As a result, the primary purpose of this study is to create a patient health monitoring system that will inform hospital staff so that patients may receive timely care.

Advantages

The following are the benefits of the suggested technique:

Easy and Reliable for Doctors

In a hospital, either a nurse or a doctor must physically move one person for a health check to another, who may not be able to monitor their circumstances on an ongoing basis. As a result, any serious problems cannot be easily identified unless the nurse or doctor evaluates the person's health at the moment. This can be stressful for doctors who must care for a large number of patients in the hospital.

Increase Effectiveness

The number of nurses required to perform an ICU patient check might be greatly reduced.

More Accurate

There is also less danger of human mistake when examining certain health criteria, and the information may be updated on a regular basis.

CONCLUSION

We successfully created and demonstrated a portable heartbeat and respiratory measurement machine that can assist a person in monitoring his or her personal health. Cardiovascular illnesses can be minimized as a result. This technology has numerous advantages, including being small, precise, and consuming very little power. Future improvements are possible, but the system's cost may rise. This gadget has the benefit of being easy to use by anybody who is not an expert and of measuring the pulse and respiratory rate.

This transportable gadget may transmit a warning signal whenever a patient stops breathing.

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