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REMOTE MONITORING OF HEART BEAT AND BODY TEMPERATURE OF A PERSON USING PPG AND GSM

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ABSTRACT

The need of doctor is very essential for proper patient care. But he may not be present in every place to provide treatment immediately. So the right solution is the remote monitoring of patient's health. The major problem in remote monitoring is the unavailability of proper internet connection in remote areas. So this made us to use a GSM module for our project as the telecommunication network is spread globally. This system monitors physical parameters like heart beat, body temperature and sends the measured values directly to a doctor through an SMS. The system has been realized using software modules and later through hardware circuit. Our project utilizes the system hardware consisting of a heartbeat sensor, microcontroller interface circuit and a GSM MODEM. Also, the design for the software has been presented through the use of GSM AT commands. This system uses the AT89C52 microcontroller unit with rich internal resources to meet the necessities of the system for handy operation. Our device can even measure heartbeat ranging from a baby to an adult. The low cost of the device will help us to provide suitable home based effective monitoring system.

Keywords: photoplethysmography, cardiovasculardiseases, heart rate sensing, AT89C52, optical technology, GSM

1. INTRODUCTION

Optical health monitoring sensors incorporated into the medical field can be operated by portable systems to provide early detection of heart abnormalitiesin order to overcome some common problems. Recently there is a great development in the medical fields which gave rise to a new method to overcome our problems using wireless communications. Also the physiological sensing opens the way for miniature, low power and intelligent heartbeat monitoring devices. Heartbeat and body temperature are two important parameters to be considered in order to assess a persons' health condition. Heartbeat measurement will show the condition of the heart. Heart rate will differ according to age, person's physical and mental condition. Human heart rate for a healthy adult is around [60 -100] bpm (beats per minute). While for an athlete, it is lower because they do a lot of exercises which maintains good blood flow throughout their body. Their heart doesn't require to pump blood with great effort. For a baby, on the other hand, the heart rate is relatively higher which is around [119-161] bpm and for children it is around [74 - 111] bpm. Abnormal heart rate such as lower than the normal is called 'Bradycardia'. Whereas a higher heart rate is called 'Tachycardia'. The general way of heart rate measuring is by putting our finger on the pulsing artery and counting the pulses within a minute (60 seconds). This way is quite easy but inaccurate particularly when the artery pulse state is high. The most precise method to measure heart rate is by using an electrocardiogram (ECG), but this equipment is very expensive and could not be afforded by common people.

Why to use "PPG"?

Photoplethysmography (PPG) helps in the detection of blood levels by a time-resolved study of the absorbed or reflected optical infrared light. Prior methods of heartbeat detection used Electrocardiogram (ECG) signal which is acquired from various parts of the body and then observed. This process of detection needs a medical executive to identify the heartbeat and moreover the device is very expensive such that it could not be afforded by normal people. Also, the patient is required to visit the hospital for checking. Our proposed method of PPG makes use of optical technology which makes it an efficient, user-friendly and handy device.

2. SENSORS OVERVIEW

Heartbeat sensor

The infrared sensor is a typical light sensing module which detects the intensity of light and also the difference between differentcolors. An infrared reflective sensor consists of an emitter (Light emitting diode) and a receiver (Photodiode). When a reflective surface (usually white) ispresentunderneath the IR LED, the rays are reflected and are detected by the receiver (refer Figure-1 (a)). While in the case ofablack surface, the light gets totally absorbed and hencethe receiver does not get any rays. In our project, this reflective nature of the infrared rays has been used to detect the flow of blood through the blood vessels. Haemoglobin molecules present in the blood absorbs the infrared rays and reflects a small amount of light. The heartbeat is measured by placing our fingertip above the IR- sensor part. Depending up on the expansion and the contraction of the heart, the volume of blood through the finger changes and in turn the received infrared light varies.

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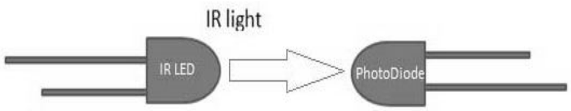

Figure-1 (a). IR Detection (direct).

The IR LED transmits the light in a straight line. A photodiode placed in its path can detect the amount of light falling on it and produces the proportional current out of it.

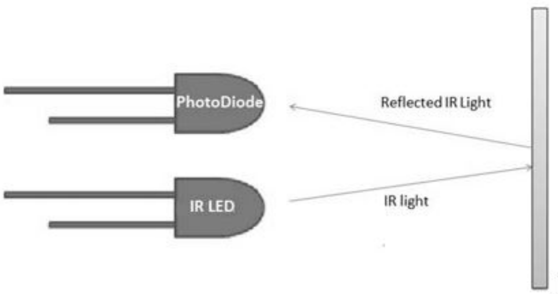

Figure-1 (b). IR Detection on reflection.

The strength of reflected light entirely depends on the blood volume flowing inside the blood vessels of our fingertip. In this way, depending up on the heartbeat, the measured reflected infrared light changes marginally. This could be significantly detected by the photodiode placed next to it.

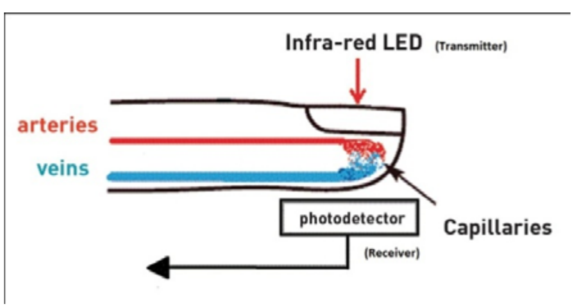

Figure-2. Designed PPG sensor.

The sensor is designed in such a way to identify even a small change in the amount of blood through the blood vessels in the finger. For this, a potentiometer is used in order to regulate the sensitivity of the photodiode. The detected signal consists of an AC component along with a high frequency DC component. The AC component is due to the variation of blood levels proportional to the heartbeat and the DC component is due to the tissues present in the skin. Our intention is to extract this AC component, for which the signal has been passed through a signal conditioning stage.

Temperature sensor (Thermistor)

This is a type of resistor which has a negative temperature coefficient (NTC) where the resistance increases with a decrease in the temperature. A voltage has been applied across the terminals of the circuit shown below and the output is seen across the Thermistor. As the temperature changes, the resistance changes and in turn the output voltage changes. This voltage is sent to the microcontroller for further processing.

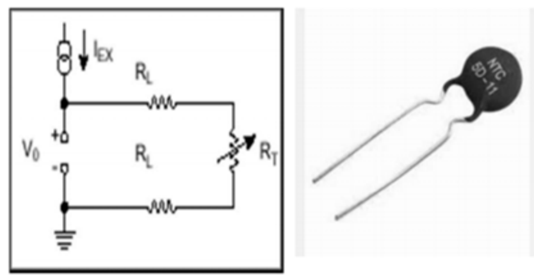

Figure-3. Thermistor.

3. SYSTEM IMPLEMENTATION

The block diagram of the entire system is shown below. An additional feature has been employed in the circuit which is the emergency button. Whenever a person is in a need of immediate health assistance, pressing the button for 2-3 seconds activates a buzzer and also sends a message to a stored mobile number. The emergency button is made touch sensitive for easy use.

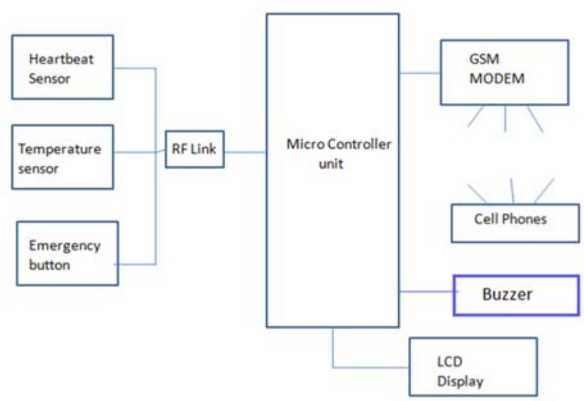

Figure-4. Block diagram.

The system consists of heartbeat sensor, temperature sensor and a button. The heartbeat sensor is designed using PPG technique along with some additional signal conditioning circuitry. The output of the photodiode is too weak to identify by the microcontroller and so it needs to be amplified before sending to the microcontroller. The amplification is done using an operational amplifier LM 324 which is a quad opamp. The signal is first sent through a two stage low pass filter circuit in order to remove the high frequency DC

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component and then amplified. A comparator is used in the next stage where in the amplified signal is compared with a threshold voltage level in order to produce a train of pulses at the output corresponding to the AC variation in the signal.Each Stage Gain = 1 + (R_f *C_f) where R_f=feedback resistor, C_f=feedback capacitor. The output of this signal conditioning circuit, the Thermistor and the button are send to the microcontroller through an RF Link. This RF link has been utilized to send the data to the main circuit wirelessly. This makes the device even portable as there will be no need of carrying the circuit everywhere. The RF link has got a range of 200meters. The circuit could be placed in our home or in the hospital wherever needed and only the sensor can be attached to the person. The data from the sensors is continuously sent to the microcontroller through the RF link.

The microcontroller used in our project is AT89c52.AT89c52 micro-controller is an Atmel's family micro-controller which has got 8KB of flash memory and an EPROM (electrically programmable read only memory) and 128 bytes of on chip RAM. It is a 24 MHz fully static CMOS controller. It is having 32 I/O pins with 3 timers a 3-Level Program Memory Lock.

Upon receiving the data from the sensors, the microcontroller starts the processing part. The normal values of heartbeat (60-100) bpm and the body temperature (36.7ºC) are set in the microcontroller. These electrical signals are converted to digital using Analog to Digital Convertor (ADC). The microcontroller takes inputs from ADC and processes the information. Whenever the received values from the sensors exceed the preset values, a buzzer will be activated and immediately a message is sent to the stored mobiles numbers using the GSM modem (SIM 900). Also the Liquid Crystal Display (LCD) shows the pulse beats and body temperature.

AT89C52:

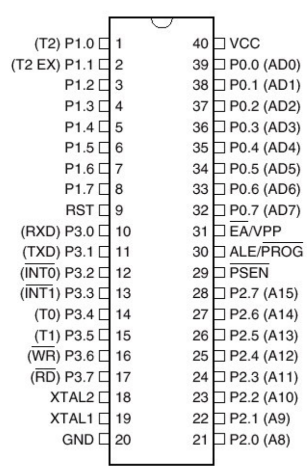

Figure-5. Pin Diagram for AT89C52.

Software implementation

The measurement of heart beat and the body temperature is primarily implemented using National Instruments' software package named LabVIEW (Laboratory virtual Instrument Environment Workshop) along with a Data Acquisition device (DAQ). The DAQ helps in acquiring real time signals and processing through software modules. This implementation consists of mainly three stages. They are: 1.) Data Acquiring 2.) Data Processing 3.) Data Representation.

The first stage comprises of signal acquiring into the computer through the DAQ and threshold detection. As mentioned previously, the output of the heartbeat sensor is a train of pulses and in order to count the number of pulses our heart is producing in a minute, a virtual instrument (VI) has been constructed that can detect the pulse amplitude. The output of the sensor is acquired through the analog pin of the DAQ. A threshold voltage level is considered for comparing the amplitude of the input pulse acquired. Logic '1' is produced when the input amplitude exceeds the threshold and logic '0' is produced when it is less than the threshold.

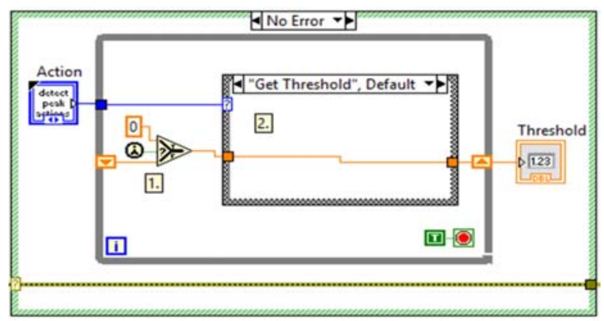

Figure-6. VI for threshold detection.

The next stage includes the counting of pulses based on the logic produced in the previous stage. The pulses are considered for every 15 seconds and the number of one's or zero's obtained are counted. This value is multiplied by '4' to get the pulses produced per minute. A loop has been constructed for continuous input acquisition.

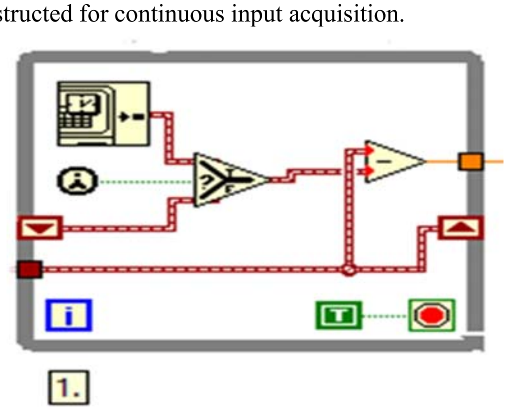

Figure-7. VI for BPM count.

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The last stage includes data presenting which displays the graphical as well as the digital information of the heartbeat on the screen. A signal simulator and the graphical palette are used in the LabVIEW to get the final output display. The VI for data presenting is shown below.

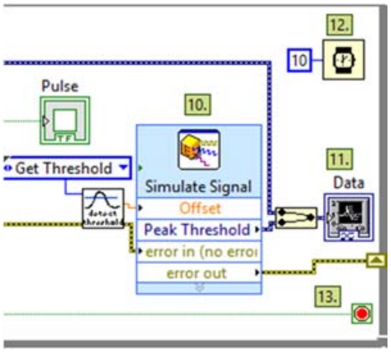

Figure-8. VI for data presentation.

Hardware implementation

After successful implementation through the software package, the circuit is now constructed using the AT89c52 microcontroller as mentioned earlier. The circuit consists of the sensors, microcontroller unit, LCD display, Buzzer and a GSM modem. The microcontroller is programmed using Keil uvision 4. The source code has been written in assembly language. The normal values of heartbeat and temperature are stored in the microcontroller. The output of the sensors is acquired by the microcontroller through the RF link into the Analog to Digital converter (ADC). Here, the obtained analog amplitude of the signal is converted into digital data. The corresponding Hexa decimal values of the input are compared with the preset normal values. Any abnormality will be immediately detected and this will activate the GSM Modem. The interfacing of the GSM modem to the microcontroller is done using MAX 232 IC. This converts the signal from a serial port to signal compatible to the TTL digital logic circuits. The modem used here is SIM 900. Using the AT commands, the GSM modem is programmed to send messages to the stored mobile numbers.

Figure-9. Circuit designed.

Also the LCD display shows the values of the parameters. The pulses are counted by acquiring the input from ADC for every 15 seconds and then multiplying by '4' to get the count for 1 minute. The temperature is measured using a Thermistor. A particular voltage value is applied for the Thermistor and the output is seen across it. As the temperature changes, the load or the resistance changes. This will bring a change in the output voltage. This value is converted in to the temperature by making use of the Steinhart-Hart thermistor third-order approximation and displayed on the LCD screen.

Figure-10. LCD display used.

Parameters considered

Power supply

This designeddeivce works with a 5V battery in view of its smallpackaging being used. Maximum power consumption of thisdevice is 0.7Watts.

Robustness

This gadget operates in an extensive variety of temperature environment rangng from [0^0C to 710^0C]. Thisdevices' bundling has been made to withstand extreme utilization.

Operating speed of the device

Our device is designed upon an embedded platform where a real time signal is acquired and then interfaced with a digital controller board for processing. This makes the speed of operation of the device increase and monitoring very effective.This gives accurate result to the user even under critical conditions.

Fidelity

The circuit we have designed can be operated at different temperatures and can be usedon a long run. It has also got variable sensitivity (Potentiometer) by which we can modify the output signal based on the atmospheric conditions and as per our requirements.

4. WIRELESS LINKS USED

RF Link

The RF Link has been implemented by using the RF 434MHz module consisting of a transmitter and

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receiver. This link has been made in order to isolate the sensors from the main circuit. Making the sensors independent of main circuit makes it so easy to wear the sensors any time. The RF module used is shown below. This module operates at radio frequency. The digital data here is represented in the form of variations in the amplitude of the carrier wave which is termed as Amplitude Shift Keying (ASK). RF transmission is used because signals can travel through longer distances. The RF module sends the serial data through the antenna. As the output of the sensors needs to be sent simultaneously, the parallel data is first encoded into serial data using the Encoder IC – HT12E.

The encoder converts 12 bit parallel data (8 bit address+4bit data) into serial data. Upon enabling the transmission enable (TE) pin of the IC, the serial data is sent to the receiver. The receiver module receives the serial data transmitted and sends it to the Decoder IC HT-12D. The decoder converts the serial data to parallel data bits. This parallel data is latched onto one of the ports of the microcontroller.

GSM

A GSM modem is a dedicated modem device with serial connection, which accepts a SIM card and operates over a subscription. Basically, in our project, we used the GSM module to send SMS to the phone. GSM module is used to get the connection between a computer or a controller board and a mobile phone. It can be generally used to send and receive messages. It can be used to enable the higher data transmission rate.

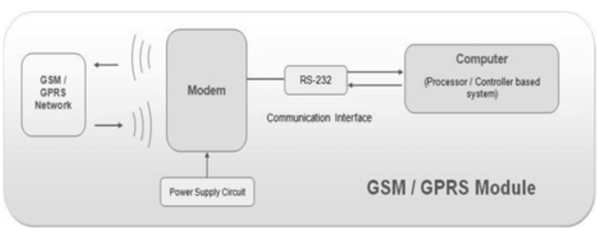

Figure-11. GSM Module.

These wireless MODEMS are the devices which will generate the data from the mobile network for the network establishment between the mobile system and the computer. These wireless modems use the serial communications with the help of the AT commands which can be used to send the information to the system.

It requires a SIM (Subscriber Identity Module) card just like a mobile phone which can activate communication with some network. It also has an IMEI (International Mobile Equipment Identity) number which defers from mobile to mobile. So it can be used for unique mobile identification. The following are the tasks it can do:

a) Receive, send or delete SMS message in a SIM
b) Read, add, search phonebook entries of the SIM
c) Make, Receive, or reject a voice call.

The MODEM needs AT commands for interacting with the microcontroller, which can be communicated through serial communication.

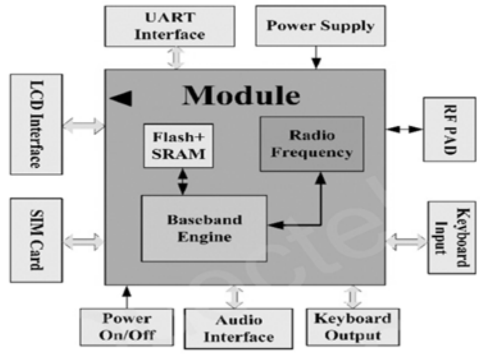

Figure-12. GSM block diagram.

5. RESULTS

This circuit has been observed on various platforms. An initial simulation is done using NI-LabVIEW software package.

a) Simulation results (NI-LabVIEW)**:**

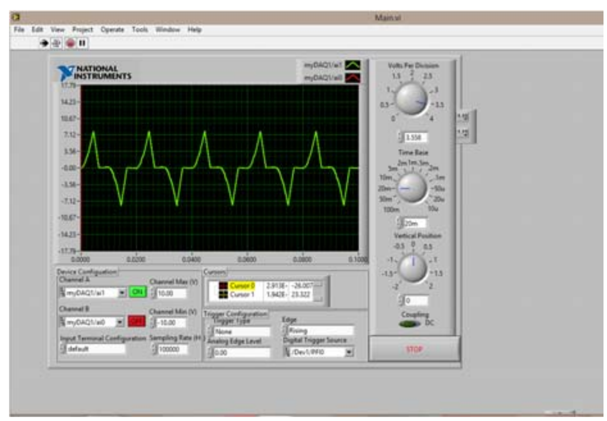

Figure-13. Initial sensor output.

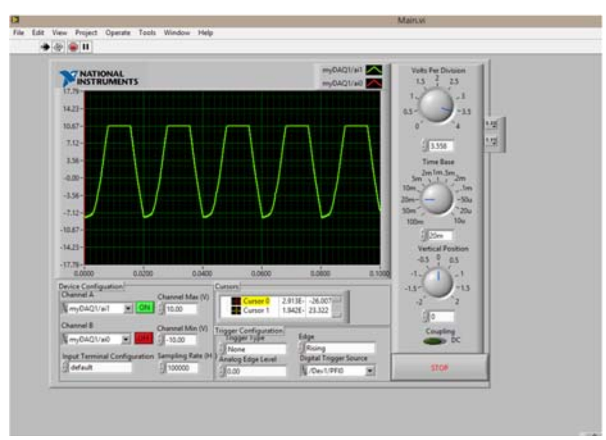

Figure-14. Output of the comparator.

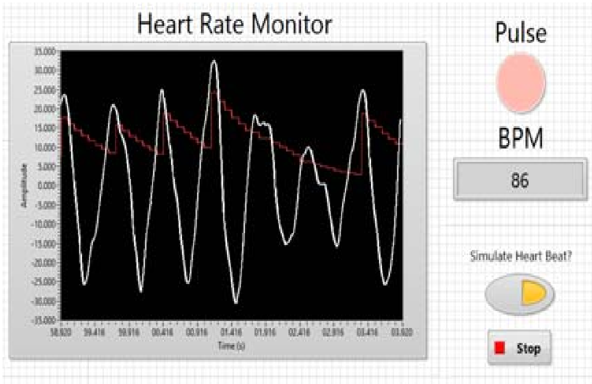

Figure-15. Waveform and pulse rate after last stage of processing.

b) Hardware results

Figure-16. Output of the microcontroller.

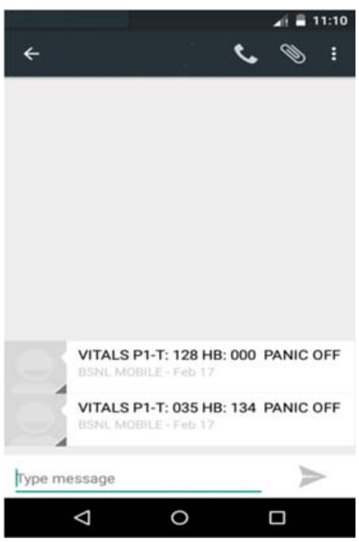

Figure-17. SMS received by the mobile phone.

The message from the GSM modem is received upon encountering vital conditions.

6. CONCLUSION AND FUTURE SCOPE

A portabledevice which can monitor the heartbeat and body temperature of a person has been successfully designed an tested. The current status of the project needs to be improved such that we can handle a huge amount of data from a wide variety of people and senditto a nearby hospital for providing immediate health assistance. It is noteworthy that the initiative of our work is to show the opportunity of having a valuable andeconomical solution for health assistance, utilizing the existing systems in telecommunications filed at the area of interest and the use of efficient software tools for the development of applications needed.Further improvement in this project can be made by developing a software application which can replace the controlling part of the main circuit. This may include the usage of Android SDKtool kit for developing the application.We are looking forward to advancing our project so that it reachsevery person in the society and help them in the greatest way possible.The concluding model of the system by ourselves was optimistic and also got encouraged endlessly for its development and was implemented in a sensible manner. Also, the use of LabVIEW made us study the rel time signal very effectively and quickly.

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