HEART BEAT MONITORING SYSTEM USING HEART RATE SENSOR (PIC)

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Abstract

This heart beat monitoring system using heart rate sensor(PIC) is designed to measure heart beat (pulse count), by using embedded technology. It can measure and monitor the patient's condition. This describes the design of a simple, low-cost controller based wireless patient monitoring system. Heart rate of the patient is measured from the thumb finger using IRD (Infra-Red Device sensor. The heart rate can be measured by monitoring one's pulse using specialized medical devices such as an electrocardiograph (ECG), portable device. E.g. The patient heart beat monitoring systems is one of the major wrist strap watch, or any other commercial heart rate monitors which normally consisting of a chest strap with electrodes.

Keywords: *Microcontroller, heart rate, patient, sensor*

I. Introduction

This heart beat monitoring is useful in medical applications and offers less cost and size than ECG (Electro cardiogram). In the case of emergency, for people who are suffering with heart diseases continuous monitoring of the patient are required which is sometimes not possible in the hospital or the patient location is far away from the hospital. In such case this prototype circuit is useful to measure the heart rate and the information is transmitted to the medical advisory for the preliminary precautions so that patient can be under control. The market leader is the Finnish company 'Polar Electro OY'. Their heart rate monitoring system consists of a belt worn around the chest and a receiving unit [1].One for getting and processing ECG which is implemented[2].There are several cardiological condition in which it is desirable to monitor critical reflexs and responses from a free swimming patients through water of an acoustic signals representing in electrocardiogram[3].

II. Photoplethysmography

Photoplethysmography (PPG) is an uncomplicated and inexpensive optical measurement method that is often used for heart rate monitoring purposes. PPG is a non-invasive technology that uses a light source and a photodetector at the surface of skin to measure thevolumetric variations of blood circulation.Photoplethysmography is the process of optically estimating the volumetric measurement of an organ. Pulse oximetry, cardiovascular monitoring, heart rate monitoring etc. are few common applications of photoplethysmography. Let us have a look at the application of photoplethysmography in heart rate monitoring from the fingertip. When the heart expands (diastole) the volume of blood inside the fingertip increases and when the heart contracts(systole) the volume of blood inside the fingertip decreases. The resultant pulsing of blood volume inside the fingertip is directly proportional to the heart rate and if you could somehow count the number of pulses in one minute, that's the heart rate in beats per minute (bpm). For this an IR transmitter/receiver pair placed in close contact with the fingertip. When the heart beats, the volume of blood cells under the sensor increases and this reflects more IRwaves to sensor and when there is no beat the intensity of the reflected

beam decreases.

III. Working Principle

The system majorly consists of three components like heart rate sensor circuit, GSM modem and MCU.[Fig.1] represented let us see the brief explanation of circuitry.

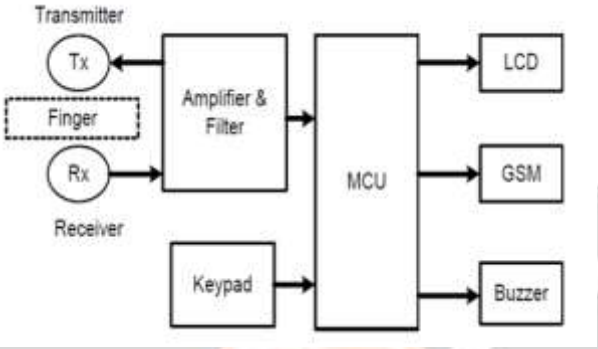

Fig 1: Block Diagram of Real time heart beat monitoring system

3.1. Heart Beat Sensor

The sensor consists of an IR light emitting diode transmitter and an IR photo detector acting as the receiver. The IR light passes through the tissues. Variations in the volume of blood within the finger modulate the amount of light incident on the IR detector. The Heart Beat signal is obtained by LED and LDR combination. Pulses form hands interrupts the light reaching the LDR and this signal is read by microcontroller, The RF signal is transmitted by transmitter in a digital format. This circuit uses Manchester encoding to avoid a long trail of one or zero. The protocol is well defined for different device types ensuring compatibility with your whole entertainment system 5-bit address and 6-bit command length.

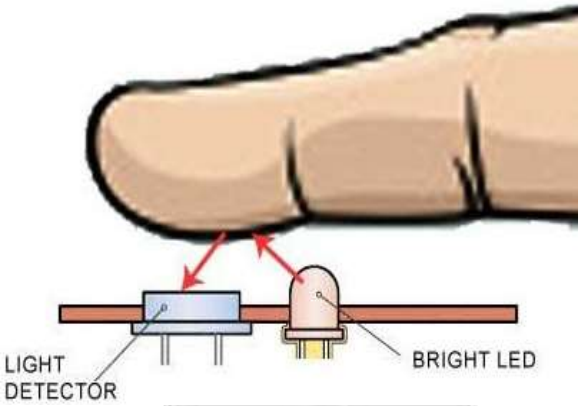

Fig .2 Pulse sensor with LED indicator

3.2. GPS Receiver System

This is a high gain GPS Receiver (5V Serial) with 4pin. Receiver is made with third generation POT (Patch Antenna on Top) GPS module. The built in 3V to 5V level convertor enable us to interface with normal 5V Microcontrollers. The 4 Pins are 5V, TX, RX, and GND. Yes, there is no setting required, just plug in to the power (5v), your data (NMEA 0183) is ready at TX pin. This is a standalone 5V GPS Module and requires no external components.[Fig.2]represented it is built with internal RTC back up battery. It can be directly connected to Microcontroller's UART. With the use high gain GPS engine providing a solution that high position and speed accuracy performances as well as high sensitivity and tracking capabilities in urban conditions & provides standard NMEA0183 strings in "raw" mode for any microcontroller. The module provides current time, date, latitude, longitude, speed, altitude and travel.

3.3. Heart rate monitoring

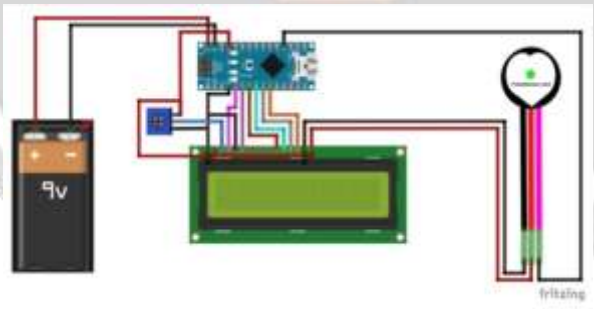

Fig.3:Heart Rate Monitoring Circuit

Signal conditioning may vary in complexity from a simple resistance network or impedance matching device to multi-stage amplifiers and other complex electronic circuits. Signal conditioning usually include functions such as amplification, filtering shown in [Fig 3]

Conversion or signal transmission circuitry. They help in increasing the sensitivity of instruments by amplification of the original signal or its transuded form. The buffer amplifier, which is usually an instrumentation amplifier, is proposed in this paper which provides impedance buffering, signal gain and common mode rejection. It has high input impedance, 100Mohms or more to reduce the effects of any signal distortion.

3.4. IR Sensor

The infrared sensor is responsible for sending infrared light to the body.The sensor consists of an IR light emitting

diode transmitter and an IR photo detector acting as the receiver. The IR light passes through the tissues. Variations in the volume of blood within the finger modulate the amount of light incident on the IR detector. IR transmitter and receiver placed on the same plane and the finger functioned as a reflector of the incident light. The IR receiver monitors the reflected signal. Here, an infrared LED (OPB100EZ) and phototransistor (OPB100SZ) is used as sensordevice.

3.5 . Amplifier and Filter Design

Filtering process is required to remove the undesirable noises. The weak nature of the IR signal and the noise affecting on it, requires the implementation of a range of filters and differential amplifiers. The signal conditioning circuit consists of two identical active low pass filters with a cut-off frequencyofabout2.5Hz. Cut OffFrequency =1/2πRfCf = 1/2×3.1416×68K×1uF=2.34 Hz; where,
Rf=R1=R4=68KΩ and Cf=C1 =C3=1μf. This indicates that the maximum measurable heart rate is about 150 bpm. The gain of each filter stage is set to 11, giving the total amplification of about 121. Gain of each stage=1+Rt/Ri=1+ 680KΩ/ 68KΩ=11; where, Rt=R2=R5=680KΩ andRi=R3=R6=68KΩ. A 1 uF capacitor at the input of each stage is used to block the dc component in the signal. The equations for calculating gain and cutoff frequency of the active low pass filter. The two-stage amplifier/filter provides sufficient gain to boost the weak signal which is 3-4 mV and coming from the IR sensor unit, and convert it into a pulse.

3.6. ECG Sensor

The market leader is the Finnish company 'Polar Electro OY'. Their heart rate monitoring system consists of a belt worn around the chest and a receiving unit [1].One for getting and processing ECG which is implemented[2].There are several cardiological condition in which it is desirable to monitor critical reflexs and responses from a free swimming patients through water of an acoustic signals representing in electrocardiogram[3].

3.7. Microcontrollers

Microprocessors and microcontrollers are widely used in embedded systems products. *Microcontroller is a programmable device*. A microcontroller has a CPU in addition to a fixed amount of RAM, ROM, I/O ports and a timer embedded all on a single chip. The fixed amount of on-chip ROM, RAM and number of I/O ports in microcontrollers makes them ideal for many applications in which cost and space are critical.

The Intel 8051 is Harvard architecture, single chip microcontroller (μC) which was developed by Intel in 1980 for use in embedded systems.

8051 is an 8-bit processor, meaning that the CPU can work on only 8 bits of data at a time. Data larger than 8 bits has to be broken into 8-bit pieces to be processed by the CPU. 8051 is available in different memory types such as UV-EPROM, Flash and NV-RAM. The present project is implemented on Keil vision. In order to program the device, Preload tool has been used to burn the program onto the microcontroller. The AT89s52 is a low-voltage, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable memory. The device is manufactured using Atmel's high density nonvolatile memory technology and is compatible with the industry-standard MCS-51 instruction set. The on-chip flash allows the program memory to be reprogrammed in system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89s52 is a powerful microcomputer, which provides a highly flexible and cost-effective solution to many embedded control applications.Instrument Science and Technology plays a significant role in the field of information Science[4].

The results of the heartbeat.

Test conducted to subjects	Heart Rate Under Normal Condition	Heart rate after walking Up & Down the stairs
Shashidhar	78(Normal)	96(High)
Uday	84(Normal)	105(High)
Nikhil	72(Normal)	94(High)
Kalyan	82(Normal)	110(High)
Shashank	75(Normal)	112(High)
Naga kiran	74(Normal)	98(High)
Matheen	78(Normal)	92(High)
Meher	71(Normal)	97(High)
Adithya	70(Normal)	101(High)
Somaraju	55(Low)	120(High)
Lingaiah	57(Low)	118(High)
Sailaja	52(Low)	121(High)
Satyaraju	75(Normal)	115(High)
Shivaiah	60(Low)	113(High)

Fig.4: Table showing the heart rate value of the subjects in different conditions

Heart Rate Value Range:

[Fig .4] represents

1. Normal heart value ranges between 60&70.

2.If the heart rate value is below 60 then it is considered as low heart rate.

3.If the heart rate value is above 90 then it is considered as high heart rate.

A normal resting heart rate for adults range from 60 to 100 beats per minutes .Generally a lower heart rate at rest implies more efficient heart function and better cardio vascular fitness[5].The study assessed the influence of work social support on self monitored heart rate, blood pressure and salivary cortisone recorded.[6].

3.8. LCD Display

The Model JHD 162A Series LCD is the typical standard HD44780 type of LCD with 16characters x 2 row LCD module.Since this project the Heart Rate, temperature, adders and contact no to display; therefore, a LCD module is necessary. Electronioc technology permeats everything it touches and has a wide range of application and in combination with other industrial technology has generated a number of new many new products and expanded into many new markets.[7] shown in Fig.5

Fig.5 LCD Display

3.9. Wireless Monitoring

Monitoring and control is the core of the real- time monitoring system for patient physical states, and it can dispose,display,save, query and analyse the data from each patient. To know the physical states of inpatient, the physical parameters need to be monitored real –time. With the increase in the number senior citizens and chronic diseases, the number of elderly patients who need constant assistance has increased.[8]. One key point of all critical care for elderly patient is the continuous monitoring of their vital signs. The results prove that the mobility, usability and performance of our proposed system have impacts on the user's attitude, and there is a significant positive relation between the user's attitude and the intent to use our proposed system. This proposed system is expected to monitor the electrical activity of heart of the patient under critical care more conveniently and accurately for diagnosing which can be interfaced with PIC 16F877 to bring it under a network system widely for the doctor to monitor the patient's condition sitting in his own office without being physically present near to the patients bed.
Wireless – networked embedded device includes signal conditioning circuitry, sensors and a PIC controller with a wireless Transceiver module. To measure or monitor human movements or activities, a graphical LCD display is selected for its low price, small size, capability of continuous measurement, and ease of integration.

4. Result and Discussion

This project is initiated to alert the family members about patient's heartbeat via SMS. It fulfils the objective to detect and monitor patient's heartbeat rate using PPG technique, interfaced with GSM modem and sends alert to the family or/and medical experts via SMS.

The connection between microcontroller and HyperTerminal is successfully established before the system can be interfaced to the GSM modem. At the moment, ongoing test on sending alert directly from PIC circuit to mobile phone is still carry out to get a stable system[Fig.6] For future development, this project can be properly designed. It can be modified to become very light, portable, smart and elegant. E.g. like a watch or embed with i-POD.The modem is coming with VTTL interface,which allows you to connect directly to 5 Volt microcontroller.[9]

By using the value of heart rate, we also can know the ages, oxygen contents in human body and patient's weight. By using this prototype circuit containing AT89S52 MCU, GSM Modem, LCD and other hardware circuit so that the page messages can be transferred at fixed time intervals to the corresponding medical expert to give necessary precautions to take care about the patient.

Fig.6 Testing Circuit

Application of the Project

The Health care industry is responding to the increasing popularity and availability of technological innovations, such as tablets and Smartphone. Utilizing Smartphone and employing it in the field of health care and medicine is helpful as it simplifies the operation of medical devices to enable lightly trained individuals whether patients or medical practitioners to reliably collect medical data for diagnosis and prognosis. This Phone Accessory Heart Rate Monitor is therefore a part of a greater project that intends to make health monitors used in clinical practices compact and available to the public with straightforwardness to use and no consideration of time or place. Having the data on the phone, it can be used as a health monitor or sent to a physician elsewhere for remote evaluation so the patient can seek advice from his physician without having to book for an appointment.

Program Code:

```
#include <Wire.h>
#include "MAX30105.h"
#include <LiquidCrystal.h>
#include "heartRate.h"
MAX30105 particleSensor;
LiquidCrystal lcd(2, 3, 4, 5, 6, 7);
const byte RATE_SIZE = 4; //Increase this for more
averaging. 4 is good.
byte rates[RATE_SIZE]; //Array of heart rates
byte rateSpot = 0;
long lastBeat = 0; //Time at which the last beat
occurred
float beatsPerMinute;
int beatAvg;
void setup()
{
Serial.begin(9600);
```

```
lcd.begin(16, 2);
Serial.println("Initializing...");
// Initialize sensor
if (!particleSensor.begin(Wire,
I2C_SPEED_FAST)) //Use default I2C port,
400kHz speed
{
Serial.println("MAX30105 was not found. Please
check wiring/power. ");
while (1);
}
Serial.println("Place your index finger on the sensor
with steady pressure.");

particleSensor.setup(); //Configure sensor with
default settings
particleSensor.setPulseAmplitudeRed(0x0A);
//Turn Red LED to low to indicate sensor is running
particleSensor.setPulseAmplitudeGreen(0); //Turn
off Green LED
}
void loop()
{
long irValue = particleSensor.getIR();
if (checkForBeat(irValue) == true)
{
//We sensed a beat!
long delta = millis() - lastBeat;
lastBeat = millis();
beatsPerMinute = 60 / (delta / 1000.0);
if (beatsPerMinute < 255 && beatsPerMinute > 20)
{
rates[rateSpot++] = (byte)beatsPerMinute; //Store
this reading in the array
rateSpot %= RATE_SIZE; //Wrap variable
//Take average of readings
beatAvg = 0;
for (byte x = 0 ; x < RATE_SIZE ; x++)
beatAvg += rates[x];
beatAvg /= RATE_SIZE;
}
}
Serial.print("IR=");
Serial.print(irValue);
Serial.print(", BPM=");
Serial.print(beatsPerMinute);
Serial.print(", Avg BPM=");
Serial.print(beatAvg);
if (irValue < 50000)
Serial.print(" No finger?");
Serial.println();
lcd.setCursor(0,0);
lcd.print("BPM: ");
lcd.print(beatAvg);
lcd.setCursor(0,1);
```

```
lcd.print(" IR: ");
lcd.print(irValue);

}
```

V. Conclusion

The instrument has simple structure stable and reliable operation,high accuracy,low power consumption, good portability full featured function, and extensive application occasion. The real time monitoring system for cardiac patient physical state is based on wireless transceiver module technology.The light from the IR led passes through the finger which is detected by the photodiode the heart rate is estimated using the change in volume of the blood flow through the finger. It can be taken by patient and keep the patient moment intact because it is miniature and portable .The system can monitor and record the physical states and moment parameters real time, and the provide auxiliary means for the correct diagnosis of doctor. With intelligent transceivermodule, the sign of acute disease for patient can be found early, and then the patient can be helped in time, the sudden death of patient can be avoided. The wireless transceiver module technology can be suited for short distance communication, and the transmission distance is limited only about 10 meters, and then It can be suitable for in- patient monitoring. The system is important to be applied to patient care.

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