Heartbeat Monitoring Alert via SMS

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***Abstract*— The heart rate can be measured by monitoring one's pulse using specialized medical devices such as an electrocardiograph (ECG), portable device e.g. wrist strap watch, or any other commercial heart rate monitors which normally consisting of a chest strap with electrodes. Despite of its accuracy, somehow it is costly, involve many clinical settings and patient must be attended by medical experts for continuous monitoring. For a patient whom already diagnosed with fatal heart disease, their heart rate condition has to be monitored continously. This paper proposed an alert system that able to monitor the heart beat rate condition of patient. The heart beat rate is detected using photoplethysmograph (PPG) technique. This signal is processed using PIC16F87 microcontroller to determine the heart beat rate per minute. Then, it sends sms alert to the mobile phone of medical experts or patient's family members, or their relatives via SMS. Thus, doctors can monitor and diagnose the patient's condition continously and could suggest earlier precaution for the patients themselves. This will also alert the family members to quickly attend the patient.**

***Keywords*—heartbeat; photoplethysmograph; SMS; Microcontroller**

I. INTRODUCTION

Cardiovascular disease has shown that heart beat rate plays a key role in the risk of heart attack. Heart disease such as heart attack, coronary heart disease, congestive heart failure, and congenital heart disease is the leading cause of death for men and women in many countries. Most of the time, heart disease problems harm the elderly person. Very frequently, they live with their own and no one willings to monitor them for 24 hours a day.

Indeed, this paper presented a system that being developed which able to monitor and alert the patient's relatives and/ or doctors about the patient's heartbeat conditions. A heartbeat sensor circuits which adopted photoplethysmograph (PPG) technique is designed using MPLAB software. Signals detected are then processed and analysed before sent via sms to alert medical experts or family members. It is beneficial in terms of cost, no complicated settings, save time and even very helpful for patient whom lives alone.

II. BACKGROUND STUDY

A. Heart Beat Rate

When the heart beats, a pressure wave moves out along the arteries at a few meters per seconds (appreciably faster than the blood actually flows). This pressure wave can be felt at the wrist, but it also causes an increase in the blood volume in the tissues, which can be detected by a PPG [1]. Table 1 shows the average heartbeat rate range versus the age of person.

TABLE I AVERAGE HEARTBEAT RATE [2]

AGE	RANGE	AVERAGE RATE
0 – 1 Month	100 – 180	140
2 – 3 Month	110 – 180	145
4 – 12 Month	80 – 180	130
1 – 3 Years	80 – 160	120
4 – 5 Years	80 – 120	100
6 – 8 Years	70 – 115	92.5
9 – 11 Years	60 – 110	85
12 – 16 Years	60 – 110	85
> 16 Years	60 – 100	80

B. Photoplethysmograph

PPG is a simple and low-cost optical technique that can be used to detect blood volume changes in the microvascular bed of tissue. Frequently, it is used non-invasively to make measurements at the skin surface [3]. A PPG is often obtained by using a pulse oximeter which illuminates the skin and measures changes in light absorption [4]. Typically, a PPG tools uses an emitter-receiver pair to determine blood flow. It consists of a matched infrared emitter and photodiode, which transmits changes in infrared reflectance resulting from varying blood flow.

A light emitting diode (LED) is used to transmit light through the skin. The detector, which is positioned on the surface of the skin, can detect the reflection or transmission of waves from various depths and from highly absorbing or weakly absorbing tissues. However, the PPG signals can vary widely, based on a number of factors, including transducer location, ambient temperature, respiration, and subject differences.

C. Previous Work

The authors in [5-7] have adopted PPG techniques in their design. Researchers [5] presented their idea of a device being developed for monitoring the cardiovascular state of the patients. It serves for monitoring the cardiovascular state of the patients. It stores all the recorded physiological signals (ECG, PPG-photopletysmograph) for medical post-processing. They also proposed that relatives or doctors can be informed by an automatically sent SMS if in case of critical values of the measured parameters occurs. However, no further results on this research are disclosed.

A practical system for monitoring heartbeat where it does not use the self–count pulsation of blood or ECG signal is developed in [6]. The output of the sensor is viewed through the numbers of beat count on the counter display using a 7-segment display. The result on the counter display updates its reading for every two seconds. Method for heartbeat is adopted in this project development.

The main objective of system development in [7] is to construct a heart rate monitor by using the wireless transmission to a receiver which displays the heart rate measured in beats per minute. It uses bluetooth technology to communicate the data with a terminal computer. The drawback of this system is the distance between the computer and sensor is not more than 20 meter which seems not practical to be implemented.

III. PROPOSED SYSTEM

A. System Block Diagram

Fig. 1 shows the system block diagram used in designing this project. Hardware development involves design and development of sensor circuit, PIC circuit and MAX232 circuit. PROTEUS 7 is used for simulation, schematic capture, and printed circuit board (PCB) design. The whole program is written and assembled using MPLAB IDE [8]. The program is written based on the PIC16F84A specific instruction in [9].

When finger is placed between LDR and Super-Bright LED at the sensor circuit, the output is detected at pin 7 of OpAmp LM358. PIC16F84 microcontroller is used to perform the signal processing from the sensor circuit. MAX232 connects the microcontroller circuit to GSM modem via RS232 cable. An alert message will be sent to mobile phone by modem.

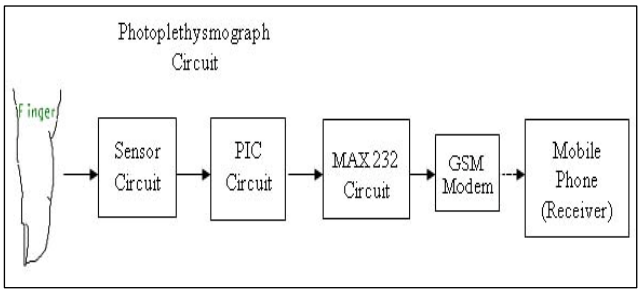

Figure 1. Overall System Block Diagram

B. Heartbeat sensors circuit

Heartbeat is sensed by using a high intensity type LED and LDR. The change in volume caused by the pressure pulse is detected by illuminating the fingertip's skin with the light from an LED using a photodiode sensor. With each heart beat, a surge of blood is forced through the vascular system, expanding the capillaries in the finger, and changing the amount of light returning to the photodetector [4].

Very small changes in reflectivity or in transmittance caused by the varying blood content of human tissue are almost invisible. Valid pulse measurement therefore requires extensive preprocessing of the raw signal. A suitable operational amplifier is needed to amplify the heartbeat signal, due to its very low amplitude compare to the surrounding noise. For this project, LM358 is chosen. A super bright LED is suggested in the circuit as it can also perform well as light sensor. An LDR, whose resistance changes in response to the amount of light shining on it is employed to perform as photodiode sensor. The overall effect is that as illumination increases, the LDR resistance falls.

B. PIC Circuit

When the heartbeat signal is detected as high, the input is processed and analysed. The input value is converted into binary coded decimal number to be displayed at 7-segment. MAX-232 will interface the microcontroller with RS-232. The interfacing between PIC circuits to GSM modem is established by using HyperTerminal.

C. GSM Modem

In this project, Wavecom Fastrack M1306B GSM Modem type is used. A GSM modem can be an external device or a PC Card / PCMCIA Card. Typically, an external GSM modem is connected to a computer through a serial cable or USB cable [14]. Like a GSM mobile phone, a GSM modem requires a SIM card from a wireless carrier in order to operate.

GSM modems support a common set of standard AT commands. With the AT Command, reading and sending message can be done without any doubt. The number of SMS messages that can be processed by a GSM modem per minute is very low which only about six to ten SMS messages per minute.

IV. RESULT & ANALYSIS

A. Sensor Device

The LDR is positioned besides the super bright LED in Fig.2. For simulation purposes, the LDR has been replaced with push button switch. Whenever light is detected, the push button is consired ON. Hence, there will be an output and the green LED will illuminate. The detectors photo current (AC Part) is converted to voltage and amplified by an operational amplifier (LM358). Output is given to another non-inverting input of the same LM358. The sensor circuit is illustrated in Fig.2.

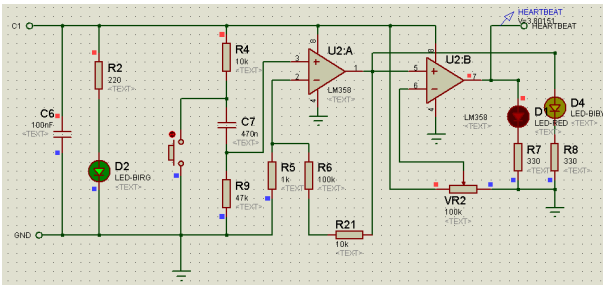

Figure 2. Sensor Circuit Diagram

In Fig. 2, the reading for pin 1 of LM358 is 3.81V and the reading for pin 7 (output) is 3.80V. It is assumed that whenever the switch is pushed, there is signal detected and both LED will be illuminated. The resulting pulses detected at the output pin can be referred to Fig.3. In Fig.4, the red and green LED illmuminated and blinked when pulse is detected.

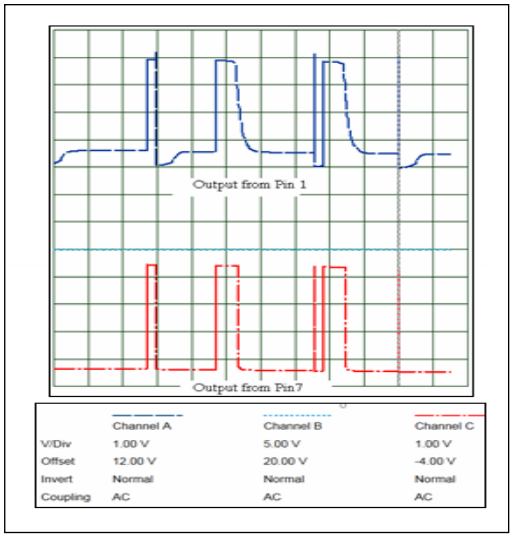

Figure3. Output Pulse using Virtual Oscilloscope at pin 1 and pin 7 of LM358 in Sensor Circuit

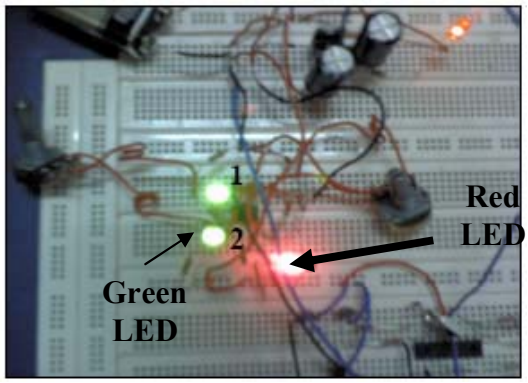

Figure 4. When patient's finger is placed between the LED and LDR, the red and green LED will be illuminated and blinked.

The result taken from oscilloscope at pin 7 of LM358 can be seen as in Fig. 5. The calculation for the heart rate result taken from this oscilloscope is shown in (1).

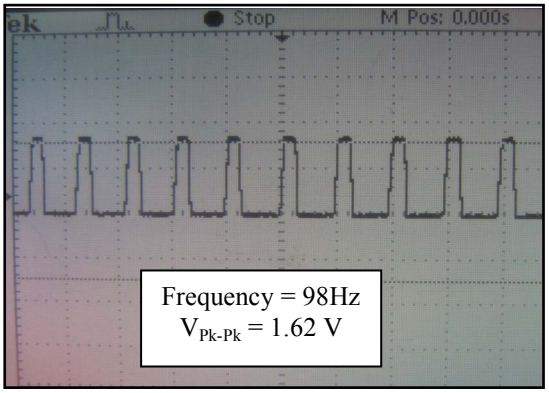

Figure 5. Output from Pin 7 LM358, at Frequency = 98Hz and $V_{peak\ to\ peak}$ = 1.62V

The oscilloscope display for the signal gives the reading of heartbeat in term of frequency. The peak of the two consecutive signals is compared with the the R-R peak of the ECG signal. The value is divided by 100 for the reason to obtain the perfect value of heart rate in beat per minutes (BPM) as in (1).

$$HR = \left(\frac{60}{RR} \right) \tag{1}$$

Where:
HR is Heart Rate
RR is the peak of two consecutive signals.

B. Hyper Terminal Test

The communication between HyperTerminal and GSM modem is estabilised to allow sms alert to be sent. USB serial communication is used for this purpose. The Com port connection and baud rate need to be assigned at the hardware device manager. The baud rate of 115200 bps is chosen since it is compatible with the GSM baud rate.

The frequently used baud rate of 9600 cannot be used since it is not matched with the GSM modem.

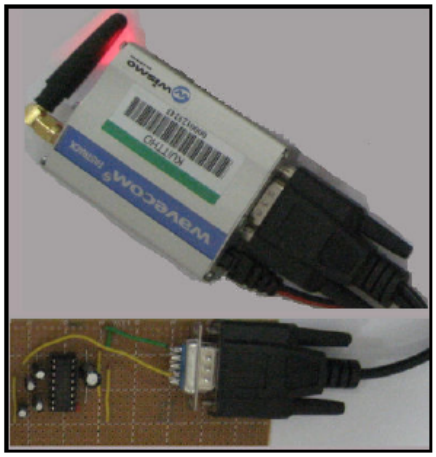

Figure 6. GSM Modem Connection with DB9

Fig.6 illustrates how the GSM modem is connected to RS232 and through MAX232 using connector DB9-M. A simcard is inserted into the GSM Modem. The GSM modem has to be tested for functionality using HyperTerminal as shown in Fig.7.

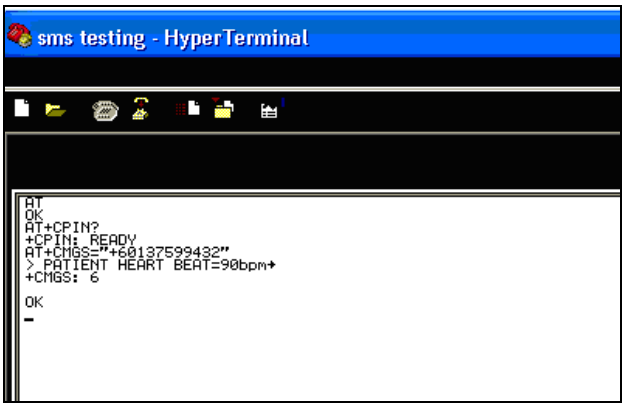

Figure 7. Communication with GSM Modem using AT Command.

After the communication is establish, the message can be sent from PIC circuit to the mobile phone. Fig. 8 displays the output obtained from HyperTerminal which is 'PATIENT HEART BEAT = 90 BPM'. This shows that the GSM modem and computer is successfully connected.

Figure 8. SMS Testing from GSM Modem to Cell phone. Alert message appears on mobile phone screen.

V. CONCLUSION

This project is initiated to alert the family members about patient's heartbeat via SMS. It fulfills 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. 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. By using the value of heart rate, we also can know the ages, oxygen contains in human body and patient's weight.

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