

Design and Implementation of PIC based Portable Heart Rate Measurement Unit

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ABSTRACT: In this paper, a portable heart rate measurement unit based on a PIC microcontroller has been described. This unit consists of an amplifying section which amplifies the output signal from the heart rate measurement unit via sensor and a microcontroller pic16F877a which displays the result. In an LCD 16 x 2 alphanumeric display the circuit is first tested using a simulation in the proteus design suite. Apart from the hardware implementation, programming of the microcontroller is described. This device can be utilized for accurate measurement and display of heart rate thereby helping people to keep a track of their health.

KEYWORDS: PIC Microcontroller, Heart Beat Rate, LCD display.

I. INTRODUCTION

According to a medical website [1], the heart rate is defined as the number of times that our heart contracts or beats in a minute. A normal heart beats at 60-100 times per minute. Heart rate may vary from one person to another with age health condition and the reaction of body to different circumstances like exertion shock etc.

Basically heart rate indicates the present condition of body. According to the global atlas on cardiovascular disease prevention and stroke over 17.3 Million people die each year all over the world due to cardiovascular diseases [2]. As the number of heart related diseases increase a fuss free and portable heart rate measurement unit can be very useful to monitor the daily health of a person on his own.

In this paper, we have proposed and demonstrated a simple design of a heart rate measurement unit. The heart rate measurement unit which consists of an IR source and a photodetector kept close to each other with a barrier in between senses the heart beat and sends the signal to the amplifier section. This amplified signal is counted per minute and shown on an lcd alphanumeric display. The circuit implementation shall be described in details in subsequent sections.

II. CIRCUIT DESIGN

The block diagram of the circuit is given in Fig. 1.

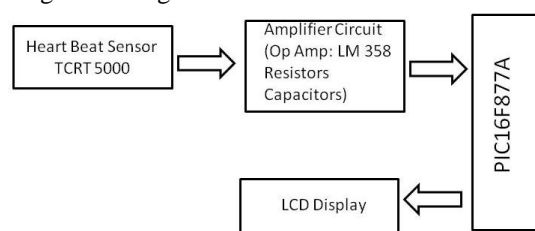


Fig. 1 Block Diagram of Circuit

The heart beat sensor TCRT 5000 is an optical sensor which is reflective in nature. It has a transistor output. It consists of an IR source and a photodetector placed in close vicinity of each other but a barrier is present between them to avoid false signals. When a finger is placed on this sensor light from the IR source gets reflected. According to the flow of blood in the finger, this reflected signal is detected by the photodetector. More or less light is transmitted depending on the blood volume in tissue. Consequently, as the pulsing of blood varies due to pumping of heart, the reflected light intensity varies with heart beat. The variation of the reflected light with time is otherwise known as photoplethysmographic or ppg signal [3]. The ppg signal is a combination of a large DC component and a pulsating AC component. The DC component is attributed to the total blood volume of the tissue which is under examination. The AC component which is synchronous to the pumping action of the heart carries vital information including the heart rate. It is much smaller in magnitude than the large DC component. The two maxima, called Systolic and Diastolic peaks are observed in the PPG signal. They provide essential information about the current condition of the cardiovascular system. The instantaneous heart rate is given by the time duration between two consecutive systolic peaks. The signal from the photodetector is then amplified by the op amp LM358. It is used since it consists of two independent high gain frequency operational amplifiers designed to operate from single supply over a wide range of voltages. The amplified signal is fed into the PIC microcontroller. The microcontroller counts the number of pulses and displays it in the 16X2 alphanumeric LCD display. An LCD display is economical and easily programmable.

III. CIRCUIT DESIGN SIMULATION AND SOFTWARE DESCRIPTION

The circuit was simulated in Proteus v8.0 before hardware implementation. In this software, all the components required were selected from the device library and connections were done by wire. The program was compiled using mikroc the hex file of the program was loaded into the PIC16F877A microcontroller finally the simulation was done fig 2 shows the amplifier section

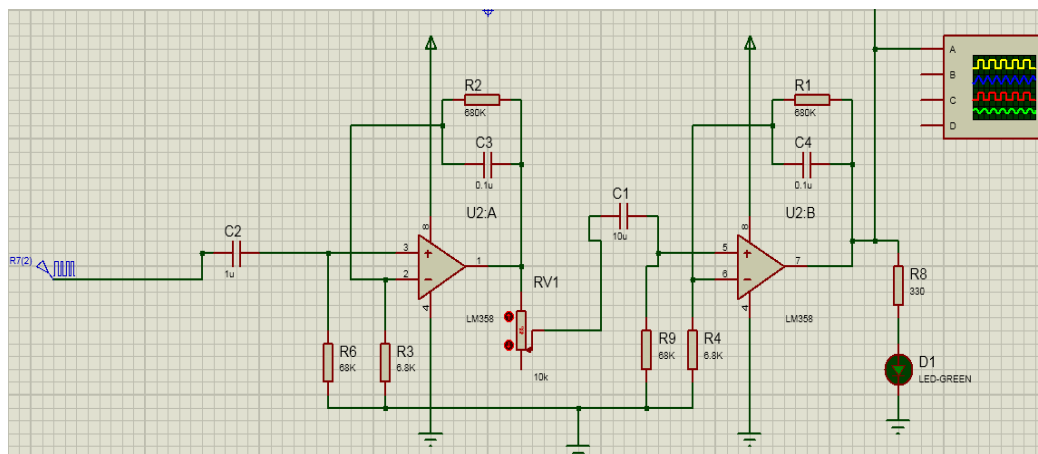


Fig. 2 Amplifier Circuit Simulation in Proteus Design Suite

The photoplethysmographic or ppg signal coming from the photodetector is weak and noisy. So, an amplifier is required and filter circuits need to be designed to amplify and clean the signal. A two-stage amplifier circuit has been used. Each stage consists of a passive RC high pass filter (HPF) to block the DC component of the ppg signal followed by an op-amp based active low pass filter (LPF). Stage II is an exact replica of stage I. Gain and cut off frequency of each stage is calculated as follows

$$\text{Gain} = 1 + \frac{R_f}{R_i} = 1 + \frac{680K}{6.8K} = 101$$

$$\text{Cut-off frequency} = \frac{1}{2\pi R_f C_f} = 2.34 \text{ Hz}$$

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A potentiometer is connected at the output of stage I which acts as a manual gain control. The LED at the output glows, every time a pulse is received. When a pulse input is applied, the amplified signal can be observed at the Digital Oscillator connected at the output. Fig. 3 shows the amplified signal at the output on the digital oscilloscope.

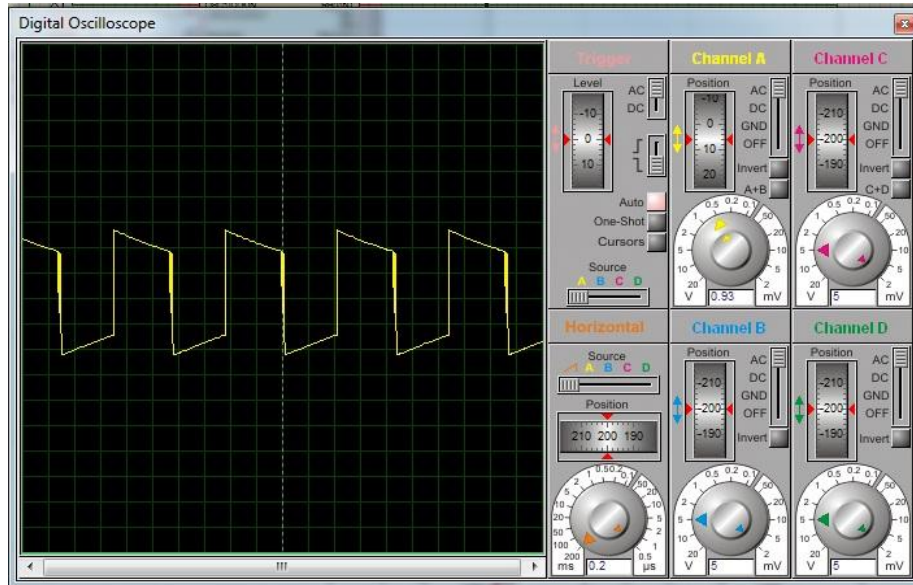


Fig. 3 Amplified Signals at Output in Digital Oscilloscope

Fig. 4 shows the simulation of PIC microcontroller circuit connected to the LCD display.

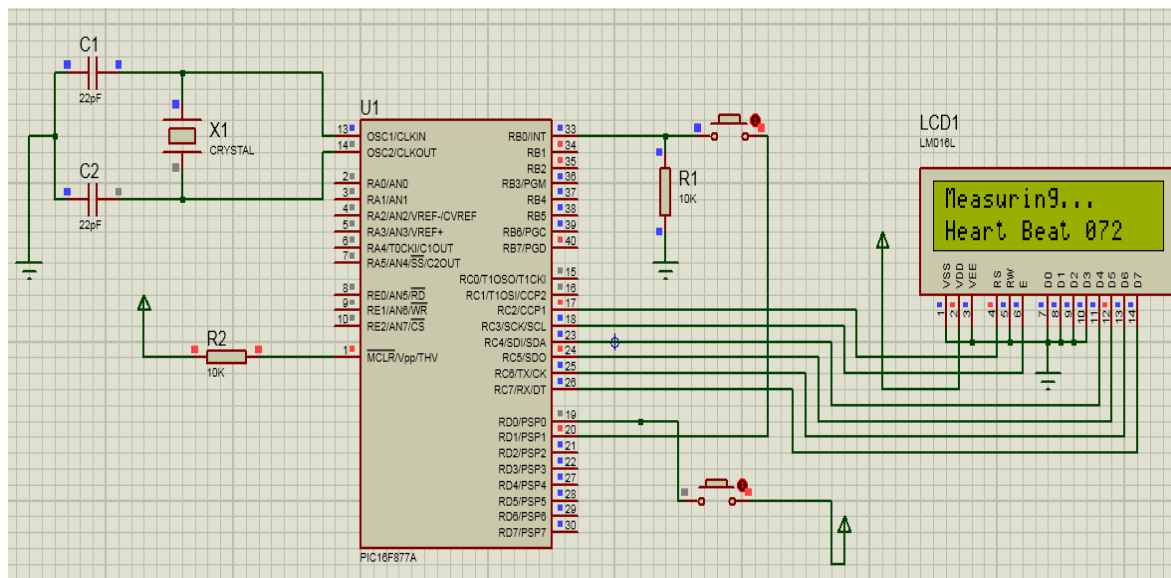


Fig.4 Simulation of PIC microcontroller circuit

In the circuit, the switch connected to RD0 is responsible for starting the measurement. The program is written in such a way that the amplifier circuit remains ON through RD1 for a particular time period. The amplified output signal is given to RB0. When the amplifier circuit is switched OFF, the microcontroller calculates the number of pulses and displays the result accordingly. In the circuit simulation, the output at RD1 is directly connected to RB0, bypassing the amplifier

circuit for simplicity. The number of pulses may be changed by using the switch between RD1 and RB0 in order to check if the microcontroller is calculating correctly and displaying it on the LCD monitor. The program is written in C language and compiled in mikroC software. The hex file is generated and burned into the microcontroller through a programmer.

IV. HARDWARE IMPLEMENTATION

All the components have been assembled on a vero board. It can be observed that, the circuitry is simple and occupies little space. The complete unit can be easily put together into a small package to make it a handy device.

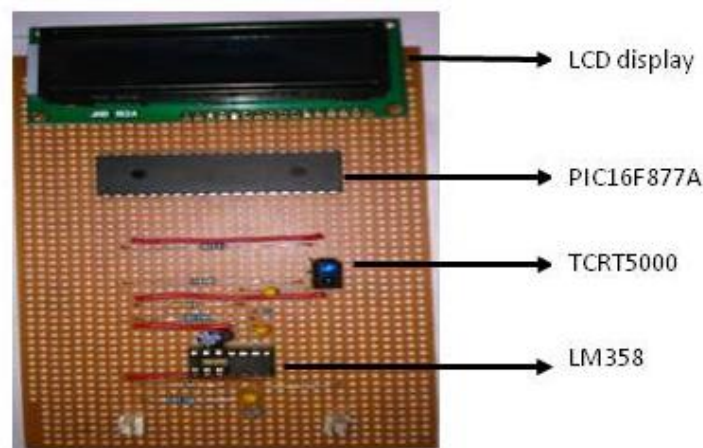


Fig. 5 Hardware Implementation of the Circuit

V. CONCLUSION

We have successfully designed and demonstrated a portable heart beat measurement unit which can help a person to monitor his health on his own. As a result, cardiovascular diseases can be reduced. This system has many advantages like it is compact, accurate and consumes very low power. Further modifications can be done, although the cost of the system may increase. A GSM module can be attached to this system as an added feature to send an SMS to a doctor or nurse after every reading. Alternatively, this hardware can be realised in a PCB and a smaller display can be used, thereby making it more compact and wearable.

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