LOW COST AND PORTABLE HEARTBEAT RATE MEASUREMENT FROM THE FINGER

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ABSTRACT

In this study, portable and low cost heart beat rate measurement device has been designed with using PIC 16F877. It measures heart beat rates from finger using optical sensors and the rate is then averaged and displayed on a text based LCD. The finger tip probe has been selected from commercial products. The device works with 1 x 9V battery. Also it measures ambient temperature and humidity in addition to heart beat. The measurement accuracy is acceptable. The hardware that has been designed in this study is available for checking the pulse with education purpose. The hardware can be improved adding wireless data transfer devices in telemedicine applications. The device has the advantage that it can be used by non-professional people at home to measure the heart rate easily and safely. This paper report describes how to build a digital heart-rate monitor using a PIC 16F877 microcontroller (MCU). The heart beat rate per minute is displayed on an LCD.

Keywords: biomedical instrumentation, heart rate measurement, bio electronic, PIC 16F877

I. INTRODUCTION

The heart is a strong pump which pumps between 5-35 litre blood to the body with changing speed between 60-80 beats per minute and approximately 9000 litres in a day. The regular control and the measurement of heart beat per minute (bpm) of an organ , active in body like this, are quite important. One of the mostly used and certain methods for measuring the heart rate is electro-cardiogram (ECG). ECG is an expensive device and it is not economical for heart rate measurement. There are also some devices like wrist whatches which are low-cost. These devices can give certain results but although they are low-cost, their price is very high which makes them uneconomic.

There are many measurement methods valid for this. However, the use of digital sensors in measurements makes having much certain and correct results possible. In fact, these measurement sensors have started to being placed in smart phones in modern day. However, this technology is getting more expensive as it is getting smaller.

Sport is in every step of life. Mostly, athletes have lower heart rates than people who move relatively less. While the heart rates of older children are about 90, the heart rates of babies are about 120. The heart rate gradually increases while doing exercises and it returns slowly to the rest value after exercises. The revealing rate, when the pulse is normal, is the indicator of how healthy the person is. The values below the normal heart rate are usually signs of bradycardia; and the values above the normal heart rate are signs of tachycardia. However, the sport can cause a heart attack when it is done unconsciously. The heart attack was the second illness is stated 722,130 between 2000-2011. These results prove the importance of regular cardiac rhythm control [10].

When the literature is reviewed for the studies made about this issue, it is possible to see some other low cost more developed studies or like the present one.

In their study Hashem and his colleagues combine analogue and digital signal processing techniques to keep the device simple and to efficiently suppress the disturbance in signals. Their experimental studies show that the heart rate can be filtered and digitized so that it is possible to calculate the accurate pulse rate.

In Laghrouche's study, arterial oxygen saturation in the patient's blood signal is measured with an optical sensor and converted to digital data using a microcontroller system. Then the digital data are sent to a receiver where it is in 433 MHz FM-FSK transmitter. At the receiver, the digital data are reconverted to analog signal to be monitored and recorded on the PC.

In Mamun's study, a measurement circuit is developed by using a low cost ATmega8 microcontroller system from ATMEL. This measurement circuit can be easily used by families, hospitals, clinics and sports centre.

In Toral and his colleagues' study, pulse, SpO2 and temperature signals are conveyed to computer and displayed with LabVIEW program. In this study, wireless communication technologies are not used.

The aim of this study is to design a low-cost and portable cardiac rhythm measuring instrument and to make a critical measurement real. The designed device is working with 1x9V the ambient temperature and moisture. The design circuit and graphics (software program) about the device are shared in this study.

II. THE PULSE OXIMETRY DEVICE

The pulse oximetre are devices that measure the oxygenation of blood passing through tissue bed which is between photodedector and light source that give out red and infrared light with special probes placed on finger or ear. The block diagram of mentioned device is shown in Figure 1. Actually, the device consist of infrared transmitter LED and infrared receiver photodiode. The transmitter-sensors is fixed to finger of the subject. (Figure 2)

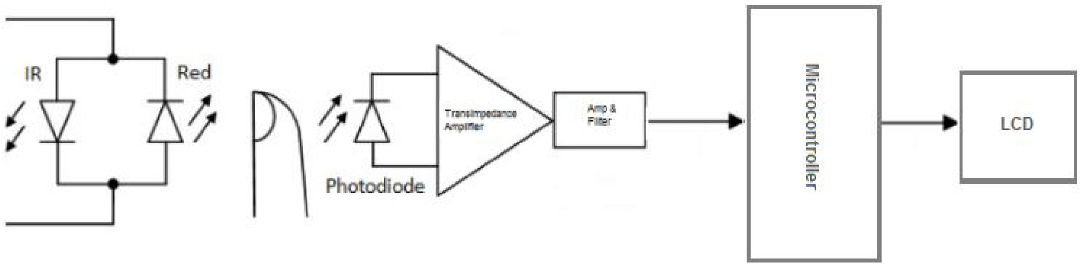

Figure 1: Block diagram of the measurement device

Figure 2: Transmitter-sensors is fixed to finger of the subject

The LED sends infrared light to the finger. Photo-transistor detects this ray and measures the change in blood amount from finger artery. This signal as pulse, then is increased, filtered and sent to the low-cost microcontroller to analyze and show. The microcontroller counts the number of pulses in certain intervals and therefore, the heart rate of the subject is obtained. This input is collected for a while and averaged to see the heart rate accurately. The calculated heart rate is displayed on LCD as beats per minute. The circuit diagram of measurement device is shown in Figure 3 and printed circuit diagram is shown in Figure 4 and sample measurement results are shown in Figures 5-6-7.

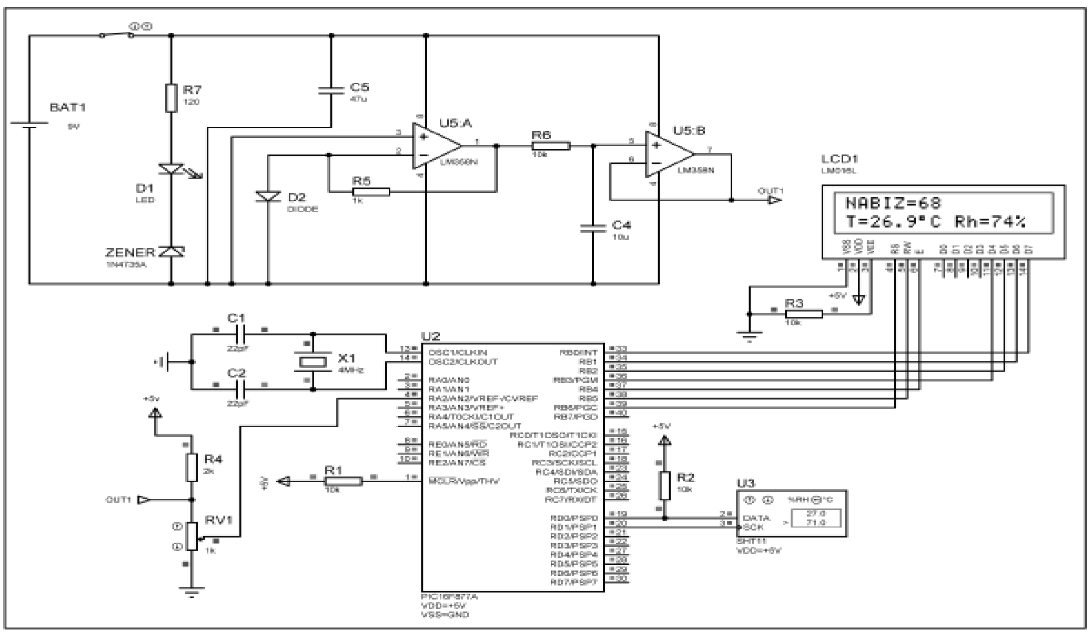

Figure 3: Circuit diagram of measurement device

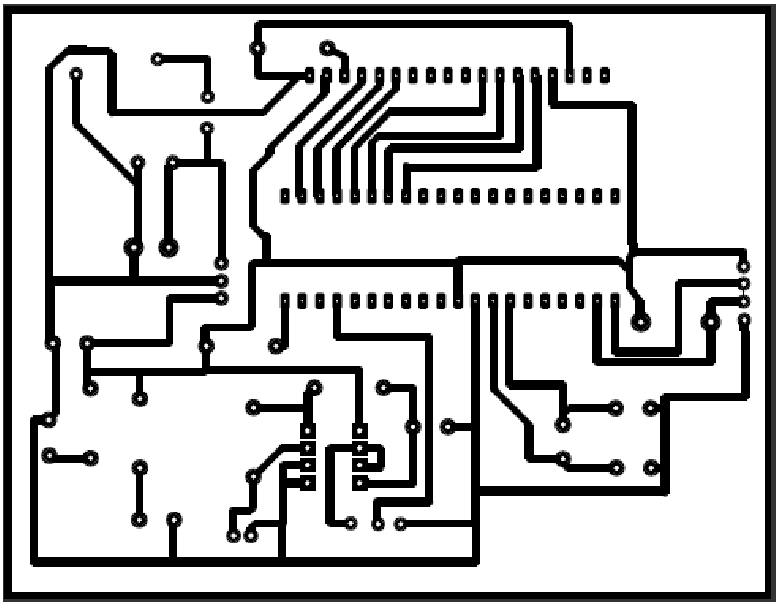

Figure 4: Printed circuit diagram

Figure 5: Sample measurement results

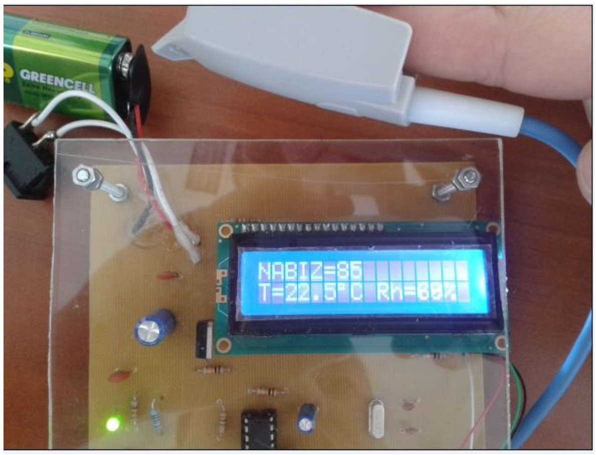

Figure 6: Sample measurement results

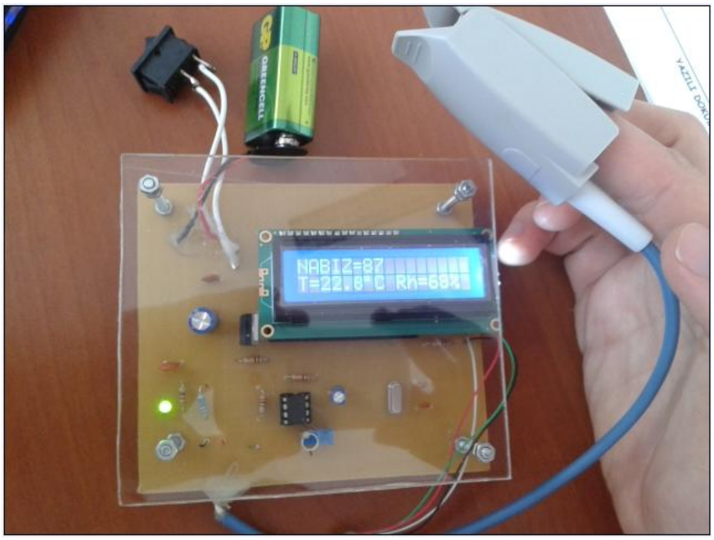

Figure 7: Sample measurement results

III. THE STRUCTURE AND OPERATION OF CIRCUIT

The circuit basically consist of two functional amplifiers, a low-pass filter, a microcontroller and an LCD. During the studies, it is determined to use low-pass filter in the circuit to filter the high frequency noise coming from surroundings. The corner frequency of amplifier is chosen as 1.6 Hz. The output of amplifier is connected to one of the digital inputs of PIC16F877 version microcontroller via R4 resistance and RV1 trimpot. In order to decrease the cost of circuit, the microcontroller is worked from 4 MHz resonator. The output ports of microcontroller are connected to the LCD. The circuit starts when it is pressed on push-button switch working with 9V battery.

When the structure of circuit is analysed; C5 (47 uF) capacitor functions as filter. R7 (10K) resistance is a current limiting resistor that prevents the high current that will follow on D1 (IR LED) diode. D1 and D2 diodes in the circuit diagram consist of IR Led Transmitter and photodiode receiver which form the internal structure of device called pulse oximeter. After the pulse oximeter is fixed to the index finger, a signal is sent to zener diode by D1 (IR) transmitter as to pressure of blood flowing through fingertip. This signal sent to the zener diode starts to sway smoothly. D2 (Photodiode) receiver diode receives the signal sent by D1 (IR) transmitter diode and voltage is formed upon the amount of signal. This voltage is enhanced with maximum lucrative LM358N (U5:A) op-amp. A signal is obtained in response to the voltage enhanced by op-opamp.This signal is filtered from low pass filter consisting of R6 resistance and C6 capacitor. After that, oscillation is decreased to minimum and is implemented to the output of LM358N (U5:B) op-amp and the analogue input of microcontroller (MCU). The implemented voltage is calibrated with RV1 trimpot. And this calibrated voltage is transformed into an understandable numerical value with software program and then it is conveyed to LCD screen via PORTB that is the output of microcontroller. In addition to the pulse number, ambient temperature and moisture are also conveyed to the LCD screen after being measured with the SHT11 heat and moisture sensor connected to the PORTD output of MCU. This pulse oximeter device is low-cost and its accuracy rating is not high enough, so it is quite important to place the finger's plump point properly into the device's slot.

IV. THE SOFTWARE OF CIRCUIT IN COMPUTER LANGUAGE

The software is developed by using popular C basic compiler and CCS-C is used as program description language. In Figure 8 below, the program listing of microcontroller is given. When it is mentioned about the written program; at the beginning of the program, variables used in program are referred. RB0-RB7 and RD0-RD1 pins of PORT B are used as outputs. RA2 pin of PORT A is set as input port. The Program starts when the key, which works with 9V battery, is on and after the pulse oximeter is fixed to fingertip. As the analogue-digital converter pin of microcontroller, RA2 pin transforms the voltage that is transmitted from finger into a numerical value. After that, the pulse value measured from finger is transmitted to for loop and a sample of pulse value is obtained in every 50 ms. And this process is repeated 30 times. The reason for this repetition is to reach the truest pulse value by obtaining many samples. These 30 samples are averaged and divided by 60. The numerical value of voltage coming from fingertip as a result of measurements is multiplied by 2, because the response of this voltage gives the real pulse value. And this is the reason for dividing the average by 60. If the device is not fixed to finger or the pulse value is lower than 50 or higher than 140, pulse value will not be displayed and *"WRONG MEASUREMENT"* will be displayed as a warning. And lastly; with the measure pulse value, ambient temperature and moisture are also displayed on LCD screen.

Program Software

```
#include <16F877A.h>
#device adc=10
#FUSES XT,PROTECT
#use delay(clock=4MHz)
#include <Port-B-LCD.c>
#include <sht11.c>
float restemp, truehumid;
float olcum;
int1 a;
int8 say;
long ort;
void main()
{
    setup_adc_ports(ALL_ANALOG);
    setup_adc(ADC_clock_div_32);
    setup_psp(PSP_DISABLED);
    setup_spi(SPI_SS_DISABLED);
    setup_timer_0(RTCC_INTERNAL|
    RTCC_DIV_1);
    setup_timer_1(T1_DISABLED);
    setup_timer_2(T2_DISABLED,0,1);
    setup_comparator(NC_NC_NC_NC);
    setup_vref(FALSE);
    lcd_hazirla();
    output_low(pin_b4);
 set_adc_channel(2);
 delay_ms(1);
 sht_init();
 while(TRUE)
 {
     ort=0;
     for (say=0;say<30;say++)
     {
            olcum=read_adc();
            ort=ort+olcum;
            delay_ms(50)
}
   sht_rd (restemp, truehumid);
   olcum=ort/60;
   imlec(1,1);


  if(olcum>50&&olcum<140)
  {
            printf(lcd_veri,"NABIZ=%2.0f        " ,olcum);
    }
    else
    {
            a++;if (a==0) printf(lcd_veri,"HATALI OLCUM!");
 if (a==1) printf(lcd_veri,".............");
 }
 imlec(2,1);
printf(lcd_veri,"T=%3.1f%cC", restemp,223);
imlec(2,10);
printf(lcd_veri,"Rh=%2.0f%%   ", truehumid);
  }
```

V. CONCLUSION

In order to measure the heart rate, low-cost and microcontroller based device is described. The device has an advantage that it can be used by any people who is not professional and it makes it possible to measure the heart rate safely and easily.

The device can be developed in some areas as shown below:

- Voice can be added to the device and therefore; voice output will be possible during the pulse.
- The highest and lowest heart rate numbers can be displayed after a while.
- Serial output can be added to the device and therefore; heart beats can be sent to the PC for online and offline analysis.

Warnings or abnormalities (as too high or too low heart beats) can be shown on the LCD or with a LED or with a bell.

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