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Designing of PPG based Heart-beat Monitor

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Abstract—The objective of this paper to presents an overview of the design process undertaken to implementation of a low cost wearable PPG system. using basic available component in the lab. The detailed explanation of the various modules of the design and their implementations is provided. Each module was simulated and tested on hardware .The aim of this paper has been made to extract the PPG signal from the body and suppressed the present artifacts using signal conditioning circuit. Further heart beat is calculated using microcontroller and display on LCD. The calculation of heart beat is based on the beat to beat(R-R interval method).
Keyword- heart beat, noise, signal conditioning , and microcontroller, and PPG.

I. INTRODUCTION

Heart beat is the most common physiological factor to assess the cardiovascular condition[1,2,3] It can also help to diagnose further diseases like coronary disease, blood pressure and thyroid etc..The normal heart beat of the adult ranges 60 to 100 beats per minute(BPM)[4]. Heart beat varies with body fitness and it can be divided in two part. a) tachycardia (higher than the normal heart rate) b) bradycardia(lower than the normal heart rate) .It is the commonly measurable physiological parameter and easily available in the form of electronic gadget like wrist watches[5], wrist belt, mobile application, exercise machine and blood pressure machine etc. For measuring the heart rate, various methods are available. First method a). Direct method (manual method), b) Indirect method (Electronic Instrument) . In manual method, heart beat can be observed at any point on the body by pressing the artery using index or middle finger. Normally radial artery and carotid arteries is the right place to measure the heart beat. In indirect method, ECG, and Plethysmography,(an instrument used to measure changes in blood flow or air volume in different parts of the body) are used. For accurate measurement of heart beat, ECG method is more suitable than **photoplethysmogram** (**PPG**). But for continues monitoring, PPG method is used, because it is robust and more comfortable for patient as well it does not require any direct electrical connections to the body. Due to advancement in recent technology, many wearable heart beat monitor were designed [6]-[16] that can extract and process bio-signals generated by the human body. And the wireless heart beat monitor was also designed. These all available devices are the contacting type heart beat monitor devices because it requires physical contact with the body to capture the signal for further processing. Recently, the new technique of HR measurement was reported called as smart home HR monitor[16], in which no physical contact requires to extract the signal. But this method appropriate for controlled settings but unsuitable for smart homes. It will fail in the presence of multiple users or extraneous motion. Thistypically requires the user to lie on the bed while facing the device. Furthermore, it can give the accurate result when the subject are in close proximity. In this paper we proposed a design of basic PPG based heart beat monitor system using microcontroller**.**

II. DESIGN METHODOLOGY

The design methodology of PPG based heart beat monitor is mentioned in Figure 1 which consists of IR transmitter and receiver, buffer amplifier, 2-stage band pass filter, amplifier, comparator, microcontroller and display device. The signal collects from the subject via finger placed between the IR transmitter and receiver. Collected signal will pass to the buffer amplifier, which is used to couple the output of the IR receiver to the input of band pass filter to avoid loading. The buffered signal fed to the band pass filter of frequency range 0.5 Hz – 2.34 Hz. It removes the high frequency noise and low frequency noises. The output of the band pass filter is then fed to amplifier having gain of 100 to amplify the signal in enough amounts to further comparison. It will compare the output voltage (Vo) to set threshold voltage (Vth). The output of comparator is interfaced with the microcontroller in interrupt mode. These interrupt enable at the every rising age of the input pulse. When the rising edge of the pulse coming then interrupt (INT1) occurs and the timer (T1) count the number of cycles of microcontroller pulse. After the counting, calculating the time period of input pulse and frequency is given by using this equation:

$$T = N*1.085\ \mu s \text{ and } f = 1/T$$

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Heart beat(HR) = 60* f (BPM)

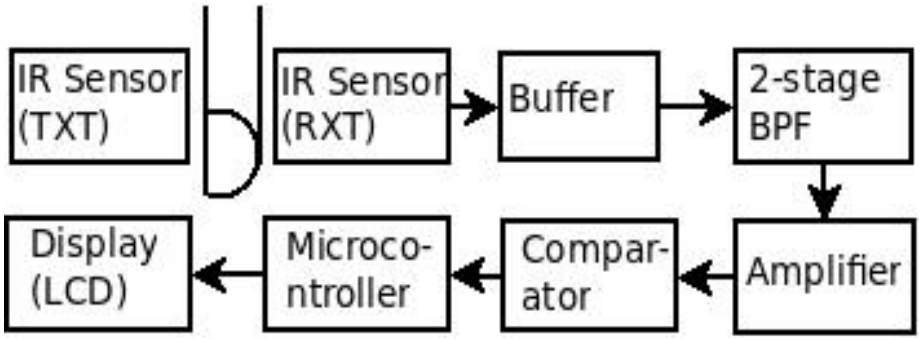


Fig. 1. Design methodology of PPG based HR monitor system

III. DESIGN CIRCUIT

The complete circuit diagram of PPG based heart monitor is shown in Figure 2, is designed with the help of IR sensor, four LM358 op-amp IC , microcontroller(89s52) and LCD(16x2). The LM358 is the low voltage single supply IC. It is used for designing the Buffer amplifier, band pass filter and Comparator designated as B1, B2, B3 and B4 respectively. Further microcontroller(89s52) designated as B5.The input signal captures via IR receiver , is send to the buffer(B1), BPF(B2, B3) and then comparator(B4). Conditioning output from the comparator fed to the microcontroller (B5) for further processing.. In microcontroller, port 2 is used to interface with data pins (D_0 to D_7) of LCD and port 1 is used for the control signal to the LCD. Control signal of LCD RS, RW and EN are connected to P1.0, P1.1 and P1.2 of port1 respectively. P3.3 (INT1) pin of microcontroller enable in interrupt mode and internal timer (T1) is activated. The interrupt INT1 is activated every rising edge of the input pulse. When the rising edge of the pulse coming then interrupt (INT1) occurs and the timer mode (T1) count the number of cycles of microcontroller pulse. Hence the heart beat will calculated using the above mentioned formula.

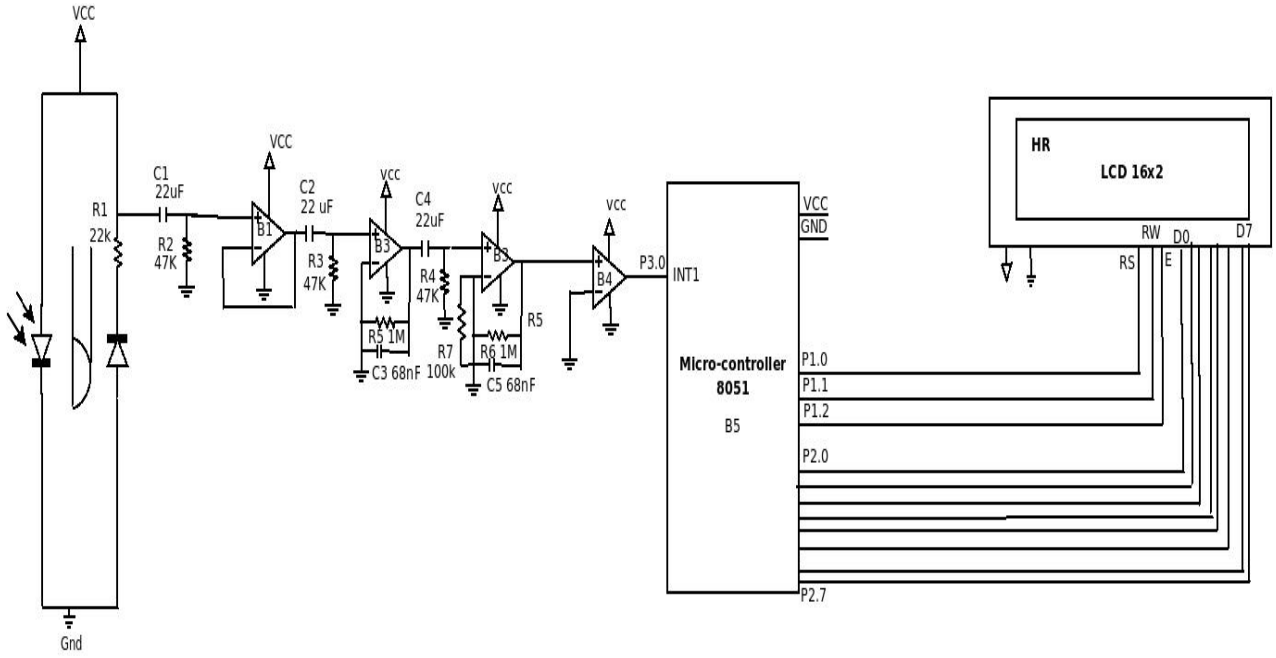


Fig. 2 Circuit diagram of PPG based HR monitor system

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IV. RESULTS

The result of 1st stage and 2nd stage band pass filter and amplifier are observed on DSO is shown in Figure 3 and 4 respectively. The Figure 3 shows the output of 1st stage BPF and amplifier and Figure 4 shows the output of BPF and amplifier.

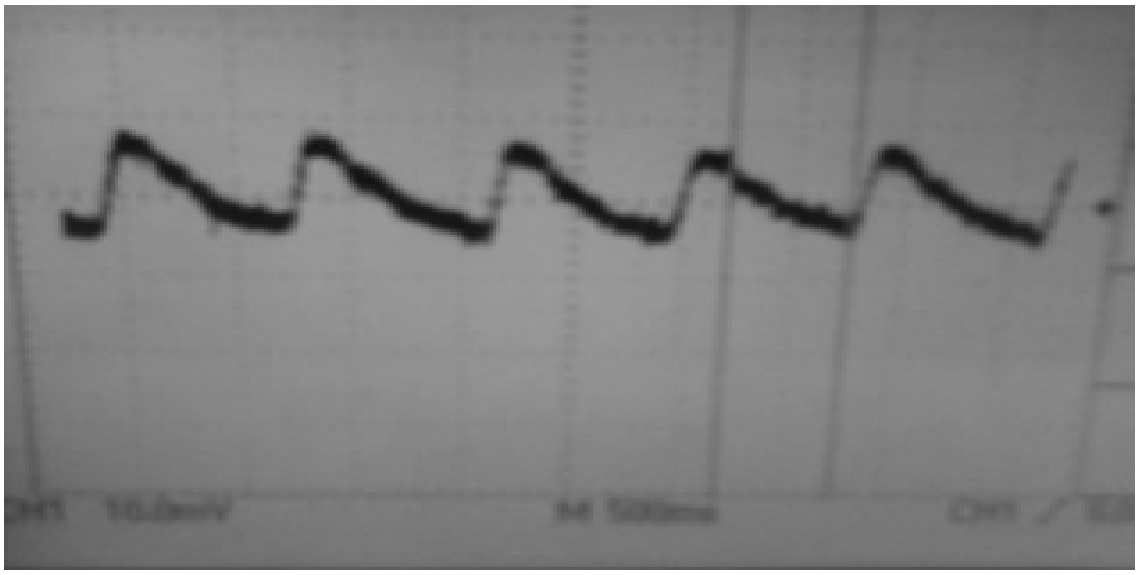


Fig. 3 Filtered output of 1st stage BPF and amplifier

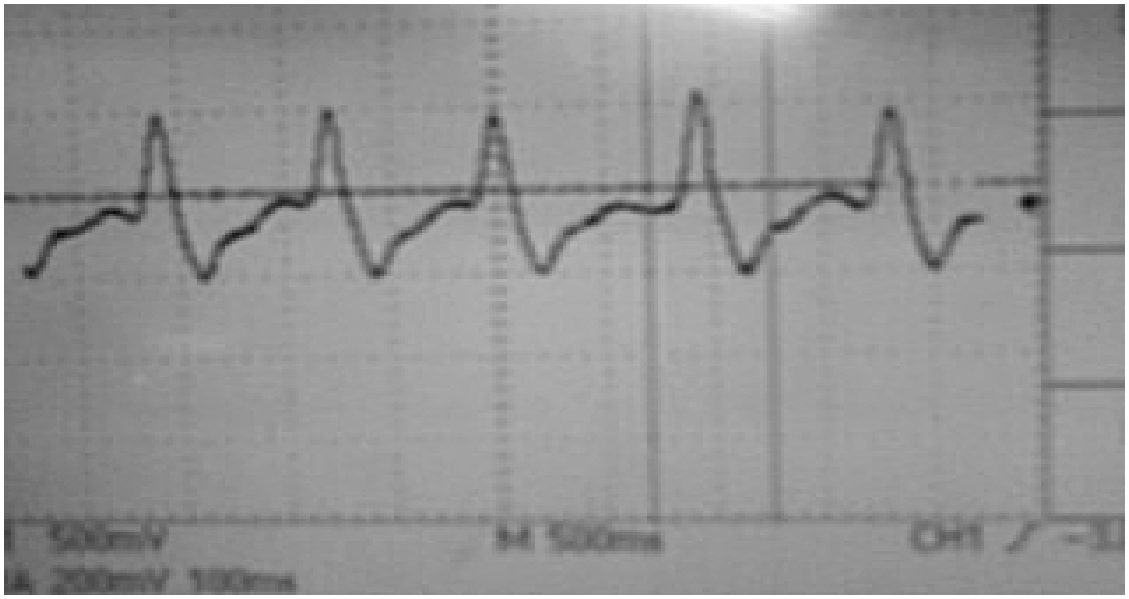


Fig. 4 Filtered output of 2nd stage BPF and amplifier

V. CONCLUSION

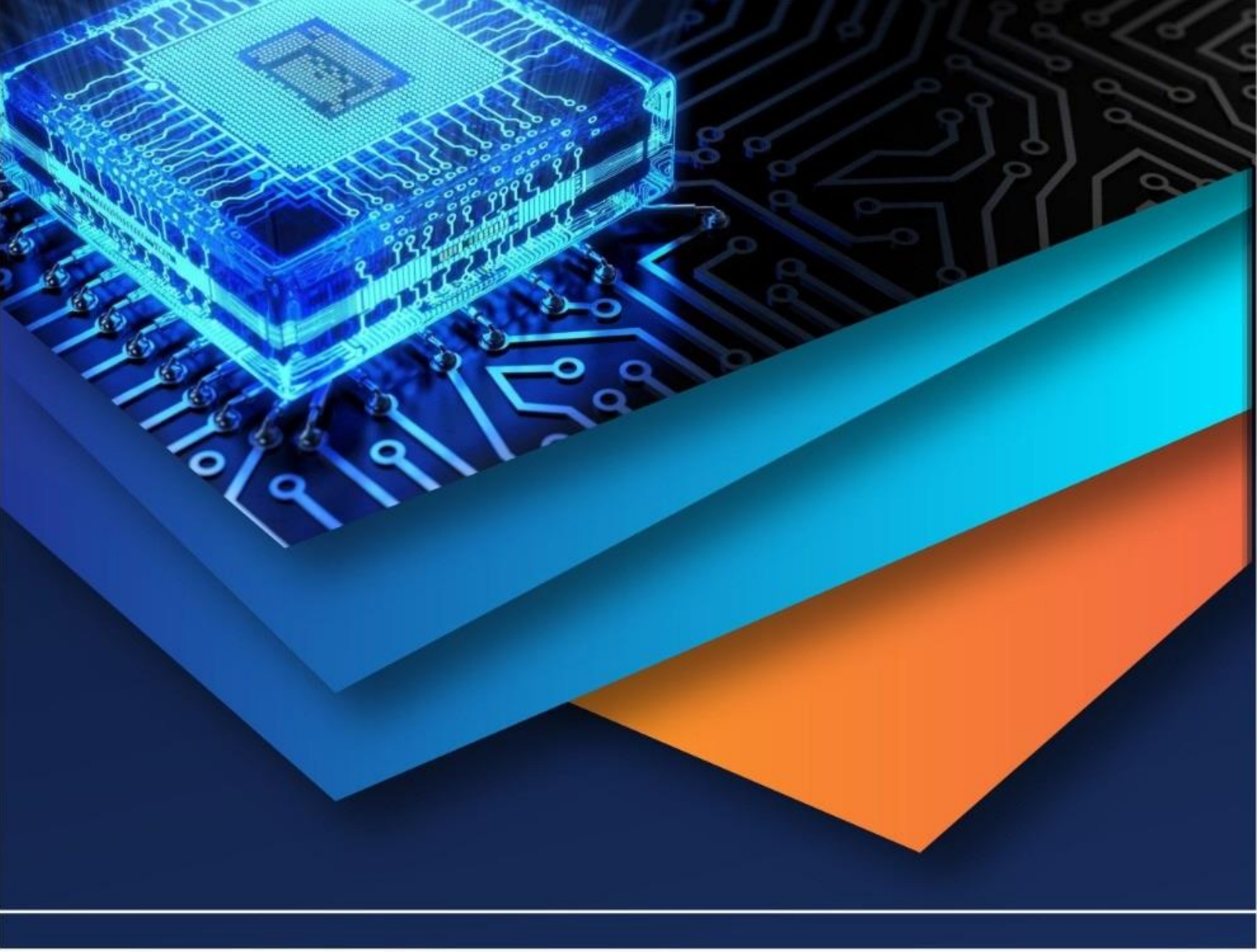
We successfully designed and tested the PPG based heart beat monitor system using micro-controller at low cost on bread board. This circuit will help to monitor the heart beat. To get better result without noise, we need to encapsulate IR sensor setup in wooden clip. Also use shielded cable to carry denoising signal from the body to the circuit. The limitation of this PPG based technique is that the subject movement can change the output as well as the specific condition.

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