# EE236: Project - Heart Rate Monitor

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## 1 Aim of the project

Designing a heart rate monitor circuit based on reflective photoplethysmogram (PPG) using IR LED - photo-transistor pair TCRT 5000 to detect PPG signal.

## 2 Methods

TCRT 5000 is used to detect the blood volume changes in the micro vascular bed of tissue during one cardiac cycle. The sensor output is provided as input to IC LM324N (which contains four op-amps). For our circuit we require only three op-amps of which two are used to make the band pass filter(consists of a passive high pass filter and an active low pass filter) to reduce noise in the sensor output and the other op-amp is used to amplify the sensor output after filtering. The output is observed on the DSO by connecting the probes accordingly and the heart rate of the person is measured.

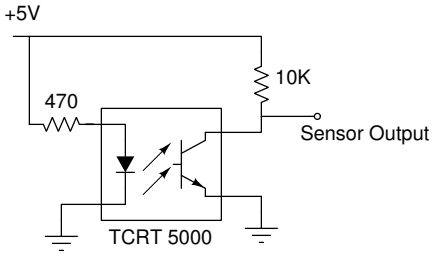


Figure 1: Sensor Stage Circuit

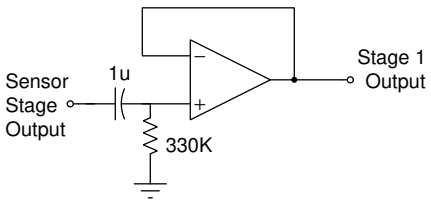


Figure 2: Stage-1 Circuit(Passive HPF)

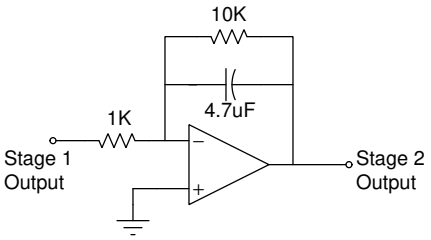


Figure 3: Stage-2 Circuit(Active LPF)

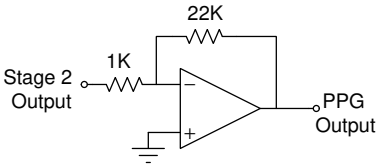


Figure 4: Stage-3 (Inverting amplifier)

## 3 Results

### 3.1 Observations

We completed the experiment in two rounds. During the first round of experiment, the output we got had the correct frequency, but it contained a distinct secondary peak and had a lot of noise. Moreover, we had to reduce the Volts/div knob to a very low value (5mV/div) to obtain

the output. At first, we tried replacing the sensor and capacitors but got the same output.

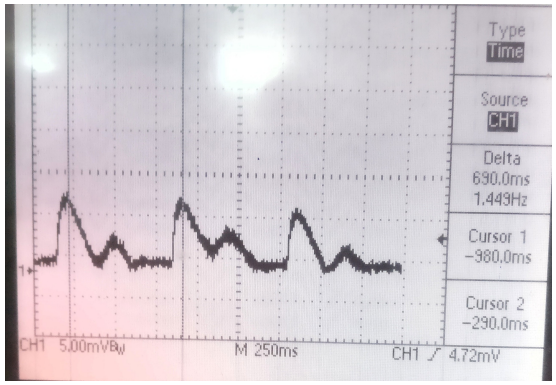


Figure 5: First Part

Time difference between adjacent waves=690ms or Frequency=1.449Hz.
In our second round, we realized our IC was damaged and replaced it with a working one. After replacing the damaged IC, we were able to reduce the noise to a much greater extent than before. Also, no secondary peak was observed in addition to systolic and diastolic peaks and the output was observed keeping the Volts/div knob at 2V/div.

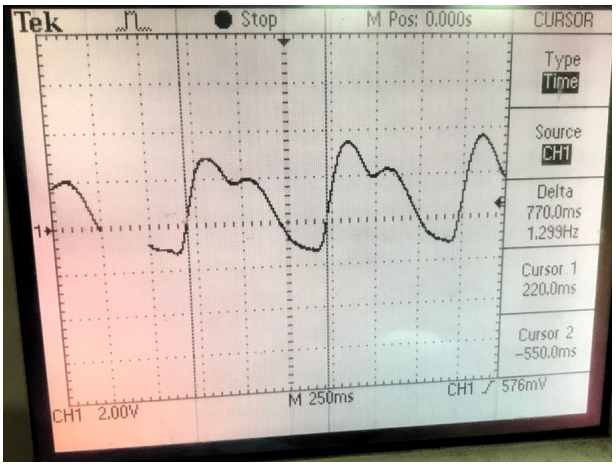


Figure 6: Second Part

Time difference between adjacent waves=770ms or Frequency=1.299Hz.

### 3.2 Inference

In the first case, maybe the sensor was not tightly pressed against the skin and hence a secondary peak was observed in addition to the systolic and diastolic peaks. Also due to the faulty LM324, there was a lot of noise in the output voltage.
Heart beat in first case=$60*f=\frac{60}{t}$ $\approx$ 87bpm.
In the second case, a functional IC was taken hence noise was reduced.
Heart beat in second case=$60*f=\frac{60}{t}$ $\approx$ 78bpm.

## 4 Learning objectives

The main learning objective was to understand the working of a heart rate sensor and learning the construction of band pass filters to remove noise from input signals/waveforms.

## 5 Quick feedback

### 5.1 What about this experiment did you find helpful?

This experiment tested our basics in circuit designing. We were presented with the problem statement to design a heart rate sensor on our own and the process of figuring out the components and methodology for the entire experiment on our own was really intellectually stimulating. We were introduced to concepts of filtering signals and also learnt the different uses of opamps.