Non-Invasive Measurement of Blood Parameters through Fingertip

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Overview

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Objective

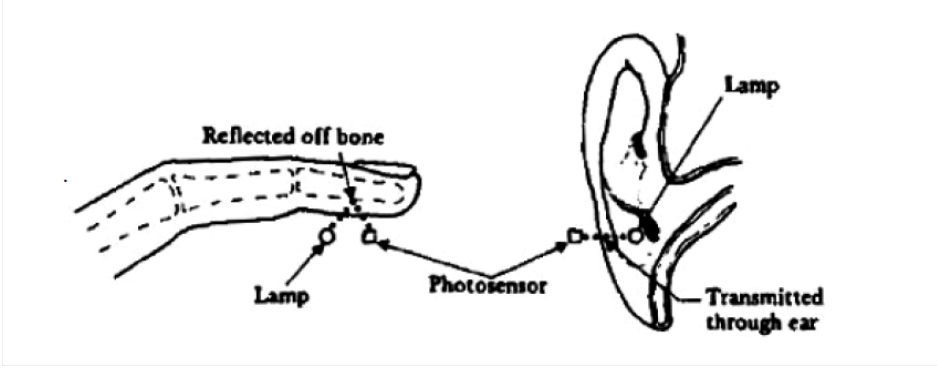
This work proposes a low cost method for estimation of blood parameters using photo-plethysmography (PPG) technique. Data is obtained non-invasively from the fingertip, which is processed to estimate heart rate and hemoglobin concentration. Invasive methods of blood parameter estimation tend to be time consuming and resource consuming. Estimation is done via chemical methods which take time to show results. In this case we have shown a method which aids in estimation of parameters instantly, with limited resource usage.

Photo Plethysmography

- Plethysmographs measure changes in volume.
- PPG or photo-plethysmography is a way of measuring relative changes in volume.
- PPG can be used for detection of blood parameters, by studying passage of electromagnetic light rays through the skin.
- Information about blood parameters can be obtained non-invasively through PPG.

Sensor Configuration

- Consists of an LED which illuminates the skin, and a photosensor.
- The sensor can be used in two configurations: reflection and transmission.
- The photosensor measures the light reflected (off the bone) or transmitted (through the skin).
- This work uses the reflection mode.



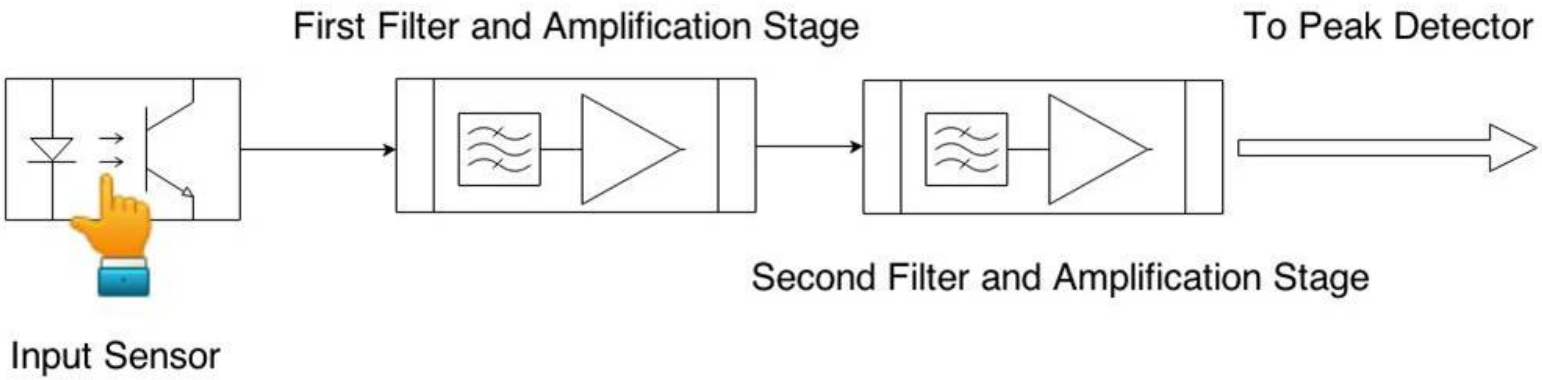
Figur: Sensor Configurations for PPG Sensor

Design

The work comprises two parts:

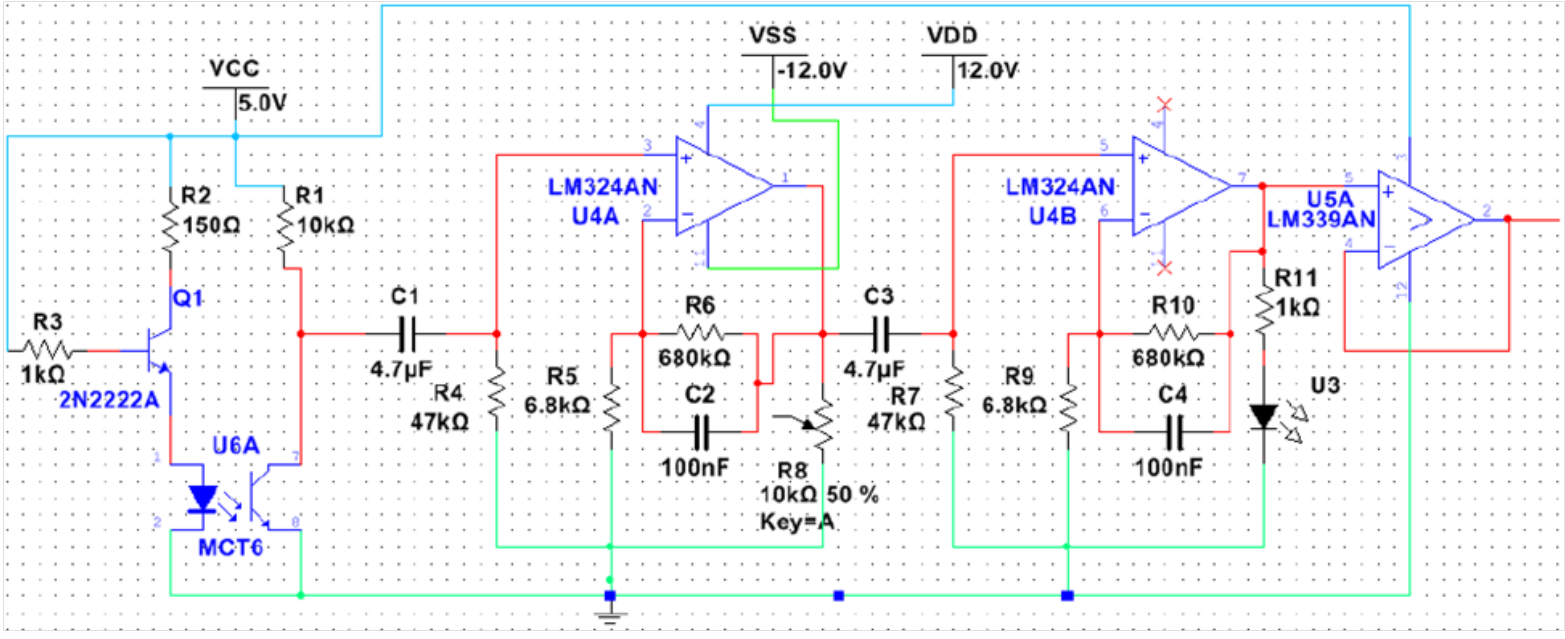
- Hardware Part
- Software Part

Hardware Part



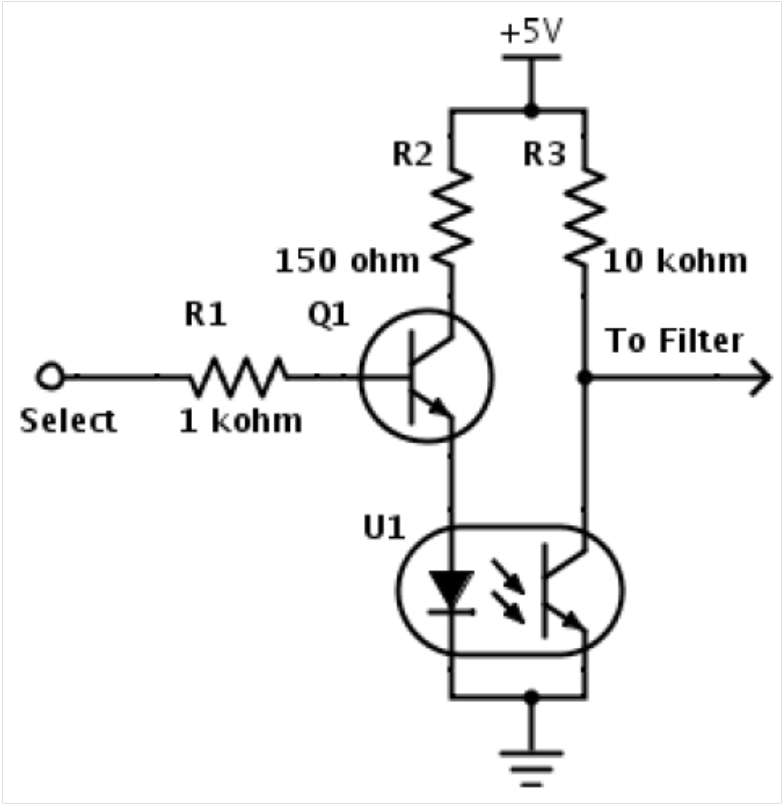
Figur: Hardware Component of the Measurement System

Circuit

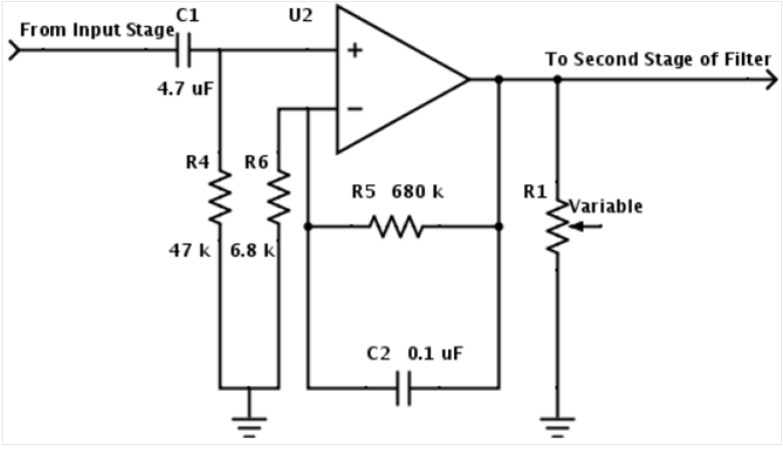


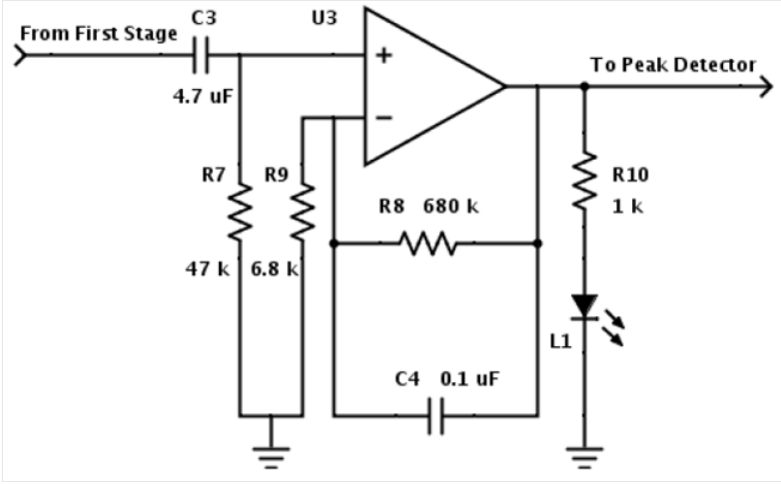
Figur: Circuit Diagram

PPG Signal Acquisition

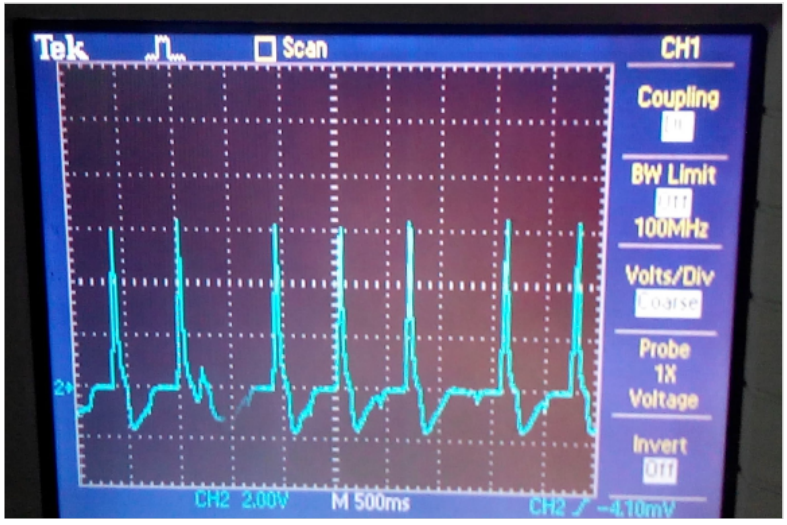


Signal Amplification and Filtering Circuit



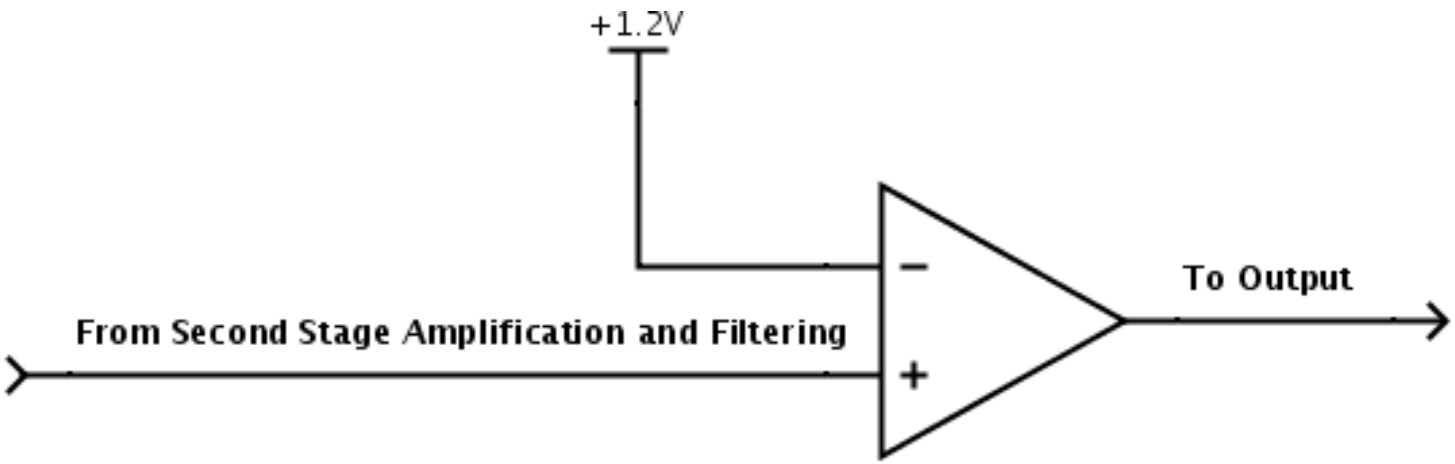


Signal Amplification and Filtering Circuit



Figur: Observation of output of Second Stage of Signal Amplification and Filtering

Peak Detector



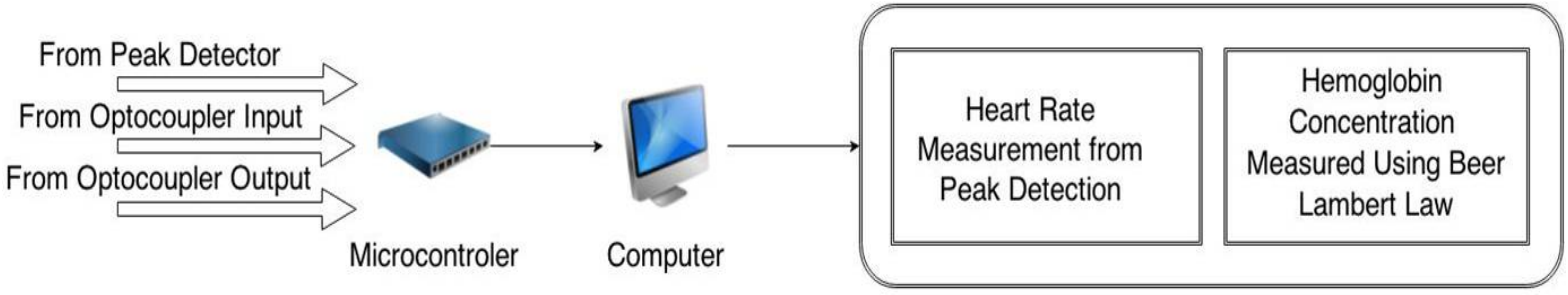
Heart Rate and Hemoglobin Estimation

- The heart rate is computed by estimation of the frequency of the output square wave of the peak detector, in bpm (beats per minute).
- Beer Lambert Law is used to compute the hemoglobin levels:

$$T = \frac{I}{I_0} = 10^{-\epsilon c l}$$

where,
T is the transmittance; **I** is the light intensity transmitted from the solution; I_o is the incident light intensity; ϵ is molar extinction coefficient of the solution; **c** is the concentration of the solution; **l** is the length of the liquid through which the light passes

Software Part



Figur: Software Component of the Measurement System

Result

	Observed Values		
Sl. No.	Actual Heart Rate (bpm)	Observed Heart Rate (bpm)	Observed Hemoglobin Concentration (gm/dL)
Subject 1	78	75	12.8
Subject 2	73	75	12.1
Subject 3	92	90	13.7
Subject 4	81	83	12.5

Figur: Tabulated Results

Conclusion

In this paper, heart rate and hemoglobin levels of human blood have been estimated non-invasively with a good level of accuracy. The easy realization of concept and added benefits of low cost components can help in increasing the availability of cheap healthcare in remote areas. The technique also promises a decrease in discomfort and time lag associated with traditional methods.

Discussion

Future extension of the work can be done in the following directions:

- Measurement of some other blood parameters that can be done by Photo Plethysmography:
  - Blood Pressure
  - Blood Glucose Level
  - Respiration Rate
  - Partial Pressure of Oxygen
- Data can be send by a wireless mode of communication using a micro-controller to a standalone computing unit
- Using cloud storage for storage of medical diagnosis history

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