Study of Photoplethysmography for Vascular Diagnostics

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Abstract: In this paper we study the photoplethysmography; several engineering issues regarding this monitoring technique must be considered .These issues include ambient light and motion artifact, the wide dynamic signal range and the effect of direct light source coupling. The later issue was investigated and preliminary results show that direct coupling can cause attenuation of the detected PPG signal.

Keywords: **Contact, Non-contact, Photoplethysmography, Plethysmography.**

Introduction

Plethysmograph (PPG) is a combination of the Greek word 'Plethysmos' meaning increase and 'Graph' is the words for write. It is an instrument used mainly to determine and register the variation in blood volume or blood flow in the body. These transient changes occur with each heartbeat. [1]There are several different types of Plethysmograph, which vary according to the type of transducer used. The common types include air, impedance, photoelectric and strain gauge Plethysmograph. Each type of PPG measures the changes in blood volume in a different manner and is used in different types of applications [2].

I. Photoplethysmography

The Photoplethysmography is a non-invasive device for detecting blood volume changes by optical means and was first described by Hertzman [3]. Compared to the other types of Plethysmograph PPG is easy to set-up, simple use and low in cost. In addition PPG has the ability to take measurement without having direct contact with the skin surface as is necessary with other plethysmography methods and having good result [6]. There are two methods of PPG and one of them is reflection PPG and other is transmission PPG. In the non invasive reflection PPG method uses the back-scattered optical signals for analysis of skin blood volume pulsations. The periodical increase of blood volume in micro-vessels due to their expansion during the systolic raise of pressure with the following diastolic contraction.(i.e. relaxation) Over each heartbeat causes corresponding changes in absorption of optical signals traveling within the working volume. Consequently, the time dependent parts of the properly filtered PPG signals adequately reflect the skin blood volume during microcirculation. In the transmission method optical signal changes according to its absorption at the pulsation as oxygenated Hb allows Red wavelength more and deoxygenated blood allows infrared wavelength. Which is form spectral characteristics as shown in Fig.1 [4].

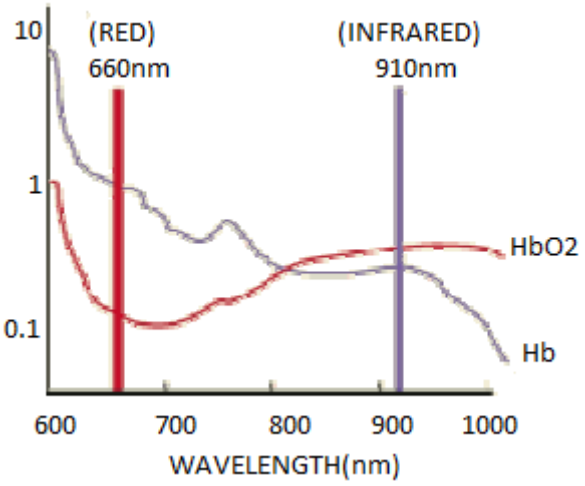

Fig.1. spectral characteristics

I.e. It employs the principle that oxygenated blood is bright red, whereas reduced or deoxygenated blood is dark red so combination of red and near infrared LEDs and photo sensor. By monitoring optical absorption over cardio cycle and consider the absorption to arterial blood alone all other. Absorbance is constant and not varies over cardiac cycle [5].

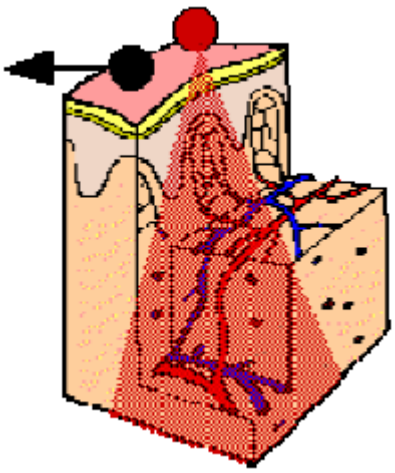

Fig.2.Concept of Pulse Oximetry

Concept of Pulse Oximetry shown in fig.2 an LED illuminates the vascular bed, where pulsating arteries modulate the incident light pulsating which is subsequently detected by a photo sensor.

II. Issues regarding PPG

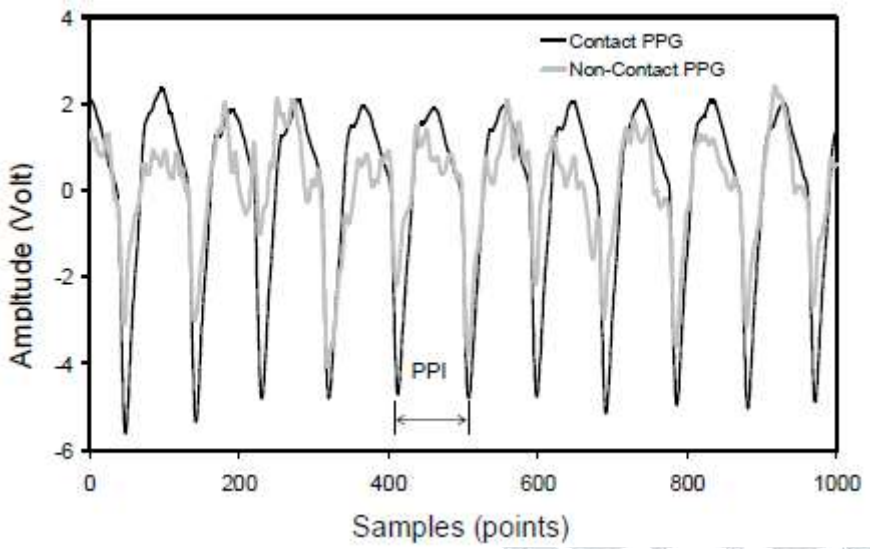

Fig.3.Contact and Noncontact PPG

There are several issues that need to be considered with PPG monitoring. The first issue concerns the contact and noncontactPPG, in which both are has nearly same potential only difference in the amplitude of the received signal and clarity. In the non-contact PPG in which both are has nearly same potential only difference in the amplitude of the receive signal and clarity. In the non-contact PPG signals are not so cleared as compared to contact type [6] as shown in Fig. (3). The second issue concerns the dynamic range of the detected signal. The detected pulsatile (AC) signal is very small compared to the non-pulsatile (DC) signal as shown in fig.4.

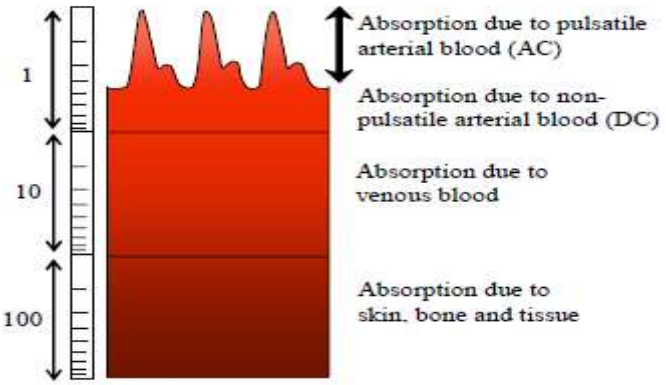

Fig.4.Breakdown of the component of detected PPG signal

The third issue is ambient light artifact. The detector will receive increased ambient light due to the probe separation from the tissue bed. Introducing close packaging of finger bed with detector could reduce this effect. The final issue is the effect of motion artifact. To achieve greater amplification for the AC signal amplifier is used, which can be implemented electronically must be considered. This includes any voluntary and non-voluntary probe and tissue bed. This effect is minimized by increasing the field of view of the source and detector. The detected PPG can be modeled as [2]

PPG signal = DC blood and tissues + AC blood modulates.

III. Design of the PPG sensing devices

The first version of the single channel finger sensor is intended for Clinical use in conjunction with any standard storage Oscilloscope or PC. These basic modules are needed for its operation: The sensor head (fingertip probe with amplifier), signal conditioning circuit and storage Oscilloscope for display or PC with A/D converter. The proposed block diagram is as follows

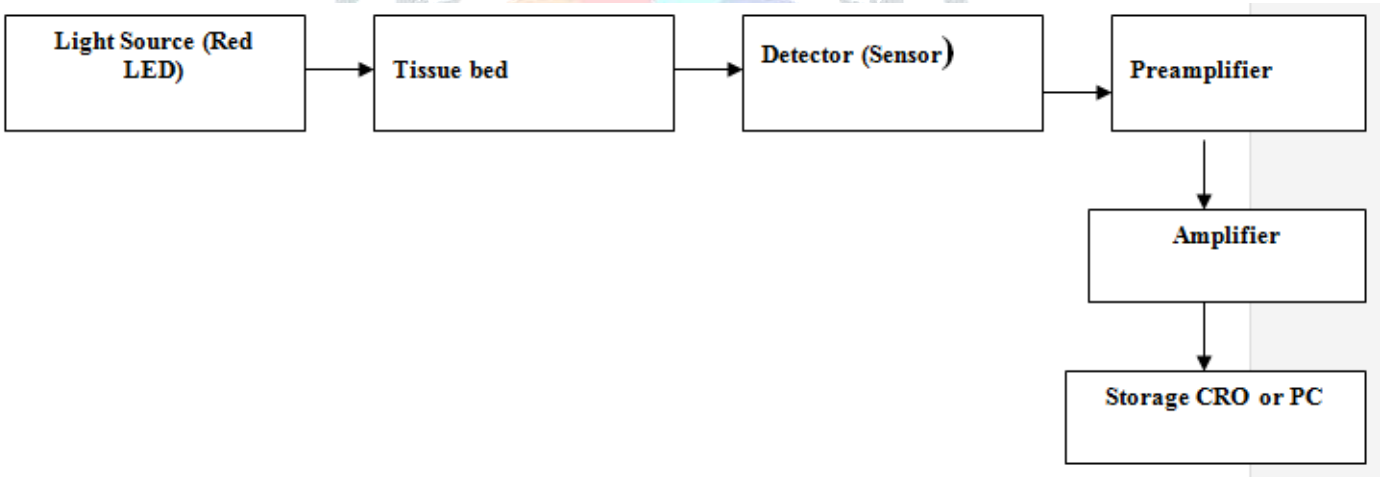

Fig.5. Block Diagram of PPG

It consist mainly Light source, Detector (sensor),Pre-amplifier, Amplifier, Storage Oscilloscope or Computer.

Light Source

The PPG device incorporates a light source and detector, which are placed against the surface of skin. Incident light passes through the tissue and blood and diffuses in the tissue bed. Thus we have to use RED LED as RED LED'S output non-monochromatic i.e. achromatic (is not single valued) i.e. There are different wavelength present in o/p of LED. For e.g. Red LED consist at least 4 wavelengths near about 600 nm. The most important thing is that the requirement of light source such that it should not increase the temperature i.e. there should not be localized heating of finger bed (tissue bed) because it affects the reading. The advantage of using LED as light source is that, it can be operated at smaller biasing voltage. It is low cost and less temperature dependent.

Detector

The detector is photo detector we should consider its response at various wavelengths, so that it should give good response at our usable frequency range to near about 550 nm to 600 nm. The photo detector can be use as a PN junction photodiodes, LDR and solar-cell. All three are wavelength depending can be used but PN junction photodiodes response for very smaller variation is quiet good and also sensitivity is good as compare to solar cell and LDR.The photodiode is used in photoconductive mode, fig.(6).

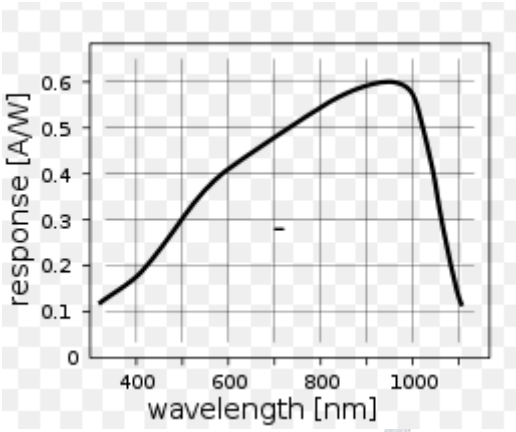

Fig.6.Spectral Response

Pre-amplifier

The detected signals from the detectors can be weak and to get correct prediction we have to amplify it by using high input impedance amplifier having smaller gain but more bandwidth is required. Our signals are having frequency 1.2 Hz or round about it depending on the persons and its physical, medical problems. So our requirement is to achieve good responsivity at given frequency.

Amplifier

The preamplifier signal again amplify to view on storage oscilloscope or to process it for storage on the computer by using ADC.

Storage Oscilloscope

The waveforms are very slow having frequency near about 1.2 Hz so it cannot be observed on general purpose CRO because its sweeping time is generally maximum in seconds and minimum in micro second. But for this signal we require more accuracy and signals can be clearer on storage oscilloscope. There are different types of storage oscilloscopes. One, which we are going to use, is dual channel digital storage oscilloscope, which is having many facilities facility. One of the most important facilities is filter. It have digital filter HP, LP, BP whose frequency and bandwidth can be adjusted.

Conclusion

The present work will help to diagnose the patient from PPG signals suffered by arthritis or diabetes or not and many more parameters can be analyzes from PPG.

Future work

The proposed work can be utilized for analysis of different waveforms of different patient's diagnosis .Our future work is to implement the working model of PPG and analyze the received signal for different diseases.

References

[1] Cromwell "Biomedical instrumentation and measurements"

[2] Peck Y.S., Cheng and P. R. Smith "An overview of noncontact PPG", Dept. of Electronics and Elect. Engg. Loughborough University, LE11 3TU, UK..

3] Joydeep Bhattacharya, Partha Pratim Kangilal "Analysis and characterization of photo-plethysmography signal", IEEE transactions on Biomedical Engg. Vol.48, no.1, Jan 2001.

[4] R.S. Khandpur "Hand book of biomedical instrumentation''.

[5] Vincent P. Crabtree et.al. "Prospective Venox Feasibility Study", Department of Electronic and Electrical Engineering, Loughborough University, LE11 3TU, UK
[6] Sijung, "Comparison of pulse interval in contact and non-contact photoplethysmography" Department of Electronic and Electrical Engineering, Loughborough University, Ashby Road, Loughborough.

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