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PPG Signal Detection in Arterial Blood Pressure

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Abstract—
As being describe PTT is a delay time measured from R wave of electrocardiogram (ECG) to base point of Photo PlethysmoGramm (PPG). Since PPG can be acquired from finger, ear, brachial or toes, in this project the PPG is taken firm finger utilize the finger probe of pulse oximetri. Describe the PTT which is measured from time of peak of ECG (R) to the foot point of PPG corresponding to the R wave before it rises. Therefore this project is aimed at designing a non invasive cuff-less blood pressure estimation system based on pulse transit time (PTT) technique. Based on previous work of others, the photo-plethysmographic (PPG) as MATLAB communication interface. The algorithm to measure PTT from R of generated electrocardiogram (ECG) to base point of PPG waveform was developed using Visual Basic 6 (VB6) which this programming also used to develop the graphical user interfaces (GUI) to display the estimated SBP and DBP by offline and online process. The results have shown that the PTT measurement between ECG and PPG of pulse oximeter have a great potential for blood pressure estimation.

Keywords—
EEG; ECG; PPG; PIT

I. Introduction

Blood pressure is the most often measured and the most intensively studied parameter in medical and physiological practice. The blood pressure signal is important to determine the functional integrity of the cardiovascular system. Supplemented by information about other physiological parameters, the blood pressure is an invaluable diagnostic aid to access the vascular condition of certain illnesses Blood Pressure measurement techniques are basically put into two classes: direct and indirect. The direct method measurement is used when the very high level of accuracy, dynamic response and continuous monitoring is required. In invasive or direct measurement, the operation uses a pressure transducer that is coupled to the vascular system through catheter that is inserted to blood vessel. In early eighteenth century, the first blood pressure measurement is attributed to Reverend Stephen Hales, who has conducted an experiment by connected water-filled glass tubes in the animals' arteries and correlated their blood pressure to the height of the column of fluid in the tube The classical method of an indirect measurement of blood pressure is by using a cuff over arm containing the artery. The indirect techniques are non-invasive, with improved patient comfort and safety, but at the expense of accuracy introduce a continuous blood pressure recording system using a pneumatic-driven finger cuff and then extended the ideas and develop a continuous blood pressure recording system using water-driven cuff At present, since technology grow, the development of wearable cuff-less blood pressure measurement device using new techniques, such as Pulse Wave Velocity (PWV), Pulse Transit Time (PTT) and Photo PlethymoGramm (PPG) amplitude approach becomes interest among biomedical engineering researchers. Assist by nano-technology semiconductor, the bio-instrument can be designed smaller and light to carry around by users thus, their heath conditions can be monitored during daily activities.

In modem world, demands to improve living styles causes most people not to really concerned however since the awareness of high blood pressure is the biggest known cause of disability and premature death through stroke, heart attack and heart disease, medical doctor recommended a regular self monitoring of blood pressure to make sure of the necessary to control blood pressure and prevent it from taking the shape of either hypertension or hypotension.

Mention that the evolution of e-health systems from desktop platform to wireless mobile shows the disadvantages of conventional blood pressure meter that limited their application in home monitoring. These conventional blood pressure meters can be consider as bulky and the capability to use these instrument several times for daily monitoring is inconvenience. Indeed, the invention of wireless technology in medical system and different approach to measure blood pressure is the basic motivation of the present work. Herein, this research is done to estimate blood pressure, using cuff-less method base on pulse transit time. In addition, a graphic user interface is designed to display the measurement of systolic and diastolic blood pressure via computer plat form wirelessly to describe wireless mobile healthcare as future trend.

This research is intended to estimate blood pressure different from conventional oscillation technique. Therefore, the objectives of this research are: To design a non-invasive cuff-less blood pressure meter based on pulse transit time (PTT).

To display the estimated value of systolic blood pressure and diastolic blood pressure using graphic user interface. In order to archive the objectives, this project research is done guided by the following scope: Designing an electronic circuit which consists of sensor, amplifier circuit and a band-pass filter to obtain the Photo PlethymoGramm (PPG) waveform. Calculating the Pulse Transit Time from generated ECG waveform and PPG waveform and then estimate the diastolic blood pressure and systolic blood pressure base on equation designing of micro-controller circuit to perform an analog to digital converter and to transmit the signal to computer via Bluetooth module interface. Designing software to perform an algorithm to measure the Pulse Transit Time and then a graphic user interface to display the estimated systolic blood pressure and diastolic blood pressure.

II. Block Diagram

Blood Pressure measurement based on Pulse Transit Time (PTT) approach is chosen for this project. As being describe PTT is a delay time measured from R wave of electrocardiogram (ECG) to base point of Photo Plethysmo Gramm (PPG). Since PPG can be acquired from finger, ear, brachial or toes, in this project the PPG is taken firm finger utilize the finger probe of pulse oximetri. Describe the PTT which is measured from time of peak of ECG (R) to the foot point of PPG corresponding to the R wave before it rises.

Measurement of pulse transit time from ECG and PPG Then based on estimation equation of diastolic blood pressure and systolic blood pressure provide the blood pressure is being estimate using PTT measured from R wave of generated ECG waveform and PPG measured from finger using Nellcor Pulse Oximetri Sensor.

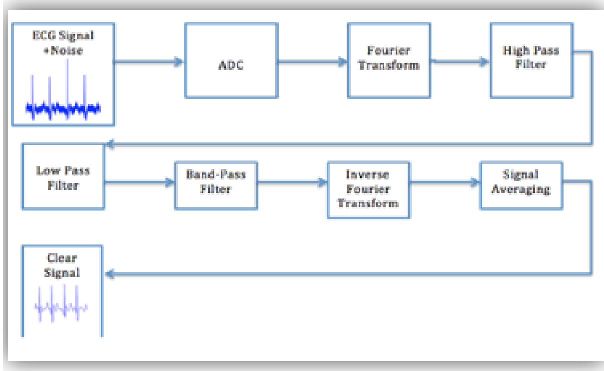

Fig 1. Block Diagram

III. Method And Equipment

The parameters that can be measured with this device are pulse shape and PPG signal delay time. Calculations are necessary to pinpoint the PPG signal "footprint" or minimum. This in turn means that the signal can’t be filtered because the filter changes the signal shape and the phase shift. The equipment novelties are the abandonment from the standard sensors, equipment design simplicity and a digital signal in PPG sensor. Selected silicon PIN photodiode OSRAM - BPW34-FA - with daylight filter and the active surface area of $7mm^2$ and the peak spectral response wavelength of 880nm was used. A SMD type of an infrared radiant diode model which is SIR91-21C/F7 was used with a peak wavelength of 875 nm, a transmission angle of 20°, and a diameter of 1.9 mm. A housing material is cured polyurethane sealant, especially suitable for mounting of electronic circuit components. A special screening

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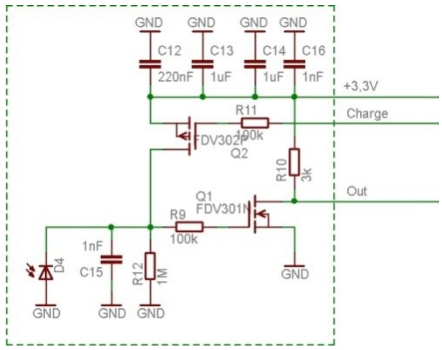
barrier for photodiode was made within the sensor to lower the influence of ambient light.

Another important improvement is the use of a solid state digital field transistor (physically close to the photodiode). In our case, it is necessary to place the sensor ~ 0, 5 - 1 m away from the measurement unit. Thus, the impact of movements during measurements will result with corrupted PPG signal. Block diagram of the equipment is shown in figure 1. The key novelty is that the design does not contain analog amplifiers, filters and capacitors in the signal input circuit.

The circuit has an integrated LED driver that provides stable power throughout the battery discharge range. The only filter integrated in the design is a second order Butterworth low pass filter with the cut off frequency of 42Hz @ 3dB. This filter did not distort the signal shape and phase because typical bandwidth of the PPG signal is 0,05 – 40Hz. The measured noise level of the device is -30 to -40dB compared to the PPG signal level. The real physiological noise is considered as a signal recorded from sensor placed on the skin with completely occluded blood circulation.

Originally this device was designed for scientific purpose, which requires analog signal output to one common data acquisition system. Therefore digital PPG signal was converted using 12-bit eight-channel digital - to - analog converter (TLV5610). Three channels are used to regulate LED current.

In the sensors, there is an integrated signal conversion scheme (Fig. 2). The PPG method uses N-channel transistors that are digital FET. The transistor Q2 charges capacitor C15 and a photodiode with a supply voltage of +3.3V. While Q1 converts the signal level from the analog to digital, the resistor R12 is a pull-down resistor that discharges capacitor C15 and diode D4. R10 is a pull-up resistor, so that the cable length connecting the sensor to the main circuit board is almost irrelevant because of the transmitted logic levels of +3.3V. Parallel to the photodiode D4 is the added capacitor C15 with a capacity of 1nF. Photodiode capacity following the manufacturer's specifications is 72pF, which is little compared to the C15, which acts as ballast. If prolonging the duration of the discharge, it will increase the signal amplitude, but reduce sample rate. Discharge time is fixed to 1ms, which corresponds to 1000 measurements per second. Capacitor C15 and photodiode D4 is charged with the measurement clock frequency 1 kHz. Capacitor charging time is constant - 30us (lower waveform figure 3). We performed tests with different charging times and found out that this is the minimum required to charge the 1nF capacitor. After each charging cycle, the discharge takes place, which is measured and depending on the photodiode, the incident radiation intensity is also measured



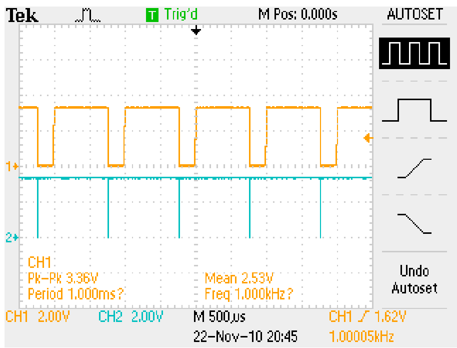
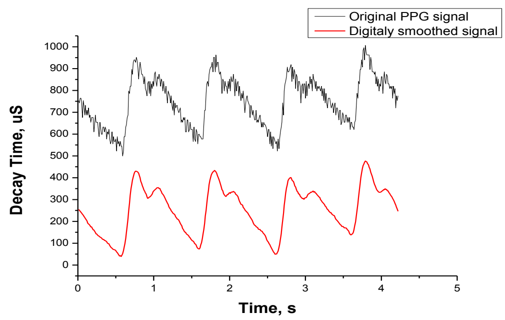


Figure 2. Electronic circuit of the sensor.

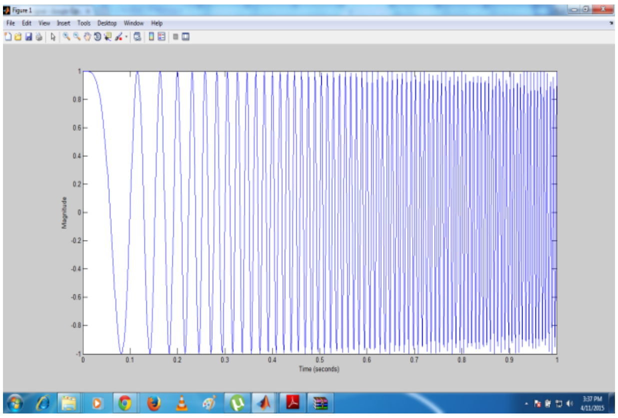


A B

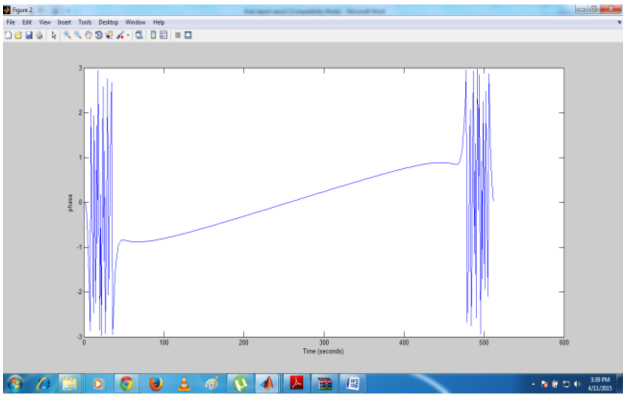
Figure 4. Photoplethysmography signals measured within infrared spectrum (940 nm). A - Represents a signal output from the earlier device [3], B - shows signal captured with our improved

methodology and device. Waveform is original unfiltered directly outputted from the device.

IV. Result And Discussion



Output 1



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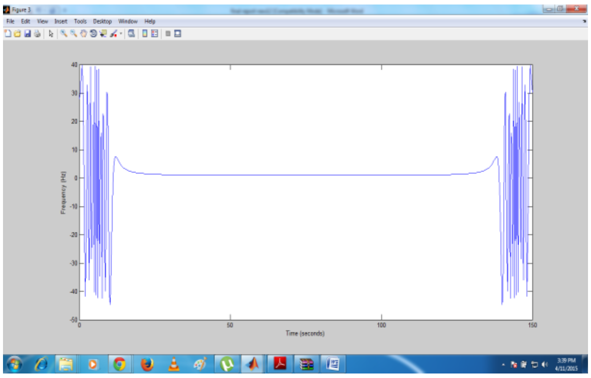
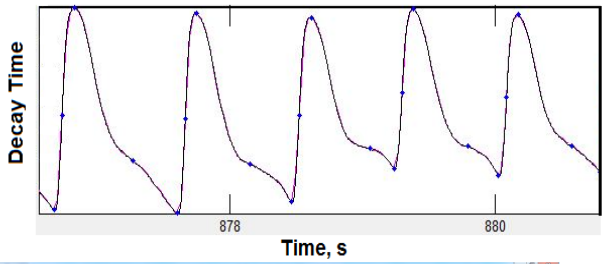
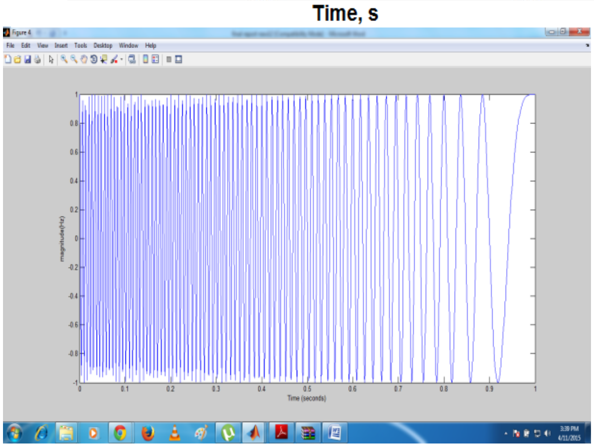


Output 3





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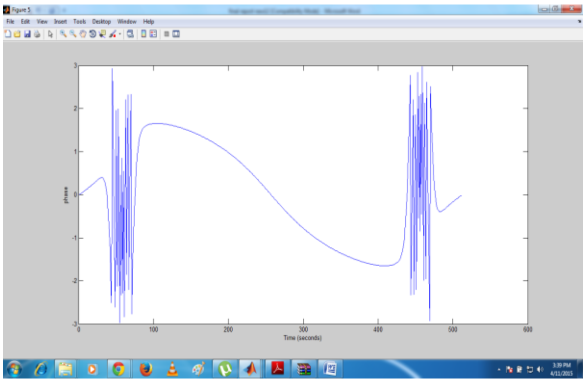
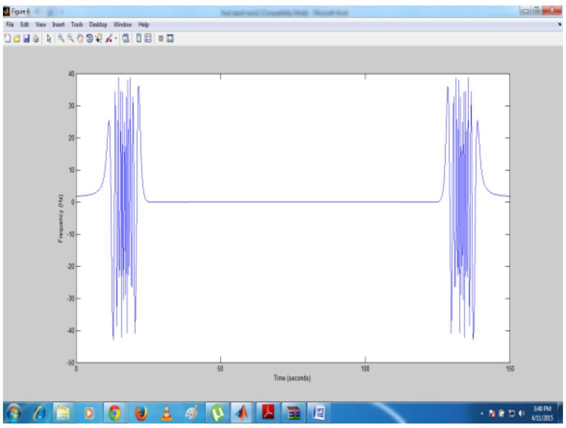


Output 5



Output 6

V. Conclusions

The analysis can lead to identify the content of PPG signal which is different for healthy and cardiovascular patients. From the table it is clear that the original signal and db4 denoised signal are more correlated compared to other wavelets used. Hence it can be used for analyzing PPG. Analyzing PPG signals carefully can give us information related to diabetes and arthritis patient, because in their case there is a difference in the pulse shape changes as a function of disease which can be well observed visually. We also investigated heart rate and respiratory rate using PPG signal.

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