DR NOPRICK

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Abstract— Examination of blood in order to obtain accurate values of blood glucose and hemoglobin has always involved removal of blood from the human body via painful methods such as pricking through needles etc which is a nightmare for children and adults alike. Our project aims to design a non-invasive technology to measure these parameters with accuracy and immediately. This is not only a cost effective and least painful but also a boon in emergencies. The fundamental principle behind this is photoplethysmography. The fiber optics plays a important role in electronic communication as well as in biomedical operations. The concatenation of photoplethysmography along with optical fiber is the basic working model of the project. The finger tip of a human subject will be subjected to illumination by laser/infrared sources, the corresponding absorption of light by the blood cells takes place and the unabsorbed light is obtained at the photodiode on the other end. The statistical analysis of the results after due amplification and filteration, gives us the corresponding hemoglobin and blood glucose levels.

Index Terms—Non Invasive,Optical fiber,Laser,Hemoglobin,Photoplethsmography,Blood Glucose

1 INTRODUCTION

1.1 Motives and Background

The suffering, pain and discomfort of patients(especially those suffering from diabetes) and infants undergoing the needle to get their blood checked was the driving source to invent a non invasive device which would reduce these to a greater extent. The application of photoplethysmography came as a rescue which helped eliminate the need of needle thus making the process painless. Also, since this process gave much faster results it could prove to be lifesaving in case of emergencies when a patient cannot wait for hours to get the results.
[3] [5]

1.2 Problem Statement

The targeted objectives are as follows

- To eliminate the need of pricking the blood out of body for the measurement of parameters like Blood glucose and hemoglobin.
- Provide immediate and error free measurements without need of huge lab setups, which can help serve even in rural districts.

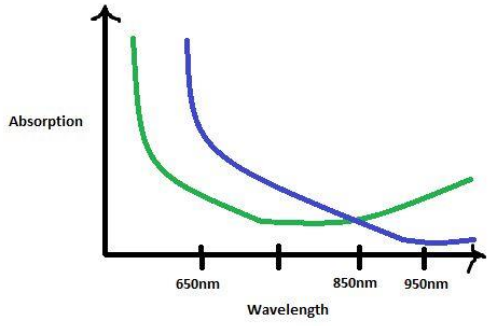
1.3 Cost Management and Sustainablility

Introduction of non –invasive techniques can be revolutionary as it can change the way many of the blood parameters are measured. Huge lab setups can be replaced with portable and cheaper devices. Also, since blood isn't removed from the body , the need for preservation and maintaining the hygiene can be done away with thus marginally reducing the cost of checkups. This will directly benefit even the poor and rural citizens. Thus a cost effective and painstaking system can be designed with a minimum cost of around 3000 INR.

1.4 Underlying principle

The basic principle on which our proposed system works is illumination of finger of human subject with light of different wavelengths. The end results are in the form of PPG waveforms. The pulsatile change in absorbance in show in a graphical form and waveforms. This is called the "plethysmographic trace".
The light from the laser source is coupled with single mode Optical fiber which has higher bandwidth.
Hemoglobin is the protein molecule in blood cells which carries oxygen from lungs to the body tissues.
The blood hemoglobin consists of two subtypes i.e. Oxy-hemoglobin and DeOxy-hemoglobin. The deoxy hemoglobin is not oxygen bound whereas the other one isn't. Oxy-hemoglobin absorbs more infrared light than red light & deoxy-hemoglobin absorbs more red light than infrared light which has a wavelength of approximately 650 nm as shown in above figure 1

Figure 1



The other is an infrared light, which has a wavelength of 950 nm. The amount of light absorbed is proportional to the concentration of Hb in the blood vessel. However, some

factors which affect the absorption are thickness of tissues and arteries, concentration of light etc which must be overcomed. Absorption is also based on Beer Lambart's law which is stated as below:

Beers Lambert's law states that the amount of light absorbed by the medium is directly proportional to thickness of the medium through which light is being transmitted, multiplied by the concentration of medium shown in figure 2 and also,

A = ebc

Where, A -> absorbance, e -> molar extinction coefficient, b -> thickness of the solution, c ->concentration of medium. It can also be given as,

$$\text{Log}_{10} I_o/I = \varepsilon lc$$

Where

$I_o$is the output optical intensity

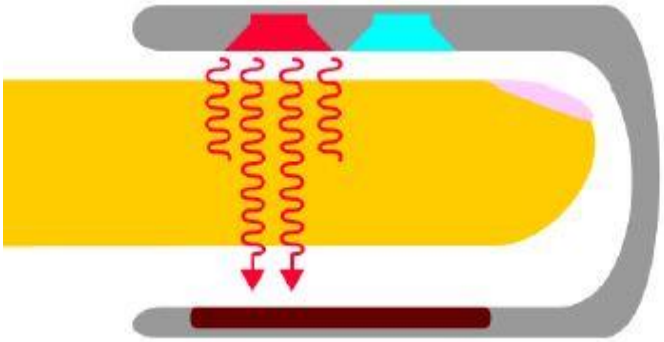
I is the input light intensity

ε is molar coefficient

l is the length of human finger

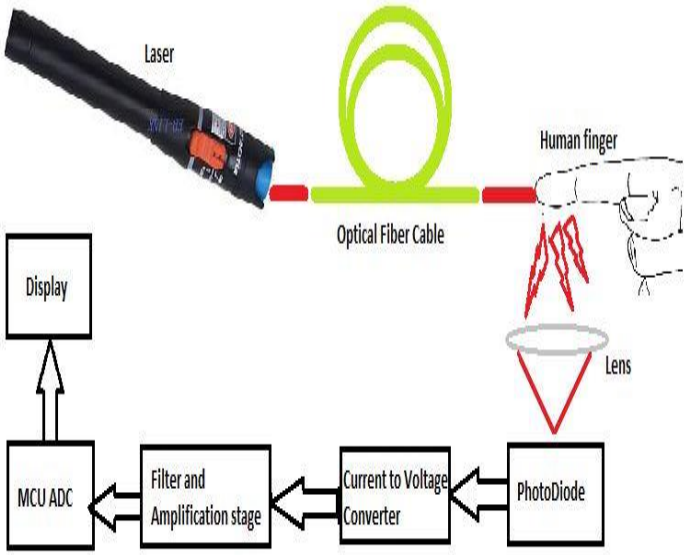
and c is the concentration of solution inside the human subject

Figure 2



SR NO	Picture	Component
1		Visual Fault Locator used as a Red Laser
2		Infra red LED(Emitter and Detector)
3		Single mode Fiber
4		Photodiode BPW34
5		Micro Controller Unit(MCU)
6		CRO/PC

Figure 3 Basic Block Diagram



2 PROPSED METHODOLOGY

Table 1.Components Used

Table 2. Specifications

SR NO	Component	Specification
1	Visual Fault Locator	• 10mW Power • λ=650nm±20nm • 2.5mm Universal Connector • Output power≥10mW
2	IR LED(Pair)	• VSML3710 • 5mm photodiode • λ=940nm(Tx) • λ=940nm(Rx)
3	Optical fiber	• Single mode fiber • PC-SC Connector • Higher Bandwidth • Ins Loss =0.09dB and Ret.Loss=51.9dB
4	Photodiode for Red Laser	• BPW34 • $\lambda_{0.1}$=430-1100nm • Suitable for visible and near Infrared radiation
5	Microcontroller Unit	• Microcontroller Kinetis K53 • 24 single ended ADC 16 bit ADC channels • Core up to 100 MHz and bus speed up to 50MHz
6	CRO/PC	• To observe the PPG waveforms and analyze them

3 WORKING MECHANISM

3.1 Input Stage

We are using two light sources in order to detect Oxy Hemoglobin and De-oxy Hemoglobin. One is a CW Red laser and the other is Infrared LED.Red laser has wavelength about 650nm and IR LED has wavelength about 950nm.Lasers provide faster speed and has narrow spectral width dealing with less spot area.Lasers give more penetration when compared to LED and Laser gives stimulated emission.The light from these sources is coupled into a optical fiber to give a more sharper beam and hence more penetration into the human subject.Optical fiber is a single mode fiber giving higher bandwidth.Tables 1,2 gives components and their specifications.

3.2 Intermediate Stage

The light coming out from a fiber depends on the numerical aperture i.e. light gathering capacity of fiber.The light from the fiber is given to the human subject that is it is placed on a human finger.A lens can be used to receive a more sharper beam on the detector side.The photo diode BPW34 is used for red laser detection and PD333-3B/H0/L2 IR detector are placed on the both the sides of finger that is,at the opposite end as well at the transmitting end because some light will get transmitted whereas some will be reflected.The emitted light will be equal to sum of light absorbed,light reflected and light transmitted through the finger. These parameters can be calculated using Beer's Lambert's law and solving equations simultaneously on placing photo diodes on both the ends.

3.3 Reception Stage

The signal coming from photo diode is in the form of some current which needs to be converted into a voltage for results.Hence we use a current to voltage converter and the signal is further given to filter and amplification stage consisting of low pass,high pass and notch filter in figure 4 operated at suitable frequencies and also a amplifier having gain of 31.Filters,amplifiers are used for noise and Dc component removal generated due to skin,tissues and any other substance which is non moving in the blood,since we need to analyze only the results generated due to the arterial or moving blood and neglect everything else.Now we get a noise free and a simple AC signal which is very small but a more amplified signal than before. [4]

4 EXPERIMENTAL SETUP

Figure 4

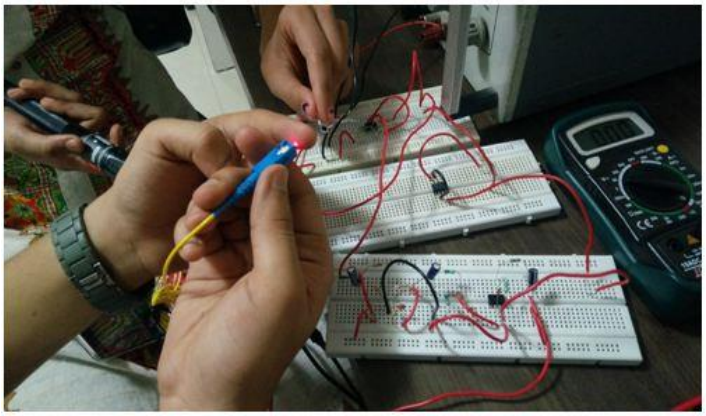
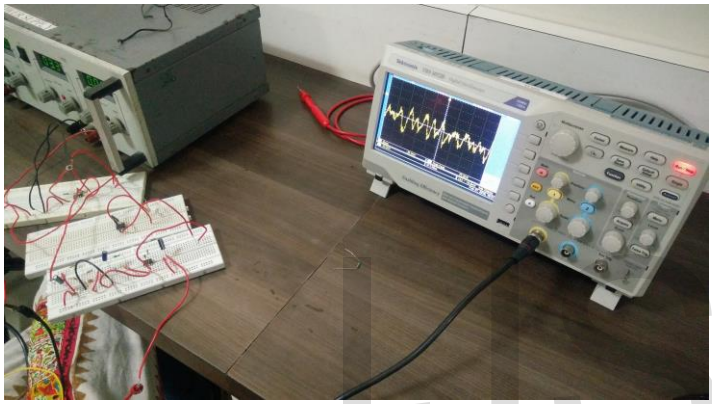


Figure 5



5 RESULTS AND ANALYSIS

This AC signal is a pleth and we need to analyze that pleth or a graph using photo-pleth-smography process for determination of percentage of Oxygen Saturation (SpO2).One sample of Red and IR sample is taken every 1ms and captured by the 16 bit ADC where analog to digital conversion is done and filtered using FIR software on K53 and samples are stored on the software buffer and averaged.A peak detection algorithm is used to determine the AC component of the signal generated by the arterial blood absorption.This part of the signal is used for Spo2 determination.This PPG waveform is very small when compared to Dc component generated due to skin,tissues etc.A healthy patient or a patient having good hemoglobin will have a very good Pleth as shown in figure 5.As we need only the AC part ,the total signal consisting of AC and DC part is subtracted from the DC part only to obtain a pure AC signal.A pleth tells us how good the pulsatile signal is.PPG waveform consists of a Systole and a Diastole.In Systolic phase,diameter of artery is increased,hence there is more blood which indicates more absorption.Ac part is due to systolic phase as shown in the figure.So the Basic idea is to determine ratio of red to the IR light absorbed and give it to compuer and finally display the Percentage of Oxygen Saturation or Oxy hemoglobin on the PC or a LCD. [1] [2]

6 CONCLUSION

In this article we have presented a non-invasive blood hemoglobin meter that can provide hemoglobin measurements painlessly with the help of two wave length 650nm and 940nm, without a blood sample or finger pricks, within a few seconds. The device can be easily adapted to provide continuous blood oxygen level and maintain a history of these measurements. The device algorithm can also be modified to provide other capabilities like heart rate and blood glucose using the same devices and sensors.

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