NON-INVASIVE MONITORING OF GLUCOSE

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Introduction :

Diabetes is a trivial disease as heart attack and cancer. Diabetes can lead to kidney failure, blindness, and amputation. It was estimated by the World Health Organization that there will be 177 million who suffered diabetes in 2000.In 2030, diabetes is predicted to be the 7th leading cause of death in the world. Available glucometers uses invasive mechanism. Diabetic patients need to monitor their blood glucose two to three times a day.

A recent studies have indicated that the health risks associated with diabetes are significantly reduced when the blood glucose level are well and frequently controlled. Thus having proper monitoring at home or work is important. At present, the common existing methods of blood glucose monitoring require obtaining a blood sample by pricking a fingertip with a needle. These methods sometimes discourage the patient to take the test because the procedure is invasive. Non-invasive methods of monitoring blood glucose level are more superior to the current invasive method. A portable and non-invasive glucose meter is highly demanded by the society. There are many approaches on designing non-invasive glucose meter. Near infrared method is safe as there is no direct electrical contact between the patient and the device. The concentration of glucose in the blood is calculated based on the scattering and absorption of light through the blood. The level of the concentration is displayed on the LCD. In addition to near infrared method, there are a variety of the optical methods for the non-invasive technique like Raman's spectroscopy, photo acoustic spectroscopy, polarization technique, polarimetry and light scattering. So, developing a non invasive way of measuring blood glucose would be much more convenient from the end user prospective. The aid from irritation and unease due to frequent finger pricks and reduction in medical waste would be the main advantages of non invasive glucose meter. Non invasive analysis of the glucose minimizes all the above troubles involved and hence cut down the healthcare cost.

The NIR circuit includes an infrared emitter and a photodiode mounted side-by-side and pressed closely against the skin. The output of the photodiode is connected to the amplification circuitry. The amplified signal is fed as an input to the microcontroller where the glucose level is calculated using regression analysis. The calculated value of glucose is displayed on the LCD. The pulse sensor involves an in-built circuitry which is used to obtain the voltage values in analog form. The voltage values obtained are converted into glucose level by carrying out the regression analysis in the microcontroller. The obtained glucose level is then displayed on LCD.

Objective:

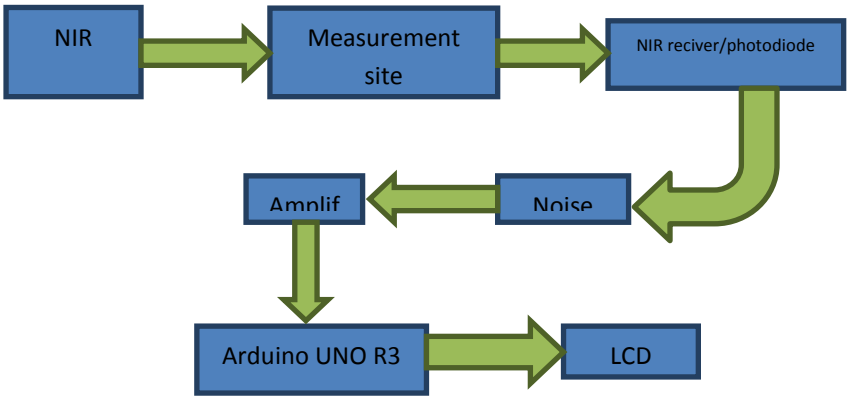
The objective of the project is to monitor glucose level using non invasive technique by optical technique. The proposed sensor circuit consists of IR LED's of wavelength 650-2500nm for optical blood glucose measurement and NIR photodiodes (InGaAs) and pulse sensor to receive the reflected light from body parts to determine the glucose level.The NIR circuit includes an infrared emitter and a photodiode mounted side-by-side and pressed closely against the skin. The output of the photodiode is connected to the amplification circuitry. The amplified signal is fed as an input to the microcontroller where the glucose level is calculated using regression analysis. The calculated value of glucose is displayed on the LCD. The pulse sensor involves an in-built circuitry which is used to obtain the voltage values in analog form. The voltage values obtained are converted into glucose level by carrying out the regression analysis in the microcontroller. The obtained glucose level is then displayed on LCD.

Methodology:

This project involves non-invasive monitoring of glucose using NIR and pulse sensor. Near-infrared spectroscopy (NIRS) is a spectroscopic method that uses the near-infrared region of the electromagnetic spectrum (from 780 nm to 2500 nm).Near infrared measurements are based on specific absorption bands in the electromagnetic spectrum between 800 and 2500 nanometers (nm). This region is just above the visible light region of 400 - 700 nm. Electromagnetic waves in the region have the best combination of energy, sensitivity and absorption to be useful for quantitative measurements of solid materials

The basic pulse sensor consists of a light emitting diode and a detector like a light detecting resistor or a photodiode. The pulses causes a variation in the flow of blood to different regions of the body. When a tissue is illuminated with the light source, i.e. light emitted by the led, The amount of light absorbed depends on the blood volume in that tissue. The detector output is in form of electrical signal and is proportional to the pulse rate.

Block Diagram :



The block diagram consists of the following components

i. NIR emitter
ii. Measurement site
iii. NIR receiver/photo diode
iv. Noise filter

v. Amplifier
vi. Arduino UNO R3 microcontroller
vii. LCD

NIR emitter:- NIR sensor of range 900nm -1100nm as the emitter is used.
Measurement site:- The measurement site can be finger or earlobe. In this project finger is chosen is finger.

NIR receiver/photodiode:-The photodiode converts the light signal to voltage signal. The range of the voltage signal is in mV.

Noise filter: The noise filter is used to remove the unwanted signals/ripples.
Amplifier:-The amplifier is used to amplify the signal which is to be fed as input to the microcontroller.

Arduino UNO R3 microcontroller.The microcontroller used here is arduino UNO R3 .The ATmega328 has 32 KB (with 0.5 KB used for the boot loader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library).
LCD: A 16x2 liquid crystal display is used to display the glucose level obtained.

Working:

The near infrared circuit involves the use of NIR sensor of range 900nm -1100nm as the emitter and photodiode as detector. These two are mounted side by side in a finger cap and the finger is pressed against these two .The photodiode converts the light signal to voltage signal. The magnitude of the obtained signal is in mV. The output of photodiode is connected to the amplification circuit. The amplification circuit makes use of the op-amp LM324, resistors of the range 220Ω,1KΩ, 1.8KΩ,8.2KΩ,39KΩ,68kΩ,470KΩ,capacitors of range 0.1µF and 1µF and transistor 2N3904. The output of this amplification circuit is fed as an input to the A0 pin of the microcontroller. The microcontroller used here is Arduino UNO R3. Regression analysis which gives the relation between input and output parameters is carried out to calculate the glucose levels in mg/dl in microcontroller. The glucose level obtained is displayed on the LCD (16X2 LCD display) which is connected to the digital pins of the arduino UNO R3 or it can also be displayed on the serial window.

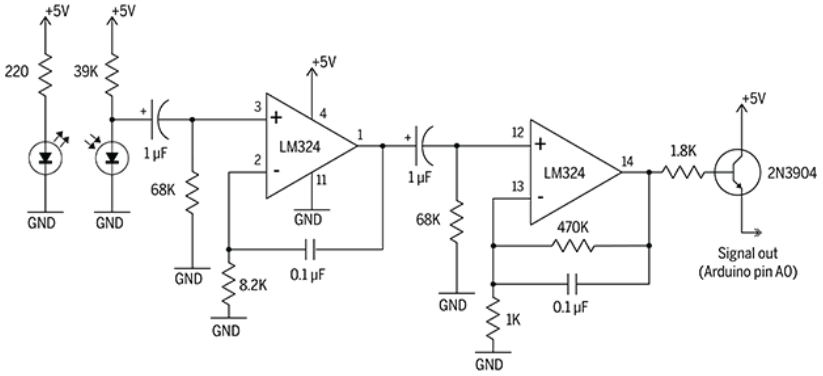


Fig.1 Schematic diagram of the NIR sensor and its amplification circuit

A high pass filter is a filter which passes high-frequency signals and blocks, or impedes, low-frequency signals.

In other words, high-frequency signals go through much easier and low-frequency signals have a much harder getting through, which is why it's a high pass filter.High pass filters can be constructed using resistors with either capacitors or inductors. A high pass filter composed of a resistor and a capacitor is called a high pass RC filter. And a high pass filter with a resistor and an inductor is called a high pass RL filter.A high pass RC filter, again, is a filter which passes through high-frequency signals, composed of a resistor and capacitor. As a capacitor is a reactive device, it offers differing resistance to signals of different frequencies entering through it. A capacitor is a reactive device which offers very high resistance to low-frequency, or DC, signals. And low resistance to high-frequency signals. As it offers very high resistance to DC signals, it blocks them from entering through, as you can see in the circuit diagram above. So this type of filter only allows high-frequency signals to pass through and not DC. This type of capacitor also functions as a coupling capacitor because it couples the AC signal from one part of a circuit to another, while blocking the DC.

An amplifier, electronic amplifier or (informally) amp is an electronic device that can increase the power of a signal (a time-varying voltageor current). It is a two-port electronic circuit that uses electric power from a power supply to increase the amplitude of a signal applied to its input terminals, producing a proportionally greater amplitude signal at its output. The amount of amplification provided by an amplifier is measured by its gain: the ratio of output voltage, current, or power to input. An amplifier is a circuit that has a gain greater than one.

The pulse sensor involves an in-built circuit as shown in fig.3. Pulse sensor is connected to A0 pin of the microcontroller(arduino UNO R3).The pulse sensor is used is to obtain the analog voltage.The analog voltage is converted into mg/dl(unit of glucose level)using the equation.The output is displayed on a 16X2 LCD .The serial window can also be used to display the output.

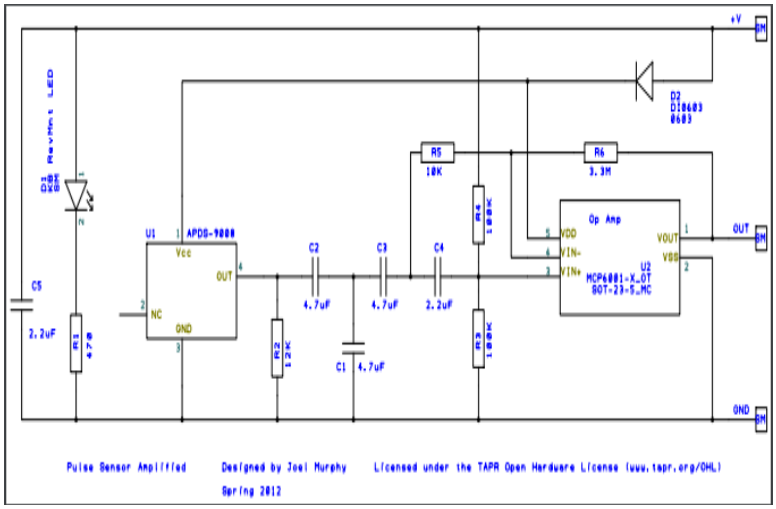


Fig.2. interior circuit of pulse sensor

Fig.3.Pulse sensor

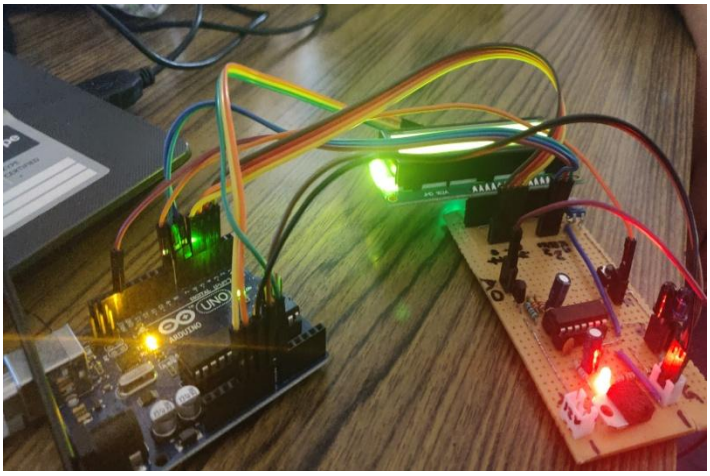
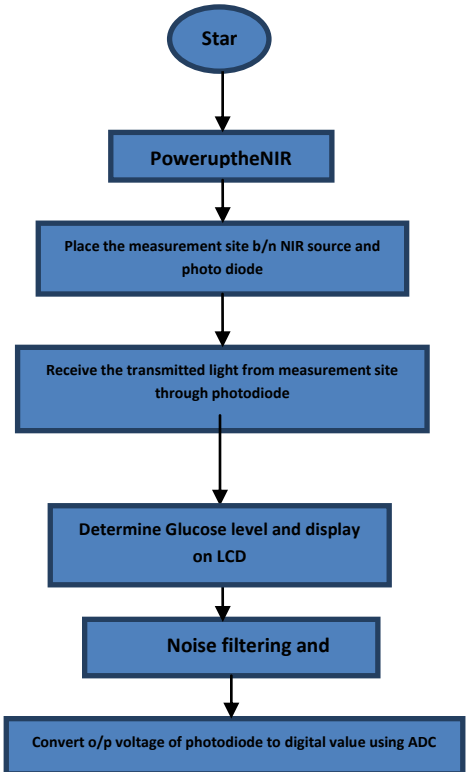


Fig.3 Hardware Kit

Flowchart :



Results And Conclusions :

Constructed system determines a method for the prediction of blood-glucose level for human using non invasive methods.

By using this voltage value as X value in regression polynomial, glucose concentration can be predicted.

Data sets of 4 subjects using the invasive method and non invasive method(NIR sensor and PULSE sensor) and a comparison between the both is made .

SL.NO	NAME	GLUCOMETER READING	NIR SENSOR READING	PULSE SENSOR READING
1.	Patient 1	112	93.85	116.26
2.	Patient 2	124	106.24	147.65
3.	Patient 3	176	166.37	171.05
4.	Patient 4	123	103.46	143.81

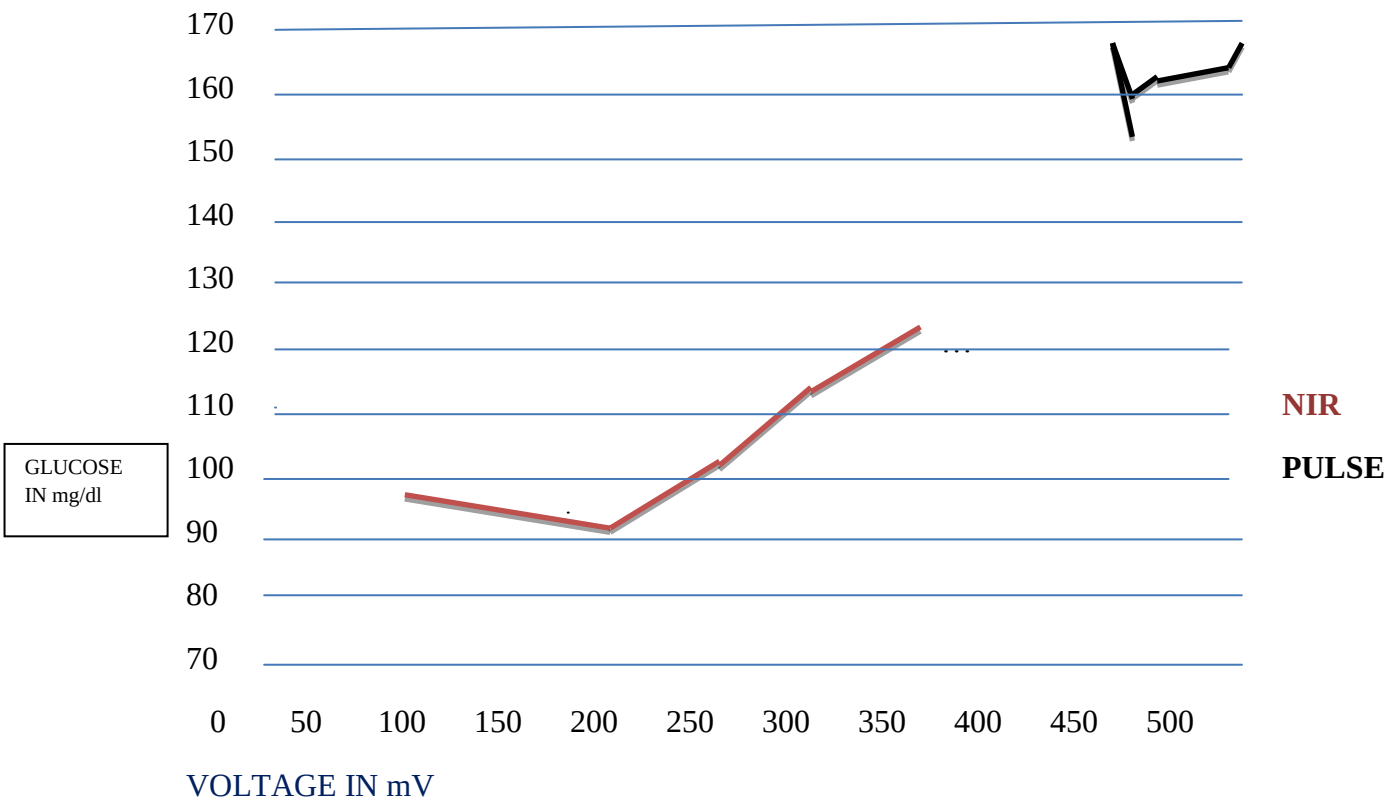
A slight variation in the readings is observed in the invasive and non-invasive method a tolerance level of +-50% is observed in the non-invasive method.

Dataset of 6 subjects using non invasive methods by carrying out the regression analysis.

Sl.no	Name	NIR sensor reading	Voltage value in mV	Pulse sensor reading	Voltage value in mV
1.	Patient 1	123.19	357.0	165.43	521
2.	Patient 2	96.82	248	160.05	501
3.	Patient 3	118.34	337	159.78	500
4.	Patient 4	97.05	246	167.06	527
5.	Patient 5	105.55	283	159.51	499
6.	Patient 6	92.77	227	156.85	489

By using the equation (8*pow(10,-5)*Signal*Signal)+(0.1873*Signal)+(46.131) i.e the equation for regression analysis and subtituting the voltage values the glucose level is obtained.

By refering the above table a graph of voltage Vs glucose level is plotted for both NIR and pulse sensors reading.



Conclusion :

We have designed and implemented the idea using NIR sensor and pulse sensor for non-invasive measurement of blood glucose level which offers several advantages, such as absence of pain and exposure to sharp objects, the potential for increased frequency of testing and tighter control of the glucose concentration and lower cost.In this prototype of device developed, wavelength of 950 nm obtained using NIR sensor and finger as a body site is used for predicting blood glucose level for the healthy adults. A low cost framework for non-invasive blood glucose measurement has been designed and implemented on printed circuit board and results are validated.

Future Scope:

Improving the accuracy and eliminating the error is the key future scope of the project. The tolerance level can be reduced by using some other technique along with the NIR technique .Various other techniques are available which are used to determine the glucose level which include the impedance technique ,light spectroscopy the only drawback of these techniques is lower accuracy. The hardware module can be made more compact and influence of the external light should be controlled as it effects the readings taken by the NIR sensor.