University of Moratuwa

Faculty of Engineering

Department of Electronic and Telecommunication Engineering

NIR Based Non-Invasive Glucometer

BM 1190: Engineering Design Project

Group Members

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Abstract

Non invasive glucometer provides a prospective approach for patients with diabetes with the advantages of no pain and enabling continuous monitoring. A near infrared LED and photo detector is used to measure the blood concentration. The blood glucose level is calculated based on the scattering and absorption of infrared light through blood and then displayed on OLED.With our device we hope the patients can get an indication about the glucose level and take necessary actions. We believe the user friendliness of the device will meet the user needs of the target market as well as ensure the technical feasibility of the device to expected levels of the market.

Contents

Problem Description

1.1 Arriving at the Problem

There are several reasons not to use a traditional finger prick glucometer:

- Some diabetes patients require regular testing of blood glucose levels, and using the finger prick can be painful. This pain might create reluctance in them to take regular tests, which can be risky for some patients.
- Due to the needle used in finger pricks, it can cause skin infections and irritations with regular use of the same needle.
- If the same glucometer is used by several patients, there is a high risk of spreading blood-based diseases such as STD, Hepatitis, Malaria, etc.
- A certain group of people who fear needles and who are hemophobic might face several difficulties in using the traditional glucometer.

1.2 Arriving at a Solution

Non invasive glucometer provides a prospective approach for patients with diabetes with the advantages of no pain and enabling continuous monitoring. A near infrared LED and photo-detector is used to measure the blood concentration. The blood glucose level is calculated based on the scattering and absorption of infrared light through blood. 940nm was chosen as suitable wavelength as it optimizes the absorption by glucose molecules.

1.3 Motivation

The proposed device is capable to overcome the shortcomings in the traditional invasive methods to measure blood glucose levels and make it comfortable for the user.The user friendliness of the device makes it suitable for usage by any person and get an indication about their glucose levels anywhere at anytime.This device also leads the pathway for CGM(Continuous Glucose Monitoring) which can be vital for early detection of diabetes.

1.4 Justification

As per the survey conducted by our team Meditrones that included several groups of people who were suffering from diabetes or had close proximity to a diabetes patient revealed that the majority of them have access to a diabetes patient.

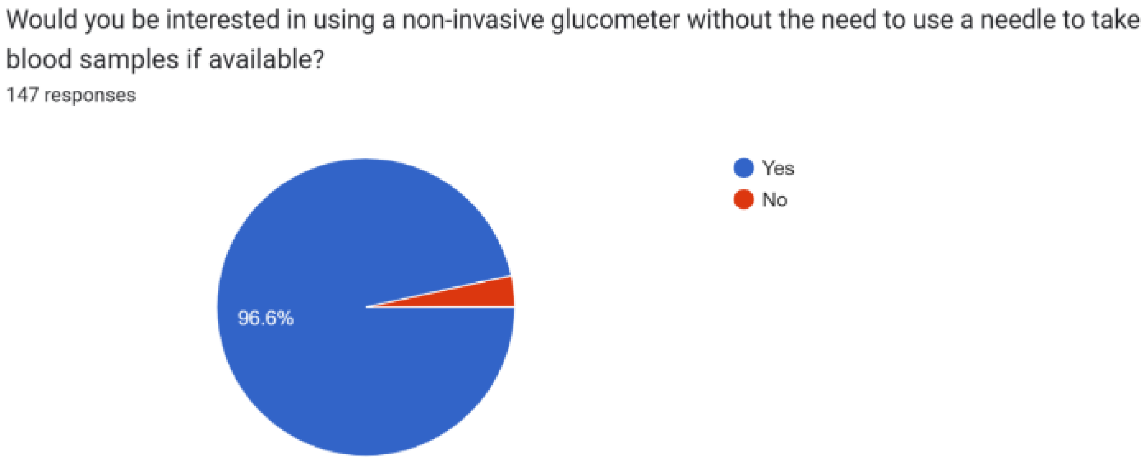

Figure 1: Survey Results

We believe that a non-invasive glucometer would be an ideal replacement for the finger prick glucometer and can be more user friendly for the patients but it requires to maintain a precise accuracy in the readings as well which could be a challenge in our project however with the deployment of proper technological methods we are eager to make it a reality so that we can make blood glucose monitoring more efficient and safe.

2. Feasibility

2.1 Technical Feasibility

All our resources were obtained easily from the local market thus it is technically feasible.Filter circuits and amplification processes were done from circuits built using passive and active elements. PCB was designed by us and the components were soldered by us to the PCB, the enclosure was also designed by us and got it printed using PLA+ white and black material using 3D printing.

2.1.1 Hardware Feasibility

All the required hardware components were available in the local market and we were able to implement the expected circuit from them. Following hardware components were mainly used in our project:

- Atmega 328P-AU
- SMD Resistors
- Ceramic and mylar Capacitors

- JST connectors and step up booster
- CJ-MCU OPTO 101 light reciever module
- Main PCB to connect other components

2.1.2 Software Feasibility

Software requirements for our micro controller are C++.The software utilizes algorithms to process sensor data, calibrate readings, and ensure accurate glucose level estimation without the need for invasive procedures.Overall, the software is feasible with a focus on accurate data processing, user-friendly interface, and reliable performance integration with the non-invasive sensor.

2.2 Economic Feasibility

The device aims to address the significant market need for non-invasive glucose monitoring. Potential benefits include reduced long-term healthcare costs due to improved diabetes management and patient compliance in comparison to the invasive methods that requires constant replacement of pricks which could be costly.The target pricing should be competitive yet reflective of the value provided by non-invasive monitoring, considering both production costs and market expectations.

Overall, the economic feasibility indicates that with strategic cost management and a clear market advantage, the non-invasive glucometer is a viable investment.

3. Usage

This device targets individuals that requires to get an indication about the blood glucose levels and get necessary actions for further medications. We expect this device to be used in households only to get a substantial idea about the current glucose level and to make sure early identification is done for patients with high risk without the need of invasive methods.

4. Product Architecture

The product architecture consists of the following sub-systems:

i. Signal Transmission and Receiving

We use a Receiver Module(CJ-MCU OPTO 101) to receive the IR beam emitted by an IR LED of wavelength 940nm implemented on the PCB and the output voltage of the module is fed into the next circuit for further analysis.

ii. Signal Analysis

The received voltage signal is sent through a low pass filter to cut off the power line interference and then through a high pass filter to make it a band pass signal within the centre frequency of the glucose resonant frequency, all the filter circuits are active filters making it more suitable for signals with high noise then the output of this circuit combination is fed into the MCU.

iii. Output

After proper analysis of the received signal to the MCU it compares the voltage value with the pre calibrated values and the corresponding calculated glucose value will be displayed on the OLED screen.

iv. Power supply

Power to the circuit is obtained using a 3.7V 500mAh Lipo battery and it is fed into a up convertor booster of 1.5A to obtain an output voltage of 12V which is then regulated to 5V using a voltage regulator and distributed along the PCB for the relevant connections.

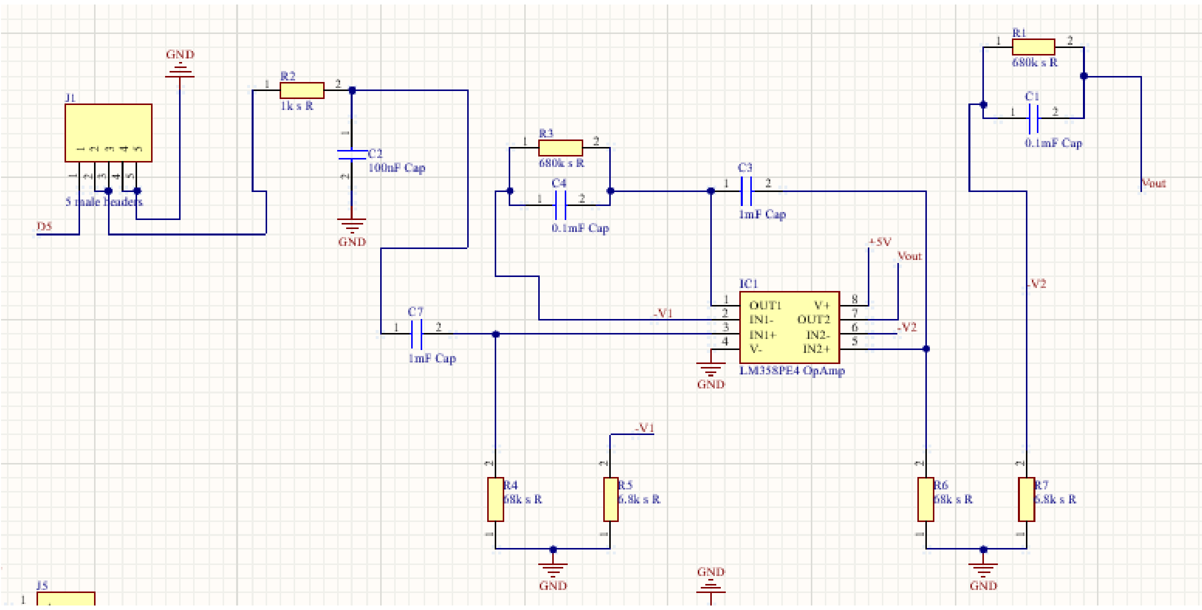

Figure 2: Filtering and Amplifying Circuit

5. PCB Design

The PCB Design of our device is shown below where we had one main PCB and another PCB for the transmitter:

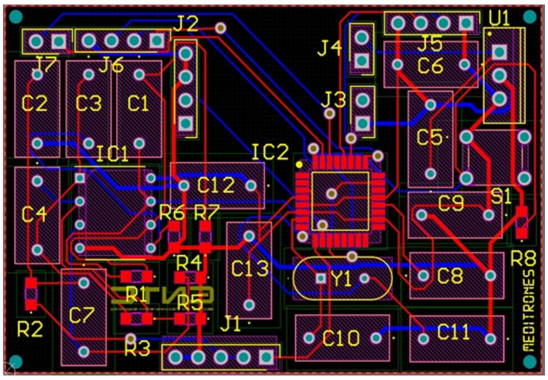

Figure 3: Main PCB

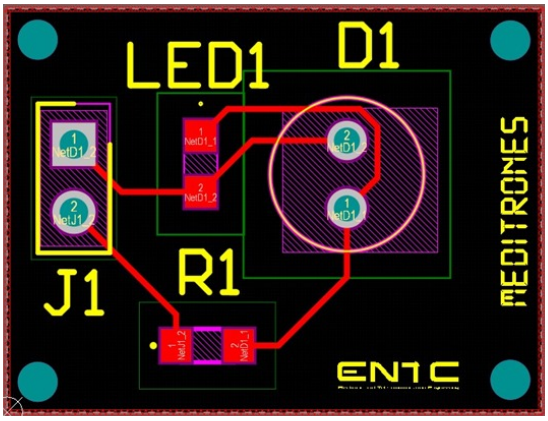

Figure 4: PCB for transmitter

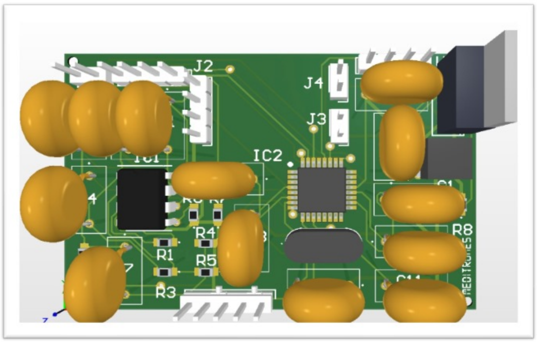

Figure 5: 3D view of Main PCB

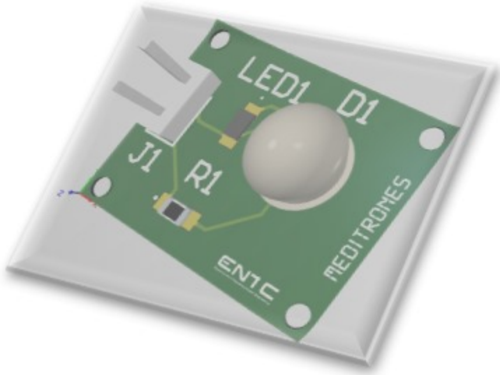

Figure 6: 3D view of Transmitter PCB

6. Enclosure Design

The Enclosure was designed using solidworks and the sketches are shown below, we used PLA+ material to print our enclosure and Black TPU for the padding:

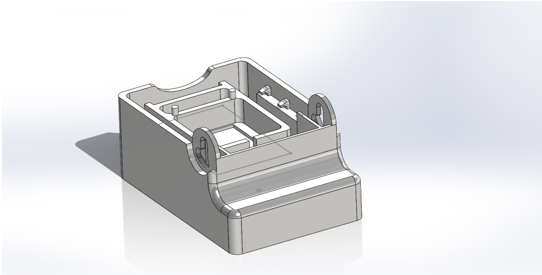

Figure 7: Bottom Compartment

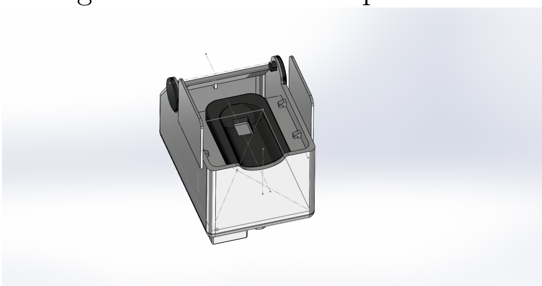

Figure 8: With finger padding

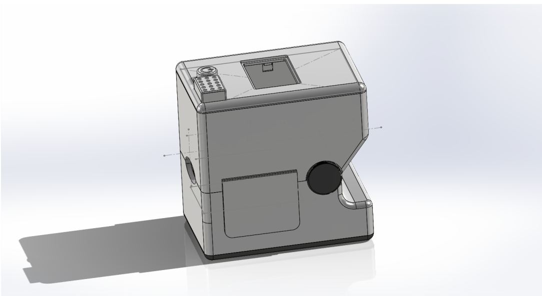

Figure 9: Combined Compartments

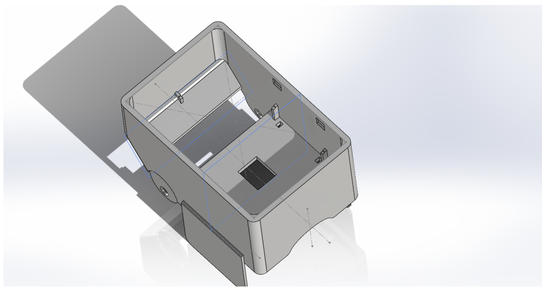

Figure 10: Top Compartment

7. Final Product and User Guidance

Figure 11: Final Assembled Device

Press the power button to turn on the device. Open the clamp and place your finger inside with the nail facing upwards. Ensure your finger is fully inserted, then release the clamp. Remain still while the device is measuring to get an accurate reading. The device will automatically start measuring your blood glucose level. Read the Results after 30 seconds, the results will display on the screen.The glucometer will automatically turn off after a few seconds of inactivity.

8. Problems Encountered and Solutions

1. Finalizing the circuit was a challenge at first due to extreme noise and filter deformations,as a solution we decided to utilize active filters and we got better results afterwards, furthermore to reduce the cost we used a dual Op-amp for the filters.
2. We were not able to obtain a reasonable output from the traditional IR receiver LED thus we decided to use a light receiving module (CJ MCU-OPTO 101) which gave us expected results.
3. Due to a technical faulty we were not able to program the atmega 328p-au chip but we used a TQFP-32 clamp shell and successfully uploaded the code afterwards.

9. Marketing, Sales, and After-Sale Service Analysis

Marketing Strategy

Our primary focus will be to educate the public on the non-invasive glucometer's convenience and safety for household use. The device is designed to provide an indication of blood glucose levels, helping users monitor their health at home. However, it is essential to consult a healthcare professional for diagnosis and treatment decisions. Marketing efforts will include collaborations with local pharmacies, clinics, and online campaigns targeting individuals and families managing diabetes.

Sales Approach

The glucometer will be available for purchase at local pharmacies and through an online store, making it easily accessible to households across Sri Lanka. We will also work with healthcare providers to promote the device as a supplementary tool for at-home monitoring.

After-Sale Service

We are committed to supporting our customers with after-sale services that include guidance on proper use, customer support , and routine updates. It's important to note that while the glucometer is useful for regular monitoring, it should not replace professional medical advice. Always consult a doctor for accurate diagnosis and treatment.

10. Task Allocation

- **Research:** Aazir, Manuri, Banuka
- **Circuit Development:** Aazir, Banuka, Sahan
- **PCB Design:** Sahan
- **Enclosure Design:** Aazir, Manuri
- **Circuit Implementation:** Banuka, Sahan
- **Code:** Aazir, Banuka
- **Documentation:** Manuri, Banuka

11. Project Budget

Component	**Unit Price**	**Quantity**	**Price(Rs.)**
Passive Elements			100
Dual Op-Amp	30	1	30
OLED Display	450	1	450
PCB			350
3D Printing			2500
Receiver Module (CJ MCU-OPTO 101)	2000	1	2000
JST Connectors	20	3	60
Lipo Battery	200	1	200
Booster Module	150	1	150
5V Regulator	50	1	50
Atmega 328P-AU Chip	1500	1	1500
Push Button	10	1	10
Total			Rs.7400

Table 1: Project Budget