Non Invasive Blood Glucose Monitor

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Agenda:

- Idea
- Introduction
- Motivation
- Current Methods
- Circuit Diagram
- Results
- Challenges
- Future Work

What?

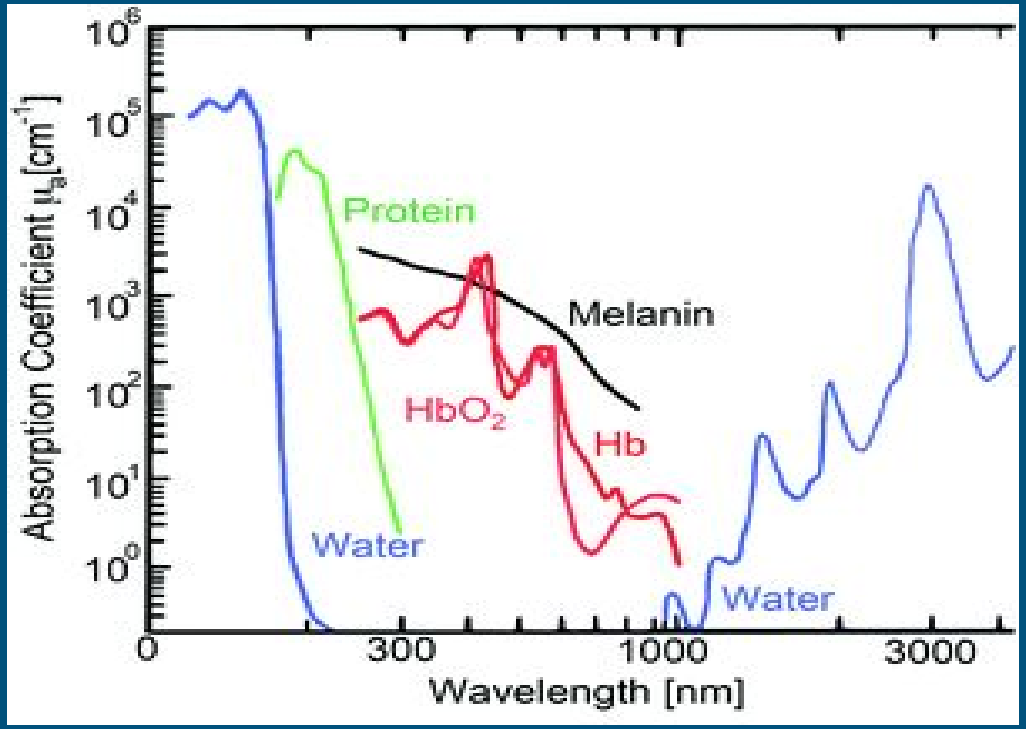
Idea

- Non-invasive alternative to the finger stick glucometer
- Based on a set of techniques used in analytical chemistry called absorption spectroscopy
- Here the solution is the blood in our body

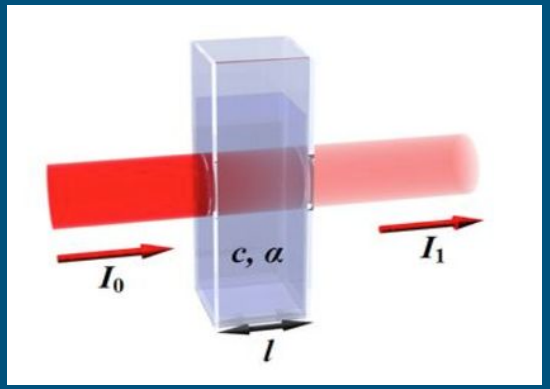
Introduction (What is Diabetes?)

- Diabetes is also known as Diabetes Mellitus (DM)
- Diabetes type-1 is a condition when the body is unable to produce insulin which regulates the blood sugar levels in the body
- Diabetes type-2 occurs when the body doesn’t produce enough insulin or it resists the produced insulin

Basic Principles



Basic Principles (Contd..)



Beer-Lambert law

- The absorbance of a incident radiation depends on two external assumptions.

1. The absorbance is directly proportional to the concentration (c) of the solution

2. The absorbance is directly proportional to the length of the light path (l), which is equal to the width of the cuvette

$$A=\epsilon cl$$

$$A=\log_{10}(I_o / I)=\epsilon lc$$

Why?

Motivation

- Diabetes is expected to proliferate from 422 million in 2016 to 700 million by 2030
- 50% of the Diabetes patients are anticipated to be suffering from nerve damage
- Control of elevated glucose levels is critical for avoiding severe secondary health complications in multiple organs including the retina, kidney and vasculature

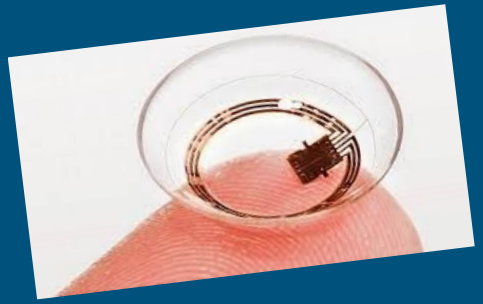
Motivation (Contd..)

- Current Methods are invasive and are not suitable for continuous monitoring
- The world is inching towards continuous monitoring when it comes to health monitoring in general
- Invasive methods are especially not suited for kids diagnosed with Type-I diabetes

How?

Proposed Solution

- Most of the biological cells and tissues are transparent in the wavelength region of 700–1100 nm.
- Placing a finger between the IR LED (peak wavelength 940 nm) and the detector (Photodiode).
- The blood glucose level is inversely proportional to the obtained output voltage



Current Methods

Invasive Techniques:

Capillary Blood Glucose Test

- Test is performed by piercing the skin for blood to ooze out
- Uses a chemically active disposable strip
- Measures an electrical characteristic and relate that to glucose level

Conventional Blood Test

- Blood is drawn from the vein and analyzed by the lab technician
- Sugar builds up in the blood of patient and combines with hemoglobin, becoming "glycated."
- The average amount of sugar in your blood can be determined by measuring HbA1c.

Advantages:

- Accurate and Precise
- Reliable
- Low Cost

Disadvantages

- A prick, each time one needs to test
- Cannot monitor continuously
- Might create infections and allergy

Non Invasive Techniques:

Google Contact Lens

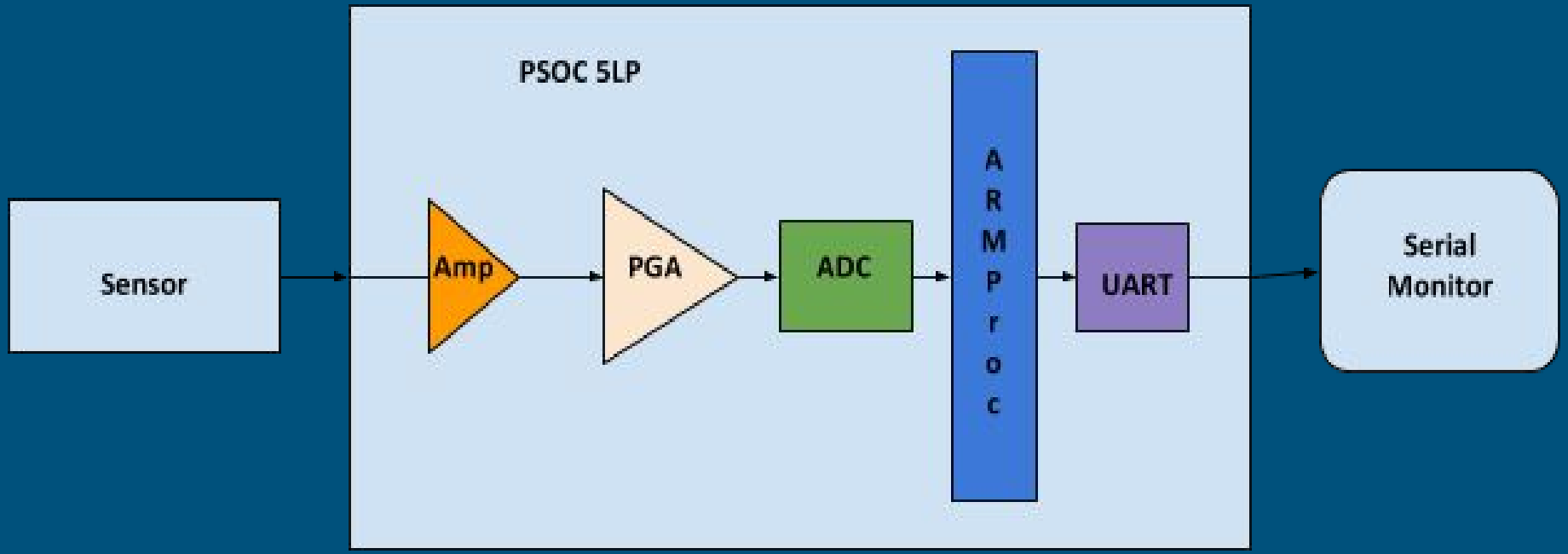
- Google is working on continuous glucose monitoring techniques by measuring the glucose level in tears using contact lens

Glucose monitoring using Saliva

- Startups are working on measuring blood glucose level using saliva
- Saliva is captured by means of a single use wick
- Wick is inserted into an analyzer that outputs glucose levels

Implementation

Circuit Diagram



Circuit Diagram (contd..)

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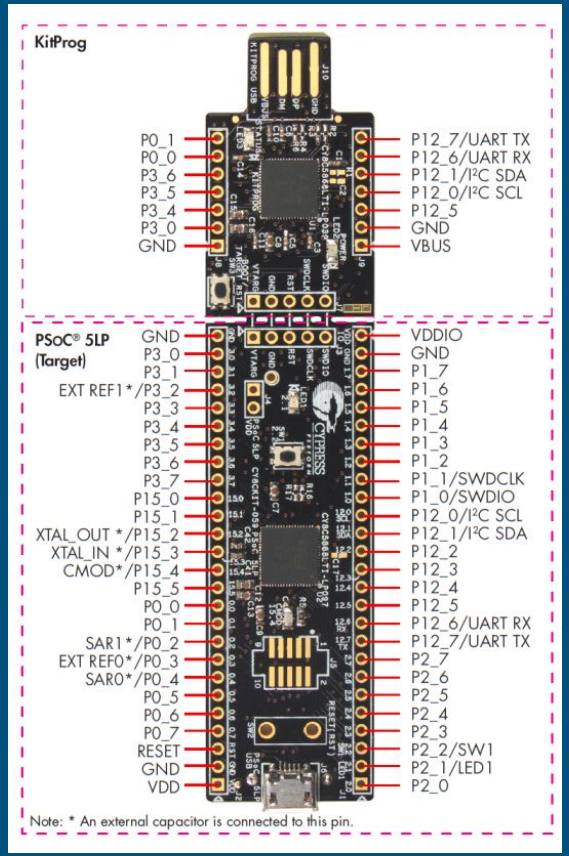
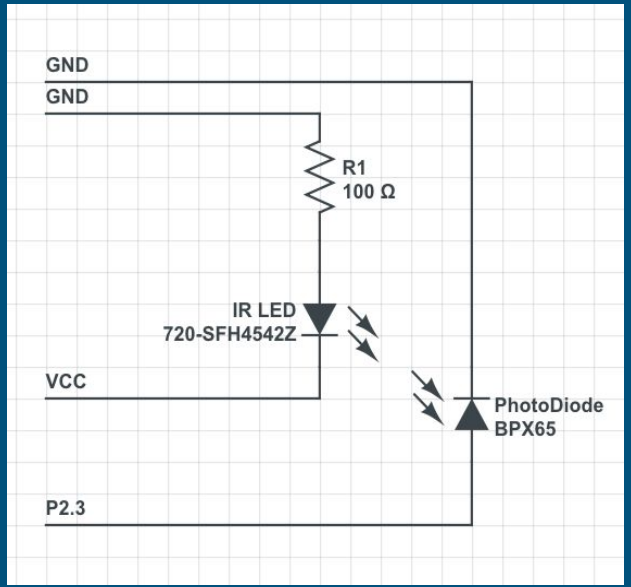




Implementation (contd..)

- Designed a circuit using PSoC creator to process the signal
- Receives the signal in the range of millivolts which also includes noise
- For additional precision we use an amplifier (Programmable Gain Amplifier) with a gain of 2
- Signal is converted into Digital using Analog to Digital Converter with a resolution of 20 bits

Implementation (contd..)

- UART transmits data to serial monitor to print and log the data
- Denoising the signal is done by subtracting the ambient reading from the output reading
- Used Teraterm to log the data into text files and Makerplot for plotting the graph in real time

Results:

- According to the American Diabetes Association, the blood glucose levels for an adult without diabetes are:

    1. Below 100 mg/dL before meals and fasting

    2. Less than 140 mg/dL two hours after meals

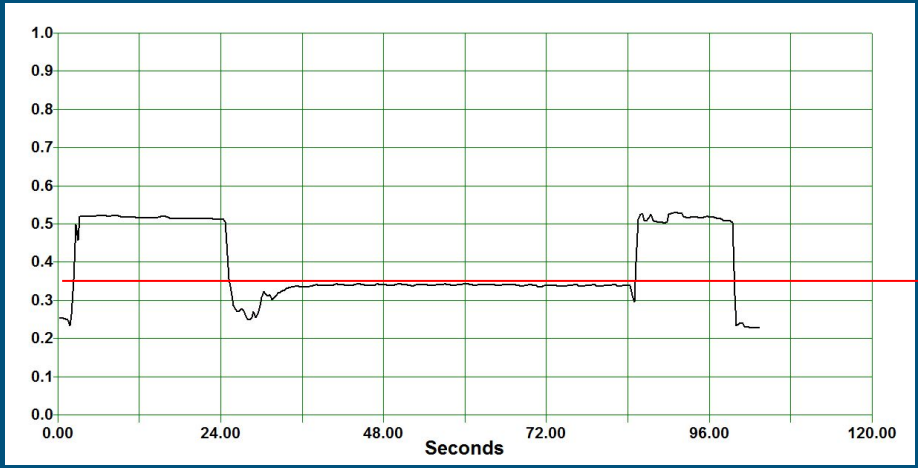
- We followed a timeline similar to the traditional techniques to conduct our experiments

- Some tests are yet to be conducted as we are waiting for the 3D model of the designed device.

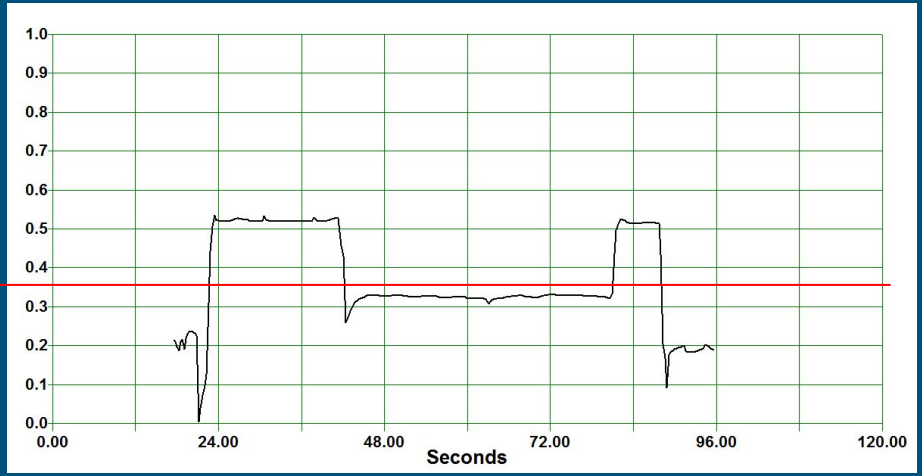
Results (Contd..)

- We planned to conduct tests on different concentrations of glucose solution and also on few of our friends
- We did tests on our subject before his/her breakfast early in the morning and also after breakfast (100 min). (figures in next slide)
- We also did tests on tap water and glucose solution to check the correctness of the implementation.
- The correlation factor between the glucose and voltage level has to be determined (Next Step)

Test 1 : Test case (Non- diabetic healthy person)

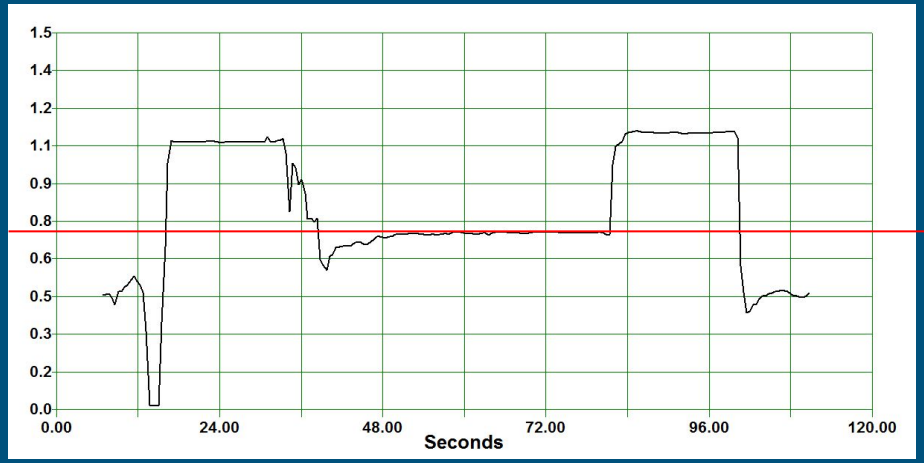


Before breakfast

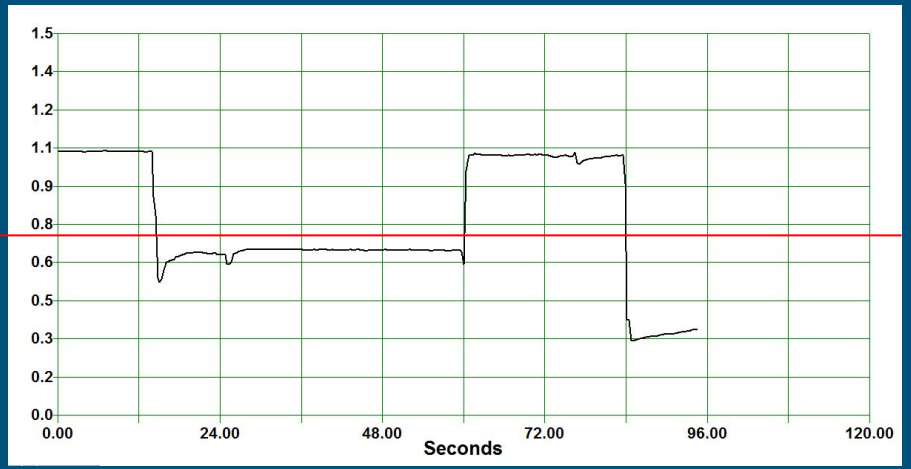


After breakfast

Test 2 (amplified) : Test case (Non- diabetic healthy person)

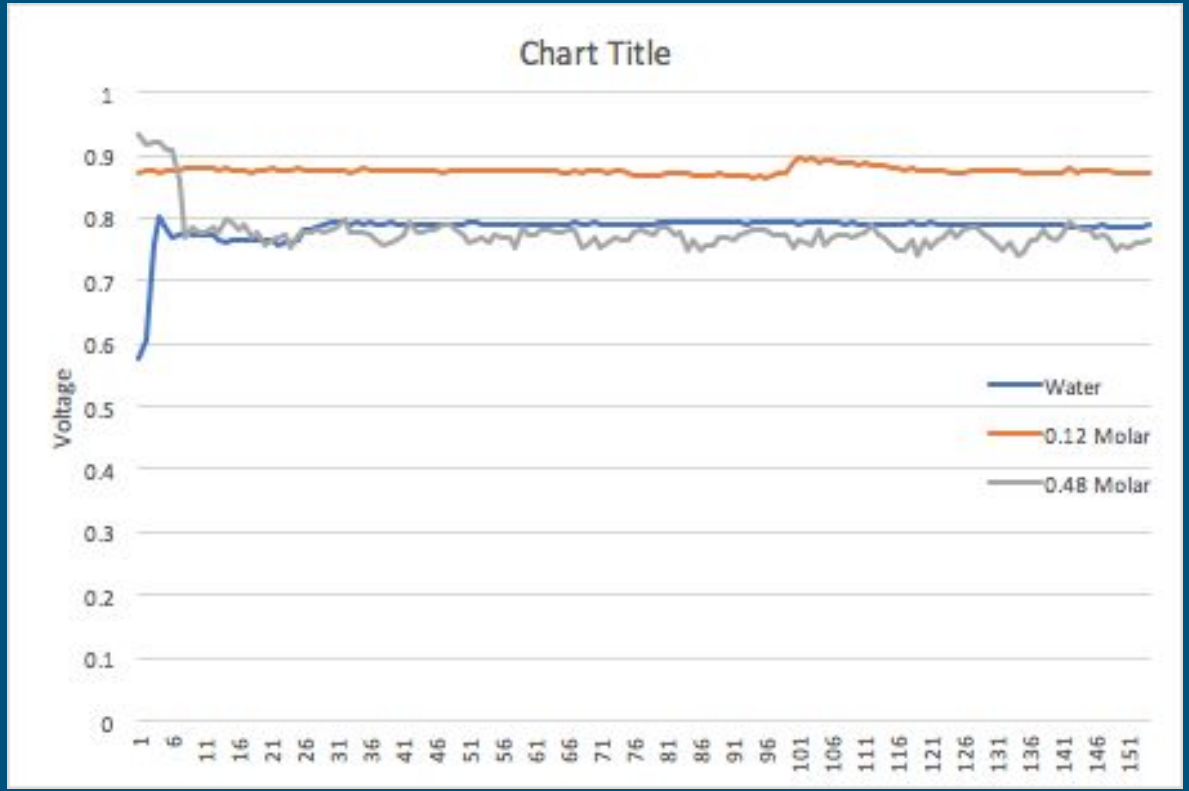


Before breakfast



After breakfast

Test 3(amplified): Test case (Glucose Solutions)



Challenges

- Ambient light could vary and our prototype should address that by being isolated from ambient illumination
- PSoC has a limited precision on the output voltage and so do the other SoCs like Arduino(12-bits) and Raspberry Pi (depends on the ADC shield used)
- Initial calibration requires a large set of known accurate readings

Future Work:

- The dependence on the output voltage of the photodiode and the glucose level may not be exactly linear
- This problem could be addressed by gathering a huge set of accurate results and fitting a multiple (or even simple) linear regression model
- Deep Learning techniques could also be used for the same

Future Work (contd.):

- A Continuous Glucose Monitoring system which would alert you and the doctor of unacceptable glucose levels
- Diabetes patients also suffer from other degenerative disorders like cataract, cardiovascular disease, nerve damage etc.
- Continuous monitoring and trend analysis, could predict and take measures if not completely preempt the degeneration

THANK YOU!

Q & A