Self-Powered Glucose Biosensor

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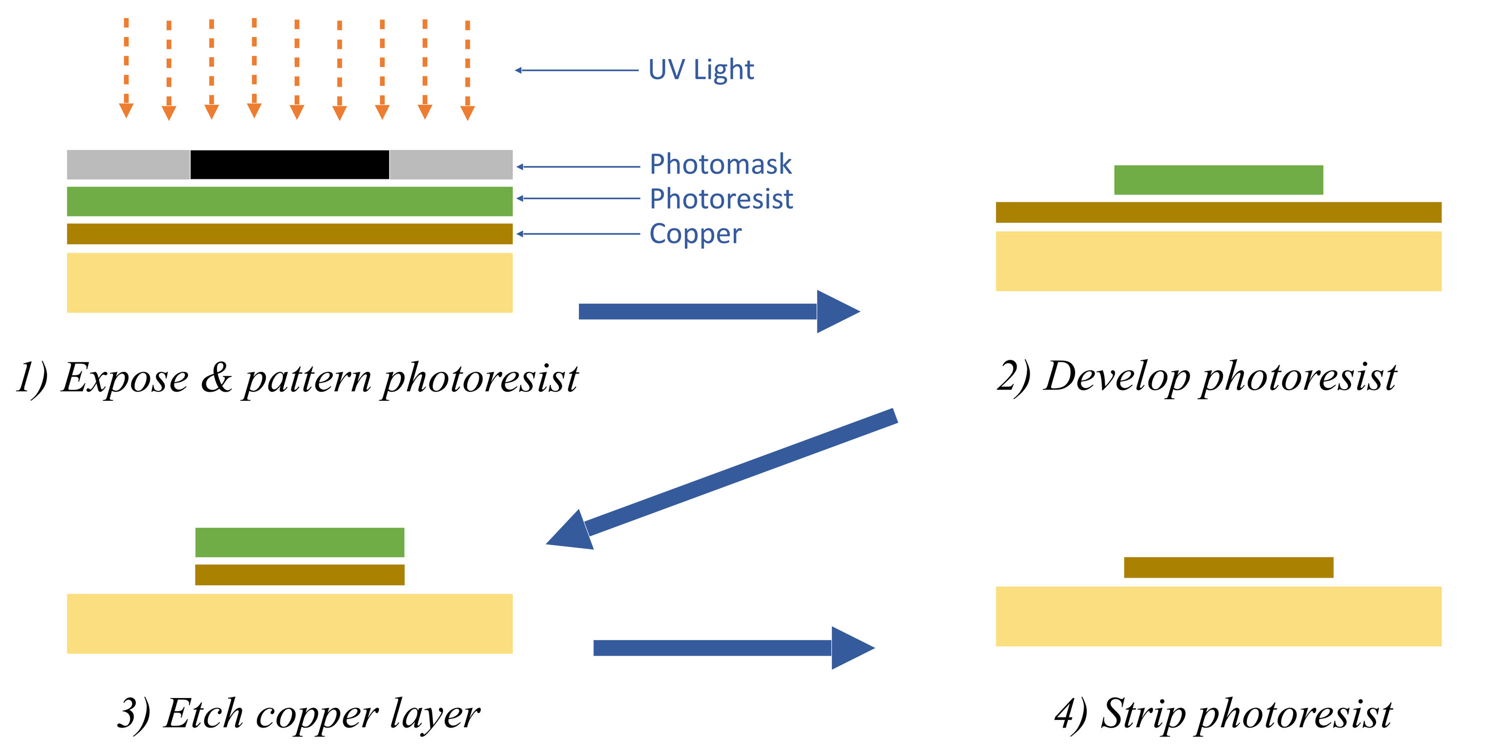
Overview

Introduction:
Diabetes affects 29.1 million people in the US and the disease is the 7th leading cause of deaths in the nation according to the Center of Disease Control (CDC) report (2014). Current glucose monitoring devices, such as glucometers and continuous glucose monitoring devices (CGMs), are bulky, painful and require frequent calibration. A painless, minimally invasive and invisible glucose monitoring device that is painless, minimally invasive and invisible to the user in highly desired.

Methods:
- Printable circuit board fabrication
- DC/DC step-up converter circuit characterization
- Powering devices with varying supply voltages
- Integration of both components of the sensing unit on the PCB

Fabrication and Experiments

Printable Circuit Board (PCB) Fabrication:



Charge Pump:

- An output capacitor was incorporated in the circuit shown in Figure 1 to serve as the transducer for sensing glucose levels and to provide a triggering signal to the DC/DC step-up converter IC
- The charge/ discharge cycle of the capacitor is directly proportional to the glucose levels

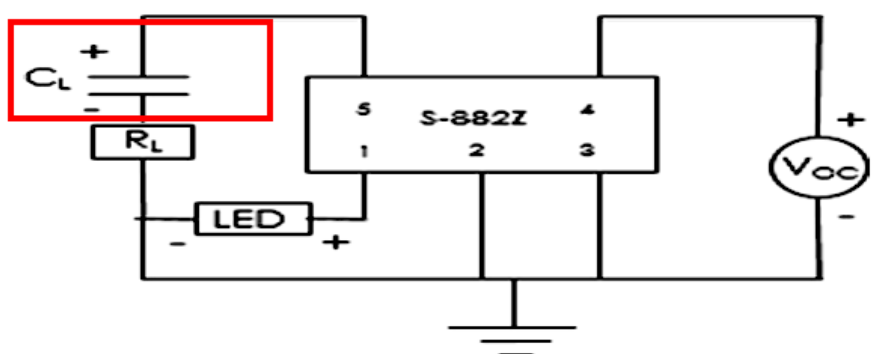


Figure 1: Charge pump circuit and the output capacitor

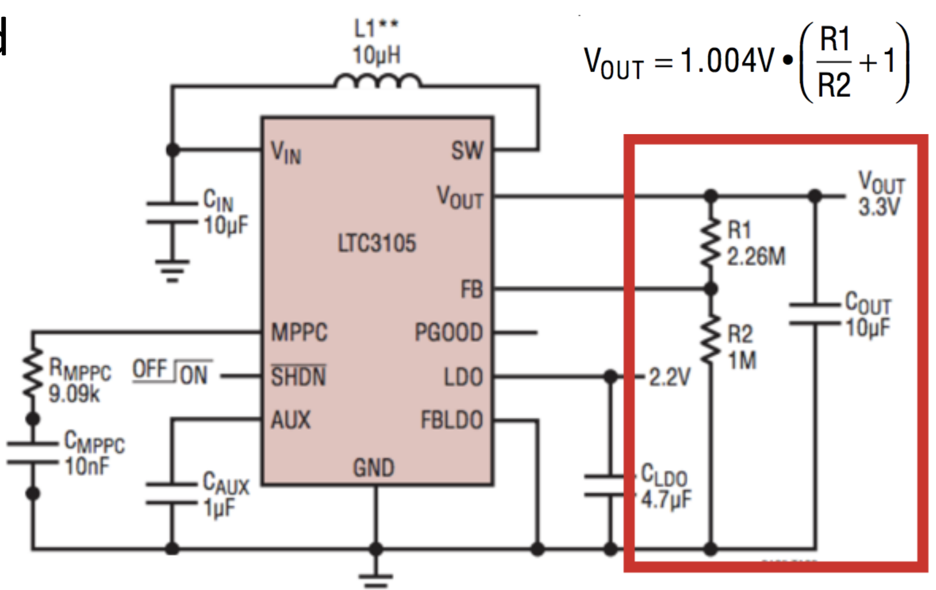


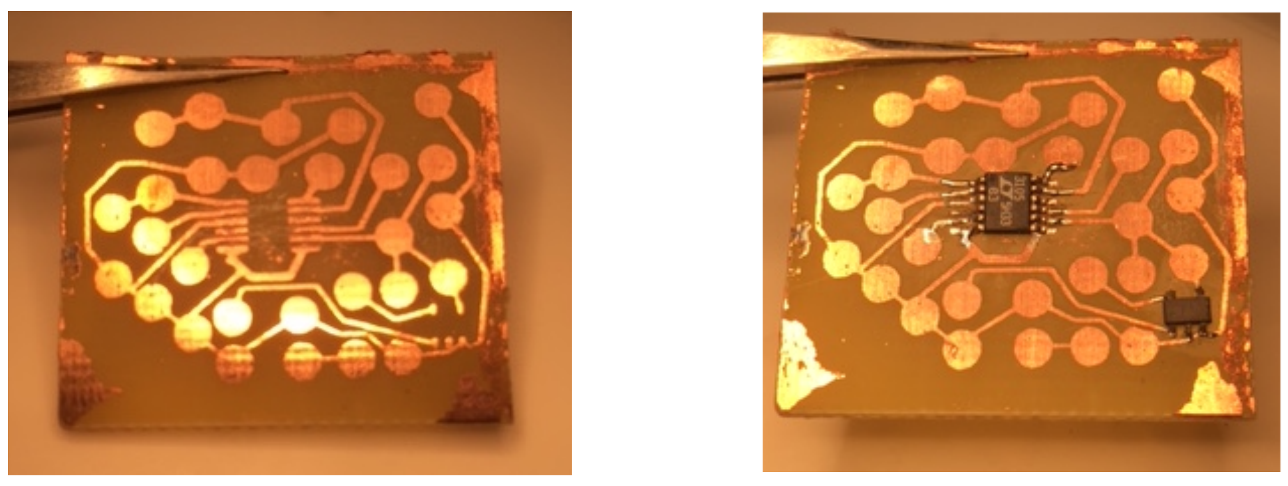
Figure 2: DC/DC step-up converter circuit and the formula explaining the output voltage

DC/DC Step-up Converter:

- Output voltage from a glucose biofuel cell is insufficient of power microelectronic devices
- Obtain experimental output voltages of the DC/DC step-up converter circuit when varying R1, and keeping R2 at a constant 1MΩ
- Powering various devices that require different voltages

Results and Discussion

- The PCB is a base for testing circuits that incorporate the DC/DC step-up converter and the charge pump integrated circuits (ICs)



(a) (b)

Figure 3: (a) Printable circuit board and (b) the DC/DC step-up converter IC and the charge pump IC soldered onto the PCB

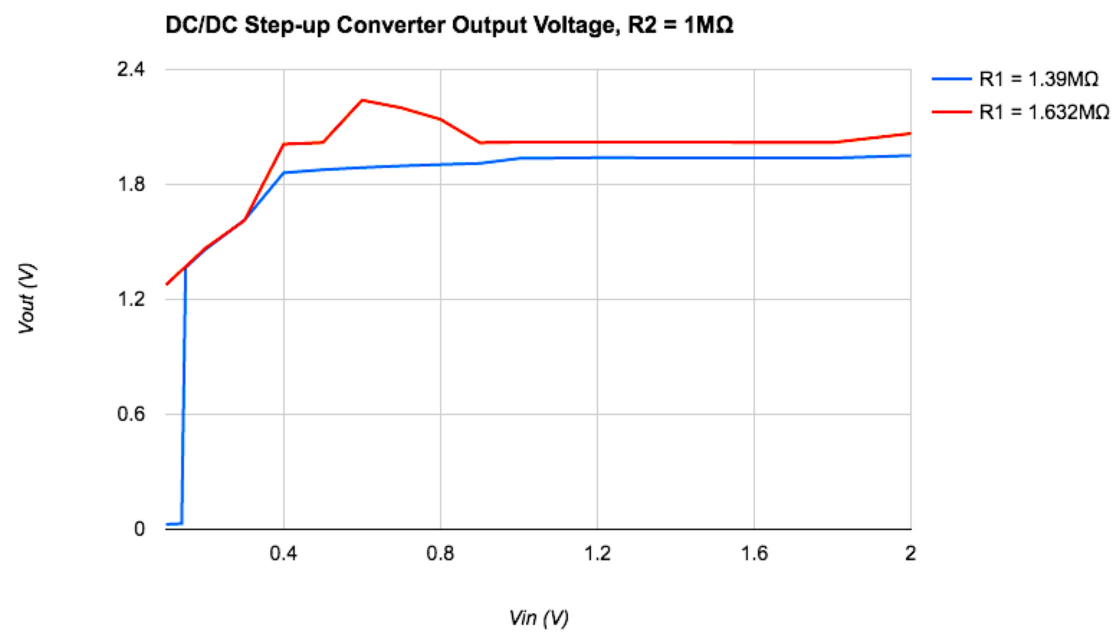


Figure 4: The output voltage of the DC/DC step-up converter circuit when R1 is varied

Experimental and Theoretical Output Voltages, Percent Error Rwhen R2 = 1MΩ

	R1 = 1.39MΩ	R1=1.632MΩ	R1 = 2.26MΩ
Vout_experimental (V)	1.951	2.066	3.2
Vout_theoretical (V)	2.399	2.643	3.3
Percent Error (%)	18.674	21.831	3.030

- Experimental output voltages deviate from the theoretical output voltages
- Loose connections between the inductor and the PCB
- Sharp 90° turns in the copper traces
- Energy dissipation in the form of heat

- When R1 = 1.39MΩ, the following devices were powered:
  - LED (1.8V required supply voltage)
  - Thermometer (1.5V required supply voltage)

- When R1=2.26MΩ, 3.2V was produced and was capable of powering a glucometer which requires a minimum of 3V supply voltage

Conclusion & Future Work

- Constructed a stable glucose monitor system
- The self-powered glucose biosensor is capable of powering devices with a maximum supply voltage of 3.2V
- This system is capable of detecting hypoglycemic, normal, and hyperglycemic glucose levels.
- Future work involves testing the new integrated sensing unit PCB
- Transmit the charging cycle frequency of the charge pump circuit capacitor wirelessly via Bluetooth Low Energy

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