Engineering Log Section 1 – Overview (6/8/25)

Project: Galvanic Biosensor For Measuring Stress Levels

Concept: When a person is stressed, their sweat glands open up, increasing the resistivity of the skin. This project aims to use this property in order to measure the stress levels of the subject.

Requirements:

→ Initial budget of \$100 or below

→ Must not cause pain – standard for medical devices is 10 μA

→ Must be easily replicated

Materials as of 6/9/25:

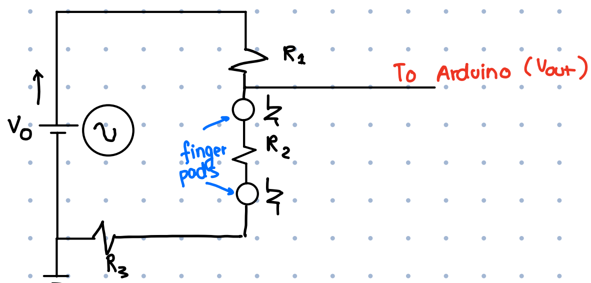
- Arduino Uno (\$27.60, from Amazon)
- Connecting Wire, USB-A to USB-B (\$7.34, from Amazon)
- M+M and M+F connecting pin wires (\$5, FaceBook Marketplace)

Softwares:

- KiCad - for PCB Schematics
- Arduino IDE & Arduino Cloud Editor - for Arduino code & signal analysis
- Notability - for engineering log
- GitHub - tracking changes & version control

Section 2 – Schematic (6/9/25)

Version 1



Design Logic: A constant current is run through both fingers and some resistors. Consider the resistivities of the two fingers to be R_{finger} each. (In reality, each finger will have different resistances, but the combined finger resistance of $2R_{finger}$ will be constant. Thus, for the purposes of verification, we can model the two fingers as having equal resistances, provided the Galvanic skin response remains constant.)

This is a single loop series circuit with a constant current I. The Arduino will recieve and measure the voltage V_{out}.

Known: V_0, R_1, R_2, R_3, V_{out}

Find: R_{finger}

$$I(R_1 + R_{finger} + R_2 + R_{finger} + R_3) = V_0$$

$$V_0 - IR_1 = V_{out}$$

$$I = \frac{V_{out} - V_0}{R_1}$$

$$I = \frac{V_0}{R_1 + R_2 + R_3 + 2R_{finger}}$$

$$\frac{V_{out} - V_0}{R_1} = \frac{V_0}{R_1 + R_2 + R_3 + 2R_{finger}}$$

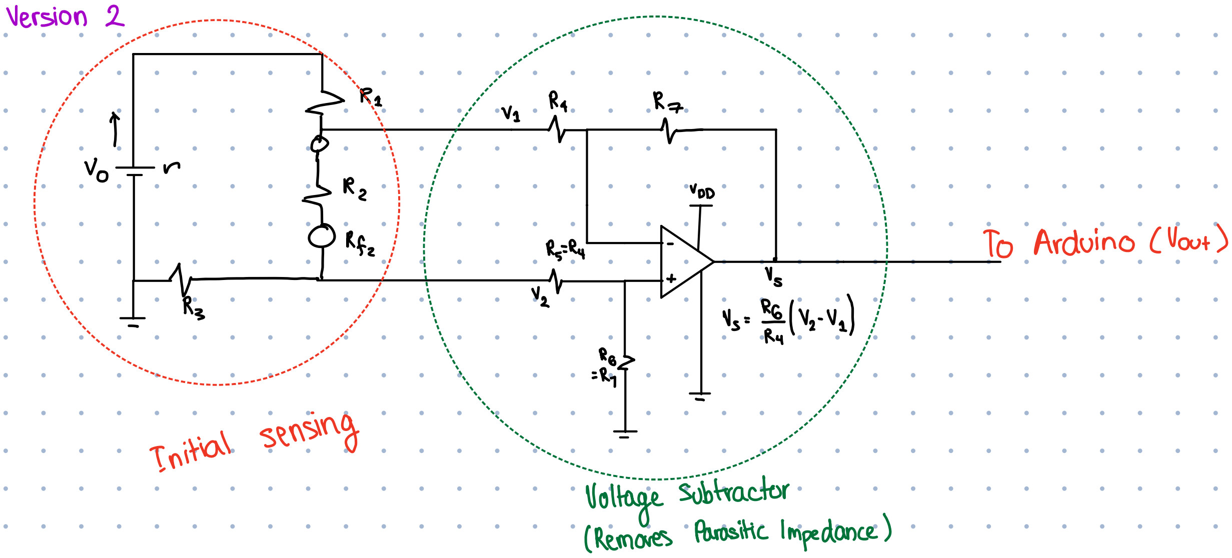
$$(V_{out} - V_0)(R_1 + R_2 + R_3 + 2R_{finger}) = V_0 R_1$$

$$R_1 + R_2 + R_3 + 2R_{finger} = \frac{V_0 R_1}{V_{out} - V_0}$$

$$\boxed{R_{finger} = \frac{1}{2}\left(\frac{V_0 R_1}{V_{out} - V_0} - R_1 - R_2 - R_3\right)}$$

Problems with this design:
- no filtering → subject to noise
- no protection against voltage surges
- very low values → hard to differentiate between voltage input to Arduino and noise

Version 2

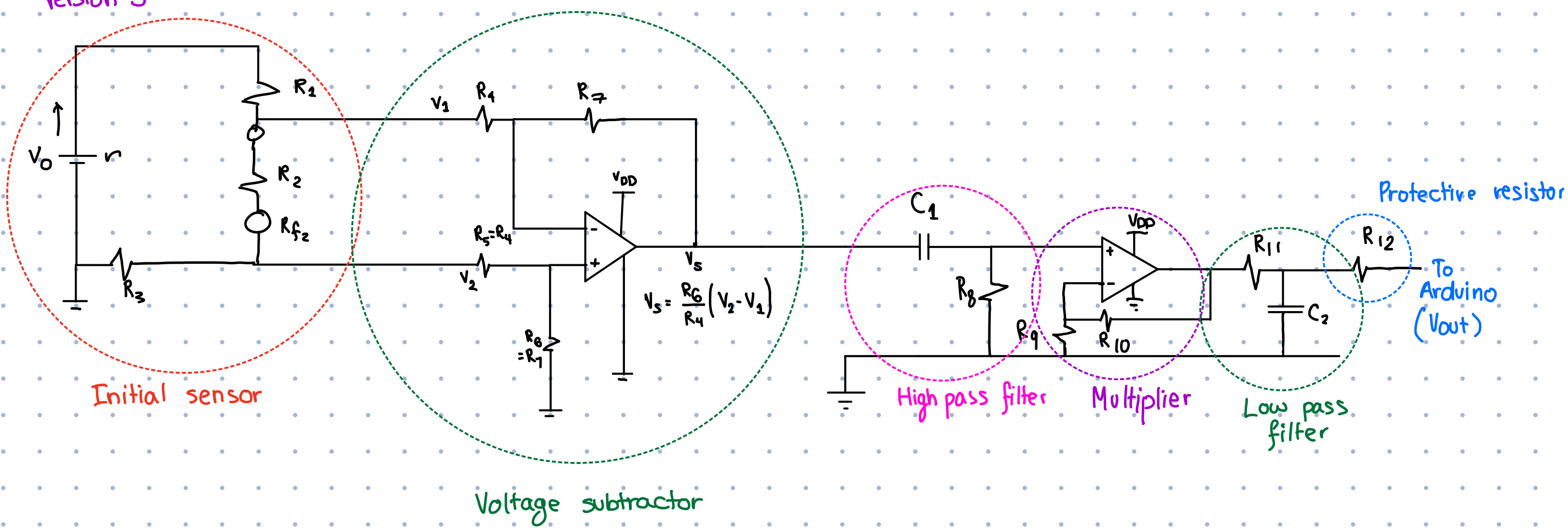


Design Logic: In this schematic, I added a voltage subtractor in order to isolate the voltage difference of just the two fingers. This does not precisely measure the voltage difference across the two fingers due to the inclusion of resistor 2; however, this circuit does output $V_{out} = V_{fingers} + V_{R_2}$, leading to a more direct correspondence between signal strength and stress levels.

$V_{fingers} = V_1 - V_2$

Problems with this design:
- same as above

Version 3



Design Logic: This schematic adds a high pass filter to eliminate low signal frequency noise. This filtered signal is then amplified to increase signal strength, allowing for more differentiation between low/high skin responses. It is then sent through a low pass filter to eliminate high frequency signal noise. Lastly, a protective resistor is added in order to shield the Arduino port from damage due to sudden voltage shifts.

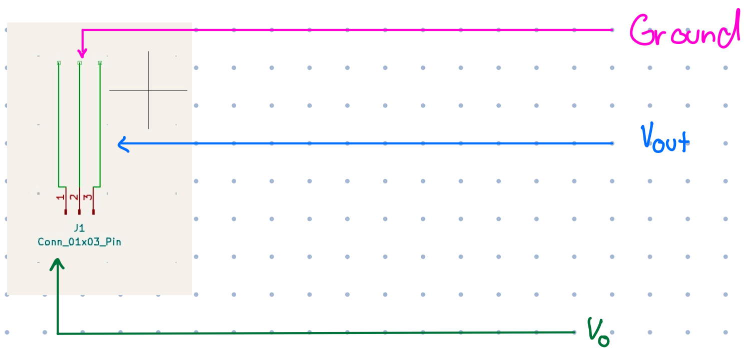
Section 3 – KiCad PCB Schematic (6/9/25)

Connector

- Signals shared between Arduino and PCB
  - V_{out}
  - V_0
  - Ground

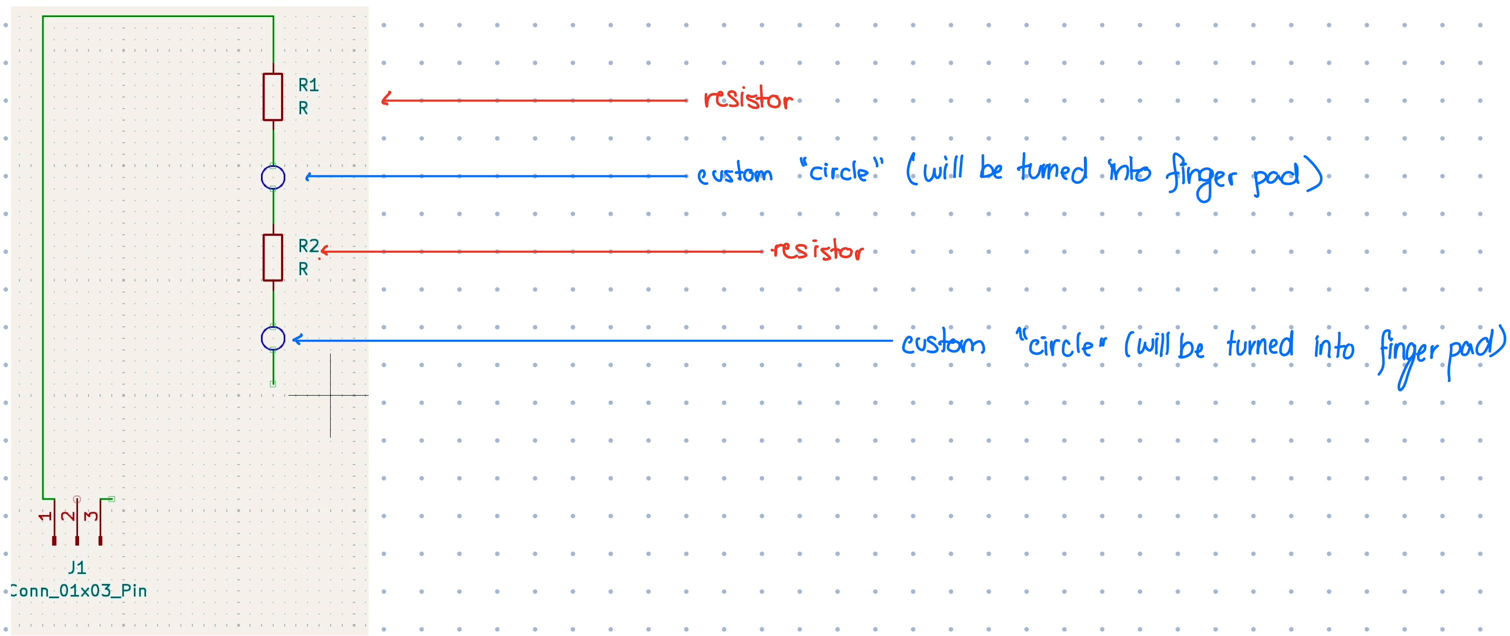
→ Therefore a 3 pin connector is appropriate

- Pins:
  - → Pin 1: V_0 (power supply for PCB)
  - → Pin 2: Ground
  - → Pin 3: V_{out} (output signal of PCB)



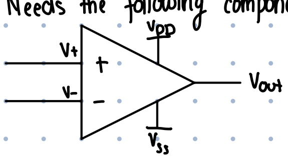
Finger Pads

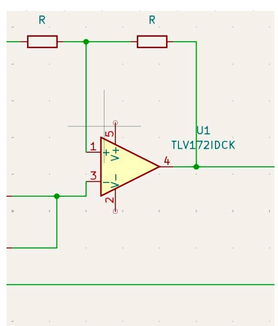
- Idea 1: use coins or copper tape → doesn't integrate seemlessly with PCB
- Idea 2: use a KiCad copper zone



Operational Amplifier (Op-Amp)

Needs the following components:





Model Used: U1 TLV172IDCK

→ will likely need additional PCB input for V_{DD}