HANDY HEALER

Circuit Functionality & Mechanism Demonstration

Isabella Rossi & Aethar Marhon

PRIMARY USER PERSONA

Name: Joanne Miller (she/her)

Age: 29 y/o

Occupation: Clinical engineer

Role: Device user

Characteristics:

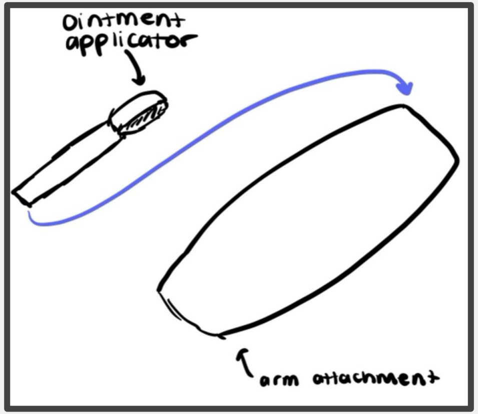
- Joanne's right hand is amputated and has severe burn wounds on her left arm from an accident **6 months ago**.
- Joanne lives alone and requires an ongoing wound management device for topical ointment application.

User values:

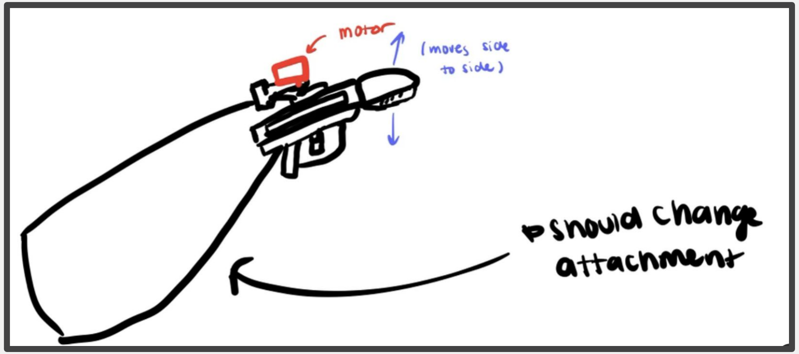
- Independence in her healing journey
- Ease of use
- Comfort

DESIGN ITERATIONS

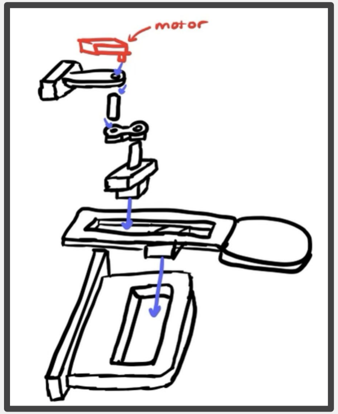
1



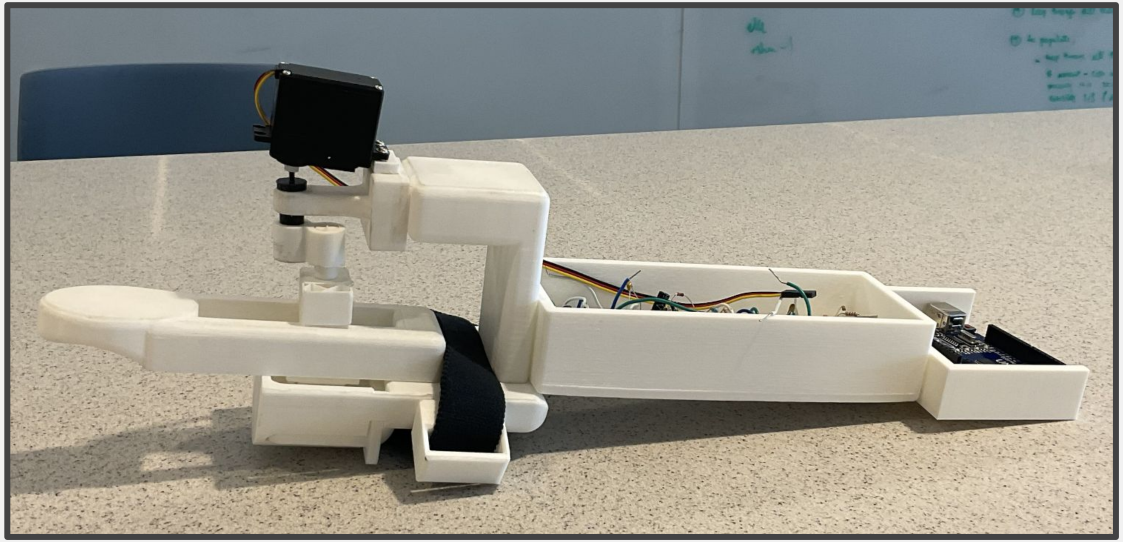
2

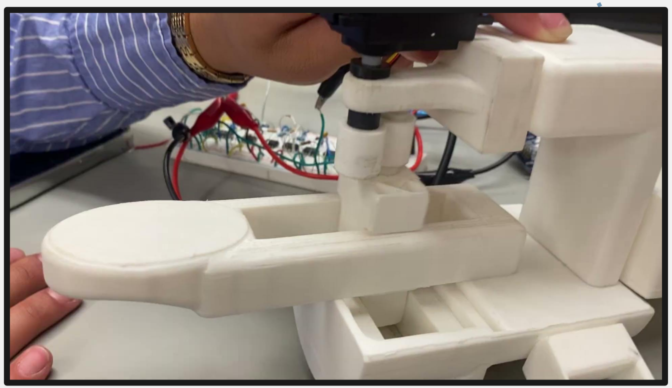


3



FINAL MECHANISM





ENGINEERING SPECIFICATIONS

Objective: to assist **severe burn victims** who have undergone an **amputation**, by providing **precise** and **gentle movements** necessary for ongoing **wound management**, including the **application of topical creams.**

Precision

- ➔ Smooth & controlled rotation for topical cream application via the HSR-1425CR motor
- ➔ Achieved through consistent & controlled linear motion

Range of Motion

- ➔ Device's applicator moves left & right in a smooth & controlled manner due to the motor's 360 deg rotation

Arduino & EMG Integration

- ➔ Motor exclusively triggered based on EMG signalling (muscle contraction)

Device Weight

- ➔ Lightweight to ensure comfort, reduce strain on the residual limb, and prevent irritation.
- ➔ Upper limb prosthetics range from 755 - 1,400g for optimal function and usability
- ➔ The device weights 347g

Torque and Pressure

- ➔ Gentle & controlled pressure application for burn-affected areas & creams of varying viscosities

ENGINEERING SPECIFICATIONS

- ➔ The maximum torque provided by the HSR-1425CR motor is 0.27-0.33 Nm

$$\text{Mechanical Advantage} = \frac{\text{crank movement}}{\text{device movement}} = \frac{360°}{180°} = 2$$

The force applied by the applicator is twice the force applied by the crank

Length of rotating arm (r) → 0.017 m
Torque from servomotor → 0.27 - 0.33 Nm

$$\tau = r \times F$$

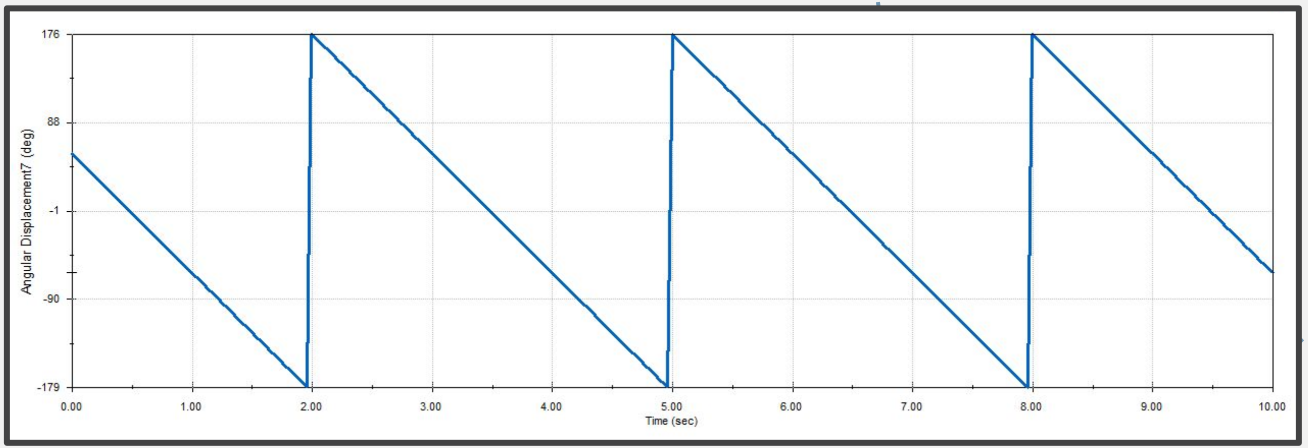
$$F_{crank} = \frac{0.27 \text{ Nm}}{0.017 \text{m}} = 15.88 \text{ N} \qquad F_{crank} = \frac{0.33 \text{ Nm}}{0.017 \text{m}} = 19.41 \text{ N}$$

$$F_{device} = F_{crank} \times MA = 15.88 \times 2 = 31.76 \text{ N} \qquad F_{device} = F_{crank} \times MA = 19.41 \times 2 = 38.82 \text{ N}$$

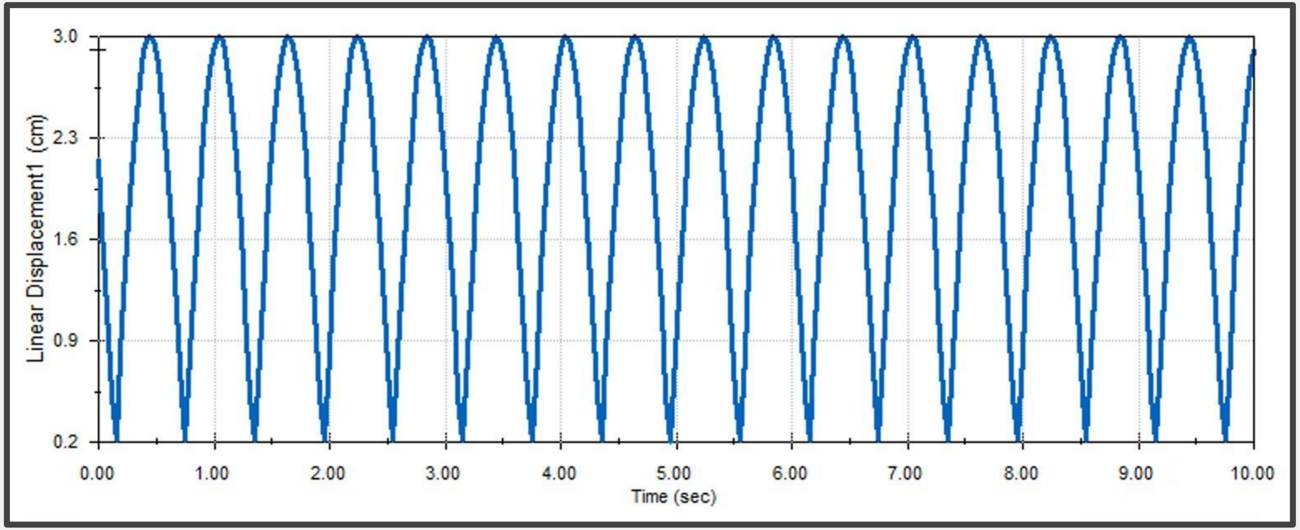
- ➔ Moderate pressure applied for ointment application to delicate wound sites

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{31.76\text{N}}{0.04396\text{m}^3} = 722.47\text{Pa} \rightarrow \text{Pressure} = \frac{\text{Force}}{\text{Area}} = \frac{38.82\text{N}}{0.04396\text{m}^3} = 883.08 \text{ Pa}$$

Angular Displacement (deg) vs. Time (sec)



Linear Displacement (cm) vs. Time (sec)



INSTRUMENTATION AMPLIFIER + VOLTAGE BUFFER

Instrumentation Amplifier:

Desired Gain	1% Standard Table Value of R_G
2	100 kΩ
5	24.9 kΩ
10	11 kΩ
20	5.23 kΩ
33	3.09 kΩ
40	2.55 kΩ
50	2.05 kΩ
65	1.58 kΩ
100	1.02 kΩ
200	499 Ω

Expected Gain: 200

$$\text{Actual Gain} = \frac{V_{out}}{V_{in}} = \frac{2.09}{0.010} = 209$$

Voltage Buffer:

$$V_{out} = V_{in} \times \frac{R_2}{R_1+R_2}$$

$$2.5 = 5 \times \frac{R_2}{R_1+R_2}$$

$$0.5 = \frac{R_2}{R_1+R_2}$$

$$R_1 = R_2$$

Select $R_1 = R_2 = 1.5\,M\Omega$ and $C = 10\,\mu F$

- Large resistor and capacitor values for voltage buffer
- Ensures stable Vref

MULTIPLE-FEEDBACK BANDPASS FILTER

Multiple-Feedback Bandpass Filter

$f_L = 10\text{ Hz}$, $f_H = 600\text{ Hz}$

Select $C_2 = 1\mu F$ and $C_4 = 33\text{ nF}$

Centre Frequency:

$$f_0 = \frac{600-10}{2} + 10$$

$$= 305\text{ Hz}$$

Passband Width:

$$\Delta f = 600 - 10$$

$$= 590\text{ Hz}$$

Selectivity Factor:

$$Q = \frac{f_0}{\Delta f}$$

$$= \frac{305}{590} \Rightarrow 0.516949$$

$$R_1 = \frac{Q}{G 2\pi f_0 C_4}$$

$$= \frac{0.516949}{1 \times 2\pi \times 305 \times 33\times10^{-9}}$$

$$= 8174.365492\ \Omega$$

$$\approx 8.2\ K\Omega$$

$$R_5 = \frac{Q(C_2 + C_4)}{2\pi f_0 C_2 C_4}$$

$$= \frac{0.516949(1\times10^{-6} + 33\times10^{-9})}{2\pi \times 305 \times 1\times10^{-6} \times 33\times10^{-9}}$$

$$= 8444.119553\ \Omega$$

$$\approx 8.4\ K\Omega$$

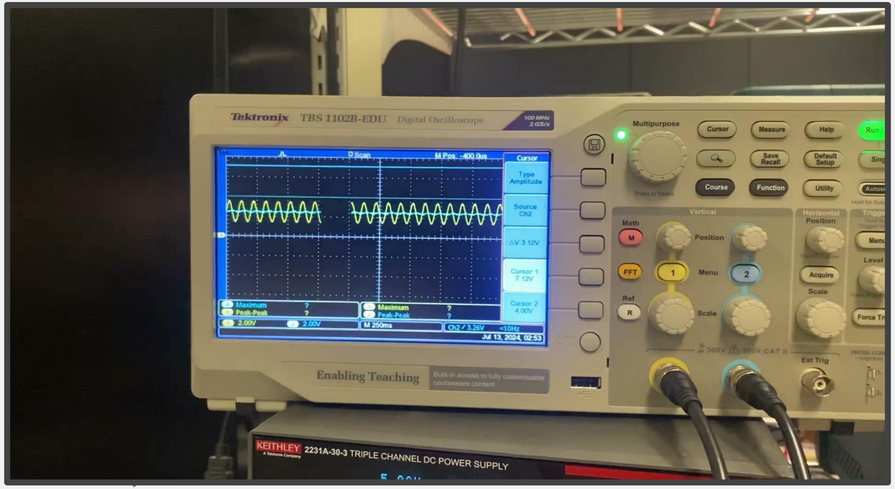
$$R_3 = \frac{1}{(2\pi f_0)^2 R_5 C_2 C_4 - \frac{1}{R_1}}$$

$$= \frac{1}{(2\pi \times 305)^2 \times 8444.119553 \times 1\times10^{-6} \times 33\times10^{-9} - \frac{1}{8174.365492}}$$

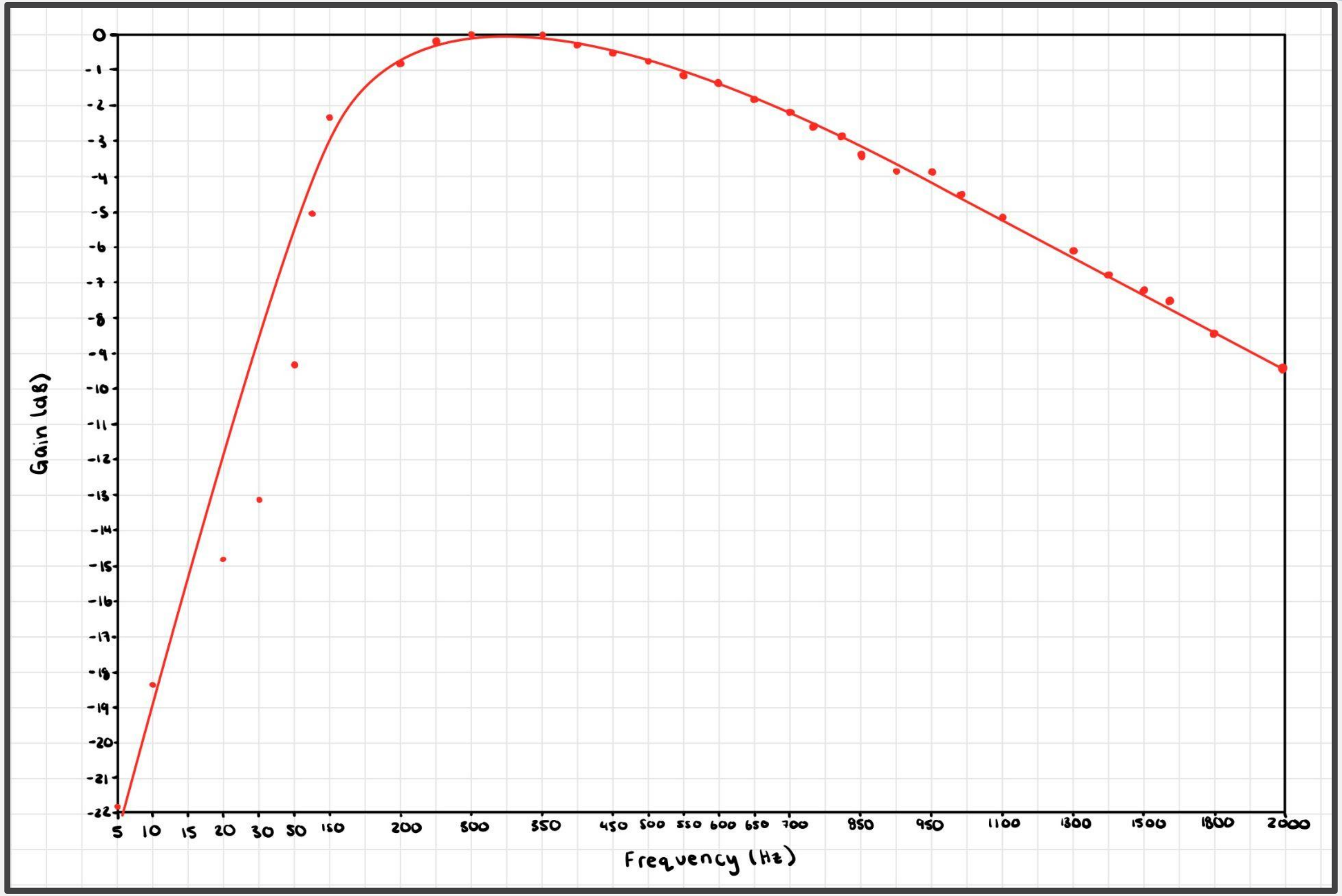
$$= 1031.746607\ \Omega$$

$$\approx 1.0\ K\Omega$$

Remove signals below **10 Hz** and above **600 Hz**



MULTIPLE-FEEDBACK BANDPASS FILTER - BODE PLOT

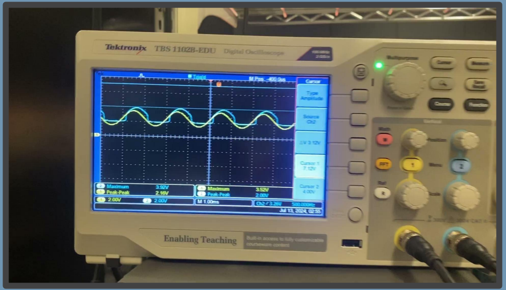


Actual Cutoffs:

f_L: 100 Hz ⟶ 0.76 V
f_H: 700 Hz ⟶ 0.75 V

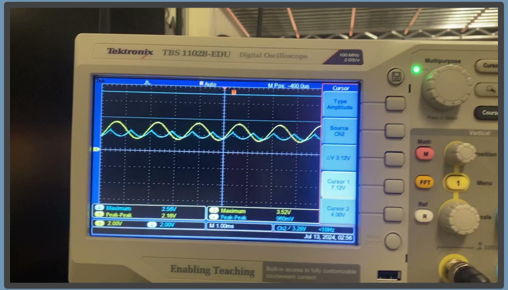
PRECISION FULL-WAVE RECTIFIER

1



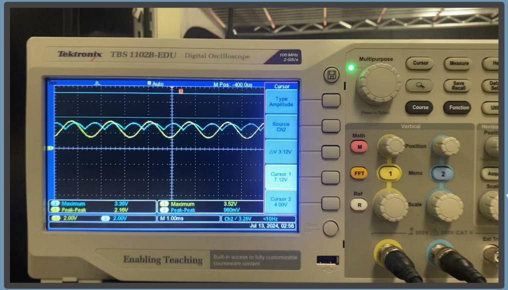
Half-Wave Rectified

2



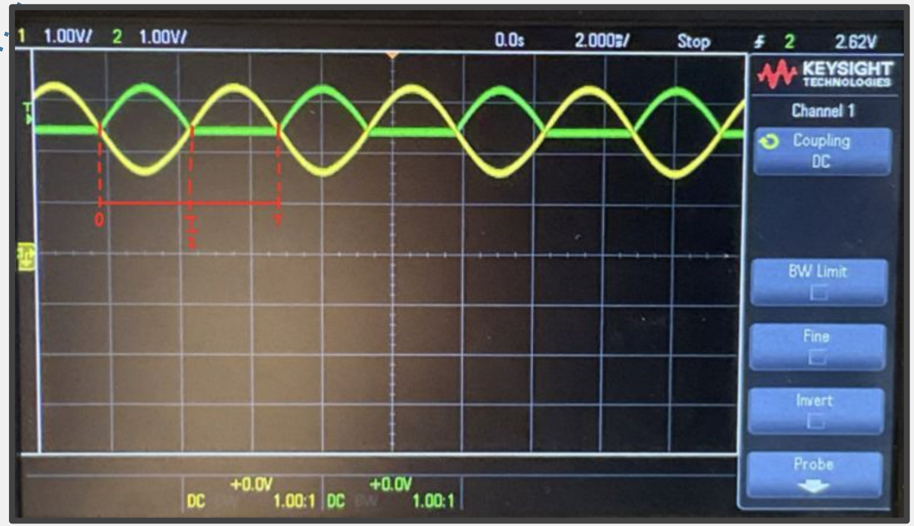
Full-Wave Rectified

3



Full-Wave Rectified & Inverted

PRECISION FULL WAVE RECTIFIER



Total:

$$V_o = V_o' + V_o''$$
$$= \frac{-V_1}{R_1} R_f - \frac{V_2}{R_2} R_f$$
$$= -\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right) R_f$$

Inverting

For 0 to $T/2$:

$$V_o' = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right)$$
$$= -20K\left(\frac{1.01}{10K} + \frac{-1.85/2}{20K}\right)$$
$$= -1.095\ V$$
$$\frac{V_o}{V_i} = \frac{-1.095}{1.81}$$
$$= -0.605$$

For $T/2$ to T:

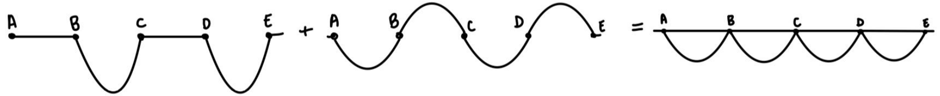
$$V_o'' = -R_f\left(\frac{V_1}{R_1} + \frac{V_2}{R_2}\right)$$
$$= -20K\left(0 + \frac{1.85/2}{20K}\right)$$
$$= -0.925\ V$$
$$\frac{V_o}{V_i} = \frac{-0.925}{1.81}$$
$$= -0.511$$

Total Gain: $-0.605 + (-0.511) = -1.116 \doteq -1$

$V_o = -2$ [inverted half wave rectified waveform] + [inverted waveform]

= Inverted and full wave rectified wave

$V_o =$



PEAK DETECTOR & NON-INVERTING AMPLIFIER

Time Constant:

$$\tau = RC$$

$$= (200\,k\Omega)(33\,nF)$$

$$= 6.6\,ms$$

Non-Inverting Amplifier

$$A_v = \frac{V_{out}}{V_{in}} = 1 + \frac{R_F}{R_i}$$

$$\frac{3.38}{2.09} = 1 + \frac{2.2K}{8.2K}$$

$$1.62 \doteq 1.27$$

TL-V117 ADJUSTABLE & FIXED LOW-DROPOUT VOLTAGE REGULATOR

$$V_{out} = V_{ref}\left(1+\frac{R_2}{R_1}\right) + (\overset{0}{I_{ADJ}} \times R_2)$$

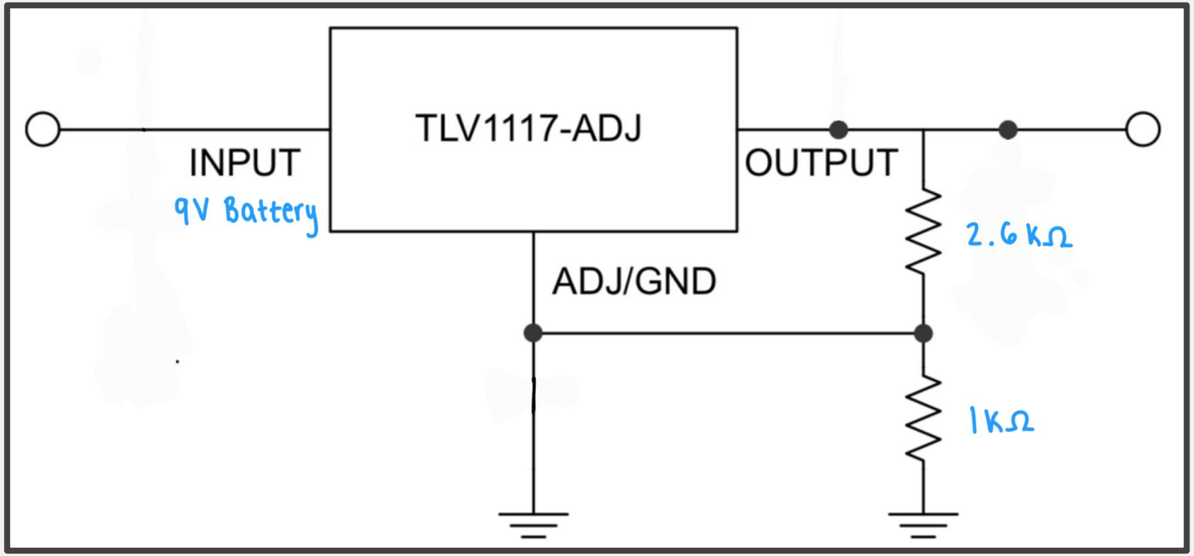
$$6 = 4.75\left(1+\frac{R_2}{R_1}\right)$$

$$\frac{6}{4.75} - 1 = \frac{R_2}{R_1}$$

$$0.26 = \frac{R_2}{R_1}$$

Select $R_2 = 2.6\,k\Omega$ and $R_1 = 10\,k\Omega$

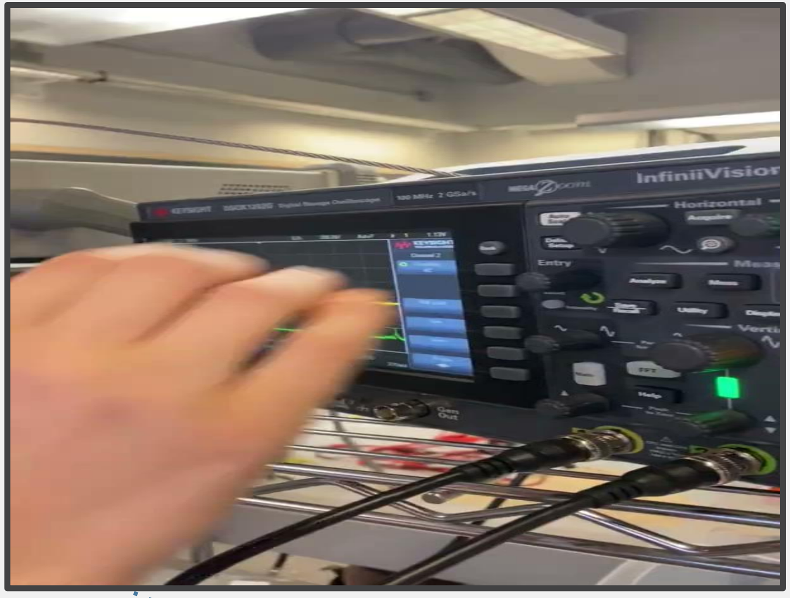
➔ Regulates & stabilizes the **9V input** to **5.3V** to power the motor



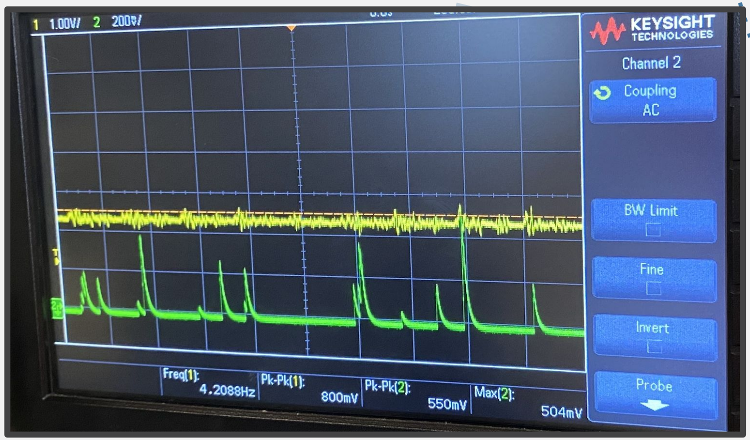
Since R2 is adjustable, it can be altered to 1kΩ to get the desired output voltage ranging from 4.8 - 6V

DATA SHEET

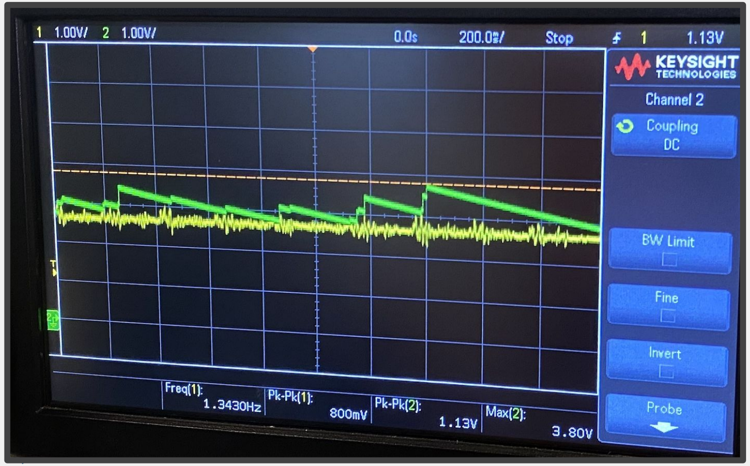
EMG INTEGRATION



AC



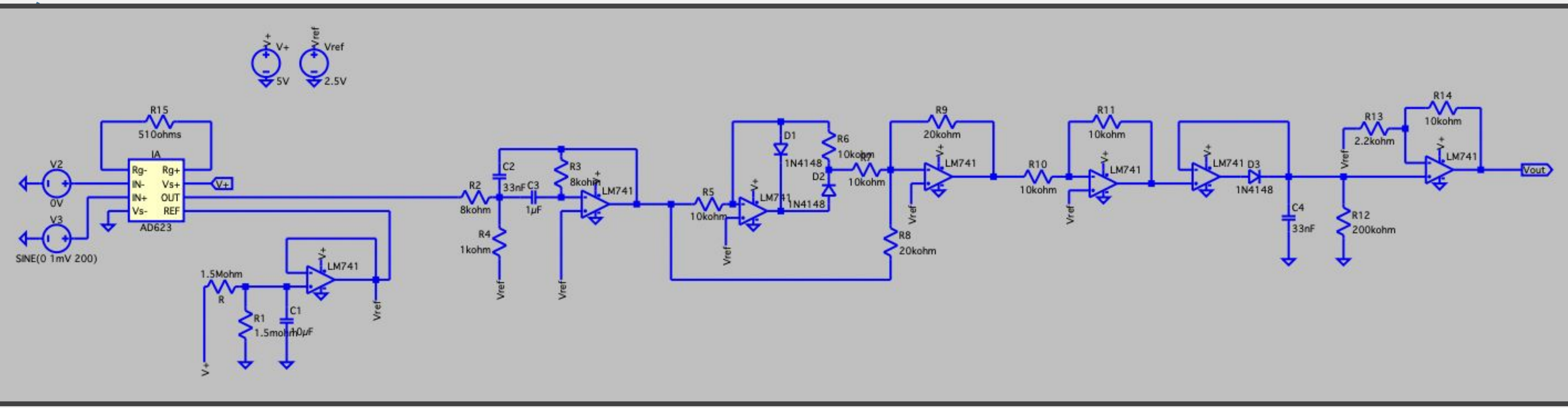
DC



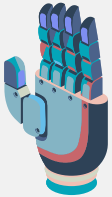
ARDUINO UNO

```
const int motorPin = 9; // PWM pin
const int voltagePin = A0; // Analog input pin

// Define the threshold voltage (3.12V)
const float thresholdVoltage = 3.12;
// Define the reference voltage of the Arduino
const float referenceVoltage = 5.0;

void setup() {
  pinMode(motorPin, OUTPUT);
  // Start the serial communication for debugging
  Serial.begin(9600);
}

void loop() {
  // Read voltage from analog pin
  int sensorValue = analogRead(voltagePin);
  // Convert analog reading (0-1023) to voltage (0-5V)
  float voltage = sensorValue * (referenceVoltage / 1023.0);

  // Print the voltage to the serial monitor
  Serial.print("Voltage: ");
  Serial.println(voltage);

  // Check if the voltage is greater than the threshold
  if (voltage > thresholdVoltage) {
    // Turn on the motor
    analogWrite(motorPin, 255); // Maximum PWM value (motor on)
  } else {
    // Turn off the motor
    analogWrite(motorPin, 0); // Minimum PWM value (motor off)
  }

  // Delay for stability
  delay(100);
}
```

CIRCUIT SCHEMATIC



THANK YOU!



Handy Healer

Objective

To assist **severe burn victims** who have undergone an **amputation**, by providing **precise** and **gentle movements** necessary for ongoing **wound management**, including the **application of topical creams.**

Engineering Specifications

Precision

- Smooth & controlled rotation for topical cream application via the HSR-1425CR motor

Range of Motion

- Device's applicator moves left & right in a smooth & controlled manner due to the motor's 360° rotation

Torque and Pressure

- Gentle & controlled pressure application for burn-affected areas & creams of varying viscosities

Arduino & EMG Integration

- Motor exclusively triggered based on EMG signalling (muscle contraction)