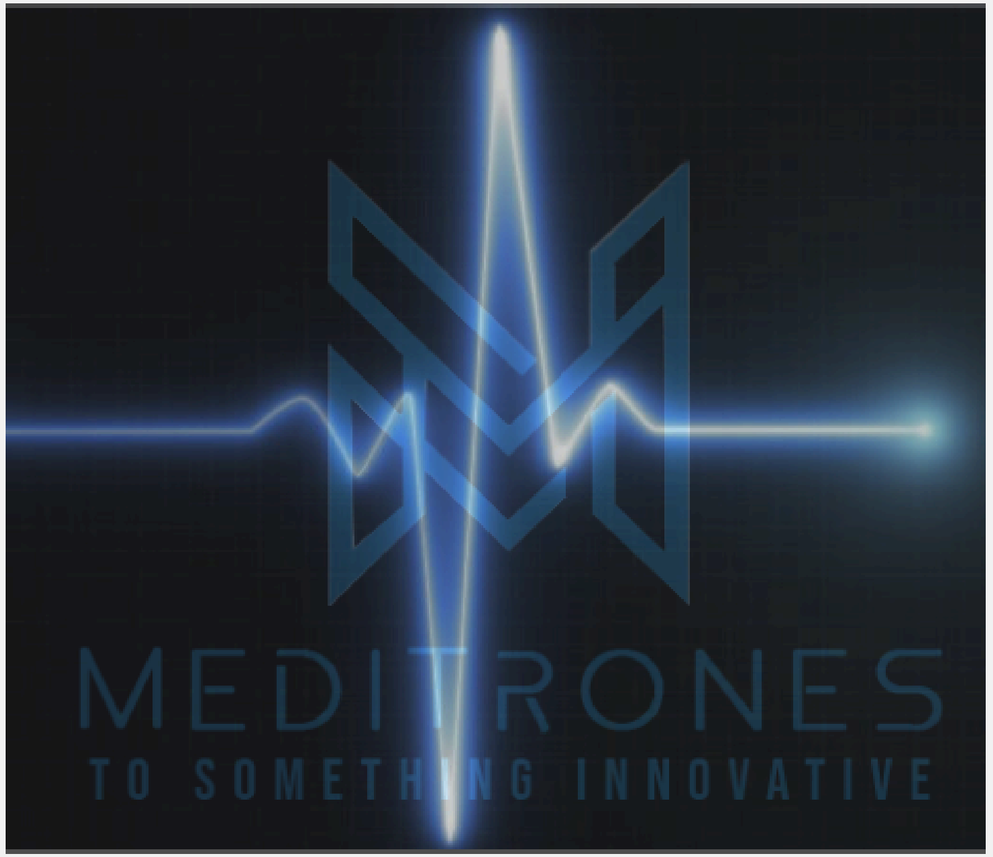
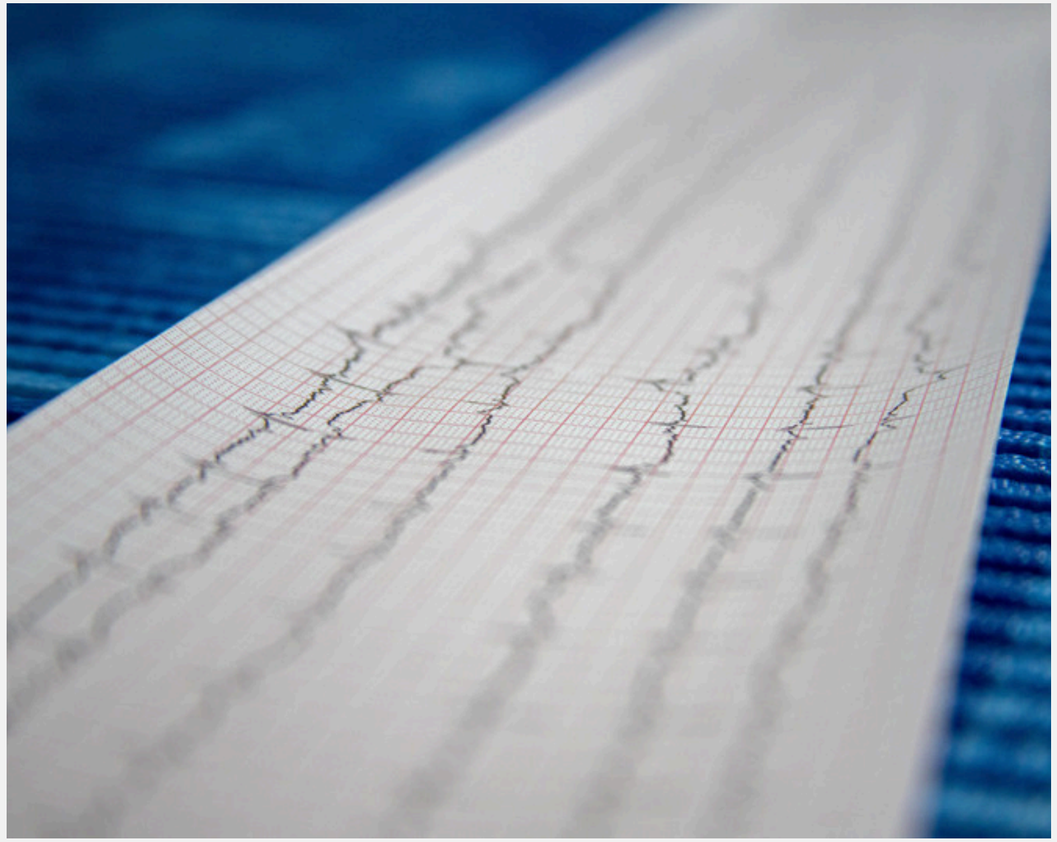
ANALOG HEART

HEART ECG MONITOR

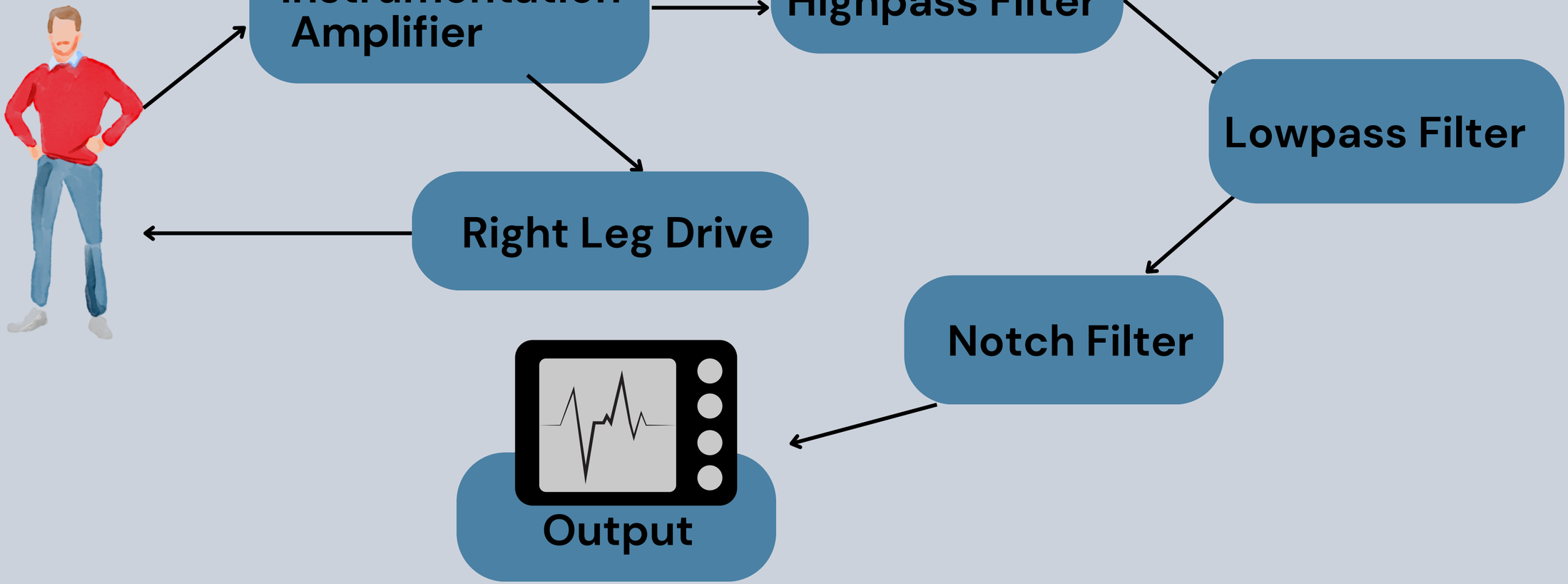


INTRODUCTION

- An ECG (Electrocardiogram) monitor measures the electrical activity of the heart to detect abnormalities in heart rhythm.
- It records the heart's electrical signals using electrodes placed on the body.
- The goal of our project is to design and build a high precision ECG monitor using analog components.
- The device will amplify and filter the heart’s electrical signals to produce a readable ECG waveform.

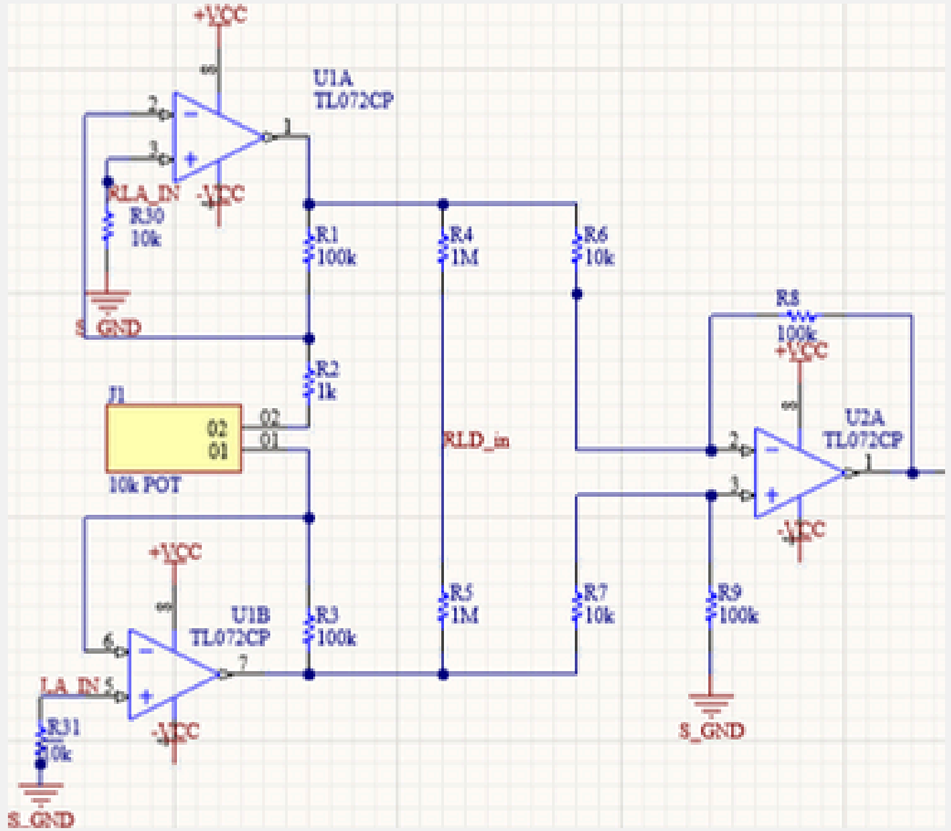


SYSTEM ARCHITECTURE



INSTRUMENTATION AMPLIFIER

- Used to amplify the small differential voltage produced by the heart's electrical activity while rejecting common noise
- Gain – $1 + \frac{2R_1}{R_{\text{var}}}$ = $1 + \frac{2 \times 100}{R_{\text{var}}}$

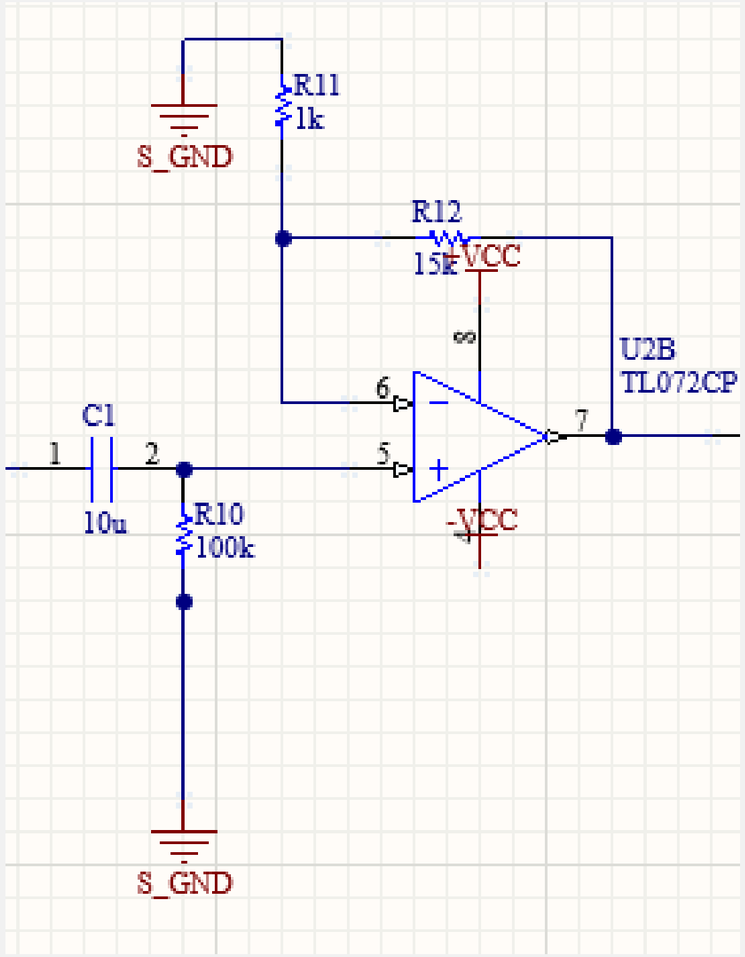


HIGHPASS FILTER

- Used to remove low-frequency noise and the DC offset from the ECG signal, such as baseline wander caused by patient movement or breathing.
- Gain - 17.25
- Cutoff frequency - 0.15 Hz

$$G = 1 + \frac{R_{13}}{R_{12}}$$

$$f_c = \frac{1}{2\pi RC}$$

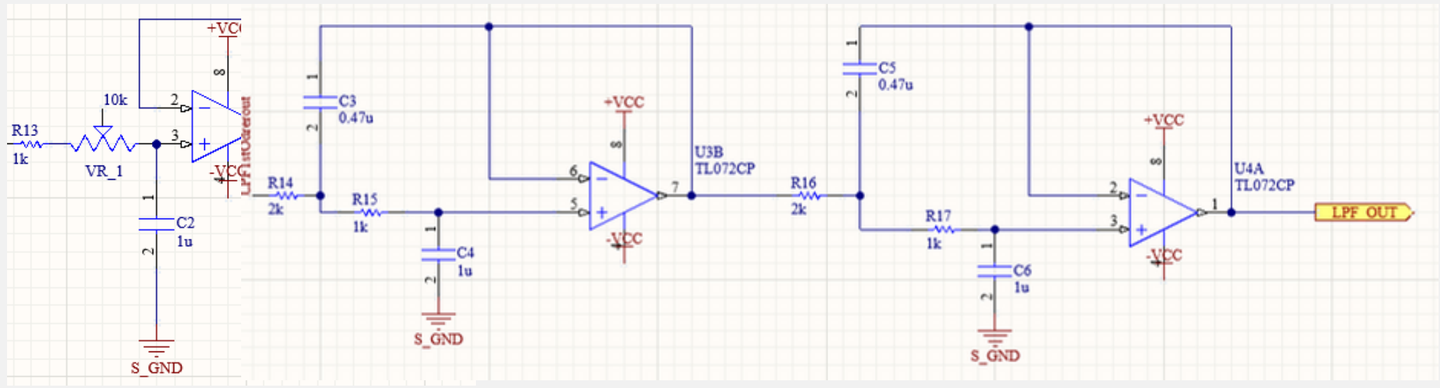


LOWPASS FILTERS

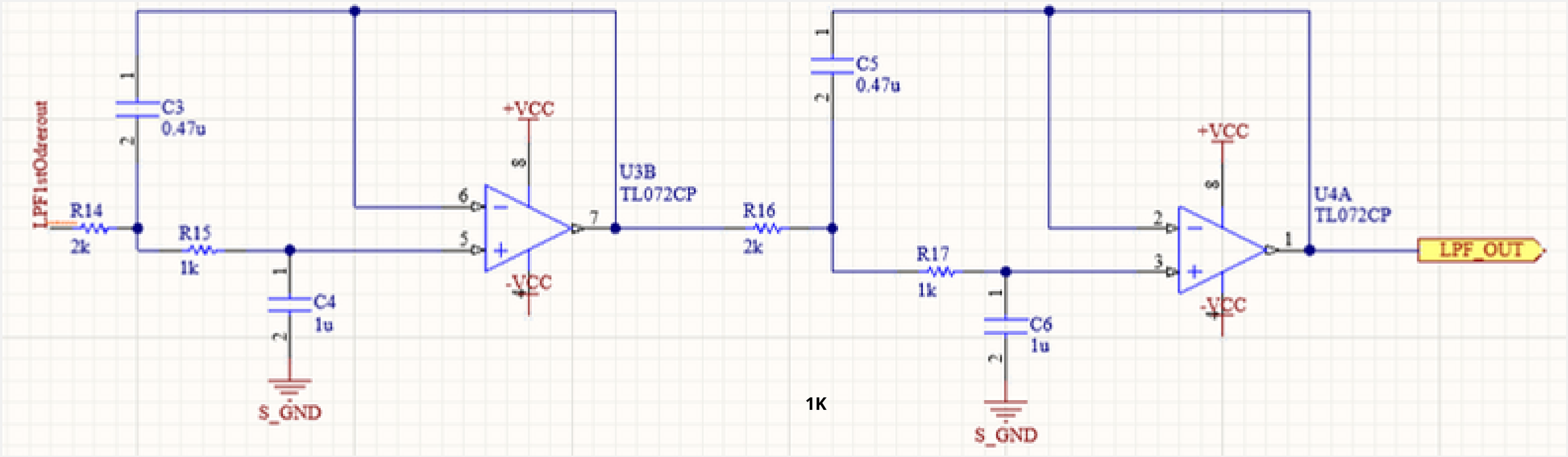
- Used to eliminate high-frequency noise from the ECG signal, such as muscle artifacts or electromagnetic interference.
- Fifth order bessel filter is used.
- Cutoff frequency - 164.15 Hz

$$f_c = \frac{1}{2\pi\sqrt{R_{21}R_{24}C_6C_7}}$$

$$= \frac{1}{2\pi\sqrt{2 \times 1 \times 0.47 \times 1}}$$



LOWPASS FILTERS



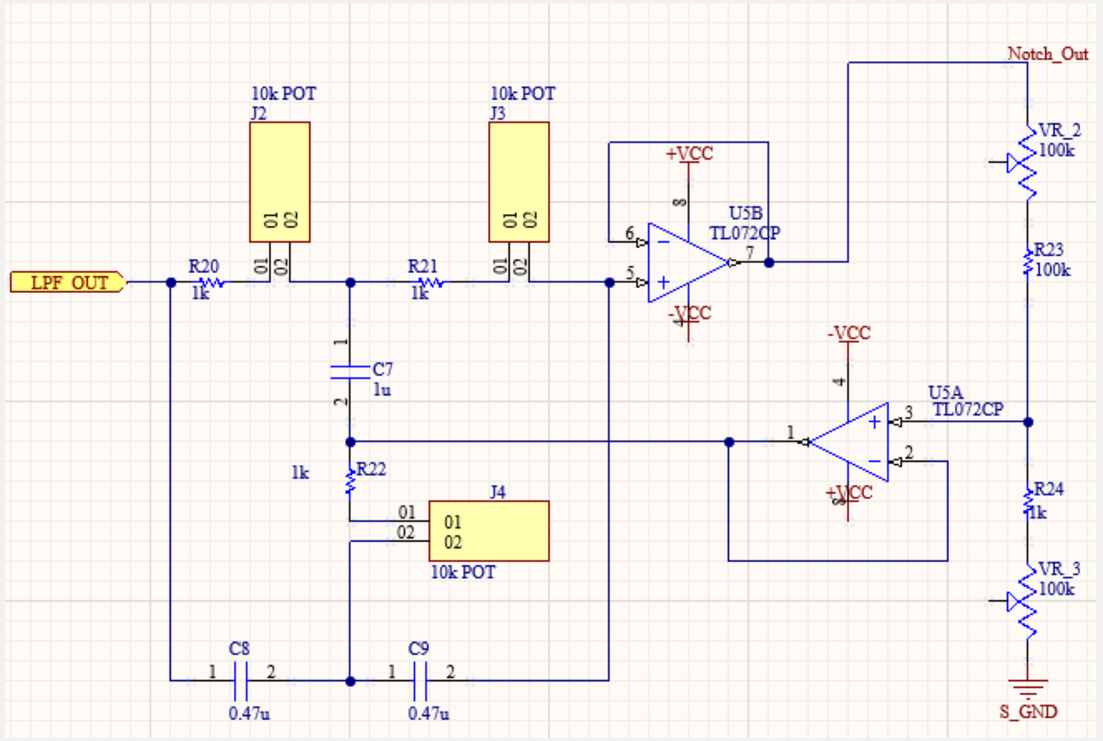
1K

NOTCH FILTER

- Used to eliminate power line interference, which typically occurs at 50 Hz
- Twin-T Notch Filter with feedback is used.
- Notch frequency – 50Hz

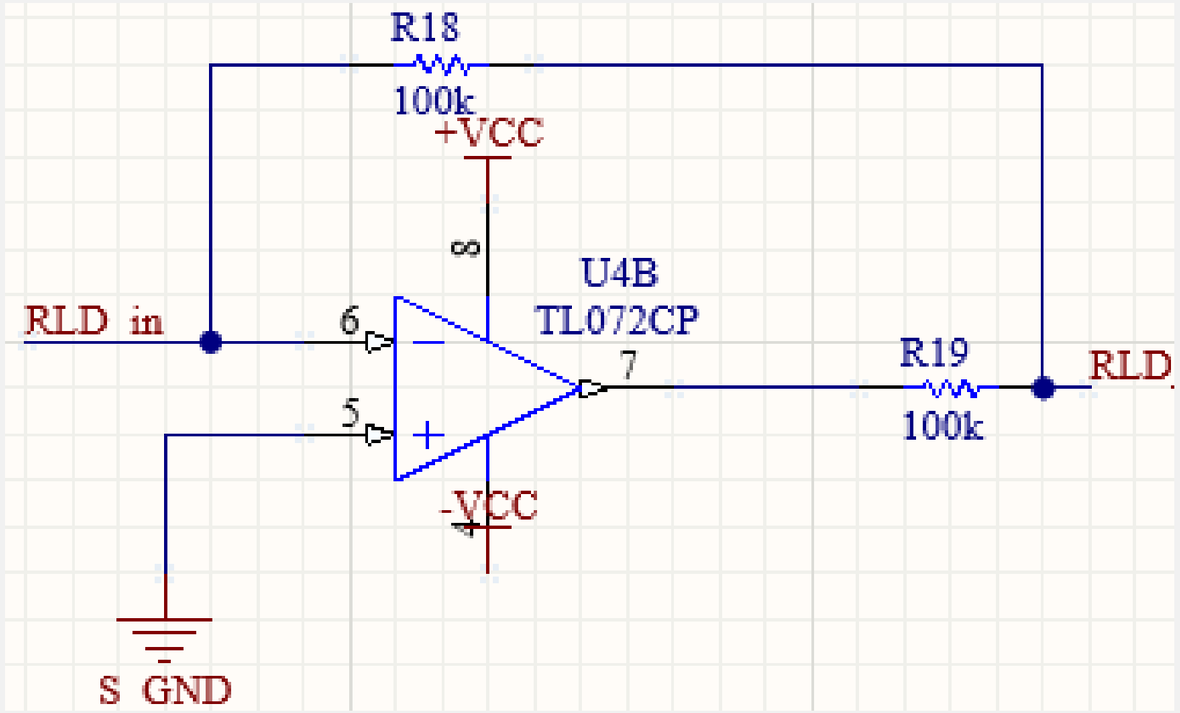
$$f_n = \frac{1}{2\pi RC}$$

$$= \frac{10^3}{2\pi \times 6.8 \times 0.47}$$



RIGHT LEG DRIVE

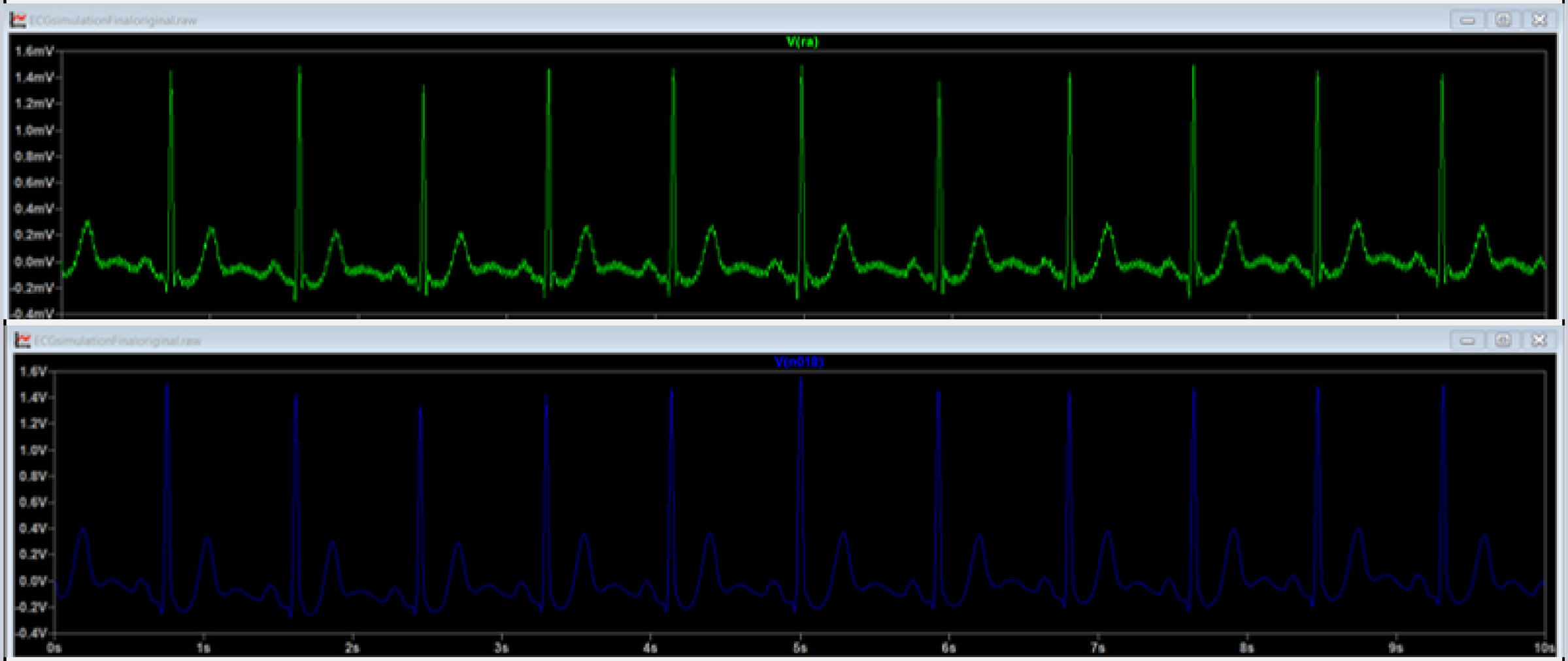
- Used to reduce common-mode interference (such as 50/60 Hz noise) by stabilizing the patient’s body potential.



POWER CIRCUIT

- We are using a boost converter TPS61040 to produce +12V and -12V to power up the Opamps.
- Also we have used a DC-DC booster to power up the ESP-32 module after regulating through ams117-3.3 regulator.
- Furthermore we have proposed to use to a Lipo Battery to make the device portable and a charging module to make it user friendly for the user to recharge.

SIMULATION

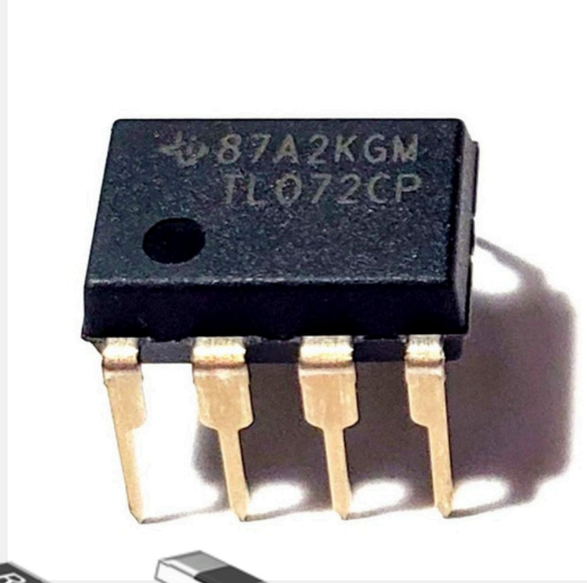

ECGsimulationFinaloriginal.raw
V(ra)
1.6mV
1.4mV
1.2mV
1.0mV
0.8mV
0.6mV
0.4mV
0.2mV
0.0mV
-0.2mV
-0.4mV
ECGsimulationFinaloriginal.raw
V(n018)
1.6V
1.4V
1.2V
1.0V
0.8V
0.6V
0.4V
0.2V
0.0V
-0.2V
-0.4V
0s
1s
2s
3s
4s
5s
6s
7s
8s
9s
10s

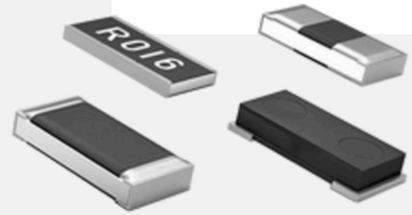
COMPONENT SELECTION - JUSTIFICATION

- TL072 Op-Amp:
  - Low noise, high input impedance, and low power, good for ECG signals.
  - Dual op-amps reduce PCB space and cost.

- SMD Resistors and Capacitors:
  - Compact size for portable design.
  - Better signal integrity and noise performance.

- External Potentiometers:
  - Enables real-time filter adjustment for signal clarity.
  - Adjustable cutoff frequencies

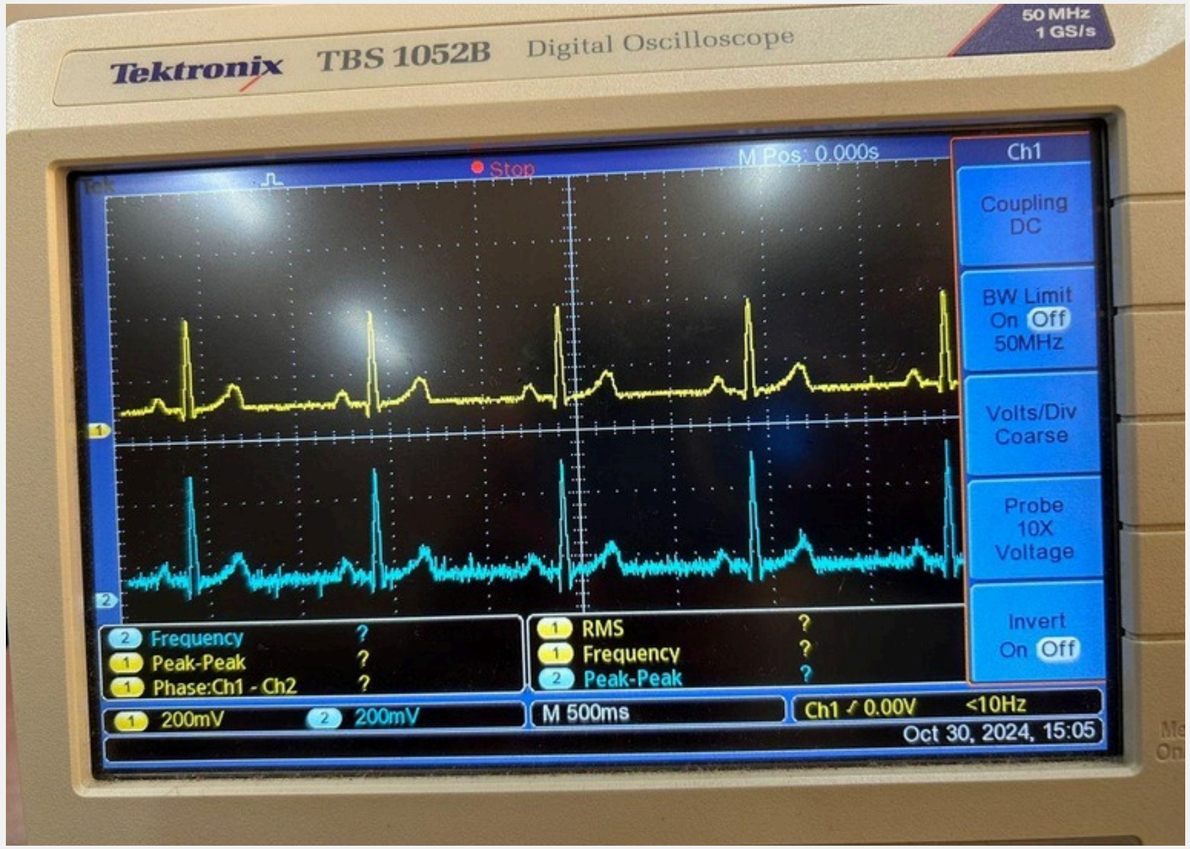




COMPONENT SELECTION - JUSTIFICATION

- LiPo Battery
  - Portability: Enables wearable, mobile ECG monitoring.
  - Battery-Powered Operation: Eliminates direct connection to mains power, significantly reducing 50 Hz interference from power line noise.
  - High Energy Density: Provides long-lasting power in a small form factor.
  - Rechargeable: Reduces costs and environmental impact.
  - Stable Output: Ensures consistent performance for sensitive circuits.
  - Safety: Built-in protection against overcharging and overheating.

CIRCUIT TESTING

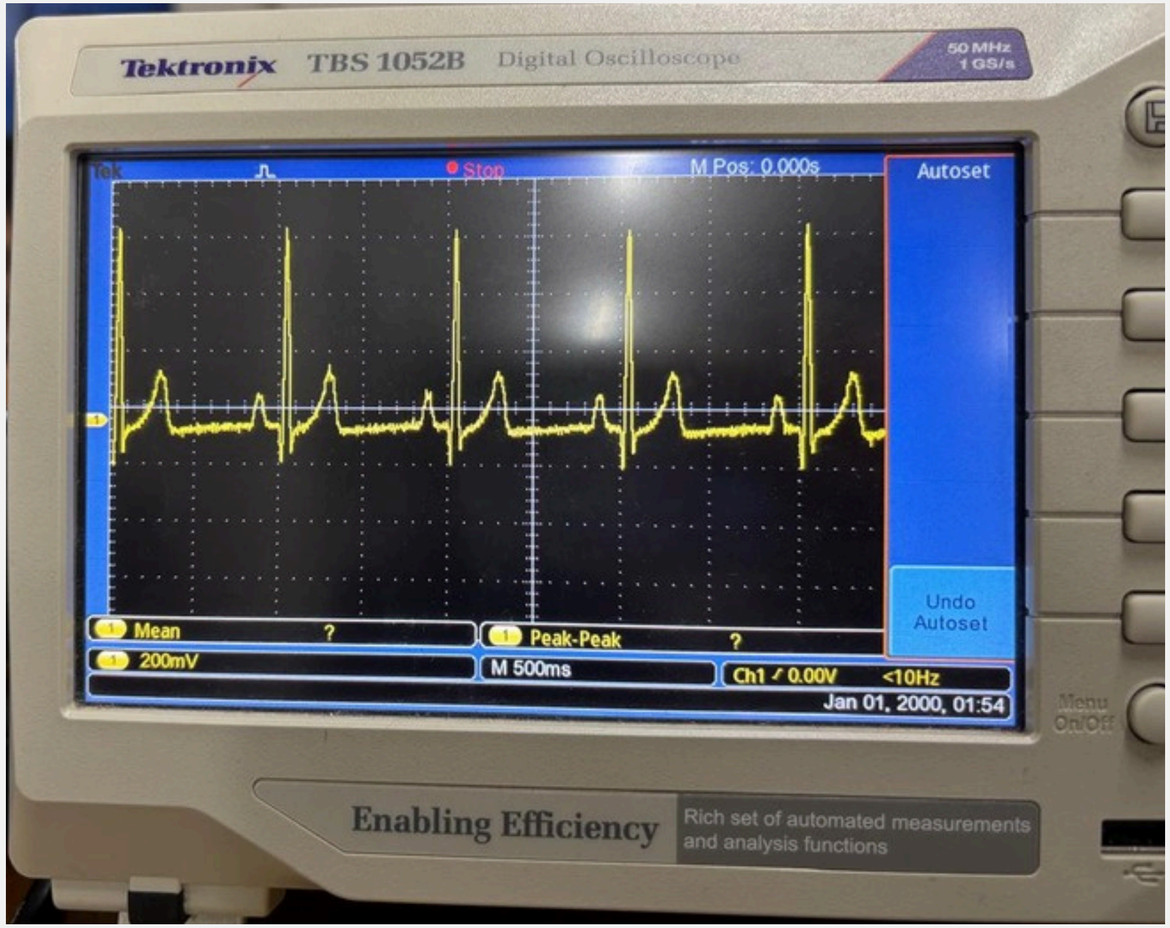


Breadboard circuit - fluke

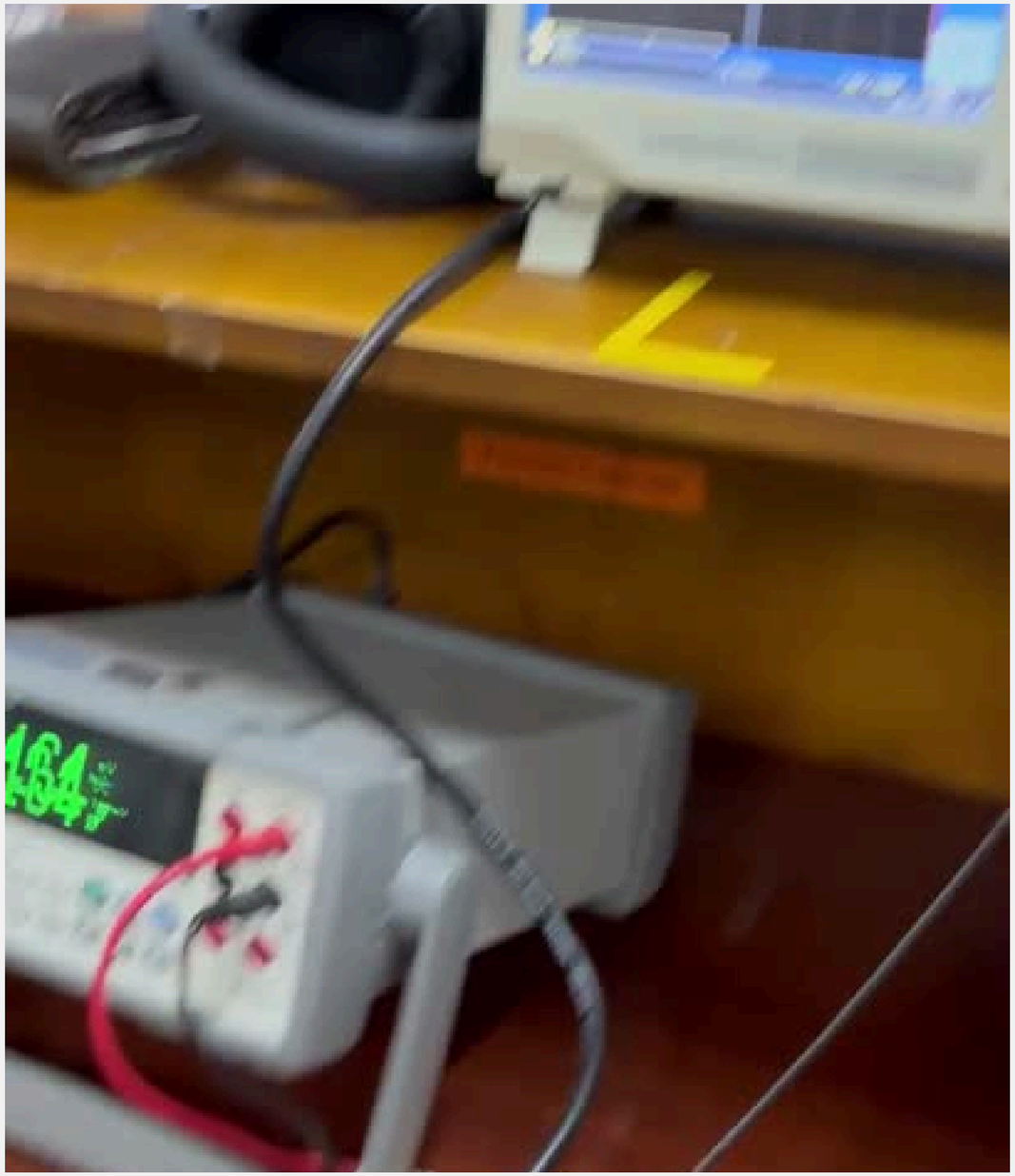
CIRCUIT TESTING

Breadboard circuit - human testing

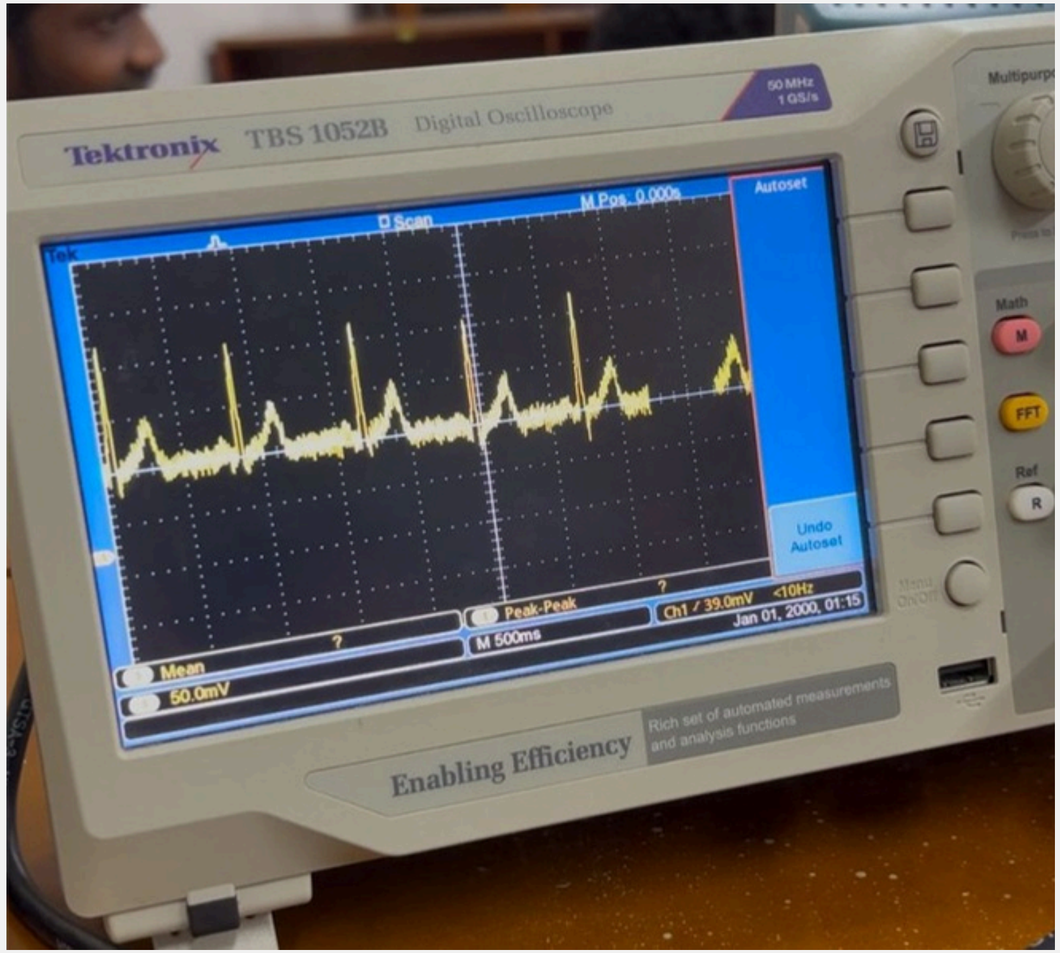
CIRCUIT TESTING



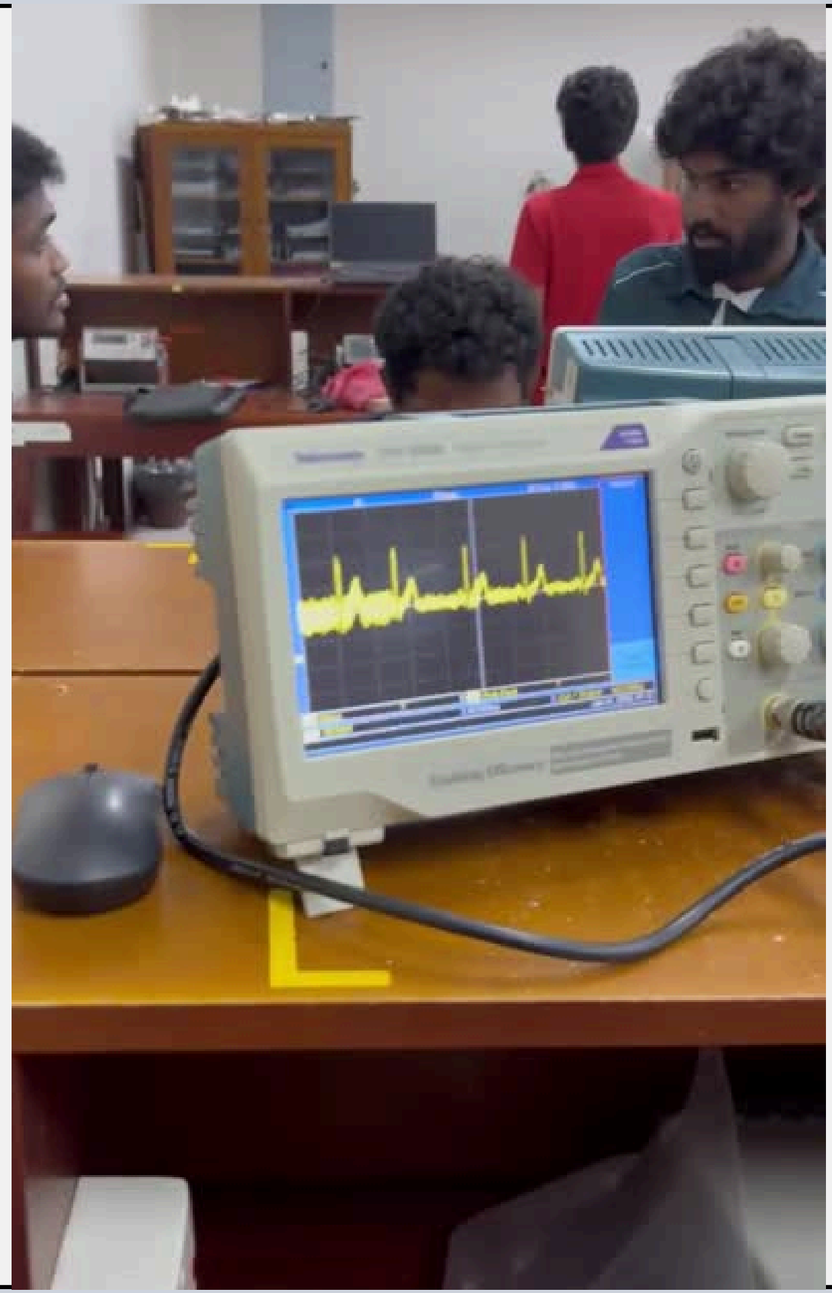
PCB circuit - fluke



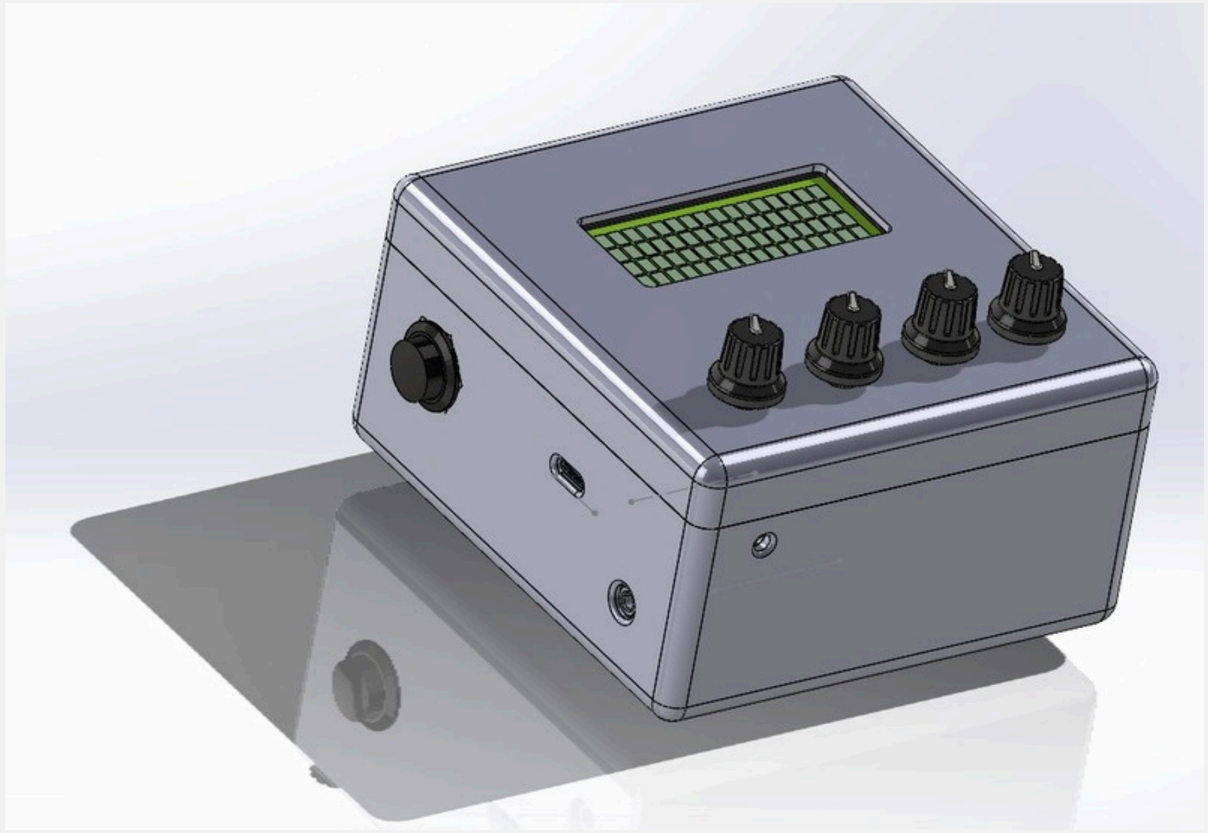
CIRCUIT TESTING

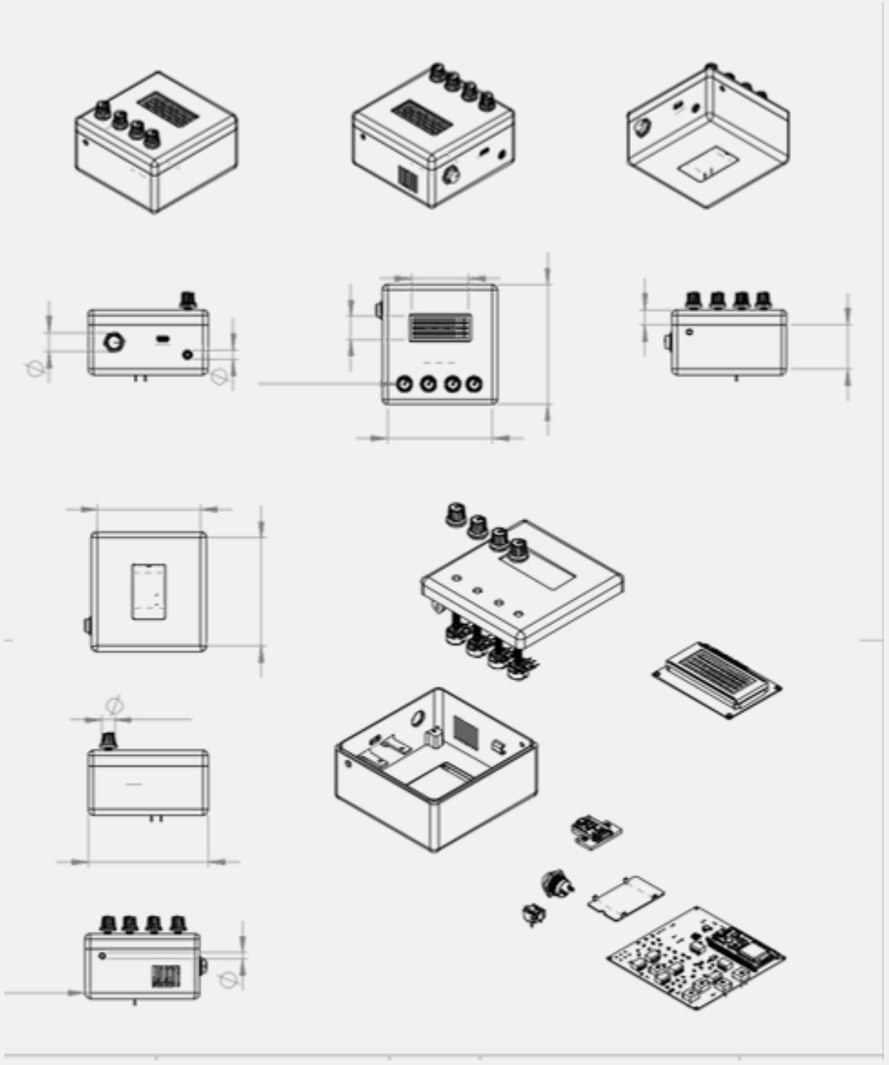


PCB circuit - human testing

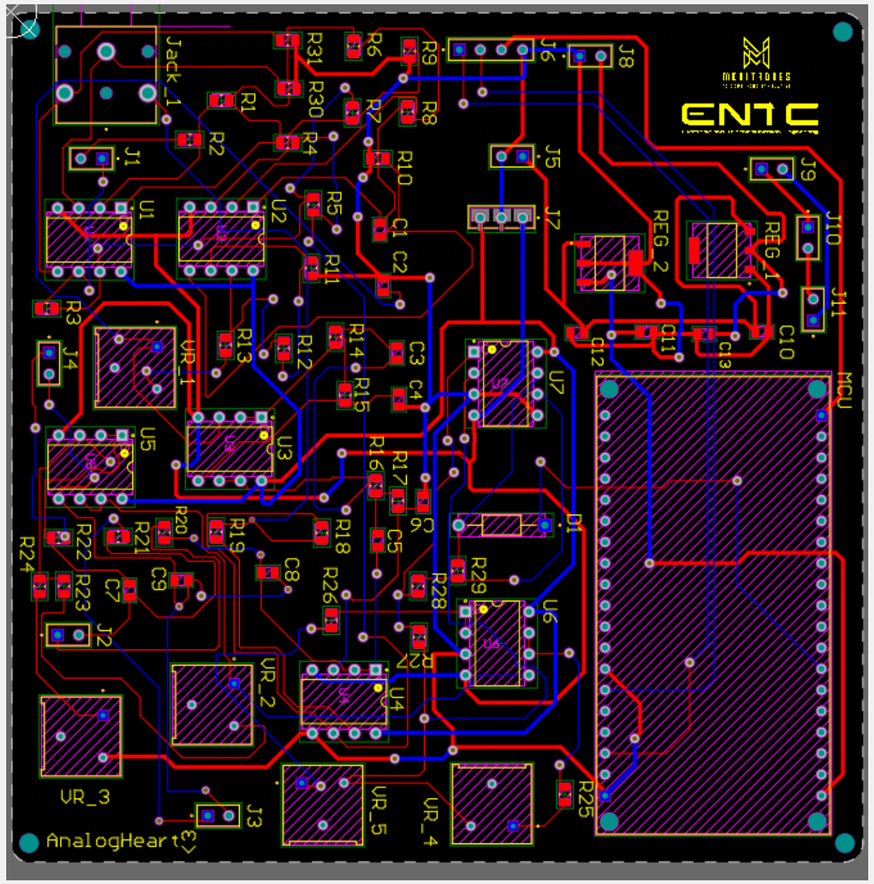


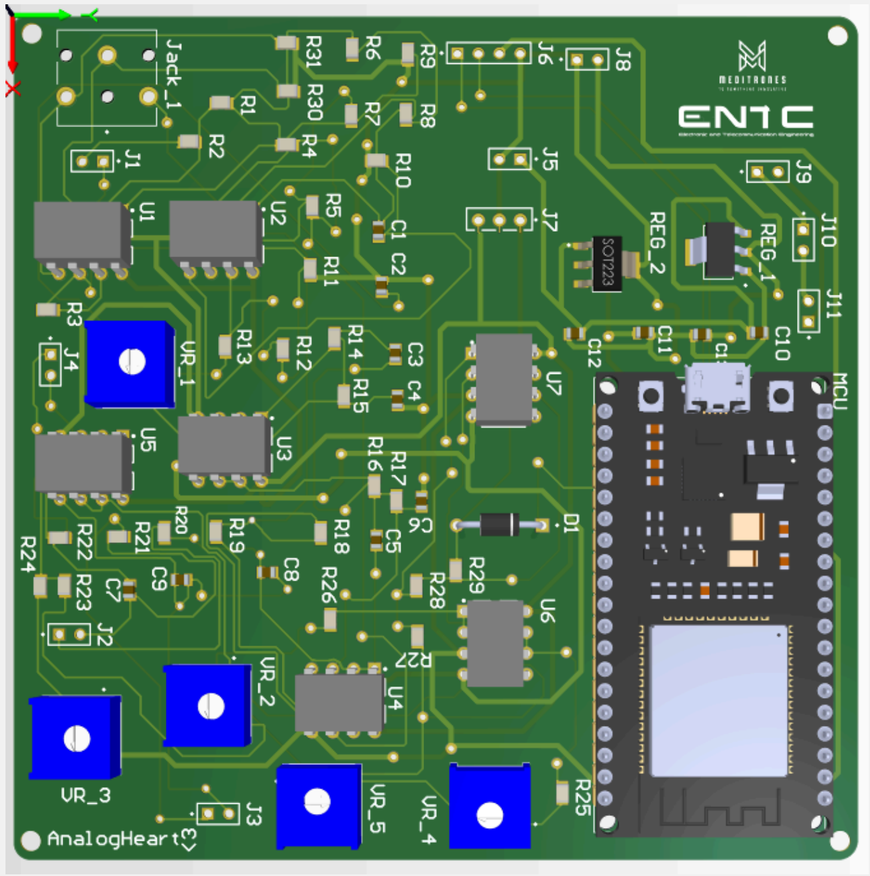
ENCLOSURE





PCB


MEDITRONES
ENTC
MCU
REG_1
REG_2
Jack_1
VR_1
VR_2
VR_3
VR_4
VR_5
AnalogHeart


MEDITRONES
ENTC
MCU
REG_1
REG_2
SOT223
Jack_1
VR_1
VR_2
VR_3
VR_4
VR_5
AnalogHeart

TASK ALLOCATION

- 220005R Aazir M.A.M. - Circuit design and enclosure design
- 220074B Boralugoda M.S. - PCB design and documentation
- 220362G Liyanage D.L.B.B. - Circuit testing and PCB design
- 220374U Madusanka S.P.S. - Enclosure design and Lab Testing

THANK YOU!