Project Title: Instrumentation Amplifiers For Measurement of EMG Signals
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The project aims to design and build a low-noise amplifier tailored for EMG (electromyography) signals, which typically have low voltages ranging from 0.1 mV to 5 mV and frequencies between 0 and 500 Hz. EMG signals are inherently delicate, and most of the signal's energy is concentrated in the 50 to 150 Hz range. This project seeks to amplify these low-voltage signals effectively while minimizing noise, ensuring the amplified signal retains its original characteristics as closely as possible.

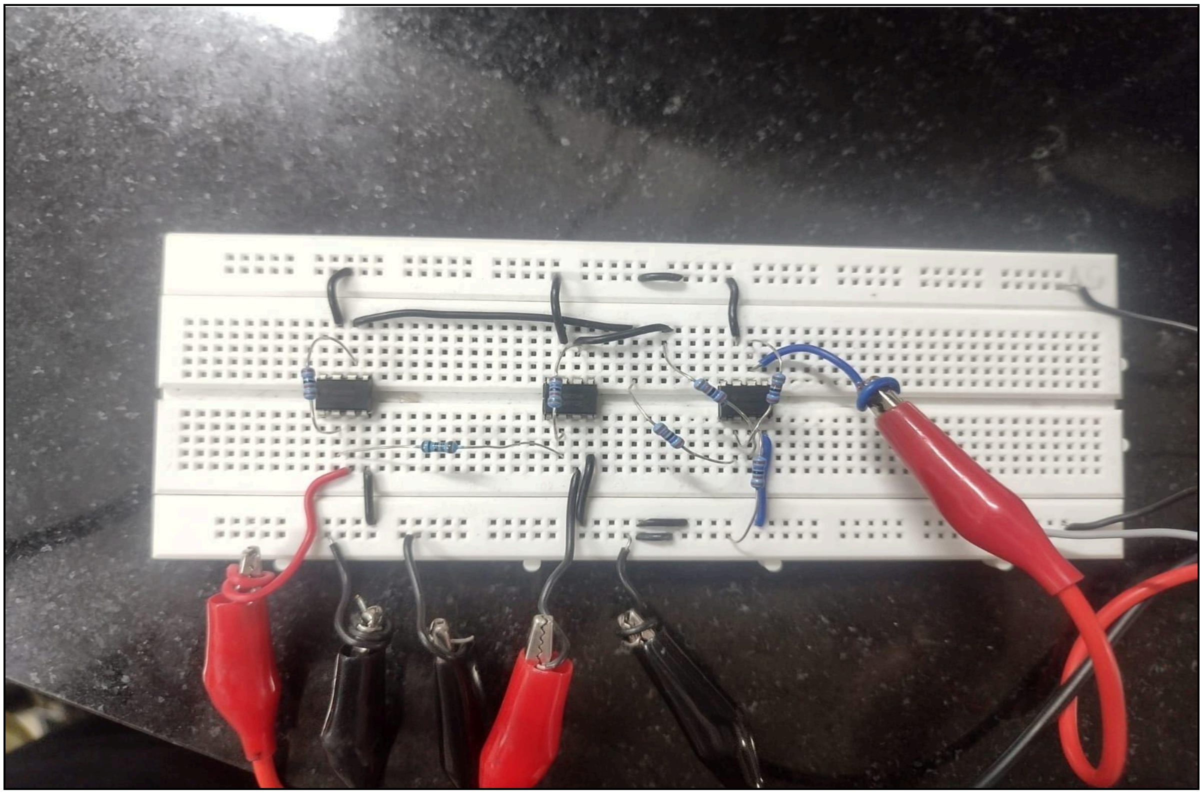
To achieve these goals, the design is divided into two main functional blocks:

1. **Instrumentation Amplifier Block**:
   This first block uses a three-op-amp instrumentation amplifier configuration, chosen for its high common-mode rejection ratio (CMRR) and low power consumption. An instrumentation amplifier is essential here because it will reduce common-mode noise, which can arise from environmental interference or other external sources. By canceling this common noise, the instrumentation amplifier ensures that the useful EMG signal is preserved and amplified accurately. This configuration is particularly effective for biomedical applications due to its ability to handle differential signals and its stable gain settings.
2. **Bandpass Filter Block**:
   Following the instrumentation amplifier, the signal passes through a 6th-order bandpass filter, specifically designed to pass frequencies within a range of 50 Hz to 250 Hz. This range includes the frequency band where most of the EMG signal's energy resides (50 to 150 Hz) while filtering out noise outside this band. The 6th-order design provides a steep roll-off outside the passband, which helps further reduce any unwanted low-frequency drift and high-frequency noise, resulting in a cleaner signal. The filter’s bandwidth is set at approximately 200 Hz, allowing for an effective trade-off between filtering precision and preserving the essential components of the EMG signal.

This amplifier is designed for EMG applications, where low noise and signal integrity are critical. The combination of a high-quality instrumentation amplifier and a selective bandpass filter ensures that the final amplified signal is both clear and highly representative of the original EMG activity. This approach is commonly used in biomedical engineering, where capturing accurate physiological signals is vital for reliable analysis and diagnostics.

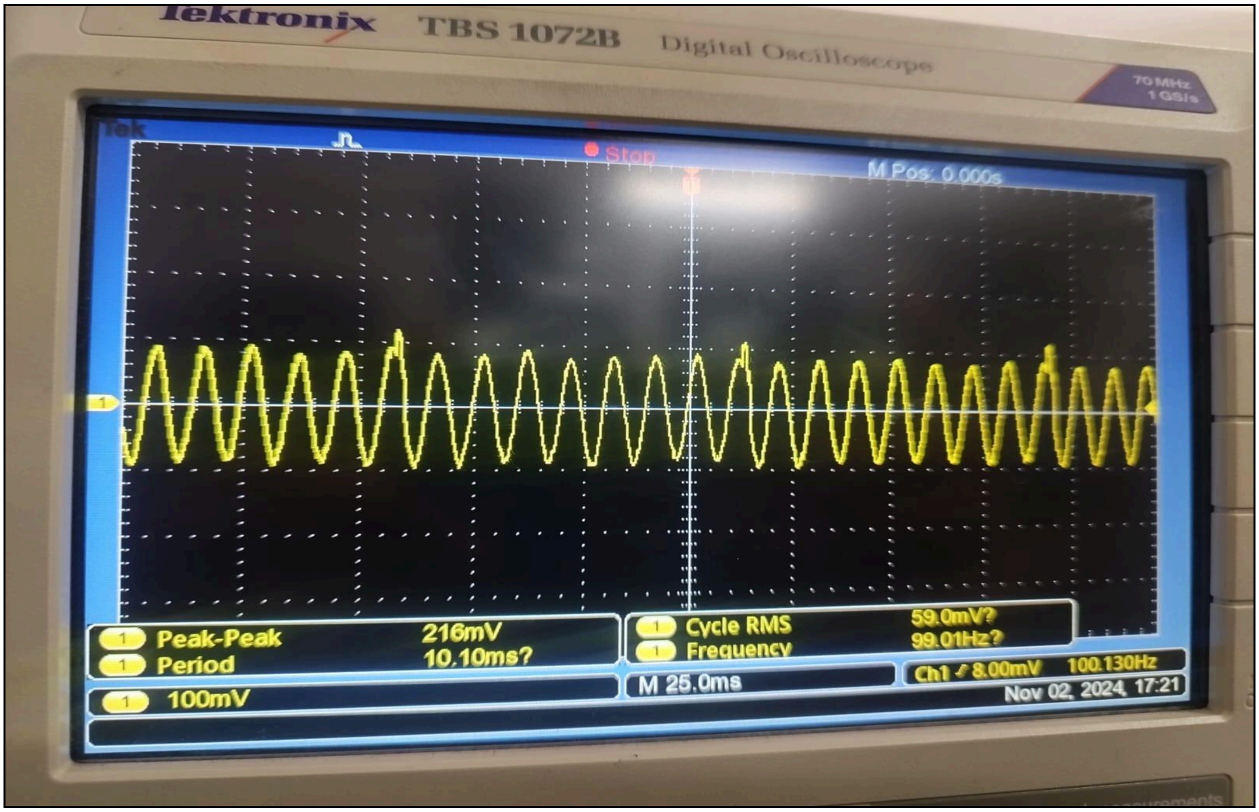
Instrumentation amplifier Block:

Circuit Diagram:



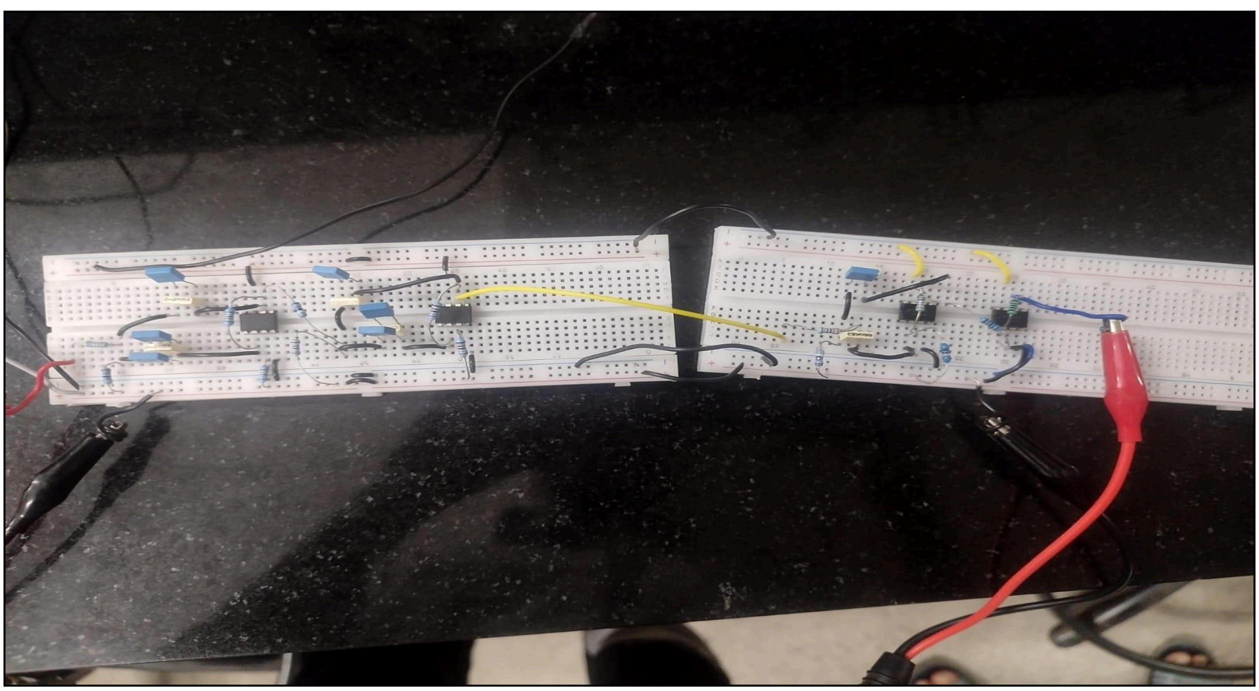
We tested the circuit by applying a common-mode input signal of 2 mV peak-to-peak, with the inputs of the instrumentation amplifier set 180 degrees out of phase. The calculated gain was 55 V/V. Observing the output, we got 216 mV, giving an actual gain of 54 V/V, which is very close to our expected value. This indicates that the instrumentation amplifier is functioning correctly.

Output:



Bandpass Filter Block:

Circuit Diagram:

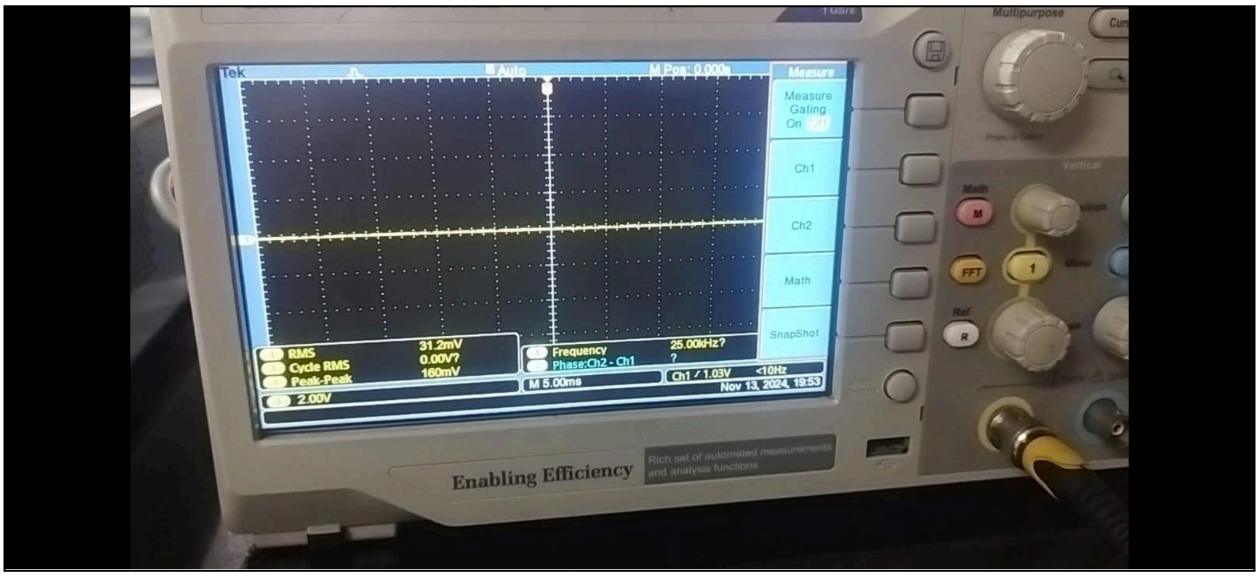


To test the bandpass filter, we applied a 100 mV input signal. At a frequency of 20 Hz, we observed the output was significantly attenuated. This clearly shows that the filter is effectively blocking frequencies outside its passband.

Output:

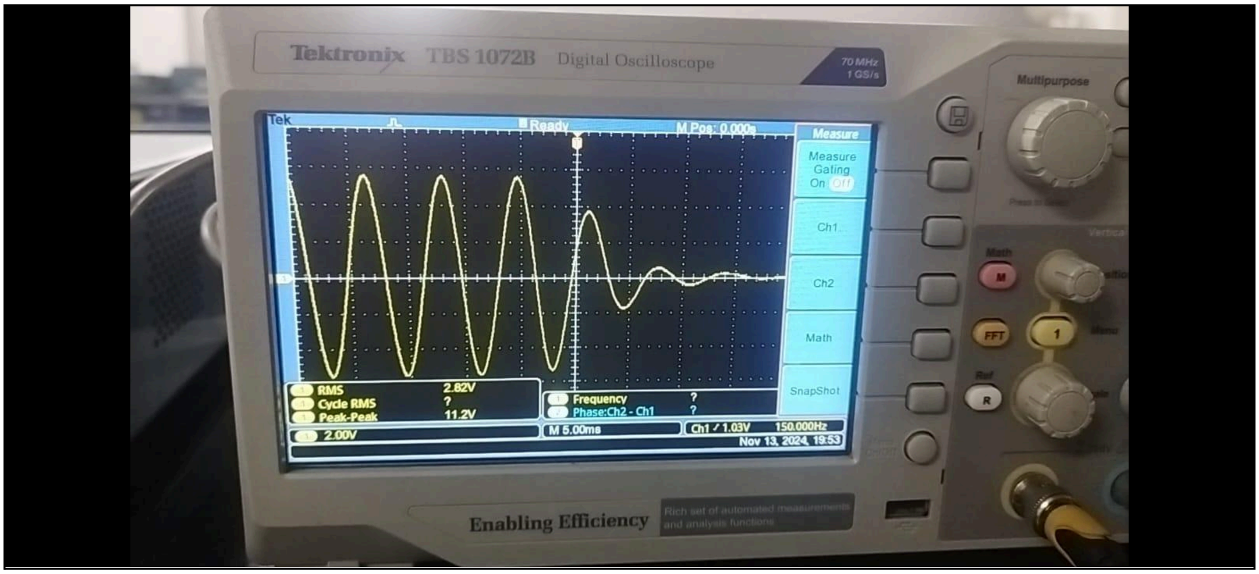
(frequency of 20 Hz)

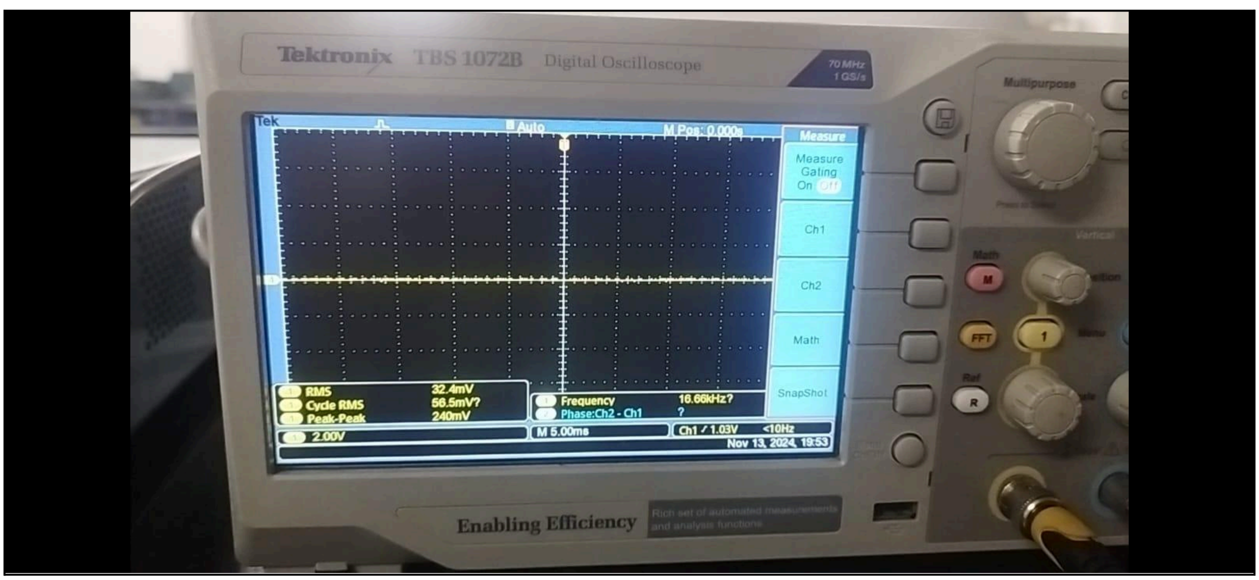
At a frequency of 20 Hz, we observed the output was significantly attenuated. This clearly shows that the filter is effectively blocking frequencies outside its passband.



(frequency of 1 KHz)

At a frequency of 1 kHz, we observed significant attenuation in the output. The first image clearly shows the signal during the attenuation process, and the second image shows the stabilized output, confirming that the 1 kHz frequency is effectively attenuated by the filter.





PCB design:

- Screenshot of Schematic diagram :

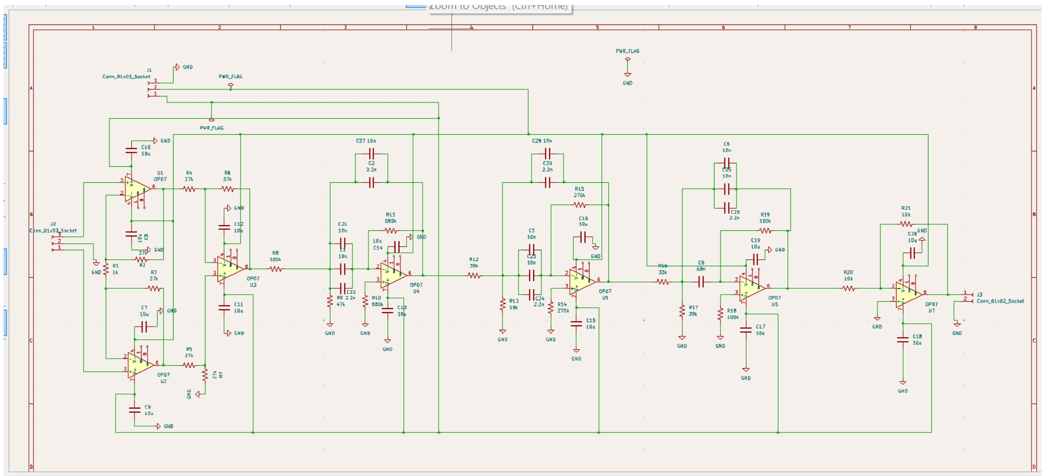


Fig.1 Schematic diagram

- Footprint Assignment table :

Footprint Filters:

Symbol : Footprint Assignments

1	C1 –	10n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
2	C2 –	2.2n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
3	C3 –	10n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
4	C5 –	68n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
5	C6 –	10n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
6	C7 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
7	C8 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
8	C9 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
9	C10 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
10	C11 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
11	C12 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
12	C13 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
13	C14 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
14	C15 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
15	C16 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
16	C17 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
17	C18 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
18	C19 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
19	C20 –	10u	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
20	C21 –	10n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
21	C22 –	2.2n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
22	C23 –	10n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
23	C24 –	2.2n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
24	C25 –	10n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
25	C26 –	2.2n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
26	C27 –	10n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
27	C28 –	10n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
28	C29 –	2.2n	Capacitor_THT:CP_Radial_D8.0mm_P3.50mm
29	J1 –	Conn_01x03_Socket	Connector_PinSocket_2.54mm:PinSocket_1x03_P2.54mm_Vertical
30	J2 –	Conn_01x03_Socket	Connector_PinSocket_2.54mm:PinSocket_1x03_P2.54mm_Vertical
31	J3 –	Conn_01x02_Socket	Connector_PinSocket_2.54mm:PinSocket_1x02_P2.54mm_Vertical
32	R1 –	1k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
33	R2 –	27k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
34	R3 –	27k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
35	R4 –	27k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
36	R5 –	27k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
37	R6 –	27k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
38	R7 –	27k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
39	R8 –	100k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
40	R9 –	47k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
41	R10 –	680k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
42	R11 –	680k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
43	R12 –	39k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
44	R13 –	18k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
45	R14 –	270k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
46	R15 –	270k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
47	R16 –	33k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
48	R17 –	39k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
49	R18 –	100k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
50	R19 –	100k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
51	R20 –	10k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
52	R21 –	10k	Resistor_THT:R_Axial_DIN0309_L9.0mm_D3.2mm_P12.70mm_Horizontal
53	U1 –	OP07	Package_DIP:DIP-8_W7.62mm
54	U2 –	OP07	Package_DIP:DIP-8_W7.62mm
55	U3 –	OP07	Package_DIP:DIP-8_W7.62mm
56	U4 –	OP07	Package_DIP:DIP-8_W7.62mm
57	U5 –	OP07	Package_DIP:DIP-8_W7.62mm
58	U6 –	OP07	Package_DIP:DIP-8_W7.62mm
59	U7 –	OP07	Package_DIP:DIP-8_W7.62mm

Fig.2 Footprint assignment table

- Electrical Rule Checker Screenshot

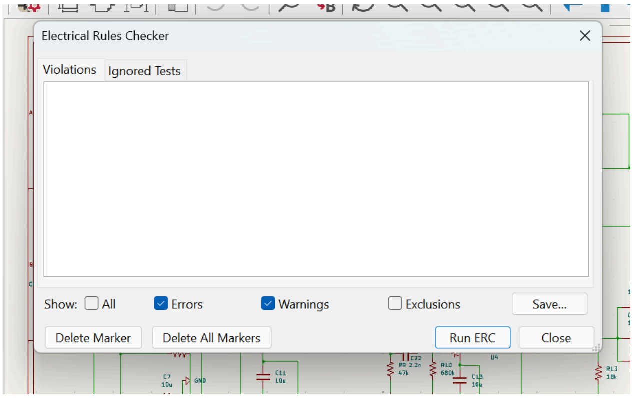


Fig.3 Electrical rule checker

- PCB layout of the circuit

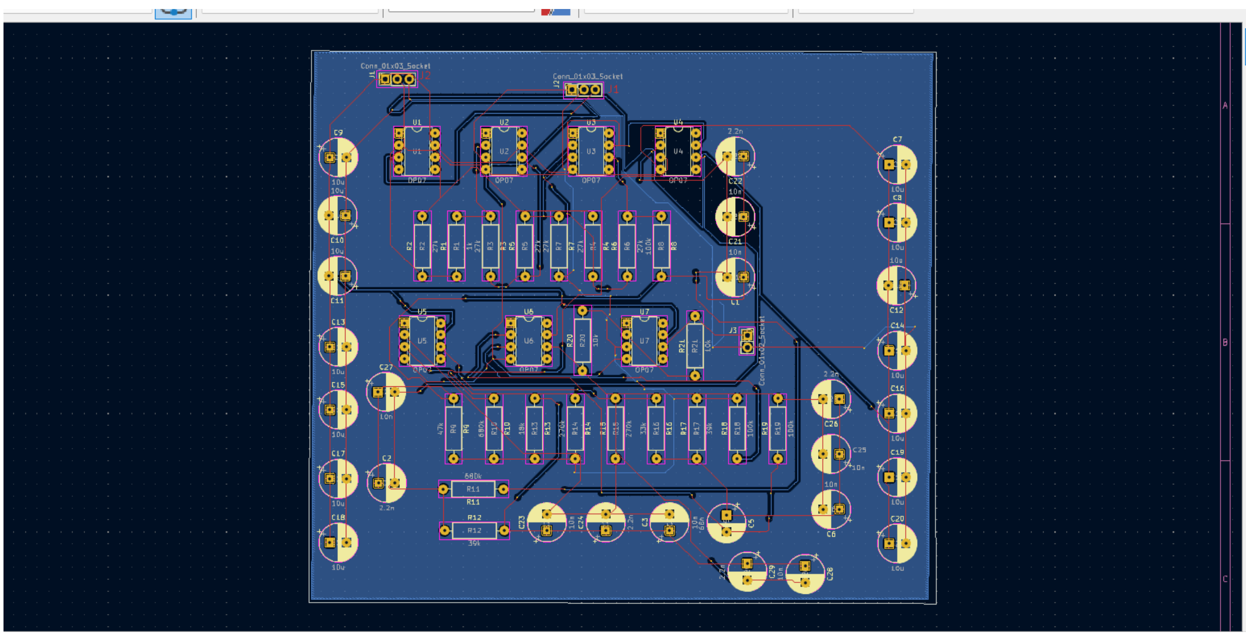


Fig.3 PCB design

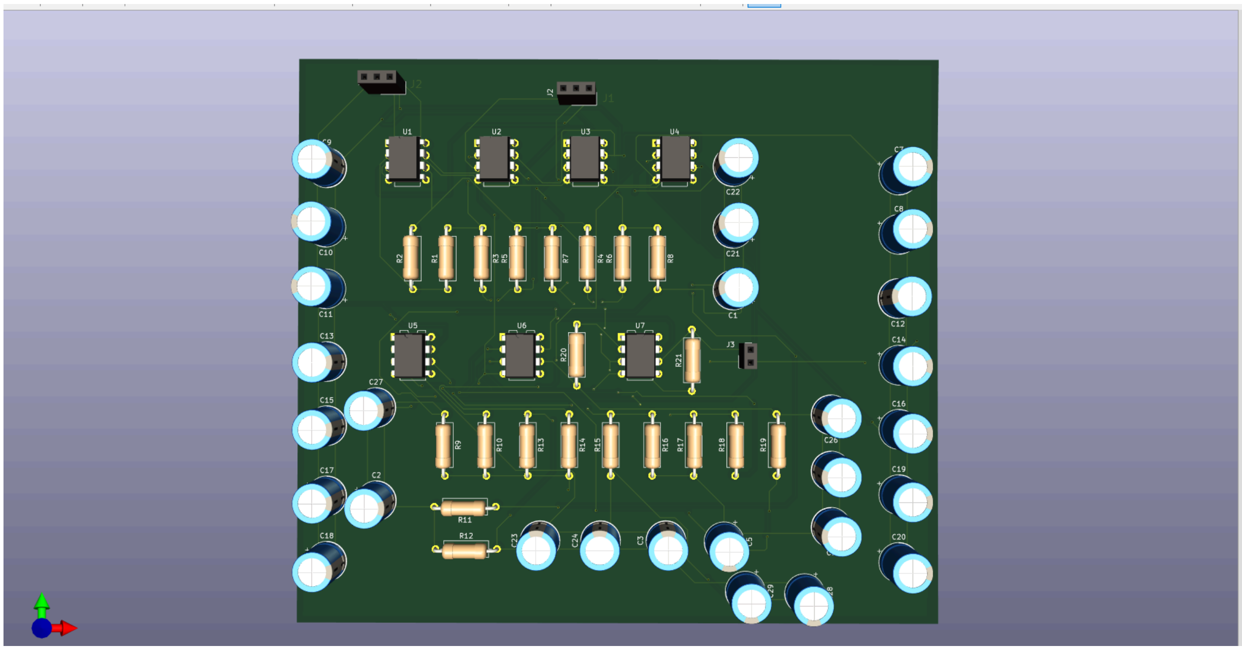


Fig.4 3D PCB dsign

- DRC report list

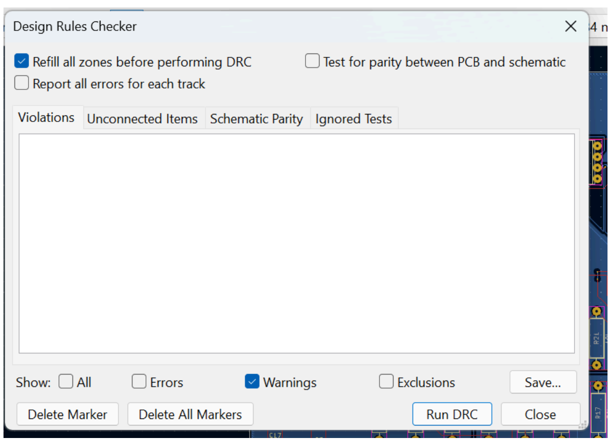


Fig.5 DRC report