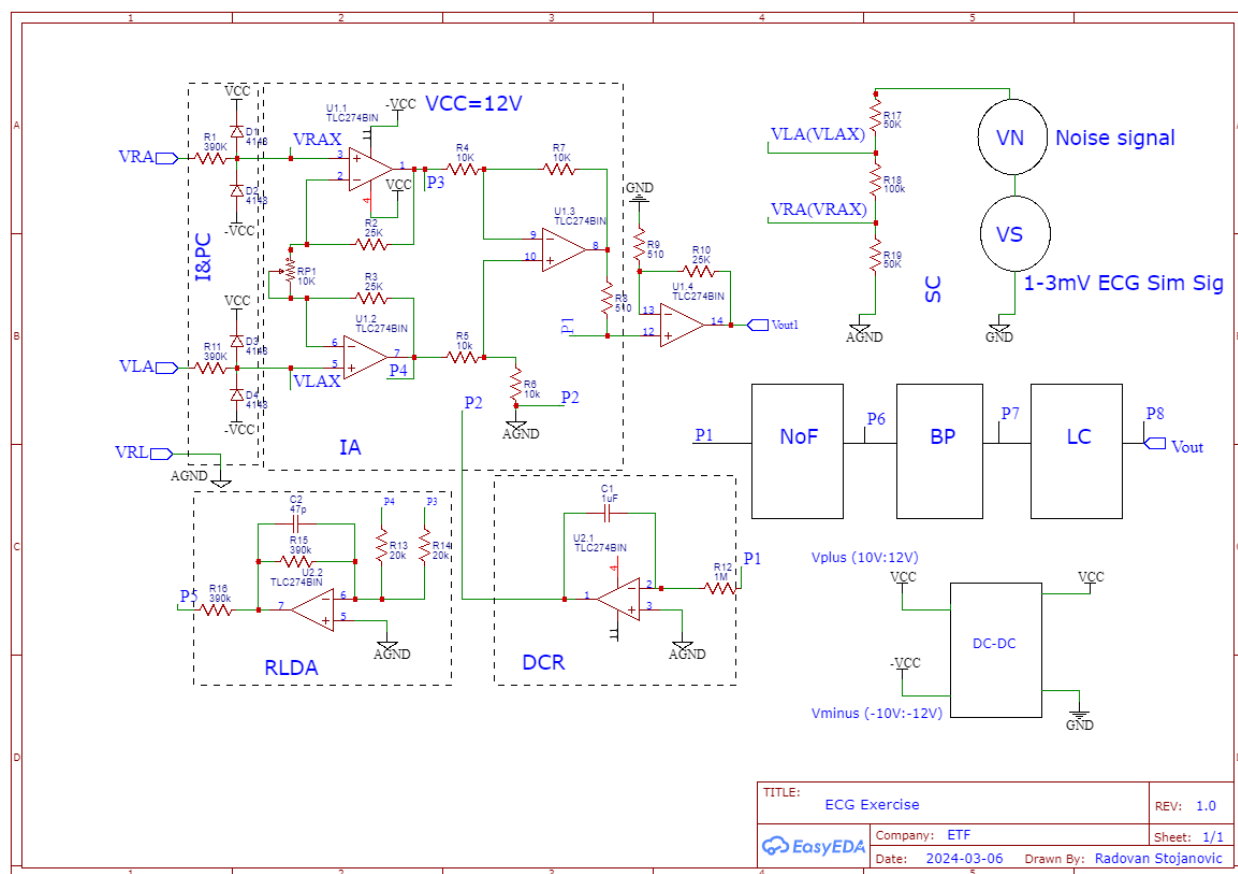


Slika 1: Šema ECG pojačavača



Slika 2. Scenario nadogradnje ECG pojačavača sa Slike 1.

Komponente (blokovi)

Potrebno je provjeriti način rada postojećih i projektovati dodatne blokove sistema sa slike 2, koristeći LT Spice.

1. **Basic differential (instrumentation) amplifier (IA).**
 - a. Connect SC to IA via points (Ps) VLAX and VRAX.
 - b. Fed simulation signal ECG to VS (VN is short circuited).
 - c. Observe signals in VRAX, VLAX, VS, VP1 and VOUT1.
 - d. Adjust RP1 and R10 to have final gain of $\text{abs}(V_{\text{out1}}/(V_{\text{rax}}-V_{\text{lax}}))=1000$.
 - e. Attach description and simulation diagrams
2. **Input protection circuit (I&PC).**

- a) Connect I&PC circuit between VRA->VRAX and VLA ->VLAX.
- b) Fed VN signal as high voltage noise of $\pm 1\text{KV}$ and duration 0.5s.
- c) Observe signal VS+VN, VRAX, VLAX and VP1.
- d) Calculate in noise moments current via R1, R11, and protection diodes D1...D4.
- e) Try to implement AC coupling circuit between VRA->VRAX and VLA ->VLAX.
- f) Attach description and simulation diagrams

3. DC offset restoration circuit (DCR)

- a. Between points P1 and P2 connect DCR circuit. P2 is instead AGND (in this case the AGND is disconnected from P2) .
- b. Put the VN as low frequency (slowly changed) noise between 0.25-1Hz frequency and 1-10mV amplitude.
- c. Observe signal in P1 and Vout1 for different frequencies and amplitudes of VN.
- d. Adjust R12 and C1 for diagnostic mode, monitoring mode and quick restoring mode. Modes are selectable by switches that also request to be simulated.
- e. Attach description and simulation diagrams

4. Right Leg Drive Amplifier Circuit (RLDA)

- a. Between points P3, P4, P5 connect RLDA circuit. Remove VN.
- b. Observe signal in P5 for different frequencies and amplitudes of VN.
- c. Calculate current via R16.
- d. Attach description and simulation diagrams.

5. Notch filter (NoF)

- a. Design 2d order Notch Filter with rejection of 50Hz frequency.
- b. Select components and do the simulation observing time diagrams in P1 and P6. Put VN as 50Hz noise.
- c. Attach description and simulation diagrams.

6. Band Pass Filter (BPF)

- a. Design 2d order Notch Filter with rejection filter border frequencies [0.5Hz-150Hz).
- b. Select components and do the simulation observing time diagrams in P1 and P6. Put VN as series of different noise, one of 0.1Hz and the second of 500Hz.
- c. Attach description and simulation diagrams.

7. Level convertor (LC)

- a. Design level convertor which signal from $\pm 2\text{V}$ transform in a different ranges i) 0-1.1V ii) 0-2.5V iii) 0-5V.
- b. Simulate typical cases, observe diagrams.
- c. Attach description and simulation diagrams.

8. DC-DC converter (DC-DC)

- a. To supply the above ECG with dual power supply $\pm 12\text{V}$ from single power supply of 12V it is necessary to design DC-DC convertor and to convert $\pm 12\text{V}$ in

negative voltage (as example -10.8V). It can be done with diode charge pump and timer 555.

- b. Design and simulate such DC-DC converter for different load currents (or load impedance).
- c. Attach description and simulation diagrams.

9. System integration and protection (SI)

- a. It is necessary to integrate all components 1-8 or 1-7 in one system with following characteristics.
- b. ECGgain=1000, [0.5Hz-150Hz], 50Hz rejection, 2s DC restoration time, <10mA consumption.
- c. Safety for the operator and patient can be maintained when the applied current (sink or source) is limited to less than 10 μ A rms, even during single-fault failures. It means, all currents from-to circuit should be limited to 10uA or in the worst case 100uA.
- d. Check all above characteristics for designed ECG amplifier and do correction where it is necessary.
- e. Integrate all components and
- f. Attach description and simulation diagrams.

10. Instrumentation amplifier with 2 operation amplifiers

- a. Perform simulation in time and frequency domain for circuit given at <https://www.multisim.com/content/9EztvhqJmQcCYHrPGWbWxT/two-op-amp-instrumentation-amplifier/>
- b. Consider ECG signal from previous cases, as in 1).