Laboratory 2

Design of a bio-instrumentation amplifier for ECG

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Scope of the lab:

1. Design a multistage bioinstrumentation amplifier for ECG.
2. Acquire ECG data for the three standard leads.
3. Plot the frontal vector cardiogram derived from lead I, II, and III ECG voltages.

Pre-lab:

1. Review ECG concepts; familiarize yourself with standard electrode configurations.
2. Design a multistage bioinstrumentation amplifier for ECG signals. The amplifier should have the following stages:

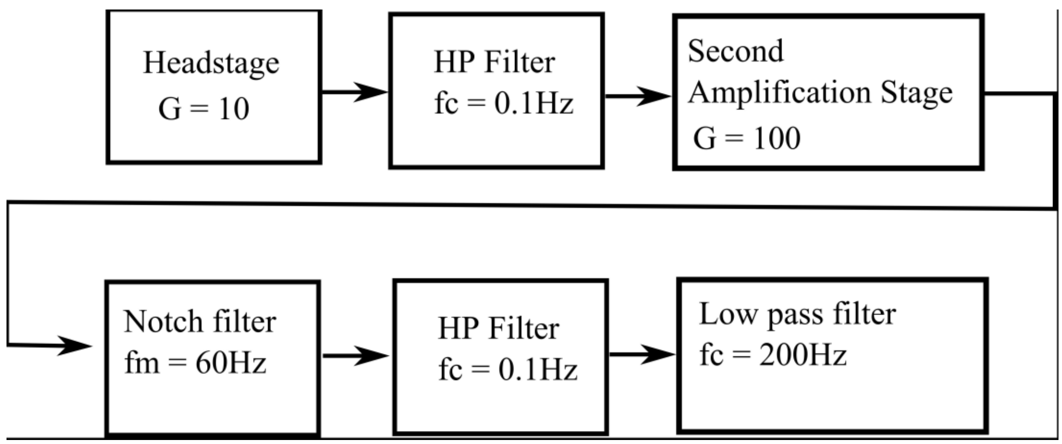

Figure 1: Block diagram of a bioinstrumentation amplifier suitable for ECG measurements

3. Specifications:
   - *Note: You are required to use 1% resistors with standard values.*
   - Headstage - Use instrumentation amplifier LT1920. G=10.
   - HP Filters – Passive, use capacitor value 2.2uF and compute the proper resistor value.
   - Second Amplification Stage – Use TLC2274 in a non-inverting configuration. G=100.
   - Notch filter – Active twin-T, use TLC2274. Use capacitor value 56nF. Use an adjustable resistor to allow tuning**.**
   - Low pass filter – use a Sallen-Key topology to implement a second order Tchebyscheff filter with 3dB pass band ripple. Use capacitors C_1 = 33nF; C_2 = 330nF; verify that C_2 value is properly chosen; compute the proper resistor values.
   - Write a short report describing the design; what does each stage do? Include schematics. The report should be delivered to the TA at the start of the lab.

During the lab

A. Test and adjust the performance of the circuit
   1. Build the circuit that you designed in your pre-lab using the MacECE BiomedLab platform.
   2. Bypass the second amplification stage so that you have an overall gain of 10.
   3. Connect your circuit to the signal generator and to the oscilloscope as in Figure 2.
   4. Check the gain of your circuit for frequencies between DC to 300Hz.
   5. Find the gain at 60Hz.

6. Plot gain vs. frequency for signals between DC and 300Hz.

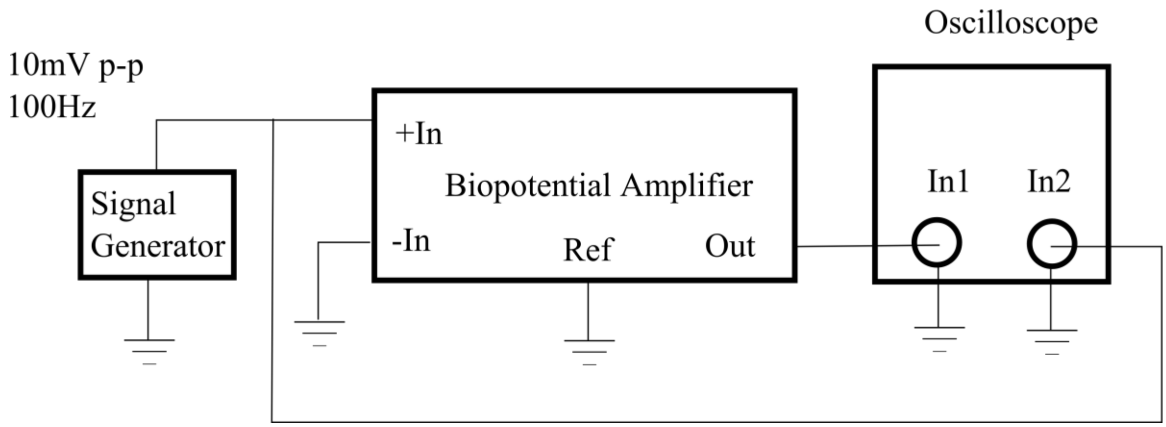

Figure 2: Connections for performance evaluation and tuning

B. Acquire ECG signal
- *Sim1*: Attach Multi-Parameter Patient Simulator to your circuit using RA and LA as the + and - inputs and RL as ground. Turn unit on and select 60 Hz waveform and view amplifier output using the oscilloscope.
    - Is your notch filter removing the differential noise?
- *Sim2*: Select the Lead I ECG output and observe on the scope - vary the beat rate and try different functions on the simulator.
- *Sim3*: Try different settings and demonstrate to the TA that you can use this unit and your amplifier works prior to putting on electrodes.

1. Add the isolation amplifier at the output of the bioinstrumentation amplifier.
2. Add the second amplification stage so you have an overall G=1000.
3. Connect the electrodes to your amplifier using a Lead I connection.
4. Connect the output of the isolation amplifier to the NI Analog to digital board.
5. Start the LabVIEW program used for data acquisition.
6. Turn on the power on the ECEBiomed Lab board.
7. Your ECG should be on the screen. Go to Part C.
8. Save the ECG data for a couple of heart beats.
9. Connect the electrodes in Lead II configuration and save data.
10. Connect the electrodes in Lead III configuration and save data.
11. Identify the PQRST components in your ECG trace (provide plot for all three lead configurations).

C. Checking performance of the system
1. Find the magnitude of the DC offset in your input signal.
2. Turn the ECEBiomed Lab board power off; bypass the 60 Hz notch filter; Turn the power on and start the LabVIEW program again; Collect a Lead I signal.
    - Does the ECG signal look different?
    - Where do you think the 60 Hz is coming from?
3. Go back to B8.

After the lab:

1. Prepare a report that includes:
   - The MATLAB code to compute your heart rate
   - A plot of your vector cardiogram (include MATLAB code)
   - Plots requested in **A.6, B.11**
   - Answers to questions **A.5, C.2**

Always include your code in your report!