

Laboratory 3
Design of a bio-instrumentation amplifier for EMG Richard
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Scope of the lab

1. Design a multistage bioinstrumentation amplifier for EMG.
2. Acquire EMG data.
3. Perform simple analysis of EMG data.

Before the lab

1. (5pts) Design a multistage bioinstrumentation amplifier for EMG signals. The amplifier should have the following stages

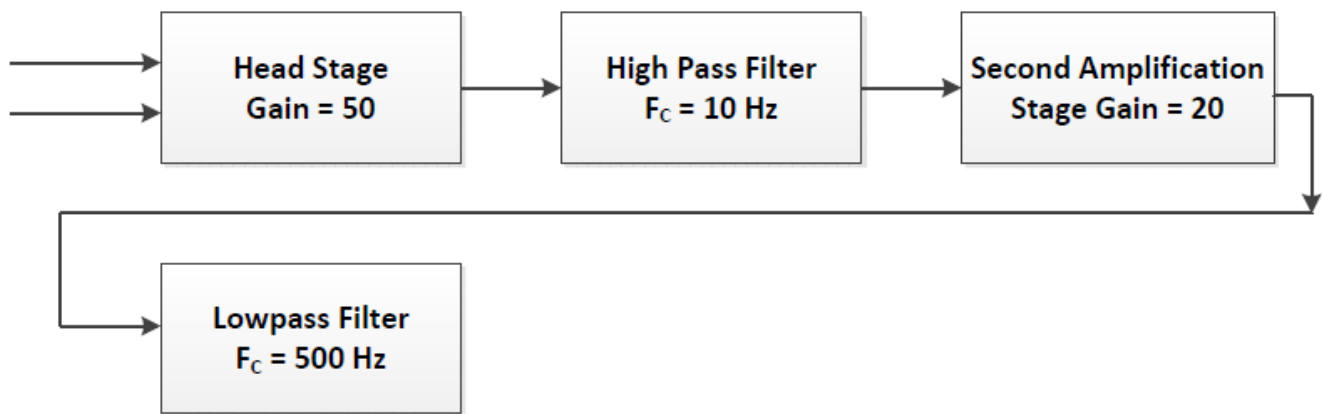


Illustration 1: Block diagram of a bioinstrumentation amplifier suitable for EMG measurements

Specifications

You are required to use 1% resistors with **standard values**.

Headstage - Use a differential amplifier LT1920. Gain of 50.

First HP Filter & Second Amplification Stage – Active with a cutoff frequency of 10 Hz; Capacitor value 330 nF with standard resistor value to get as close to 10 Hz as possible; Use ¼ TI C2274 in a non-inverting configuration.

Low pass filter – use a Sallen - Key topology to implement a second order Tchebyscheff filter with 1dB pass band ripple. Set the cut-off frequency at 500Hz. Use capacitors $C_1 = 33\text{nF}$; $C_2 = 330\text{nF}$; verify that C_2 value is properly chosen; compute the resistors values.

Write a short report describing the design. Include schematics. The report should be delivered to the TA before starting the lab.

2. Review the EMG and muscle fatigue concepts. Do a literature search and find the definitions for isometric contraction and dynamic contraction.

During the lab

A. Test and adjust the performance of the circuit

1. Build the circuit that you designed using the ECE-Biomed Lab.
2. Replace the gain resistor of the second stage such that instead of a gain of 20 you have a gain of 2.
3. Connect your circuit to the signal generator and to the oscilloscope as in Illustration 2.
4. Check the gain of your circuit for frequencies between DC to 600Hz.
5. Plot gain vs. frequency for signals between DC and 600Hz. (See **After the lab.**)

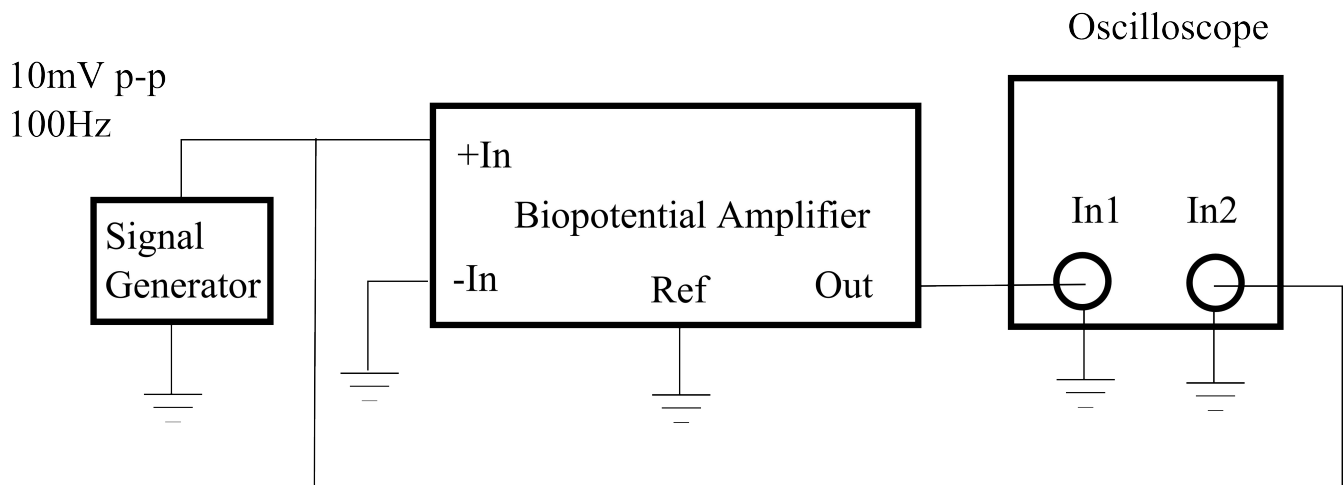


Illustration 2: Connections for performance evaluation and tuning

B. Acquire EMG signal

1. Add the isolation amplifier at the output of the bioinstrumentation amplifier.
2. Readjust the gain of the second amplification stage to 20.
3. Place the two measuring electrodes spaced about 1 inch apart on the belly of the biceps brachii. Place a third ground electrode on the arm lateral to the measuring electrodes.
4. Connect the measuring electrodes to the bio-instrumentation amplifier input; ground electrode to the ground.
5. Connect the output of your circuit to the NI Analog to digital board.
6. Start the Labview program used for data acquisition.
7. Turn on the power.
8. Save EMG data from an isometric contraction.
9. Save EMG data from a dynamic contraction.
10. Hold a heavy textbook, backpack handle or similar weight in the palm of your hand, keeping arm bent at 90 degrees, with forearm parallel to the ground. Record at least a minute of data to examine the effects of fatigue.
11. With your arm in the same 90 degree position, begin recording data with no weight in your palm. Then add a weight/textbook after a couple seconds, then a second, and finally a third. This is to compare EMG magnitude to lifting force.
12. Perform spectral and RMS analysis on the data that you acquired using software of your choice, ie MATLAB. (See **After the lab.**)

After the lab

1. (5pts) Prepare a report that includes
 - A6: Plot of gain vs frequency
 - B8: The time domain and frequency domain plot for an isometric contraction (B8)
 - B9: The time domain and frequency domain plot for an dynamic contraction (B9)
 - B10: Break the minute of data into 10 second intervals. Compute the rms and centroid frequency (Matlab function) value (using FFT) for each interval and plot over time. Describe any changes you see.
 - B12: Break the recording into the sections where the different weights were applied. Rectify each section (abs value) and compute the average magnitude. Plot the relationship between weight vs magnitude. You should have 4 points to plot and just use a normalized weight value (ie 0,1,2,3 units). Describe the relationship (linear, exponential, etc).