Introduction to Sensors, Instrumentation, and Measurement Final Project - Electromyography

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Circuit Design

The purpose of this project was to create an electromyogram (EMG), which is a device that detects the electrical activity of skeletal muscles. We designed a circuit that would filter and amplify the electrical signal that comes from these muscle contractions.

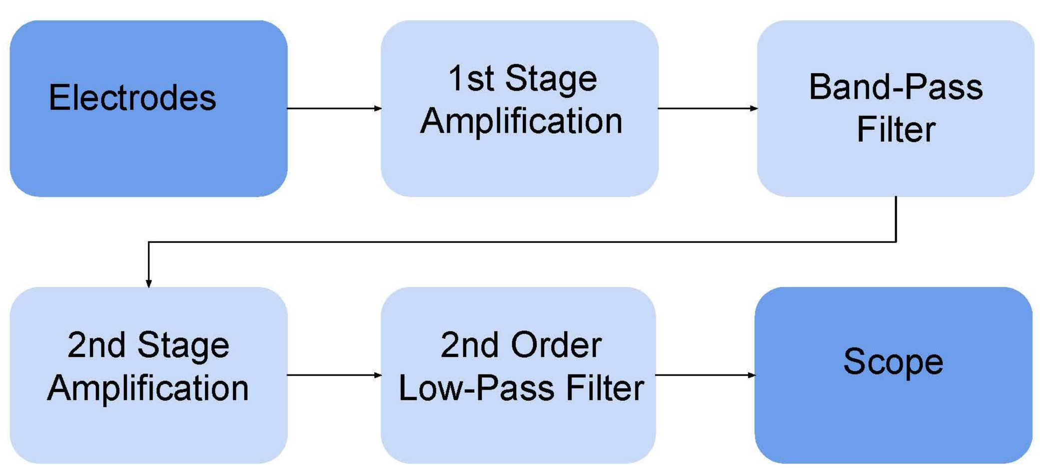

Fig 1. A functional block diagram describing the different stages of our planned circuit.

The test subject wears 3 electrodes that are connected to the circuit in order to record the electrical activity across their muscle. Two of these electrodes were placed across the muscle we were recording the activity of, and the third electrode would be "grounded" on an area of relatively low muscle activity (a "bony" area, like the wrist or elbow).

Our filters were designed to cut off frequencies above 160 Hz and below 40 Hz. Surface EMG signals have a frequency range from 0 Hz to 500 Hz, but are most commonly between 50 and 150 Hz. Our first stage of filtering (the band-pass filter) focused on frequencies between 40 and 200 Hz, and the second stage (the second order low-pass filter) cut off frequencies above 160 Hz.

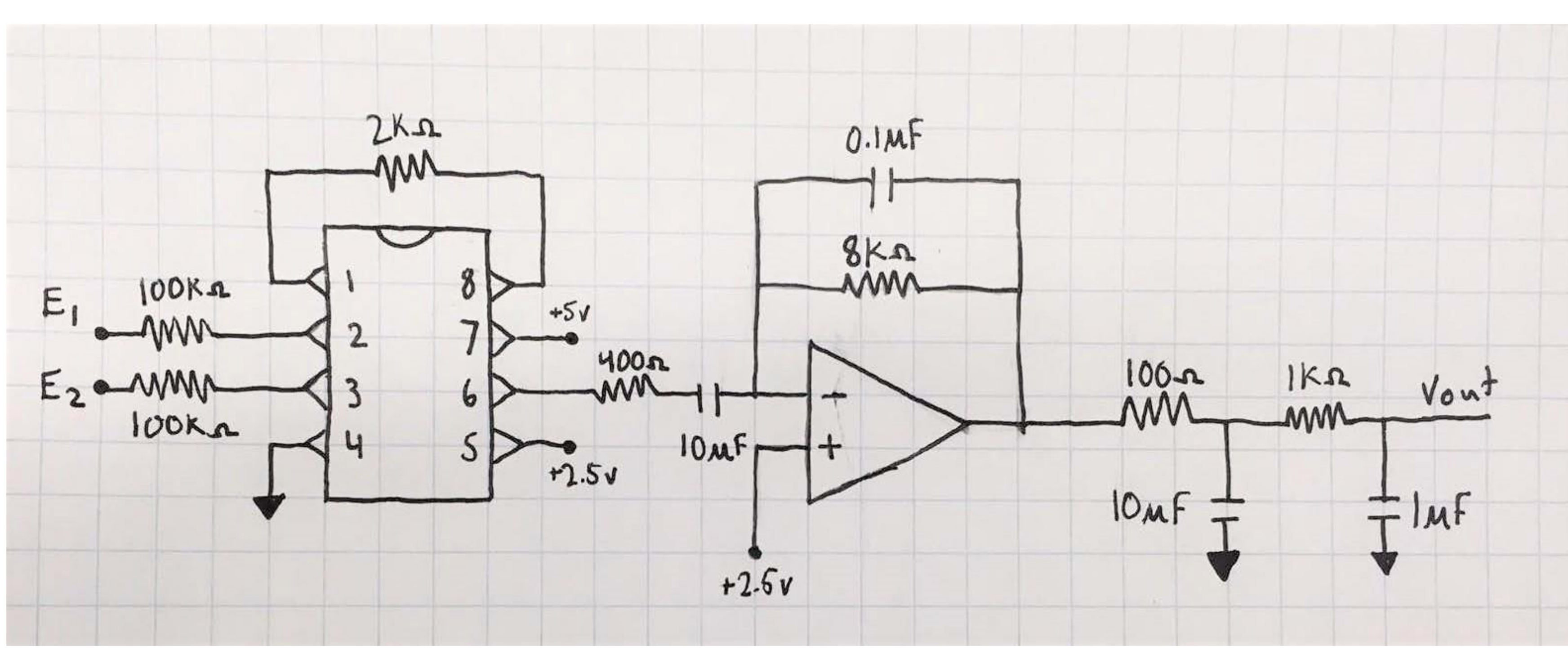

Fig 2. Our circuit schematic, with the calculated values of our different components.

The signal from the electrodes (E1 and E2) were amplified with an instrumentation amplifier. The subsequent band-pass filter through the op-amp further amplified and filtered the signal. Lastly, a second order low-pass filter filtered the final signal.

We collected the data with an Analog Discovery connected to a laptop with Waveforms software. We then converted this data into more readable plots using MATLAB.

Arm Wrestling Results

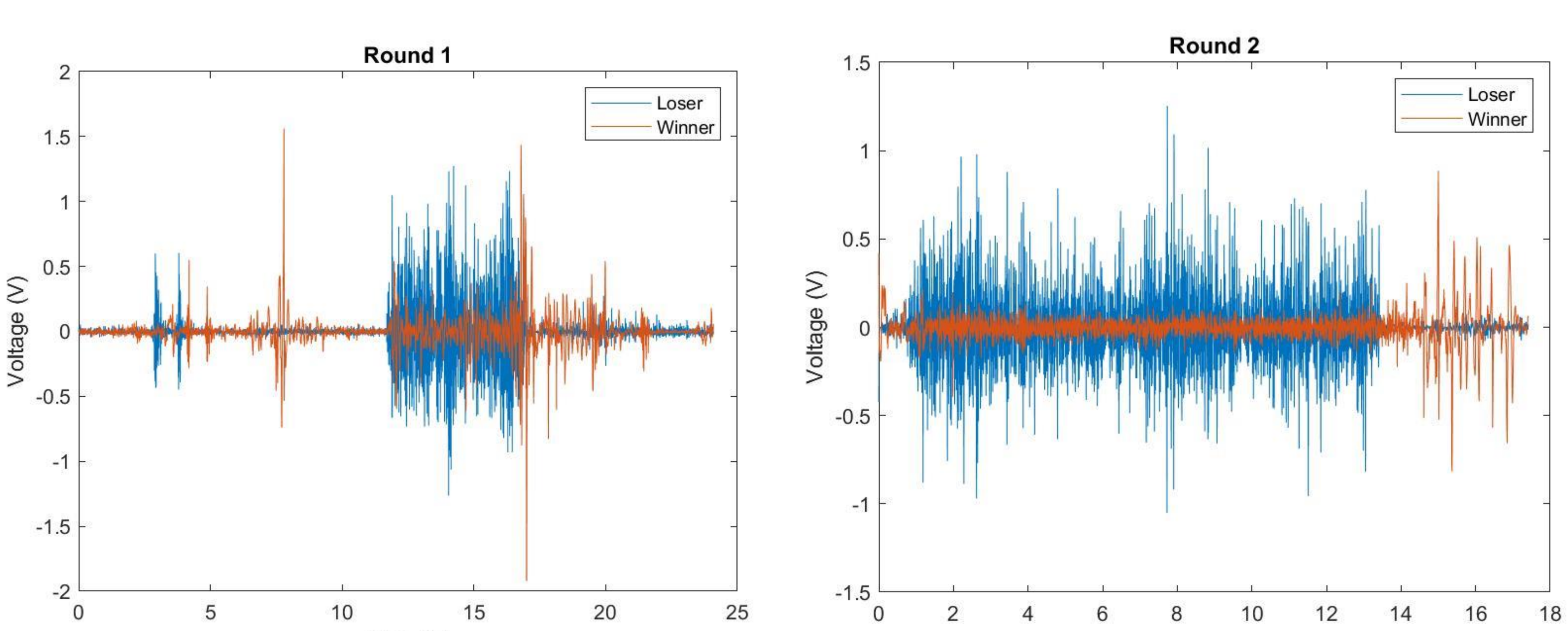

Fig 5. Two different arm wresting matches with the loser/winner indicated. The winner of the match appeared to have less muscle activity than the loser of the match.

Our final test of the EMG was to map the progression of an arm wrestling match between two subjects. We duplicated the circuit and monitored the bicep response of the two subjects simultaneously.

Arm Motion Results

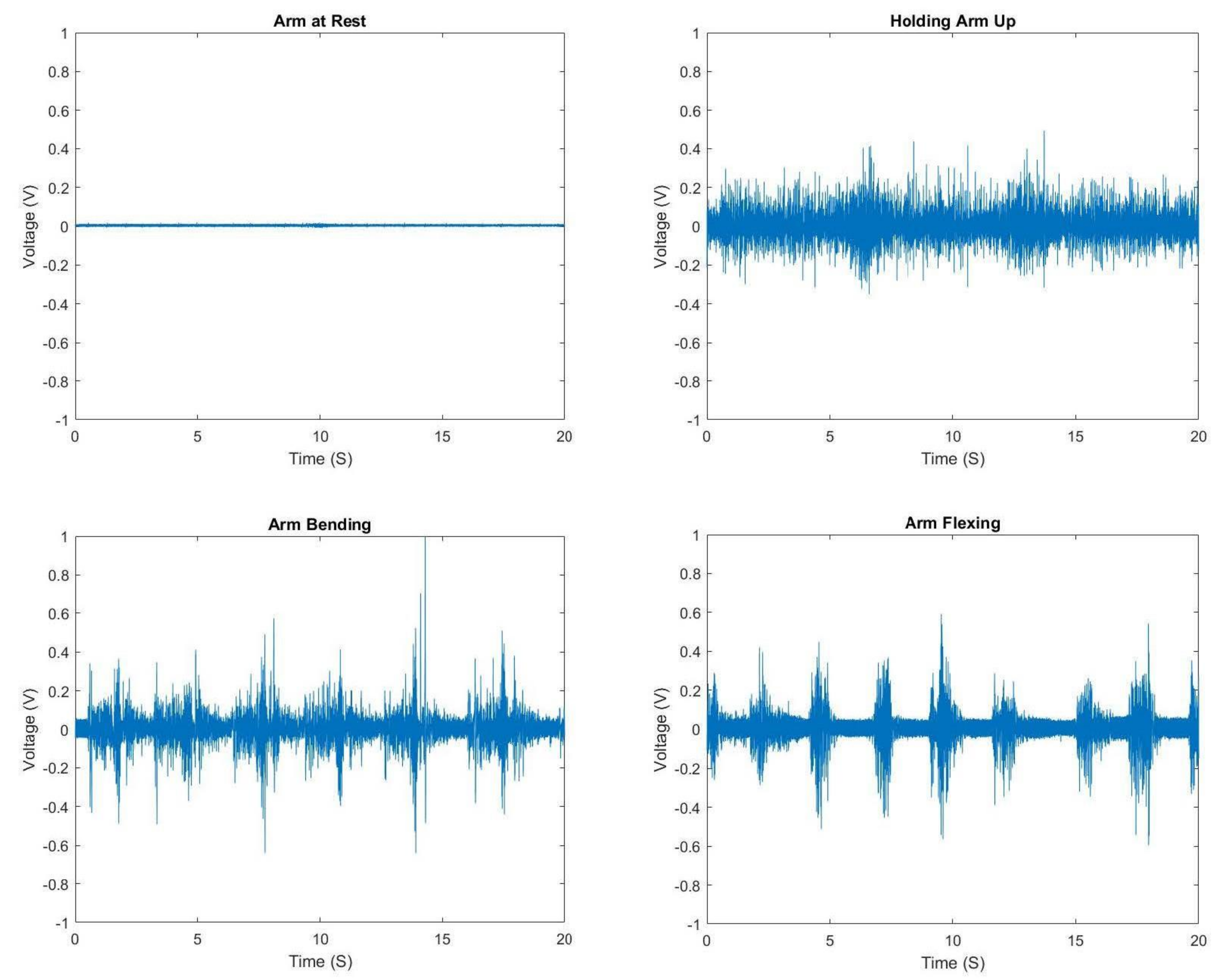

Fig 3. Plots of voltage vs. time as we recorded electrical activity across a test subject's arm.

After building and testing the individual parts of the circuit, we attached the electrodes to the bicep of one of our team member's arms. They then performed a series of tasks and the results were recorded.

The initial tasks were simple and used to create a baseline that we could compare later actions to. These tasks included being at rest, holding the arm in question perpendicular to the body, bending the arm normally, and purposefully flexing the arm/bicep.

The results showed little electrical activity across the muscle when the arm was relaxed and at rest, a surprising amount of electrical activity when the arm was being held still but in the air, and a varying amount of electrical activity when the arm was in motion and performing actions such as bending and flexing.

Lifting Weights Results

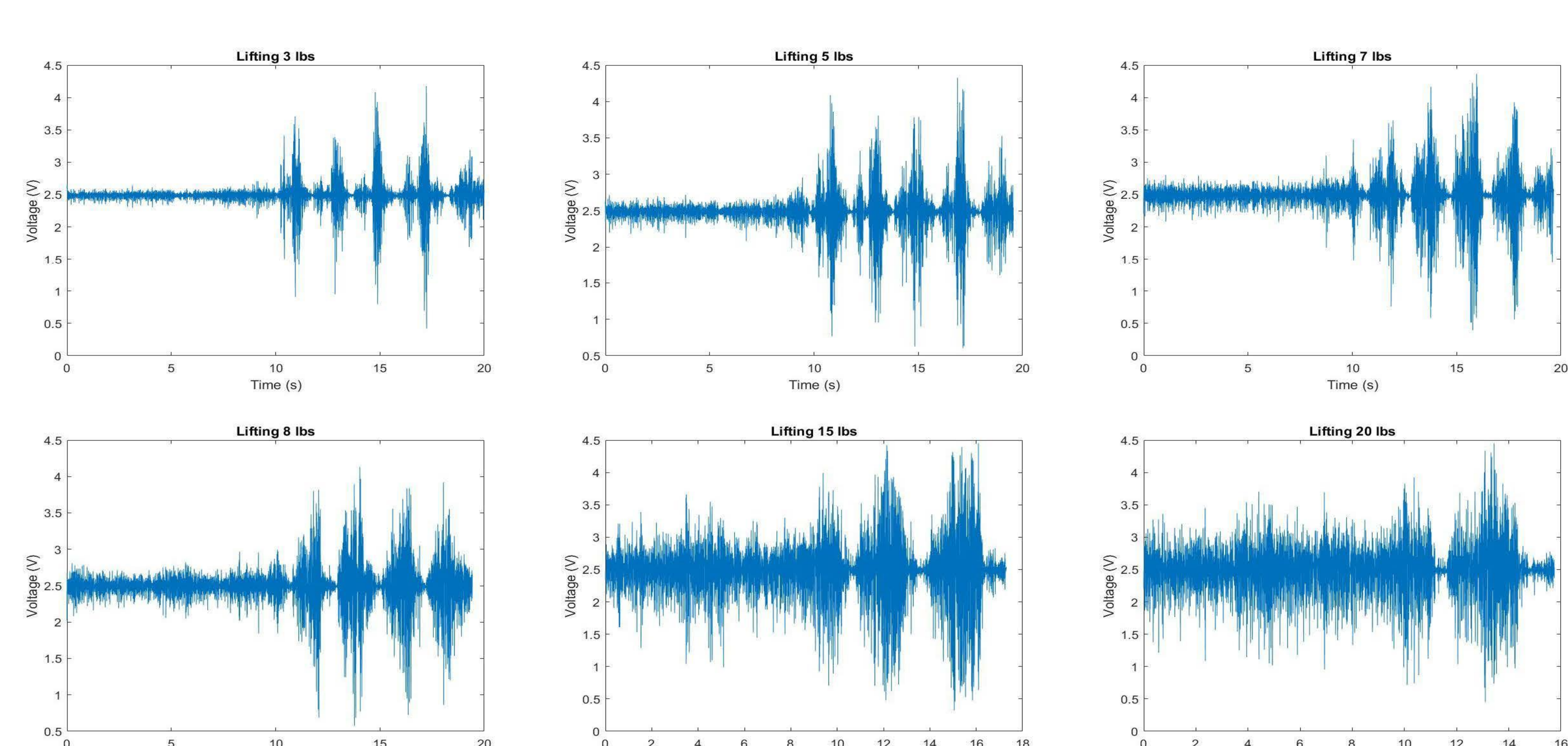

Fig 4. We recorded the data as our test subject lifted different weights. The graphs show that there is not much difference in the amplitude of the voltage peaks, however there were many more high amplitude signals with higher weights.

In order to test the EMG, we had a test subject lift different weights, hold them for about ten seconds, then do bicep curls with the weights for the remaining time. Each progressive weight was more difficult to lift and worked the muscle more. Interestingly enough, this is more notable when the weight was just being held. When doing bicep curls, the amplitudes of the peaks stay similar but more electrical activity occurs building up to that peak for the larger weights.