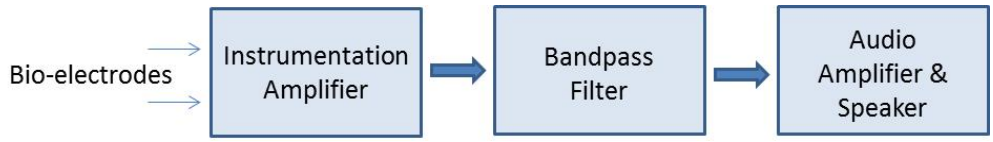
Design of an EMG Amplifier – part 2

Introduction:

You are tasked to design and validate an EMG amplifier that will produce sounds proportional to the intensity of the EMG signal measured with bio-electrodes. The amplifier works with a single 5V dc voltage supply source. The basic layout of the amplifier is shown below. The instrumentation amplifier amplifies the difference between the potentials captured with the 2 bio-electrodes placed on the muscle. The bandpass filter attenuates the frequency signals outside the range of the normal EMG. The audio amplifier produces a replica of the bandpass filter output signal with more power (current) to energize the loudspeaker.



In part 2 of this laboratory, you will experiment with, design, and validate your instrumentation amplifier. The instrumentation amplifier captures the difference in electric potential between two points of the body surface and amplifies it to a level that make it possible to be processed by the rest of the circuitry. Common-mode voltage, that is voltage that is equally present at the locations of the two bio-electrodes, is not amplified.

Prelab:

Instrumentation amplifier: Information on the instrumentation amplifier is provided in the tutorial MT 061 "Instrumentation Amplifier Basics" (Analog Devices, October 2008) and in the "Designer's guide to instrumentation amplifiers" (Analog Devices, 2004). A brief introduction is found in chapter 14 of the Floyd textbook. Browse through these sources to get a working understanding of the instrumentation amplifier function.

With your lab partners, perform the following preparation and reflect on the following questions:

1. Derive the expression for the output voltage of a difference amplifier (see tutorial MT 061, Fig. 2). If resistor R'1 = 1.01 X R1 and R'2 = 0.99 X R2, what is the output voltage when V1 = V2 and R2 = 1000 X R1?
2. What are the differences between the instrumentation amplifier and this difference amplifier (see tutorial MT 061)?

In the laboratory, you will work with the instrumentation amplifier AD 623 (data sheet included). This device, like the op-amp TLC 2272 is a rail-to-rail device that can operate in single supply circuits.

3. How is this instrumentation amplifier used in a single supply circuit?
4. What value of the amplifier gain should you aim for to have an output signal magnitude in the order of 0.5 – 1 V, given the magnitude of the EMG?

Build a Multisim model of the instrumentation amplifier circuit built around the AD 623 that uses a gain in the range of that useful for EMG amplification and that works with a single supply source. You will need to include the virtual ground circuitry you built in part 1 of this experiment.

Verify that your amplifier produces the desirable output when a voltage source is connected between its input pins with a voltage magnitude comparable to that of the EMG.

One issue that arises when using instrumentation amplifiers with bioelectrodes is that the electrodes behave as capacitors. Read the Designer's guide to instrumentation amplifiers (pages 5-1 and 5-2).

5. Assuming the electrode capacitance is in the order of 1 uF, what range of resistance value can you use to ensure the EMG signal is not attenuated? Include such resistances and capacitances in your Multisim design and verify the circuit performance is not altered.

Expected for the prelab:

- Answers to questions 1 – 5
- Multisim design of the instrumentation amplifier circuit operating with virtual ground and a gain in the range of that you will use in the laboratory.
- Method to measure experimentally the gain and frequency response of the amplifier in the lab

Report:

Each work group will submit a report due one week after the laboratory experiment which should include the following sections:

1. Initial answers to the questions of the assignment

2. Tested Multisim design of the instrumentation amplifier circuit that also operates with an AD 623 and a 5 V supply. This should be the designs you settled in after the lab discussion.

3. Measurement of the voltage gain of the instrumentation amplifier with same ac signal applied to both inputs and ac signal applied to only one input.

4. Your analysis and interpretation of the measurements.

5. A discussion of important issues you would consider when designing single-supply instrumentation amplifiers for measurement of biopotentials.

6. The data sheets for the components you used in the laboratory, including a discussion of what information you used in the data sheets for your designs.