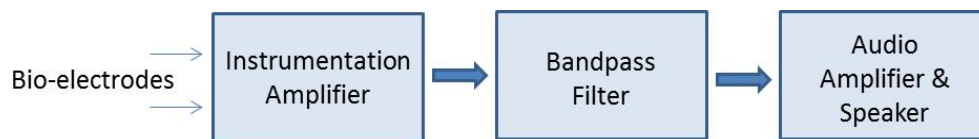


## Design of an EMG Amplifier – part 1

### 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 1 of this laboratory, you will experiment with basic operational amplifier circuits working with a single power supply. You will also design and validate your bandpass filter. This bandpass filter is made of a high-pass filter that lets all the frequencies above a certain critical frequency  $f_{c1}$  pass through followed by a low-pass filter that lets all the frequencies below a certain critical frequency  $f_{c2} > f_{c1}$  pass through.

### Prelab:

Part 1: single supply op-amp amplifiers: basic amplifier circuits built with the operational amplifier (op-amp) have been discussed in class and are also described in application note SLAA068A (Texas Instruments – April 2000) and in your textbooks. The traditional designs assume a split-supply but many modern devices use a single supply voltage (for instance USB-powered and battery powered devices).

With your lab partners, reflect on the following question:

Question 1: What problems do you anticipate with the traditional inverting and non-inverting amplifiers designs circuits if you tried to use them with a single supply?

Guidelines for designing single supply op-amp circuits are provided in Application report SLOA058 (Texas Instruments – April 2000). Read through the first two sections of the application note. Why is a unity gain buffer or voltage follower used in the design of the virtual ground circuit?

Use the information provided in the application note to design a non-inverting amplifier with a gain of 5 (+/- 10%) that operates out of a single 5 V supply. Build and test your circuit with Multisim. Use the TLC2272 op-amp for your Multisim design if it is available. Otherwise, use any op-amp.

You will assemble and test this circuit in the lab using a single TLC 2272 op-amp device. The data sheet for this device is included in the project documentation package.

## Part 2: band-pass filter built with a single supply op-amp amplifiers for EMG measurement

Research and summarize the origin of the EMG signal.

Questions 2 - 3: What is the expected magnitude for the EMG signal? What is the typical range of frequencies that contains useful information in the EMG signal?

An EMG amplifier device amplifies signals mostly in that frequency range. As mentioned in the introduction, after the signal is amplified with a differential instrumentation amplifier, a bandpass filter in the EMG device attenuates the signal for frequencies outside of the useful range for EMG measurements.

Electronic filters are abundantly used in bioinstrumentation. Descriptions of the different types of filters are given in the "Practical Electronics for Inventors" textbook at the beginning of chapter 9. Simple designs for op-amp filters that operate with a single supply are discussed in application note SLOA058.

As discussed in the "Practical Electronics for Inventors" textbook filter design can become very complicated very quickly if we try to design the filter by hand. Fortunately, computers programs have been developed that greatly simplify the design and implementation of these filters. One such program is webench developed by Texas Instruments. Webench can be accessed through the URL:

<http://www.ti.com/lscds/ti/analog/webench/webench-filters.page?DCMP=sva-web-filter-en&HQS=sva-web-filter-vanity-en>

A video tutorial for the basic use of webench is found at:

<https://www.youtube.com/watch?v=bdtLbtfTV8A>

For this lab, we will select to create two pole filters of type Butterworth. You can select the type of filter by pressing on the radio button "Specify filter". You may need to create a user id to access the Webench design.

As you design your filter, you must consider the values and tolerances for the passive components we have in the lab. You can use the E12 (10% precision) series for the capacitors and resistors.

After parts and topology is specified for high pass filter and for the low pass filter, implement each circuit in Multisim using the TLC2272 op-amp. Test the frequency response of your filter.

In the lab, you will assemble and test these two filters. You will measure the frequency response of each filter experimentally. Before coming to the lab, research a practical method to measure the frequency response of a filter. You will characterize each filter separately, then arrange them in cascade to attenuate the frequencies outside the useful range for the EMG.

### **Expected for the prelab:**

- Answers to questions 1 – 3 - Provide the reference sources for the EMG information
- Multisim design of a 5 (+/- 10%) gain amplifier operating with a single 5 V supply
- Multisim design of a high pass filter and a low pass filter (2 pole Butterworth) that cutoff frequencies outside of the EMG bandwidth

- Method to measure experimentally the response of the filters 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. Results of the Multisim simulations for the 5-gain inverting amplifier that operates from a single 5 V supply and for the EMG bandpass filter that also operates from a 5 V supply
3. The designs you settled in after the lab discussion
3. Your data (measurements and calculations of voltages, gains, and frequency response for the circuits you tested)
4. Your analysis and interpretation of the data
5. A discussion of important issues you would consider when designing single-supply op-amp amplifiers and single-supply bandpass filters
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