EE3810 Lab 3: ECG and voltage divider

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1. data acquisition
2. analog vs. digital signals
3. electrodes
4. amplifiers
5. breadboard
6. potentiometer
7. voltage sources
8. voltage divider
9. gain
10. dynamic range
11. modular design

1 Objectives

In this lab, you will

1. gain further experience recording bioelectric signals with electrodes
2. refresh your memory on constructing circuits, probing nodes, and operating the electornic lab equipment
3. understand the function of voltage divider and potential applications
4. gain experience with data acquisition and better understand differences between analog and digital signals

2 Pre-lab reading / assignment

- Sketch the circuit schematic for a voltage divider which takes the ECG signal from the LabQuest 2 to myDAQ adapter and outputs a scaled version of the input signal.
- How will you carry out part 3? Outline the steps.
- Plan out your table and calculations for part 5

3 Background

3.1 Controlling the amplitude of a signal

Sometimes, we need to control the amplitude of an output signal, so we can view it or use it in the right range of amplitude. For example, to use the neural signals from the brain or electromyographic signals from a muscle to control a prosthetic arm, the controller circuit will be expecting inputs in a certain range. So, we can amplify the signal, or add gain to the acquisition system. However, if we do not know the raw input amplitude ahead of time, we might need a way to make it adjustable. For this purpose, we can use a voltage divider circuit. With this circuit, we can only scale down, or attenuate, the signal, but this allows us to control the amplitude. This is similar to controlling the volume dial of a music player.

We usually quantify the attenuation as a ratio of output amplitude to the input amplitude expressed on a logarithmic scale. This scale is called decibel. The definition is the same as gain, but when gain is between 0 and 1, we call it attenuation. The definition is given by Equation 1:

$$G = 20 \log \frac{|V_{out}|}{|V_{in}|} \tag{1}$$

3.2 Breadboarding

The breadboard is useful for building a circuit quickly when you need to test out a circuit. It is easy to plug components in and take them out if any part of the circuit needs to be changed. For that same reason, it is not very good for building circuits that are reliable long-term. It also can easily get messy, whereas once you know what circuit *design* works, you can spend more time making the circuit *look* nice and be much more difficult to change. The breadboard is divided into a grid-like pattern. You will see rows and columns, and a section of 5 columns separated from the other sections of 5 columns. Each row in the same section are electrically connected - i.e., there is metal inside the hole connecting anything plugged into those 5 holes together at the same electric potential. The distance between two holes spanning the two adjacent sections is exactly the distance between two pins on an integrated circuit chip so that a chip can be plugged in across that gap. There are also long rows and/or columns, usually with a painted blue or red line alongside them, around the perimeter of the board. These are called the power (red) and ground (blue) strip. These holes along the same strip are all electrically connected. Because power and ground are needed at many places in the circuit, it makes sense to have many places around the circuit board to connect to power and ground.

4 Procedure

You will conduct this lab modularly, ensuring first that your voltage divider is working as expected using known inputs, and then connecting the ECG sensors.

4.1 Setting up and testing your circuit

1. Wire up your breadboard to take in a signal from the function generator and output the scaled down signal.

2. We are going to first test out the circuit with 0-5V, 2kHz sin wave from the function generator; i.e., the signal should have an amplitude of 2.5V and a frequency of 2kHz. We can treat this like the audio signal coming out of your radio.

3. First verify that you are generating the desired sin wave.

4. Once the instructor has checked that you have generated the input signal correctly, feed this signal into your voltage divider circuit. Control the "volume" of your signal, and determine the attenuation in decibels.

5. Create a table that shows the resistance of your variable resistance, the amplitude of your output voltage, and compares the theoretical to the actual output voltage.

6. Now connect a speaker to the output.

7. Have fun playing with the volume.

4.2 Recording ECG with adjustable output amplitude

1. Attach the electrodes to record ECG, according to the Lab 2 instructions.

2. Now feed the ECG electrode signal into your voltage divider via the myDAQ adapter.

3. View the output analog ECG waveform on the oscilloscope.

4. Adjust the amplitude and compare it to the raw ECG waveform.

5. Create a similar table as you did in part 5, at a minimum of 3 different measurement points.

5 Questions

1. Describe the main differences between the waveforms aquired in this lab with those acquired in Lab 2 with the LabQuest device.

2. How does a voltage divider work? How did the results compare to your expectations?

3. Explain what we mean by modular design. How do you see modular design in our experiments?

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