Stony Brook University

EEO335

Spring 2024

Electrocardiogram (ECG)

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Assignment 10 - Electrocardiogram (ECG)

This Assignment aims at verifying and expanding, with experiments and supporting simulations, your knowledge and understanding of electrocardiogram circuits, including their high sensitivity and common-mode rejection.

Please document each step with snapshots, pictures, and your observations. Please make visible on WaveForms the date and time fields (top left) and the serial number (bottom right) of your Analog Discovery. Also, please include this page.

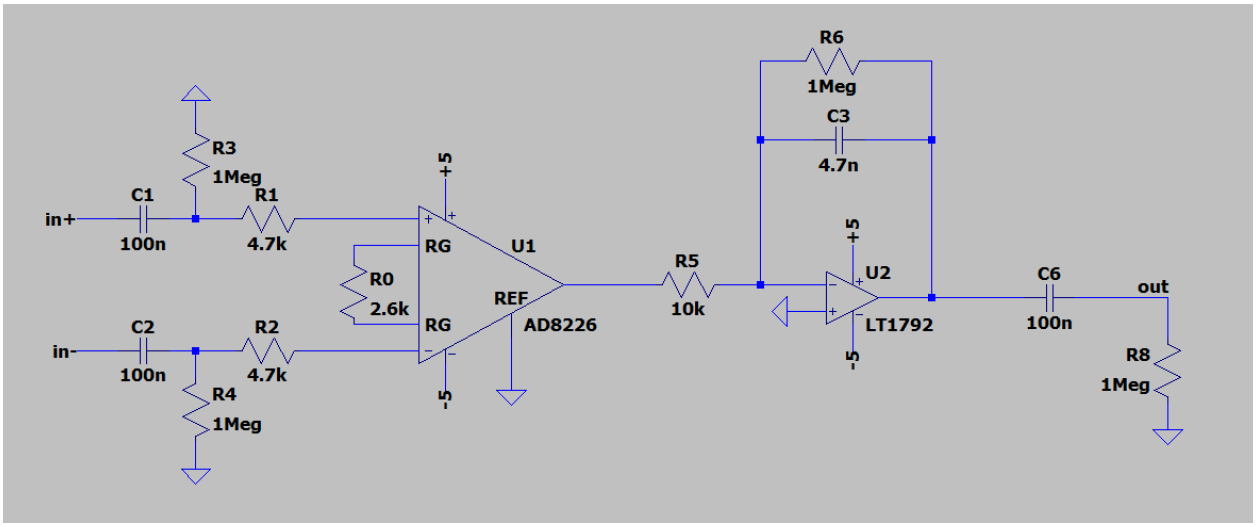

Figure 1 - ECG circuit

1) Using the simulator, design the circuit shown in Fig. 1 (**20pts**)

a) simulate and show the response to a 50Hz 1mV sinusoidal signal connected between the positive in+ and the negative in- inputs and calculate the gain

b) explain in your own words how the circuit operates: what are the roles of the two amplifiers?

2) Build the circuit at (1) and experimentally reproduce the simulations (**40pts**)

a) in place of the AD8226 you can use the INA111 (AP or BP) or the AMP02

b) in place of the LT1792 you can use the AD711 or an alternative low-noise JFET input amplifier

c) keep the negative input in- grounded and apply a 1mV ~signal at the positive input by using a ~10mV and a ~x10 resistor divider

3) Demonstrate a ECG measurement (**40pts**)

a) use two shielded cables (e.g. from a R/L audio cable) to build and connect the two inputs to two electrodes; see example in Figure 2

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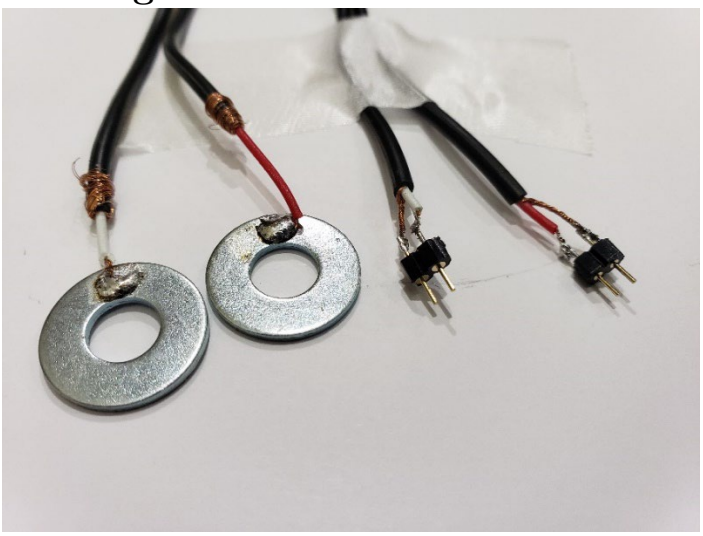

Figure 2: Example of shielded cable with electrodes for the ECG

b) Connect the two electrodes to your left and right wrists; you must obtain a measurement as shown in Figure 3

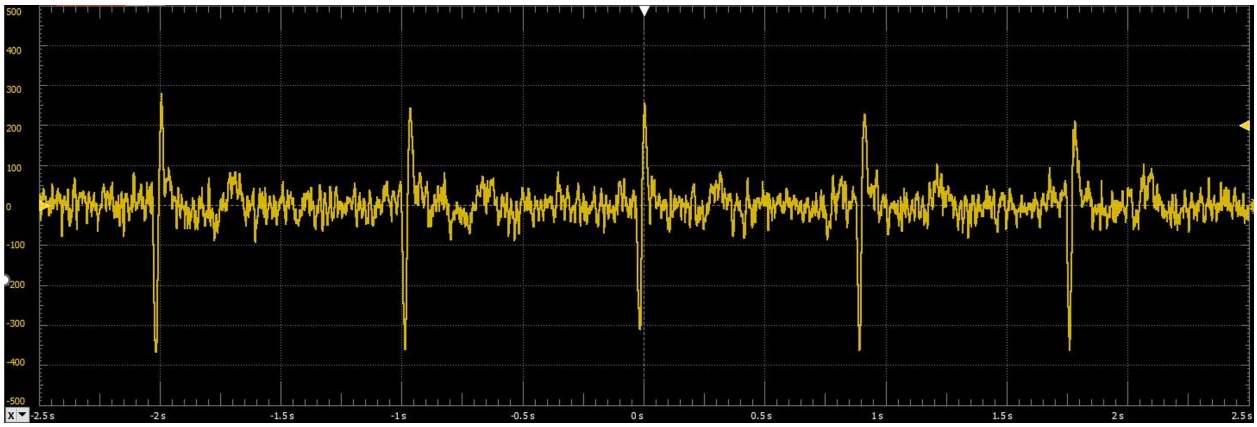

Figure 3: Example of wrist ECG measurement

Hint 1 - The circuit is very sensitive to microphonics: you may need to keep the wires very firm during the measurement.

Hint 2 - The circuit is very sensitive to 60 Hz: you may need to step out of your house (e.g. in your car) with your battery-operated laptop.

Overview

In this lab, we design, simulate, and build an Electrocardiogram (ECG) circuit to deepen our understanding of its operation. Through simulations, the response to a 50Hz 1mV sinusoidal signal is analyzed, with subsequent experimental tasks using components like the INA111 or AMP02 and the AD711 amplifiers. Finally, ECG measurements are demonstrated by connecting electrodes to our wrists, with precautions taken against microphonics and 60 Hz interference.

1 Using the simulator, design the circuit shown in Fig. 1

a)

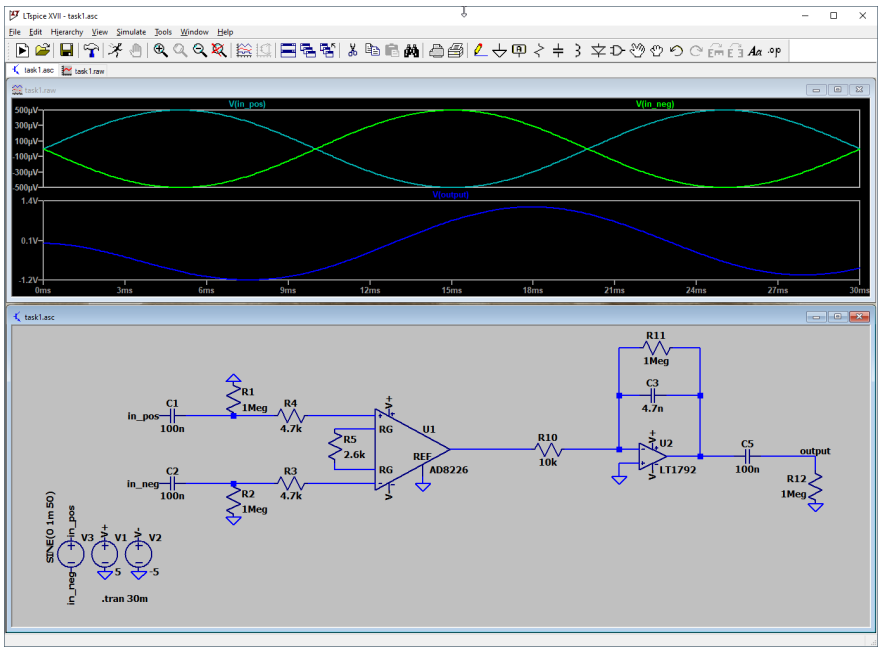

Figure 1: Simulate and show the input and the response at the output

b)

Show in Figure 1 is a two stage differential amplifier. U1 is a differential amplifier used to amplify the difference in ECG signals in the human body. U2 is an inverting voltage gain amplifier used to amplify the relatively small output from U1 by about 100x so we can easily display on our Analog Discovery Oscilloscope. Naturally, the signal will be inverted. U2 also forms a low pass filter to remove high frequency noise from our signal.

2 Build the circuit at (1) and experimentally reproduce the simulations

a)

For this circuit I chose the AMP02 IC designed by Analog Devices.

b)

For this circuit I chose the AD711 IC designed by Analog Devices.

c)

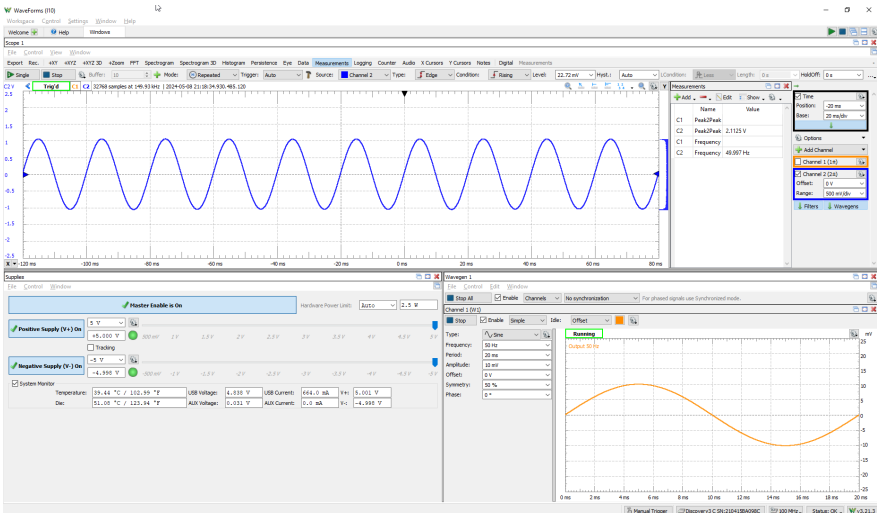

Figure 2: Negative input in- grounded and apply a 1mV signal at the positive input by using a 10mV and a x10 resistor divider. There is a system gain of ≈ 2000.

3 Demonstrate a ECG measurement

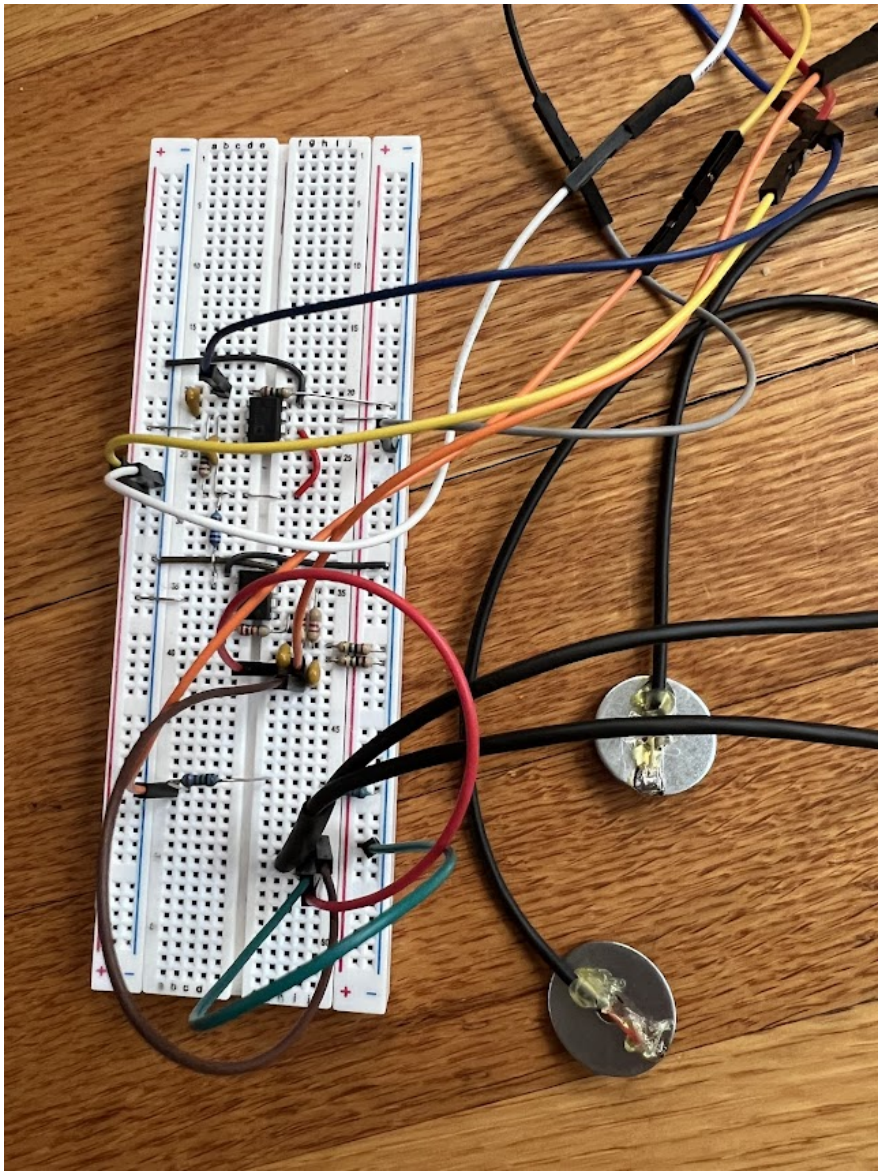

Figure 3: Circuit prototype.

Figure 4: Electrodes soldered and strain-relieved with hot glue.

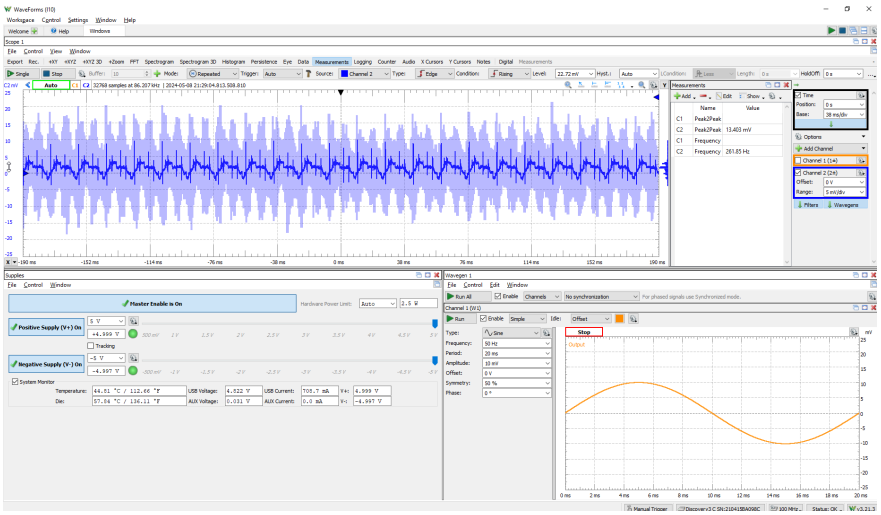

Figure 5: After many hours of troubleshooting over several days, I was not able to get a characteristic heartbeat waveform. I verified the circuit build and tests OK, verified electrode path match, verified no electrode wiring shorts, increased conductivity of electrode contact, moved away form 60Hz sources, and more.