EKG/ECG

We are going to build a fully-operational 3-wire ECG measurement instrument using a differential amplifier. The three-wire connection is the simplest that will yield a usable trace (not just a heart rate). The resulting ECG will reveal all the electrical activity of the heart, only lacking the benefit of ECG signals measured between other body contact points. A full ECG diagnosis involves the connection of 12 electrodes across the chest and on the extremities. We will only be connecting electrodes to the arms and ankle.

Disclaimer
WE ARE NOT MEDICAL DOCTORS and neither are you. Please don't attempt to interpret anything other than possibly your heart rate (beats per minute) from your ECG. Experts on ECG interpretation form an entire specialization.

Safety
Medical instrumentation safety standards are regulated in the USA by the Association for Advancement of Medical Instrumentation (AAMI), American National Standards Institutes (ANSI), and Underwriters Laboratories (UL). AAMI standards have been adopted as official practice b the American Medical Association.

We are performing an AAMI Type B connection to the body, since we are potentially connecting a direct ground to the patient (you). This is considered risky because of the possibility of a ground loop if any other Type B medical instrumentation is connected that may have a different ground connection. Our ground connection is established through the 5 VDC USB power supply in your notebook computer, which may (but usually doesn't) connect to the building wiring ground via the power brick's wall plug ground prong. To fully comply with AAMI recommendations:

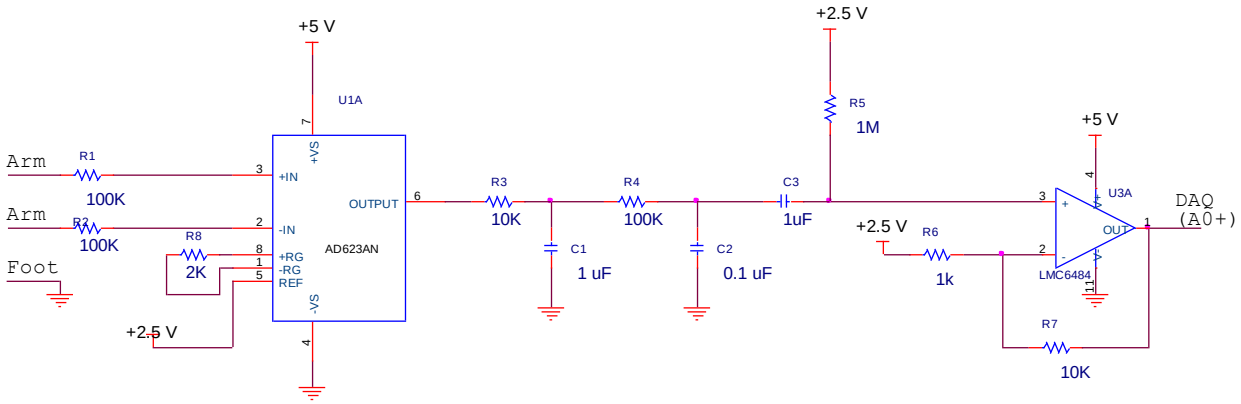
1. Don't connect yourself to any other AC-powered instrumentation while you are doing this experiment. Do not connect yourself to ground by holding onto an earth connection such as a water fixture.
2. Unplug the power brick from your notebook computer, and run the notebook on its batteries during the ECG experiment. This converts the connection to a Type BF (fully floating) connection

About Privacy
Finally, if you are AT ALL concerned about submitting your personal ECG plot in your lab report, YOU DO NOT HAVE TO DO SO. This could be construed as medical information protected under Federal HIPAA privacy laws, i.e.,
http://www.hhs.gov/ocr/privacy/hipaa/understanding/index.html.
You may alternatively borrow one of the instructors who will serve as your patient.

Circuit

The circuit is really quite simple. By now, you should have a basic understanding that we will leave it to you to figure out what is going on. The reason for two stages of amplification is that some people will have a relatively large, but real, DC voltage difference between your arms. If the first gain is too large, you may saturate your amplifier. In fact, since all people are different, you may need to adjust the gains of the two amplifier stages from what we have selected here.

The circuit you will build is shown below:



To connect to the circuit you will need a patient (yourself if you would like, or one of the course instructors) three of the adhesive electrode pads, and three alligator clip leads. Two of the pads should be placed on the inside of the elbow. The third should be on the ankle. The alligator clip leads will connect to the metal tab on the electrodes. The other end will grab a short piece of wire and connect to your protoboard. Your ankle should connect directly to the ground on the protoboard. The arms should connect to the AD623 through the 100K resistor. The 100 K resistor is for safety to isolate you from the power sources on the DAQ.

The output of the circuit should go to the DAQ and you should measure the output relative to 2.5V.

For your lab writeup you only need to include a snapshot of a clean EKG (you should not identify the “patient” in your lab report), and a short analysis of the circuit. Explain what each part does briefly, and for any filters explain what its cutoff frequency is. That’s it, it’s a pretty easy lab.