Your name: ___________________ **Lab section:** M Tu Wed Th F

TA name: _____________________ 8 10 12 2 4

Lab 7. AC Signals

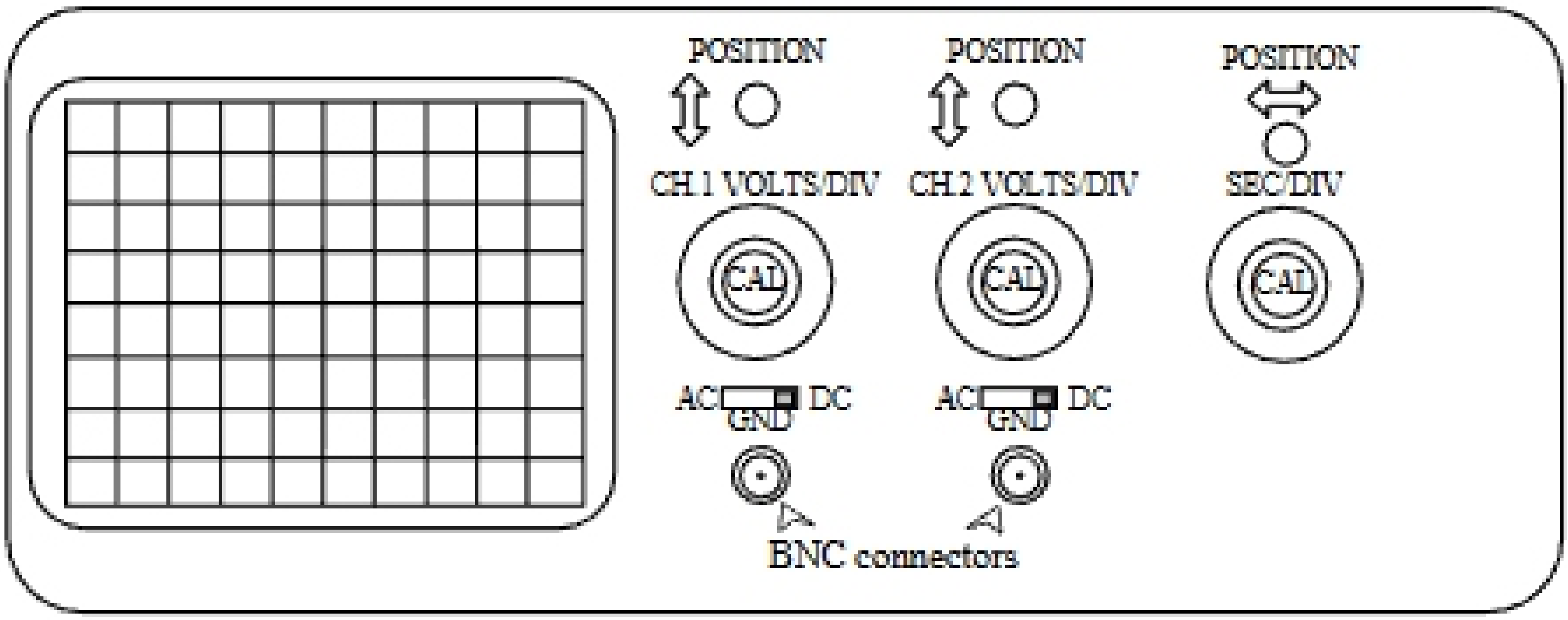
INTRODUCTION

In this experiment, you will use an oscilloscope to measure the time-varying (AC) voltages from two quite different sources: a signal generator and your heart.

Almost every AC measurement is done using an **oscilloscope**, which is a very useful tool for measuring voltages that are changing in time. Think of the oscilloscope just like the DMM you have used in previous labs – it measures voltage, but now it plots it out in time (voltage on the vertical axis and time on the horizontal axis). The grid that you see on the screen is used to measure the voltage and time of your signal – think of it like graph paper. Each little box on the grid is called a *division*, and you can adjust the scale of the voltage and time axes with the **volts/div** and the **sec/div** knobs, respectively. For example, if the volts/div knob is set to "5", this means that each box on the grid is equal to 5 volts.

There is small knob in the center of both the volts/div and time/div knobs, called the CAL or calibration knob. This should always be in the fully CW position in order for the volt/div and sec/div scale settings to be correct. Under the volts/div knob is a 3-position switch which reads (AC - ground - DC). This should be in the AC position for AC measurements.

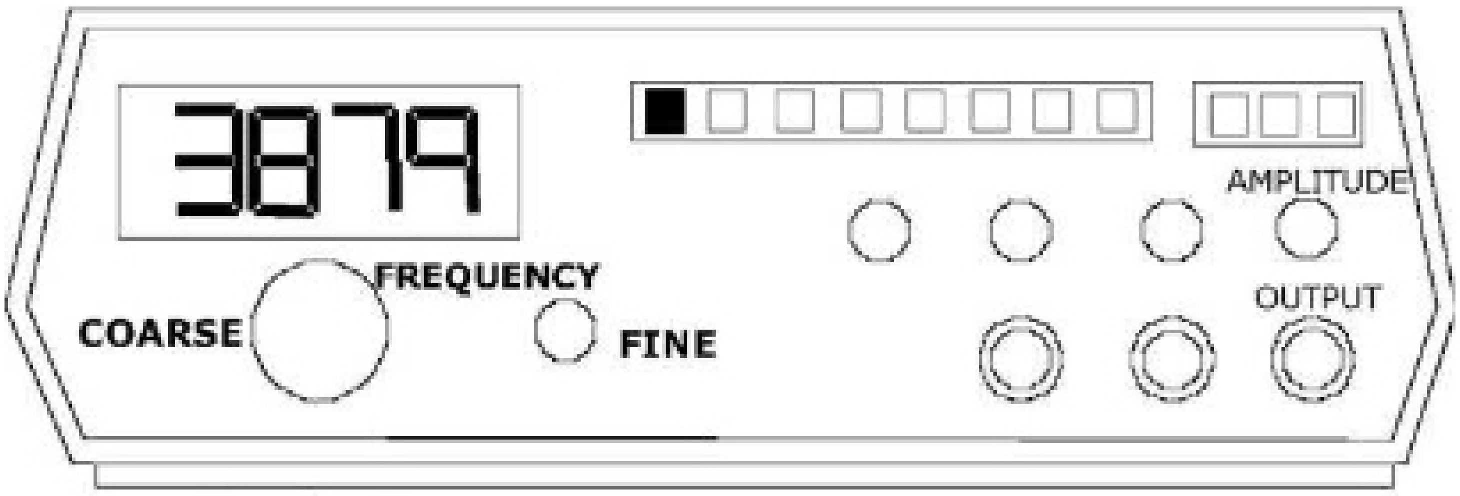
Oscilloscope Front Panel



Whenever you use an oscilloscope, pay close attention to the horizontal and vertical scales (SEC/DIV and VOLTS/DIV).

PART I: MEASURING THE FREQUENCY RANGE OF YOUR HEARING

At your table you should have a speaker, a signal generator, a microphone, and an oscilloscope. The speaker is driven by a signal generator which produces a sinusoidal voltage of adjustable frequency and amplitude. Note that there are both coarse and fine adjust knobs for the frequency, as well as "decade" buttons which can adjust the frequency by factors of 10.



Function Generator

Connect the signal generator directly to the oscilloscope and turn it on. Adjust the amplitude of the signal generator and the scales of the oscilloscope so that you see a couple of complete sine waves on your scope. Write down the frequency setting of the signal generator. From the oscilloscope trace, calculate the period of the alternating voltage signal. From this, calculate the frequency. Does your oscilloscope measurement match the setting on the signal generator? If not, why not?

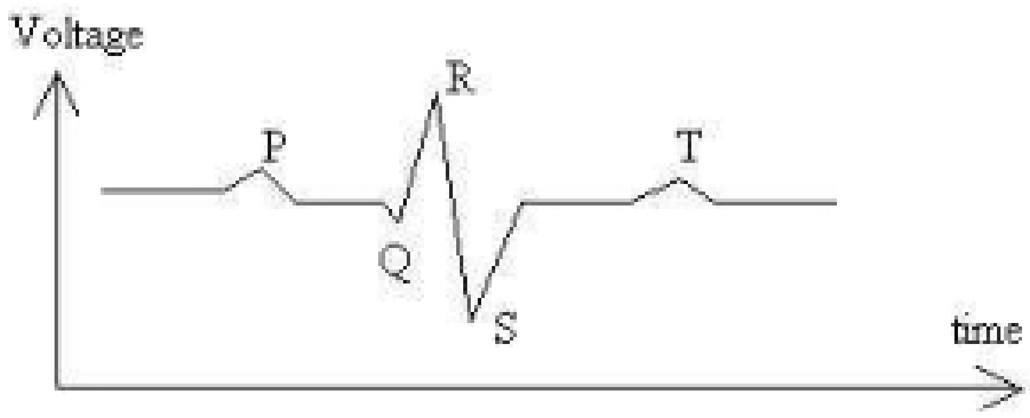
Turn down the amplitude on the signal generator. Now connect the signal generator to the speaker, and connect the microphone to the oscilloscope. Turn the volts/div knob on the oscilloscope all the way up, to maximize its sensitivity. Place the microphone near the speaker and adjust the signal generator amplitude up until you can see a signal. Adjust the frequency and amplitude until you can hear a mid-range tone at a quiet but audible volume. Record the frequency setting on the signal generator, and calculate the period and frequency of the wave from the oscilloscope. Do they match? If not, why not?

Devise and carry out a (simple) method with this equipment to experimentally measure the frequency range of your own hearing (which means to identify the highest and lowest frequencies you can easily detect with your ears). Is this range the same for everyone in your group?

PART II: LOOKING AT YOUR HEARTBEAT

Every living person's heart produces electrical signals that can be measured on the surface of the skin. An EKG (electrocardiograph) is an instrument that can measure these signals and produce a visual image (and sometimes an audible sound, as in the "beep … beep … beep …" you hear in movies). Your goal for this experiment is to obtain an accurate recording of this voltage signal from one of your lab mates, and to determine what things affect this signal. Our makeshift electrocardiograph is an oscilloscope with two large copper terminals and an amplifier (some details are in your textbook, section 17-11).

Your heart is a complicated electrochemical machine that produces time-varying voltages as it beats. These heart voltages produce small voltage differences between points on your skin that can be measured and used to diagnose the condition of your heart. Usually nine electrodes, positioned at various points of the patient's body, are used when recording a full electrocardiogram. However, in this lab, we will only use two electrodes to measure ΔV between your right and left hands.



A typical plot of voltage difference between two points on the human body vs. time is shown above. The **P** deflection corresponds to the contraction of the atria at the start of the heart beat. The **QRS** group corresponds to the contraction of the ventricles. The **T** deflection corresponds to a recovery (or re-polarization) of the heart cells in preparation for the next beat. Every heart pattern is slightly different, and the interpretation of an EKG requires experience with many patients.