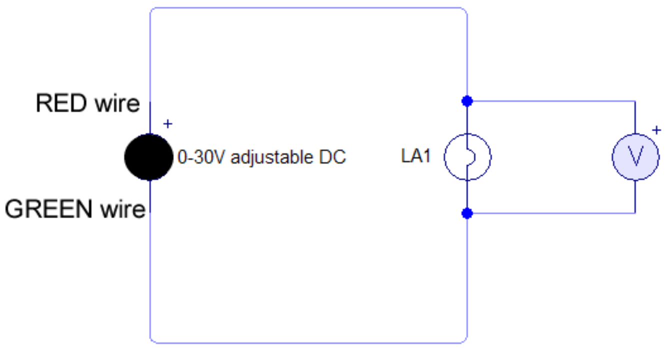
A211
Lab #14-1

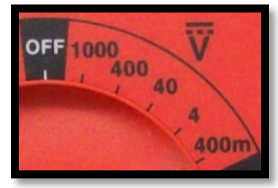
Voltage Measurement

1. Build the circuit below on your breadboard. Make certain to leave the DC voltage supply OFF.



The Binding posts (Red,Green,Black) on the breadboard do not make a connection to anything. Typically you must use the wires connected to them to connect to the breadboard. I have already done this for you. 😊 The V+ is coming from the right side adjustable supply on the RED wire, V- is coming from the left side adjustable supply on the Black wire, and GND on the Green wire. It should be set to that the Right voltage control effects both + and -.

2. Set your Volt-Ohm-Meter to read DC voltage (*shown to right*), make sure that the red lead is plugged into the VΩ jack on the meter (*see photo to left*) .



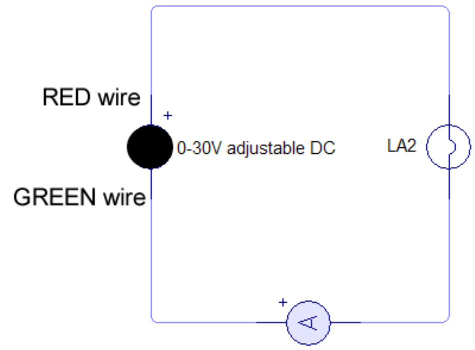
Set the range to the lowest setting that is above 10 volts. The lower the setting the more accuracy your reading will have. However, the setting represents the highest value that the meter can read so it must be higher than the highest voltage you will measure.

3. Adjust the right voltage control on the DC voltage supply all the way down (counterclockwise). This will set the output to 0 volts. Now, double check that your circuit is built as shown above. Turn on the DC voltage supply and slowly adjust the voltage up until the readout on the power source reads 10V. The meter on the power source and the VOM should read the same value.

4. What happened to the light bulb as you raised the voltage?

Current Measurement

5. Build the circuit to the right on your breadboard. Make certain to start with the power source OFF.



6. Set your VOM (Volt-Ohm-Meter) to read DC current and set the range to 300mA. Move the red lead of the VOM to the mA jack on the meter.

7. You are about to watch the current meter as voltage is started at 0V and moved up to 10V. What do you expect the current to do?

8. Check that your breadboard circuit is **exactly the same** as the schematic above.

Once you are sure, check with the instructor before proceeding!!!!!!

9. With the voltage control **all the way down**, turn on the power source. Slowly turn up the voltage control to 10 volts. How does the current change as the voltage increases?

10. What is happening to the Power dissipated by the light bulb when voltage is increased?

11. Now turn the voltage back all the way down.

12. Remove the light bulb and replace it with an LED.

13. Slowly turn up the voltage source to 3.3V. This is a good voltage for these LEDs.

14. Adjust the “Current” control down. You should see the voltage drop below the 3.3V you set and the red LED next to the current control should light up.
    This control sets the Current Limit of the power supply. It will not allow more current to come out of the supply than you have set it to.

15. Adjust the current limit until just above what would limit current in your circuit and try to increase the voltage. What happens?

16. Now turn the voltage control down all the way and the current limit control up all the way.

17. Now turn the voltage control up to and then past 3.3V. What happened?

Oscilloscope *EXTREME!*

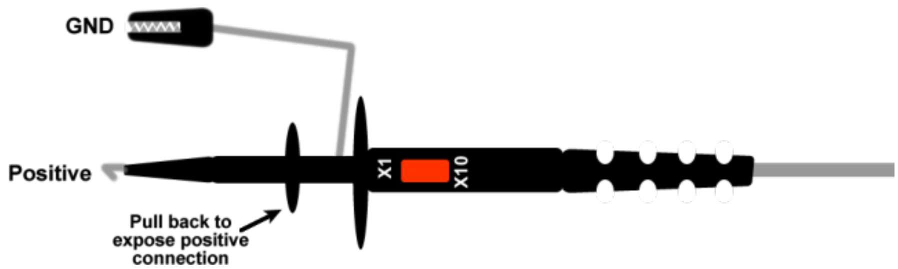
Oscilloscope I/O

The oscilloscopes in the lab are computer based, we will also work with a stand-alone oscilloscope this semester. The PC oscilloscopes we will be using have two channels and also include a Function Generator (*much like the AWG from the lab kits*).

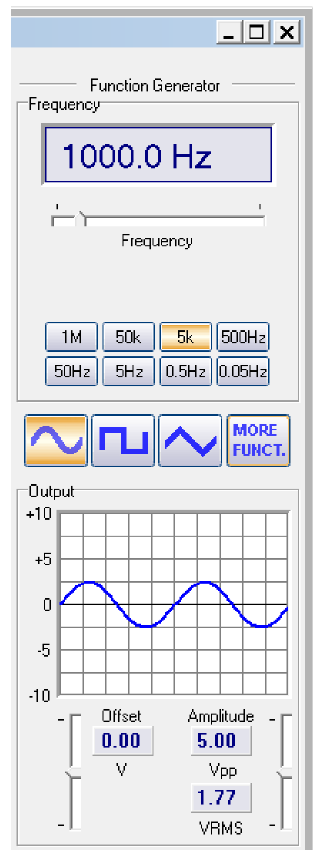
18. Open up 

PcLab2000LT on the lab PC.

19. Connect the Function Generator Output to the Channel 1 probe.
    - Function Generator Output connects to a wire with a Red(+) and Black(-) alligator clip.
    - The Probe allows you to connect to whatever you are testing. Note that there is a Positive and a GND connection. (*see image below*)



The **Function Generator** section is on the far right of the screen. This allows you to generate precise values of AC and or DC waveforms. Click on the Sine Wave and set the Frequency at the top of the screen and the voltage near the bottom. In both cases you can either type in a number or move the slider. For Frequency you must select a range from the buttons below the slider. For Voltage you can enter either a V_{PP} ($V_{PK\text{-}PK}$) or V_{RMS} value. The "Output" display at the bottom shows what is being sent out of the Generator output.

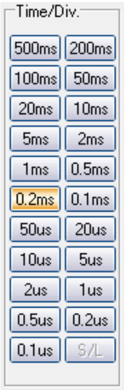


If you want to output DC only from the Function Generator, click on the "MORE FUNCT." button to choose DC.

To add DC to an AC waveform use the "Offset" control, entering a numeric voltage or moving the slider. This can be a positive or negative voltage.

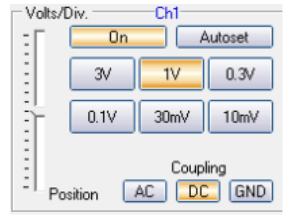
20. Click on the sine wave image to start generating a sine wave.
21. Select a frequency on the Function Generator
22. Click the "**Run**" button to start the Oscilloscope.
23. Adjust the oscilloscope controls manually (*see next page*) to get between one and four cycles of the sine wave on the oscilloscope screen.

Setting the Oscilloscope



Time is shown from left to right on the screen and each square is the amount of time selected in “Time/Div”. If, for instance you have a 1kHz sine wave, setting the Time/Div to 0.5mS would set the display so that each left to right division would be one half of a cycle. Use this thought process to decide what Time/Div to use before changing it. Do NOT simply click on settings randomly.

Voltage is shown from top to bottom on the screen. Since often you don’t know exactly what voltage you are testing a good practice is to just set this to that the waveform is as large as possible on the screen.



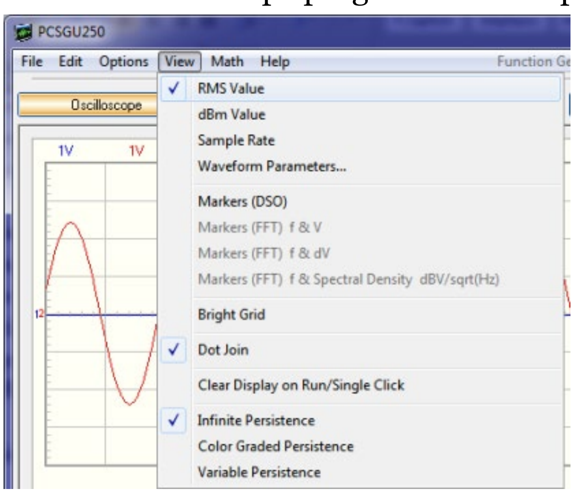
What you are setting here is Volts/Div or **Volts per division**. This defines how many volts each division of the screen (the horizontal lines) indicate.

It is important still to think before you change the settings. If the waveform is too large (part of it is not showing on the screen) then you want to make each division LARGER. If the waveform is too small you want to make each division SMALLER.

24. Try a couple different AC waveforms with and without DC added as well as DC only. Change frequency and reset the screen for a good picture each time.

25. Figure out V_{RMS} for the waveform by finding $V_{PK\text{-}PK}$ using the oscilloscope screen, then find V_{PK} and V_{RMS} using math. What is the V_{RMS} value?

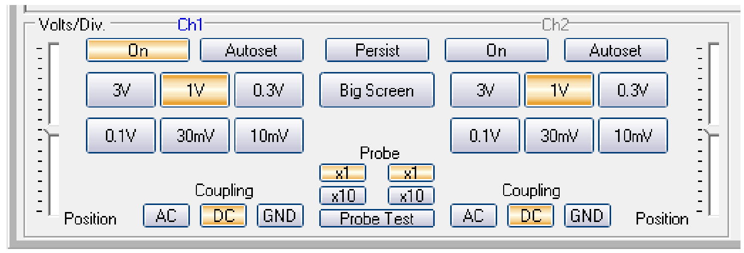
26. The oscilloscope program has the option of showing a numeric value for V_{RMS}. Under “View” select “RMS Value” then compare that value with the one that you got using math. If they are different (to a single decimal place) then figure out what you did wrong and re-calculate the value.



27. Now calculate the frequency of the waveform. This will be difficult to get exact but try to do it using the oscilloscope screen and math and then compare to what you have chosen in the Function Generator. You can also set the Oscilloscope to show the frequency as well as V_{RMS} (using the same View menu). Do this and compare your answer, the Oscilloscope’s answer and the setting in the Function Generator. Write all answers below. If there are any large discrepancies figure out what went wrong.

Function Generator	Oscilloscope	Math

Oscilloscope Exploration



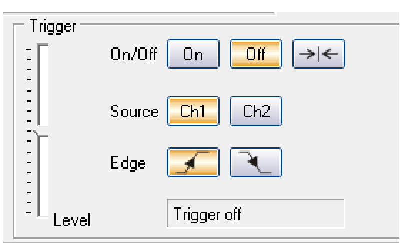
Now let's explore more of the Oscilloscope. We will Start with the Volts/Div area.

"Position" Slider: to the far left of each channel there is a slider control. This moves the waveform for that channel up and down on the screen. This is used to show both channels on separate halves of the screen or just to offset them in some way.
"On" switch: this turns display of that channel on or off. If you are viewing V_{RMS} it will be for Channel 1 if it is on, Channel 2 if Channel 1 is off.
"Autoset": chooses reasonable settings for Volts/Div and Time/Div. This takes a bit of time and I ask that you *DO NOT USE* this during labs as it limits the learning experience.

"Voltage setting": this setting determines how much voltage is represented by each square dividing the screen from top to bottom.
"Coupling": this determines what kind of voltage the oscilloscope is showing:

AC: AC is displayed but DC is not
DC: AC and DC are both displayed
GND: this sets the channel to 0 volts
(*it is used to set the position slider where you would like 0 volts to sit*)

Probe "X1" and "X10": These are used to match the Probe being used. Most probes have a X10 switch on them which divides all input voltages by 10 (like a pad in audio). When you select X10 in the oscilloscope software, it corrects all voltage measurements to be correct with the switch flipped to X10 on the probe.



To the right of the Chan 2 Volts/Div section is the **Trigger Section.** The trigger determines how the signal is captured. It is somewhat like the Clock Signal in digital audio. Most of the time you will not need to adjust this. If you find that the waveform is moving on the screen too much you can turn the trigger on and set it to the channel you are interested in. It should then stop the waveform from moving on the screen.

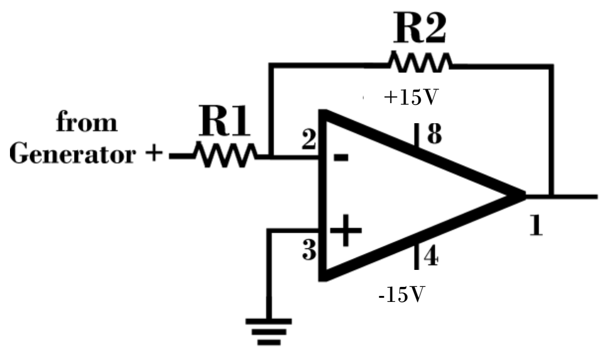
Part 2: Let's Play Operation

Required Materials:

- Resistors: 1-100KΩ , 2-10KΩ, 1-1.8KΩ, and 1-180Ω
- Capacitors: 3-2.2 µF (n.p.), and 1-0.047µF
- I.C.s: 1-SA5532AP dual OpAmp (or 4558 or 4560)

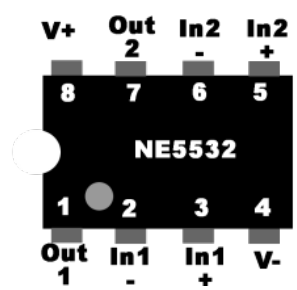
28. The Power supply wiring has V+ coming from the right-side adjustable supply on the RED wire, V- coming from the left side adjustable supply on the Black wire, and GND on the Green wire. It should be set to that the Right voltage control effects both + and -.

29. Construct the circuit to the right on your breadboard. We are utilizing an IC that has 2 OpAmps on it. We will only use one. The pin-outs for the IC are shown below the schematic.



30. Start with R1=10KΩ and R2=10KΩ. What should the gain of the circuit be with these values?

31. How many dB of gain is that?



32. Connect the Function Generator to R1 and Oscilloscope Chan 1 to the output. Adjust the Function Generator output level and the oscilloscope so that the sine wave reaches as close to possible to the top of the screen on its positive half and the bottom on its negative half. Set the Signal Generator to a Sine Wave of 1kHz (*with no DC offset*). Write down your Function Generator Level and what the OpAmp output should be with these resistor values.

	FUNCTION GENERATOR setting	Expected Output	Actual Output
V_{PK}			
V_{RMS}			

33. Now measure and add the V_{PK} and V_{RMS} of the OpAmp output to the chart above. Do your expected and Actual values come close? (remember that you can set the Oscilloscope to show V_{RMS})

Change IT

34. If we change R2 to 1.8KΩ what should happen to the level of the output? What will the gain of the circuit be with these values?

35. How many dB of gain will that be?

36. Go ahead and change R2 to 1.8KΩ. Write down the V_{PK} and V_{RMS} of the OpAmp output.
Did It change as you expected?

	FUNCTION GENERATOR setting	Expected Output	Actual Output
VPK			
VRMS			

Invert the Inverter

37. Now convert your circuit to a non-inverting amplifier by changing only 2 things.
38. What should the gain be?

39. Measure it, do you get what you expected?

Break IT

40. What is the purpose of R2 and what will happen if you remove it entirely?

41. Remove R2 and describe what you see on the Oscilloscope. Was the change what you expected? If not, figure out and explain why.
Note, think about the maximum level you can see on your screen. If you need to see larger voltages, use the x10 switch on the probe and click the x10 button on the scope controls.

42. Adjust the level of the FUNCTION GENERATOR and describe how this affects the output with R2 missing.

43. Is the waveform distorted? If so why?

44. Is there any way (other than replacing R2) to get rid of the distortion?