

Introduction to Electronic Equipment

Introduction

This semester you will be exploring electricity and magnetism. In order to make your time in here more instructive we've designed this laboratory exercise to introduce you to some of the equipment you'll be using in this course. Some of the terms that will be used will be more thoroughly explained in subsequent labs, but will be used here without much explanation to get you started.

Here is a list of the equipment you will be using today:

1. **DC (Direct Current) power supply.** This is a source of voltage whose polarity does not change, as it does in an AC (Alternating Current) voltage source. Standard electrical outlets supply AC voltage. Using this power supply will be just like using a dry cell battery, except that you will be able to vary the voltage used.
2. **Signal Generator.** This device generates an AC signal in the form of sine, saw tooth, or square wave. The frequency (the rate at which the signal's polarity changes) as well as the amplitude (which, in this exercise, will be the same as the voltage) can be varied to the user's choosing. This will be a safer and more flexible alternative to using the AC voltage from a wall socket.
3. **Digital Multimeter.** As the name implies, this device measures (or *meters*) multiple quantities associated with electrical circuits. A multimeter can be used as a **voltmeter** (to measure voltage), an **ammeter** (to measure current, both *DC* and *AC*) and an **ohmmeter** (to measure resistance).
4. **Oscilloscope.** This piece of equipment looks to be the most confusing of all the equipment you'll be using today. It is, however, essentially just a voltmeter that can show time varying changes in the voltage.

Part 1. Measuring Voltage, Current, and Resistance with a Digital Multimeter.



Three different multimeters are provided for this lab: the Fluke 77, the Radio Shack, and the Tenma. The operation of these multimeters is quite similar, so we will focus here on the Fluke 77. The large central knob is used to determine the type of measurement that is made. The types of measurements that can be made are *AC* voltage (\tilde{V}), *DC* voltage (\bar{V}), *DC* voltage below 300 mV ($300 \bar{mV}$), resistance (Ω), *AC* current (\tilde{A}) and *DC* current (\bar{A}). The sensitivity of the meter can be selected by pressing the yellow button on the center of the knob. The meter has a 4½ digit display (four full digits plus the first digit that can be either 1 or nothing), so positive or negative values from 0 to 19,999 can be displayed. Pressing the yellow button can shift the decimal point, or you can use the autorange function that automatically sets the decimal point. You should always use the most sensitive scale possible to obtain the maximum number of significant figures.

At the bottom of the multi-meter are four jacks. These are used to connect the object being measured to the multimeter. To measure *DC* volts, *AC* volts, and ohms, use the two jacks labeled "VΩ" and "COM". When measuring voltages, the "VΩ" jack (red) is positive and the "COM" jack (black) is negative. To measure *AC* or *DC* currents, use the "10A" or the "300mA" jack and the "COM" jack. The "300mA" jack is for measuring currents less than 300 mA, and the "10A" jack is for measuring currents greater than 300mA but less than 10A. If you are ever unsure about the amount of current in a circuit, it is always best to use the higher 10A connection first to avoid damaging the meter or blowing the fuse for the lower 300mA connection. If you find that your meter is not functioning properly, you can check the integrity of the fuse by using another multimeter to measure the resistance of the ammeter circuit (which should be only a few ohms, not "OL" for overload or infinite resistance, which usually indicates that the fuse has been blown and needs to be replaced). If your multimeter takes a long time to stabilize when reading a voltage, the battery may be low (indicated by the "low battery" symbol on the display). Your lab instructor can assist you if you need help replacing either a fuse or a battery. The accuracies of the multimeters are provided in the appendix.

How to Use the DMM:

In this segment, we'll be measuring voltage, current, and resistance with a digital multimeter. **Voltage** is the difference in electrical potential *between two points* in a circuit measured in units of **Volts**. **Current** is the amount of electricity flowing *through a circuit* segment measured in units of **Amperes**, or **Amps**. **Resistance** is the opposition to current flow measured in units of **Ohms**.

First set up a simple circuit by connecting the small light bulb to the power supply with two banana plug cords. **Make sure the power supply is turned all the way down (the control knob should be rotated fully counterclockwise).**

Note: the color of the wires is not of critical importance. The color helps identify polarity (red for positive, black for negative) and is used as a standard visual aid.

Slowly turn the power supply control knob clockwise until the bulb glows with medium brightness (the knob should be about halfway to the maximum value on the scale, the exact position is not critical). **Be careful not to burn out the bulb by supplying too much voltage!** Do not change this setting, as it will be used in the procedure that follows this one. We will now measure the voltage that the power supply is providing to the circuit.

DO NOT turn the power supply much past the halfway point – setting the voltage higher than this easily damages the bulbs!

Turn the multimeter on, set it to measure DC Volts and plug in wires from the meter to the power supply. The wires should plug into the multimeter into the socket marked “COM” (the negative terminal) and the socket marked with a “V”. These wires should then plug into the power supply on top of the wires to the light bulb (“piggy-back” style). You are now measuring the voltage *across* the two terminals of the power supply. In the space provided below, write the voltage with the correct units and uncertainty.

Note: According to the manufacturer, the Fluke 77 meters are rated with an accuracy of \pm (0.3% of reading + least significant digit) for voltages between 0.001 V and 320 V. (Example: 10.00V \pm (.03 + .01)V) The Micronta meters are rated with an accuracy of \pm (0.5% of reading + least significant digit) for voltages between 300 mV and 3 V, and \pm (1.0% of reading + least significant digit) for voltages between 3 V and 1000 V.

Voltage of power Supply: _____ \pm _____

What does it mean if you get a negative value for the voltage? (hint: polarity) _____

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We will now use the multimeter to measure the current through the circuit. Since measuring the *current through* a circuit is much different than measuring the *voltage across* two points in a circuit, we will have to adjust how we put the multimeter into the circuit. The circuit path must be broken and the ammeter connected so that the current is forced to pass through the multimeter.

Switch the power supply off without touching the control knob. Remove the multimeter wires from the power supply. On the multimeter, move the wire from the socket marked “V” to the socket marked “300 mA”. Now remove one of the wires running to the light bulb and replace it with the multimeter and its wires. Plug one wire from the multimeter into the power supply and the other into the light bulb. Set the multimeter to measure DC Amps and switch the power supply back on. Your meter should now be measuring *current flowing through* the circuit. In the space provided below, write the current with the correct units and uncertainty.

Note: The Fluke 77 meters are rated with an accuracy of \pm (1.5% of reading + 2 * least significant digit) for currents up to 10A. The Micronta meters are rated with an accuracy of \pm (1.0% of reading + least significant digit) for currents up to 30 mA, \pm (1.5% of reading + least significant digit) for currents between 30 mA and 300 mA, and \pm (2.0% of reading + least significant digit) for currents between 0.3 A and 10 A.

Current through the circuit: _____ \pm _____

What does it mean if you get a negative value for the current? _____

We will use the multimeter for one last measurement of this circuit. We will measure the resistance of the light bulb. Resistance is measured in a similar way to measuring voltage. The meter wires are placed on either side of circuit element and the resistance is read off of the meter. The difference between a voltage measurement and a resistance measurement is that the multimeter, when put into resistance mode, passes a small current through the circuit element using its own battery. *Resistance measurements must be made with the component removed from the circuit.*

Switch the power supply off again. Remove the light bulb from the circuit completely. Set the multimeter’s control knob to the setting marked “ Ω ” (this is Greek symbol omega, which is the symbol used for Ohms). Connect a wire from one side of the bulb to the V Ω socket and another wire from the COM socket to the other side of the bulb. Make sure to record your value with the correct units.

Note: The Fluke 77 meters are rated with an accuracy of \pm (0.5% of reading + least significant digit) for resistances up to 3.2 M Ω . The Micronta meters are rated with an accuracy of \pm (1.0% of reading + least significant digit) for resistances up to 300 k Ω , \pm (2.0% of reading + least significant digit) for resistances between 300 k Ω and 3 M Ω , and \pm (3.5% of reading + least significant digit) for resistances between 3 M Ω and 30 M Ω .

Resistance of the light bulb (power off): _____ \pm _____

Part 2. Measuring Voltage with an Oscilloscope.

This part of the lab will be very similar to part 1 in that you'll be measuring voltage from a simple DC circuit. You will be using an oscilloscope in this case, however.

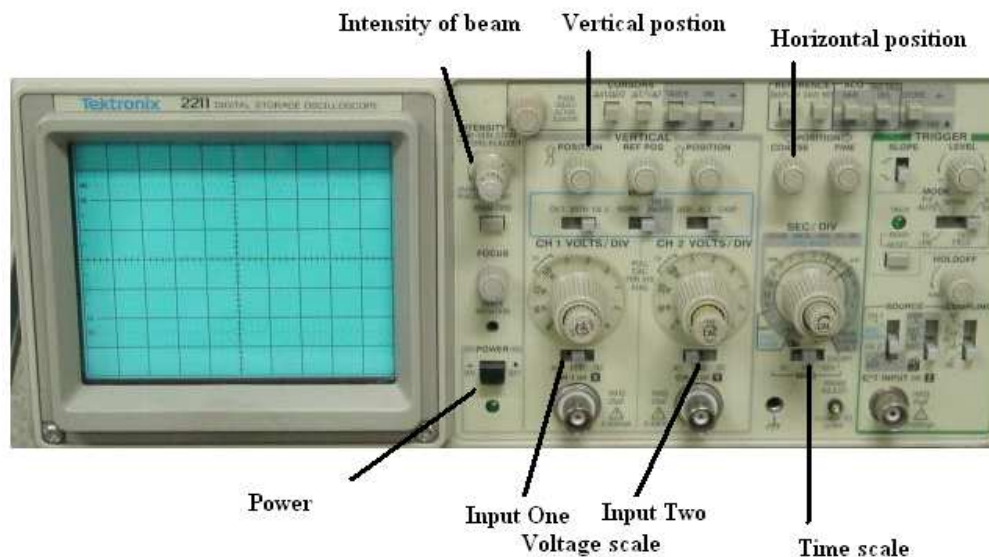
A brief discussion of oscilloscopes

An oscilloscope functions very much like a television tube, where a beam of electrons is directed towards the back of the screen by variable electric and magnetic fields. The screen is covered with a phosphor coating that fluoresces when struck by the electrons. A further, more in depth discussion can be found in a number of electronic reference materials. The most important controls on the oscilloscope are the gain, and sweep settings. The *gain* setting (measured in *volts per division*) adjusts the scale of the vertical *voltage* coordinate. The *sweep* setting (measured in *seconds per division*) adjusts the horizontal scale of the horizontal *time* coordinate. The screen of the oscilloscope looks very much like a Cartesian coordinate system. The coordinate axes are divided into large divisions (about 1cm in length) and smaller divisions in between the larger ones.

The large divisions along the vertical are referred to as the gain units of volts per division. So, if you were measuring the voltage of a AA battery (maximum of 1.5 volts) with a gain setting of 1 volt/division, you would see the horizontal trace of the scope appear at 1.5 large divisions above the center line (with correct polarity; below the line with polarity reversed). If the gain setting were changed to 2 volts/division, the trace would appear 3 units above the centerline.

The large divisions on the horizontal scale are referred to as the sweep units of seconds per division. A higher sweep setting will show more of the signal trace (like a wide angle lens on a camera). A low sweep setting will zoom in on a smaller part of the signal trace. The sweep setting will help you to fit a signal trace onto the screen so that better measurements can be taken from it. The sweep is used most often when dealing with an AC signal, while the gain is used to adjust both AC and DC signals.

Note: The inner knobs on the Gain and Sweep settings must be turned fully clockwise to ensure that they are calibrated properly; otherwise your measurements may be inaccurate.



Procedure

First you will need to power up the oscilloscope and make sure it's set up correctly. You should see a bright green horizontal line across the screen. Adjust the vertical position of the trace line until it lines up with the centerline of the oscilloscope grid. Adjust the intensity and/or focus until you get a thin focused line. You are now ready to measure the voltage of your DC power supply visually.

Connect banana plug wires from the power supply to the oscilloscope (remember polarity!). As before, set the voltage at about half the maximum setting. If you do not see the horizontal trace any more, adjust the gain setting until the trace is visible again. Record the gain setting and the displacement of the trace on the screen.

Gain setting on scope: _____

Number of divisions: _____ ± _____

Voltage of power supply: _____ ± _____

What does it mean if you get a negative value for the voltage? _____

Now we will be dealing with an AC signal. This signal will come from a *signal generator*. These devices might seem just as confusing as an oscilloscope, with just as many knobs and switches; a signal generator does just what its name implies, it generates a signal. You specify the frequency and the waveform (we will be dealing only with sine and square waves) and it generates a signal to your specifications. The most important controls are the *range switches*, the *function switches* and the *fine adjust knob*. With the range switches, you can adjust between frequencies as low as a fraction of a cycle per second (Hz) to millions of cycles per second (MHz). The function switches select between sine, square, and sawtooth wave patterns. The fine adjust knob tells you where in the range (selected by the range switches) you are. The knob typically has a scale that runs from 0 to 1. So if you had selected the 1kHz range and set the knob to about 0.75, you would be dealing with a signal whose frequency was about 750Hz.

NOTE: Always turn the amplitude knob to its maximum value (i.e. all the way clockwise) this will give you the full signal from the generator.

Set up the oscilloscope as you did in the previous section (make sure you have zeroed the trace, etc.). Connect the oscilloscope to the signal generator with banana plug wires. Power up the signal generator and set it to give a 60Hz sine wave. Adjust the sweep and gain until two complete cycles can be seen on your screen. Once you have the signal on the screen, determine its frequency noting the sweep setting and the number of divisions for one cycle of the waveform.

Sweep setting on scope: _____(sec/div)

Number of divisions for one cycle: _____ \pm _____

Period: _____ \pm _____

Frequency of signal: _____ \pm _____

Is the frequency you determined the same as what you expected from the signal generator? _____

If not, have your TA help you.

