

Instrument Usage in Circuits Lab

This document contains descriptions of the various components and instruments that will be used in Circuit Analysis laboratory. Descriptions currently exist for the following items, listed in the order in which they will be used this quarter:

- Solderless breadboard;
- Connecting wires;
- DC power supply;
- Fluke handheld multi-meter;
- Fluke benchtop multi-meter;
- Component resistors;
- Decade resistance box;
- Siglent function generator;
- Tektronix oscilloscope.

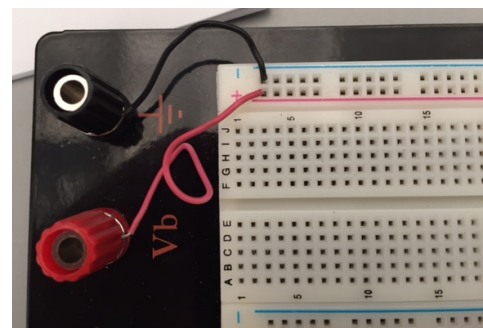
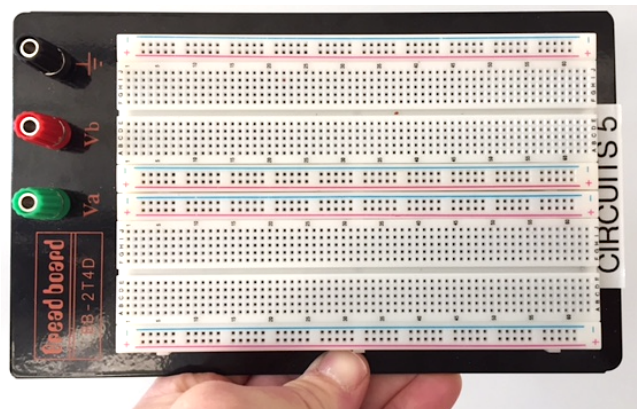
Solderless Breadboard

Students use a solderless breadboard to build and test circuits by temporarily connecting components together. The **solderless breadboard** shown at the right is a plastic-covered board with many holes into which you can insert the leads of components. Underneath the plastic cover are strips of metal that connect some of the holes to each other. By inserting component leads into the proper holes, you connect the components to each other without having to solder them together.

The breadboard has three screw-type posts on the left side. These posts serve as a connection point between wires to your instruments and the breadboard itself. The posts are not connected to any part of the breadboard so it is necessary to add wires like the red and black ones shown at the right. The wires are added by screwing the posts up, stripping and inserting a wire into the hole beneath the post, tightening the posts down on the wire and then inserting the other end of the wire into the breadboard.

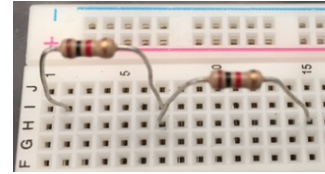
The holes in the breadboard are arranged in rows and columns. All holes in the + (red) and – (blue) rows are tied together the entire width of the breadboard. However, the rows are not connected to each other. These are commonly used for signals like **Power** and **Ground** that may have many connections to your circuit.

The holes in between the + and – rows are connected vertically in groups of five holes by a metal strip beneath the breadboard's plastic cover, but those five holes are not connected to any of the other holes on the breadboard.



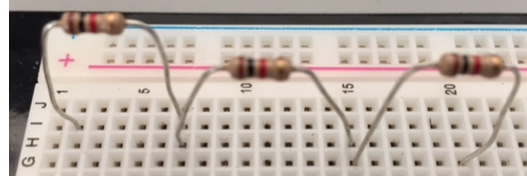
Connecting Two Components in Series

The picture at the right shows two resistors on a breadboard. Notice that each resistor has one lead (or "leg") inserted into a hole in column 7 thus connecting the two resistors to each other at this point. Notice that the resistor's other leads are **not** connected together. When two resistors are connected in this particular way, they are said to be **connected in series**. In the same way, we could connect two capacitors in series, or two inductors in series, or a capacitor and a resistor in series, and so forth.



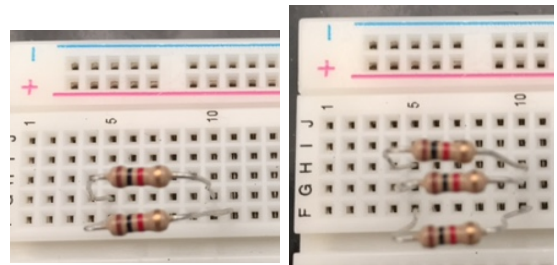
Connecting More than Two Components in Series

The picture at the right shows **three** resistors connected in series. The first and second resistors are connected because they each have a lead inserted into column 7. The second and third resistors are connected because they each have a lead inserted into column 15.



Connecting Two Components in Parallel

The two resistors shown at the immediate right are **connected in parallel**. Notice that the left-hand leads of the resistors are connected to each other in column 5 and the right-hand leads are connected together in column 10. To measure the total resistance, R_T , of these two resistors, you would touch one of the ohmmeter's test leads to either resistor's left-hand leads and the other test lead to either of the resistor's right-hand leads.



Connecting More than Two Components in Parallel

Extending the idea of two resistors in parallel, we can connect three, four, or more resistors in parallel. The picture at the far right above shows three resistors connected in parallel.

Connecting Wires

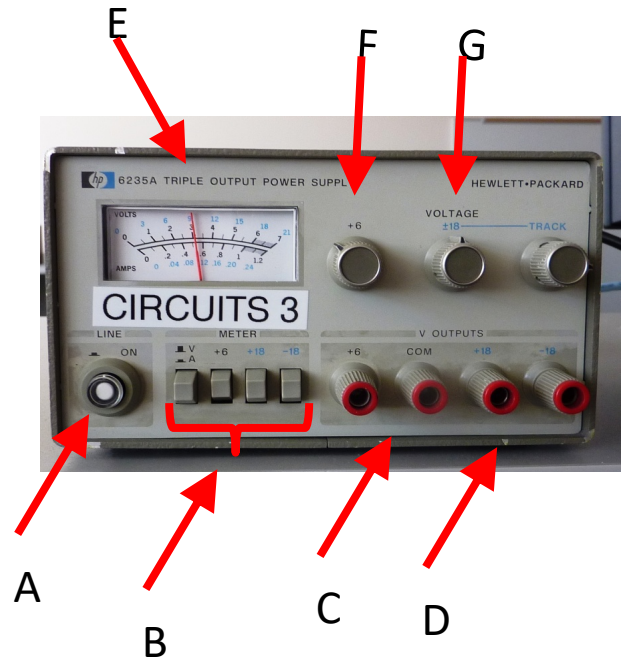
The picture at the right shows the wires that will be used in lab to connect instruments to each other or to your breadboard. These wires come in a variety of lengths. Typically, red wires are used for positive (+) signals and black wires are used for negative (-) signals including **GND** or **COM** connections.



DC Power Supply

DC power supplies are used to provide a DC voltage (and in some cases a DC current) to your circuit. The DC supplies we use in the laboratory are HP6235A Triple output power supplies shown at the right. Each lab station is equipped with this model. The table below explains what the buttons and outputs are used for.

Legend	Function
A	Power On/Off switch. White is ON.
B	Four selector switches to choose what quantity is displayed on the meter (E).
C	0 - 6VDC terminals. Attach a red lead to +6 and a black (Gnd) lead to the COM terminal for 0 - 6VDC. Adjust the voltage with knob F.
D	0 - 18VDC terminals. Attach a red lead to the +18 terminal and a black lead to the COM terminal for 0 - 18VDC. Adjust with knob G.
E	Meter that displays voltage or current. Note this meter is not very accurate.
F	Knob adjust for 0-6VDC.
G	Knob adjust for 0-18VDC.



Digital Multi-Meters

A **Digital Multi-meter (DMM)** can measure voltage, current, resistance, capacitance, or frequency depending on the setting of a selector switch. DMM's can cost anywhere from a few dollars to \$100's and even \$1000's of dollars depending on the quality, accuracy, and functions you wish to have available for use. DMM's come in two basic varieties; hand-held and benchtop.

Fluke Handheld Multi-Meter

Hand-held DMM's are portable, battery powered, and have basic measuring functions. These instruments are used extensively throughout industry and universities. Each lab station is equipped with a Fluke 115 True RMS multimeter.

The rotary function dial has nine settings. These settings are described briefly below. Since the symbols on the meter are hard to draw, I will refer to them using word descriptions.



Switch Position	Function	Description
1 (Off)	Off switch	Meter is turned OFF in this position
2	AC Volts	Measures RMS AC voltage or frequency (yellow button) (1)
3	DC Volts	Measures DC voltage (1)
4	DC milli-volts	Measures smaller DC voltages for better accuracy (1)
5	Resistance	Measures resistance (1)
6	Resistance	Measures resistance with an audible indicator for low values
7	Diode test	Used for testing diodes. Also gives an audible indicator if the resistance is less than about 200Ω. (1)
8	AC current	Measures AC current or frequency (2)
9	DC Current	Measures DC current (2)

- (1) Test leads (like those shown at the right) should be attached to the two terminals on the **lower right of the meter**, the positive test lead (red) to the right-most terminal and the negative (Gnd, black) test lead to the middle terminal (COM).
- (2) To measure current, the positive test lead (red) needs to be inserted into the left-most terminal and the negative test lead (Gnd, black) needs to be inserted into the COM (middle) terminal.



A multimeter **must not be set** to measure current when it is connected as a voltmeter, or set to measure voltage when it is connected as an ammeter.

Fluke Benchtop Multi-Meter

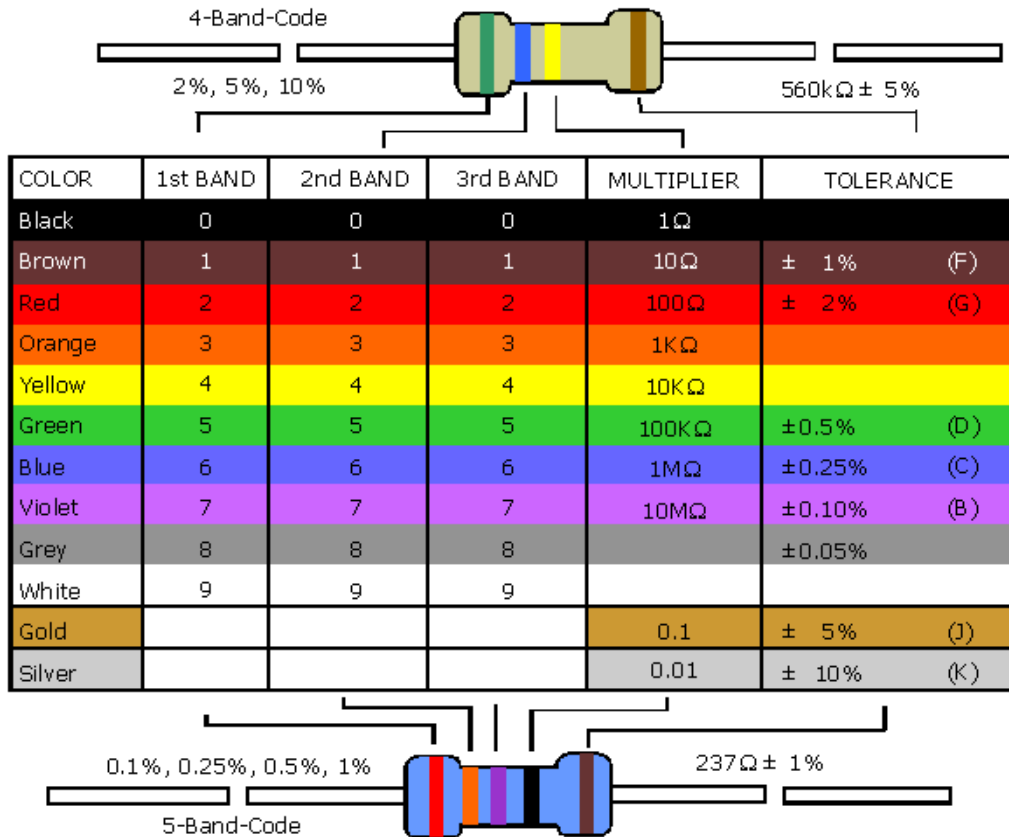
Benchtop DMM's typically have more functions than handheld DMM's, have better performance, and cost more. Most lab stations in engineering schools and industry contain a benchtop meter, although some higher end hand-held DMM's can perform most or all of the functions of a benchtop DMM. In addition to the basic measuring quantities, some benchtop meters can measure parameters such as frequency, duty cycle, temperature, period, capacitance, inductance, and will likely have some ability to process or store the signals, and communicate to a computer via USB or another standard interface. Each lab station is equipped with a Fluke 45 Dual-display DMM, shown at the right. Students can deduce what the functions and proper terminals are for this meter based on what they already know from a handheld DMM.



Component Resistors

Lab experiments will require the use of individual resistors located in a resistor bin shown at the right. The resistors are arranged by value and the value of any one resistor is determined by a color code which is stamped on each resistor. The standard color code is shown on the following page:





Decade Resistance Box

Each lab station is equipped with a **Decade Resistance Box**, an instrument that has a number of internal resistances and selector switches to select a wide variety of resistance values. The decade resistance box shown at the right can output any resistance from 0Ω - $1,111,110\Omega$ in 1Ω steps. Simply attach leads to the two yellow terminals at the right and dial in the resistance you desire. Resistors are uni-polar, meaning it makes no difference which direction you put a resistor in your circuit.

Note: *Never, ever, set the resistance to 0Ω when the decade resistance box is in an energized circuit.*



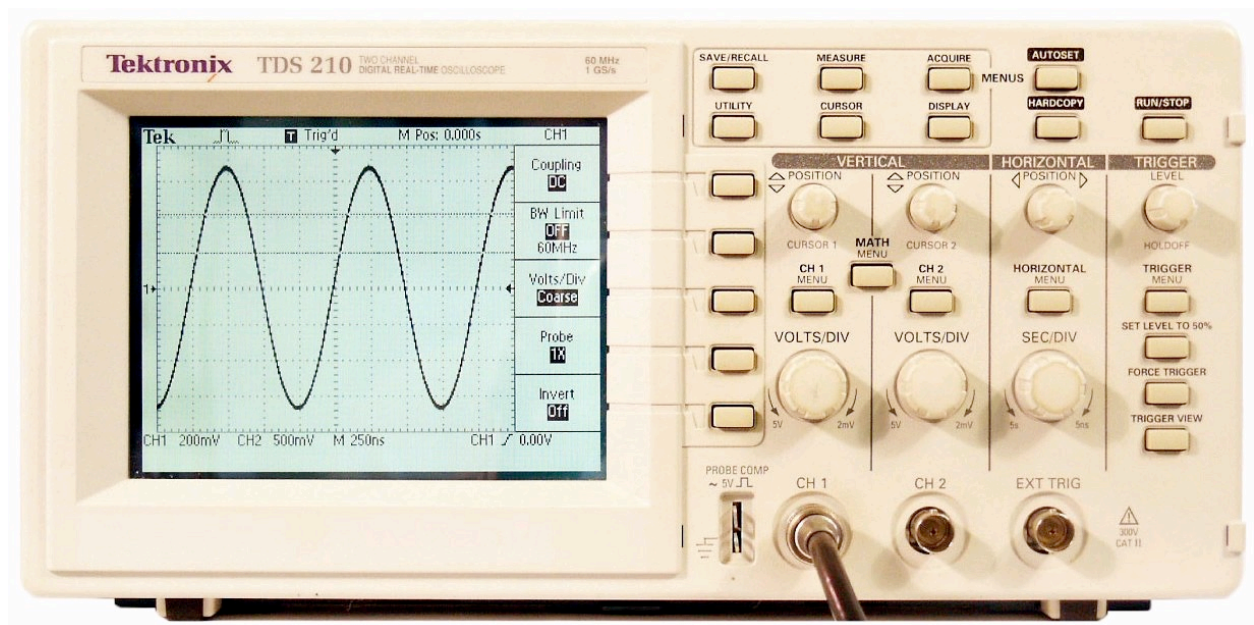
Siglent Arbitrary Function Generator Model SDG 805

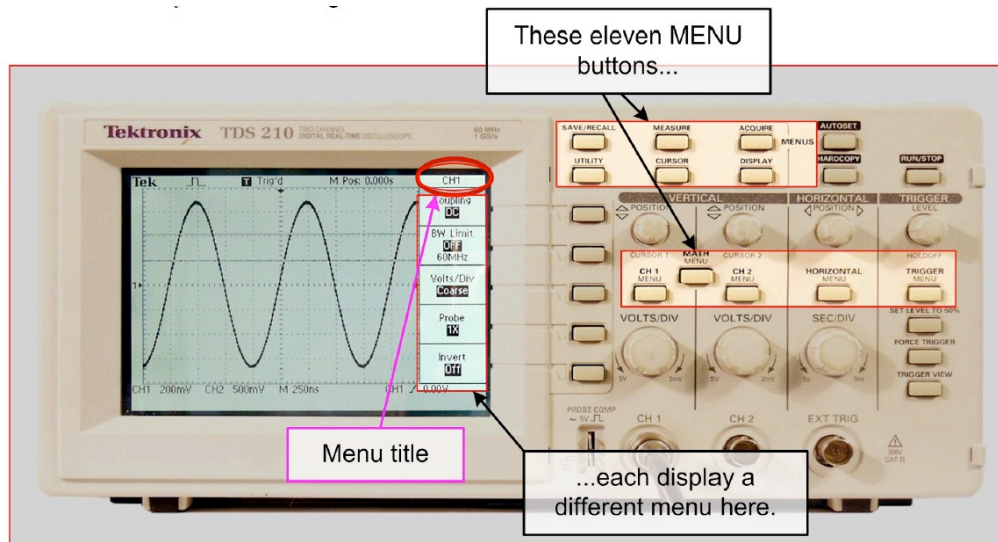
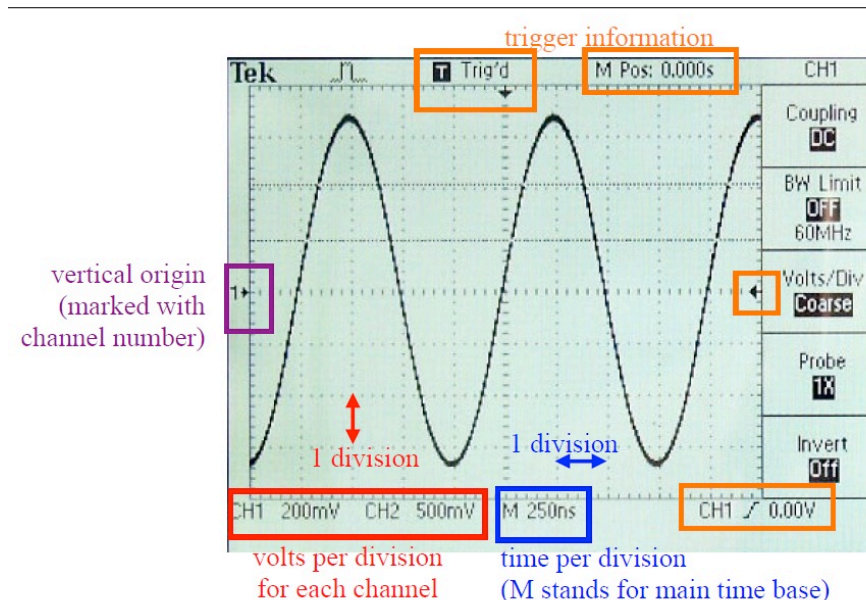
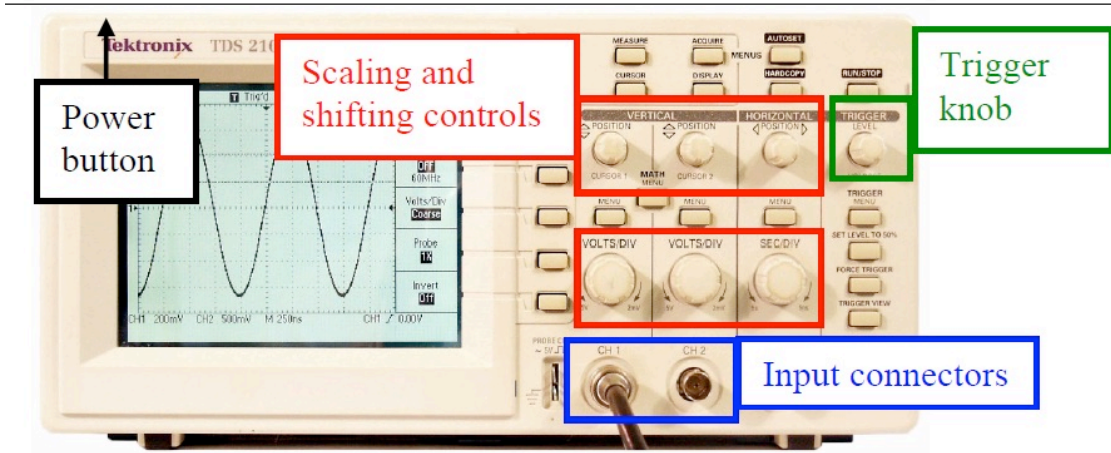
Each lab station is equipped with a Siglent SDG 805 Function Generator shown on the following page. These models generate sine, square, triangle, pulse and other waveforms. Frequency range is from 0.1 Hz to 5MHz. These models can also sweep from one frequency to a higher frequency with controllable rate and range. Like some of the other lab instruments, you will only use a subset of the features available. The user interface is modern and students can likely determine usage intuitively.



Tektronix TDS 210 Oscilloscope

Each lab station is equipped with a Tektronix TDS 210 Oscilloscope. Like the function generator, this is a more complex instrument and its use will be described by the instructor during lab time. The oscilloscope is an instrument used to graphically display voltage waveforms for both AC and DC signals. Shown below are several pictures of this instrument.





Try the MENU buttons to watch the display change as you press each one.