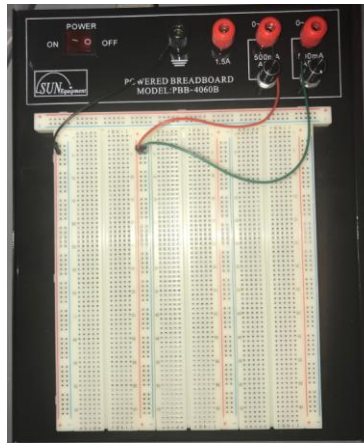


How to use a Circuit Breadboard

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A convenient way to assemble an electronic circuit, without having to solder components, is to use a prototyping solderless breadboard (or protoboard). Protoboards are appropriate for circuits operating at low frequencies ($f < \text{few MHz}$); at high frequencies, the large capacitance between adjacent rows of holes interferes with circuit operation. The protoboard used in the Lab is a powered Sun Equipment brand, shown above. It has sets of holes into which wires can be inserted. A wire pushed into one of the (plastic) holes is snugly received by a metallic socket. Sets of sockets are connected together internally. Those sets are arranged in rows and columns.

In the following, a generic breadboard (refer to Figure 1) is described and tips on its proper use are provided

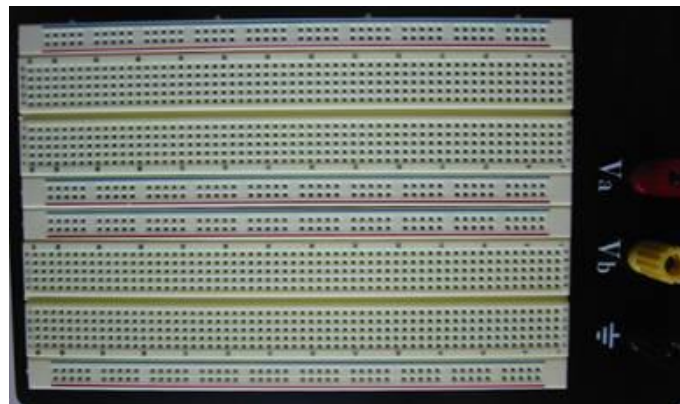


Figure 1. A solderless prototyping breadboard (or protoboard).

A section of the protoboard is shown in Figure 2 (a), and its corresponding internal connections are shown in Figure 2(b). For example, the set of 5 holes defined by row 1 and columns {A, B, C, D, E} are connected together, and can form a single node in a circuit; similarly for a row under the F, G, H, I and J labels. On both sides of the

horizontally connected holes, there are pairs of columns of holes (drawn between the blue and red lines).

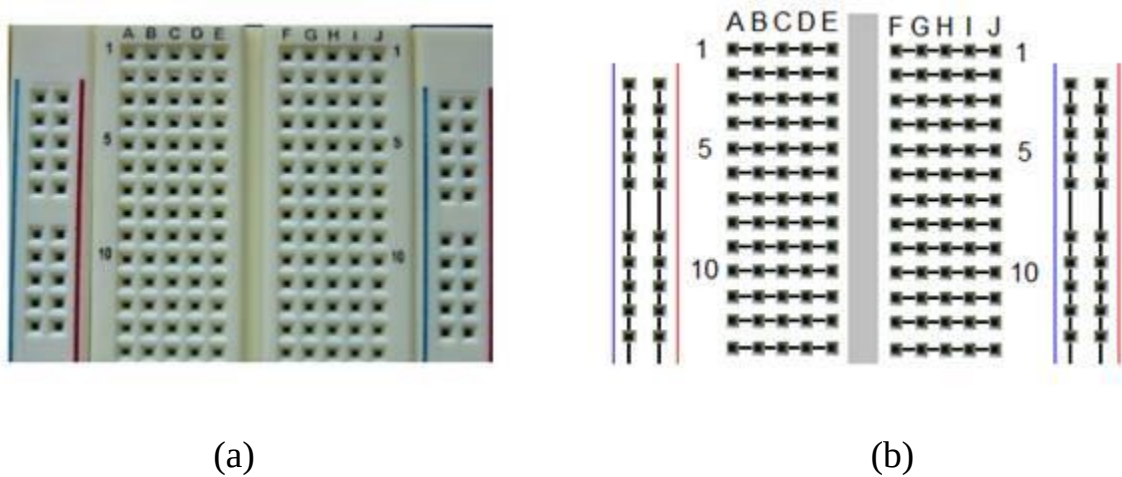


Figure 2. A section of the protoboard (a) and its corresponding internal connections (b).

The holes in the column that is located immediately to the left of the red line are connected together. Similarly, the holes in the column to the right of the blue line are connected together; those columns are used to carry, power, ground, or other signals that must be accessed from many parts of the circuit. Figure 3 shows a typical use for one set of red and blue column holes used to supply power to the circuit. Here, the red column holes are connected to the red binding post (labeled V_a), and the blue column holes are connected to the black post (labeled by the ground symbol). A pair of banana plug test leads originating from (say) a DC power supply, can now be connected to the red and black binding posts.

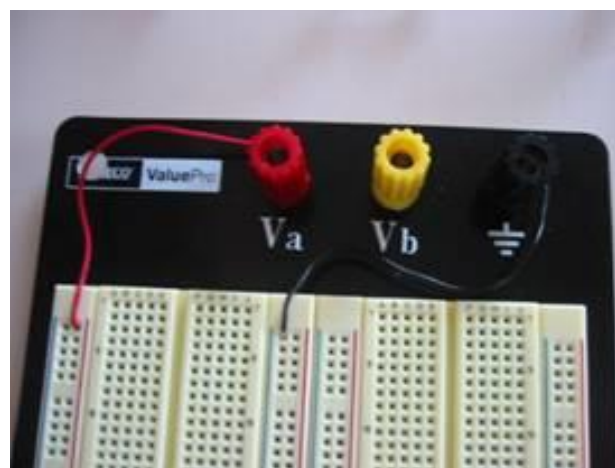


Figure 3. Typical use for the blue and red columns of holes is to supply power to the circuit.

The gray area, between the {A, B, C, D, E} and {F, G, H, I, J} sets of columns in Figure 2(b), represents the trough in the protoboard. The protoboard can be used for

prototyping a circuit that uses a component integrated circuit (IC) in DIP (double in-line pins) packaging. In such circuits, the IC is mounted such that it straddles the trough (see Figure 4). The pins on the right side of the IC connect to a set of adjacent holes in the “F” column; similarly, the left hand side IC pins connect to a set of adjacent holes in the “E” column.

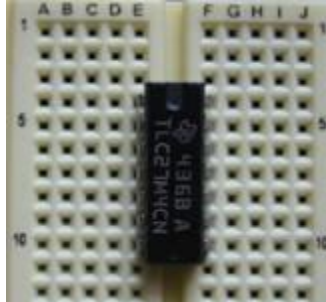


Figure 4. Positioning a DIP packaged IC on the protoboard.

Pieces of insulated solid (as opposed to stranded) wire are inserted in the holes to make connections between circuit components. The appropriate wire diameter is #22 to #24 AWG (American Wire Gauge standard). Sets of connecting wires in various length and colors (see Figure 5) are available in the lab. When making a connection, the bare end of a connecting wire should be inserted vertically, all the way, into a hole.

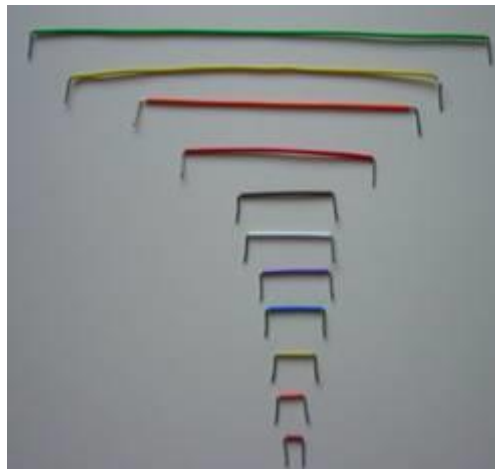
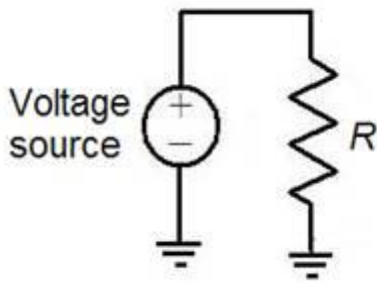
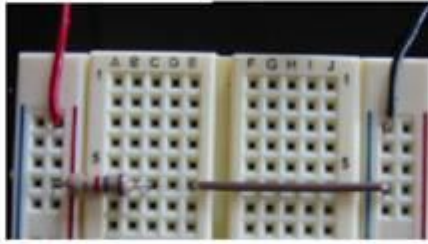


Figure 5. A set of connecting wires for use with the protoboard.

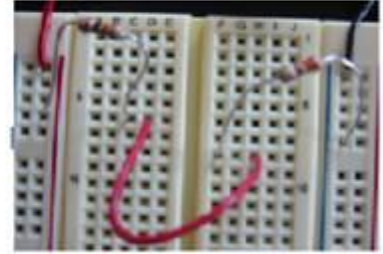
Capacitors, resistors, and some inductors can also be plugged directly into a protoboard. In order to help you find wiring mistakes, it is important that you wire the circuit neatly. Figure 6(b) shows an example of “neat” wiring and component placement for the simple circuit in Figure 6(a). You should avoid building messy circuits, as in Figure 6(c). Figure 7 provides two additional examples of neat circuit wiring. The reader is invited to confirm that the circuit in Figure 7(a) has two resistors connected in series, and that the resistors in Figure 7(b) are connected in parallel.



(a)

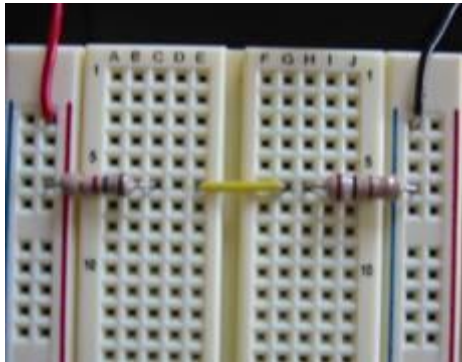


(b)

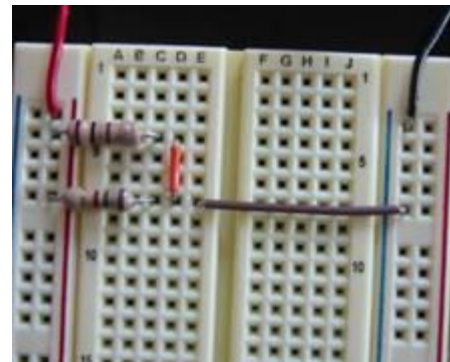


(c)

Figure 6. A simple circuit (a) and its “neat” (b) and “messy” (c) prototypes.



(a)



(b)

Figure 7. Connections for series resistors (a) and parallel resistors (b).

The following is a list of important circuit prototyping practices:

- The power must stay off as you are building a circuit, and as you modify an existing one.
- Make connections as short as possible by using pre-cut wires of proper length. Long wire can cause interference through undesirable electromagnetic interactions with your circuit.
- Connect components directly whenever possible (i.e., minimize the use of wires). In Figure 7(b), one wire has been saved by directly connecting the left terminals of the resistors.
- Keep the wires flushed with the protoboard surface.

- Color-code your connections. For example, use red wires to connect components to the positive terminal of the power supply and black for wires connected to ground.
- Connect the power supply (or function generator) to the available posts on the protoboard. The circuit can then be supplied power by making connections with the posts, as shown in Figure 3. This should help make the connections to the power supply mechanically more stable.
- When using a multimeter to perform circuit measurements, you should connect the alligator clips (located at the end of the multimeter test leads) to short connector wires, as shown in Figure 8. Make sure that the connection at the alligator clip is tight. Then, insert the connector wire's other end in the appropriate hole.
- After you build your circuit on the protoboard, you should inspect all connections. Then, have your instructor double check your connections. Only then you may apply power or connect the function generator to your circuit.
- Active circuits (e.g., ICs) require *dc* power (to appropriately bias the active components) and an input signal (say, a sinusoidal voltage signal that is generated by a function generator). For such circuits, turn on the power supply first then connect the function generator to the circuit. When turning power off, first disconnect the function generator and then turn the power supply off. Some IC can be damaged if you do otherwise.

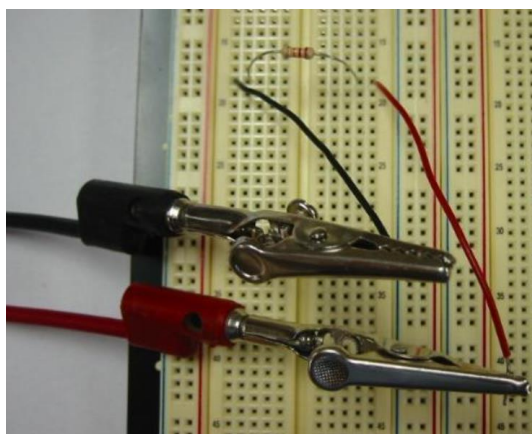


Figure 8. Alligator clip terminated test probes.