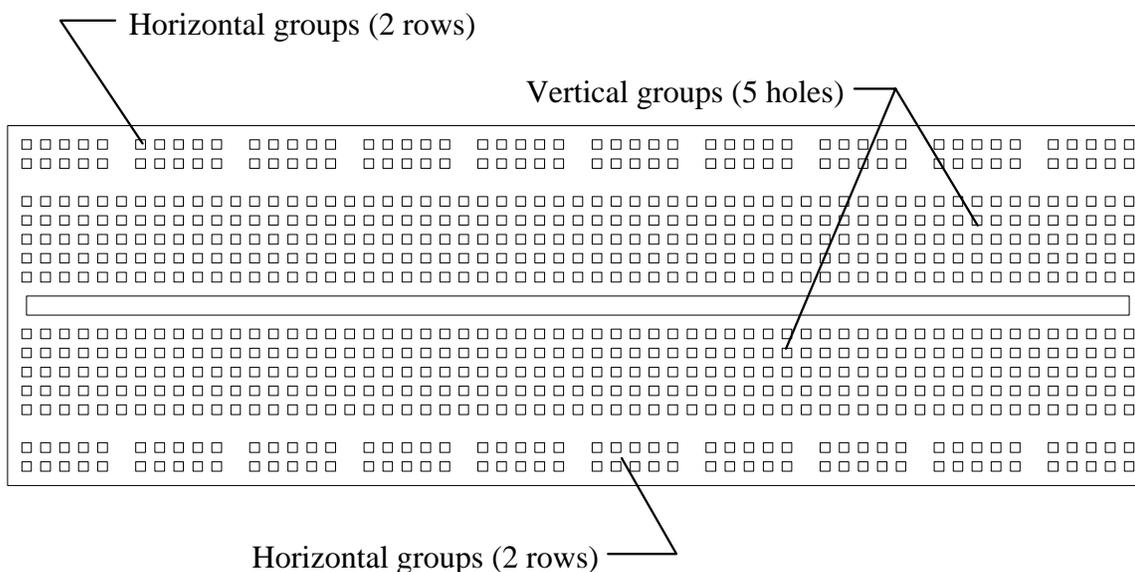# Breadboard Circuit Techniques

Breadboards are frequently used to develop circuits in a rapid and easily changed fashion. A typical breadboard layout is shown below. The holes are uniformly spaced at 0.1 inches.

Horizontal groups (2 rows)

Vertical groups (5 holes)

Horizontal groups (2 rows)

The four horizontal groupings of connections are typically used to distribute power to the circuits. In EE terminology this forms a "bus." A common strategy is to use the top row for a +15 V bus, the second row for a +5V bus, the next to the bottom row for a ground (GND) bus, and the bottom row for a -15V bus. The power supply is connected by "banana" plugs to the breadboard holder. A short piece of insulated, 22-24 gauge solid wire connects the banana plug jack to the associated row.

Circuit connections are made with the 5 hole vertical groupings of connections. A dual inline package (DIP), such as a 741 op-amp, is inserted across the "valley" in the center of the board, as shown below.

Some tips for successful breadboarding are described below:

- Color-code your 22-24 gauge solid wires for different functions. Red wire is commonly used for power (+5V), while black is often used for ground. Yellow, white, blue, grey, etc. can be used for signal wires.

- Strip about 1/4 to 3/8 inch of insulation from the wire, and cut the end of the wire on a 45 degree angle for easy insertion into the breadboard. Push the wire in as far as it will go to insure a good connection.

- 1/4 watt resistors and most capacitors can often be directly inserted into the breadboard, after the tips are cut on a 45 degree angle. Avoid forcing large diameter (14-18 gauge) wire into the holes, since it will pull out easily and will deform the spring clip that makes the desired electrical connection in the breadboard.

- Minimize the number of connections whenever possible. For example, a high-pass filter uses a resistor with one connection to ground. Insert one leg of the resistor directly in the ground bus rather than using a short piece of black wire to make the connection.

- Use the banana plug connectors to provide power to the board. Short pieces of color coded wire can be clamped under the banana plug and routed to the designated "bus" on the breadboard.

- Avoid the use of "alligator" clips (particularly the uninsulated type), since they are prone to electrical "shorts" and other mis-connections.

- When signals are routed to or from the breadboard (e.g., to a Wheatstone bridge circuit), the ideal solution is to use 22-24 stranded wire that has been "tinned" with solder at the breadboard end. Alternatively, 22-24 gauge solid wire can be used.

- If two or more wires are routed together (such as a signal and ground wire), either twist or tape the wires together at several locations along their length. This will reduce the effects of electrical "noise," allow easier debugging of circuits, and reduce the chances of wires being pulled loose from the circuit board.

- Note that the breadboard is used for an electrical connection, not a mechanical one. Do not allow wires to hang from the breadboard in an unsupported fashion, since they can be easily pulled from the holes. EE's use the term "strain relief" to indicate mechanical support systems for wires.