Lecture 02.03 Circuit prototyping

When one is building a circuit for a one-time application or for a prototype, it is best to use a temporary construction. Production circuits are almost invariably constructed as *printed circuit boards* (PCBs), like that depicted in Figure 02.7, which can be cheaply and reliably mass-produced. PCBs have recently become economical for even low-volume projects, with custom orders costing only tens of dollars per board, or less (plus components).

printed circuit boards

If a lightweight and reliable prototyped circuit is required, constructing the circuit via soldered wires and components is usually best. However, even before this, a more flexible prototype is often required.

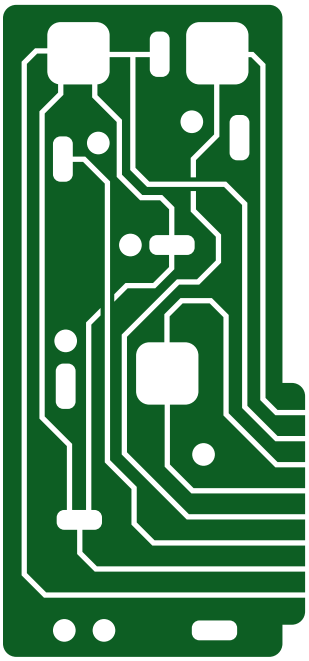

Figure 02.7: a depiction of a printed circuit board, adapted from openclipart Cheeseness (2018).

02.03.1 Breadboards

Breadboards, such as the one shown in Figure 02.8, are plastic-and-metal boards that have several pin holes for easily building temporary circuits. Pins and leads can be inserted into the breadboard holes to make connections.

power rails

The *bus strips* or *power rails* on each side of the boards are marked with

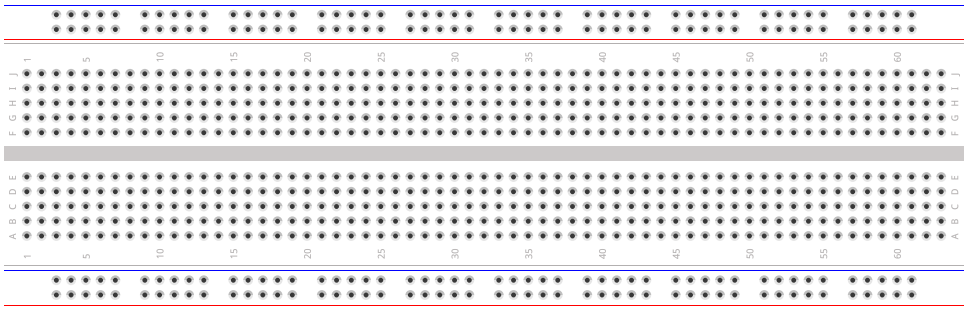

Figure 02.8: a breadboard with two each of blue and red power rails.

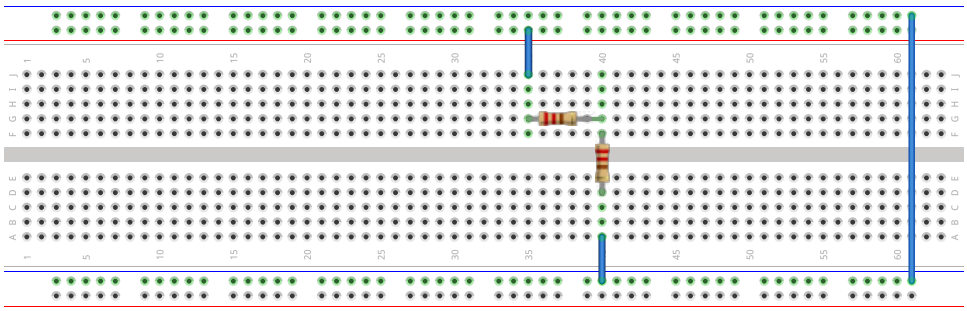

Figure 02.9: a breadboard with a voltage-divider circuit.

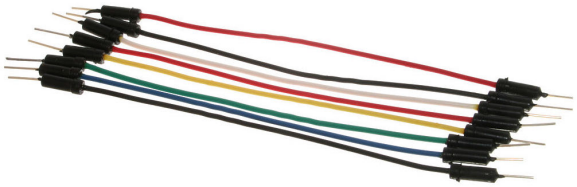

Figure 02.10: jumper wires for wiring breadboard circuits (Commons, 2018b).

red (+, hot) and blue (−, ground) stripes, each being connected along its row.

The numbered *terminal strips* run vertically in the center of the board. Numbered columns are connected, but split into two halves by the center notch such that each side of the notch is disconnected. The center notch is conveniently spaced such that standard *integrated circuits* or *chips* can be connected across it.

terminal strips

integrated circuits

An example of a voltage divider circuit is shown in Figure 02.9. Two resistors are shown, sharing a node at row 40. Power is connected to the upper power rails, and the upper ground rail is bridged to the lower ground rail. In addition to the built-in connections among breadboard holes, *jumper wires*, such as those in Figure 02.10, are often used to make connections among holes.

jumper wires

02.03.2 Coaxial cables

coaxial cables

Connecting instruments such as function generators and oscilloscopes to a breadboard circuit requires *coaxial cables*, which have an inner hot wire surrounded by but insulated from a tubular shield that conducts the ground.

Therefore, when an instrument is connected to a circuit via a cable, it is connected *in parallel*.

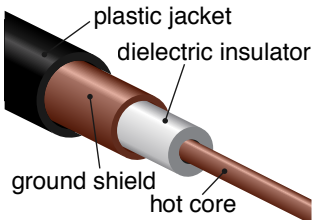

Figure 02.11: coaxial cable, adapted from Commons (2018a).

02.03.3 BNC connectors

BNC connectors

In instrumentation, coaxial cables almost universally have *BNC connectors*, shown in Figure 02.12. On the left is a male connector and in the center and on the right are two views of a female connector. The male connector is spring-loaded such that mating the two with a twist gives a reliable connection that can easily be felt by the user.

Figure 02.12: BNC connectors, adapted from openclipart boudinpg (2018).

The outer "barrels" of both male and female connectors are connected to the coaxial ground shield.

02.03.4 Alligator clips

alligator clips

In order to connect coaxial cables to breadboards, connectors with *alligator clips*, shown in Figure 02.13, are often used. These each have a single conductor, with a black clip typically being used for ground and a red clip for hot. Often, the will clip directly to a jumper wire.

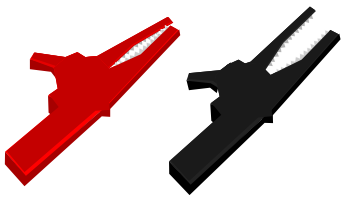

Figure 02.13: alligator clips, adapted from openclipart goios (2018).

Connections with alligator clips are convenient, but relatively insecure. They should be used only in very temporary prototypes and never when the circuit is to undergo acceleration.