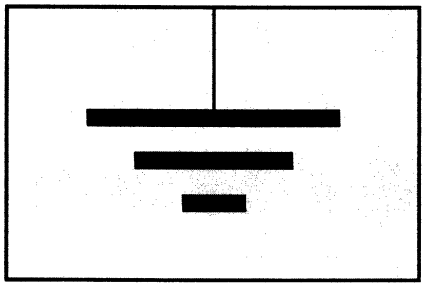
A FIRST LAB IN CIRCUITS AND ELECTRONICS

YANNIS TSIVIDIS
Columbia University

John Wiley & Sons, Inc.

New York | Chichester | Weinheim | Brisbane | Singapore | Toronto



GROUND CONNECTIONS

Introduction

The issue of ground connections is one that will concern you again and again, in this and in other labs. Read this chapter carefully, and try to understand it as much as possible. Not everything in it may make perfect sense in the beginning; some of this material will become clearer as you gain laboratory experience. Nevertheless, it pays to have a preliminary understanding at this point. As you attempt to connect various instruments in future experiments, you may need to return to this chapter for advice.

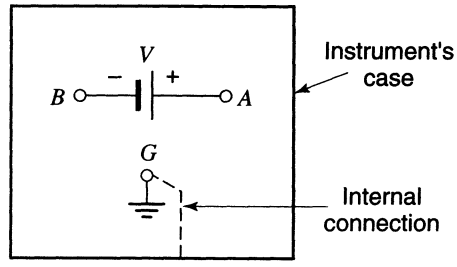
Producing positive or negative supply voltages with respect to ground

Lab instruments have terminals so that you can connect them to the circuits you are working with. For example, a "floating" power supply has plus (+) and minus (–) terminals. The voltage between them is a well-defined quantity, which you can set at will. However, the voltage between one of these terminals and a third point, such as the instrument's metal case (if it has one) or the case of another instrument, may not be well defined and may depend, in fact, on instrument construction and parasitic effects that are not under your control. Parasitic voltages can interfere with proper operation of the circuits you are working with, or can even damage them. Worse, in some cases they can cause an electric shock. To avoid such situations, the instruments have an additional terminal called the *ground,* often labeled GND or indicated by one of the symbols shown in Fig. 1; the use of this terminal will be explained shortly. The ground terminal may be connected to the internal chassis of the instrument (it is sometimes referred to as the chassis ground); to the instrument's metal case; and if the power cord of the instrument has three wires, to the ground lead of the cord's plug. When you plug in the instrument, this lead comes in contact with the ground terminal of the power outlet on your bench, which is connected to earth potential for safety and other reasons. In fact, other instruments on your bench, on other benches, or even elsewhere in the building may have their grounds connected to that same point, through the third wire of their power cords.

Fig. 1

When you use a power supply with the output floating (i.e., with neither of the output terminals connected to ground), you get the situation shown in Fig. 2. The little circles indicate terminals for making connections to the instrument's output or ground. In the following discussion, V_{XY} will denote the voltage from a point *X* to a point *Y.* In Fig. 2, V_{AB} is the power supply's output voltage *V,* and it is well-defined. However, V_{AG} and V_{BG} are *not* well defined and can cause the problems already mentioned. To avoid this, you should strap one of the two output terminals to the ground terminal, as shown, for

Fig. 2



example, in Fig. 3(a). Now *all* voltages are well defined: $V_{AB} = V$, $V_{BG} = 0$, and $V_{AG} = V_{AB} + V_{BG} = V + 0 = V$. If we assume that V is a positive quantity, the connection in Fig. 3(a) develops a positive voltage at terminal A with respect to ground. If you happen to need a negative voltage with respect to ground instead, you would use the connection in Fig. 3(b). Here terminal B has a potential of $-V$ with respect to ground. In some power supplies, ground connections as shown in Fig. 3 are permanent, and you do not have access to them. In other power supplies, it is up to you to make such connections.

Connecting one grounded instrument to another

When more than one instrument or circuit with ground connections are used, one should think carefully. Consider the situation in Fig. 4, where it is attempted to connect the output of one instrument to the input of another. For example, instrument 1 can be a function generator, discussed in Experiment 3. Instrument 2 can represent an oscilloscope, or an oscilloscope probe, also discussed in Experiment 3. At first sight, the connections shown seem to be correct. However, there is a *big* problem. Although not apparent from Fig. 4, the ground terminals are connected not only to the instrument cases *but also to the common ground of the power outlet on the bench* (through the ground pin on the power plug, as explained earlier). Making these connections explicit, we have the situation shown in Fig. 5. It is now clear that the second instru-

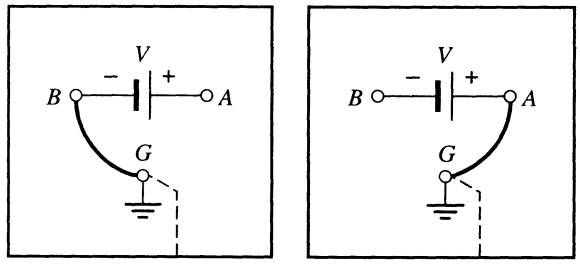


Fig. 3 (a) (b)

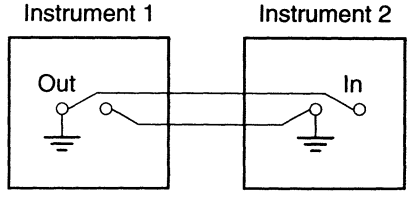


Fig. 4

ment's ground connections short the first instrument's output across *CD* (i.e., they place a short circuit across it; you can trace this short circuit along the path *CIHGED*). Not only will this prevent a voltage from being developed at that output, but also it can damage the instrument. The problem is solved if the connection between the two instruments is modified, so that *instrument ground is connected to instrument ground*, as shown in Fig. 6.

At this point, one may wonder what the connection marked *x* is needed for in Fig. 6, given that the two ground terminals are connected together anyway through the power cables, as shown by the heavy lines. The answer is that there may not always be a ground terminal on the power plug, and even if there is one, it may not be reliable; although ideally all ground terminals on power receptacles should be at the same potential, they sometimes are not. In addition, the long ground wires (*IH* and *GH* in Fig. 6) may act as antennas, picking up interference. To be safe, then, use a short connection such as *x* between the ground terminals of the two instruments.

A final word of caution: Since an instrument's case is in contact with ground connections, you need to be sure that cables and devices do not accidentally come into contact with it. If this happens, malfunction or damage can occur.

These guidelines will be sufficient for the purposes of this lab. Grounding is actually a complicated issue, and you should not expect the simple practice discussed above to be adequate in all situations. As you gain experience, you will obtain a better feel for grounding practices.

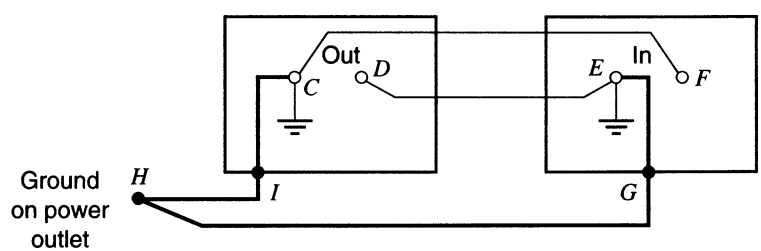


Fig. 5

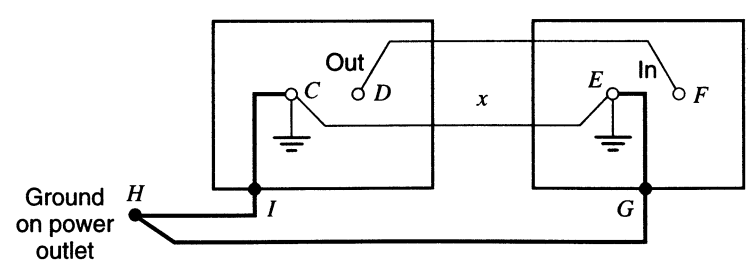


Fig. 6