Grounding

The term ground applies to which of the following?

- A reference point for measuring voltage (0 volts).
- The return path for current in a circuit.
- The outer braid on a cable.
- The third pin on a power plug.
- The dirt we stand on when we are outside.
- A thumb nut on the back of a mixer or preamplifier.
- All of the above.

Probably 80% of the problems encountered in wiring an audio system are related to ground. Symptoms of ground trouble include hum, weak signal, hum, radio interference, hum, crackling noises, hum, electric shocks, and hum.

Ground is first and foremost, the zero voltage point, the reference the circuits use when they amplify signals. One of the trickier things to understand about ground is that although the voltage is 0, plenty of current can be flowing by.

The need for current return paths is obvious when you remember that electricity travels in circuits. If you have a wire carrying current from one device to another, there must be a second wire for the current to get back. In many circuits, the current return path is designated as ground. When equipment is designed for balanced connections, there is a second wire inside the cable for the return path. With unbalanced gear, the shield is used for the return path.

A lot of what we call grounding is really shielding. The shield is a metal case or wrapping that is supposed to protect the internal wiring from picking up unwanted currents from any magnetic fields that pass by. Our buildings are cluttered with many such fields, generated by distant radio stations and nearby AC wiring. In order for a shield to do its thing, it must be connected to ground, and there must be no current flowing through the shield itself.

For safety reasons, the government has decreed that all external metal parts of electrical equipment must be connected to a stake in the dirt outside the building. This safety ground connection is supposed to short out the power and trip a circuit breaker

instead of electrocuting somebody if the power wiring comes in contact with the case. Some equipment is exempt from this rule.

All of these uses of ground are not only confusing, they conflict with each other in electrical ways. For instance, the safety ground can sometimes cause current to flow in shields. Ground problems can be persistent and their cause can be hard to nail down, but if you follow these rules, your studio should be hum free.

Rule 1: Power everything from the same source.

The power outlets in a room may differ in voltage by a surprising amount. There are three wires going to the outlet- one is called hot: it has a somewhat distorted sine wave that swings about 170 volts from peak to peak (120 rms). Another is the neutral- it's at the mid point of the hot wave, and is not supposed to have a waveform. The third is the safety ground.

The problem is, all this is derived from a high voltage three phase feed from the power company. This is commonly done with a big transformer that has three outputs: two are hot and 180 degrees out of phase with each other, the third is the neutral, taken from a center tap of the transformer. Center taps are often not quite center, so there could be a bit of voltage waveform on the neutral. Therefore the neutral is connected to the ground wire, ideally at the point where the ground wire actually is grounded. This stuff is probably a long way from the power outlet you are using. The resistance of the wire between the transformer and the outlet will develop a bit of voltage waveform on the neutral. If you use two outlets, the neutrals may not be at the same voltage. Even worse, the hot wire of one might be 180 degrees out of phase with the other. Either condition will inspire 60hz current to flow from one device to another.

If you must violate this rule because the equipment is in separate rooms or there's too much equipment for one circuit, try several outlets to see which ones work best.

About Power Conditioners

There are three types of these:

Overvoltage protectors keep your gear from frying if there is a power spike due to lighting or your neighbor trying to steal power with a pair of jumper cables and blowing out the whole block. (True story!) They are cheap, often included in power strips you are going to need anyway.

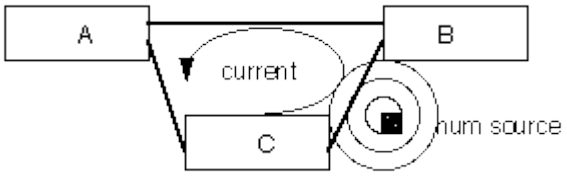
Uninterruptable Power Supplies keep computers from crashing when there's a slight dip in the power. Unfortunately, many of these use high frequency switching circuits and provide very dirty power. They should be keep out of the studio.

Balanced Power Conditioners provide exceptionally clean power with the neutral at -60 volts and the hot at 60. These are beautiful, and solve all of your power problems for a little less than $100 an ampere.

While I'm on the subject, make sure that the audio system is the only thing plugged into that circuit. Vacuum cleaners and soda dispensers really mess up the power lines.

Rule 2: Keep Wiring Neat to Avoid Ground Loops

Ground loops happen when you connect three pieces of gear in a triangle. If piece A is connected to piece B, and the power is OK, there's no reason for current to flow in the shielding of the cable, and no path for it flow back.



But, if A is connected to B which is connected to C which is connected back to A, there's a circular path in the shields through which current will flow with the slightest encouragement. Encouragement can come from lots of things, such as those stupid power transformers blocking most of the holes in the power strips. It wouldn't be much of a studio without some complex patching, so here's how to minimize the damage:

- Keep all audio cables in a single bundle or tray.
- Route the bundle in a C around the backs of the gear, not in a circle (even if some wires wind up longer than you'd like.)
- Keep the above well away from the AC wiring and power transformers (including those hidden inside equipment).
- Make sure power cables cross the audio cables at right angles.

Rule 2a: Don't defeat the safety ground (unless you have to)

Sometimes, the ground in the power wiring provides that critical third connection necessary to establish a ground loop. You can tell this is happening because using a

two prong adapter makes the hum go away. In this situation, you should do all you can to remove the hum without resorting to the adapter. If other measures fail, you have to choose between the hum and the risk of shock. Of course, if the device is grounded another way (such as being bolted into a rack with other grounded equipment) there's no danger. If you use the adapter, confirm a good ground with a resistance meter.

Some really funky equipment will hum if the plug is turned around in the outlet. There are at least three problems here:

- You aren't supposed to be able to turn the plug around.
- It's a guitar amp right? If it's like that you can get shocked from the guitar strings!
- If it behaves this way, it's going to hum no matter what you do, so dump it and get something decent.

Rule 3: Balance or Unbalance, but not Both

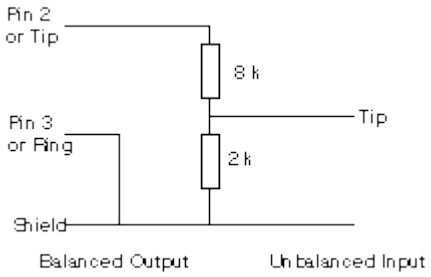
Balanced connections are best for keeping noise out of a system. In a balanced connection, the input circuit responds to the difference in voltage between the two wires. Since the wires are twisted together within the cable, any extraneous signal induced on one will be induced on the other. That means there will be no difference in the noise voltages for the input circuit to respond to. With balanced connections, about the only way to get hum is from current flowing in the cable shield.

If all of your equipment is balanced, you can prevent current in the shields by connecting them at only one end. I favor leaving the end connected to outputs free, but it can be either, as long as they are all the same. If there is a patch bay and you do this, make sure your patchcords carry the shield through.

If your gear is unbalanced, you must connect the shields at both ends. Keep the wire short, because the longer it gets, the more efficient it is as an antenna for 60hz. 20 feet is the most I've ever gotton away with. Usually, unbalanced connections are made with balanced (two conductor) wire, because that is just about all you can buy. I connect the extra wire to the shield/ ground at both ends. I've seen the suggestion that you connect the second wire this way but leave the shield unconnected at one end. Some audiophile type cables are triaxial with the outer shield connected at one end only. This is effective in difficult situations, but expensive with premade cables and hard to wire yourself.

If you have a mix of balanced and unbalanced gear, you can add balancing boxes (at $50 a channel) to a few items, but most often you will have to give up the benefits of balanced connections and wire it all unbalanced. I unbalance by connecting the cold (pin 3 or ring) wire to the shield at the unbalanced end. I don't know if this reduces hum, but I tell myself it'll be easier to convert to balanced when the opportunity comes.

It's the level difference that makes it hard to mix balanced and unbalanced gear. Most modern balanced devices have a switch to change the level of the output, but if it's not there, you should put a pair of resistors in the output connector:



Some equipment does not take kindly to being unbalanced in this way. The frequency response is messed up by shorting one of the output pins to the shield. This happens mostly with vintage gear, especially tube circuits. In that case you must use an impedance matching transformer to connect it to unbalanced inputs.

Rule 4: Make all zeros the same

Sometimes, despite doing all of the above, hum will occur when two particular pieces of gear are connected together and to nothing else. The brute force approach to this problem is to use some # 10 wire to connect the cases of the devices together. This can create ground loops and make matters worse, but if a ground loop already exists, it provides a lower impedance path for the loop current than the cable shields, and will reduce the hum. Some engineers recommend running wires like this from each piece of gear to a central grounding point, probably at the mixing console.

A more likely occasion to use an extra grounding wire is with some hi-fi or musical instrument gear that has no grounding at all- these items have two prong power cords and shield connections insulated from the case. They are OK in a permanent setup, but if you take the connections to a patch bay and patch with the power on, there will be a speaker blowing buzz when the cord is inserted (as the tip of the cord passes the shield of the device output). You can cure this with a ground wire from an output jack

to the console, or by a jumper at the patchbay from a shield of the device to a shield from the console. (If the preceding creates a ground loop, use a 10 ohm resistor instead of the jumper.)

When All Else fails, Isolate

There are some connections that will hum, no matter what. Many devices are simply not up to the specifications of professional audio, but they must be used just the same. Guitar amps and computer sound cards are common offenders this way. The worst part is, sometimes patching one of these bad boys into the system can make noise appear everywhere. Isolation transformers are the only solution.

Source: http://www.co-bw.com/Audio_Grounding.htm