# Freedom from Hum, Noise, & Distortion

General Guidelines to Audio Devices Integration

by Born2BeWired
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So you build an Audio Power amplifier circuit that work flawlessly when used tested all by it self. You just also finished constructing a separate preamplifier circuit that tested perfect. But when you finally combined the two, nothing seems to work right. You hear loud hum even when the volume is set at minimum. Music does not sound right. Your favorite artist sounds noticeably different. You hear creepy sounds that you know are not supposed to be there.

Sounds a too familiar experience, doesn't it? Don't flatter yourself into thinking you are the only one experiencing this kind of problem. Even accomplished DIY'ers are not immune from this. In fact, it is a very common problem every Audio DIY'ers has to deal with from time to time.

Less experienced builder would probably set an accusing eye to the components, or even the circuit itself, as the cause of the problem. As a consequence, he would spend countless hours trying to fix the problem without getting anywhere near a permanent solution.

If it is not the component, or the circuit, what else then could cause all these troubles?

## A less than perfect ground.

We are often taught in school the simplest approach of assuming all ground points are all at zero volt potential. This assumption, in most cases, would work well in paper. Consider an audio setup as shown in figure 1a, and pay attention to the manner the grounds are connected. Even if the setup is physically wired exactly as it is diagrammatically shown, we will not notice any potential problem. That is because we are ready to accept that all ground points are at the same 0V potential.

The problem is, like everything else, things work a bit differently in real world. Nature decreed that perfect ground circuit simply does not exist.A perfect ground cannot exist because real world conductors cannot have zero resistance. In fact, copper, the most common conductor used in electronics assembly, never exhibit superconductivity (0 ohm) even if you cool it down near to absolute zero.

With this fact in find, let us return to our audio setup, this time, revealing the ground wire resistance as they appear at each junction as shown in figure 1b. As ohms law would have it, if you pass a current through a conductor, a voltage will develop across it. This may be an AC or DC or a combination of both, depending on the activity on each leg of the wiring setup.

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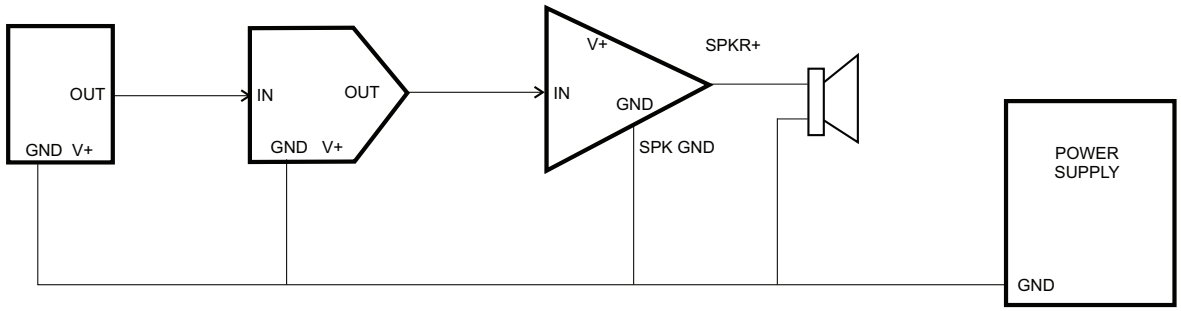


*Figure 1a. A typical audio setup showing ground wiring. We tend to view the ground wirings in ideal sense, that is, they are all at the same 0V potential.*

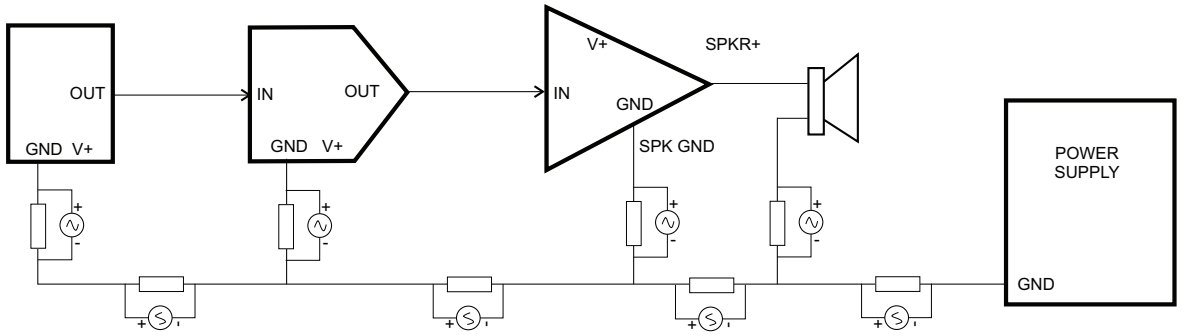


*Figure 1b. In real world, every bit of ground connections has a measurable ohmic resistance associated to it. If we include this in the schematic, together with the equivalent voltage that develops across it, the potential bad effects becomes pretty obvious.*

Now, it is obvious we may have a problem in hand. These voltages may be small, but it is a voltage difference nevertheless, and they like to appear in the wrong places in your circuit. If you happen to work on a circuit with fairly large noise immunity threshold, e.g. digital logic gates circuits; this may not present a problem at all. But if you are working with linear and sensitive circuits (an audio amplifier falls into this category), things can get really interesting.

## Ground Loops

Undesired potentials will invariably cause unwanted current flow as well. These undesired currents are collectively called Ground loops, and this is the main character causing all those hum, distortions, and other nasty noises coming out of your audio setup.

Just because you cannot get a perfect ground circuit does not mean you cannot get rid of these bad effects. At first, keeping the ohmic drop low may seem the logical solution,  but, surprise, it is

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not always a practical option. A better solution is to keep the signals from being contaminated by these undesirables. It may not sound much, but this is one of those “easier said than done” thingy. You have to earn the skill, and that will take some time to develop. The good news is, it is not that terribly hard. The bad news is, it is not easy either. Lot of practice and a long patience is required.

In this discussion, we will formulate some simple wiring and cabling rules you can follow without us having to delve into lot of whys. In other words, we will be skipping details - you may not have the patience for that at this time anyway. We will cover board level wiring only. And more important, you must be aware of the fact that if the circuit on the PCB itself is badly laid out in the first place, everything we are about to discuss will be of little help when applied to these bad boards.

## Wiring Rules

Rule No. 1 – Ground should connect to one point only.

This is probably the most important rule. Avoid multiple ground connections. Audio devices don’t like many ground paths.  For example, if your amplifier is housed in a metal/conductive enclosure, the enclosure itself may already be connected to one ground point (e.g. rectifier circuit ground). In this case, allowing the input connectors (i.e. RCA jack) ground to come into contact with the enclosure will create a ground loop, hence would be a very bad idea. This is a very common DIY’ers mistake.


*Photo Credit: Andre Marc*
*Belles Soloist 3 Preamp Review*
*www.avrev.com*

*Figure 2. Take a peek on the rear side of your amplifier (or AV receiver) and see how the RCA jacks are mounted. You know that the amplifier chassis is connected to system ground, but notice how the manufacturers build their product to ensure the outer shell (ground contact) does not come into contact with the chassis.*

Rule No. 2 – Separate ground paths between sensitive low power circuits and high power circuits.

The power amplifier section draws a lot of power, hence, could easily generate appreciable ground currents. Hence, to minimize the power amplifier from affecting the sensitive low power circuits (i.e. preamplifiers, program source), an isolated power source is preferable.

An isolated power supply is a circuit that is not electrically connected with the power amplifier power supply. It can be another rectifier circuit feeding on a separate winding on a transformer used in common (Fig 3). Figure 4 shows how an isolated power must be connected to the low power circuits. Notice how the low power ground is connected – only at the device power supply ground terminal. As rule No. 1 requires, nothing else should connect it at any other point along the ground circuit.

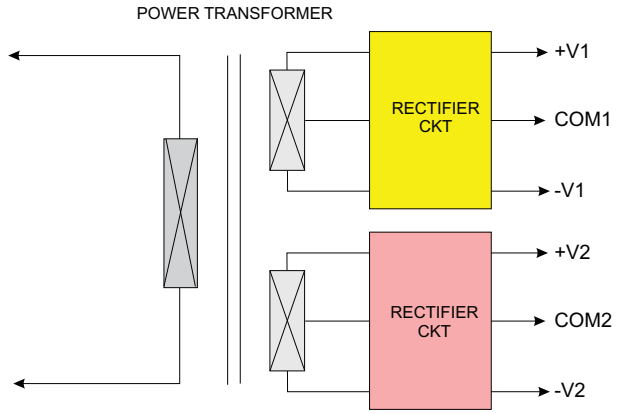


*Figure 3. A common power amplifier power supply configuration. Electrical isolation between the two rectifier circuit is achieved with the use of separate secondary windings.*

Consider what will happen if you connect the low power (accessory) supply ground directly with the power amplifier supply ground as depicted by the red dashed line in Figure 5. The two ground points now create a ground loop, as highlighted by the red path. This is a very common mistake. This is almost guaranteed to make your audio setup hum like crazy and/or sound funny. If for any reason, the direct supply ground to ground connection cannot be removed, the power supply ground connections of the low power circuit must be disconnected. I must reiterate that while the just mentioned step

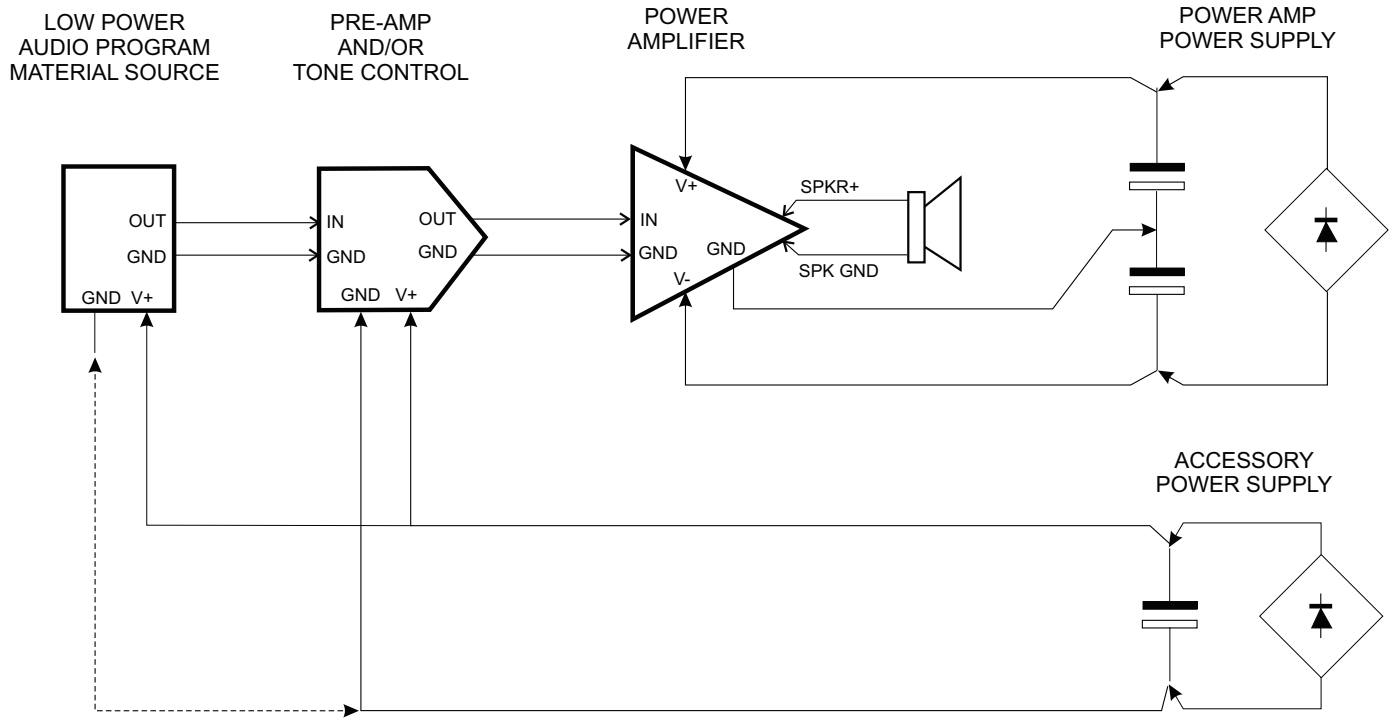


*Figure 4. Audio amplifier system recommended ground wiring setup. This illustration shows the preferred set-up, one that employs isolated power supply for the power amplifier and low power circuits. Note how the signal path grounds are connected from stage to stage – only through the input and output ground pins assigned for the purpose. Since both the preamp and audio source shares the same power supply circuit, adding a ground wire as depicted by the dashed line connection will create a ground loop, hence must be avoided.*

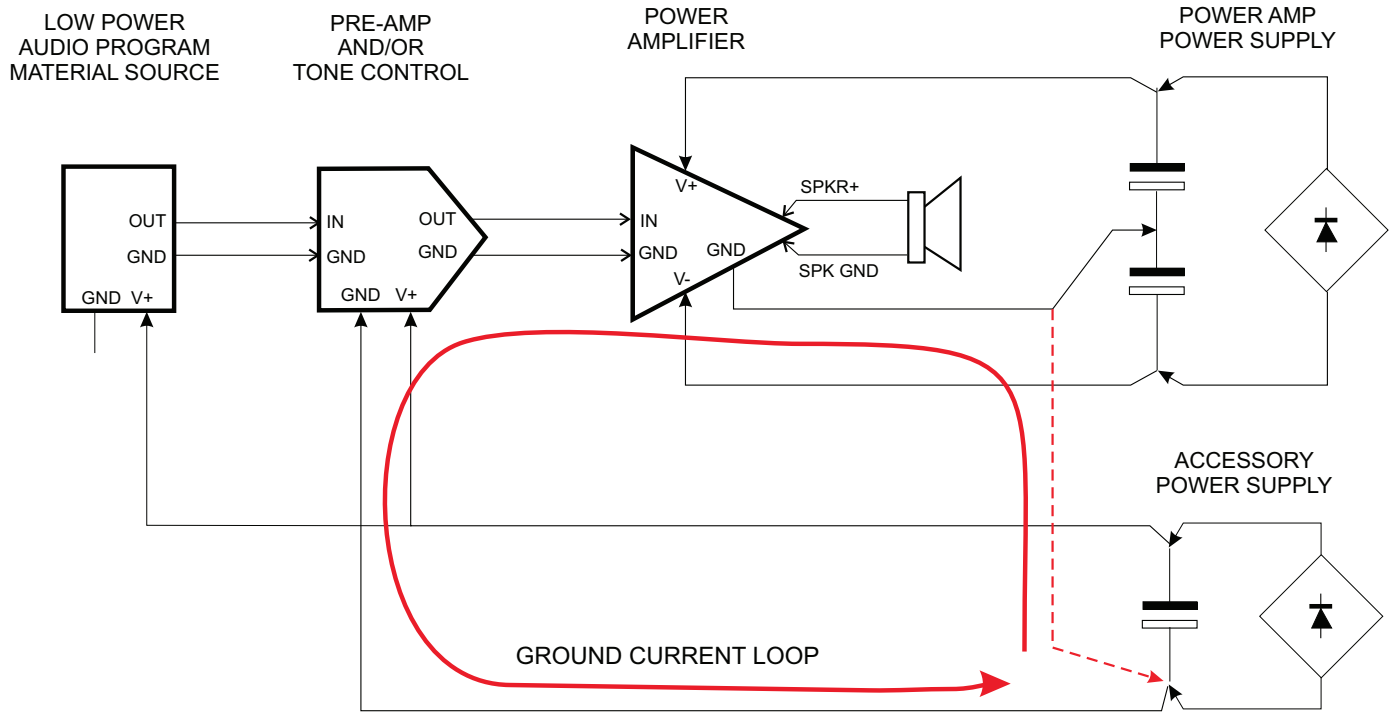


*Figure 5. This schematic highlights the most troublesome yet most common mistake - a ground wire (red dashed line) connecting the two power supply grounds directly. This creates a ground loop passing through the power circuitry and low power circuit. Hum and distortion is inevitable.*

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may eliminate hum, it may not help much in reducing overall distortion.

If a separate and isolated power supply is not practical, then rule No. 3 becomes even more important in your setup.

Rule No. 3 – Connect through designated input and output grounds only.

If you take a closer look, you will notice that audio devices have input and output ground points, in addition to a separate power supply ground point. Of course, these ground points are all electrically connected together, but by now, you are already aware that they are not electrically at the same points, hence should be treated as such. Figure 4 already shown you the correct way of connecting one output to another stage's input. The output ground of the preceding stage should connect directly and only to input ground of the succeeding stage. It is a simple but very important rule. Connecting the ground any other way will just give you unnecessary troubles.

As mentioned in the later part of Rule 2, this becomes even more important if the power supply is shared by the power amplifier and low power circuits, i.e., non-isolated power supply source. Figure 6 shows how the subsections must be connected together. Notice that the power supply ground of the low power sections are left unconnected! DC ground connections are carried solely through the input and output ground points.

## Conclusion

Admittedly, this short discussion could not possibly cover everything we need to know; it is just a scratch in the surface, so to speak. We did not even discussed shielding, safety ground, and other equally important stuffs. But what we covered so far is probably enough to make you better equipped in troubleshooting and solving the most common annoyance in DIY audio setup, hum and distortion.

One more important thing worth mentioning - Ground loops problem usually causes loud 120Hz hum. 60Hz Hum (and noise pick up) are probably due to some different caused (e.g. Shielding). Learn to differentiate between the two. •

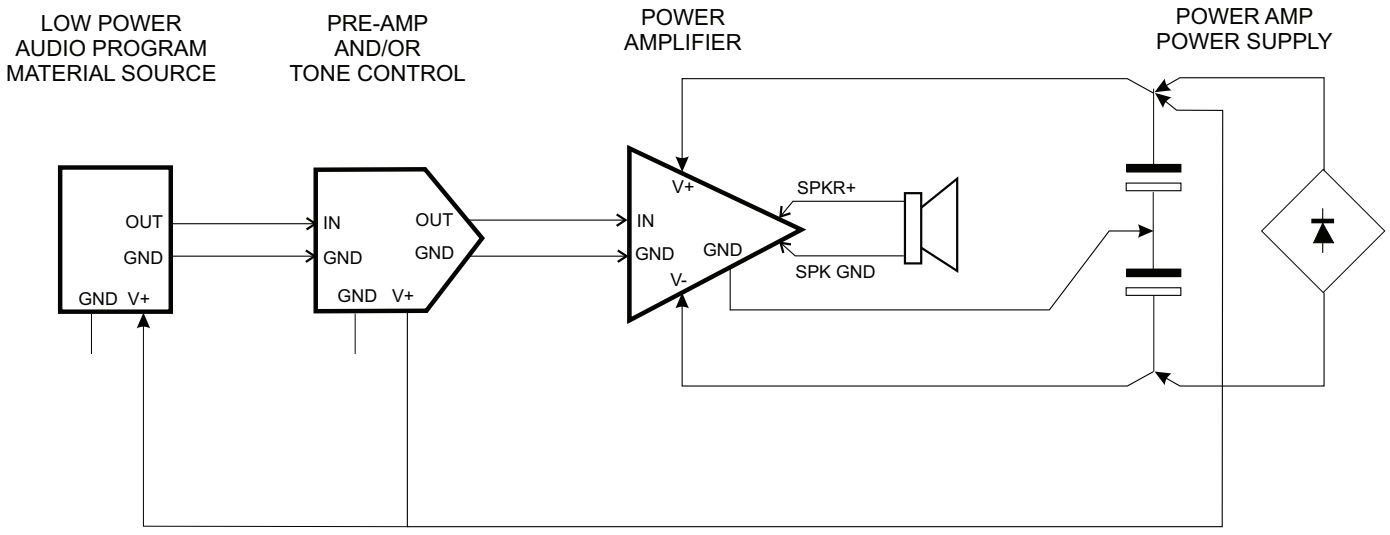


*Figure 6. If the setup shares a common power supply between the power amplifier and the low power circuitry, the best ground wiring for the low power circuits is no power ground at all! Low power DC supply ground connection is shared with the input and output signal grounds.*