Big Bad Grounds

Debunking the 12-volt myths behind bad grounds.

by Richard Clark

All installers have had their share of problems with electronics, and if you ask what those problems were, the explanations will vary. But, the real problem with most electronic failure is almost always heat related. Sometimes the cause of the heat is varied, but the failure mode is still heat. Excessive current causes heat. Too little ventilation causes heat. Overloading causes heat. Overdriving causes heat. Overpowering causes heat. Shorted wiring causes heat. Even though the heat is a result of many factors, the final cause of failure is usually heat resulting in melted electronic parts.

Sometimes, there's not much we can do about overheating; however, many times the installer, and not the operator, is to blame. It's a commonly known engineering fact that lowering the operating temperature of a component by 10 degrees can increase its life by as much as three times. Depending on what direction you look at that formula, there's a lot to be gained by a little attention given to the operating temperature of components. Considerations given to amp loading can have drastic influences on the life of both speakers and amplifiers. Mounting amplifiers where they look good as opposed to where they can ventilate well is sometimes the deciding factor. Considering that lowering the temp of an amp by only 10 degrees can triple its life, the addition of a fan seems to me to be a no-brainer.

Bad wiring connections can cause heat as well. But unlike most other heat related problems, a bad wiring connection causes excessive heating at the connection itself and not inside the component. There's probably not an installer that hasn't had a problem with a bad ground in a car. Done carelessly, a bad ground can cause all sorts of problems for an audio system. Since the ground usually connects to the frame or body of the car, loose connections or dirty or corroded connections are more likely to occur in the ground than anywhere else in the system.

In any electrical system, there's a requirement for current. Since a car audio system only has a 12-volt potential in order for it to do any real work, it's necessary for lots of current to flow to make up for lack of voltage. In a modern car, it's not unusual to find an alternator capable of 100 amps or more and a battery capable of many hundreds of amps. Today's high-powered car stereos can easily draw hundreds, or even thousands, of amps. On the other hand, many houses have entire electrical services of no more than 100 or 200 amps. One requirement that cannot be avoided if there's a need for lots of current, is large wire and very tight connections. It's this fundamental requirement for large wire and clean tight connections that make proper ground connections paramount in any car audio system. For long term reliability, it's also a good idea to coat, paint, or seal ground connections in some manner. Of course, this requirement applies to all power connections in the car, not just the ground, but the ground seems to get most of the attention and blame.

A loose connection or too small a wire for a ground will impede the flow of current just like a kink in a garden hose impedes the flow of water. In electrical terms, we call this condition resistance. The term is literal in that the problem results in a resistance to the flow of electrons. Anything that makes things difficult for current to flow makes for a reduction in power. Due to the amount of current required for 12-volt car audio systems, the reduction in power from only a small amount of resistance can be serious. For example, Ohm's law tells us that if only one amp of current flows in 1 ohm of resistance, then we'll have voltage drop of 1 volt! Applying this formula to a real-world example of a large amp drawing 100 amps of current, if we have only .1 Ohm of resistance we will lose nearly 10 volts from our battery. This leaves us with only 2 volts to power the amp. The interesting thing is that one tenth of an ohm is almost nothing! And, with only 2 volts, that's what we'll get out of our amp — nothing. Most car amps will not even turn on with less than 9 or 10 volts.

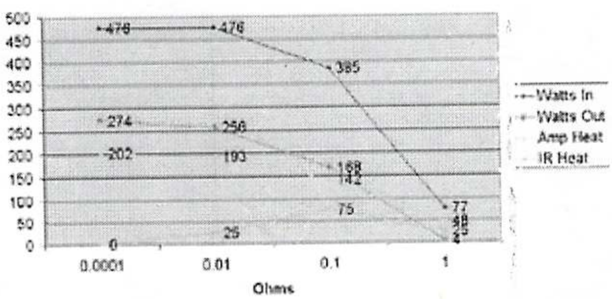
A bad ground will result in unstable system performance. The amp may not always work, or it may play at low levels and then shut off when turned up loud. Many times, this can be hard to diagnose because the ground connection may be difficult to access. This is due to the fact that ground connections are rarely displayed proudly like the gold-plated +12-volt connections.

Many installers are under the impression that a bad ground can lead to excessive heat and thermal shut down of amps in a system. Actually, the exact opposite is true. Remember, the bad ground prevents the amp from getting enough power. Since an amp cannot make power if it's starved for power, then it cannot get hot. If a person is starved for food, they rarely get fatter. Since overheating from a bad ground seemed to be a widely-held belief, I thought it might be a good reason to do some tests to actually see the results.

In the following test, we chose two amplifiers. One of the amps had a normal power supply and the other had a tightly regulated supply. In each chart, four wattage values are plotted. They are: power into the amp from the battery, power to drive the speaker out of the amp, power lost as heat in the bad ground connection due to resistance, and the power left in the amp that's turned into heat.

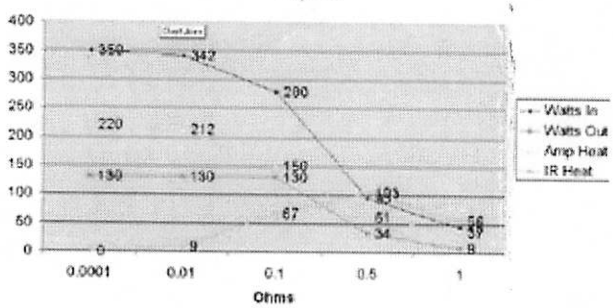
Test One shows the results of different amounts of resistance added to the ground connection of an amp (Figure 1). Note that not until the resistance exceeds .01 ohms (one hundredth of an ohm) does it have much effect on the temperature of the amp as shown. And the effect of higher resistance grounds is less heat and less output power to drive the speaker.

Fig.#1

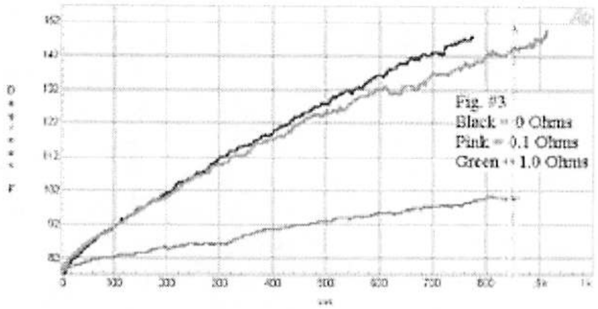


Test Two shows the results of a slightly smaller amp with a tightly regulated power supply (Figure 2). While the actual values differ, the general shapes of the curves are almost the same. It's interesting to note that this problem is magnified with larger amps. While .01 ohm may not affect a smaller amp like the ones we tested, the power loss curves would show greatly reduced power at the lower resistances due to the higher current demands. The amp-heating problem, however, would be just as much a non-issue.

Fig. #2



To actually convert these power curves to temperature, we did another test where we actually measured the heat sink temperature of the amp with different quality ground connections (Figure 3). The third chart shows the temperature of an amp with a good ground, a bad ground, and a very poor ground with the amp being driven as hard as it could be driven. Note that as the ground resistance increased, it took longer for the amp to heat up. You should also note that with the really bad ground the amp never even got hot. Of course, this was because it was starved for power and, therefore, could not produce much power to drive the speaker.



When diagnosing a bad ground, remember that a bad connection will cause the ground connection itself to get hot while the amp itself will not overheat, as it's not able to draw enough power to get hot.

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