

Go to your room — you're grounded!

I've always loved troubleshooting ground problems. Well, maybe not always. Certainly not until I figured out the best way to do it. But once I found the method for troubleshooting grounds, I began to enjoy watching the bizarre behavior of ground circuit problems. The more bizarre the problem, the more I liked it, because they were so easy to troubleshoot once I knew how.

It took me a while to figure out the best way to handle grounds problems. I started back in the 1960's when I first entered the industry, by talking to old-timers. They had a lot of experience in the auto repair industry, so I naturally assumed they knew how to troubleshoot ground problems. But each one I talked to told me something different about how they checked grounds.

Some said "use your eyeballs to look for a bad ground connection — a ground connection that *looks bad is bad.*" I quickly found out that wasn't always true: Some bad-looking connections were good; some good-looking connections were bad.

Some said "consider every ground a bad ground." That wasn't always true either, plus I wasted a lot of time fumbling around with grounds that were fine.

Some looked at me bewildered and tried to conceal the fact that they simply didn't know how to check grounds but had too much pride to admit it. One honest old-timer admitted he didn't understand ground problems and didn't think he ever would.

I found no consensus among them on how to check grounds, which left me with little encouragement about progressing in my chosen career. Where could I go for the answers if not to experienced people? I searched through trade publications, tech manuals and attended the training classes available in the 1960's. I found very little information about ground problems, much less about why ground problems could have such bizarre effects.



My own breakthrough in understanding ground problems came in a surprising way, in the form of a 1970 Pontiac sedan. Long-time readers of my *Import Service* articles may remember this story, but I'd like to repeat it because it represented a turning point in my career. The lesson I learned on that car has helped me too many times to count. It showed me the right way to troubleshoot grounds, and I've used that knowledge ever since.

What Was Wrong?

The FM section of the AM/FM radio on the Pontiac mysteriously went dead every time the driver stepped on the brake pedal. The radio would resume playing as soon as he released the brake pedal. The AM section of the radio was not affected. At first glance, that extra piece of information just made the problem harder to diagnose. Then I also noticed the dash lights dimmed when the radio went off, so I reasoned there had to be more than a radio problem involved. As we shall see, there was a clear reason why the radio acted this way.

Okay, I thought to myself, I'll hide in the back of the shop until someone else fixes it, and then ask what he did. I had no clue what to do. What would I do if I were called upon to tackle this car? I felt like I could work on it for the rest of my life and probably never fix it.

Well, nobody else knew what to do, either. The Pontiac dealership had changed the radio, antenna, speakers, brake lamps and brake switch. Nothing had brought them any closer to solving the problem. Now it was in our shop with a signed repair order, begging someone to fix it. The old-timers jumped right in and changed everything again. Then they changed the radio three more times, trying to find ‘one that would work.’

As I eavesdropped on the conversations around that car, I began to hear those dreaded words: “Let’s change the harness — that’s all that’s left.” After long hours of frustrating work changing parts without correcting the problem, the old-timers decided to take a break for other work before they ordered a new wiring harness.

My curiosity had gotten the best of me. On top of that, I was getting cramps in my legs after spending all morning crouched behind the tire racks. So the old-timers agreed to let me have a crack at the problem before they replaced the harness. I felt sure all the parts they had already changed couldn’t be the problem. It had to be something they had overlooked.

Nobody had picked up a VOM to check any voltages, so I grabbed mine while nobody was looking. It was an old swinging-needle meter. Remember, this was 1970. Who had a DMM in those days, except for electronics engineers in laboratories? I started checking voltages. I found the B+ to the radio was a solid battery voltage when the FM radio went off and didn’t change when it came back on. That eliminated a problem on the voltage-supply side of the radio.

Then I checked the radio’s ground. At first the ground checked good. That is, the VOM needle didn’t move when I checked between the radio’s ground wire and the dashboard sheetmetal. That meant zero volts — a good ground. So I went looking for other problems. Eventually I came back to the voltage and ground at the radio, since I couldn’t find anything else. I noticed that once in a while I got a very small voltage twitch of the VOM’s pointer on the ground side just as the FM radio went off. At other times there was no voltage twitch, even as the radio went off.

That was puzzling, and I just sat there mulling it over and over. I crawled under the dash or had my head in the engine compartment for hours — checking, thinking, then checking and thinking some more. It didn’t make sense that I could have a voltage reading one time but not the next. That annoyed me even more than the radio going off, but I was convinced that understanding the difference in those readings would solve the ground side problems.

Since I had an intermittent reading on the ground side, I reasoned that I was indeed dealing with a radio ground problem. But what about the dimming dash lights? Oh well, I would have to worry about that later. One problem at a time.

It finally dawned on me! I got a voltage-drop reading on the ground side of the radio when I grounded the VOM to the battery negative terminal, but *didn’t* get a reading when I grounded the VOM to the sheetmetal in the passenger compartment. What did that mean? I wondered. That fact was very intriguing, but I still had the radio problem, and still had no answer why.

Next I grounded the radio directly to the battery negative terminal. Now the radio kept working normally while I depressed the brake pedal. Aha! The radio worked consistently while the brakes were on. But what would I do now?

Flashback to 1970: ‘No, old-timer, I can’t leave that long radio ground wire dangling under the hood. I need to figure this out or find another job.’

At least I was certain the radio had a ground problem. Tracing the radio ground circuit to the sheetmetal determined the sheetmetal ground was okay. I confirmed this by doing a voltage drop check of the radio to sheetmetal when the radio went off. Next I checked the voltage drop between the sheetmetal and the battery negative terminal when the radio went off. A large VOM needle twitch indicated almost five volts lost between the sheetmetal in the passenger compartment and the battery negative terminal. Wow! What a voltage drop! When I released the brake pedal, the radio came back on, and the voltage reading decreased to about one volt. Hmm, why didn’t it go down to zero?

Flashback to 1970: ‘Hold on old-timer, stop laughing, I’m on to something here. But what the heck is it?’

At least I knew the passenger compartment sheetmetal was not properly grounded. But where was its ground? At that time, being a green rookie on automotive electrical systems, I didn’t realize the engine and the battery negative post must be grounded to the sheetmetal. I didn’t know that engine mounts were not metal-to-metal conductive. I had never pulled an engine or changed a motor mount. I supposed the engine ground cable from the battery also grounded the body sheetmetal through the motor mounts.

Then I spotted it: a braided jumper wire between the firewall and the valve cover. This wire grounded the sheetmetal to the block, which was grounded through the negative battery terminal. Even though I had seen the ground jumper during my many head-scratching visits under the hood, it never dawned on me that this was the ground problem I sought. The ground jumper was in place, so at first I dismissed it as being a bad ground. But when I pulled on it, it was loose at the firewall. A few turns to tighten the ground screw corrected the radio and the flickering dash lights problems. Such a simple fix for such a bizarre problem. But isn’t that just like a groundside problem?

Flashback to 1970: ‘Hey old-timer, come over here and look at what I found!’

The FM radio turned off, but the AM still played because the FM radio section was separate from the AM section. The FM operated on 8.2 volts, while the AM section needed as little as 5-6 volts. The FM section took 12 volts B+ from the power supply inside the radio and dropped it down to 8.2 volts.

When you pushed the brake pedal, the brake light circuit drew so much current through the loose ground jumper at the firewall that an equivalent 5-volt drop in B+ occurred at the loose connection, effectively reducing the B+ available to the radio. This caused the FM radio’s 8-volt power supply to drop too far below the 8.2 volts threshold needed to operate the FM. Meanwhile, the AM still functioned at 7 volts. The dash lights went dim because they shared the same loose ground connection with the radio and the brake light circuits.

It all finally made sense, and it only took four hours to figure out. How time flies when you are having fun! But can you guess how long it took me to find the problem on the second car that acted the same way? The investment in time spent on that first vehicle has made ground side problems fun and quick to troubleshoot ever since.

From this I learned to always ground the voltmeter to the battery negative terminal, especially when checking ground circuits. The negative terminal is always easy to reach, unless the manufacturer hides the battery under the seat or in the fender well.

Now let’s apply this technique to the primary electrical system schematic used in Part 1 (“Think Positive,” February 2000 *Import Service*), where we covered voltage testing the voltage- (power-) side of the circuit.

Figure 1 shows the complete schematic diagram for this two-part

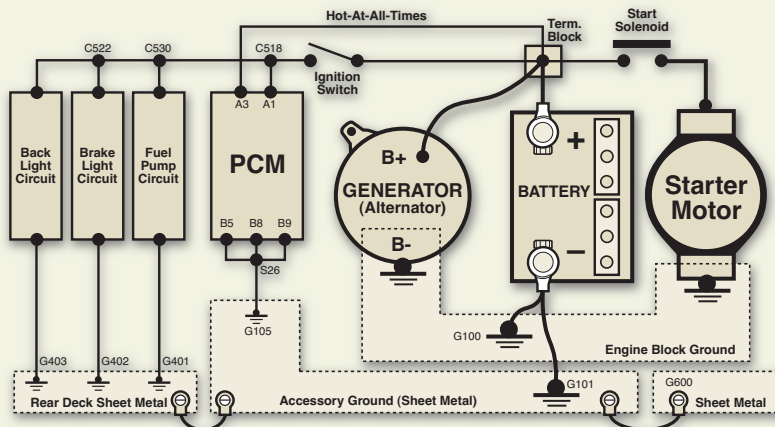


Figure 1: Sample electrical system

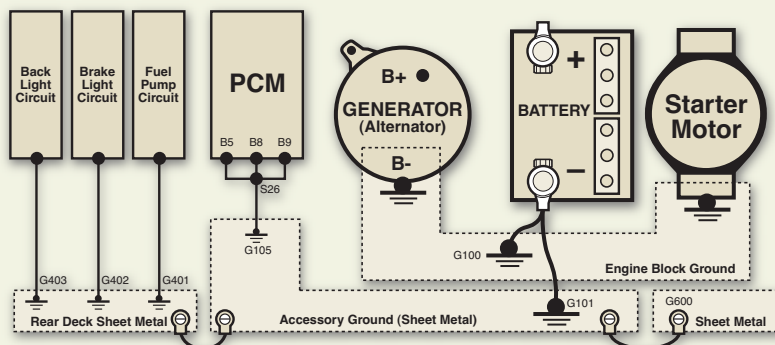


Figure 2: The ground side of the sample electrical system

series. This time we’ll focus on the ground side of the circuit. **Figure 2** shows only the ground side connections. There are two primary grounds in the ground circuit. Ground G100 grounds the engine block or connects the engine block to the negative battery terminal. Ground G101 grounds the main body sheetmetal, usually to a fenderwell or to the bulkhead (formerly called the *firewall*). Left of the accessory ground is a jumper wire connecting to the rear-deck sheetmetal. This ensures the rear deck provides a good ground for the very important fuel pump, brake light and backup light circuits.

The ground jumper is not identified with a number. Many manufacturers fail to show all ground jumpers on schematics, which makes it difficult for us to determine when one is used. A manufacturer may decide to rely on the

sheetmetal grounding, without the supplementary use of a ground jumper. In any event, we should make note of these often hidden ground jumpers whenever we see them, so we will know where to look if we run into a similar problem in the future. Better yet, write it down or draw it somewhere, as on your schematic diagram.

At the right side of the accessory ground is another ground jumper connecting G101 with G600. This represents a separate piece of sheetmetal requiring an independent ground jumper to complete its circuits, due to its electrically isolated location on the vehicle. This ground jumper also may not be shown on the schematic diagram, but we might be able to spot it while inspecting the vehicle. Remember, it exists, and write down its location so you don’t forget it.

Figure 3: Checking generator and engine ground

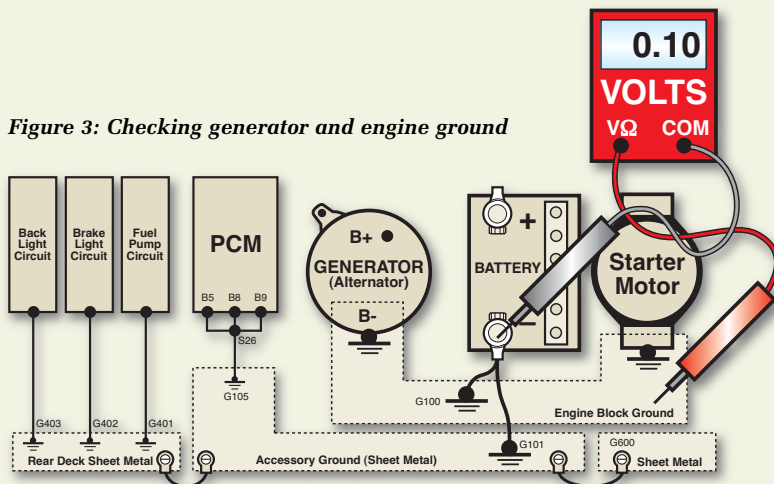
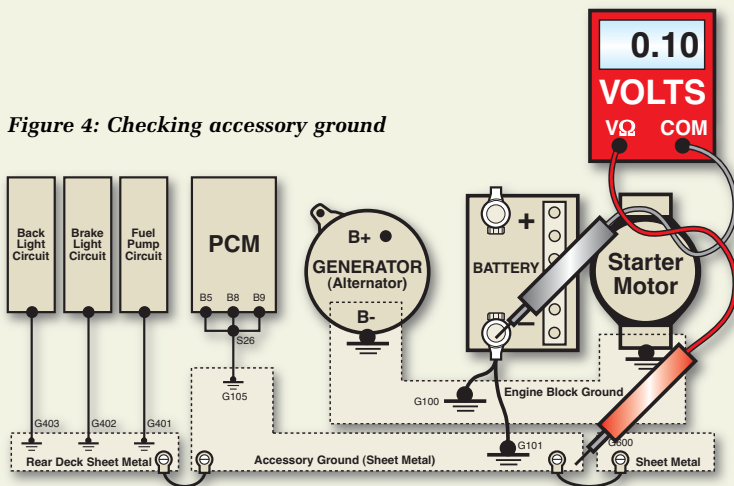


Figure 4: Checking accessory ground



Now let's begin a series of voltage drop checks to verify whether the vehicle has an intact ground system. Notice I said *a series of voltage drop checks*, not *a series of resistance checks*. Some in our industry promote the idea of resistance checks for ground circuits. I guess they believe a low resistance ground is a good ground. That may be true. However, you have to perform a resistance check of a ground circuit with a digital ohmmeter while the circuit is powered down to protect the ohmmeter. Does that always mean the ground circuit will still be good once the circuit is turned back ON and current begins to flow?

That is a dubious assumption to make, which can lead to diagnostic problems in troubleshooting. Here's why:

Suppose a stranded cable is used for a ground wire. Suppose further only one strand is still connected because all the other strands have broken loose. A digital ohmmeter sends a very small current through the ground path to check resistance. All it takes is that one remaining wire strand to present a good resistance reading on the ohmmeter. This could lead you to believe the ground cable is good when it is actually bad. It can have continuity without being able to carry the electrical load.

When the ground current flows, the single strand can't handle the normal circuit current; so a voltage drop develops across the ground cable, creating a ground side problem. Sadly, the problem may be overlooked because the technician may think the ground is good due to the ohmmeter reading and look for something else amiss in the circuit. An ohmmeter reading with the circuit OFF can pass a defective ground path that has a problem only when the circuit is ON. Don't be fooled using an ohmmeter to check grounds. Check ground circuits for voltage drops when the circuit is ON and load current is flowing.

Figure 3 shows the most effective way to check the engine ground for an excessive voltage drop. Notice the DMM black test lead connects directly to the battery's negative terminal. Follow this procedure for *all* groundside voltage drop checks. Then place the red DMM test lead at any point on the engine block. There is no need to find the exact location where the engine ground cable is connected. There will be continuity through the casting.

This test must be performed while cranking the engine or while the engine is running. While cranking the engine, the reading should be no more than 0.30-0.50 volt. If you test while the engine is running, a reading of no more than 0.10 volt indicates a good engine ground.

The generator also receives its ground through the engine block. Move the red DMM test lead to the generator casting to check the generator ground circuit. If the reading is still 0.10 volt or less, the ground circuit is good from the generator body, through the engine block, through the battery negative cable, back to the negative battery terminal.

Figure 4 shows the correct method for checking the accessory ground for a voltage drop. Perform this test with the engine

running, and the reading should be no more than 0.10 volt for a good accessory ground.

Figure 5 shows the correct method for checking the PCM ground. Since computer operation may be affected by a ground voltage drop of as little as 0.10 volt, don't settle for a voltage drop of more than 0.05 volt with the engine running. If you don't find it, clean the connections until you get it.

Figure 6 shows the correct method for checking the rear deck sheetmetal ground. This provides the ground for the fuel pump on this vehicle, as well as for the brake and backup light circuits. Perform this test with the engine running; the reading should be no more than 0.10 volt for a good rear deck ground. To verify each circuit is properly grounded, measure the voltage drop from the ground pin in the component's connector also. If the reading is greater than 0.10 volt with the engine running, clean and reconnect the un-numbered ground jumper wire between G101 and the rear deck sheetmetal.

Figure 7 shows the correct method for checking the sheetmetal ground at G600. Perform this test with the engine running; the reading should be no more than 0.10 volt for a good sheetmetal ground for any circuits using G600 as a ground circuit. If the reading is greater than 0.10 volt with the engine running, clean and reconnect the un-numbered ground wire jumper between G600 and G101.

See how simple it is to run through the ground system of any vehicle? Even if you do not see a ground jumper wire, you can determine whether the engine block or any sheetmetal on the vehicle is properly grounded by conducting a voltage drop test, as long as you ground your DMM at the battery negative terminal. Stay grounded in the basics — pun intended. ■

— By Vince Fischelli

Figure 5: Checking PCM ground

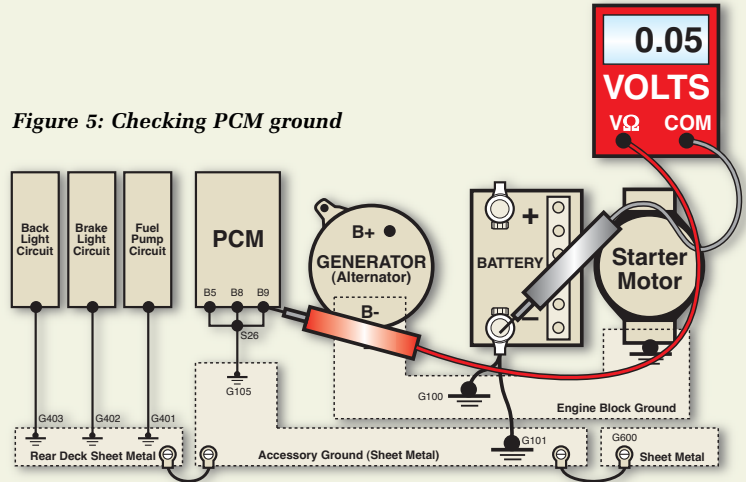


Figure 6: Checking rear deck sheet metal ground

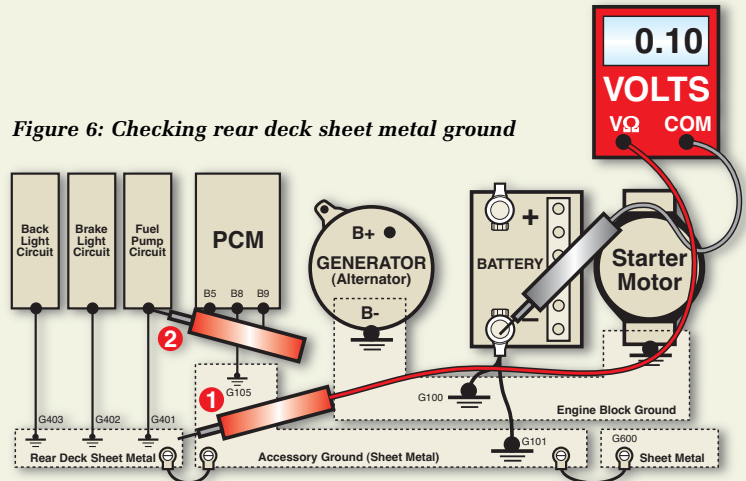


Figure 7: Checking other sheet metal grounds

