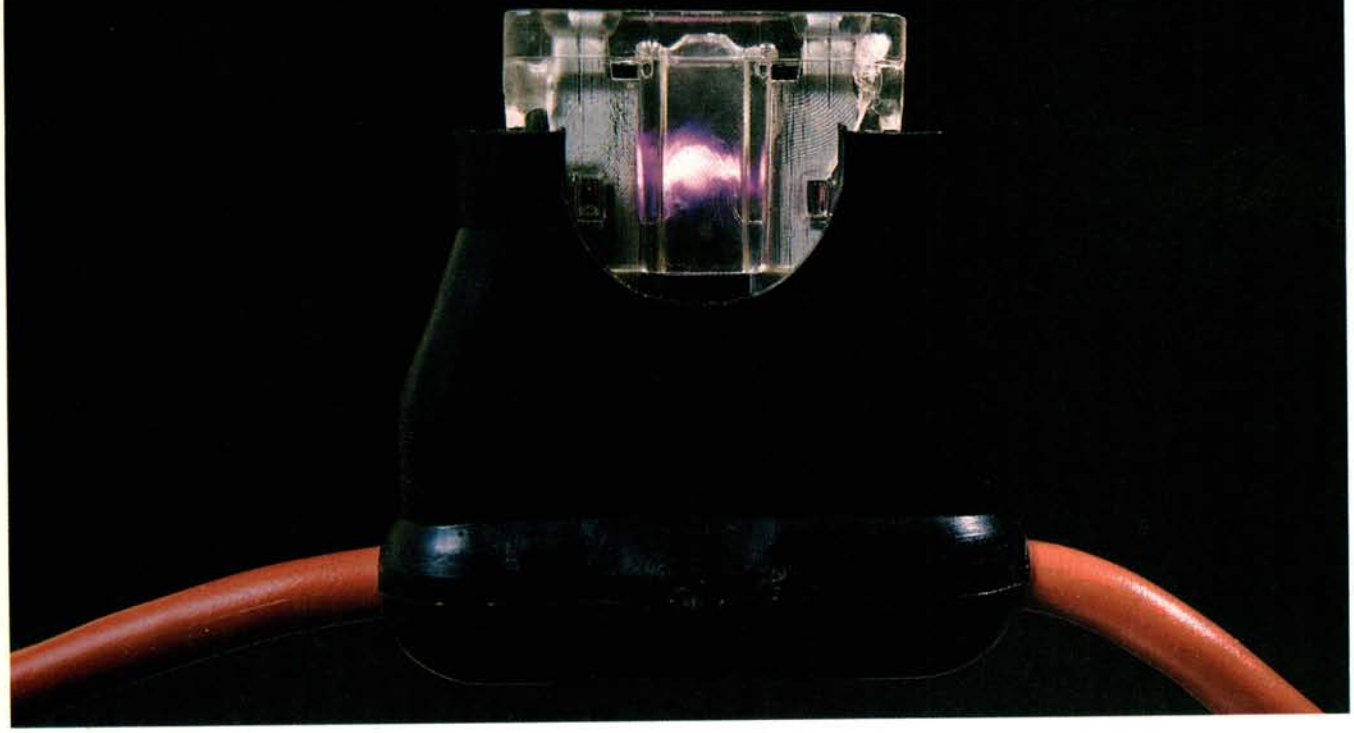
# Troubleshooting Electrical Shorts



## Checking Electrical Shorts

Troubleshooting electrical shorts can be a rewarding experience when you find the short quickly. It can also be a frustrating and annoying experience when a seemingly simple job turns into an all day project. In fact, there are few things in life as frustrating as that difficult-to-find short circuit problem.

Customers will frequently complain that their car has a "short in it somewhere." They use the term short to describe any number of electrical problems ranging from a burned out lamp bulb to a no-start condition.

Technicians sometimes misuse the word short as well. Since the customer is familiar with the term, techs often describe any number of electrical problems as shorts, just so they can give the customer a quick answer.

## Just What Is A Short?

Both the customer and the technician need to understand what a short really is. After we take a moment to decide what makes a short different from other kinds of electrical problems, we can look at some short cuts for repairing short circuits.

In fact, a short circuit is a lot like a short cut. You've all heard the story about the guy who was always looking for a short cut to get him to his destination a little sooner. His wife was constantly annoyed by all this foolishness, and when she finally had enough she screamed, "Are we lost, or what?"

The driver smiled and said, "Yeah we're lost, but we're making great time."

Well, a short circuit is a lot like that.

When there's a breakdown in the insulation that keeps automotive electricity on the road it's supposed to be taking, it gets a mind of its own and takes that side road. Sometimes it gets there plenty early, only to find that it's in the wrong place. At other times, it gets lucky, chooses a different route, and no damage is done.

But either way, a short circuit is electricity that uses the wrong road.

## Types of Shorts

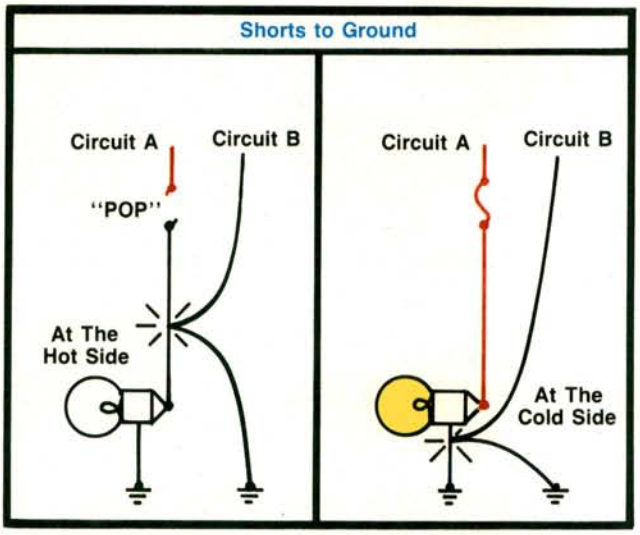
There are two types of shorts:

- **Shorts to ground.**
- **Shorts to voltage.**

The difference in the two depends on how the car was wired in the first place. There will be times when there just isn't any good substitute for a wiring diagram. You have to know what a wire is supposed to be doing before you can tell if it is or isn't doing its job.

The short to ground is the more common type of short in automotive applications, because insulation around the wiring is often rubbed away by the metal chassis. In negative ground systems, the chassis is connected to the negative terminal of the battery. When the bare, hot wire touches the chassis, it's the same as touching it to the negative terminal of the battery itself.

**Figure 1**



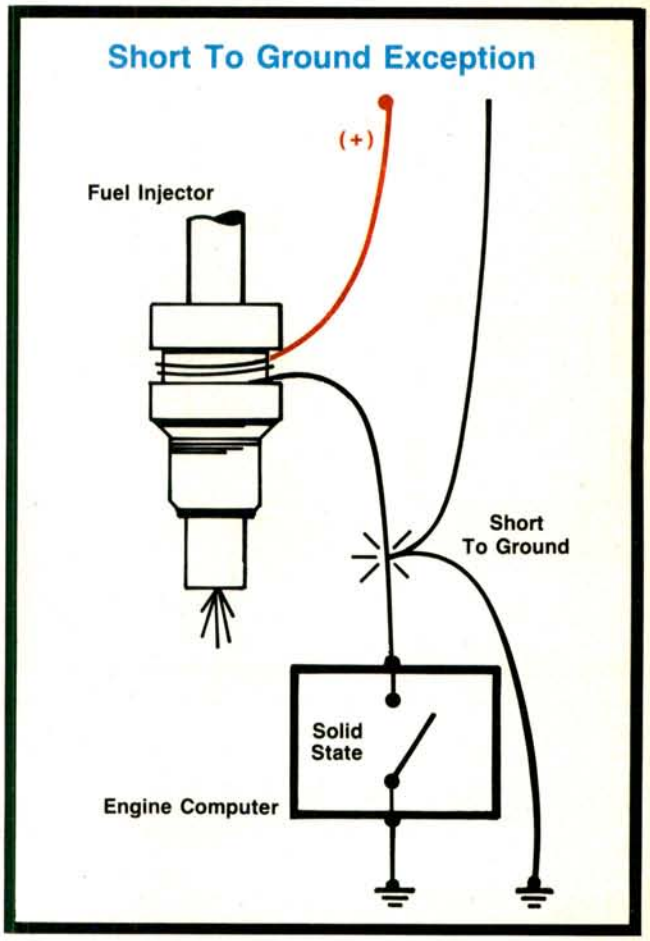

Let's look at an example. In Figure 1, the "hot" side of circuit A (the operating voltage side of the circuit) is shorted to ground. If the fuse doesn't blow, we end up with a lot of heat as the current flow gets greater than the wire's capacity to carry it. We end up with smoke, smell, and maybe even fire. Fires from voltage circuits shorted to ground don't need credentials as former Boy Scouts to get a good blaze going.

If the "cold" or ground side of the circuit is shorted, you may not notice any problem at all, since that wire is normally connected to the ground, or return side of the circuit. The short simply duplicates a normal circuit condition.

## An Exception To The Rule

What would life be without an exception to the rule? Let's suppose that circuit A in Figure 2 is turned on by applying a pulsed or intermittent ground. Fuel system computers do this to fire fuel injectors. They decide how long they want the fuel injector to stay open and then they apply ground for that period of time—and no more.

**Figure 2**




A short to ground at the cold side of the injector circuit bypasses the computer. If one side of the injector is hot all the time, and the short provides a continuous ground, the injector opens—and stays open. Talk about a rich condition. Try passing an emissions test with that kind of short to ground.

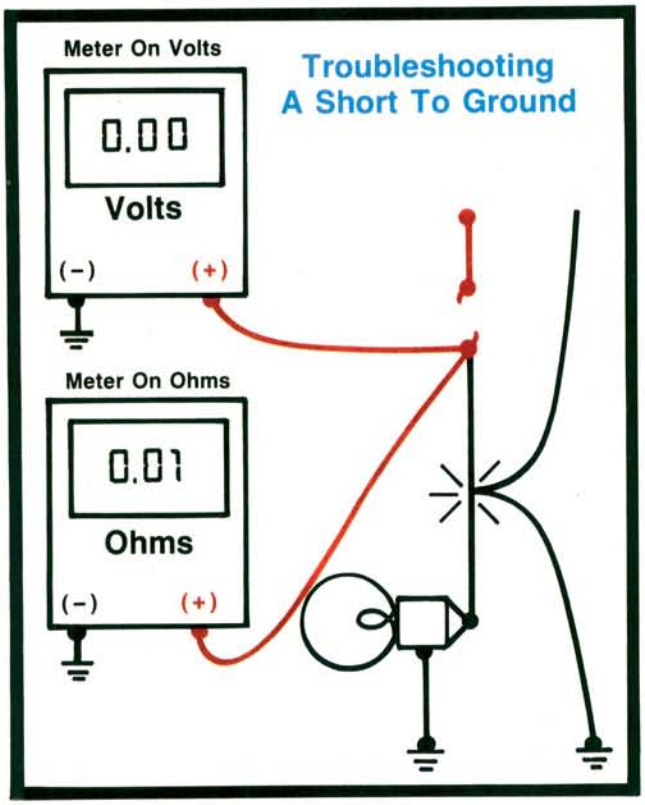
## Troubleshooting Shorts To Ground

Grab your DVOM. You'll be using it as a voltmeter and as an ohmmeter for this test. Disconnect the power from the line to interrupt the current flow to ground. (Turn off a switch or pull a fuse.) Use the DVOM as a voltmeter to be sure there's no voltage in the circuit. See Figure 3.

Ground the negative test lead of DVOM number 1 and connect the red test lead to the circuit you think is shorted. Select the 20 volt range and make sure the circuit has no voltage.

Then, without moving your leads, switch to the ohmmeter setting on the DVOM. Use a low ohm setting. The ohmmeter will safely read the short to

Figure 3




ground. If there is a short in the circuit, the reading should be less than 1-3 ohms.

If you're using a digital meter with a tone for low resistance, you can listen for the tone to go away as the cause for the short is eliminated. As the short is corrected, you'll also get a high resistance reading.

By the way, don't forget to replace the fuse or turn the power back on when you're done.

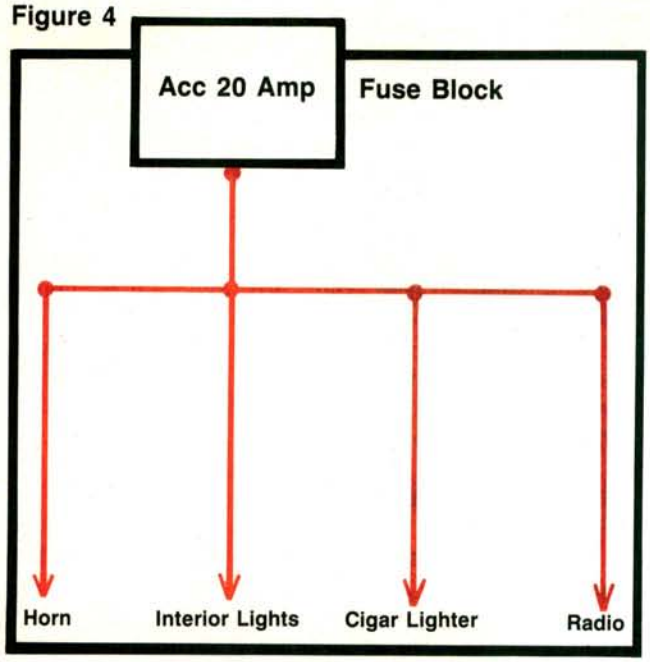
## A Common Short Circuit Problem

How about a more complicated problem? If a main fuse blows on an intermittent basis, what do you do? What if that main fuse feeds four separate circuits? Which circuit is the troublemaker, and how do you find it? This is a tough one, since every time the main fuse blows, all four subcircuits are dead.

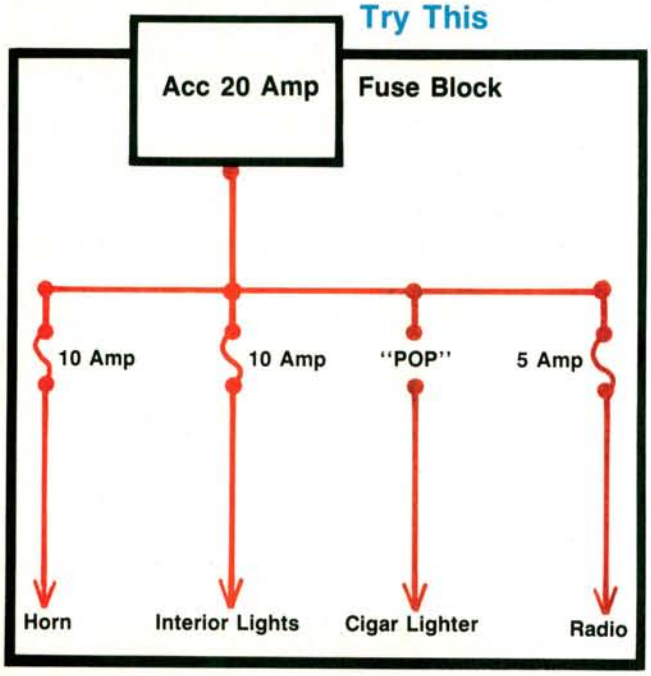
One approach is to install a fuse in each of the circuits. Match the in-line fuses to the current drain of each circuit, and install them as close to the current source as possible.

The next time that intermittent ground does his dirty work, he'll blow the fuse in the shorted circuit. The main fuse and the good circuits will continue to work. In this particular case, the fuse for the cigar lighter blew. Now we know that the cigar lighter circuit is the problem and we can look more closely at that circuit.

Figure 4




Try This




## Different Strokes

Here's how some technicians around the country troubleshoot shorts to ground. And while we're at it, let's have some fun.

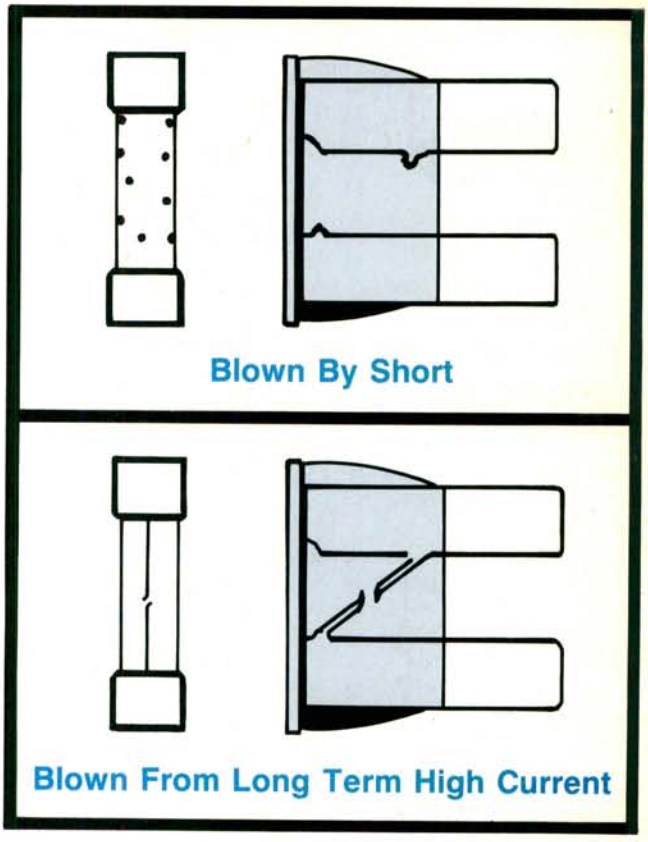
• **Ed Collins** is a shop foreman in San Antonio, Texas. He places a small 12-volt buzzer in place of the blown fuse when troubleshooting shorts to ground. The buzzer sounds off loudly until the short has been corrected. (If you need to talk to Ed in person, please speak loudly.)

• **Skip Burroughs** is a shop owner in Amarillo, Texas. He doesn't like noise and uses a light bulb in place of a buzzer. Skip's also a bit daring. In simple circuits, he'll wire the circuit directly to the battery and look for telltale signs of smoke. He said that in some circuits, it takes less time to repair the extra damage caused by this procedure than it does to find the short. (I wonder if we'd find pennies behind the fuses in Skip's house.)

• **Greg McGoniga** is a shop owner in Fort Wayne, Indiana. He prefers a signal injector when tracing shorts to ground. The injector sends a signal through the wires. A detector is used to follow the signal through the circuit. It's like a homing device. When he gets to the short, the signal disappears to ground. Talk about mission impossible. (If you visit Greg's shop, he'll be the one wearing knee pads as he crawls around with his detector.)

• **Mike Nixon** and **Kenny Steinbach** have a shop in Baltimore, Maryland. They have a different approach. They carefully examine the blown fuse. The appearance of the blown fuse can tell you a lot.

Figure 5




The appearance of a blown fuse can give you a clue about how bad the short circuit is. A fuse element blown completely away indicates a short to ground. If the short is really bad, the fuse element will splatter as it explodes, coating the inside of the fuse.

A blown fuse with drooping ends at the open fuse element tells you that this fuse was exposed to high current for a long period of time. The fuse element burned through gradually from the excessive heat caused by the higher than normal circuit current.

How would we get higher than normal current in the circuit? A decrease in circuit load resistance is one possibility. An example of this would be partially shorted windings in a solenoid. This partial short would reduce the resistance in the winding, increasing current flow.

**Figure 6A**

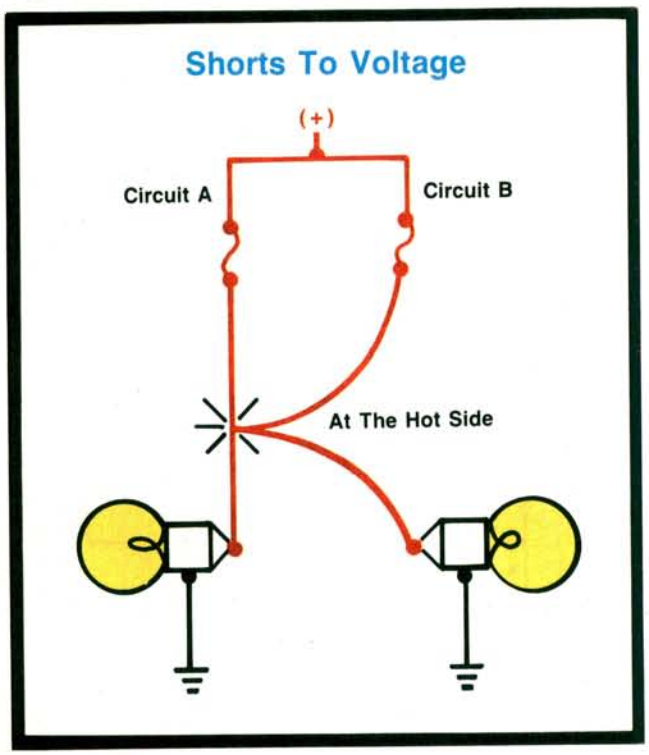
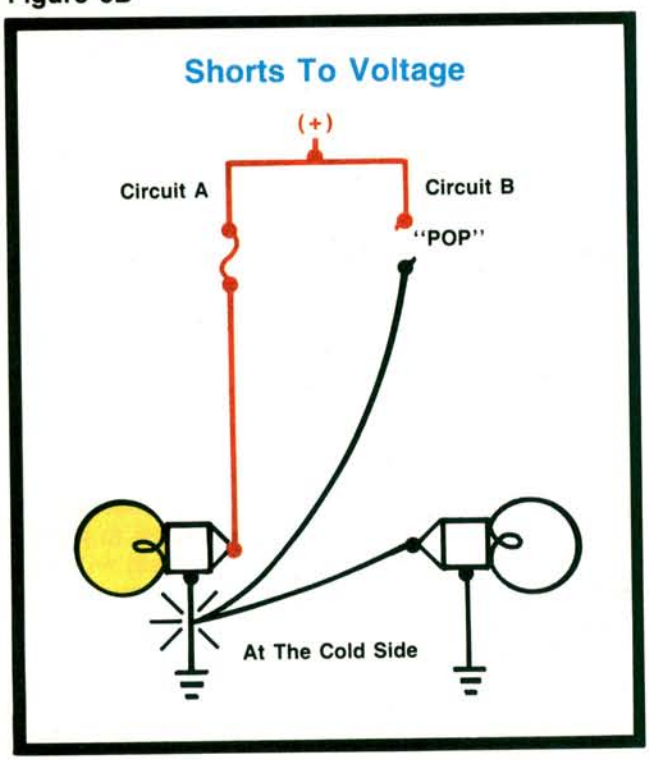



**Figure 6B**




Another possibility would be a high resistance short to ground. This happens when the insulation on a hot wire is damaged, but not damaged badly enough to cause a dead short. In this situation, moisture can provide a high resistance path to ground, increasing current flow. This type of short can be very hard to find, and may only act up on rainy days.

One peculiar response of an ohmmeter checking a high resistance short to ground is that the resistance reading usually varies constantly. Readings will go up and down, a few ohms at a time.

In contrast, a dead short to ground usually reads a steady, low resistance of 1-3 ohms or less. Standard short to ground troubleshooting techniques will find either type of short circuit condition.

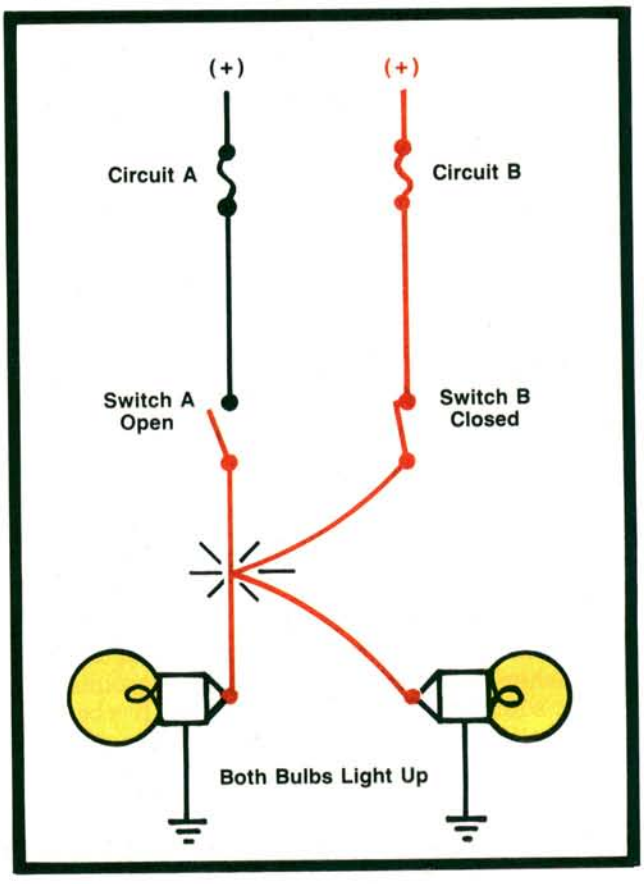
## Shorts To Voltage

Our second kind of electrical short is the short to voltage.

If the short to voltage is to the "hot" side of the normally "hot" side of circuit A in Figure 6A, you may not notice any difference. We have a normal condition, so no problem will be noticed. Our current takes the wrong road, but still ends up in the right place. Dumb luck.

If the short to voltage touches the ground side of circuit A, we have a different situation. In Figure 6B

**Figure 7**



we see that our short to voltage is actually a short to ground. The fuse will blow.

We have now come full circle. We started with shorts to ground, looked at shorts to voltage, and ended up with another short to ground.

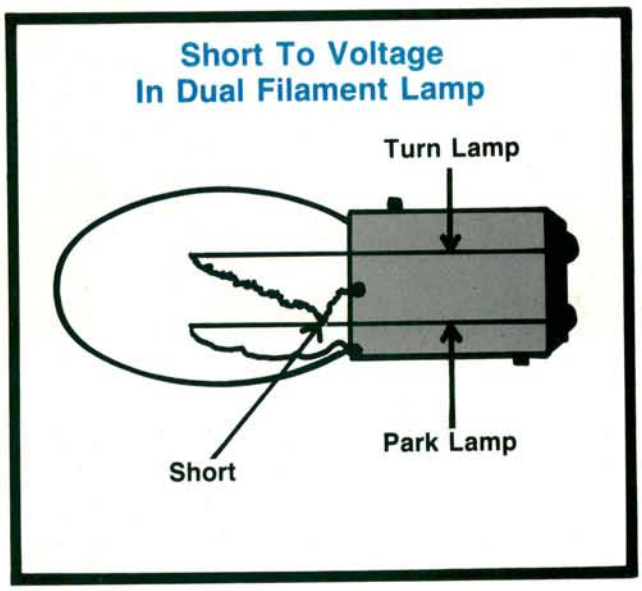
## Another Exception

We have another exception to note. Refer to Figure 7.

If circuit A is normally off, and is switched to voltage to turn it on, a short to voltage will turn on circuit A whenever circuit B is switched on. Circuit A works when circuit B is turned on.

Dual filament bulbs in the turn signal and park lamp circuits are a classic example of a short between two separate hot circuits. One or both of the filaments will sag. The filaments then contact one another. All kinds of weird things start to happen. See Figure 8.

**Figure 8**




Crossed filaments can cause park lamps to come on when the turn signals or brake lamps are on. Turn signal lamps will come on when the park lamps are turned on. On one car recently, all the lamps turned on when either the park or turn signals were used, but there was no flashing of the turn lamps. The culprit was a dual filament bulb with crossed filaments.

A new bulb corrected the short, but the flasher can also had to be replaced before the turn lamps would flash. Although the bad bulb was the original cause of the problem, the flasher can element had burned up trying to supply current to all the bulbs at once.

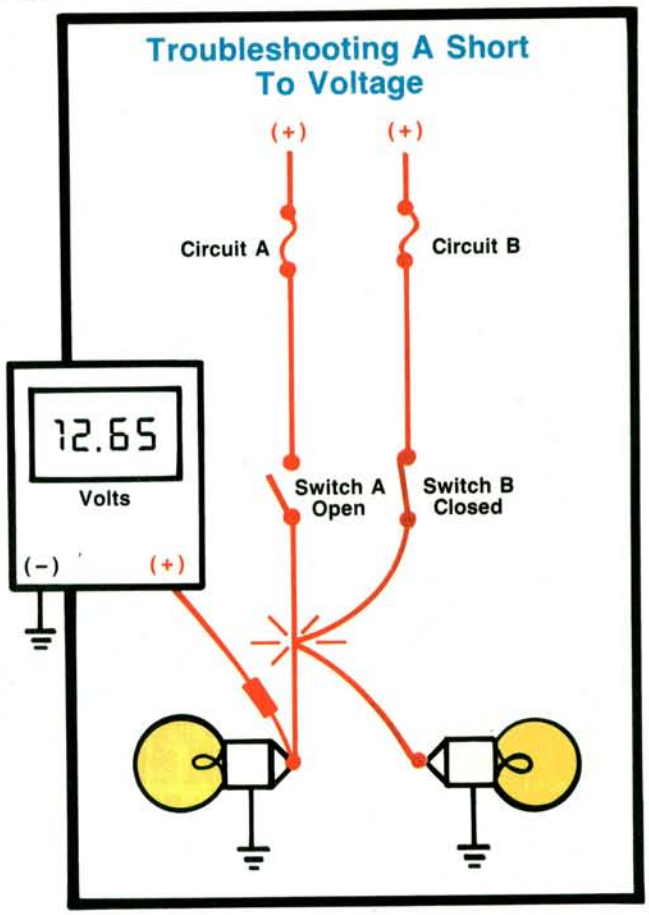
## Troubleshooting Shorts To Voltage

We didn't get nearly as much input from our peers on the subject of shorts to voltage as we did with shorts to ground. Maybe they're not as well understood.

If the "hot" side of circuit B is shorted to the "hot" side of circuit A, you may not notice anything unusual as long as both circuits are normally on at the same time. This short only simulates a normal condition.

But if circuit A is normally off and grounded all the time, we'll have a definite problem when circuit B is powered up. Now circuit B powers circuit A, turning it on too. Check the hot side of circuit A with your DVOM, as shown in Figure 9.

**Figure 9**




There shouldn't be any voltage in circuit A when the switch is turned on in circuit B. If there is voltage in circuit A when circuit B is closed, you know where it's coming from.

If circuit B is shorted to the cold side of circuit A, check as you would for a short to ground. Again, we've come full circle.

## Some Final Pointers

Never use a larger than recommended fuse to cover up an intermittent short. If a circuit is blowing a fuse of the recommended amperage, installing a heavier fuse is asking for trouble. Shorts don't heal themselves, they only get worse. The best thing that can happen is that the heavier fuse will start blowing too.

In the meantime, you may be damaging wiring harnesses and maybe even one of those pricey

computers.

When repairing damaged wiring, do it right. Never just twist wire ends together and tape them. Always clean the wire ends being repaired and solder them with a small (100 watt) soldering iron using 60/40 rosin core solder.

Heat shrink tubing is also preferable to tape. You get a much better insulated repair, and the tubing won't unravel over time like tape will.

The only advantage to a poorly done repair is that it gives you a lot of practice when it keeps coming back. You know, we call 'em "rechecks."

## When A Short Is Not A Short

There are times in life when the unusual occurs and throws us for a loop. Here's a classic example.

A 1984 Nissan Diesel was suffering from a bad case of no-turn-over-in-the-morning. The starter motor, starter solenoid, and battery had all been replaced by the vehicle's owner.

When that failed, he took the vehicle to two separate shops. Both gave up before the problem was solved. One of the shop owners had shrugged his shoulders and told the owner that the vehicle had a "bad short" in it.

See what I mean?

I have a motto: When all the parts have already been replaced, and the problem hasn't been fixed—READ THE BOOK. In this case, the book was the wiring schematic for this particular vehicle.

Look at Figure 10. Study it for few moments until you're familiar with how the starter circuit is wired. Then I'll list the resistance and voltage checks I made to diagnose the problem. See if you can name the problem.

Now that we've looked at the schematic, let's list the symptoms in more detail.

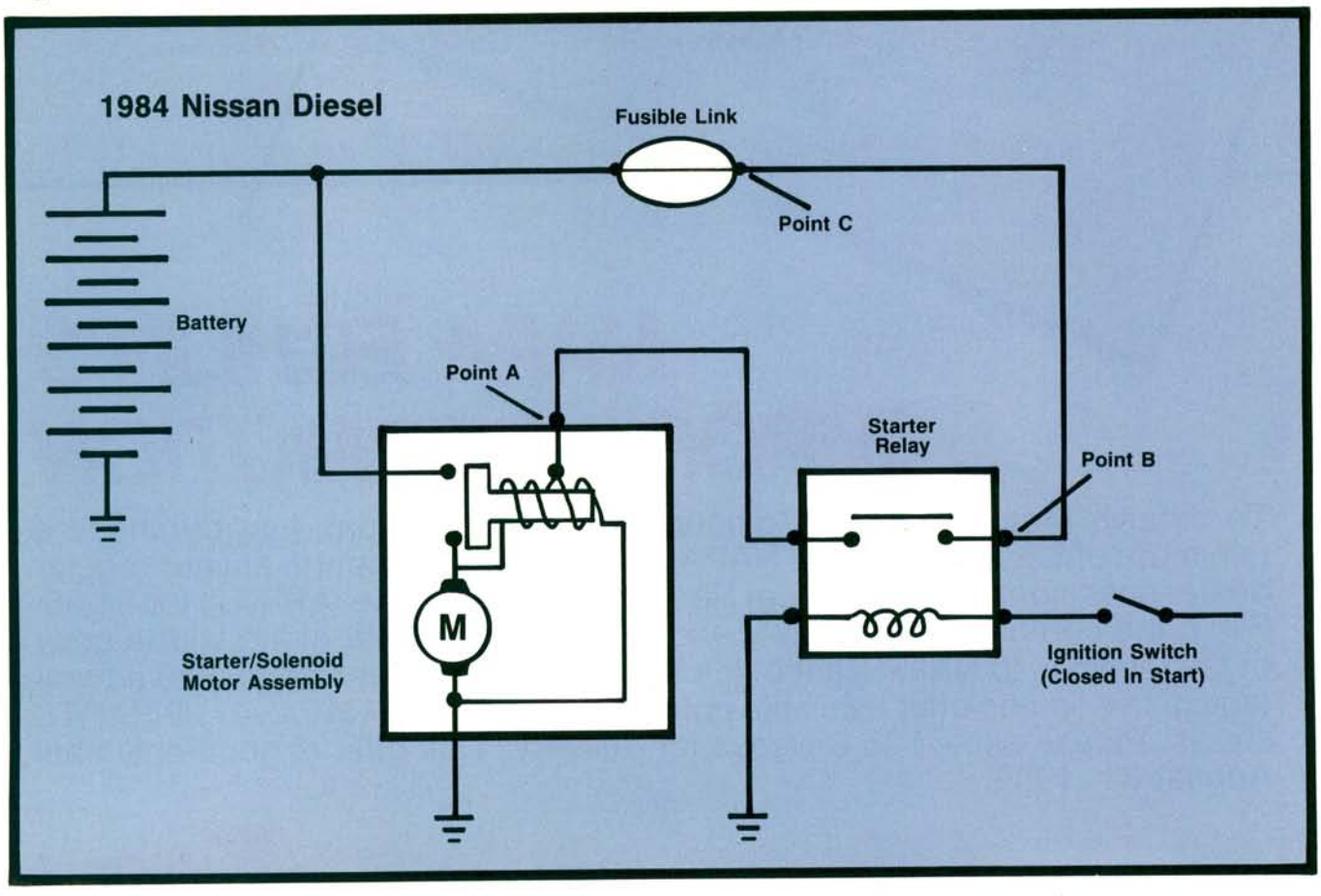
- The starter relay clicked when the key was turned to the start position.
- The starter did nothing.

Since the starter relay clicked, I knew that things were okay between the ignition switch and the relay. I also knew that the winding in the relay was good.

But what about the circuit between the relay and the starter solenoid? I asked the owner to turn the key to the start position while I checked for voltage at point A. No voltage at point A.

Since one of the shop owners had told the customer that the starter solenoid/starter motor assembly had a "bad short" in it, we stopped here to check resistance between point A and ground. We got a very

**Figure 10**



low resistance reading of 0.3 ohms. Is this good or bad?

This sure looks like a short to ground. But the starter worked intermittently. If it had worked even once, wouldn't 12 volts seeing only 0.3 ohms at point A let maximum current flow? Wouldn't the fusible link be blown if the starter worked even once?

We checked the fusible link and it was good. How can this be?

We went on with our tests. I measured the voltage at point B. When the key was not in the start position, I read 12 volts. But as soon as the key was turned to the start position, the voltage dropped to zero at point B.

Finally, I checked voltage at point C and found that I had 12 volts all the time, even with the key in the start position. Gotcha! Now I know the problem.

Can you tell what's wrong here?

- Are the starter solenoid/starter motor windings shorted?
- Are the starter relay contacts bad?
- Does this circuit have a "bad short" at point B?

## And The Winner Is . . .

We don't have a short circuit at all. We have a voltage drop. We know that we have 12 volts at point C, even with the key in the start position. But the instant we turn the key to the start position, the voltage at point B disappears.

There is such a high resistance in the circuit between points C and B that the entire 12 volts is dropped in the circuit before it ever gets to point B. There isn't any voltage to transfer from point B to point A when the starter relay closes.

And that 0.3 ohm reading at the solenoid, what about it? The solenoid is okay. It just happens to be a low resistance winding. It has less windings than a relay solenoid would, and they're made of a heavier gauge wire. Since that low resistance coil is grounded through the starter motor, it reads only 0.3 ohms to ground, and might fool us into thinking we had a short to ground.

(For more information about voltage drops, see the October 1988 issue of *Import Service*.)

Finally we fixed the problem by replacing the wire between points C and B. All connections were soldered and protected with heat shrink tubing. The customer then started the car and drove us to lunch.

He bought.

**—By Vince Fischelli**