

Honda Main Relay Insider



In previous articles we discussed electrical troubleshooting techniques for measuring circuit voltages and voltage drops using a DMM. We also discussed using a DMM to measure resistance. But let's not get so focused on the theory of DMM's and voltage and resistance measurement. If we do, we risk overlooking the application of these principles to troubleshoot circuits and fix cars.

The other day, I was thumbing through a Honda service manual and ran across an interesting circuit that should be familiar to most Honda techs. It is the PGM-FI relay circuit, presenting many opportunities for delving into the practical side of electronic troubleshooting. This proves that something that looks very simple can also be very important yet none too easy at the same time.

Figure 1, (page 9) shows the schematic of the PGM-FI Main Relay. It is actually two relays in one housing, and it has seven pins. We have marked the top relay coil as L1 and the bottom coil as L2. The contacts for L1 are labeled as S1 and the contacts for L2 as S2. Also notice there are no spike suppression diodes or resistors across the relay coils. There are, however, *three diodes* in the relay.

What are the diodes for?

We know a diode lets current flow in one direction only. Placing a diode in series with a circuit, as we see with all three diodes in this Main Relay, determines current can flow only one way through each of the two coil circuits. Describing current through the circuit by electron flow, you would say that electrons flow *opposite* the arrow's direction. Describing current conventionally, from positive to negative, you would say current flows *in the same direction* the arrow points.

Therefore, in each of the two relay coil circuits, current can flow only one way (the 'right' way, with the polarity the engineers intended) through each relay coil circuit. What could make current flow the wrong way, you might ask? How about reversing the jumper cables during an attempted jump-start? That would apply reverse polarity voltage to the main relay as well as to the car's battery terminals, just as would happen if the battery cables were connected backwards on a new battery.

Current can flow either way through a relay coil, and the relay contacts will still close because the resulting electromagnetism will attract the relay arm regardless of whether it is north- or south-pole magnetism. But in this relay, the diodes prevent such a reversed connection. The diode at pin 5 of the Main Relay determines the direction of current flow through coil L1.

The diode at pin 2 determines the direction of current through coil L2. The diode between pin 7 and the top of coil L2 determines the direction of current produced by the B+ at pin 7. By wiring in the diodes as shown, current can only flow through the relay coils when the battery's positive terminal is positive and the battery's negative terminal (ground) is negative.

If someone clamps jumper cables backwards to the battery terminals, the normal positive terminal becomes negative, and normal negative terminal becomes positive. Without the diodes, current would flow through the relay coils with reverse polarity voltage, driving a current the opposite way through the coil windings and close the relay contacts. The three diodes connected in series prevent current from flowing the wrong way through each relay coil, to keep the contacts from closing. If the contacts were able to close, reverse polarity voltage from the jump-start battery would instantly cook the PCM/ECM. These diodes can thus be called *Polarity Protection Diodes*.

Referring back to **Figure 1**, we see each pin of the Main Relay marked with an explanation of its connection into the overall vehicle circuit. Pin 5 and pin 3 are the L1 coil terminals. When pin 5 is B+ and pin 3 is B-, when the system has correct voltage polarity, current flows through the coil and through the diode. If the polarity were reversed, pin 5 would be B- and pin 3 would be B+.

This reversed polarity cannot produce a current through the coil because D1 blocks current in that direction, insuring the contacts remain open. When the contacts of S1 close (under normal polarity), B+ from pin 7 is connected to pin 6 to supply operating voltage to the PCM and to the injector resistors. Diode D3 also allows B+ to go through to the top of coil L2.

The terminals of coil L2 are connected to pins 2 and 1. Pin 2 is the B+ terminal from the starter switch, and pin 1 is grounded by the PCM. In start-mode, B+ is present on pin 2, and pin 1 is grounded by a driver in the PCM for two seconds. The contacts close and B+ from pin 5 (fed to the top contact of S2) connects through the closed contacts to the fuel pump. For the PCM to keep the relay coil energized, it must receive run pulses (reference pulses) to confirm the engine is running.

If the run pulses cease, the PCM will remove the ground from pin 1, and the S2 contacts will open, shutting off the fuel pump. The PCM/ECM never loses control of fuel pump operation because it always controls the voltage at pin 1 (low = pump ON, high = pump OFF).

Main Relay Circuit Operation

Figure 2 is a more detailed view of the Main Relay circuit schematic and surrounding circuitry. The Main Relay is in the center of the diagram. On the left is the battery, as well as a circuit from the ignition switch connected to the Main Relay. The service manual says, "if the car starts and continues to run, the PGM-FI Main Relay is okay." This strongly suggests if the car does *not* start or does *not* keep running, the PGM-FI Main Relay should be one of the first things to check. Some techs might make the mistake of simply changing the relay if the car will not start or keep running but then *assuming* the relay circuit is not the problem. If the symptoms do not change and the car still will not start or run even with

a new relay, that may well mean the circuit around the Main Relay is defective, rather than the relay itself. Let's look at some voltage checks and circuit analyses to help pinpoint a Main Relay circuit problem.

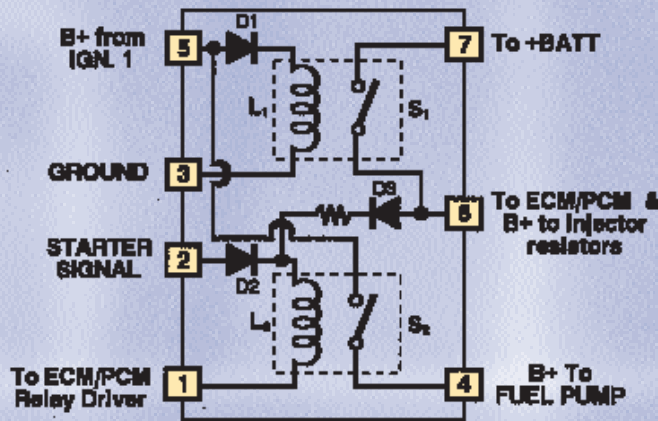
When the ignition switch is moved to the ON or START position, first B+ appears at pin 5. This confirms the section of the ignition switch circuit and the 15-amp fuse are good. Since pin 3 is always

grounded, the top relay winding, L1, energizes and closes the S1 contacts. B+ is supplied through the S1 contacts to pin 6, which supplies B+ to two PCM/ECM pins and to the injector resistors. The actual PCM/ECM pin numbers are different for four- and for six-cylinder engines. The PCM/ECM powers up from this B+ source and gets ready to monitor and control engine functions.

Next, the driver turns the ignition switch to the START position, and B+ arrives at pin 2. This confirms the 7.5 A fuse is good and the Gear Position Switch contacts are closed for manual transmission-equipped models (clutch fully depressed). The bottom of the coil at pin 1 goes to the PCM/ECM for a ground through a driver-transistor. The PCM/ECM is programmed to turn ON the driver-transistor and ground pin 1 of the Main Relay for two seconds.

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Figure 1: PGM-FI Main Relay



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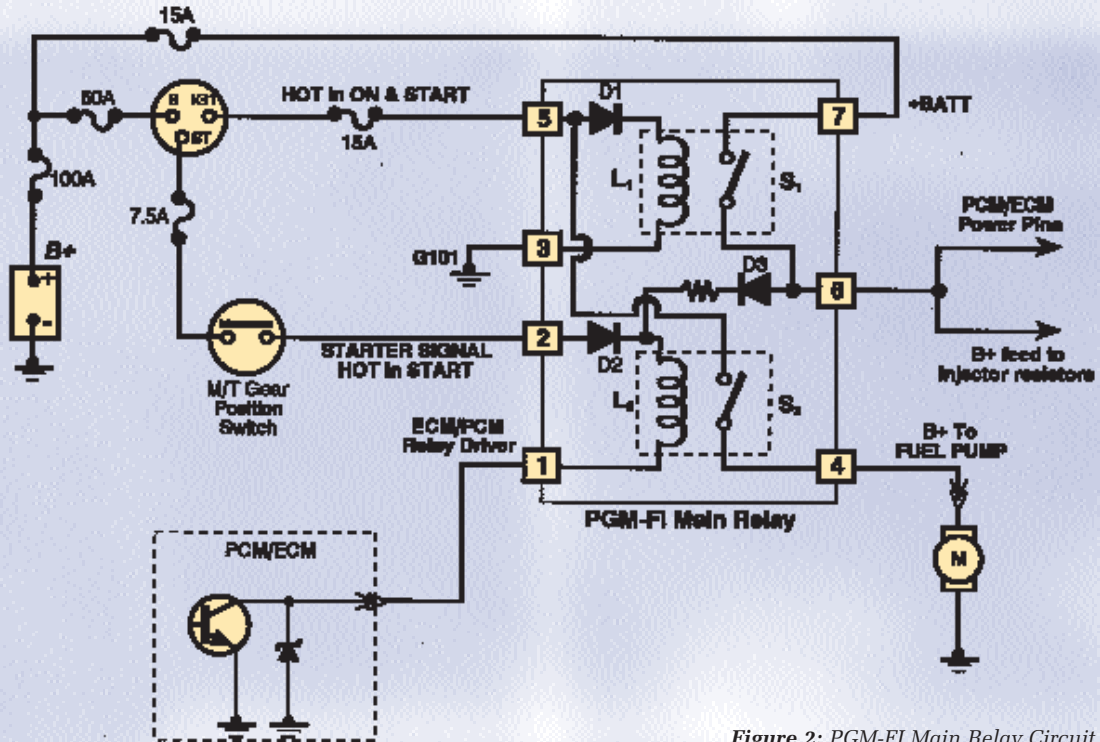


Figure 2: PGM-FI Main Relay Circuit

The bottom relay energizes and closes S2 contacts, which feeds B+ (from pin 5) to pin 4 and on to the fuel pump through the wiring harness. The fuel pump turns ON and builds fuel pressure to supply the injectors with pressurized fuel. As the engine cranks, the PCM/ECM *must* receive run pulses to maintain the ground at pin 1. This is a fail-safe feature to keep the fuel pump from pumping fuel into the fuel rail unless the engine is running.

Troubleshooting the Main Relay

Some time ago, I worked on a car with this circuit that had an intermittent running problem. Sometimes the car would run, and sometimes it would not. There was no rhyme or reason. After trips to several different shops, everything had been replaced, including the battery, the starter, various ignition parts, the Main Relay, etc. Some parts were replaced more than once, just to make sure (Ever been there?). Someone had even borrowed a PCM/ECM from another car in a desperate attempt to solve the problem. Still the intermittent failure continued. I was on the spot to solve the problem because I was getting the big bucks. At least that's what everyone thought, because it was my own shop.

I already knew some electrical problems could show up even when the car is apparently operating normally, if you just know where to look and what to look for using a DMM. Relays happen to be

among the components you can troubleshoot and discover problems with using a DMM, even when a relay appears to be working properly.

At this time the problem car was starting and running normally. I took a few minutes to look at voltages around the Main Relay to see whether I could detect a problem even though the vehicle was running. I checked the B+ at pin 5 and got almost full charging voltage. So far, so good!

Next I checked the voltage between pin 3 and the battery ground terminal and found about 2.5 volts. Whoa! The voltage drop at the ground pin should have been 0.10 volt or less. That surprised me because it was so easy to find. Pin 3 had a poor ground because the ground screw was loose. The bad ground connection sometimes kept the top relay coil, L1, from closing its S1 contacts, so the PCM/ECM and injectors would not operate just at those times.

When the bad ground connection happened to provide a better contact, it allowed just enough current through the L1 coil to close the contacts, and then the car ran fine. Another intermittent problem solved with a DMM, just because we knew where to look and what to look for! The car didn't have a gremlin after all — just an intermittent loose ground. Once the ground screw was tightened, the voltage drop at pin 3 decreased to 0.08 volt, and the problem was solved (I gave myself a raise after this one).

Here's a troubleshooting question for you: If the top half of the relay does not operate, will the fuel pump run for two seconds? Check the answer at the end of the article after you review the wiring diagram and think about the question.

Pin 7 should have B+ all the time. Be sure to check for that voltage during engine START and RUN, so any wiring voltage drop will show up. Do not check the voltage on pin 7 with the key ON and then assume the voltage will be the same when in START or RUN. A bad wire or high-resistance connection at the 15A fuse could cause low voltage at pin 7 only when current is flowing.

Check the voltage at pin 6 (B+ to PCM and resistors) when the ignition is at RUN. The voltage should not drop more than 0.3 volt between the B+ at pin 7 and pin 6. If the voltage drop is 0.3-0.5 volt or more, the relay contacts are corroded and/or have been damaged by arcing. In that case, install a new relay. If the relay contacts start dropping more than 0.5 volt due to corrosion or arcing damage, it will only get worse with time and cause a problem in the near to medium future.

Keeping the Fuel Pump Running

Coil L2 is initially powered up with B+ at pin 2 from the START section of the ignition switch. Once the car is running, the ignition switch toggles to the RUN position, and the B+ at pin 2 disappears. This could cause the L2 coil to de-energize and open the S2 contacts, shutting off the fuel pump. But notice the circuit that prevents this: Once the S1 contacts close, B+ is also supplied from the bottom S1 terminal through D3 and a resistor to the top of coil L2. This keeps L2 energized as long as the PCM/ECM is grounding pin 1, so the fuel pump keeps running.

D3 prevents L2 from being energized in the event that reverse polarity voltage was accidentally applied to the vehicle's battery terminals. The resistor in the circuit limits the current available to L2 so the PCM/ECM driver transistor doesn't burn up. By the way, the voltage on pin 1 should be close to 0.80 volt in operation due to the normal voltage drop of the driver transistor in the PCM/ECM.

The S2 contacts must be in good, low-resistance condition because they must handle fuel pump load current. Measure the B+ at pin 5 and then pin 4 with the engine running. Any voltage drop greater than 0.5 volt at pin 4 indicates a voltage drop through the S2 contacts due to arcing. If the drop is about 1.0 volt, it's probably a good idea to replace the Main Relay because that will start to choke off current to the fuel pump.

Always recheck your voltage readings after replacing the relay to make sure the voltage readings have dropped within the acceptable thresholds we've identified here. That's the only way to know for sure whether you've actually fixed the problem, especially if it was intermittent to begin with. If the voltage drop readings do not change (improve), you may have to adjust your definition of 'acceptable' readings. These experiences help us learn the difference between 'really good' and 'really bad' readings. ■

— By Vince Fischelli

Answer to the troubleshooting question on page 10: NO! If the top relay contacts (S1) do not close, the PCM/ECM will not get B+ to turn ON. So the PCM/ECM cannot ground pin 1 for two seconds.