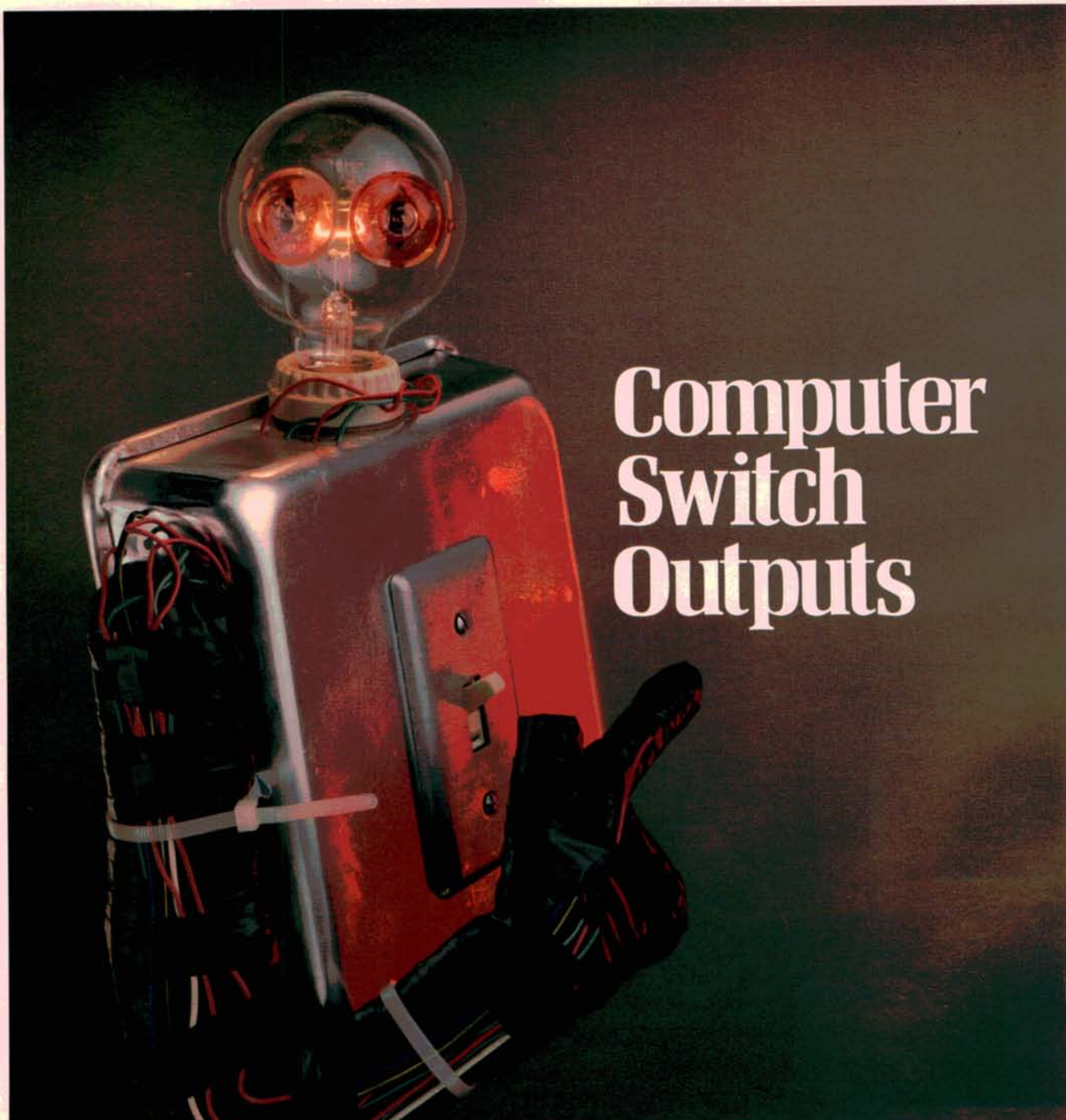


Computer Switch Outputs

We all know how to turn on a switch. We do it every time we flip on the lights at home. This article will show you how an automotive computer flips the switches to turn different output circuits either "on" or "off." We'll also discuss ways to protect sensitive computer output circuits from death and destruction.

We turn on a light with the flick of a switch, using our finger. A computer turns on a circuit by flipping one of its two kinds of switch output circuits. It doesn't have fingers, but the results are the same. So let's start by looking at the familiar mechanical switch for clues about circuit switching.

We need to know where voltage exists in a circuit when switches are either open or closed. Understanding voltage distribution in mechanical circuits is the first step in understanding computer switch circuits since the results of both mechanical and computer switching are identical.

Two Kinds of Switches

There are two kinds of switch circuits, depending on whether the switch controls voltage or ground.

- **If the switch controls voltage, it is called a Switch to Voltage circuit.**
- **If the switch controls ground, it is called a Switch to Ground circuit.**

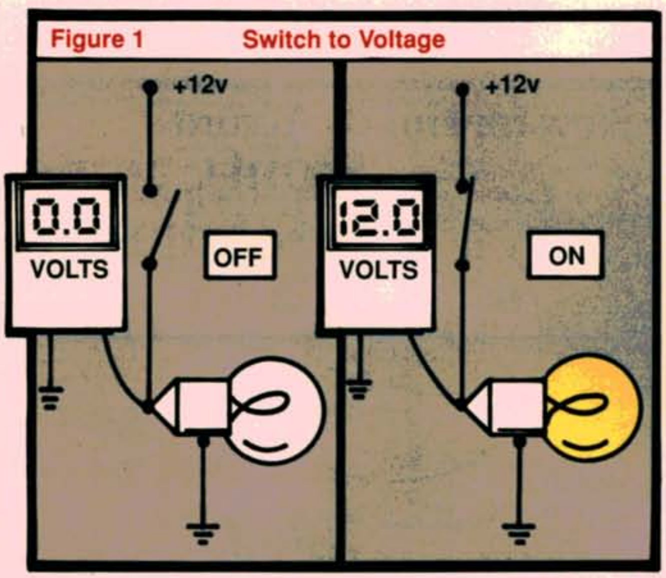
Let's take them one at a time.

Switch to Voltage

A Switch to Voltage may be the easier of the two to visualize for most of us. The concept of the Switch to Voltage circuit is shown in **Figure 1.** Notice that in a Switch to Voltage circuit, the load (in this case a light bulb) is permanently connected to ground.

Circuit switching takes place on the voltage side.

When the switch is open, voltage is not available to the lamp. When the switch is closed, voltage appears at the lamp which goes on. In this case, the switch switches voltage to the lamp. That's why we call it a Switch to Voltage circuit.

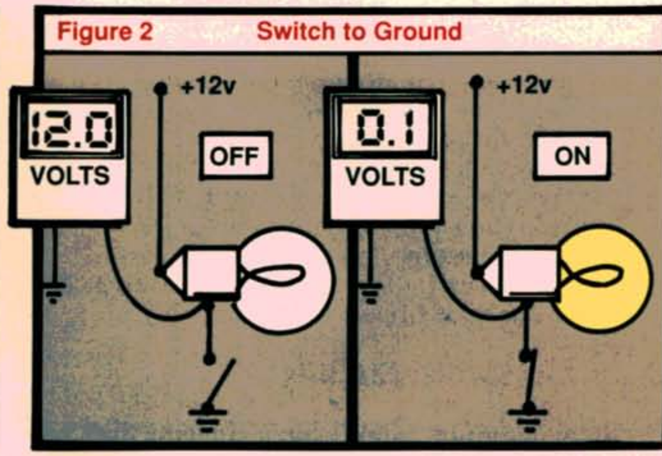


Switch to Ground

In **Figure 2**, we see a Switch to Ground circuit.

This can be just as easy to understand as the Switch to Voltage circuit. The only difference is that this time the load is permanently connected to voltage, and the switching takes place on the ground side of the circuit.

The point which seems to confuse us at times, has to do with the fact that in a Switch to Ground circuit, we have voltage at the ground side of the lamp when the switch is open. That's because when the switch in this type circuit is open, there is no ground at the lamp.



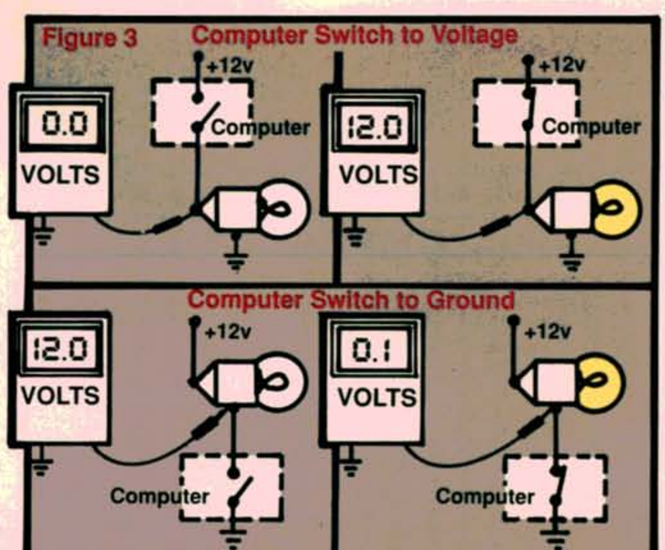
Voltage is available all the way through the filament of the lamp, and as a result, we can "see" it at the ground side terminal with our voltmeter. When the switch is closed, we have ground applied to the ground side of the filament. Circuit current begins to flow through the lamp which drops virtually all the voltage.

This leaves us with less than 0.1 volt at the ground side of the lamp when the switch is closed, indicating a good circuit. (In a future article, we'll spend the entire article discussing the ground side of the circuit.)

Computer Switching

When a computer switches the lamp on, it performs the same function as our finger does when it flips the light switch. **Figure 3** shows the computer working as a switch. Notice that the voltage readings are the same for the computer switching as they were for mechanical switching.

And logically, our computer switches are placed in the same circuit locations as the mechanical ones were.



Computer Switch Outputs

In the Switch to Voltage circuit, the computer switch is again placed on the voltage side of the load. When the computer closes its switch, voltage is supplied to the load (in this case, once again, our load is a simple lamp).

In the Switch to Ground Circuit, the computer switch is placed on the ground side of the consumer. When the computer closes its internal switch, ground is supplied to the lamp.

Our voltmeters indicate the correct readings and test points for each circuit.

Computer Switch Circuits

Since computers don't have fingers, they use transistors in place of mechanical switches. The computer does one of two things:

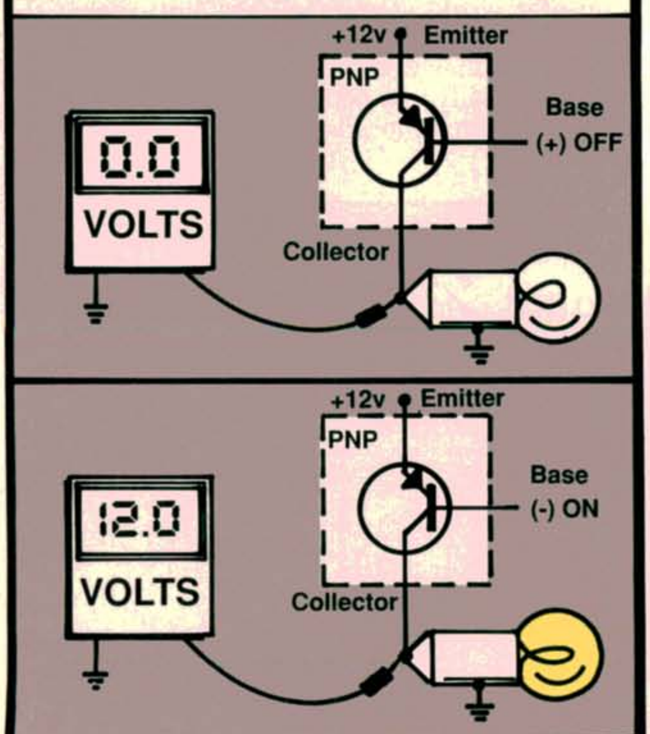
- **It turns the transistor switch ON, closing the switch.**
- **It turns the transistor switch OFF, opening the switch.**

PNP and Switch to Voltage

In **Figure 4**, a PNP transistor is used for the Switch to Voltage circuit.

- The **emitter** is tied to 12 volts all the time.
- The **collector** is connected to the lamp (consumer or load).
- The computer controls the ON/OFF state of the transistor by changing voltage at the **base** of the transistor.

Figure 4 PNP Transistor Switch to Voltage



Possible Problems With PNP Switch Circuits

It's clear that a good 12 volts will make the lamp work best.

- Check the charging voltage to be sure the "12 volts" is a solid 13.8 to 14.5 volts (charging voltage).
- Make sure that full charging voltage is reaching the computer's voltage input pin.
- If the PNP transistor becomes shorted between the emitter and collector, the lamp will stay on all the time since the computer can't reach out with a finger to shut off the load.
- If the load becomes shorted, it fries the PNP transistor, ruining the computer. The replacement computer will also be destroyed unless the shorted load is repaired.

If the voltage applied to the base of the transistor is the same as the voltage at the emitter, the transistor is OFF (switch open). The DVOM reads zero volts. The lamp stays off.

If the computer lowers the voltage applied to the base of the transistor (usually by about 1.0 volt), the transistor turns ON, closing the switch. The DVOM shows 12.0 volts. The lamp lights as emitter current flows through the collector and through the lamp to ground.

Computer Switch Outputs

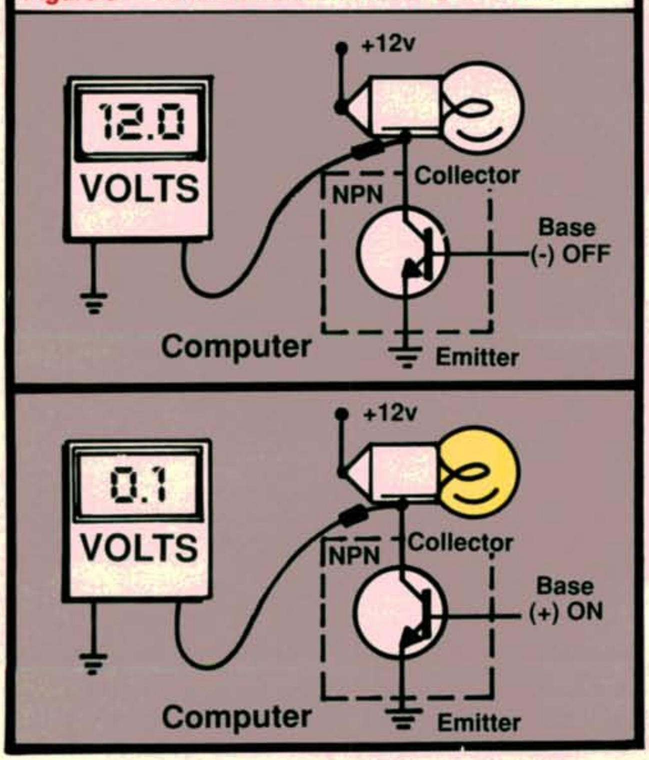
NPN and Switch to Ground

In **Figure 5**, the NPN transistor is used for the Switch to Ground circuit.
- The **emitter** is connected to ground at all times.
- The **collector** is connected to the ground side of the lamp (load).
- The computer controls transistor ON/OFF by controlling the voltage to the **base** of the transistor.

If the computer puts ground (0 volts) at the base, the transistor turns OFF, staying open. The DVOM reads 12.0 volts. The lamp is off.

If the computer puts a slightly higher voltage on the base (about 1.5 volts), the transistor turns ON, completing the circuit to ground. The current flows through the lamp to ground, and voltage is dropped across the lamp as it lights.

Figure 5 NPN Transistor Switch to Ground



Possible Problems with NPN Circuits

We mentioned the importance of a good voltage supply to the PNP transistor. The NPN's emitter is equally dependent, but this time it's dependent on a good ground.
- Verify that the computer ground is good.
- If the NPN transistor becomes shorted between the emitter and collector, the lamp stays on all the time (just like it did in a shorted PNP circuit).
- If the load becomes shorted, the NPN transistor fries just like the PNP transistor did in like circumstances.

PNP VS. NPN

You may not need to understand the inner workings of a transistor to diagnose computer switch outputs, but you should be able to recognize PNP and NPN transistor types in a schematic. That way you can identify the type of circuit being tested—Switched to Voltage, or Switched to Ground.

We offer the following illustrations, as well as a brief explanation of how each type does its job. Maybe a quick comparison to something more familiar would make transistor switching easier to understand.

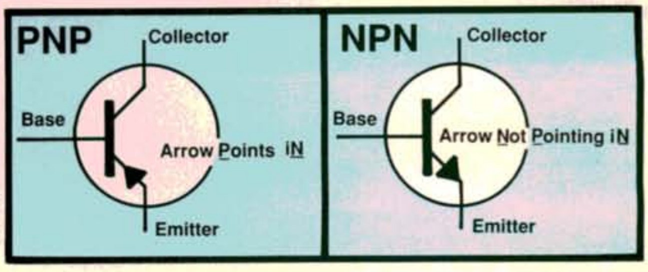
Think of a regular old electro-mechanical relay. A relay is a switching device as we all know, and it can be used to switch to voltage, or switch to ground.

A transistor might be thought of as a tiny relay with no moving parts. Both PNP and NPN transistors have three terminals:
- A supply terminal called an Emitter. This terminal is hooked to 12 volts in a PNP transistor, and to ground in an NPN transistor. It is a fixed input to the transistor in either instance and waits for the transistor to connect that input (either voltage or ground) to a load.
- A control terminal called a Base. The base receives a voltage signal from the computer. This signal applied to the base causes switching to take place. (In a relay, switching takes place when current flows through a holding coil to ground. The electro-magnet moves a mechanical arm to either close or open a circuit.)
- An output terminal called a Collector. The collector can supply either voltage (PNP) or ground (NPN) to the load through the Emitter terminal. The computer's signal to the Base terminal either opens or closes the connection between the Collector and Emitter.

PNP and NPN Schematics

In the schematic representation for PNP transistor, the diode arrow points in toward the base. Just remember, the arrow Points iN for a PNP.

In an NPN transistor the arrow points outward, away from the base. Just remember Not Pointing iN for NPN. Now you can identify the type of circuit being tested with a quick glance at the schematic.

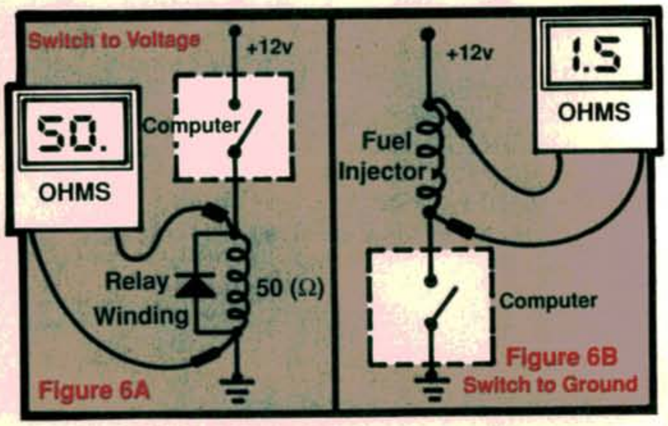


Computer Switch Outputs

More On Shorted Loads

It seems clear that whether we're using a PNP transistor to Switch to Voltage, or an NPN transistor to Switch to Ground, the load resistance must be within specifications or the transistor will be destroyed.

Check load resistance with a digital ohmmeter, as shown in **Figure 6A**. Here we verify the resistance of a relay winding. Then we compare it



to the resistance of a known good relay. A low relay winding resistance could cause the computer's PNP switch to voltage circuit to fail.

In **Figure 6B**, the resistance of a fuel injector is checked with a digital ohmmeter. Low resistance across the injector's winding can cause a switching circuit failure, this time in the NPN circuit.

Load Testing to Protect Computer Switch Circuits

Sometimes a computer switch load circuit will check good with a digital ohmmeter. Later, after the computer has operated the load for a period of time, the circuit will warm up and a short will develop at that time. To avoid missing these potential warm component problems, perform a load test as shown in **Figures 7A and 7B**.

The load tests involve the use of a digital ammeter in series with the load after the load has been disconnected from the computer. (The ammeter takes the place of the computer, completing the circuit.)

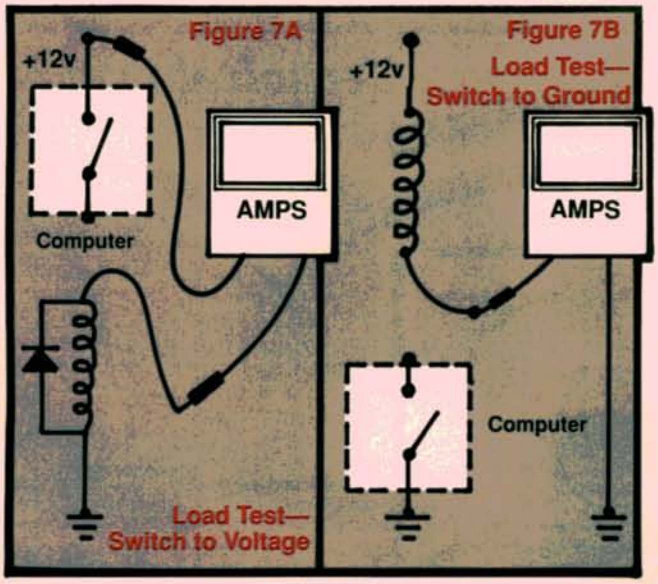
Look at **Figure 7A.**

- If the load current holds steady, at a normal level for several minutes, the load is safe. Go ahead and connect it to the computer.
- If the load current rises as the load warms up, it indicates a low resistance under warm conditions. This could damage the computer.

Exact current readings can be determined using Ohm's Law, or with factory specs where available.

Look at **Figure 7B**.

In this figure, our ammeter connects between ground and the voltage side of the relay winding. This completes the relay winding circuit through the ammeter. Leave the ammeter connected for 5 to 10 minutes to verify that the load current stays constant when the relay winding gets hot.



Learning From Experience

The tests we've shown may not become daily ritual when you do normal troubleshooting. But they do become valuable when a customer returns a car for its second computer in as many weeks.

If replacement of the computer temporarily corrected an injector misfire, but killed the new computer in the process, it may be time to perform load tests of the injector circuits.

Your local parts man will undoubtedly sell you as many computers as you want, but the customer is seldom willing to pay for the first one—let alone the second or third.

—By Vince Fischelli