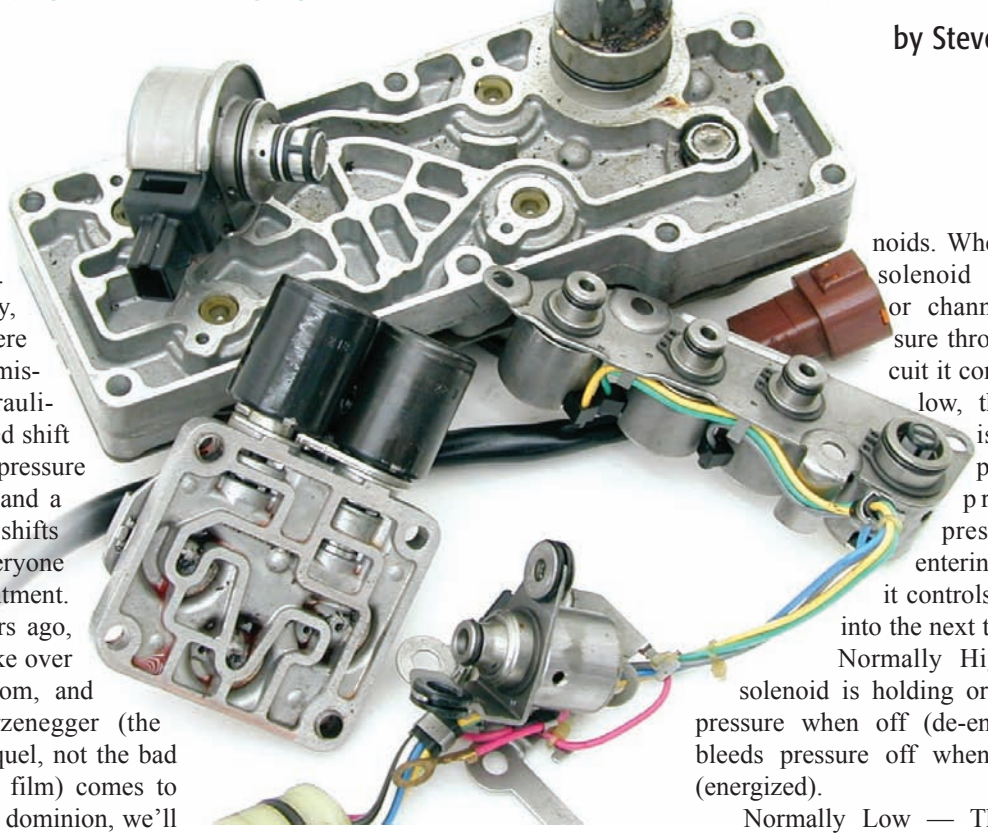
Understanding Transmission Solenoids

by Steve Bodofsky



Long, long ago, in a galaxy… well actually, right about here, where we are now… transmissions operated hydraulically. A governor varied shift timing by controlling pressure based on road speed, and a TV system altered the shifts based on load. And everyone lived in joy and contentment.

But about 25 years ago, computers began to take over the automotive kingdom, and until Arnold Schwarzenegger (the good one from the sequel, not the bad one from the original film) comes to save us from their evil dominion, we'll have to deal with them.

Today's computer systems control transmission operation through a series of solenoids. Okay, but what is a solenoid? In simplest terms, a solenoid is a valve that's controlled electrically (figure 1). When the solenoid is closed, it blocks fluid flow; when it's open, it allows fluid to flow. Sounds simple enough, doesn't it?

I wish. But there's a lot more to it than just that. Let's start by defining a few terms that are used to describe solenoids and their operation.

Common Solenoid Terms

Normally Open — The solenoid is open (allows flow) when de-energized, and closes (blocks flow) when energized.

Normally Closed — The solenoid is closed (blocks flow) when de-energized, and opens (allows flow) when energized.

High/Low — These are new terms introduced by Bosch to describe the hydraulic condition of a their solenoids. When high, the solenoid is holding or channeling pressure through the circuit it controls; when low, the solenoid is releasing pressure, or preventing pressure from entering the circuit it controls. This leads into the next two terms:

Normally High — The solenoid is holding or channeling pressure when off (de-energized); it bleeds pressure off when turned on (energized).

Normally Low — The solenoid bleeds pressure off when off (de-energized); it holds or channels pressure when on (energized).

On/Off Solenoid — The solenoid

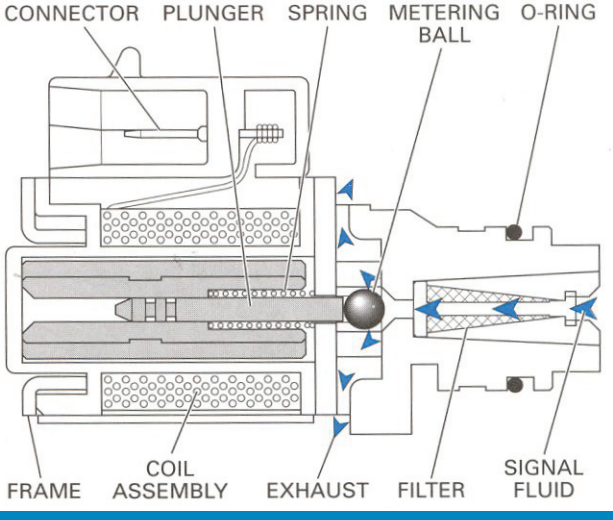


Figure 1: In general terms, a solenoid is nothing more than an electrically controlled valve. The computer controls the electrical signal to open and close the valve, which controls the flow of transmission fluid.

is either on (energized) or off (de-energized); there's no in-between. Most shift solenoids are on/off solenoids)

Pulse Width Modulated (PWM) — Also called Duty Cycled solenoids. The solenoid received a partial electrical signal that varies how much the solenoid is open. These solenoids are usually used to control pressure.

Feed Controlled — The solenoid is normally grounded, usually through the transmission case, and the computer supplies power to control solenoid operation. Feed controlled solenoids will usually have only one wire to them.

Ground Controlled — The solenoid receives system voltage all the time, either from the computer or a control relay. The computer controls solenoid operation by supplying or releasing the ground. Ground controlled solenoids usually have two wires: the power feed and the control wire.

Basic Solenoid Operation

If every manufacturer controlled their solenoids the same way, it'd be easy to understand and diagnose them. That's how you can be sure that's not the case. In fact, virtually every manufacturer has a different way of controlling their transmissions using solenoids.

In most cases, manufacturers use on/off solenoids to control shift valve operation (figure 2). In general terms, the solenoids act as a bleed for the shift valve control circuit; when the solenoid is open the pressure bleeds off, allowing the shift valve to remain in the rest position. Then, when it's time for the shift, the computer closes the solenoid. This lets pressure build up against the shift valve, forcing the valve to stroke, which shifts the transmission.

In other cases, the solenoid actually redirects oil pressure to the shift valve (figure 3). When the solenoid closes, the pressure to the valve shuts off and exhausts at the solenoid. This allows the valve to return to the rest position.

By forcing different combinations of shift valves to stroke or return, two or three solenoids can control three, four, five and even six shifts or more. The solenoids simply alter the positions of different shift valves, which in

turn shift the transmission.

A few manufacturers have gone a step further, allowing the solenoids to control clutch packs directly. Chrysler is a good example of this type of control system. But so far, only one or two other manufacturers have followed suit, and only on a couple transmissions in their line.

Most converter clutch systems also include a type of shift solenoid to apply and release the TCC. Others control the TCC exclusively with a pulse width modulated solenoid, to control the level of clutch apply. This builds a certain amount of slip into the converter clutch, which provides them with the ability to control TCC apply feel. Still others use both: an on/off solenoid to apply the clutch, and a pulse width modulated solenoid to control apply pressure, and smooth out the TCC apply.

All Solenoids Bleed

One thing to remember about transmission solenoids is that they're all just valves. On/off solenoids simply bleed or redirect pressure as the solenoid opens or closes. A pressure control solenoid is more of a variable orifice.

But in every case, the solenoid's operation depends on the pressure being applied to its circuit from the pump. If the pressure coming in is too low, the pressure going out will be too low. The solenoid doesn't make the pressure; it just controls how it flows, and where it applies.

Pressure Control Solenoids

A few years after the first solenoids started showing up in transmissions, a couple manufacturers came up with a new plan: What if they could vary the solenoid bleed? Then they could actually vary pressures electrically.

That's the basic concept behind all pressure control solenoids. In general terms the solenoid is still just an electrically controlled valve. What's different is how they're controlled: Instead of a simple on/off electrical signal, the computer pulses the signal, varying the current flow. This lets the computer control the solenoid bleed more precisely, allowing it to control pressure.

The one thing that's nearly universal in transmission solenoids is how

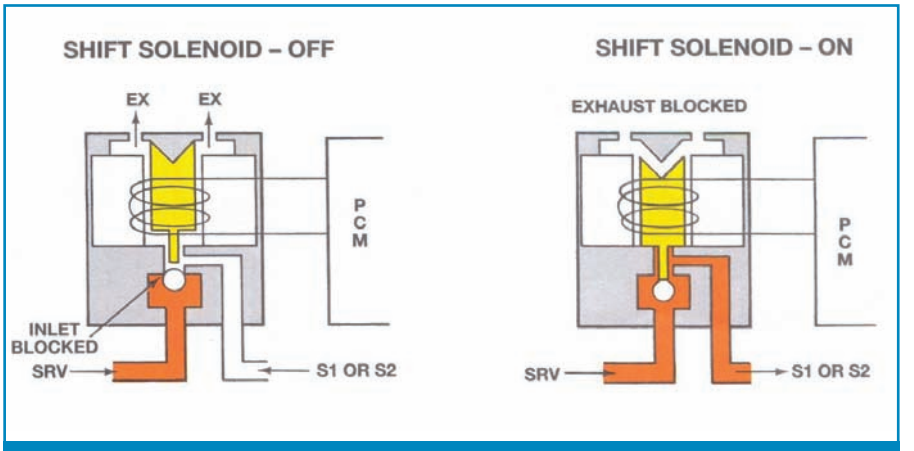


Figure 2: This type of shift solenoid bleeds pressure when open and seals it when closed. What differs between them most often is whether they're normally open and closed when energized, or normally closed and open when energized.

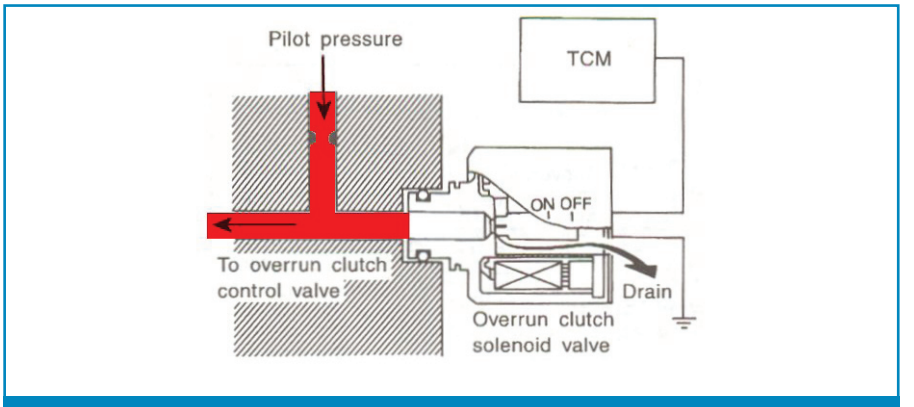


Figure 3: On this type of solenoid, the solenoid valve opens and closes to feed a passage to the shift valve. When the valve opens, pressure strokes the shift valve; when it closes, the pressure bleeds off of the shift valve circuit, allowing the valve to return to the rest position.

manufacturers operate electronic pressure control. In virtually every case, pressure will be high when the solenoid is off (de-energized). The reason for this is simple: If the computer system loses power, the manufacturer wants pressure to rise to maximum; not drop to minimum. That keeps the clutches grabbing firmly, so the trans won't burn up every time a fuse burns out.

What this means is pressure will *increase* as current flow *decreases;* to lower the pressure, the computer increases current to the solenoid.

An important consideration about pressure control solenoids is they tend to have much lower resistance than on/off solenoids. This makes them more responsive to voltage changes, so they operate faster. But this can cause problems if you install the solenoids in the wrong place, or use an older, higher resistance solenoid to replace a lower resistance one.

If the solenoid resistance is too low for the circuit, it could draw too much current. This could set a computer code, or even burn out the solenoid or computer. If the solenoid resistance is too high, the solenoid won't respond quickly enough, and the computer may set a low-current code.

For a detailed explanation of the electrical signals and diagnostic procedures for used for pressure control solenoids, check out these articles at ATRAonline.com, or in your back issues of *GEARS:*

Diagnosing Pressure Control Solenoids, Part 1; October 2003

Diagnosing Pressure Control Solenoids, Part 2; November/December 2003

Diagnosing Pressure Control Solenoids, Part 3; January/February 2004

Identifying and Examining Repetitive Digital Signals; November/December 2004

Current Limiting Pressure Control Solenoids; July 2006

QUIZ

Test Your Solenoid Skills Here!

1. Tech A says a sticking shift solenoid can cause wrong gear starts.
Tech B says incorrect feed pressure to the solenoids can cause wrong gear starts.
Who's right?

A. A only
B. B only
C. Both A and B
D. Neither A nor B

2. Which of these conditions can cause the computer to set an "excessive solenoid current draw" code?

A. A solenoid with too little resistance
B. A solenoid with too much resistance
C. A solenoid with an open winding
D. All of the above.

3. Tech A says a normally open solenoid allows flow whenever it's energized.
Tech B says a normally closed solenoid prevents flow whenever it's energized.
Who's right?

A. A only
B. B only
C. Both A and B
D. Neither A nor B

4. Tech A says on/off solenoids will usually have lower resistance than pulse width modulated solenoids.
Tech B says most shift solenoids are on/off solenoids.
Who's right?

A. A only
B. B only
C. Both A and B
D. Neither A nor B

5. Ground controlled solenoids:

A. usually have two wires.
B. have power applied all the time.
C. are controlled by the computer supplying ground.
D. All of the above.

ANSWERS: 1. C; 2. A; 3. D; 4. B; 5. D