Toyota ABS

There are few things in life more unnerving than hitting the brake pedal and realizing that you're in a slide. Flying down the road like a rudderless frisbee is no fun at all. We're talking dry mouth and sweaty palms.

And if you panic and stand on the brakes at that point, you only make things worse. The vehicle wants to spin, and steering control is lost.

Good drivers will pump the brakes, releasing them every time traction is lost. But what about the inexperienced driver? And what about someone who just plain loses his cool?

ABS (Anti-lock Braking Systems) are now available on many cars. These braking systems monitor the speed of individual wheels and compare those speeds. A computerized control unit then decides if one or more of the wheels is sliding relative to the others and controls the fluid pressure at each wheel through a fluid-controlling actuator.

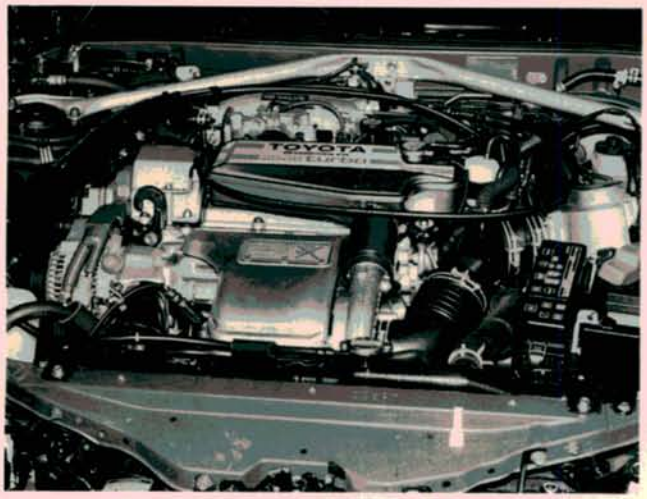
With this system, the wheels rotate and grip, rotate and grip, looking for that lost traction. Directional stability is improved during panic stop conditions as a result.

Limitations?

Under normal driving conditions, the brakes on this Celica function like any other conventional braking system. ABS constantly monitors individual wheel speeds, however, and it is automatically activated when it senses a panic stop.

ABS does have limitations. Don't expect it to pull you out of every jam you get into, especially if you drive like a maniac. Let's face it, the faster you go, the farther you have to go to stop—even on dry pavement. Under driving conditions where traction is reduced you'll need to use some common sense and leave an even greater distance between yourself and the nearest unfriendly object.

It's also important to remember that proper operation of the conventional braking system is essential to proper operation of ABS Linings, brake lines, hydraulic components, and all brake hardware must be in good working order. ABS won't compensate for wear or damage in the normal brake system.



This turbocharged All-Trac Celica doesn't have enough room under the hood for cold air! As a result, Toyota mounted the ABS actuator inside the car at the base of the rear seat.

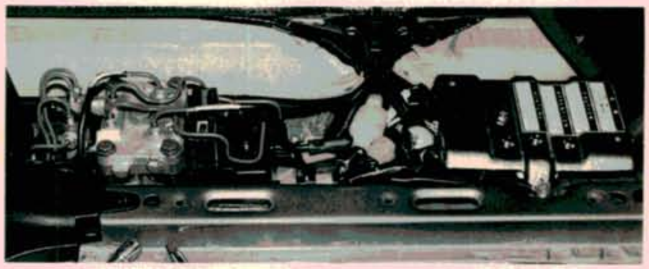
Speed Sensors

The speed sensors used on this ABS system are actually tiny generators. A permanent magnet, a winding, and a metal yoke are mounted near a serrated rotor. The rotor turns with the wheel. The rotor moves past the magnet of the speed sensor, and as the teeth in the rotor pass the sensor, the width of the magnetic field changes. The speed at which these teeth pass the magnet is, of course, determined by the speed of the wheel.

This movement of the rotor past the sensor magnet causes the sensor to give off a small voltage. (In our article on Basic Electricity in the January issue we noted, "Whenever there is a movement of magnetism near an electrical conductor, electricity is produced in that conductor.")

The frequency with which that current is generated is proportional to the speed of the wheel. This electrical message is sent to the computer. This All-Trac equipped Celica has a sensor on each front wheel and a third sensor mounted at the driveshaft.

The driveshaft sensor measures the average speed of the rear wheels. (On the front wheel drive model, each rear wheel has its own separate sensor since there is no driveshaft to the rear wheels.)



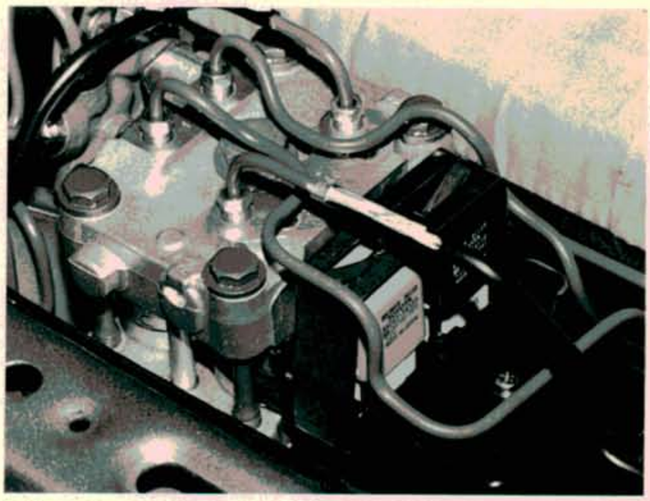
It took some digging to unearth the control center for this system. You have to remove two protective covers to see the actuator (left) and the brain box (right). It's a pain to get at, but at least it's clean and dry in here.

Fluid Control—The Actuator

The computer studies the messages from the speed sensors and decides whether or not any of the wheels is about to lock. Once this determination is made, the computer decides to activate the ABS system. The electro-mechanical link between the computer and the brakes is called the actuator.

The actuator is the most mechanically complicated part of the system. Its main components are:

- **A three position solenoid** which operates to increase, decrease, or simply hold the pressure to a given wheel brake cylinder.
- **A bypass solenoid** which allows brake fluid to bypass the three position solenoid for the front brakes when ABS is not activated.
- **A reservoir and pump** which store any vented brake fluid and return it to the brake master cylinder.
- **A damper** which softens pedal pulsation when the ABS is activated.

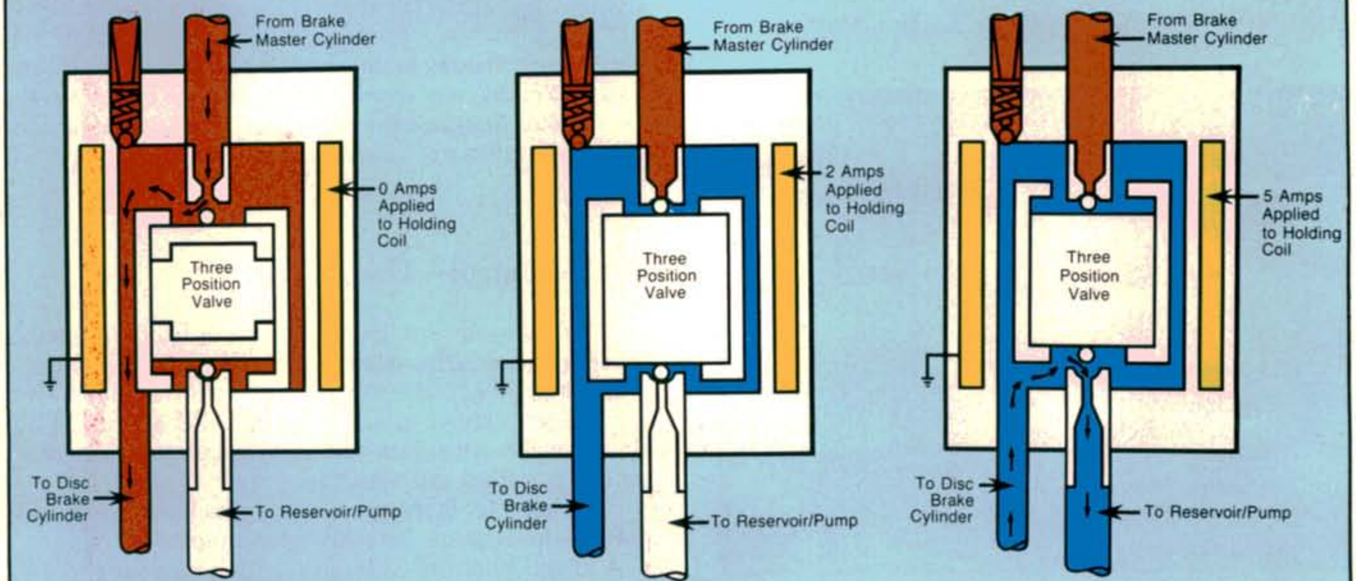


This actuator is not a serviceable component. Parts aren't available, and the repair manual doesn't even discuss its inner workings. The unit is never to be repaired or adjusted in the field. Besides, who wants the liability?

ABS at Work

Let's get down to the nitty gritty and see just how the actuator reacts during normal braking, and how it reacts when ABS is applied.

The following diagrams will give you some idea how the three-position valve routes and reroutes the flow of brake fluid to apply, release, or simply hold the braking on a given wheel. Even though you won't be repairing these actuators, it always helps to understand how something works when diagnosing a specific problem.



Pressure Increase Mode **Holding Mode** **Pressure Release Mode**

Diagram #1

This is the **pressure increase mode.** Hydraulic pressure from the brake master cylinder flows past the open check ball at the inlet side of the valve. Notice that no voltage is applied to the holding coil in the valve, allowing the check ball to open. Fluid pressure passes through a cavity in the valve to the brake line feeding a given wheel cylinder. The brake is applied.

Diagram #2

In the **holding mode,** pressure is maintained in the line to the wheel cylinder. Two amps from the control unit move the valve to close the check balls and trap existing pressure. In this mode, the fluid pressure to the wheel cylinder remains constant and braking to that wheel is maintained at a fixed level.

Diagram #3

This is the **pressure release mode.** The computer has sensed that a wheel is about to lock up. It applies five amps to the holding coil. This moves the valve to its third position. The inlet pressure from the master cylinder is shut off (even though you're still standing on the brake pedal) by the check ball at the inlet side of the valve.

Residual pressure in the line to the wheel cylinder is reduced, however, as the lower check ball opens and vents pressure from that line to a reservoir. A small cam-driven plunger-style pump returns this excess fluid to the master cylinder reservoir. The pump works whenever ABS is activated.

Since the computer is constantly checking for a potential lock-up, the actuator may switch back and forth very rapidly to compensate for changing road conditions.

What If It Breaks?

The ABS computer has self-diagnostic capabilities and will store fault codes when a malfunction is detected in the sensing system. A light will flash on the dashboard, and the computer will disable the system. Since the car has a conventional braking system as well as the ABS system, normal braking is assured. The worst that can happen, with ABS out of the picture, is that you'll fail-safe with the conventional braking system.

Fault codes are flashed by the Anti-Lock warning light on the dash when the ignition is turned on and the two-wire actuator check connector is unplugged.

Malfunction Codes

If everything is okay with the system, the code you receive in the test mode will be a consistent two flashes per second.

If there *is* a problem, the computer will pause for a period of four seconds. The light will then flash rapidly a given number of times, pause and then flash again. The number of rapid flashes before the pause are the first digit of the failure code. The number of flashes after the pause are the second digit. (Three rapid flashes, a pause, and three more rapid flashes will give you a code 33, for example.)

All codes will be two digits long, except when there's a computer problem. In this case the light will simply stay on. If there is more then one fault code, they will be displayed in sequence starting with the lowest number. There will be a pause of two and a half seconds between succeeding faults.

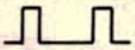
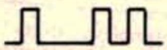
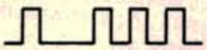
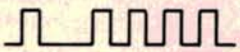
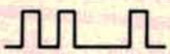
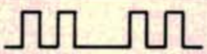
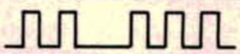
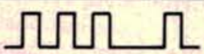
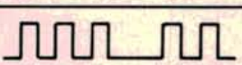
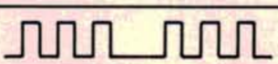
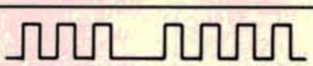
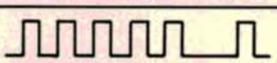
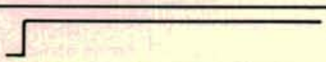
Clearing the Memory

Let's say you got that code 33 from the computer. Let's also say that you replaced the rear wheel speed sensor. (Remember that the code is indicating a malfunction in the signal being received by the computer from a given sensor. Simply replacing a sensor may not eliminate a problem with wiring or a bad connection.)

As a result, we always want to clear the memory and recheck the system after a repair has been made. Unless we clear the memory, the computer will continue to flash a fault code even though we've corrected the problem.

To clear memory, turn the ignition to the on position, disconnect the actuator check connector, and pump the brake pedal at least eight times within three seconds. If the code for normal operation returns, reconnect the test check connector. If the fault code returns, you still have a problem.

—By Ralph Birnbaum

Code No.	Light Pattern	Malfunction
11	ON OFF 	Solenoid Relay Circuit Wire Severed.
12		Solenoid Relay Circuit Wire Shorted.
13		Pump Motor Relay Circuit Wire Shorted.
14		Pump Motor Relay Circuit Wire Shorted.
21		Right Front Wheel 3 Position Solenoid Circuit Wire Severed or Shorted.
22		Left Front Wheel 3 Position Solenoid Circuit Wire Severed or Shorted.
23		Rear Wheels 3 Position Solenoid Circuit Wire Severed or Shorted.
24		Bypass Solenoid Circuit Wire Severed or Shorted.
31		Right Front Wheel Speed Sensor Circuit Signal Malfunction.
32		Left Front Wheel Speed Sensor Circuit Signal Malfunction.
33		Rear Wheel Speed Sensor Circuit Signal Malfunction.
34		Front Speed Sensor Circuit Wire Severed.
41		Battery Voltage Low (9.5V or Lower).
42		Abnormally High Battery Voltage (16.2V or Higher).
51		Pump Motor Locked.
Always On		Computer Malfunction.