



"TRAINING FOR THE PROFESSIONAL TECHNICIAN"

ABS-101

Anti-Lock Brakes

**CARQUEST
Supports**



ABS101v1.0

Student Name: _____

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CTI Mission

Our Mission is to conduct world-class training for professional technicians and automotive repair facility owners offered through CARQUEST Auto Parts stores that will improve their ability to diagnose and repair today's vehicles productively and profitably and to create an enjoyable learning experience while adhering to ASE CASE certification activity standards.

Objectives

When asked, the learner will be able to categorize, and describe the operational theory of the computer controlled anti-lock brakes. The learner will be able to select the correct diagnostic equipment. Upon request the learner will be able to explain the diagnostic procedures and discuss the results of the diagnosis. The learner will also be able to discuss the important maintenance procedures for anti-lock brakes.

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Objectives

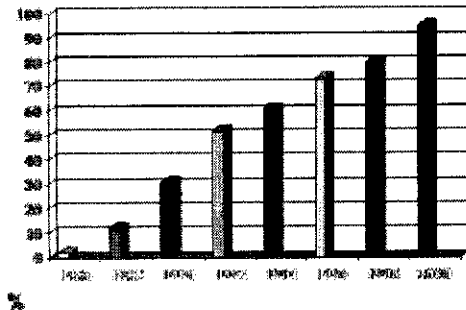
- Introduce you to the:
 - Principles
 - Basic operation
 - Components
 - Diagnostics
 - Service procedures

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Welcome to the anti-lock brake series. This class will introduce you to the principles and diagnostics of ABS brakes.

There are many ABS systems. Before we go into the individual systems, we will cover basic operation, components, diagnostics, and service procedures. It is important to gain a competent level of knowledge before tackling some of the more complicated systems.

ABS is Growing



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Cars & Trucks



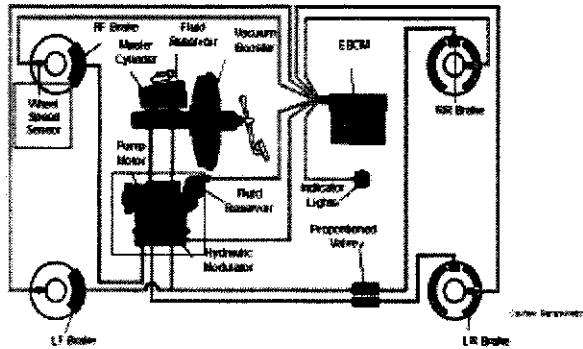
4

NOTES:

Base Brake System



ABS Added On.....



ABS Configuration

- **Integral system**
 - Master cylinder, power booster, ABS hydraulic unit is one system
- **Non-integral system**
 - Master cylinder, power booster, ABS hydraulic unit are separate

In the diagram, you can see the proportioning valve. As a vehicle comes to a stop, the weight is shifted to the front. A proportioning valve compensated for this by reducing the pressure to the rear brakes avoiding lock up. The first ABS systems were just an add on to this system.

There are integral and non-integral ABS systems. Testing the two different systems will be the same. The systems are different, however, when a part must be replaced.

NOTES:

Channels

- There are different type of ABS systems:
 - Rear only ABS
 - Four wheel ABS (three channel)
 - Four wheel ABS (four channel)

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There are different types of ABS systems. One distinguishing factor is the number of channels the system has.

Rear Only ABS

- Rear only ABS systems:
 - Anti-lock protection for rear wheels only
 - Improves straight line control
 - Does not help with loss of steering control
 - Single fluid/pressure channel

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Used mostly on light trucks, the rear only systems control the rear wheels. It is a single fluid/pressure channel system. This system helps the vehicle stop in a straight line, but does not help the driver control the vehicle. This system uses only one speed sensor.

Four Wheel ABS (Three Channel)

- Four wheel ABS (three channel)
 - Anti-lock protection for rear wheels
 - Anti-lock protection for front wheels
 - Helps with steering control
 - Three fluid/pressure channels
 - One fluid/pressure rear channel
 - Two fluid/pressure front channels

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On a three fluid/pressure channel system, the two front wheels are controlled separately. They each have a speed sensor and hydraulic valves. The rear is a single system. This system offers anti-lock protection for all 4 wheels and assists in steering control.

NOTES:

Four Wheel ABS (Four Channel)

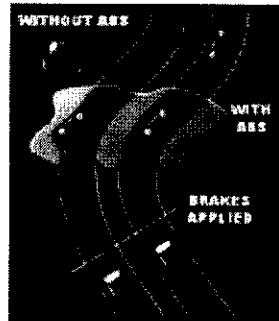
- Four wheel ABS (four channel)
 - Anti-lock protection for rear wheels
 - Anti-lock protection for front wheels
 - Helps with steering control
 - Four fluid/pressure channels
 - Two fluid/pressure rear channel
 - Two fluid/pressure front channels

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On a four fluid/pressure channel system, all four wheels are controlled separately. They each have a speed sensor and hydraulic valves. This system offers lock protection for all 4 wheels and assists in steering control.

Why was ABS Necessary?

- Prevents wheels from locking up
 - Provides steering control



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When the wheels lock up, the vehicle cannot be controlled. ABS prevents wheel lock up and allows the driver to steer the vehicle. Many experienced drivers pump the brakes in a panic stop to avoid having the wheels lock up. ABS does this for you.

Anti-lock Braking

- ABS is not used under normal braking conditions.
- ABS prevents wheel lock-up, providing the driver with steering control.
- A computer controls brake pressure to prevent lock up.

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Pumping the brakes means applying and releasing the pressure to the wheels. The ABS computer controls electric solenoids to do the same thing.

NOTES:

Faster Than Pumping the Pedal

- ABS systems are capable of modulating hydraulic pressure up to 15 times per second.
- Base brake components must be able to apply and release at the same rate.

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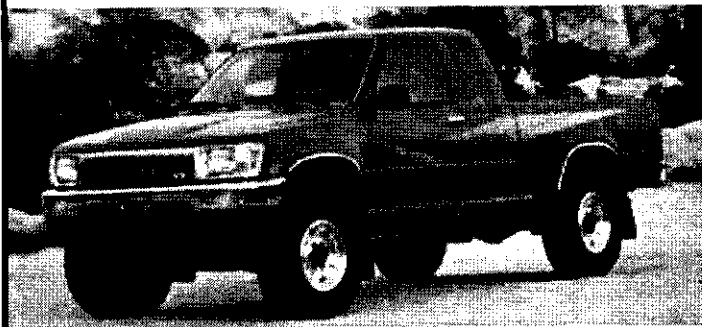
The computer can apply and release the pressure up to 15 times per second. This is much faster than even the best driver can pump the brakes. The basic brake components must be able to respond to the ABS action.

- Worn or fatigued brake components can reduce ABS function.

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In order for the ABS system to function properly, the basic brake system must be in good working condition.

Service Techniques Change



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A technician must know and understand the different service procedures involved when working on ABS equipped vehicles.

NOTES:

Basic Brakes First

- The vehicle may have an ABS problem.
 - Caused by the conventional base brake components

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A basic brake problem can cause an ABS problem. A technician must inspect and test the basic brake components before looking at the ABS system. A wheel may lock up from something simple like oil on the brake surface.

Complete Brake Inspection Includes:

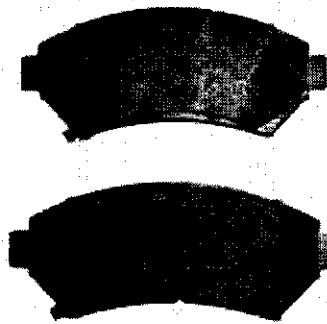
- Correct friction material
- Rotors and drums
- Wheel cylinders and calipers
- Brake fluid
- Wheel bearings (if applicable)
- Adjust wheel speed sensors (if applicable)

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Is something in the basic brake system causing the problem? Taking the time to ensure they are working correctly is important.

Correct Friction

- Semi-metallic
- Organic
- Ceramic
- Shimmed
- Slotted
- Chamfered
- Beveled
- Premium



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Today's vehicles utilize an array of different friction materials. More than once, someone has installed the wrong type of brakes on a vehicle.

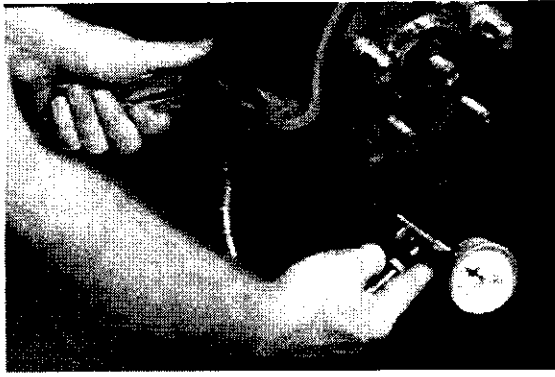
NOTES:



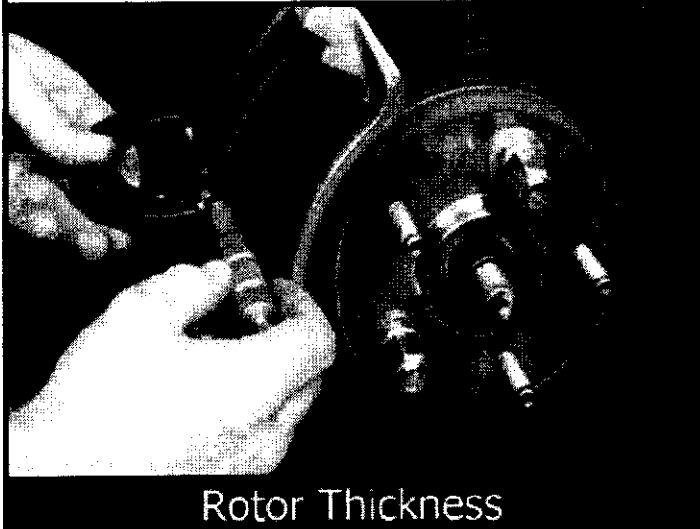
- ✓ Hard spots
- ✓ Pitting
- ✓ Heat checked
- ✓ Bearing noise

Inspecting for pitting, heat cracks, hard spots, and bearing problems will ensure the rotor is not the cause of the problem.

Dial Indicator Will Measure A Warped Rotor



A warped rotor can cause the ABS system to fail.



Rotor Thickness

Never use a rotor that does not meet the minimum thickness requirement.

NOTES:

Rotor Finish

- 50 micron or less surface smoothness
- Sharp cutting bits
- Finish cut
- Lathe integrity
- Do not cut a new rotor



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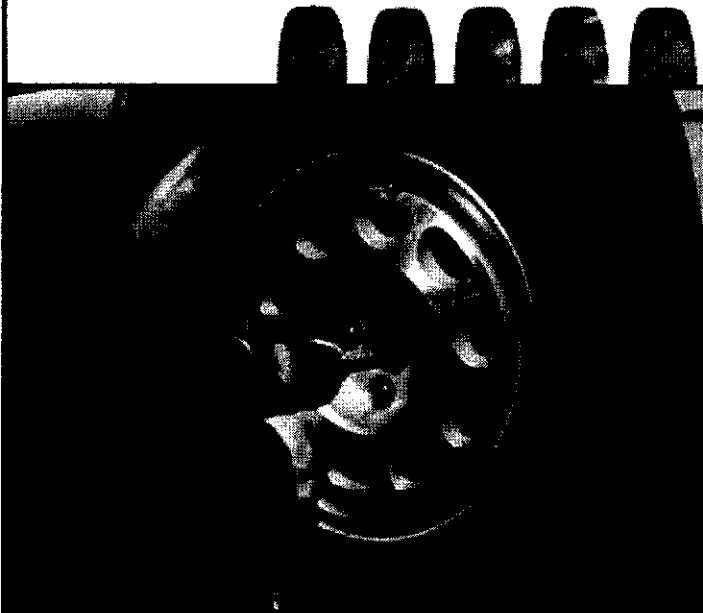
Taking the time to put the correct finish on the rotor is a very critical step.

Tire Size

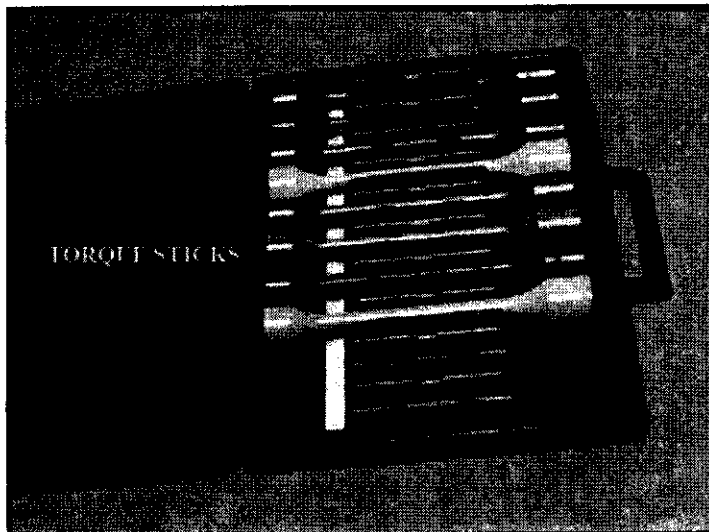
- Replacement tires should be the same size as their originals.
- Tires should be replaced by axle.
- Tire tread affects ABS operation.



When replacing tires, they should be done in pairs. Tires should be the same size as the originals. Tire size variation can adversely affect the ABS operation and may set a computer fault code. Tire tread wear also has an affect on the stopping distance and the vehicle's operation.



NOTES:



Torque sticks allow you to put the correct torque on each lug nut. Improper torque on the lugs can lead to many problems.

ABS Function

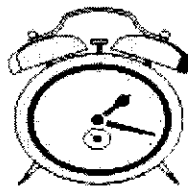
- Monitors brake switch and speed sensor inputs
- If a wheel(s) is about to lock up, the ABS system modulates brake pressure to assist the vehicle in stopping.
- This modulation provides vehicle stability and control.

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A driver monitors the vehicle's speed and applies the brakes as necessary. The computer of the ABS system does the same thing. It monitors wheel speed instead of vehicle speed. It also monitors the brake switch. The computer then pumps the brakes through solenoids to control brake pressure.

The Computer Must Wake Up

- The ignition switch sends the wake-up call to an ABS system.
- The ABS computer then does a self-test.
- The computer goes back to sleep.

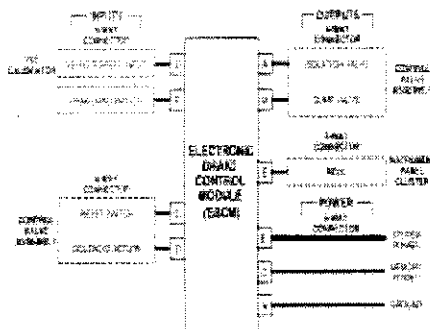


28

When the ignition switch is turned on, the ABS computer wakes up. It will do a self-test. Different systems do different self-tests. After the self-test, the computer goes back to sleep.

NOTES:

Wake Up & Test



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This is a schematic of a simple rear wheel only ABS system. When the computer receives this signal, it becomes active. It will do an internal self-test. If the computer fails the test, it will disable the ABS and illuminate the ABS warning lamp. If it passes the first part of the test, it will continue with the inputs and outputs. If anything fails, the computer disables the ABS system and illuminates the warning lamp. If it passes, it goes back to sleep.

The Brake Switch

- If the brake switch closes, it is seen by the computer.
- The computer wakes up and begins to monitor the wheel speed sensor(s).
- The computer compares wheels.

30

When the driver applies the brakes, the brake switch closes and the computer wakes up and begins to monitor the speed sensor(s).

Pedal Travel Switch

- Some vehicles are equipped with a pedal travel switch.
 - This is a switch that detects brake pedal movement.

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Some vehicles are equipped with a pedal travel switch. It is a simple switch that detects brake pedal movement. When the switch signals the computer, the brake pedal has been depressed and the computer wakes up. The switch is mostly used in conjunction with a hydraulic pump. It is adjustable and is used to alert the computer and turn on the pump.

NOTES:

Back-up switch

- Some vehicles use a switch to back-up the brake switch.

For safety reasons, the vehicle may have a switch to detect brake pedal movement in the event the brake switch fails.

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Switch Testing

Normally Open

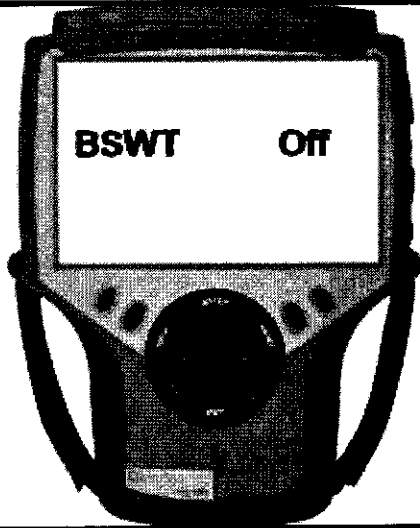


Normally Closed



Switches are tested to see if they will open and close the circuit. Switches are normally open or closed. Use a DVOM for testing.

33



If the system supplies data, you can see the status of the switches on a scan-tool. This computer is reading the status of this brake switch as off. If you step on the brake, the status should change to on.

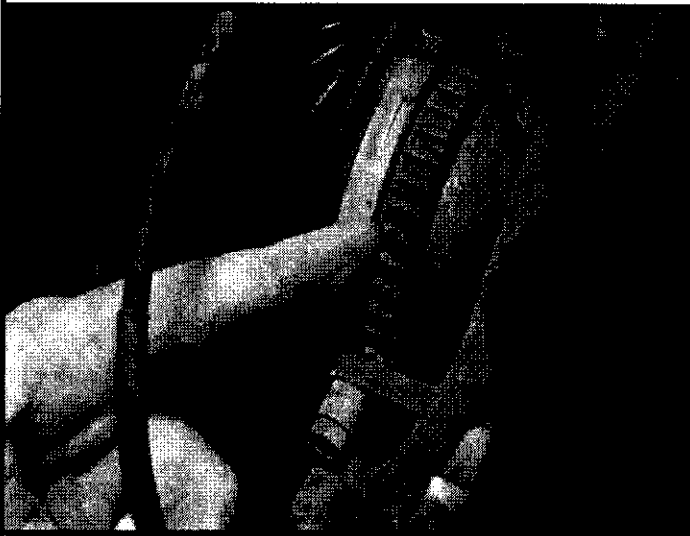
34

NOTES:

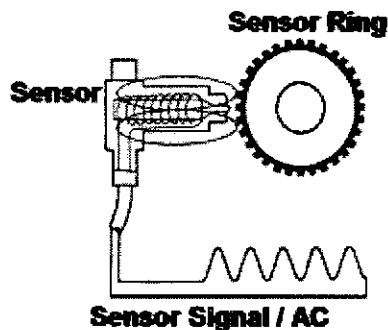
Wake Up & Monitor Sensors

- After the computer wakes up, it monitors the speed sensors.
 - Compares the wheel speeds to each other
 - Compares speed to a program

36



Speed Sensor



37

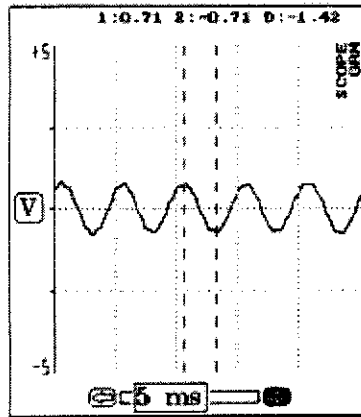
Once the computer has been signaled by a switch, it must prepare for possible ABS action. The first thing is to determine if ABS action is required. The computer monitors the speed sensors and compares them against each other. If one or more of the wheels are slowing down (possible lock-up) faster than the others, the computer applies ABS action to that wheel. If the vehicle is a 1 channel system and has only one speed sensor, the computer compares the signal from the sensor to a computer program to determine if ABS action is required.

After the computer wakes up, it monitors the wheel speed sensors. This is a sensor ring. This one is mounted on the axle assembly. On a 1 channel system, the ring may be mounted inside the differential assembly.

The speed sensor is a permanent magnet type sensor. (PM) wire is wrapped around the magnet. As the magnetic field is interrupted by the sensor ring, AC voltage is induced into the wire. The faster the sensor ring turns, the more voltage the sensor produces.

NOTES:

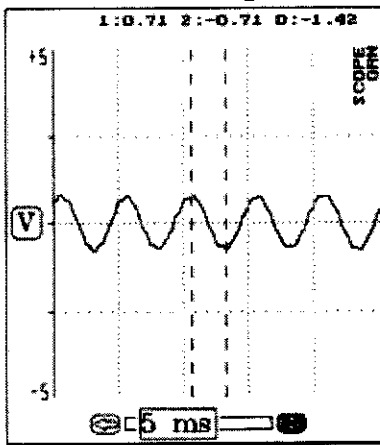
The AC Signal



38

This is a waveform of a wheel sensor where the wheel is being hand turned. A very important characteristic of AC voltage is that it alternates between positive and negative polarities. This signal can be viewed with a DSO for its repetitive shape and to look for any noise riding on the signal. The DSO or a DVOM may be used to look at the amplitude of the signal. The number of cycles the signal completes is measured in frequency. When amplitude and frequency are combined, they show the condition of the sensor.

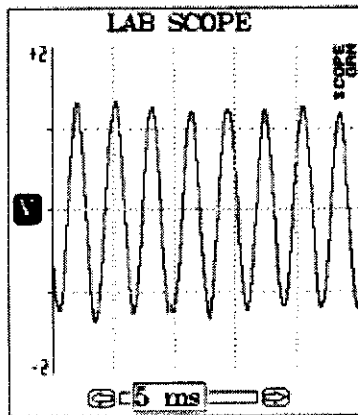
The AC Signal



39

Waveform taken at 15-20 MPH.

The AC Signal

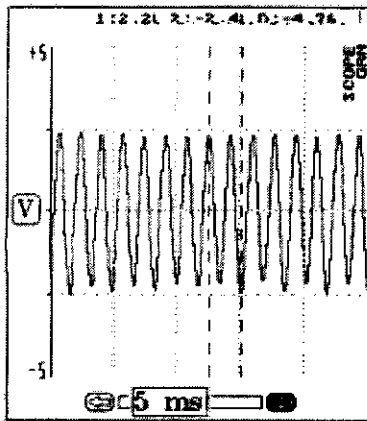


40

Waveform taken at 50-55 MPH.

NOTES:

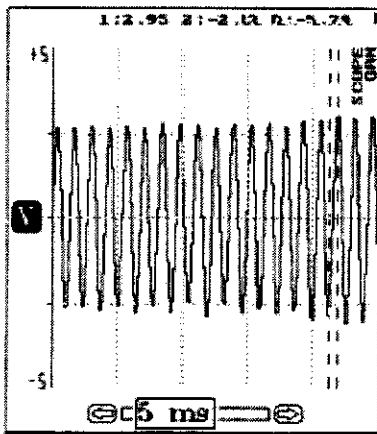
The AC Signal



41

Waveform taken at 60-65 MPH.

The AC Signal



42

Waveform taken at 70-75 MPH.

AC Signal

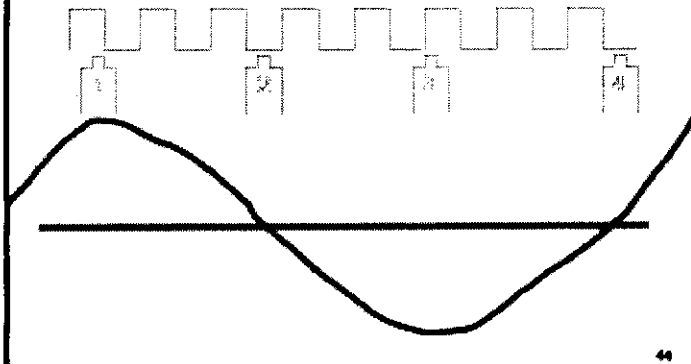
- AC voltage is created by the sensor.
- The amount of voltage is dependent upon:
 - The number of turns of the wire
 - The speed of the sensor ring
 - The air gap

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The sensor is designed to send a specific voltage value at a certain wheel speed. It is engineered with the correct numbers of turns of wire and how many teeth the ring will have. These together determine the output at any given wheel speed.

NOTES:

AC Signal



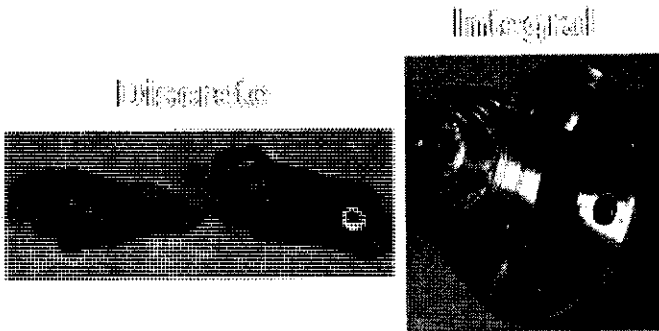
Here we can see that the sensor is creating the signal as the ring moves past it. The relationship between the sensor and the ring builds a different section of the waveform.

Other Factors

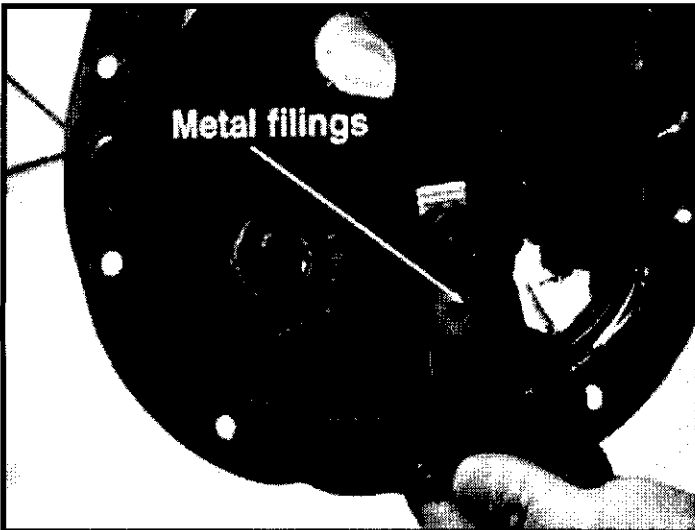
- Cleanliness
- Air gap
- Teeth condition
- Cracked ring
- Run out, wobble or egg shape
- Connections, wiring
- Sensor often replaced unnecessarily

These are the other factors that will affect the signal output of a speed sensor.

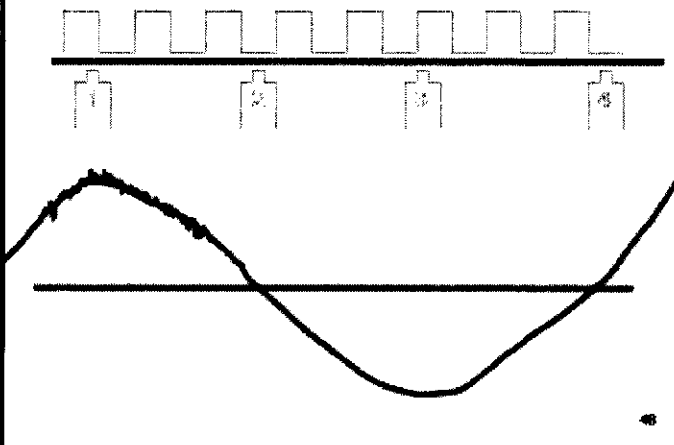
Speed Sensors



NOTES:



AC Signal



If there are metal filings or any other build up of debris on the ring, the waveform will have noise on it, as well as possibly having less output.

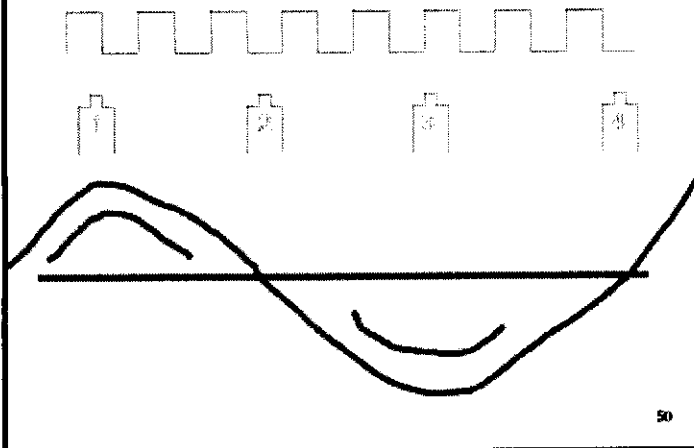
Air Gap Measurement



Here the air gap is being measured. Some sensors are adjustable and others are not. Because the sensor is a permanent magnet, a non-ferrous feeler gauge is used. The teeth of the sensor on this vehicle are in good condition. The sensor would not work properly if the teeth were damaged.

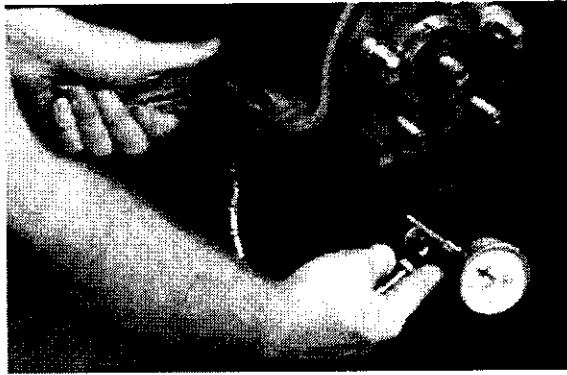
NOTES:

AC Signal



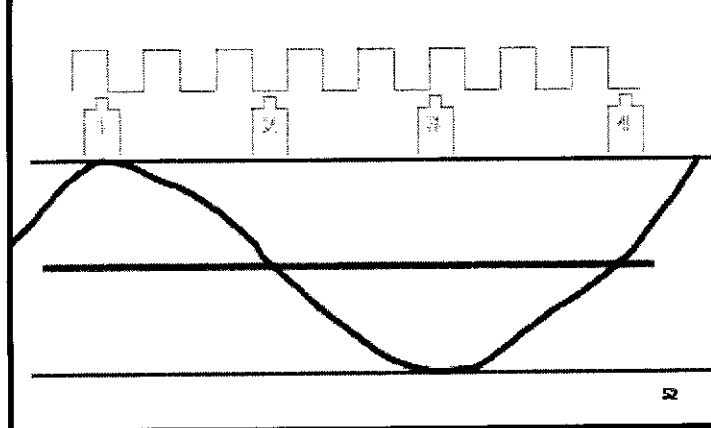
If the distance between the sensor and ring increases, the voltage decreases.

Run Out, Wobble or Egg Shape



Hitting the curb during parking or off-road use may damage the axle wheel assembly. The sensor ring must run true for the sensor to work correctly. As we did with the rotor, run out must be checked.

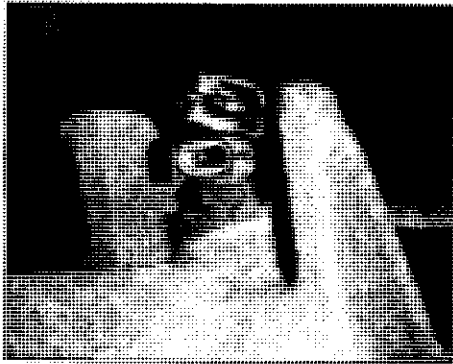
AC Signal



If the ring has too much run out, the peak voltage levels will be different.

NOTES:

Wiring and Connections



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All wiring and connections of the speed sensors must be checked. Because the wiring and connections are under the vehicle, they are exposed to a harsher environment.

Speed Sensor Testing

- Scan-tool
- DVOM
- Digital Storage Scope

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There is more than one way to test the speed sensors. A technician can use a scan-tool, DVOM, or a DSO.

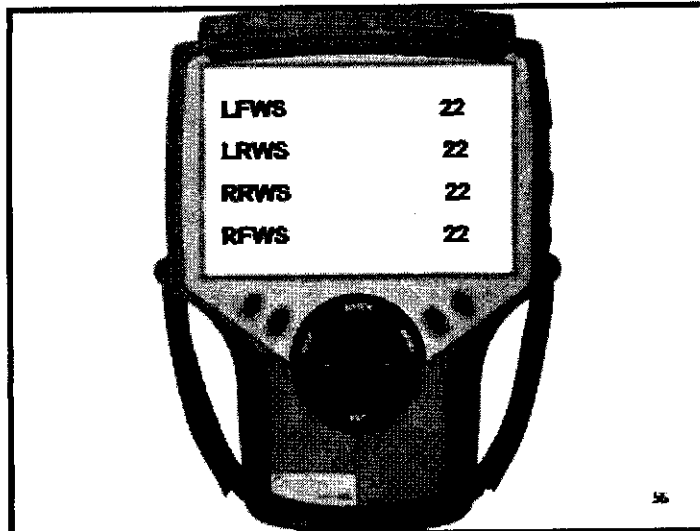
Scan-tools

- Used to:
 - View data
 - Trouble codes
 - Bi-directional control

55

Scan-tools will help you look at the data from the ABS computer, as well as trouble codes. Many of the systems allow you to access bi-directional control.

NOTES:



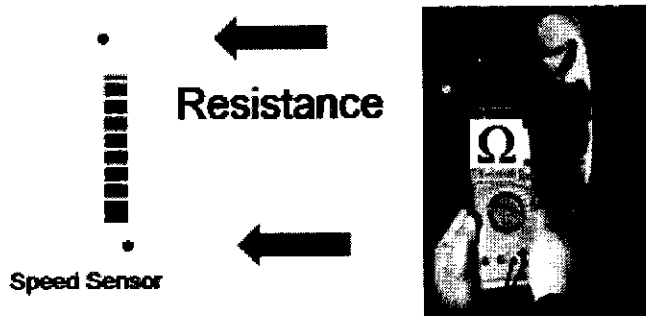
This is a Genisys scan-tool. When you want to look at the wheel speed sensors, this is how the screen would look. Which sensor on the left and the wheel speed in miles-per-hour on the right. The MPH value for each sensor should be the same. The first test is to see if they match the vehicle speed sensor and then are they the same reading. If a reading is different, that is the sensor you want to test.

DVOM Testing

- Measure the resistance of the speed sensor.
- Measure the voltage signal of the speed sensor.
- Measure the frequency of the speed sensor.

When using a DVOM to test the speed sensor, there are three basic tests to make: resistance, frequency and voltage.

DVOM Testing



Use the DVOM to measure the resistance of the speed sensor and compare it to the expected value. This is a static test and is not a complete test for the speed sensor.

NOTES:

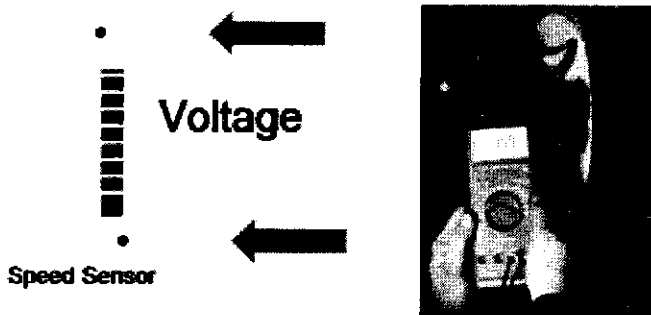
DVOM Testing

- Incorrect resistance:
 - Not within specifications/too low
 - A smaller signal will be created
 - Not within specifications/too high
 - A smaller signal will be created

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If the resistance of the speed sensor is not within specifications, an incorrect signal will be produced. This causes the computer to think that the wheel is turning at a different speed than it actually is. The computer then makes an incorrect ABS action.

DVOM Testing



60

Use the DVOM to measure the voltage output of the speed sensor. This is a dynamic test. Voltage should increase as wheel speed increases.

DVOM Testing



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As the ring is turned faster, the voltage level increases.

NOTES:

Monitors the Speed Sensors

- After the computer wakes up, it monitors the speed sensors:
 - Compares the signal to a program
 - Compares the signal to the other speed sensor's signal

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ABS Action

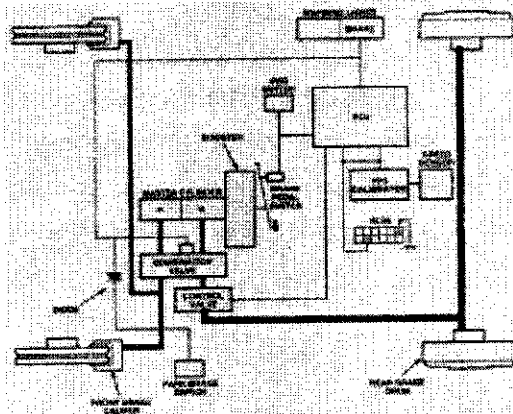
- Isolates the pressure that has been applied to the wheel(s)
- Dumps the pressure
- Allows the pressure to build
- Repeats ABS action up to 15 times a second

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If the vehicle is equipped with only one speed sensor, the computer compares the signal to a program. The engineers program the computer to recognize normal stopping characteristics. If the computer sees other than normal stopping (lock-up), it starts the ABS action. If the vehicle is equipped with more than one speed sensor, the computer will compare them to each other. If one wheel is slowing faster than the others, the computer will apply ABS action to that wheel only.

ABS action is the process of isolating, dumping, and allowing the pressure to build again. This is repetitive up to 15 times a second.

ABS Action

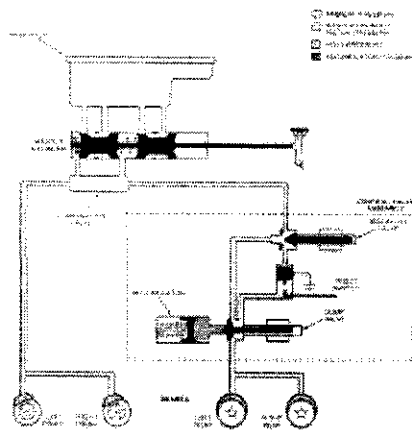


64

This is a common rear only ABS system. It is a simple one channel ABS system. It has one speed sensor. When the computer applies ABS action, both rear wheels are affected at the same time. When ABS action is required, the computer isolates the pressure that has been built up to the rear wheels.

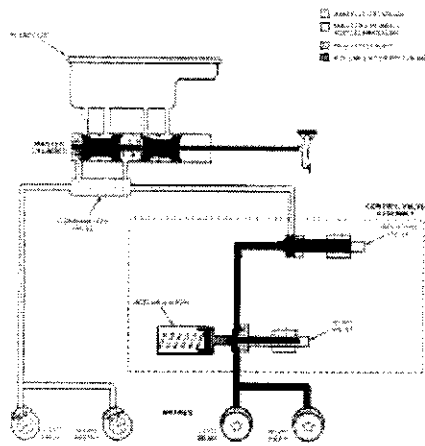
NOTES:

Normal Braking



When the brakes are applied, fluid under pressure from the master cylinder flows through the isolation valve past the dump valve to the rear wheels.

Isolation



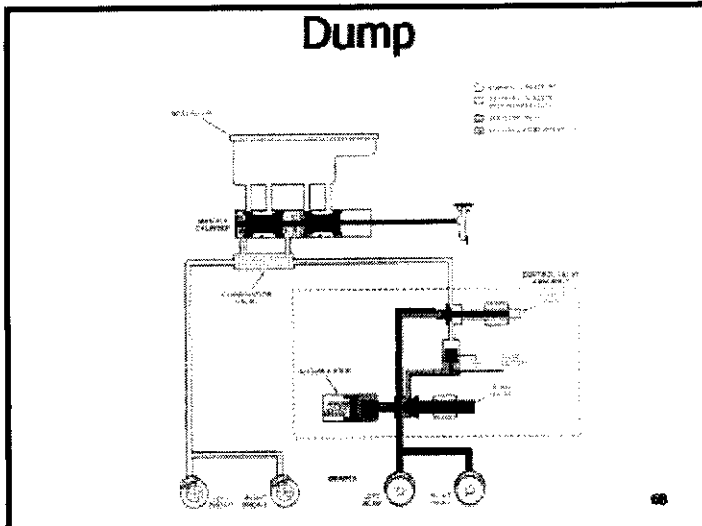
The pressure has been sealed to the rear wheels. The fluid/pressure that was applied by the normal brake system has been isolated by the isolation valve. This is the first step of any ABS action. Stop further build up of pressure in an attempt to keep the wheels from locking up.

Dump

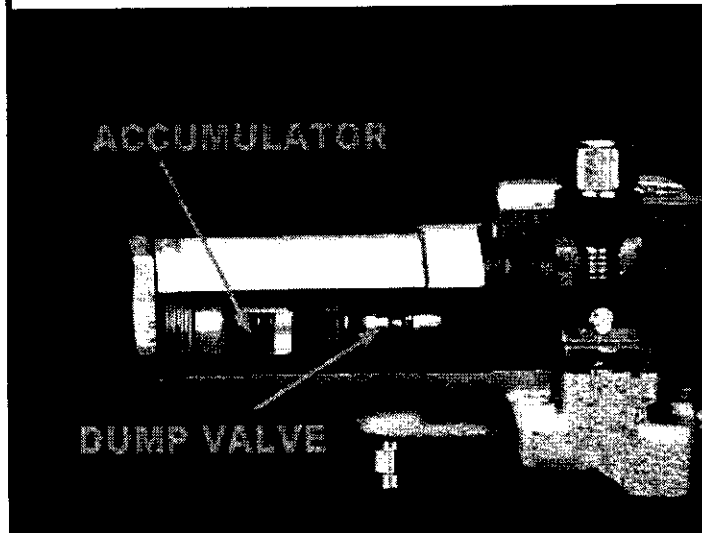
- The computer continues to monitor the speed sensor after it has isolated the channel that controls the wheel that was locking up.
- If the wheel continues to lock up, the computer will dump the pressure to the channel.

After the computer has isolated the wheel that was locking up, it will continue to monitor the speed sensor. If the wheel continues to lock up, the computer dumps the pressure from that channel.

NOTES:



The computer has applied the dump valve and the pressure will bleed off into the accumulator on this system. The isolation valve is still applied. The computer toggles the isolation and dump valve to control the wheel(s).



When the cycle is complete, the isolation valve is open and the dump valve is closed. The spring and piston in the accumulator pushes the fluid past the dump valve seat into the master cylinder channel and the system is ready for another application. At this point, the computer returns to the sleep function.

Accumulator

- Used to store brake fluid under pressure
 - Uses an inert gas and diaphragm
 - Uses a spring and diaphragm

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Accumulators are used in ABS systems to store brake fluid under pressure. Some are high pressure systems with up to 2,500 psi.

NOTES:

Testing Solenoids

- **Electrical test:**
 - The solenoid is ground side controlled.
 - To turn the solenoid on and off, the computer supplies a ground for the solenoid or opens the ground circuit.
- **Mechanical test:**
 - As the solenoid opens and closes, fluid/pressure passes through the solenoid.

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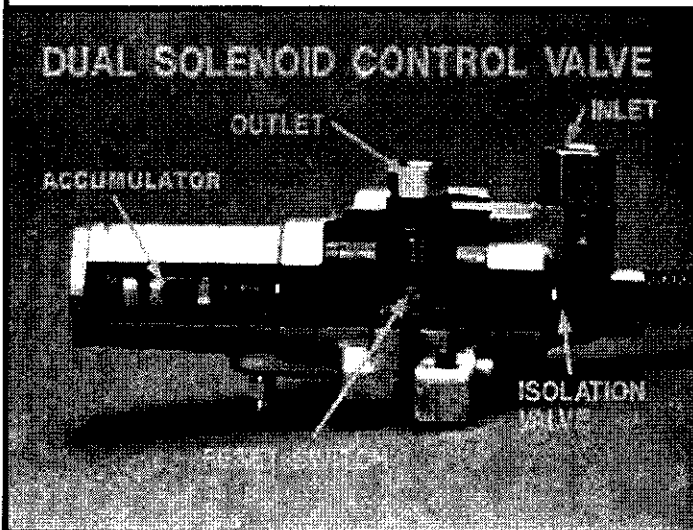
Testing ABS solenoids is no different from testing any other solenoid.

Testing Solenoids

- **Mounted inside a hydraulic control unit**
 - Can be simple to complicated
 - All test the same way

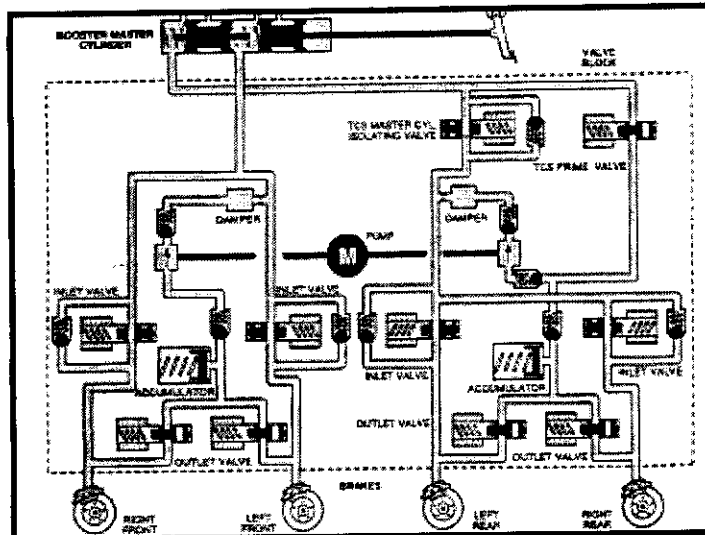
72

Solenoids in an ABS system are not stand alone. They are part of an assembly. There may be one isolate and dump solenoid or four of each.



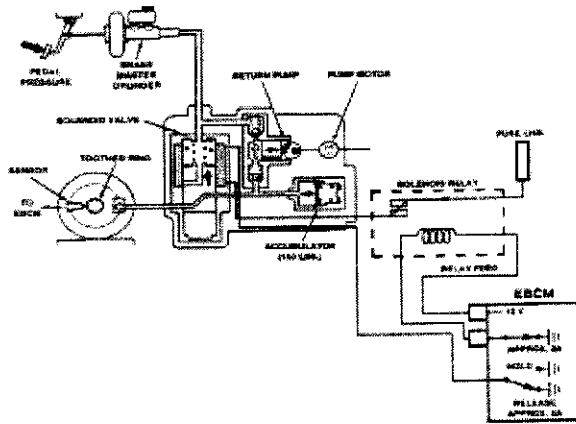
This is a simple unit for a rear only ABS system.

NOTES:

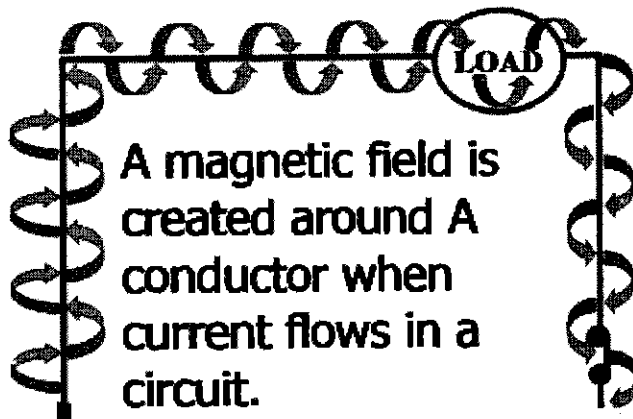


Here is a drawing of a four channel ABS system. This system calls the isolate valves inlet valves. There are four of them. The outlet valves (dump) are also shown. All the valves are inside the control unit.

Testing Solenoids



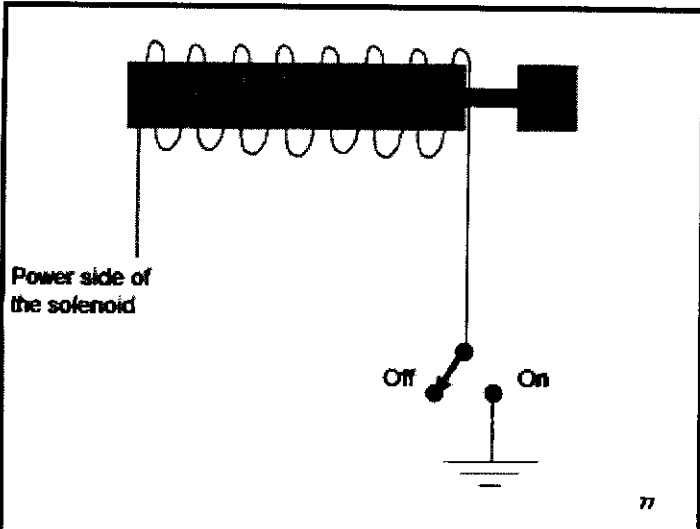
This is a solenoid that is wired to the computer. The power for the solenoid is supplied by a relay. The control side (ground) is wired to a driver inside the computer. When the driver is closed, the solenoid is grounded turning it on.



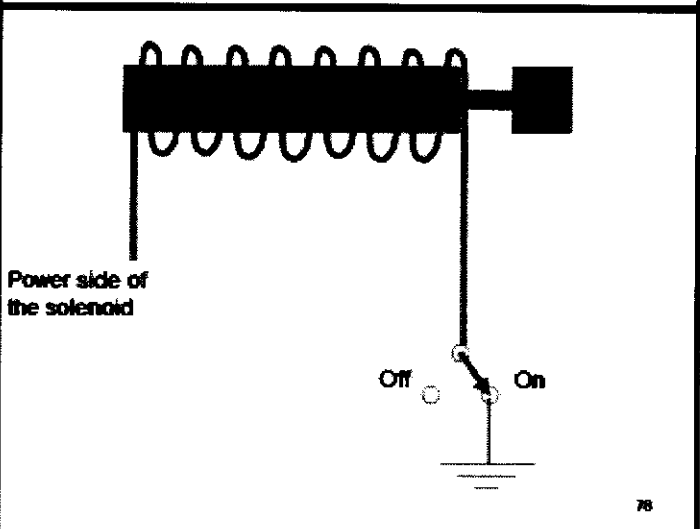
A magnetic field is created around A conductor when current flows in a circuit.

A magnetic field is created around the conductor and the solenoid as current flows through the circuit. The magnetic field causes a valve inside the solenoid to move.

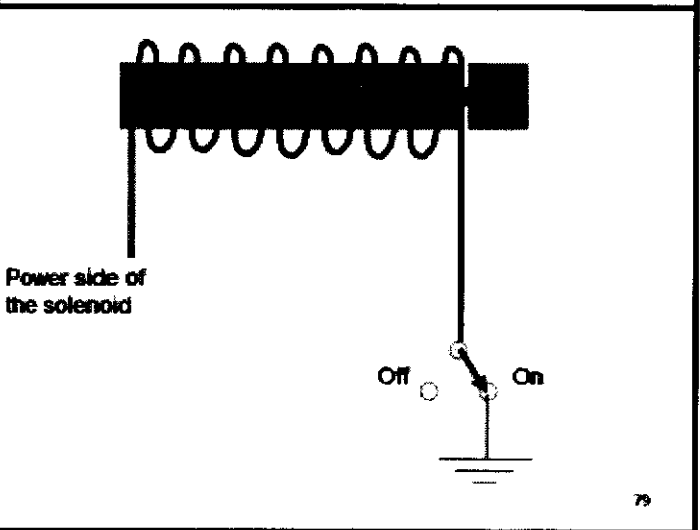
NOTES:



With power supplied to the one side of the solenoid windings and the ground side open, no current flows through the circuit.

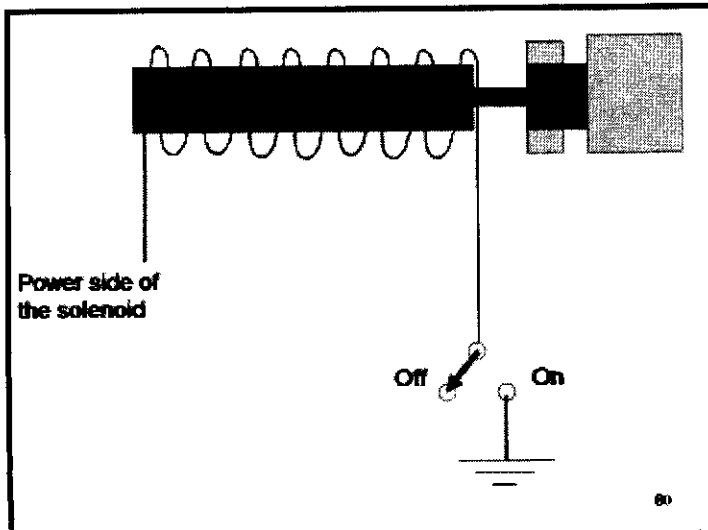


The solenoid becomes an electro magnet when the ground circuit is completed and current flows through the circuit.

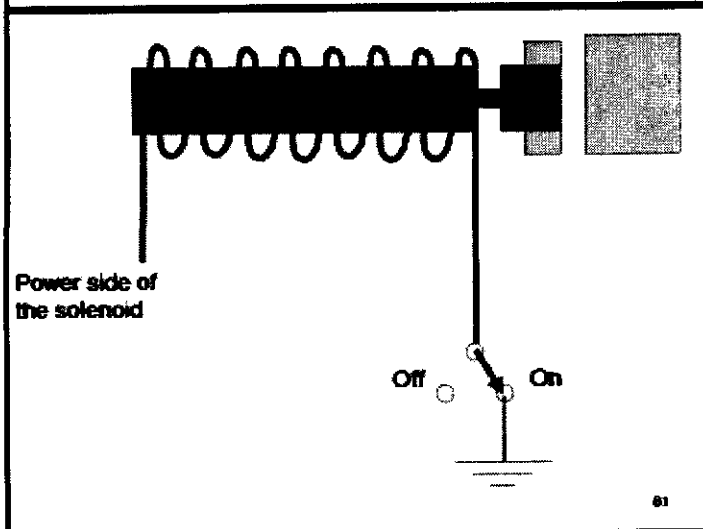


When the magnetic field is created, the valve moves inside to open a passage.

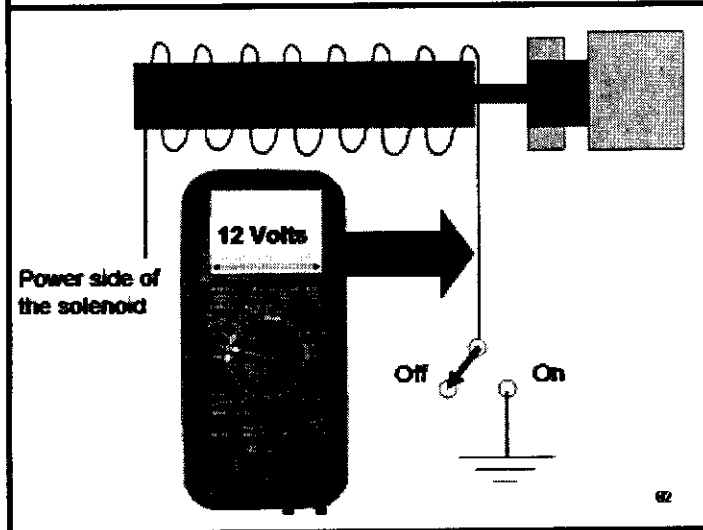
NOTES:



This solenoid is normally closed. No fluid can pass through it.

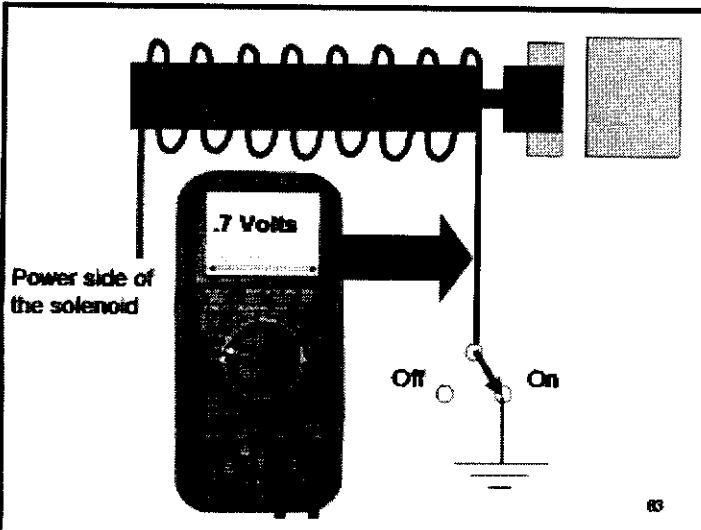


When the solenoid is turned on, the passage is opened and fluid will flow. A normally open solenoid reacts the opposite.

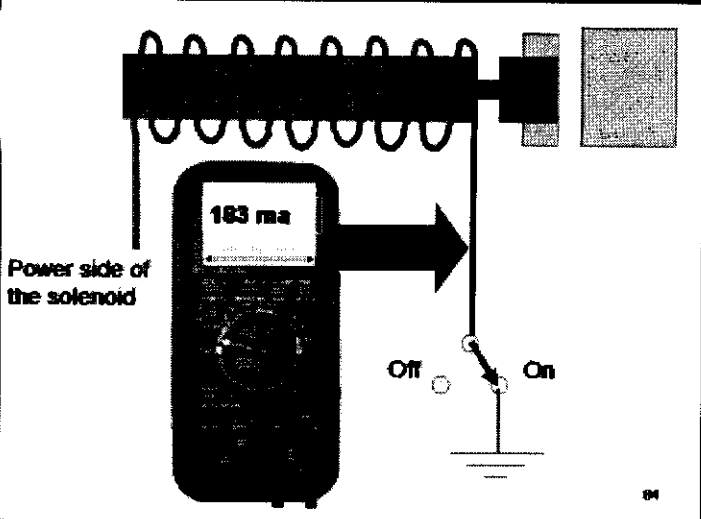


With the solenoid turned off, the voltage at the ground side should be system voltage.

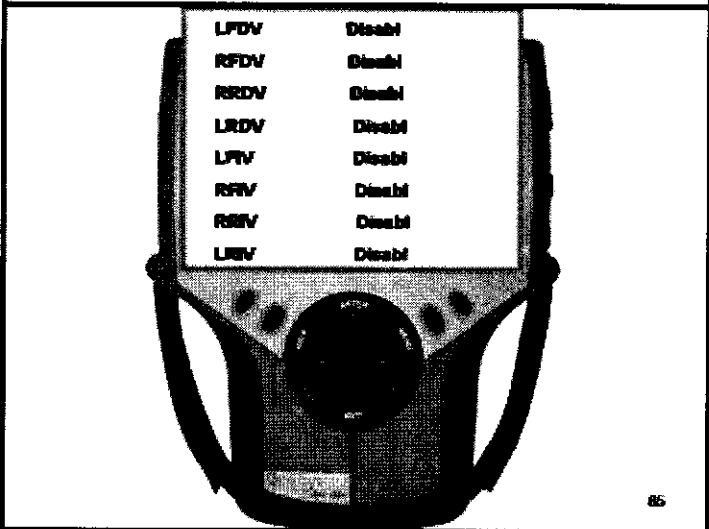
NOTES:



With the solenoid on, the voltage should be below 1 volt. This tests the electrical side of the solenoid and its driver inside the computer.



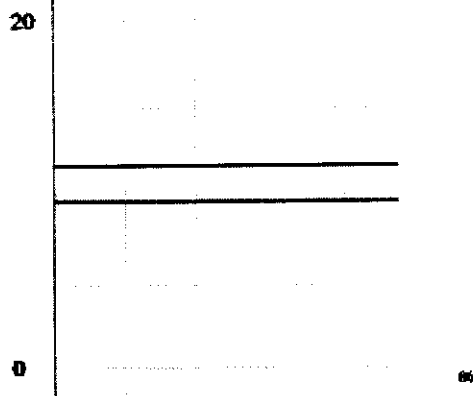
With the same connection to the solenoid, change the DVOM over to the milli-amp function. This turns the solenoid on. The computer supplies the ground to turn it on and that is the same thing that the DVOM is doing. The circuit is completed through the DVOM and measures the amount of current the solenoid is drawing.



On the scan-tool, you can see the valves on the left and the status of the valve on the right. When there is no ABS action, the valves are disabled. The status changes to enabled when the computer is turning the valve off and on controlling wheel lock-up.

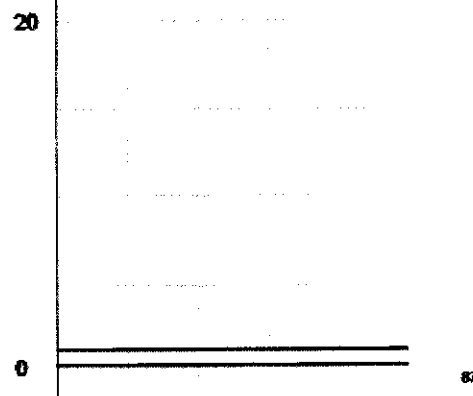
NOTES:

DSO Testing



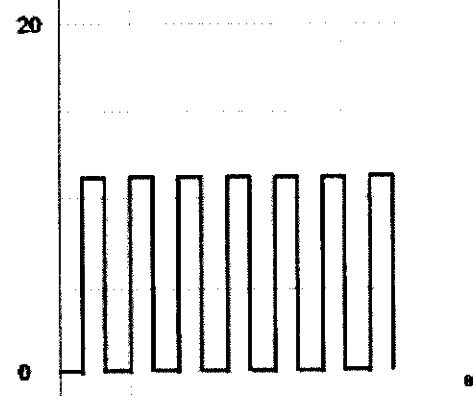
With the DSO connected to the ground (control) side of the solenoid, we view a waveform like this when the solenoid is not on.

DSO Testing



With the solenoid on, the voltage should be near zero volts as seen in this waveform.

DSO Testing



If the computer was cycling a solenoid on and off, we would view a waveform like this.

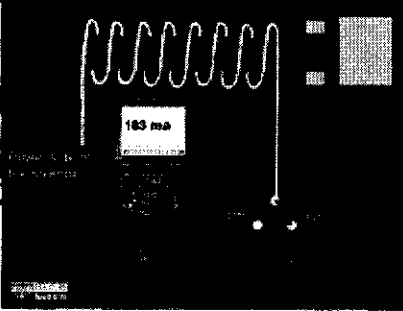
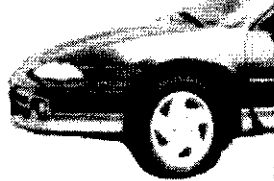
NOTES:

Mechanical Testing

- Fluid must flow through the solenoid when it is on.
- Test with a pressure gauge.
- Activate the solenoids and use the wheel to test.

Isolation Solenoid

Test



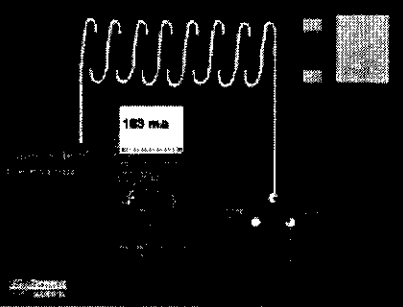
Step on the brake pedal and check to see that the wheel is locked.

Release the brake pedal and the wheel should remain locked.

89

Dump Solenoid

Test



Now activate the dump solenoid with another DVOM or fused jumper lead.

The wheel on that channel should now be free to turn.

90

91

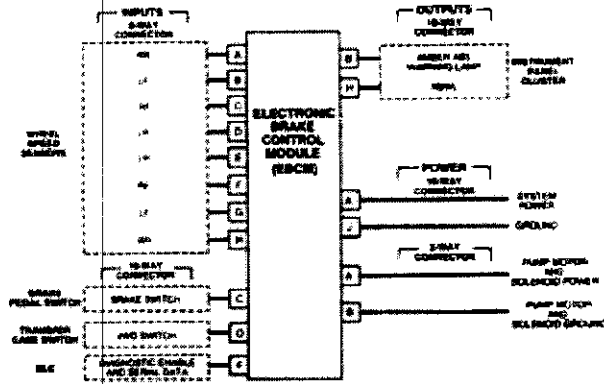
After the electrical side of a solenoid is tested, the mechanical side must be tested.

If you are going to test all the solenoids, place the vehicle on a rack. If you are going to test only one of the solenoids, you can use a jack and lift only that wheel. Have an assistant step on the brake pedal and lock the brakes. Make sure the wheel you are testing is locked by attempting to turn it. Activate the isolation solenoid with a DVOM. Have the assistant release the brake pedal. Attempt to turn the wheel that is on the channel where the isolation solenoid is activated. It should be locked. If it is, this tells you the isolation solenoid for that channel is working properly.

With the isolation solenoid still activated, use another DVOM or fused jumper lead to activate the dump solenoid. The wheel on the channel should now turn freely. This test is done after the electrical side of the solenoid is completed. Repeat the test for all the solenoids.

NOTES:

The Computer



92

The computer receives the inputs and commands the output functions of the ABS system. The computer is programmed with the logic for the ABS system. It performs self-diagnostics of the system and stores trouble codes. On some models, diagnostic trouble codes are lost when the ignition switch is turned off. Other systems keep the code alive so that they can be read.

Kelsey-Hayes RWAL/RABS ABS System

Depending on the manufacturer of the vehicle, they call their ABS system RWAL/RABS. Mostly on light trucks, the ABS system affects the rear wheels only.

93

System Configuration

- Rear wheel anti-lock (RWAL)
 - GEO
 - ISUZU
 - Suzuki
- Rear anti-lock brake system (RABS)
 - Chrysler
 - Ford
 - Mazda
 - Nissan

This is what the different manufacturers call the system.

94

NOTES:

System Configuration

- Prevents lock-up to rear wheels
- System consists of:
 - Conventional brake system
 - Electronic control unit (ECU)
 - Electro-hydraulic control valve
 - A speed sensor
 - Stop light switch
 - ABS warning light
 - On some GM vehicles a digital ratio axle controller or a vehicle speed sensor

95



System Operation

- Ignition on brakes not applied:
 - The ECU performs a self-test of the internal circuits and external circuits.
 - Cycles isolation and dump valve
- If no faults are detected, the system is operational .
- If faults were discovered, the ECU turns on the warning light and disables ABS.

97

Most of the manufacturers use the same components. On some GM vehicles, a digital ratio axle controller or a vehicle speed sensor is used.

Basic components consist of the ECU, which is the electronic control unit - computer; the speed sensor, this may be a wheel speed sensor (WSS) or a vehicle speed sensor (VSS); the digital ratio adapter which is used only with a VSS; and the EHCV, which is an electro-hydraulic control valve.

This system wakes up and performs a self-test as most systems do. If no faults are discovered, the system becomes operational and if faults are discovered, the ECU turns on the warning light and disables ABS.

NOTES:

System Operation

- Wakes up and monitors speed sensor if brakes are applied.
- If the ECU senses a lock-up condition, it will enter into ABS action.
- The ECU continues to self-test and if a fault occurs, it will turn on the warning light and disable ABS.

98

RWAL/RABS remains at rest until the ECU sees the brake switch close. At that time, it will monitor the speed sensor. Using a computer program to determine if lock-up is present, the ECU enters into ABS action. The ECU will continue to perform the self-test and turn the warning light on and disable ABS if a fault occurs.

Electronic Systems

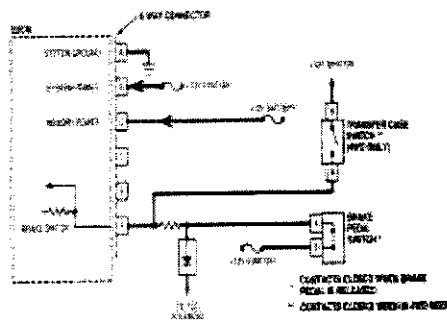
- Powers
- Grounds
- Specifications
- Connections
 - Dirt
 - Corrosion
 - Moisture

99

The electrical system for ABS is common to all computer systems. When testing, starting with powers and grounds will give us our basic information to begin diagnosing. Never replace a component until you are sure it has proper powers and grounds. It is best to use vehicle-specific information when diagnosing.

Power Supply & Protection

- Power
 - Fused ignition switch power
 - Fused memory power
 - Ground
- Multiple codes caused by poor connections



Both ignition switch power and B+ memory power are fused. The ground for the EBCM is critical since it switches the control valves to ground. Poor connections will lead to multiple codes.

NOTES:

System Components

- ECU
 - The logic
 - Control system
 - Diagnostic trouble codes

301

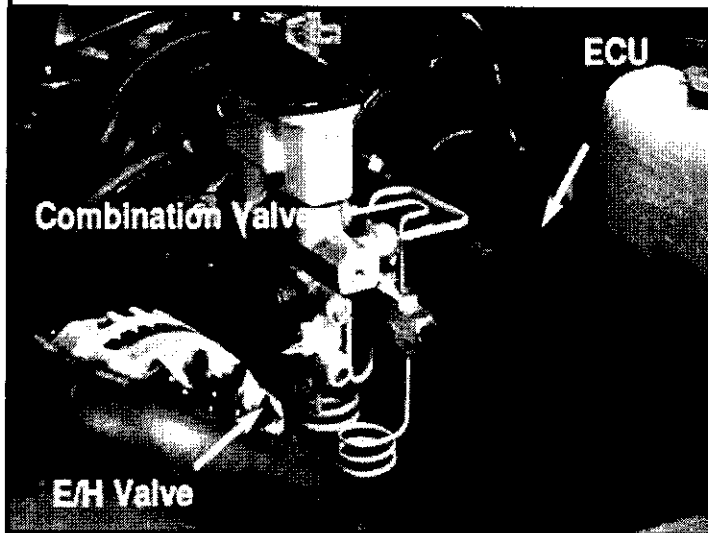
The ECU is the logic and controller of the system. It receives the inputs and makes decisions for the outputs. It has power and ground circuits that must be tested. The ECU performs a self-test and turns on the warning light. It also stores a trouble code if a fault is discovered.

System Components

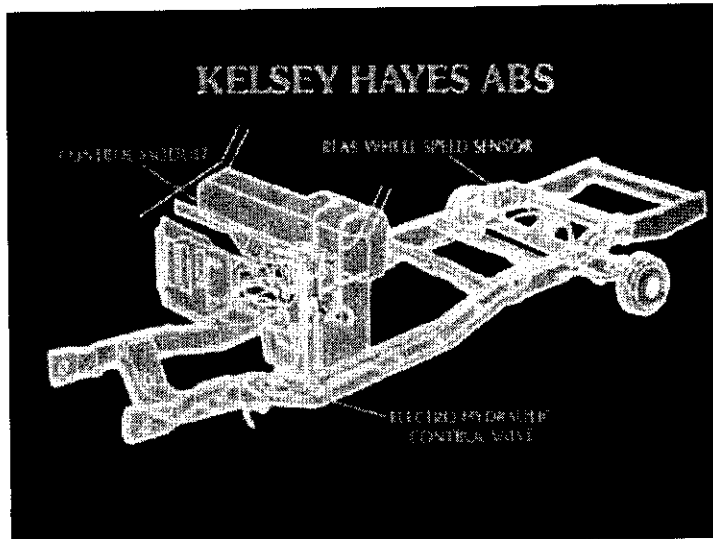
- Electro-hydraulic control valve (E-HCV)
 - Solenoid operated isolation valve
 - Solenoid operated dump valve
 - Accumulator
 - Reset switch

302

The electro-hydraulic control valve is controlled by the ECU. It houses both the isolation and dump valves. The system's accumulator is inside the E-HCV. The E-HCV also has a reset switch.

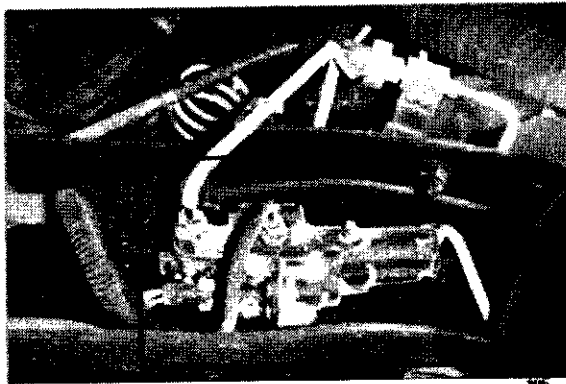


NOTES:



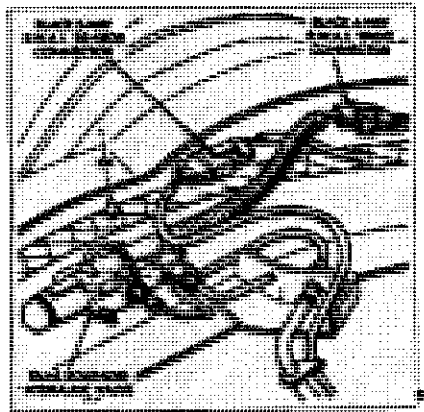
On Ford and Chrysler vehicles, they mount the EHCV on the frame. RWAL systems use a vehicle speed sensor to measure the rate of deceleration to determine wheel lock up. RWAL systems use a single channel hydraulic system to control both rear wheels.

Ford Modulator Valve Location



Ford typically mounts the hydraulic control valve inside the frame, under the driver's seat. Weather and road debris are a factor with the connections

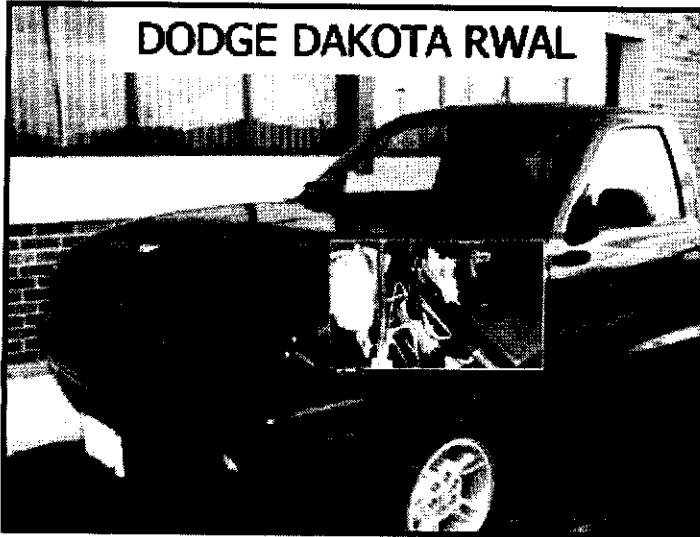
Chrysler & Asian Valve Location



Chrysler mounts the hydraulic control valve inside the frame. Connections are subjected to weather and road debris. Wires can be cut or damaged from gravel.

NOTES:

DODGE DAKOTA RWAL



System Components

- The isolation valve is a normally open valve that has 3-6 ohms of resistance.
- A dump valve is a normally closed valve that has 1-3 ohms of resistance.
 - Keeps fluid under pressure in the accumulator
- Accumulator uses a spring loaded piston
- Reset switch is a 5 volt logic into the ECU
 - Remains open if pressure is equal

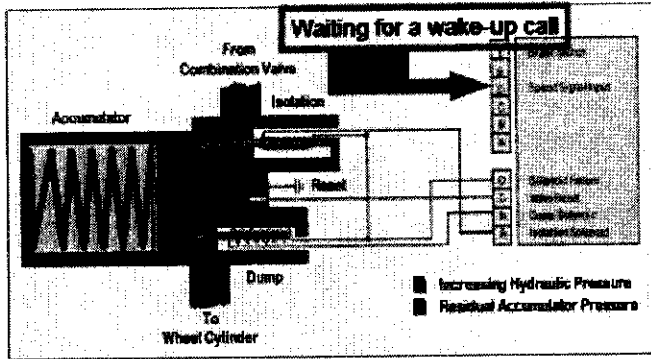
308

Both the isolation and dump valves are solenoid operated valves. Note that the resistance of the valves is not the same. This means that they each draw a different amount of current to operate. They both are common to all ABS systems in their operation. On this system, the dump valve also keeps fluid under pressure inside the accumulator. The accumulator is a spring loaded version. The reset switch is used

by the ECU to determine if pressure is equal on both sides of the valve. If a fault occurs and pressure changes on either side of the valve, the switch closes and the ECU receives a 5 volt signal. It then turns on the warning light and disables the ABS system.

NOTES:

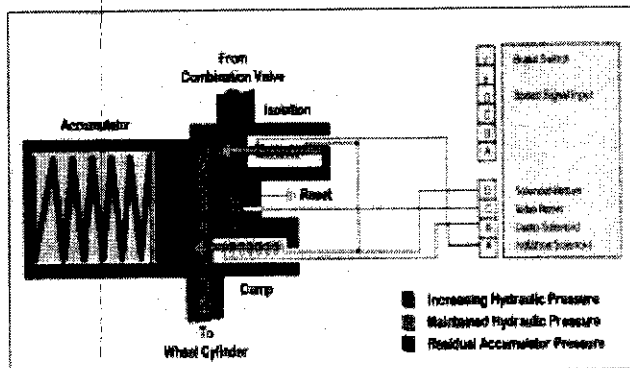
No ABS Action



109

System at rest: the ECU will wake up if it receives a signal from the brake switch, at which time it will begin to monitor the speed signal.

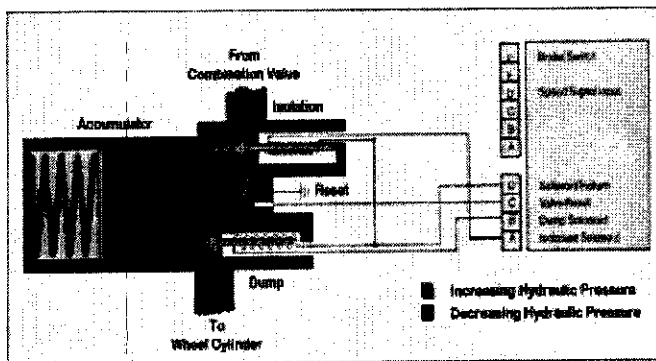
Isolation Action



110

The system has activated the isolation valve. The ECU has detected a possible lock-up and has isolated the fluid/pressure to the rear brakes.

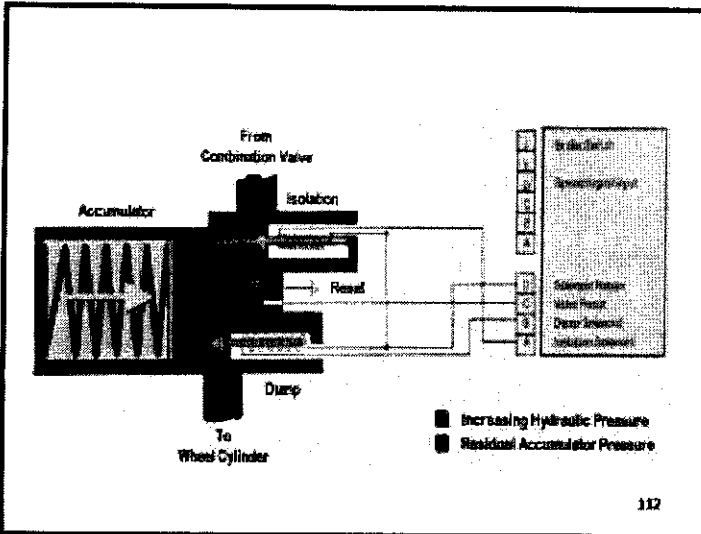
Dump Action



111

The system has activated the dump valve. The wheels are still in danger of locking-up. The ECU has dumped some of the pressure to the rear wheels into the accumulator. If the wheels require more pressure, the dump valve closes and the accumulator supplies additional pressure. If the need continues for additional pressure, the ECU opens the isolation valves. This is the ABS action and may happen up to 15 times a second.

NOTES:



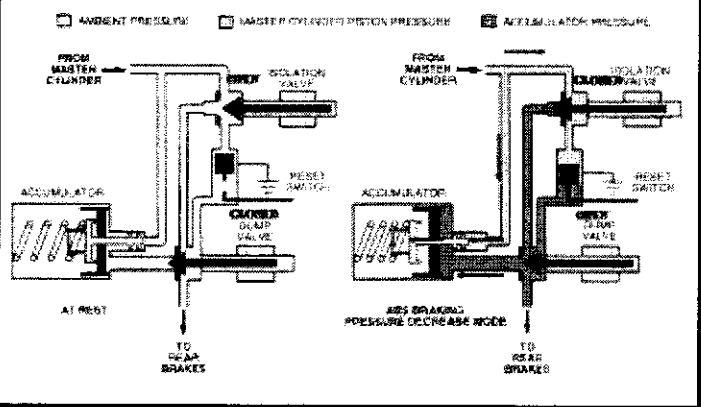
After ABS is no longer needed, the accumulator will bleed down. The spring in the accumulator pushes the accumulator piston, forcing the fluid past the dump valve into the rear brake channel. The dump valve is designed to keep a small amount of pressure in the accumulator.

Modulator Service...

- No service parts available
- Only new modulators, no remanufactured units

If any part of the electro-hydraulic valve is not functioning properly, the unit must be replaced.

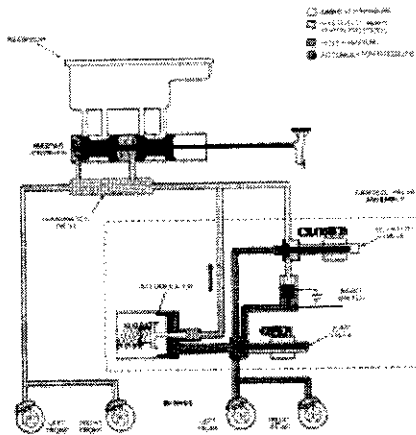
ZP RWAL Control Valve



The zero pressure RWAL is designed with an absence of pressure in the accumulator. Pressure from the master cylinder is diverted to a plunger which protrudes through the center of the accumulator piston compressing the spring. This design is used on heavy duty trucks using disc brakes in the rear. The size of the piston surface area, combined with no springs to retract the friction material, dictates the need for this zero pressure unit.

NOTES:

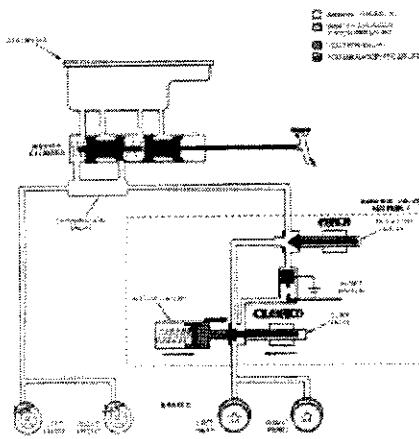
ZP RWAL Pressure Decrease



115

Since there is no spring pressure to overcome on the accumulator piston, and the dump valve is open, the fluid in the wheel channel is relieved of all pressure.

Accumulator Bleed-down



116

When the cycle is complete, the isolation valve is opened, the dump valve is closed, the reset switch is in the neutral position. The spring and piston in the accumulator pushes the fluid past the dump valve seat into the master cylinder channel and the system is ready for another application.

System Variations

- ZP RWAL
- VCM = Vehicle control module
- EBCM = Electronic brake control module

RWAL
BLACK COLORED
CONNECTOR TOP



RWAL

—IMPORTANT—

ZPRWAL
GREY COLORED
CONNECTOR TOP



ZPRWAL

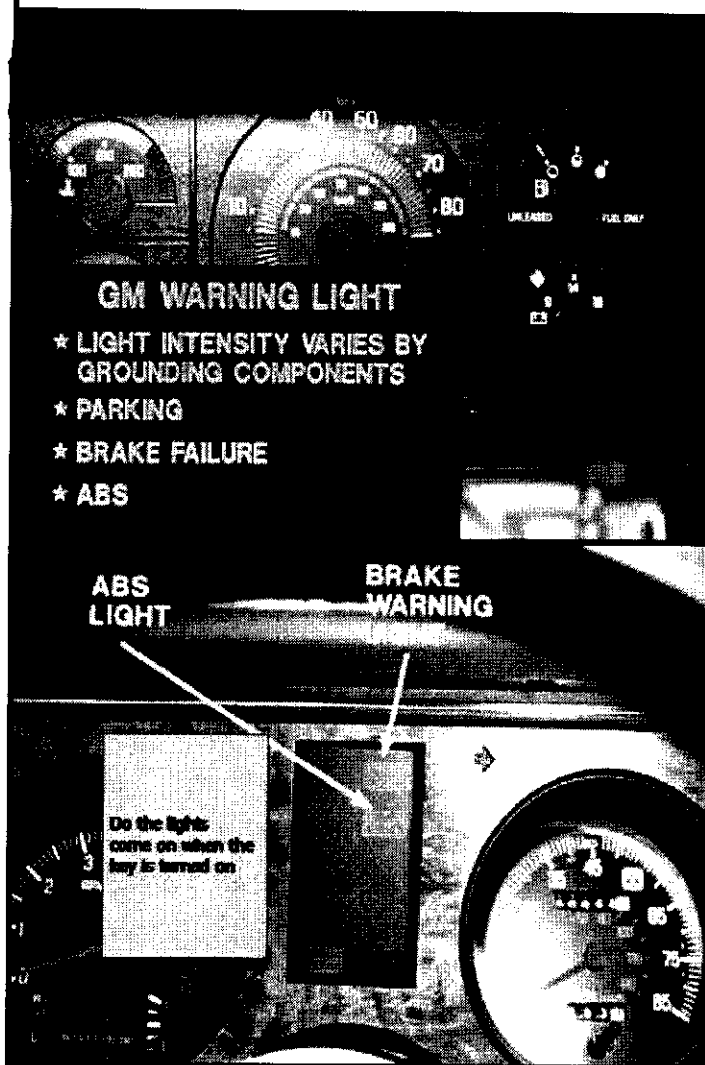
Larger vehicles with rear disc brakes use ZP RWAL valves and control modules. They operate in an identical manner to the conventional RWAL, except for the dump valve phase. The controllers are not interchangeable. Some vehicles use a VCM (vehicle control module) that performs the same function as the EBCM (electronic brake control module).

NOTES:

System Components

- Brake warning light illuminates if:
 - Parking brakes are applied
 - Hydraulic failure with basic brakes
- Some vehicles have an ABS warning light.
 - The ECU illuminates the warning light and disables the ABS system.

118



There will be one or two lights used with this system. A red brake light or an amber ABS warning light.

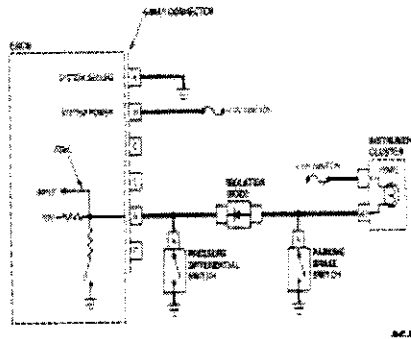
On early GM trucks and some cars, they do not have an amber brake warning light. The intensity of the red light is used to indicate a system failure or warning. The light is the brightest when the parking brake is applied. Check to see if the parking brake is applied. The light is less bright when a base brake fault is detected. Disconnect the pressure differential switch. The light is the dimmest when an ABS fault is detected. If the light is still on, there is an ABS problem.

When the ignition switch is turned on, the EBCM goes through a self-test. Part of that test is checking the brake warning lights. The bulbs should light up and then turn off, indicating that the ABS system and base brake system have no faults. If the bulbs stay on, there is a problem. If the bulbs do not come on, the system needs to be checked out to determine why.

NOTES:

Red Brake Warning Light

- Lights when
 - Parking brake
 - Pressure switch
 - Key on
 - ABS fault
 - Self-diagnostics



System Components

- Brake switch:
 - Used as an input for the ABS system
 - 12 v to the ECU if the brake switch is open
 - Less than 1 volt if the switch closes
 - This wakes the ECU and it monitors the speed sensor
 - Zero volts from the switch will set a trouble code for the switch

122

The red brake warning light is turned on when the parking brake is applied. It is also turned on when the pressure differential switch is closed. When the key is turned on, the light will come on during a bulb test or if there is an ABS fault. The red light is also used for self-diagnostics.

System Components

- Four-wheel drive switch
 - On 4X4 wheel drive vehicles
 - Open when the vehicle is in 2 wheel drive
The ECU sees 12 volts from the switch
 - Closes if the vehicle is in 4 wheel drive
The ECU sees less than 1 volt
 - Mounted in the transfer case

123

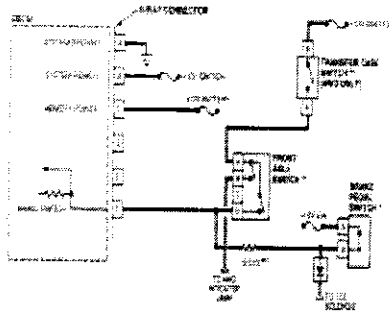
The brake switch is used by the ECU to prepare for ABS action. If the ECU sees 12 volts on the brake switch circuit, it goes into rest mode. If the ECU sees less than 1 volt on the brake light circuit, it wakes up and monitors the speed sensor. If the ECU sees 0 volts on the brake light circuit, it will set a trouble code for the light.

The ECU will disable ABS if the vehicle is placed into four-wheel drive. A switch mounted in the transfer case closes when four-wheel drive is selected.

NOTES:

Brake & 4 WD Switches

- Brake switch signals EBCM
- Four wheel drive switch disables ABS



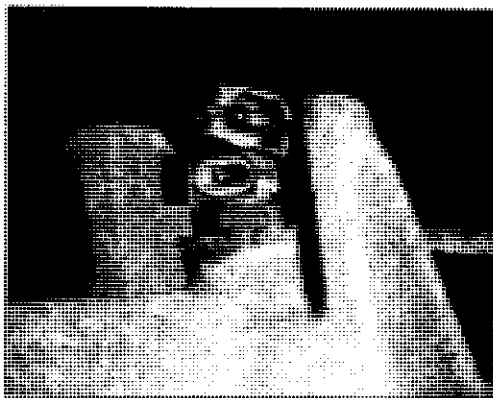
When the brake is applied, the brake switch signals the EBCM that the vehicle is in the stopping mode. In this case, the voltage at terminal F drops to zero, since the circuit is open. When the vehicle is in the four wheel drive mode, the EBCM disables the system.

System Components

- Speed sensor
 - Mounted to the:
 - Output shaft of the transmission
 - Output shaft of the transfer case
 - In the rear differential housing

This system has a common speed sensor. The difference is that there is only one. It is mounted differently in different vehicles. Because the ECU controls the wheels with one channel, only one speed sensor is needed.

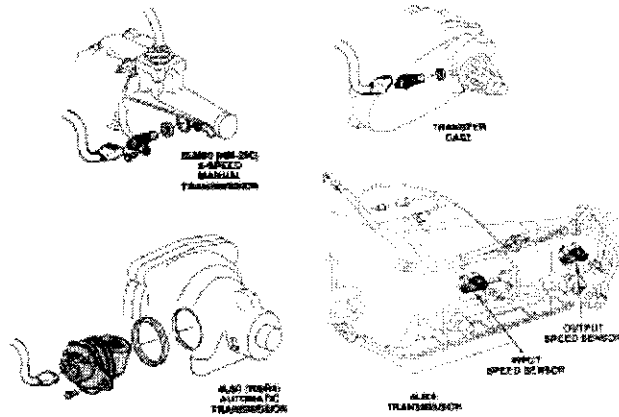
Ford Speed Sensor Location



Ford and Chrysler mount their vehicle speed sensor on the top of the differential. This location is subject to weather and road debris. Connection must be tight and dry.

NOTES:

Speed Sensor Locations



GM uses transmission and transfer case locations for their vehicle speed sensor mounting. If the vehicle is four wheel drive, they will locate them in the transfer case, otherwise they are in the transmission housing.

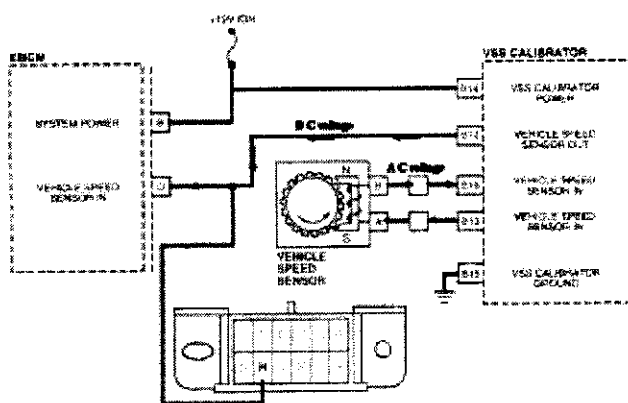
System Components VSS Calibrator

- Digital ratio axle controller (DRAC)
 - GM uses a DRAC
 - Pre-processes speed sensor signal
 - Calibrated for specific tire size and axle combinations
 - Changes the AC signal of the speed sensor to a digital signal

The digital ratio axle controller receives the AC signal from the speed sensor and changes it into a digital signal before sending it to the ECU. These are used on GM vehicles. The unit calibrates tire size and axle combinations for the ABS controller.

128

VSS Calibrator

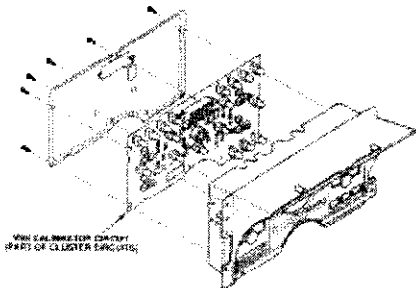


VSS produce an AC voltage. When measuring output at the sensor connection, be sure your DVOM is set on AC voltage. When measuring output at the EBCM terminal, be sure your DVOM is set on DC voltage. Since the VSS signal is of low impedance, it does not use the chassis for ground.

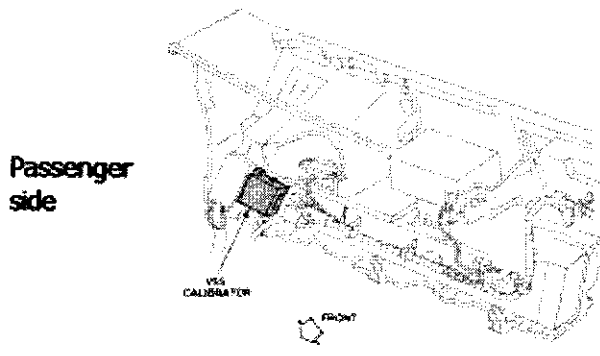
NOTES:

VSS Calibrator 88-91 C/K Series Trucks

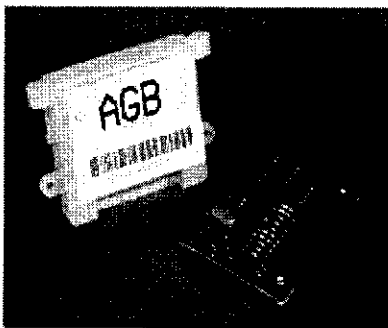
- Change tire size
- Must change calibrator



VSS Calibrator S/T series truck



VSS Calibrator



If the tire size has been changed, the speedometer and odometer calibrator must be modified. The exact procedure is outlined in the ABS service manual and is different by make and model.

The location of the calibrator on the S & T series trucks is on the passenger side of the instrument panel.

When changing calibrators, be sure to use caution when handling since static electricity can ruin them. Use a wrist static ground strap connected to the vehicle to neutralize any static charge. Refer to the manual for proper procedure in replacing the calibrator.

NOTES:

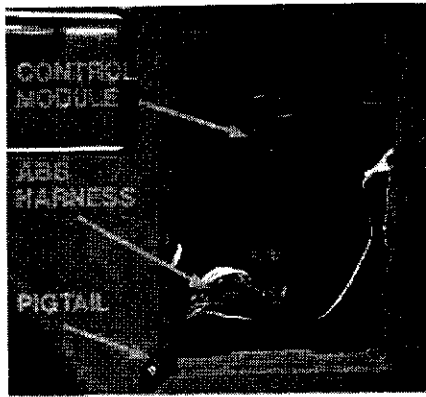
Trouble Codes

- If a fault is found during a self-test, the ECU will store a trouble code.
- Code retrieving:
 - Chrysler momentarily grounds the diagnostic connector located by the computer (tied to the harness)
 - Count flashes of ABS amber lamp

133

Trouble codes point you in the direction the ECU thinks the problem is. Do not replace a component because it has a code. A code indicates that the component requires testing. Retrieving codes will be different for different vehicles.

Flashing Ford Trouble Codes Chrysler & Asian Similar

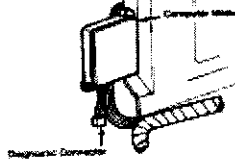


134

On Ford, Chrysler and some Asian vehicles, the procedure calls for grounding out a lead from the EBCM and watching the ABS light flash. After grounding the wire momentarily, disconnect it. You can save a lot of time by looking up the location of the wire in your service manual.

Code Retrieving

- Ford momentarily grounds the diagnostic connector located by the computer (tied to the harness)
 - Count flashes of ABS amber lamp
- Diagnostic connector not always a connector alone, sometimes in a harness



NOTES:

Code Retrieving

- GM jumper A to B in the diagnostic connector
- Others jumper H to A in the diagnostic connector
 - Jumper must be in place for at least 20 seconds before codes will flash.
 - Watch the ABS amber light if equipped or the brake warning light
- Can use a scan-tool to retrieve codes

136

Code Retrieving

- Imports
 - Momentarily ground the diagnostic connector located by the computer (tied to the harness).
 - Count flashes of ABS amber lamp.

137

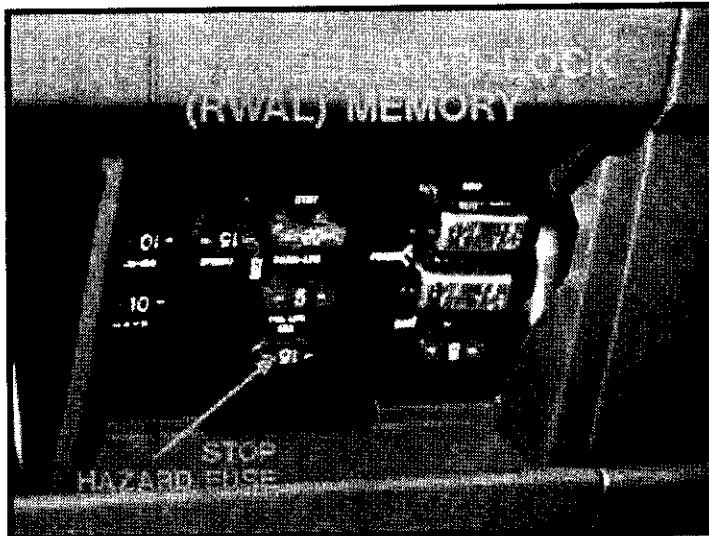
Clearing Trouble Codes

- Manual procedure - remove fuse, disconnect battery, key/drive cycles
- Scan-tool

138

Procedures to clear trouble codes vary by make, model, and year. Older models have less diagnostic capabilities and were simpler to access and clear. In order to save time, we suggest you refer to the service manual for the exact procedures on the vehicle you are working on. Using a scan-tool will help clear them quickly.

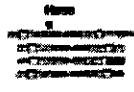
NOTES:



On older models, clearing the trouble codes from the ECM can be as simple as pulling the stop hazard fuse.

Hydraulic Systems

- Void of air
- Proper fluid
- Clean fluid
- No leaks



140

Before diagnosing the ABS system, make sure the basic brake system is not the problem. Common to the above is the brake fluid. It must be clean. When doing brake jobs, the flushing and replenishing of the fluid is often overlooked.

Brake Fluid Is Hydroscopic

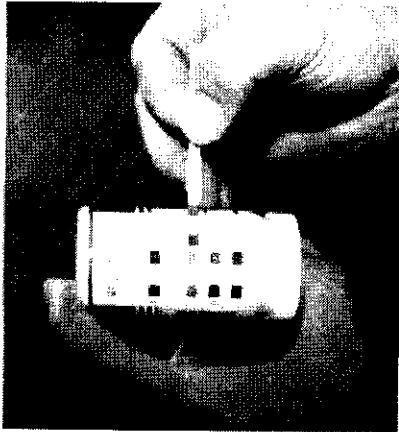
- Absorbs moisture
- Any contamination can keep the solenoids from operating
- Test
- Drain
- Flush
- Refill

Brake fluid is hydroscopic. That means it absorbs moisture. When it becomes saturated, it can no longer absorb moisture build up. The valves in the ABS system are very small. Any contamination can keep them from working. It is important to explain this to your customers when you are doing a brake job on their vehicle if it has ABS.

141

NOTES:

Brake Fluid Integrity



142

A test kit is available to test for an excess of moisture. Other test kits can cost more and are more complicated to use. Choose the one that fits your shop.

Brake Fluid Integrity



143

Brake fluid meter: this unit checks the condition of the brake fluid quickly. It boils a small sample of brake fluid in the reservoir to test for water contamination. The LCD read out gives you all the prompts for you to perform the test and gives the results.

Changing Tire Size

- All 4 tires must be the same size
- Tire size may vary by 10%
- When changing tire or axle size
 - Vehicle speed sensor calibrated
 - Procedure varies by make and model



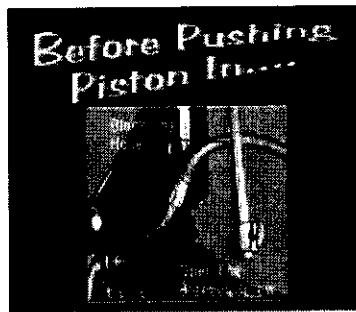
144

The ECM measures sine curve frequency from the sensor to determine wheel speed. Different tire sizes will generate a signal at a different frequency (rate) communicating to the ECM the wheels are turning at a different rate. When speed sensor is used exclusively for information to the brake ECM, the tire size has no effect as long as they are all the same size. When a VSS sensor is used, the VSS must be re-calibrated when tires or axle size is changed, since it provides the signal for the odometer, cruise control, EECM, and EBCM.

NOTES:

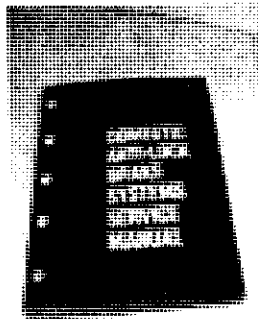
Isolating The Wheels

- Install isolation clamp on hose at all locations.



Reference Material

- A very important tool available to the technician is the service manual.
- Manuals must be current and up to date.



Diagnostics

- Low pedal diagnostics
- Low and/or spongy brake pedal
 - Generation 1 and 2, all manufacturers, all years

147

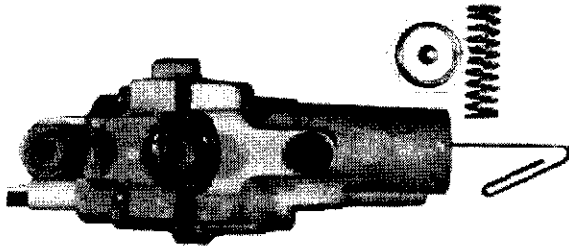
The manufacturer recommends special procedures when working on the brakes. You do not want to create an ABS problem. Before working on the vehicle's brakes, isolate calipers and wheel cylinders. We recommend using a special clamping device on the brake hose. This unit is designed to prevent harming the brake hose. Use only thumb pressure on the screw to avoid damage to the hose. The clamp is available from your supplier. After installing the clamp, open the bleeder screw and install a hose on the bleeder to divert fluid into a clear container. Force the piston back into the caliper using a C clamp.

As always, we stress vehicle-specific information.

A common problem with the RWAL system that does not set a code is leaking past the dump valve, when normally closed. The pedal feels like the master cylinder is leaking internally.

NOTES:

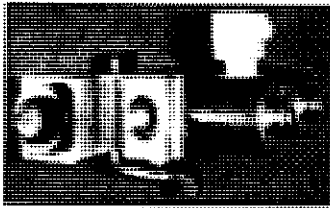
Generation 1 Valve



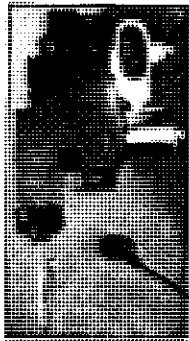
146

The procedure to determine if the dump valve is leaking is to remove the back cap on the generation one valve and monitor the piston travel with the brake applied. If the piston moves, the dump valve is leaking. If fluid comes out when the nut is removed, the seal is leaking and the valve should be replaced.

Generation II Valve



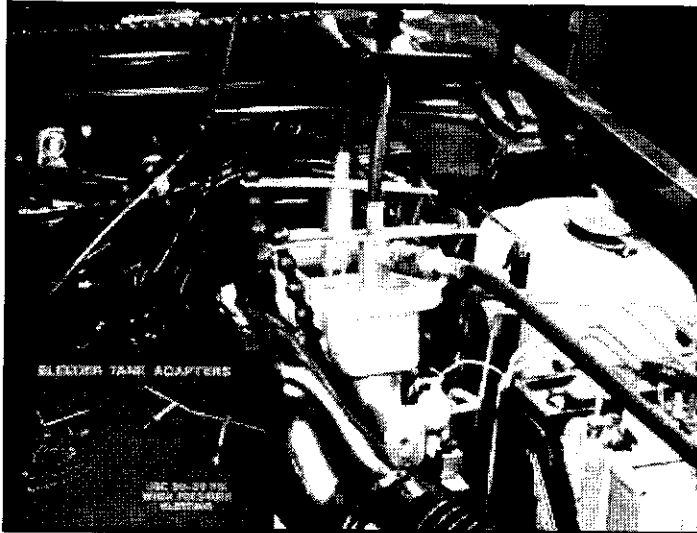
Rubber cap must be installed to prevent moisture/corrosion intrusion



Rubber Cap

149

The procedure on the second generation valve is to remove the rubber cap and insert the end of a paper clip till it bottoms. Press the brake pedal. If the clip moves, the normally closed dump valve is allowing fluid to leak by. If fluid is present when the rubber cap is removed, the seal on the piston is bad, replace the valve.

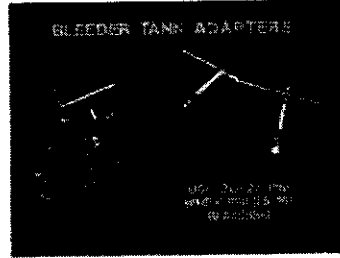


When bleeding the brakes, the procedure is the same as a vehicle without 4WAL.

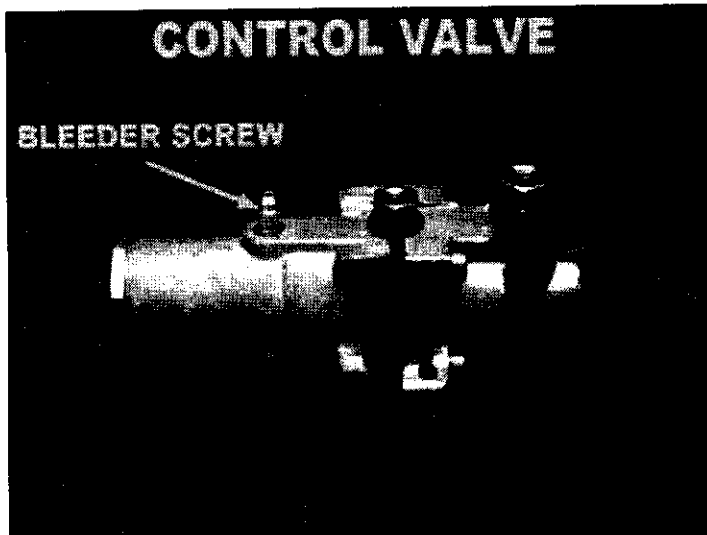
NOTES:

RWAL Brake Bleeding

- Manual methods
- Pressure
- Vacuum



Bleeding the base brakes of an ABS system is identical to non-ABS systems. Conventional methods are effective as long as the modulators have not been replaced, or the master cylinder reservoir has not drained dry. In the event the modulator must be bled, refer to the brake bleeding sequence guide for directions and procedures.



In many cases, when replacing the modulator (EHCV) the unit may require a special procedure, to remove any air trapped in it. In the case of this RWAL unit, the bleeder screw must be opened and bleed before bleeding the wheels. We suggest that you refer to the service manual and/or the bleeding sequence guide to save time.

NOTES:

Tips & Tricks

- False modulation, pedal pulsates or ratchets
 - Check for grabby brakes
 - Temporarily disable ABS
 - Disconnect ABS controller harness, ignition OFF
 - Evaluate hydraulic brake operation; repair as required
 - If ABS issue, check for VSS drop-outs using scan-tool
 - Check sensor output voltage

153

When the brake is applied, any variation in wheel speed signal will cause the ECM to operate the EHCU in an attempt to get the wheels to turn at the same rate. If the braking is erratic, the signal will be erratic causing the ECM to cycle the EHCU. If the base brake system is suspect, disable the ECM and operate the vehicle and check brake operation. If the brake system continues to operate in an erratic manner, the problem is in the base brakes. If the problem goes away, reconnect the ECM and check wheel speed sensors for proper resistance and voltage values. If they are within parameters, check the connections and cables and monitor their output while operating the vehicle.

Tips & Tricks RYVAL...

- Changing tire size on GM
 - Early - DRAB/DRAC - Chip
 - Late - Tech 1, 1A, Mastertech, Tech 2

154

Since this system uses a vehicle speed sensor, the signal feeds the speedometer, cruise control, engine ECM, and EBCM. The signal that is generated by the sensor is AC. The signal must be converted to digital in order for the control unit to function properly. This is done by the DRAC (digital ratio adapter control) or the DRAB (digital ratio adapter buffer).

NOTES:

Diagnosing RWAL...

- Trouble codes
 - Flash codes manually, domestics and imports
 - Scan-tool

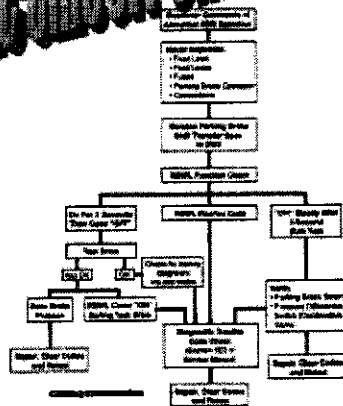
155

Flashing Out Codes RWAL...

Example: One long flash and ten short flashes adds up to A code 11.

156

MANAGEMENT CHECK



157

Procedures for retrieving trouble codes from RWAL systems vary depending on make, model, and year. The service manual should be referenced in order to save time. If you do not have a scan-tool, you may be able to get the codes on many vehicles by grounding out the EBCM diagnostic lead.

By counting the number of bulb flashes, you can determine the code that is stored in the EBCM. In some cases, you may get a preemptive code such as a code 12 and then get the actual trouble code. Since the procedure changes by make, model, and year; it is always a good idea to reference your service manual to interpret the flashes correctly.

In the event the bulb does not light, you should refer to the diagnostic section in your service manual to determine where the problem may be. The diagnostic charts help you determine where the problem is in the fastest possible way. By following the prescribed procedures, you will not overlook something and will not have to back track, which wastes time.

NOTES:

Diagnosics RWAL...

- EBCM Function Test
 - Bulb test
 - Tests isolation valve
 - Tests dump valve
 - Tests VSS circuit

158

Tips & Tricks RWAL...

- Low and/or spongy brake pedal
 - Generation 1 and 2, all manufacturers, all years

159

Modulator Service...

- No service parts available
- Only new modulators, no remanufactured units

160

The EBCM lights the bulbs at start up, tests the circuit to the isolation valve for resistance and continuity, tests the circuit to the dump valve for resistance and continuity, and tests the vehicle speed sensor circuit for resistance and continuity.

A common problem with the RWAL system that does not set a code is the leaking of the dump valve, when normally closed. The pedal feels like the master cylinder is leaking internally.

If any part of the electro-hydraulic valve is not functioning properly, the unit must be replaced.

NOTES:

Service Bulletin
PYVAL

Code 7 - iso solenoid circuit or EBCM are hard codes

- Code 6 and 9, VSS signal and code 10 brake light circuit are soft codes

161

Trouble codes fall into two categories: Soft type 1 is when the ABS is disabled and the red warning light stays on for that ignition cycle only. Soft type 2 is when the ABS is disabled and the red warning light stays on as long as fault persists. Hard is when the ABS is disabled and the red warning light stays on until the vehicle is serviced

Delco VI

- Anti-lock brake system/traction control
- Non-integral
- ABS and TCS use the same control module
- ABS occurs during braking
- TCS occurs during acceleration (not all models)

162

Delco VI also incorporates traction control on some models.

Delco VI System

- Non-integral unit
- Modulator bolted to master cylinder
- Added to base brake system

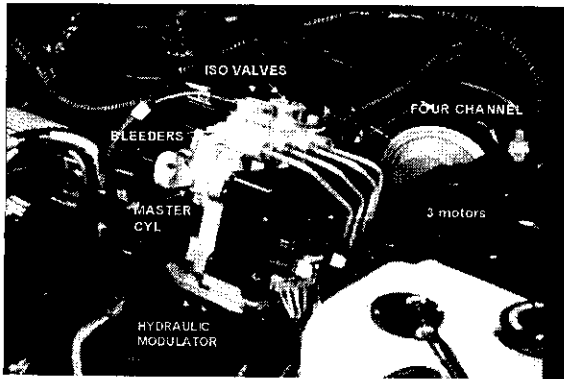


163

This system is a non-integral unit that uses a conventional master cylinder and booster for the base brake components. At first glance it may appear to be an integral system, since the master cylinder is attached to the modulator.

NOTES:

Delco VI Modulator/Master Cylinder



On this platform, the modulator is bolted to the master cylinder. On others, the modulator may be located away from the master cylinder. The modulator consists of the hydraulic control unit and motor pack. The isolation valves are easily serviceable.

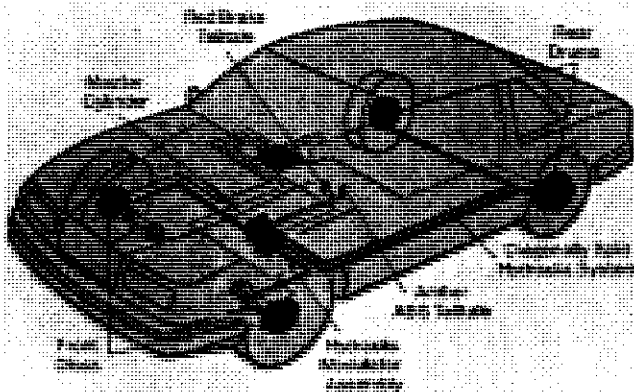
Some Differences

- The use of an expansion spring brake
- The use of an electromagnetic brake
- Traction control

There are new subjects to learn when working on the Delco VI system.

166

HYDRAULIC CHANNEL



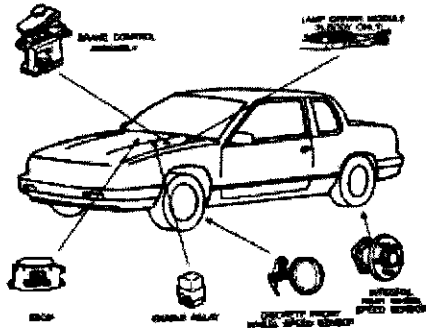
FRONT/REAR OR SPLIT DIAGONAL

166

The hydraulic channel configuration is the three channel split front to rear.

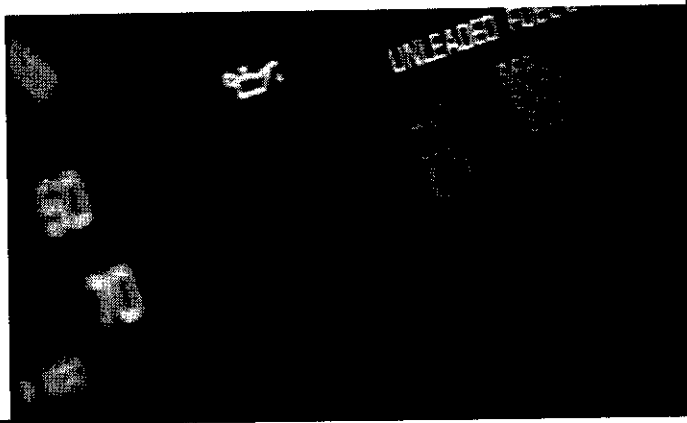
NOTES:

ABS Components



Delco VI components consist of a modulator, EBCM, enable relay, WSS and rings, warning lamps, and electrical connections.

Instrument Panel Lamps



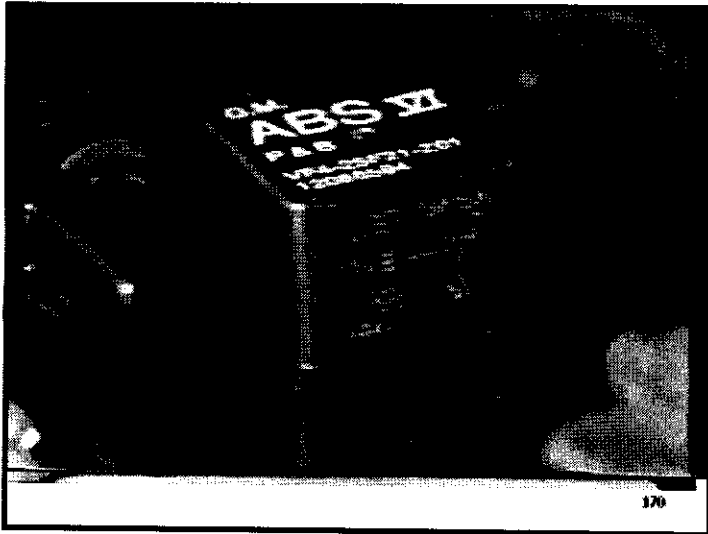
When the ignition switch is turned to the run position, the amber ABS lamp, red brake lamp, and low traction lamp (if equipped) will illuminate for approximately 3 seconds and go out. When the switch is turned to the crank and then returned to the run position, the cycle will repeat itself.

ABS Faults

- The ABS amber lamp illuminates and remains on.
- A flashing amber ABS lamp indicates that a problem with the brakes has been detected.
- If the ABS controller detects an ABS fault, it will disable the ABS system.

If a fault is detected, the EBCM illuminates the amber ABS lamp and sets a diagnostic trouble code. 1995 and older Delco VI systems will flash the ABS lamp if a minor fault has been detected and the controller has not turned off the ABS system.

NOTES:



In most cases, the EBCM is located in the bulk head or under-the-dash and is accessible for testing. The ABS system is powered by an enable relay and system components are protected by fuses and fusible links. A wiring schematic assists in locating the proper circuit/wire to be tested. It is not serviceable and must be replaced as a unit. The relay

switches power to the DC motors, isolation solenoids, and the electromagnetic brake.

EBCM Function

- Monitor wheel rotation
- Controls hydraulic channels during ABS and TCS operation
- Monitors electrical circuits
- Stores trouble codes during diagnostics

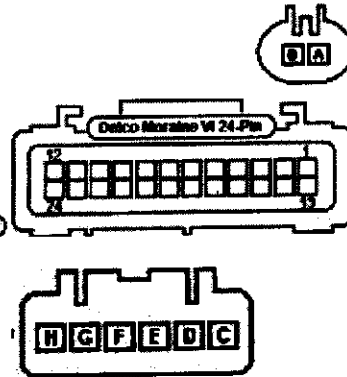


Whenever the ignition is in the run position, the ECM continuously monitors the speed of each wheel and the electrical status of the modulator/motor pack assembly. When the EBCM detects that the brakes have been applied and wheel slip is detected, the EBCM commands appropriate positions in the modulator/motor pack assembly to control hydraulic pressure to one or more wheel channels.

NOTES:

EBCM Functional Test

- Battery voltage
- WSS circuits
- Relay circuit
- Motor circuit
- Iso valve circuit
- EMB circuit
- Brake switch circuit
- Throttle adjuster circuit



172

EBCM Inputs

- Ignition (power)
- Brake switch
- Wheel speed sensors
- Fluid level switch
- Combination valve
- Red brake light lamp

173

EBCM Inputs W/TCS

- TCS switch
- Torque converter
- Throttle position sensor

174

When the ignition is turned on, the EBCM checks battery voltage, wheel speed sensor circuits, the relay circuit, the motor circuit, the isolation valve circuit, the electromagnetic brake circuit, the brake switch circuit, and the throttle adjuster circuit. After the vehicle reaches 3 to 9 MPH and the brake is not applied, it will operate the relay, motors, iso valve, and electromagnetic brake. Some noise may be heard during the test. As an example, the connectors shown are for a 1991 Cutlass:

A= Relay switched power

B= Power ground

Using vehicle-specific information will help you make the electrical test when the EBCM fails one of the tests and sets a code.

The ignition switch is an EBCM input, as well as, wheel speed sensors, brake switch, fluid level switch combination valve switch, and red brake light lamp.

On models equipped with TCS, the TCS switch status is an input into the EBCM. The torque converter lock up solenoid and the TPS are also inputs.

NOTES:

Ignition Switch

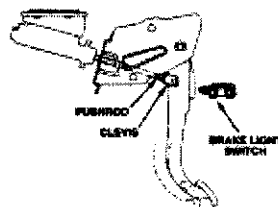
- Fused power to enable relay
 - Special relay contacts
 - High currents
- IPC indicator lamps
- Powers EBTCM
- Extremely sensitive to low voltage

175

When the ignition switch is on, fused power is available to the enable relay. The relay has special coated contacts to handle the high current drawn by the motor pack, when under load. Power is also available to the instrument panel cluster lamps. Power through the relay is available to the EBTCM or EBCM. The system is extremely sensitive to low voltage. Check source voltage and grounds first.

Brake Switch

- Fused power
- Normally open
- Switch alerts ABS
- No signal - No ABS



176

Power to the brake switch is fused and ground side switched. Applying brakes initiates ABS. The EBTCM or EBCM will not function without a brake switch signal.

EBCM Outputs

- ABS (amber) lamp
- Red brake lamp
- ABS enable relay
- Motors
- ISO valve
- Electro magnetic brake
- Serial data.

177

The EBCM controls the ABS lamp driver, the red brake lamp, the ABS enable relay, motors, ISO valve, and electro magnetic brake. Serial Data may be read on scan-tools.

NOTES:

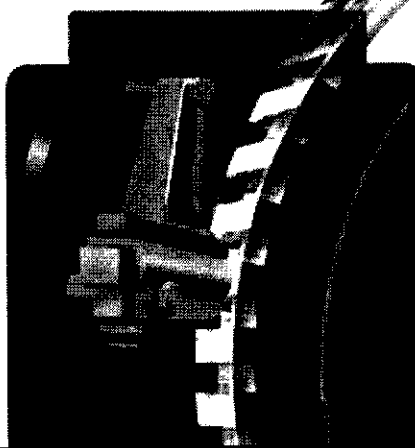
EBCM Outputs W/TCS

- TCS switch
- TCS lamp
- TCS enable relay
- TCS motors
- TCC request
- Retard request
- TPS

178

When equipped with TCS, there are other outputs to consider.

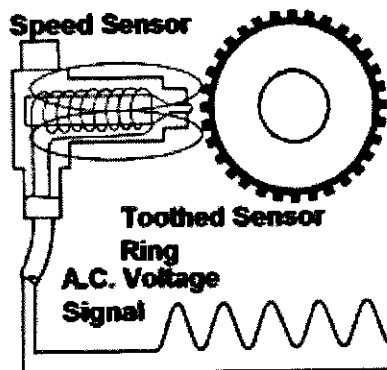
Wheel Speed Sensor



179

The Delco-VI system uses four wheel speed sensors.

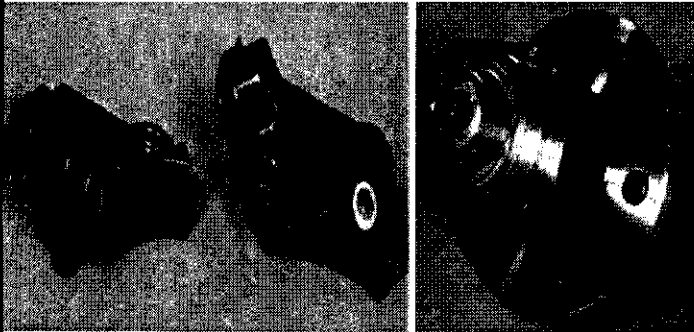
Speed Sensor Operation Review



180

NOTES:

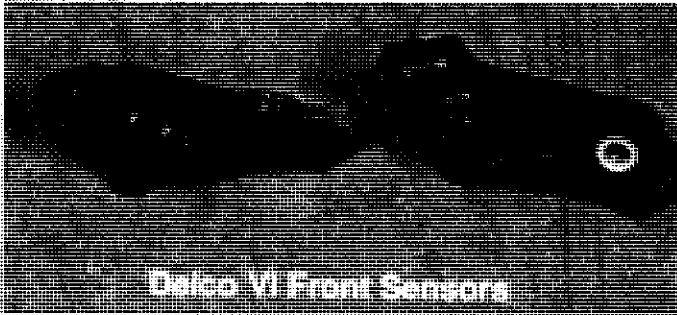
Speed Sensors



181

The type of sensor used is based on the drive train design. Integral sensors may be used in the front or rear, as is the case with the discrete style sensor.

Discreet Sensors



182

On the Delco-VI system, the sensors are made with a plastic casing and care must be taken when using brake clean around them. The connectors are exposed to the elements and should be checked for tightness and cleanliness.



Here is a front wheel speed sensor mounted on a vehicle. This is typical for the Delco-VI system.

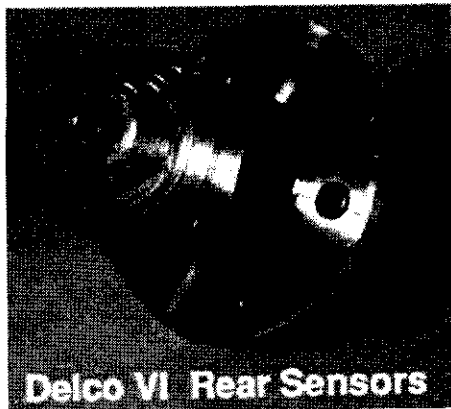
NOTES:

Front Wheel Speed Sensor

- Mounted on the steering knuckle assembly
- No air-gap adjustment
- On the C/V joint (boot must be replaced)
- Make sure a replacement C/V joint has the correct ABS sensor ring for the application
- Made of plastic (handle with care)

104

Integral Sensors

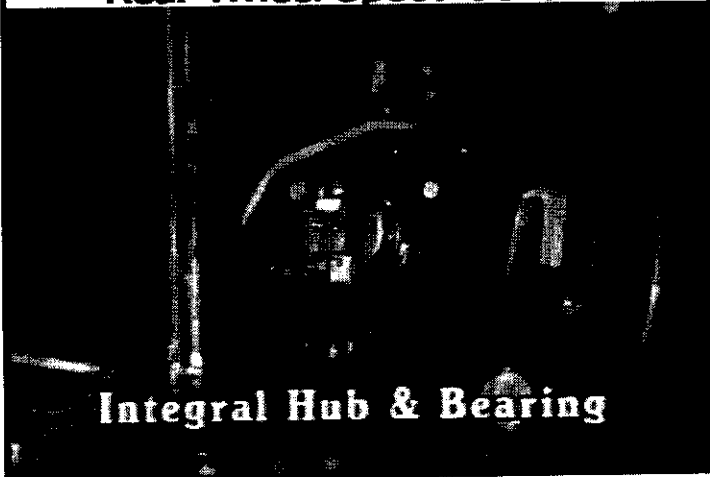


Delco VI Rear Sensors

105

In the event the integral sensors are bad, the entire bearing assembly must be replaced. An erratic signal could be caused by a bad bearing assembly. The sensor may test good with a DVOM when the vehicle is not under a load.

Rear Wheel Speed Sensor



Integral Hub & Bearing

The rear sensors are located in the rear bearing and hub assembly.

NOTES:

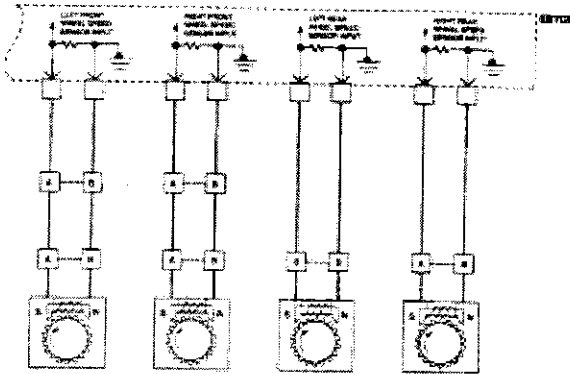
Rear Wheel Speed Sensor

- Mounted in the rear wheel bearing and hub assemblies
- Replaced as a complete assembly
- No air-gap adjustment

387

The rear sensors are also non-adjustable. They can be replaced as assemblies only.

Wheel Speed Sensor Circuits



Since the wheel speed sensor generates electricity and is sensitive to stray current, it uses a shielded two wire system to the EBCM for input.

Wheel Speed Sensor Circuits

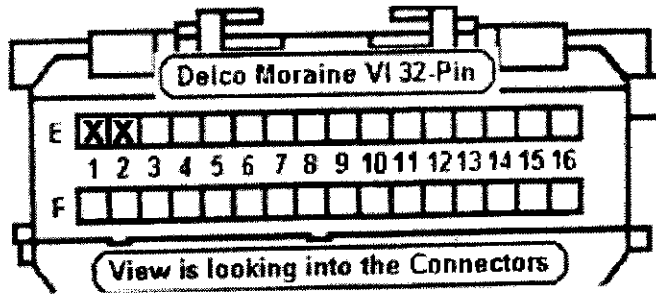
- The two wires are twisted together.
- This eliminates the circuit from being effected by any outside electrical noise.
- Do not use if the pair has been damaged.

389

The pair is twisted to reduce any electrical noise affecting the signal from the sensors.

NOTES:

1994-1995 Connector



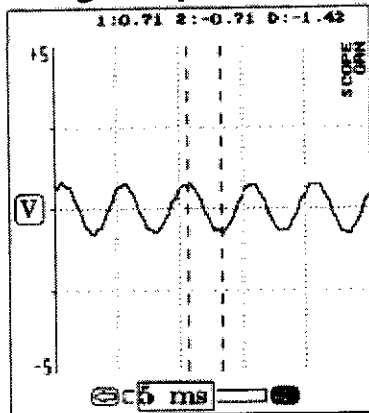
E-1 and E-2 are the cavities for the LR wheel speed sensor.

E-1 (BLK) and E-2 (RED) are a twisted pair.

190

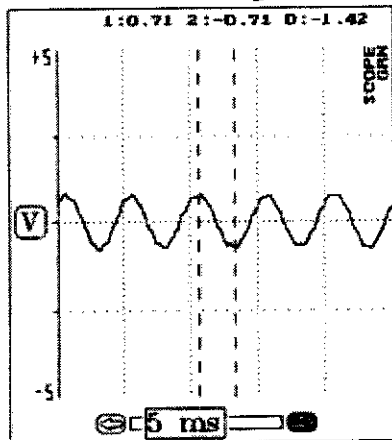
On this vehicle, cavities E-1 and E-2 are used for the left rear wheel speed sensor.

The AC Signal (Hand-turned)



191

The AC Signal

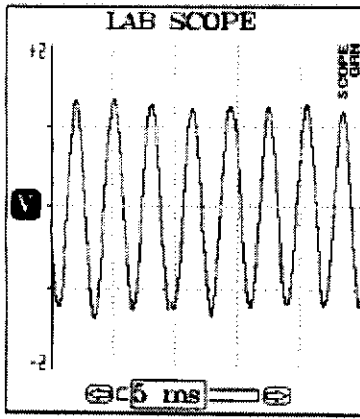


192

Waveform taken at 15-20 MPH.

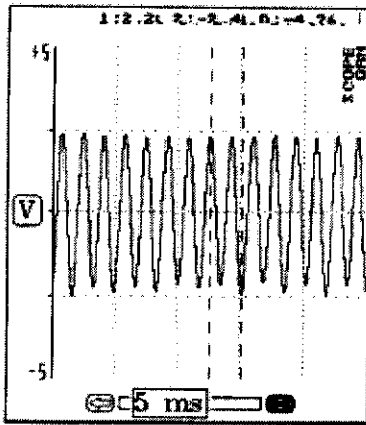
NOTES:

The AC Signal



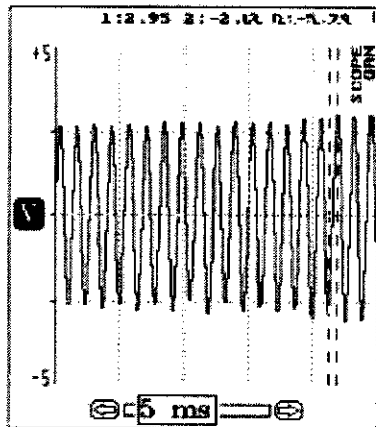
Waveform taken at 50-55 MPH.

The AC Signal



Waveform taken at 60-65 MPH.

The AC Signal



Waveform taken at 70-75 MPH.

NOTES:

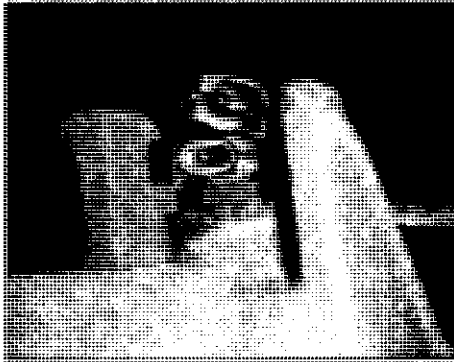
AC Signal

- AC voltage is created by the sensor.
- The amount of voltage is dependent upon:
 - The number of turns of the wire
 - The speed of the sensor ring
 - The air gap

196

The sensor is designed to send a specific voltage value at a certain wheel speed. It is engineered with the correct numbers of turns of the wire and how many teeth the ring will have. These together determine the voltage output at any given wheel speed.

Wiring and Connections



197

As with all wiring and connections on the different systems of the vehicle, the ABS speed sensors must be checked. Because the wiring and connections are under the vehicle, they are exposed to a harsher environment.

Speed Sensor Testing

- Scan-tool
- DVOM
- Digital Storage Scope

198

There is more than one way to test the speed sensors. A technician can use a scan-tool, DVOM, or a DSO.

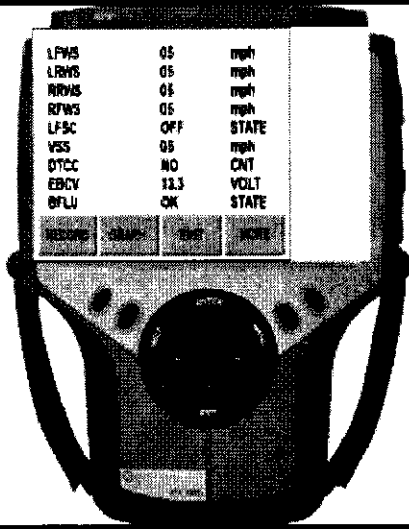
NOTES:

Scan-tools

- Used to:
 - View data
 - Trouble codes
 - Bi-directional control

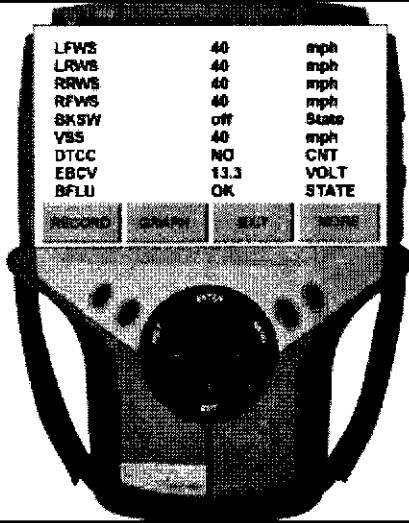
199

Scan-tools will help you look at the data from the ABS computer as well as the trouble codes. Many of the systems allow you to access bi-directional control.



200

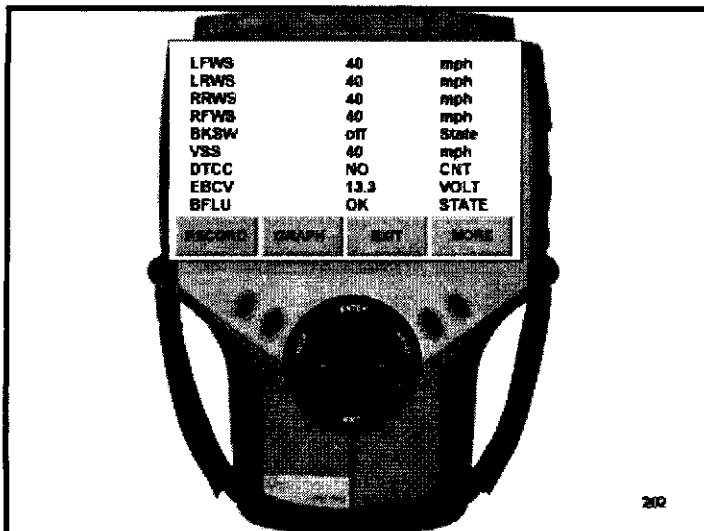
This is a Genisys scan-tool connected to a Delco-VI.



201

This is a normal stop on a dry surface.

NOTES:



This is a stop on a snow covered parking lot. Here we see the wheels stopping at different speeds. The right wheels lock up and stay locked up. You can see the left wheels locking and un-locking.

DVOM Testing

- Measure the resistance of the speed sensor.
- Measure the voltage signal of the speed sensor.
- Measure the frequency of the speed sensor.

When using a DVOM to test the speed sensor, there are three basic tests to make: resistance, frequency and voltage.

Combination Valve

- The combination valve has a piston between the two channels on the normal brakes.
- If there is a fluid loss in one channel, the piston shifts to the side.
- The red brake light comes on.
- The signal is sent to the EBCM.
- The EBCM disables the ABS.

This is a common valve used on vehicles without ABS. The signal from the valve is the same as the electrical circuit that drives the brake light. If hydraulic pressure is lost in either the secondary or primary side of the master cylinder, the red brake light is turned on and the EBCM receives that signal.

NOTES:

Fluid Level Switch

- Normally open
- Closed when fluid level is low
- EBCM enables the ABS when it receives a signal from the switch.

205

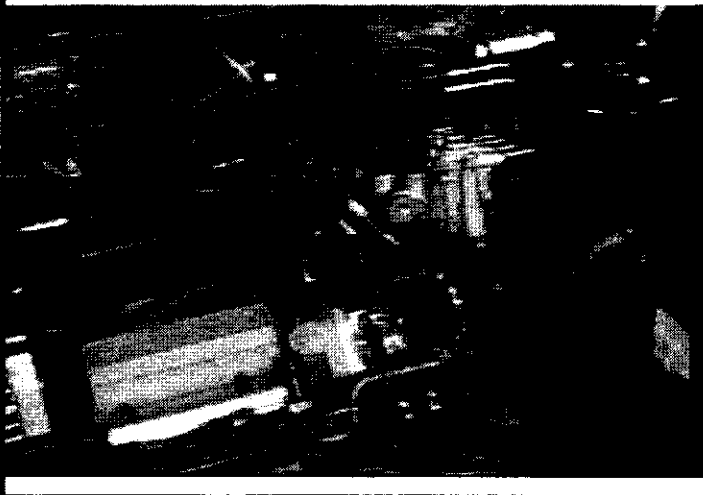
The fluid level switch is a normally open switch that closes when the brake fluid is low. As the fluid is used to take up the space left by the caliber piston moving out to compensate for brake pad wear, the fluid level in the master cylinder reservoir lowers. When the level gets to a critical point, the switch closes.

EBCM Outputs

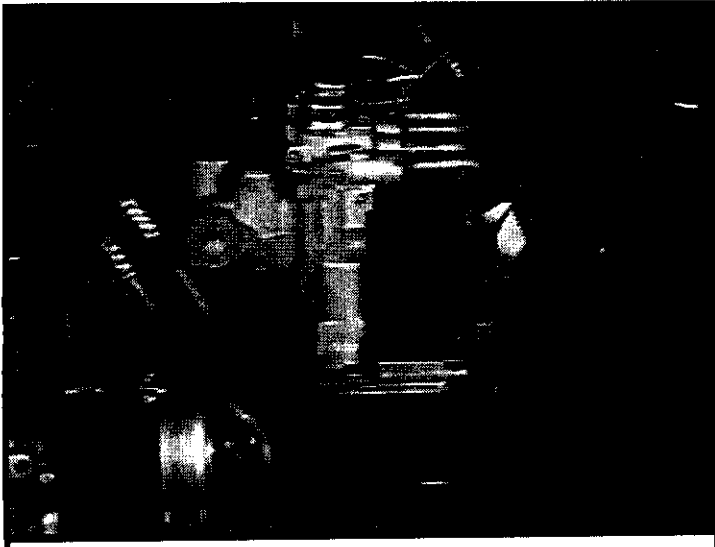
- ABS (amber) lamp
- Red brake lamp
- ABS enable relay
- Motors
- ISO valve
- Electro magnetic brake
- Serial data

206

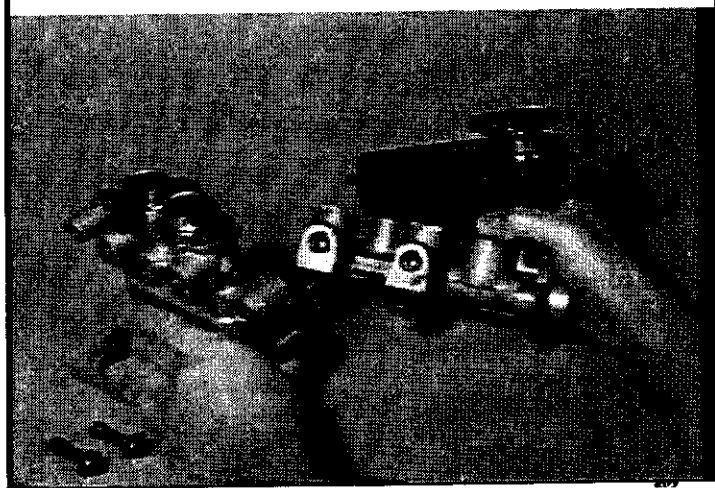
As with any computer, there are output devices.



NOTES:



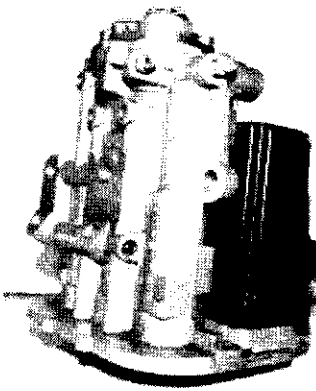
The hydraulic assembly and motor pack is attached to the master cylinder.



In this photo, the hydraulic assembly and motor pack are separated.

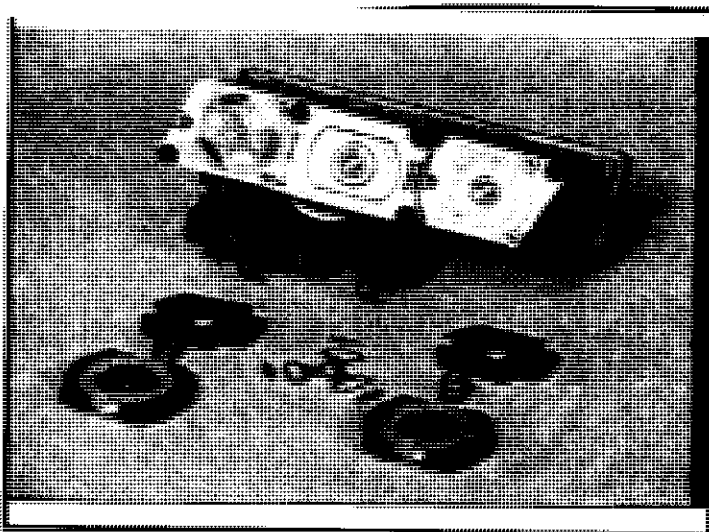
Master Cylinder Mounting

- Mounting banjo bolts
- Transfer tubes
- Do not reuse
- Transfer tubes and "O" rings included with m/cyl



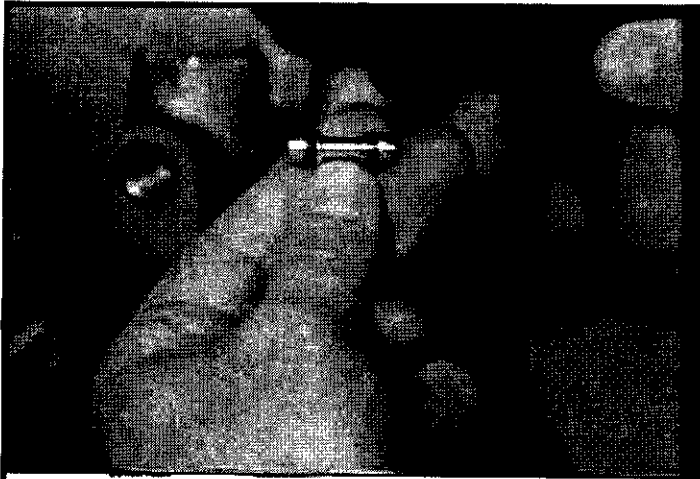
The master cylinder is connected to the modulator by two banjo bolts and two fluid transfer tubes. These tubes cannot be reused. Fluid moves from the master cylinder through the banjo bolts to the rear wheel circuit. The transfer tubes allow fluid to move from the master cylinder to the front wheel channels. Raybestos includes the transfer tubes and "O" rings with their master cylinders.

NOTES:



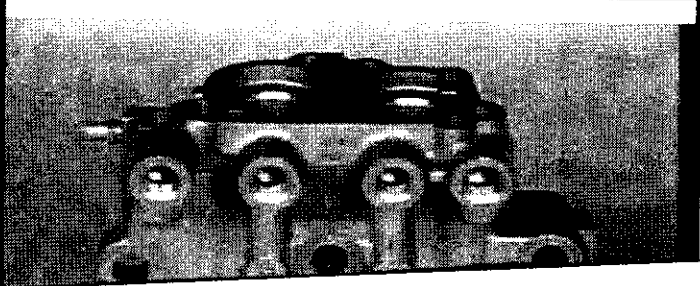
On some models, the three motors have electromagnetic brakes. (EMB)

NOTES:



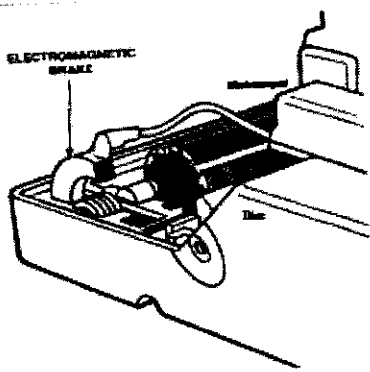
This cutaway shows the mounting of the master cylinder and modulator with the use of the banjo bolts and fluid transfer tubes. The transfer tubes and their "O" rings are not to be re-used.

211

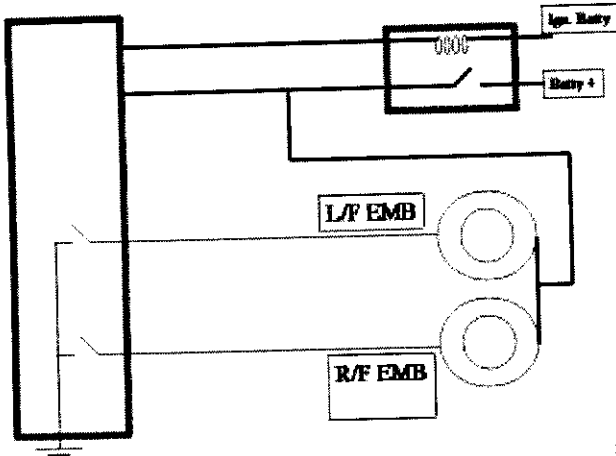


The hydraulic assembly and motor pack contain four fluid chambers for all four brakes and four check valves. There are also two isolation valves in the assembly.

Electromagnetic Brake



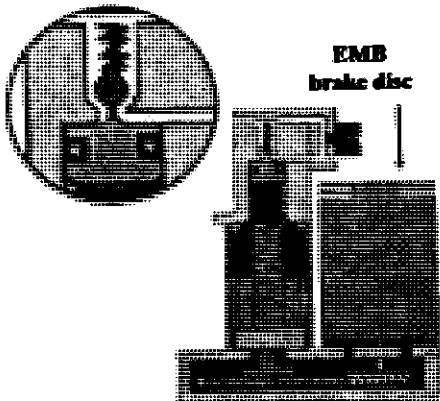
This is a clutch brake configuration that is applied by spring pressure holding the motor shaft from turning, in turn holding the piston in place. The electromagnet overcomes the holding force applied by spring pressure when piston travel is required. Friction pucks on the disc wear out, allowing the piston to move downward under pressure. The friction pucks are replaceable.



The EBCM controls the EMBs ground side switching. Battery power is supplied through the enable relay. The relay is powered by ignition power.

218

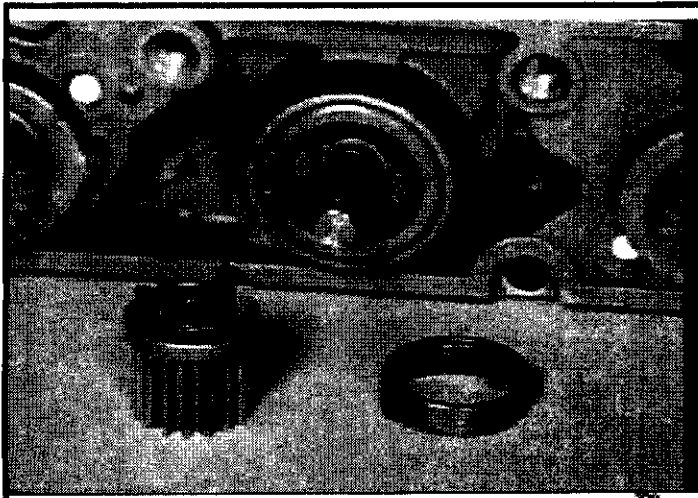
EMB Brake



The electromagnetic brake is located at the top of the motor and is normally applied by spring pressure.

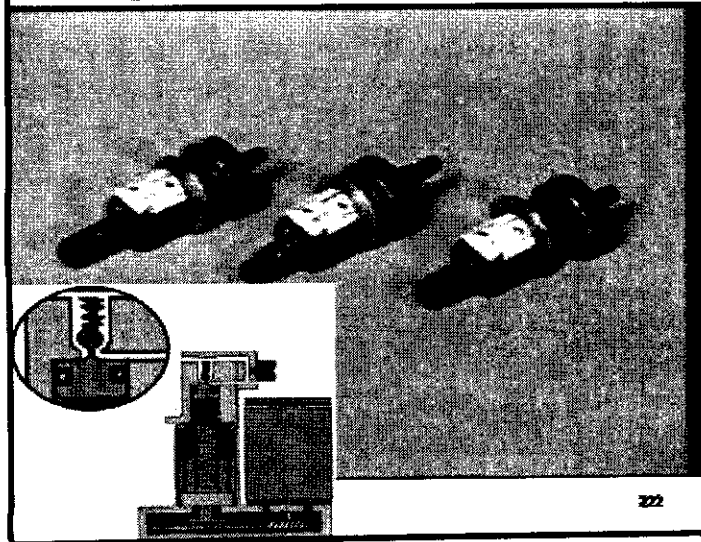
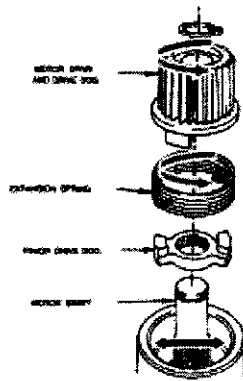
219

NOTES:



Spring Brake Assembly

- Piston forced downward
- Gear drive is reversed
- Spring is expanded
- Pressure against wall prevents turning

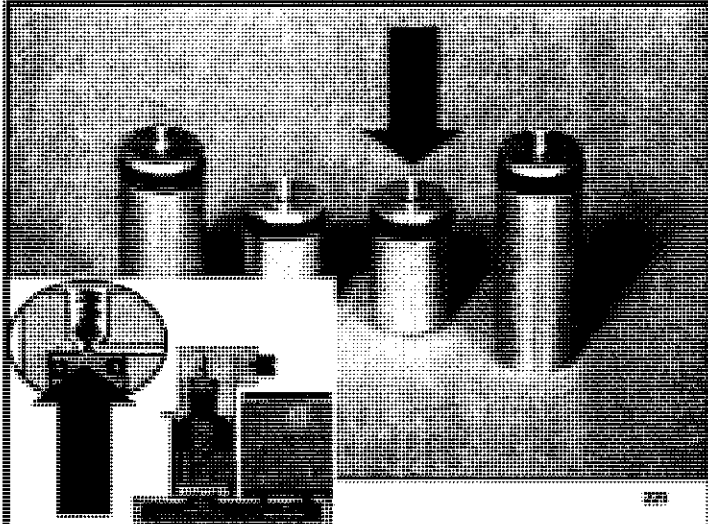


There may or not be expansion spring brakes. (ESB) Some models have an EMB instead of the ESB. It performs the same functions as the ESB but is mechanical.

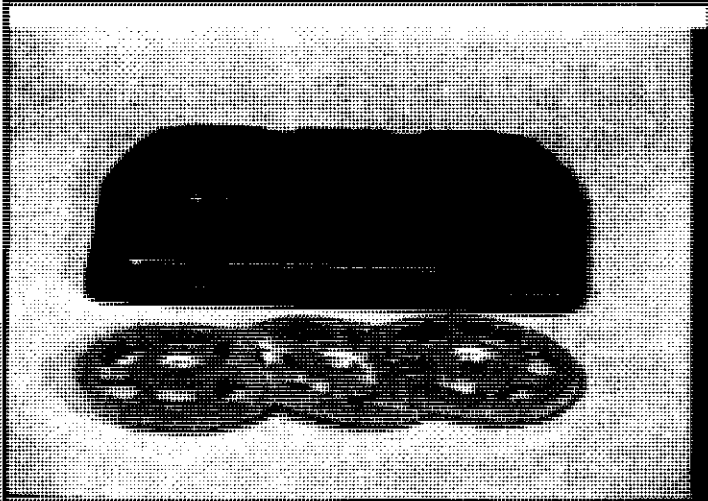
The spring is retained in a housing at close tolerance. One end of the spring is in contact with the motor drive dog and the other end is in contact with the pinion drive dog. Brake pressure is present on the top of the modulator piston applying a downward force. The force applies a counterclockwise torque to the motor pinion which tries to rotate the spring counterclockwise. The counterclockwise torque expands the spring outward within the housing and prevents gear rotation.

The assembly has three ball screw assemblies. They are the link between the motors and the pistons.

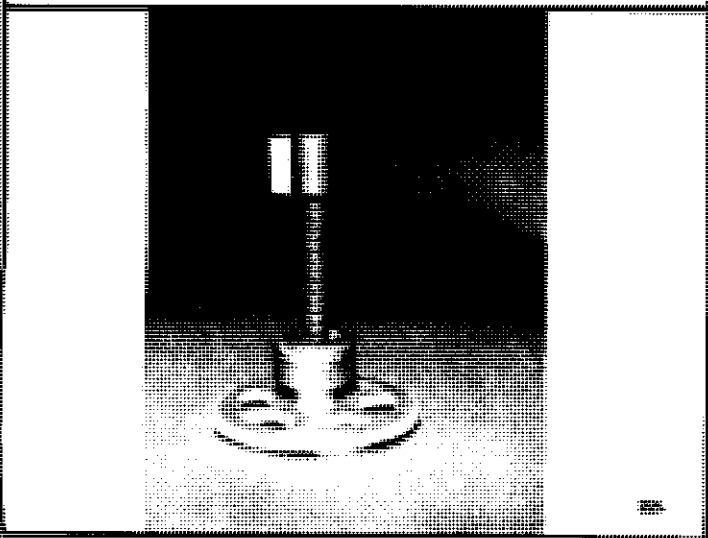
NOTES:



There are 4 pistons in the assembly. As we will see later, the extension tip on top of the piston is what will unseat the check valve.



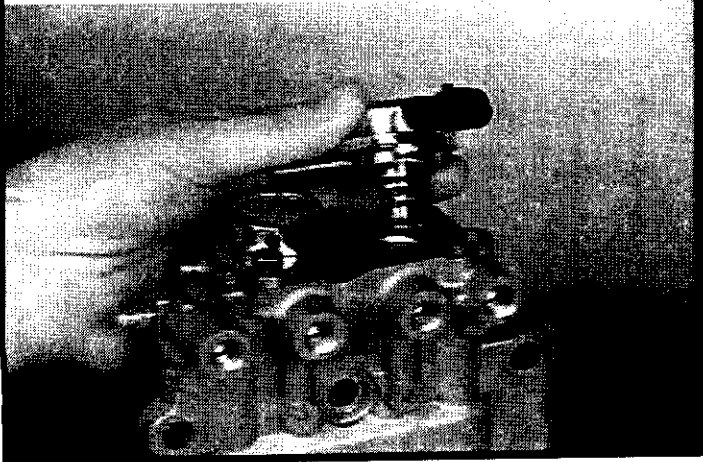
There is a gear cover and a gear drive set that is also a part of the assembly. The gears are driven by the motors and drive the ball screws.



A motor drives the gear. The gear is attached to a worm gear shaft. The bearing is stationary. The piston rides in a channel and cannot rotate. Rotating the worm gear shaft causes the piston to move up and down on the shaft. The piston is at TDC when it is in the home position.

NOTES:

Isolation Solenoids



The isolation solenoids are used to isolate each front wheel as the EBCM detects wheel lock up. There is one solenoid for each front wheel.

Isolation Solenoids

- The rear wheels do not use an isolation solenoid.
- Because of weight transfer during braking
- A combination valve reduces brake pressure to the rear wheels during braking

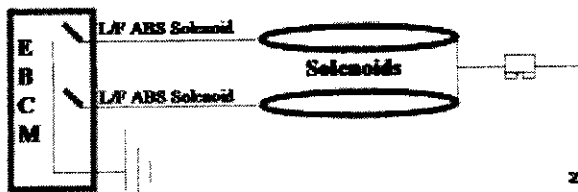
The rear wheels do only about 20 % of the vehicles braking and don't require an isolation valve. They use a combination valve.

227

Isolation Valves

- 1996 and after models:
Solenoids were grounded and power was sent from the EBCM for control

The isolation valves are controlled by the EBCM turning the ground on and off on model years 1996 and newer.

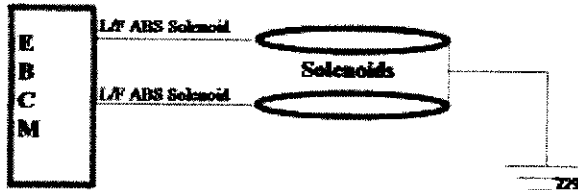


228

NOTES:

Isolation Valves

- 1995 and before models:
Solenoids were grounded and power was sent from the EBCM for control



The isolation valves were controlled by the EBCM turning the power on and off on model years 1995 and before.

Isolation Solenoids

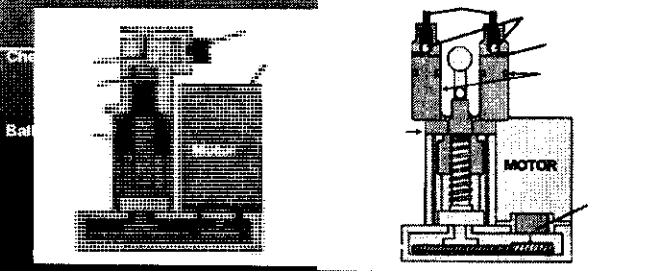
- Do not work like other isolation valves on other ABS systems
- Do not open and close
- Isolates the identified brake circuit and keeps that circuit isolated as long as ABS action is required

On most ABS systems, the isolation and decay valves open and close many times a second to control pressure to a brake circuit. On the Delco-VI system, the isolation valve isolates the brake circuit and that circuit remains isolated as long as ABS action is required.

DELCO VI MODULATOR FUNCTION

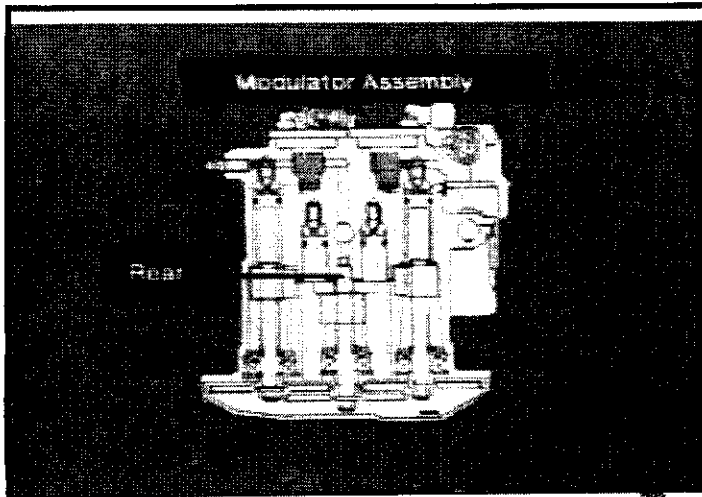
FRONT

REAR



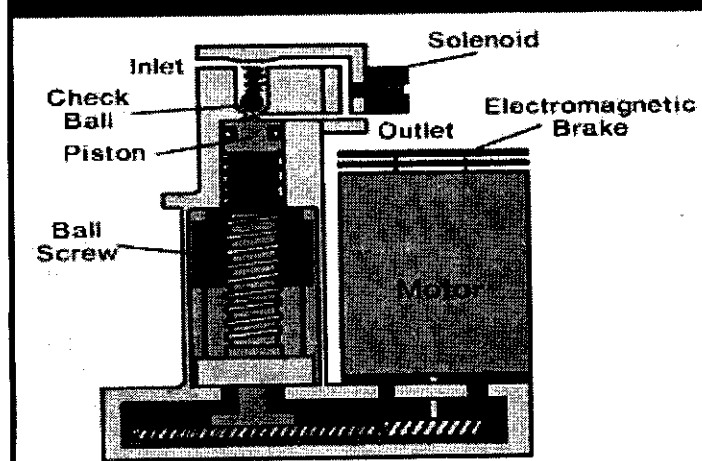
This is another view of the internal parts of the modulator. Shown are the check ball, the piston, screw assembly, and the isolation valve.

NOTES:

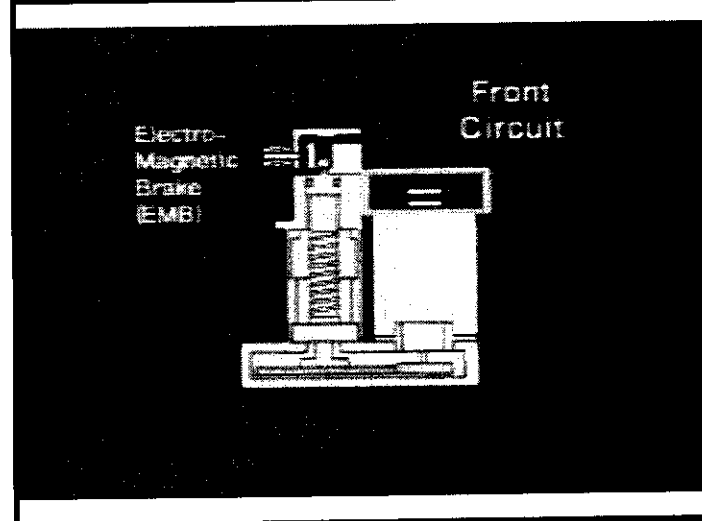


The front brakes are controlled individually and the rear brakes are controlled as a pair.

Front Circuit



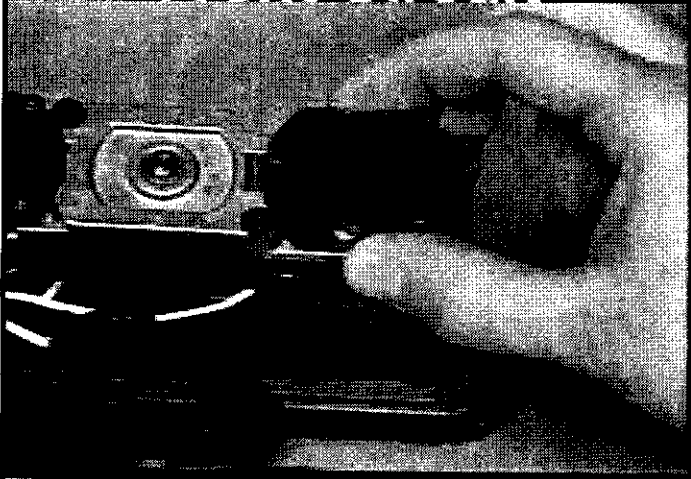
This is a drawing of the front brake circuit.



There is an isolation valve, check ball, ball screw and piston, DC motor, gear drive, and an EMB for each of the front brake circuits.

NOTES:

Front Circuit



Normal Braking

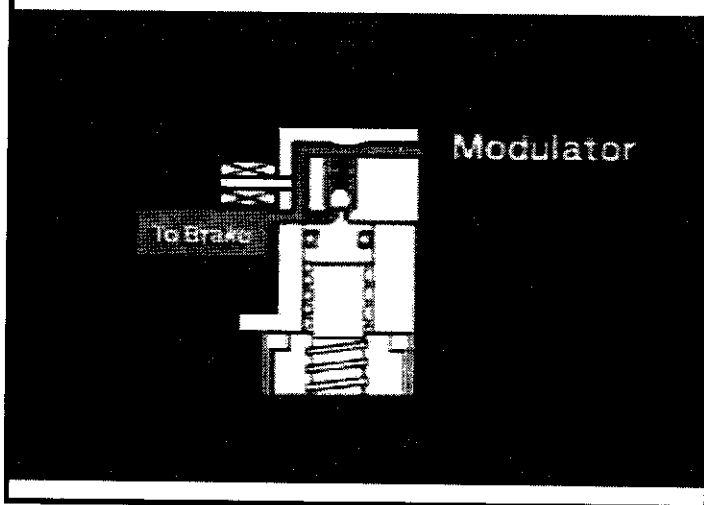
- Fluid will pass through the master cylinder and the module.
- The ball screw is in the home position.

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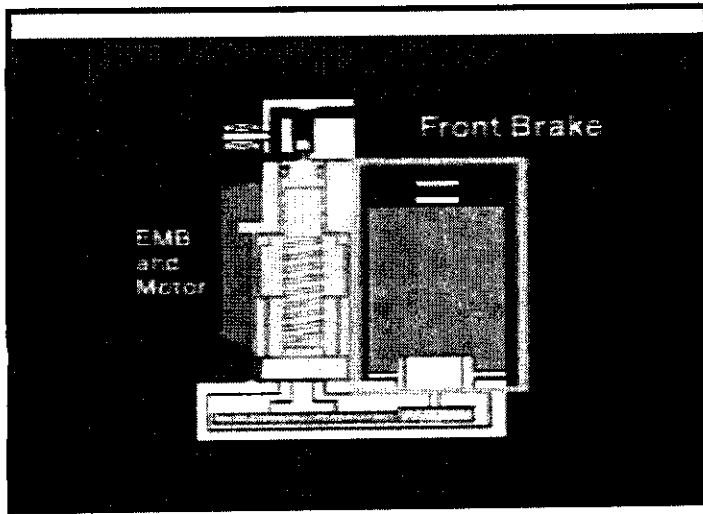
The EMB is a brake used to control the motor located on the top of the front motor assembly. The spring and pad pushes down on the assembly when no voltage is applied. This holds the motor from turning. If voltage is applied to the EMB, the electro magnet pulls up on the plate and disengages the brake. The motor is free to turn.

During normal braking, the fluid passes through the master cylinder and the module to each wheel. The home position is when the ball screw and piston is at its highest position.

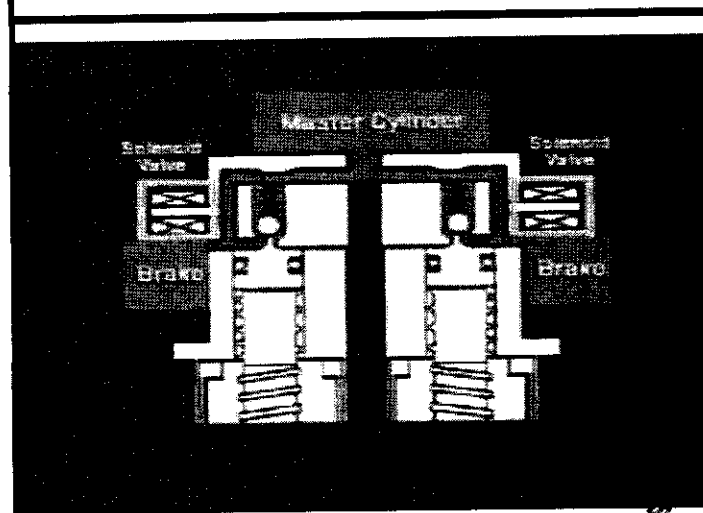
The ball screw is in the home position during normal braking. The check ball is held open and fluid passes through to the brake circuit.



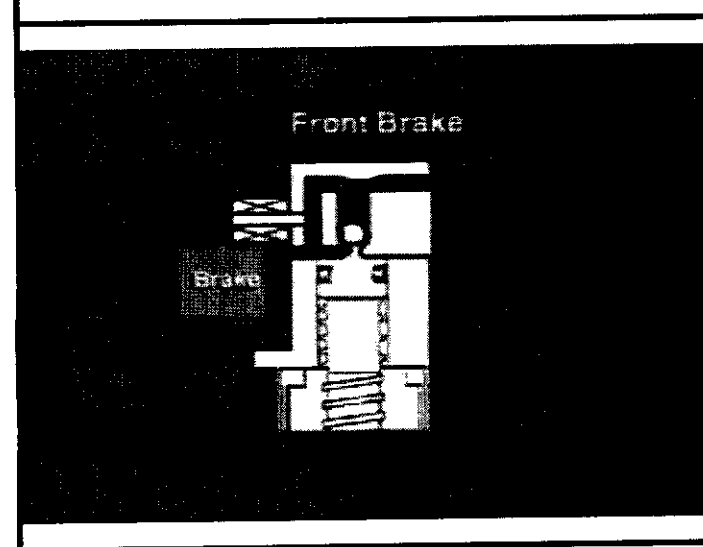
NOTES:



The ball screws and pistons are held in the home position by the EMBs. When there is no current to the EMB, it keeps the motors from turning.

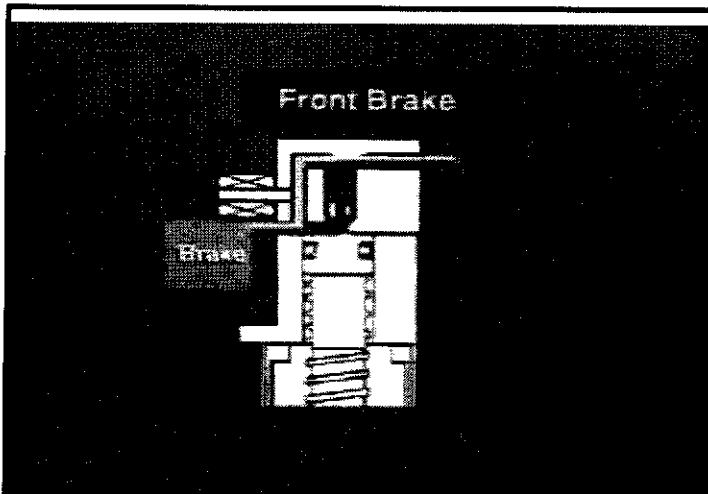


The two isolation valves are normally open valves. Brake fluid passes through them when they are not activated.

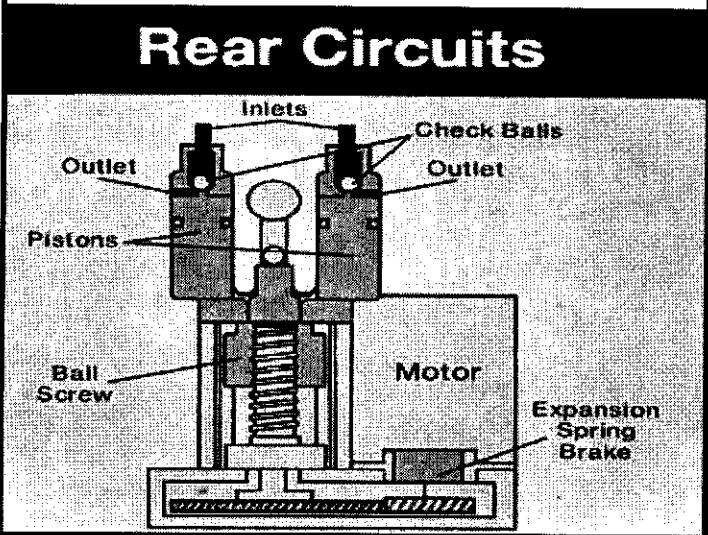


This is the ball screw assembly and check ball in the home position when no ABS action is required.

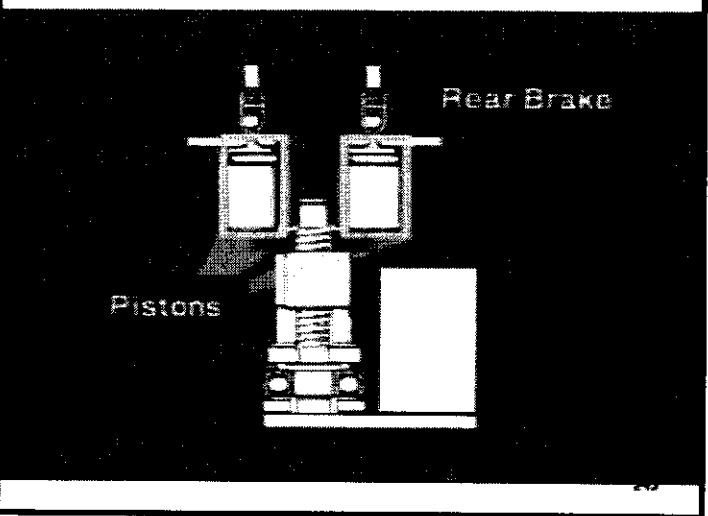
NOTES:



There are two fluid passages to the front brakes, in case an isolation valve or ball screw assembly fails. One channel is through the modulator, around the check ball and out to the brake circuits. The other is through the modulator, past the normally open isolation solenoid, and out to the brake circuits.

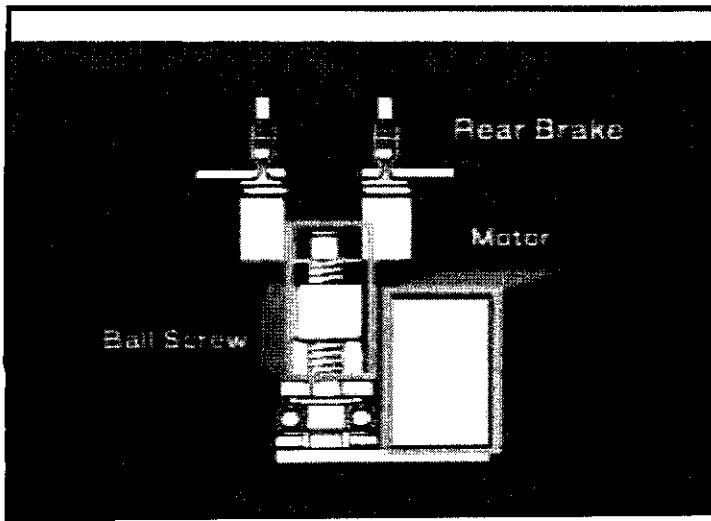


The rear wheel channels operate with the use of two pistons and check ball assemblies, but do not have an isolation valve. The two pistons are operated by one motor. When one wheel approaches lock up, the motor drives the two pistons downward. The check ball valves are closed isolating the pressure from the master cylinder. As long as the pistons are in a downward position, fluid cannot get to the rear wheels.

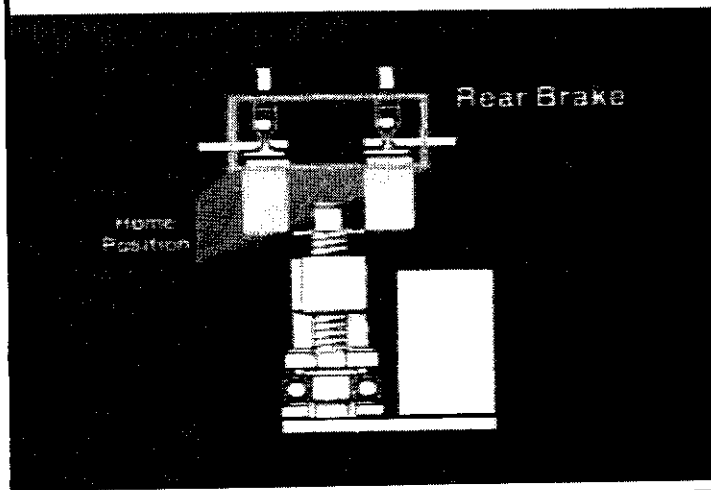


There is a piston chamber for each of the rear brakes.

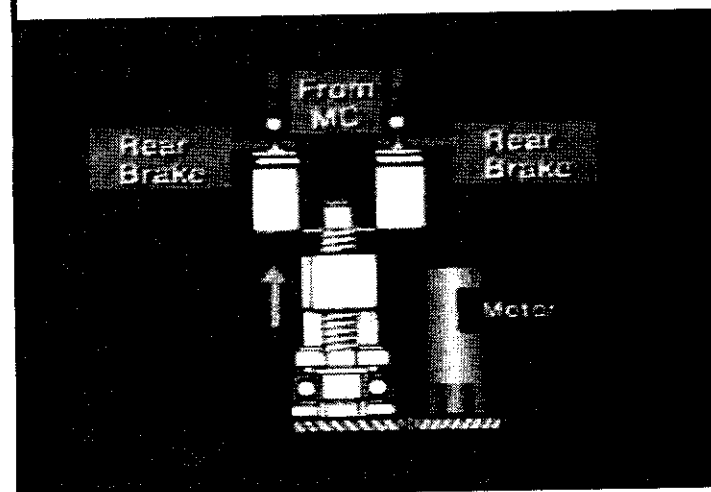
NOTES:



They use the one ball screw and motor.

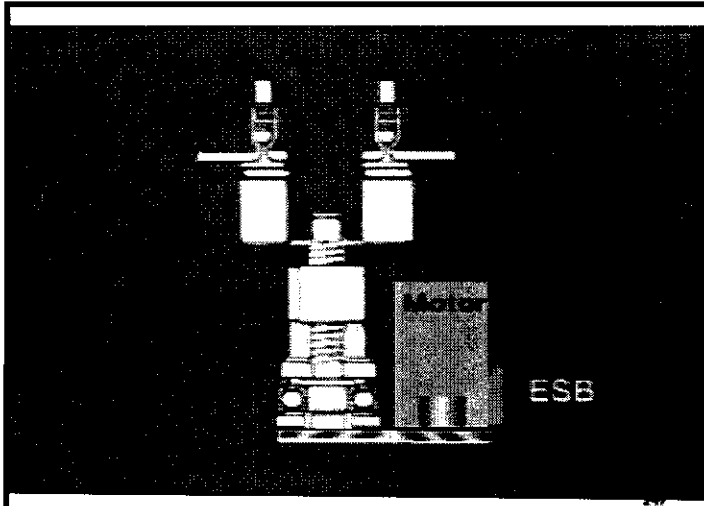


During non-ABS braking, the ball screw is in its home position.

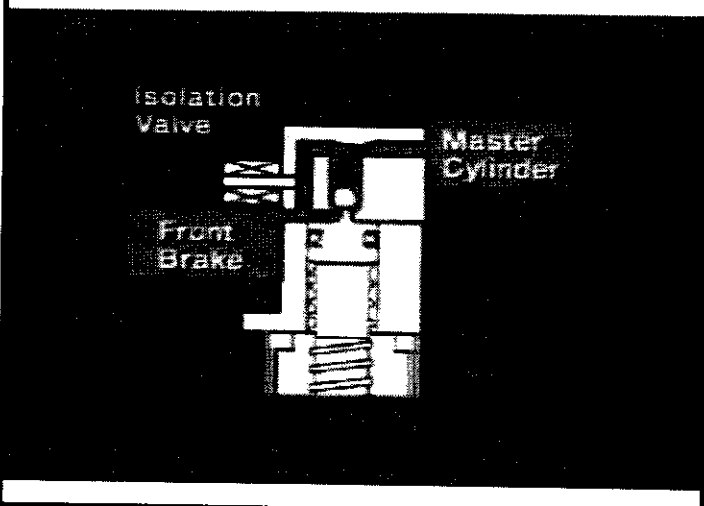


This keeps the check balls open and allows fluid to flow through.

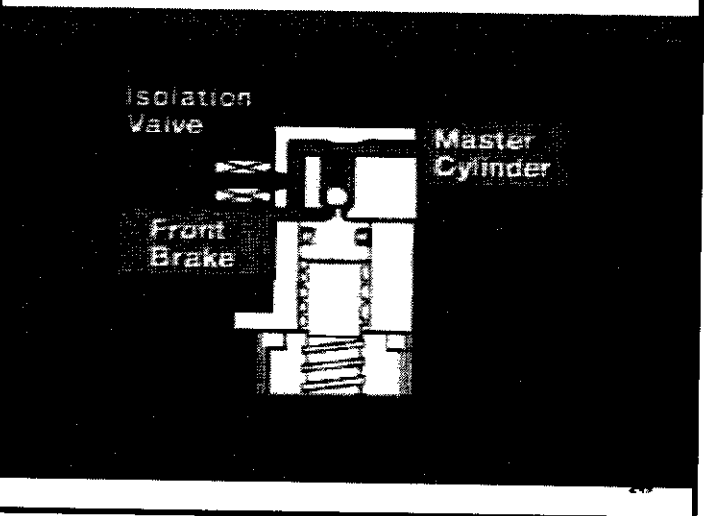
NOTES:



An expansion spring brake (ESB) holds the motor in this position until current is applied to the motor. The ESB is a mechanical brake that works like an overriding clutch.

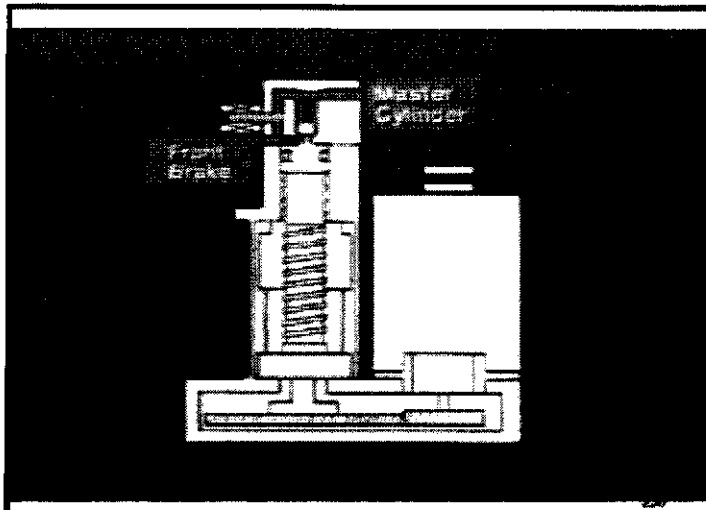


Let's discuss ABS action on the front brakes. This system uses a select low principal of operation. The WSS with the lowest signal is the one that is most likely to lock up. This circuit will receive the ABS action first.

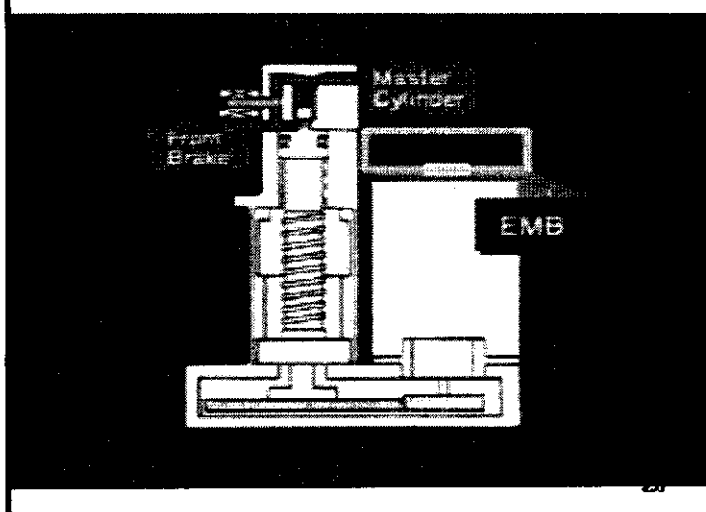


As with any system, the first step of ABS action is to isolate the wheel that is about to lock up. This blocks any additional fluid passing through and going to the calipers.

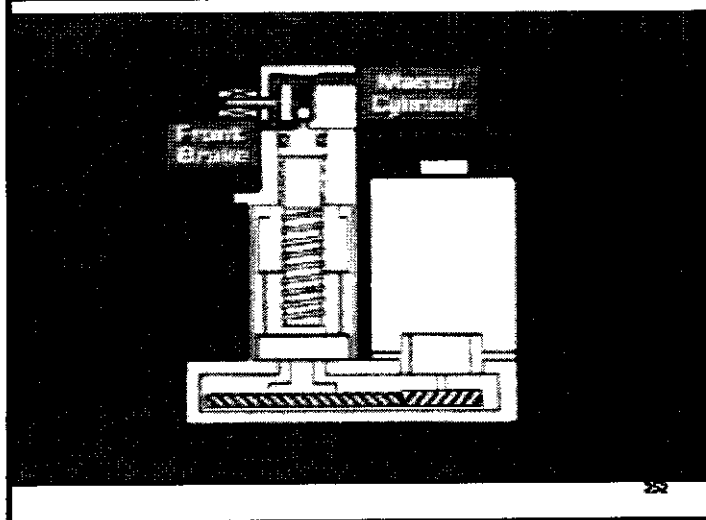
NOTES:



When the isolation valve is activated, it blocks off one of the passages through the modulator.

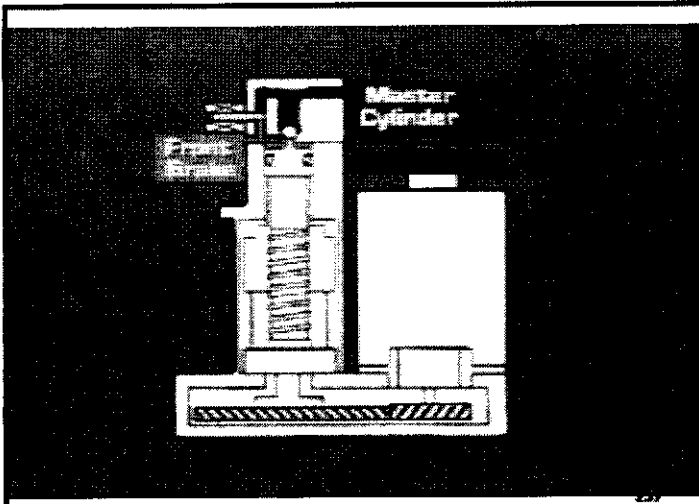


When current is applied to the EMB, the motor is released and free to turn.

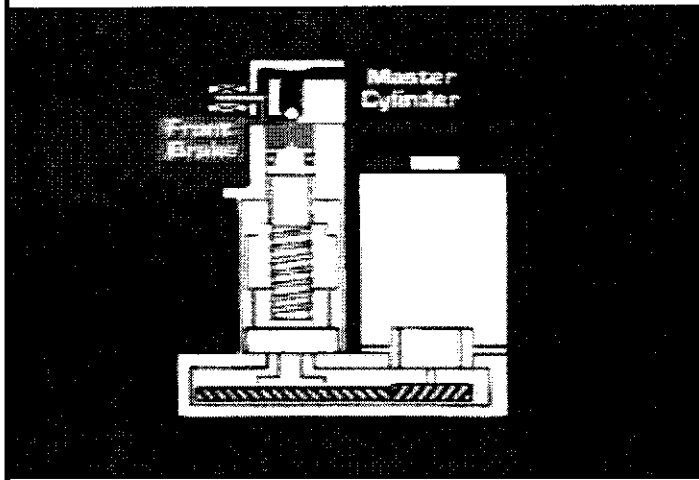


The motor will begin to turn and draw the ball screw and piston down. The check valve seats and that brake circuit is isolated.

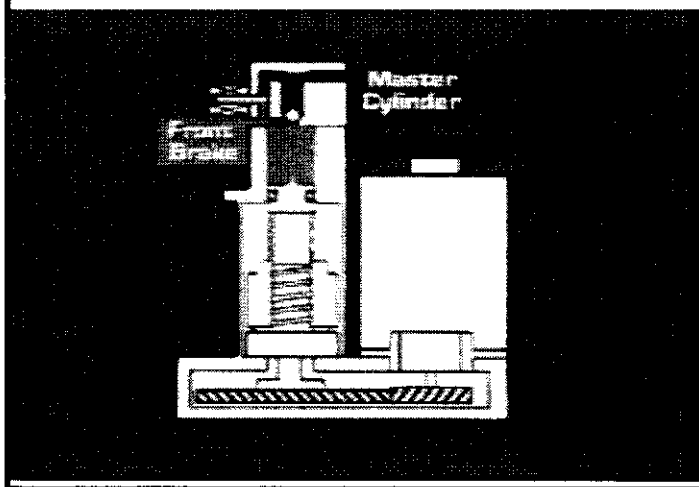
NOTES:



Here we see the fluid beginning to fill the space above the space left by the downward motion of the piston.



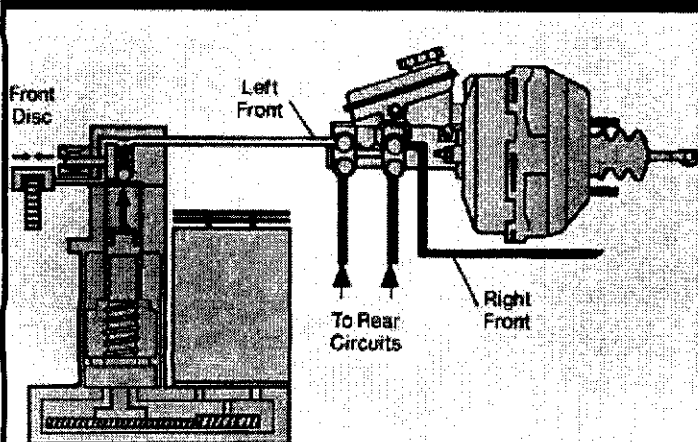
The pressure in the brake circuit applies pressure through the piston to the ball screw.



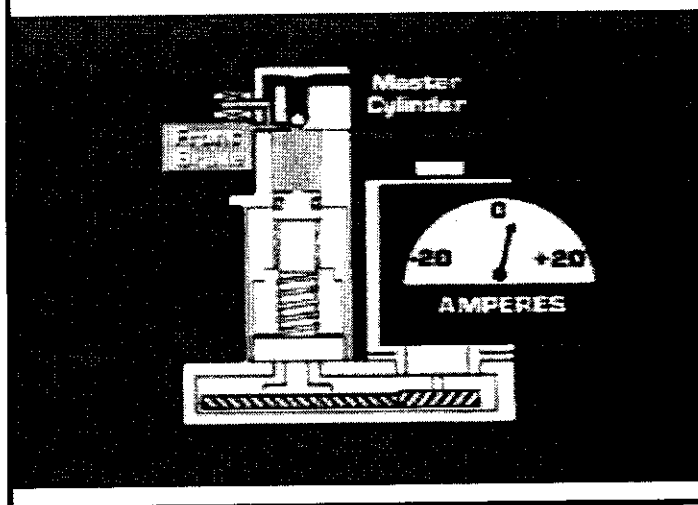
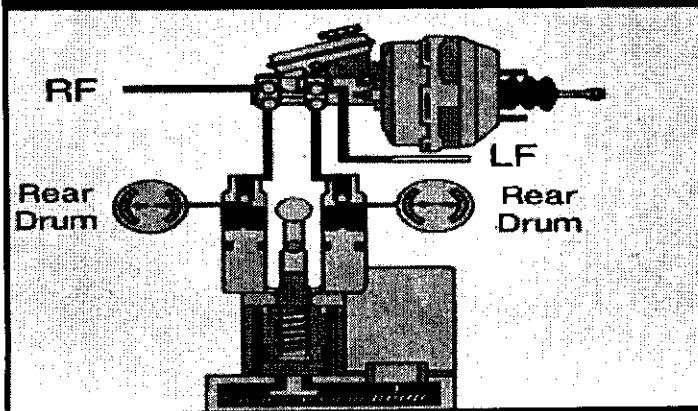
The motor will continue to turn until the pressure above the piston is equal to the pressure exerted by the motor against the ball screw.

NOTES:

ABS Pressure Increase



ABS Rear Circuit Pressure Decrease

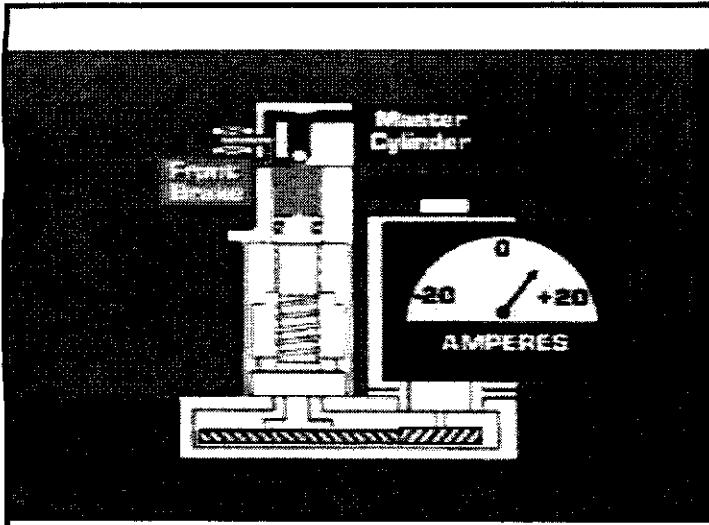


As the wheel starts to turn, the piston is moved upward increasing the pressure in the wheel channel applying the brakes once again. The EBCM regulates the brake pressure in the channel by controlling the current to the motor. More current, more pressure.

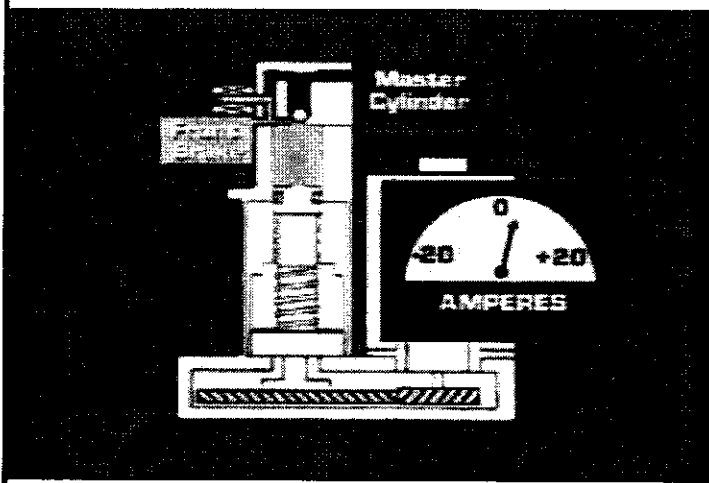
As the wheel continues to lock-up, the motor continues to drive the two pistons downward reducing the pressure in both wheel channels until the wheel begins to turn again. If the rear modulator brake fails and the piston moves and allows the check ball to close, there are no rear brakes. The pistons must be at TDC in order to bleed the rear wheels. With motor pack in place, manually turn the center gear until it stops, (it will only turn one way). The piston is at TDC and will allow the fluid to flow to the rear wheels.

When the pressure is equal, the motor stops turning and current is supplied to the motor by the EBCM. This holds the motor steady.

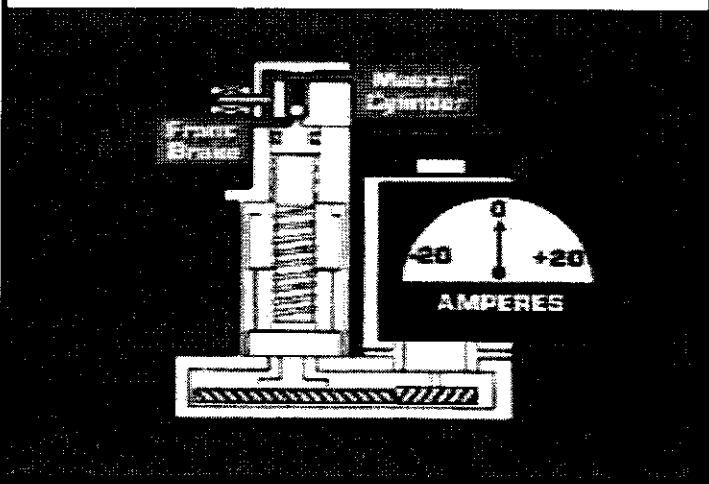
NOTES:



If the WSS signal indicates the wheel is turning too fast, pressure can be reapplied by the motor driving the ball screw and piston back up.

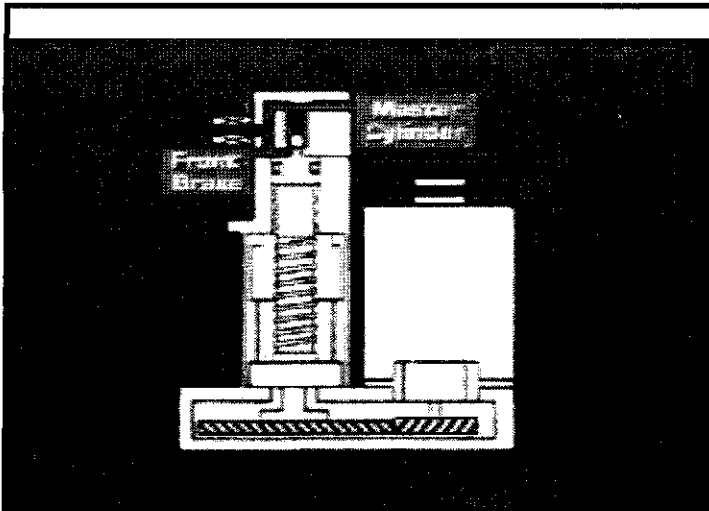


The EBCM commands the motor forward and reverse to increase or decrease the pressure as needed.

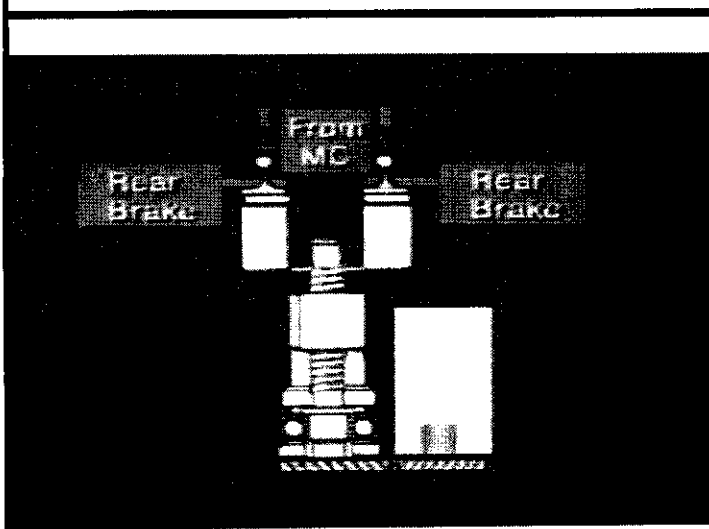


When ABS action is no longer required, the EBCM commands the motor to return the ball screw and piston to the home position. This unseats the check ball and opens one of the passages for the brake circuit.

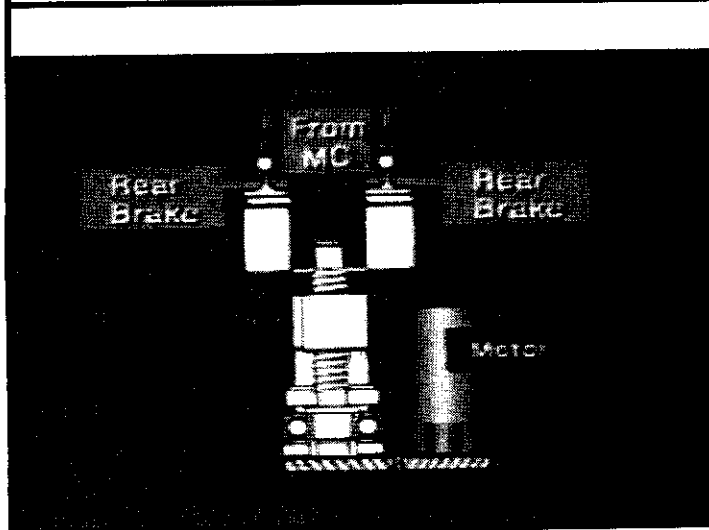
NOTES:



The EMB is turned off and holds the motor in the home position. Current is removed from the isolation valve and returns to its normally open position allowing fluid to pass through the second passage way.

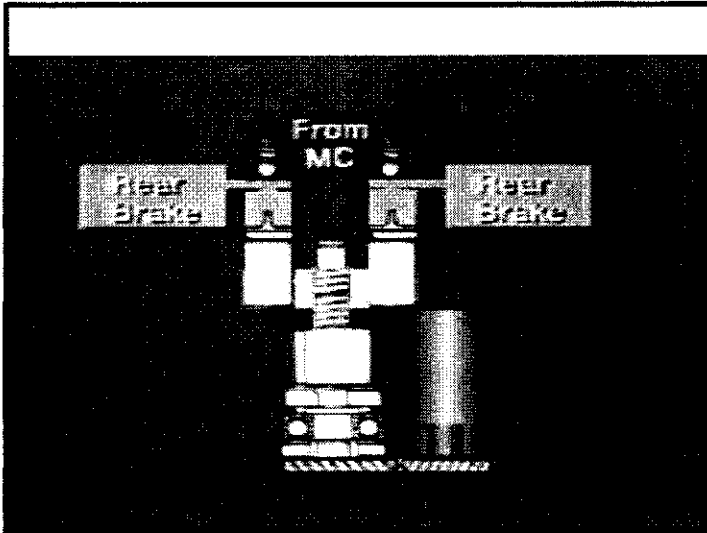


The rear brakes work the same in principle. There are two pistons and one ball screw. This ball screw moves both pistons at the same time. There is one motor and one EMB.

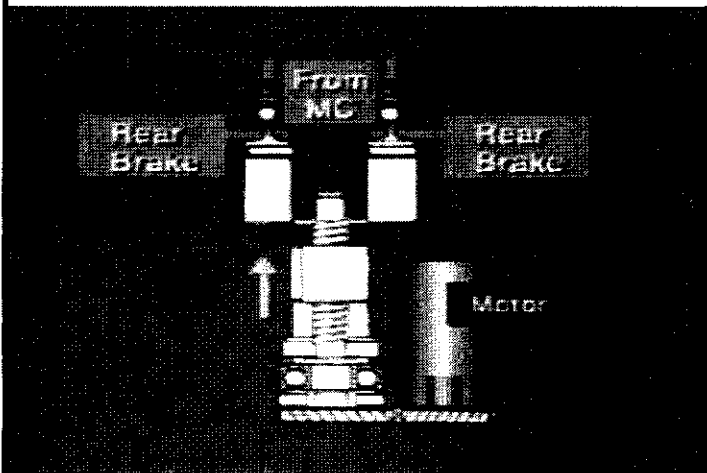


When ABS action is required, the brake circuits are no longer diagonally split. Both rear wheels are controlled as one brake channel.

NOTES:

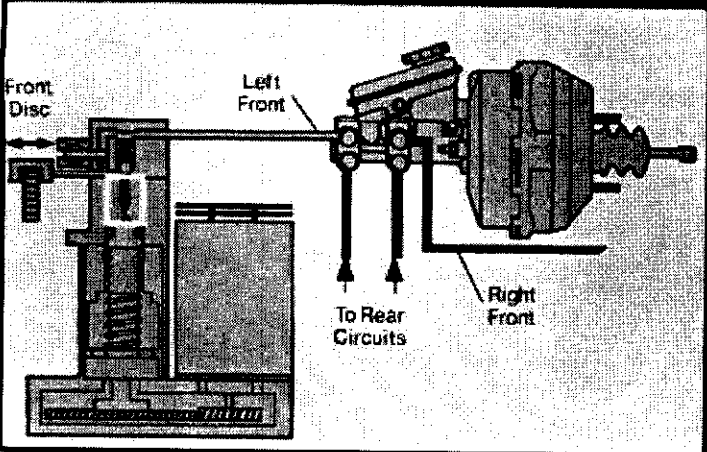


The empty space left by the pistons moving down will be filled with fluid until the pressure is equal.



The increase and decrease operations are the same as the front brakes.

ABS Pressure Decrease

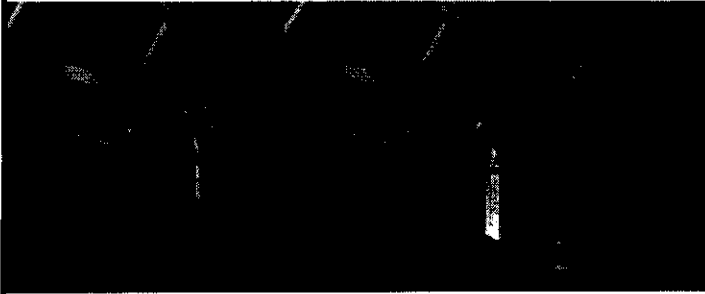


When the wheel approaches lockup, the isolation valve closes, stopping fluid from getting to the caliper. At the same time the piston is moved downward, closing the ball check valve, stopping fluid from getting to the wheel cylinder through that channel. Pressure from the master cylinder is isolated from the wheel. If the wheel continues to lock up, the piston continues to move downward, reducing pressure in the wheel channel.

NOTES:

Diagnostics

- Never connect any of the ABS components with the ignition turn on



When Welding

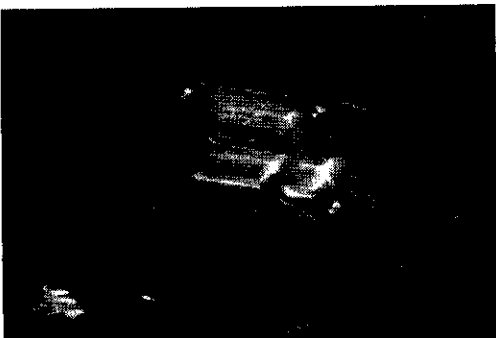
- Disconnect the EBCM harness



260

When Fast Charging the Battery

- Disconnect the EBCM Harness



270

If a fast charge is needed on the vehicle, disconnect the EBCM to protect it from damage.

NOTES:

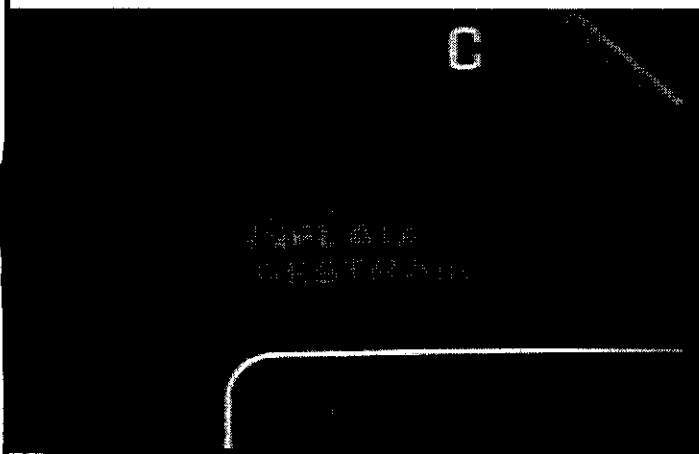
Brake Fluid

- Use DOT 3 or 4 depending on the vehicle
- Do not use DOT 5



Do not use DOT 5 brake fluid in the Delco-VI ABS system. Use only DOT 3 or 4 depending on the vehicle.

Vehicle with Air Bags



If the vehicle has air bags, they should be de-activated when doing any electrical work. This will avoid setting a false code or accidentally deploying the air bag.

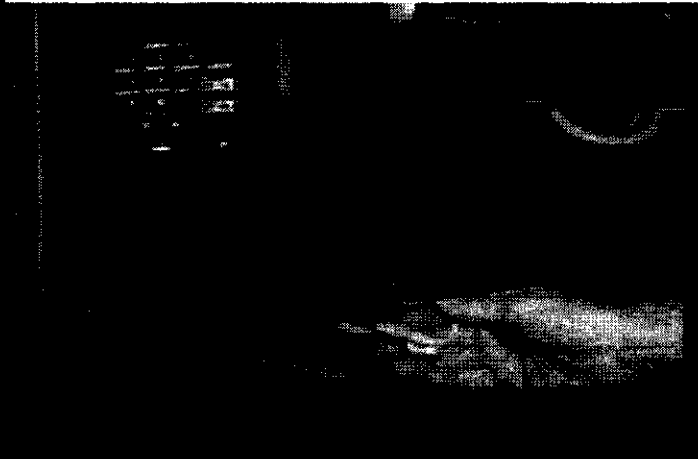
Remove The Fuse



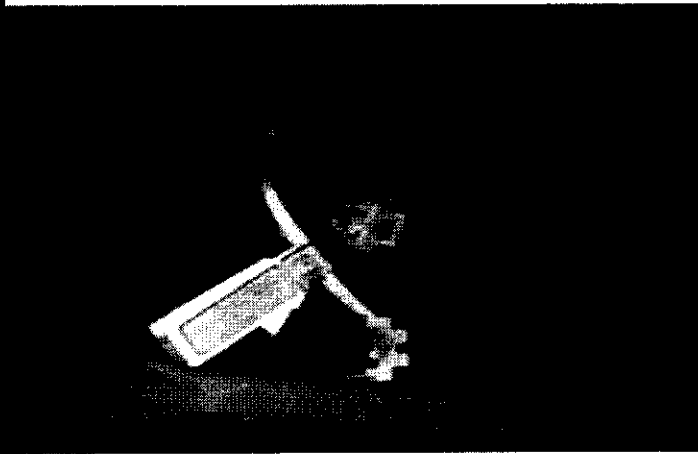
To de-activate the air bag, remove the fuse.

NOTES:

Disconnect the Air Bag



Disconnect The Air Bag



Electronic Systems

- Source voltage
- Common ground
- Proper values
- Connections
- Corrosion
- Moisture
- Dirt

Never connect/disconnect
any electrical components
while the key is on

276

Disconnect the yellow air bag connector at the base of the steering column.

Disconnecting the main vehicle battery will also de-activate the air bag. Remember the air bag control module has a small battery that can keep the system active for up to 10 minutes. If you disconnect the main vehicle battery, you will not have power for the ABS diagnostics.

Whenever working on any electrically controlled systems, the first place to start is with the source of power. After assuring there is proper source voltage and ground, continue checking for loose or dirty connections, moisture or corrosion, and broken wires. When working on electronic control devices, never disconnect or connect components with power applied. Never fast charge battery with computers connected.

NOTES:

Hydraulic Systems

- Void of air
- Proper fluid
- Clean fluid
- No leaks

277

In order for the hydraulic system to operate effectively, there should be no air in the fluid chambers. In the case of ABS, the system should contain clean brake fluid as recommended on the master cylinder cover. The system must not have any internal or external leaks. Never open a hydraulic chamber that has fluid under pressure.

Trouble Shooting

- Slow, sinking brake pedal?
 - May be a slipping EMB / ESB in the motor pack
 - Press pedal - observe gears
 - Should not turn



278

When the ABS is not operating, the front wheel isolation solenoids are open, allowing fluid pressure to be applied to the modulator pistons, as well as to the rest of the system. If the motor brakes are worn out, the piston will be forced downward onto the screw. If this should happen, the effect on the pedal will be the same as a defective master cylinder. Remove the cover to the gears and

with the piston at TDC, press the pedal and note if the gears move. If they do, inspect the motor brake for wear.

NOTES:

Trouble Shooting

- 93 Corsica, Beretta
- GM added trouble code 31 (no signal from two wheels)
- Check harness connector from rear wheels
 - May be set by operating vehicle on lift or in mud or snow.

279

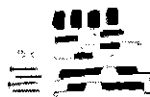
A trouble code of A031 has been added to the diagnostic charts. When the vehicle speed has reached 10 MPH and the parking brake is off, if the EBCM does not see any wheel speed from two wheels simultaneously for 20 seconds, a code A031 will be set and the ABS will be disabled. This condition can occur if the vehicle is operated on a lift, or on a slippery surface. Since both rear

wheel sensors and the fuel sender are connected through a common harness connector, the connector should be suspect and checked to be sure it is clean and tight. The wire harness should be checked for cuts and abrasion. Code 31 may be set by operating vehicle on lift or in mud or snow.

Ref Mitchell Chev 93-46-5 10/28/92

Trouble Shooting

- False Modulation
 - 1992 - 93 Cavalier, Corsica, Beretta, Achieva, Grand Am, Sunbird
 - Rear wheels locking up
- Replace
 - Drums
 - Shoes
 - Hardware



280

Since the rear brakes tend to grab when applied, it causes the wheels to lock up momentarily and skid, then release. This sends a signal to the EBCM and causes the unit to modulate. The repair is to replace the hardware, shoes, and drums. Inspect the backing plate and parking brake cables, to assure proper operation.

Bulletin ST97-23

NOTES:

Trouble Shooting

- Erratic / excessive variation speed sensor codes may be:
 - Tone ring related
 - Bearing related

281

If tone rings (sensor rings) are missing teeth, cracked, out of round, wobble, or if a bearing assembly is bad, the EBCM could mis-interpret the signal, causing false modulation. This problem could cause motors to run excessively causing failure and motor brakes to wear out quickly.

Mechanical Systems

- Operational condition
- Free movement
- Proper lubrication
- Proper components
- Proper adjustment

282

All mechanical devices must be able to perform their designed function. They should move according to their purpose, and where required be lubricated with the proper lubricant. Mechanical components must stay within adjustment tolerances to perform properly. When replaced, they must be able to perform equal to the original part.

Compact Spare Tire

- Use of tire will not set code
- ECM compensates
- Stopping distance is reduced

283

Use of the compact spare tire will not set a code. The ECM is programmed to accept the variation. The ABS unit will not function as efficient as if all tires were the same size. Stopping distance may be longer.

NOTES:

Scan-tool Diagnostics

- Data
- Code history
- Trouble codes
- Recording data
- Bi-direction test

294

You can use a scan-tool on the Delco-VI system. Data, code history, current trouble codes, recording data, and bi-directional test be accessed with a scan-tool.

Data

- Wheel speed sensors
- Vehicle speed sensor
- System voltage
- Warning light
- Brake switch solenoid status
- Amp. Reading for motors
- EMB status
- Enable relay status

295

With a scan-tool you can view the data list. The data list is not the same for all vehicles.

History Codes

- History of codes that were set
- Stored in order they were set
- Number of drive cycles since the code was set
- A drive cycle is completed when the ignition is turned on and the vehicle is driven over 10 MPH.

296

History codes will help you when diagnosing the system. The codes are stored in the order they were set. The history codes will help you determine if the earlier fault is linked to the present fault.

NOTES:

Trouble Codes

- Current trouble codes
- Stored even when power is removed
- Can clear codes (50 drive cycles)

287

Current codes should be diagnosed first. Diagnose the lowest numbered code first.

Recording Data

- Record the data on a test drive and review
- Drive the vehicle on a dirt road
- Make a hard stop

288

You must be careful on a test drive. Do not watch the scan-tool. Record the data and review it after you have come to a safe stop.

Bi-Direction Test

Manual Test

- Motors
- EMBs
- Isolation solenoids
- Enable relay

289

You can turn on and off the outputs with the manual test.

NOTES:

Bi-Direction Test

- Automatic test (some scan-tools)
- Modulator and motor pack
- Light test
- Battery voltage test
- System ID test
- Gear tension relief test

290

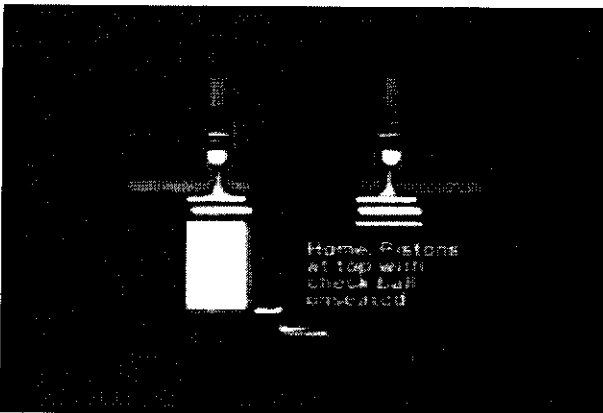
On some scan-tools, an automatic test will test the mechanical functions of the modulator and motor pack. The test will also perform light, battery voltage, system ID, and gear tension relief test. On some scan-tools the gears relief test is called "home motors".

Bleeding Procedures

- Right rear
- Left rear
- Right front
- Left front

291

Bleeding Procedures

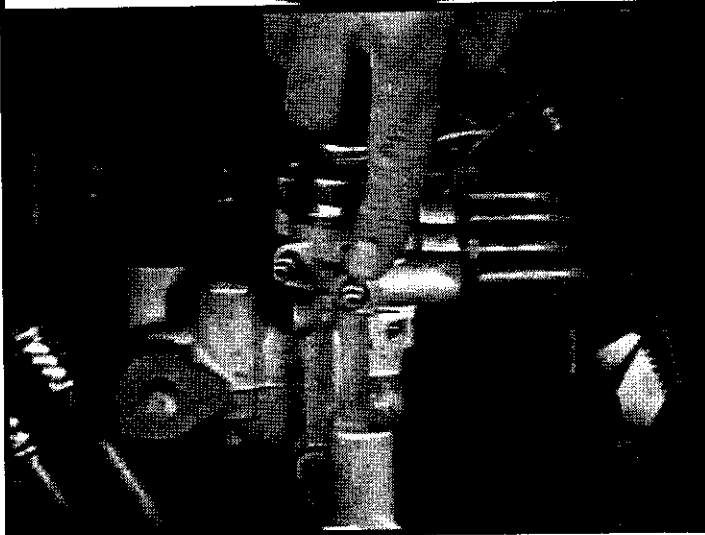


You must make sure the rear pistons are in the home position. The check balls must be unseated or you will not be able to bleed the rear brakes.

NOTES:



293



Delphi Chassis VI Traction Control

- Traction control management
 - Spark retard
 - Fuel cut-off
 - Throttle relaxer assembly
 - Brake intervention

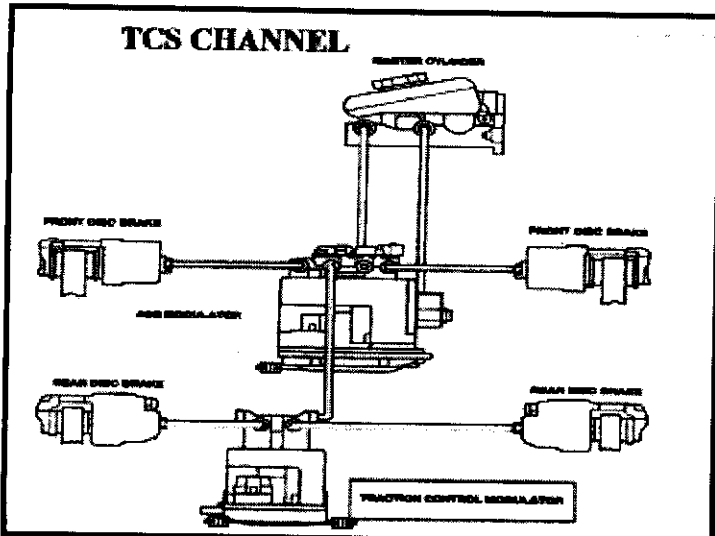
295

You can use the manual functions of your scan-tool to home the motors.

Without a scan-tool, you must first bleed the modulator. There are two bleeder screws, make sure you use the front one for bleeding the modulator. Then bleed the front brakes. Bleed the right one first. Drive the vehicle above 3 MPH. The system will reset itself and home the rear motor. You can then bleed the rear brakes.

Traction control can be managed by the ABS system. When the EBTCM detects positive wheel slip, that information is fed to the ECM. The ECM will first retard the engine timing, if it continues to detect wheel slip, it will then shut down the injectors. If the wheel continues to slip, it will back off the throttle, and if it still continues, the EBTCM will apply the brake to the wheel.

NOTES:



The traction control modulator is very similar to the brake modulator. It is downstream of the brake modulator and may have only one brake line supplying it. Two brake lines from the TCS modulator supply two drive wheels.

Traction Control

- Motor pack
- Modulator
- Gears
- Pistons at BDC

This modulator uses two motors, one for each drive wheel. Gears drive the piston assembly just like the brake modulator. The pistons are parked in the bottom position, waiting for the EBTCM command.

TCS At Rest Mode

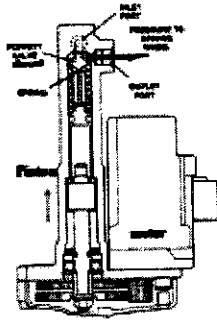
- Motor at rest
- Piston BDC
- Poppet valve open
- No fluid pressure

When traction control is at rest, the motor has no power to it. The piston is at the bottom position and, the poppet valve is in the open position. The unit performs no function at this time.

NOTES:

TCS Applied Mode

- Motor energized
- Piston applies pressure
- Poppet valve closed
- Pressure to drive wheel
 - Piston must be at BDC to release pressure from drive wheel

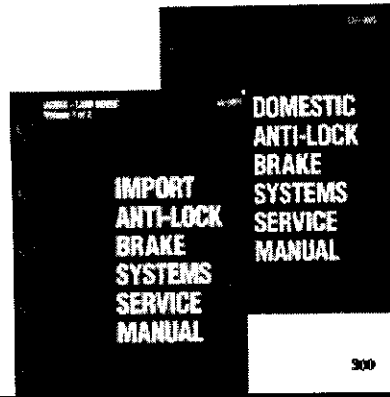


299

When the EBTCM detects positive wheel slip by comparing drive wheel speed to the other wheels, it turns the motor on that controls that wheel channel. The motor drives the piston up and applies spring pressure to the poppet valve closing the line to the master cylinder. As the piston continues, closing pressure is applied to the rear channel applying the brake. If the motor stops in the up position, fluid will not be released since the poppet valve will be held closed. This may act like a faulty brake hose.

Service Manuals

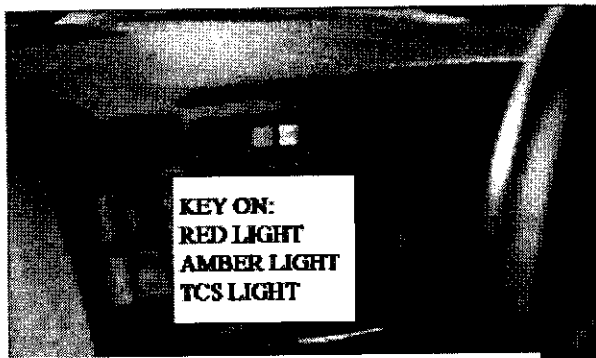
- ABS manual mandatory
- Procedures
- Diagrams
- Code identification



300

Manuals or a comparable resource is required to work on ABS equipped vehicles, since there are so many variations in procedures and systems. Following diagnostic charts and proven procedures, save time and money.

Lamp Diagnostics



Flashing amber lamp - fault in red light circuit 1995+

TCS light will come on during ABS operation

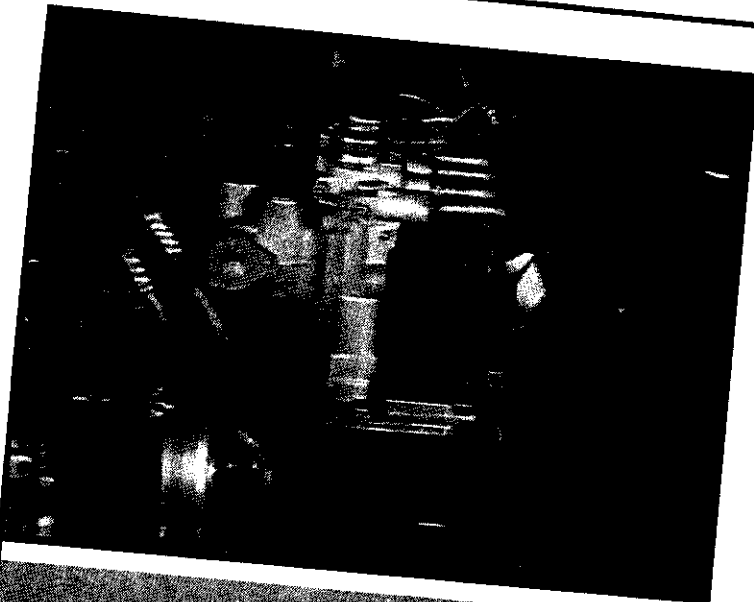
301

When the key is turned on, the red, amber and TCS light will turn on. In vehicles after 1995, if a fault is detected in the red light circuit, the amber light will flash. During ABS stops, the amber light and the TCS light will come on. The TCS will stay on for 3 to 4 seconds after the ABS stop is completed.

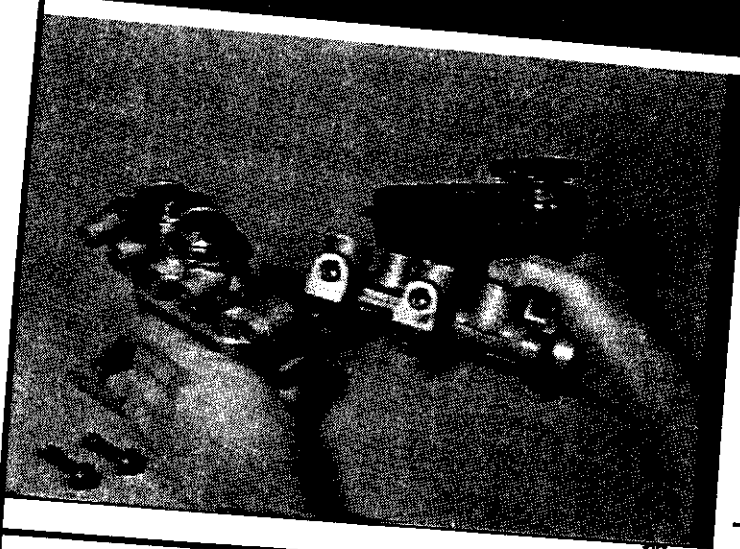
NOTES:

Anti-Lock Brakes ABS-101 Pre-Test

1. True or False: The pedal travel switch replaces the brake stop light switch on some vehicles.
True _____ False _____
2. Wheel speed sensors are _____ type sensors.
A. Digital B. Hall effect C. Permanent magnet D. Potentiometer
3. Wheel speed sensors create _____ voltage.
A. AC B. DC C. Digital D. All the above
4. True or False: As voltage increases the frequency decreases on a wheel speed sensor.
True _____ False _____
5. The first ABS action the PCM will perform to prevent a wheel from locking up is:
A. Dump Pressure B. Release pressure C. Isolate the wheel D. Un-lock the wheel
6. After the PCM sets a DTC it will:
A. Isolate the wheels B. Abort ABS action C. Dump wheel pressure D. None of the above
7. On Delco VI ABS systems the PCM changes the pressure to the wheels with:
A. Dump valves B. Isolation valves C. Both A&B D. None of the above
8. True or False: On Delco VI systems the rear wheels are never isolated.
True _____ False _____
9. Use _____ brake fluid only in ABS systems.
A. DOT 3, 4 or 5 B. DOT 3 or 4 C. Only DOT 5 D. Only DOT 2
10. When the brake fluid hygroscopic value is zero the fluid is:
A. New B. Acceptable C. Not acceptable D. None of the above



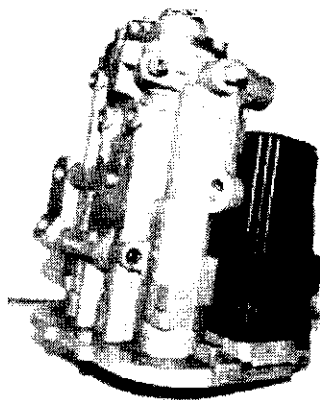
The hydraulic assembly and motor pack is attached to the master cylinder.



In this photo, the hydraulic assembly and motor pack are separated.

Master Cylinder Mounting

- Mounting banjo bolts
- Transfer tubes
- Do not reuse
- Transfer tubes and "O" rings included with m/cyl

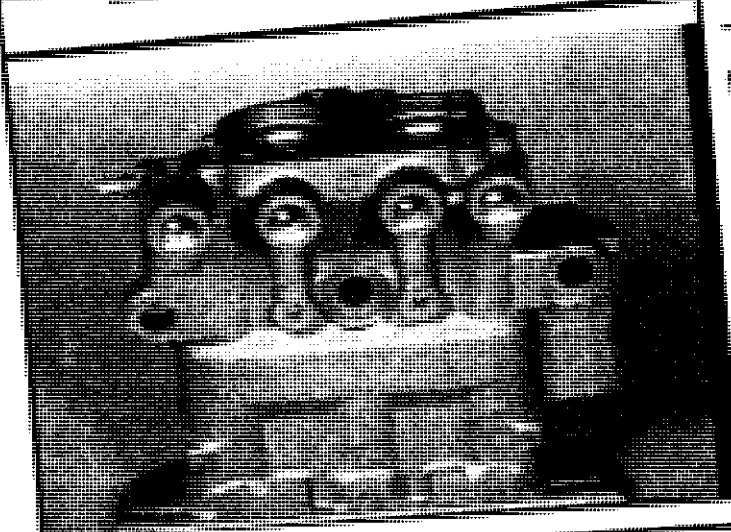


The master cylinder is connected to the modulator by two banjo bolts and two fluid transfer tubes. These tubes cannot be reused. Fluid moves from the master cylinder through the banjo bolts to the rear wheel circuit. The transfer tubes allow fluid to move from the master cylinder to the front wheel channels. Raybestos includes the transfer tubes and "O" rings with their master cylinders.

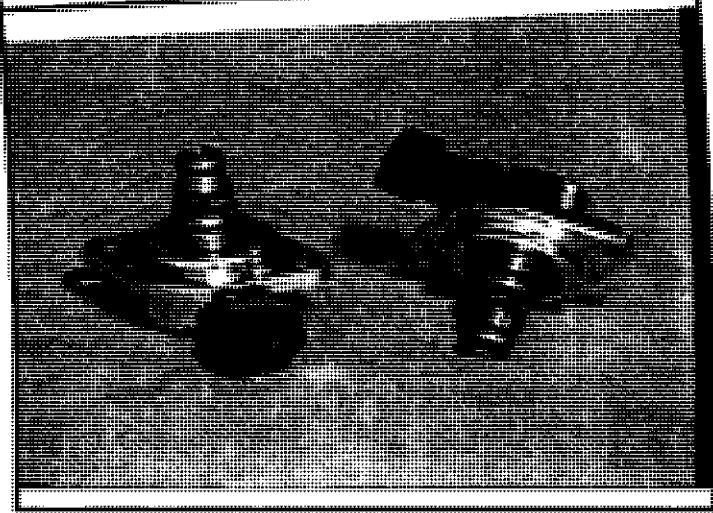
NOTES:



This cutaway shows the mounting of the master cylinder and modulator with the use of the banjo bolts and fluid transfer tubes. The transfer tubes and their "O" rings are not to be re-used.

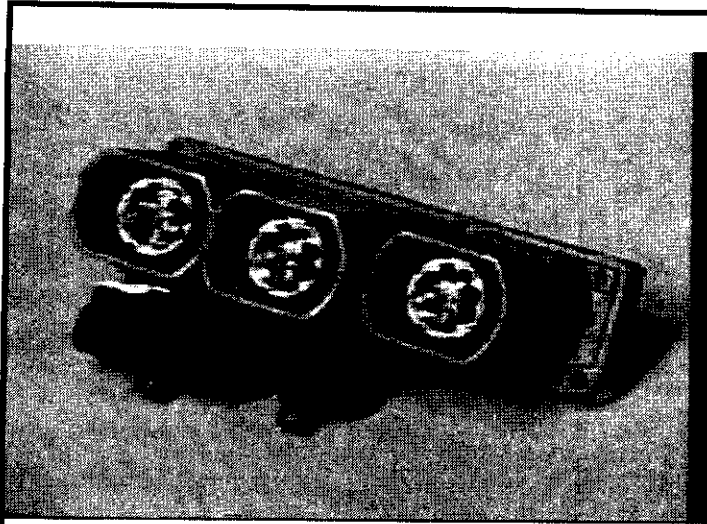


The hydraulic assembly and motor pack contain four fluid chambers for all four brakes and four check valves. There are also two isolation valves in the assembly.

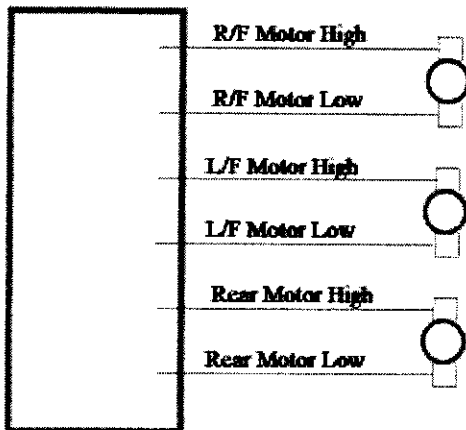


There are two isolation valves in the assembly.

NOTES:

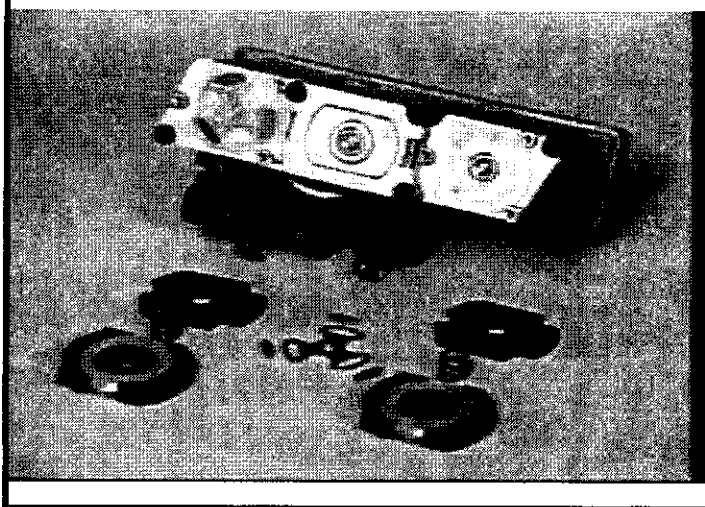


The motor pack in the assembly has three bi-direction motors.



The three motors are for the right and left brake circuits. The rear brake circuit has only one motor.

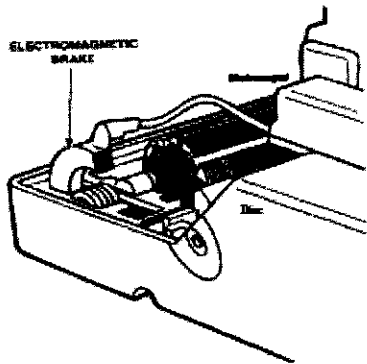
215



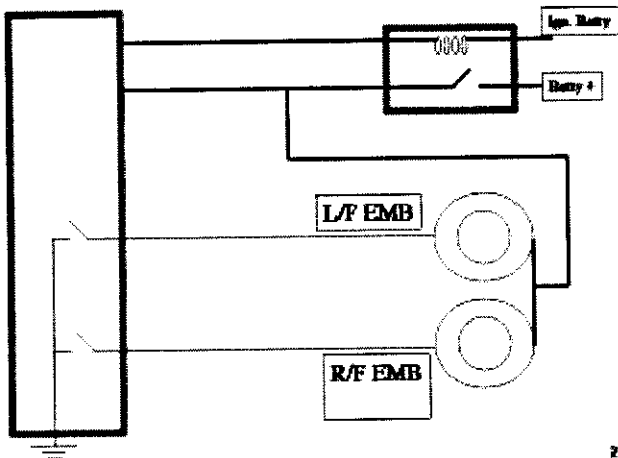
On some models, the three motors have electromagnetic brakes. (EMB)

NOTES:

Electromagnetic Brake

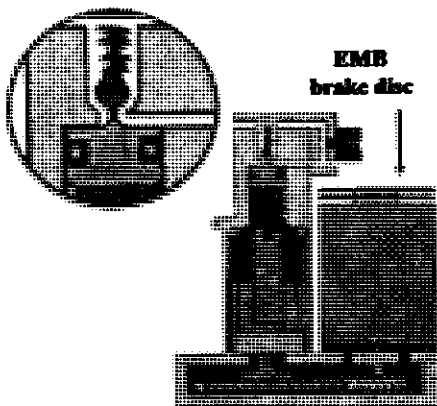


This is a clutch brake configuration that is applied by spring pressure holding the motor shaft from turning, in turn holding the piston in place. The electromagnet overcomes the holding force applied by spring pressure when piston travel is required. Friction pucks on the disc wear out, allowing the piston to move downward under pressure. The friction pucks are replaceable.



The EBCM controls the EMBs ground side switching. Battery power is supplied through the enable relay. The relay is power by ignition power.

EMB Brake



The electromagnetic brake is located at the top of the motor and is normally applied by spring pressure.

NOTES:
