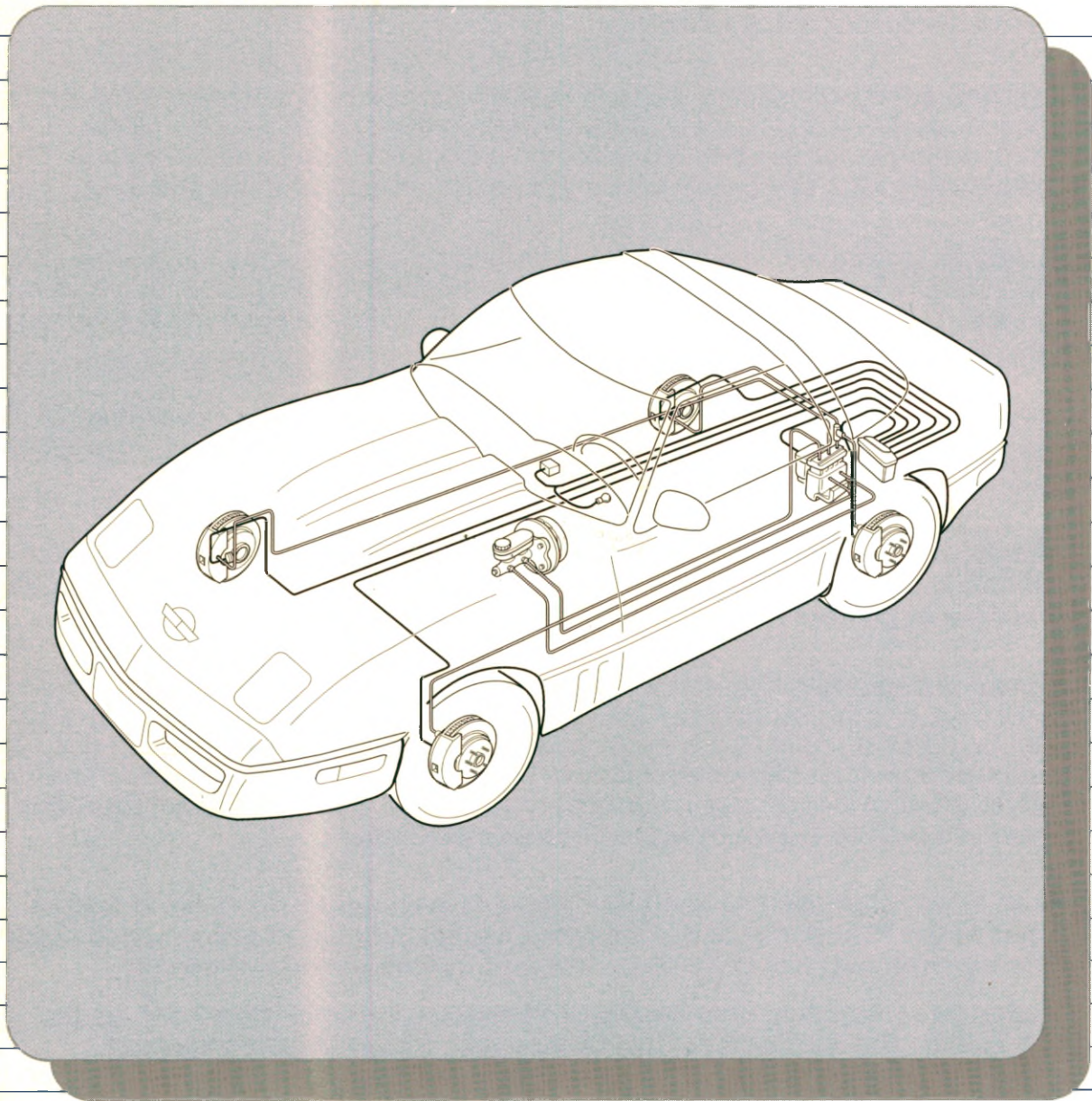


Introduction to Antilock Brake Systems



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Caution

In order to reduce the chance of personal injury and/or property damage, carefully observe the instructions that follow.

Service information provided by General Motors Corporation is intended for use by professional, qualified technicians. Attempting repairs or service without the appropriate training, tools, and equipment could cause injury to you or others. This could also damage the vehicle, or cause the vehicle to operate improperly.

Proper vehicle service and repair are important to the safety of the service technician and to the safe, reliable operation of all motor vehicles. If you need to replace a part, use the same part number or an equivalent part. Do not use a replacement part of lesser quality.

The service procedures we recommend and describe in this manual are effective methods of performing service and repair. Some of the procedures require the use of tools that are designed for specific purposes.

Accordingly, any person who intends to use a replacement part, a service procedure, or a tool that is not recommended by General Motors, must first establish that there is no jeopardy to personal safety or the safe operation of the vehicle.

This manual may contain "Cautions" that you must observe carefully in order to reduce the risk of injury to yourself or others. This manual also contains "Notices" that must be carefully followed in order to avoid improper service that may damage the vehicle, or damage tools or equipment. These "Cautions" and "Notices" are not exhaustive. General Motors can not possibly warn of all the potentially hazardous consequences of your failure to follow these instructions.

If the vehicle being serviced is equipped with a Supplemental Inflatable Restraint (SIR), refer to the "Cautions" in the following service manual section/service category type before performing a service on or around SIR components or wiring:

- Section 9J — Supplemental Inflatable Restraints, refer to "Cautions" under "On-Vehicle Service" and the SIR Component Wiring Location view, or
- Section — Body and Accessories, Sub-section - Restraints, refer to "Cautions" under "On-Vehicle Service" and the SIR Component Wiring Location view

Failure to follow these "Cautions" could cause air bag deployment, personal injury, or otherwise unneeded SIR repairs.

In order to help avoid accidental air bag deployment and personal injury, whenever you service a vehicle that requires repair of the SIR and another vehicle system, we recommend that you first repair the SIR, then go on to the other system.

Introduction to Antilock Brake Systems

Foreword

This manual contains information about the Antilock Brake Systems (ABS) used on General Motors vehicles. Always refer to the applicable vehicle Service Manual and appropriate Dealer Technical Service Bulletins for additional information regarding system operation and diagnostic/repair procedures.

When this manual refers to a brand name, a number, or a specific tool, you may use an equivalent product in place of the recommended item.

All information, illustrations and specifications in this manual are based on the latest product information at the time of publication approval. General Motors reserves the right to make changes at any time without notice.

Published by NORTH AMERICAN OPERATIONS, General Motors Corporation, Warren, Michigan 48090-9008.

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About This Handout

This handout gives you an overview of antilock brake systems. There are five main sections:

1. **Introduction:** Presents a system overview and explanation of terms used.
2. **Components:** Identifies and locates the major ABS components and identifies different systems used in GM vehicles since 1986.
3. **Operation:** Describes how the components operate individually and as an integrated system.
4. **Diagnostics:** Covers the correct procedures for accurately diagnosing ABS malfunctions.
5. **Service and Diagnostic Tools:** Lists special tools used for diagnosis of the antilock brake system.

Special Information and Abbreviations

Throughout this handout, you will see special information as follows:

- **IMPORTANT** indicates information that deserves special attention. Often, "important" clarify information or point out exceptions.
- **NOTICE** indicates the potential for vehicle or service equipment damage unless specific steps are followed.
- **CAUTION** indicates the potential for personal injury. For your own safety, please read these reminders carefully.

Also, several abbreviations are used to describe system components:

- **ABS:** Antilock Brake System
- **ASR:** Acceleration Slip Regulation
- **BCM:** Body Computer Module
- **BPMV:** Brake Pressure Modulator Valve
- **DIC:** Driver Information Center
- **DRA:** Digital Ratio Adapter
- **DRAB:** Digital Ratio Adapter Buffer
- **DRAC:** Digital Ratio Adapter Calibrator
- **EBCM:** Electronic Brake Control Module
- **ECM:** Engine Control Module
- **EHCU:** Electro-Hydraulic Control Unit
- **OVP:** Over Voltage Protection
- **PMV:** Pressure Modulator Valve
- **RBWL:** Red Brake Warning Lamp
- **RWAL:** Rear Wheel Antilock
- **TCS:** Traction Control System
- **VSS:** Vehicle Speed Sensor
- **WSS:** Wheel Speed Sensor
- **4WAL:** Four Wheel Antilock

1. Introduction

Introduction

For over 20 years, engineers have been developing electronic Antilock Brake Systems (ABS) for cars and trucks. In the last decade, significant improvements in sensor technology and microprocessors, along with increased public demand, have led to ABS being available in all GM passenger cars and light trucks.

Antilock brakes represent perhaps the single most important safety enhancement for cars and trucks in this decade. It may be more accurate to state that ABS is a collision avoidance system. ABS allows the driver to maintain steering control of the vehicle while in hard braking situations. In many cases, it affords shorter stopping distances than most drivers can achieve manually, particularly as the road traction deteriorates. The computerized ABS is designed to keep the wheels from locking as the brakes are applied. A locked wheel provides little or no directional control.

This course introduces the student to antilock brake systems:

- Components and variations in hardware
- Operation
- Diagnostic procedures
- Safe service techniques and diagnostic tools

1. Introduction

Why ABS?

In critical braking situations, many people tend to do the wrong thing. Aside from law enforcement personnel and professional race car drivers, few people are prepared for evasive maneuvers or sudden stops (Figure 1-1). In addition, wet or icy pavement substantially reduces traction, making it more difficult to stop and steer safely while braking.

Safe Braking Requirements

The safest stop is one where the driver can:

- Continue to steer the vehicle (directional control)
- Stop straight (directional stability)
- Stop in the shortest distance

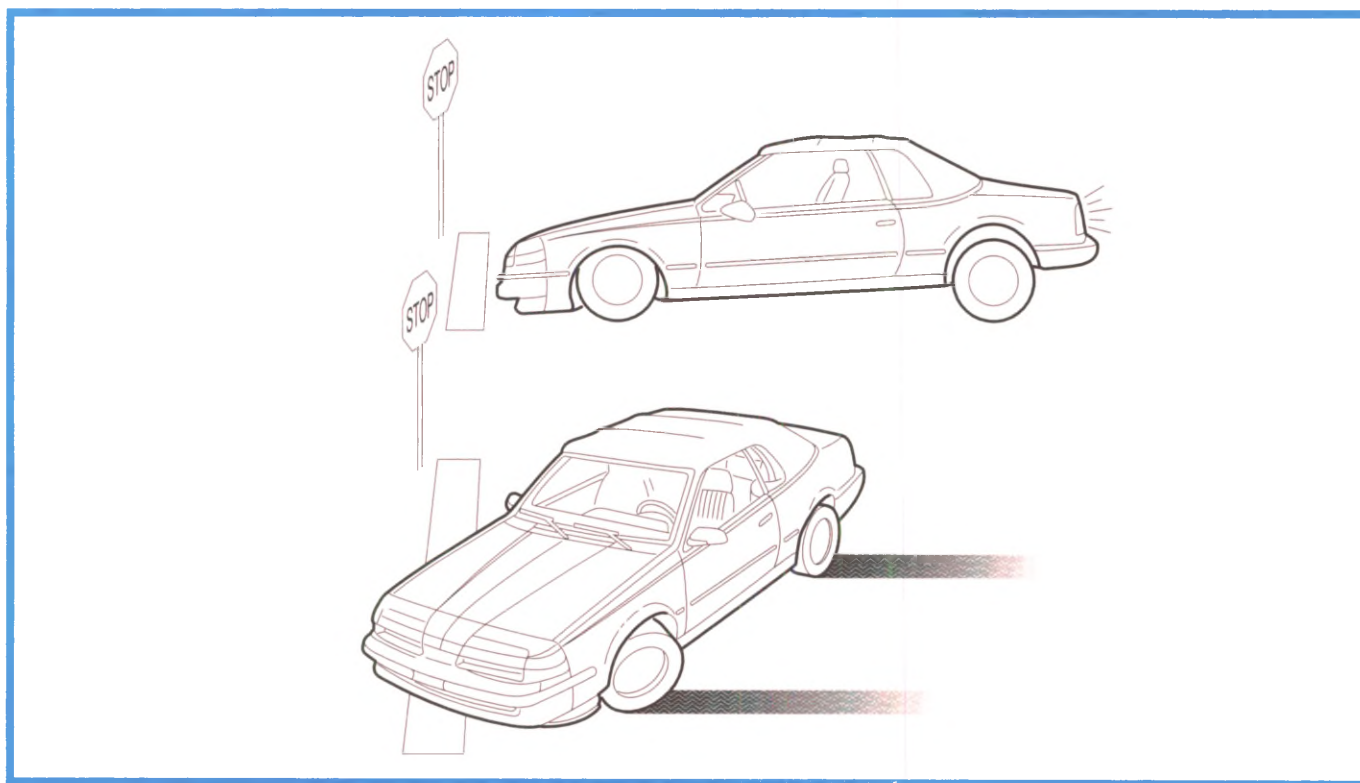


Figure 1-1, Antilock and Non-Antilock Braking

Whether the vehicle can stop safely depends on several factors. Factors that may affect the stopping ability include:

- Base brake components
- Sufficient friction between the wheel and road (traction)
- Driver skill
- Driver reaction time

For the best stopping performance, the wheel should slip 10% to 20% against the road surface.

— IMPORTANT —

**0% slip is a free-rolling wheel. 100% slip is a locked wheel sliding along the pavement.
Optimum braking occurs when the wheels are at 10-20% slip.**

Negative Wheel Slip

Negative wheel slip occurs during braking. During negative wheel slip, wheel speed is less than vehicle speed. ABS maintains the optimum wheel slip for best braking.

Positive Wheel Slip

Positive wheel slip occurs during acceleration. During positive wheel slip, wheel speed is greater than vehicle speed. Traction control systems, which use many ABS components, maintain positive wheel slip for best acceleration.

Uncontrolled Braking

Uncontrolled braking occurs when the wheels are locked (100% slip). 100% slip leads to three problems:

- Loss of directional control (driver can't steer the vehicle)
- Loss of directional stability (vehicle may slide sideways, especially if the rear wheels lock)
- Increased stopping distance

100% slip can be caused by insufficient traction between the wheel and road due to (Figure 1-2):

- Road surface (wet or slippery road surface)
- Traction surface (poorly maintained tires)
- Overcoming the laws of physics (the vehicle is operated beyond its safe capability)
- Vehicle weight and tire loading

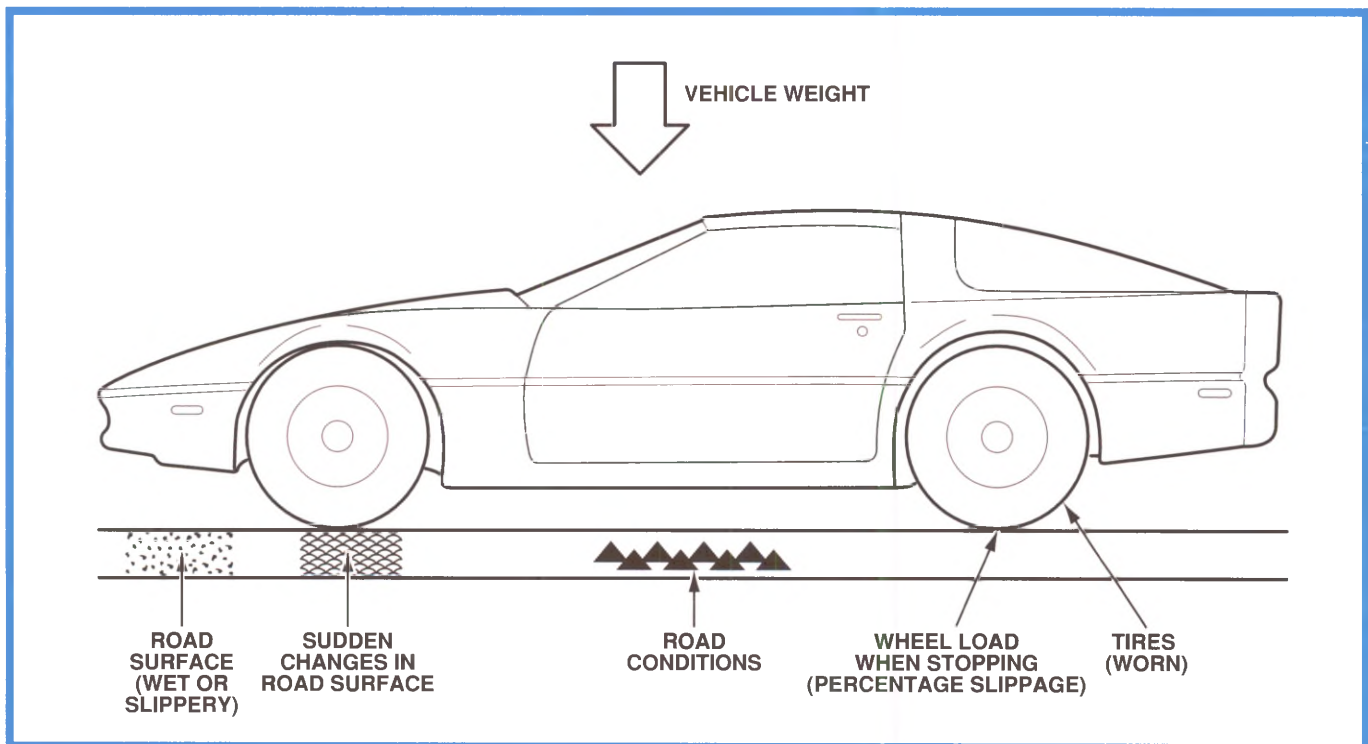


Figure 1-2, Causes of Uncontrolled Braking

The Goal of ABS: Safety and Security

Antilock brake systems are designed to keep wheels near the optimum slip level of 10 to 20% during braking so the driver can steer safely under hard braking maneuvers (Figure 1-3).

Non-ABS Braking

Vehicles not equipped with antilock brake systems rely on the driver to provide the correct pedal pressure to prevent wheel lockup. Depending on the judgment, training, driving experience and reaction time, drivers may:

- Feel the wheels approaching lockup
- Pump the brake pedal, operating all four wheel brakes, one-to-three (1-3) times per second. The wheels will slip-steer-slip-steer until stopped.

ABS Braking

Vehicles equipped with ABS use a microprocessor computer (called an electronic brake control module or EBCM) to prevent wheel lockup. The antilock brake system does not rely on training, experience or reaction time of the driver. The EBCM can:

- Detect when a wheel is approaching lockup
- Apply ABS braking only to the affected wheel or axle
- Pump the brakes up to 15 times per second until ABS braking is no longer needed.

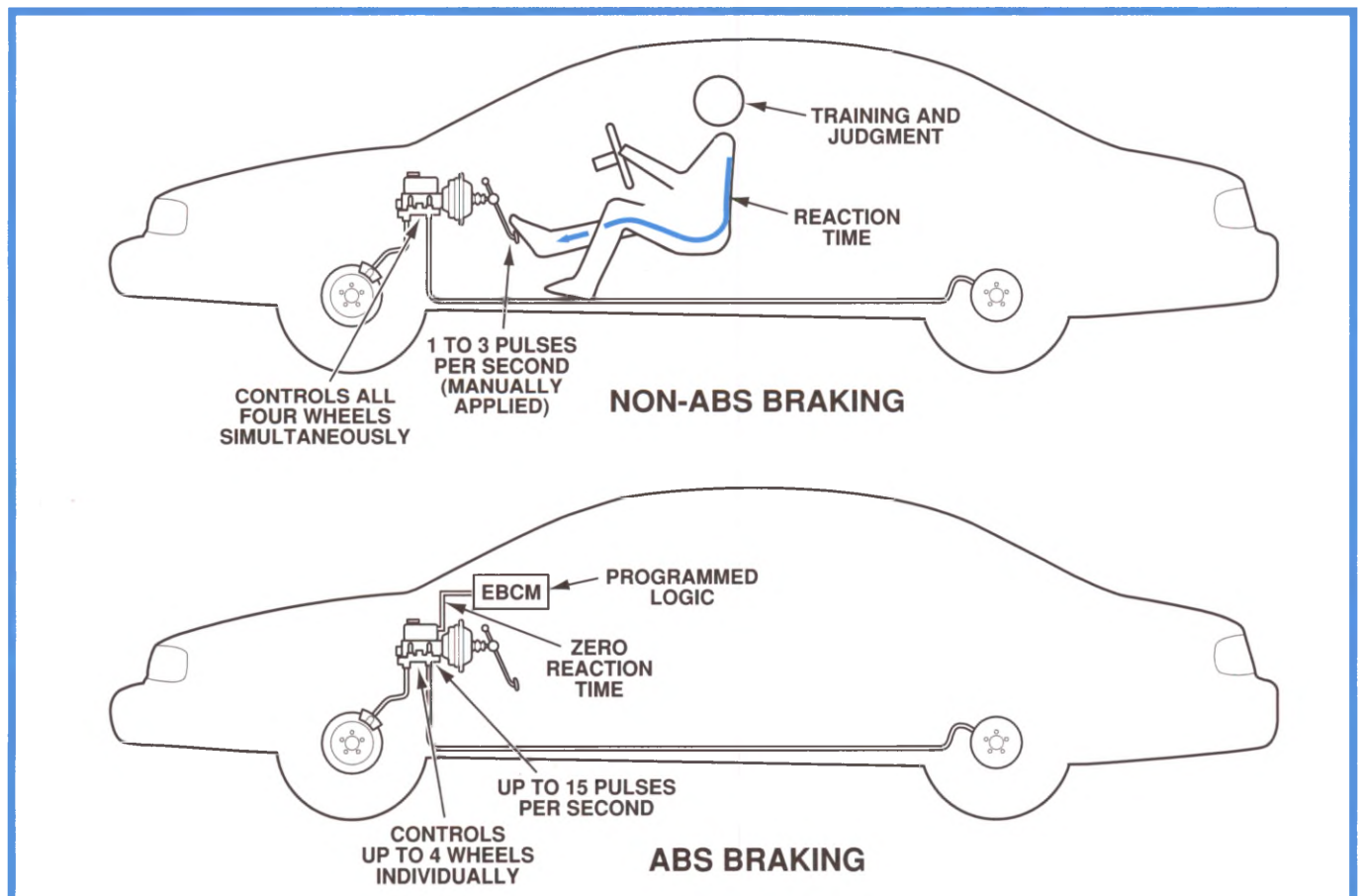


Figure 1-3, Non-ABS and ABS Braking

1. Introduction

Base Brake System Components

The term base brakes appears throughout this handout. Base brakes are the parts of the braking system found on all vehicles, even if not equipped with ABS.

The base brake system consists of:

- Master cylinder
- Power booster
- Brake calipers and wheel cylinders
- Brake pads and linings
- Brake rotors and drums
- Brake lines
- Parking brake
- Proportioner valve(s)
- Red brake warning lamp (RBWL)

Antilock Brake System Components

As with any automotive computer system, to control braking, the antilock brake system (ABS) relies on:

- A microprocessor
- Inputs from sensors and switches
- Outputs from the microprocessor

Microprocessor

The electronic brake control module (EBCM) performs the following functions (Figure 1-4):

- Monitors wheel speed and hydraulic unit functions
- Monitors brake pedal position
- Detects potential wheel lockup conditions during brake pedal application
- Prevents wheel lockup while maintaining optimum braking performance
- Alerts the driver to system malfunctions
- Stores and displays ABS diagnostic trouble codes (most models).

The EBCM also monitors the system at vehicle start-up and during vehicle operation. If the EBCM detects an error it can take any or all of the following actions:

- Disable the antilock function
- Store a diagnostic trouble code in memory
- Turn the amber ABS warning lamp "ON" to alert the driver

GM vehicles utilize several variations of this ABS input/output diagram depending upon specific vehicle application.

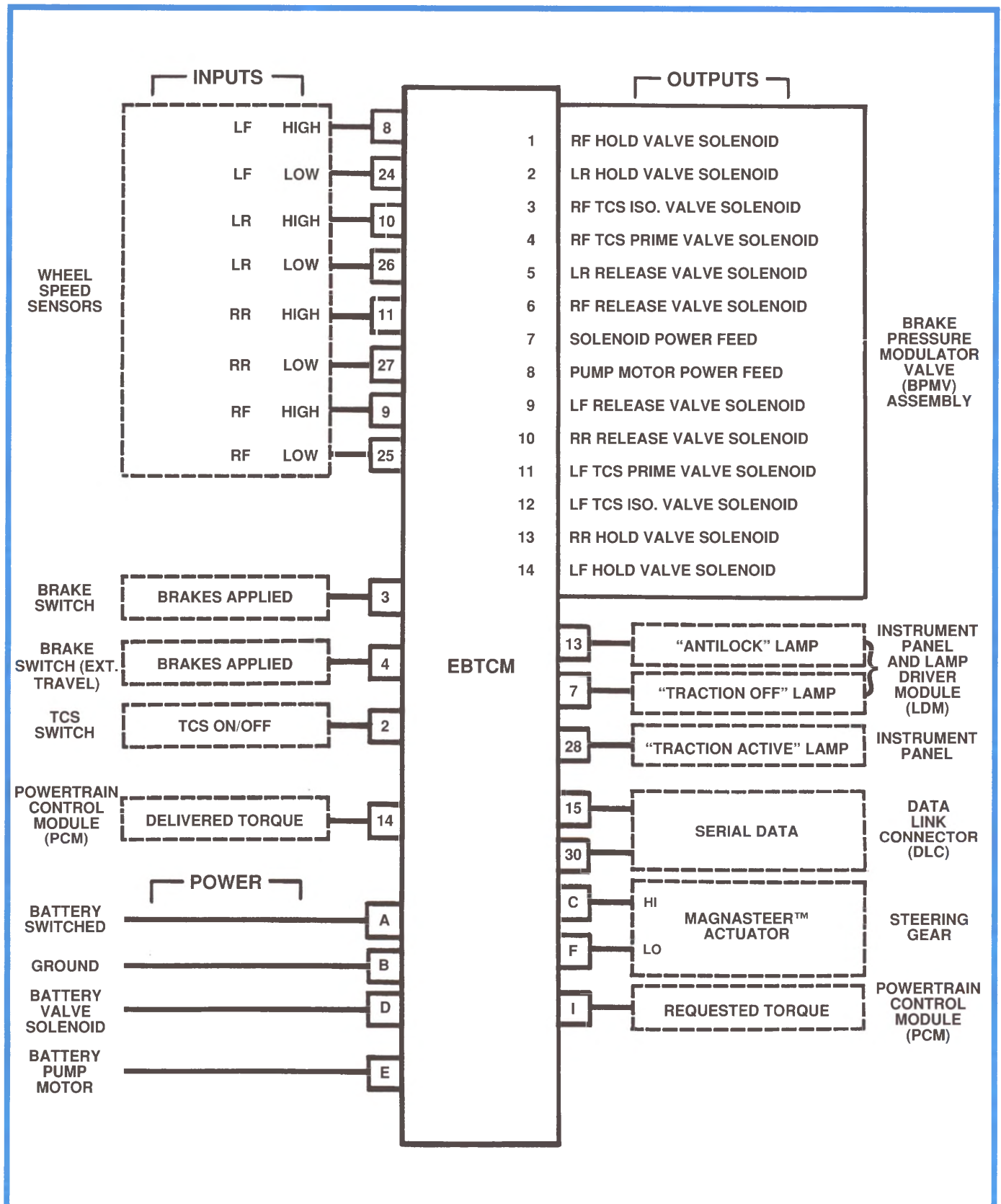


Figure 1-4, EBCM Block Diagram (Sample, Delco/Bosch 5)

1. Introduction

Inputs

The EBCM must initiate antilock braking at the appropriate time. As shown in Figure 1-5, two inputs supply information to the EBCM:

- Brake switch
- Wheel speed sensors

Brake Switch

The brake switch indicates that the driver has pressed the brake pedal, signaling the EBCM that antilock assist may be necessary.

Wheel Speed Sensor

Each wheel or axle has its own wheel speed sensor (WSS). The WSS generates a signal that changes with wheel speed. A signal that suddenly goes much slower than the others indicates a wheel is approaching lockup or is slipping.

Outputs

The EBCM continuously checks the speed of all wheels to determine if any are beginning to lock. When the wheel speed sensors signal pending wheel lockup, the EBCM actuates hydraulic valves to modulate brake pressure to a specific wheel circuit. There are separate valves for each wheel circuit.

The EBCM controls brake pressure by operating the hydraulic valves in three modes:

- Pressure hold – wheel cylinder isolated from the master cylinder stopping the further application of brake fluid to the affected circuit.
- Pressure decrease – EBCM reduces hydraulic pressure in the affected circuit, reducing pressure on the brake pads allowing one wheel to continue rolling.
- Pressure increase – pressure builds up again to continue slowing the vehicle once the tire begins to slip excessively.

– IMPORTANT –

The antilock brake system cannot increase hydraulic pressure higher than the pressure produced by the base brake system. When the ABS performs pressure increases in hydraulic circuits, it allows base brake pressure to enter a circuit in which the ABS had previously commanded a pressure hold or pressure decrease.

The EBCM continues to modulate brake pressure until:

- The driver releases the brake pedal
- Wheel speed sensors no longer detect a lockup condition
- The vehicle stops.

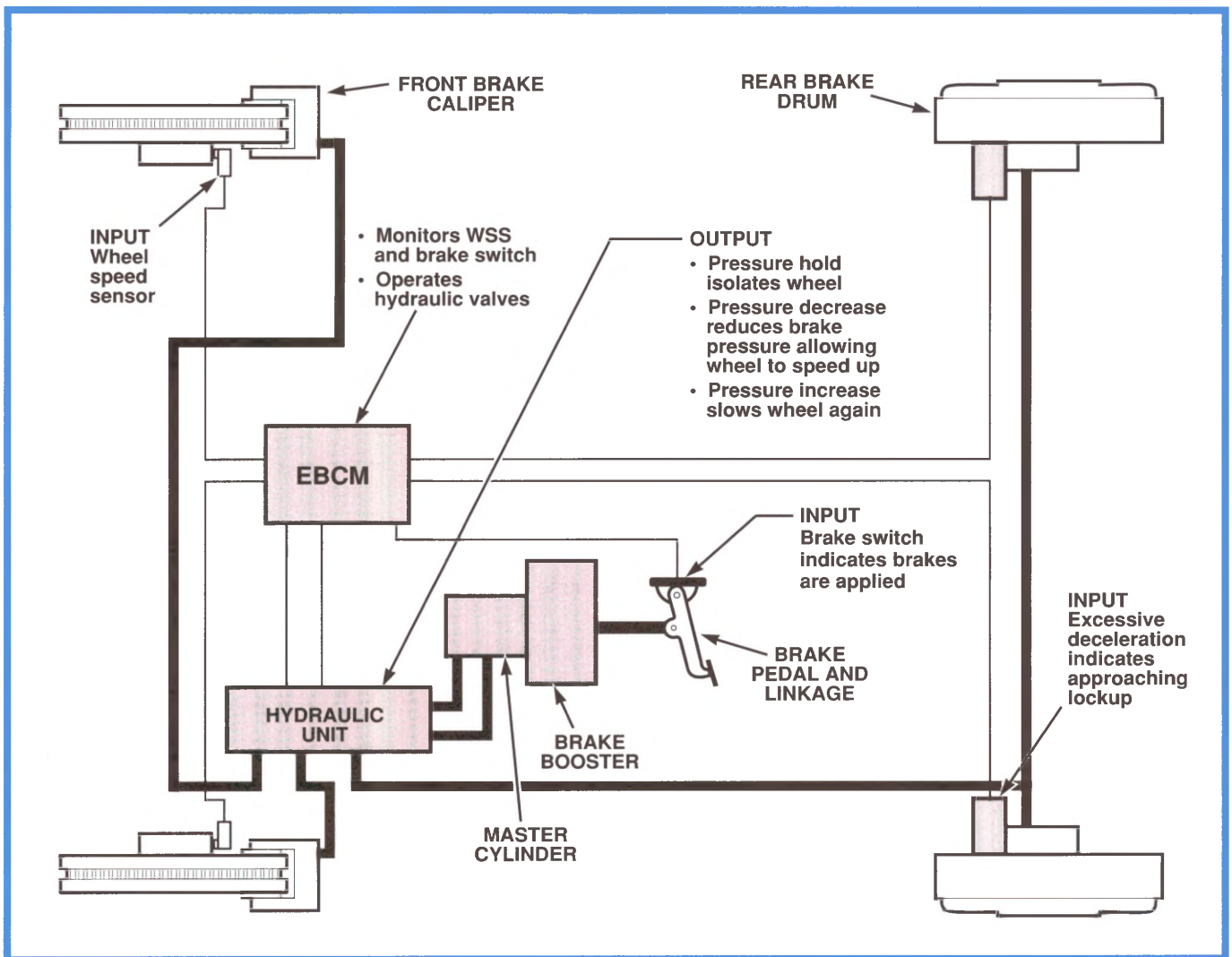


Figure 1-5, ABS Inputs and Outputs

1. Introduction

System Designs

Since ABS was introduced in GM passenger cars in 1986, there have been several different designs and modifications. The significant differences in designs include:

- Channels (hydraulic circuits)
- Hydraulic systems
- Sensors
- Hydraulic control valves and solenoids

This section highlights some of the more common configurations found on GM vehicles.

Channels

Channels are the number of hydraulic lines controlled independently by the ABS.

One-Channel ABS

One-channel ABS is used extensively in light trucks (Figure 1-6). One-channel ABS controls braking to both rear wheels simultaneously. One-channel ABS is economical because it doesn't require multiple wheel speed sensors or control circuits.

Rear-wheel antilock (RWAL) is a one-channel system used exclusively on trucks. Trucks are likely to have significant variations in the load the vehicle carries on the rear axle. These variations make rear wheel antilock control particularly appealing for truck applications.

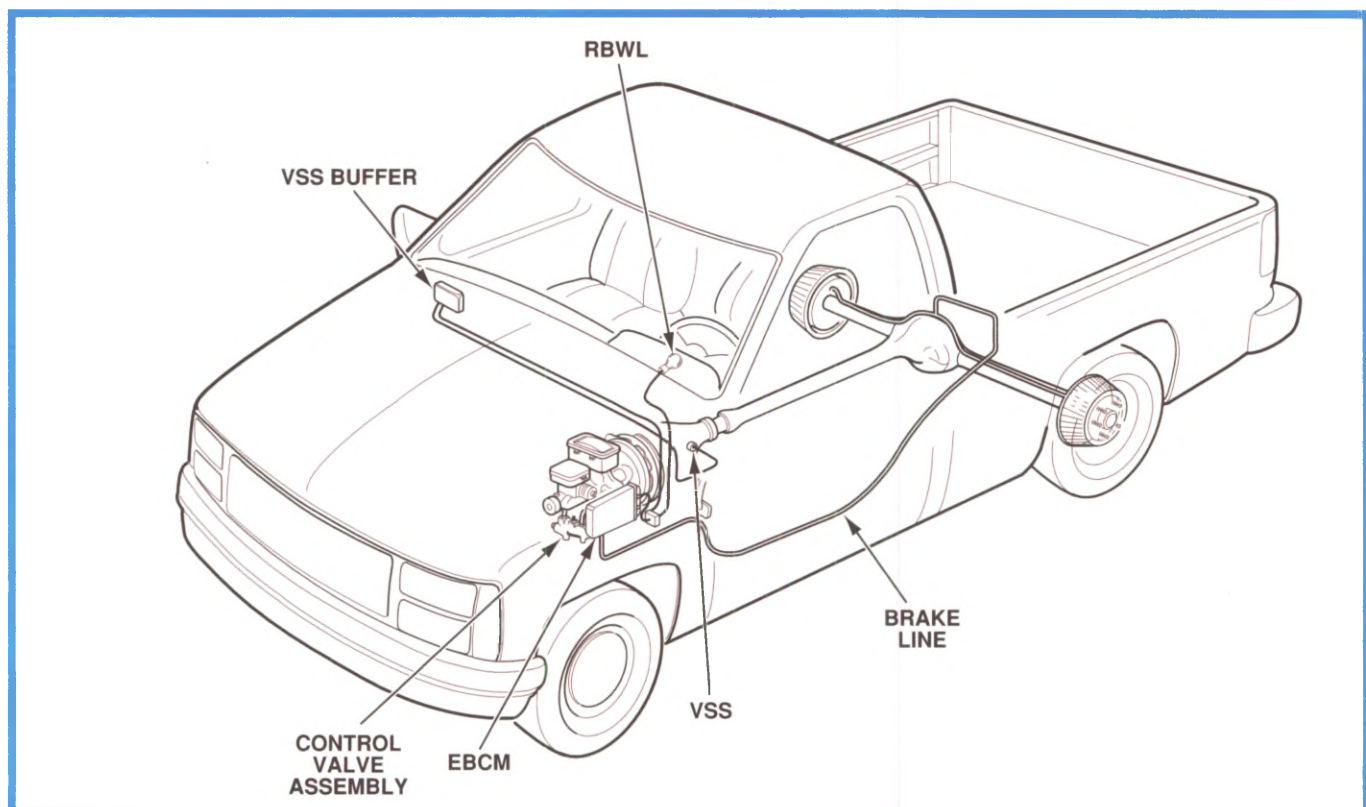


Figure 1-6, One-Channel ABS – Kelsey-Hayes Rear Wheel Antilock (RWAL)

Three-Channel ABS

Three-channel ABS is the most widely used in GM passenger cars and light trucks (Figure 1-7). The three-channel circuits are:

- Left front wheel
- Right front wheel
- Rear wheels

The rear wheels are controlled as a “set.”

Rear axle sets are sometimes monitored by a single sensor mounted in the rear axle, transfer case or transmission.

Select-Low Systems

Many GM antilock brake systems use the “select-low” principle when monitoring rear wheel speed sensors.

Most GM vehicles have three hydraulic channels. The rear wheels are controlled together by a single hydraulic circuit.

Even though they can't be controlled individually, each rear wheel has a wheel speed sensor. The EBCM monitors both signals, then selects the lowest-speed signal to modulate the brake pressure.

If one rear wheel is approaching lockup, the EBCM uses that signal to begin antilock braking for both wheels of the rear axle.

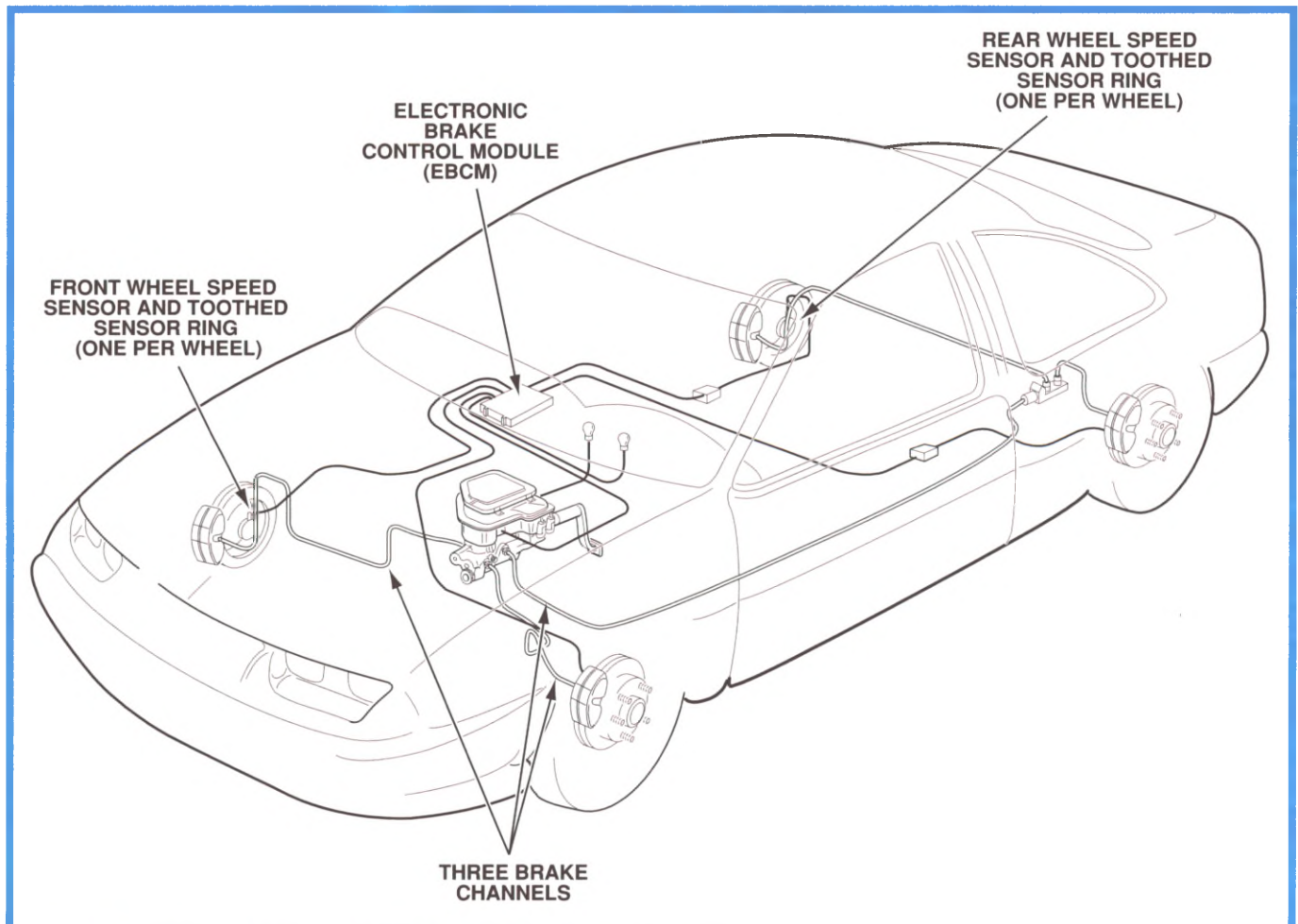


Figure 1-7, Three-Channel ABS – Delco Moraine III

1. Introduction

Four-Channel ABS

Four-channel ABS in the past was used only on luxury vehicles because of the higher cost and complexity. Today, four-channel Antilock Brake Systems are more widely used on GM vehicles. The following are four-channel Antilock Brake Systems (some of these systems have applications that are three-channel):

- Bosch III
- Teves Mark IV
- Bosch 5 (may be three or four-channel)
- Bosch 5.3 (may be three or four-channel)
- Delco/Bosch 5

The four-channel systems have individual hydraulic control channels for each wheel (Figure 1-8).

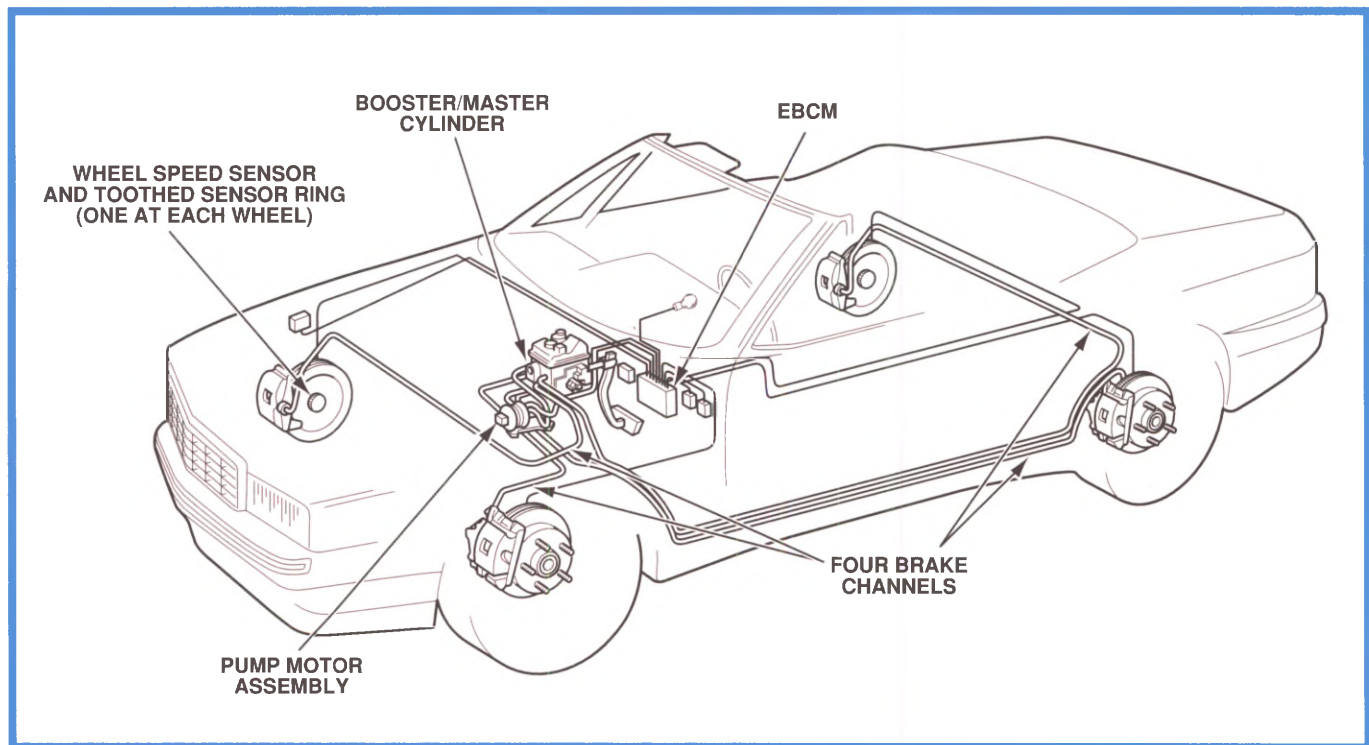


Figure 1-8, Four-Channel ABS – Bosch III

ABS Hydraulic Systems

Integral ABS

In integral antilock brake systems, the ABS unit replaces the conventional base brake master cylinder and booster assembly (Figure 1-9). The integral hydraulic unit includes:

- Master cylinder with reservoir
- Hydraulic brake booster
- Brake pressure pump/motor
- Pressure accumulator
- Pressure monitoring switches (2)
- Brake pressure modulator valves
- Fluid level sensor

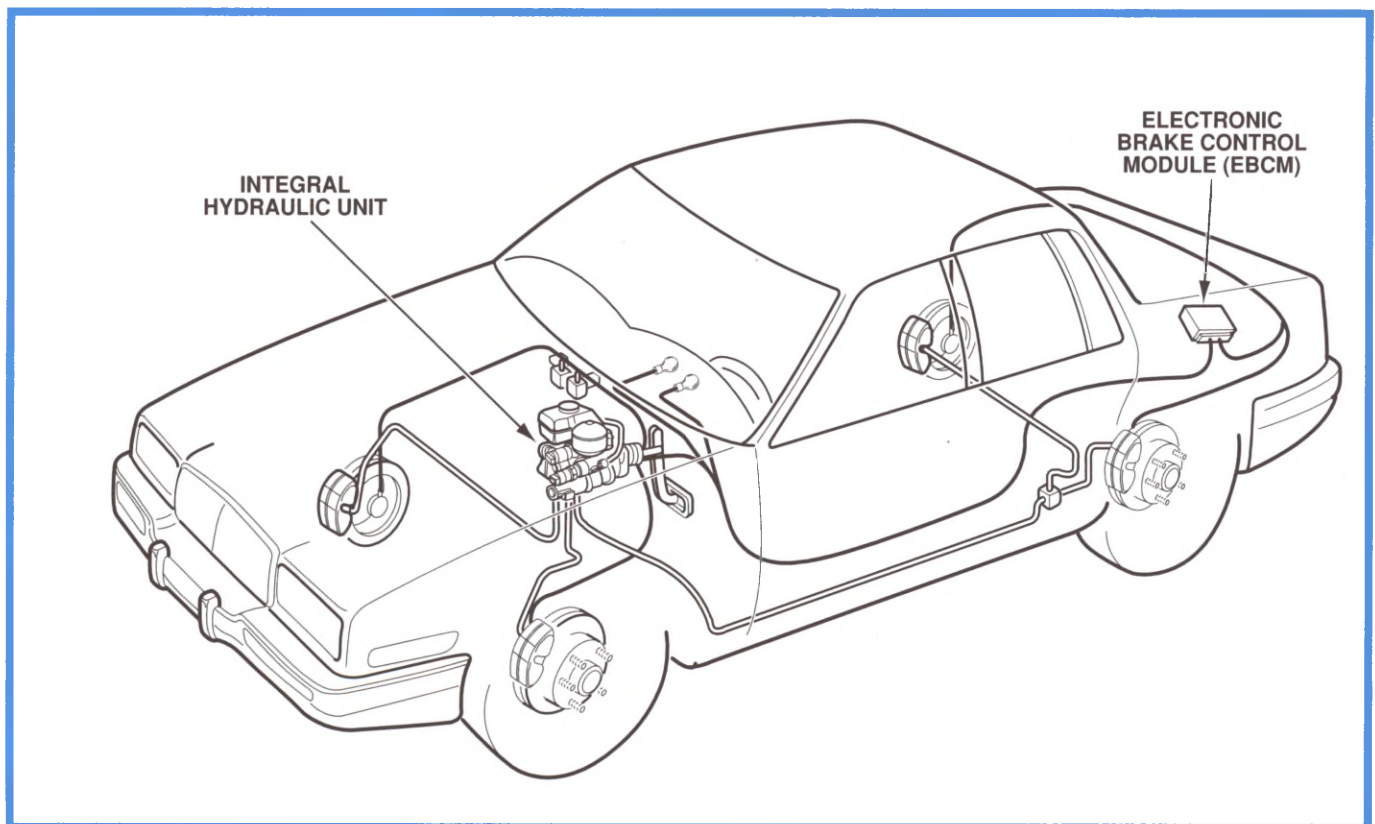


Figure 1-9, Integral ABS (Teves Mark II)

1. Introduction

Non-Integral (Add-On) ABS

Non-integral ABS is added to a base brake system (Figure 1-10). The vehicle retains the original master cylinder and booster. The ABS hydraulic unit is added in series with the hydraulic brake pipes.

Some non-integral systems utilize a pump for fluid recirculation. The pump is not used for power booster assist; this will be covered in more detail later.

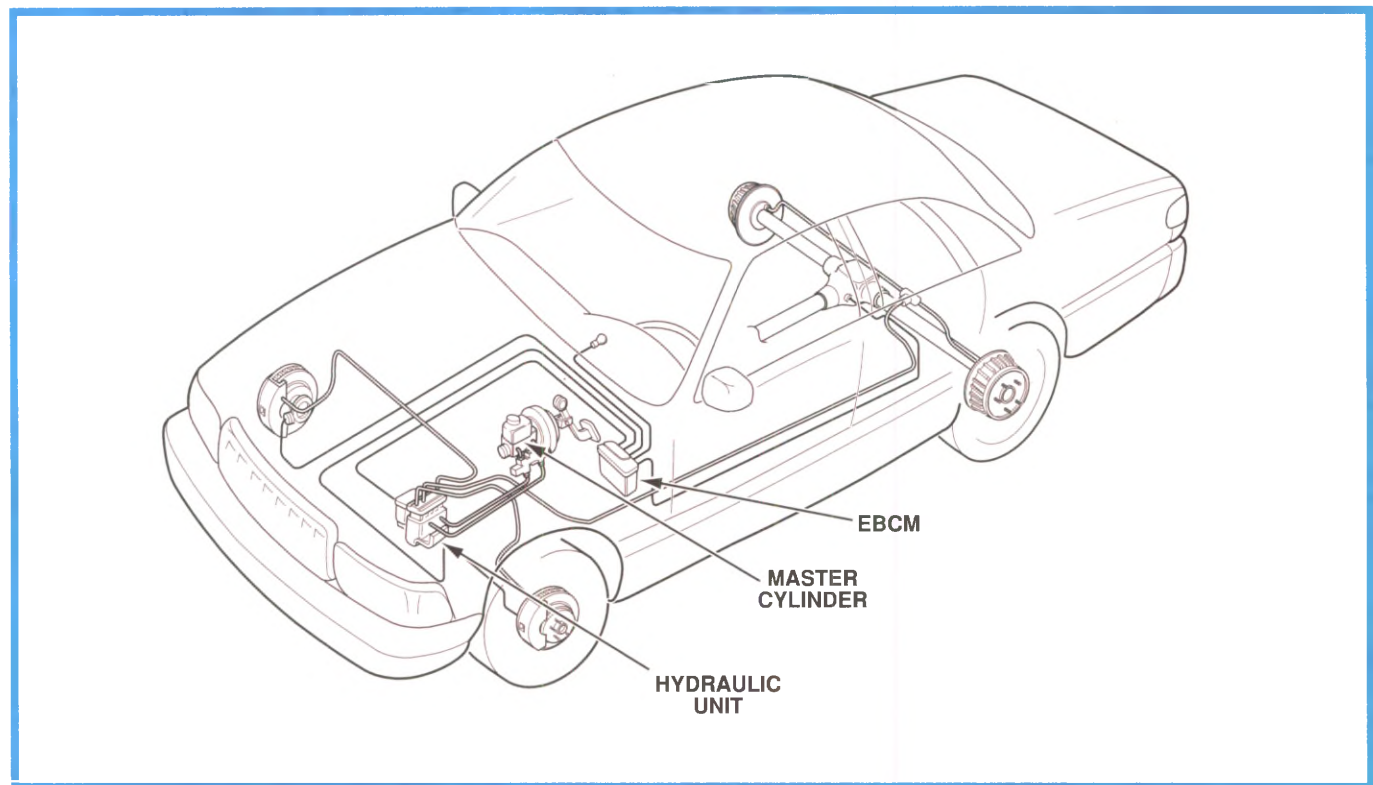


Figure 1-10, Non-Integral ABS (Bosch 2U)

Driving with ABS

Widespread use of ABS on GM vehicles did not start until the mid-1980s. Because of this, there are some drivers who have not experienced an ABS braking event. These drivers will notice differences between base braking events and ABS braking events. These drivers will also have to adjust their driving style during critical braking situations. Vehicles equipped with ABS react very differently during these situations than vehicles not equipped with ABS.

Operation Noise/Self Test

The first thing drivers often notice is the noise made by the ABS. Most antilock brake systems make noise during antilock braking:

- Solenoid valves click as they open and close
- Some systems also use an electric pump, which can be audible from the passenger compartment.

Most systems go through a self test when the car is first started and driven. The solenoids click and the pump motor runs briefly as the EBCM verifies that they are operating properly. Make sure the customer is aware of noises which are to be considered normal.

Warning Lamp Operation

Drivers unfamiliar with ABS will also notice an amber ABS warning lamp. The lamp may light:

- During bulb check
- Before the accumulator is fully charged after being parked for some time (on hydraulically assisted systems)
- When ABS is disabled due to a malfunction

Brake Pedal Pulsation

During antilock braking, the modulator valves quickly modulate the brake pressure. On some systems, drivers may notice this as a rapid pulsation in the brake pedal. This is a normal function of ABS.

— CAUTION —

ANTILOCK BRAKING DOES NOT FUNCTION IF THE DRIVER PUMPS THE BRAKE PEDAL. WARN DRIVERS NOT TO PUMP THE BRAKE PEDAL DURING ANTILOCK BRAKING.

1. Introduction

Notes

[illegible]

2. Components

Components Introduction

This section identifies the components of antilock brake systems. There are many ABS designs depending on division, carline, and model year. This section presents the components and variations found in the different systems (Figure 2-1).

ABS components are identified by the following criteria:

- **Configuration:** Includes physical layout of the system such as the hydraulic control unit and hydraulic pipes.
- **Electronic monitor and control:** Includes components that monitor and control ABS operation.
- **Power supply and circuit protection:** Includes components that power and protect the hydraulic unit and EBCM.
- **Hydraulic system:** Includes the hydraulic unit, hydraulic unit subcomponents and wheel brakes.

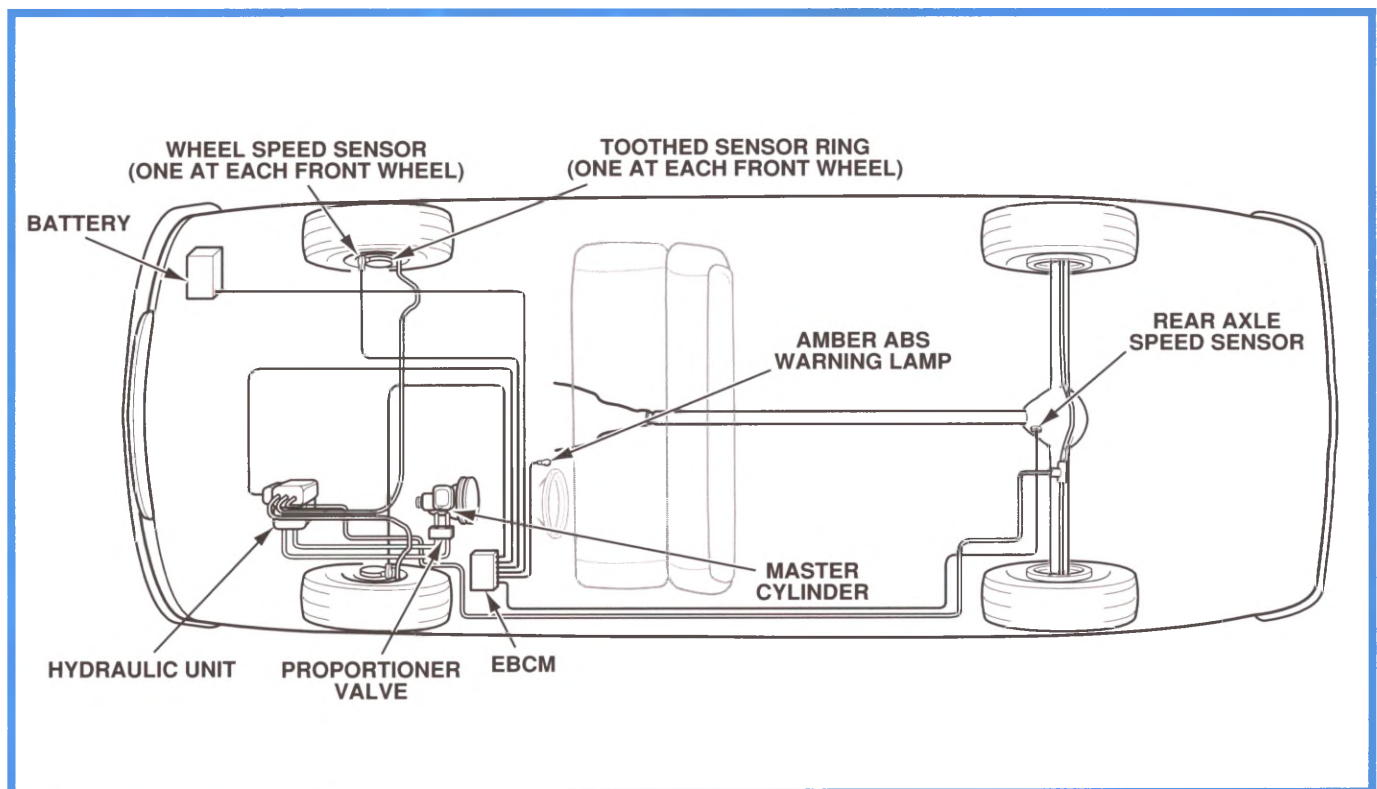


Figure 2-1, Typical ABS System and Components (Bosch 2U)

2. Components

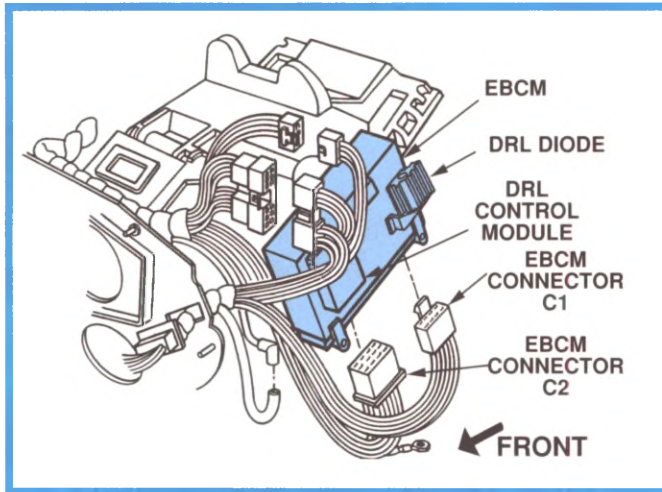


Figure 2-2, Delphi Chassis VI (W-Car) – Under I/P

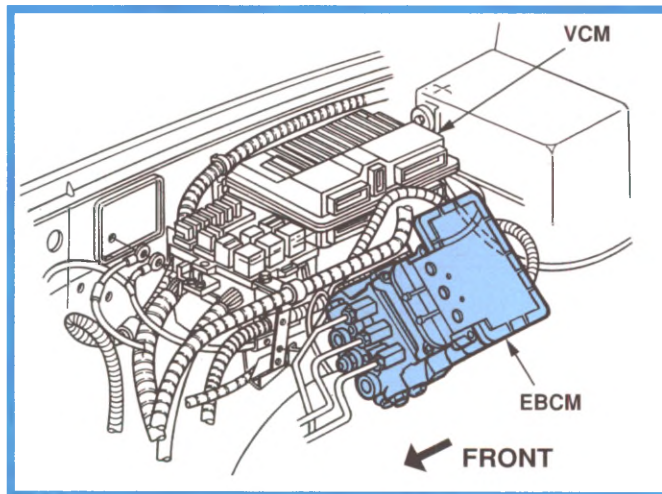


Figure 2-3, 4WAL EBC 310 (C/K Truck) – Underhood

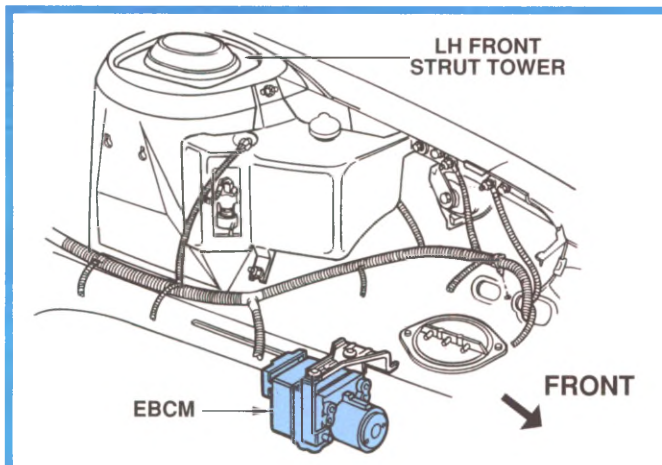


Figure 2-4, Delco/Bosch 5 (H-Car) – Engine Compartment

Component Locations

Electronic Brake Control Module (EBCM) Locations

The location of the EBCM varies depending on the vehicle and the Antilock Brake System. Figures 2-2, 2-3 and 2-4 show some of the more common locations for the EBCM.

Speed Sensors

Wheel Speed Sensors

All wheel speed sensors are permanent magnet generators that produce an AC voltage signal (Figures 2-5 and 2-6). The signal frequency is proportional to wheel speed.

The Electronic Brake Control Module (EBCM) compares the speed sensor signals to determine which wheel(s) is approaching lockup. The EBCM then controls brake pressure in that hydraulic channel(s) to prevent lockup.

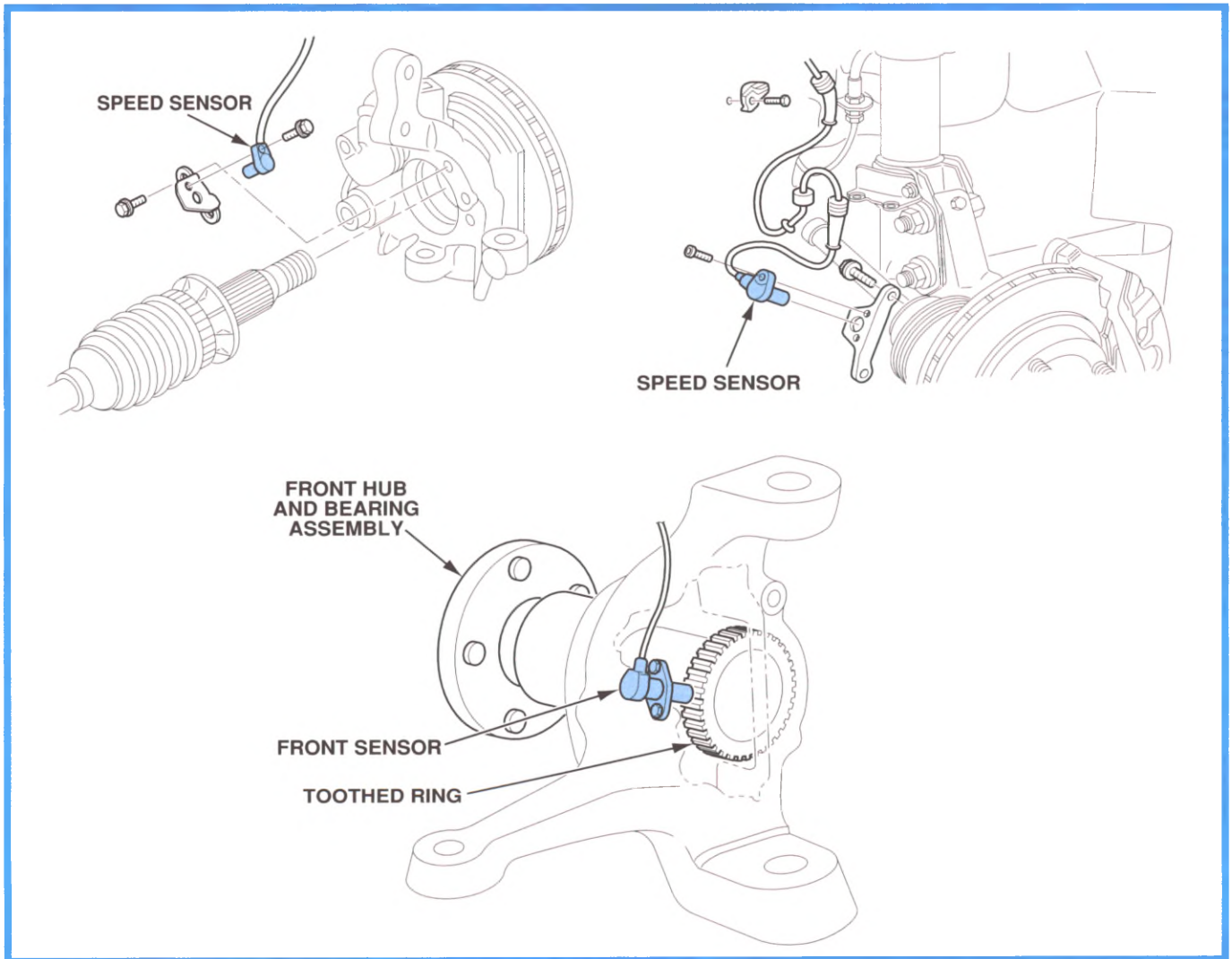


Figure 2-5, Front Wheel Speed Sensor Locations

2. Components

Speed Sensors (Con't)

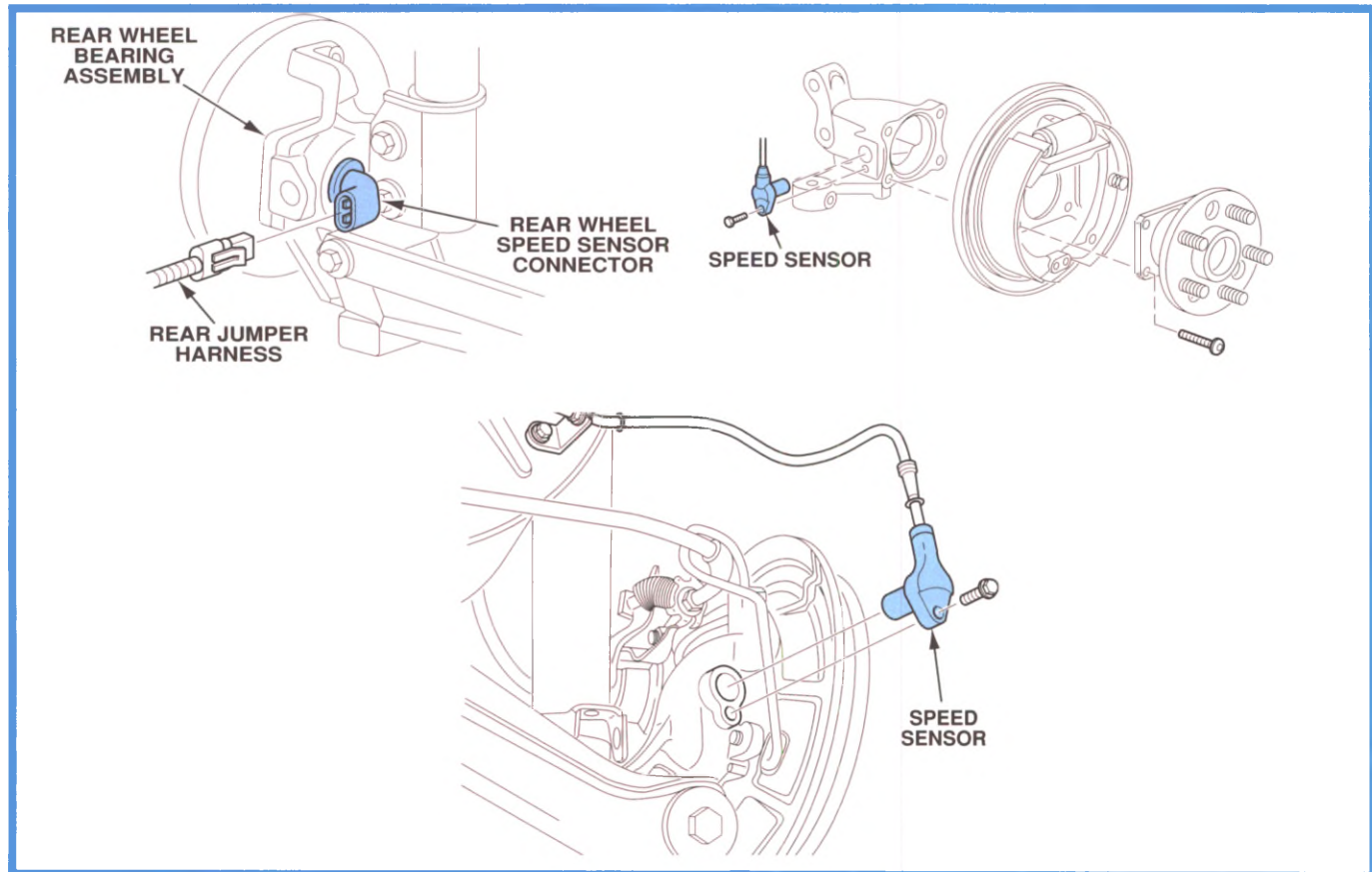


Figure 2-6, Rear Wheel Speed Sensor Locations

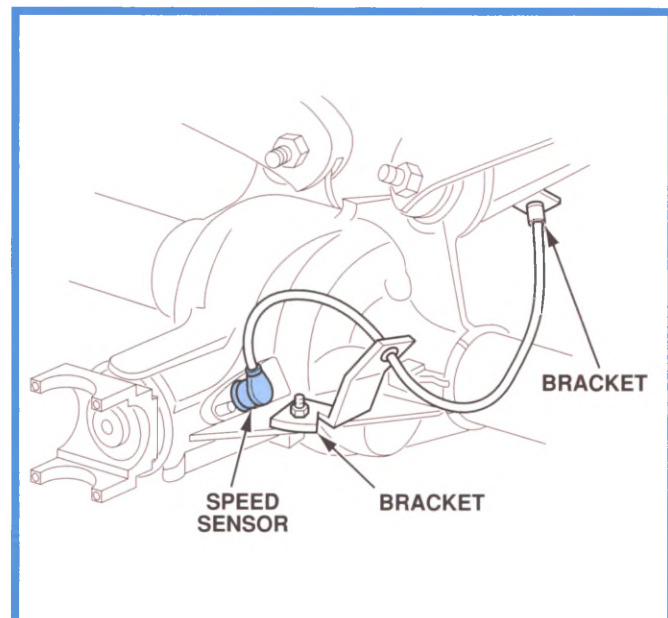


Figure 2-7, Rear Axle Speed Sensor Location

Rear Axle Speed Sensors

Some rear wheel drive vehicles use a single rear axle speed sensor instead of sensors on both rear wheels (Figure 2-7). The toothed sensor ring is pressed onto the differential pinion shaft or differential case. The sensor is bolted to the nose of the differential housing.

Vehicle Speed Sensors

Some systems use the vehicle speed sensor (VSS) signal from the output shaft of the transmission (Figure 2-8). The same VSS signal is also used for the speedometer, odometer, torque converter clutch and transfer case control module.

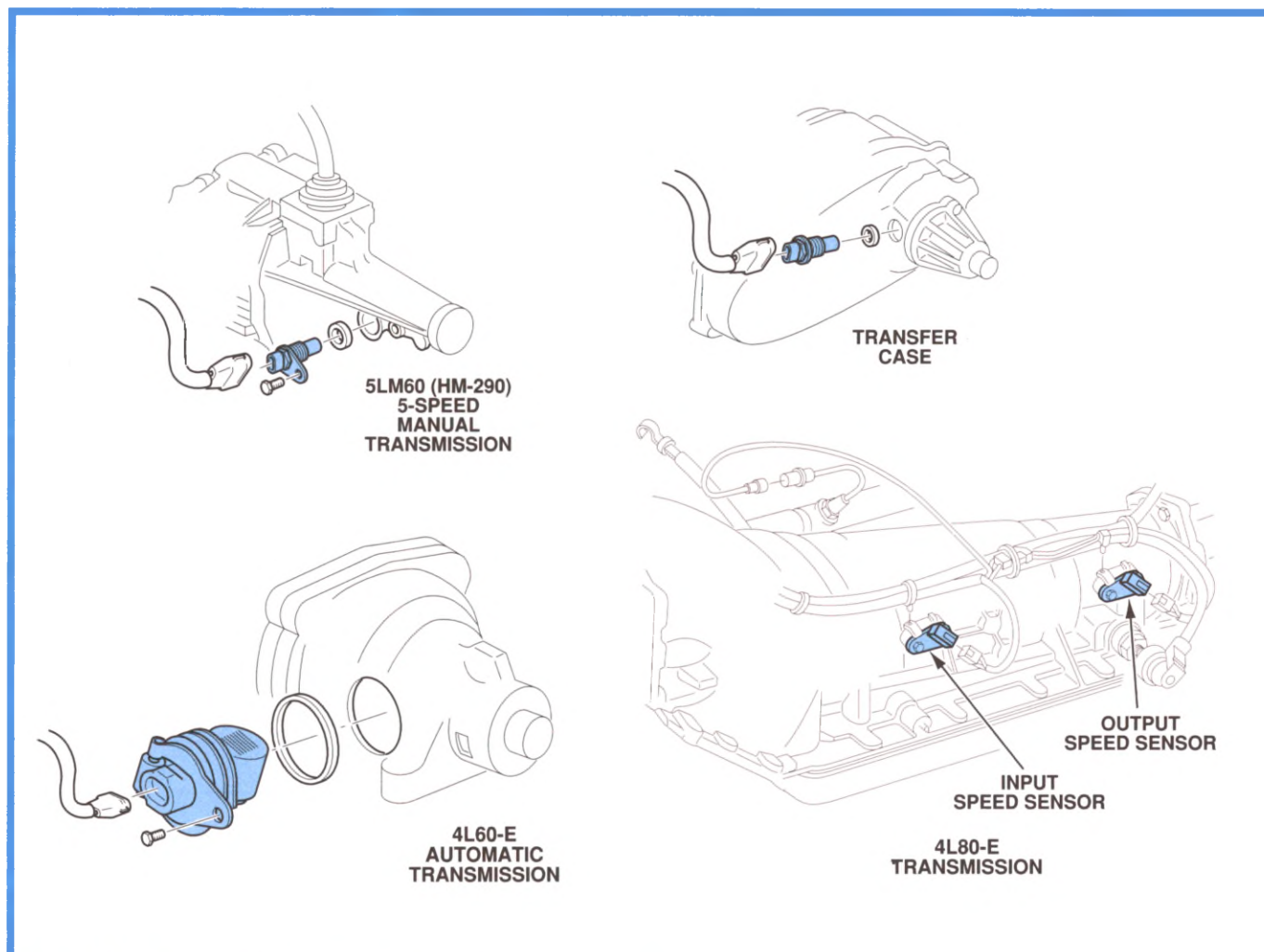


Figure 2-8, Vehicle Speed Sensors

2. Components

GM ABS Applications

The charts in Figures 2-9 and 2-10 list the vehicle applications for the different Antilock Brake Systems. The charts list applications through the 1998 model year.

<u>TEVES MARK II (INTEGRAL)</u>		
Pontiac 6000 STE (A) 1986-91 Pontiac 6000 STE/AWD (A) 1989-91 Pontiac Bonneville SSE (H) 1988-90 Pontiac Bonneville (H) 1989-90 Buick Electra/Park Ave (C) 1986-90	Buick Riviera (E) 1988-90 Buick Reatta (E) 1988-90 Oldsmobile 98 Regency (C) 1986-90 Oldsmobile 88 (H) 1987-90	Oldsmobile Toronado (E) 1988-90 Cadillac DeVille/Fleetwood (C) 1986-90 Cadillac Eldorado (E) 1988-90 Cadillac Seville (K) 1988-90
<u>TEVES MARK IV (NON-INTEGRAL)</u>		
Pontiac Bonneville (H) 1991-95 Pontiac Bonneville SSE (H) 1991-95 Buick Park Avenue (C) 1991-95	Buick Le Sabre (H) 1991-95 Buick Riviera (G) 1995-98 Oldsmobile Delta 88 (H) 1991-95	Oldsmobile Aurora (G) 1995-98 Oldsmobile 98 (C) 1991-95 Cadillac DeVille (C) 1991-93
<u>LUCAS/SUMITOMO HYBRID (NON-INTEGRAL)</u>		
Chevrolet Prizm (S) 1998		
<u>BOSCH 2 (NON-INTEGRAL)</u>		
Chevrolet Corvette (Y) 1986-89 (2S) Chevrolet Corvette (Y) 1990-93 (2S Micro) Chevrolet Corvette (Y) 1992-94 (ASR 2 U) Chevrolet Corvette LT5 (Y) 1995 (ASR 2U) Chevrolet Caprice (B) 1991-94 (2U)	Chevrolet Impala SS (B) 1994 (2U) Oldsmobile Toronado (E) 1991-93 (2U) Cadillac Fleetwood (D) 1990-94 (2U) Cadillac Eldorado (E) 1991-94 (2U) Cadillac Allante (V) 1993 (2U)	Cadillac Concours (K) 1994 (2U) Cadillac Catera (V) 1997 (2SH) Buick Riviera (E) 1992-93 (2U) Buick Wagon (B) 1991-94 (2U) Buick Roadmaster (B) 1993-94 (2U)
<u>BOSCH 3 (INTEGRAL)</u>		
Cadillac Allante (V) 1987-92		
<u>BOSCH 5.0 (NON-INTEGRAL)</u>		
Chevrolet Corvette LT1 (Y) 1995 Chevrolet Corvette (Y) 1996 Chevrolet Caprice (B) 1995-96 Chevrolet Impala SS (B) 1995-96	Buick Wagon (B) 1995-96 Buick Roadmaster (B) 1995-96 Cadillac Eldorado (E) 1995-96 Cadillac Seville (K) 1995-96	Cadillac Deville (K) 1995-96 Cadillac Concours (K) 1995-96 Cadillac Fleetwood (D) 1995-96

Figure 2-9, ABS Applications Chart

<u>BOSCH 5.3 (NON-INTEGRAL)</u>		
Chevrolet Camaro (F) 1998 Oldsmobile Intrigue (W) 1998	Pontiac Firebird (F) 1998 Pontiac Grand Prix (W) 1998	Cadillac Catera (V) 1998
<u>DELCO/BOSCH 5.0 HYBRID (NON-INTEGRAL)</u>		
Buick Park Avenue (C) 1996-98 Buick LeSabre (H) 1996-98 Oldsmobile Ninety Eight (C) 1996 Oldsmobile Eighty Eight (H) 1996-98	Chevrolet Corvette (Y) 1997-98 Pontiac Bonneville (H) 1996-98 Cadillac Eldorado (E) 1997-98	Cadillac Seville (K) 1997-98 Cadillac Deville (K) 1997-98 Cadillac Concours (K) 1997-98
<u>DELCO MORaine III (INTEGRAL)</u>		
Buick Regal (W) 1989-91	Pontiac Grand Prix (W) 1989-91	Oldsmobile Cutlass Supreme (W) 1989-91
<u>DELPHI CHASSIS ABS VI (NON-INTEGRAL)</u>		
Chevrolet Cavalier (J) 1992-98 Chevrolet Lumina (W) 1992-98 Chevrolet Corsica/Beretta (L) 1991-96 Chevrolet Camaro (F) 1993-97 Chevrolet Monte Carlo (W) 1995-98 Chevrolet Malibu (N) 1997-98 Buick Skylark (N) 1991-98 Buick Regal (W) 1992-98	Buick Century (A) 1994-96 Buick Century (W) 1997-98 Oldsmobile Calais "I" Series (N) 1991 Oldsmobile Achieva (N) 1992-98 Oldsmobile Cutlass Supreme (W) 1992-97 Oldsmobile Cutlass (N) 1997-98 Oldsmobile Cutlass Ciera (A) 1994-96 Oldsmobile Intrigue (W) 1998 Pontiac Grand Am (N) 1991-98	Pontiac Sunbird (J) 1992-94 Pontiac Sunfire (J) 1995-98 Pontiac Grand Prix (W) 1992-97 Pontiac Firebird (F) 1993-97 APV - Lumina/Venture, Trans Sport, Silhouette (U) 1992-98 Geo/Chevrolet Metro (M) 1995-98 Geo Prizm (S) 1993-97 Geo/Chevrolet Tracker (E/J) 1996-98
<u>KELSEY HAYES RWAL (NON-INTEGRAL)</u>		
L/M Van 1990-92 C/K Truck 1988-93 S/T Truck 1989-95	Suburban 1990-91 Blazer 1991	G-Van 1990-92 Geo Tracker 1991-95
<u>KELSEY HAYES 4WAL (NON-INTEGRAL)</u>		
C/K Truck 1992-98 L/M Van 1990-98 G-Van 1993-98	Suburban 1992-98 Blazer 1992-98	S/T Truck 4-door 1991-98, 2-door 1992-98 P Chassis (KH 310) 1998

Figure 2-10, ABS Applications Chart

2. Components

System Types

The following illustrations highlight the differences between the major GM antilock brake systems.

Bosch 2U/2S

Channels:	Three
Hydraulic System:	Non-integral
Speed Sensors:	Three or four (depending upon vehicle application)
Modulator Solenoids:	Three position solenoid
Diagnostics:	Blink codes and bi-directional scan tool

This system type has been adapted for use with acceleration slip regulation (ASR) to reduce wheelspin on hard acceleration (Corvette). Refer to Figure 2-11 for an application of the Bosch 2U/2S Antilock Brake System.

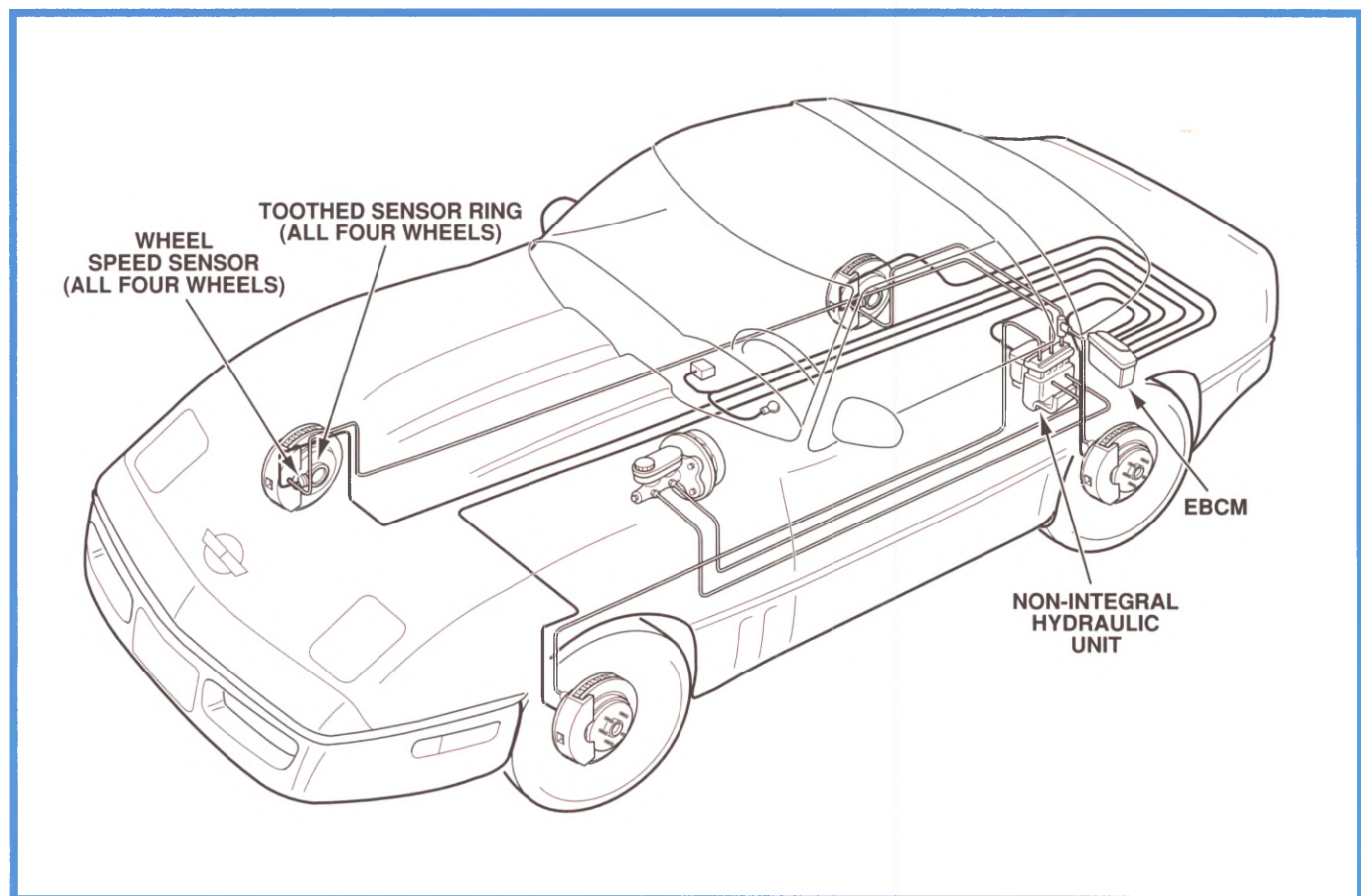


Figure 2-11, Bosch 2U/2S ABS (Y-Body Application)

Bosch III

Channels:	Four
Hydraulic System:	Integral
Speed Sensors:	Four WSS
Modulator Solenoids:	Three position solenoid
Diagnostics:	Blink codes, driver information center and ABS tester

This system type has been adapted for use with traction control system (TCS) to reduce wheelspin on hard acceleration. Refer to Figure 2-12 for an application of the Bosch III Antilock Brake System.

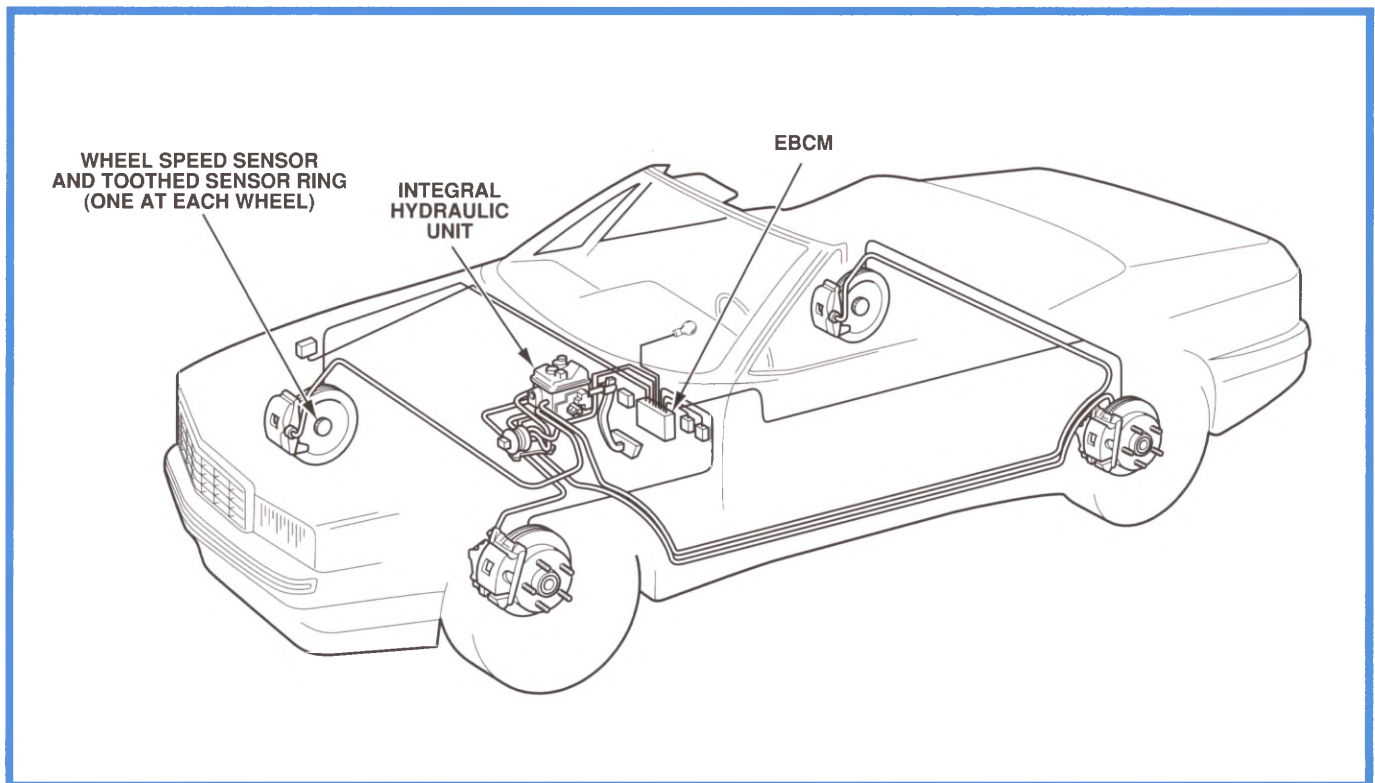


Figure 2-12, Bosch III ABS (V-Body Application)

2. Components

Delco Moraine III

Channels:	Three
Hydraulic System:	Integral
Speed Sensors:	Four WSS
Modulator Solenoids:	Two solenoids/two valves
Diagnostics:	Bi-directional scan tool

Diagnostic data is through a bi-directional scan tool only. There are no blink codes. Refer to Figure 2-13 for an application of the Delco Moraine III Antilock Brake System.

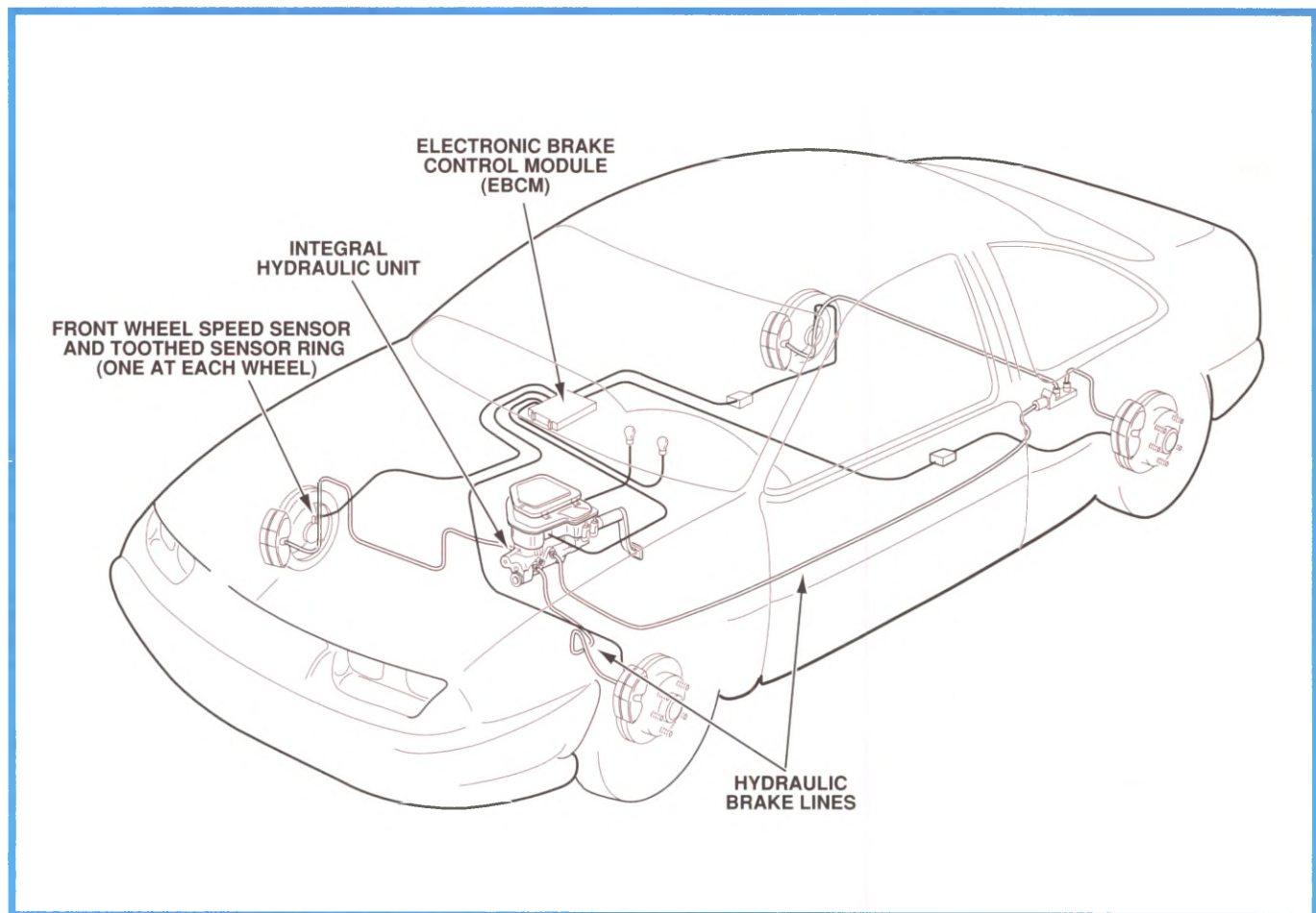


Figure 2-13, Delco Moraine III ABS (W-Body Application)

Delphi Chassis VI

Channels:	Three
Hydraulic System:	Non-integral
Speed Sensors:	Four
Modulator Solenoids:	Piston modulators/Two solenoids
Diagnostics:	Bi-directional scan tool

Refer to Figure 2-14 for an application of the Delphi Chassis VI Antilock Brake System.

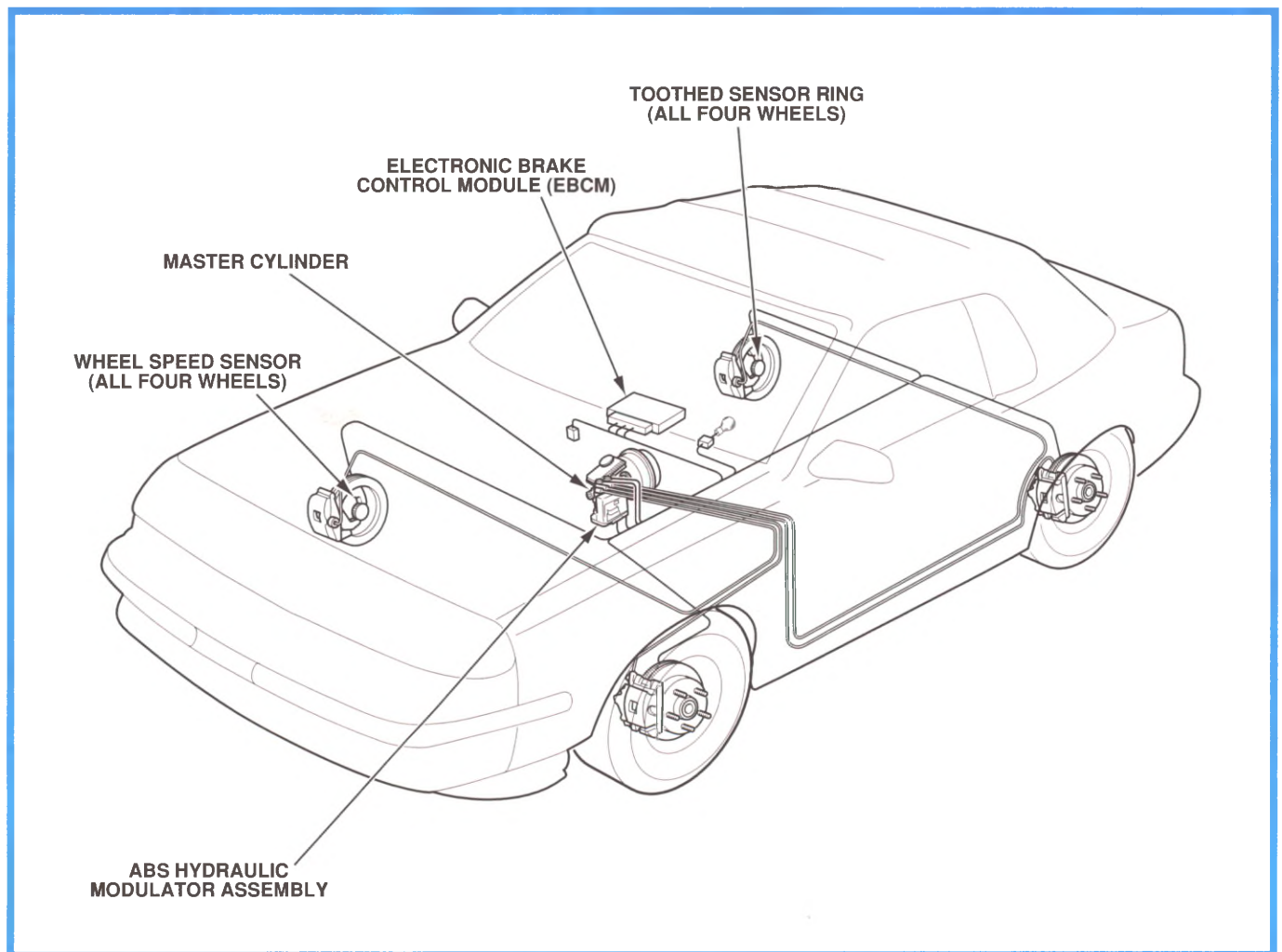


Figure 2-14, Delphi Chassis VI ABS (J-Body Application)

2. Components

Kelsey-Hayes Rear-Wheel Antilock (RWAL)

Channels:	One
Hydraulic System:	Non-integral
Speed Sensors:	Vehicle speed sensor
Modulator Solenoids:	Two solenoids/two valves
Diagnostics:	Blink codes and bi-directional scan tool

Refer to Figure 2-15 for an application of the Kelsey-Hayes Rear-Wheel Antilock Brake System.

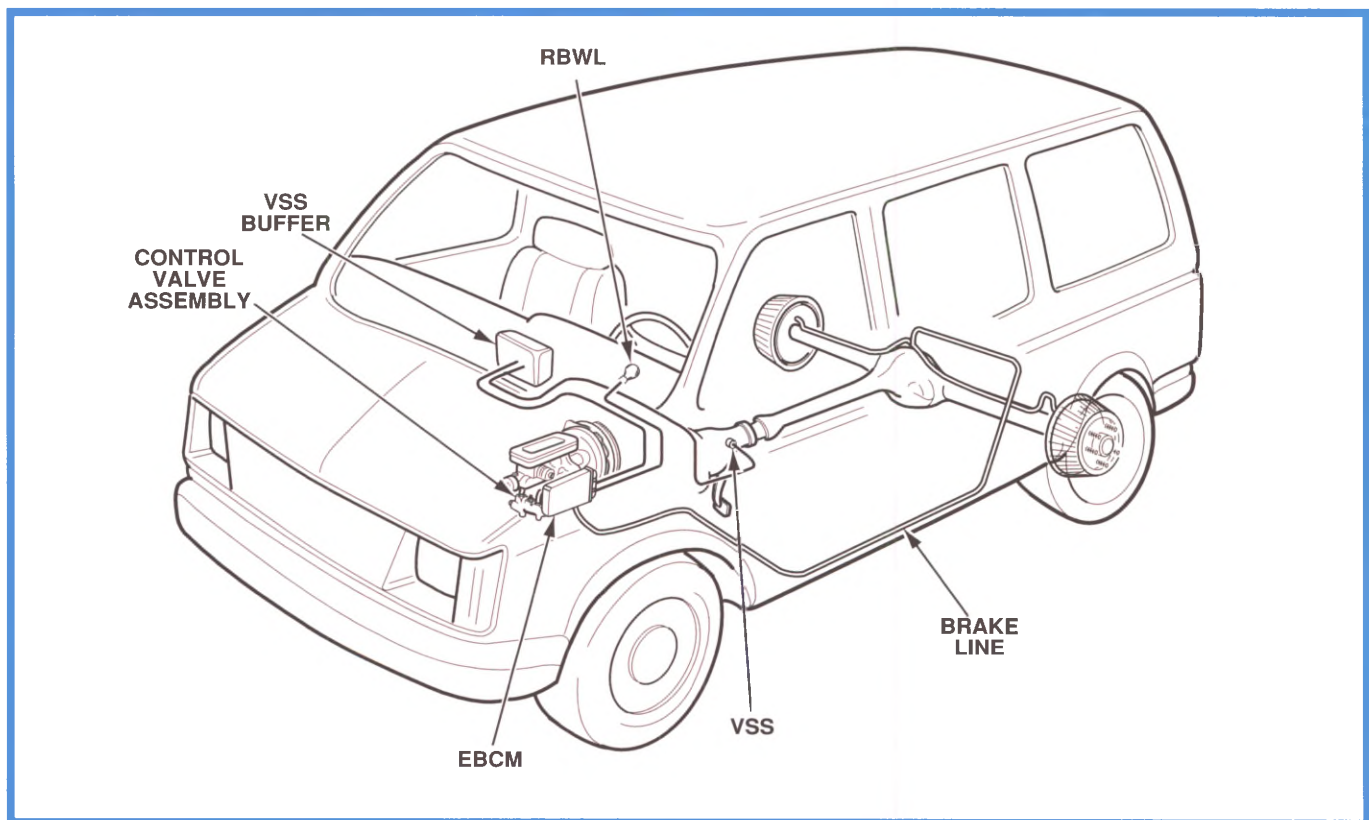


Figure 2-15, Kelsey-Hayes Rear-Wheel Antilock (RWAL) (M-Van Application)

Kelsey-Hayes Four-Wheel Antilock (4WAL)

Channels:	Three
Hydraulic System:	Non-integral
Speed Sensors:	Two WSS and one VSS on 1993 and newer vehicles. Four WSS on vehicles prior to 1993.
Modulator Solenoids:	Two solenoids/two valves
Diagnostics:	Blink codes and bi-directional scan tool

Currently there are two configurations of the Kelsey-Hayes Four-Wheel Antilock Brake System:

- EBC4: the Electro-Hydraulic Control Unit (EHCU) is only serviced as a complete unit. This system was used from 1990 to 1995.
- EBC310: the EHCU is a modular design, allowing replacement of the EBCM, Brake Pressure Modulator Valve (BPMV) and combination valve. This system was first used on the 1995 C/K trucks and is the Kelsey-Hayes 4WAL configuration currently used.

Refer to Figure 2-16 for an application of the Kelsey-Hayes Four-Wheel Antilock Brake System.

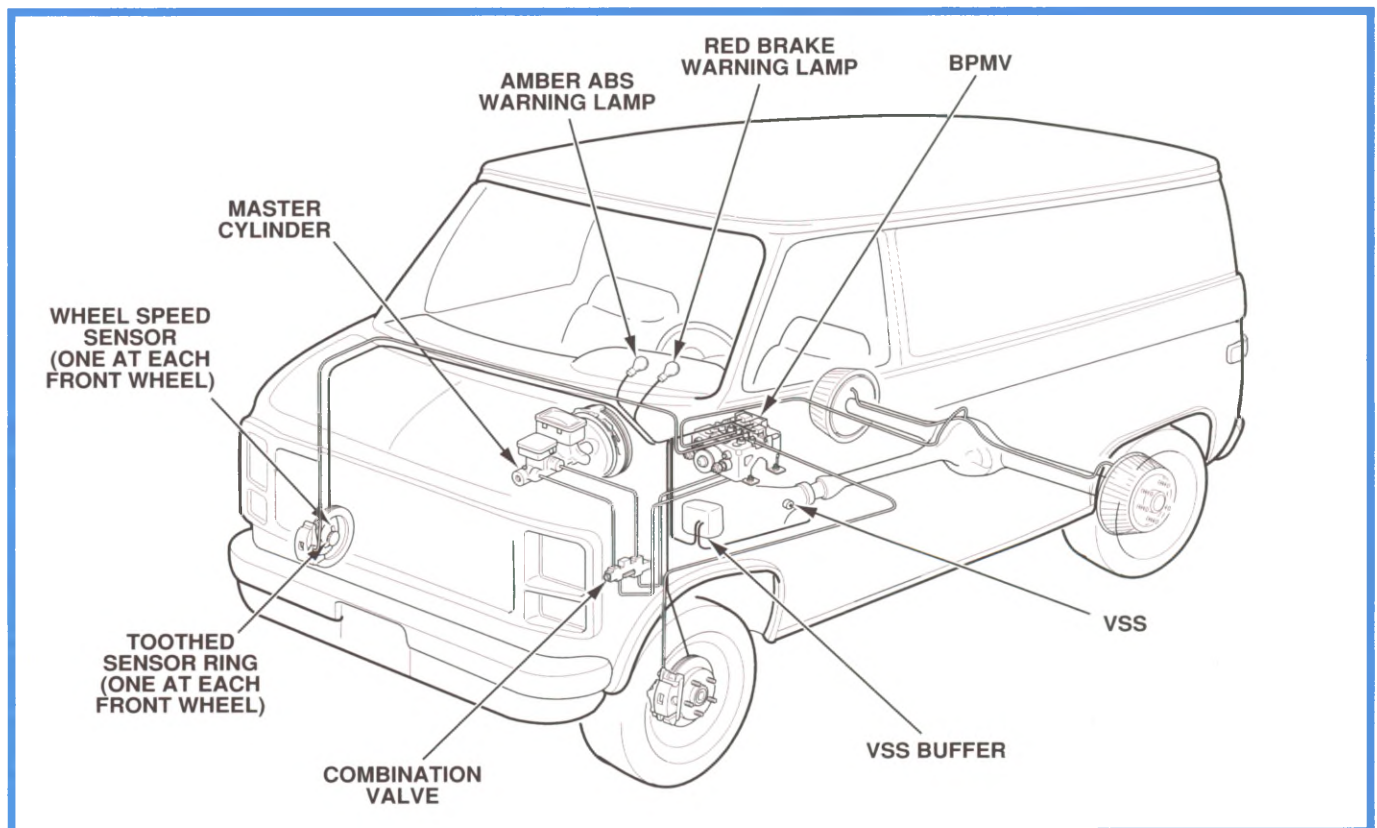


Figure 2-16, Kelsey-Hayes Four-Wheel Antilock (4WAL) (G-Van Application)

2. Components

Teves Mark II

Channels:	Three
Hydraulic System:	Integral
Speed Sensors:	Four WSS
Modulator Solenoids:	Two solenoids/two valves
Diagnostics:	Blink codes, lamp sequence and driver information centers (depending on application)

Refer to Figure 2-17 for an application of the Teves Mark II Antilock Brake System.

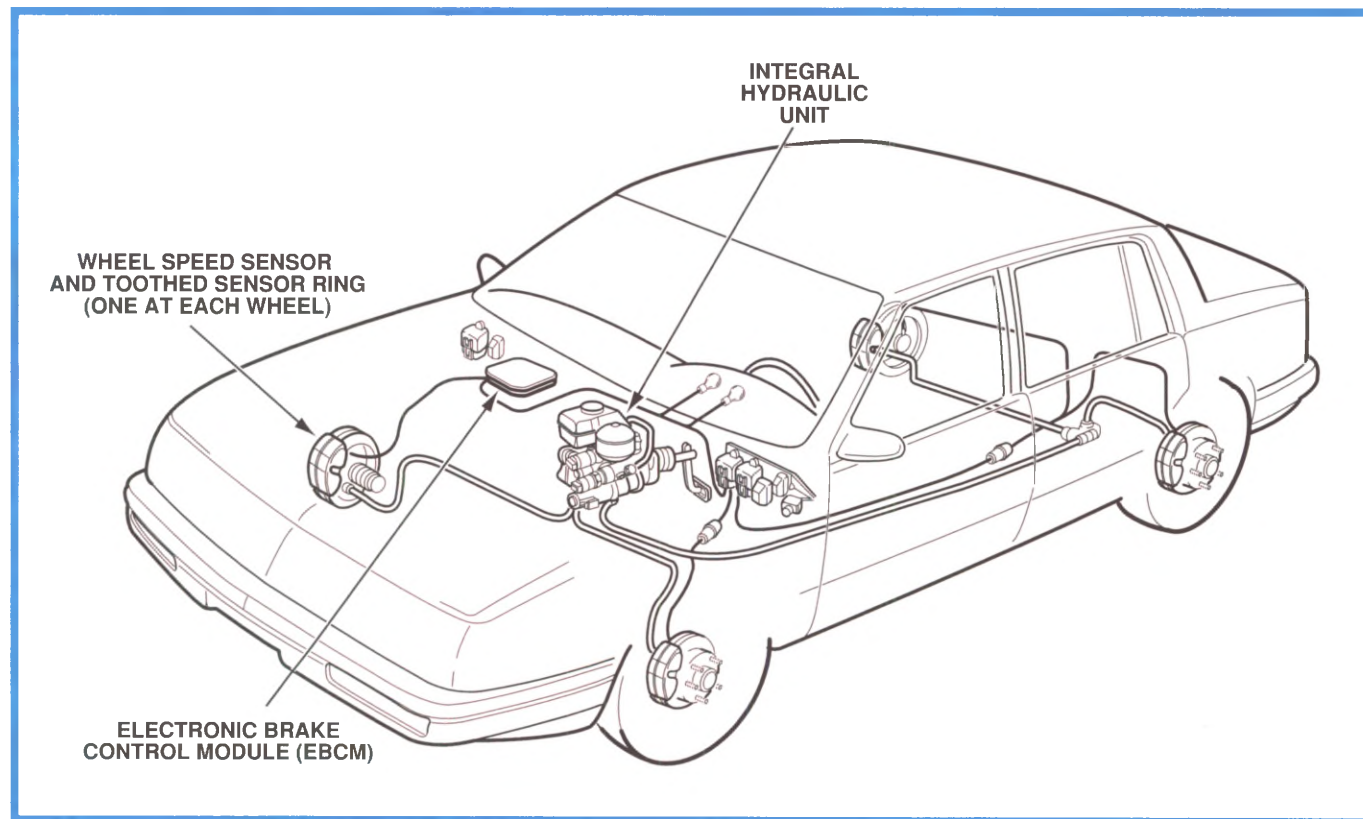


Figure 2-17, Teves Mark II ABS (C/H-Body Application)

Teves Mark IV

Channels:	Four
Hydraulic System:	Non-integral
Speed Sensors:	Four WSS
Modulator Solenoids:	Two solenoids/two valves
Diagnostics:	Bi-directional scan tool

Refer to Figure 2-18 for an application of the Teves Mark IV Antilock Brake System.

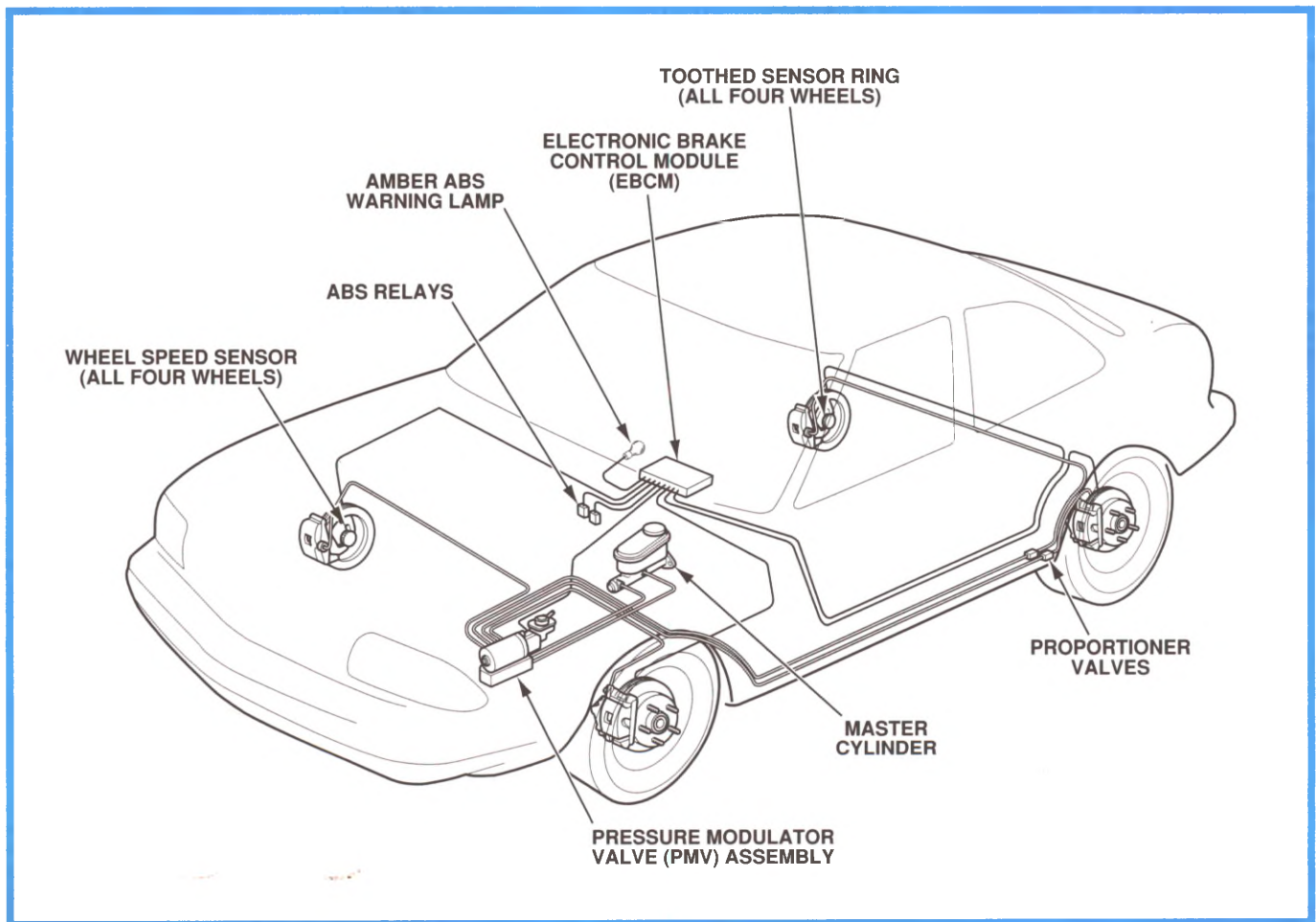


Figure 2-18, Teves Mark IV ABS (H-Body Application)

2. Components

Bosch 5

Channels:	Three (B-body) or Four
Hydraulic System:	Non-integral
Speed Sensors:	Two WSS and VSS (B-body) or Four WSS
Modulator Solenoids:	Two solenoids/two valves
Diagnostics:	Bi-directional scan tool

Some systems are adapted for use with a traction control system (TCS) to reduce wheel spin on hard acceleration. Refer to Figure 2-19 for an application of the Bosch 5 Antilock Brake System.

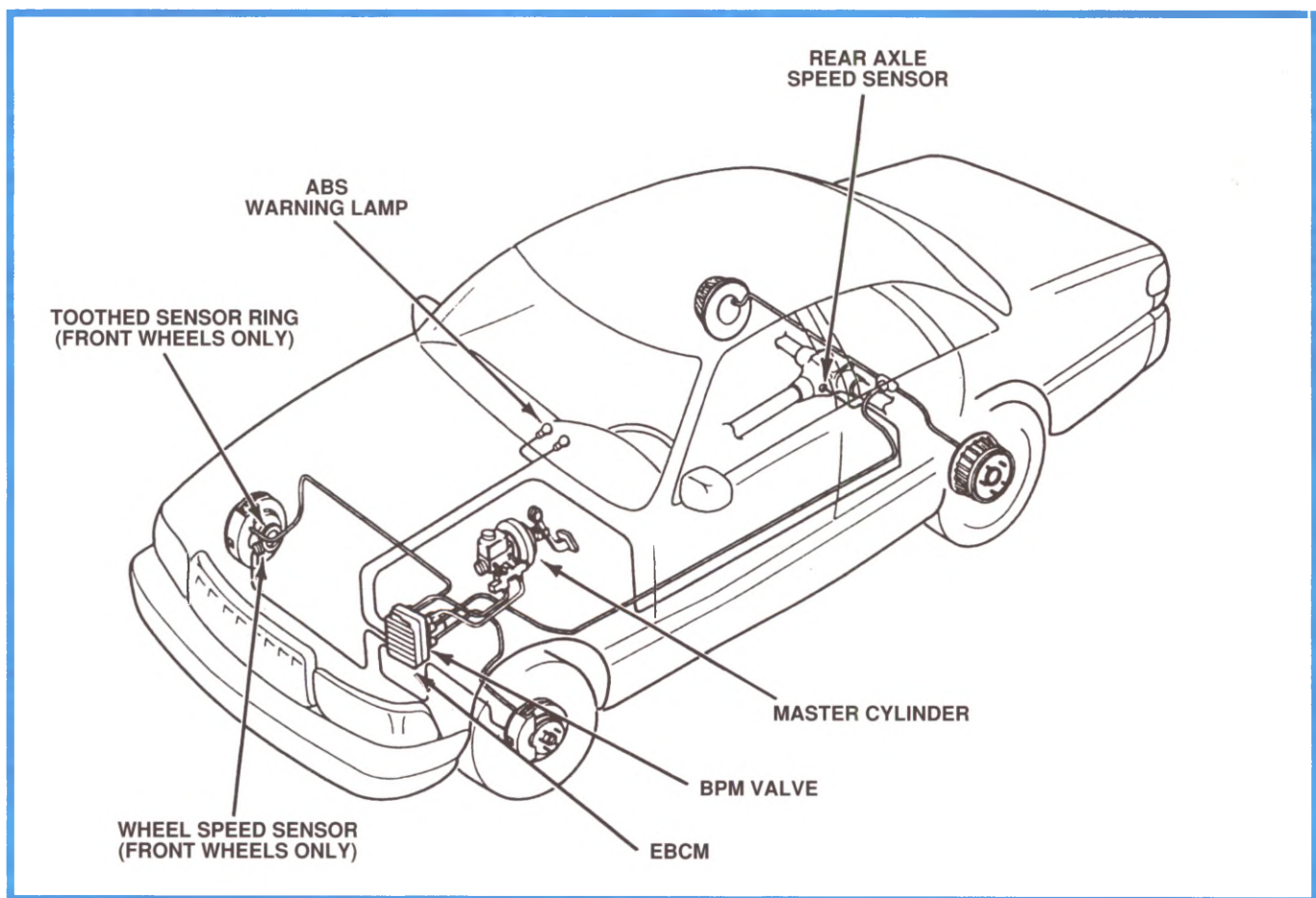


Figure 2-19, Bosch 5 ABS (B-Body Application)

Delco/Bosch 5

Channels:	Four
Hydraulic System:	Non-integral
Speed Sensors:	Four WSS
Modulator Solenoids:	Two solenoids/two valves
Diagnostics:	Bi-directional scan tool

Some systems are adapted for use with a traction control system (TCS) to reduce wheel spin on hard acceleration. Refer to Figure 2-20 for an application of the Delco/Bosch 5 Antilock Brake System.

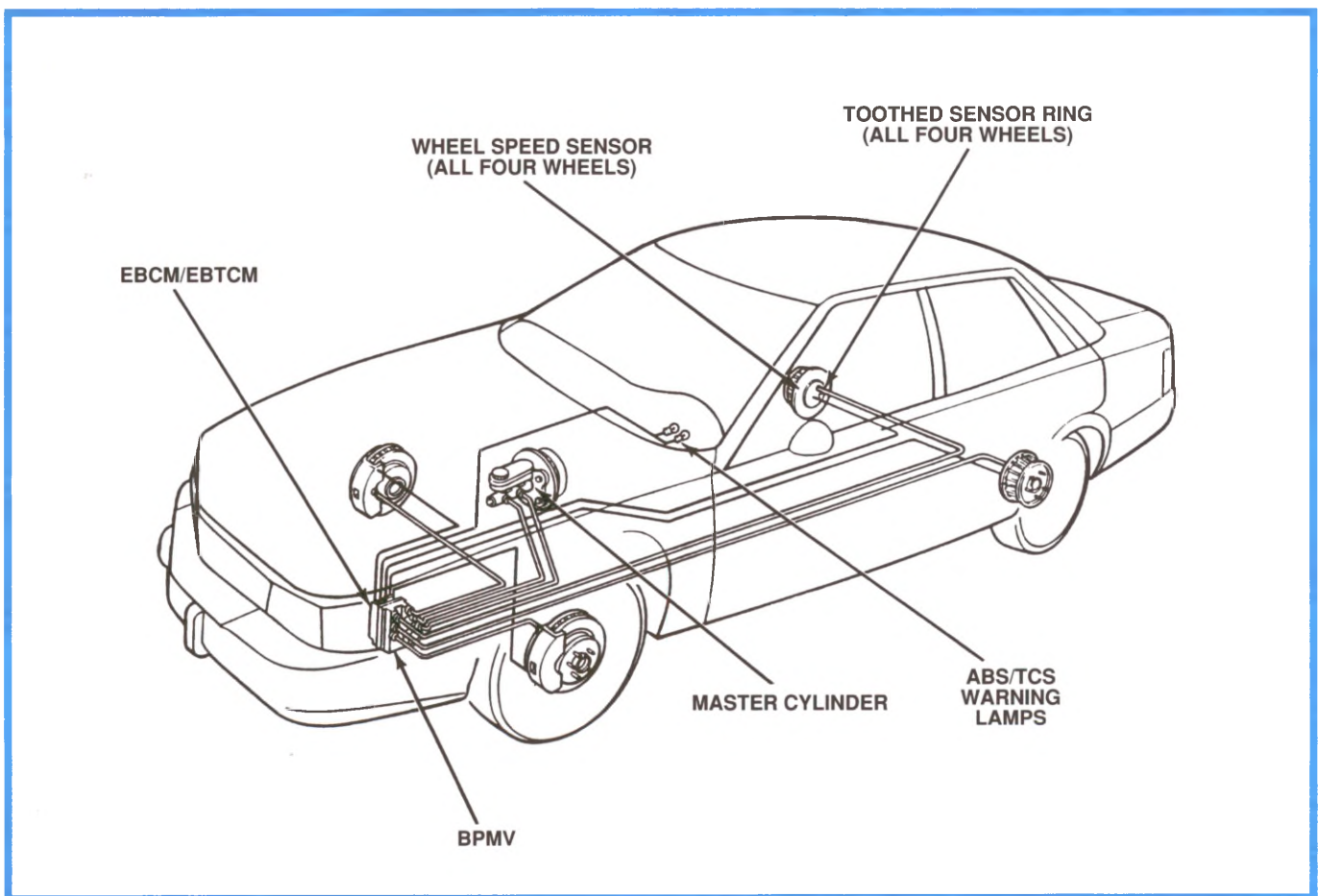


Figure 2-20, Delco/Bosch 5 ABS (E/K-Body Application)

2. Components

Bosch 5.3

Channels:	Three (F-car without TCS) or Four
Hydraulic System:	Non-integral
Speed Sensors:	Two WSS and VSS (F-car without TCS) or Four WSS
Modulator Solenoids:	Two solenoids/two valves
Diagnostics:	Bi-directional scan tool

Some systems are adapted for use with a traction control system (TCS) to reduce wheel spin on hard acceleration. Refer to Figure 2-21 for an application of the Bosch 5.3 Antilock Brake System.

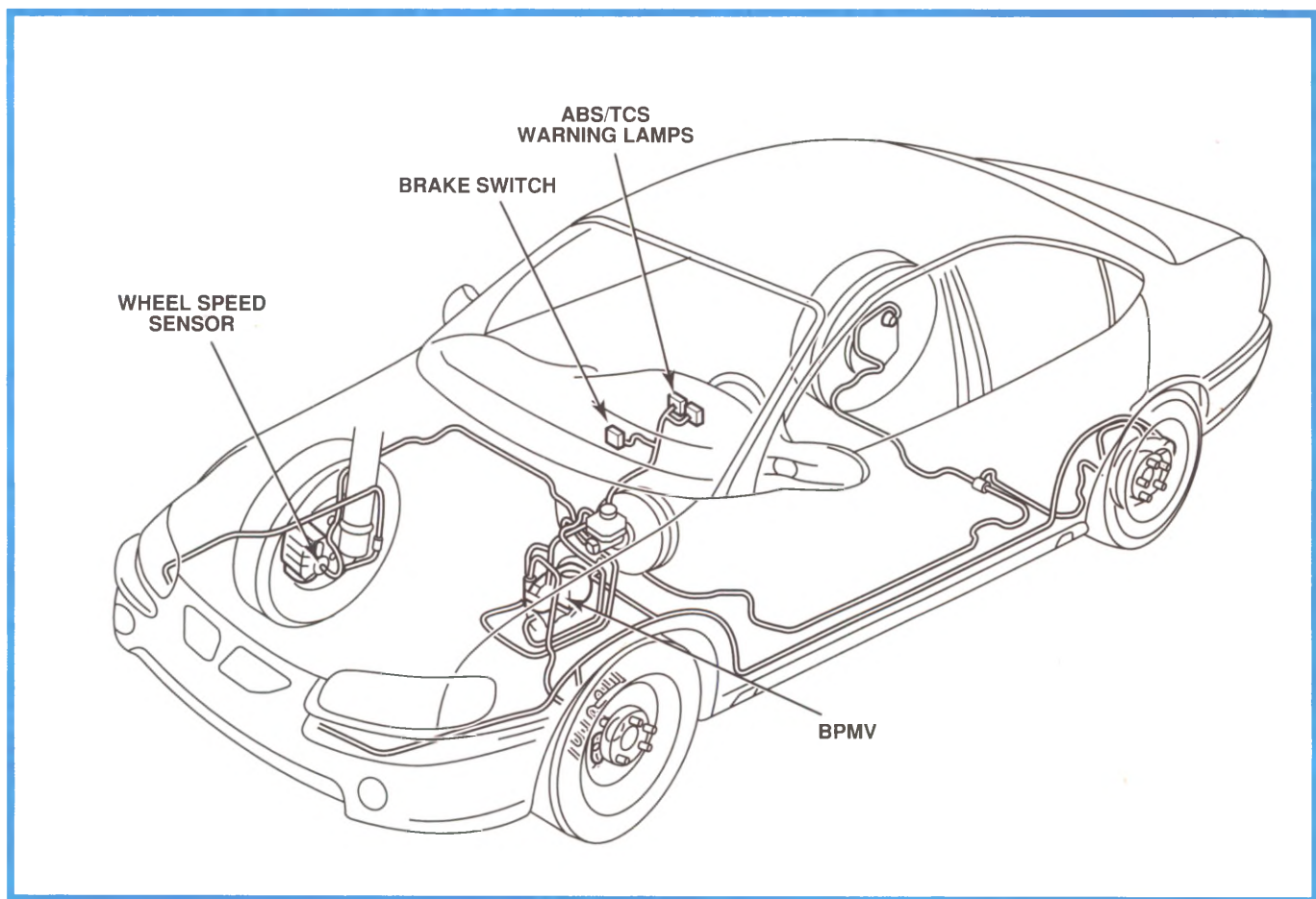


Figure 2-21, Bosch 5.3 ABS (W-Body Application)

Operation Introduction

Under most conditions, ABS operates the same as non-ABS brakes. Components added with the antilock brake system operate only when one or more of the wheels is beginning to lockup during braking.

This section outlines the operation of the components in the antilock brake systems that differ from a non-antilock brake system.

ABS Component Operation

This section describes ABS operation both for individual components and for the integrated system (Figure 3-1). Major components of the typical antilock brake system are:

- Electronic brake control module (EBCM)
- EBCM ABS inputs – wheel speed sensors, brake switch
- EBCM non-ABS inputs – brake pressure switch, pump monitor, ignition input, etc.
- EBCM outputs – valve solenoids, enable relays, amber ABS warning lamp
- Pump assembly and accumulator
- Hydraulic modulator unit

Electronic Brake Control Module (EBCM)

- Monitors wheel speed and hydraulic unit functions
- Monitors brake pedal position
- Detects potential wheel lockup conditions during braking
- Prevents wheel lockup while maintaining optimum braking performance
- Alerts the driver to system malfunctions
- Stores and displays ABS diagnostic trouble codes

The diagram illustrates the electrical connections for the Electronic Brake and Traction Control Module (EBTCM). It features four wheel speed sensors (LF, RF, LR, RR) and an anti-lock indicator. The sensors are connected to the EBTCM via a multi-pin connector. The anti-lock indicator is connected to the EBTCM via a two-pin connector. The lamp driver module is connected to the EBTCM via a three-pin connector. The serial data line is connected to the EBTCM via a two-pin connector. The diagram also shows the internal wiring of the sensors and the anti-lock indicator.

Wiring Diagram Details:

- Wheel Speed Sensors:**
 - LF Wheel Speed Sensor:** Connected to HI (830), LO (873), and C120 (873).
 - RF Wheel Speed Sensor:** Connected to HI (872), LO (833), and P101 (872).
 - LR Wheel Speed Sensor:** Connected to HI (884), LO (885), and C121 (884).
 - RR Wheel Speed Sensor:** Connected to HI (882), LO (883), and P403 (882).
- Anti-lock Indicator:** Connected to HI (8) and LO (24).
- Lamp Driver Module:** Connected to C2 (13), C (852), and E (875).
- Instrument Panel Cluster (IPC):** Connected to C1 (A5) and A5 (875).
- Serial Data Line:** Connected to C2 (15) and 30 (800).
- EBTCM Module:** Labeled as ELECTRONIC BRAKE AND TRACTION CONTROL MODULE (EBTCM/EBTCM).

3-2

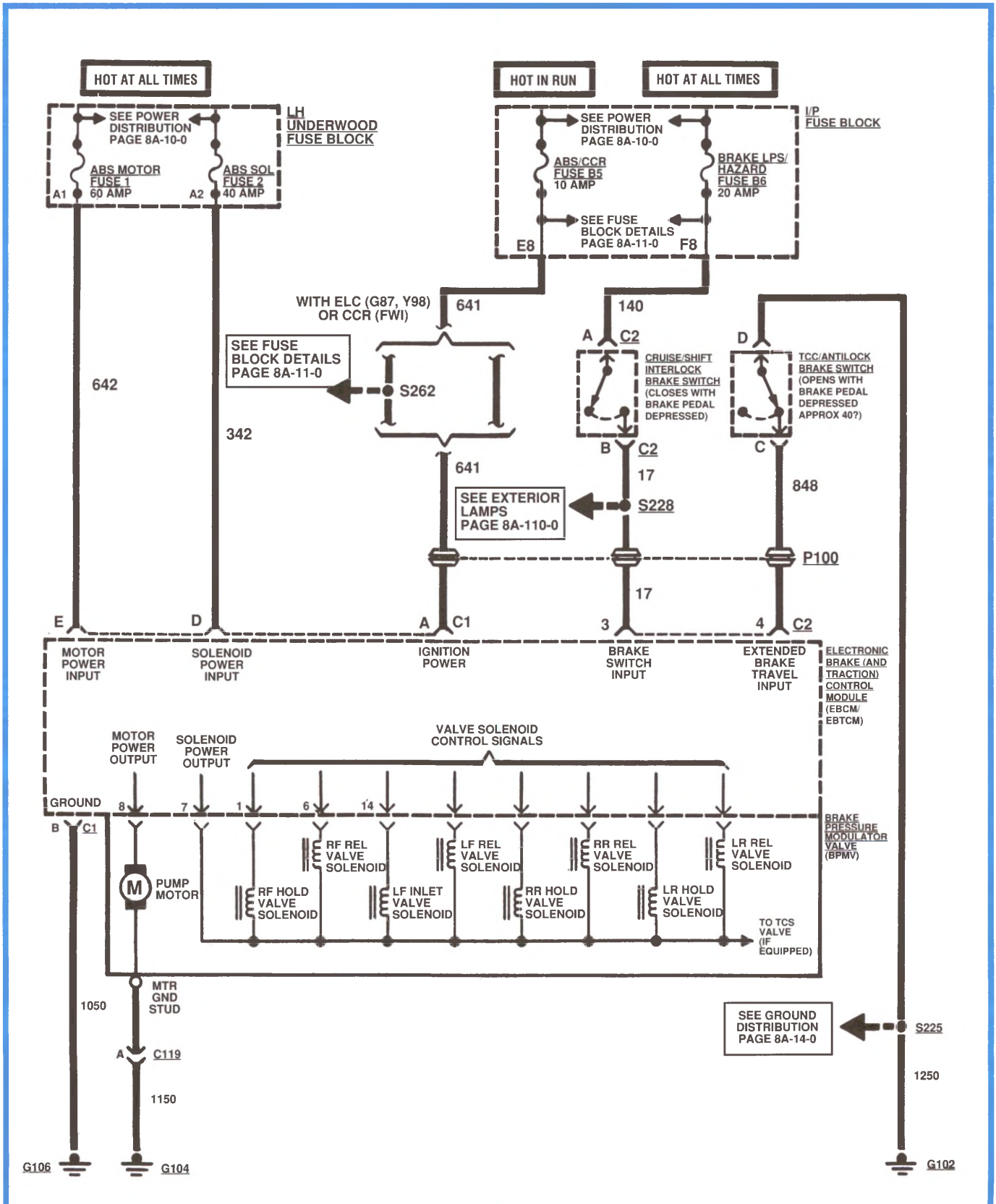


Figure 3-2, Typical Electrical Schematic (Delco/Bosch 5 Shown)

3. Operation

EBCM Input, Output and Power Supply

The EBCM is the power center of the antilock brake system (Figure 3-3). The EBCM gathers information from input signals, then controls outputs to accomplish its tasks. Power and ground are required for EBCM and component operation. Inputs/outputs vary depending upon system application.

Other possible inputs are:

- Brake fluid level
- Lateral acceleration
- Hydraulic reset switch
- Pump and relay monitor

Other possible outputs are:

- Solenoid relay
- RBWL
- Lateral acceleration sensor power and ground
- Dump valve
- Electro-magnetic brake

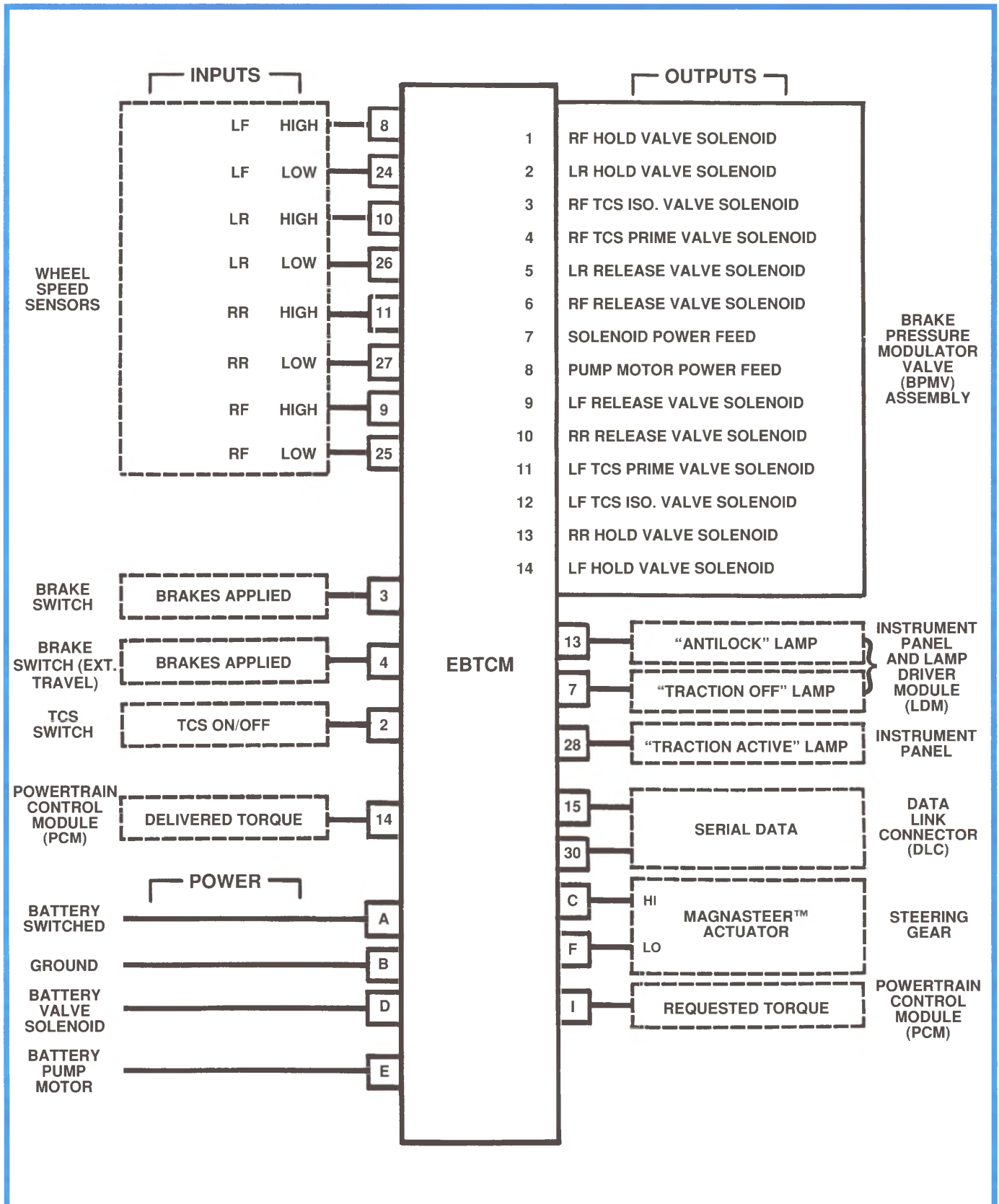


Figure 3-3, Typical Input, Output, and Power Supply (Delco/Bosch 5 Shown)

3. Operation

EBCM Inputs

The Electronic Brake Control Module (EBCM) uses inputs from the brake switch and the wheel speed sensors to determine when to begin antilock braking. Non-ABS inputs allow the EBCM to determine if the system is functioning properly.

Speed Sensor

Each wheel has a stationary magnetic wheel speed sensor and toothed sensor ring. The toothed sensor ring rotates at the same speed as the wheel. As the wheel turns, teeth on the toothed sensor ring pass by the sensor. Each tooth moves the sensor's magnetic field and generates an AC voltage (Figure 3-4). The sensor sends this AC voltage pulse to the EBCM through a pair of twisted, shielded wires. The EBCM uses these pulses to monitor the acceleration and deceleration rate of each wheel.

Speed Sensor Operation

Wheel speed sensors (WSS) are a magnetic inductive type, consisting of three components:

- Coil
- Magnet
- Toothed sensor ring (reluctor)

As the toothed sensor ring rotates at wheel speed, the teeth disrupt the magnetic field (Figure 3-3). The pulsing magnetic field induces an AC voltage into the surrounding coil winding. This AC signal has a frequency proportional to wheel speed.

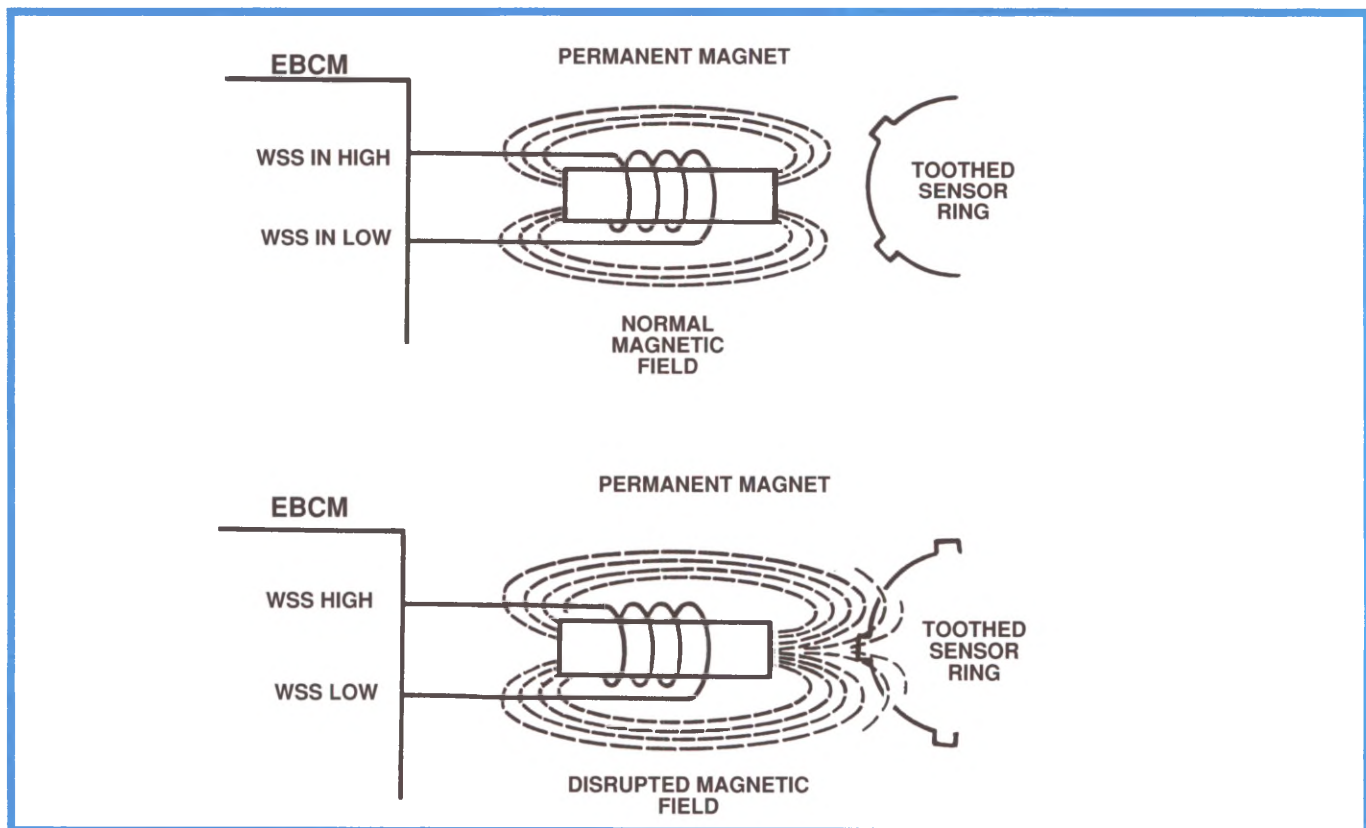


Figure 3-4, Wheel Speed Sensor Operation

Speed Sensor Signals

Speed sensors generate a characteristic sine wave when displayed on an oscilloscope (Figure 3-4). The oscilloscope is useful in diagnosing:

- Normal pattern
- Missing/broken tooth
- Excessive toothed sensor ring runout

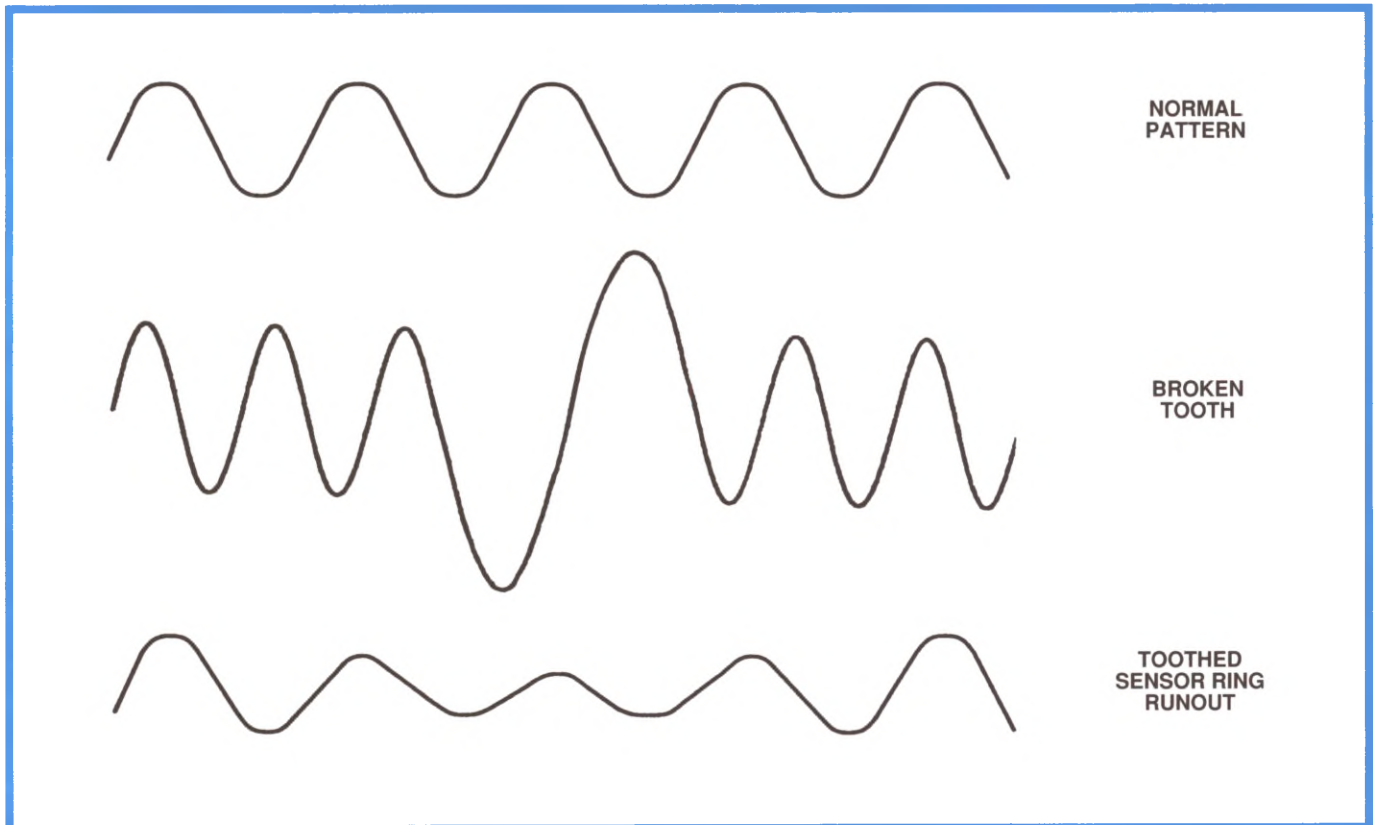


Figure 3-5, WSS Oscilloscope Patterns

3. Operation

The AC signal is processed in the EBCM (Figure 3-6). The signal determines the speed of each wheel or axle and allows the EBCM to determine when a wheel is approaching lockup.

The gap between the wheel speed sensor and toothed sensor ring is critical. If the gap is too small, the sensor could overreact to ring speed fluctuations from irregular road surfaces and could cause unwanted ABS activation. If the gap is too wide, the signal will be low or nonexistent at low speeds, resulting in sensor signal "drop out."

— IMPORTANT —

The factory sets the wheel speed sensor air gap. The gap does not normally require adjustment. If sensor gaps vary from wheel to wheel, and if this gap variance results in different sensor outputs, the variance could be interpreted as a wheel approaching lockup and the EBCM may engage unwanted antilock control during braking. Removing the WSS for any reason requires adjustment check of the sensor gap. See the vehicle Service Manual for more information.

The wheel speed sensor produces a variable frequency AC signal. The frequency changes with wheel speed.

The EBCM compares the signals from all the sensors. The EBCM begins antilock braking when sensors indicate:

- One wheel at a significantly lower speed than the other wheels
- Excessive wheel deceleration

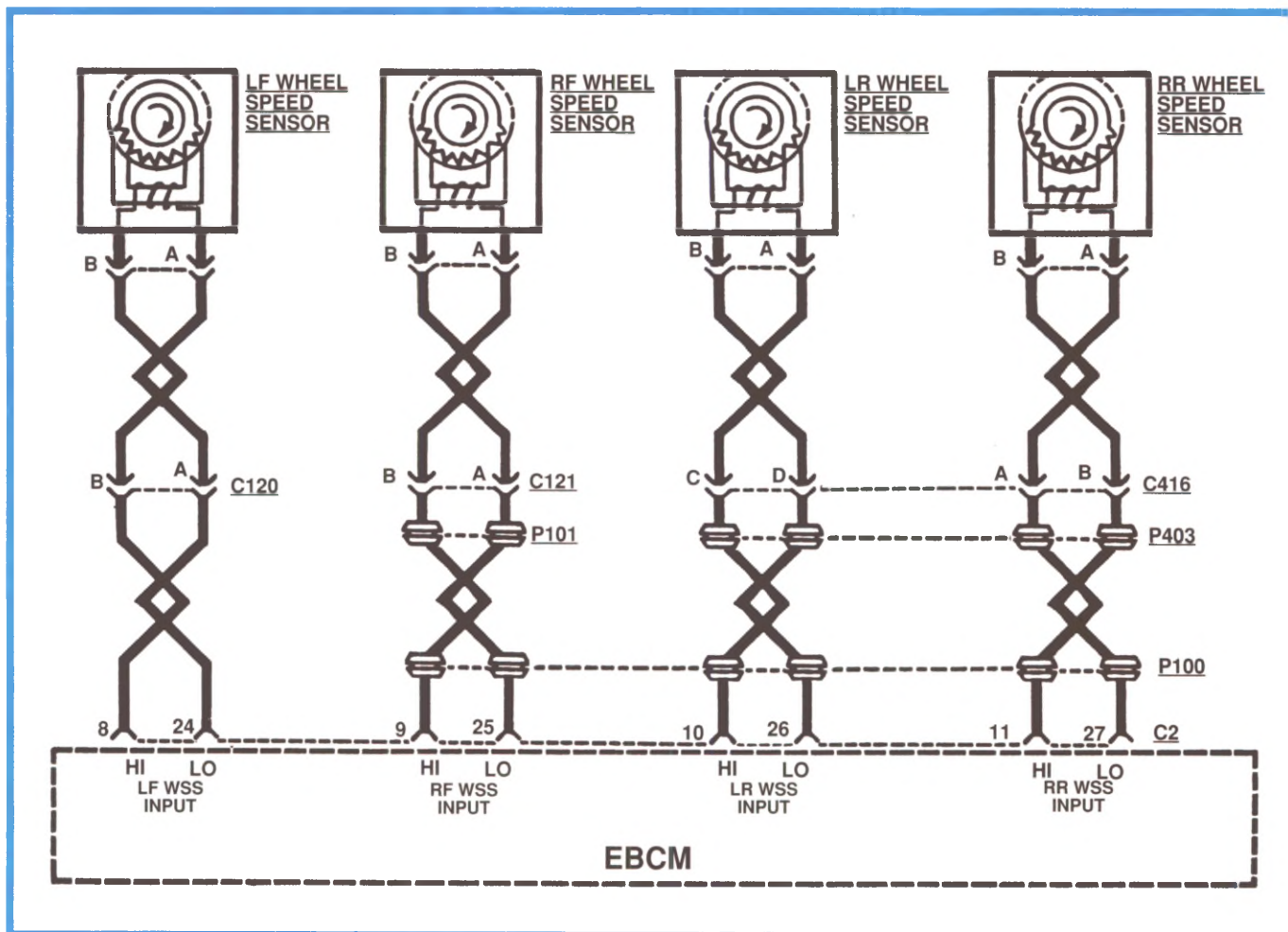


Figure 3-6, Speed Sensor Circuit (Delco/Bosch 5 Shown)

Vehicle Speed Sensor

Rear wheel antilock (RWAL) and some four wheel antilock (4WAL) ABS in trucks use the vehicle speed sensor (VSS) signal as the rear wheel speed input (Figure 3-7). The vehicle speed sensor (VSS) signal is shared by the ABS, the engine control module, vehicle speedometer, and the transfer case control module (TCCM).

These Kelsey-Hayes systems use a VSS calibrator to condition the VSS signal for tire size and axle ratio, then sends the signal to the EBCM.

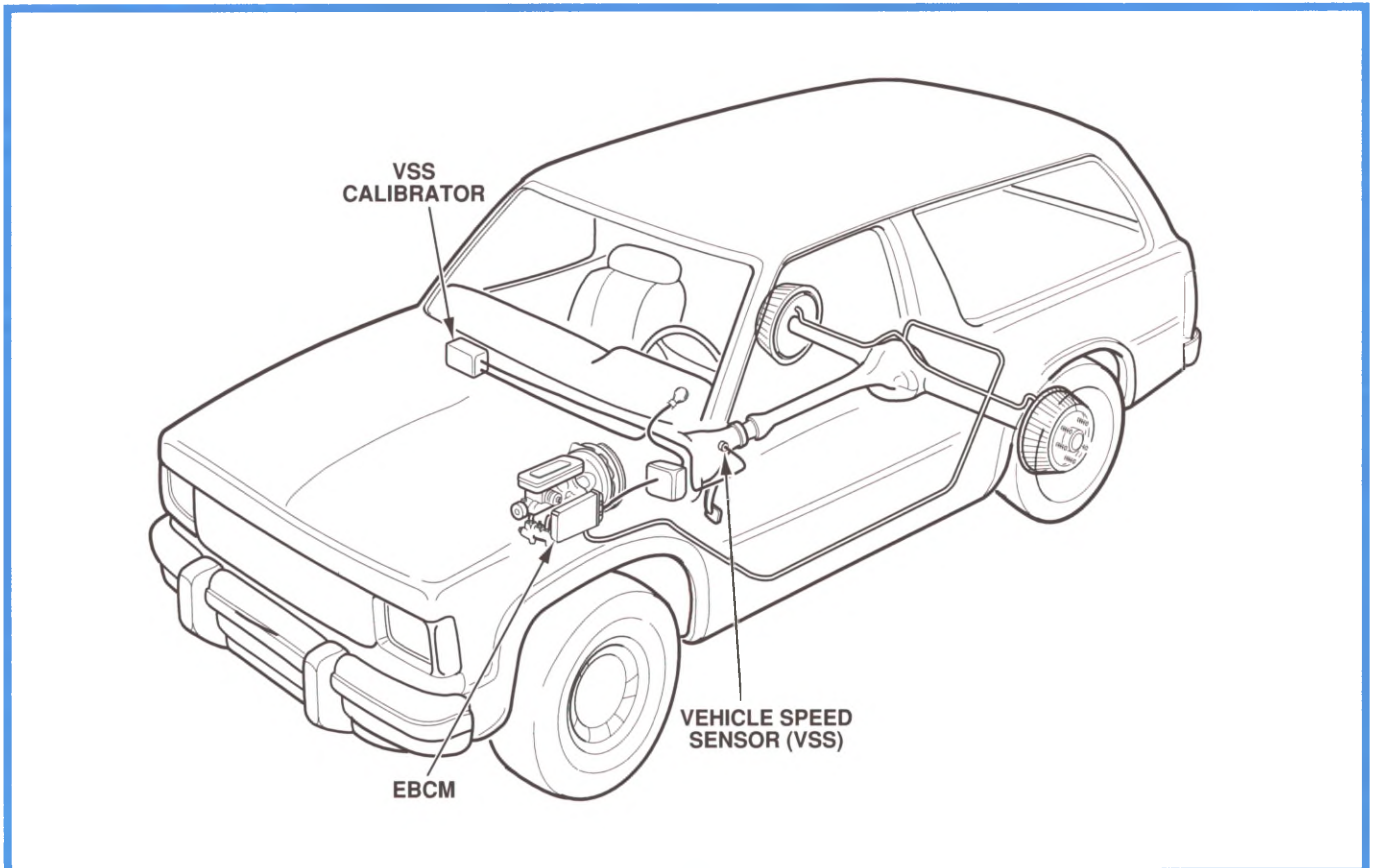


Figure 3-7, Vehicle Speed Sensor Operation (RWAL Application)

3. Operation

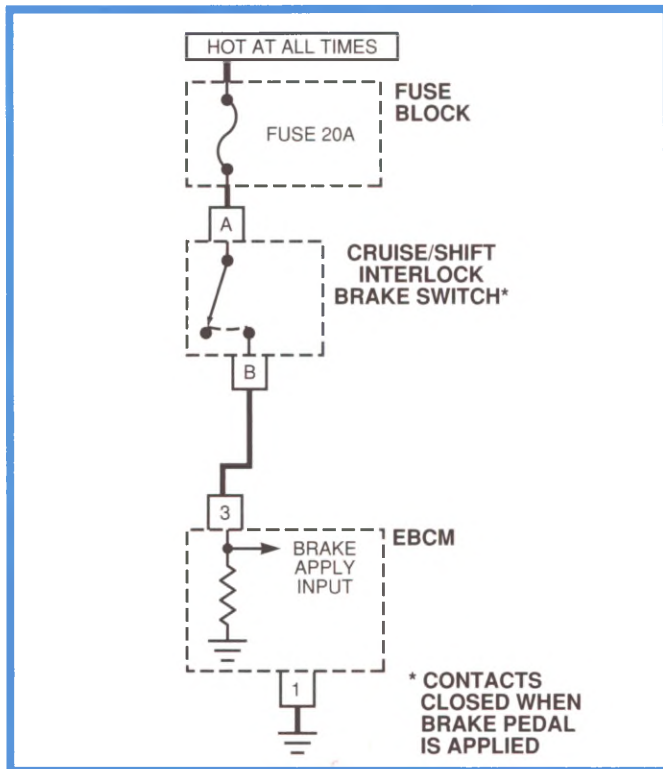


Figure 3-8, Brake Switch Circuit

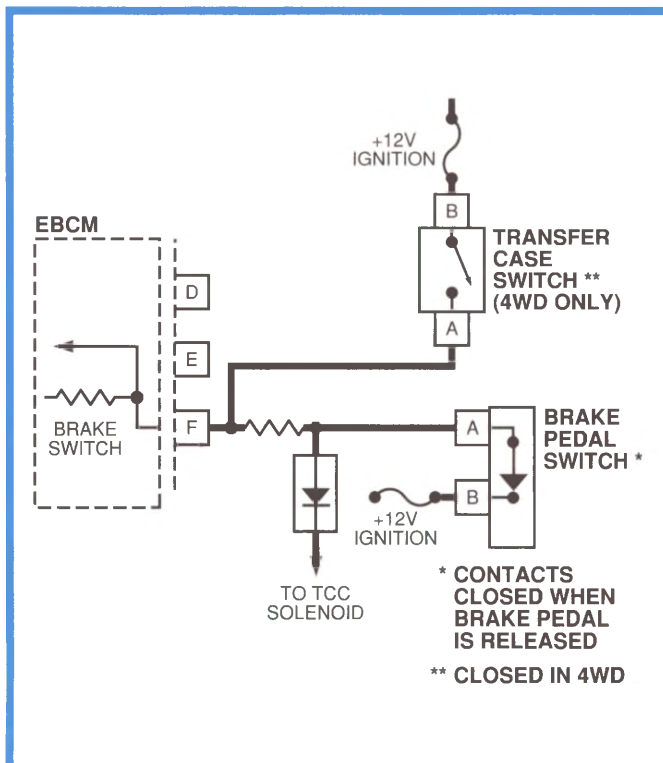


Figure 3-9, RWAL and 4WAL Brake Switch Circuit

Brake Switch

In most models, the EBCM will not initiate ABS braking until it receives a signal from the brake switch (Figure 3-8).

Pressing the brake pedal closes the brake switch on most current models. Current flows:

- From the STOP fuse
- Through the switch
- To the EBCM
- Current from the switch also lights the brake lights.

RWAL and 4WAL Brake Switch

RWAL and 4WAL system brake switches are normally closed, applying 12 volts to the EBCM brake switch input (Figure 3-9). The switch opens when the driver presses the brake pedal.

— IMPORTANT —

Some early systems did not use a brake switch input signal for ABS braking. Occasionally, rough terrain could cause wheel deceleration signals from the wheel speed sensor that would initiate antilock braking.

Brake Pressure and Fluid Level

The EBCM must determine whether the base brake system can operate safely (Figures 3-10 and 3-11). Therefore, the EBCM monitors signals from:

- Brake fluid pressure switch
- Brake fluid level switch

Low pressure or low fluid can cause the EBCM to disable ABS and light an amber ABS warning lamp on the dashboard on many systems.

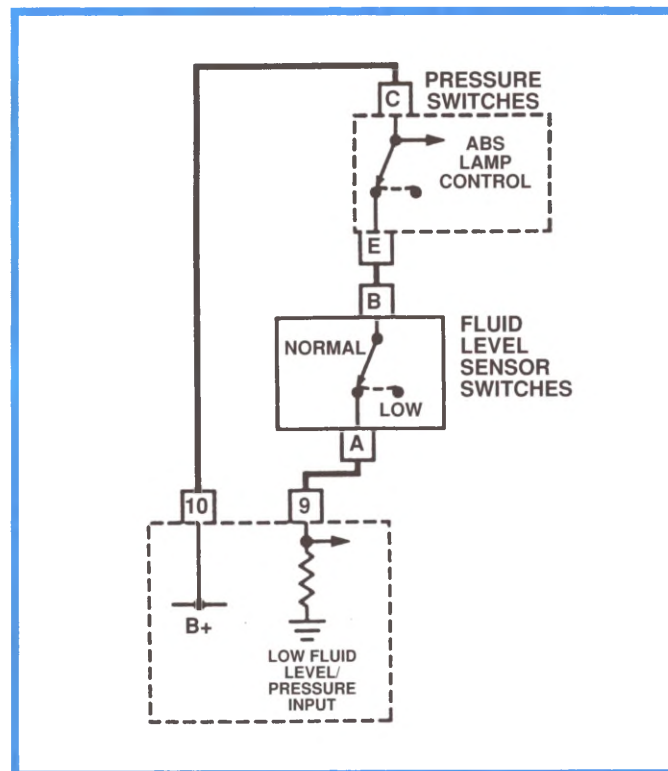


Figure 3-10, Brake Pressure & Brake Fluid Level Switch Circuits (Teves II)

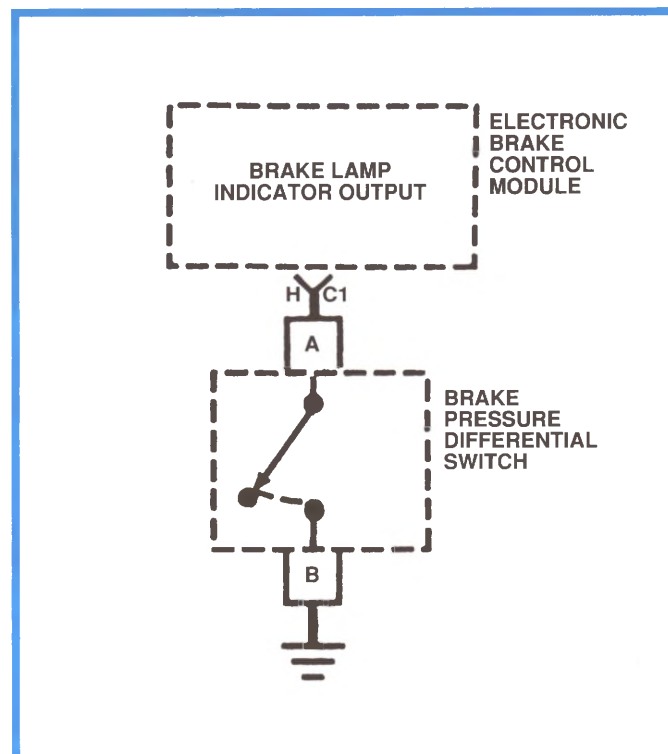


Figure 3-11, Brake Pressure Switch Circuit (4WAL)

3. Operation

Lateral Acceleration

Some models include a lateral acceleration sensor or switch that measures the vehicle's cornering force (Figure 3-12). The sensor signals the EBCM to modify its control logic for hard cornering conditions.

Crank Sense

Crank sense disables the EBCM while the engine is cranking. Engine cranking can cause fluctuating system voltage that could damage the EBCM. In place of crank sense, some applications use an ignition "ON" signal that doesn't wake up the EBCM until the key turns from CRANK to RUN.

Ignition "ON"

Ignition "ON" signals the EBCM to begin operating.

Battery Sense

Battery sense sets a diagnostic trouble code when voltage at this terminal drops below a specified voltage, usually near 9.5 volts. The EBCM and solenoids cannot operate properly with low voltage. If the voltage falls below a specified level, the EBCM disables ABS.

Serial Data I/O

Bi-directional scan tools communicate with the EBCM on a single serial data line. The serial data line acts as both input to the EBCM and output from the EBCM to the scan tool.

Pump Motor Monitor

The pump motor monitor signals the EBCM when the pump motor is running. The pump motor monitor sets diagnostic trouble codes indicating:

- Pump motor does not operate
- Pump motor runs too long
- Pump motor runs too often
- Pump motor monitor circuit open

In some models, the EBCM briefly activates the pump motor and verifies operation using the pump monitor input.

RBWL

Some systems utilize the RBWL as an input to notify the EBCM of a base brake malfunction.

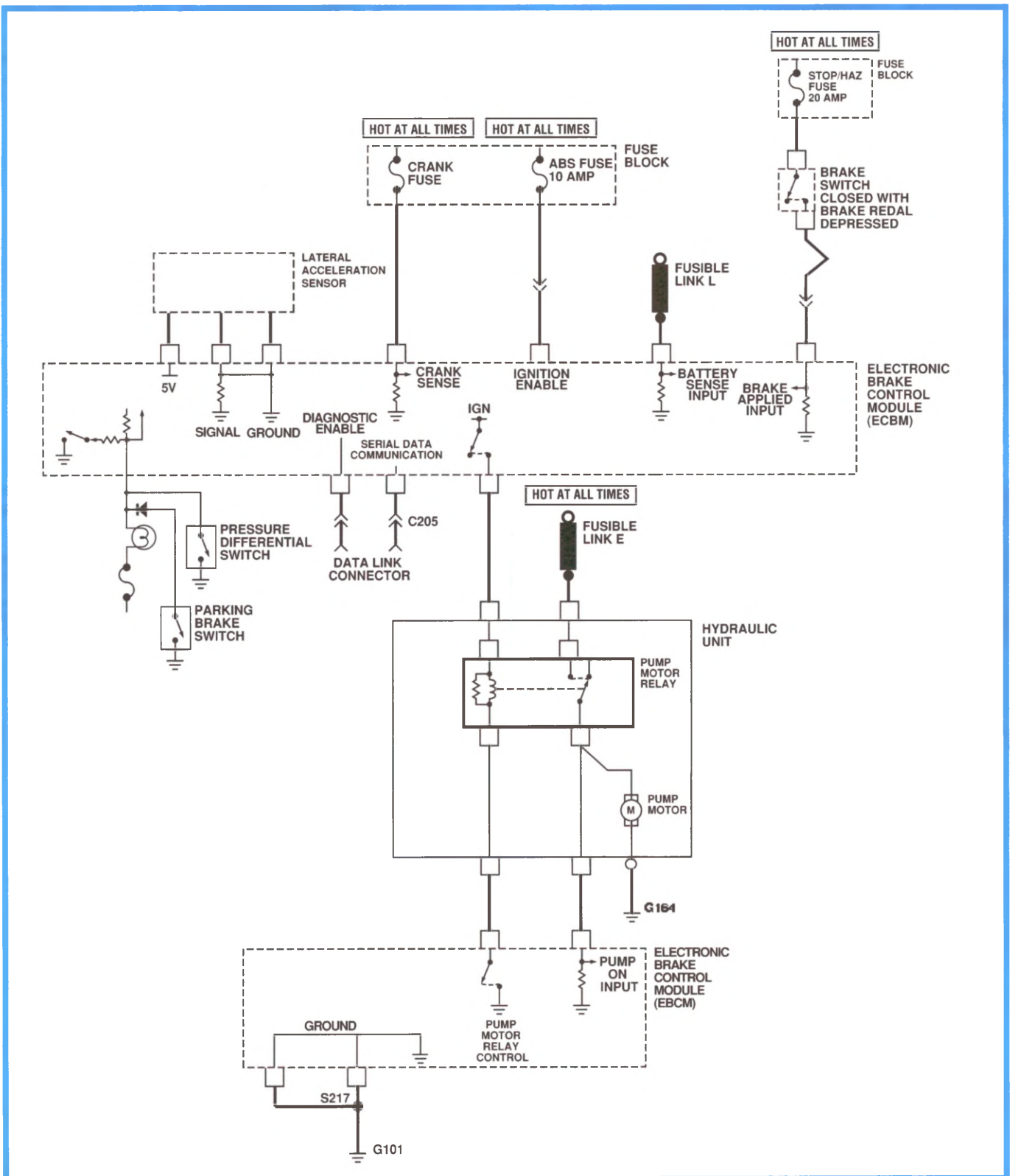


Figure 3-12, EBCM Inputs

3. Operation

EBCM Outputs

The EBCM controls several outputs to accomplish antilock braking and other functions. EBCM outputs include:

- Valve solenoids (hold and release)
- Power relay
- Diagnostic data (trouble codes, serial data)
- Amber ABS warning lamp

Valve Solenoids

During antilock braking, the EBCM controls solenoid-operated hydraulic valves that modulate pressure to the hydraulic channels. Although there are several different valve designs, all produce the same three-mode cycle:

- Pressure hold – Isolates brake pressure to the wheel circuits.
- Pressure decrease – Reduces brake pressure to the wheel circuits.
- Pressure increase – Resumes brake pressure to the wheel circuits.

The EBCM modulates these modes up to 15 times per second.

— CAUTION —

ANTILOCK BRAKING DOES NOT FUNCTION IF THE DRIVER PUMPS THE BRAKE PEDAL. THE EBCM INTERPRETS A PUMPED BRAKE PEDAL AS AN INTERRUPTION IN BRAKING REQUEST FROM THE DRIVER. WARN DRIVERS NOT TO PUMP THE BRAKE PEDAL DURING ANTILOCK BRAKING.

Main Power Relay

A main power relay provides power for the (Figure 3-13):

- EBCM
- Wheel valve solenoids

The EBCM energizes the relay only when the EBCM:

- Receives a signal from the ignition “ON” input
- Determines all related circuits are operating correctly (functional check)

If the EBCM identifies a problem, it disables ABS by de-energizing the power relay and lighting the amber ABS warning lamp.

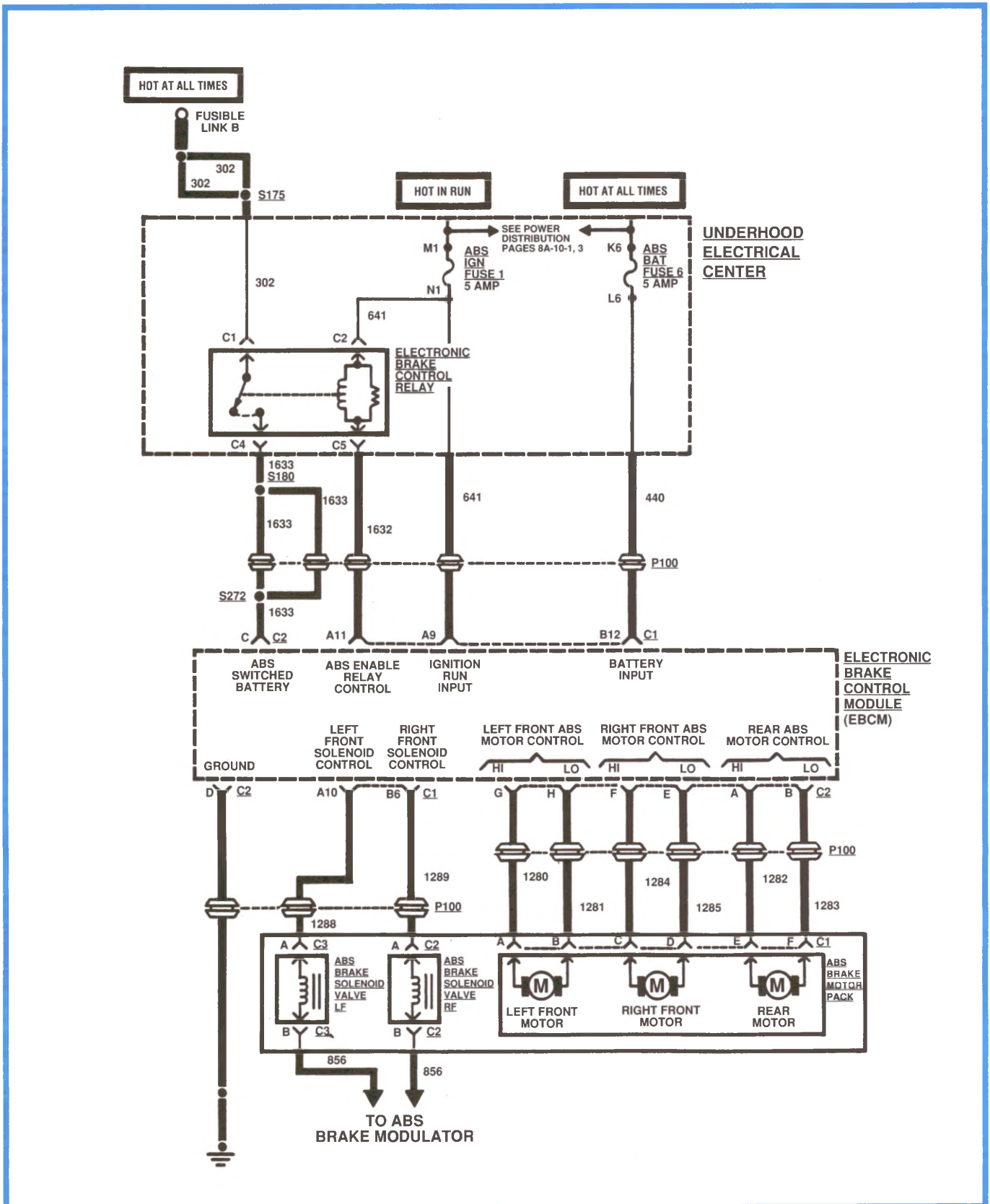


Figure 3-13, Main Power Relay Circuit (Delphi Chassis VI)

3. Operation

Return Pump

Bosch 2U/2S uses a pump to return brake fluid to the master cylinder reservoir (Figure 3-14). The pump begins operating during the ABS release mode and remains energized through the antilock braking cycle.

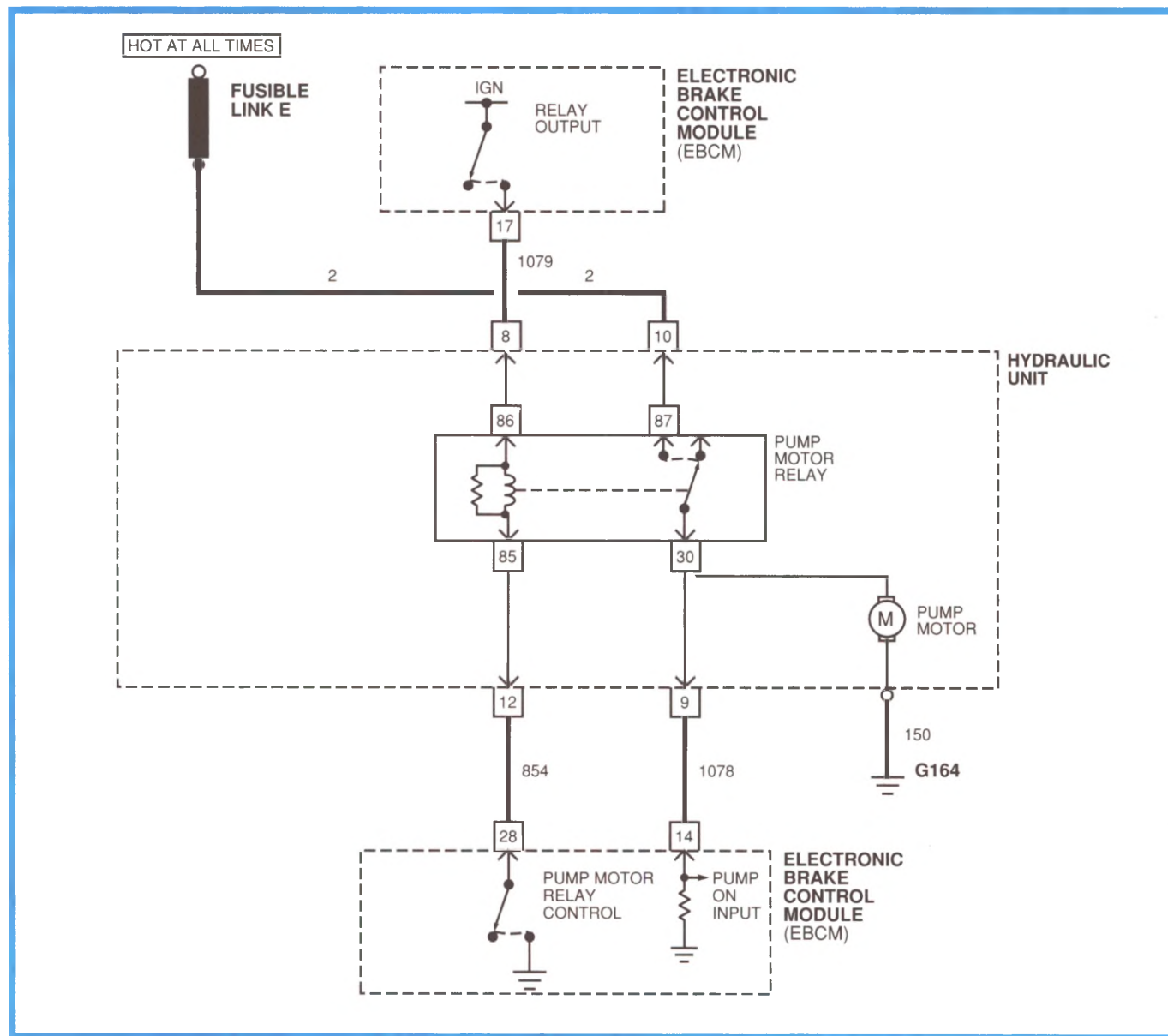


Figure 3-14, Return Pump Schematic (Bosch 2U/2S)

Diagnostic Data

Many EBCMs also communicate diagnostic trouble codes and diagnostic data to a bi-directional scan tool through the DLC (Figures 3-15 and 3-16). Scan tools include:

- TECH 1
- TECH 2
- Techline Diagnostic Terminal

The scan tool may display information from the EBCM such as:

- Current diagnostic trouble codes (DTC)
- History DTCs
- Conditions occurring when codes were stored
- Data flowing into and out of the EBCM

Some scan tools also operate the EBCM outputs so the technician can determine whether relays and solenoid valves operate normally.

EBCM diagnosis using blink codes and diagnostic data is discussed in the specific Service Manual for that application.

	None	Blink Codes	Bi-directional Scan Tool	Driver Information Center
Bosch 2U/2S	*	X	X	
Bosch III		X		X
Delco III			X	
Delphi Chassis VI			X	
Kelsey-Hayes RWAL		*	X	
Kelsey-Hayes 4WAL		*	X	
Teves Mark II	*	*		*
Teves Mark IV			X	
Delco/Bosch 5			X	*
Bosch 5			X	
Bosch 5.3			X	*

* Depending on model year and application

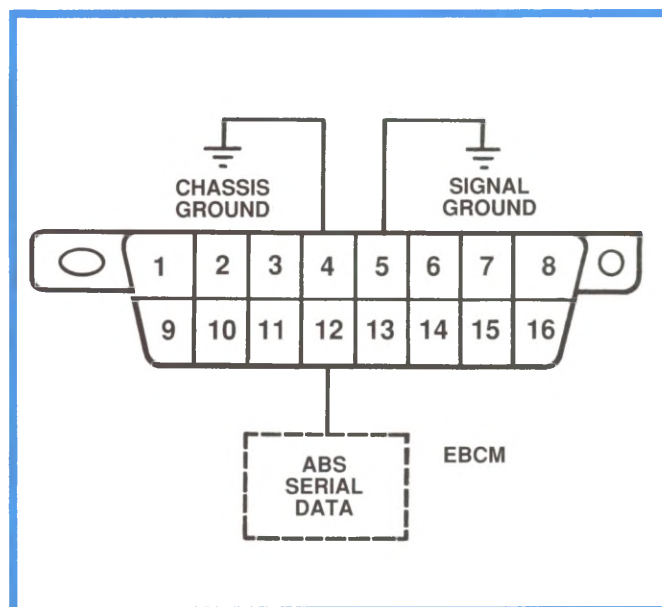


Figure 3-15, Diagnostic Enable Circuit (16-Pin DLC)

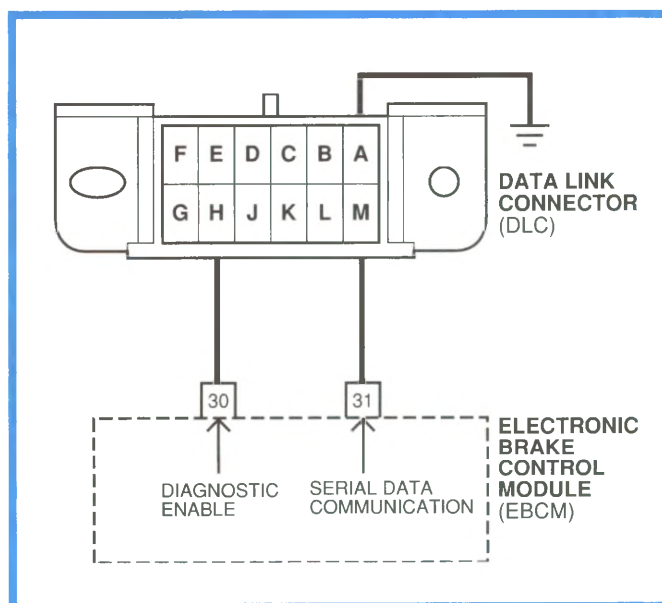


Figure 3-16, Diagnostic Enable Circuit (12-Pin DLC)

3. Operation

Amber ABS Warning Lamp

Depending on the system, the EBCM may use the amber ABS warning lamp to:

- Alert the driver that ABS is disabled (lamp “ON” steady)
- Alert the driver of malfunctions that are not serious enough to disable ABS (lamp flashing)
- Blink diagnostic trouble codes for diagnosis (diagnostic mode)

Lamp “ON” Steady

The amber ABS warning lamp alerts the driver when the antilock brake system is disabled because:

- The EBCM detects a malfunction in the ABS
- The main power relay is not energized when the key is “ON.”

The diode allows the EBCM to light the amber ABS warning lamp, even if the relay is still “ON.” Current flows:

- From the fuse
- Through the amber ABS warning lamp
- Through the EBCM lamp control to ground

The amber ABS warning lamp lights to indicate the system is disabled.

On some GM ABS systems, both the EBCM and the ABS main relay can operate the amber ABS warning lamp (Figure 3-17). When the main solenoid is de-energized, current flows.

- From the fuse
- Through the amber ABS warning lamp
- Through the ABS diode
- Through the closed contact in the main relay to ground.

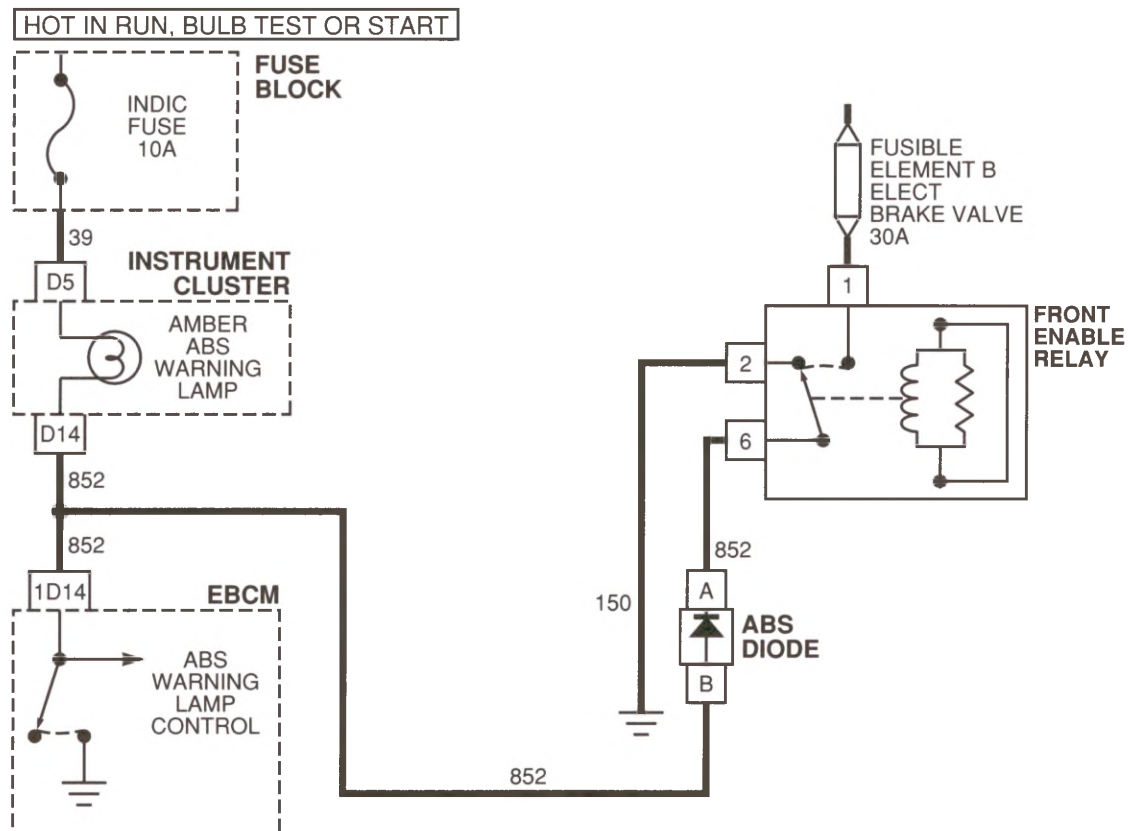


Figure 3-17, Amber ABS Warning Lamp Circuit (Delco Moraine III)

3. Operation

Red Brake Warning Lamp (RBWL)

The red brake warning lamp (RBWL) (Figure 3-18):

- Notifies the driver of conditions affecting operation of the base brake system (the same as non-ABS braking).
- Indicates a loss of accumulator pressure (power boost pressure).

Depending on the system, the following components ground the red brake warning circuit and light the red brake warning lamp:

Component	Condition
Lamp driver module or pressure switch	Accumulator pressure low
Ignition switch	Bulb test or start position
Brake fluid level sensor	Brake fluid level low
Parking brake switch	Parking brake applied

Some ABS systems use the RBWL as an input. Some EBCMs can control the operation of the RBWL.

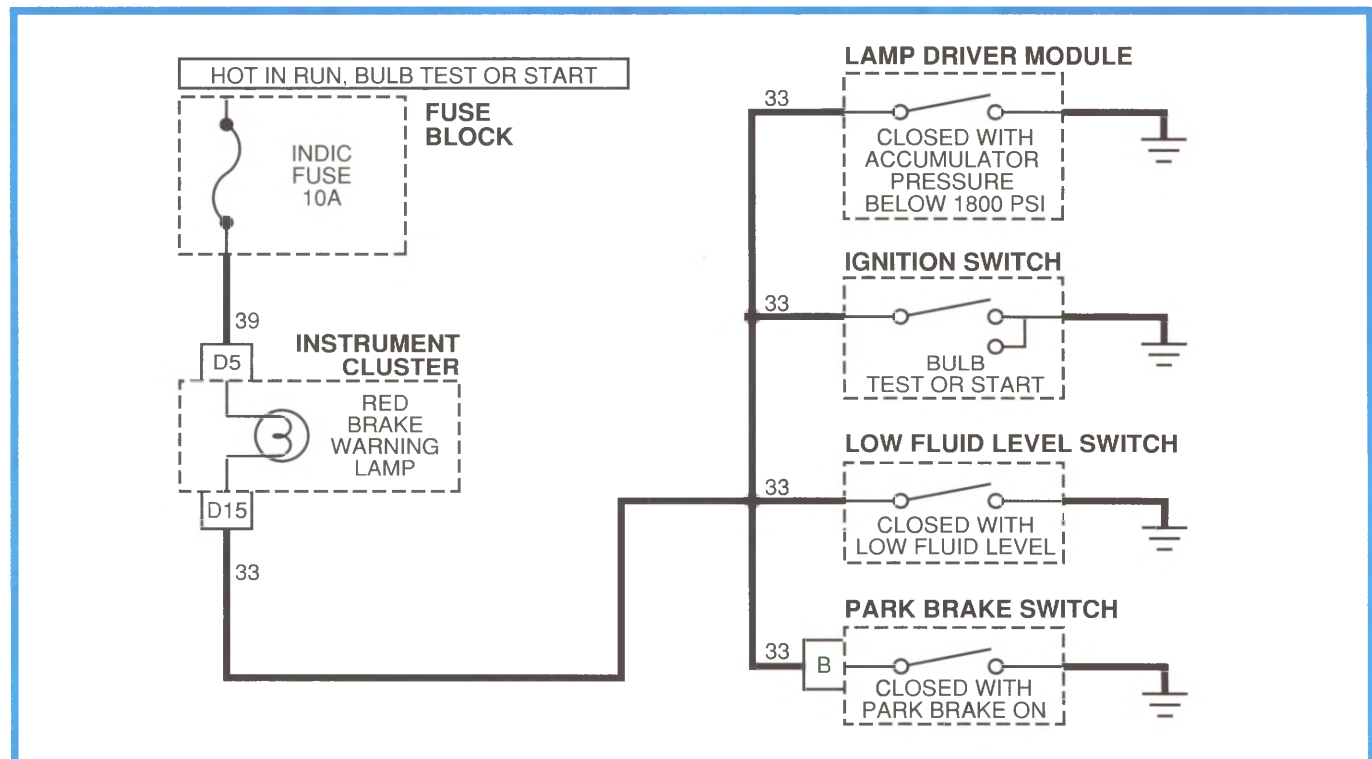


Figure 3-18, Red Brake Warning Lamp (RBWL) Circuit (Delco Moraine III Shown)

Pump Assembly

On some systems, the pump motor assembly pressurizes brake fluid to the accumulator for ABS and power assisted braking (Figure 3-19). The typical assembly includes:

- Pump motor and pump
- Pump relay
- Accumulator
- Pressure Switch

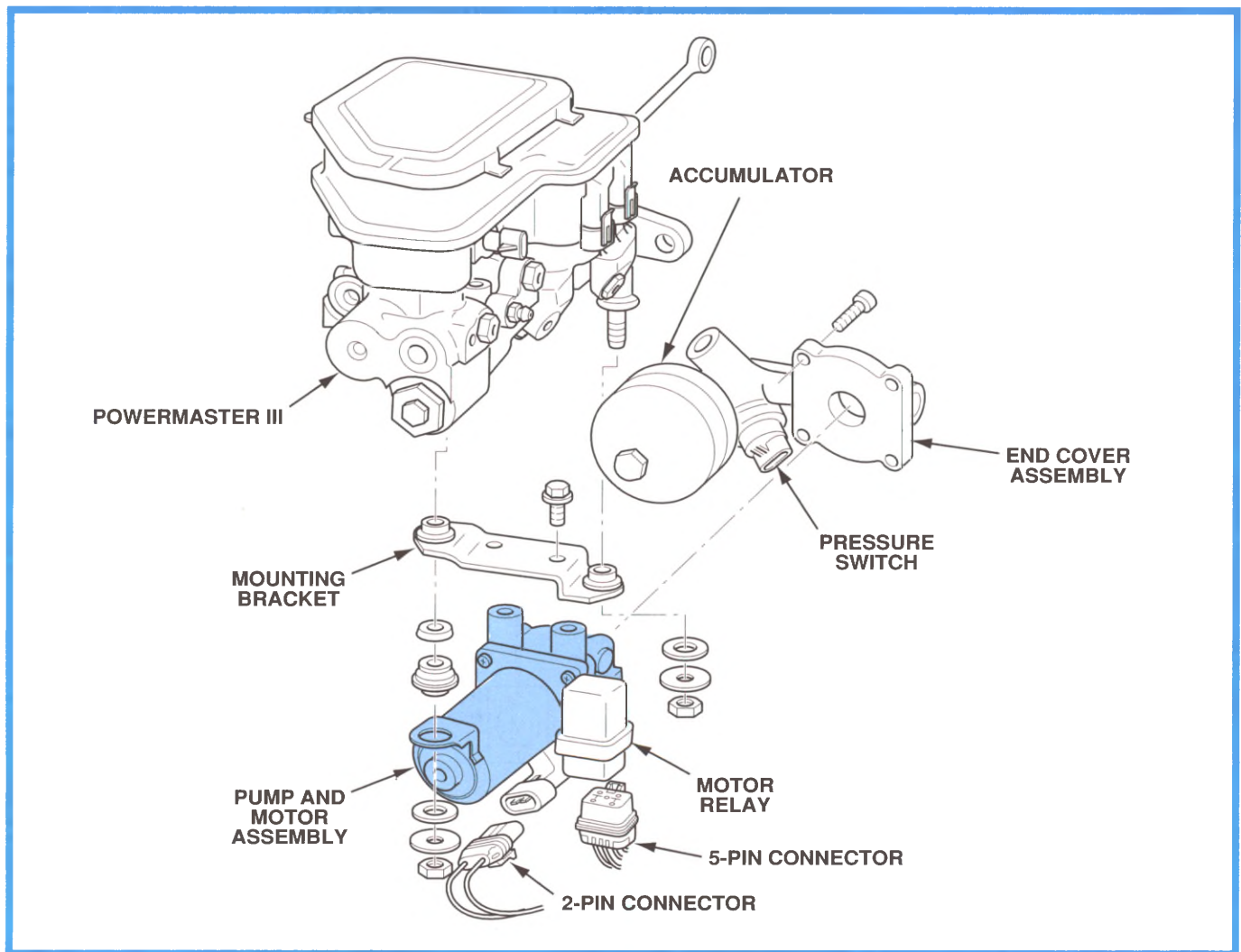


Figure 3-19, Pump Motor Assembly (Delco Moraine III Shown)

3. Operation

1. The electric motor operates the pump.
2. The pump sends pressurized brake fluid to the accumulator. The accumulator stores pressurized brake fluid so the pump does not run continuously.
3. When accumulator pressure drops below a specified pressure, the pressure switch grounds, causing the pump to run (Figure 3-20).
4. At the specified pressure, the pressure switch opens, turning the pump "OFF."
5. A hydraulic pressure relief valve opens at a specified pressure, allowing excess fluid to return to the reservoir.

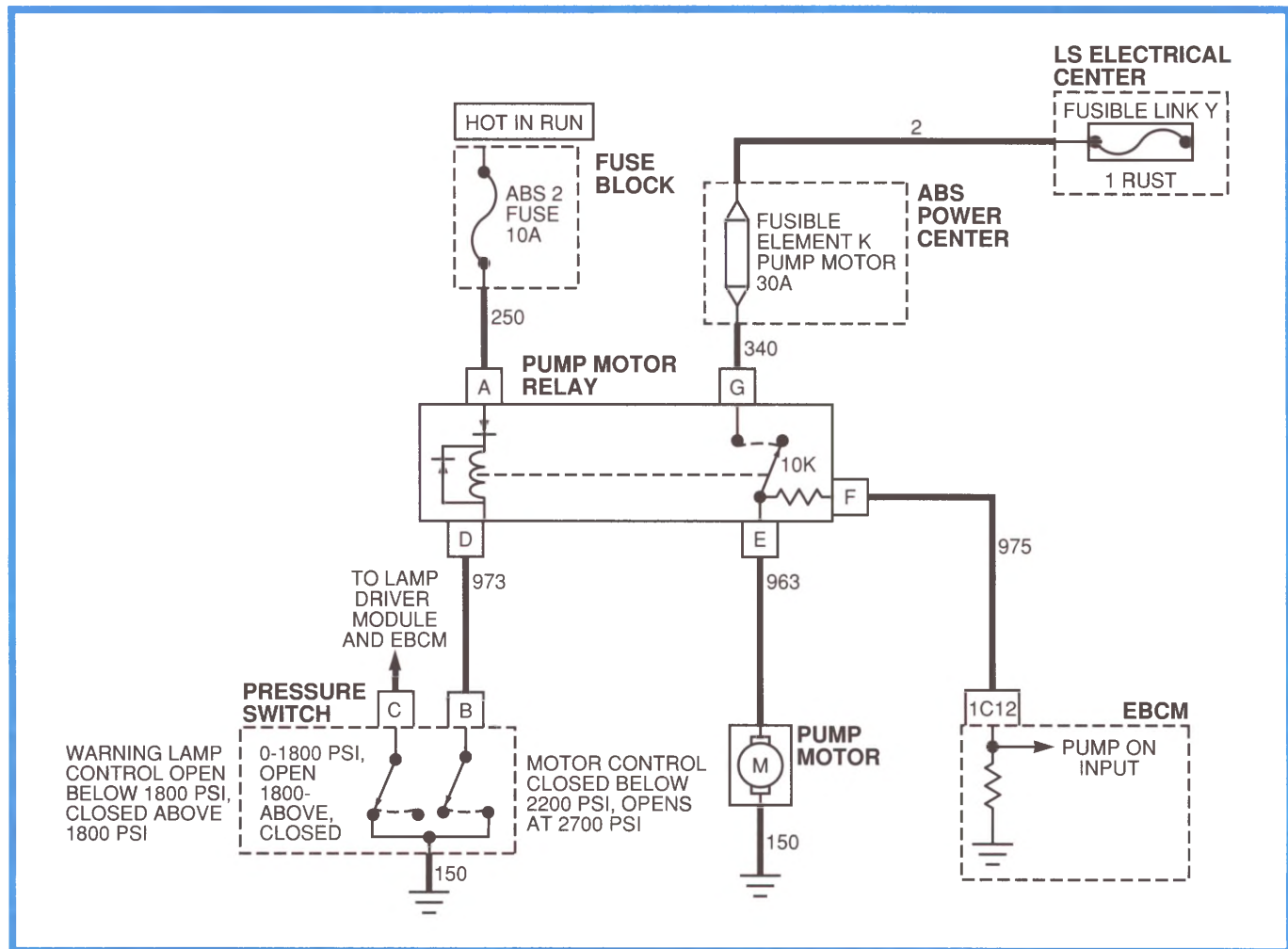


Figure 3-20, Pump Motor Electrical Circuit (Delco Moraine III Shown)



Accumulator

On accumulator equipped vehicles, the accumulator contains either:

- A spring-loaded chamber, or
- A thick rubber diaphragm with a gas precharge.

The accumulator is precharged to a specified psi.

The accumulator stores pressurized brake fluid assuring a supply of pressurized fluid is available for antilock or non-antilock braking.

Depending upon its application, the accumulator:

- Decreases pump run time
- Reserves pressurized fluid for power brake assist
- Provides brake fluid for power brake assist
- Replenishes brake fluid during antilock braking pressure increase mode

— CAUTION —

THE ACCUMULATOR IS UNDER EXTREMELY HIGH PRESSURE. IMPROPER REMOVAL OR DISASSEMBLY OF THE ACCUMULATOR COULD RESULT IN PERSONAL INJURY, VEHICLE DAMAGE AND ABS FAILURE. ALWAYS DEPRESSURIZE THE ACCUMULATOR BEFORE SERVICING THE HYDRAULIC SYSTEM.

3. Operation

Braking Operation At Rest Position

With the brake pedal at rest, the hydraulic unit establishes a 2-way path from the master cylinder to the wheel circuits (Figure 3-21). Brake fluid is at atmospheric or ambient pressure throughout the system.

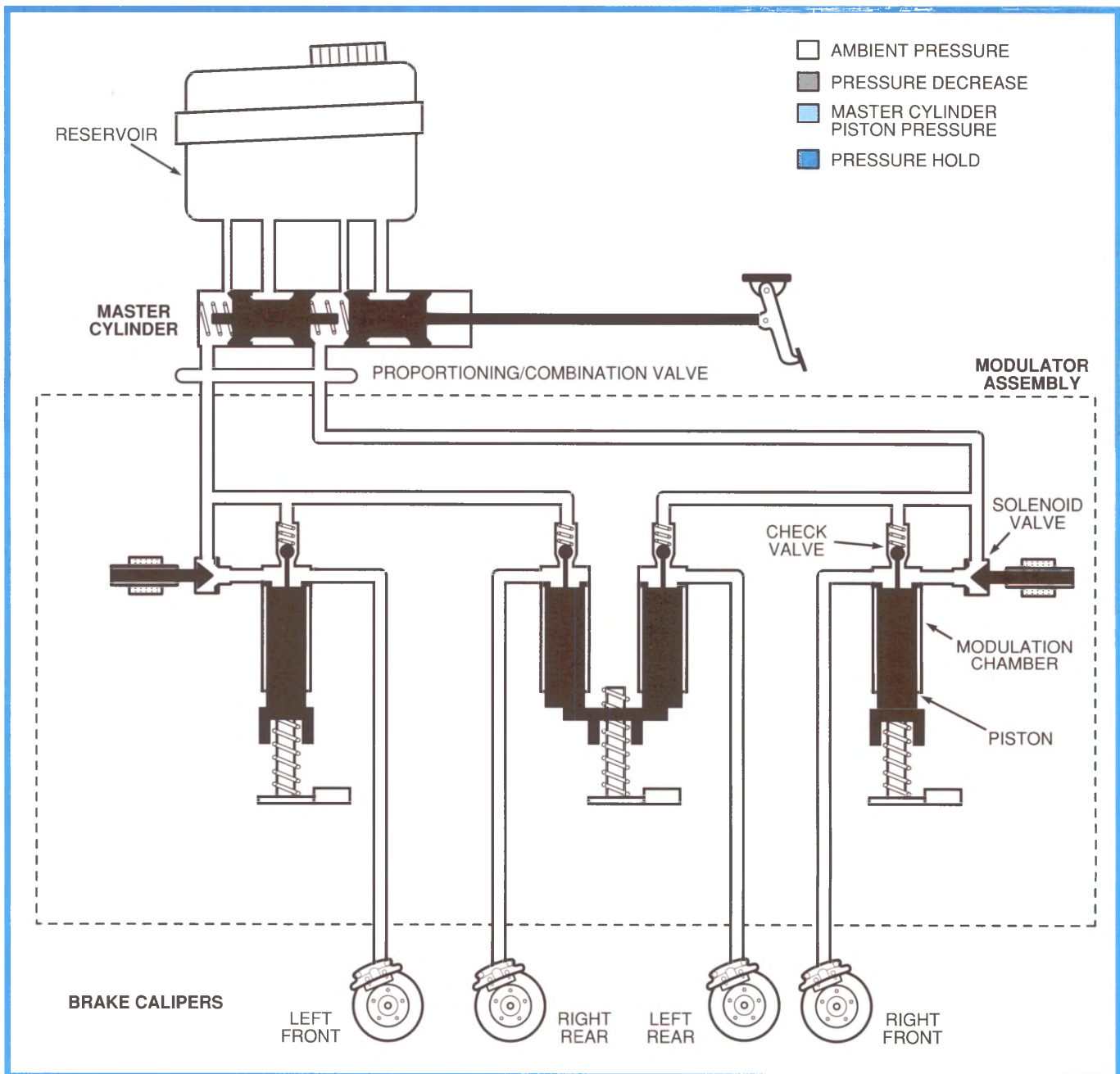


Figure 3-21, Delphi Chassis VI ABS – At Rest

Non-ABS Braking

When the driver applies the brakes during non-ABS braking, the valves are all open or in the at rest position (Figure 3-22). Each wheel cylinder or caliper receives full master cylinder pressure.

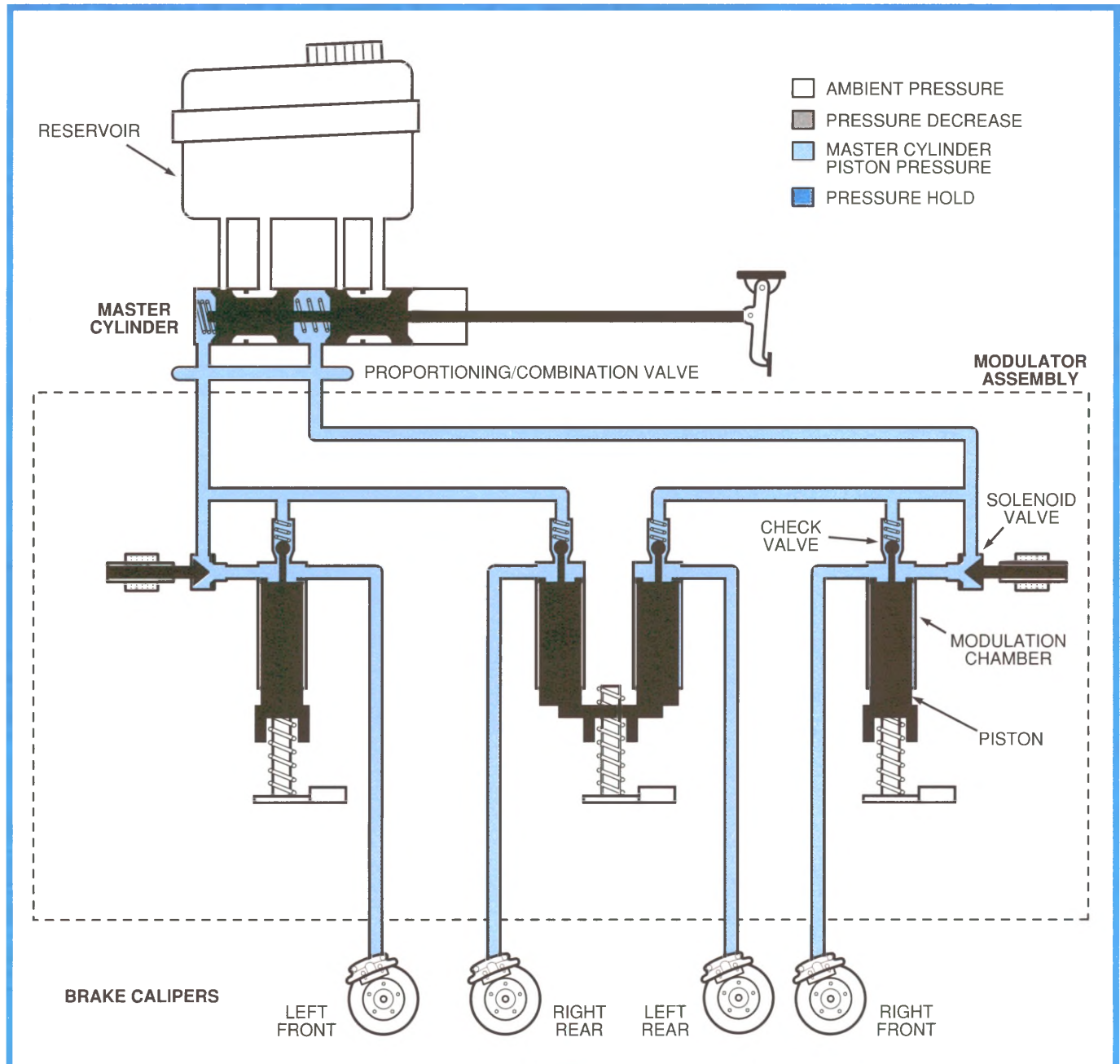


Figure 3-22, Delphi Chassis VI ABS – Non-ABS Braking Mode

3. Operation

Antilock Braking Pressure Hold

Antilock braking usually begins with the pressure hold mode (Figure 3-23). The EBCM selects pressure hold when:

- There is a signal from the brake switch
- Wheel speed sensors indicate excessive deceleration from one or more wheels

The EBCM energizes the solenoid valve to isolate the brake caliper or wheel cylinder from the master cylinder, trapping pressure in the circuit. Even though the driver may increase pressure on the brake pedal, there is no increase in pressure at the wheel cylinder or caliper.

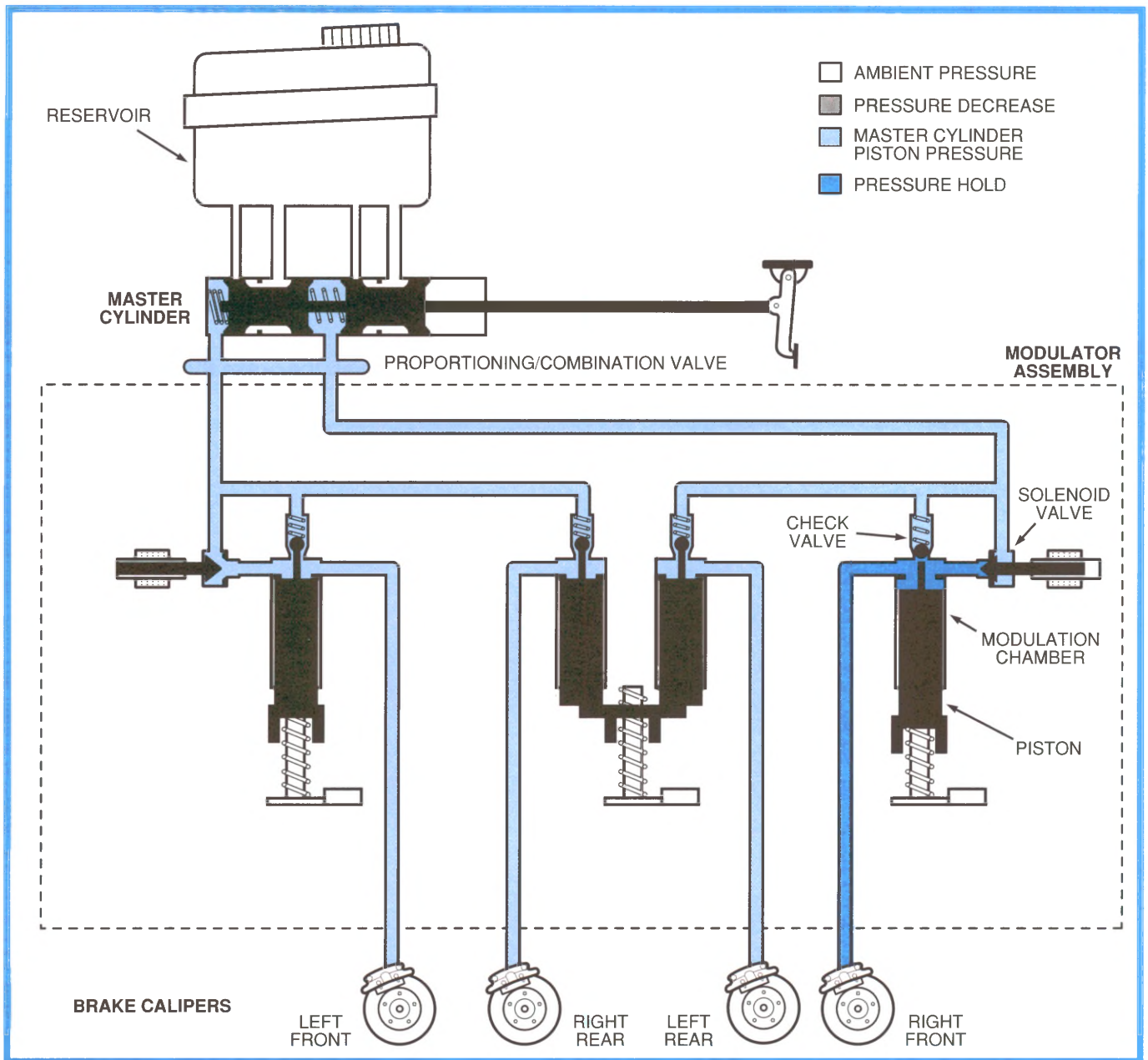


Figure 3-23, Delphi Chassis VI ABS – Pressure Hold Mode (Right Front)

3. Operation

Pressure Decrease

The EBCM selects pressure decrease when (Figure 3-24):

- There is a signal from the brake switch
- Wheel speed sensors indicate continued excessive deceleration
- The EBCM has already attempted to control wheel lockup with pressure hold mode

Delphi Chassis VI moves the piston down, reducing the volume of fluid in the brake caliper. Other systems open an outlet valve, returning pressurized brake fluid to the reservoir.

During pressure decrease mode, the hold valve remains closed.

— IMPORTANT —

During the pressure decrease mode, most systems replenish the brake fluid in the affected hydraulic channel.

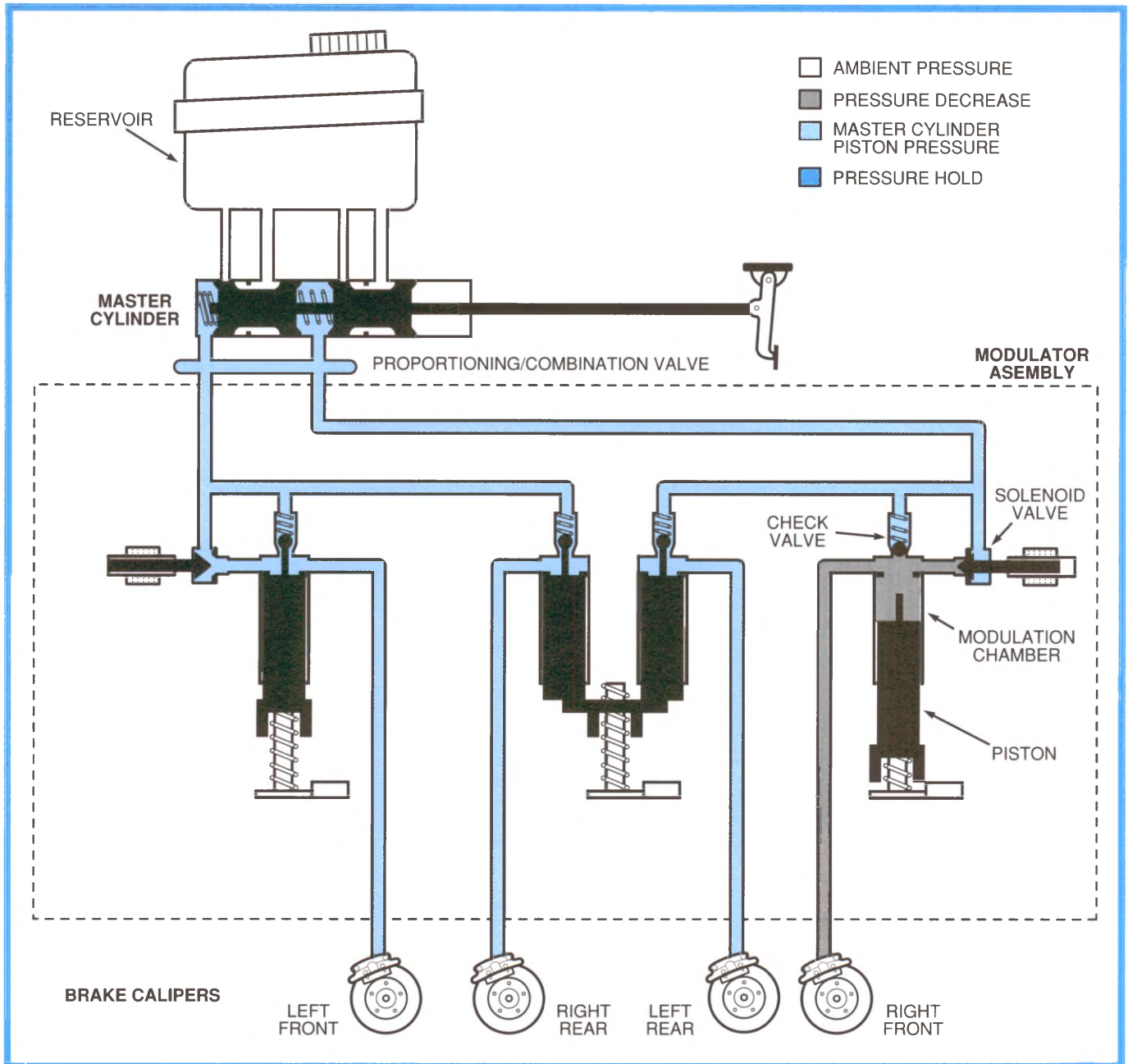


Figure 3-24, Delphi Chassis VI ABS – Pressure Decrease Mode (Right Front)

3. Operation

Pressure Increase

The EBCM selects pressure increase when:

- There is a signal from the brake switch
- Wheel speed sensors indicate deceleration is no longer excessive
- The EBCM successfully controlled wheel lockup with pressure hold and/or pressure decrease mode.

In pressure increase mode, the EBCM (Figure 3-25):

- Delphi Chassis VI moves the piston up to open the check valve. Master cylinder pressure once again applies the hydraulic circuit. Other systems reopen the inlet valve to the master cylinder.

metering - hold off
proportion - limits PSI on Rear. ^{from 250² to 150²}

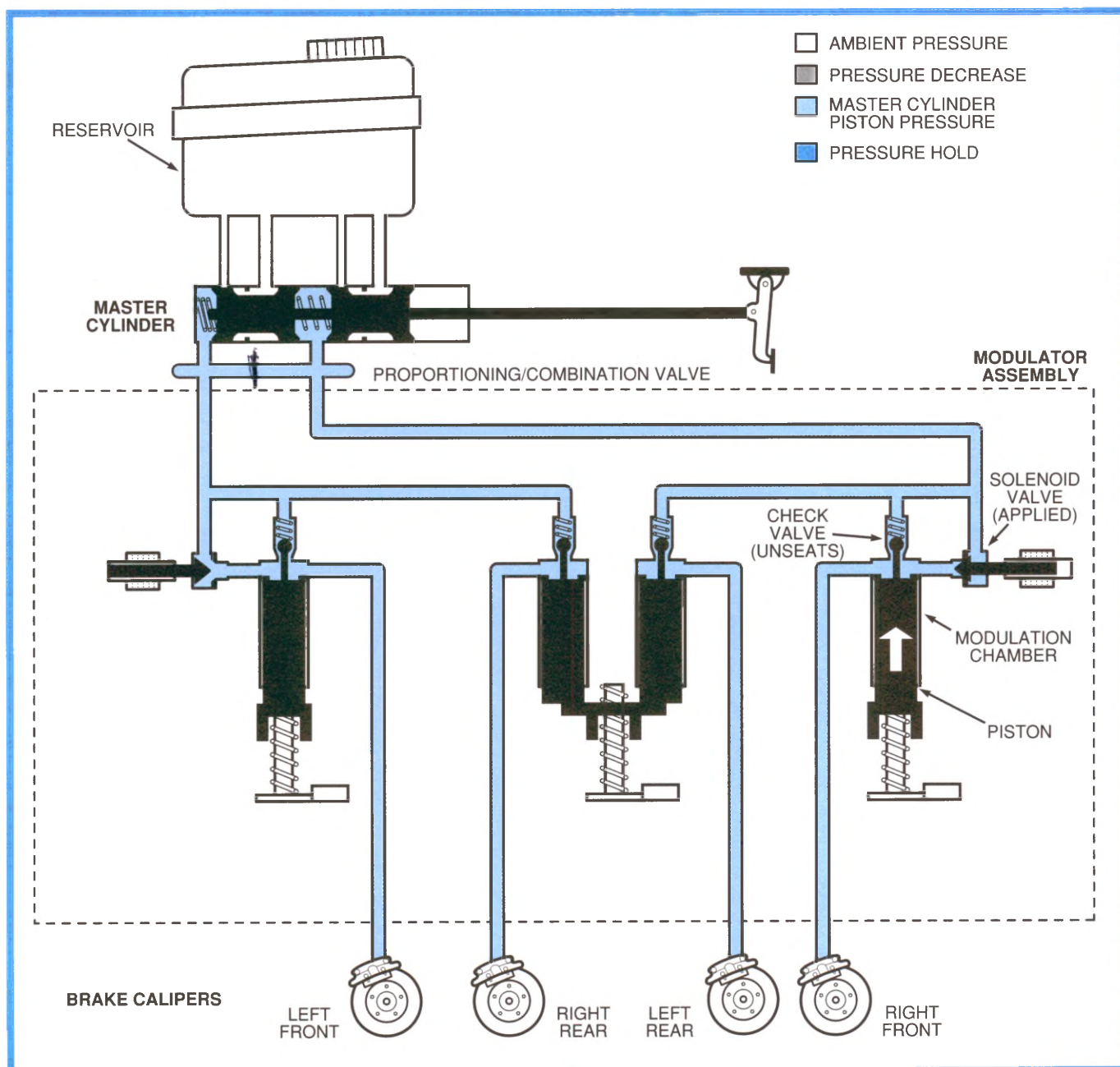


Figure 3-25, Delphi Chassis VI ABS – Pressure Increase Mode (Right Front)

3. Operation

Brake Pressure Modulators

The Electronic Brake Control Module (EBCM) operates solenoids that control hydraulic valves. The valves modulate brake pressure to the wheel circuits during antilock braking.

In many antilock brake systems, each hydraulic channel has an inlet and outlet passage operated by a valve. The two valves allow the EBCM to select from three modes.

	Inlet or Isolation	Outlet or Release
Pressure Increase	Open	Closed
Pressure Hold	Closed	Closed
Pressure Decrease	Closed	Open

Three Position Solenoid Valve

Bosch ABS installed in GM vehicles uses a single solenoid to operate a three position valve. The EBCM controls the position of the valve by varying the current applied to the solenoid.

A three-channel system has three valve solenoids, a separate valve for each hydraulic channel.

Systems using three position modulator valves are:

- Bosch 2U/2S (Figure 3-26)
- Bosch III (Figure 3-27)



Two Solenoids with Two Valves

In some systems, the EBCM controls separate solenoids for the inlet and outlet channels. A three-channel system has six valve solenoid valves.

Systems using two solenoids with two valves on each channel are:

- Delco Moraine III (Figure 3-28)
- Teves Mark II (Figure 3-30)
- Teves Mark IV (Figure 3-31)
- Kelsey-Hayes RWAL (Figure 3-32)
- Kelsey-Hayes ZPRWAL (Figure 3-33)
- Bosch 5 (Figure 3-35)
- Delco/Bosch 5 (Figure 3-36)
- Bosch 5.3 (Figure 3-37)

Pulse Width Modulated (PWM) Valve

In Kelsey-Hayes 4WAL models, a solenoid can also control a hydraulic valve position by varying the electrical pulse width (Figure 3-34). Their operation is similar to CCC carburetor solenoids and pulse-width modulated EGR controls.

PWM solenoids control the amount of pressurized brake fluid released from the brake calipers during antilock braking.



Piston Modulator

In Delphi Chassis VI models, a motor driven piston parallel with the hydraulic channel modulates brake pressure (Figure 3-29).

3. Operation

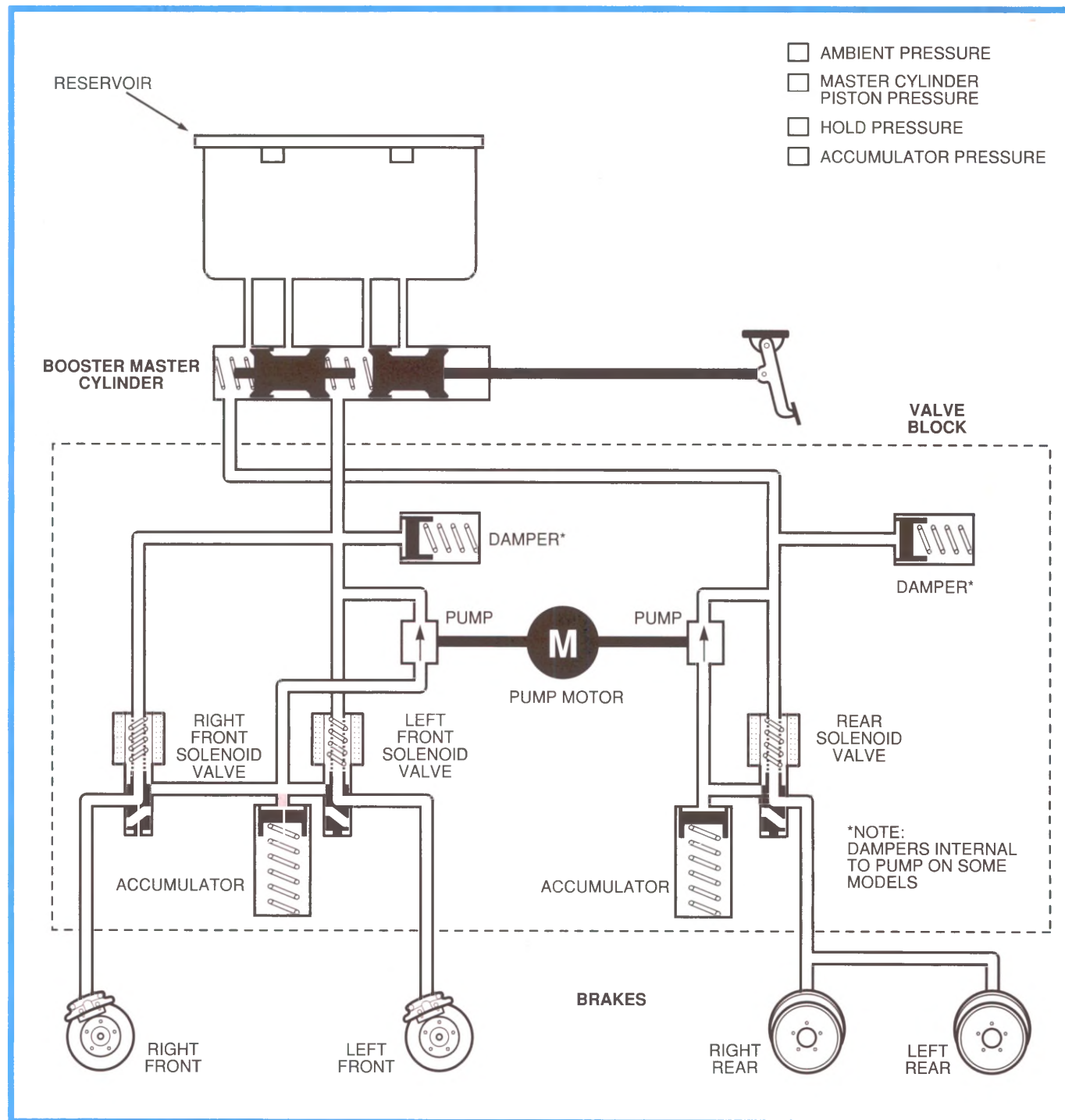


Figure 3-26, Bosch 2U/2S Hydraulic System (Three-Position Solenoid Valve)

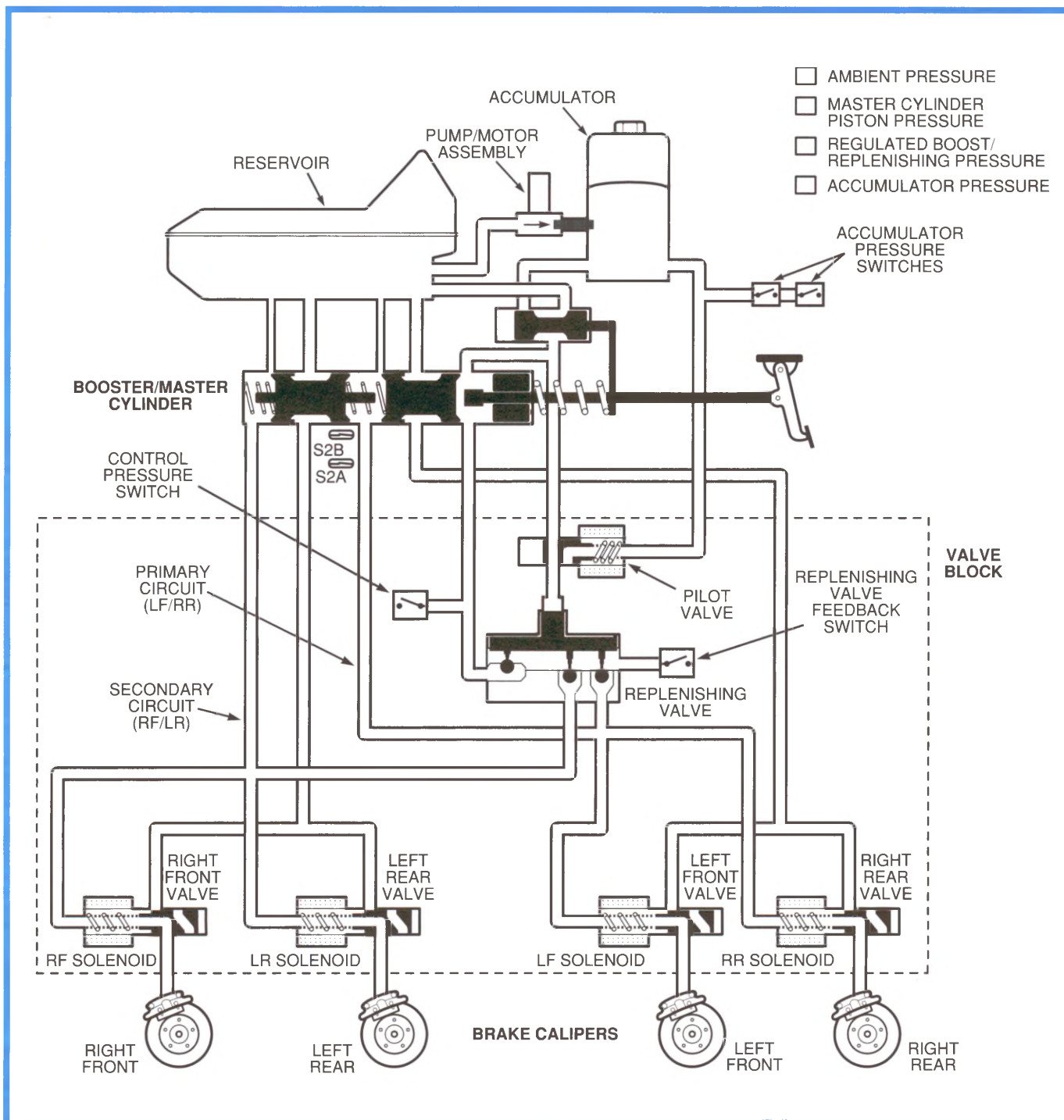


Figure 3-27, Bosch III Hydraulic System (Three-Position Solenoid Valve)

3. Operation

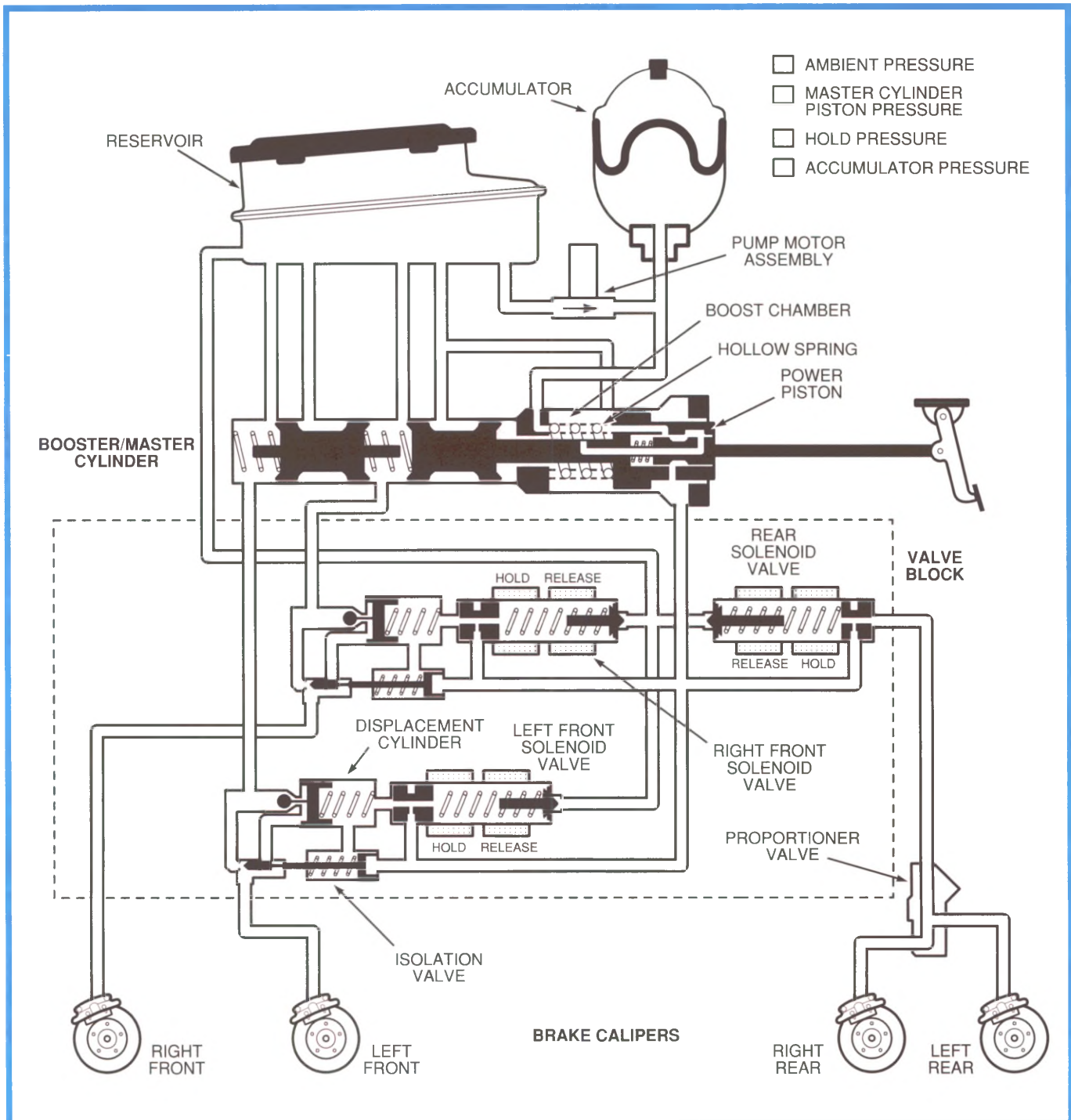


Figure 3-28, Delco Moraine III Hydraulic System (Two Solenoids/Two Valves per Channel)

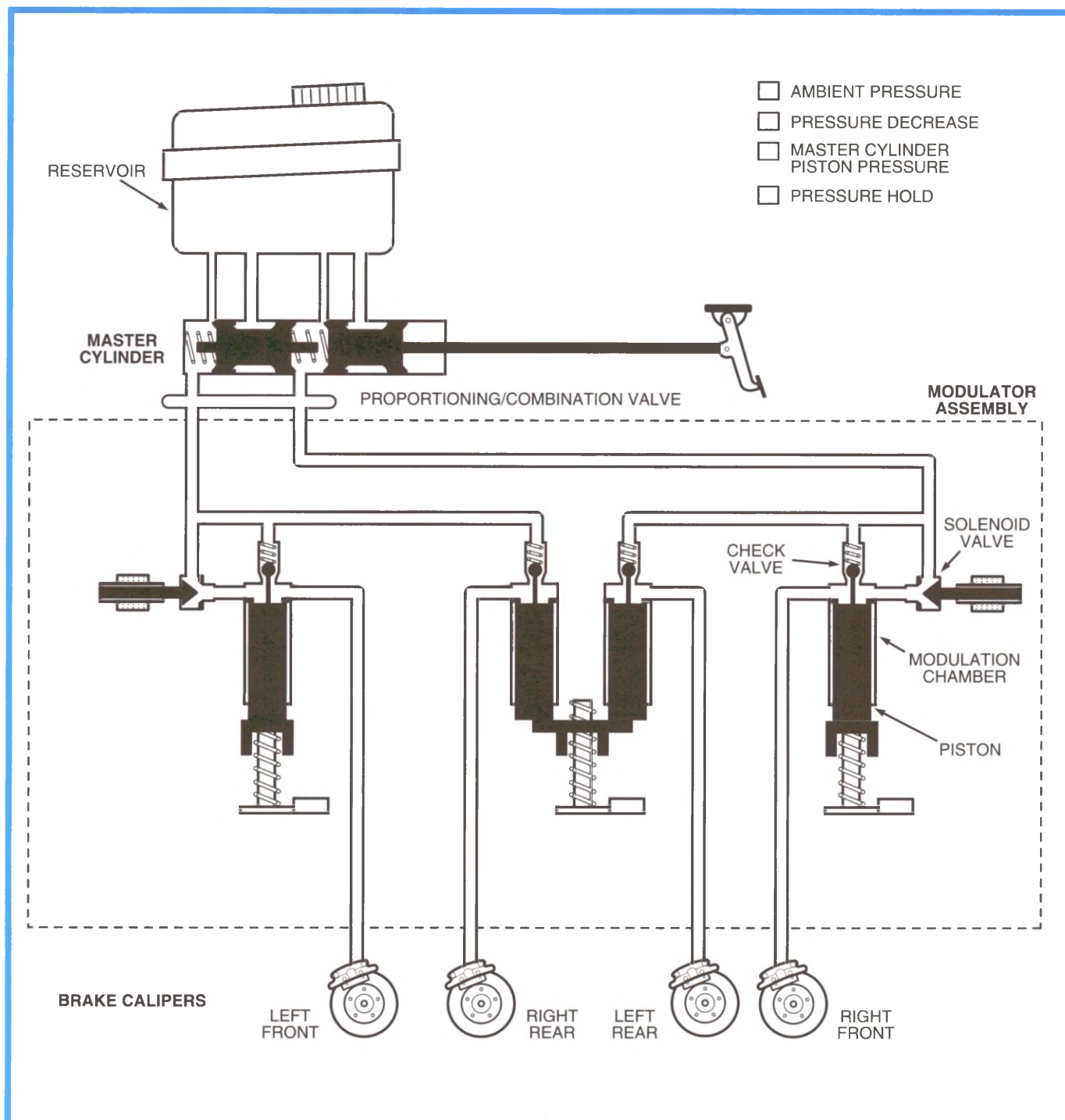


Figure 3-29, Delphi Chassis VI Hydraulic System (Piston Modulator)

3. Operation

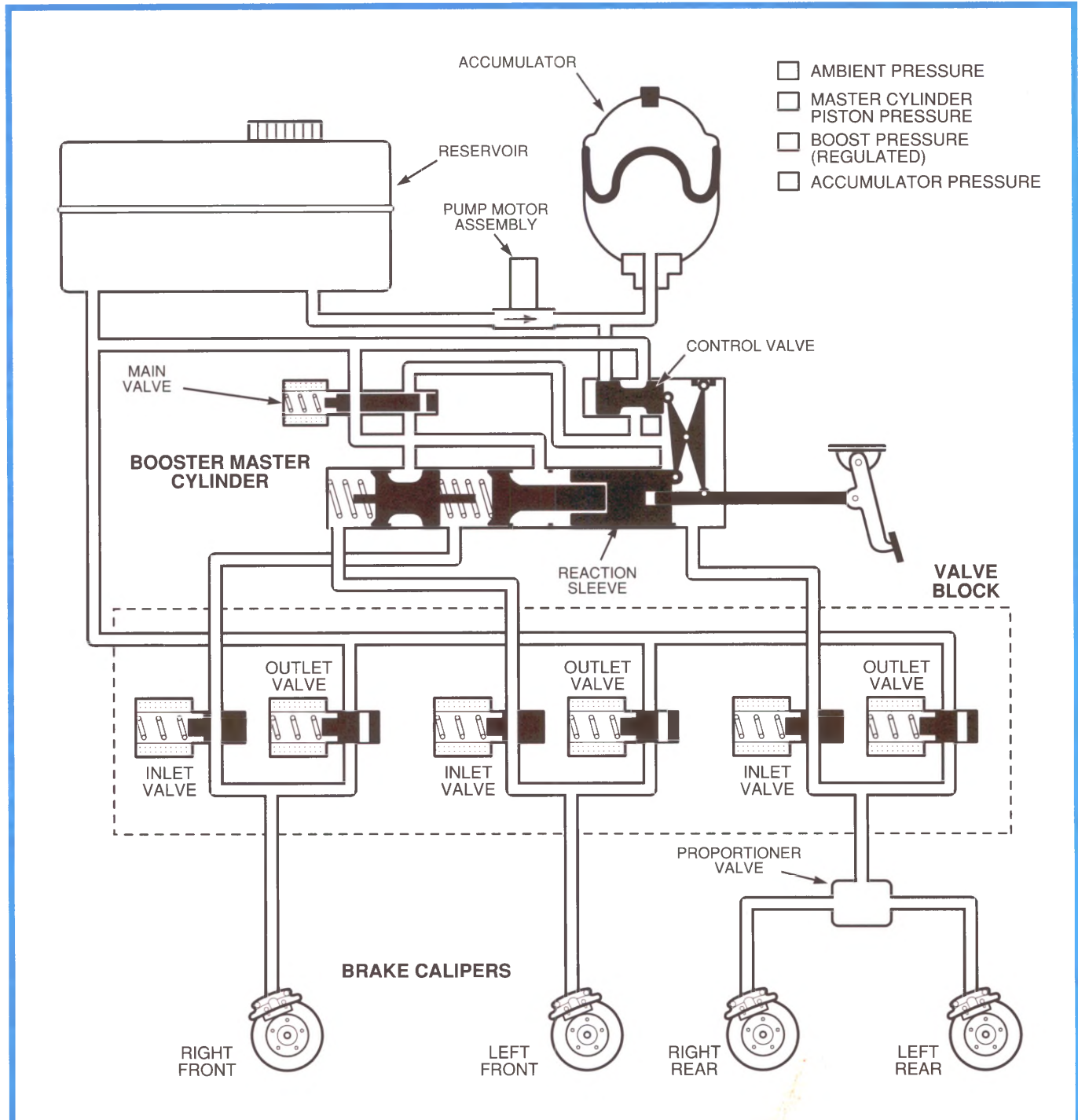


Figure 3-30, Teves Mark II Hydraulic System (Two Solenoids/Two Valves per Channel)

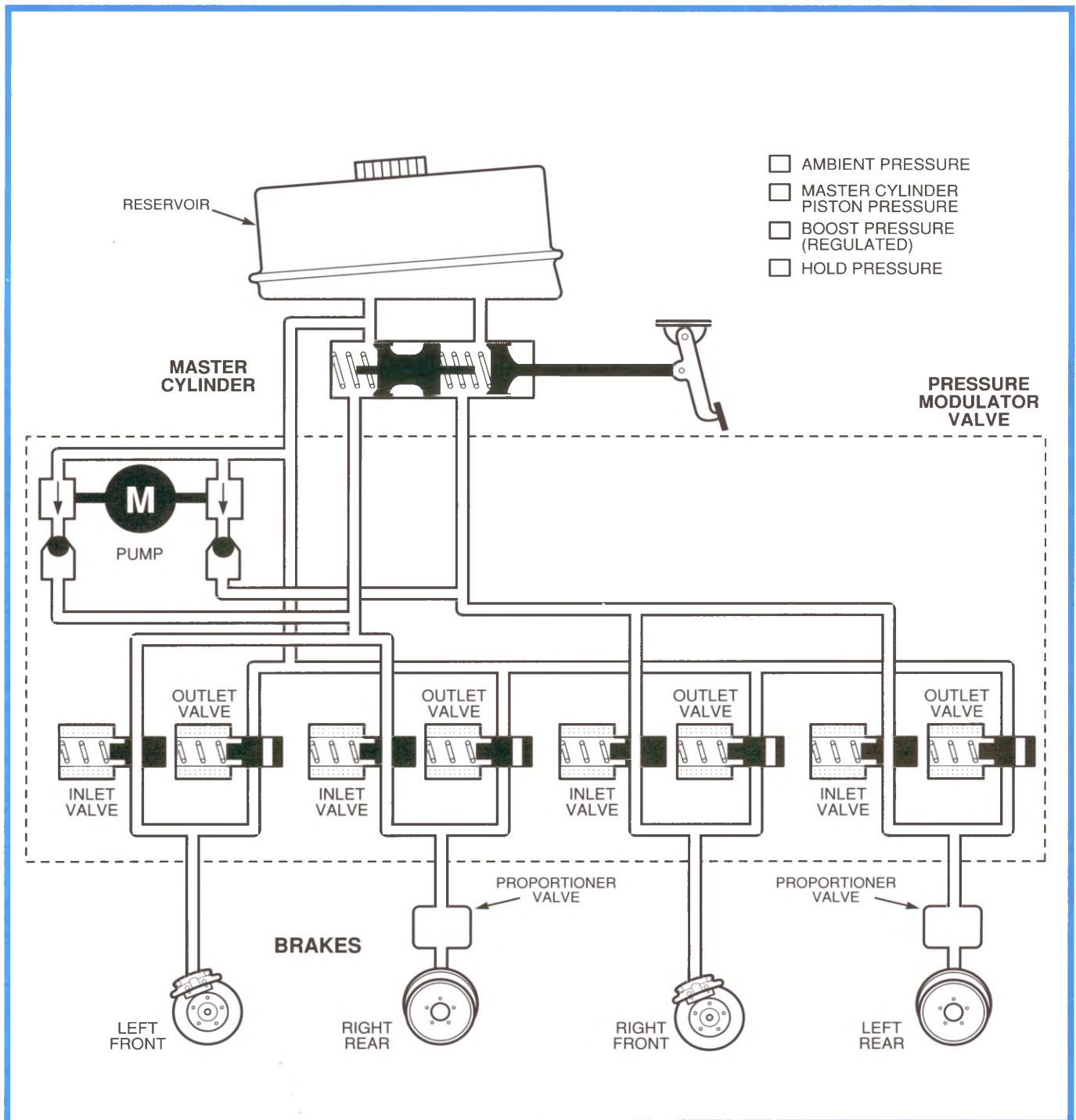
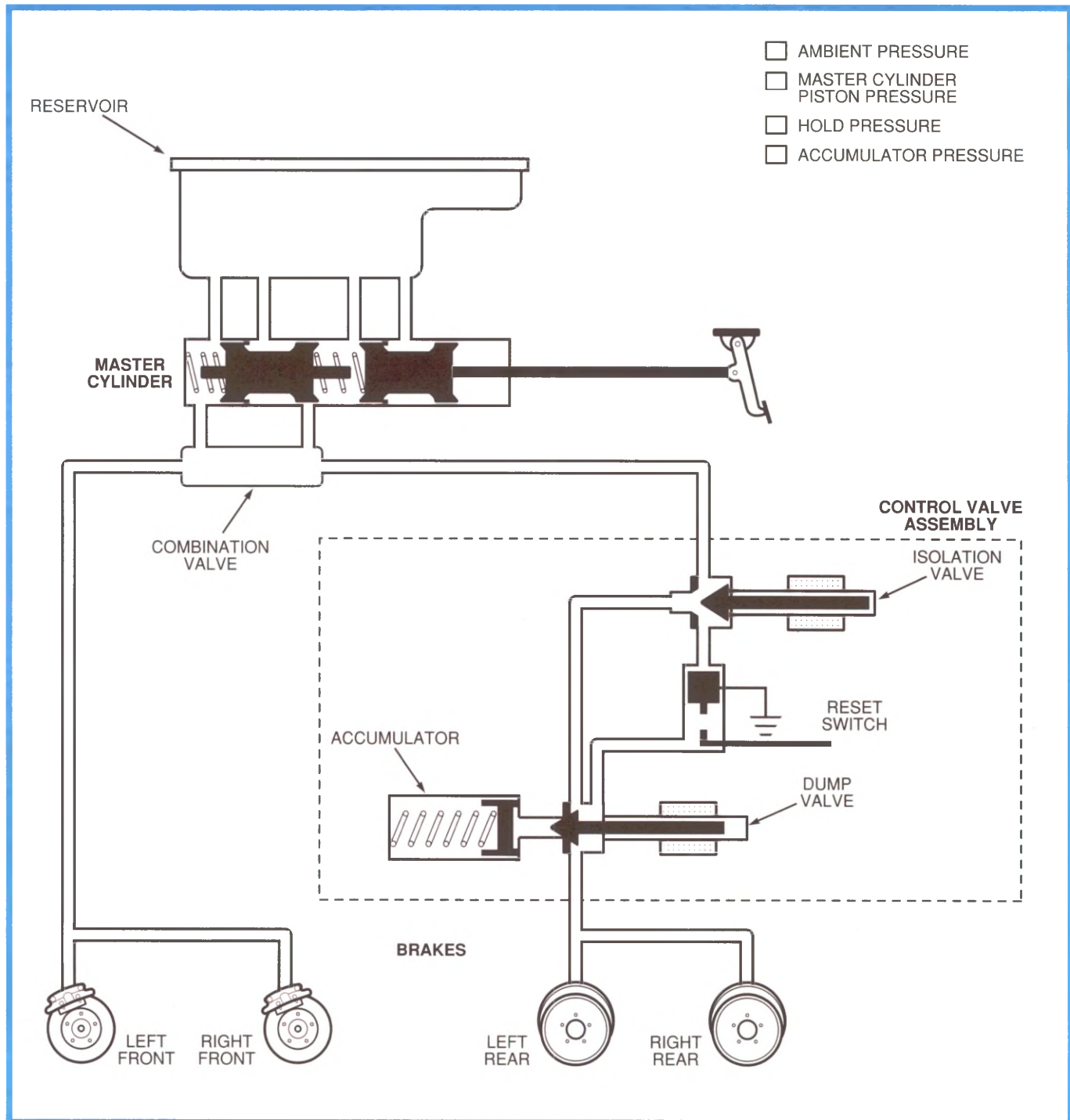


Figure 3-31, Teves Mark IV Hydraulic System (Two Solenoids/Two Valves per Channel)

3. Operation



**Figure 3-32, Kelsey-Hayes RWAL Hydraulic System
(Two Solenoids/Two Valves per Channel)**

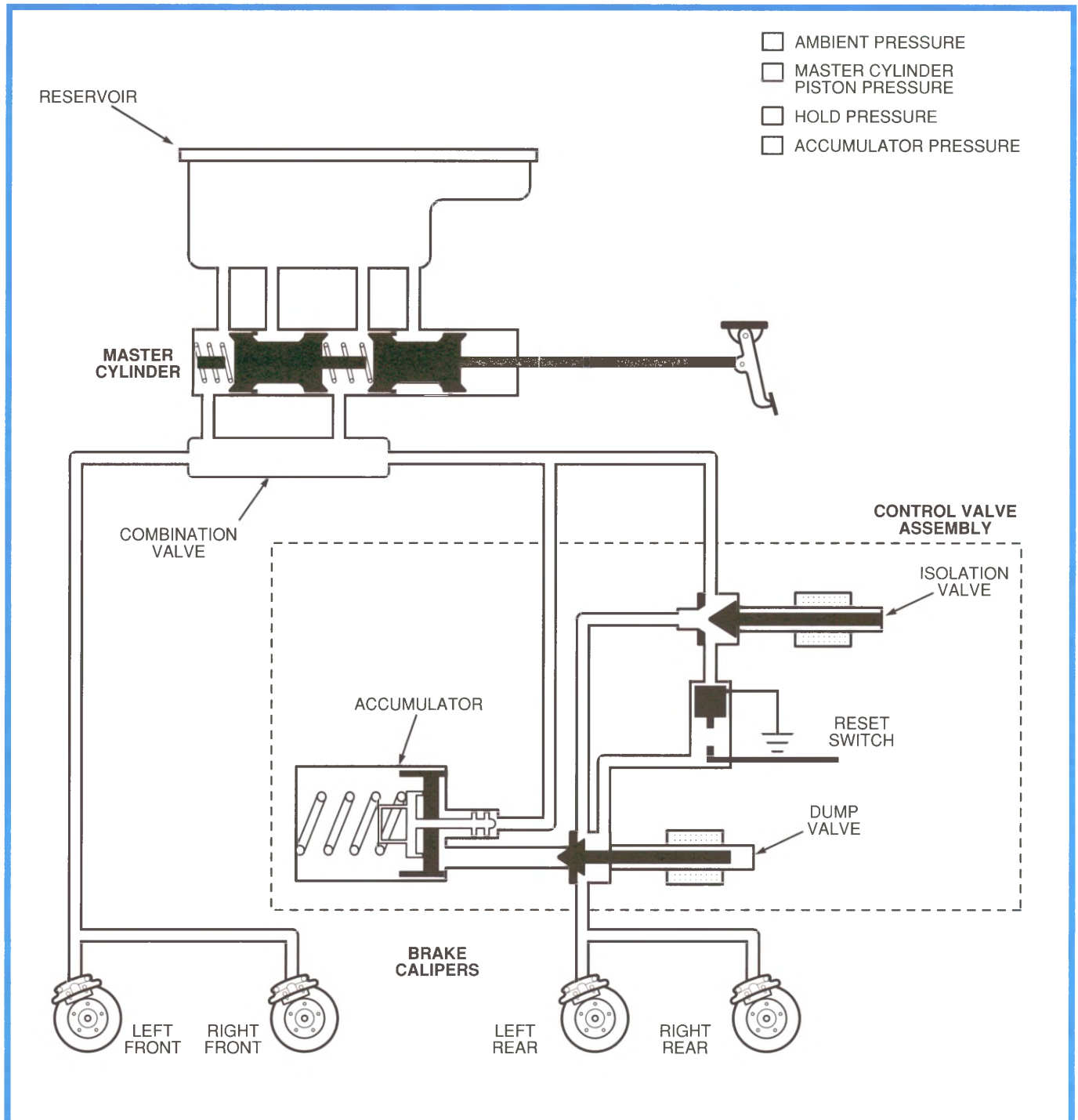


Figure 3-33, Kelsey-Hayes ZPRWAL Hydraulic System (Two Solenoids/Two Valves per Channel)

3. Operation

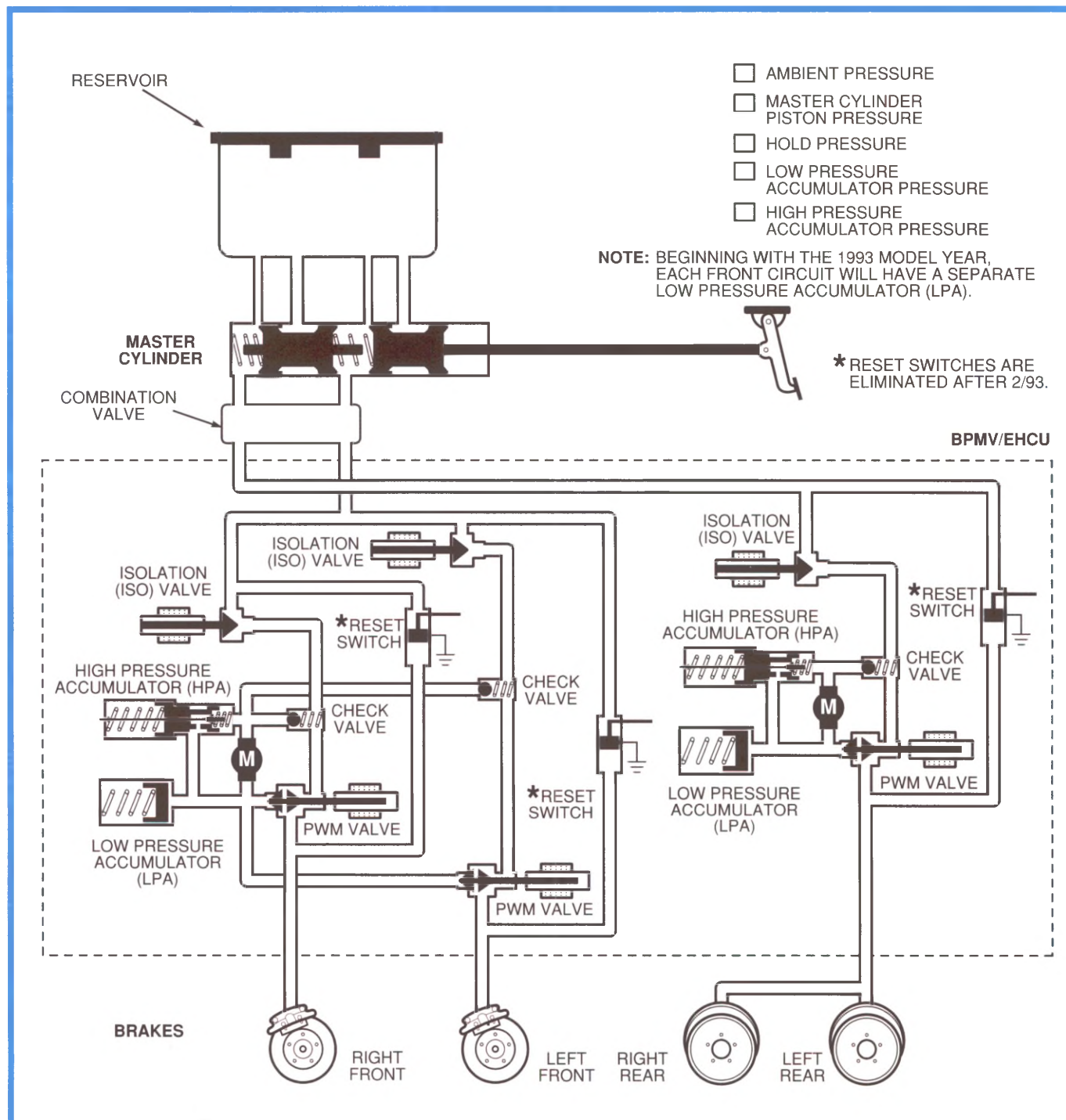


Figure 3-34, Kelsey-Hayes 4WAL Hydraulic System (Pulse Width Modulator Valve)

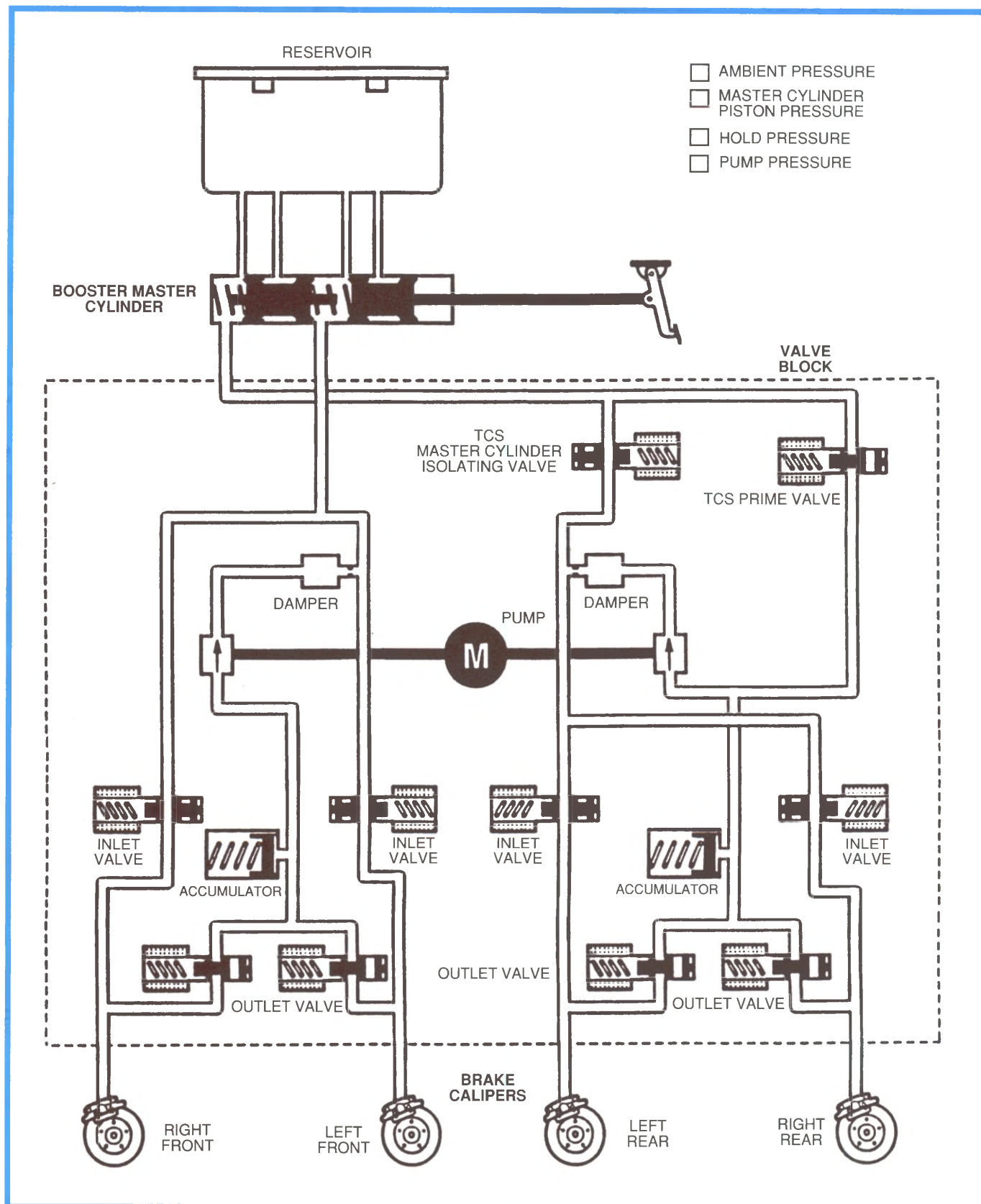


Figure 3-35, Bosch 5 Hydraulic System (Two Solenoids/Two Valves per Channel)

3. Operation

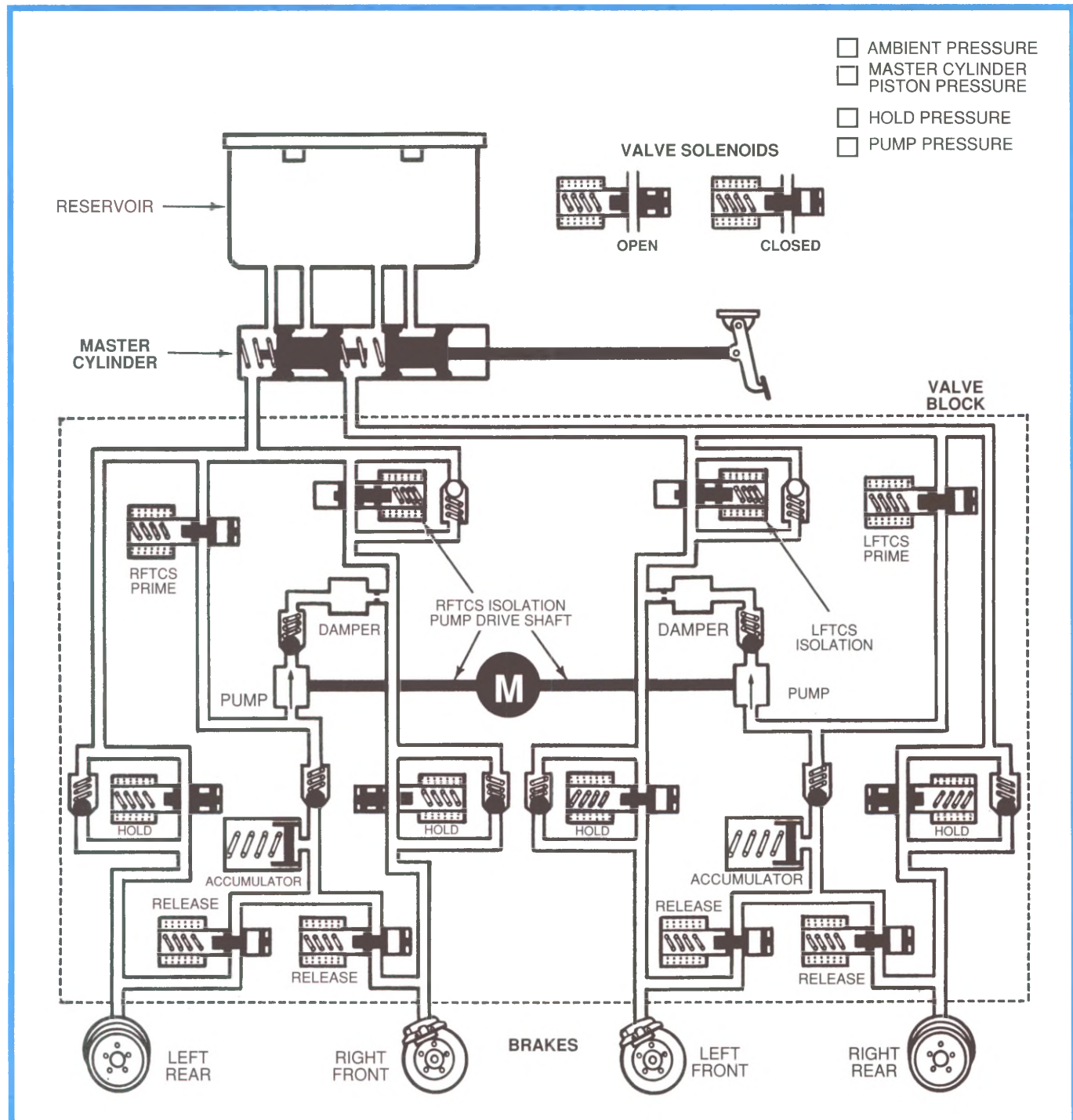


Figure 3-36, Delco/Bosch 5 Hydraulic System (Two Solenoids/Two Valves per Channel)

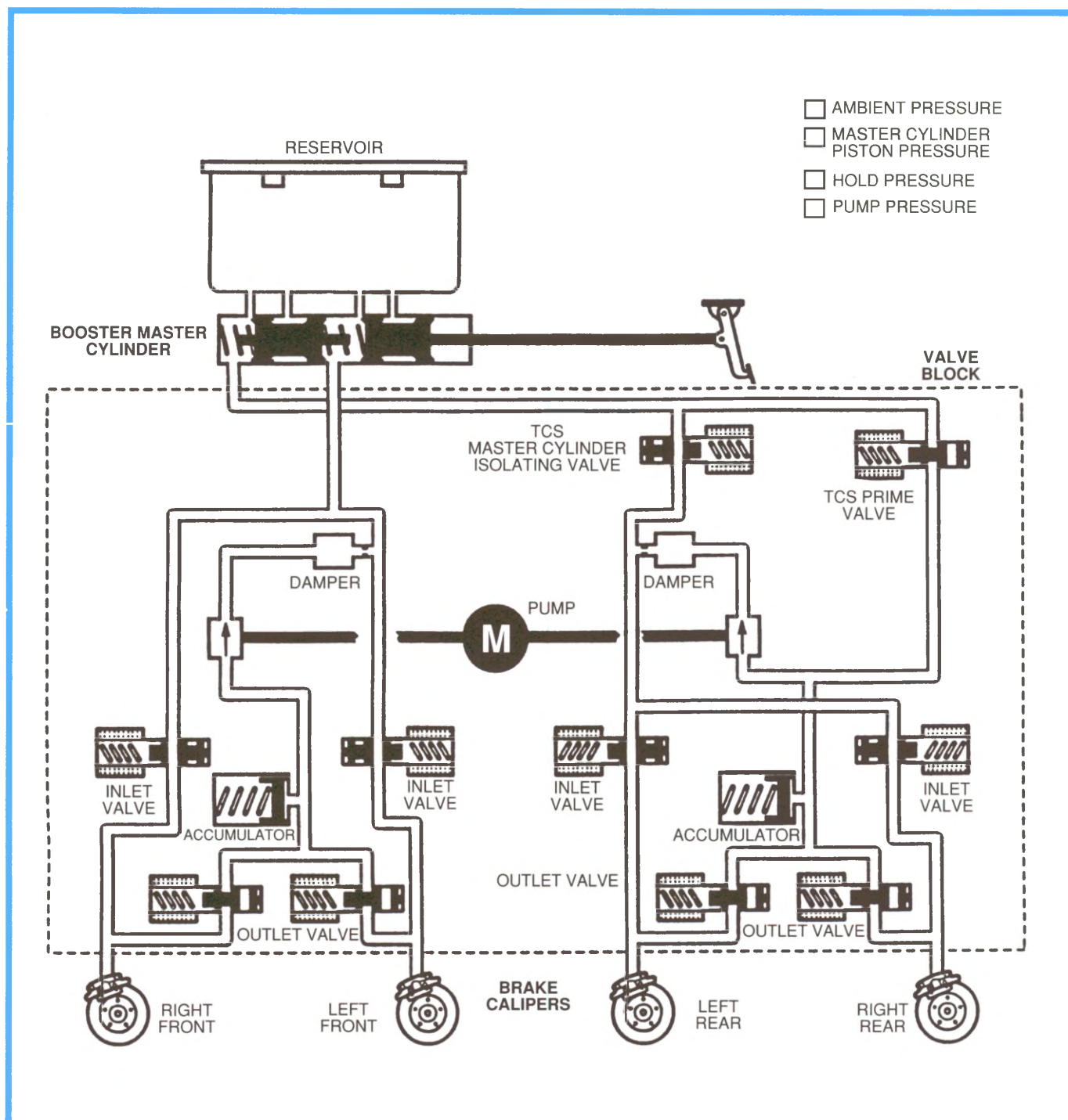


Figure 3-37, Bosch 5.3 Hydraulic System (Two Solenoids/Two Valves per Channel)

3. Operation

Advanced ABS Functions

ABS monitors wheel speed and prevents wheel slip on deceleration. Systems that control traction use the same sensors, hydraulic valves and control modules to control wheel slip during acceleration.

During acceleration, wheels slip when engine power is greater than the traction between the tire and the road surface. Traction control systems provide:

- Reduced wheel slip during acceleration
- Enhanced directional control during acceleration on normal or low-traction road surfaces
- Improved straight-line and cornering maneuverability on most road surfaces

When traction control systems detect wheel slip during acceleration, the EBCM may control wheel slip in any of several ways:

- Signal the engine control module to limit engine torque through spark or fuel control
- Reduce throttle opening to limit engine output
- Apply brake pressure to the slipping drive wheels

Traction Control Systems

Bosch III TCS

Beginning in 1990, Traction Control System (TCS) was made available on Cadillac Allanté, the first application on a front-wheel drive vehicle. TCS is added to the Bosch III antilock brake system. TCS limits wheel slip during acceleration (Figure 3-38)

The Electronic Brake Control Module (EBCM) monitors all four wheel speed sensors. If the EBCM determines the front (driven) wheels are accelerating too rapidly:

1. The EBCM signals the engine control module (via the body computer module) to reduce engine torque by shutting down one to four fuel injectors.
2. If the wheels continue to slip, the EBCM:
 - Opens the appropriate brake circuit hydraulic valve
 - Activates the TCS plunger to apply brake pressure to the appropriate wheel circuit(s).

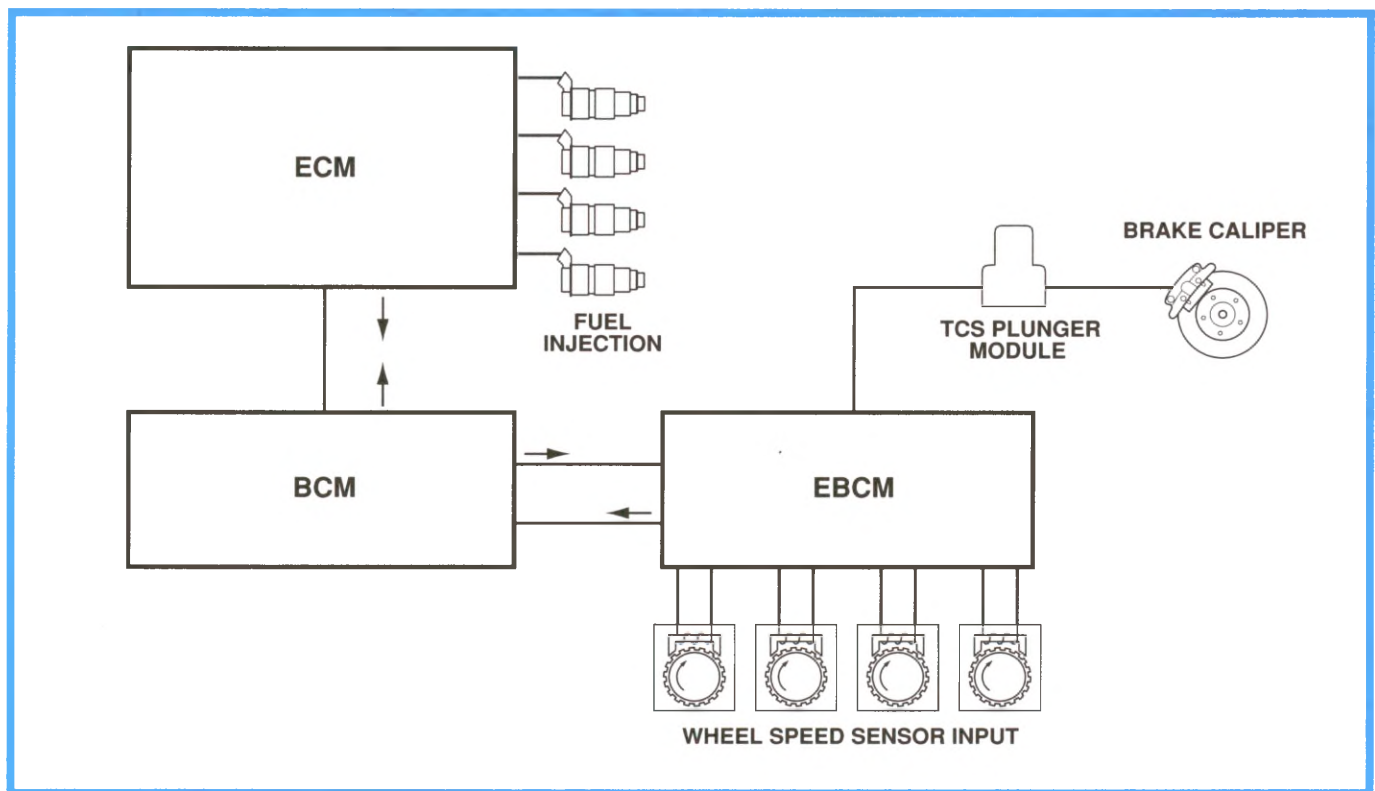


Figure 3-38, Typical TCS Controls (Bosch III)

3. Operation

Teves Mark IV TCS

TCS capabilities were also added to Teves Mark IV ABS in 1992. When Teves Mark IV determines the front wheels are accelerating too rapidly:

1. The EBCM isolates the front wheel hydraulic circuits from the master cylinder and rear circuits.
2. The EBCM energizes the hydraulic pump
3. The EBCM controls the inlet and outlet valve, allowing pump pressure to apply the brakes and slow the front wheels until the wheel slip stops.

Teves Mark IV ABS controls the brakes only. Engine torque management is not used on early models.

Bosch 2U/2S Acceleration Slip Regulation

Corvette models since 1992 have acceleration slip regulation (ASR) as a standard part of the Bosch 2U/2S antilock brake system (Figure 3-39).

ASR uses two inputs:

- During acceleration, wheel speed sensors indicate wheel slip.
- During cornering, the lateral acceleration sensor measures cornering force.

When wheel slip due to acceleration or cornering becomes excessive, the ASR module can control any (or all) of three outputs.

1. The EBCM signals the engine control module (ECM) to reduce engine torque by retarding timing.
2. If the wheels continue to slip, the EBCM reduces the throttle valve opening, reducing engine power.
3. Depending on the amount of wheel slip, the EBCM can also:
 - Activate the hydraulic pump
 - Open the appropriate hydraulic valve
 - Apply brake pressure to the wheels.

Engine torque control is the fastest, most efficient way to reduce excessive wheel slip.

The above systems are used to illustrate the different approaches to traction control system operation. In addition to these systems, traction control is also available on certain vehicles equipped with the following Antilock Brake Systems:

- Delphi Chassis VI
- Bosch 5
- Delco/Bosch 5
- Bosch 5.3

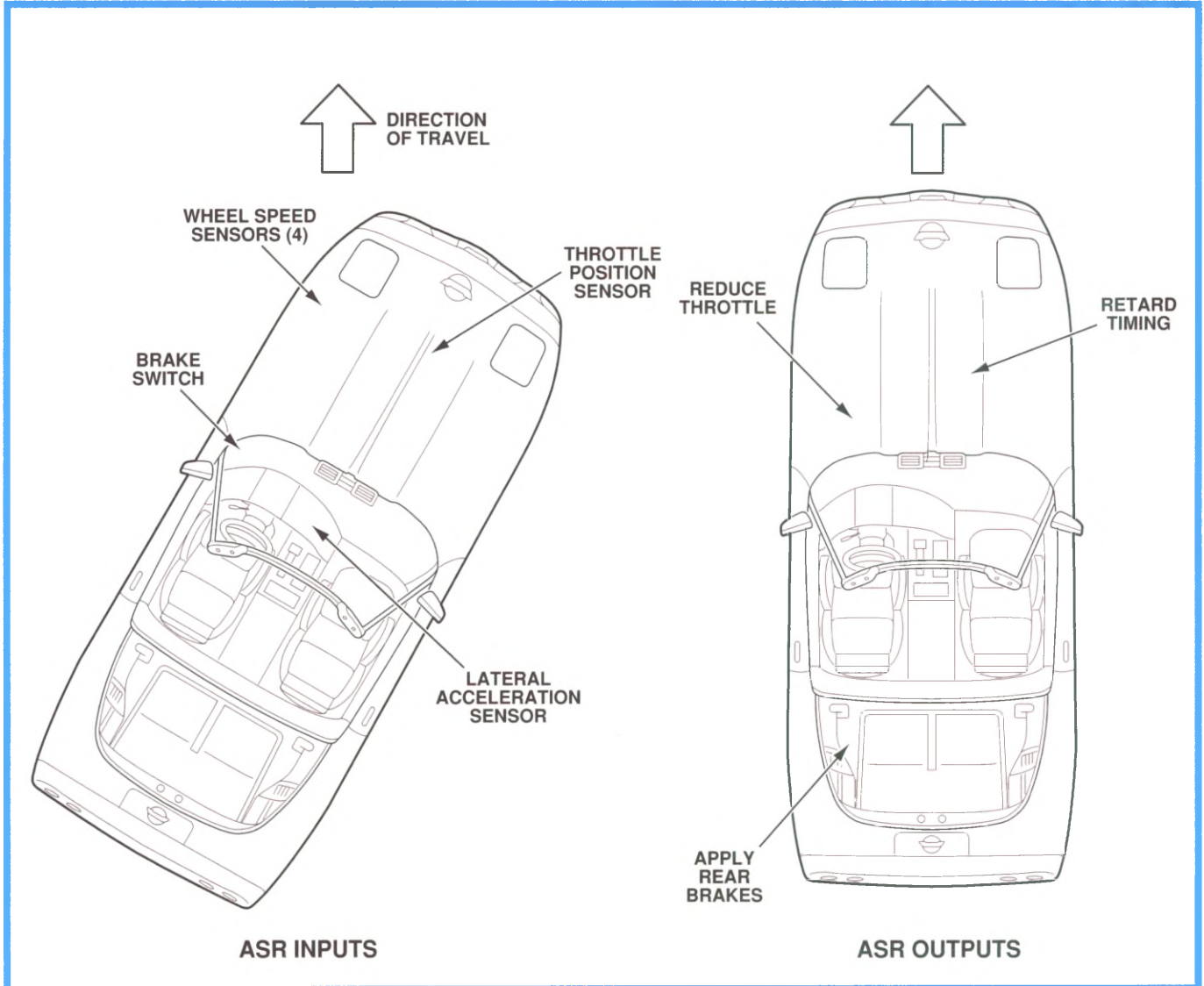


Figure 3-39, Acceleration Slip Regulation

3. Operation

Notes

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4. Diagnostics

Introduction to Diagnostics

This section provides a comprehensive overview of diagnostic techniques you can use to pinpoint ABS/TCS malfunctions. Refer to vehicle Service Manual for specific diagnostic information.

- Section 5E1 – covers ABS only, and includes DTCs.
- Section 5E2 – covers ABS/TCS, and includes DTCs.
- Section 8A-44 includes ABS and TCS electrical schematic diagrams.

Other parts of the Service Manual contain related information and should not be overlooked:

- Section 5, brakes, general
- Section 5A, master cylinder
- Section 5B, brake calipers
- Section 5C, drum brakes
- 5D1, brake booster assembly

In Service Manuals that are in the Electronic Service Information (ESI) format, all ABS information is located in Section 5.

4. Diagnostics

Strategy Based Diagnostics

As a retail service technician, you are part of the General Motors service team. The team goal is **FIX IT RIGHT THE FIRST TIME** for the satisfaction of every customer. You are a very important member of the team as you diagnose and repair customer vehicles.

You have maximum efficiency in diagnosis when you have an effective, organized plan for your work. The Strategy Based Diagnostics (SBD) flow chart, shown in Figure 4-1, provides you with guidance as you create and follow a plan of action for each specific diagnostic situation.

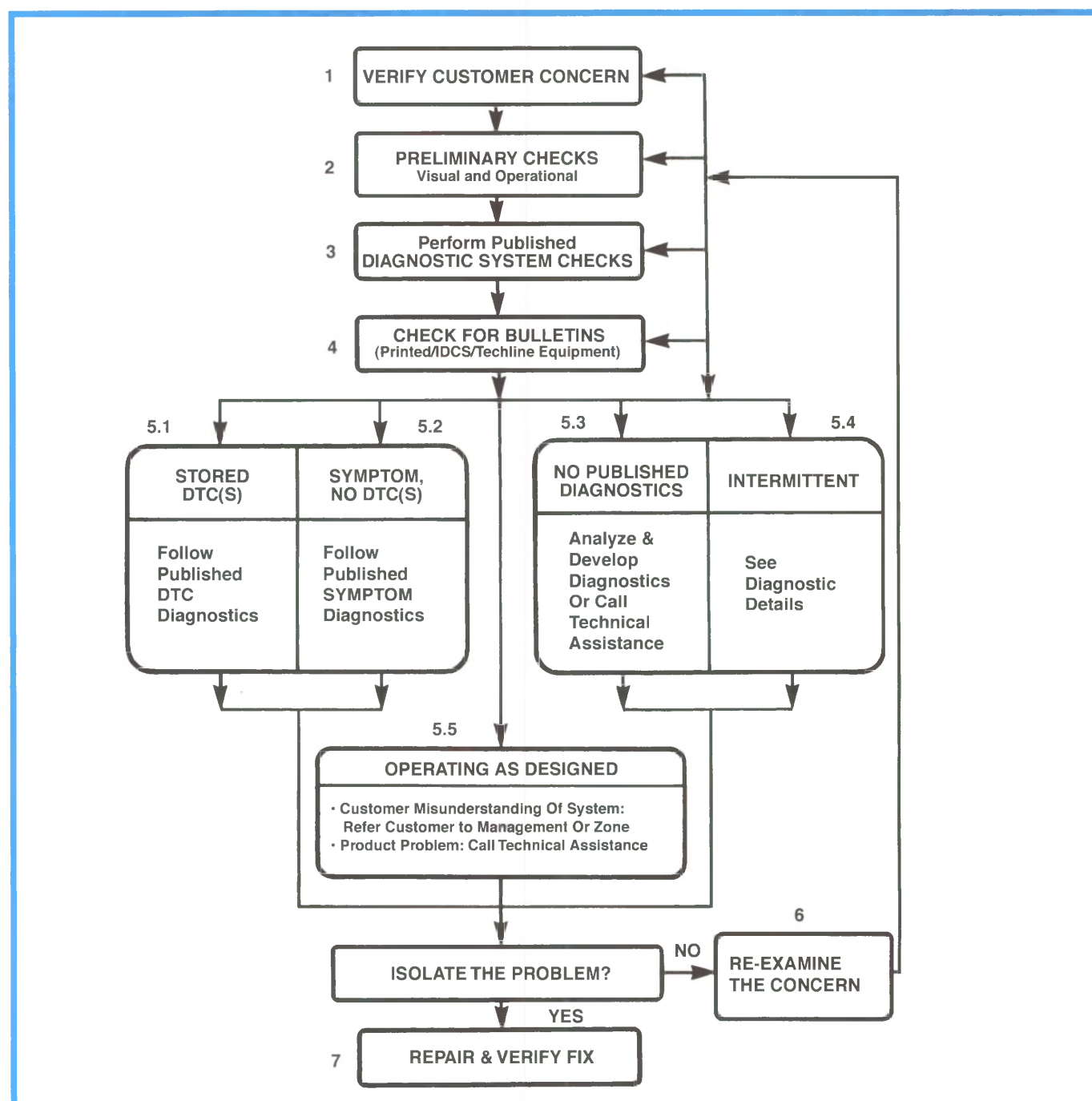


Figure 4-1, Strategy Based Diagnostics (SBD) Flow Chart

Strategy Based Diagnostics is an organized approach to vehicle diagnostics which seeks to optimize your ability to Fix-It-Right-The-First-Time. This approach consists of three parts:

1. The Diagnostic Thought Process (Problem Solving)
2. The Diagnostic Flow Chart (The Diagnostic Details)
3. The Knowledge and Experience of the Technician

The Diagnostic Thought Process (Problem Solving) consists of a pattern of thinking and evaluating data (leading to a powerful process of elimination) that allows you to make decisions based, in part, on looking for GOOD parts/systems as well as searching for the BAD parts/systems.

The Diagnostic Flow Chart (Diagnostic Details) provides a logical and systematic method of gathering and analyzing diagnostic data. When used in conjunction with the Diagnostic Thought Process, the result is a system that optimizes your ability to diagnose and fix vehicles right the first time.

Your knowledge and skills are the most important component of Strategy Based Diagnosis. The Strategy Based Diagnostics chart and the Diagnostic Thought Process are simply systems to optimize the abilities of the technician.

It is important to note that the order in which the steps are conducted will vary depending on the experience of the technician with the system.

4. Diagnostics

1 — Verify The Customer Concern

What you should do

To verify the customer concern, you need to know the correct (normal) operating behavior of the system and verify that the customer complaint is a valid failure of the system.

The following information will help you to verify the customer concern:

- WHAT the vehicle model/options are
- WHAT aftermarket and dealer-installed accessories exist
- WHAT related system(s) operate properly
- WHEN the problem occurs
- WHERE the problem occurs
- HOW the problem occurs
- HOW LONG the condition has existed (and if the system ever worked correctly)
- HOW OFTEN the problem occurs
- Whether the severity of the problem has increased, decreased or stayed the same

What resources you should use

Whenever possible, you should use the following resources to assist you in verifying the customer concern:

- Service Manual Theory or Circuit Description sections
- Service Manual “System Performance Check”
- Owner Manual operational description
- Technician experience
- Identical vehicle for comparison
- Circuit testing tools
- Vehicle road tests
- Concern check sheet
- Contact with the customer



2 — Perform Preliminary Checks

– IMPORTANT –

An estimated 10 percent of successful vehicle repairs are diagnosed with Preliminary Checks.

What you should do

You perform preliminary checks for several reasons:

- To detect if the cause of the complaint is VISUALLY OBVIOUS
- To identify parts of the system that work correctly
- To see if the concern is easily identified by a troubleshooting hint

The initial checks may vary depending on the complexity of the system and may include the following actions:

- Operate the suspect system
- Make a visual inspection of harness routing and accessible/visible power and ground circuits
- Check for blown fuses
- Make a visual inspection for separated connectors
- Make a visual inspection of connectors (includes checking terminals for damage and tightness)
- Sense unusual noises, smells, vibrations or movements
- Investigate the vehicle service history (call other dealerships, if appropriate)



What resources you should use

Whenever appropriate, you should use the following resources for assistance in performing preliminary checks:

- Service Manual information:
 - Component locations
 - Harness routing
 - Wiring schematics
 - Procedures for viewing DTCs
 - Troubleshooting hints
- Dealership service history file
- Vehicle road test
- Identical vehicle or system for comparison

4. Diagnostics

3 — Perform Published Diagnostic System Checks

What you should do

The “System Checks” in most Service Manual Sections and in most cells of section 8A (electrical) provide you with:

- A systematic approach to narrowing down the possible causes of a system fault
- Direction to specific diagnostic procedures in the Service Manual
- Assistance to identify what systems work correctly
- Access to Diagnostic Trouble Codes (DTCs) stored by vehicle computers

What resources you should use

Whenever possible, you should use the following resources to perform Service Manual checks:

- Service Manual
- Techline equipment (for viewing DTCs and analyzing data)
- Digital multimeter and circuit testing tools
- Other tools as needed

4 — Check For Bulletins

– IMPORTANT –

An estimated 30 percent of successful vehicle repairs are diagnosed using Service Bulletins.

What you should do

You should have enough information gained from preliminary checks to accurately search for a bulletin and other related service information.

What resources you should use

You should use the following resources for assistance in checking for bulletins:

- Printed bulletins
- Techline equipment to search for bulletins
- Divisional technical information (not Technical Assistance):
 - Newsletters
 - Service Guild letters
- Videotapes
- Pulsat programs

4. Diagnostics

5.1 — Diagnostic Procedures For DTCs

5.2 — Diagnostic Procedures For Symptoms With No DTCs

– IMPORTANT –

An estimated 40 percent of successful vehicle repairs are diagnosed using the Service Manual.

What you should do

When directed by Service Manual diagnostic checks, you must then carefully and accurately perform the steps of diagnostic procedures to locate the fault related to the customer concern.

What resources you should use

Whenever appropriate, you should use the following resources to perform Service Manual diagnostic procedures:

- Service Manual
- Techline equipment (for analyzing diagnostic data)
- Digital multimeter and circuit testing tools
- Essential and Special tools



5.3 — No Published Diagnostics

When there is no DTC stored and no matching symptom for the condition identified in the Service Manual, you must begin with a thorough understanding of how the system(s) operates. Efficient use of the Service Manual combined with your experience and a good process of elimination will result in accurate diagnosis of the condition.

What you should do

Step 1: Identify and understand the suspect circuit(s)

Having completed steps 1 through 4 of the Strategy Based Diagnostics chart, you should have enough information to identify the system(s) or sub-system(s) involved. Using the Service Manual, you should determine and investigate the following circuit characteristics:

- Electrical:
 - How is the circuit powered (power distribution charts and/or fuse block details)?
 - How is the circuit grounded (ground distribution charts)?
 - How is the circuit controlled or sensed (theory of operation):
 - If it is a switched circuit, is it normally open or normally closed?
 - Is the power switched or is the ground switched?
 - Is it a variable resistance circuit (ECT sensor or TP sensor, for example)?
 - Is it a signal generating device (MAF sensor or VSS, for example)?
 - Does it rely on some mechanical/vacuum device to operate?
- Physical:
 - Where are the circuit components (component locators and wire harness routing diagrams):
 - Are there areas where wires could be chafed or pinched (brackets or frames)?
 - Are there areas subjected to extreme temperatures?
 - Are there areas subjected to vibration or movement (engine, transmission or suspension)?
 - Are there areas exposed to moisture, road salt or other corrosives (battery acid, oil or other fluids)?
 - Are there common mounting areas with other systems/components?
 - Have previous repairs been performed to wiring, connectors, components or mounting areas (causing pinched wires between panels and drivetrain or suspension components without causing an immediate problem)?
 - Does the vehicle have aftermarket or dealer-installed equipment (radios, telephones, etc.)

4. Diagnostics

Step 2: Isolate the Problem

At this point, you should have a good idea of what could cause the present condition, as well as what could not cause the condition. Actions to take include the following:

- Divide (and separate, where possible) the system or circuit into smaller sections
- Confine the problem to a smaller area of the vehicle (start with main harness connections while removing panels and trim as necessary in order to eliminate large vehicle sections from further investigation)
- For two or more circuits that do not share a common power or ground, concentrate on areas where harnesses are routed together or connectors are shared (refer to the following hints)

Hints

Though the symptoms may vary, basic electrical failures are generally caused by:

- Loose connections:
 - Open/high resistance in terminals, splices, connectors or grounds
- Incorrect connector/harness routing (usually in new vehicles):
 - Open/high resistance in terminals, splices, connectors or grounds
- Corrosion and wire damage:
 - Open/high resistance in terminals, splices, connectors or grounds
- Component failure:
 - Opens/shorts and high resistance in relays, modules, switches or loads
- Aftermarket equipment affecting normal operation of other systems

You may isolate circuits by:

- Unplugging connectors or removing a fuse to separate one part of the circuit from another part
- Operating shared circuits and eliminating those that function normally from the suspect circuit
- If only one component fails to operate, begin testing at the component
- If a number of components do not operate, begin tests at the area of commonality (such as power sources, ground circuits, switches or major connectors)

What resources you should use

Whenever appropriate, you should use the following resources to assist in the diagnostic process:

- Service Manual
- Techline equipment (for data analysis)
- Experience
- Technical Assistance
- Circuit testing tools



5.4 — Intermittent Diagnosis

By definition, an intermittent problem is one that does not occur continuously and will occur when certain conditions are met. All these conditions, however, may not be obvious or currently known. Generally, intermittents are caused by:

- Faulty electrical connections and wiring
- Malfunctioning components (such as sticking relays, solenoids, etc.)
- EMI/RFI (Electromagnetic/radio frequency interference)
- Aftermarket equipment
- Water intrusion

Intermittent diagnosis requires careful analysis of suspected systems to help prevent replacing good parts. This may involve using creativity and ingenuity to interpret customer concerns and simulating all external and internal system conditions to duplicate the problem.

What you should do

Step 1: Acquire Information

A thorough and comprehensive **customer check sheet** is critical to intermittent problem diagnosis. You should require this, since it will dictate the diagnostic starting point. The **vehicle service history** file is another source for accumulating information about the concern.



Step 2: Analyze the Intermittent Problem

Analyze the customer check sheet and vehicle service history file to determine conditions relevant to the suspect system(s). Using Service Manual information, you must identify, trace and locate all electrical circuits related to the malfunctioning system(s). If there is more than one system failure, you should identify, trace and locate areas of commonality shared by the suspect circuits. Shared circuits are shown on power distribution, fuse block details and light switch details in the Service Manual.

Step 3: Simulate the Symptom and Isolate the Problem

Simulate the symptom and isolate the system by reproducing all possible conditions suggested in Step 1 while monitoring suspected circuits/components/systems to isolate the problem symptom. Begin with the most logical circuit/component.

Isolate the circuit by dividing the suspect system into simpler circuits. Next, confine the problem into a smaller area of the system. Begin at the most logical point (or point of easiest access) and thoroughly check the isolated circuit for the fault, using basic circuit tests.

4. Diagnostics

Hints

You can isolate a circuit by:

- Unplugging connectors or removing a fuse to separate one part of the circuit from another
- If only one component fails to operate, begin testing the component
- If a number of components do not operate, begin tests at areas of commonality (such as power sources, ground circuits, switches, main connectors or major components)
- Substitute a known good part from the parts department or the vehicle system
- Try the suspect part in a known good vehicle

See **Symptom Simulation Tests** on the next page for problem simulation procedures. Refer to Service Manual sections 6E and 8A for information about intermittent diagnosis. Follow procedures for basic circuit testing in Service Manual section 8A.

What resources you should use

Whenever appropriate, you should use the following resources to assist in the diagnostic process:

- Service Manual
- Bulletins
- Digital multimeter (with a MIN/MAX feature)
- TECH 1 or TECH 2 and a printer
- Techline equipment
- Circuit testing tools (including connector kits/harnesses and jumper wires)
- Terminal repair kit
- Experience
- Intermittent problem solving simulation methods
- Customer concern check sheet



Symptom Simulation Tests

1. Vibration

This method is useful when the customer concern analysis indicates that the problem occurs when the vehicle/system undergoes some form of vibration.

For connectors and wire harness, slightly shake vertically and horizontally. Inspect the connector joint and body for damage. Also, tapping lightly along a suspected circuit may be helpful.

For parts and sensors, apply slight vibration to the part with a light tap of the finger while monitoring the system for a malfunction.

2. Heat

This method is important when the concern suggests that the problem occurs in a heated environment. Apply moderate heat to the component with a hair drier or similar tool while monitoring the system for a malfunction.

– CAUTION –
CARE MUST BE TAKEN TO AVOID OVERHEATING THE COMPONENT.
DAMAGE MAY RESULT.



3. Water and Moisture

This method may be used when the concern suggests that the malfunction occurs on a rainy day or under conditions of high humidity. In this case, apply water in a light spray on the vehicle to duplicate the problem.

– CAUTION –
CARE MUST BE TAKEN TO AVOID DIRECTLY EXPOSING ELECTRICAL CONNECTIONS
TO WATER. SHORT CIRCUITS AND CORROSION MAY RESULT.

4. Electrical Loads

This method involves turning systems ON (such as the blower, lights or rear window defogger) to create a load on the vehicle electrical system at the same time you are monitoring the suspect circuit/component.

4. Diagnostics

5.5 — Operating as Designed

This condition refers to instances where a system operating as designed is perceived to be unsatisfactory or undesirable. In general, this is due to:

- A lack of understanding by the customer
- A conflict between customer expectations and vehicle design intent
- A system performance that is unacceptable to the customer

What you should do

You can verify that a system is operating as designed by:

- Reviewing Service Manual functional/diagnostic checks
- Examining bulletins and other service information for supplementary information
- Compare system operation to an identical vehicle

If the condition is due to a customer misunderstanding or a conflict between customer expectation and system operation, you should explain the system operation to the customer.

If the concern is due to a case of unsatisfactory system performance, you should contact Technical Assistance for the latest information.

What resources you should use

Whenever possible, you should use the following resources to facilitate the diagnostic process:

- Vehicle service information (Service Manual, newsletters, etc.)
- Technical Assistance
- Experience
- Identical vehicle or system for comparison



6 — Re-Examine The Concern

When you do not successfully find/isolate the problem after executing a diagnostic path, you should re-examine the customer concern.

What you should do

In this case, you will need to backtrack and review information accumulated from steps 1 through 4 of Strategy Based Diagnostics. You also should repeat any procedures that require additional attention.

A previous path may be eliminated from consideration only if you are certain that all steps were executed as directed. You must then select another diagnostic path (step 5.1, 5.2, 5.3 or 5.4). If all possible options have been explored, you may call Technical Assistance or seek field service assistance.

What resources you should use

Whenever possible, you should use the following resources to facilitate the diagnostic process:

- Service Manual
- Accumulated information from a previous diagnostic path
- Service information and publications
- Technical Assistance

4. Diagnostics

7 — Repair And Verify Fix

What you should do

After you have located the cause of the problem, you must execute a repair by following recommended Service Manual procedures.

When the repair is completed, you should verify the fix by performing the system checks under the conditions listed in the customer concern.

If applicable, you should carry out preventive measures to avoid a repeat concern.

What resources you should use

Whenever possible, you should use the following resources to facilitate the repair process:

- Electrical repair kits and procedures
- Service Manual information and publications
- Videotapes of repair procedures



Diagnostic Hints


ABS/TCS Operation Observations

Before examining the various controlling and operational circuits of ABS/TCS, you should understand the system from the driver's perspective. The following ABS/TCS characteristics should be considered part of normal operation.

- Upon start-up, all brake/ABS/TCS indicator lamps should turn "ON" as part of the instrumentation bulb self-test procedure. The lamps should then turn "OFF" after a few seconds.
- During an ABS stop, there may be minor fluctuations in brake pedal feel as the valves regulate hydraulic pressure. This is known as "pedal feedback" and is normal.
- Audible clicks or pump motor operation from the modulator assembly should also be considered normal. At approximately three to 10 miles per hour (approx. 3-10 mph) after each engine start-up, the auto test cycles all ABS/TCS motors and solenoids to verify operation.
- The driver may feel accelerator pedal movement as the adjuster assembly works during a TCS throttle close down event.

Intermittent Conditions

Most intermittent conditions are caused by problems with electrical connections or wiring. Check circuits for:

- 
- Poor mating of connector halves
 - Terminals backed out
 - Improperly formed or damaged terminals
 - Poor terminal-to-wire connections
 - Worn or damaged wire insulation
 - Wheel speed sensor cables not attached to retainers or improperly routed
 - EMI/RFI (Electromagnetic interference/radio frequency interference)

Intermittent Service Indicator Lamps

Intermittent "SERVICE ABS" or "SERVICE TCS" indicator lamp operation may indicate low system voltage. These lamps remain lit (and ABS/TCS is disabled) as long as system voltage is low.

4. Diagnostics

Diagnostic Trouble Codes

Most EBCMs generate diagnostic trouble codes when a failure in the antilock brake system occurs. Each code refers to a "diagnostic trouble tree" in the service manual. Follow the trouble tree carefully to diagnose the cause of the diagnostic trouble codes.

Diagnostic trouble codes indicate a problem with a circuit, not necessarily a component, and the type of failure. Do not replace components based only on codes without following the diagnostic trouble tree.

— IMPORTANT —

Depending on the system, one or more codes may be stored at one time.

— IMPORTANT —

Some systems do not store diagnostic trouble codes once the key is shut off. When a malfunction occurs that causes a diagnostic trouble code, the RBWL lights. Do not turn the key "OFF." Turning the key "OFF" will erase the trouble code and may require another test drive to set the code again.

Displaying Diagnostic Trouble Codes

There are three ways to display diagnostic trouble codes:

- Blink the code on the amber ABS warning lamp
- Communicate code information to a bi-directional scan tool
- Display the code on the driver information center (DIC)

Depending on the system being tested, the EBCM may provide any combination of display methods. Refer to the chart on page 3-17 for specific applications.

Repair, Verify, and Retest

Servicing the ABS/TCS should always include a final test drive to verify all repairs and adjustments. Make sure all lamps indicate normal operation. If you find any ABS or TCS diagnostic trouble codes during the diagnostic procedure, verify that the codes do not reappear after the test drive.

Vehicle Test Drive

— CAUTION —

BEFORE TEST DRIVING THE VEHICLE ON THE ROAD, CHECK THE BRAKES AT LOW SPEED IN AN OPEN AREA. MAKE SURE THE VEHICLE STOPS PROPERLY. IF THE RBWL IS "ON," THERE MAY BE REDUCED BRAKING CAPABILITY.

Some ABS/TCS conditions require a test drive because several diagnostic trouble codes will not set unless the vehicle is moving. The test drive will hopefully duplicate the condition experienced by the customer and reset the diagnostic trouble code.

Key Turned to "RUN"

Normal Operation

The first indication of correct operation comes when the key is turned to "RUN."

1. Release parking brake
2. Turn key to "RUN" (do not start)
 - Amber ABS warning lamp on instrument panel "ON" for a few seconds then turns "OFF"
 - Red BRAKE warning lamp on instrument panel "ON" for a few seconds then turns "OFF"
3. Verify proper brake pedal feel
4. Proceed with test drive

4. Diagnostics

Non-ABS Braking

Test drive the vehicle up to 25 mph in a safe place. Operate the brakes (non-ABS braking). Determine if the base brake system is operating properly. Test drive as you would for brake concerns on a non-antilock brake system.

- Verify braking distance, quiet, smooth operation, etc. Brakes should not drag, pull or slip.

Ensure proper brake hydraulic and mechanical operation. Diagnose and repair any abnormalities before testing ABS.

Normal Operation

- Warning lamp should remain "OFF"

Abnormal Operation

If a warning lamp remains "ON":

- EBCM has detected a failure in the ABS

If the red "BRAKE" warning lamp remains "ON":

- Parking brake not released
- Low brake fluid level
- There is a base brake fault, which may reduce braking performance

ABS Braking

Test for proper operation under ABS braking. In a safe area from at least 25 mph, press firmly and steadily on the brake pedal to induce an ABS stop.

Normal Operation

- Brake pedal may pulsate slightly
- Depending on the tire condition and road surface, there may be intermittent tire chirp
- Motor noise coming from the engine compartment

If OK, the antilock brake system is operating properly, preventing unwanted wheel lockup and lamps will remain "OFF."

Abnormal Operation

If one or more wheels slip:

- ABS not controlling brakes because of faulty sensor or control solenoid circuits

TCS Operation

In a safe, open area, on a surface with poor traction, accelerate rapidly to initiate TCS operation.

Normal Operation

The following conditions indicate normal TCS operation:

- TCS indicator lamp turns "ON" (on some models)
- Audible noise from the engine compartment may occur as brake intervention takes place
- Slight accelerator pedal movement as the adjuster assembly closes down the throttle (F-body models only)

Abnormal Operation

The following conditions indicate a TCS malfunction:

- The service TCS indicator lamp turns "ON" (check for DTCs)
- The "BRAKE" light comes "ON"
- Excessive wheel slip while TCS is operational

4. Diagnostics

Notes

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There is no text or other markings on the paper.

5. Service and Diagnostic Tools

Special Tools

Depending on the antilock brake system, various tools required for service include (Figure 5-1):

- J 36210 ABS tester (Bosch)
- J 35890 ABS tester (Corvette)
- J 35604 pressure tester (adapter required)
- J 39700-25 pinout box adapter
- J 35592 break-out box
- 9400100-A TECH 1 diagnostic computer
- TECH 1 mass storage cartridge with chassis application
- TECH 2 scan tool
- J 39700 universal breakout box
- J 41247 valve pinout box

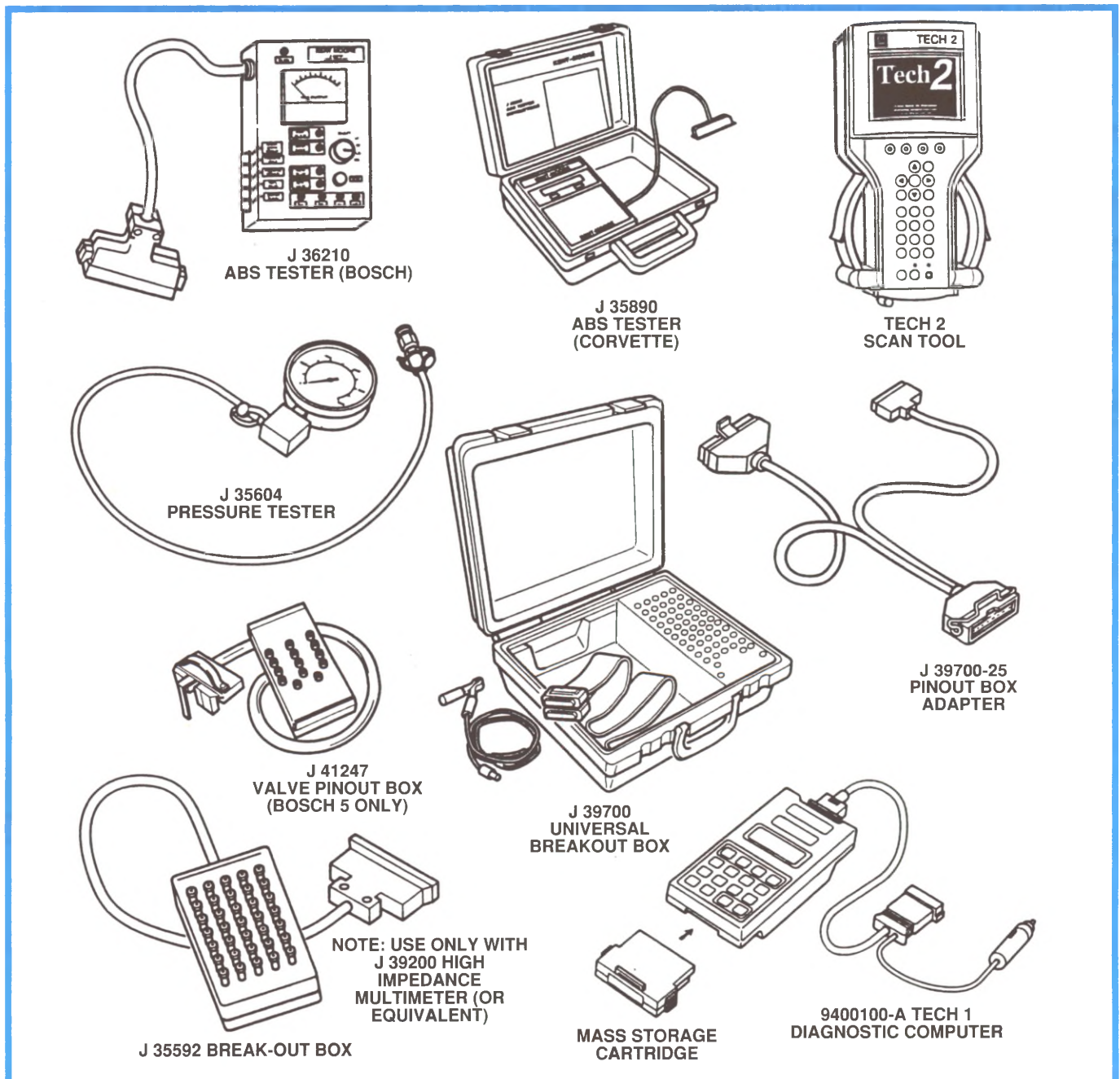


Figure 5-1, Diagnostic Tools

5. Service and Diagnostic Tools

TECH 1 Mass Storage Cartridge

Beginning with the 1993 model year, the TECH 1 mass storage cartridge (MSC) is the only cartridge that will be sent to GM dealers. The MSC replaces all previous TECH 1 cartridges, including:

- 81-93 Powertrain (replaces ECM and transmission cartridges)
- 88-93 Chassis (replaces Brake and RWAL/4WAL cartridges)
- 88-93 Body Systems (replaces 88-92 body cartridge)
- 90-93 Service Programming (replaces EEPROM data and EEPROM service)

Updates for the MSC will be shipped automatically through Techline CD-ROM and the Techline Diagnostic Terminal. A GM CPT video (56010.00) explains the mass storage cartridge as well as EEPROM programming of ECMs. Individual application cartridges will still be available. The MSC may be updated monthly via the Techline CD-ROM terminal.

TECH 2 Scan Tool

The TECH 2 is the bi-directional scan tool used on all current vehicles. It is important that the TECH 2 is updated on a monthly basis to ensure that the most current diagnostics are installed into the TECH 2. The TECH 2 is updated by connecting it to a Techline terminal and performing the Techline update procedure. A TECH 2 with "out-dated" software can cause mis-diagnosis.

Techline Diagnostic Terminal

Techline diagnostic terminals may be updated monthly via Techline CD-ROM terminal.

GENERAL MOTORS TRAINING MATERIALS

- Authentic GM Training Manuals & Instructor Materials
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