ASE 5 - Brakes

Module 10a
Delphi VI ABS/TCS
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Module 10a – Delphi VI ABS/TCS

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Objectives

At the conclusion of this course the technician will be able to:

Use a Tech 1 or Tech 2 to perform system diagnosis.

Describe the operation of:

- expansion spring brake (ESB)
- electromagnetic brake (EMB)
- torque management
  - spark retard
  - EGR operation
  - transmission upshift control
  - fuel cut-off
- brake intervention
- ABS/TCS operation

Locate and perform Service Information diagnostics and repair procedures

Perform preliminary inspection checks and look for:

- EMI/RFI
- visual inspection
- wire wiggle test

Describe the benefits of the system's enhanced diagnostics

Diagnose and repair system faults

Properly bleed the brake hydraulic system

Perform component service procedures on the:

- modulator assembly
- solenoids
- adjuster Assembly cable adjustments
- motor pack
- wheel speed sensors integral non-integral
- EBCM
A-5 Competencies for Delphi Chassis Series VI & DBC 7 ABS/TCS

A. Identify Components of Delphi ABS/TCS Systems
   1. Describe antilock brake control.
   2. Identify traction control.
   3. Describe steering control.
   4. Identify tire inflation monitoring system.

B. Operation of Delphi ABS/TCS Systems
   1. Explain anti-lock brake control functional system.
   2. Explain traction control functional operation.

C. Diagnostic Procedures for Delphi ABS/TCS
   1. Identify the correct diagnostic process for Delphi ABS/TCS.
   2. Describe the inputs to the Steering Control Function.
   3. Describe the outputs of the Steering Control Function.

NATEF Task List

V. BRAKES

G. Antilock Brake and Traction Control Systems
   1. Identify and inspect antilock brake system (ABS) components; determine necessary action.
   2. Diagnose poor stopping, wheel lock-up, abnormal pedal feel or pulsation, and noise concerns caused by the antilock brake system (ABS); determine necessary action.
   3. Diagnose antilock brake system (ABS) electronic control(s) and components using self-diagnosis and/or recommended test equipment; determine necessary action.
   4. Depressurize high-pressure components of the antilock brake system (ABS).
   5. Bleed the antilock brake system's (ABS) front and rear hydraulic circuits.
   6. Remove and install antilock brake system (ABS) electrical/electronic and hydraulic components.
   7. Test, diagnose and service ABS speed sensors, toothed ring (tone wheel), and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO) (includes output signal, resistance, shorts to voltage/ground, and frequency data).
8. Diagnose antilock brake system (ABS) braking concerns caused by vehicle modifications (tire size, curb height, final drive ratio, etc.).

9. Identify traction control system components.

**STC Tasks:**

GM-ASEP Embedded Competency List for Delphi Chassis Series VI & DBC 7 ABS/TCS

A-5

A. Identify Components Of Delphi ABS/TCS System

1. Describe antilock brake control.
2. Identify traction control.
3. Describe steering control.
4. Identify tire inflation monitoring system.

B. Operation Of Delphi ABS/TCS System

1. Explain anti-lock brake control functional system.
2. Explain traction control functional operation.

C. Diagnostic Procedures For Delphi ABS/TCS

1. Identify the correct diagnostic process for Delphi ABS/TCS
2. Describe the inputs to the Steering control Function.
3. Describe the outputs of the Steering control Function.
1. Introduction

Module Behavioral Objectives
At the conclusion of this chapter the student will be able to:

• Identify vehicle ABS/TCS model application.
• Describe ABS/TCS system operation.
• Describe benefits of ABS/TCS.
• Identify vehicle ABS/TCS components and variations.

STC Tasks: GM-ASEP Embedded courses and Competency lists
A-5 Competencies for Delphi Chassis Series VI & DBC 7 ABS/TCS
A. Identify Components Of Delphi ABS/TCS
   1. Describe antilock brake control

Performance Objectives:
Given a vehicle equipped with Delphi VI ABS/TCS, service information, the student will correctly identify and inspect antilock brake system (ABS) components; determine necessary action, according to manufacturer’s recommendations. (NATEF Task V. Brakes, G. Antilock Brake and Traction Control Systems, number 1)

Given a vehicle equipped with Delphi VI ABS/TCS, service information, the student will correctly identify traction control system components, according to manufacturer’s recommendations. (NATEF Task V. Brakes, G. Antilock Brake and Traction Control Systems, number 9)
Delphi Chassis VI ABS/TCS Introduction

There are two types of current Delphi Chassis VI systems: Delphi Chassis VI antilock brake system (ABS), and Delphi Chassis VI with ABS and traction control system (TCS).

General Motors introduced Delphi Chassis VI ABS in 1991 on N-body. In 1992 J, L, U and highline W-bodies were added to the list of General Motors vehicles incorporating this new system. Delphi Chassis VI with traction control (TCS) was first made available on 1993 1/2 U-van. In 1995 Delphi Chassis VI ABS/TCS was expanded to include F-body, as well as an enhanced traction system (ETS) on some 1995 J-body and 1996 N-body. Delphi Chassis VI ABS/TCS systems have several different configurations, all of which will be covered in this training course.

This handout covers Delphi Chassis VI ABS, as well as Delphi Chassis VI ABS/TCS systems.

<table>
<thead>
<tr>
<th>Delphi VI Model</th>
<th>Carline</th>
<th>First Model Year</th>
<th>ABS Design Features</th>
<th>Hydraulic Channels</th>
<th>Hydraulic Split</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS III</td>
<td>W</td>
<td>1988</td>
<td>Integral</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABS VI</td>
<td>N</td>
<td>1991</td>
<td>Integral</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>1992</td>
<td>Non-integral</td>
<td>3</td>
<td>Front/Rear</td>
</tr>
<tr>
<td></td>
<td>L</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>U-van</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>W</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Z (opt.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>1993</td>
<td></td>
<td>Front/Rear</td>
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<tr>
<td></td>
<td>S</td>
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<td></td>
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<tr>
<td></td>
<td>A</td>
<td>1994</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>M</td>
<td>1995</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tracker</td>
<td>1996</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ABS/TCS VI</td>
<td>U</td>
<td>1993 1/2</td>
<td>Diagonal</td>
<td>4</td>
<td>Front/Rear</td>
</tr>
<tr>
<td></td>
<td>F</td>
<td>19941/2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>J</td>
<td>1995</td>
<td>(ETS only)</td>
<td>3</td>
<td>Diagonal</td>
</tr>
<tr>
<td></td>
<td>N</td>
<td>1996</td>
<td>(ETS only)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Delphi Chassis VI ABS/TCS

The Delphi Chassis VI antilock brake system/traction control system improves vehicle stability during hard braking and acceleration by preventing wheel slip. As a vehicle’s tires slip or loose traction directional control is severely affected.

System Classifications

Non-Integral

Delphi Chassis VI is considered a non-integral brake system because its components are separate from the conventional master cylinder and booster assembly. Other antilock systems are considered integral because the antilock components and master cylinder are combined into a single unit, which takes the place of the conventional master cylinder.

In essence, antilock braking and traction control are separate from the existing power-assisted brake system.

System Operation

The same electronic brake traction control module (EBCM) controls the antilock brake system (ABS) and traction control system (TCS).

ABS Operation

ABS operation can occur during vehicle braking. The EBCM monitors the speed of the front and rear wheels. If any of the wheels begin to slip, the EBCM temporarily regulates brake pressure to that brake channel. At all other times, the EBCM monitors wheel speed but does not affect base brake operation.

TCS Operation

TCS operation can occur during vehicle acceleration. The EBCM again monitors wheel speed, in this case to determine if wheel slip occurs at the drive wheels. The EBCM can use engine torque management strategies, brake intervention, or a combination of both to bring the wheel slip condition under control.

Enhanced Traction System

The enhanced traction system (ETS) is standard on some 1995 J-body and 1996 N-body when the vehicle is equipped with electronic four-speed transmission (4T40E). The ETS and the ABS share the same wheel speed sensors and electronic brake and traction control module (EBCM). When the drive wheel speed exceeds a given limit, ETS becomes active. The EBCM determines the desired wheel torque and transmission gear to optimize drive wheel traction. This information is sent to the powertrain control module (PCM) via the serial data link. The PCM then calculates a spark retard value to achieve the requested torque and upshifts the transmission if needed.
**Benefits of ABS/TCS**

The ABS portion of the system provides the average driver with:

- Enhanced directional stability during a wheel slip condition
- Enhanced steering control by enabling the vehicle to move in a driver-controlled direction during hard braking.
- Enhanced brake performance by reducing vehicle speed in the shortest possible distance during hard braking.

TCS provides the average driver with:

- Reduced wheel slip during acceleration.
- Enhanced directional control during acceleration on normal or marginal driving surfaces.

Improved straight-line maneuverability on most driving surfaces.

**ABS Components**

Delphi Chassis VI ABS components added to the base brake system include:

- Electronic brake control module (EBCM)
- Wheel speed sensors
- ABS hydraulic modulator
- ABS motor pack assembly
- ABS indicator lamps
- ABS relay
- Lamp driver module
- Brake switch input to EBCM

**TCS Components**

Delphi Chassis VI TCS components include:

- Electronic brake traction control module (EBCM/EBTCM)
- TCS hydraulic modulator
- TCS motor pack assembly
- Throttle position sensor (TPS)
- Engine control module/powertrain control module (ECM/PCM)
- Adjuster assembly (throttle)
- TCS relay
- TCS enable switch
- TCS indicator lamps
- Lamp driver module
System Variations

Delphi Chassis VI ABS Without Traction Control

Some models are equipped with an ABS-only version of the Delphi Chassis VI system and do not include traction control. F-body vehicles with ABS only use three vehicle speed sensors; all other applications use four sensors.

Outlet Pipes and Speed Sensors

Because the Delphi Chassis VI system is installed in different vehicle platforms, it has several variations in hardware. The variations are in:

- Hydraulic modulator assembly outlet pipes
- Number and location of speed sensors
- Remote mount modulator locations vs. master cylinder mounted locations
- Mounting location of the proportioner valves

Hydraulic Unit Outlet Pipes

The hydraulic unit may have three or four outlet pipes depending on configuration and application.

- 3-channel with 3 pipes, front/rear split (F-body with ABS only)
- 3-channel with 4 pipes, diagonal split

Wheel Speed Sensors

The vehicle may have three or four wheel speed sensors (the F-body with ABS only uses three sensors):

- Left front wheel
- Right front wheel
- Rear axle

All other vehicles have four wheel speed sensors:

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

Proportioner Valve

On diagonally split systems, the proportioner valves are integral to the master cylinder. On F-body, the combination valve contains the proportioner valve, which is mounted to the ABS modulator.
2. Components

Module Behavioral Objectives
At the conclusion of this chapter the technician will be able to:

- Identify location of Delphi VI ABS/TCS components.
- Identify and describe the purpose of Delphi VI ABS/TCS components.

GM-ASEP Embedded Courses And Competency List
A-5 Competencies for Delphi Chassis Series VI & DCB 7 ABS/TCS

A. Identify Components Of Delphi ABS/TCS
   1. Describe antilock brake control.
   2. Identify traction control.

Performance Objectives
Given a vehicle equipped with Delphi VI ABS/TCS, service information, the student will correctly identify and inspect antilock brake system (ABS) components; determine necessary action, according to manufacturer’s recommendations. (NATEF Task V. Brakes, G. Antilock Brake and Traction Control System, number 1)
Components Introduction

This section identifies and locates the major components of the Delphi Chassis VI ABS and Delphi Chassis VI ABS/TCS. Components are divided into the following categories:

Electronic monitor and control: Includes components external to the hydraulic modulator/motor pack assembly that monitor and control ABS/TCS operation.

Power supply and circuit protection: Includes components that power and protect the hydraulic modulator/motor pack assembly and EBCM.

Hydraulic system: Includes the hydraulic modulator/motor pack assembly and its sub-components and base brake components.

Figures 10a-1 through 10a-4 show the location and relationship among major components. The quick-reference charts list ABS/TCS components and describe component location and function. For more information, refer to the operation section of this handout.

Figure 10a-1, ABS/TCSM System Component Locations on N-Body
Figure 10a-2, System Component Locations on F-Body

Figure 10a-3, System Component Locations on U-Body
### Electronic Monitor and Control

<table>
<thead>
<tr>
<th>Component</th>
<th>Location</th>
<th>Function</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic Brake Traction Control Module (EBCM)</td>
<td>Mounted either in the under dash area, or in the engine compartment</td>
<td>Monitors and detects wheel locking and slipping tendencies; Controls the brakes during antilock and traction control operation; Monitors the ABS/TCS system for proper electrical operation; Stores and displays ABS and TCS diagnostic trouble codes</td>
<td>ABS/TCS</td>
</tr>
<tr>
<td>Toothed Sensor Rings</td>
<td>Mounted at each wheel</td>
<td>During wheel rotation, teeth on the toothed sensor ring pass close to the wheel speed sensor, generating an AC voltage proportional to wheel speed</td>
<td>ABS/TCS</td>
</tr>
<tr>
<td>Rear Axle Toothed Sensor Ring</td>
<td>Mounted in the rear axle (F-body only)</td>
<td>Provides wheel speed input to the EBCM. The EBCM constantly monitors this input to detect wheel locking or slipping tendencies.</td>
<td>ABS/TCS</td>
</tr>
<tr>
<td>Wheel Speed Sensors</td>
<td>Front wheel speed sensors mounted on the left and right steering knuckle; Rear wheel speed sensors mounted at each end of the rear axle housing; Rear axle speed sensor mounted in the rear axle differential</td>
<td>Provides electrical connections for the wheel (or axle) speed sensors</td>
<td>ABS/TCS</td>
</tr>
<tr>
<td>Sensor Harness Connectors</td>
<td>Front wheel sensor harness connectors are located in the engine compartment, near the driver-side and passenger-side wheel wells; Rear wheel sensor harness connectors are under the driver-side rear of the car and in the front of the luggage compartment, under the rear shelf; Rear axle speed sensor harness connector is located below the left-hand rear floor pan</td>
<td>Provides electrical connections for ABS/TCS</td>
<td>ABS/TCS</td>
</tr>
<tr>
<td>ABS hydraulic modulator Assembly</td>
<td>Mounted underhood on the master cylinder assembly</td>
<td>Control hydraulic modulation to the individual brake circuits</td>
<td>ABS</td>
</tr>
<tr>
<td>TCS hydraulic modulator assembly</td>
<td>Mounted underhood down line from the master cylinder assembly</td>
<td>Control hydraulic modulation to the individual brake circuits</td>
<td>TCS</td>
</tr>
<tr>
<td>Adjuster Assembly (F-body only)</td>
<td>Mounted in the engine compartment near the throttle body, in-series with the throttle cables and throttle lever cam</td>
<td>Acts as a cable extender for the throttle cables. During a wheel slip event, the EBCM can command this extender to move throttle cam toward the closed throttle position. This action reduces engine power to minimize wheel spin.</td>
<td>TCS</td>
</tr>
<tr>
<td>TCS &quot;OFF&quot; Switch</td>
<td>Mounted on the instrument panel</td>
<td>Acts as a manual override for the TCS</td>
<td>TCS</td>
</tr>
<tr>
<td>ABS Indicator Lamps</td>
<td>Instrument panel cluster</td>
<td>Notify driver of ABS system status (&quot;ABS ACTIVE&quot;) and system faults (&quot;ABS&quot;)</td>
<td>ABS</td>
</tr>
<tr>
<td>TCS Indicator Lamps</td>
<td>Instrument panel cluster</td>
<td>Notify the driver of TCS system status (&quot;ACTIVE&quot; or &quot;OFF&quot;) and TCS system faults (&quot;SERVICE TCS&quot;)</td>
<td>TCS</td>
</tr>
<tr>
<td>Brake Light Switch</td>
<td>Mounted on the brake pedal bracket</td>
<td>Signals the EBCM that the brakes have been applied. If traction control is enabled when the EBCM receives brake switch input, the EBCM disables the TCS</td>
<td>ABS/TCS</td>
</tr>
</tbody>
</table>
Power Supply and Circuit Protection

<table>
<thead>
<tr>
<th>Component</th>
<th>Location</th>
<th>Function</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuse Block</td>
<td>Varies with vehicle</td>
<td>Supplies power to ABS and TCS components</td>
<td>ABS/TCS</td>
</tr>
<tr>
<td>Underhood Electrical Center</td>
<td>Underhood</td>
<td>Provides power to the ABS and TCS relays and solenoids</td>
<td>ABS/ETS</td>
</tr>
<tr>
<td>Fusible Link</td>
<td>Varies with vehicle</td>
<td>Provides power to the ABS and TCS relays and solenoids</td>
<td>ABS/TCS</td>
</tr>
<tr>
<td>Enable Relays</td>
<td>Varies with vehicle</td>
<td>Provides power for system operation</td>
<td>ABS/TCS</td>
</tr>
</tbody>
</table>

Hydraulic System

<table>
<thead>
<tr>
<th>Component</th>
<th>Location</th>
<th>Function</th>
<th>System</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABS Modulator Assembly</td>
<td>Engine compartment</td>
<td>Regulates hydraulic pressure to the brakes during ABS operation</td>
<td>ABS/TCS</td>
</tr>
<tr>
<td>TCS Modulator Assembly</td>
<td>Engine compartment</td>
<td>Regulates hydraulic pressure to the drive wheels during TCS operation</td>
<td>TCS</td>
</tr>
<tr>
<td>ABS Motor Pack</td>
<td>Engine compartment</td>
<td>Drive the pistons in the hydraulic modulator to control ABS system hydraulic modulation</td>
<td>ABS</td>
</tr>
<tr>
<td>TCS Motor Pack</td>
<td>Engine compartment</td>
<td>Drive the pistons in the hydraulic modulator to control TCS system hydraulic modulation</td>
<td>TCS</td>
</tr>
<tr>
<td>ABS Solenoids</td>
<td>Attached to the ABS modulator assembly</td>
<td>Isolates hydraulic channels during the pressure HOLD mode</td>
<td>ABS</td>
</tr>
</tbody>
</table>
Components
EBCM, PCM, Adjuster Assembly

Figure 10a-4, EBCM

Figure 10a-5, PCM

Figure 10a-6, Adjuster Assembly
ABS Hydraulic Modulator Assembly

Figure 10a-7, ABS Hydraulic Modulator Assembly
TCS Hydraulic Modulator Assembly

Figure 10a-8, TCS Hydraulic Modulator Assembly
Speed Sensors

Figure 10a-9, Rear Axle Speed Sensor (F-body with ABS)

Figure 10a-10, Rear Axle Speed Sensors (F-body with TCS)
Figure 10a-11, Discrete Front Wheel Speed Sensor (J, L, M, N, W, S, Z-bodies)

Figure 10a-12, Integral Front Wheel Speed Sensor (U, F-bodies)

Figure 10a-13, Integral Front Wheel Speed Sensor (J, L, N, S, U, W-bodies)
3. Operation

Module Behavioral Objectives

At the conclusion of this chapter the technician will be able to:

• Demonstrate the operation of ESB/EMB
• Demonstrate the operation of engine torque management
• Describe the operation of brake intervention
• Describe the operation of ABS/TCS intervention
• Describe the operation of normal base brake operation

Diagnose and perform component service procedures on:

• ABS modulator
• ABS solenoids
• ABS motor pack
• TCS modulator
• TCS motor pack
• TCS adjuster assembly, cable adjustments
• Wheel speed sensors, integral & non-integral
• EBCM

STC Tasks: GM-ASEP Embedded Courses And Competency List

A-5 Competencies for Delphi Chassis Series VI & DBC 7 ABS/TCS

A. Identify Components Of Delphi ABS/TCS Systems
   2. Identify traction control.
   3. Describe steering control

B. Operation Of Delphi ABS/TCS Systems
   1. Explain anti-lock brake control function system.
   2. Explain traction control functional operation.

C. Diagnostic Procedures For Delphi ABS/TCS
   2. Describe the inputs to the Steering Control Function.
   3. Describe the outputs of the steering Control Function.
Performance Objectives:
Given a vehicle equipped with Delphi VI ABS/TCS, service information, DVOM, and basic hand tools, the student will correctly diagnose poor stopping, wheel lock-up, abnormal pedal feel or pulsation, and noise concerns caused by the antilock brake system (ABS); determine necessary action, according to manufacturers recommendations. (NATEF Task V. Brakes, G. Antilock Brake and Traction Control Systems, number 2)

Given a vehicle equipped with Delphi VI ABS/TCS, service information, and basic hand tools, the student will correctly remove and install antilock brake system (ABS) electrical/electronic and hydraulic components, according to manufacturers recommendations. (NATEF Task V. Brakes, G. Antilock Brake and Traction Control Systems, number 6)

Given a vehicle equipped with Delphi VI ABS/TCS, service information, DVOM, scope and basic hand tools, the student will correctly test, diagnose and service ABS speed sensors, toothed ring (tone wheel), and circuits using a graphing multimeter (GMM)/digital storage oscilloscope (DSO) (includes output signal, resistance, shorts to voltage/ground, and frequency data, according to manufacturers recommendations. (NATEF Task V. Brakes, G. Antilock Brake and Traction control Systems, number 7)

Introduction to Delphi Chassis VI ABS/TCS Operation
This section describes operation for the individual ABS and TCS components, as well as for the entire integrated system. Major topics include:

• ABS/TCS Component Operation
  – EBCM
  – EBCM inputs
  – EBCM outputs
  – Power supply and circuit protection
• Hydraulic Modulator/Motor Pack Assembly Operation
• Antilock Braking System Operation
• Traction Control System Operation
  – TCS Engine Torque Management
  – TCS Brake Intervention

The antilock brake system and the traction control system are both part of the same hydraulic and electric system. Both systems use many of the same components and a problem in either system may disable the other system until it is repaired. Antilock braking controls wheel slip when braking, traction control controls wheel slip when accelerating.
Delphi Chassis VI Base Brake Operation

Under normal operating conditions, the brake system will operate using conventional braking by means of brake pedal force, the vacuum booster, and the compact master cylinder. On the two non-drive wheels, the brake fluid flows from the master cylinder, through the ABS hydraulic modulator, and then out to the wheel circuits. On the drive wheels, the fluids flow through the master cylinder, through the ABS hydraulic modulator, through the TCS hydraulic modulator, and then out to the drive wheels.

Figure 10a-14, System Diagram for a Typical ABS Equipped Vehicle
Figure 10a-15, System Diagram for a F-Body TCS Equipped Vehicle

Figure 10a-16, System Diagram for a U-Van TCS Equipped Vehicle
ABS/TCS Driver Communications

Antilock Brake System Driver Observations

Normal Lamp Operation

1. Key turned to “RUN” position -the amber “ABS” lamp, red “BRAKE” lamp, and “LOW TRAC” lamp (if equipped) will illuminate for approximately 3 seconds then go out.

2. After the ignition is turned to “START” and back to “RUN”, this cycle will repeat.

3. If the vehicle enters an ABS stop, the “LOW TRAC” lamp (if equipped) will illuminate during the ABS event and for 3 to 4 seconds after the ABS event.

ABS Malfunction

1. Solid “ABS” lamp indicates a malfunction has been detected that affects ABS operation.

2. Flashing “ABS” lamp may indicate a base brake problem or a malfunction in the red “BRAKE” warning lamp circuit.

Traction Control System Driver Observations

Normal Lamp Operation

1. Key turned to the” RUN” position - the “ABS”, “TCS OFF”, “ETS OFF” and “LOW TRAC” lamps will illuminate and go off after approximately 3 seconds.

2. “TCS OFF” lamp is controlled by the driver to turn off traction control for the current key cycle, or until driver presses the switch again. The “LOW TRAC” lamp will illuminate whenever the vehicle is in a TCS event.

TCS Malfunction

1. If EBTCM identifies a problem in TCS, the “TCS OFF” lamp will illuminate, disabling TCS. ABS will still be available. If both “ABS” and “TCS OFF” lamps illuminate, both systems will be disabled.

Notice

Prior to 1995, a flashing AMBER lamp indicated that there was a minor fault detected which would not disable ABS. Starting 1995, a flashing AMBER Indicator lamp Indicates that there Is a serious problem with the ABS system requiring immediate attention.

Notice

Traction control warning lamp identifies the need for TCS service. On F-body, this lamp also comes on when the TCS switch is used to disable the system.
ABS EBTCM Inputs, Outputs, and Power Circuit Operation

The EBTCM is the control center for the Delphi Chassis VI ABS/TCS. The inputs and outputs are shown in Figures 10a-17. These inputs and outputs are covered in detail later in this section. The Delphi Chassis VI ABS/TCS electrical system consists of:

- EBTCM inputs including wheel speed sensor, ignition, brake switch, proportioner valve, serial data, red BRAKE lamp, TC switch, torque output and TP sensor inputs.
- EBTCM outputs including lamp drivers, IPC lamps, enable relays, motors, isolation solenoids, EMB's, serial data, torque request, retard request and throttle control.
- Power distribution circuits such as fuses and grounds.

Electronic Brake Traction Control Module (EBTCM)

The electronic brake traction control module is a microprocessor that monitors and controls ABS and TCS operation. EBTCM primary functions include:

- Detect wheel locking tendencies
- Monitor the rotational speed differences of each wheel
- Control the brake system during antilock and traction control operation
- Monitor the ABS and TCS to ensure proper electrical operation
- Store ABS and TCS diagnostic trouble codes during diagnostic mode operation.

Whenever the ignition is in “RUN”, the EBTCM continuously monitors the speed of each wheel and the electrical status of the hydraulic modulator/motor pack assembly. If wheel slip is detected, the EBTCM commands appropriate positions in the hydraulic modulator/motor pack assembly to modulate hydraulic pressure to one or more wheel circuits. The EBTCM continues to control hydraulic pressure until the wheel slip tendency subsides.

The powertrain control module (PCM) controls engine torque management during traction control operation.
EBCM Inputs

Wheel Speed Sensor Input

The EBCM continuously monitors wheel speed sensor input. All ABS/TCS vehicle applications are equipped with a rotating toothed sensor ring and a stationary speed sensor at each of the four wheels. F-body with ABS only is equipped with three sensors, one WSS at each of the front wheels and one for both rear wheels. F-body with ABS/TCS has 4 wheel speed sensors, one for each front and one for each rear wheel.

Wheel speed sensors operate as follows:

1. The toothed sensor ring rotates at the same speed as the wheel.
2. Teeth on the toothed sensor ring pass the wheel speed sensor.
3. As each tooth passes the sensor, it interrupts the sensor’s magnetic field. The momentary interruption induces an AC voltage pulse in the sensor’s coil.
4. The AC voltage signal travels:
   - Through the twisted pair wire harness.
   - To the main ABS/TCS wiring harness.
   - To the EBCM for processing.

Each front wheel is monitored independently. Rear wheels are monitored:

- Through a single speed sensor assembly on the rear axle differential assembly (F-body).
- Through individual sensors at each rear wheel.

ABS/TCS speed sensor circuit wiring is extremely sensitive to electromagnetic and radio frequency interference. Poor connections, worn wire insulation, and misrouting can increase the likelihood of intermittent failures.

Notice

The air gap between the toothed sensor ring and speed sensor is preset during assembly. This gap is not adjustable but should be checked. If sensor gaps vary from wheel to wheel, sensor output may also vary. The EBCM may interpret this variance as a slipping wheel and inappropriately engage ABS or TCS control.

Notice

Wheel speed sensor shock is a condition in which a vehicle vibration can cause the generation of a false sensor signal and modulator valve activation. Speed sensor wiring harness routing is of particular concern on some vehicles due to the placement of components producing high EMI or RFI levels.
Wheel Speed Sensor Jumper Harness

Between each wheel speed sensor and the main wiring harness is a jumper harness made up of highly flexible twisted pair wiring. This wiring exists because the main harness must connect to the suspension of the vehicle; thus the wiring in this area is subjected to the same motion as a spring or shock absorber. Consequently, no repairs to this section of wiring should be attempted; replacement is the only approved method of repair. Soldering or crimp splicing will result in stiffening and, therefore, eventual failure due to wire fatigue.

Tires and ABS/TCS Spare Tire

Using the compact spare supplied with the vehicle will not affect the operation of ABS/TCS. The EBCM software can compensate for this smaller tire. However, increased stopping distances may occur due to reduced tire tread width on compact spare tires.

Replacement Tires

Tire size is important for proper performance of the ABS/TCS. Replacement tires should be the same size load range and construction as the original tires. Replace tires in axle sets and only with tires of the same TPC (Tire Performance Criteria) specification number. Use of any other tire size or type may seriously affect the ABS/TCS operation. For more information on original equipment and replacement tires refer to Service Information.
Ignition Input

The EBCM will not initiate ABS operation until it receives battery power from the ignition switch. The Delphi Chassis VI system is extremely sensitive to low voltage conditions which will set a DTC. Current flows:

- Through the ignition switch.
- From the fuse (varies with model).
- Through the IPC indicator lamps.
- To the EBCM.

ABS/TCS Input, Power and Ground

The TCS enable relay is a normally-open contact type relay. It uses a special material on the contact surfaces of the points to handle the high currents used during operation. The relay allows battery voltage and current to be supplied to the EBCM, which supplies power to the TCS motors.

![Diagram of ABS/TCS Input, Power and Ground]

Figure 10a-19, ABS/TCS Input, Power and Ground
Brake Switch Input

The EBCM will not initiate ABS operation until it receives a signal from the brake switch. The brake switch closes when the driver presses the brake pedal. Current flows:

- From the fuse (varies with model)
- Through the brake switch
- To the brake lights and EBCM

![Brake Switch Circuit (U-Van)](image)

Red Brake Lamp Input

The EBCM will not initiate ABS operation if it receives a signal from the combination valve (differential switch) through the red BRAKE lamp. The combination valve (differential switch) grounds the circuit if there is a fault in the base brake system. Current flows:

- From the EBCM
- Through the brake combination valve switch
- To ground
EBCM Outputs Motor Pack Output

The Delphi Chassis VI hydraulic modulator/motor pack assembly provides brake fluid modulation for the individual wheel hydraulic circuits during antilock braking. During the antilock mode the modulator assembly can hold, decrease or increase brake fluid pressure independent of the pressure generated in the master cylinder. The modulator assembly cannot provide more pressure than is applied by the master cylinder. A combination of motor positions produce one of three phases at each wheel during an ABS event.

- Pressure hold (maintain, isolate)
- Pressure decrease
- Pressure increase

When the EBCM initiates system operation it sends current to the motor packs to control hydraulic modulation. Current flows:

- From the EBCM.
- Through the motors.
- Back to the EBCM

Refer to the vehicle Service Information (SI), and the system schematics for circuit details.

![Figure 10a-21, ABS Motor Circuit (TCS is similar)](image-url)
Electromagnetic Brake (EMB) Output

The electromagnetic brake (EMB) used on some applications, uses and electric disc brake configuration to hold the piston in place. Small electromagnets release the clamping force required to hold the motor in place. When the magnets are de-energized, springs apply the brake’s clamping force. The electromagnets release the brakes when piston travel is required.

When the EBCM initiates ABS/TCS operation, it sends current to the EMB to control the clamping action. Current flows:

- From the fuse (varies with model)
- Through the enable relay
- Through the EMB’s
- To ground

![Electromagnetic Brake (EMB)](image1)

*Figure 10a-22, Electromagnetic Brake (EMB)*

![EMB Circuit](image2)

*Figure 10a-23, EMB Circuit*
ESB

The expansion spring brake (ESB) is used to hold the ABS piston in the upper most (or home) position (Figure 10a-11). The function of the ESB is identical to an EMB; however, an ESB is not controlled by the EBCM. An ESB is a spring that is retained in a housing at a close tolerance. One end of the spring is in contact with the motor drive dog and the other end is in contact with the pinion drive dog. In normal braking, brake pressure is present on the top of the ABS piston, applying a downward force. The force applies a counterclockwise torque to the motor pinion which tries to rotate the spring counterclockwise. The counterclockwise torque expands the spring outward within the housing and prevents gear rotation. ESB’s are used only in the ABS modulator, ABS units will use only ESB’s after 1995.

Figure 10a-24, Expansion Spring Brake (ESB)
**Isolation Solenoid Output**

The solenoid in the front circuits provides an alternate brake pressure path to the wheel. With this arrangement if the ABS were to lose power or malfunction with the piston not in its uppermost position, a redundant brake fluid path is available. During front wheel ABS operation the solenoids are turned “ON” to isolate the brake pressure path to the wheel.

The rear channel operates in a similar manner except no solenoid is used. Both rear brake pressures are controlled by the same motor and both rear brake pressures are controlled together. If either rear wheel begins to lock, brake pressure to both rear wheels is reduced together to maximize vehicle stability.

When the EBCM initiates ABS/TCS operation it sends current to the motor packs to control hydraulic modulation. Current flows:

- From the EBCM
- Through the isolation solenoids
- To ground

*Figure 10a-25, Isolation Solenoid Circuit*
Warning Lamps

The EBCM provides the appropriate grounds to illuminate the IPC warning lamps as required.

During bulb test and system faults, the EBCM illuminates the IPC warning lamps. Current flows:

- From the fuse
- Through the lamps
- To ground:
  - through the lamp driver or
  - through the EBCM

![Diagram of Warning Lamp Circuit](image)

*Figure 10a-26, Warning Lamp Circuit*
EBTCM Functional Checks

The EBTCM continuously monitors itself and all other ABS/TCS components for proper operation.

- **Vehicle Start-Up**: Immediately after start-up the EBTCM performs a functional check of the ABS/TCS circuits including:
  - EBCM circuits
  - Battery voltage
  - Wheel speed sensor circuits
  - Relay circuit
  - Motor circuits
  - Isolation solenoid circuits
  - EMB circuits
  - Brake switch circuit
  - Throttle adjuster circuit

Vehicle In-Motion: When the vehicle reaches 3-9 mph (4-12 km/h), the EBTCM performs a functional check of the system. During this self-test the EBTCM cycles each solenoid and motor. The driver may hear audible clicks when the system is cycled. These clicks should be considered part of normal operation. The functional check occurs only once per ignition cycle.

If any problems are detected during either functional check, the EBTCM disables the appropriate system (ABS or TCS) and illuminates the “ABS INOP” and/or “SERVICE TCS” indicator lamp.

System - Self Test (Initialization)

During initialization the EBTCM will not only perform self-diagnostics but will also verify modulator, solenoid, relay, and lamp operation to ensure all ABS and TCS components are functioning properly. The EBTCM also checks the wheel speed sensor circuitry for open circuits and shorts to ground or voltage at this time. If the EBTCM detects a malfunction in either itself or other ABS/TCS components, it will store a diagnostic trouble code (DTC) and turn “ON” the ABS warning lamp, the TCS warning lamp, or the red “BRAKE” warning lamp if applicable.

A slight mechanical noise may be heard during the system initialization, which is normal. The entire initialization is run about 2-3 seconds after the engine starts. If your foot is on the brake pedal when the engine is started, the system will not initialize until your foot is removed or 5 km/h (3 mph).
ABS Hydraulic Operation

Delphi Chassis VI Hydraulic Modulator/Motor Pack Operation

The non-integral hydraulic modulator/motor pack assembly in the ABS/TCS hydraulic assembly includes the following components:

- Motorpack
- ESB/EMB
- Isolation valve solenoids
- Ball screws
- Pistons
- Check valves

ABS Hydraulic Modulator Assembly Fluid Flow

Each front wheel channel consists of a motor, isolation valve solenoid, ESB/EMB, ball screw, piston, and check valve. Under non-ABS base brake operating conditions, the piston is held in the up most (or “home”) position and the solenoid is open (not energized). This is accomplished by turning the ball screw via the motor to drive the nut upwards. Once at the upper most position, the piston is held by an expansion spring brake (ESB) or electromagnetic brakes (EMB), depending upon application. Two paths are available to transfer braking pressure to the wheels:

- through the ABS modulator, around the check valve, and out to the wheels.
- through the ABS modulator, past the normally open solenoid, and out to the wheels.

Braking Operation

The EBCM can enable the ABS if any wheel speed sensor detects an excessively negative wheel slip condition when the brake pedal is depressed.

ABS System at Rest

With the brake pedal at rest, the hydraulic modulator/motor pack assembly establishes a two-way path from the master cylinder to the wheel circuits (Figure 10a-27). Brake fluid is at atmospheric pressure throughout the system.
Figure 10a-27, Delphi Chassis VI ABS Fluid Flow at Rest Position
Non ABS Braking

Under normal operating conditions, the brake system will operate using conventional braking by means of brake pedal force, the vacuum booster, and the compact master cylinder. On the two non-drive wheels, the brake fluid flows from the master cylinder, through the ABS hydraulic modulator, and then out to the wheel circuits. (See Figure 10a-28)

Figure 10a-28, Delphi Chassis VI ABS Non-ABS Braking
Antilock Brake System Operation

Pressure Hold

If any wheel(s) begins to slip, the EBCM will control the three motors and two solenoids appropriately to control brake pressure to the affected wheel(s). During non-drive wheel ABS operation the solenoids are turned “ON” to isolate that brake pressure path to the wheel. The EBCM constantly monitors wheel speed via input from the wheel speed sensors. If a wheel speed sensor indicates excessive deceleration during braking, the EBCM hydraulic modulator/motor pack assembly valve assembly will:

- Closes the normally open solenoid valve in the appropriate hydraulic circuit
- Energizes the EMB (if applicable) allowing the motors to move downward allowing the check valve to seat

This prevents additional fluid from entering the circuit. Brake pressure is maintained in the circuit.

Notice

Delphi VI ABS cannot increase the brake pressure above the master cylinder applied by the driver and cannot apply the brakes by itself.

Figure 10a-29, Delphi Chassis VI ABS Braking – Pressure Hold (RF)
Pressure Decrease

The brake pressure to the wheel is now a function of the controlled volume within the piston chamber. To reduce brake pressure the motor drives the nut further downward. If the wheel continues to decelerate too rapidly, the EBCM hydraulic modulator/motor pack assembly valve assembly:

- Continues blocking fluid from the master cylinder by keeping the isolation solenoid closed.
- Continues to drive the piston down to decrease hydraulic circuit pressure. (See Figure 10a-30)

Figure 10a-30, Delphi Chassis VI ABS Braking – Pressure Decrease (RF)
Pressure Increase

To reapply or increase brake pressure the motor drives the nut and piston upward. If ABS was entered during low brake pressure (such as on ice) and dry pavement is then encountered during reapply, the piston is driven all the way to the top. This results in the unseating of the check valve and a return to base brakes until sufficient brake pressure exists to cause the wheel to slip again. At this point, the ABS cycle would start again. This process can occur in less than one second if the driver is pressing firmly on the brake pedal.

If the wheel speed sensor detects potential slip at this time, the EBCM repeats the hold, decrease, and increase modes. This sequence may repeat many times a second, until antilock braking is no longer required. At the end of the ABS event, the piston is re-homed to the upper most position. The solenoids on the front channels are simultaneously opened (de-energized) to again provide a redundant base braking path. (See Figure 10a-31)

Figure 10a-31, Delphi Chassis VI ABS Braking – Pressure Increase (RF)
**Traction Control System Operation**

The traction control system (TCS) is added to the Delphi Chassis VI antilock brake system. The TCS provides the ability to control wheel spin at each drive wheel. This improves the ability to maintain vehicle stability and acceleration (drive traction) under changing road and vehicle load conditions.

Traction control occurs when the EBTCM determines one or both of the drive wheels are accelerating too rapidly and the brake switch is released. The EBTCM processes wheel speed sensor data and controls wheel slip by using up to three different methods:

- Engine Torque management.
- Close the throttle plate, thereby reducing engine torque output.
- Brake intervention through the use of the TCS hydraulic modulator.

*Figure 10a-32, Delphi Chassis VI ABS/TCS System (Typical)*
**Engine Torque Management**

If wheel slip is detected at any drive wheel, the EBTCM first uses engine management strategies to reduce torque at the appropriate wheel(s). A pulse width modulated (PWM) torque reduction request is an output from the EBTCM to the PCM as necessary for engine torque management. TCS engine management strategies vary from model to model.

However, all models follow the same basic sequence:

There are six modes of engine torque reduction for U van, all done by the PCM:

1. Lean air/fuel ratio
2. Lean air/fuel ratio and spark retard
3. Lean air/fuel ratio, spark retard and 100% EGR
4. Lean air/fuel ratio, spark retard and one cylinder fuel cut-off
5. Lean air/fuel ratio, spark retard and two cylinder fuel cut-off
6. Lean air/fuel ratio, spark retard and three cylinder fuel cut-off

**Spark Retard**

TCS-induced spark retard cannot decrease timing beyond top dead center (TDC). Spark retard is limited to help control catalytic converter temperature and maintain acceptable engine performance. Regardless of the degree of retard required, spark retard duration is limited to only a few seconds per event.

**Cylinder Fuel Cut-Off**

On some vehicles, the EBTCM sends a “torque request” signal to the PCM. The torque request, a pulse-width modulated (PWM) signal, specifies the desired engine torque level for adequate traction control. If torque request signal duty falls between 10% (100% torque reduction) and 90% (0% of torque reduction), the PCM selectively disables fuel to certain cylinders. With less fuel to burn, engine output power decreases, thereby reducing drive-wheel torque.

If brake application does not effectively control a wheel slip condition, the PCM shuts “OFF” fuel to a single cylinder. If further traction control is required, the PCM shuts off additional cylinders, one by one, up to three cylinders. Once normal traction resumes, the PCM turns the “dead” cylinders back in the “RUN” position.
Relaxer Assembly

On F-body with an eight-cylinder engine, engine torque reduction is done differently. Most of the torque taken out is done with a relaxer assembly. The relaxer assembly automatically closes the throttle when current is applied to it from the ABS/TCS controller. Spark retard is also done, but only at certain times during the TCS event. Unlike the U-van, there is an engine-torque only mode on the F-car. If the brake TCS is disabled due to thermal shutdown or speed (brake TCS is disabled above 50 mph), the relaxer assembly will continue to operate. Engine-only TCS will also continue if the brake is applied, unlike the U-van.

Brake Intervention

A separate hydraulic modulator mounted down stream from the ABS modulator performs brake intervention. The TCS modulator applies and releases brake pressure to the drive wheels if the driven wheel speeds exceed the undriven wheel speeds by a certain amount. Antilock brake assist is always available during traction control operation. If the antilock brake system is disabled for any reason (diagnostic failure, thermal shutdown), engine TCS is also disabled. If the PCM cannot perform engine torque reduction, the brake TCS will continue to operate.

Torque Request/Retard Output

ETS torque reduction request and ignition timing retard request is output from the EBTCM to the PCM as necessary for engine torque management.

![Figure 10a-33, Torque Management Circuit (U-Van)](image)
Enhanced Traction System

The enhanced traction system (ETS) is standard on some 1995 J-body's with 2.3L and 1996 N-body when the vehicle is equipped with electronic four-speed transmission (4T40-E). The ETS and the ABS share the same wheel speed sensors and EBTCM. When the front wheel speed exceeds a given limit, ETS becomes active. The EBTCM determines the desired wheel torque and transmission gear to optimize front wheel spin. This information is sent to the PCM via the UART line. The PCM then calculates a spark retard value to achieve the requested torque and upshifts the transmission if needed.

Figure 10a-34, UART Circuit
Variable Effort Steering

On some vehicles (N-body) the variable effort steering (VES) control logic is integrated in the EBCM. The EBCM receives inputs from the ABS wheel speed sensors and the steering wheel speed sensor. The EBCM processes this information and sends a control signal to the EVO (Electronic Variable Orifice) actuator to vary the rate of fluid flow output by the power steering pump.

The Variable Effort Steering (VES) system controls the amount of steering effort needed to steer the vehicle as vehicle speed, or steering wheel position sensor input changes. The Electronic Brake Control Module (EBCM) controls an Electronic Variable Orifice (EVO) actuator located in the power steering pump’s output fluid orifice. The actuator consists of an electromagnetic coil and a pintle valve, which moves in, and out of an orifice regulating power steering fluid flow. The EBCM commands current to the actuator from 0-619 ma. At low speeds, no current is commanded to the actuator and the pintle valve is fully retracted, which provides maximum fluid flow and full assist for easy turning and parking maneuvers. At higher speeds, more current is commanded to the actuator causing the pintle valve to move closer to the orifice, which decreases fluid flow providing firmer steering (road feel) and directional stability. The VES system uses the steering wheel position sensor input to sense abrupt driving maneuvers. When the EBCM detects a abrupt maneuver, less current is commanded to the actuator to provide full steering assist. The VES system also uses the two rear Antilock Brake System (ABS) wheel speed sensor inputs to determine vehicle speed.

Diagnostic trouble codes (DTC’s) are stored in the EBCM for EVO actuator or steering wheel speed sensor malfunctions. There are three DTC’s to aid in VES diagnostics. Ensure all ABS DTC’s are diagnosed and corrected prior to clearing VES DTC’s. Clearing VES DTC’s will automatically clear ABS DTC’s resulting in a loss of DTC history data.

![Variable Effort Steering Circuit](image)

*Figure 10a-35, Variable Effort Steering Circuit*
Throttle Control Output

Adjuster Assembly

The adjuster assembly for throttle and cruise control cables on F-body is mounted in the engine compartment and is positioned in series with the throttle cables. The EBTCM commands the adjuster assembly to close down throttle angle during TCS to help reduce engine torque. This reduced torque helps limit rear wheel slip.

The adjuster reduces throttle opening through the use of a unidirectional (works in one direction only) DC motor. The motor is used to close down the throttle; an internal adjuster spring returns it to the pedal-directed position. The cables are connected at the adjuster’s cams:

- Cruise control
- Accelerator pedal to adjuster
- Adjuster to throttle body

The EBTCM provides the appropriate power and grounds to actuate the adjuster assembly as required. Current flows:

- From the EBTCM
- Through the adjuster assembly
- Back to the EBTCM

Figure 10a-36, Adjuster Assembly Circuit
**TCS Brake Intervention**

When the EBTCM determines brake intervention is required to minimize positive drive wheel slip, it signals the hydraulic modulator assembly to apply and release brake pressure at one or both drive wheel circuits as needed. Based upon a comparison of front wheel and rear wheel speeds, the EBTCM determines the need for brake intervention to assist engine torque management and adjuster assembly close-down functions.

TCS cannot be entered if the brake switch is “ON”. If TCS is being used and the brake switch is depressed, the EBTCM will immediately command the TCS motors to re-home the TCS ball screws and pistons.

Traction control can apply brake pressure at the drive wheels. When commanded, the traction control motor pack drives the piston and poppet valve assembly upward. The poppet valve seals against the top of the chamber isolating the fluid path from the master cylinder and the ABS modulator (Figure 10a-38). As the motor continues to turn, the piston is driven up compressing the spring and brake fluid above the piston. This action holds the poppet valve seated and applies brake fluid pressure through the outlet port to the wheel for brake application.

When the need for traction control ends, the EBTCM commands the piston and poppet valve assembly downward and the circuit is reopened (Figure 10a-37). If the driver applies the brakes during a traction control sequence, brake pressure will easily overcome the spring force that supports the poppet valve. This allows the driver-applied brake pressure to reach the wheel. In fact, ABS requirements always take priority over traction control events.

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**Figure 10a-37, Non-TCS Hydraulic Flow**

**Figure 10a-38, TCS Hydraulic Flow**
**Thermal Modeling**

The system also has “thermal modeling” for traction control. This logic in the EBTCM shuts down operation when the controller determines components are about to overheat. Prior to 1996 there are no diagnostic trouble codes (DTC’s) stored in these cases. However, on F-Car, the traction warning lamp comes “ON”. On U-Van, the traction enable switch lamp goes “OFF.” After a programmed cool-down period, operation is enabled.

The system is always “ON” whenever the ignition is first turned “ON.” However, all traction control functions can be disabled or enabled during a key cycle by pressing the system’s switch. If equipped, the switch’s lamp turns “OFF” when the driver disables the system. Based on time versus an amount of (and duration of) TCS application, TCS is disabled. The warning lamps in the cluster also identify this condition.

**F-Body with ABS/TCS**

F-body ABS with traction control differs slightly. After the front/rear split master cylinder, two lines carry fluid to the remotely mounted ABS hydraulic modulator assembly. After the ABS modulator, the two front circuits go directly to the front calipers. The shared rear circuit (one line) must first go to the TCS hydraulic modulator assembly and then two individual lines go in to the rear calipers.

*Figure 10a-39, F-Body Hydraulic Flow*
Warning/Indicator Lamps

The red “BRAKE” warning lamp comes “ON” for base brake concerns or parking brake engagement, like any brake system. However, the EBCM can also turn “ON” the red “BRAKE” warning along with the amber “ABS” or traction control lamp anytime it does not see motor movement as commanded.

The amber ABS warning lamp identifies that a fault exists and ABS operation is disabled, although base brake operation is unaffected. The ABS warning lamp is controlled by the EBCM. A flashing ABS warning lamp alerts the driver to a system malfunction that may have also affected the base brake system. These cases should be treated like a red “BRAKE” warning lamp and requires immediate service.

Regarding traction control, there is also an amber warning lamp to identify that the system is disabled and requires service. This lamp also turns “ON” when the driver uses the F-body’s traction control switch to disable the system. The traction control warning lamp is controlled by the EBTCM.

The low traction lamp illuminates to identify that either an ABS or traction control event is occurring. This is done by the EBTCM. The minimum “ON” time for the low traction lamp is four seconds. However, if ABS or TCS action occurs for a longer time period, the lamp will remain “ON” for that period of time.

On F-body, the necessary lamp driver modules are integrated into the instrument cluster. On U-Van, the TCS lamp driver is a separate component. Chevrolet Lumina APV uses two lamp drivers, one for ABS, another for TCS.

Figure 10a-40, Warning/Indicator Lamp Circuits (F-body)
TCS Switch

The TCS switch is located on the instrument panel. The exact location varies from model to model. The TCS enable switch is a normally open push-to-ground switch. Pressing this switch toggles the TCS “ON” and “OFF.” When the TCS is off, the “TCS INOP” lamp illuminates and the ABS remains enabled. The U-van has an active/non-active light in the switch to indicate switch status.

Refer to the vehicle Service Information and the system schematics, for circuit details.

Figure 10a-41, TCS Switch
4. Diagnostics

Module Behavioral Objectives
At the end of this module the student should be able to:

• Perform preliminary inspection checks and look for:
  – visual inspection
  – wire wiggle test
• Describe the benefits of the enhanced diagnostics
• Describe the various diagnostic hints
• Explain cause of intermittent conditions
• Identify normal operation of ABS/TCS
• Diagnose and repair system faults.

STC Tasks: GM-ASEP Embedded Course and Competency List
A-5 Competencies for Delphi Chassis Series VI & DBC 7 ABS/TCS

C. Diagnostic Procedures For Delphi ABS/TCS
  1. Identify the correct diagnostic process for Delphi ABS/TCS

Performance Objectives:
Given a vehicle equipped with Delphi VI ABS/TCS, DVOM, Tech 1 or Tech 2, service information and basic hand tools, the student will correctly diagnose antilock brake system (ABS) electronic control(s) and components using self-diagnosis and/or recommended test equipment; determine necessary action, according to manufacturer’s recommendations. (NATEF Task V. Brakes, G. Antilock Brake and Traction Control Systems, number 3)

Given a vehicle equipped with Delphi VI ABS/TCS, service information, and basic hand tools, the student will correctly diagnose antilock brake system (ABS) braking concerns caused by vehicle modifications (tire size, curb height, final drive ratio, etc), according to manufacturer’s recommendations. (NATEF Task, V. Brakes, G. Antilock Brake and Traction Control System, number 8)
Diagnostic Hints

ABS/TCS Operation Observations

Before examining the various controlling and operational circuits of ABS/TCS, it’s important to 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 miles per hour (3 mph with brakes applied) 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 (Electric magnetic 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.
Diagnostic Trouble Codes (DTC’s)

Although diagnostic trouble codes are an important tool, the recommended diagnostics procedure does not begin with retrieving codes. DTC’s can only be cleared from EBCM memory by using the Tech 1 (or Tech 2) or by performing 100 drive cycles.

**Important:**

Always begin your diagnostic procedure with a thorough visual inspection and vehicle test drive

Repair, Verify, and Retest

Servicing the Delphi Chassis VI 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 the codes do not reappear after the test drive.

Vehicle Test Drive

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.

**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,” may be reduced braking capability.

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”
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 comments 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 road 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 isolation 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 DTC’s)
- The “BRAKE” light comes “ON”
- Excessive wheel slip while TCS is operational
5. Service and Diagnostic Tools

Module Behavioral Objectives

At the conclusion of this chapter the technician will be able to:

• Demonstrate how to use a Tech 1 or Tech 2 during system diagnosis to perform the following tests:
  • Diagnosis/Misc. Test
  • Manual Control
  • ABS Motor Test (Apply/Release)
  • TCS Motor Test (Apply/Release)
  • Solenoid Test (“ON/OFF”) Hydraulic Control Test
  • ABS No Gear Movement
  • Gear Tension Relief
  • ABS/TCS Relay Test
  • Voltage Load Test
  • Lamp Test
  • System ID
  • Bleed Prep
  • Know the proper bleed procedure for the hydraulic system

Performance Objectives:

Given a vehicle equipped with Delphi VI ABS/TCS, Tech 1 or Tech 2, service information and basic hand tools, the student will correctly diagnose antilock brake system (ABS) electronic control(s) and components using self-diagnosis and/or recommended test equipment determine necessary action, according to manufacturer’s recommendations. (NATEF Task V. Brakes, G. Antilock Brake and Traction Control Systems, number 3)

Given a vehicle equipped with Delphi VI ABS/TCS, service information and basic hand tools, the student will correctly bleed the antilock brake system’s (ABS) front and rear hydraulic circuits, according to manufacturer’s recommendations. (NATEF Task V. Brakes, G. Antilock Brake and Traction Control Systems, number 5)

Service Tools

Tools required to service the Delphi Chassis VI ABS/TCS (Figure 5-1):

• J 35589 brake bleed adapter
• Tech I or Tech 2 diagnostic computer
• J 39200 Digital Multimeter
• J 35616 Jumper Kit

Mass Storage Cartridge (MSC)
Personal Computer Memory Card Industry Association Card - (PCMCIA)

Beginning with the 1993 model year, the Mass Storage Cartridge (MSC) is the only cartridge that will be sent to GM dealers. The MSC replaces all previous essential cartridges used in the Tech 1. The Tech 2 uses a Personal Computer Memory Card Industry Association (PCMCIA) card in place of the MSC. The PCMCIA has ten times the memory capacity of the MSC, but it is updated in the same manner as the MSC.

Updates for the MSC/PCMCIA will be shipped automatically through Techline CD-ROM for the Techline diagnostic terminal. A GM CPT video (56010.00) explains how to update the MSC as well as EEPROM programming of ECM's. Some individual application cartridges are still available.

Tech 1 and Tech 2 procedures are covered in a general manner in this handout. Refer to the vehicle Service Manual for specific procedures.

Hand Held Diagnostic Computer Diagnosis

Hand held diagnostic computers like the Tech I or Tech 2 include several tests that can help diagnose ABS/TCS faults. This section covers the test functions and how to use them when testing ABS/TCS concerns. For detailed information, see the tool operator’s guide and the vehicle Service Manual.

Tech I or Tech 2 Vehicle Hook-Up

Before operating the TECH I or Tech 2, the following steps must be performed.
1. Make sure the ignition is "OFF."

2. Insert the Mass Storage Cartridge into the master cartridge slot on the bottom of the Tech I. Verify that no other master cartridge is installed in the auxiliary slot at the top of the Tech I.

3. Connect the Tech I or Tech 2 cable to the top of the Tech I or Tech 2 and tighten the screws.

4. Connect the cable plug (and the Tech I or Tech 2) to the vehicle DLC.

5. Insert the power plug into the cigarette lighter socket and the power-up display will be visible on the screen.

6. Press "ENTER" and select "Chassis" (F2) for ABS/TCS.
Tech I or Tech 2 Diagnosis

After the Tech I or Tech 2 has been connected to the vehicle diagnostic data is available. In general, the scan tool has six test modes for diagnosing the ABS/TCS. The six test modes are as follows:

- Data List
- DTC History
- Diagnostic Trouble Codes
- Snapshot
- Miscellaneous Tests Bleed Prep
- Bleed Prep

Data List

Data list continuously monitors vehicle parameters. The scan tool allows you to display diagnostic parameters for the ABS/TCS. The Tech I or Tech 2 displays data parameters in pairs. You can use pre-programmed pairs, or you can create your own pairs. In this test mode, the tool continuously monitors wheel speed data, brake switch status and other inputs and outputs.

DTC History

DTC history determines the conditions that occurred when the diagnostic trouble code was stored.

- Ignition cycles since the diagnostic trouble code set
- Vehicle speed (mph or km/h)
- Brake light switch ("ON"/ "OFF")
- ABS state (active/ passive)

The first five and last DTC set are included in the DTC history data.
Enhanced diagnostic information found in the DTC History function is designed to provide the service technician with specific malfunction occurrence information. For each of the first five and the very last diagnostic trouble code set, data is stored to identify the specific DTC, the number of occurrences, and the number of drive cycles since the malfunction first and last occurred. A drive cycle occurs when the ignition is turned to "RUN" and the vehicle is driven faster than 16 km/h (10 mph) and the key is cycled "OFF". However, if a malfunction is present, the drive cycle counter will increment by turning the ignition to "RUN" and "OFF." These first five diagnostic trouble codes are also stored in the order of occurrence. The order in which the first five DTC's occurred can be useful in determining if a previous malfunction is linked to the most recent malfunction, such as an intermittent wheel speed sensor which later becomes completely open.

During difficult diagnosis situations, this information can be used to identify malfunction occurrence trends. Did the malfunction only occur over a large number of drive cycles, indicating an unusual condition present when it occurred? Does the malfunction occur infrequently over a large number of drive cycles, indicating that special diagnosis techniques may be required to identify the source of the malfunction?

If, for example, a malfunction occurred 1 out of 50 drive cycles, the malfunction is intermittent and has not recurred for 49 drive cycles. This malfunction may be difficult or impossible to duplicate and may have been caused by a severe vehicle impact (large pothole, speed bump at high speed, etc.) that momentarily opened an electrical connection or caused unusual vehicle suspension movement. Problem resolution is unlikely, and the problem may never recur (check diagnostic aids provided for that DTC). If, for example, the malfunction occurred 3 out of 15 drive cycles, the odds of finding the cause are still not good, but you know how often it occurs. If the malfunction occurred 10 out of 20 drive cycles, the odds of finding the cause are very good, as the malfunction may be easily reproduced. By using the additional malfunction data, you can also determine if a malfunction is randomly intermittent or if it has not recurred for long periods of time due to weather changes or a repair prior to this visit.

Say a DTC occurred 10 of 20 drive cycles but has not recurred for 10 drive cycles. This means the malfunction occurred 10 of 10 drive cycles but has not reoccurred since. A significant environmental change or a repair may have occurred 10 drive cycles ago. A repair may not be necessary if customer information can confirm a recent repair. If no repair was made the service technician can focus on diagnosis techniques used to locate difficult-to-recreate problems, such as those suggested in "Diagnostic Aids" for the DTC in question.
Diagnostic Trouble Codes

In the test mode, the hand held diagnostic tool displays ABS/TCS diagnostic trouble codes (DTC's) stored in the EBCM. The hand held diagnostic tool is used to clear stored DTC's in this mode. Using a Tech 1 or Tech 2 is the easiest way in which DTC's may be cleared, removing battery power will not clear DTC's. If the EBCM completes 100 drive cycles without the fault reoccurring, the DTC's will also be cleared. Both current ignition cycle and history may be displayed or cleared.

Snapshot

Use the Snapshot feature to isolate an intermittent problem. The scan tool stores data list information before and after a problem occurs. The snapshot can be set to trigger off of a forced manual key press or a preset DTC setting. Snapshot phases include:

- Set-up
- Data capture
- Data display

Also, set the Snapshot to trigger:

- Manually
- When data parameters meet engineering test specifications (automatic trigger)

Use snapshot while test driving and wiggling wires and connectors. When the fault occurs, review the data list to determine the cause of failure.

Miscellaneous Tests

Miscellaneous Tests allow the Tech I or Tech 2 to control the ABS outputs to help in fault isolation and system service. In Miscellaneous Tests mode, error conditions can be further identified by testing and observing the results. Delphi Chassis VI ABS/TCS miscellaneous tests include:

- Manual control
- Voltage load
- Hydraulic control
- Lamp test
- Motor test
- System ID
- Relay test
- Gear tension relief
Bleed Prep

In the first part of this mode, the Tech 1 or Tech 2 commands the EBCM to re-home the motors on the ABS hydraulic modulator and the TCS hydraulic modulator. In the second part of bleed prep, the Tech 1 or Tech 2 cycles the TCS modulator to move any trapped air that may be remaining to the top of the TCS modulator so that it may be removed when bleeding is continued. This mode must ALWAYS be used prior to bleeding the brake system.

Important:
Pressure tests normally take approximately fifteen seconds.
<table>
<thead>
<tr>
<th>DTC #</th>
<th>DTC Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1214</td>
<td>ABS Enable Relay Contact Circuit Open</td>
</tr>
<tr>
<td>C1215</td>
<td>ABS Relay Contact Control Circuit Active</td>
</tr>
<tr>
<td>C1216</td>
<td>ABS Enable Relay Coil Circuit Open</td>
</tr>
<tr>
<td>C1217</td>
<td>ABS Enable Relay Coil Circuit Shorted to Gnd</td>
</tr>
<tr>
<td>C1218</td>
<td>ABS Enable Relay Coil Circuit Shorted to Batt</td>
</tr>
<tr>
<td>C1221</td>
<td>Left Front Wheel Speed - 0</td>
</tr>
<tr>
<td>C1222</td>
<td>Right Front Wheel Speed - 0</td>
</tr>
<tr>
<td>C1223</td>
<td>Left Rear Wheel Speed - 0</td>
</tr>
<tr>
<td>C1224</td>
<td>Right Rear Wheel Speed - 0</td>
</tr>
<tr>
<td>C1225</td>
<td>Left Front Excessive Wheel Speed Variation</td>
</tr>
<tr>
<td>C1226</td>
<td>Right Front Excessive Wheel Speed Variation</td>
</tr>
<tr>
<td>C1227</td>
<td>Left Rear Excessive Wheel Speed Variation</td>
</tr>
<tr>
<td>C1228</td>
<td>Right Rear Excessive Wheel Speed Variation</td>
</tr>
<tr>
<td>C1232</td>
<td>LF Wheel Speed Snr CKT Open or Short to Gnd/Batt</td>
</tr>
<tr>
<td>C1233</td>
<td>RP Wheel Speed Snr CKT Open or Short to Gnd/Batt</td>
</tr>
<tr>
<td>C1234</td>
<td>LR Wheel Speed Snr CKT Open or Short to Gnd/Batt</td>
</tr>
<tr>
<td>C1235</td>
<td>RR Wheel Speed Snr CKT Open or Short to Gnd/Batt</td>
</tr>
<tr>
<td>C1236</td>
<td>Low System Voltage</td>
</tr>
<tr>
<td>C1237</td>
<td>High System Voltage</td>
</tr>
<tr>
<td>C1238</td>
<td>Left Front ESB Will Not Hold Motor</td>
</tr>
<tr>
<td>C1241</td>
<td>Right Front ESB Will Not Hold Motor</td>
</tr>
<tr>
<td>C1242</td>
<td>Rear ESB Will Not Hold Motor</td>
</tr>
<tr>
<td>C1244</td>
<td>Left Front ABS Channel Will Not Move</td>
</tr>
<tr>
<td>C1245</td>
<td>Right Front ABS Channel Will Not Move</td>
</tr>
<tr>
<td>C1246</td>
<td>Rear ABS Channel Will Not Move</td>
</tr>
<tr>
<td>C1247</td>
<td>Left Front ABS Motor Free Spins</td>
</tr>
<tr>
<td>C1248</td>
<td>Right Front ABS Motor Free Spins</td>
</tr>
<tr>
<td>C1251</td>
<td>Rear ABS Motor Free Spins</td>
</tr>
<tr>
<td>C1252</td>
<td>Left Front ABS Channel in Release Too Long</td>
</tr>
<tr>
<td>C1253</td>
<td>Right Front ABS Channel in Release Too Long</td>
</tr>
<tr>
<td>C1254</td>
<td>Rear ABS Channel in Release Too Long</td>
</tr>
<tr>
<td>C1255</td>
<td>EBTCM Malfunction (ABS)</td>
</tr>
<tr>
<td>C1256</td>
<td>Left Front ABS Motor Circuit Open</td>
</tr>
<tr>
<td>C1257</td>
<td>Left Front ABS Motor Circuit Shorted to Gnd</td>
</tr>
<tr>
<td>C1258</td>
<td>Left Front ABS Motor Circuit Shorted to Voltage</td>
</tr>
<tr>
<td>C1261</td>
<td>Right Front ABS Motor Circuit Open</td>
</tr>
<tr>
<td>C1262</td>
<td>Right Front ABS Motor Circuit Shorted to Gnd</td>
</tr>
<tr>
<td>C1263</td>
<td>Right Front ABS Motor Circuit Shorted to Voltage</td>
</tr>
<tr>
<td>C1264</td>
<td>Rear ABS Motor Circuit Open</td>
</tr>
<tr>
<td>C1265</td>
<td>Rear ABS Motor Circuit Shorted to Gnd</td>
</tr>
<tr>
<td>C1266</td>
<td>Rear ABS Motor Circuit Shorted to Voltage</td>
</tr>
<tr>
<td>C1276</td>
<td>Left Solenoid Circuit Open or Shorted to Gnd</td>
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<tr>
<td>C1277</td>
<td>Left Solenoid Circuit Shorted to Voltage</td>
</tr>
<tr>
<td>C1278</td>
<td>Right Solenoid Circuit Open or Shorted to Gnd</td>
</tr>
<tr>
<td>C1281</td>
<td>Right Solenoid Circuit Shorted to Voltage</td>
</tr>
<tr>
<td>C1282</td>
<td>Calibration Malfunction</td>
</tr>
<tr>
<td>C1286</td>
<td>EBCM Turned On Brake Warning Indicator</td>
</tr>
<tr>
<td>C1291</td>
<td>Open Brake Lamp Switch Contacts During Deceleration</td>
</tr>
<tr>
<td>C1292</td>
<td>Open Brake Lamp Switch When ABS Was Required</td>
</tr>
<tr>
<td>C1293</td>
<td>Set in Current or Previous Ignition Cycle</td>
</tr>
<tr>
<td>C1294</td>
<td>Brake Lamp Switch Circuit Always Active</td>
</tr>
<tr>
<td>C1295</td>
<td>Brake Lamp Switch Circuit Open</td>
</tr>
<tr>
<td>U1300</td>
<td>Class 2 Data Link Low in Data Link Comm.</td>
</tr>
<tr>
<td>U1301</td>
<td>Class 2 Data Link High in Data Link Comm.</td>
</tr>
</tbody>
</table>
Exercise A5

Read each question carefully and choose the correct response.

1. In the Delphi Chassis VI Traction Control System (TCS), what circuit does the EBCM use to signal the PCM that a loss of traction is occurring?
   a. Torque reduction
   b. Delivered Torque
   c. Nominal Torque
   d. Serial Data Class 2

2. Which version of the Delphi system uses bi-directional motors to modulate brake pressure?
   a. Delphi Chassis VI
   b. DBC 3
   c. Both Delphi Chassis VI and DBC 3
   d. DBC 7

3. The Delphi Chassis VI version modulates brake hydraulic pressure during antilock braking through the use of:
   a. motors, ball screws and pistons.
   b. solenoid valves and pumps.
   c. motors and pumps.
   d. spool valves and pumps.

4. The expansion spring brakes, in the ABS modulator, are used to hold the hydraulic modulator piston in the "_________" position.
   a. lowest
   b. retracted
   c. home
   d. hold

5. If the EBCM/EBTCM loses power or ground, the amber ABS warning lamp will:
   a. be OFF.
   b. flash.
   c. be ON.
   d. be OFF, along with all instrumentation.
6. The steering control function of the Delphi system provides more power steering assist at _______ vehicle speeds.
   a. lower
   b. higher
   c. constant
   d. normal

7. The Steering Wheel Position Sensor:
   a. mounts on the power rack-and-pinion steering gear.
   b. provides a signal voltage that changes from approx. 0.4 - 4.7 volts as the steering wheel rotates.
   c. mounts in the power steering pump discharge fitting.
   d. has two wires.

8. The EVO solenoid valve varies:
   a. electromagnetic force in the power steering gear.
   b. fluid flow from the power steering gear.
   c. electromagnetic force in the power steering pump.
   d. fluid flow from the power steering pump.

9. During anti-lock conditions, the purpose of the Delphi Chassis VI isolation solenoid is to:
   a. reduce master cylinder pressure to the channel(s).
   b. isolate the master cylinder from the channel(s).
   c. reduce braking pressure at the caliper.
   d. isolate the modulator chamber piston from the caliper.

10. During ABS, in the Delphi Chassis VI system, brake pressure is controlled by movement of the modulator's:
    a. solenoids.
    b. adjuster assembly.
    c. check balls.
    d. pistons.
11. Which of the following is an input for the Delphi ABS/TCS that provides the EBCM with a signal related to a possible brake hydraulic fault?
   a. Wheel Speed Sensor
   b. Stoplamp Switch
   c. Brake Fluid Pressure Sensor
   d. Brake Fluid Level Switch

12. Technician A says that the TCS can control positive wheel slip by applying the brake. Technician B says that positive wheel slip can be controlled by reducing engine torque. Which technician is correct?
   a. Technician A
   b. Technician B
   c. Both Technicians
   d. Neither Technician

13. What would indicate a TCS malfunction?
   a. LOW TRAC lamp illuminated
   b. Intermittent low traction lamps
   c. TCS OFF lamp illuminated
   d. Base brake malfunction

14. The EBTCM cannot command an ABS event unless the electronic brake control relay is:
   a. open.
   b. closed.
   c. enabled by a signal from the TCS.
   d. enabled by a signal from the TIMS.

15. Hydraulic brake pressure for Delphi Chassis VI traction control is provided by the:
   a. poppet valve.
   b. piston.
   c. solenoid.
   d. transfer tube.
16. As vehicle speed increases, current flow to the EVO solenoid ___________.
   a. increases.
   b. decreases.
   c. remains constant.
   d. fluctuates.

17. Which of the following is a feature of the EVO solenoid valve?
   a. It has three wires
   b. The EBCM operates it by providing a reversible power feed and ground
   c. It assists or opposes the torsion bar in the power steering gear
   d. It mounts on the power steering discharge fitting

18. On a TCS equipped vehicle, the repair order states "Intermittent LOW TRAC light." The ABS function is operating normally. What is the condition causing the light?
   a. The TCS modulator is not cycling during ABS stops
   b. The Throttle Adjuster is not functioning during ABS stops
   c. A TCS Diagnostic Trouble Code is stored in memory
   d. This is normal during a TCS event

19. The ECBM will NOT initiate ABS operation if it does NOT have a signal from the:
   a. traction Control Switch.
   b. brake Switch.
   c. cruise Control Switch.
   d. BCM.

20. During ABS pressure HOLD mode, the isolation solenoid is in the ____________ position.
   a. open/energized
   b. open/de-energized
   c. closed/energized
   d. closed/de-energized