SAFETY NOTICE

This publication’s purpose is to provide technical training information to individuals in the automotive trade. All test and repair procedures must be performed in accordance with manufacturer’s service and diagnostic manuals. All **warnings**, **cautions**, and **notes** must be observed for safety reasons. The following is a list of general guidelines:

- Proper service and repair is critical to the safe, reliable operation of all motor vehicles.
- The information in this publication has been developed for service personnel, and can help when diagnosing and performing vehicle repairs.
- Some service procedures require the use of special tools. These special tools must be used as recommended throughout this Technical Training Publication, the diagnostic manual, and the service manual.
- Special attention should be exercised when working with spring- or tension-loaded fasteners and devices such as E-Clips, Cir-clips, snap rings, etc. Careless removal may cause personal injury.
- Always wear safety goggles when working on vehicles or vehicle components.
- Improper service methods may damage the vehicle or render it unsafe.
- Observe all **warnings** to avoid the risk of personal injury.
- Observe all **cautions** to avoid damage to equipment and vehicles.
- **Notes** are intended to add clarity and should help make your job easier.

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Vehicle Communication System Diagnosis
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INTRODUCTION

This course is designed to introduce dealership technicians to the diagnostic concepts of vehicle communication networks. The course design allows students to develop the skills needed to perform accurate and timely repairs using the proper diagnostic tools. At the end of class, technicians will have the opportunity to demonstrate their level of understanding of the following objectives by diagnosing a vehicle with a communication fault.

COURSE OBJECTIVES

After completing this course, the technician will be able to:

• Configure the network systems—build configuration and PROCSI
• Diagnose a loss of communication with scan tool fault
• Diagnose hub and star network design communication circuits
• Diagnose daisy chain network design communication circuits
• Diagnose stub network design communication circuits
• Diagnose a single-wire design network communication system circuit
# ACRONYMS

The following is a list of acronyms used throughout this publication:

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACK</td>
<td>ACKnowledgement</td>
</tr>
<tr>
<td>BCM</td>
<td>Body Control Module</td>
</tr>
<tr>
<td>BSM</td>
<td>Braking System Module</td>
</tr>
<tr>
<td>CAN</td>
<td>Control Area Network</td>
</tr>
<tr>
<td>CKP</td>
<td>CranK Position sensor</td>
</tr>
<tr>
<td>CRC</td>
<td>Cyclic Redundancy Check</td>
</tr>
<tr>
<td>CTM</td>
<td>Convergence Telematics Module</td>
</tr>
<tr>
<td>DLC</td>
<td>Data Link Connector</td>
</tr>
<tr>
<td>DMM</td>
<td>Digital Multi Meter</td>
</tr>
<tr>
<td>DNA</td>
<td>Dynamic/Natural/All-weather (driving mode selector for Alfa Romeo)</td>
</tr>
<tr>
<td>DTC</td>
<td>Diagnostic Trouble Code</td>
</tr>
<tr>
<td>EPS</td>
<td>Electric Power Steering</td>
</tr>
<tr>
<td>ECC</td>
<td>Electronic Climate Control</td>
</tr>
<tr>
<td>ECM</td>
<td>Engine Control Module</td>
</tr>
<tr>
<td>ECT</td>
<td>Engine Coolant Temperature</td>
</tr>
<tr>
<td>ECU</td>
<td>Electronic Control Unit</td>
</tr>
<tr>
<td>EOF</td>
<td>End Of Frame</td>
</tr>
<tr>
<td>ESM</td>
<td>Electronic Shifter Module</td>
</tr>
<tr>
<td>HaLF</td>
<td>Haptic Lane Feedback</td>
</tr>
<tr>
<td>IPC</td>
<td>Instrument Panel Cluster</td>
</tr>
<tr>
<td>KBPS</td>
<td>Kilo Bits Per Second</td>
</tr>
<tr>
<td>LIN</td>
<td>Local Interconnect Network</td>
</tr>
<tr>
<td>OBDII</td>
<td>On-Board Diagnostic II</td>
</tr>
<tr>
<td>OL</td>
<td>Out of Limit</td>
</tr>
<tr>
<td>ORC</td>
<td>Occupant Restraint Controller</td>
</tr>
<tr>
<td>PAM</td>
<td>Parking Aid Module</td>
</tr>
<tr>
<td>PCM</td>
<td>Powertrain Control Module</td>
</tr>
<tr>
<td>PROCSI</td>
<td>PROgramming and Configuration of Systems Integrated</td>
</tr>
<tr>
<td>PTS</td>
<td>ParkTronic System</td>
</tr>
<tr>
<td>RCU</td>
<td>Roof Control Unit</td>
</tr>
<tr>
<td>RRM</td>
<td>Radio Receiver Module</td>
</tr>
<tr>
<td>SDM</td>
<td>Sensing Diagnostic Module</td>
</tr>
<tr>
<td>SOF</td>
<td>Start Of Frame</td>
</tr>
<tr>
<td>TTM</td>
<td>Trailer Tow Module</td>
</tr>
<tr>
<td>YRS</td>
<td>Yaw Rate Sensor</td>
</tr>
</tbody>
</table>
Notes:

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LESSON 1  INTRODUCTION TO VEHICLE COMMUNICATIONS SYSTEMS

TYPES OF COMMUNICATION NETWORKS
The way the modules are connected on the network is called the network architecture. The physical layout of the network can determine how certain modules communicate when a wiring fault is present and how the scan tool accesses each module.

Table 1  Network Architectures

<table>
<thead>
<tr>
<th>Network Type</th>
<th>Stub</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Name</td>
<td>CAN-C</td>
<td>CAN-B</td>
<td>CAN-IHS</td>
<td>CAN-A/T</td>
<td>DIAGNOSTIC CAN-C</td>
</tr>
<tr>
<td>Network Speed</td>
<td>500 KBPS</td>
<td>83.3 KBPS</td>
<td>125 KBPS</td>
<td>125 KBPS</td>
<td>500 KBPS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Network Type</th>
<th>Hub</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Name</td>
<td>STAR CAN-C</td>
<td>STAR CAN-IHS</td>
<td>BCM CAN-B</td>
<td></td>
</tr>
<tr>
<td>Network Speed</td>
<td>500 KBPS</td>
<td>125 KBPS</td>
<td>50 KBPS</td>
<td></td>
</tr>
<tr>
<td>Model Year Range</td>
<td>2011 - current</td>
<td>2011 - current</td>
<td>2012 - current</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Network Type</th>
<th>Daisy Chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Name</td>
<td>CAN-C</td>
</tr>
<tr>
<td>Network Speed</td>
<td>500 KBPS</td>
</tr>
<tr>
<td>Model Year Range</td>
<td>2012 - Current</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Network Type</th>
<th>Stub/Daisy Chain Hybrid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Name</td>
<td>CAN-C1 CAN-C2 CAN-BH</td>
</tr>
<tr>
<td>Network Speed</td>
<td>500 KBPS 500 KBPS 125 KBPS</td>
</tr>
<tr>
<td>Model Year Range</td>
<td>2015 - ____ 2015 - ____ 2015 - ____</td>
</tr>
</tbody>
</table>
Not all communication networks are designed the same. The way modules are placed on the network, how fast the network can share information, and how the modules and scan tools communicate over the network can vary from one network to another. Understanding the key concepts of how a network is constructed, what it is used for, and how each module interacts with the scan tool will aid in diagnosing concerns.

Architecture is also determined by whether a network is composed of a single wire or a twisted-pair of wires. Networks using single- or twisted-pair wiring can be laid out in many configurations.
The stub network design connects all modules to a main trunk line that runs throughout the vehicle. Each module has a short stub that connects to the main trunk. Stub is considered to be the traditional CAN bus network architecture and is found on Chrysler’s first CAN bus equipped vehicles.
The hub-style network configuration connects all the modules through a parallel circuit in a centrally located bus bar. The central connection point is located inside a module. When a module is used as the hub, they are typically spread out across multiple connectors. The hub-style network operates independently from the internal electronics of the module in which it is located. As long as the connector is seated, the network can communicate even if the module is not functional.
Introduction to Vehicle Communications Systems

Star Network Configurations

The star-style network configuration is a subset of the hub-type network. The star is unique because it uses a connector as the central bus bar instead of a module. When a connector is used as the bus bar, each individual module is connected through a dedicated connector.

Star networks can have one or more connectors in an individual network. Star connectors use a separate ground wire to isolate electrical interference or noise.
Daisy Chain Network Configurations

In the daisy chain network configuration, modules are laid out in a series running from one module to the next. The connection inside each module is done in a parallel circuit so that each operates independently from the internal electronics of the module in which it is located. As long as the communication circuit connections are complete, the network can communicate even if an individual module is not functional.
Figure 6  Single-wire Communication Networks

The single-wire network configuration places each module in-line with the main module. The main module is central to the local interconnect network (LIN) bus system. All LIN modules connect to a main module through the LIN bus circuit. The main module is also wired to a CAN bus for information sharing and to allow for scan tool diagnosis.
The fundamental way modules communicate is through voltage pulses. Modules are capable of both transmitting and receiving voltage pulses. These voltage pulses are regulated in frequency, then combined in a series and used to represent a specific piece of information, either a unit of measure from a sensor, or a command for a control device. A module on a communication network is exposed to every signal sent by all the other modules, but can sort out which signals to use and which to disregard.

Each module on the network monitors the input sensors and output actuators for a fault. If a fault occurs with a particular input or output, the module that is hard-wired to that particular device may be designed to detect it and set a diagnostic trouble code (DTC) as a result. These DTCs can be accessed via the communication network, using a specialized scan tool.
For a vehicle communication system to operate normally, certain physical components must be present. Different communication systems may have different components with different operating characteristics, but the basic components are still necessary.

For a vehicle communication network to exist, at least two modules must be present. Most modern vehicle communication networks consist of more than two modules. Depending on the network type, approximately 5–30 modules are found on current communication networks.

For proper communication to occur, each of these modules must have adequate power, ground, and bus.
Some vehicles use a dedicated bus for either scan tool diagnostics or for a dedicated connection from one module to another.

TIPM-based vehicles use a Diagnostic CAN-C bus to connect the DLC to the gateway module. This network has no bearing on vehicle operation. It is only used for diagnostics with the vehicle. In this scenario, all commands and data shared between modules and the scan tool must travel through the gateway module.

Vehicles equipped with a Body Control Module (BCM), connect each module directly to the DLC for scan tool diagnostics. The BCM may be required to identify the vehicle in order to begin a diagnostic session. However, once the session has initiated, the scan tool communicates directly with each module on the bus. Depending on the vehicle, the scan tool communicates with the BCM over different networks. Refer to service information to determine which network the BCM uses to communicate with the scan tool.

Dedicated CAN busses can be found on most vehicles and are typically a Class C network. They can be used for a direct communication line between an ABS module and a vehicle dynamics sensor, or from a Cummins dosing control unit (DCU) to a powertrain control module (PCM).
ACTIVITY 1  DIAGNOSE USING WIRING DIAGRAMS

TASK ONE: SERVICE INFORMATION DIAGNOSIS

1. What vehicle is assigned by your instructor (Year/Model/VIN)?

2. According to service information, how many CAN bus networks are on the assigned vehicle?
   a. What are they?
   b. What type of bus configuration are they (Stub, Hub, Star, Daisy Chain)?

3. According to the System Operation page of the Communication section in service information, which modules are dominant on the car?

4. According to service information, how many LIN bus networks are on the assigned vehicle?
   a. Which CAN modules use one or more LIN busses?

Instructions: Connect the scan tool to the assigned vehicle and answer the following questions.

5. According to the network topology screen, what separates the different CAN networks?

6. According to the network topology screen, is the DLC connected directly to the busses or to a module?

7. Do any of the LIN busses on the vehicle appear on the network topology screen?
TASK TWO: IDENTIFY THE MODULES ON EACH CAN BUS

Instructions: Record the VIN of the vehicle in the classroom. Use service information to complete the following steps.

1. What are the steps required to access the wiring diagrams for this particular vehicle?

2. According to the wiring diagrams, list all modules connected to the CAN-C bus.

3. According to the wiring diagrams, list all modules connected to the CAN-B bus.

Instructions: Connect the scan tool to the vehicle and answer the following questions.

4. What modules appear on the CAN-C bus?

5. What modules appear on the CAN-B bus?

6. Are there any modules equipped on the vehicle (according to wiring diagrams) that are not displayed on the scan tool topology screen?
   a. If yes, what module(s) and why?
DEMONSTRATION 1  DIAGNOSE A CAN BUS FAULT

PART ONE: DIAGNOSE A NO-SYMPTOM FAULT

Instructions: The vehicle came into the dealership for routine maintenance. When the scan tool is connected it will not communicate with the vehicle. Using the scan tool, DMM, and the CH7002 DLC break-out-box, diagnose the concern.

1. Install the CH7002 DLC break-out-box and the scan tool; attempt to communicate with the vehicle.
   a. Will the scan tool communicate with the vehicle?

2. Does the LED indicate that there is power and ground from the DLC?
   a. Does the vehicle exhibit any symptoms of a fault?
   b. With the scan tool connected, will the engine start?

3. Using the DMM and breakout box, record the CAN-C bus voltages.

<table>
<thead>
<tr>
<th>Breakout Box</th>
<th>CAN Bus</th>
<th>Scan Tool Connected</th>
<th>Scan Tool Disconnected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 6</td>
<td>CAN-C (+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pin 14</td>
<td>CAN-C (-)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Why does the voltage change when the scan tool is connected?
5. What do the voltage measurements without the scan tool connected indicate about the CAN-C bus?

6. What would you do next to verify the cause of the concern?

PART TWO: DIAGNOSE A NO-COMMUNICATION CONCERN

1. Connect the scan tool.

2. Remove the fuse powering the radio.
   
   a. What concern would the customer have if this power feed was open?

   b. Can the radio communicate with the scan tool?

3. Replace the fuse and disconnect the bus wires from the star connector.
   
   a. What concern would the customer have if the bus wires were open?

   b. Can the radio communicate with the scan tool?

4. List the steps that should be taken to diagnose a vehicle with these symptoms, when it arrives at the dealership.
Lesson 2 Build Configuration

Vehicle Build Configuration

To support service replacement of modules using (plug and play) programming, a registry of the vehicle’s modules and options are stored in the TIPM or BCM. This information is known as the vehicle build configuration. This is important when servicing the TIPM or BCM. A special procedure must be followed to ensure the proper vehicle build configuration is entered into the new TIPM or BCM. If a fault occurs with the programming of this module, certain communication errors can occur that may seem to point toward a module failure. Ensure proper programming when replacing a TIPM or BCM to prevent this concern.

A backup copy of vehicle build configuration is stored in another module which can vary by model; refer to the description and operation section of service information for the vehicle being serviced.
Build Configuration

Types of Build Configuration

FCA Group vehicles use one of two types of build configuration. TIPM- and Powernet-based vehicles use “Vehicle Build Configuration” and Compact US Wide-based vehicles use “PROCSI”.

**Programming and Configuration of Systems (Electronic) Integrated (PROCSI)**

The PROCSI build configuration (contained in the BCM) includes the purchased vehicle content and legally required operating features based on the region in which it is sold. During vehicle assembly, an end of line (EOL) tester, the manufacturing version of the scan tool, sends the PROCSI file to all electronic control units (ECUs) that require configuration. The PROCSI message contains specific programming instructions for each module on CAN-IHS and CAN-C. The behavior of each module is determined by its portion of the PROCSI message.

For example, on the Dodge Dart, PROCSI configuration is used by all of the modules on CAN-IHS except the integrated center stack (ICS). PROCSI configuration is used on all CAN-C modules except the steering column control module (SCCM), gear shift module (GSM), and the powertrain control module (PCM) for the 1.4L engine.

Whether or not a module will require PROCSI configuration is determined close to vehicle launch based on such factors as standard equipment level and vehicle regulations in the countries in which it will be sold. Refer to service information to determine which modules require PROCSI configuration during service.
Each time the ignition key is cycled to the ON position, the BCM sends a message to all PROCSI-configured modules on the vehicle. Each module will respond to the message with its configuration code. The configuration code includes a cyclic redundancy check (CRC). The BCM uses the configuration code to verify that each module is configured correctly. If a module does not respond, or responds with the incorrect CRC, a DTC is set. After three key cycles, the BCM sends a message to the IPC which commands the odometer to flash.

When a PROCSI-configured module is replaced, the technician must program the new module with the scan tool. The scan tool reads the information from the BCM PROCSI file and writes it to the new module. There is no limit to the number of times a PROCSI module can be configured. However, modules such as the radio frequency hub can only be programmed once (for security reasons).
**Build Configuration**

During normal operation, on TIPM-based vehicles, the CGW sends the vehicle build configuration data to all modules every two seconds, providing that the current vehicle information number (VIN) data in the PCM matches the stored VIN in the CGW.

If the CGW module is replaced, the new module can learn the vehicle build configuration from the backup module. When a replacement CGW is initially installed, it requires VIN programming. If the current VIN broadcast from the PCM matches the original VIN in the backup module, the backup vehicle build configuration data is programmed into the replacement CGW.

**WARNING:** BECAUSE THE VEHICLE BUILD CONFIGURATION FUNCTION DEPENDS ON THE VIN, AVOID SWAPPING MODULES BETWEEN TIPM- OR POWERNET- BASED (NON-PROCSI) VEHICLES. SWAPPING MODULES FROM DIFFERENT VEHICLES FOR TEST PURPOSES COULD RESULT IN THE LOSS OF THE VEHICLE BUILD CONFIGURATION, RENDERING THE VEHICLE AND THE DONOR VEHICLE INOPERATIVE.

![Vehicle Scan Report](image-url)
Performing a PROCSI Alignment

There are two different PROCSI related procedures in the scan tool that need to be performed during various conditions.

PROCSI Alignment

When a module is replaced on a vehicle, if that module relies on PROCSI, a PROCSI alignment must be performed. This procedure sends the PROCSI file, which contains vehicle options and programming from the BCM to the new module.

BCM Replaced

When the BCM is replaced, a master copy of all configuration items must be sent to the new BCM from DealerCONNECT.
A single VIN inquiry can be run using DealerCONNECT to see the complete list of options equipped on a particular vehicle. In order to run a single VIN inquiry, the last eight digits of the VIN and the vehicle’s mileage must be obtained.

This report shows much more information than just the equipped options, such as warranty coverages, owner information, open recalls/TSB’s, as well as much more.
MODIFYING BUILD CONFIGURATION

From time to time, the build configuration may need to be modified in order to add or remove certain options and accessories to a vehicle after it has arrived at the dealership. The build configuration can only be changed in DealerCONNECT by someone with the proper access rights. Once modified in DealerCONNECT, after a brief (approximately one hour) time, the build configuration can be restored/re-aligned using the scan tool, which will “turn on/off” the affected features.

Added features, such as remote start or towing packages will not function until the vehicle’s build configuration has been updated.
ACTIVITY 2 BUILD CONFIGURATION AND PROCSI

TASK ONE: IDENTIFY BUILD CONFIGURATION

Instructions: Connect the scan tool to the classroom vehicle and answer the following questions.

1. Select a module on the CAN network. Navigate to the Configuration tab.
2. What are the top three configuration items listed in the module?

<table>
<thead>
<tr>
<th>Configuration Item</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

3. According to the build configuration, what type of seat belt pretensioner is the classroom vehicle equipped with?

4. Is it possible to change the configuration status of any of the configured items from the configuration screen?

   a. If not, how is build configuration modified?

   __________________________

   __________________________

   __________________________
Build Configuration and PROCSI

TASK TWO: IDENTIFY PROCSI MODULES

Instructions: Connect the scan tool to the classroom vehicle and answer the following questions.

1. Where is the PROCSI alignment procedure found?

2. According to the PROCSI alignment procedure, which modules use PROCSI?

3. According to the PROCSI alignment procedure, do any modules on the classroom vehicle require a PROCSI alignment to be run?

4. What would cause a PROCSI alignment to be required?

5. What are the symptoms of a non-PROSCI aligned module in a vehicle?

6. What procedure must be performed if the BCM is replaced?
   a. Other than a BCM replacement, when would this procedure need to be performed?
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LESSON 3 DIAGNOSE STUB NETWORKS

CHARACTERISTICS OF A STUB NETWORK

<table>
<thead>
<tr>
<th></th>
<th>Diagnostic CAN-C</th>
<th></th>
<th>CAN-IHS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CAN-C</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 17 Stub Network Topology

Stub networks use a main trunk line running throughout the vehicle, which all other modules connect to, through individual branches. Each individual branch must not be longer than 1 meter (3.3 feet). Each branch connects to the main trunk line through either a splice, connector, or junction block. The trunk line can have multiple connection points throughout the harness and can connect to one or several modules at each point.

Stub networks are considered to be the traditional CAN bus architecture and have been used for many years. Stub networks are used across many FCA platforms and can support CAN-C, CAN-IHS, CAN-A/T, and CAN-B networks.

A gateway module is used to link together the various communication networks on the vehicle.
**BUS BIAS**

Each CAN bus module can bias the network. This means the module will determine the voltage, and change in voltage, transmitted on the bus wires. Keep in mind there are many modules wired in to the network. Arbitration allows for all modules to share information in an orderly manner. Modules with messages deemed highly important take priority.

<table>
<thead>
<tr>
<th></th>
<th>CAN (+)</th>
<th>5</th>
<th>CAN (-)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Dominant State</td>
<td>6</td>
<td>Recessive State</td>
</tr>
<tr>
<td>3</td>
<td>Voltage Difference</td>
<td>7</td>
<td>Bus Bias Voltage</td>
</tr>
<tr>
<td>4</td>
<td>Recessive State</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

With the exception of CAN-B, stub network CAN busses are biased at 2.5 volts. The voltage on each circuit fluctuates 1.0 volt during communication. The voltage on CAN (+) goes from 2.5 to 3.5 volts and the voltage on CAN (-) goes from 2.5 volts to 1.5 volts.

CAN (+) and (-) appear as a mirror image when viewed in real-time with an oscilloscope.

These actual voltages can only be seen using an oscilloscope. DMMs average the readings. When using a DMM, normal voltage levels on CAN (+) are approximately 2.5V to 2.7V, and on CAN (-) are approximately 2.5V to 2.3V. Minor fluctuations on the meter display indicate a bus that has communication occurring.

**NOTE:** Adding aftermarket modules, such as the MOPAR electronic vehicle tracking system (EVTS) or other data logger may have an effect on the bus voltage.
The CAN-B bus may be active whether the ignition is in the ON or OFF position and voltages can be measured as long as the modules on the network are awake. Voltages on the CAN-B network will be different from the other CAN networks found on FCA Group vehicles. Similar to other networks, CAN-B modules provide their own bias, allowing them to alter the bus voltages.

<table>
<thead>
<tr>
<th></th>
<th>CAN (+) Dynamic Range, Dominant State</th>
<th>4</th>
<th>Bus Voltage Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>CAN (-) Dynamic Range, Dominant State</td>
<td>5</td>
<td>CAN (-) Recessive State</td>
</tr>
<tr>
<td>3</td>
<td>CAN (+) Recessive State</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 19  CAN-B Bus Voltages

While other stub networks operate on a 2.5 volt bias, CAN-B operates on a 5 volt bias. CAN-B (+) is normally at 0.5 volts and is pulled high, to 4.5 volts during communication. CAN-B (-) is normally at 4.5 volts and is pulled low, to 0.5 volts during communication.

Just like other CAN networks, CAN-B (+) and (-) appear as a mirror image when viewed in real-time with an oscilloscope.

When measuring CAN-B bus voltage with a DMM, the approximate voltage for CAN (+) is 0.5V–1.0V and 4.0V–4.5V for CAN (-).

**NOTE:** Actual voltages can only be seen using an oscilloscope. DMMs average the readings.
Diagnose Stub Networks

FAULT TOLERANCE

The majority of stub networks are not fault tolerant (CAN-B is highly fault tolerant and will be discussed separately). The majority of faults result in a complete loss of communication with the entire network. One of the first steps in proper diagnosis is identifying what type of fault is present. Lost time and improper repairs may result if the concern is not properly verified and identified.

Whenever a communication network fault is suspected, the first step is to connect the scan tool and check for communication and U-codes. If communication cannot be established, or an entire network is non-responsive, use a DMM to determine the cause. Bus voltage can be measured anywhere on the network. This includes in-line connectors, module connectors, and the DLC (on certain models only). For this reason, during initial diagnosis, measurements should be taken at the easiest-to-access location.

Figure 20 No Communication with Scan Tool
Fault Symptoms and Diagnosis

When faults occur on CAN bus circuits, such as a short to ground or short to power, the vehicle will exhibit various symptoms based on which network is affected. For example, if the CAN-C network is shorted to ground, the vehicle will experience a no crank/no start with the MIL illuminated. U-codes may be found in any but not all of the modules on the bus.

If either CAN (+) or CAN (-) is shorted to ground, voltage, or together at any place in the circuit, communication is not possible. When an open occurs in the circuit, any module downstream of the open will not communicate. It is possible for a module to fail, resulting in loss of communication with that particular module. If internally shorted, a module fault may bring the whole network down, resulting in no communication on the entire CAN network. If this type of concern occurs, typically the network will begin to communicate normally if the faulty module is disconnected. Remember to verify power and ground, as well as connector faults, before replacing any module.

SHORT CIRCUIT DIAGNOSIS

After determining a short to power, ground, or across the bus wires is the cause of a loss of communication, the location of the short must be determined.

Short to Power

To locate a short to power, begin by removing fuses, one at a time, while monitoring the bus voltage with a DMM, or viewing the network topology on the scan tool. Once the fuse that is providing power to the short is removed, the bus voltage and communication should return to normal.

Next, determine if it is a module causing the short. If the fuse provides power to a module, reinstall the fuse and unplug the module. If the short goes away, the issue is in the module.

If the fuse is powering a component other than a module, use wiring diagrams to determine any similar locations in the wiring harness between the component in question and bus circuitry.

Short to Ground and Cross-Short (Bus + to -)

To locate a short to ground or a cross short, begin by separating the main trunk line of the bus using any in-line connectors. A connector in the middle of the bus will speed up diagnosis. Once the shorted section of the network is determined, unplug modules one at a time to determine if the cause of the short is a faulty module. If all modules have been unplugged and the short has not gone away, unplug in-line connectors until the shorted harness is found.
Networks may experience data corruption as data is transferred. Message corruption faults exhibit unique symptoms. If corruption occurs, the network can still communicate. However, the communication will be erratic. The topology screen on the scan tool can aid in detecting and isolating network corruption. The topology view shows the affected modules. Corruption may cause the network modules to flash between yellow and red, indicating intermittent communication. If a module stays red (not communicating) and does not flash, suspect a concern with the module, the module connectors, or the network circuits leading up to the module.

The list below includes some common causes of message corruption:

- An open circuit on either the CAN (+) or CAN (-) circuit can cause message corruption. When a module attempts to communicate over only one wire, the partial message interferes with normal messages being sent out by other modules.

- Failed modules may produce message corruption. When a module fails, it may attempt to communicate (bias) on only one CAN circuit, (+) or (-), causing corruption.

- Electromagnetic interference (EMI) can cause message corruption due to stray voltages from high-voltage magnetic fields or untwisted communication wires.
FAULT TOLERANCE (CAN-B)

As mentioned previously, CAN B is highly fault tolerant. Most of the modules used on CAN-B are able to detect abnormal conditions, such as one of the bus circuits to ground or shorted to power, or detect if the bus circuits are shorted together or open. When this occurs, the CAN-B module switches the communication to an alternative path and continues to operate in a state called single-wire mode.

For example, if the two bus wires become shorted together, the CAN-B module uses the two circuits shorted together as one path and the vehicle chassis as the other. As long as one of the circuits has a potential difference from vehicle ground or battery voltage, CAN-B will continue to operate normally. The communication then continues but a fault (U-code DTC) is likely to be set.

Since the bus speed of CAN-B is much slower than that of the other networks, single-wire communication is possible during a fault. Modules on the CAN-B network have the capability to turn off one of the CAN circuits.

When an open circuit occurs on both CAN (+) and CAN (-), any module downstream of the open will not communicate, but others will continue to operate normally. If both circuits have a short, then communication will be lost.
SLEEP STRATEGY

Sleep strategy and voltage levels vary with network classification and follow the same grouping as bus bias. As modules enter sleep mode, voltage levels move to their sleep position gradually. This can be seen with a DMM.

**Figure 22  Typical CAN Sleep Mode Voltage**

In sleep mode, voltage on CAN-B (+) goes to 0.0 v and CAN-B (-) goes to approximately battery voltage. Voltage on both bus (+) and (-) circuits of most other CAN networks drop to 0.0 v during sleep mode.
TERMINATION RESISTANCE

Figure 23 Termination Resistance

Stub networks have terminating resistors wired parallel in the circuit. Termination resistance allows for CAN (+) and CAN (-) circuit voltages to pull in different directions as well as absorb any stray voltage spikes throughout the network, preventing network signal interference. For most stub networks, optimal bus termination resistance is 60 ohms (although CAN-B is a little higher). This is often achieved using two 120-ohm resistors located inside dominant network modules, which are located at either end of the bus. Diagnostic CAN-C uses a single 60-ohm resistor inside the gateway module (TIPM).

Non-dominant modules on some vehicles have internal resistance, ranging from 2.8–43 kilo-ohms, but this resistance is part of the modules’ data transmit/receive processors, and is not used to stabilize the network. A non-dominant module with this resistance will have an effect on the total network resistance when measured with a DMM. Because this is a parallel circuit, each resistor that is added will lower the overall circuit resistance.

NOTE: Adding aftermarket modules, such as the MOPAR electronic vehicle tracking system (EVTS) or other data logger may have an effect on the bus’ total termination resistance.
Termination resistance can be measured at any point on the bus. This test should be first performed at the easiest point of access in the system (along with measuring voltage). In a stub network, this is usually at a module.

Termination resistance cannot be measured on CAN-B because bus (+) is connected to bus (-) through electronics that open the circuit when power is removed from the module (a necessary step in measuring bus resistance).
When a dominant module is disconnected from the bus, the termination resistance reading will increase to approximately 120 ohms.

It can be difficult to diagnose the location of an open circuit on a stub network because voltage is present as long as one module is connected to the bus. For this reason, an ohmmeter must be used to diagnose an open circuit on most stub busses.

Diagnosing an open circuit on a stub-style CAN-B network must be done with the assistance of the scan tool.
To isolate the location of an open circuit, use a jumper wire to short bus (+) to (-) at each module. For example, in the image above, if the bus is shorted at the ORC, the reading on the ohmmeter will not change. If the short is moved to the SAS, the ohmmeter will read close to zero ohms. This indicates the open is between the ORC and the SAS.
If a fault is suspected on a single CAN-B circuit, begin by using the scan tool to view the topology screen. One at a time, short CAN (+) to ground, then short CAN (-) to ground. If both circuits are good, shorting one circuit at a time will result in no loss of communication. If one circuit on the bus is open, the module with the open leg will go down when the good circuit is shorted to ground. Single-wire mode operation will continue as long as one circuit on the hub style network is intact with no opens, shorts, or other concerns. The vehicle and all the systems will continue to operate without any fault symptoms or customer concerns.
Although this lesson focuses primarily on stub networks, many of the operating characteristics of the individual modules (bias, termination resistance, sleep mode, fault tolerance) apply to other communication networks within the same classification. For example, stub CAN-IHS and star CAN-IHS operate the same but have different diagnostic methods due to their unique wiring layout. This is also true for stub CAN-B and hub CAN-B, etc.

Individual networks may contain combinations of different architectures. For example, a CAN-C bus may use both stub and daisy chain architectures in order to connect all modules.
Diagnose Stub Networks

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PART ONE: DIAGNOSTIC CAN-C VOLTAGE MEASUREMENTS

Instructions: Using a DMM, measure the Diagnostic CAN-C bus voltage in all modes.

1. List all networks connected to the data link connector (DLC).

2. In the table below, record the voltages on the bus with the ignition OFF and the bus in sleep mode; then record the voltages with the ignition ON and bus active.

<table>
<thead>
<tr>
<th>Circuit Name</th>
<th>Ignition OFF (Sleep Mode)</th>
<th>Ignition ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnostic CAN-C (+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnostic CAN-C (-)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. With the bus in sleep mode, cycle the ignition ON and OFF.
   a. Does the bus wake up and become active? (Yes/No)

4. With the bus in sleep mode, open and close the passenger door.
   a. Does the bus wake up and become active? (Yes/No)

5. With the bus in sleep mode, lock and unlock the doors using the key FOB or FOBIK.
   a. Does the bus wake up and become active? (Yes/No)

6. Can a voltmeter be used to determine when a bus has entered sleep mode? (Yes/No)

7. Why is it important to recognize when the bus enters sleep mode?
PART TWO: DIAGNOSTIC CAN-C RESISTANCE MEASUREMENTS

Instructions: Measure the termination resistance of the Diagnostic CAN-C bus.
1. Disconnect the battery.
2. Measure the resistance between Diagnostic CAN-C (+) and (-) circuits.
   a. Record your results.

3. Can the termination resistance of the Diagnostic CAN-C bus be measured? (Yes/No)
   a. Explain your answer.

Instructions: Test the Diagnostic CAN-C (+) and (-) circuits for a short to ground.
4. Measure the resistance between Diagnostic CAN-C (+) and chassis ground and record the results.

5. Measure the resistance between Diagnostic CAN-C and chassis ground and record the results.

6. Reconnect the battery.
Notes:
ACTIVITY 3 DIAGNOSE A STUB NETWORK FAULT

Instructions: The vehicle will not start. Diagnose the cause of the concern

1. What should you do to diagnose this condition?

   a. Are there any modules that are not communicating on the bus?

   b. If yes, which modules are not communicating?

2. Using a DMM, measure and record the bus readings to complete the charts below.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on CAN-IHS (+)</td>
<td></td>
</tr>
<tr>
<td>Voltage on CAN-IHS (-)</td>
<td></td>
</tr>
</tbody>
</table>

3. Disconnect the battery and perform the resistance checks on the network.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termination Resistance</td>
<td></td>
</tr>
<tr>
<td>CAN (+) Resistance to Ground</td>
<td></td>
</tr>
<tr>
<td>CAN (-) Resistance to Ground</td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the voltage measurements taken in the previous step, answer the following questions.

   a. Is there a short to ground? (Yes/No)

   b. Is there a short to power? (Yes/No)

   c. Are the circuits shorted together? (Yes/No)

   d. Is there an open circuit? (Yes/No)
Diagnose a Stub Network Fault

5. Based on the DMM measurements taken in the previous step, what is the most likely cause for this concern?

   a. How would you isolate the fault to narrow down where to begin looking?

6. What is the circuit ID or component responsible for the cause of this concern?
LESSON 4 DIAGNOSE DAISY CHAIN NETWORKS

CHARACTERISTICS OF A DAISY CHAIN NETWORK

Daisy Chain Network Components

The daisy chain bus architecture is configured in a series-type layout, however, each module is connected in parallel to the bus. Parallel connections are established to the bus within each module, not the connector. For this reason, multiple modules will lose communication if one is disconnected.

Modules that lose communication with the vehicle due to loss of power, ground, or internal failure will not prevent other modules from communicating.
Diagnose Daisy Chain Networks

OPERATING CHARACTERISTICS

<table>
<thead>
<tr>
<th></th>
<th>Daisy Chain CAN-C</th>
<th>2</th>
<th>Stub Network CAN-C</th>
</tr>
</thead>
</table>

Figure 30 Stub Vs. Daisy Chain

Bias
Bus bias does not change based on network architecture. For more information on bus bias for a particular vehicle or network, review the associated section in the lesson on stub networks and the description and operation sections of service information.

Sleep
CAN bus sleep strategy does not change based on network architecture. For more information on sleep strategy for a particular vehicle or network, review the associated section in the lesson on stub networks and the description and operation sections of service information.

Fault Tolerance
A network’s level of fault tolerance does not change based on network architecture. For more information on fault tolerance for a particular vehicle or network, review the associated section in the lesson on stub networks and the description and operation sections of service information.

Network Corruption
Daisy chain networks will suffer from corruption similarly to other network styles and should be diagnosed according to the procedures laid out in the stub networks lesson.
Similarly to other configurations, modules on a daisy chain network are wired in parallel with two 120-ohm resistors. A daisy chain bus utilizes a dominant module at both ends of the bus to establish the optimal amount of termination resistance. Non-dominant modules typically contain 42K ohms so that they do not have a great impact on total termination resistance.
Because of the layout of the daisy chain network, a single non-communicating module in the middle of the bus can be attributed to a loss of power or ground, or an internal failure and is not the result of an open or shorted bus circuit.

**Short Circuit Diagnosis**

A unique characteristic for the daisy chain configuration is that when an open circuit is present in either of the bus circuits, multiple modules will be affected. The only exception to this is the last module on the bus; in which case there are no other modules that rely on the throughput circuitry to connect to the bus. However, since the module on the end is a dominant module, total network communication may be affected.

As with other networks, when a short is present anywhere on the bus, the entire network will lose communication.

To diagnose a total loss of communication on a daisy chain network, begin by measuring voltage and resistance at either end of the bus (the DLC is usually the easiest access point) to determine if the cause is a short to power, ground, or if the bus is cross-shorted. The next step is to disconnect modules on the bus, one at a time, while monitoring circuit voltage with a DMM, in order to isolate the location of the short. Begin with a module in the middle of the network in order to speed up diagnosis. Continue to disconnect modules until the root cause of the fault is found. Causes of short circuits can be in the wiring, connectors, or internally shorted modules.
As mentioned in previous lessons, some networks use a combination of layouts. Combination networks can, at first, appear confusing and intimidating. However, when diagnosing a communication fault, techniques discussed throughout this course for each particular network design can be used in synch.
For instance, if CAN-C1 is found to have a short to ground, disconnect the daisy chain modules to isolate the faulty section of the bus. Once isolated to a particular section, continue with a standard stub network diagnosis until the faulty module, wiring, or connector is found.
Diagnose Daisy Chain Networks

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PART ONE: CAN-C VOLTAGE MEASUREMENTS

Instructions: Using a DMM, measure the CAN-C bus voltage in all modes.

1. List all networks connected to the data link connector (DLC).

2. In the table below, record the voltages on the bus with the ignition OFF and the bus in sleep mode; then record the voltages with the ignition ON and bus active.

<table>
<thead>
<tr>
<th>Circuit Name</th>
<th>Ignition OFF (Sleep Mode)</th>
<th>Ignition ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN-C (+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAN-C (-)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. With the bus in sleep mode, cycle the ignition ON and OFF.
   a. Does the bus wake up and become active? (Yes/No)

4. With the bus in sleep mode, open and close the passenger door.
   a. Does the bus wake up and become active? (Yes/No)

5. With the bus in sleep mode, lock and unlock the doors using the key FOB or FOBIK.
   a. Does the bus wake up and become active? (Yes/No)

6. Can a voltmeter be used to determine when a bus has entered sleep mode? (Yes/No)

7. Why is it important to recognize when the bus enters sleep mode?
PART TWO: CAN-C RESISTANCE MEASUREMENTS

Instructions: Measure the termination resistance of the CAN-C bus.

1. Disconnect the battery.

2. Measure the resistance between CAN-C (+) and CAN-C (-).
   a. Record your results.

3. Can the termination resistance of the CAN-C bus be measured? (Yes/No)
   a. Explain your answer.

Instructions: Test the CAN-C (+) and CAN-C (-) circuits for a short to ground.

4. Measure the resistance between CAN-C (+) and chassis ground and record the results.

5. Measure the resistance between CAN-C (-) and chassis ground and record the results.

6. Reconnect the battery.
ACTIVITY 4 DAISY CHAIN NETWORK DIAGNOSIS

Instructions: A vehicle is towed into the dealership for a no start condition. The customer states that the warning lamps in the IPC illuminated while driving. After pulling over and turning off the ignition, the vehicle will not restart. Diagnose the cause of the concern.

1. What should you do to diagnose this condition?
   
   a. Are there any modules that are not communicating on the bus?

   b. If yes, which modules are not communicating?

2. Using the CH7002 Breakout Box and DMM, measure and record the readings to complete the chart below.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading with Ignition On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on CAN (+)</td>
<td></td>
</tr>
<tr>
<td>Voltage on CAN (-)</td>
<td></td>
</tr>
</tbody>
</table>

3. Disconnect the battery and perform the resistance checks on the network.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termination Resistance</td>
<td></td>
</tr>
<tr>
<td>CAN (+) Resistance to Ground</td>
<td></td>
</tr>
<tr>
<td>CAN (-) Resistance to Ground</td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the voltage measurements taken in the previous step, answer the following questions.

   a. Is there a short to ground? (Yes/No)

   b. Is there a short to power? (Yes/No)

   c. Are the circuits shorted together? (Yes/No)

   d. Is there an open circuit? (Yes/No)
5. Based on the DMM measurements taken in the previous step, what is the most likely cause for this concern?

   a. How can you isolate the fault and narrow down where to begin looking?

6. Based on the results of your diagnosis, what is the circuit ID or component causing the concern?
PART ONE: NETWORK CONFIGURATION

Instructions: Using wiring diagrams and service information, answer the following questions.

1. List all networks connected to the data link connector (DLC).
   a. What is unique about this?

2. What bus configuration type does this vehicle use for either CAN-C network?

PART TWO: NETWORK DIAGNOSTICS

1. Does the network topology view in the scan tool match the layout found in the wiring diagrams?

2. Which network does the scan tool use to communicate with the gateway module (BCM)?

3. What is the best way to begin diagnosing a short circuit in this type of hybrid network?
Atlantis Network Operation

4. Why do modules communicate on multiple busses?

5. Pull the main fuse for the BCM and describe the results.

6. What happens if the IPC has an open circuit on the CAN-IHS bus?

   a. What happens if the IPC has an open circuit on CAN-C1?
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Hub networks use a central location for multiple modules to connect to the bus. These configurations can use connectors, splices, or modules as hubs. In some cases, the modules can be disconnected easily from the hub for diagnosis (i.e. splice blocks), while others are more difficult (i.e. BCM-hub).

In either case, the diagnostic strategy will remain similar, as the communication strategy for the varying designs is alike.
A hub network, like previously discussed CAN busses, connects all modules in a parallel circuit. This ensures that all modules on the network can communicate with all others, without relying on a single module. Hub networks are used with various communication protocols, including CAN-B and CAN-C classifications.

**Scan Tool Diagnosis**

When the scan tool connects to a hub network vehicle, the network topology may appear as if it is wired in a stub configuration. Remember, the scan tool only shows modules that are connected on the bus, not necessarily how they are connected on the bus. Always refer to service information and wiring diagrams for the correct bus wiring.
Figure 37  Total Loss of Communication

**Bias**

Bus bias does not change based on network architecture. For more information on bus bias for a particular vehicle or network, review the associated section in the lesson on stub networks and the description and operation sections of service information.

**Sleep**

CAN bus sleep strategy does not change based on network architecture. For more information on sleep strategy for a particular vehicle or network, review the associated section in the lesson on stub networks and the description and operation sections of service information.

**Fault Tolerance**

A network's level of fault tolerance does not change based on network architecture. For more information on fault tolerance for a particular vehicle or network, review the associated section in the lesson on stub networks and the description and operation sections of service information.

**Network Corruption**

Hub networks will suffer from corruption similarly to other network styles and should be diagnosed according to the procedures laid out in the stub networks lesson.
Hub style networks (with the exception of star networks, discussed in the next lesson) use dominant modules to house the buss’ termination resistors. Each dominant module (two total) connects bus (+) to bus (-), internally, through a 120-ohm resistor. This brings the total bus termination resistance to approximately 60 ohms. Non-dominant modules may contain high-value resistors (between 3K - 42K ohms). This ensures the bus is not drastically effected by the addition or subtraction of a non-dominant module. Refer to the description and operation sections of service information to determine which are the dominant modules for the vehicle being serviced.

Termination resistance can be measured anywhere on the bus and should be done with the battery disconnected and all bus circuits intact.

**NOTE:** Termination resistance of CAN-B cannot be measured with a DMM.
As with other networks, when a short circuit is present anywhere in a hub style network, no module communication will be possible. To diagnose a short in a hub style network, the cause of the short must be isolated from the rest of the bus. The method for locating the short will vary based on the layout of the hub. On a hub network where a module is used as the main connection point, and individual modules cannot easily be disconnected one at a time, a DMM should be used to monitor for a change in state of the bus. An ohmmeter can be used to check for a cross-short or a short to ground at individual circuits coming off of the main connectors at the hub.

Diagnosing a short to power should be done by first removing fuses until the short disappears and then isolating the modules and circuitry in question.

Because each module is wired independently to the hub, an open circuit will usually only effect the module after the open. It is possible, however, for an open on a single bus circuit to cause corruption which can effect communication among multiple modules. In this case, follow earlier directions for diagnosing corruption faults, found in the stub network lesson.
Diagnose Hub Networks

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DEMONSTRATION 5  HUB NETWORK OPERATION

PART ONE:  CAN-B VOLTAGE MEASUREMENTS

Instructions: Using a DMM, measure the CAN-B bus voltage in all modes.

1. List all networks connected to the data link connector (DLC).

2. In the table below, record the voltages on the bus with the ignition OFF and the bus in sleep mode; then record the voltages with the ignition ON and bus active.

<table>
<thead>
<tr>
<th>Circuit Name</th>
<th>Ignition OFF (Sleep Mode)</th>
<th>Ignition ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN-B (+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAN-B (-)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. With the bus in sleep mode, cycle the ignition ON and OFF.
   a. Does the bus wake up and become active? (Yes/No)

4. With the bus in sleep mode, open and close the passenger door.
   a. Does the bus wake up and become active? (Yes/No)

5. With the bus in sleep mode, lock and unlock the doors using the key FOB or FOBIK.
   a. Does the bus wake up and become active? (Yes/No)

6. Can a voltmeter be used to determine when a bus has entered sleep mode? (Yes/No)

7. Why is it important to recognize when the bus enters sleep mode?
PART TWO: CAN-B RESISTANCE MEASUREMENTS

Instructions: Measure the termination resistance of the CAN-B bus.

1. Disconnect the battery.

2. Measure the resistance between CAN-B (+) and CAN-B (-).
   a. Record your results.

3. Can the termination resistance of the CAN-B bus be measured? (Yes/No)
   a. Explain your answer.

Instructions: Test the CAN-B (+) and CAN-B (-) circuits for a short to ground.

4. Measure the resistance between CAN-B (+) and chassis ground and record the results.

5. Measure the resistance between CAN-B (-) and chassis ground and record the results.

6. Reconnect the battery.
PART THREE: NO SYMPTOM DIAGNOSIS

Instructions: Using a DMM and the CH7002 DLC Breakout Box, diagnose the fault on the communication bus, and answer the following questions.

1. Can you communicate with any of the modules on the CAN-B network?

2. Using the DMM, measure and record the readings to complete the charts below.

<table>
<thead>
<tr>
<th>CAN-B Circuit Measurement</th>
<th>DMM Voltage Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on CAN-B (+)</td>
<td></td>
</tr>
<tr>
<td>Voltage on CAN-B (-)</td>
<td></td>
</tr>
</tbody>
</table>

3. Disconnect the battery to check the resistance on the circuit.

<table>
<thead>
<tr>
<th>CAN-B Circuit Measurement</th>
<th>DMM Resistance Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resistance on CAN-B</td>
<td></td>
</tr>
<tr>
<td>CAN-B Resistance to Ground</td>
<td></td>
</tr>
<tr>
<td>CAN-B Resistance to Ground</td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the DMM measurements taken in the previous steps, what is the most likely cause for this concern?

5. How would you isolate the fault to narrow down where to begin looking?
ACTIVITY 5  HUB COMMUNICATION NETWORK DIAGNOSIS

Instructions: A vehicle comes in for a routine service and the scan tool shows there are fault codes for the CAN-B bus, yet there are no symptoms associated with them.

1. What should you do to diagnose this condition?
   
   a. Are there any modules that are not communicating on the bus?
   
   b. If yes, which modules are not communicating?

2. Using the CH7002 Breakout Box and DMM, measure and record the readings to complete the chart below.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading with Ignition On</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on CAN (+)</td>
<td></td>
</tr>
<tr>
<td>Voltage on CAN (-)</td>
<td></td>
</tr>
</tbody>
</table>

3. Disconnect the battery and perform the resistance checks on the network.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termination Resistance</td>
<td></td>
</tr>
<tr>
<td>CAN (+) Resistance to Ground</td>
<td></td>
</tr>
<tr>
<td>CAN (-) Resistance to Ground</td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the voltage measurements taken in the previous step, answer the following questions.
   
   a. Is there a short to ground? (Yes/No)
   
   b. Is there a short to power? (Yes/No)
   
   c. Are the circuits shorted together? (Yes/No)
   
   d. Is there an open circuit? (Yes/No)
Hub Communication Network Diagnosis

5. Based on the DMM measurements taken in the previous step, what is the most likely cause for this concern?

   a. How can you isolate the fault and narrow down where to begin looking?

6. Based on the results of your diagnosis, what is the circuit ID or component causing the concern?
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LESSON 6 DIAGNOSE STAR NETWORKS

CHARACTERISTICS OF THE STAR NETWORK

The star network design is a variant of hub networks, discussed earlier, which means that the module communication circuits connect to a central point in the network. The main difference between a hub network and a star network is that the star networks can use multiple connection points whereas the hub network uses only the BCM (or similar) for all connections.

Star networks do not use a dedicated CAN line to connect the DLC to the gateway. Instead, each CAN network is connected directly to the DLC and the central gateway module.
Bias

Bus bias does not change based on network architecture. For more information on bus bias for a particular vehicle or network, review the associated section in the lesson on stub networks and the description and operation sections of service information.

Sleep

CAN bus sleep strategy does not change based on network architecture. For more information on sleep strategy for a particular vehicle or network, review the associated section in the lesson on stub networks and the description and operation sections of service information.

Fault Tolerance

A network’s level of fault tolerance does not change based on network architecture. For more information on fault tolerance for a particular vehicle or network, review the associated section in the lesson on stub networks and the description and operation sections of service information.
Termination Resistance

The star connectors contain all of the termination resistance for their associated networks. Various networks may have one or two star connectors depending on model and option content. On a single-star connector configuration, termination resistance of that star connector measures 60 ohms. On a dual-star connector configuration, each star connector termination resistance individually measures 120 ohms, but the total circuit resistance measures 60 ohms because the star connectors are wired in parallel.
**STAR CONNECTORS**

The star connector is a unique component and makes diagnosis easier to perform. Consider a star connector like a splice, but much easier to find, access, and separate. Each module connects to a star connector through a dedicated connector. Modules can be disconnected from the bus individually, or by group.

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bridge Connector</td>
</tr>
<tr>
<td>2</td>
<td>Module Connector</td>
</tr>
<tr>
<td>3</td>
<td>Empty Module Port (Option not Equipped)</td>
</tr>
</tbody>
</table>

Figure 43 Star Connector Take-Outs

A single set of wires for each CAN bus is connected from the gateway module to a star connector. All of the other modules on the bus are connected, individually, to a star connector. Each module is connected to a star connector through a two wire connector, for bus (+) and bus (-).

2-wire connectors are all keyed alike to the star connector and may be interchanged from port to port to aid in diagnosis. For this reason, there is no standard port location for each module in a star connector; only which group of modules are connected to which star connector.

Bridge circuits, which connect one star connector to another, add a third wire for increased shielding from interference. The third wire is connected to ground.
STAR NETWORK DIAGNOSIS

Figure 44  Star Connector

Star connectors provide a convenient way to isolate communication bus faults from just a few central points in the circuit; because each module and branch can be isolated quickly by unplugging the CAN bus connectors from the star connectors.

Unplugging a two-wire connector isolates one module and harness. Unplugging a 3-wire connector isolates an entire branch of harnesses and modules.

Because of the design of star networks, if more than one, but not all of the modules on an individual network are offline, and a bus fault is to blame, the fault must be an open circuit. Additionally, the open must be in either the star connector, or the bridge circuit between the stars (if the vehicle uses multiple stars). If the bus circuits are intact, remember to verify proper power and ground circuits.
If the entire bus is down, check the bus voltages at the DLC to determine whether the bus is shorted to power or ground, or cross-shorted. If the bus is shorted and the bus uses more than one star connector, disconnect the 3-wire bridge connector from the star connector closest to the BCM.

If the short disappears, then the fault is either in the wires going to the second star connector, or one of the modules, or the star connector itself. If the short remains, then the fault is in one of the modules or harnesses connected to the first star connector.
To isolate the fault further, one-at-a-time, unplug each 2-wire connector from the star connector on the shorted branch until the short is gone. Once you have identified the shorted branch, reconnect the branch to the star connector, and disconnect the other end of the branch from the module. If the short disappears, the fault is in the module. If it remains, the short is in the harness.
PART ONE: CAN-IHS VOLTAGE MEASUREMENTS

Instructions: Using a DMM, measure the CAN-IHS bus voltage in all modes.

1. List all networks connected to the data link connector (DLC).

2. In the table below, record the voltages on the bus with the ignition OFF and the bus in sleep mode; then record the voltages with the ignition ON and bus active.

<table>
<thead>
<tr>
<th>Circuit Name</th>
<th>Ignition OFF (Sleep Mode)</th>
<th>Ignition ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAN-IHS (+)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAN-IHS (-)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. With the bus in sleep mode, cycle the ignition ON and OFF.
   a. Does the bus wake up and become active? (Yes/No)

4. With the bus in sleep mode, open and close the passenger door.
   a. Does the bus wake up and become active? (Yes/No)

5. With the bus in sleep mode, lock and unlock the doors using the key FOB or FOBIK.
   a. Does the bus wake up and become active? (Yes/No)

6. Can a voltmeter be used to determine when a bus has entered sleep mode? (Yes/No)

7. Why is it important to recognize when the bus enters sleep mode?
PART TWO: CAN-IHS RESISTANCE MEASUREMENTS

Instructions: Measure the termination resistance of the CAN-IHS bus.
1. Disconnect the battery.
2. Measure the resistance between CAN-IHS (+) and CAN-IHS (-).
   a. Record your results.

3. Can the termination resistance of the CAN-IHS bus be measured? (Yes/No)
   a. Explain your answer.

Instructions: Test the CAN-IHS (+) and CAN-IHS (-) circuits for a short to ground.
4. Measure the resistance between CAN-IHS (+) and chassis ground and record the results.

5. Measure the resistance between CAN-IHS (-) and chassis ground and record the results.

6. Reconnect the battery.
ACTIVITY 6 DIAGNOSE A STAR NETWORK FAULT

Instructions: A vehicle is towed into the dealership. When driving, warning lights illuminated on the instrument cluster. After pulling over and switching OFF the ignition, the vehicle would not restart. Diagnose the cause of the concern.

1. What should you do to diagnose this condition?

   a. Are there any modules that are not communicating on the bus?

   b. If yes, which modules are not communicating?

2. Using the CH7002 DLC Breakout Box and a DMM, measure and record the readings to complete the charts below.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on CAN (+)</td>
<td></td>
</tr>
<tr>
<td>Voltage on CAN(-)</td>
<td></td>
</tr>
</tbody>
</table>

3. Disconnect the battery and perform the resistance checks on the network.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termination Resistance</td>
<td></td>
</tr>
<tr>
<td>CAN (+) Resistance to Ground</td>
<td></td>
</tr>
<tr>
<td>CAN (-) Resistance to Ground</td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the voltage measurements taken in the previous step, answer the following questions.

   a. Is there a short to ground? (Yes/No)

   b. Is there a short to power? (Yes/No)

   c. Are the circuits shorted together? (Yes/No)

   d. Is there an open circuit? (Yes/No)
Diagnose a Star Network Fault

5. Based on the DMM measurements taken in the previous step, what is the most likely cause for this concern?

   a. How would you isolate the fault to narrow down where to begin looking?

6. What is the circuit ID or component responsible for the cause of this concern?
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ACTIVITY 7 DIAGNOSE A STAR NETWORK FAULT

Instructions: A vehicle comes into the dealership for a concern of multiple interior system failures. Use the scan tool, a DMM, and the CH7002 DLC Breakout Box to perform this diagnosis.

1. What should you do to diagnose this condition?
   a. Are there any modules that are not communicating on the bus?
   b. If yes, which modules are not communicating?

2. Using the CH7002 DLC Breakout Box and a DMM, measure and record the readings to complete the charts below.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on CAN (+)</td>
<td></td>
</tr>
<tr>
<td>Voltage on CAN (-)</td>
<td></td>
</tr>
</tbody>
</table>

3. Disconnect the battery and perform the resistance checks on the network.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termination Resistance</td>
<td></td>
</tr>
<tr>
<td>CAN (+) Resistance to Ground</td>
<td></td>
</tr>
<tr>
<td>CAN (-) Resistance to Ground</td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the voltage measurements taken in the previous step, answer the following questions.
   a. Is there a short to ground? (Yes/No)
   b. Is there a short to power? (Yes/No)
   c. Are the circuits shorted together? (Yes/No)
   d. Is there an open circuit? (Yes/No)
Diagnose a Star Network Fault

5. Based on the DMM measurements taken in the previous step, what is the most likely cause for this concern?

   a. How would you isolate the fault to narrow down where to begin looking?

6. What is the circuit ID or component responsible for the cause of this concern?
Lesson 7 Diagnose the LIN Bus

Characteristics of LIN Bus

Specific Components

The local interconnect network (LIN) bus is a single-wire data bus system. It uses one signal wire routed between a main module and one or more controlled modules. Communication is bidirectional, and is only between main and controlled. If multiple controlled modules are on a LIN bus, they can only communicate with the main module.
The LIN network is arranged as a main module and a controlled module system. It is important to recognize that the BCM is the main module for the LIN bus network in this example. Typically, controlled modules are simple input and output devices that may not perform self diagnostics. Controlled modules are active with the ignition in the ON position, and some may be active with the ignition in the OFF position. The roof control unit (RCU) is an example of a LIN bus controlled module.

The main module is also wired to a CAN bus to share information and to allow for scan tool diagnosis. The main module is responsible for LIN diagnostics and is capable of setting fault codes for any LIN module or circuit faults. Because a controlled module cannot communicate with any other module directly, the main module relays LIN-controlled module data over the CAN bus to the scan tool.
Theory and Operation of the LIN Bus

The LIN bus is biased through the main and controlled modules. When at rest, the voltage on the LIN network is close to battery voltage. When LIN bus communication occurs, the voltage is pulled low to nearly 0V, creating a digital signal. Because modules pulse the voltage low during communication, the more modules present on a LIN bus, the lower the average voltage will be, as viewed with a DMM. If a module is unplugged from the LIN bus, it no longer pulls the voltage towards zero, and the average network voltage will increase.

NOTE: LIN voltage reads B+ when in sleep mode.
Diagnose the LIN Bus

FAULT SYMPTOMS
When the LIN bus is shorted, no modules can communicate on the LIN bus network, and all LIN module messaging stops. A loss of communication code (U-code) sets in the main module. A short to ground or to power on the LIN bus does not affect main module communication over other CAN bus systems.

Begin diagnosis by checking the voltage on the LIN bus to see if voltage is present. If an open occurs, modules downstream of the open lose functionality, and communication codes will set. If a single LIN-controlled module is not communicating, but all other LIN modules are functioning normally, always verify power, ground, and LIN voltage at the suspect module before replacing any parts. As long as at least one module on the LIN network is connected, then the circuit can be biased to communicate.

Fault Tolerance
As with any single-wire communication bus, the LIN bus is not fault tolerant. If a short to ground or power occurs on the LIN bus, the entire LIN bus loses the ability to communicate. If an open occurs within the network, modules on the other side of the break (that are no longer connected to the main module) lose communication. If an open occurs within the network, modules still connected to the main module continue to communicate. Loss of power or ground to a controlled module results in that particular controlled module losing communication; whereas loss of power or ground to a main module results in no LIN bus communication.

K-Line
Some vehicles also use another single wire network, called a K-Line. K-Lines function similarly to LIN busses and may be diagnosed as such. When diagnosing a particular K-Line, refer to service information for specific details.
Diagnose the LIN Bus

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Diagnose the LIN Bus

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DEMONSTRATION 7 LIN BUS OPERATION

PART ONE: LIN BUS VOLTAGE MEASUREMENTS

Instructions: Measure the LIN bus voltage in all modes.

1. In the table below, record the voltages on the bus with the ignition OFF and the bus in sleep mode; then record the voltages with the ignition ON and bus active.

<table>
<thead>
<tr>
<th>Circuit Name</th>
<th>Ignition OFF (Sleep Mode)</th>
<th>Ignition ON</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIN Bus</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. With the bus in sleep mode, cycle the ignition ON and OFF.
   a. Does the bus wake up and become active? (Yes/No)

3. With the bus in sleep mode, open and close the passenger door.
   a. Does the bus wake up and become active? (Yes/No)

4. With the bus in sleep mode, lock and unlock the doors using the key FOB or FOBIK.
   a. Does the bus wake up and become active? (Yes/No)

5. Can a voltmeter be used to determine when a bus has entered sleep mode? (Yes/No)

6. Why is it important to recognize when the bus enters sleep mode?

Instructions: While monitoring the LIN bus with a voltmeter, disconnect one of the LIN bus modules.

7. What happens to network voltage when a module is disconnected?
PART TWO: LIN BUS RESISTANCE MEASUREMENTS

Instructions: Test the LIN bus circuit for a short to ground.

8. Measure the resistance between LIN bus and chassis ground and record the results.

9. Reconnect the battery.
ACTIVITY 8  DIAGNOSE A SINGLE WIRE NETWORK FAULT

Instructions: A vehicle comes into the dealership because the driver’s window switch is not functioning. Diagnose the cause of the concern.

1. Are there any related symptoms?

2. After verifying the concern, what should you do to diagnose this condition?

3. With the switch connected, using a DMM, measure and record the readings to complete the charts below.

<table>
<thead>
<tr>
<th>Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Circuit</td>
<td></td>
</tr>
<tr>
<td>Ground Circuit</td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td></td>
</tr>
</tbody>
</table>

4. Disconnect the switch and retake the measurements from step 2, at the harness side of the connector.

<table>
<thead>
<tr>
<th>Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Circuit</td>
<td></td>
</tr>
<tr>
<td>Ground Circuit</td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td></td>
</tr>
</tbody>
</table>

5. Based on the voltage measurements taken in the previous steps, answer the following questions.

a. Is there a short to ground? (Yes/No)

b. Is there a short to power? (Yes/No)

c. Is there an open circuit? (Yes/No)
Diagnose a Single Wire Network Fault

6. While monitoring bus voltage, operate the switch. Does the voltage fluctuate when the switch is pressed?

   a. What does this indicate?

7. Based on the DMM measurements taken in the previous steps, what is the most likely cause for this concern?
ACTIVITY 9 DIAGNOSE A SINGLE WIRE NETWORK FAULT

Instructions: A vehicle comes into the dealership because the Select Terrain switch is not functioning. Diagnose the cause of the concern.

1. Are there any related symptoms?

2. After verifying the concern, what should you do to diagnose this condition?

3. With the switch connected, using a DMM, measure and record the readings to complete the charts below.

<table>
<thead>
<tr>
<th>Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Circuit</td>
<td></td>
</tr>
<tr>
<td>Ground Circuit</td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td></td>
</tr>
</tbody>
</table>

4. Disconnect the switch and retake the measurements from step 2, at the harness side of the connector.

<table>
<thead>
<tr>
<th>Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Circuit</td>
<td></td>
</tr>
<tr>
<td>Ground Circuit</td>
<td></td>
</tr>
<tr>
<td>Bus</td>
<td></td>
</tr>
</tbody>
</table>

5. Based on the voltage measurements taken in the previous steps, answer the following questions.
   a. Is there a short to ground? (Yes/No)
   b. Is there a short to power? (Yes/No)
   c. Is there an open circuit? (Yes/No)

6. What is the most likely cause for this concern?
ACTIVITY 10 DIAGNOSE A NETWORK FAULT

Instructions: A vehicle is towed into the dealership. When driving, warning lights illuminated on the instrument cluster. After pulling over and switching OFF the ignition, the vehicle would not restart. Diagnose the cause of the concern.

1. What should you do to diagnose this condition?
   a. Are there any modules that are not communicating on the bus?
   b. If yes, which modules are not communicating?

2. Using the CH7002 DLC Breakout Box and a DMM, measure and record the readings to complete the charts below.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on CAN (+)</td>
<td></td>
</tr>
<tr>
<td>Voltage on CAN(-)</td>
<td></td>
</tr>
</tbody>
</table>

3. Disconnect the battery and perform the resistance checks on the network.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termination Resistance</td>
<td></td>
</tr>
<tr>
<td>CAN (+) Resistance to Ground</td>
<td></td>
</tr>
<tr>
<td>CAN (-) Resistance to Ground</td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the voltage measurements taken in the previous step, answer the following questions.
   a. Is there a short to ground? (Yes/No)
   b. Is there a short to power? (Yes/No)
   c. Are the circuits shorted together? (Yes/No)
   d. Is there an open circuit? (Yes/No)
5. Based on the DMM measurements taken in the previous step, what is the most likely cause for this concern?

a. How would you isolate the fault to narrow down where to begin looking?

6. What is the circuit ID or component responsible for the cause of this concern?
Notes:

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ACTIVITY 11 DIAGNOSE A NETWORK FAULT

Instructions: A vehicle is in for routine service. Multiple DTCs are found when the scan tool is connected. Diagnose the cause of the concern.

1. What should you do to diagnose this condition?
   
   a. Are there any modules that are not communicating on the bus?
   
   b. If yes, which modules are not communicating?

2. Using the CH7002 DLC Breakout Box and a DMM, measure and record the readings to complete the charts below.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on CAN (+)</td>
<td></td>
</tr>
<tr>
<td>Voltage on CAN(-)</td>
<td></td>
</tr>
</tbody>
</table>

3. Disconnect the battery and perform the resistance checks on the network.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termination Resistance</td>
<td></td>
</tr>
<tr>
<td>CAN (+) Resistance to Ground</td>
<td></td>
</tr>
<tr>
<td>CAN (-) Resistance to Ground</td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the voltage measurements taken in the previous step, answer the following questions.
   
   a. Is there a short to ground? (Yes/No)
   
   b. Is there a short to power? (Yes/No)
   
   c. Are the circuits shorted together? (Yes/No)
   
   d. Is there an open circuit? (Yes/No)
Diagnose a Network Fault

5. Based on the DMM measurements taken in the previous step, what is the most likely cause for this concern?
   
   a. How would you isolate the fault to narrow down where to begin looking?

6. What is the circuit ID or component responsible for the cause of this concern?
Notes:________________________________________________________________________________________________________________________
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ACTIVITY 12 DIAGNOSE A NETWORK FAULT

Instructions: A vehicle is towed into the dealership. When driving, warning lights illuminated on the instrument cluster. After pulling over and switching OFF the ignition, the vehicle would not restart. Diagnose the cause of the concern.

1. What should you do to diagnose this condition?

   a. Are there any modules that are not communicating on the bus?

   b. If yes, which modules are not communicating?

2. Using a DMM, measure and record the readings to complete the charts below.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on CAN (+)</td>
<td></td>
</tr>
<tr>
<td>Voltage on CAN(-)</td>
<td></td>
</tr>
</tbody>
</table>

3. Disconnect the battery and perform the resistance checks on the network.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termination Resistance</td>
<td></td>
</tr>
<tr>
<td>CAN (+) Resistance to Ground</td>
<td></td>
</tr>
<tr>
<td>CAN (-) Resistance to Ground</td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the voltage measurements taken in the previous step, answer the following questions.

   a. Is there a short to ground? (Yes/No)

   b. Is there a short to power? (Yes/No)

   c. Are the circuits shorted together? (Yes/No)

   d. Is there an open circuit? (Yes/No)
Diagnose a Network Fault

5. Based on the DMM measurements taken in the previous step, what is the most likely cause for this concern?

   a. How would you isolate the fault to narrow down where to begin looking?

6. What is the circuit ID or component responsible for the cause of this concern?
Notes:
ACTIVITY 13  DIAGNOSE A NETWORK FAULT

Instructions: The customer concern for this vehicle is that there have been multiple electrical failures. At initial investigation no communication is possible with the vehicle. Diagnose the cause of the concern.

1. What should you do to diagnose this condition?
   a. Are there any modules that are not communicating on the bus?
   b. If yes, which modules are not communicating?

2. Using the CH7002 DLC Breakout Box and a DMM, measure and record the readings to complete the charts below.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage on CAN (+)</td>
<td></td>
</tr>
<tr>
<td>Voltage on CAN(-)</td>
<td></td>
</tr>
</tbody>
</table>

3. Disconnect the battery and perform the resistance checks on the network.

<table>
<thead>
<tr>
<th>CAN Circuit Measurement</th>
<th>DMM Measurement Reading</th>
</tr>
</thead>
<tbody>
<tr>
<td>Termination Resistance</td>
<td></td>
</tr>
<tr>
<td>CAN (+) Resistance to Ground</td>
<td></td>
</tr>
<tr>
<td>CAN (-) Resistance to Ground</td>
<td></td>
</tr>
</tbody>
</table>

4. Based on the voltage measurements taken in the previous step, answer the following questions.
   a. Is there a short to ground? (Yes/No)
   b. Is there a short to power? (Yes/No)
   c. Are the circuits shorted together? (Yes/No)
   d. Is there an open circuit? (Yes/No)
Diagnose a Network Fault

5. Based on the DMM measurements taken in the previous step, what is the most likely cause for this concern?

6. What is the circuit ID or component responsible for the cause of this concern?

   a. How would you isolate the fault to narrow down where to begin looking?
HYBRID BUS

A hybrid bus is the combination of two completely different communication architectures used on a single vehicle. Hybrid bus systems allow information to be shared across different bus networks through the use of a gateway module. Examples of other Chrysler vehicles with a hybrid bus include the following:

- 2007-2008 Chrysler Pacifica
- 2005-2007 KJ - Jeep Liberty
- 2006 DR (SRT10) – Dodge Ram
- 2008 ZB – Dodge Viper

NOTE: The term hybrid bus does not refer to a communication system used only on hybrid electric vehicles (HEV).

Figure 52 Hybrid Bus Communication Network
PCI BUS

Background

The programmable communication interface (PCI) bus system was first implemented on 1998 model year LH vehicles. The PCI bus was used to communicate with modules on a network within the vehicle in conjunction with other vehicle communication systems.

The PCI bus is a single-wire, multiplexed network capable of supporting binary messages shared between multiple modules. The PCI bus is based on the guidelines of the SAE J1850 Standard Data Communications protocol. This SAE standard defines a minimum set of data communication requirements for module communication for automotive manufacturers. This system also provides communication with aftermarket or generic scan tools to display DTCs, system data, and other information.

The principal features of Chrysler’s J1850 implementation are:

- 10.4 kbps data rate
- Single-wire transmission bus
- Two-chip implementation
- Synchronous serial interface
- One-byte headers
- Software message filtering in-frame response (IFR) allowed
Some hybrid bus vehicles use both PCI and CAN bus. These vehicles take advantage of CAN real-time high-speed communication that is required for the ESP, but allows the continued use of existing PCI control modules.

NORMAL OPERATION

Data exchange between modules is achieved by serial transmission of encoded data over a single-wire broadcast network. The PCI bus message is typically a 10,400 bits per second (bps) PWM signal. The PCI bus can support a maximum of 32 different modules, including the DRB III® scan tool.

Table 2  CCD/PCI Bus Comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>CCD Bus</th>
<th>PCI Bus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission Media</td>
<td>Twisted Pair</td>
<td>Single Wire</td>
</tr>
<tr>
<td>Speed</td>
<td>7,812.5 bps</td>
<td>10,400 bps (Average)</td>
</tr>
<tr>
<td>Meets Industry Standard</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>SAE Standard Protocol</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>OBDII Compliant</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Bus Bias Required</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Maximum No. of Modules</td>
<td>13*</td>
<td>32</td>
</tr>
</tbody>
</table>

* The scan tool is the 13th module

NOTE: The CCD bus is no longer used on any current production vehicles.
CIRCUIT DESCRIPTION

The PCI bus is identified as the D25 circuit in the service information. The modules are wired in parallel with a single wire. The vehicle chassis supplies the return. PCI bus circuit wires are usually yellow or white with a violet tracer, however, some applications may use an additional tracer color. Connections are made in the harness using splices.

Figure 53  Typical DR PCI Bus Configuration

Some vehicles use the BCM as the central connection point for the PCI bus. All modules are wired through separate pins at the BCM and are connected internally within the BCM. The BCM is considered the hub of the bus.
DIAGNOSTIC JUNCTION PORT

Some vehicles used a splice called the diagnostic junction port (DJP) to serve as the hub of the bus. The DJP was located behind the knee blocker or near the steering column. The DJP was first used on 1999 WJ vehicles. The DJP was phased out gradually and discontinued in the 2003 model year.

The DJP provides an access point to isolate most of the modules on the bus in order to assist in diagnosing the circuit. This allows individual module circuits to be tested from the DJP, saving diagnostic time. On a vehicle without the DJP, it may be necessary to separate the harness connectors in order to isolate modules.
BIAS AND TERMINATION

The PCI network requires biasing voltage and termination resistance in order to transmit messages. Each module (also referred to as a node) on the PCI bus provides its own bias and termination. Each module on the bus terminates the bus by connecting it to ground through a terminating resistor and capacitor.

There are two types of nodes on the bus:

- **Dominant node** – Terminates the bus with a 1200-3300 ohms resistor and a 3300 pF capacitor (See Table 8 for exact termination resistance)

**NOTE:** Typically the mechanical instrument cluster and/or PCM are the dominant nodes.

- **Standard node** – Terminates the bus with an 11 kilo-ohms resistor and a 330 pF capacitor (See Table 8 for exact termination resistance)

Nodes (modules) are wired in parallel. Ohm's Law tells us that in a parallel circuit, the total circuit resistance is less than the value of the lowest resistance.

The purpose of the dominant node is to establish the total bus resistance. For optimum operation, the total bus resistance must be held within a specific range. This allows other modules (standard nodes) to be added to or removed from the bus without adversely affecting it. The dominant node reduces or minimizes the effects of one module (standard node) on the bus losing ground.
<table>
<thead>
<tr>
<th>Module</th>
<th>Approx. Termination Resistance (Ohms)</th>
<th>Module</th>
<th>Approx. Termination Resistance (Ohms)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powertrain Control Module (All Except 98 LH)</td>
<td>3,300</td>
<td>Body Control Module (All Except 2002 WJ)</td>
<td>10,800</td>
</tr>
<tr>
<td>Powertrain Control Module (98 LH)</td>
<td>1,100</td>
<td>Body Control Module (2002 WJ)</td>
<td>8,000</td>
</tr>
<tr>
<td>Sentry Key Immobilizer Module</td>
<td>10,800</td>
<td>Data Link Connector</td>
<td>Open (11,400 with DRB III® Connected)</td>
</tr>
<tr>
<td>Transmission Control Module</td>
<td>10,800</td>
<td>Passenger Door Module (99-01)</td>
<td>10,800</td>
</tr>
<tr>
<td>Controller Antilock Brake</td>
<td>10,800</td>
<td>Passenger Door Module (2002)</td>
<td>8,200</td>
</tr>
<tr>
<td>Radio (Premium)</td>
<td>10,800</td>
<td>Driver Door Module (99-01)</td>
<td>10,800</td>
</tr>
<tr>
<td>Compass Mini Trip Computer</td>
<td>10,800</td>
<td>Driver Door Module (2002)</td>
<td>8,200</td>
</tr>
<tr>
<td>Left-side Impact Airbag Control Module</td>
<td>10,800</td>
<td>Memory Heated Seat Module</td>
<td>10,800</td>
</tr>
<tr>
<td>Right-Side Impact Airbag Control Module</td>
<td>10,800</td>
<td>Electronic Vehicle Information Center (CMTC, Traveler)</td>
<td>10,800</td>
</tr>
<tr>
<td>CD Changer</td>
<td>10,800</td>
<td>Automatic Zone Control (HVAC/ATC Control Heads)</td>
<td>10,800</td>
</tr>
<tr>
<td>Occupant Restraint Controller</td>
<td>10,800</td>
<td>Transfer Case Control Module</td>
<td>10,800</td>
</tr>
<tr>
<td>Mechanical Instrument Cluster (All Except 98 LH and WJ)</td>
<td>3,300</td>
<td>Front Control Module</td>
<td>10,800</td>
</tr>
<tr>
<td>Mechanical Instrument Cluster (98 LH)</td>
<td>10,800</td>
<td>Rain Sensor</td>
<td>10,800</td>
</tr>
<tr>
<td>Mechanical Instrument Cluster (99-01 WJ)</td>
<td>2,400</td>
<td>Adjustable Pedal Module</td>
<td>10,800</td>
</tr>
<tr>
<td>Mechanical Instrument Cluster (02 WJ)</td>
<td>1,200</td>
<td>Intrusion Sensor (BUX)</td>
<td>10,800</td>
</tr>
</tbody>
</table>
MESSAGE TRANSMISSION

Each module is capable of transmitting and receiving data simultaneously. Bus voltage is 0V when no modules are transmitting and approximately 7.5V when modules are transmitting.

Variable pulse width modulation (VPWM) is used for PCI bus messaging. With VPWM, both the state of the bus and the width of the pulse are used to encode bit information. A 0 bit is defined as a short, low pulse or long, high pulse. A 1 bit is defined as a long, low pulse or a short, high pulse.

A typical PCI bus message has the following four components:

- Message header
- Data byte(s)
- CRC byte
- IFR byte(s)
DIAGNOSIS

Begin diagnosis with symptom identification. If total bus failure is suspected, begin by identifying which modules the vehicle is equipped with and then attempt to get a response from the modules using the DRB III®. When connected, the DRB III® becomes one more module on the PCI bus. If any modules are responding, the failure is not related to the total bus, but can be caused by the PCI bus, power supply, or ground circuits to one or more modules.

PCI bus messages are transmitted at a rate averaging 10,400 bps. Since there is voltage present only when modules transmit, and the message length is only about 500 milliseconds, it may be difficult to measure or view bus activity with a conventional DMM. The following tools can be used for viewing bus message activity (depending on the vehicle being tested):

- DRB III® diagnostic tool with PEP Accessory Kit
- J1962 Breakout Box

When using the DRB III® diagnostic tool for viewing bus activity, connect the red scope lead to pin 2 of the J1962 breakout box (BOB). Select the 20-volt DC scale for a good view of bus activity. Voltage on the bus should pulse between 0V and approximately 7.5V. On vehicles that have a DJP, the red lab scope lead can be connected to individual pins of the DJP using the 8339 Junction Port Tester. This allows observation of bus activity on each separate leg of the PCI bus.

NOTE: NOTE: For vehicles with a DJP, use the 8339 Junction Port Tester to isolate bus problems with individual modules.

When testing the bus for opens or shorts, remember the PCI bus is a parallel circuit. In any parallel circuit, the total circuit resistance is less than the value of the lowest resistance. Refer to the termination resistance value information to compare the expected circuit resistance with measured values.
**FAILURE MODES**

Monitor the PCI bus using the DRB III® diagnostic tool. There are two types of failures that can occur on the PCI bus:

- Individual module no response or partial bus failure
- Total bus failure

Causes of individual module no response or partial bus failure include:

- Open PCI bus circuit to the affected module
- Open power circuit to the affected module
- Open ground circuit to the affected module

Causes of total failure include:

- Short to voltage
- Short to ground

Symptoms of a total bus failure include (but are not limited to) the following:

- All gauges on the mechanical instrument cluster stay at zero
- All telltales on the mechanical instrument cluster illuminate
- Mechanical instrument cluster backlighting at full intensity
- Dashed lines in the electronic vehicle information center (EVIC) ambient temperature display
- No response received from any module on the PCI bus
- No start, if equipped with sentry key immobilizer system (SKIS)

Symptoms of individual module bus failure could include one or more of the above. The difference is that at least one or more modules on the bus would respond to the DRB III®.
SCI BUS

Background

The serial communication interface (SCI) bus protocol is a Chrysler proprietary serial communication system. SCI is used by Chrysler to communicate between the PCM and the DRB III® (and its predecessors).

SCI was introduced in the 1983-1/2 model year on a few 2.2L EFI and turbo front-wheel drive vehicles. SCI was used on all 1984 fuel-injected front-wheel drive vehicles and fuel-injected rear-wheel drive vehicles starting in 1988. In addition, some carbureted vehicles using arc control computers used SCI to support limited diagnostics. The tools used to support these vehicles were the C-4805 (DRB I®) and DRB II®.

Some vehicles use the DRB III, which is the currently supported tool. On vehicles with a full CAN bus, SCI is retained only for flash functionality and is otherwise inactive. The StarSCAN™ diagnostic tool supports SCI for flash programming.

Chrysler introduced flash technology for powertrain-related modules beginning in 1993. This allowed the reprogramming and updating of module calibrations in the field. SCI is used for this feature.

The PCM uses SCI for transmit and receive functions. The TCM uses the receive function for flash programming. Some ABMs and the speed proportional steering module (on the 1996 WJ) also used SCI.

On OBDII vehicles that use the Chrysler collision detection (CCD) protocol, the SCI transmit (Tx) circuit is shared with the ISO-K circuit to meet mandated 9141-2 standards.

SCI:

- Consists of a dedicated, point-to-point, two-wire, non-multiplexed serial communication interface
- Supports both diagnostics and flash programming capability
- Supports multiple baud rates to accommodate both the low-speed diagnostic command mode (at 7812.5 bps) and the high-speed parameter interrogation command mode (at 62.5 kbps)
CIRCUIT DESCRIPTION

SCI uses a two-wire communication circuit. The circuits are identified as D21 or transmit (Tx) and D20 or receive (Rx) in the service information. Chassis ground is the return path. The data is transferred by a 5V binary signal.

Figure 54  Typical KJ SCI Bus Configuration
Transmit refers to the module transmitting data to the diagnostic tool. The diagnostic tool supplies the bias to the module on the Tx circuit. The module pulls voltage low to transmit data to the diagnostic tool.

Receive refers to the module receiving data from the diagnostic tool. The module supplies bias on the Rx circuit. The diagnostic tool pulls the voltage low to send data to the module.

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<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Scan Tool</td>
<td>3</td>
<td>Module Transmits Data</td>
</tr>
<tr>
<td>2</td>
<td>Scan Tool Transmits Data</td>
<td>4</td>
<td>Module</td>
</tr>
</tbody>
</table>

Figure 55 SCI Bus Bias
SCI CIRCUIT VOLTAGES

With the key ON, and:

- No diagnostic tool connected to the DLC, there should be 5V at the Rx circuit
- No diagnostic tool connected to the DLC, there should be 0V at the Tx circuit
- A diagnostic tool connected to the DLC; there should be 12V at the Tx circuit, this is the default voltage for ISO-K; when Engine is selected from the Select System menu, the tool turns off the 12V and applies 5V to attempt SCI communication
- A diagnostic tool connected to the DLC and Engine selected from the Select System menu, there should be 5V at the Tx circuit

Communication between the diagnostic tool and the module is always initiated at the default transmission rate of 7812.5 bps. When communication is established, a change to a higher rate may be negotiated between the module and the diagnostic tool.

- Low-speed mode is used for initializing communication or diagnostic sessions.
- High-speed mode is used for data acquisitions and flash programming.

As stated previously, normal communication between the diagnostic tool and the PCM uses SCI. The protocol used by the diagnostic tool to communicate with the TCM is either CCD or PCI, depending on the vehicle. SCI is used for the transfer of flash programming data and for acquisition of data (data recording function).
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## GLOSSARY

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>controller area</td>
<td>An OBDII-compliant vehicle communication bus standard (developed by Bosch corporation) that allows modules to share information over a communication network.</td>
</tr>
<tr>
<td>network</td>
<td></td>
</tr>
<tr>
<td>interference</td>
<td>An electrical disruption that affects an electrical circuit due to either electromagnetic induction or electromagnetic radiation emitted from an outside source.</td>
</tr>
<tr>
<td>J1850</td>
<td>A Society of Automotive Engineers (SAE) digital communication network standard.</td>
</tr>
<tr>
<td>J1962</td>
<td>A Society of Automotive Engineers (SAE) standard that designates the function of certain terminal locations in the data link connector.</td>
</tr>
<tr>
<td>multiplexing</td>
<td>A process that takes multiple digital or analog signals and combines them into one signal sent over a shared medium.</td>
</tr>
<tr>
<td>scan tool</td>
<td>A hand-held electronic device or computer application that can communicate with electronic control units on a vehicle; scan tools can read diagnostic trouble codes (DTCs), monitor input data, command actuators, and program electronic control units with new flash updates.</td>
</tr>
<tr>
<td>telematics</td>
<td>The technology of sending, receiving, and storing information via telecommunication devices including remote control and global positioning systems.</td>
</tr>
<tr>
<td>transceiver</td>
<td>An electronic device combining both a transmitter and a receiver that share common circuitry or a single housing.</td>
</tr>
<tr>
<td>voltage pulses</td>
<td>A brief burst or rise of current followed by an abrupt fall or decay.</td>
</tr>
</tbody>
</table>
Notes:

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WORLDWIDE

The special service tools referred to herein are required for certain service operations. These special service tools or their equivalent, if not obtainable through a local source, are available through the following outlet:

Mopar Essential Tools and Service Equipment
Snap-on Business Solutions

Telephone 1-855-298-2687 2801-80th Street Kenosha, WI 53143, U.S.A. FAX 1-855-303-8985

www.mopaessentialtools.com