chapter 49 CAN AND NETWORK COMMUNICATIONS

OBJECTIVES: **After studying Chapter 49, the reader should be able to:** • Prepare for ASE Electrical/Electronic Systems (A6) certification test content area "A" (General Electrical/Electronic Systems Diagnosis). • Describe the types of networks and serial communications used on vehicles. • Discuss how the networks connect to the data link connector and to other modules. • Explain how to diagnose module communication faults.

KEY TERMS: Breakout box (BOB) 533 • BUS 526 • CAN 527 • Chrysler Collision Detection (CCD) 530 • Class 2 528 • E & C 528 • GMLAN 528 • Keyword 528 • Multiplexing 524 • Network 524 • Node 524 • Plastic optical fiber (POF) 534 • Programmable controller interface (PCI) 530 • Protocol 527 • Serial communications interface (SCI) 530 • Serial data 524 • Splice pack 525 • Standard corporate protocol (SCP) 529 • State of health (SOH) 534 • SWCAN 529 • Terminating resistors 534 • Twisted pair 524 • UART 527 • UART-based protocol (UBP) 530

MODULE COMMUNICATIONS AND NETWORKS

NEED FOR NETWORK Since the 1990s, vehicles have used modules to control the operation of most electrical components. A typical vehicle will have 10 or more modules and they communicate with each other over data lines or hard wiring, depending on the application.

ADVANTAGES Most modules are connected together in a network because of the following advantages.

- A decreased number of wires are needed, thereby saving weight and cost, as well as helping with installation at the factory and decreased complexity, making servicing easier.
- Common sensor data can be shared with those modules that may need the information, such as vehicle speed, outside air temperature, and engine coolant temperature.

  ● **SEE FIGURE 49–1.**

NETWORK FUNDAMENTALS

MODULES AND NODES Each module, also called a **node,** must communicate to other modules. For example, if the driver depresses the window-down switch, the power window switch sends a window-down message to the body control module. The body control module then sends the request to the driver's side window module. This module is responsible for actually performing the task by supplying power and ground to the window lift motor in the current polarity to cause the window to go down. The module also contains a circuit that monitors the current flow through the motor and will stop and/or reverse the window motor if an obstruction causes the window motor to draw more than the normal amount of current.

TYPES OF COMMUNICATION The types of communications include the following:

- **Differential.** In the differential form of module communication, a difference in voltage is applied to two wires, which are twisted to help reduce electromagnetic interference (EMI). These transfer wires are called a **twisted pair.**
- **Parallel.** In the parallel type of module communication, the send and receive signals are on different wires.
- **Serial data.** The **serial data** is data transmitted over one wire by a series of rapidly changing voltage signals pulsed from low to high or from high to low.
- **Multiplexing.** The process of **multiplexing** involves the sending of multiple signals of information at the same time over a signal wire and then separating the signals at the receiving end.

This system of intercommunication of computers or processors is referred to as a **network.** ● **SEE FIGURE 49–2.**

By connecting the computers together on a communications network, they can easily share information back and forth. This multiplexing has the following advantages.

- Elimination of redundant sensors and dedicated wiring for these multiple sensors
- Reduction of the number of wires, connectors, and circuits
- Addition of more features and option content to new vehicles

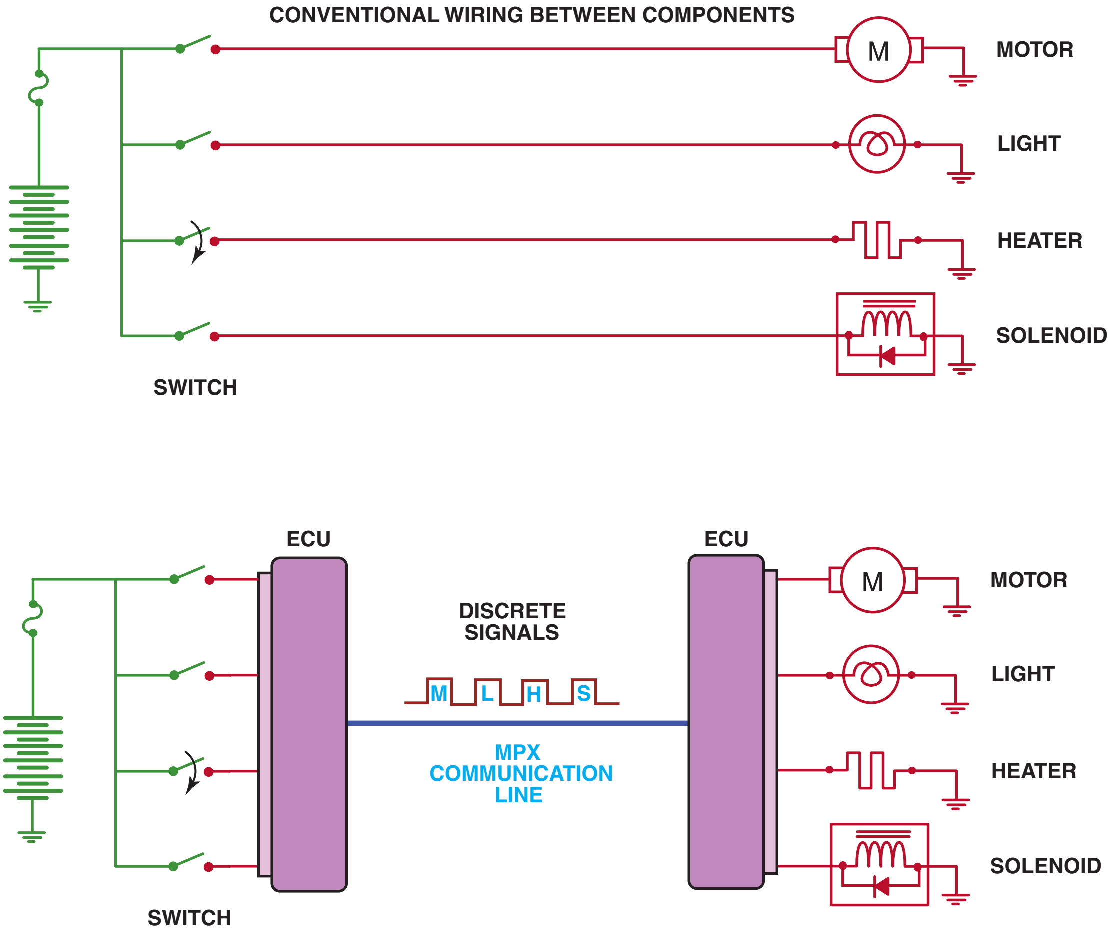


FIGURE 49–1 Module communications makes controlling multiple electrical devices and accessories easier by utilizing simple low-current switches to signal another module, which does the actual switching of the current to the device.

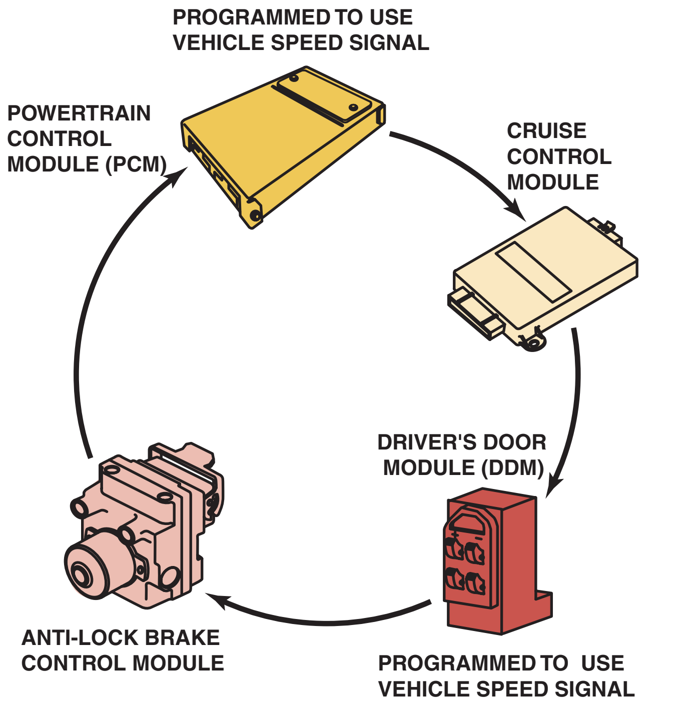


FIGURE 49–2 A network allows all modules to communicate with other modules.

- Weight reduction due to fewer components, wires, and connectors, thereby increasing fuel economy
- Changeable features with software upgrades versus component replacement

MODULE COMMUNICATIONS CONFIGURATION

The three most common types of networks used on vehicles include:

1. **Ring link networks.** In a ring-type network, all modules are connected to each other by a serial data line (in a line) until all are connected in a ring. ● **SEE FIGURE 49–3.**
2. **Star link networks.** In a star link network, a serial data line attaches to each module and then each is connected to a central point. This central point is called a **splice pack,** abbreviated SP such as in "SP 306." The splice pack uses a bar to splice all of the serial lines together. Some GM vehicles use two or more splice packs to tie the modules together. When more than one splice pack is used, a serial data line connects one splice pack to the others. In most applications, the BUS bar used in each splice pack can be removed. When the BUS bar is removed, a special tool (J 42236) can be installed in place of the removed BUS bar. Using this tool, the serial data line for each module can be isolated and tested for a possible problem. Using the special tool at the splice pack makes diagnosing this type of network easier than many others. ● **SEE FIGURE 49–4.**
3. **Ring/star hybrid.** In a ring/star network, the modules are connected using both types of network configurations. Check service information (SI) for details on how this network is connected on the vehicle being diagnosed and always follow the recommended diagnostic steps.

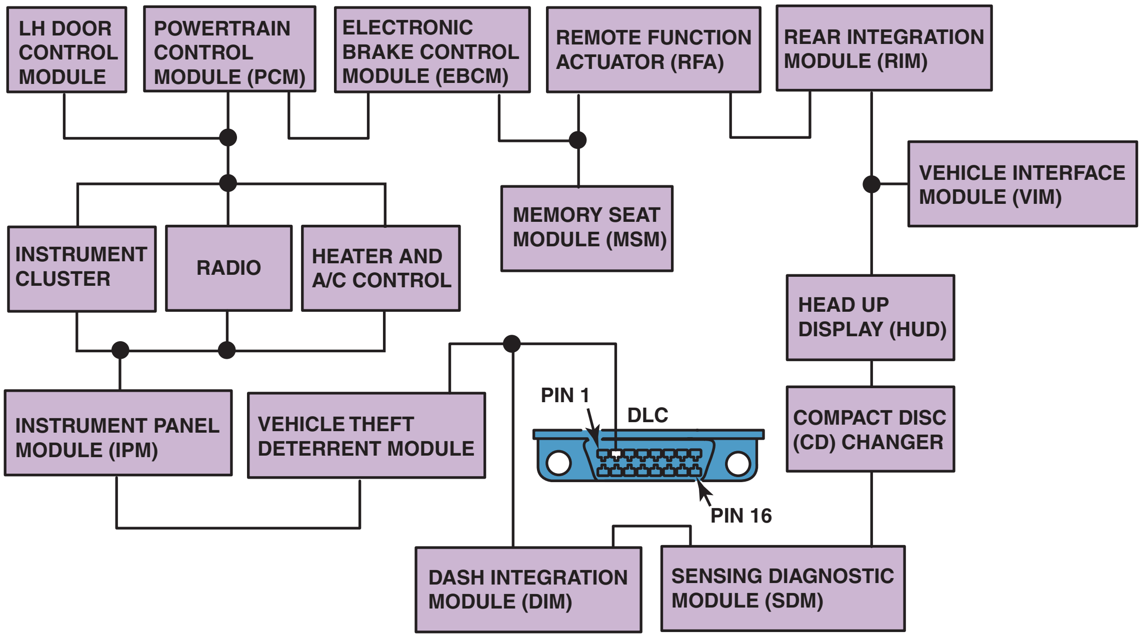


FIGURE 49–3 A ring link network reduces the number of wires it takes to interconnect all of the modules.

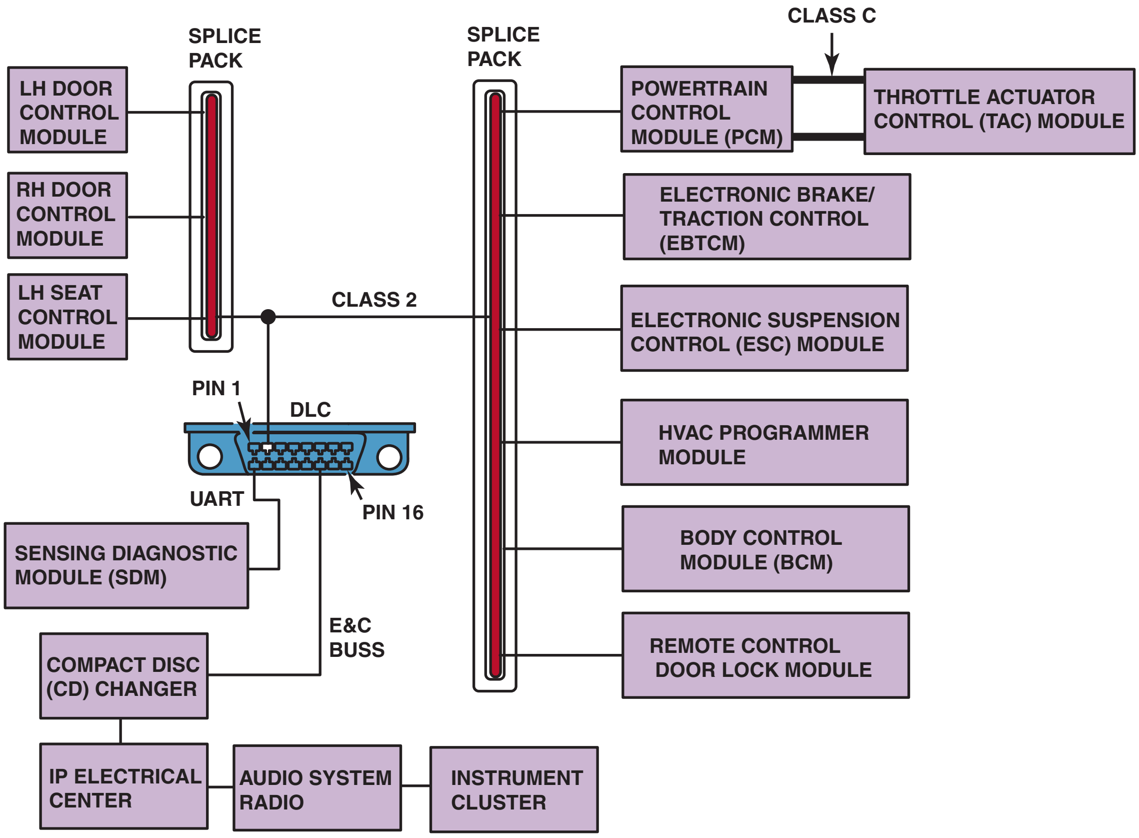


FIGURE 49–4 In a star link network, all of the modules are connected using splice packs.

NETWORK COMMUNICATIONS CLASSIFICATIONS

The Society of Automotive Engineers (SAE) standards include the following three categories of in-vehicle network communications.

CLASS A Low-speed networks, meaning less than 10,000 bits per second (bps, or 10 Kbs), are generally used for trip computers, entertainment, and other convenience features.

? FREQUENTLY ASKED QUESTION

What Is a BUS?

A **BUS** is a term used to describe a communications network. Therefore, there are *connections to the BUS* and *BUS communications,* both of which refer to digital messages being transmitted among electronic modules or computers.

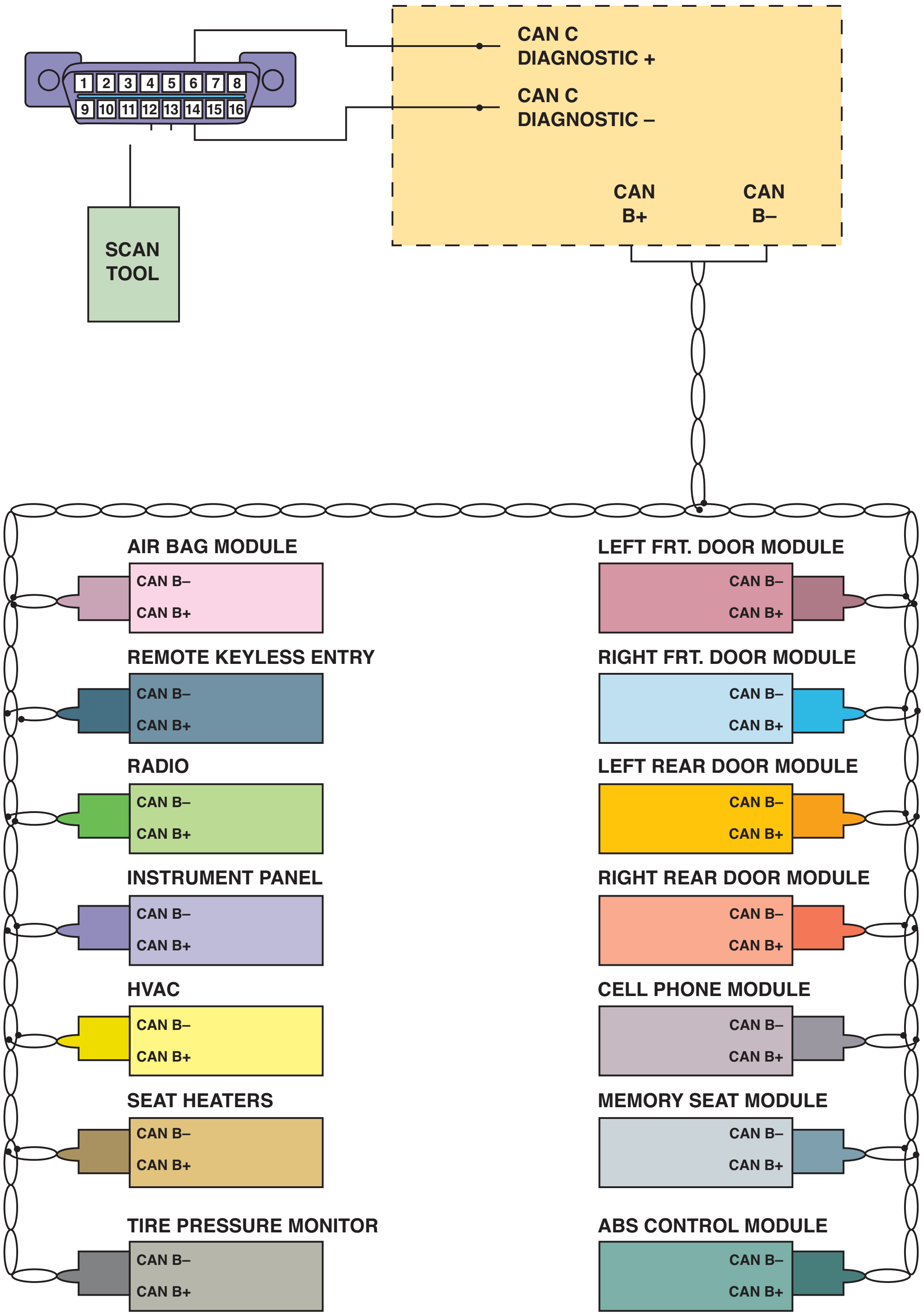


FIGURE 49–5 A typical BUS system showing module CAN communications and twisted pairs of wire.

? FREQUENTLY ASKED QUESTION

What Is a Protocol?

A **protocol** is set of rules or a standard used between computers or electronic control modules. Protocols include the type of electrical connectors, voltage levels, and frequency of the transmitted messages. Protocols, therefore, include both the hardware and software needed to communicate between modules.

CLASS B Medium-speed networks, meaning 10,000 to 125,000 bps (10 to 125 Kbs), are generally used for information transfer among modules, such as instrument clusters, temperature sensor data, and other general uses.

CLASS C High-speed networks, meaning 125,000 to 1,000,000 bps, are generally used for real-time powertrain and vehicle dynamic control. High-speed BUS communication systems now use a **controller area network (CAN).** ● **SEE FIGURE 49–5.**

GENERAL MOTORS COMMUNICATIONS PROTOCOLS

UART General Motors and others use UART communications for some electronic modules or systems. **UART** is a serial data communications protocol that stands for **universal asynchronous receive**

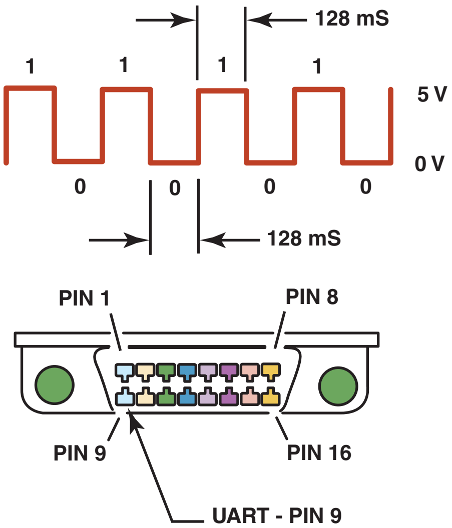


FIGURE 49–6 UART serial data master control module is connected to the data link connector at pin 9.

and transmit. UART uses a master control module connected to one or more remote modules. The master control module is used to control message traffic on the data line by poling all of the other UART modules. The remote modules send a response message back to the master module.

UART uses a fixed pulse-width switching between 0 and 5 V. The UART data BUS operates at a baud rate of 8,192 bps. ● **SEE FIGURE 49–6.**

ENTERTAINMENT AND COMFORT COMMUNICATION

The GM **entertainment and comfort (E & C)** serial data is similar to UART, but uses a 0 to 12 V toggle. Like UART, the E & C serial data uses a master control module connected to other remote modules, which could include the following:

- Compact disc (CD) player
- Instrument panel (IP) electrical center
- Audio system (radio)
- Heating, ventilation, and air-conditioning (HVAC) programmer and control head
- Steering wheel controls

● **SEE FIGURE 49–7.**

CLASS 2 COMMUNICATIONS

Class 2 is a serial communications system that operates by toggling between 0 and 7 V at a transfer rate of 10.4 Kbs. Class 2 is used for most high-speed communications between the powertrain control module (PCM) and other control modules, plus to the scan tool. Class 2 is the primary high-speed serial communications system used by GMCAN (CAN). ● **SEE FIGURE 49–8.**

KEYWORD COMMUNICATION

Keyword 81, 82, and 2000 serial data are also used for some module-to-module communication on GM vehicles. Keyword data BUS signals are toggled from 0 to 12 V when communicating. The voltage or the datastream is zero volts when not communicating. Keyword serial communication is used by the seat heater module and others, but is not connected to the data link connector (DLC). ● **SEE FIGURE 49–9.**

GMLAN

General Motors, like all vehicle manufacturers, must use high-speed serial data to communicate with scan tools on all vehicles effective with the 2008 model year. As mentioned, the standard

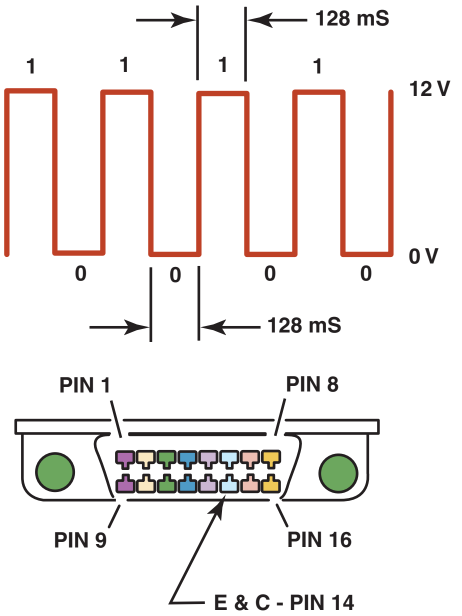


FIGURE 49–7 The E & C serial data is connected to the data link connector (DLC) at pin 14.

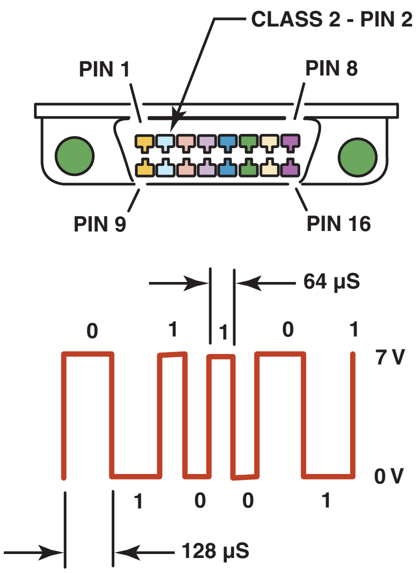


FIGURE 49–8 Class 2 serial data communication is accessible at the data link connector (DLC) at pin 2.

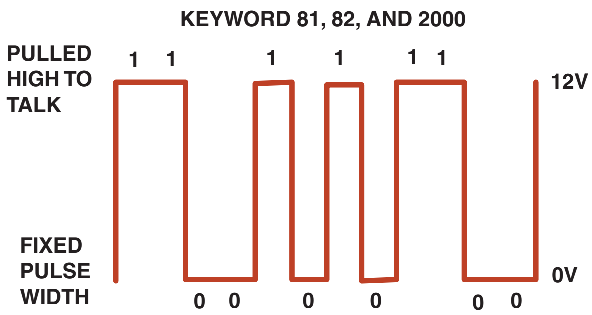


FIGURE 49–9 Keyword 82 operates at a rate of 8,192 bps, similar to UART, and keyword 2000 operates at a baud rate of 10,400 bps (the same as a Class 2 communicator).

is called controller area network (CAN), which General Motors calls **GMLAN,** which stands for **GM local area network.**

General Motors uses two versions of GMLAN.

- **Low-speed GMLAN.** The low-speed version is used for driver-controlled functions such as power windows and door locks. The baud rate for low-speed GMLAN is 33,300 bps.

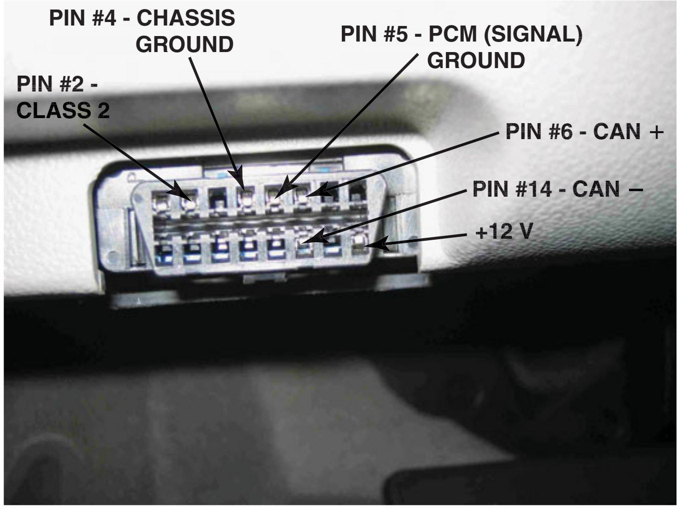


FIGURE 49–10 GMLAN uses pins at terminals 6 and 14.

FIGURE 49–12 A CANdi module will flash the green LED rapidly if communication is detected.

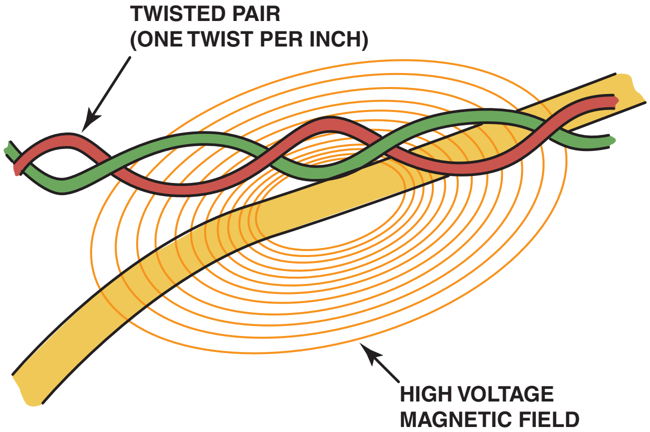


FIGURE 49–11 A twisted pair is used by several different network communications protocols to reduce interference that can be induced in the wiring from nearby electromagnetic sources.

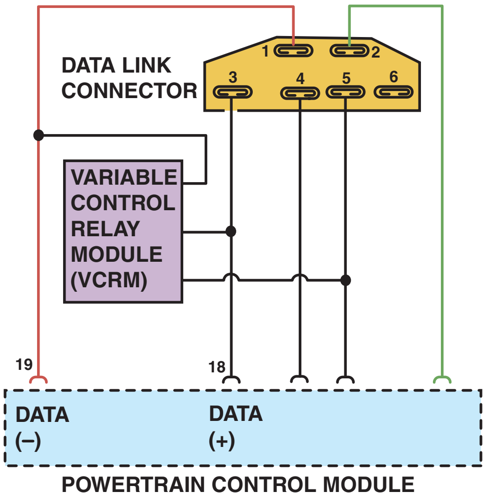


FIGURE 49–13 A Ford OBD-I diagnostic link connector showing that SCP communication uses terminals in cavities 1 (upper left) and 3 (lower left).

The GMLAN low-speed serial data is not connected directly to the data link connector and uses one wire. The voltage toggles between 0 and 5 V after an initial 12 V spike, which indicates to the modules to turn on or wake up and listen for data on the line. Low-speed GMLAN is also known as **single-wire CAN,** or **SWCAN.**

- **High-speed GMLAN.** The baud rate is almost real time at 500 Kbs. This serial data method uses a two-twisted-wire circuit which is connected to the data link connector on pins 6 and 14. ● **SEE FIGURE 49–10.**

? FREQUENTLY ASKED QUESTION

Why Is a Twisted Pair Used?

A twisted pair is where two wires are twisted to prevent electromagnetic radiation from affecting the signals passing through the wires. By twisting the two wires about once every inch (9 to 16 times per foot), the interference is canceled by the adjacent wire. ● **SEE FIGURE 49–11.**

A CANdi (CAN diagnostic interface) module is required to be used with the Tech 2 to be able to connect a GM vehicle equipped with GMLAN. ● **SEE FIGURE 49–12.**

FORD NETWORK COMMUNICATIONS PROTOCOLS

STANDARD CORPORATE PROTOCOL Only a few Fords had scan tool data accessible through the OBD-I data link connector. To identify an OBD-I (1988–1995) on a Ford vehicle that is equipped with **standard corporate protocol (SCP)** and be able to communicate through a scan tool, look for terminals in cavities 1 and 3 of the DLC. ● **SEE FIGURE 49–13.**

SCP uses the J-1850 protocol and is active with the key on. The SCP signal is from 4 V negative to 4.3 V positive, and a scan tool does not have to be connected for the signal to be detected on the terminals. OBD-II (EECV) Ford vehicles use terminals 2 (positive) and 10 (negative) of the 16 pin data link connector (DLC) for network communication, using the SCP module communications.

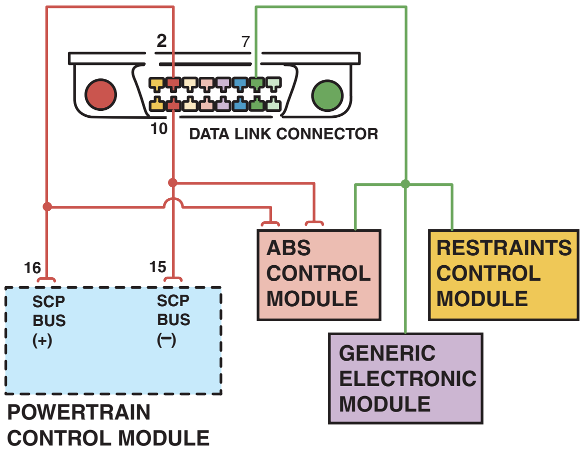


FIGURE 49–14 A scan tool can be used to check communications with the SCP BUS through terminals 2 and 10 and to the other modules connected to terminal 7 of the data link connector (DLC).

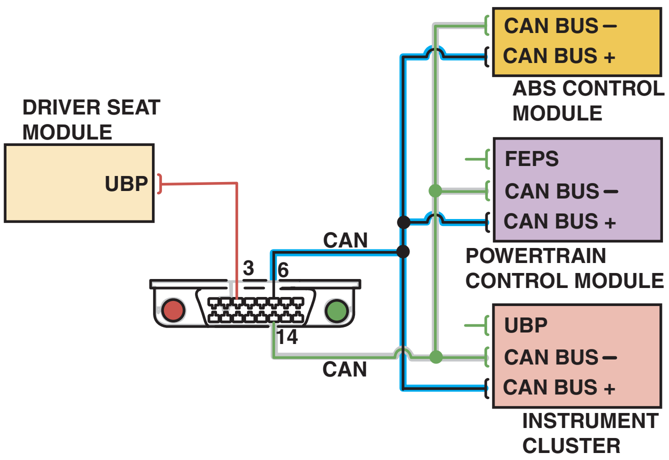


FIGURE 49–15 Many Fords use UBP module communications along with CAN.

UART-BASED PROTOCOL Newer Fords use the CAN for scan tool diagnosis, but still retain SCP and **UART-based protocol (UBP)** for some modules. ● **SEE FIGURES 49–14 AND 49–15.**

CHRYSLER COMMUNICATIONS PROTOCOLS

CCD Since the late 1980s, the **Chrysler Collision Detection (CCD)** multiplex network is used for scan tool and module communications. It is a differential-type communication and uses a twisted pair of wires. The modules connected to the network apply a bias voltage on each wire. CCD signals are divided into plus and minus (CCD+ and CCD−) and the voltage difference does not exceed 0.02 V. The baud rate is 7,812.5 bps.

NOTE: The "collision" in the Chrysler Collision detection BUS communications refers to the program that avoids conflicts of information exchange within the BUS, and does not refer to airbags or other accident-related circuits of the vehicle.

FREQUENTLY ASKED QUESTION

What Are U Codes?

The U diagnostic trouble codes were at first "undefined" but are now network-related codes. Use the network codes to help pinpoint the circuit or module that is not working correctly.

The circuit is active without a scan tool command. ● **SEE FIGURE 49–16.**

The modules on the CCD BUS apply a bias voltage on each wire by using termination resistors. ● **SEE FIGURE 49–17.**

The difference in voltage between CCD+ and CCD− is less than 20 mV. For example, using a digital meter with the black meter lead attached to ground and the red meter lead attached at the data link connector (DLC), a normal reading could include:

- Terminal 3 = 2.45 volts
- Terminal 11 = 2.47 volts

This is an acceptable reading because the readings are 20 mV (0.020 volt) of each other. If both had been exactly 2.5 volts, then this could indicate that the two data lines are shorted together. The module providing the bias voltage is usually the body control module on passenger cars and the front control module on Jeeps and trucks.

PROGRAMMABLE CONTROLLER INTERFACE The Chrysler **programmable controller interface (PCI)** is a one-wire communication protocol that connects at the OBD-II DLC at terminal 2. The PCI BUS is connected to all modules on the BUS in a star configuration and operates at a baud rate of 10,200 bps. The voltage signal toggles between 7.5 and 0 V. If this voltage is checked at terminal 2 of the OBD-II DLC, a voltage of about 1 V indicates the average voltage and means that the BUS is functioning and is not shorted-to-ground. PCI and CCD are often used in the same vehicle. ● **SEE FIGURE 49–18.**

SERIAL COMMUNICATIONS INTERFACE Chrysler used **serial communications interface (SCI)** for most scan tool and flash reprogramming functions until it was replaced with CAN. SCI is connected at the OBD-II diagnostic link connector (DLC) at terminals 6 (SCI receive) and 7 (SCI transmit). A scan tool must be connected to test the circuit.

CONTROLLER AREA NETWORK

BACKGROUND Robert Bosch Corporation developed the CAN protocol, which was called CAN 1.2, in 1993. The CAN protocol was approved by the Environmental Protection Agency (EPA) for 2003 and newer vehicle diagnostics, and a legal requirement for all vehicles by 2008. The CAN diagnostic systems use pins 6 and 14 in the standard 16 pin OBD-II (J-1962) connector. Before CAN, the scan tool protocol had been manufacturer specific.

CAN FEATURES The CAN protocol offers the following features.

- Faster than other BUS communication protocols
- Cost effective because it is an easier system than others to use

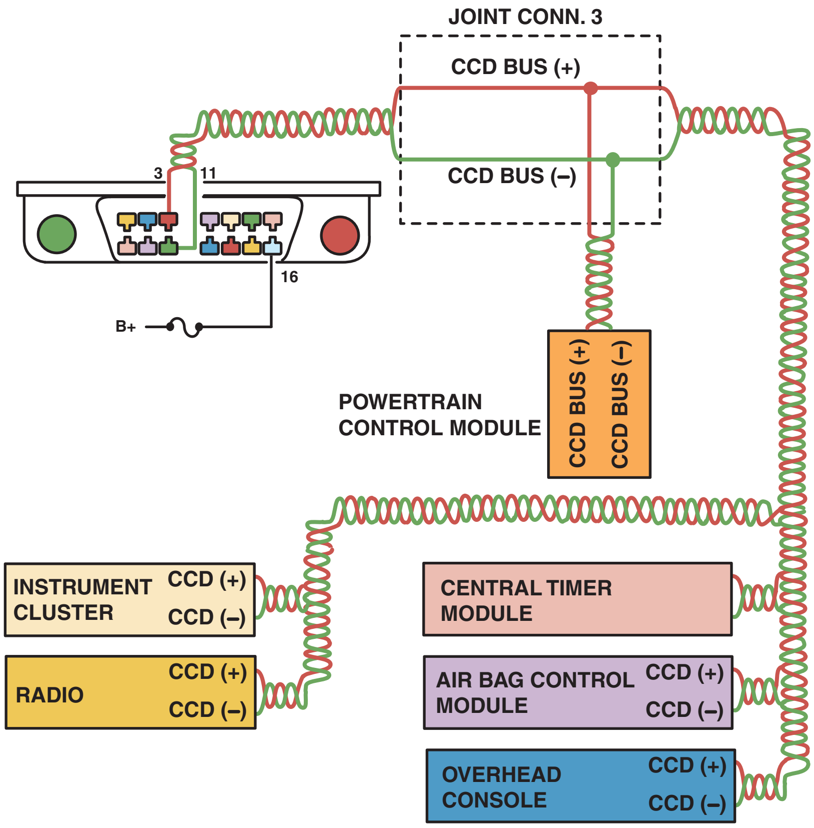


FIGURE 49–16 CCD signals are labeled plus and minus and use a twisted pair of wires. Notice that terminals 3 and 11 of the data link connector are used to access the CCD BUS from a scan tool. Pin 16 is used to supply 12 volts to the scan tool.

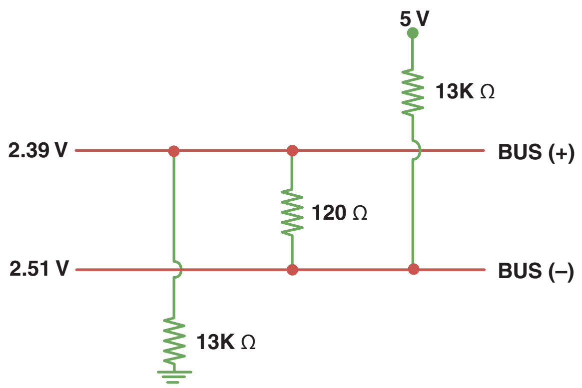


FIGURE 49–17 The differential voltage for the CCD BUS is created by using resistors in a module.

- Less effected by electromagnetic interference (Data is transferred on two wires that are twisted together, called twisted pair, to help reduce EMI interference.)
- Message based rather than address based which makes it easier to expand
- No wakeup needed because it is a two-wire system
- Supports up to15 modules plus a scan tool
- Uses a 120 ohm resistor at the ends of each pair to reduce electrical noise
- Applies 2.5 volts on both wires:
  H (high) goes to 3.5 volts when active
  L (low) goes to 1.5 volts when active

SEE FIGURE 49–19.

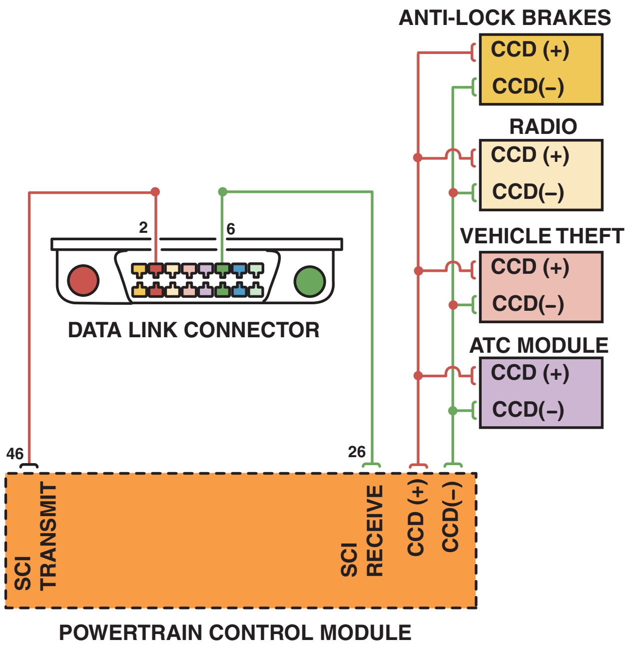


FIGURE 49–18 Many Chrysler vehicles use both SCI and CCD for module communication.

CAN CLASS A, B, AND C

There are three classes of CAN and they operate at different speeds. The CAN A, B, and C networks can all be linked using a gateway within the same vehicle. The gateway is usually one of the many modules in the vehicle.

- **CAN A.** This class operates on only one wire at slow speeds and is therefore less expensive to build. CAN A operates a data transfer rate of 33.33 Kbs in normal mode and up to 83.33 Kbs during reprogramming mode. CAN A uses the vehicle ground as the signal return circuit.
- **CAN B.** This class operates on a two-wire network and does not use the vehicle ground as the signal return circuit. CAN B

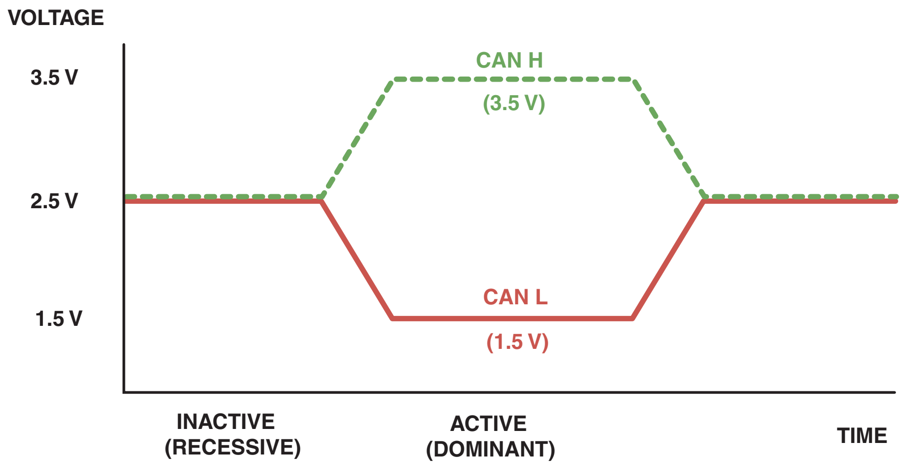


FIGURE 49–19 CAN uses a differential type of module communication where the voltage on one wire is the equal but opposite voltage on the other wire. When no communication is occurring, both wires have 2.5 volts applied. When communication is occurring, CAN H (high) goes up 1 volt to 3.5 volts and CAN L (low) goes down 1 volt to 1.5 volts.

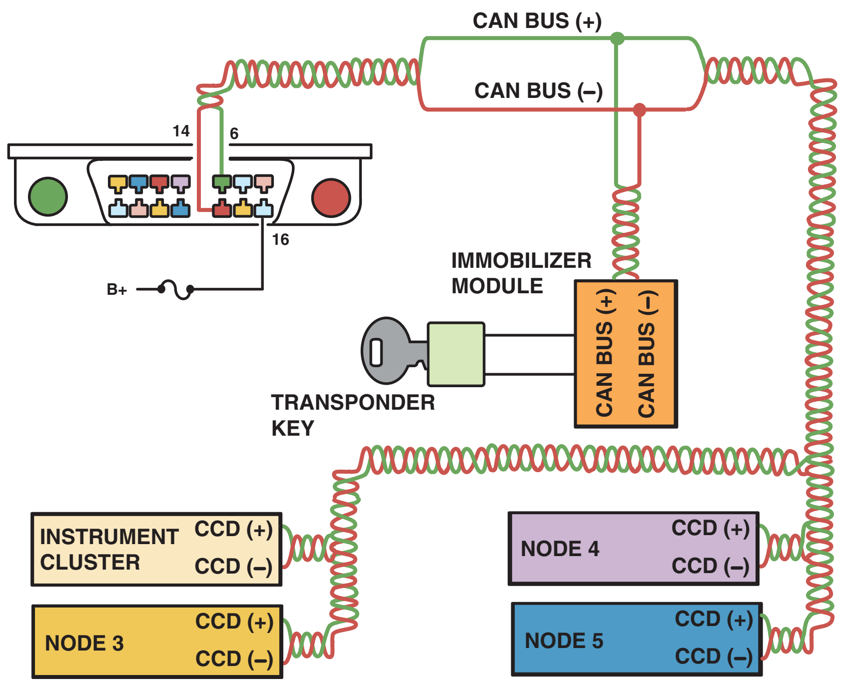


FIGURE 49–20 A typical (generic) system showing how the CAN BUS is connected to various electrical accessories and systems in the vehicle.

uses a data transfer rate of 95.2 Kbs. Instead, CAN B (and CAN C) uses two network wires for differential signaling. This means that the two data signal voltages are opposite to each other and used for error detection by constantly being compared. In this case, when the signal voltage at one of the CAN data wires goes high (CAN H), the other one goes low (CAN L), hence the name *differential signaling.* Differential signaling is also used for redundancy, in case one of the signal wires shorts out.

- **CAN C.** This class is the highest speed CAN protocol with speeds up to 500 Kbs. Beginning with 2008 models, all vehicles sold in the United States must use CAN BUS for scan tool communications. Most vehicle manufacturers started using CAN in older models; and it is easy to determine if a vehicle is equipped with CAN. The CAN BUS communicates to the scan tool through terminals 6 and 14 of the DLC indicating that the vehicle is equipped with CAN. ● **SEE FIGURE 49–20.**

The total voltage remains constant at all times and the electromagnetic field effects of the two data BUS lines cancel each other out. The data BUS line is protected against received radiation and is virtually neutral in sending radiation.

HONDA/TOYOTA COMMUNICATIONS

The primary BUS communications on pre-CAN-equipped vehicles is ISO 9141-2 using terminals 7 and 15 at the OBD-II DLC. ● **SEE FIGURE 49–21.**

A factory scan tool or an aftermarket scan tool equipped with enhanced original equipment (OE) software is needed to access many of the BUS messages. ● **SEE FIGURE 49–22.**

EUROPEAN BUS COMMUNICATIONS

UNIQUE DIAGNOSTIC CONNECTOR Many different types of module communications protocols are used on European vehicles such as Mercedes and BMW.

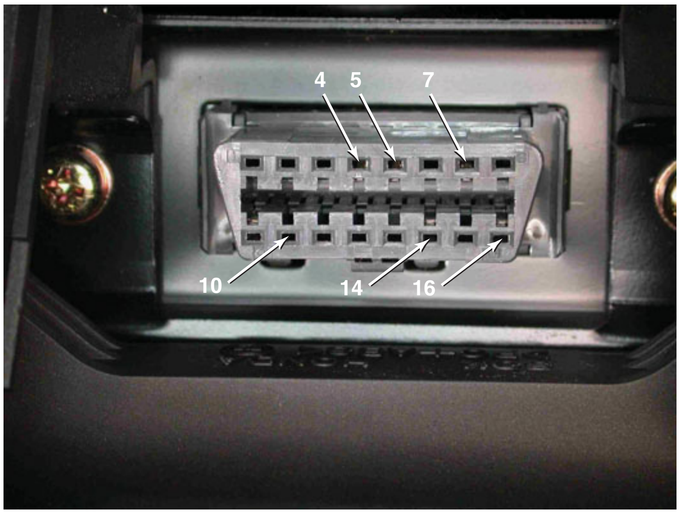


FIGURE 49–21 A DLC from a pre-CAN Acura. It shows terminals in cavities 4, 5 (grounds), 7, 10, 14, and 16 (B+).

FIGURE 49–22 A Honda scan display showing a B and two U codes, all indicating a BUS-related problem(s).

Most of these communication BUS messages cannot be accessed through the data link connector (DLC). To check the operation of the individual modules, a scan tool equipped with factory-type software will be needed to communicate with the module through the gateway module. ● **SEE FIGURE 49–23** for an alternative access method to the modules.

MEDIA ORIENTED SYSTEM TRANSPORT BUS

The media oriented system transport (MOST) BUS uses fiber optics for module-to-module communications in a ring or star configuration. This BUS system is currently being used for entertainment equipment data communications for videos, CDs, and other media systems in the vehicle.

MOTOROLA INTERCONNECT BUS

Motorola interconnect (MI) is a single-wire serial communications protocol, using one master control module and many slave modules. Typical application of the MI BUS protocol is with power and memory mirrors, seats, windows, and headlight levelers.

DISTRIBUTED SYSTEM INTERFACE BUS

Distributed system interface (DSI) BUS protocol was developed by Motorola and uses a two-wire serial BUS. This BUS protocol is currently being used for safety-related sensors and components.

FIGURE 49–23 A typical 38-cavity diagnostic connector as found on many BMW and Mercedes vehicles under the hood. The use of a breakout box (BOB) connected to this connector can often be used to gain access to module BUS information.

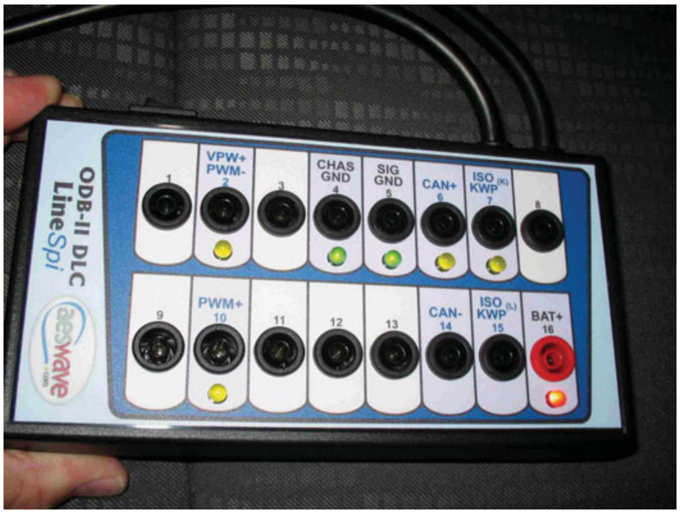


FIGURE 49–24 A breakout box (BOB) used to access the BUS terminals while using a scan tool to activate the modules. This breakout box is equipped with LEDs that light when circuits are active.

? FREQUENTLY ASKED QUESTION

How Do You Know What System Is Used?

Use service information to determine which network communication protocol is used. However, due to the various systems on some vehicles, it may be easier to look at the data link connection to determine the system. All OBD-II vehicles have terminals in the following cavities.

Terminal 4: chassis ground

Terminal 5: computer (signal) ground

Terminal 16: 12 V positive

The terminals in cavities 6 and 14 mean that this vehicle is equipped with CAN as the only module communication protocol available at the DLC. To perform a test of the BUS, use a **breakout box (BOB)** to gain access to the terminals while connecting to the vehicle, using a scan tool. ● **SEE FIGURE 49–24** for a typical OBD-II connector breakout box.

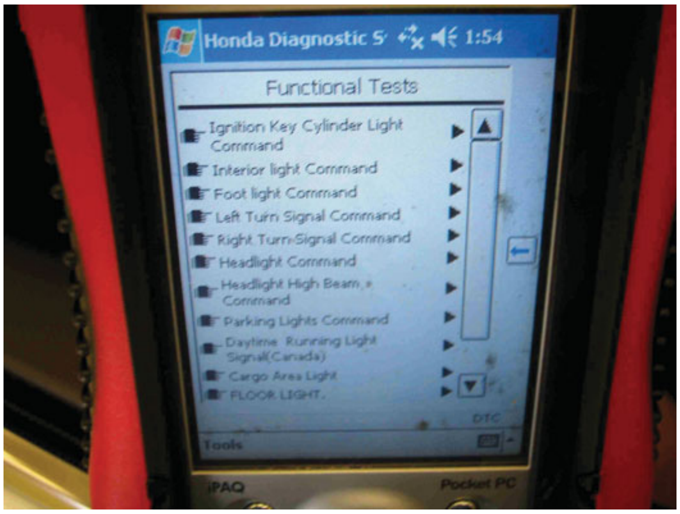


FIGURE 49–25 This Honda scan tool allows the technician to turn on individual lights and operate individual power windows and other accessories that are connected to the BUS system.

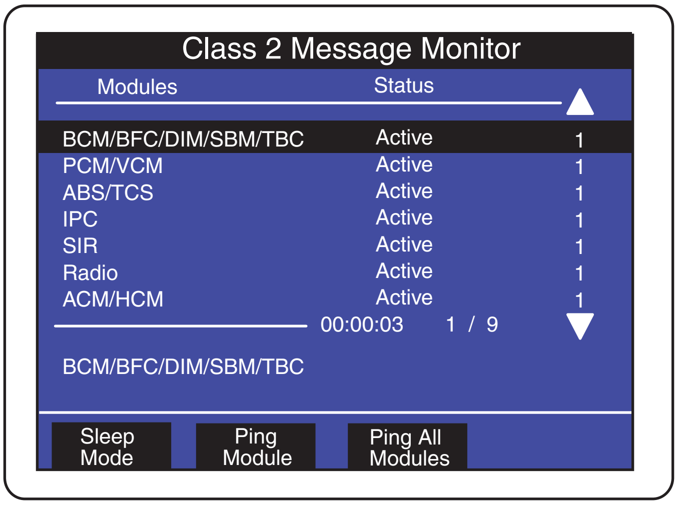


FIGURE 49–26 Modules used in a General Motors vehicle can be "pinged" using a Tech 2 scan tool.

BOSCH-SIEMANS-TEMIC BUS The Bosch-Siemans-Temic (BST) BUS is another system that is used for safety-related components and sensors in a vehicle, such as airbags. The BST BUS is a two-wire system and operates up to 250,000 bps.

BYTEFLIGHT BUS The byteflight BUS is used in safety critical systems, such as airbags, and uses the time division multiple access (TDMA) protocol, which operates at 10 million bps using a **plastic optical fiber (POF).**

FLEXRAY BUS FlexRay BUS is a version of byteflight, and is a high-speed serial communication system for in-vehicle networks. FlexRay is commonly used for steer-by-wire and brake-by-wire systems.

DOMESTIC DIGITAL BUS The domestic digital BUS, commonly designated D2B, is an optical BUS system connecting audio, video, computer, and telephone components in a single-ring structure with a speed of up to 5,600,000 bps.

LOCAL INTERCONNECT NETWORK BUS Local interconnect network (LIN) is a BUS protocol used between intelligent sensors and actuators, and has a BUS speed of 19,200 bps.

NETWORK COMMUNICATIONS DIAGNOSIS

STEPS TO FINDING A FAULT When a network communications fault is suspected, perform the following steps.

STEP 1 **Check everything that does and does not work.** Often accessories that do not seem to be connected can help identify which module or BUS circuit is at fault.

STEP 2 **Perform module status test.** Use a factory level scan tool or an aftermarket scan tool equipped with enhanced software that allows OE-like functions. Check if the components or systems can be operated through the scan tool. ● **SEE FIGURE 49–25.**

- **Ping modules.** Start the Class 2 diagnosis by using a scan tool and select *diagnostic circuit check.* If no diagnostic trouble codes (DTCs) are shown, there could be a communication problem. Select *message monitor,* which will display the status of all of the modules on the Class 2 BUS circuit. The modules that are awake will be shown as active and the scan tool can be used to ping individual modules or command all modules. The ping command should change the status from "active" to "inactive." ● **SEE FIGURE 49–26.**

NOTE: If an excessive parasitic draw is being diagnosed, use a scan tool to ping the modules in one way to determine if one of the modules is not going to sleep and causing the excessive battery drain.

- **Check state of health.** All modules on the Class 2 BUS circuit have at least one other module responsible for reporting **state of health (SOH).** If a module fails to send a state of health message within five seconds, the companion module will set a diagnostic trouble code for the module that did not respond. The defective module is not capable of sending this message.

STEP 3 **Check the resistance of the terminating resistors.** Most high-speed BUS systems use resistors at each end, called **terminating resistors.** These resistors are used to help reduce interference into other systems in the vehicle. Usually two 120 ohm resistors are installed at each end and are therefore connected electrically in parallel. Two 120 ohm resistors connected in parallel would measure 60 ohms if being tested using an ohmmeter. ● **SEE FIGURE 49–27.**

STEP 4 **Check data BUS for voltages.** Use a digital multimeter set to DC volts, to monitor communications and check the BUS for proper operation. Some BUS conditions and possible causes include:

- **Signal is zero volt all of the time.** Check for short-to-ground by unplugging modules one at a time to check if one module is causing the problem.
- **Signal is high or 12 volts all of the time.** The BUS circuit could be shorted to 12 V. Check with the customer to see if any service or body repair work was done recently. Try unplugging each module one at a time to pin down which module is causing the communications problem.

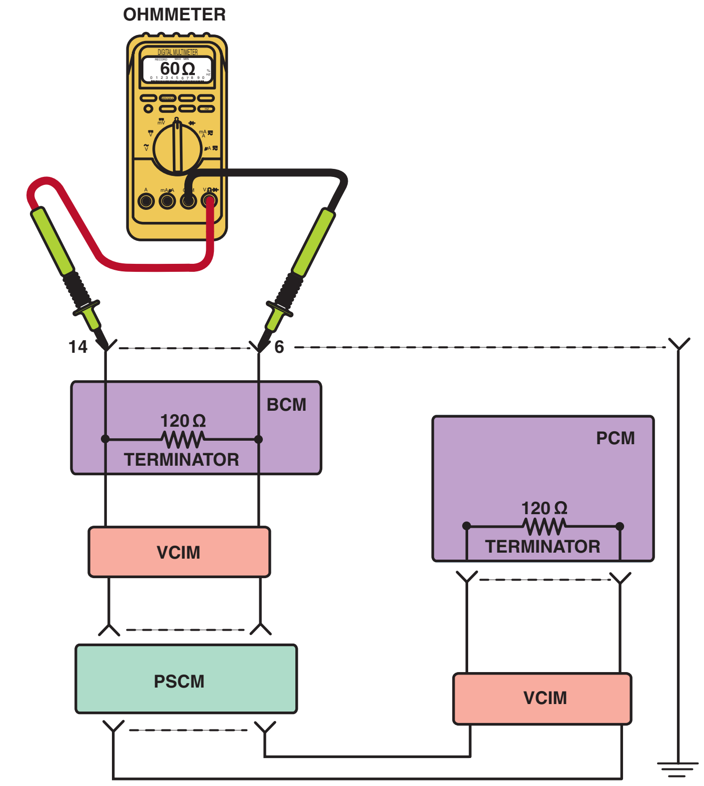


FIGURE 49–27 Checking the terminating resistors using an ohmmeter at the DLC.

FIGURE 49–28 Use front-probe terminals to access the data link connector. Always follow the specified back-probe and front-probe procedures as found in service information.

TECH TIP

No Communication? Try Bypass Mode.

If a Tech 2 scan tool shows "no communication," try using the bypass mode to see what should be on the data display. To enter bypass mode, perform the following steps.

STEP 1 Select tool option (F3).

STEP 2 Set communications to bypass (F5).

STEP 3 Select enable.

STEP 4 Input make/model and year of vehicle.

STEP 5 Note all parameters that should be included, as shown. The values will not be shown.

REAL WORLD FIX

The Radio Caused No-Start Story

A 2005 Chevrolet Cobalt did not start. A technician checked with a subscription-based helpline service and discovered that a fault with the Class 2 data circuit could prevent the engine from starting. The advisor suggested that a module should be disconnected one at a time to see if one of them was taking the data line to ground. The two most common components on the Class 2 serial data line that have been known to cause a lack of communication and become shorted-to-ground are the radio and electronic brake control module (EBCM). The first one the technician disconnected was the radio. The engine started and ran. Apparently the Class 2 serial data line was shorted-to-ground inside the radio, which took the entire BUS down. When BUS communication is lost, the PCM is not able to energize the fuel pump, ignition, or fuel injectors so the engine would not start. The radio was replaced to solve the no-start condition.

FREQUENTLY ASKED QUESTION

Which Module Is the Gateway Module?

The gateway module is responsible for communicating with other modules and acts as the main communications module for scan tool data. Most General Motors vehicles use the body control module (BCM) or the instrument panel control (IPC) module as the gateway. To verify which module is the gateway, check the schematic and look for one that has voltage applied during all of the following conditions.

- Key on, engine off
- Engine cranking
- Engine running

- **A variable voltage usually indicates that messages are being sent and received.** CAN and Class 2 can be identified by looking at the data link connector (DLC) for a terminal in cavity number 2. Class 2 is active all of the time the ignition is on, and therefore voltage variation between 0 and 7 V can be measured using a DMM set to read DC volts. ● **SEE FIGURE 49–28.**

STEP 5 **Use a digital storage oscilloscope to monitor the waveforms of the BUS circuit.** Using a scope on the data line terminals can show if communication is being transmitted. Typical faults and their causes include:

- **Normal operation.** Normal operation shows variable voltage signals on the data lines. It is impossible to know what information is being transmitted, but if there is activity with short sections of inactivity, this indicates normal data line transmission activity. ● **SEE FIGURE 49–29.**
- **High voltage.** If there is a constant high-voltage signal without any change, this indicates that the data line is shorted to voltage.
- **Zero or low voltage.** If the data line voltage is zero or almost zero and not showing any higher voltage signals, then the data line is short-to-ground.

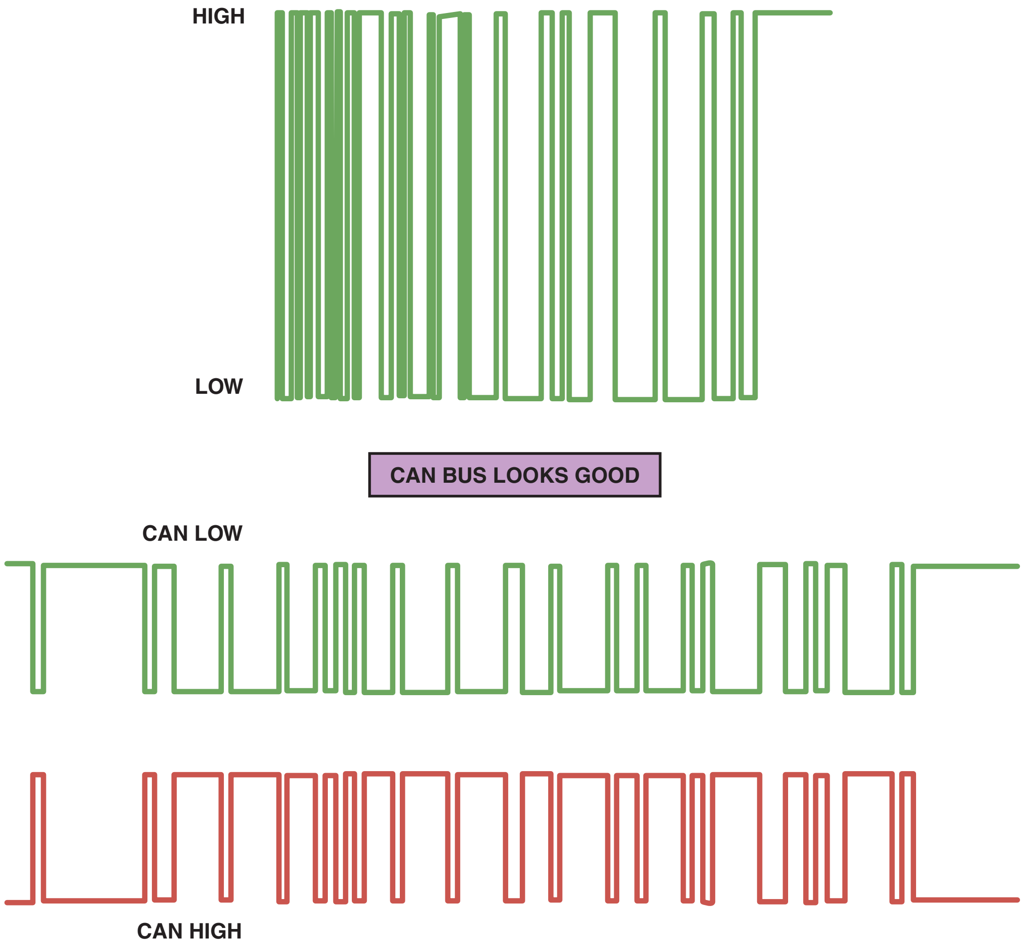


FIGURE 49–29 (a) Data is sent in packets, so it is normal to see activity then a flat line between messages. (b) A CAN BUS should show voltages that are opposite when there is normal communications. CAN H (high) circuit should go from 2.5 volts at rest to 3.5 volts when active. The CAN L (low) circuit goes from 2.5 volts at rest to 1.5 volts when active.

STEP 6 **Follow factory service information instructions to isolate the cause of the fault.** This step often involves disconnecting one module at a time to see if it is the cause of a short-to-ground or an open in the BUS circuit.

OBD-II DATA LINK CONNECTOR

All OBD-II vehicles use a 16 pin connector that includes:

Pin 4 = chassis ground

Pin 5 = signal ground

Pin 16 = battery power (4 A max)

● **SEE FIGURE 49–30.**

GENERAL MOTORS VEHICLES

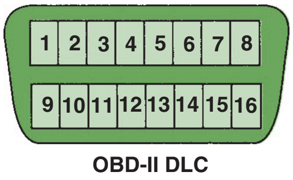
- SAE J-1850 (VPW, Class 2, 10.4 Kbs) standard, which uses pins 2, 4, 5, and 16, but not 10
- GM Domestic OBD-II

  Pin 1 and 9: CCM (comprehensive component monitor) slow baud rate, 8,192 UART

  Pins 2 and 10: OEM enhanced, fast rate, 40,500 baud rate

  Pins 7 and 15: generic OBD-II, ISO 9141, 10,400 baud rate

  Pins 6 and 14: GMLAN



PIN NO.	ASSIGNMENTS
1.	MANUFACTURER'S DISCRETION
2.	BUS + LINE, SAE J1850
3.	MANUFACTURER'S DISCRETION
4.	CHASSIS GROUND
5.	SIGNAL GROUND
6.	MANUFACTURER'S DISCRETION
7.	K LINE, ISO 9141
8.	MANUFACTURER'S DISCRETION
9.	MANUFACTURER'S DISCRETION
10.	BUS – LINE, SAE J1850
11.	MANUFACTURER'S DISCRETION
12.	MANUFACTURER'S DISCRETION
13.	MANUFACTURER'S DISCRETION
14.	MANUFACTURER'S DISCRETION
15.	L LINE, ISO 9141
16.	VEHICLE BATTERY POSITIVE (4A MAX)

FIGURE 49–30 A 16 pin OBD-II DLC with terminals identified. Scan tools use the power pin (16) and ground pin (4) for power so that a separate cigarette lighter plug is not necessary on OBD-II vehicles.

ASIAN, CHRYSLER, AND EUROPEAN VEHICLES

- ISO 9141-2 standard, which uses pins 4, 5, 7, 15, and 16
- Chrysler Domestic Group OBD-II

  Pins 2 and 10: CCM

  Pins 3 and 14: OEM enhanced, 60,500 baud rate

  Pins 7 and 15: generic OBD-II, ISO 9141, 10,400 baud rate

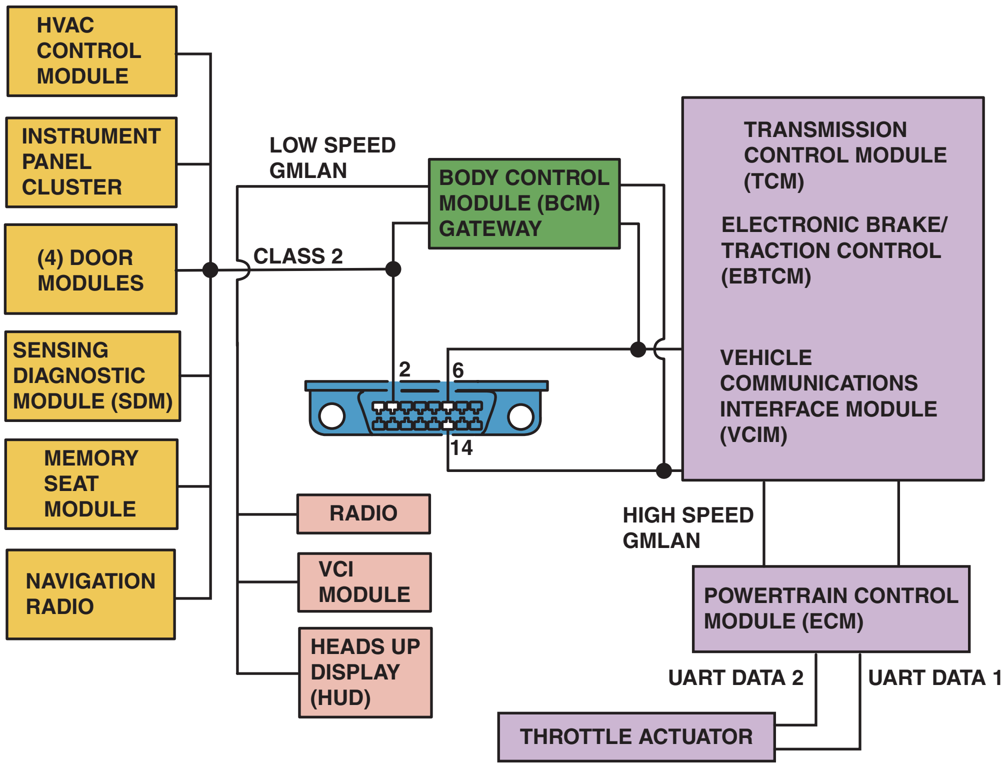


FIGURE 49–31 This schematic of a Chevrolet Equinox shows that the vehicle uses a GMLAN BUS (DLC pins 6 and 14), plus a Class 2 (pin 2) and UART.

TECH TIP

Check Computer Data Line Circuit Schematic

Many General Motors vehicles use more than one type of BUS communications protocol. Check service information (SI) and look at the schematic for computer data line circuits which should show all of the data BUSes and their connectors to the diagnostic link connector (DLC). ● **SEE FIGURE 49–31.**

FORD VEHICLES

- SAE J-1850 (PWM, 41.6 Kbs) standard, which uses pins 2, 4, 5, 10, and 16
- Ford Domestic OBD-II

  Pins 2 and 10: CCM

  Pins 6 and 14: OEM enhanced, Class C, 40,500 baud rate

  Pins 7 and 15: generic OBD-II, ISO 9141, 10,400 baud rate

REVIEW QUESTIONS

1. Why is a communication network used?
2. Why are the two wires twisted if used for network communications?
3. Why is a gateway module used?
4. What are U codes?

CHAPTER QUIZ

1. Technician A says that module communications networks are used to reduce the number of wires in a vehicle. Technician B says that a communications network is used to share data from sensors, which can be used by many different modules. Which technician is correct?
   - **a.** Technician A only
   - **b.** Technician B only
   - **c.** Both Technicians A and B
   - **d.** Neither Technician A nor B
2. A module is also known as a _____________.
   - **a.** BUS
   - **b.** Node
   - **c.** Terminator
   - **d.** Resistor pack
3. A high-speed CAN BUS communicates with a scan tool through which terminal(s)?
   - **a.** 6 and 14
   - **b.** 2
   - **c.** 7 and 15
   - **d.** 4 and 16
4. UART uses a _____________ signal that toggles 0 V.
   - **a.** 5 V
   - **b.** 7 V
   - **c.** 8 V
   - **d.** 12 V
5. GM Class 2 communication toggles between _____________.
   - **a.** 5 and 7 V
   - **b.** 0 and 12 V
   - **c.** 7 and 12 V
   - **d.** 0 and 7 V