PowerPoint® Slides to accompany

Automotive Fuel and Emissions Control Systems

SECOND EDITION

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Chapter 12: Network Communications and Diagnosis

Professional Technician
We Support ASE NATEF
Pearson Automotive

OBJECTIVES

After studying Chapter 12, the reader should be able to:

1. Prepare for ASE Electrical/Electronic Systems (A6) certification test content area “A” (General Electrical/Electronic Systems Diagnosis).
2. Describe the types of networks and serial communications used on vehicles.
3. Discuss how the networks connect to the data link connector and to other modules.
4. Explain how to diagnose module communication faults.

NEED FOR MODULE COMMUNICATIONS AND NETWORKS

- Since the 1990s, vehicles use modules to control most of the electrical component operation.
  - 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.

TYPES OF COMMUNICATIONS

- Each module, also called a **node,** must communicate to other modules.
- The types of communications include the following:
  - Differential
  - Parallel
  - Serial Data
  - Multiplexing

TYPES OF COMMUNICATIONS

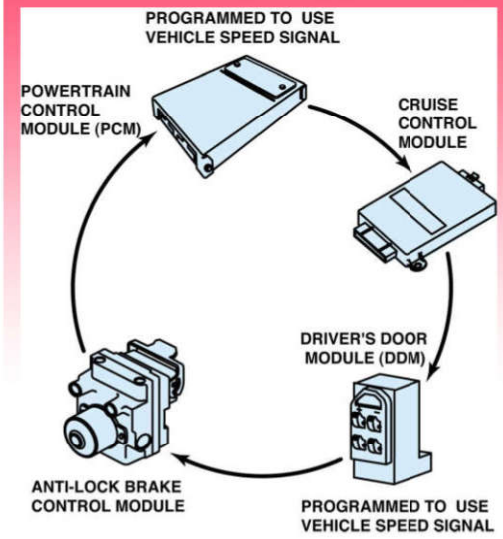


FIGURE 12-1 A network allows all modules to communicate with other modules.

MODULE COMMUNICATIONS CONFIGURATION

- The three most common types of networks used on General Motors vehicles include:
  - **Ring link networks**
  - **Star link**
  - **Ring/star hybrid**

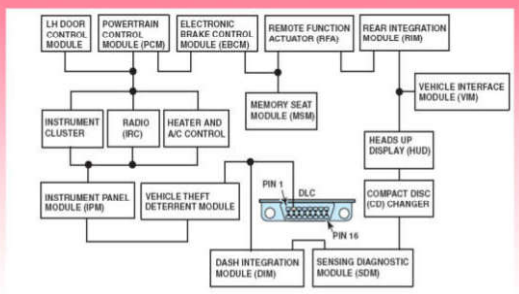


FIGURE 12-2 A ring link network reduces the number of wires it takes to interconnect all of the modules.

MODULE COMMUNICATIONS CONFIGURATION

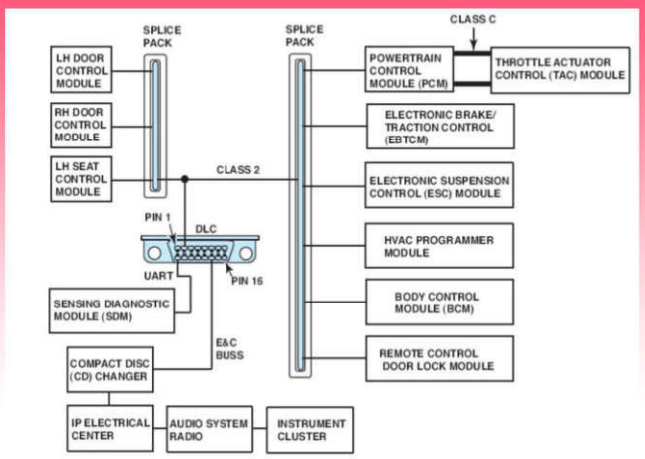


FIGURE 12-3 A star link network connects all of the modules together using splice packs.

SAE COMMUNICATIONS CLASSIFICATIONS

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

SAE COMMUNICATIONS CLASSIFICATIONS
Class C

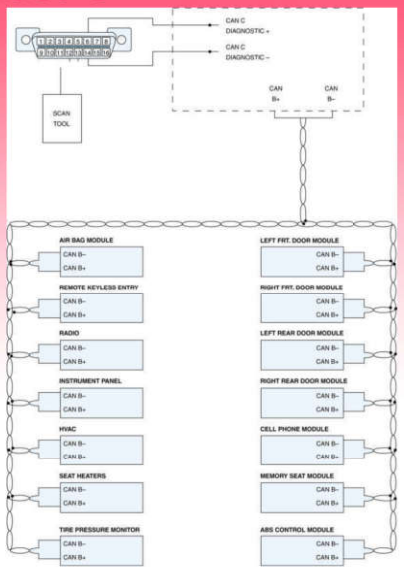


FIGURE 12-4 A typical BUS system showing module CAN communications and twisted pairs of wire.

GENERAL MOTORS MODULE COMMUNICATIONS PROTOCOLS

- General Motors uses UART communications for some electronic modules or systems. **UART** is a serial data communications protocol that stands for **Universal Asynchronous Receive and Transmit.**

GENERAL MOTORS MODULE COMMUNICATIONS PROTOCOLS

- 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.

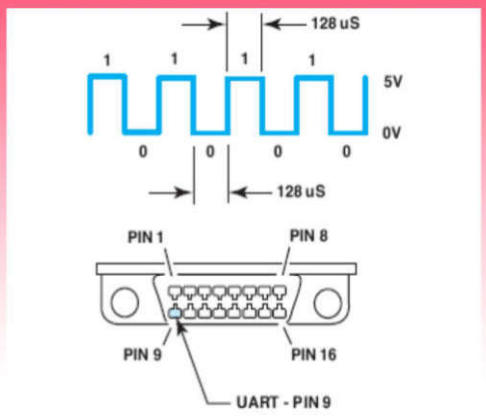


FIGURE 12-5 UART serial data master control module is connected to the data link connector at pin 9.

GENERAL MOTORS MODULE COMMUNICATIONS PROTOCOLS

- The General Motors **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 modules.

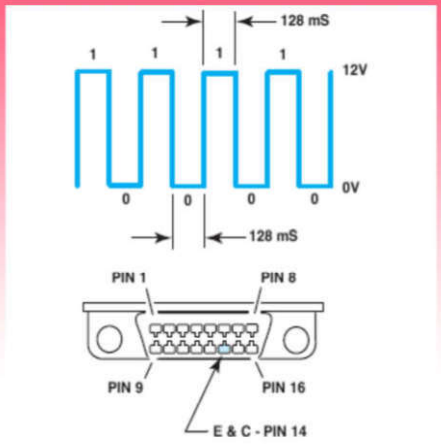


FIGURE 12-6 The E & C serial data is connected to the data link connector (DLC) at pin 14.

GENERAL MOTORS MODULE COMMUNICATIONS PROTOCOLS

- Class 2 is used for most high-speed communications between the powertrain control module, (PCM) and other control modules, plus to the Tech 2 scan tool.

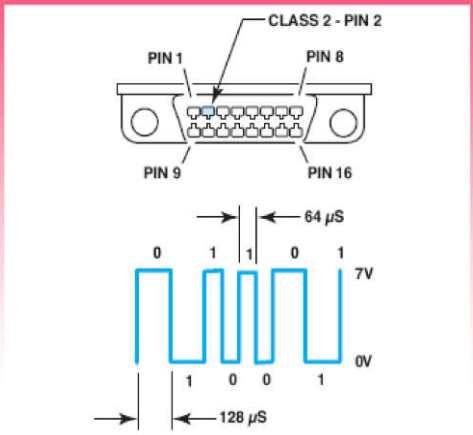


FIGURE 12-7 Class 2 serial data communication is accessible at the data link connector (DLC) at pin 2.

GENERAL MOTORS MODULE COMMUNICATIONS PROTOCOLS

- **Keyword** 81, 82, and 2000 serial data are also used for some module-to-module communications on General Motors vehicles.
- Keyword serial communication is used by the seat heater module and others, but is not connected to the data link connector.

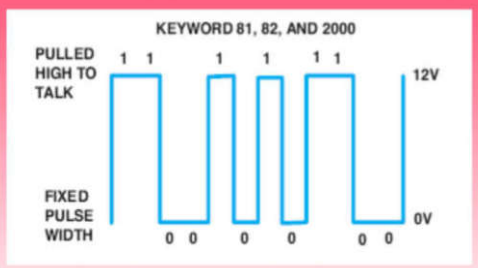


FIGURE 12-8 Keyword 82 operates at a rate of 8,192 bps, similar to UART, and keyword 2000 operates at a baud rate of 10,400 bps (the same as Class 2 communicator).

GENERAL MOTORS MODULE COMMUNICATIONS PROTOCOLS

- General Motors uses two versions of GMLAN.
  - High-speed GMLAN
  - Low-Speed GMLAN

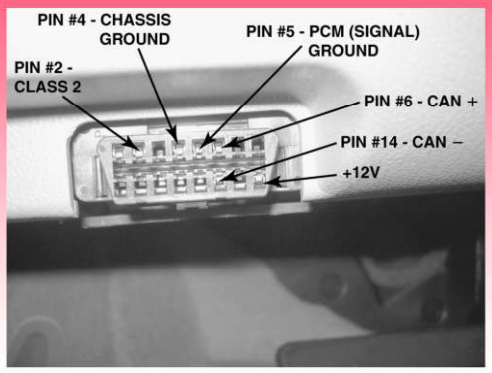


FIGURE 12-9 GMLAN uses pins at terminals 6 and 14.

WHAT IS A TWISTED PAIR?

- A **twisted pair** is where two wires are twisted to prevent electromagnetic radiation from affecting the signals passing through the wires.

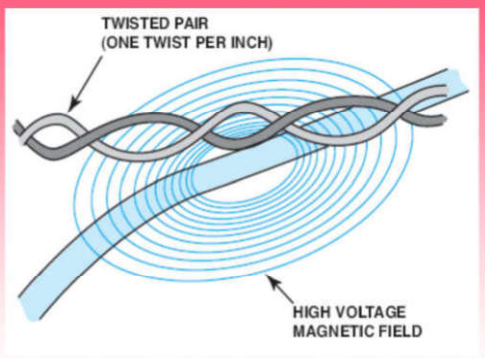


FIGURE 12-10 A twisted pair is used by several different network communications protocols to reduce interference that can be induced in the wiring from nearby electromagnetic sources.

GENERAL MOTORS MODULE COMMUNICATIONS PROTOCOLS

- 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.

FIGURE 12-11 A CANDi module will flash the green LED rapidly if communication is detected.

FORD NETWORK COMMUNICATIONS PROTOCOLS

- To identify an OBD-I (1988–1995) on a Ford vehicle that is equipped with **Standard Corporate Protocol (SCP)** and able to communicate through a scan tool, look for terminals in cavities 1 and 3 of the DLC.

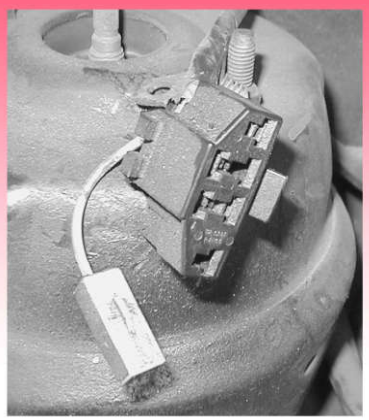


FIGURE 12-12 A Ford OBD-I diagnostic link connector. If this had SCP communications, there would be terminals in cavities 1 (upper left) and 3 (lower left).

FORD NETWORK COMMUNICATIONS PROTOCOLS

- SCP uses the J-1850 protocol and is active with the key on.

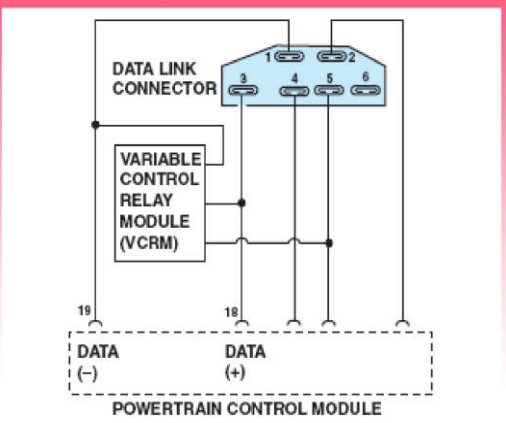


FIGURE 12-13 Notice that the SCP BUS connector to the OBD-I diagnostic connector is at terminals 1 and 3.

FORD NETWORK COMMUNICATIONS PROTOCOLS

- Newer Fords use the CAN for scan tool diagnosis but still retain SCP and **UART Based Protocol (UBP)** for some modules.

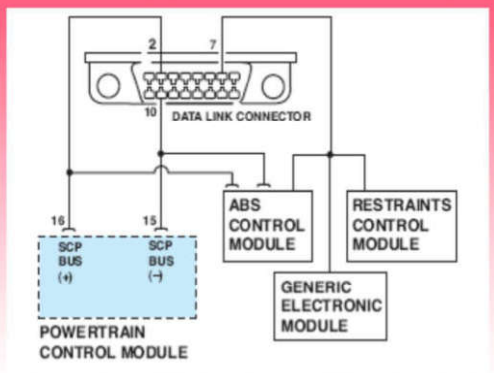


FIGURE 12-14 Start the diagnosis by using a scan tool and check to see if communications can be established with modules.

FORD NETWORK COMMUNICATIONS PROTOCOLS

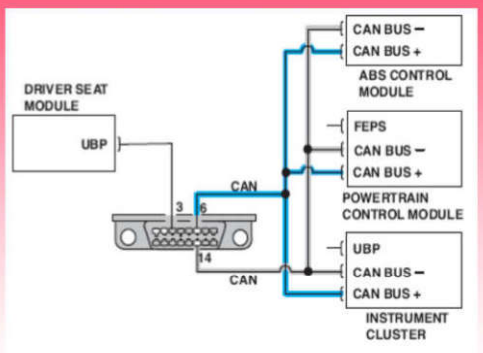


FIGURE 12-15 If there is no communication, check to see if there is a positive voltage signal on the positive side of the BUS and a negative voltage signal on the negative side of the BUS.

CHRYSLER COMMUNICATIONS PROTOCOLS

- Chrysler OBD-I (1981–1995) vehicles were equipped with a BUS system called **Serial Communications Interface (SCI)** to communicate with a scan tool through the OBD-II data link connector.

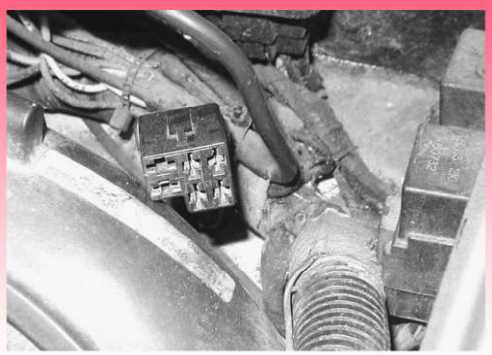


FIGURE 12-16 The PCM and scan tool communicate through terminal 2 (SCI transmit) and terminal 5 (SCI receive) to a scan tool at the OBD-I DLC connector.

CHRYSLER COMMUNICATIONS PROTOCOLS

- CCD signals are divided into plus and minus (CCD+ and CCD-) and the voltage difference does not exceed 0.02 V.

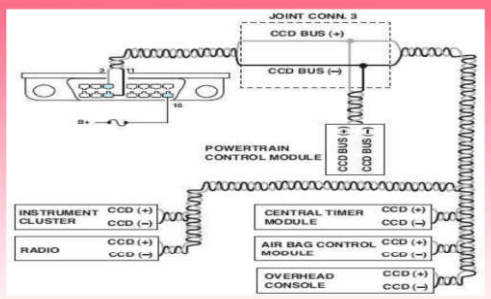


FIGURE 12-17 CCD signals are labeled plus and minus and use a twisted pair of wires. Notice that terminals 3 and 11 of the data link connector are used to access the CLC BUS from a scan tool. Pin 4 is used to supply 12 volts to the scan tool.

CHRYSLER COMMUNICATIONS PROTOCOLS

- The modules on the CCD BUS apply a bias voltage on each wire by using termination resistors.

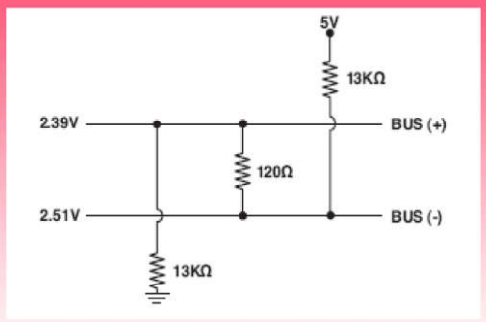


FIGURE 12-18 The differential voltage for the CCD BUS is created by using resistors in a module.

CHRYSLER COMMUNICATIONS PROTOCOLS

- The Chrysler **Programmable Controller Interface (PCI)** is a one-wire communication protocol that connects at the OBD-II DLC at terminal 2.
- PCI and CCD are often used in the same vehicle.

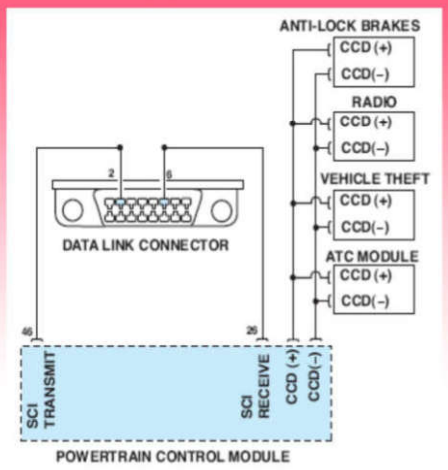


FIGURE 12-19 Many Chrysler vehicles use both SCI and CCD for module communication.

CHRYSLER PROGRAMMABLE CONTROLLER INTERFACE

- Chrysler used SCI for most scan tool and flash reprogramming functions until it was replaced with CAN.
- A scan tool must be connected to test the circuit. To perform a test of the BUS, use a **break-out box (BOB)** to gain access to the terminals while connecting to the vehicle, using a scan tool.

FIGURE 12-20 A break-out box (BOB) used to access the BUS terminals while using a scan tool to activate the modules. This break-out box is equipped with LEDs that light when circuits are active.

HOW DO YOU KNOW WHAT SYSTEM IS USED?

- Use service information to determine which network communication protocol is used.

FIGURE 12-21 The pin in terminal 6 is used for high-speed CAN+ and terminal 11 is used for high-speed CAN communications to a scan tool.

EUROPEAN BOSCH BUS COMMUNICATIONS

- 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.

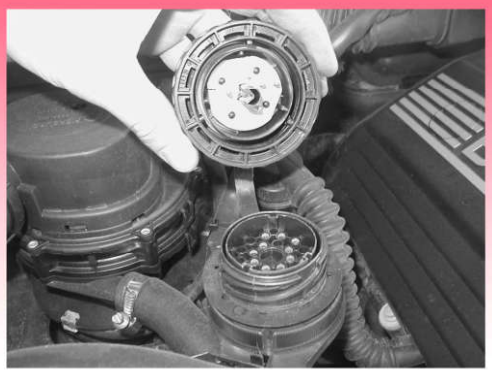


FIGURE 12-22 A typical 38-cavity diagnostic connector as found on many BMW and Mercedes vehicles under the hood. The use of a break-out box (BOB) connected to this connector can often be used to gain access to module BUS information.

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.

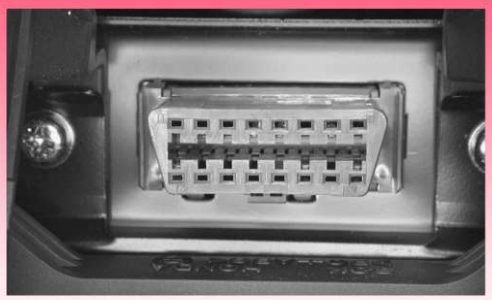


FIGURE 12-23 A DLC from a pre-CAN Acura. It shows terminals in cavities 4, 5 (grounds), 7, 10, 14, and 16 (B+).

HONDA/TOYOTA COMMUNICATIONS

- 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.

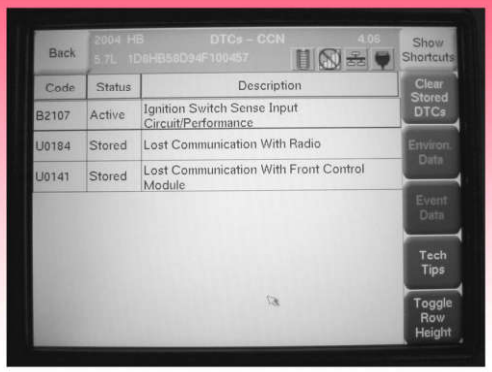


FIGURE 12-24 A Honda scan display showing a B and two U codes, which all indicate a BUS-related problem(s).

IDENTIFYING THE BUS

- In this example, the module communicates to terminals 6 and 14 of the DLC indicating that this vehicle is equipped with CAN.

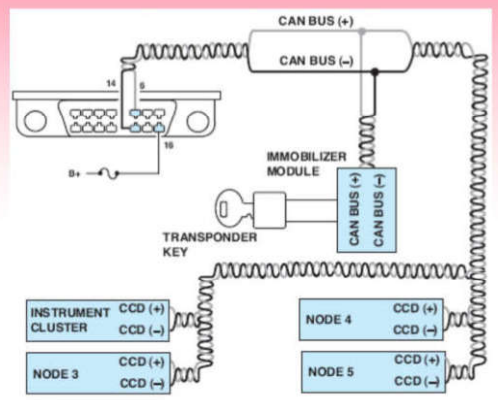


FIGURE 12-25 A typical (generic) system showing how the CAN BUS is connected to various electrical accessories and systems in the vehicle.

ADDITIONAL BUS PROTOCOLS

- MOST BUS
- MI BUS
- DSI BUS
- BST BUS
- Byteflight BUS
- Flexray BUS
- Domestic Digital BUS
- LIN BUS

NETWORK COMMUNICATIONS DIAGNOSIS

- When a network communications fault is suspected, perform the following steps.
  - Check everything that does and does not work.
  - Use a factory scan tool or an aftermarket scan tool equipped with enhanced software that allows original-equipment-like functions.
  - Use a digital multimeter and check the BUS for proper operation. This may include checking the voltage level and the resistance of the terminating resistors.
  - Use a digital storage oscilloscope to monitor the waveforms of the BUS circuit.
  - Follow factory service information instructions to isolate the cause of the fault.

NETWORK COMMUNICATIONS DIAGNOSIS

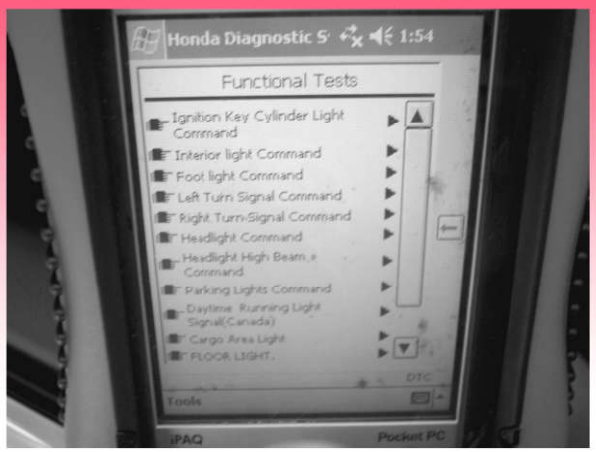


FIGURE 12-26 This Honda scan tool allows the technician to turn on individual lights and operate individual power windows and other accessories that are connected to the BUS system.

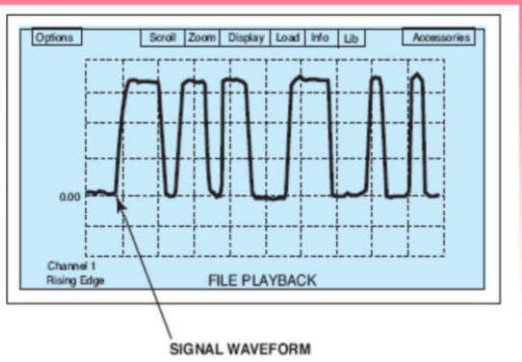
NETWORK COMMUNICATIONS DIAGNOSIS

Class 2 Diagnosis

- 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.

NETWORK COMMUNICATIONS DIAGNOSIS
Class 2 Diagnosis

FIGURE 12-27 Class 2 serial data as viewed on a DSO with the key on. Communications is occurring because the signal voltage is changing. If there was a fault, the voltage level would likely be zero (open or short-to- ground data line) or high all of the time (shorted-to-voltage).



NETWORK COMMUNICATIONS DIAGNOSIS

Ping Modules

- The soft keys under the Tech 2 display can be selected to ping individual modules or command all modules.
- The ping command should change the status from “active” to “inactive.”

NETWORK COMMUNICATIONS DIAGNOSIS

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.

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.
- Two 120 ohm resistors connected in parallel would measure 60 ohms if being tested using an ohmmeter.

TERMINATING RESISTORS

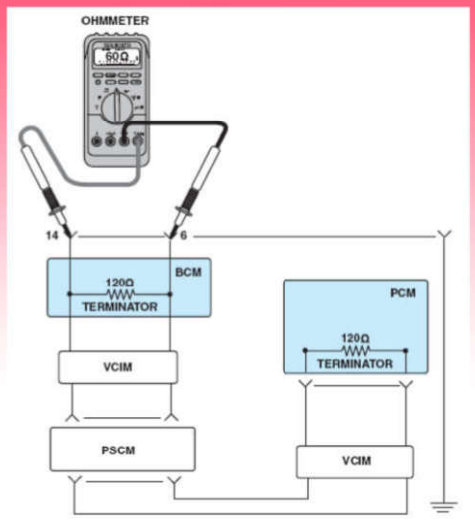


FIGURE 12-28 Checking the terminating resistors using an ohmmeter at the DLC.

TERMINATING RESISTORS

- Check voltage on pin 14 using a DMM. The other meter lead is attached to pin 4, which is a chassis ground.
- The meter should display a varying voltage with the ignition key on.

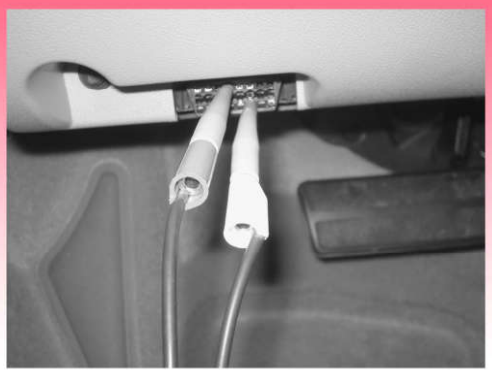


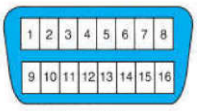
FIGURE 12-29 Use front-probe terminals to access the data link connector. Always follow the specified back-probe and front-probe procedures as found in service information.

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 (4A max)

OBD-II DATA LINK CONNECTOR

FIGURE 12-30 Sixteen-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.



OBD II DLC

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)

CHECK COMPUTER DATA LINE CIRCUIT SCHEMATIC

- 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).

CHECK COMPUTER DATA LINE CIRCUIT SCHEMATIC

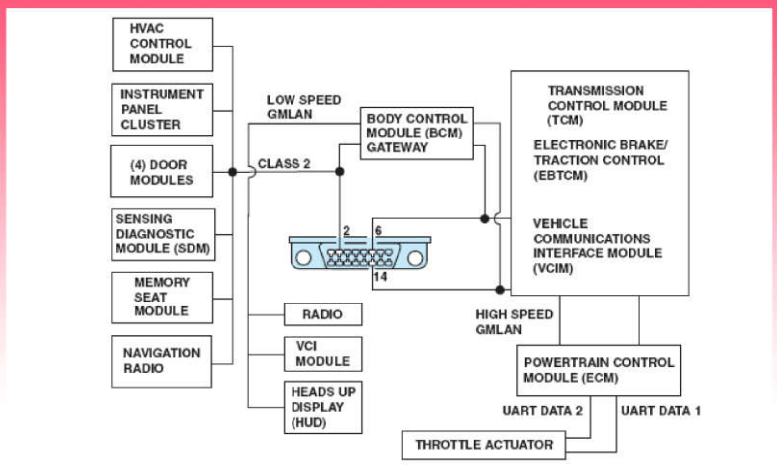


FIGURE 12-31 This schematic of a Chevrolet Equinox shows that the vehicle uses a GMLAN BUS (DLC pins 6 and 14), plus a Class 2 (pin2) and UART.

SUMMARY

1. The use of a network for module communications reduces the number of wires and connections needed.
2. Module communication configurations includes ring link, star link, and ring/star hybrid systems.
3. The SAE communication classifications for vehicle communications systems include Class A (low speed), Class B (medium speed), and Class C (high speed).
4. Various module communications used on General Motors vehicles include UART, E & C, Class 2, Keyword communications, and GMLAN (CAN).

SUMMARY

5. Types of module communications used on Ford vehicles include SCP, UBP, and CAN.
6. Chrysler brand vehicles use SCI, CCD, PCI, and CAN communications protocols.
7. Many European vehicles use an underhood electrical connector that can be used to access electrical components and modules using a break-out box (BOB) or special tester.
8. Diagnosis of network communications includes checking the terminating resistor value and checking for charging voltage signals at the DLC.