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Objectives

After completing this module, you will be able to:

- Identify the types of networks used in Mazda vehicles
- Explain the basic operating characteristics of an ISO 9141 (ISO), J1850 (SCP), and CAN 11898 (CAN) networks

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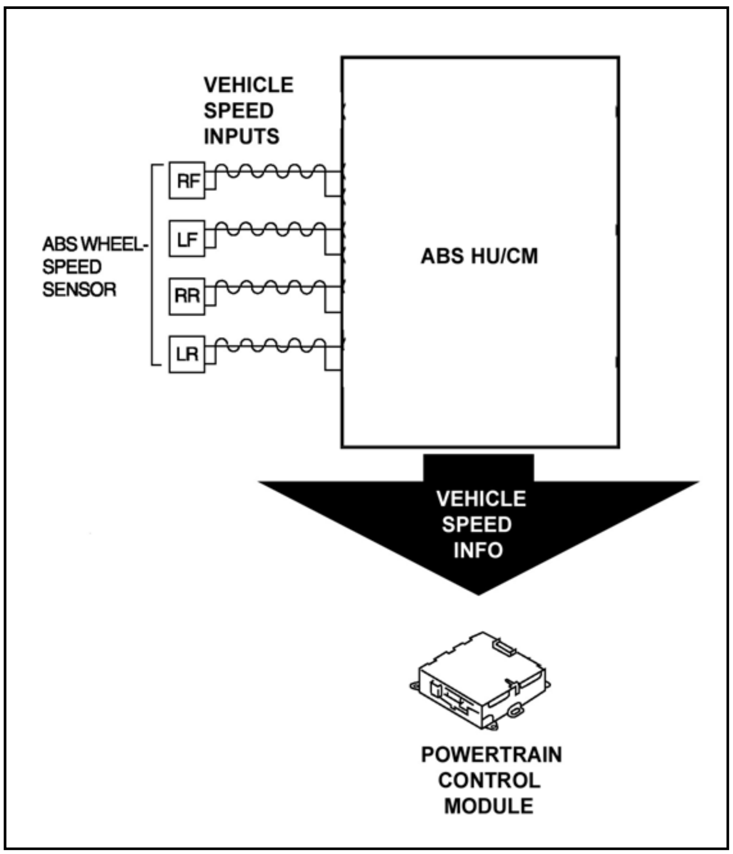
Network Overview

Introduction

Today's vehicles use electronic modules to control everything from the engine and transmission to the tires and brakes. Many of these modules require the same *input* information to operate efficiently. For example, the transmission and anti-lock brake systems both require vehicle speed information. Using vehicle speed information from the same *input* reduces the number of sensors and the amount of wiring on the vehicle. Many Mazda vehicles are able to share information like this through the use of networks.

Networks consist of two or more modules and wiring. These networks allow multiple modules to act together to perform complex vehicle operations. In addition, using networks improves vehicle diagnostic capabilities.



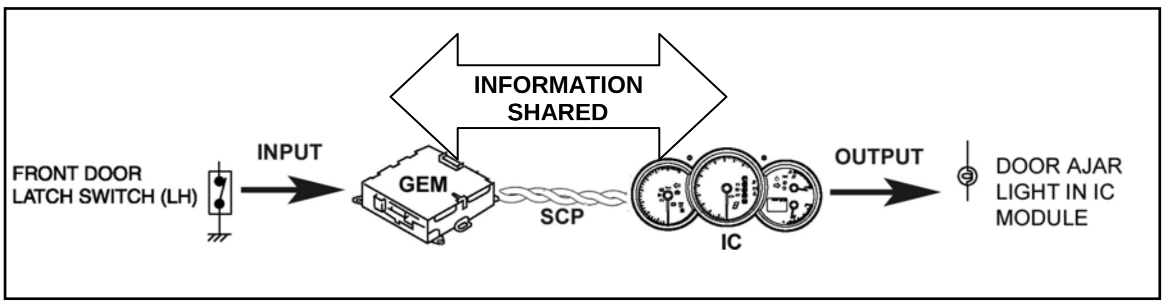
Simple Network

Networks

A network is an electronic system composed of control modules and/or a diagnostic tester (scan tool) that is connected with at least one wire. This hardware allows the modules to communicate with each other.

Here is an example of network operation on a Tribute.

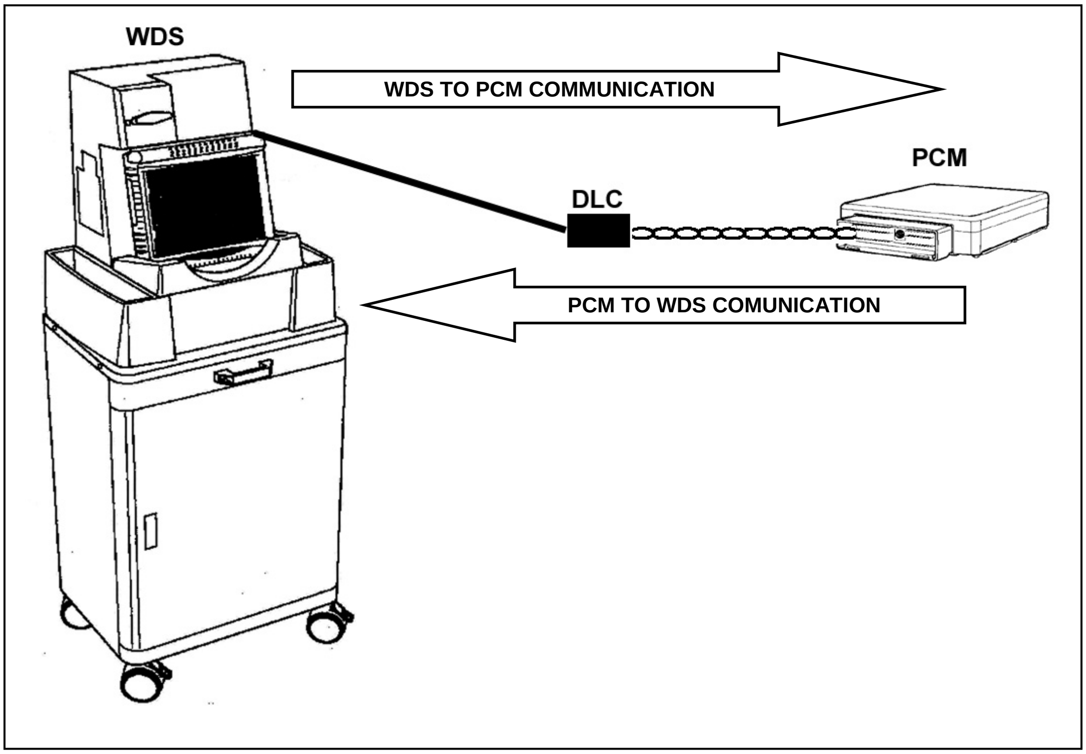
- Communication occurs between the GEM module and the IC module on the SCP line.
- The GEM module sends door ajar information it receives from the door latch switch through the network to the IC module.
- The IC module uses this information to determine operation of the door ajar light in the IC module.



Tribute SCP Network

Networks, cont.

When connecting a WDS to the Powertrain Control Module (PCM) through the Data Link Connector (DLC), both the WDS and PCM communicate with each other. This is another example of a network.

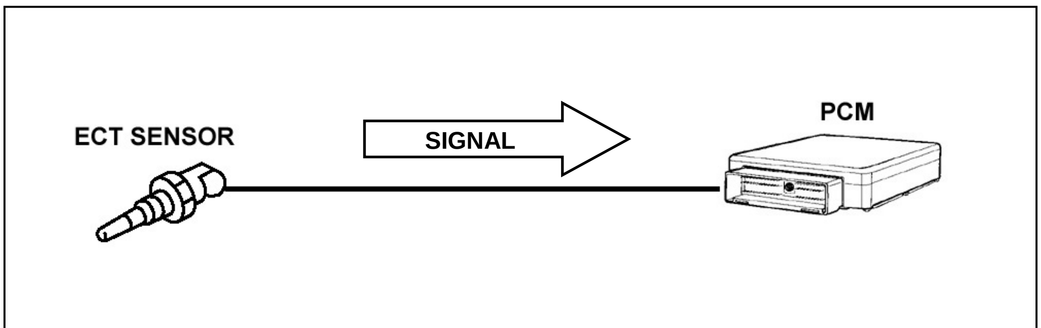


Networks, cont.

Some electronic components communicate, but not as part of a network. Sensor-to-control module communication is non-network communication. For example:

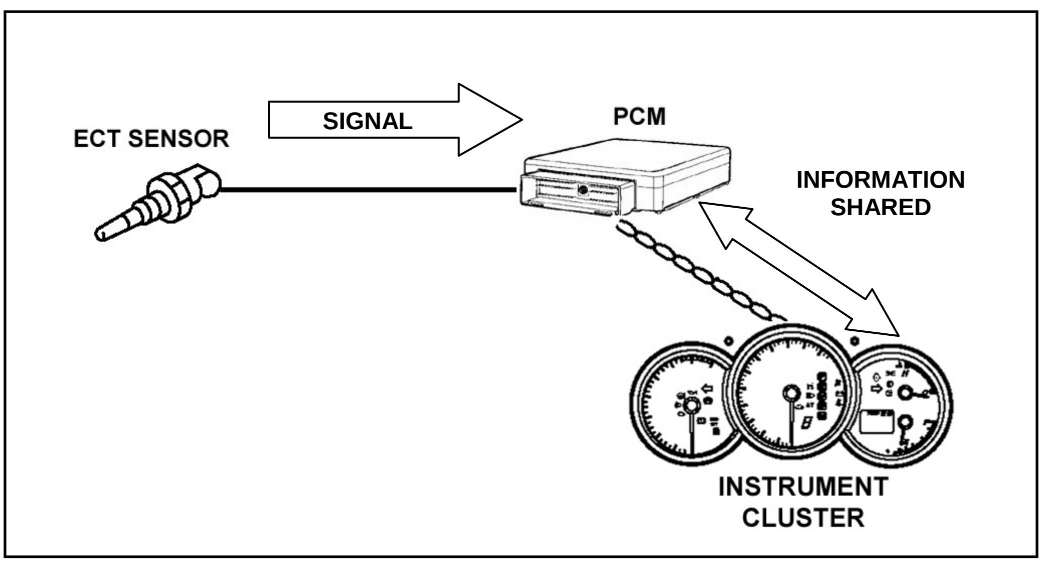
- The PCM receives a voltage signal from the ECT sensor.
- The PCM has processing capability.
- The PCM reads ECT voltage signals then processes this information to determine what the ECT signal indicates.
- The ECT sensor is a thermistor that modifies a reference voltage. It does not have any information processing capability.

  This is an example of electronic input processing that is not network communication.



NON-NETWORK COMMUNICATION

Network communication occurs when two or more modules share information.



Benefits of Networks

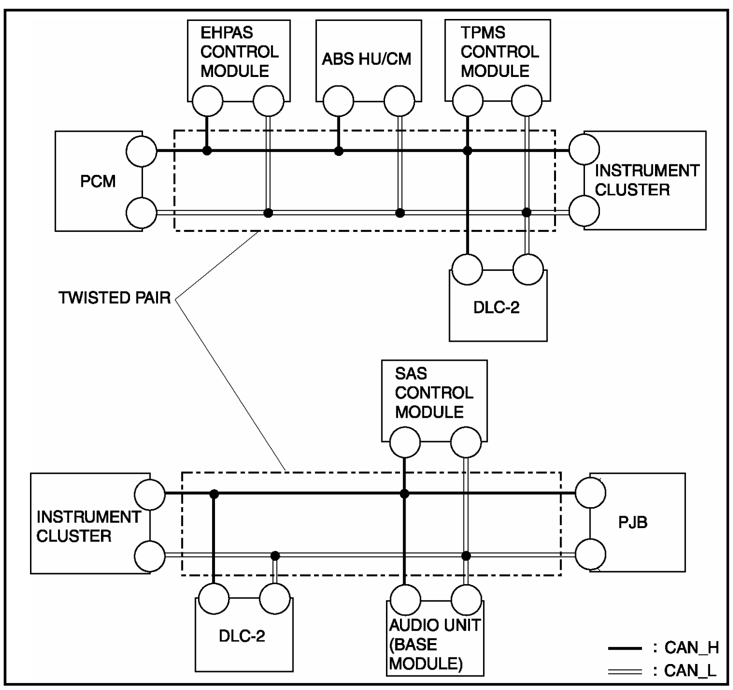
The use of networks provides several benefits. These include:

- Control modules are able to share input sensor information.
- Multiple modules are able to perform complex vehicle system operations simultaneously.
- Improved network diagnostics.

Types of Networks

Networks are identified by the electronic language they use. Control modules must "speak and understand" the same electronic language in order to function. These electronic languages are called protocols. Mazda currently uses three different protocols. They are:

- ISO 9141 (ISO)
- J1850 (SCP)
- ISO 11898 (MS/HS CAN)



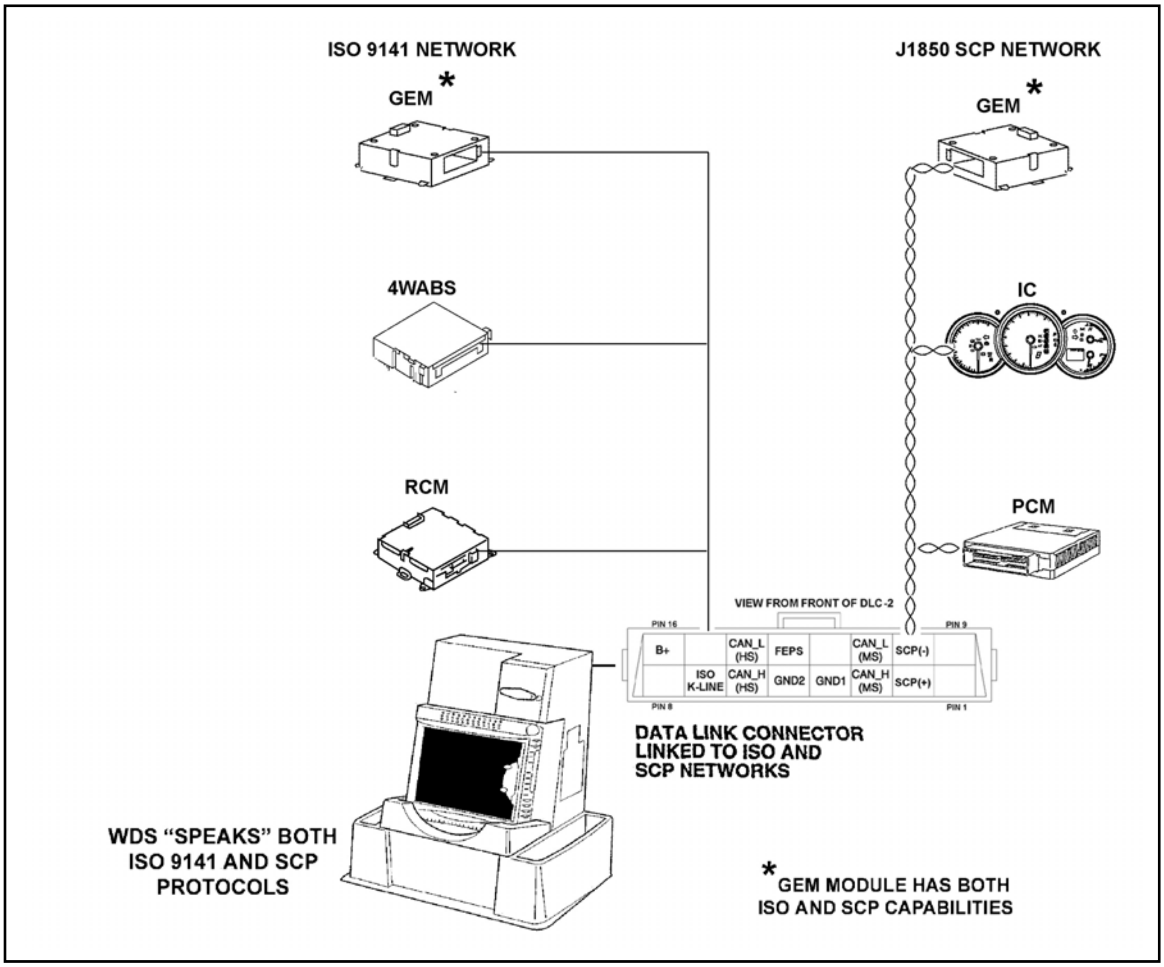
Typical network – Mazda3 CAN shown

Data Bus

The data Bus is the wire or wires that connect the modules in a network to each other and/or to the scan tool through the DLC. Electronic information moves between network modules connected by the data Bus. The number of wires that make up the data Bus differs, depending on the type of network.

- ISO 9141 (ISO) networks use a single wire connecting the modules to the DLC.
- J1850 (SCP) networks use a twisted pair of wires between modules and the DLC.
- ISO 11898 (CAN MS/HS) networks use a twisted pair of wires between modules and the DLC. *Not pictured below.*

Note: A vehicle can be equipped with more than one network.



2001 – 2003 Tribute shown

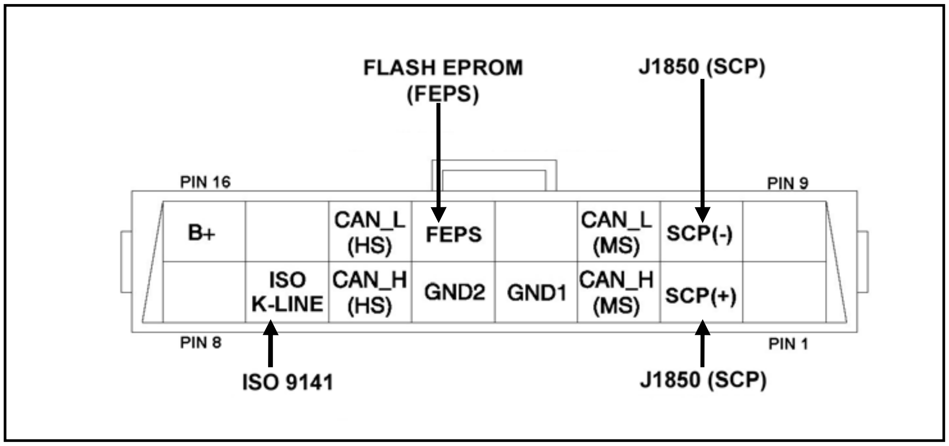
Mazda Networks

The following chart outlines Mazda vehicles and the networks used.

- ISO 9141 (ISO)
- J1850 (SCP)
- ISO 11898 (MS/HS CAN)

Vehicle	ISO	SCP	MS CAN	HS CAN
94 – 02 626	X	X		
95 – 02 Millenia	X			
01 – 03 Tribute	X	X		
04 Tribute	X	X		X
05 Tribute	X		X	X
95 – 03 Truck	X	X		
04 Truck	X	X		X
99 – up Miata	X			
99 – 03 Protege	X			
00 – 01 MPV	X			
02 – 04 MPV	X			X
03 – up Mazda3			X	X
03 – up Mazda6				X
04 – up RX-8	X			X

Data Link Connector (DLC)



View from front of DLC

PIN #	CIRCUIT	NOTES
1	Open	
2	SCP +	5 volt – No messages being sent. Alternates between 5 and 0 volts with SCP – when messages are being sent.
3	CAN_H (MS)	Key ON – 2.5v ~ 2.6v
4	Ground 1	
5	Ground 2	
6	CAN_H (HS)	Key ON – 2.5v ~ 2.6v
7	ISO K-LINE	0 – 12 volt signals
8	Open	
9	Open	
10	SCP –	0 volt – No messages being sent. Alternates between 0 and 5 volts with SCP + when messages are being sent.
11	CAN_L (MS)	Key ON – 2.3v ~ 2.4v
12	Open	
13	FLASH EPROM	For ISO, SCP, and Visteon CAN networks Signals PCM to erase EPROM and begin programming 12 – 18v signal only during programming
14	CAN_L (HS)	Key ON – 2.3v ~ 2.4v
15	Open	
16	Battery +	

ISO 9141 Network

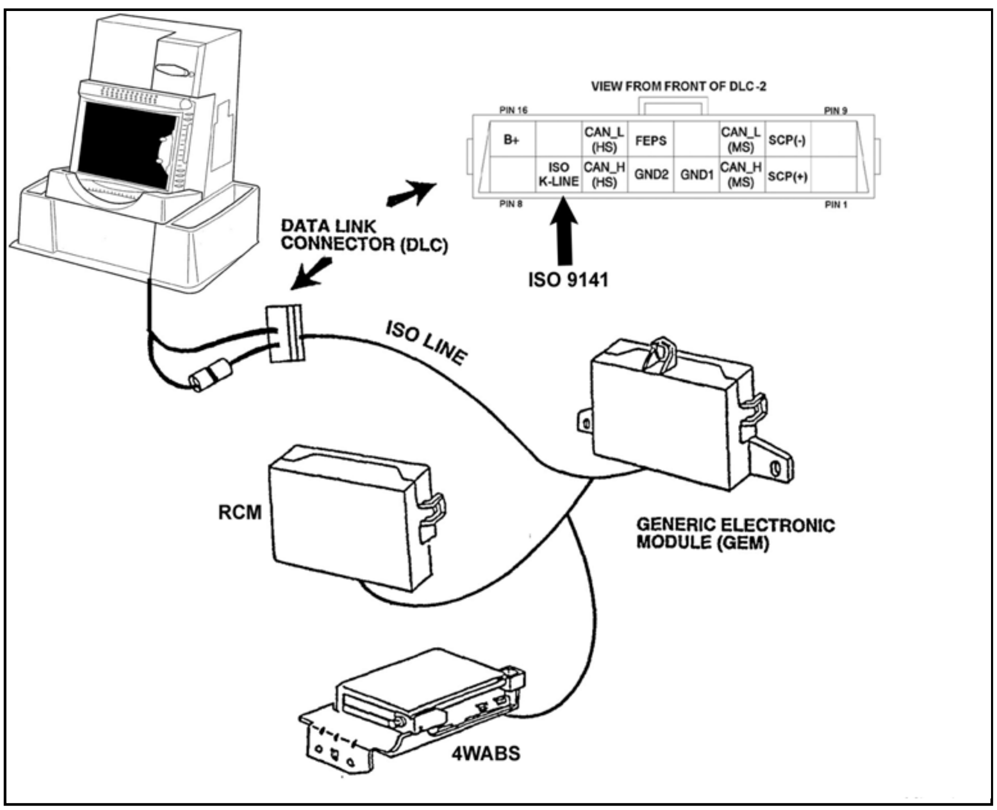
Introduction

The ISO 9141 network is installed on vehicles for diagnostic purposes. Connecting the scan tool to the DLC activates the network. Once connected to the DLC, the scan tool communicates to the modules through the networks single wire data Bus. This allows the scan tool to perform the following functions.

- Access and display DTCs
- Access Parameter Identification Data (PID)
- Initiate Active Commands
- Test network communication

Communication only occurs when initiated by the scan tool.

There is no module-to-module communication on an ISO 9141 network.



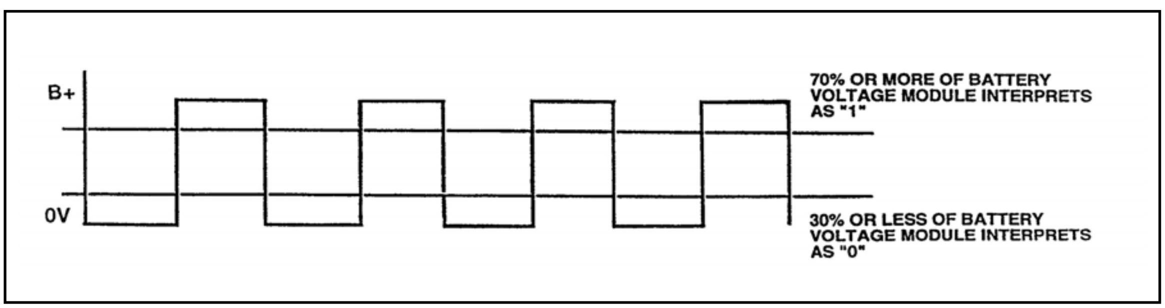
ISO 9141 Network

ISO 9141 Protocol

The ISO 9141 network uses a unique protocol (language) for communication. This network protocol consists of electrical pulses. These pulses, or messages, are converted digitally to a “1” or “0” depending upon the voltage level of the message signal.

- A signal of more than 70% of battery voltage is interpreted by the control module as a logic “1”.
- A signal of less than 30% of battery voltage is interpreted by the control module as a logic “0”.

IMPORTANT: ISO 9141s protocol speed is relatively slow (10kb). Because of this, momentary changes in Input or Output (I/O) states may not be seen on the scan tool while performing diagnostics. When performing diagnostics on an ISO 9141 network, be sure to allow time for the scan tool to display changes in I/O state.



ISO Digital Signal

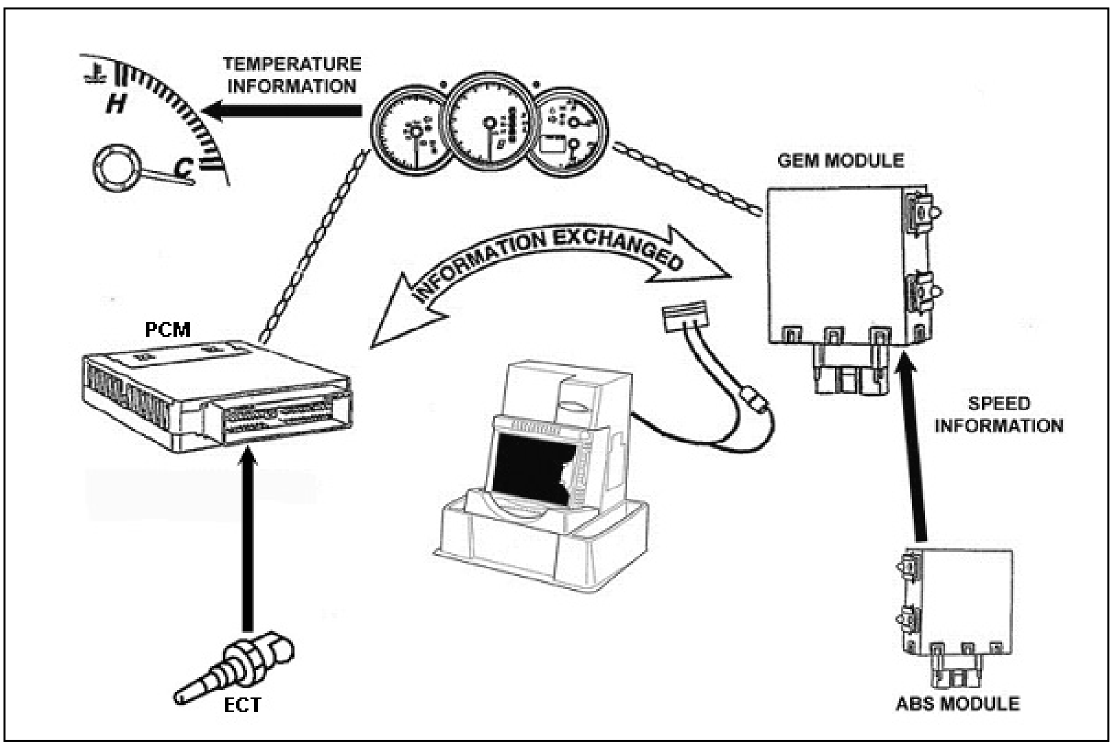
J1850 (SCP) Network

Introduction

During normal operation J1850 Standard Corporate Protocol (SCP) networks allow the electronic control modules to the network to exchange information directly with each other. For example, on some vehicles the PCM supplies the Instrument Cluster (IC) module with engine temperature information. This allows the IC module to indicate the correct engine temperature.

Input data received by one module is sent to any other module through the data Bus. An example of this is the GEM module. It receives speed information from the ABS module. The GEM broadcasts the speed information to the IC module and to the PCM for engine control.

The WDS retrieves DTCs, monitors input and output data, and activates control module outputs on the J1850 network.



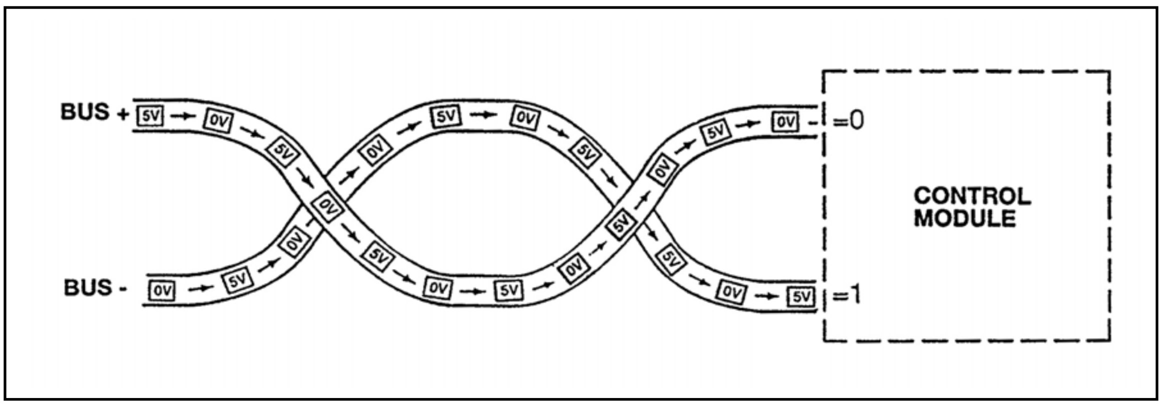
J1850 Network Operation

J1850 (SCP) Protocol

Standard Corporate Protocol (SCP) enables the network to communicate using electric signals over a data Bus at 41.6 kb. The wires in this data Bus are twisted to help resist radio interference.

- The data Bus wires are designated Bus + (SCP+) and Bus – (SCP –).
- Electrical impulses vary between 5.0 volts and zero volts to represent a digital logic "1" or "0".
- When there are no messages, Bus + is 5.0 volts and Bus – is zero volts.
- When messages are being sent, the Bus + and Bus – voltages are "mirror-image" of each other.
- During message transmission, Bus + and Bus – voltages are always opposite each other.

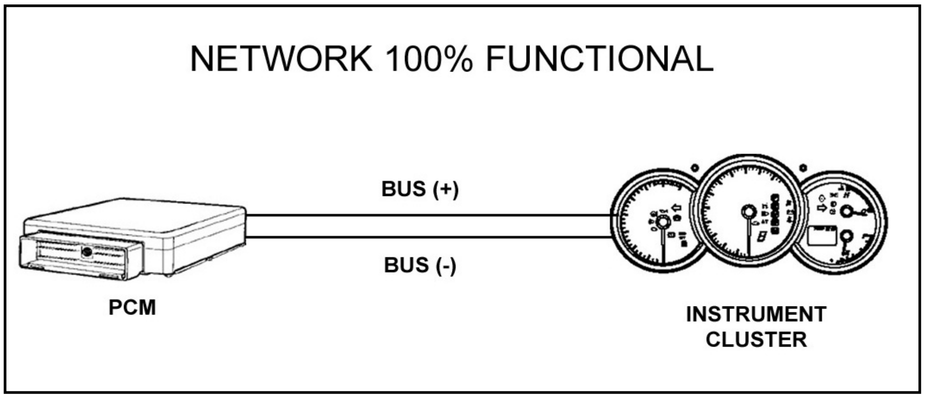
NOTE: Wires are not always shown as twisted pairs in schematics.

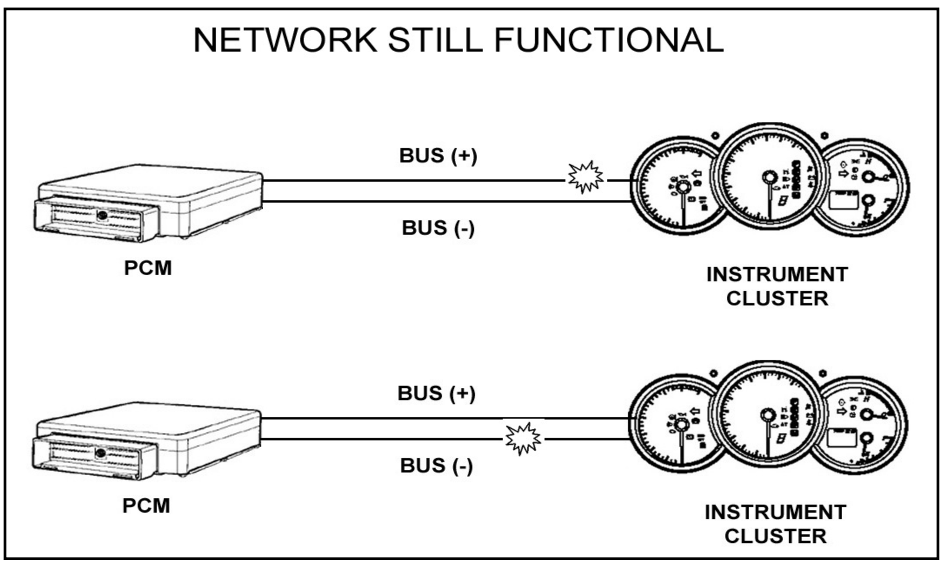


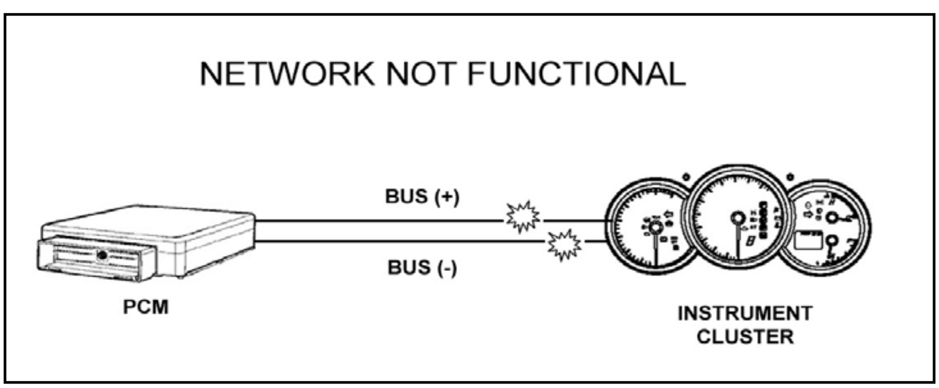
SCP Data Transmission

J1850 (SCP) Data Transmission

Data transmission on the J1850 (SCP) network occurs over a two wire data Bus. Each wire carries a mirror-image of the message on the other wire. Messages are coordinated by the originating control module so that messages do not "collide" or become jumbled on the network. If one of the two data Bus wires is open, the J1850 (SCP) network will often continue to function with no noticeable reduction in capability. There may not be any symptoms to cause a customer concern.







J1850 (SCP) Network Symptoms

In the event the network fails, certain symptoms may occur. Each, with the exception of a single open wire, may result in customer concerns.

These include:

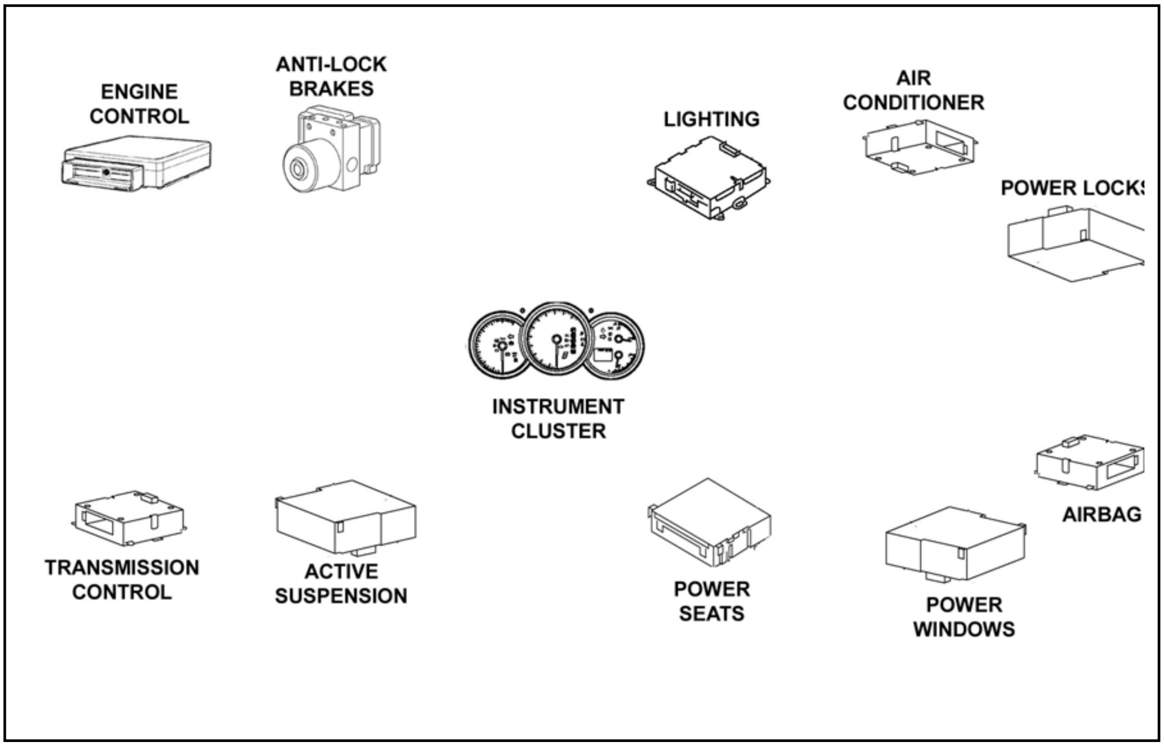
- **Both data Bus wires shorted together –** If SCP + and SCP – are shorted together, a complete network failure will occur.
- **Wire shorted to ground –** In the event either SCP + and SCP – shorts to ground, no modules will respond when the WDS is connected.
- **Wire shorted to power –** If either SCP+ or SCP – is shorted to power, a complete network failure may occur.
- **Wire open –** With a single wire open, you may be able to enter the WDS Tool Box menu and perform tests. However, any information received may be invalid.
- **Both wires open –** If both wires are open near the DLC, no communication can be established between the scan tool and the network. However, if both wires are open in one of the branches of the network, only the modules that come after the open will not be able to communicate with the scan tool.
- **Both wires shorted to ground –** If both wires are shorted to ground, complete network failure will result. All control modules will operate in Fail Safe Mode. The vehicle will start and run, but the modules will only be able to use sensors that are hardwired directly to them.
- **Internal control module failure –** An internal control module failure may result in a complete network failure.

Controller Area Network (CAN)

Introduction

In response to customer demand for better safety, comfort, and convenience, as well as government requirements to reduce pollution and fuel consumption, the automotive industry developed various electronic systems.

Examples of these systems include Engine Control Systems, Anti-Lock Brakes Systems, and Air Bag Systems to name a few.

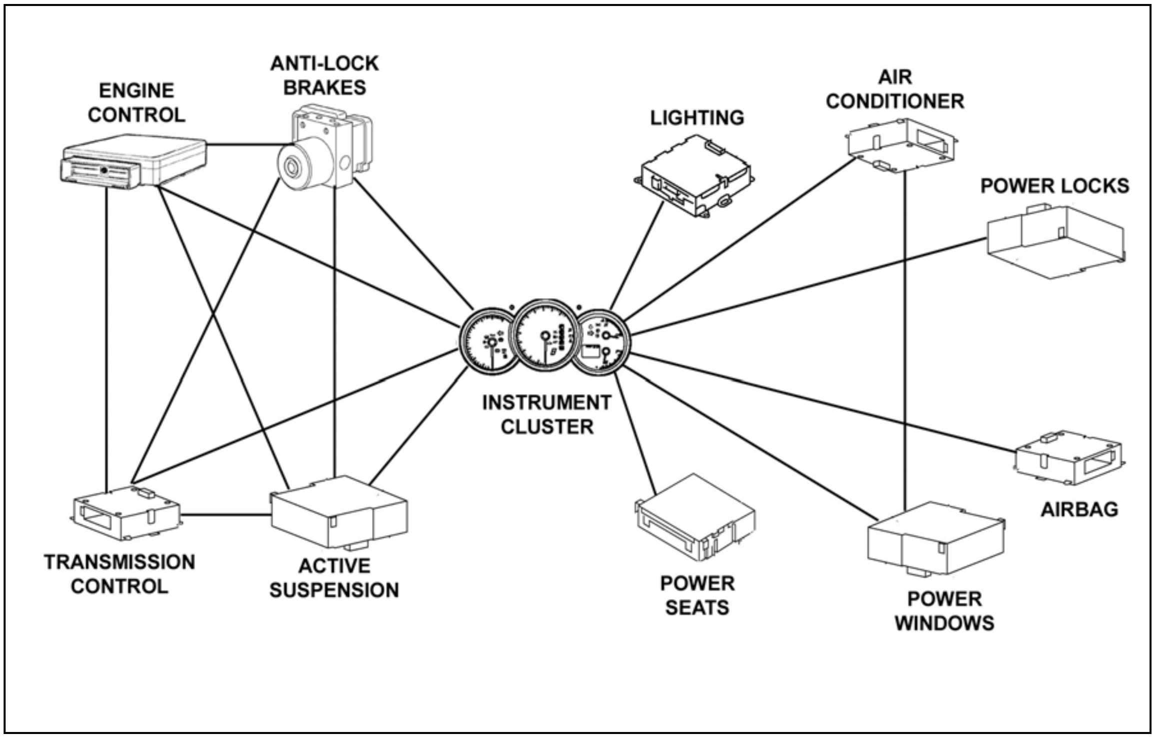


Generic System

Introduction, cont.

The complexity of these systems, and the need to exchange data between them meant that more and more hard-wired, dedicated data lines had to be provided. This made the size of the wiring looms so big that in some cases it was impossible to thread them through the vehicle. The size and number of wiring looms connecting these systems together resulted in higher production costs.

In addition to the cost, the increased number of connections posed reliability, fault diagnosis, and repair problems during both manufacture and in service.

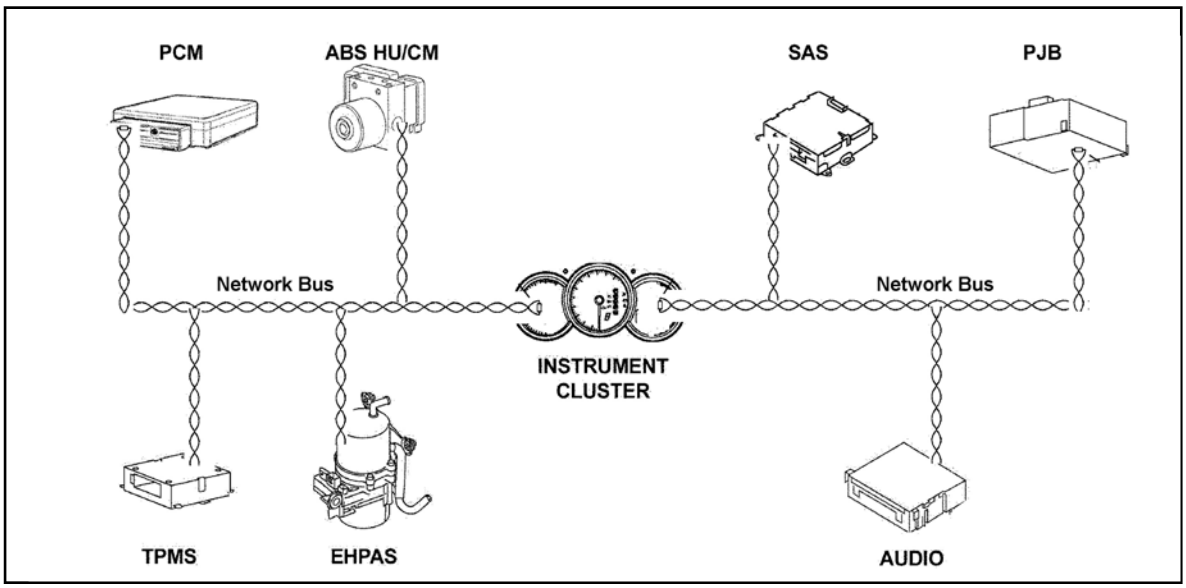


Generic System

Introduction, cont.

A solution was needed and, in the mid 1980s, the Robert Bosch Company provided the answer by introducing the Controller Area Network (CAN). The CAN solution connects all of these systems via a network Bus.

With the use of CAN, dedicated wiring is replaced by one Bus connecting all of the control systems. This is accomplished by adding CAN specific hardware to each control module that provides the “rules” or protocol for transmitting and receiving information via the twisted-pair Bus.



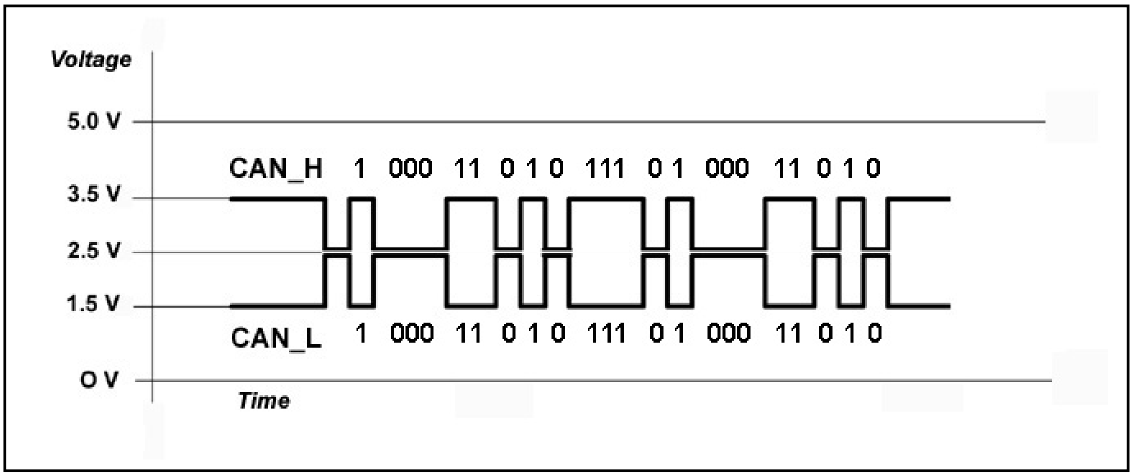
Mazda3 CAN

CAN Protocol

Digital Signals

Digital signals are transmitted simultaneously as “mirror opposites” of each other through the CAN_H and CAN_L lines. These signals are transmitted at different voltages and interpreted by the modules as binary 0 and binary 1 data.

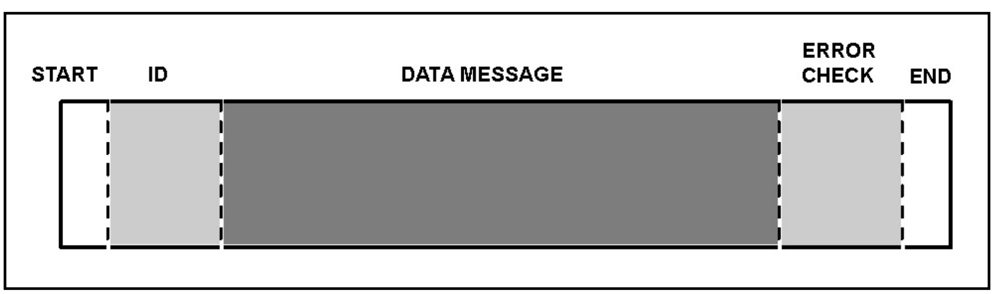
The voltages are interpreted as follows:
Binary 0 = 2.5V on CAN_H and CAN_L
Binary 1 = 3.5V on CAN_H and 1.5V in CAN_L



Message Frames

In a CAN system, data is transmitted and received using Message Frames. Message Frames carry data from a transmitting module to one or more receiving modules.
A message frame contains the following elements.

- A start identifier or “flag” describing the message beginning.
- The ID section identifies the sending module.
- The data message is the actual data being sent.
- An error check to confirm the message was received correctly.
- An end identifier indicating the end of the message.



CAN Classifications

Vehicle CAN systems are classified into three categories according to their real-time capabilities.

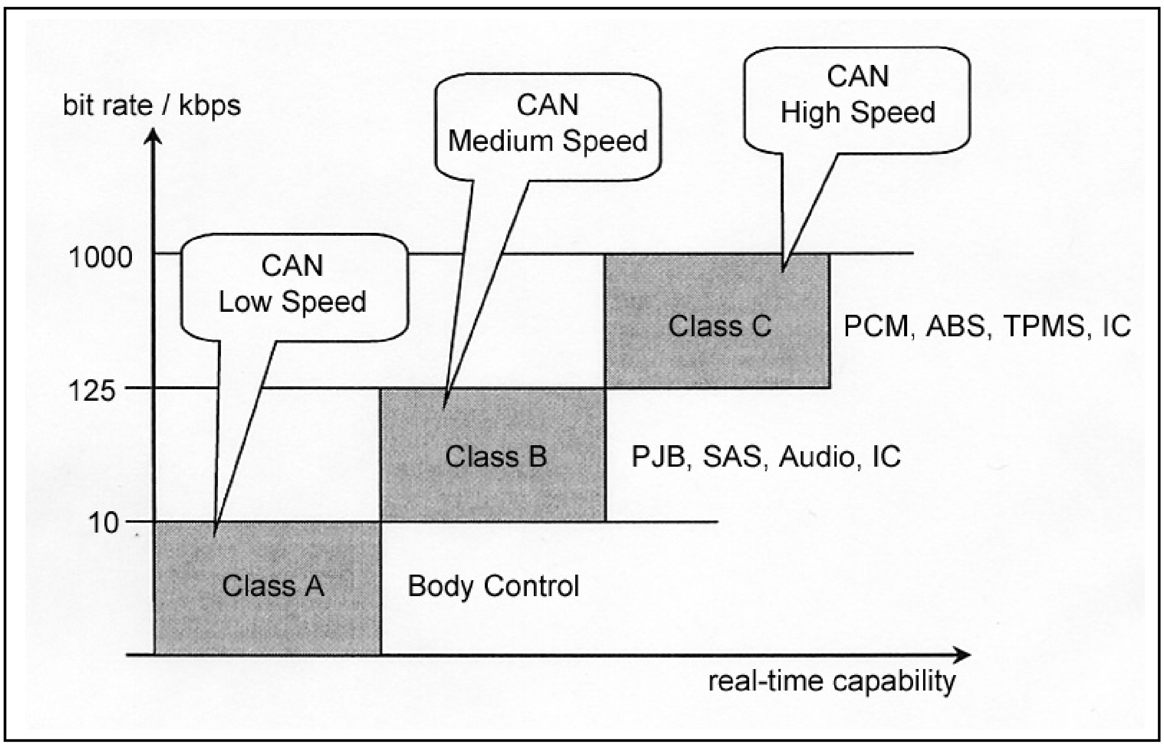
Class A – For low speed Bus lines with bit rates up 10 kbps; e.g. body control applications.

Class B – For medium speed Bus lines with bit rates from 10 kbps to 125 kbps; e.g. PJB, SAS, Audio, and IC.

Class C – For high speed Bus lines with bit rates from 125 kbps to 1 Mbps; e.g. Real-time applications like engine management and anti-lock brakes.

Mazda Medium Speed CAN = 125 kbps

Mazda High Speed CAN = 500 kbps



Message Transmission/Reception

Message frames are sent, one at a time, in order of priority. As a message frame moves along the Bus, only those modules that need the message accept it. The other modules ignore the message. If two modules attempt to send messages at the same time, a method of "arbitration" assures the message frame with the highest priority is sent first.

The graphic below shows the Mazda3 High and Medium speed CAN networks. In this example, the PCM transmits a message frame containing RPM information. As the message travels on the Bus, the modules handle the message in the following manner.

- TPMS – The Tire Pressure Monitoring System module ignores the message.

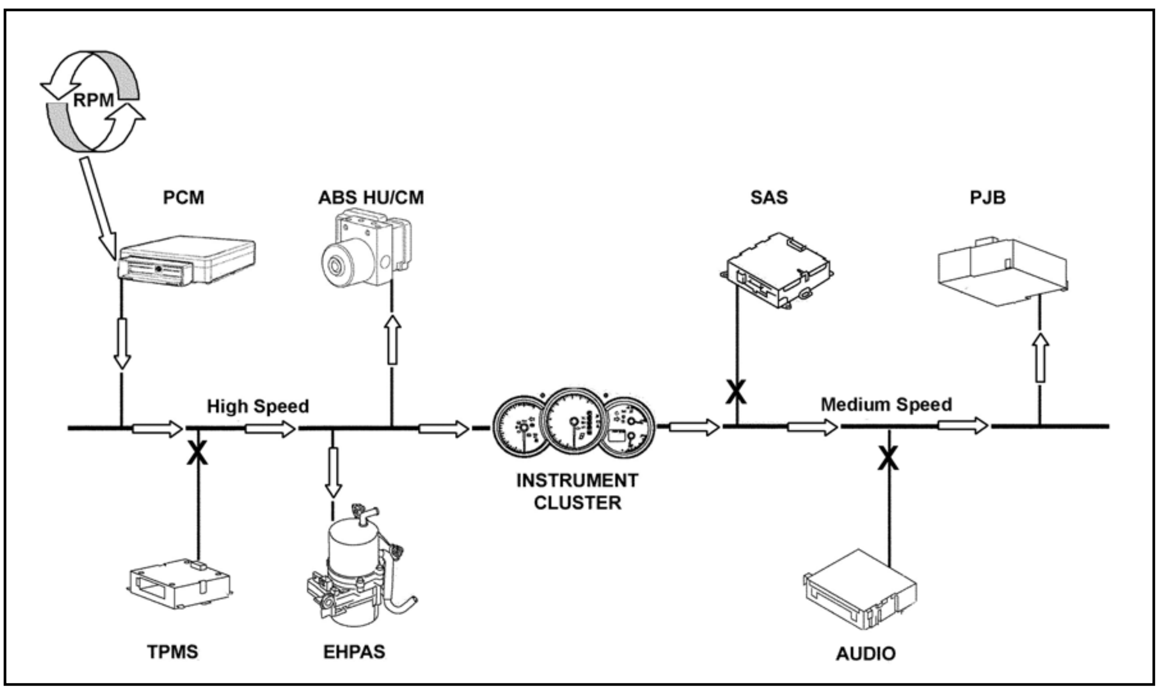
- EHPAS – The Electro-Hydraulic Power Assist System module accepts the message and uses it as an input to control power assist.

- ABS HU/CM – The Anti-Lock Brake Hydraulic Unit Control Module accepts the message and uses it for ABS control.

- IC – The Instrument Cluster module accepts the message and uses it as the input for the tachometer. The IC module also adapts the message speed for transmission on the medium speed CAN network.

- SAS/Audio – The SAS and Audio modules ignore the message.

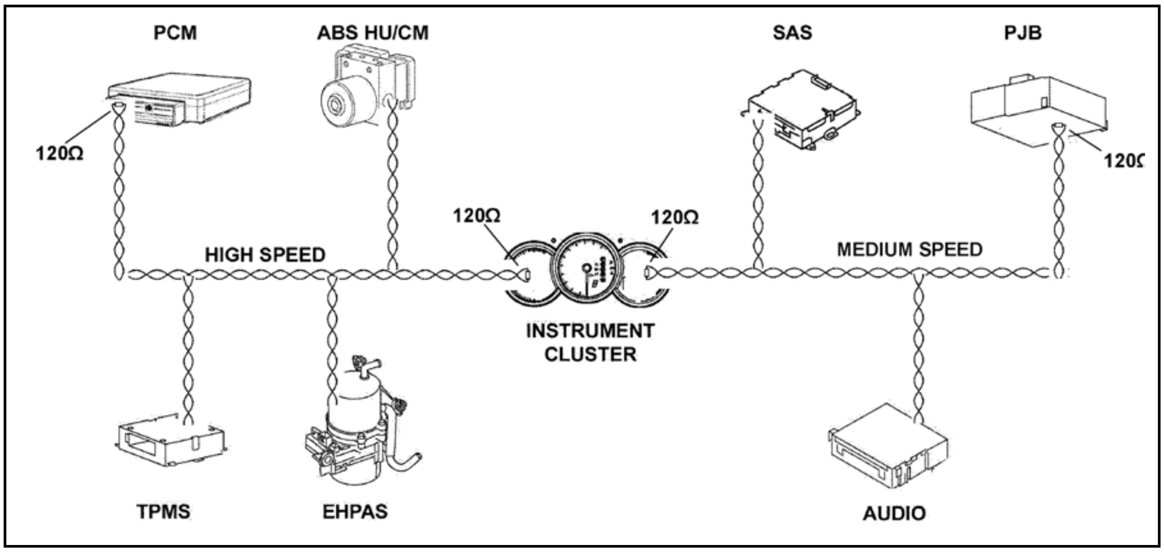
- PJB – The Passenger Junction Box accepts the message and uses it for A/C control.



Termination Resistors

Termination resistors serve an important role in the operation of a Controller Area Network. As a message frame arrives at the last module on the Bus, it is used or ignored by that module. The message then travels to the termination resistor located in that module.

When the message reaches the 120 Ohm termination resistor, the resistor absorbs and removes the message from the Bus. Without the resistors, messages would "bounce" off the ends of the wires and head back in the opposite direction.



CAN and Electromagnetic Interference (EMI)

Modern vehicles are built with an increasing number of electronic components and electrical systems. These components and electrical systems operating in close proximity to each other increase the possibility of Electromagnetic Interference (EMI).

However, due to the nature of CAN, it is insensitive to electromagnetic interference. This is because the Bus lines (CAN_H and CAN_L) are “twisted” and the signals are “mirror opposites” which leaves the signals unaffected.

For example, the nominal, or mid-point, voltage in the graphic below is 2.5 volts. The CAN_H voltage is 1.0 volt above the nominal 2.5 volt line and the CAN_L is 1.0 volt below the nominal volt line. As signals are sent on the CAN_H and CAN_L twisted pair lines, they are “mirror-opposites” of each other. The twist and “mirror-opposite” effect eliminates any electromagnetic interference.