COURSE NAME

Diagnosing Multiplexed Data Bus Networks

EL06-74.01SEM

COURSE #

STUDENT HANDOUT

General Motors' approach to training combines a variety of training delivery methods for maximum learning benefit for the service professional.

GM GENUINE PARTS | ACDelco

COURSE INTRODUCTION

COURSE DESCRIPTION

Diagnosing complex network system failures is a challenge, even for experienced technicians. In this seminar, technicians will focus on diagnostic strategies to hone their problem solving skills for serial data failure modes in multiplex networks. Network protocols, including the Controller Area Network (CAN), Local Interconnect Network (LIN), GM Local Area Network (GMLAN), Media Oriented Systems Transport (MOST®), and repair methods will be covered.

COURSE OBJECTIVES

Upon completion of this training, participants will be able to:

- Identify the operation of vehicle multiplex network protocols
- Analyze network failures and develop diagnostic procedures
- Identify service repair strategies and procedures

CAUTION STATEMENT

In order to reduce the chance of personal injury and / or property damage, carefully observe the instructions that follow.

The materials presented in this course are for training purposes only. The course materials are not intended to replace established service procedures or information provided by vehicle Original Equipment Manufacturers (OEMs). You are responsible for ensuring compliance with any such procedures or information.

This training program is intended for use by professional, qualified technicians. Attempting repairs or service without the appropriate training, tools, and equipment could cause injury to you or others. This could also damage the vehicle, or cause the vehicle to operate improperly. Proper vehicle service and repair are important to the safety of the service technician and to the safe, reliable operation of all motor vehicles. If you need to replace a part, use the same part number or an equivalent part. Do not use a replacement part of lesser quality.

Some of the service procedures described in this training require the use of tools that are designed for specific purposes. Accordingly, any person who intends to use a replacement part, a service procedure, or a tool that is not recommended by the OEM or ACDelco, must first establish that there is no jeopardy to personal safety or the safe operation of the vehicle.

ACDelco shall not be responsible for any damages, in whole or in part, from your use of this training material.

MITCHELL PRODEMAND REFERENCE

Special thanks to Mitchell ProDemand for granting permission to utilize their service information as a reference source for the development of this course. Graphics, schematics, other images, as well as Mitchell ProDemand service information content have been utilized in whole or part within this course.

ACRONYM AND ABBREVIATION LIST

The following acronyms and abbreviations will be used throughout this course:

AWG – American Wire Gauge

B+ – Battery Positive

BCM – Body Control Module

CAN – Controller Area Network

CAN-FD – Controller Area Network Flexible Data

CPA – Connector Positive Assurance

DLC – Data Link Connector

DIM – Dash Integration Module

DMM – Digital Multimeter

DSO – Digital Storage Oscilloscope

DTC – Diagnostic Trouble Code

EBCM – Electronic Brake Control Module

ECC – Electronic Climate Control

ECM – Engine Control Module

ECU – Electronic Control Unit

EPS – Electronic Power Steering

ERF – Engine Run Flag

GMLAN – General Motors Local Area Network

HMI – Human Machine Interface

HPCM – Hybrid Powertrain Control Module

HS GMLAN – High Speed GMLAN

HVAC – Heating, Ventilation, Air Conditioning

IEEE – The Institute of Electrical and Electronic Engineers

IP – Internet Protocol

IPC – Instrument Panel Cluster

ISO – International Standards Organization

kbit – Kilobits

kbit/s – Kilobits per second

LED – Light Emitting Diode

LIN – Local Interconnect Network

LS GMLAN – Low Speed GMLAN

Mbit – Megabits

Mbit/s – Megabits per second

MDI – Multiple Diagnostic Interface

MOST® – Media Oriented Systems Transport

MS GMLAN – Mid-Speed GMLAN

OBD-II – Onboard Diagnostics II

ODB – Object Detection Bus

OEM – Original Equipment Manufacturer(s)

PC – Personal Computer

PCM – Powertrain Control Module

PMMA – Polymethylmethacrylate

PMM – Power Mode Master

POF – Plastic Optical Fiber

PWM – Pulse Width Modulation

RCDLR – Remote Control Door Lock Receiver

RAP – Retained Accessory Power

RPO – Regular Production Option

RX – Receive

SAE – Society of Automotive Engineers

SDGM – Serial Data Gateway Module

SDM – Sensing Diagnostic Module

SI – Service Information

SOH – State of Health

TCM – Transmission Control Module

TPA – Terminal Position Assurance

TX – Transmit

TIS2Web – Technical Information System Web

TPA – Terminal Positive Assurance

UDP – User Datagram Protocol

VIN – Vehicle Identification Number

VPW – Variable Pulse Width

OPERATION OF VEHICLE MULTIPLEX NETWORKS

VEHICLE DIGITAL COMMUNICATIONS

Many components in a vehicle rely on and share information with other components. Serial data communication networks provide a reliable, cost-effective way for multiple devices in the vehicle to talk to one another and share information.

Computers communicate in binary code. Using binary code, a computer can send information from one computer to another. Think of binary code as a very simple language or numbering system. Our language uses complicated words built from a choice of 26 letters and numbers from a set of 10 different digits, 0 through 9. Computers use binary code with only two choices called binary digits, or bits. The two digits in binary code are often expressed as 0 and 1, but they could also be expressed as ON and OFF, or HIGH and LOW. Just as letters are combined to make words in human languages, bits are combined into bytes, or words, that have meaning for the computer.

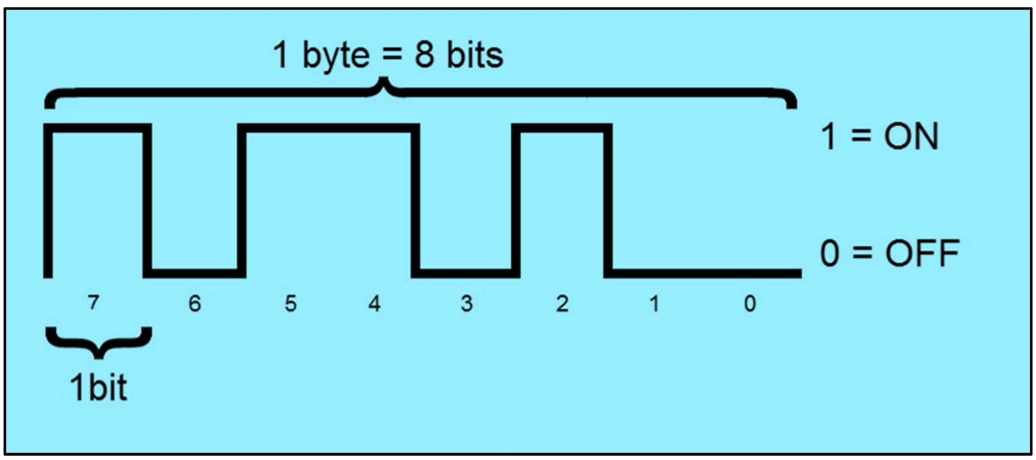


Figure 2-1, The Language of Computers

Bits are combined to make the following groups:

- A nibble is 4 bits
- A byte is 8 bits or 2 nibbles
- Two bytes make a word
- A word is 16 bits
- A double word is 32 bits
- A quad word is 64 bits

Computer processors are classified by how many words they can process at the same time. A 16-bit processor can process one word at a time. Conversely, a 64-bit processor can process four words simultaneously.

	Word															
	Byte								Byte							
	Nibble				Nibble				Nibble				Nibble			
Bit	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0

Figure 2-2, The Language of Computers

Serial Data

How do control modules transmit these bits and bytes? Imagine a lamp and momentary switch button at two locations. A wire connects both lamps and can be turned on from either switch. When the switch at one location is pressed, the lamps illuminate, representing 1 or ON. The person at the other end sees their lamp illuminate. Similarly, the control modules on the network toggle the voltage between a high and low state. When speaking of a network, we use the terms recessive and dominant. Recessive is the idle voltage state, and dominant is the active voltage state.

Technicians should focus on the physical connections between the control modules. Diagnose the electrical circuit for the faults that prevent these serial data signals from reaching the intended recipients. The control modules simply toggle the voltage on the serial data circuit. In order for normal communication to occur, the circuit cannot have an open (excessive resistance), a short to ground, or a short to voltage error. In the simple example shown in Figure 2-3, if the communication circuit between the two modules is open or has too much resistance, only the sender will see their lamp illuminate when they press the switch. If the circuit is shorted to ground, neither lamp will illuminate. If the circuit is shorted to voltage, the lamps will remain illuminated, regardless of whether the switch is pressed or not.

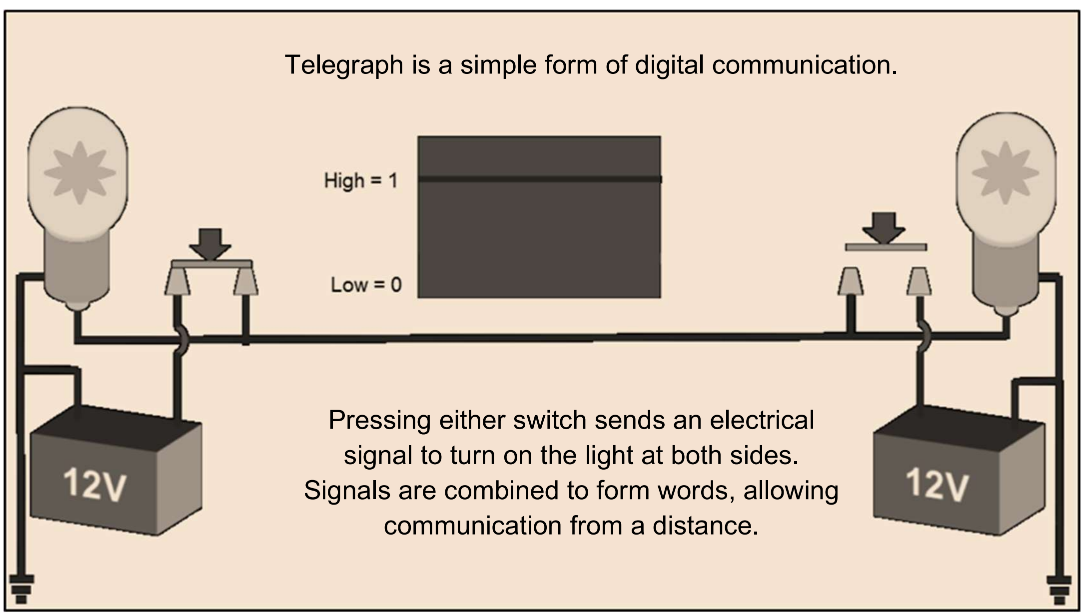


Figure 2-3, Basic Principles of Digital Communication

Network Speeds

Each network may have different minimum or maximum speeds. Vehicle networks transmit messages at different speeds, depending on the importance or complexity of the information. Each network will have a minimum or maximum transmission speed denoted in bits per second, sometimes referred to as baud rate.

The Society of Automotive Engineers (SAE) classifies networks by speed:

SAE Network Class	Speed
Class A	Up to 10 kbit/s
Class B	Up to 125 kbit/s
Class C	Up to 1 Mbit/s
Class C+	Up to 10 Mbit/s
Class D	More than 10 Mbit/s

The data on a given network generally stays local. However, some data will have to be shared on other networks. Networks with differing protocols and / or speeds cannot be directly interconnected, and require control modules, known as gateways, to perform the function of transferring data between the buses.

Voltages and Standards

The Data Link Connector (DLC) is the standardized diagnostic connection. This 16-pin connector, located near the driver's side footwell, is where the scan tool connects to the vehicle's networks.

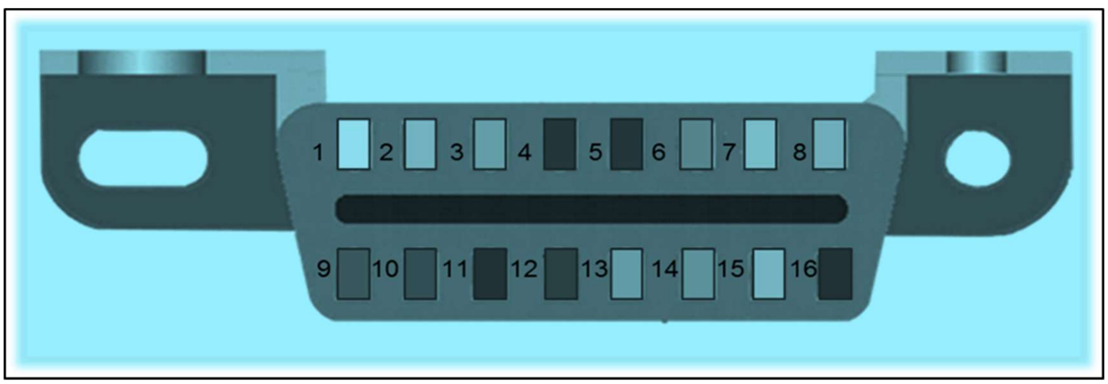


Figure 2-4, Data Link Connector

Voltage is a key measurement when diagnosing the electrical condition of a serial data network. Since the data is transferred over the network by a toggling voltage, representing the 1s and 0s of the data, a determination of the network status can be made using a Digital Multimeter (DMM), oscilloscope, or even a Light Emitting Diode (LED) lamp.

The terminal allocations for the DLC are shown in Figure 2-5:

Terminal Number	Function: SAE J1962 DLC Terminal Function	Function: Example: 2012 GM Vehicle Networks
1	Manufacturer Specified	LS GMLAN
2	Positive Line of J1850	Class 2 Communications
3	Manufacturer Specified	MS GMLAN Bus
4	Scan Tool Ground	Scan Tool Ground
5	Common Signal Ground	Common Signal Ground
6	Positive Line of ISO 15765-4	HS GMLAN+
7	K Line of ISO 9141 or ISO 14230	Keyword 2000
8	Manufacturer Specified	Not Used
9	Manufacturer Specified	Not Used
10	Negative Line of J1850	Not Used
11	Manufacturer Specified	MS GMLAN or Object Detection Bus
12	Manufacturer Specified	Chassis Expansion Bus
13	Manufacturer Specified	Chassis Expansion Bus
14	Negative Line of ISO 15765	HS GMLAN
15	L Line of ISO 9141 or ISO 14230	Not Used
16	Battery Positive	Battery Positive

Figure 2-5, DLC Terminal Allocations

The voltage on a normally operating network circuit toggles between two logical states or levels: the recessive state and the dominant state. The voltage for each of these states varies, depending on the network protocol. The following are some examples of the recessive and dominant voltage levels for some common protocols:

Note: Controller Area Network (CAN) is a common multiplexing protocol developed by Bosch. CAN, or a variation of it, has been used on all light vehicles since 2008.

High Speed CAN-C (ISO11898-2)	
Logical State	**Voltage**
Recessive	2.5 volts on both lines
Dominant	3.5 volts on CAN (+)
Dominant	1.5 volts on CAN (-)

Figure 2-6, High Speed CAN-C (ISO 11898-2)

Medium Speed CAN-B (ISO11898-3)	
Logical State	**Voltage**
Recessive	0 volts on CAN (+)
Recessive	5 volts on CAN (-)
Dominant	3.6 volts on CAN (+)
Dominant	1.4 volts on CAN (-)

Figure 2-7, Medium Speed CAN-B (ISO11898-3)

Low Speed CAN-A (J2411)	
Logical State	**Voltage**
Recessive	0 volts
Dominant	5 volts

Figure 2-8, Low Speed CAN-A (J2411)

Local Interconnect Network	
Logical State	**Voltage**
Recessive	12 volts
Dominant	0 volts

Figure 2-9, LIN

ISO 9141 or ISO 14230	
Logical State	**Voltage**
Recessive	12 volts
Dominant	0 volts

Figure 2-10, ISO 9141 or ISO 14230

J1850 Variable Pulse Width (VPW)	
Logical State	**Voltage**
Recessive (Terminal 2)	0 volts
Dominant (Terminal 2)	7 volts

Figure 2-11, J1850 Variable Pulse Width

J1850 Pulse Width Modulation (PWM)	
Logical State	**Voltage**
Recessive (Terminal 2)	0 volts on both lines
Recessive (Terminal 10)	5 volts
Dominant (Terminal 2)	5 volts
Dominant (Terminal 10)	0 volts

Figure 2-12, J1850 Pulse Width Modulation

Power Moding

On vehicles that have several electronic control modules connected by serial data communication circuits, one module will be the Power Mode Master (PMM). The Body Control Module (BCM) can function as the PMM. A PMM can be on a Class 2 or GMLAN serial data circuit. Prior to one module being the PMM, most modules had B+, ground, and ignition feed (Key On) circuits. Modules always needed a constant power source to maintain memories and provide current when the module was awake and active. Ignition voltage was used as a wake-up signal.

As a way to reduce the amount of wiring, connectors, and terminals, and the electrical load on the ignition switch, a BCM or Dash Integration Module (DIM) is assigned the PMM responsibility. The PMM receives the ignition switch inputs, and transmits data messages related to the ignition switch position to other modules on the serial data line. The ignition switch is usually a low current switch, which provides discrete ignition switch input signals to the PMM for determination of the power mode data message that is sent to other modules through a serial data communication circuit (see Figure 2-13). To determine the power mode, the PMM uses the open / closed state of the ignition switch signal circuits and the status of the engine.

In some vehicles, the Remote Control Door Lock Receiver (RCDLR) is a backup PMM in the event the main PMM (usually the BCM) has an internal fault or another fault that prevents the BCM from performing its PMM functions.

Ignition Switch Position	Accessory	Ignition 1	Off/Run/Crank	Power Mode Transmitted
Important: Switch states: 0 = inactive, 1 = active States marked with the * indicate a derived positive voltage level of 3 volts. States marked with the ** indicate a derived positive voltage level of 4 volts.				
Off	0	0	0 Key out 1 Key in	OFF/Awake or RAP
Start	0	1	1*	Crank
Accessory	1	0	0	Accessory
Run	1	1	1**	Run

Figure 2-13, Power Moding

The ignition switch positions are translated into power modes by the PMM. The following are PMM power modes with a five-position ignition switch:

- Off-awake or Retained Accessory Power (RAP) (same physical position of the switch)
- Off-wake or RAP (the same physical position of the switch)
- Unlock or RAP Unlock (same physical position of the switch)
- Accessory
- Run
- Crank

The PMM sends the following messages:

- Off-asleep: no activity on the serial data circuits; the modules are asleep
- Off-awake: activity on the serial data circuits; the modules are awake and expecting either serial data or hardware inputs
- Run: all modules are fully functional
- Accessory: those modules that have functions enabled in accessory are fully operational; the rest will be off-awake
- Crank: those modules that have no function critical to engine starting are off to provide maximum power for cranking and starting operation, and to limit customer concern

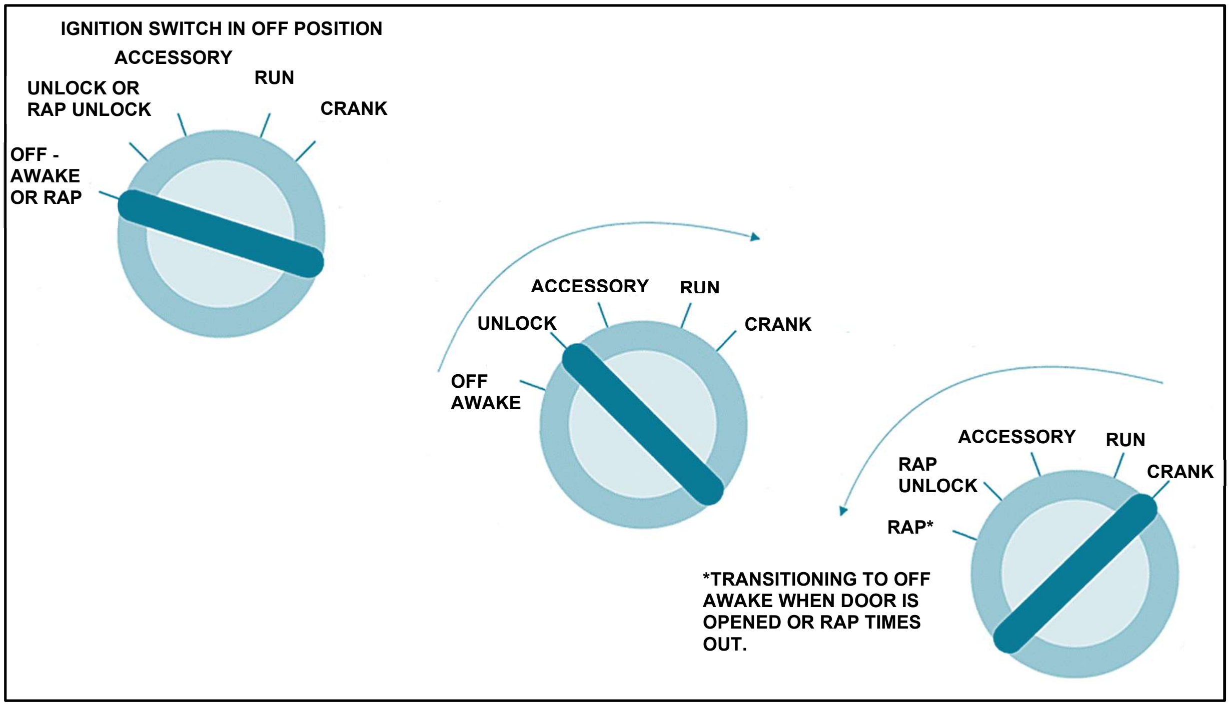


Figure 2-14, Ignition Switch Positions

Because the operation of vehicle systems depends on the power mode, there is a backup plan in place if the BCM acting as the PMM fails to send a power mode message. The backup plan covers electronic control modules with discrete ignition signal inputs, as well as those modules that use serial data messages exclusively for power mode control.

The electronic control modules that depend exclusively on serial data messages for power modes will stay in the state dictated by the last valid message from the PMM until they receive the engine status from the Engine Control Module (ECM). If the PMM fails, the modules will monitor the serial data circuit for the Engine Run Flag (ERF) serial data. If the ERF serial data is true, indicating that the engine is running, the modules will fail-safe to RUN. In this state, the modules and their subsystems can support all operator requirements. If the ERF serial data is false, indicating that the engine is not running, the modules will fail-safe to off-awake. In this state, the modules are constantly checking for a change status message on the serial data circuit, and can respond to both local inputs and serial data inputs from other modules on the vehicle.

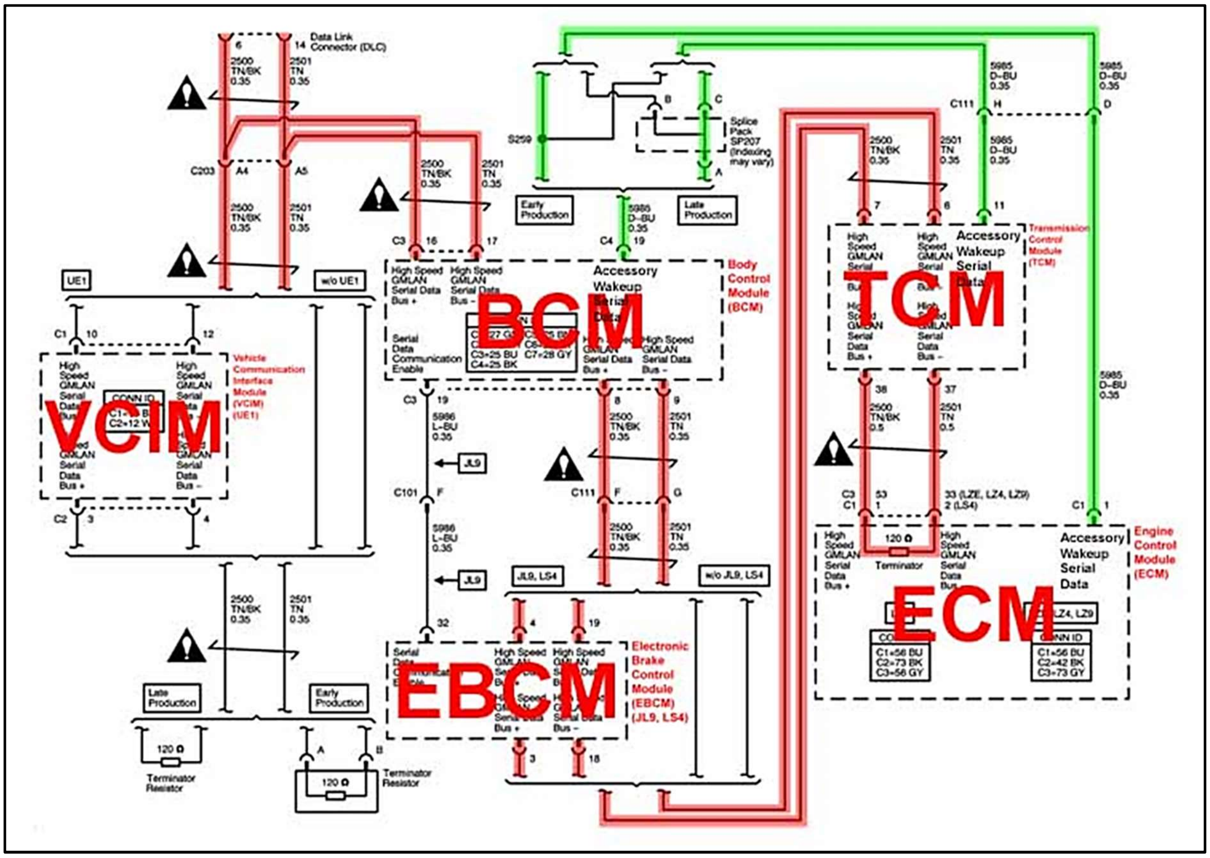


Figure 2-15, PMM Backup Function

SINGLE-WIRE SERIAL DATA CIRCUITS

GM Class 2

The Class 2 serial data network is found in GM vehicles from 1996 to 2008, and is a single-wire serial data network. The Class 2 data circuit transfers information by toggling the circuit from 0 volts to 7 volts. The data circuit at rest is 0 volts. The two pulse widths and a high transfer rate allow the Class 2 data to better utilize the serial data circuit.

Society of Automotive Engineers (SAE) J1850 regulations set the standards for vehicle manufacturers related to communication between the Powertrain Control Module (PCM) and an OBD-II scan tool. Class 2 communication meets these standards. Class 2 serial data is transmitted on a single wire at an average baud rate of 10,400 bits per second, but can be as fast as 41,600 bits per second. The average baud rate is 10,400 bits per second because the wire uses variable Pulse Width Modulation (PWM) to carry data. Depending on the message, Class 2 communication may operate faster or slower. The Class 2 bus is dominant at 7 volts and recessive at ground potential. The average message time is 5-6 milliseconds. The Class 2 line is a masterless, peer-to-peer system that can support up to 32 nodes.

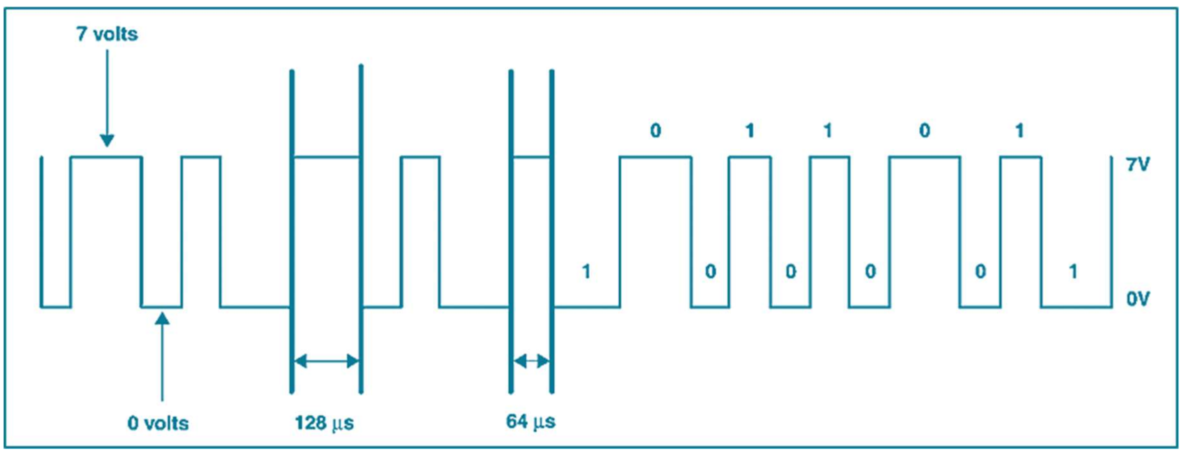


Figure 2-16, GM Class 2

When the ignition switch is moved to RUN, each module communicating on the Class 2 line sends a State of Health (SOH) message every 2 seconds, indicating communication readiness. If a module is not sending a SOH message on the data circuit, other modules that expect to receive the message will detect the fault and set related Diagnostic Trouble Codes (DTCs). For example, if the Instrument Panel Cluster (IPC) stops sending a SOH message, other modules will set DTC U1096. After a SOH message is received by a module on the Class 2 data circuit, a transmitted message can be sent.

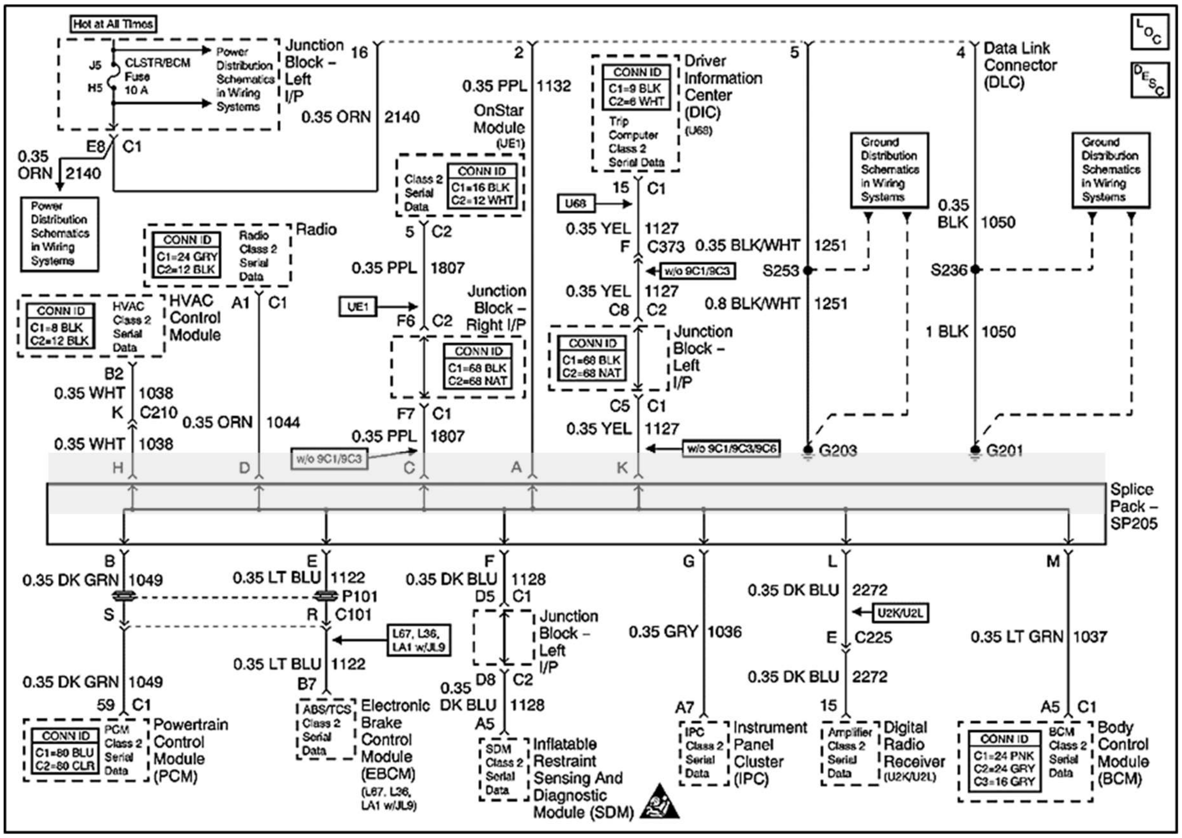


Figure 2-17, GM Class 2 Schematic with Splice Pack

Low Speed GMLAN

Low Speed GMLAN (LS GMLAN) is used in applications where a high data rate is not required. This allows for the use of less complex components. It is typically used for operator-controlled functions where the response time requirements are slower than those required for dynamic vehicle control. LS GMLAN has been used in GM vehicles since 2006.

The LS GMLAN serial data circuit transmits serial data over a single wire to the appropriate control modules. The transmission speed for LS GMLAN is up to 83.33 kbit/s. Under normal vehicle operating conditions, the speed of the bus is 33.33 kbit/s. This protocol produces a simple pulse train sent out over the LS GMLAN serial data bus. Single-wire low speed networks do not use terminating resistors at either end of the network.

The data to be transmitted over the bus is represented by varying voltage signals on the bus. When a module pulls the bus high, 5 volts, this creates a dominant logic state or 0 on the bus. When the bus is pulled low, 0 volts, it is translated as a recessive logic state or 1. To wake the control modules connected to the LS GMLAN serial data bus, a high voltage wake up pulse is sent out over the bus. The voltage level of the pulse is +10 volts.

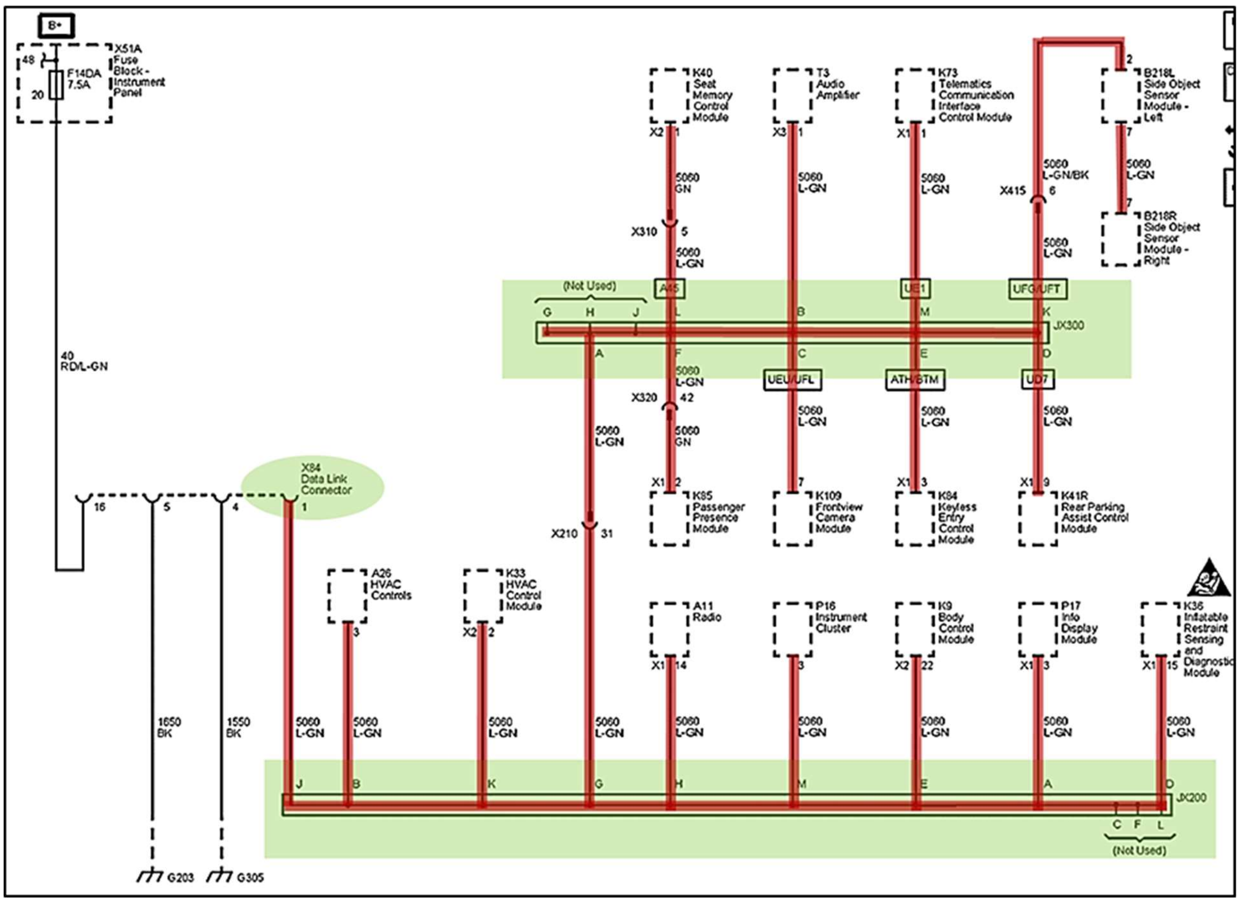


Figure 2-18, Low Speed GMLAN Schematic

Local Interconnect Network

The Local Interconnect Network (LIN) bus consists of a single wire with a transmission rate of 10.417 kbit/s. This bus is used to exchange information between a master control module and other smart devices, which provide supporting functionality. This type of configuration does not require the capacity or speed of either a HS GMLAN bus or LS GMLAN bus, and is thus, relatively simpler. LIN networks are used on many late model vehicles.

The data (1s and 0s) to be transmitted is represented by different voltage levels on the communication bus. When the LIN bus is at rest (recessive), the signal is in a high voltage state of approximately battery voltage. This represents a logic “1.” When a logic “0” is to be transmitted (dominant), the signal voltage is driven low to 0 volts.

LIN serial data circuits do not connect or terminate at the DLC, as they are master / slave networks between a master control module and slave modules / actuators / sensors.

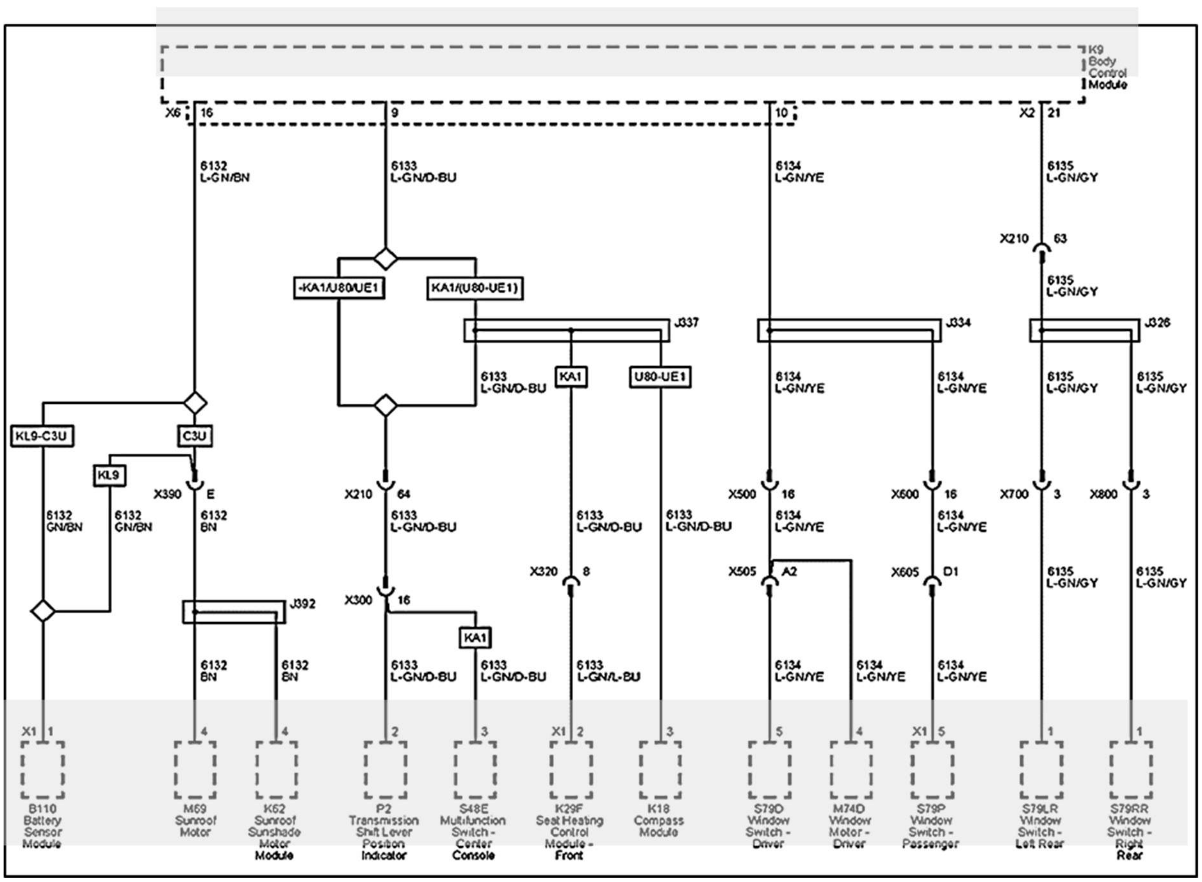


Figure 2-19, Schematic of Local Interconnect Network

ISO-14230 Keyword 2000

The keyword protocol uses a single-wire, bi-directional data line between the modules and the scan tool. The message structure is a request and response arrangement. The keyword serial data line is used for scan tool diagnostics only. The modules do not exchange data on this circuit. The circuit terminates at pin 7 of the DLC typically, but there are some GM vehicles that have two Keyword 2000 serial data circuits, with the second one terminating at pin 12 of the DLC.

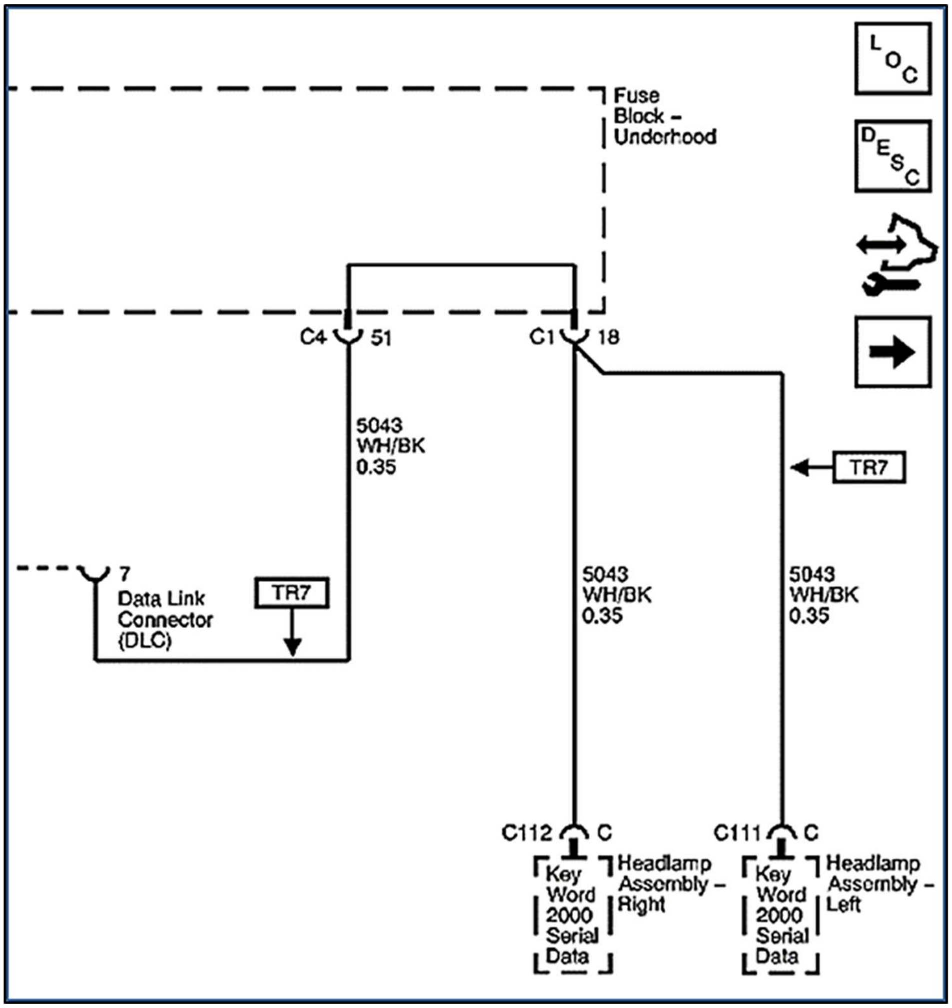


Figure 2-20, Schematic of ISO-14230 Keyword 2000

DUAL-WIRE SERIAL DATA CIRCUITS

High Speed GMLAN Bus

CAN protocol is a serial data network architecture developed by Robert Bosch Company. A variation of the CAN protocol is the HS GMLAN bus. It is used where data needs to be exchanged between powertrain chassis or safety systems.

The HS GMLAN serial data network consists of a twisted pair of wires. One signal circuit is identified as GMLAN-High, and the other signal circuit is identified as GMLAN-Low. At each end of the data bus, there is a 120-ohm termination resistor between the GMLAN-High and GMLAN-Low circuits. Data (1s and 0s) is transmitted sequentially at a rate of 500 kbit/s. The data to be transmitted over the bus is represented by the voltage difference between the GMLAN-High signal voltage and the GMLAN-Low signal voltage. When the two-wire bus is at rest, the GMLAN-High and GMLAN-Low signal circuits are not being driven; this represents a logic “1”. In this recessive state, both signal circuits are at the same voltage of 2.5 volts. The differential voltage is approximately 0 volts. When a logic “0” is to be transmitted, the GMLAN-High signal circuit is driven higher to approximately 3.5 volts (dominant), and the GMLAN-Low circuit is driven lower to approximately 1.5 volts (dominant). The differential voltage becomes approximately 2.0 (+/- 0.5) volts.

Devices on the HS GMLAN bus enable or disable communication based on the voltage level of the communication enable circuit. When the circuit voltage is high (approximately 12 volts), communications are enabled. When the circuit is low, communications are disabled.

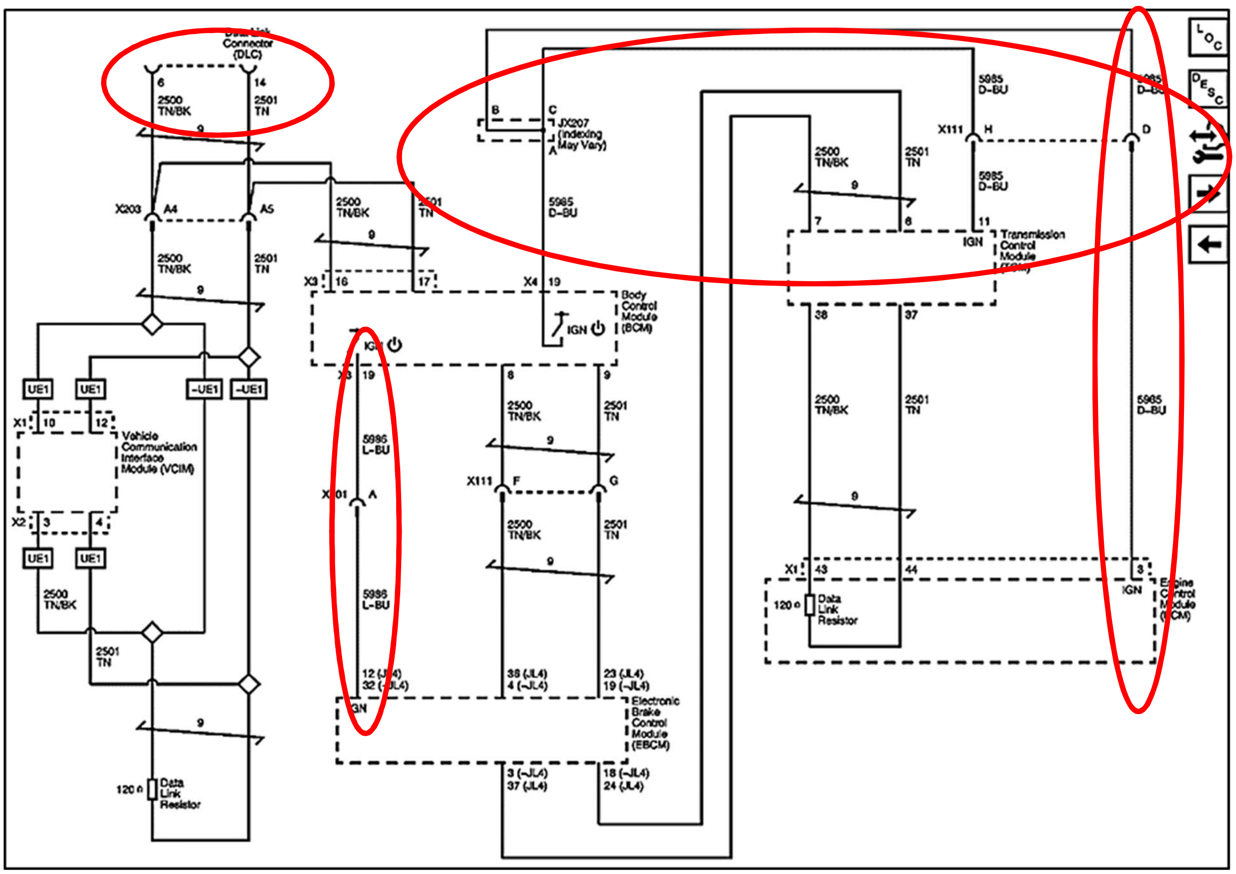


Figure 2-21, High Speed GMLAN Schematic

GMLAN Powertrain Expansion Bus

The GMLAN powertrain expansion bus is a duplicate of the HS GMLAN bus, except its use is reserved for powertrain components. The bus is optional based upon featured content. Sometimes, communication is required between the powertrain expansion bus and the primary HS GMLAN bus. This is accomplished by using the Engine Control Module (ECM) as the gateway module. Since the HS GMLAN powertrain expansion bus and the primary HS GMLAN bus operate in the same manner, the diagnostics for each are similar. The GMLAN powertrain expansion bus does not terminate at the DLC and is an isolated bus network. It is typically found on 2011 and later GM diesel and hybrid powertrains.

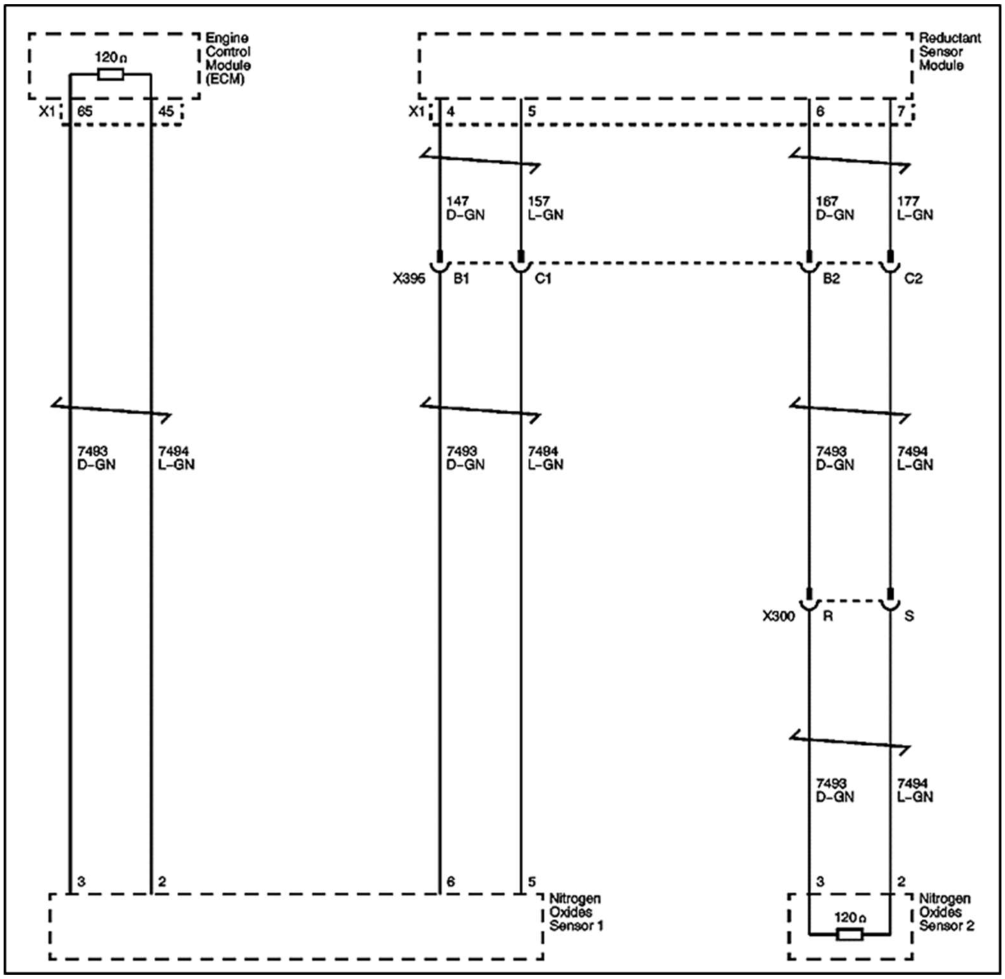


Figure 2-22, GMLAN Powertrain Expansion Schematic

GMLAN Chassis Expansion Bus

The GMLAN chassis expansion bus is a copy of the HS GMLAN bus, except its use is reserved for chassis components. This implementation splits message congestion between two parallel busses, helping to ensure timely message transmission and reception. Sometimes, communication is required between the chassis expansion bus and the primary HS GMLAN bus. This is accomplished by using the Electronic Brake Control Module (EBCM) as the gateway module. Because the HS GMLAN chassis expansion bus and primary HS GMLAN bus operate in the same manner, the diagnostics for each are similar.

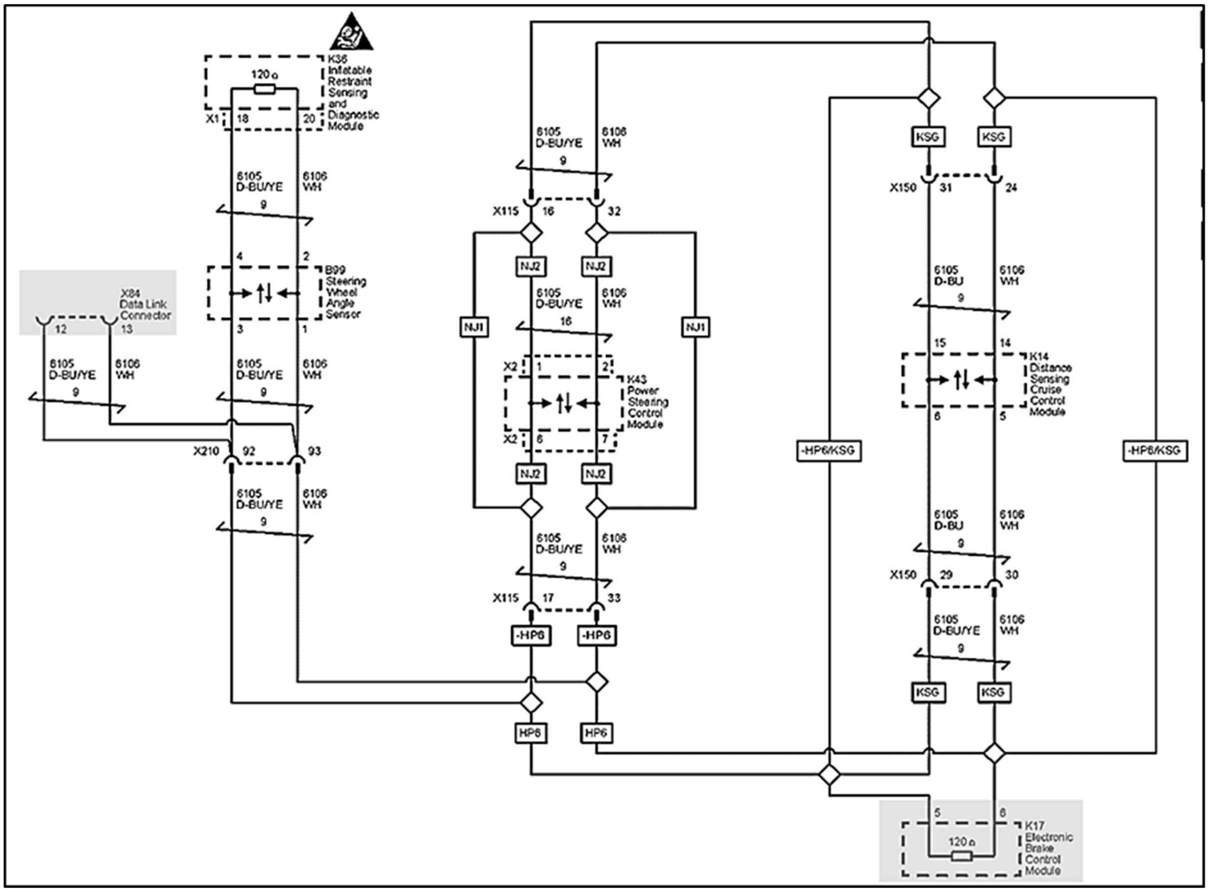


Figure 2-23, GM Chassis Expansion Bus Schematic

GMLAN Object Bus

The GMLAN object bus is basically a copy of the HS GMLAN bus, except its use is reserved for the enhanced safety system. This implementation is used to isolate the heavy communication among the enhanced safety system devices from the other vehicle networks, reducing congestion. The active safety control module is connected to the object bus, as well as the primary HS GMLAN bus, the chassis expansion bus, and the LS GMLAN bus. The active safety control module acts as a gateway module for all required communication between the object bus devices and devices on these other vehicle networks. The GMLAN object bus operates in the same manner as the chassis expansion and primary high-speed buses. So, the diagnostics are similar. The object bus is physically partitioned into a front object bus and a rear object bus, with each partition having its own communication enable circuit to activate the partition. Functional operation of both is identical.

The front object bus standard devices are as follows:

- Active safety control module
- Front view camera module
- Radar sensor module – long range

The front object bus optional devices are as follows:

- Radar sensor module – short range left front
- Radar sensor module – short range right front

The rear object bus is optional and when present, will have the following:

- Active safety control module
- Radar sensor module
- Short range rear on the bus
- Optionally the radar sensor module – short range right rear

All object bus components are powered by the active safety control module via the communication enable circuits, except the front view camera module, which is powered directly by battery.

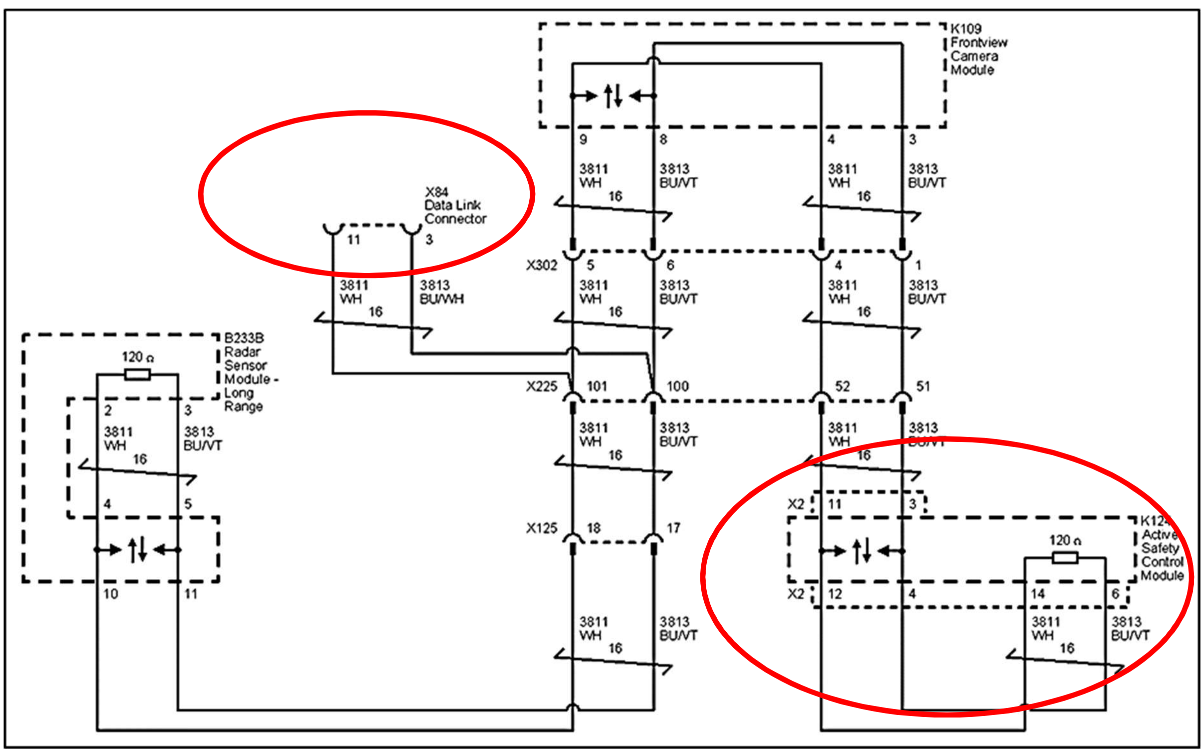


Figure 2-24, GMLAN Object Bus Schematic

Mid-Speed GMLAN

The Data Link Connector (DLC) allows a scan tool to communicate with the MS GMLAN serial data circuit. Modules connected to the MS GMLAN serial data circuit monitor for serial data communications during normal vehicle operation. Operating information and commands are exchanged among the modules when the ignition switch is in any position other than OFF. The MS GMLAN serial data bus uses a terminating resistor that is in parallel with the MS GMLAN (+) and (-) circuits.

The MS GMLAN is used in the Saturn Astra and Chevrolet Volt. It has a data transfer rate of up to 125 kbit/s. The MS GMLAN has the following characteristics:

- CAN (+): Recessive 0 volts, Dominant 3.6 volts
- CAN (-): Recessive 5 volts, Dominant 1.4 volts
- The MS GMLAN terminates at pins 3 and 11 at the DLC

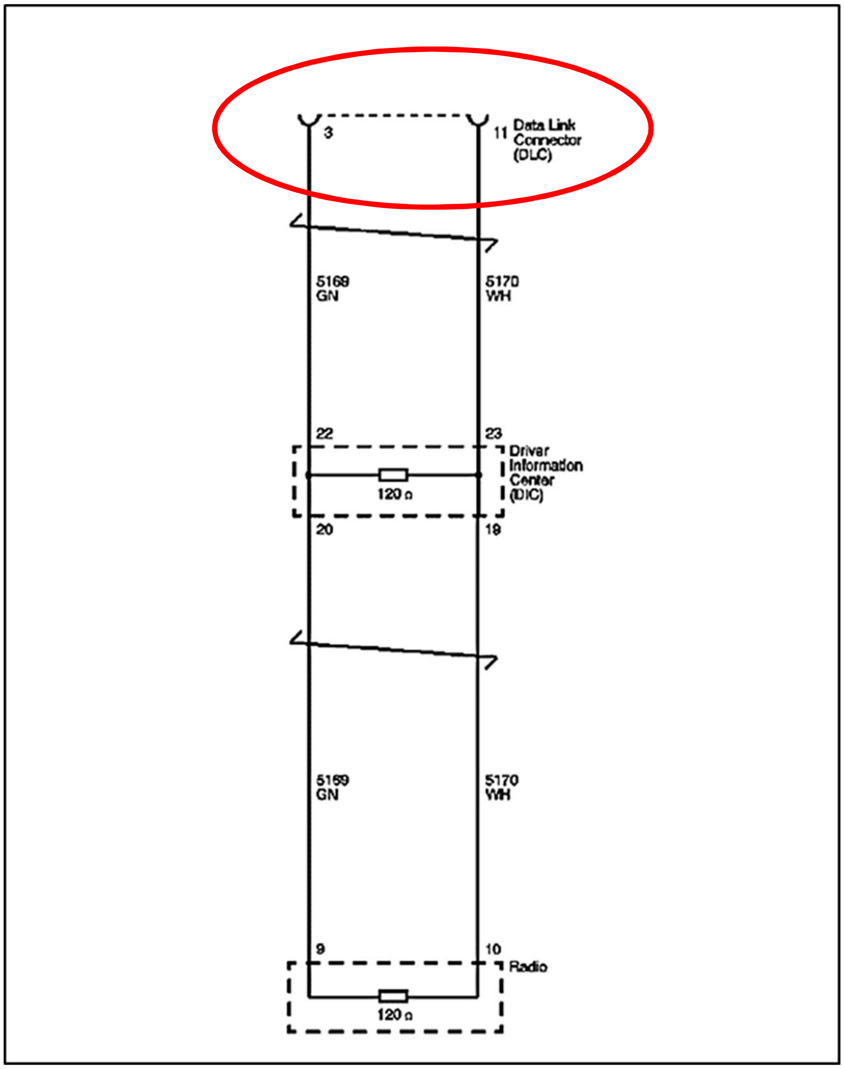


Figure 2-25, Mid-Speed GMLAN Bus Schematic

NETWORK TOPOLOGY

The physical layer consists of wiring and modules in a network. The arrangement of the physical connections between modules on the network is known as network topology. Common topologies are linear, ring, and star.

Star Topology

The star configuration has a central node module that coordinates all serial data traffic between control modules. A node is an engineering term for a module that sends or receives serial data messages. Serial data circuits connect each module back to the central node. An example of this is the PC Ethernet.

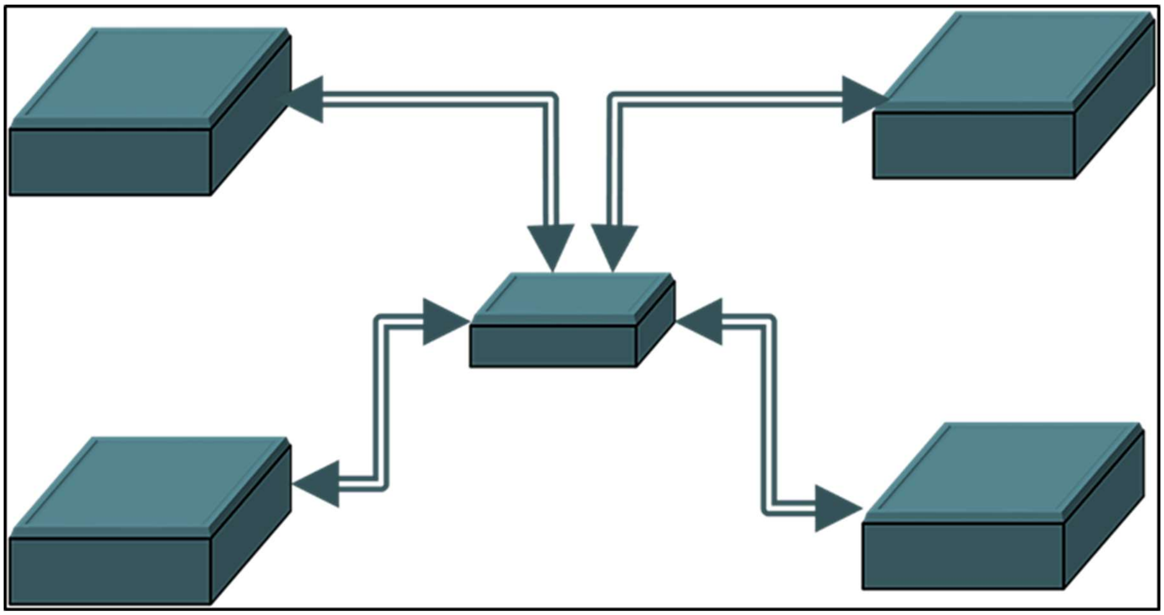


Figure 2-26, Example of a Star Network

Ring Topology

In a ring topology, data travels from one node to the other in a circular fashion. A ring topology may also incorporate a second network used to wake up the modules in the ring, and for diagnostic purposes should a break in the ring occur. An example of ring topology is the Media Oriented System Transport (MOST®) network.

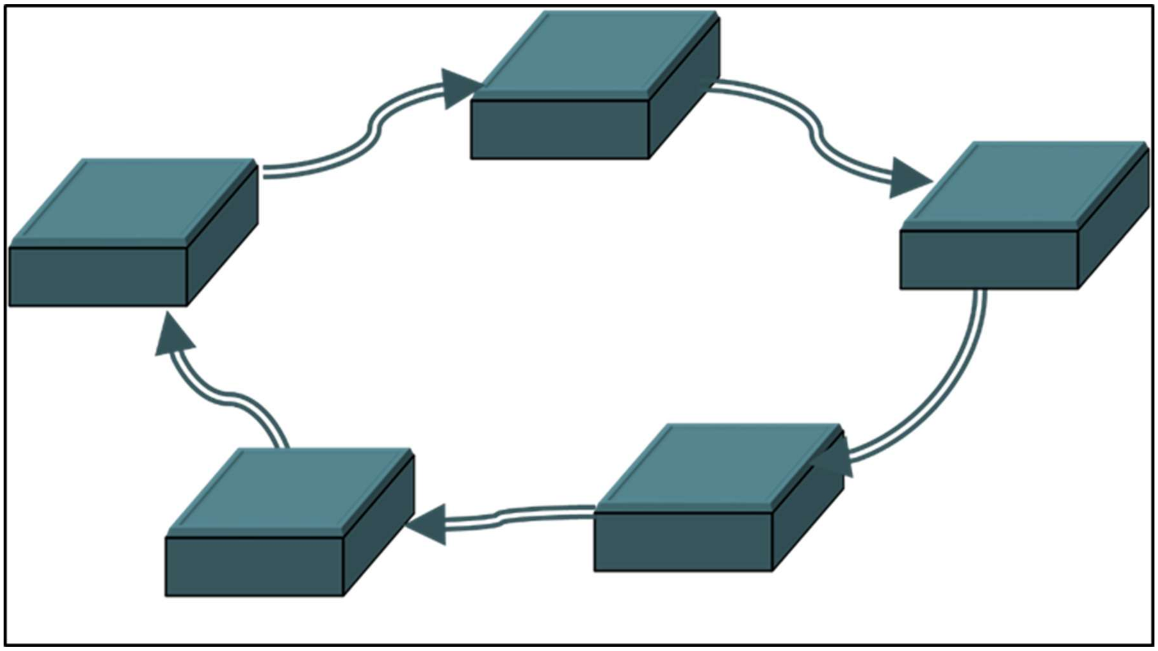


Figure 2-27, Example of a Ring Network

Linear Topology

In a linear (bus) topology, all nodes are connected via one or two wires in a parallel configuration. The branch connection to the node can be external in the wiring harness (splice pack, solder splice) or internal inside the node (control module). The internal connection is sometimes called a daisy chain configuration.

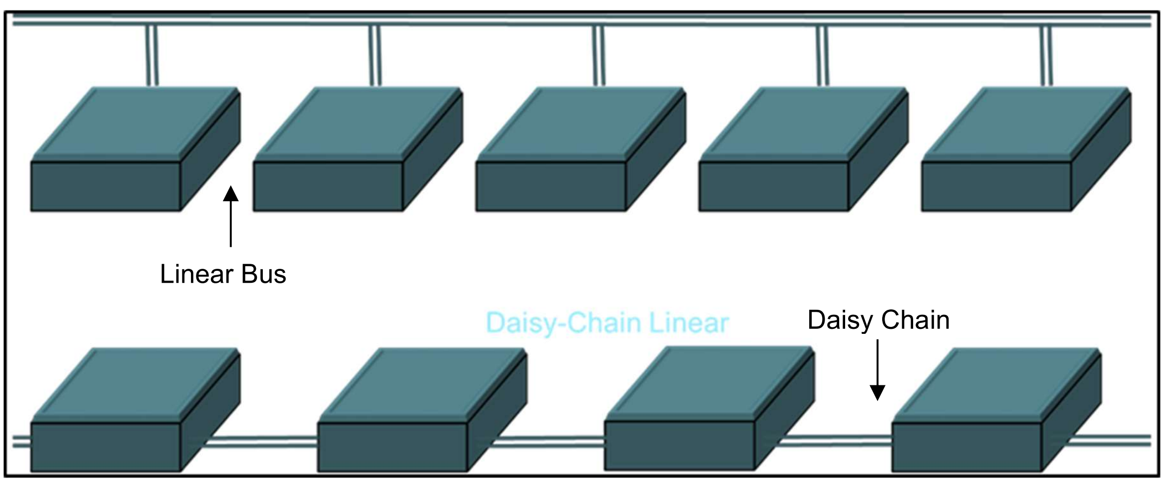


Figure 2-28, Example of a Linear Network

Hybrid Topology

Hybrid topologies combine elements of the star, linear, or ring network topologies. For example,

- Star bus topology: the central nodes of one or more star networks are parallel connected to a linear (bus) network
- Star ring topology: the central nodes of one or more star networks are connected to a main node. The central nodes of the individual star networks are ring connected within the main node

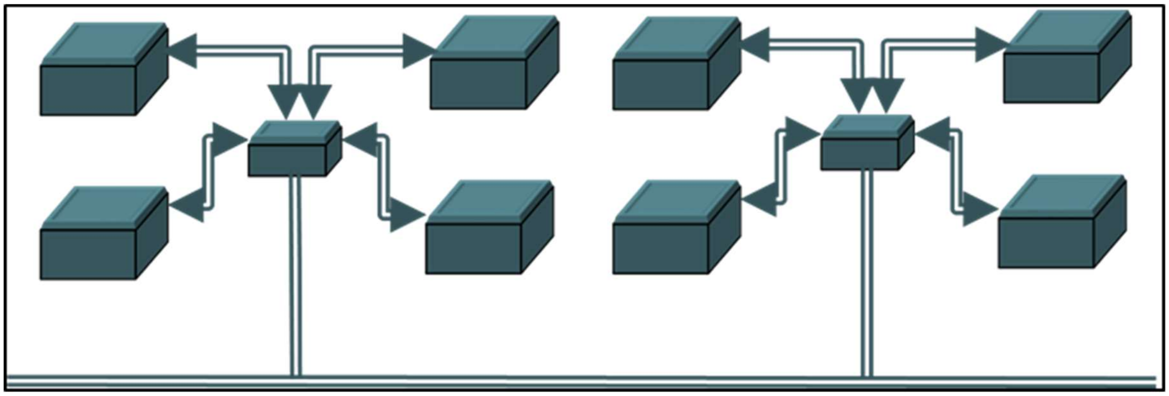


Figure 2-29, Example of a Star Bus Hybrid Network

Gateway Isolated Networks

In some vehicles, the serial data circuits at the DLC go directly to a Serial Data Gateway Module (SDGM). The SDGM is used to handle communications between multiple busses and functions as a gateway to isolate the secure networks from the unsecured networks. It was created to mitigate bus loading to support cyber security and new active / advanced safety features, like Limited Ability Autonomous Driving and Enhanced Collision Avoidance (if equipped).

Note: Continuity checks cannot be performed between the data link connector and control modules on gateway isolated serial data networks.

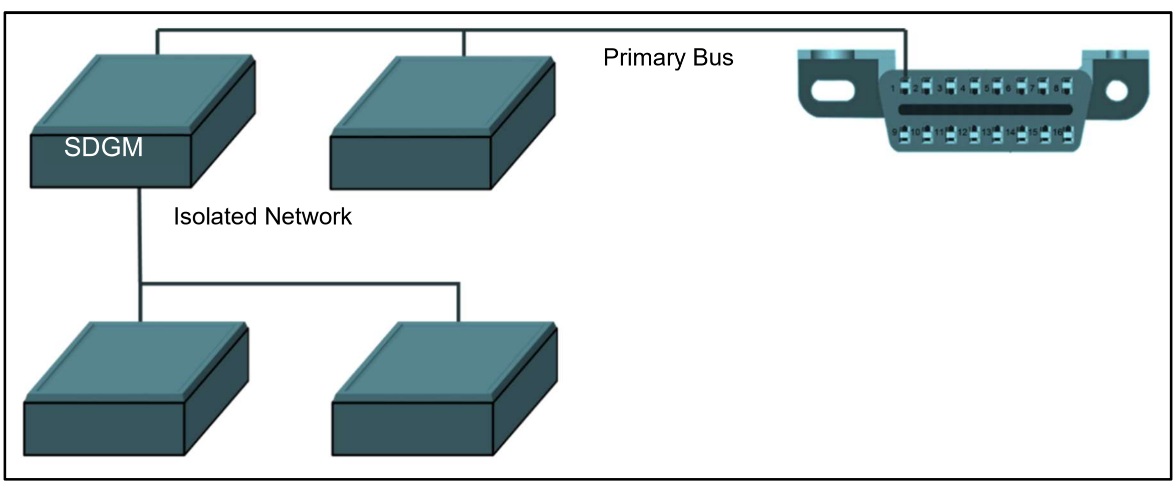


Figure 2-30, Example of Gateway Isolated Network

Media Oriented Systems Transport Networks

Vehicle infotainment systems have become more advanced and commonplace. These popular infotainment systems need to transport large amounts of data from streaming audio and even video. This need has led to a new type of network called Media Oriented Systems Transport (MOST®). MOST® is an industry standard or specification that allows manufacturers and suppliers to adapt to the needs of the vehicle design and customer.

There are two basic configurations of MOST® networks: wired and optical. There are currently three MOST® network speed specifications in use:

- MOST® 25: Optical ring network with data rate up to 25 Mbit/s
- MOST® 50: Twisted pair ring network with data rate up to 50 Mbit/s. MOST® 50 also supports optical physical layer arrangements
- MOST® 150: Optical or hardwire ring with additional channels (Ethernet) that supports 150 Mbit/s

Media Oriented Systems Transport Topology 50

The MOST® 50 infotainment network used in GM vehicles is a dedicated high-speed multimedia streaming data bus, independent from GMLAN. The MOST® 50 bus is configured in a physical hardwired loop, where each device within the bus sends and receives data on an assigned MOST® address in a set order. Each device on the MOST® bus is connected by two twisted pair wire sets. One of these twisted pair transmit (TX) data, and the other twisted pair receives (RX) data. Along with the power and ground circuits, an additional circuit serves as a 12 volt wake up and diagnostic signal line. The radio is the MOST® master and will monitor the bus for vehicle configuration, infotainment data messages, and errors on the bus.

Ring topology connects the devices together in a series. This is different from GMLAN, where modules are connected together in parallel. Each module on the GMLAN receives only the data that it needs from the network. In the MOST® network, each module receives all network data, processes only the data relevant to the module's function, and outputs all the data to the next module in the ring.

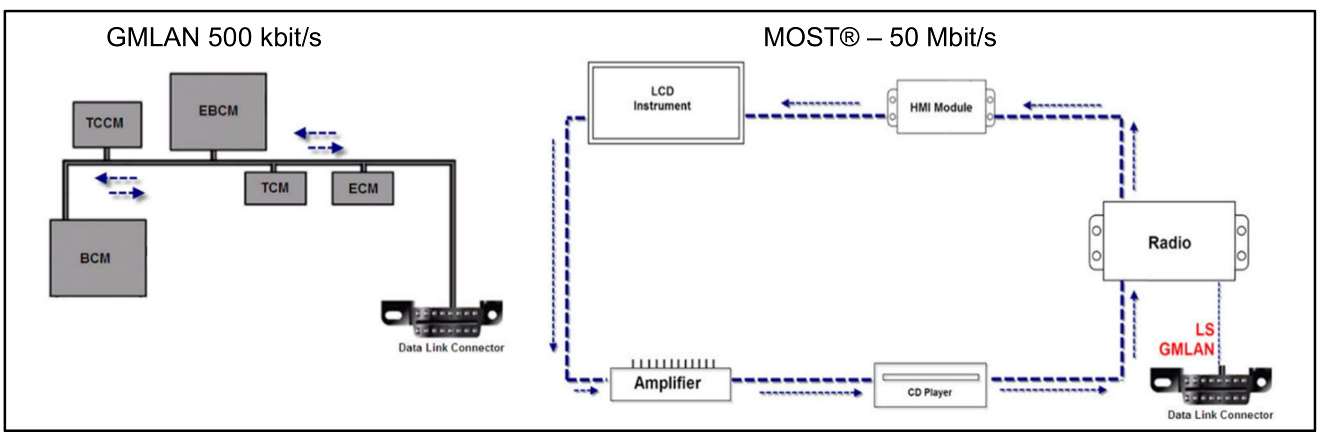


Figure 2-31, GMLAN vs MOST® 50

A key difference between MOST® and other GM networks is that communication over the MOST® network occurs in a continuous loop and in only one direction. Information is received, processed, and then transmitted, one module at a time. Other GM networks, such as GMLAN or LIN, use bidirectional communication. Most of the data circulating through the MOST® network stays local to the network. However, a gateway module is used to exchange data between the MOST® network and GMLAN.

Speed is the greatest advantage of the MOST® network. At a data rate of 50 Mbit/s, the MOST® network is 100 times faster than high speed GMLAN. The MOST® network's high data rate allows for audio and video signals to be carried in real-time or streamed over the MOST® network, along with serial data instructions.

The radio initiates communication over the MOST® network using the MOST® control circuit. This circuit is also referred to as the MOST® control line or electronic control line in service information. When the ignition is OFF, the MOST® control circuit is at a high state, which is equal to battery voltage. Each module on the network contains a pull up resistor that applies battery voltage to the circuit.

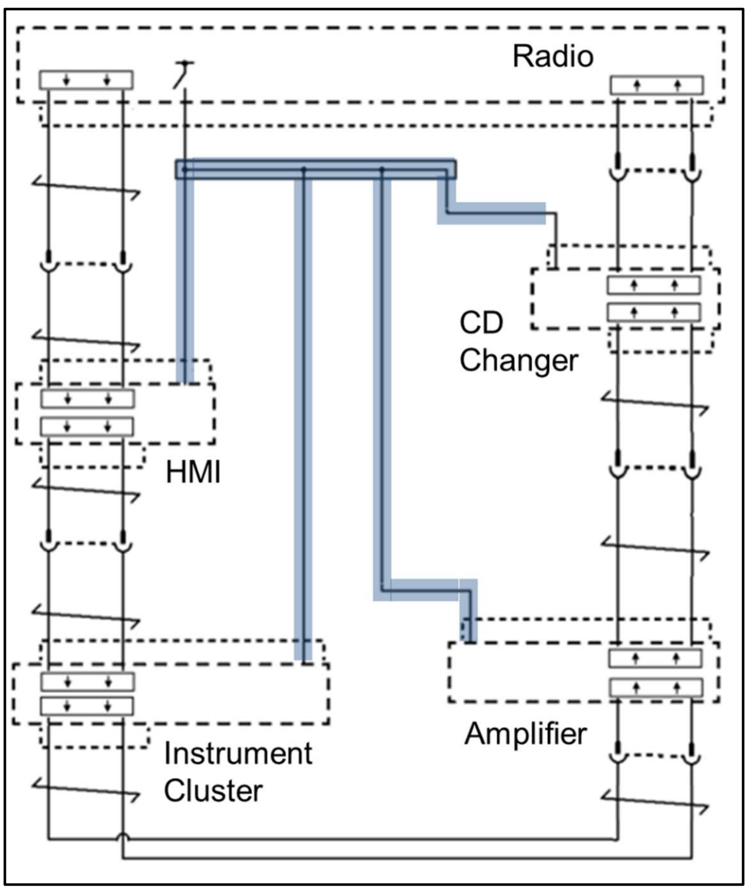


Figure 2-32, MOST® 50 Network, Ignition OFF

When the ignition is in ACCESSORY or ON, the radio will briefly apply ground to the circuit for 100 milliseconds, this 100 milliseconds pulse is the wake-up signal to the modules on the MOST® network.

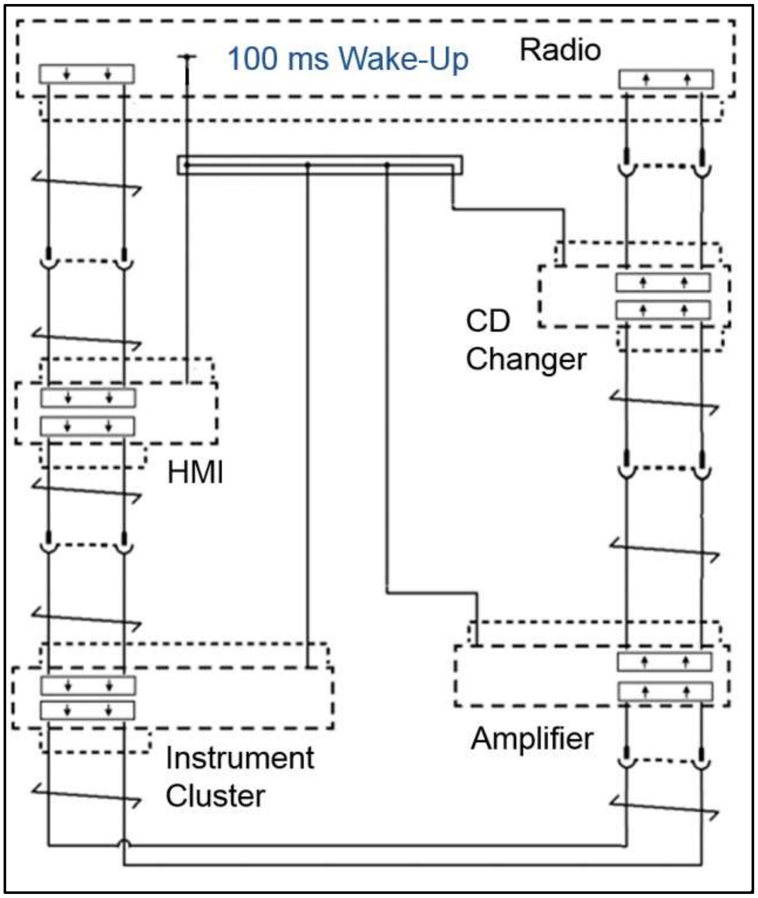


Figure 2-33, MOST® 50 Network, Ignition ON Sends 100 Millisecond Wake Up

The MOST® control line is also used for diagnostics. When a fault is detected in the MOST® bus circuit, the radio will send a 300 milliseconds pulse to initiate diagnostic protocol, known as ring break. The modules can also manipulate the voltage on the control line to provide the MOST® master with diagnostic information.

Each module in the MOST® network detects the wake up signal, activates, and then transmits blocks of data that are circulated around the MOST® ring in a continuous loop. This string of data flows from one module to the next in the direction of the arrows shown in Figure 2-34. The flow begins at the radio and progresses downstream to each module.

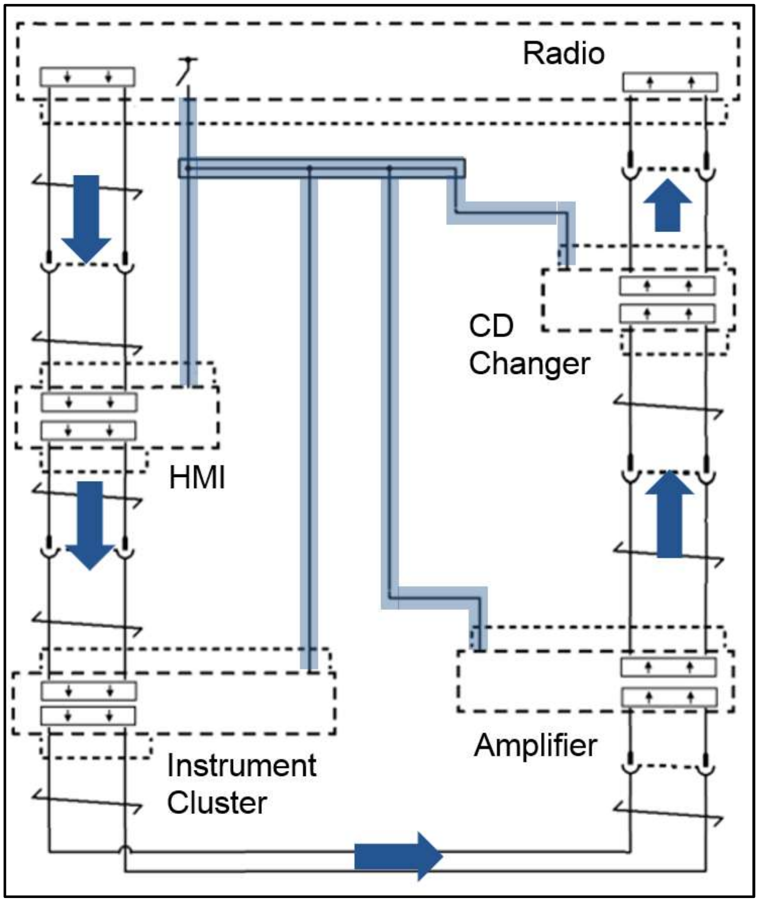


Figure 2-34, MOST® 50 Network, Data Flows in One Direction

The MOST® signal is too fast to view it accurately with the Oscilloscope Diagnostic Kit. However, we can view it with a faster lab oscilloscope (6000 series PicoScope). MOST® circuits carry a very sensitive voltage signal, +/- 300 mV as measured between each MOST® circuit and ground. The signal may be disrupted by poor terminal contact. Because of this sensitivity, poor terminal contact is a potential cause of intermittent faults.

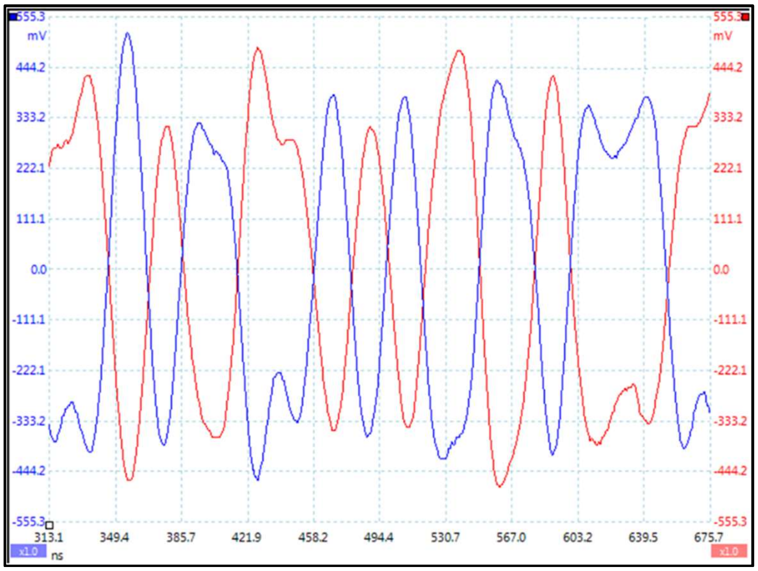


Figure 2-35, MOST® 50 Signal as Captured by 6000 Series PicoScope

Media Oriented Systems Transport 25 and 150

MOST® 25 was the first MOST® system, appearing in the early 2000s. It was optical only. It was used in Audi, Volkswagen, Mercedes, and BMW vehicles. The MOST® 25 optical bus performs the same function as the hardwired MOST® 50 bus. It carries information and streaming media data between modules. It shares the same ring topology and diagnosis / wake up circuit. The difference between the MOST® 25 and the MOST® 50 is that the MOST® 25 uses fiber optics rather than copper wires for sending data. The MOST® 25 optical bus transfers data at a rate of up to 25 Mbit/s. It uses light pulses sent through a plastic optical fiber. The light is transmitted by the module's toggling an LED. The light is received by a module's transceiver through a photodiode. The transmitted light pulses have a wavelength of approximately 650 nanometers and is visible as red light. The light signal traveling between the modules does not produce any electromagnetic interference, nor is it affected by electromagnetic interference.

The MOST® 25 network is managed by one control module, which acts as the system manager. It transmits the operational command data to turn on, and activate various functions and features through the network. There is also a module responsible for the diagnosis of the network. This diagnosis manager executes diagnosis of the optical fiber network and returns the diagnostic data of the control modules in the network to the scan tool. Because communication in the MOST® data bus cannot occur in the event of a ring break, the diagnosis is performed using the diagnosis / wake up circuit. The diagnosis / wake up circuit is connected to every control module in the MOST® bus ring, from a central connection to the diagnosis manager. The diagnosis manager is typically a gateway module and has hardware connections to the DLC.

MOST® 150 is the third generation of the MOST® standard. It can employ optical fiber or hardwire (coaxial cable), or a combination of both, physical connections. The protocol allows for an Ethernet channel over the network and can stream video, audio, and Ethernet-based data at up to 150 Mbit/s simultaneously. This system has been deployed in select vehicles since 2012 and will become more common. It can be configured as a star or ring topology, depending on the application. The optical fiber and connectors are the same as they were in the MOST® 25. The hardwire version uses special coaxial connections and cables that carry the signal and power to devices, such as camera and video displays.

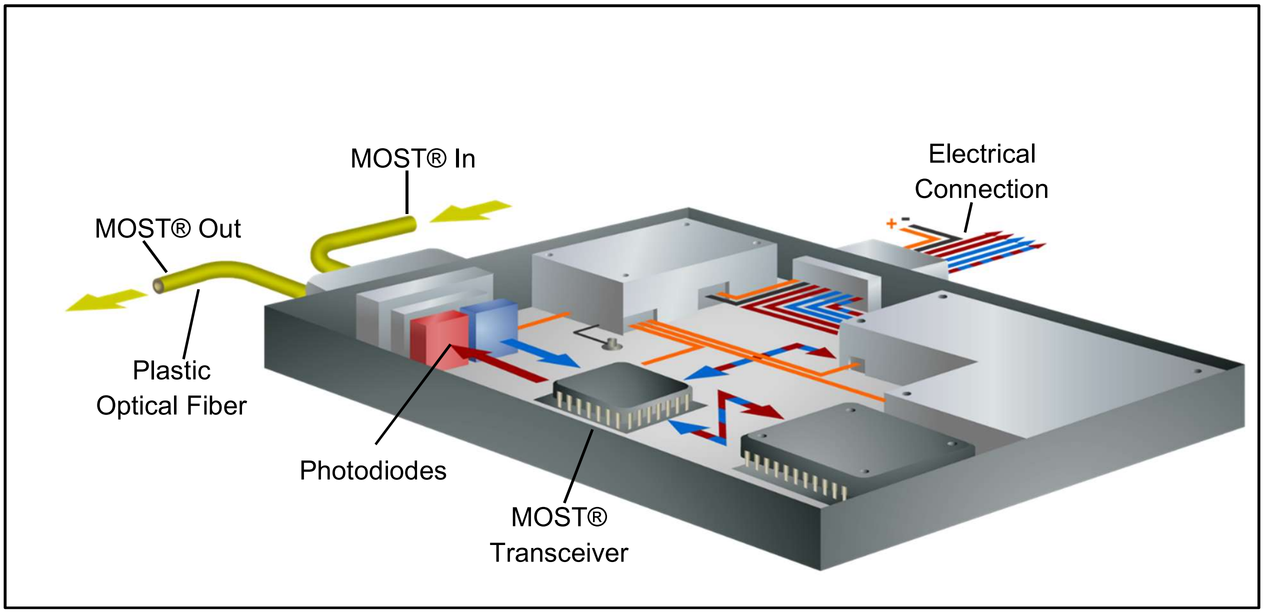


Figure 2-36, MOST® 25 Control Module

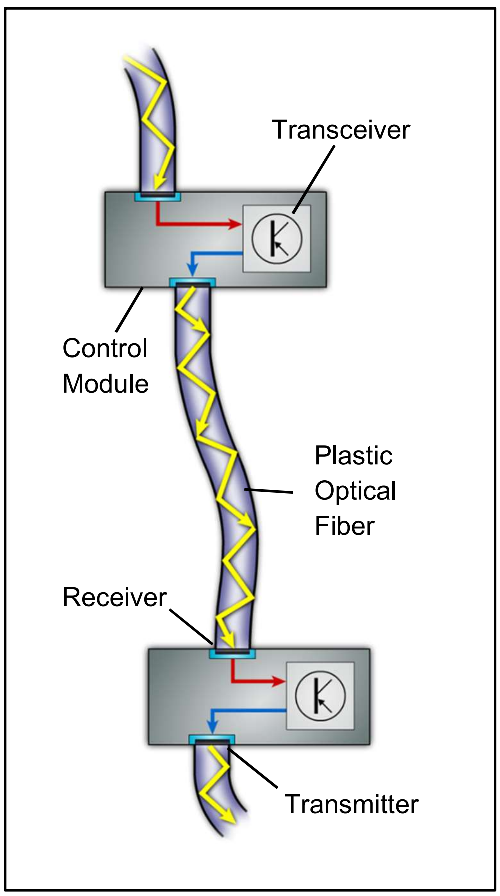


Figure 2-37, MOST® 25 Architecture

Plastic Optical Fiber Cable

The Plastic Optical Fiber (POF) cable used in MOST® systems consists of several layers and has an outer diameter of just over 2.3 mm. The central core is made of optically clear polymethylmethacrylate (PMMA) plastic that allows light to travel through it. The next layer is an optically transparent reflective coating, which produces a total reflection of the light wave, allowing it to travel efficiently through the fiber. The next layer is a black sheathing made from polyamide plastic, which prevents external light interference. Lastly, a colored outer sheathing is for visual identification, protection against abrasion, and protection from temperature damage.

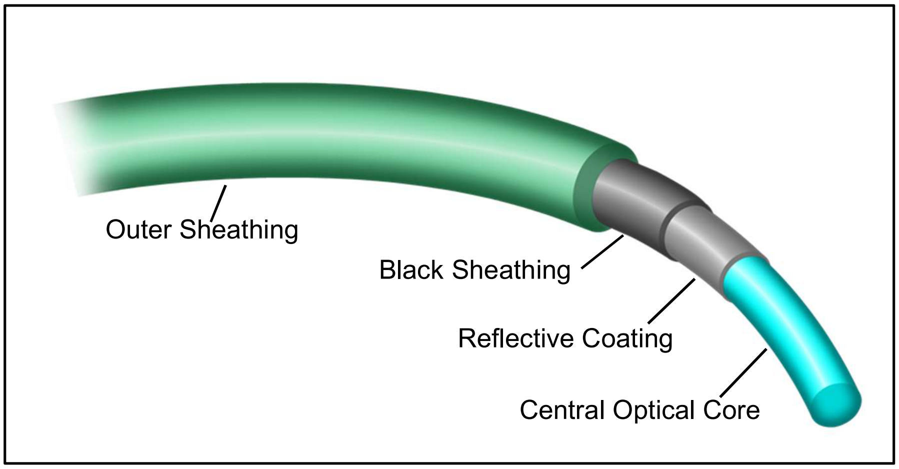
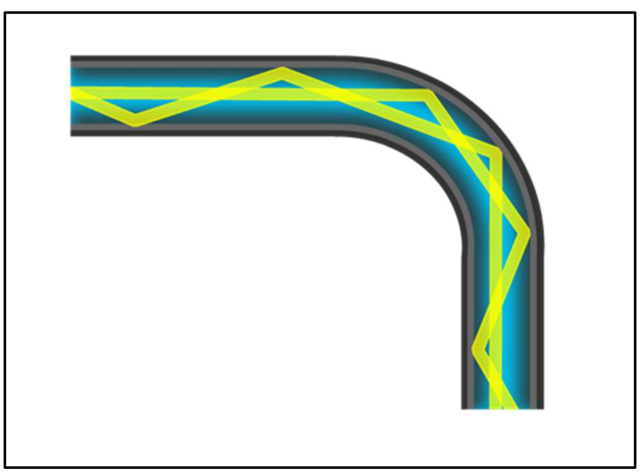


Figure 2-38, Plastic Optical Fiber

The POF cable guides a portion of the light waves in a straight line through the central optical core. Larger portions of the light waves are guided through the fiber optic cable along a zigzag path by reflection against the boundary between the reflective coating and the central core. When the light waves enter a bend, they are reflected at the borderline of the reflective core coating and are guided through the turn. The correct reflection depends on the angle of the light wave as it strikes the boundary of the central core and reflective coating layer. If the angle is too sharp, the light waves will leave the central core and be absorbed by the black sheathing, resulting in signal degradation. This can occur when the POF cable is bent too tightly or has been kinked. The minimum bend radius of the POF cable is 1 inch (25 mm).



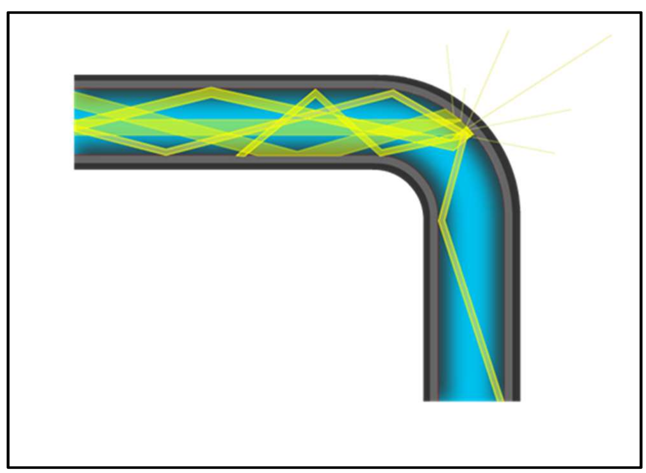


Figure 2-39, POF with Bend Radius > 1 inch

Figure 2-40, POF with Bend Radius < 1 inch

Specialized connectors are used to connect the POF cable to the control modules. Arrows are imprinted on the coupling piece to indicate signal direction. The transfer of light occurs between the end face of the POF central core and the optical transceiver of the control module. The POF is retained in the coupling piece by bonded plastic or crimped brass ferrules held by a lock tab (Terminal Position Assurance, or TPA). The coupling piece is inserted into a connector shell to mate with the connector header of the control module.

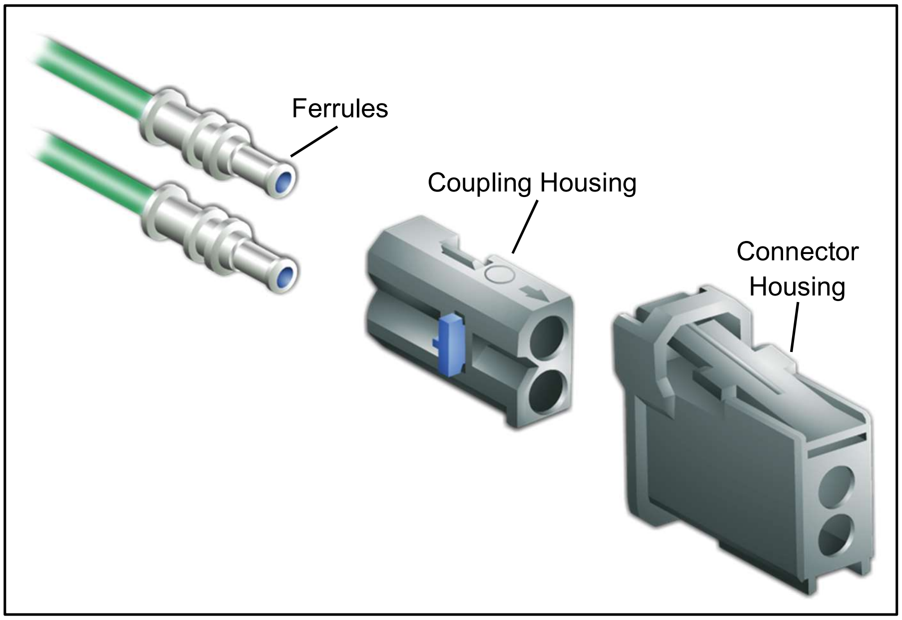


Figure 2-41, POF Connectors

Other Networking Technologies

FlexRay

FlexRay is a modern networking technology designed to provide reliable and efficient data transmission with real-time capabilities between the electronic and mechatronic devices for linking advanced functions in vehicles. FlexRay provides an optimal protocol for real-time data transfer in distributed systems found in motor vehicles. With a data transmission rate of 10 Mbit/s, FlexRay is faster than the 500 kbit/s CAN protocol that is currently used in the chassis, drive train, and suspension. In addition to the higher data transfer rate, FlexRay can support reliable operation of remaining networked systems, even in the event of individual component failure. The FlexRay protocol is an industry standard and is supported by many manufacturers, including GM.

FlexRay networks are single-channel, dual-wire networks, but can be configured as a two-channel network with a redundant two-wire bus connected to the modules. FlexRay can be connected in linear, star, or hybrid topologies. The typical voltages of the FlexRay bus when referenced to ground are:

- Idle – no bus communication 2.5 volts
- High signal – 3.1 volts (voltage signal rises by 600 mV)
- Low signal – 1.9 volts (voltage signal falls by 600 mV)

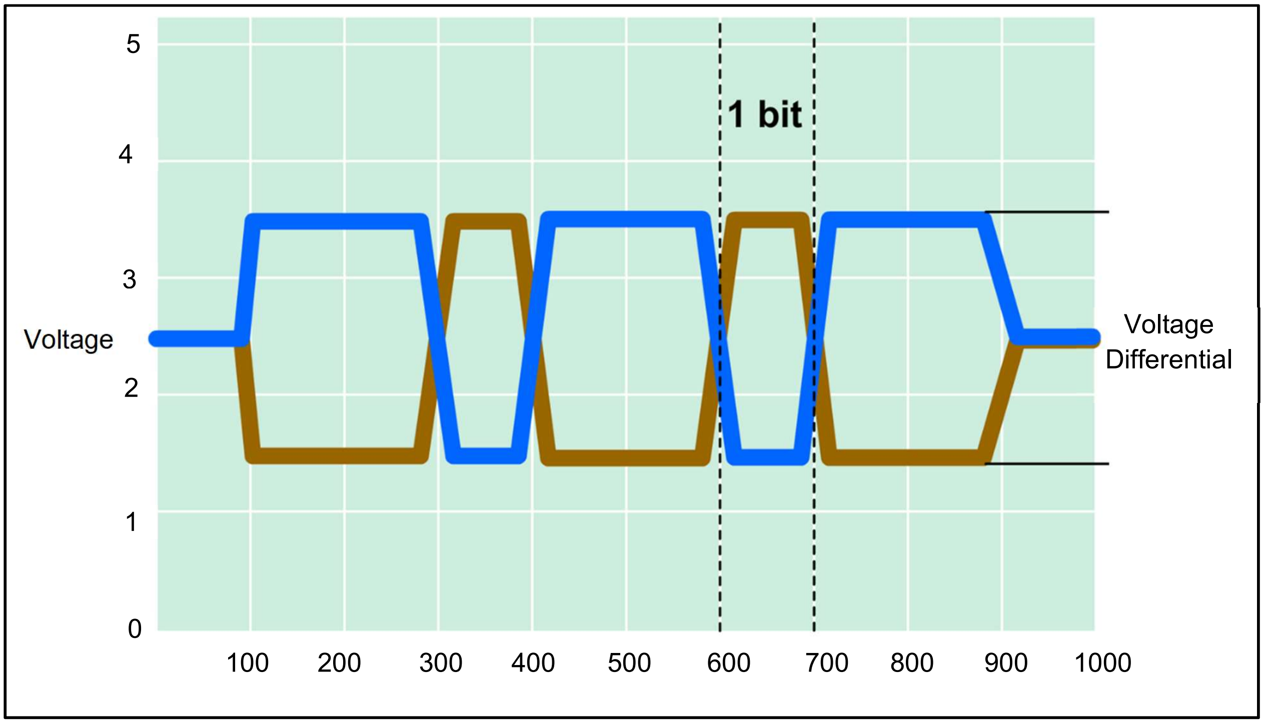


Figure 2-42, FlexRay Voltage

Termination resistance in a FlexRay network is not fixed like CAN. The terminating resistors vary in value and location, depending on the length of the bus circuits between the modules and the number of modules. The vehicle service information or schematic will identify the location and values of these resistors. Generally, the resistance across the bus wires is between 90 and 110 ohms.

Controller Area Network Flexible Data

The CAN Flexible Data (CAN-FD) protocol is a similar technological approach to the FlexRay networks. Like FlexRay, CAN-FD is intended to address the need for increasing data transfer to support future autonomous vehicle features and to extend the useful life of existing hardware. CAN-FD was developed in the 2010s and is documented in the ISO 11898-7 standard. CAN-FD structures messages differently than the standard high speed CAN. The message length can be increased from 8 bits to 64 bits, and the data rate or bits per second varies within the message. This allows data rates as high as 2 Mbit/s, compared to the 500 kbit/s of the standard CAN protocol. The wiring and topology can remain the same, as well as the transceiver within the modules. The changes are to the protocol controller within the control modules.

Hardwire Ethernet

Ethernet is a manufacturer-neutral, hardwire network technology. Most modern computer networks are based on this data transfer technology. Data transfer rates have increased since Ethernet networking was developed. The Institute of Electrical and Electronic Engineers (IEEE) has created a standard for hardwired networks that is currently in use on some vehicles. It is called IEEE 802.33xx. This specification is also referred to as fast Ethernet. The transfer protocols in use are the Transmission Control Protocol / Internet Protocol (TCP / IP) and the User Datagram Protocol (UDP). Current uses for Ethernet networking within vehicles today is diagnostics / programming and audio / video data transfer. The physical connections between modules is a star topology of twisted pair conductors.

DIAGNOSING NETWORK FAILURES

DIAGNOSING A SINGLE-WIRE SERIAL DATA CIRCUIT FAULT

When faults occur on a single-wire serial data circuit, loss of communication between control modules or the scan tool can occur. There are several methods and tools to approach the diagnosis.

Single-Wire Serial Data Circuit Testing – Digital Multimeter

One method of performing electrical checks of wired networks is to use the DMM. However, the testing principles are the same for other single-wire serial data circuits. Voltage and resistance may vary between makes and models. Note that the GMLAN network is brought directly to the DLC, but others may not be. In order to access those networks, locate the splice pack / junction, or test from a module connector. The manufacturer may also have published specific testing procedures for network communication issues, so look for that before performing a test. It may prove useful to check various vehicles that come in the shop to get a baseline of normal readings from vehicles that are operating normally.

Low Speed GMLAN (Open)

In an open circuit, modules downstream of the open will not communicate with the other modules or scan tool. Figure 3-2 shows a drawing of an open fault. Voltage measurements at the DLC will still indicate normal voltage levels from pin 1 to ground are 1 volt to 3 volts, and fluctuating. Figure 3-1 shows the DMM indicating normal voltage levels.

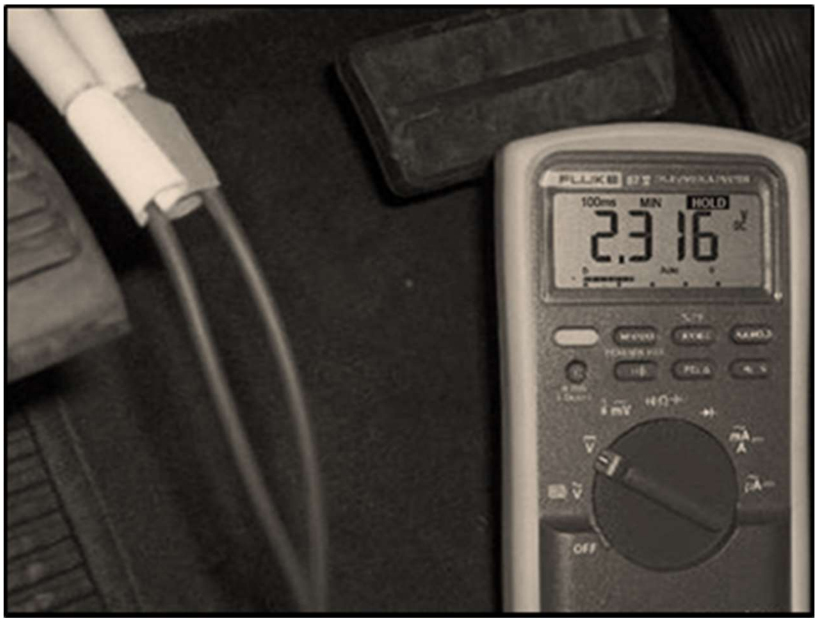


Figure 3-1, DMM Showing Normal Voltage – Pin 1 to Ground

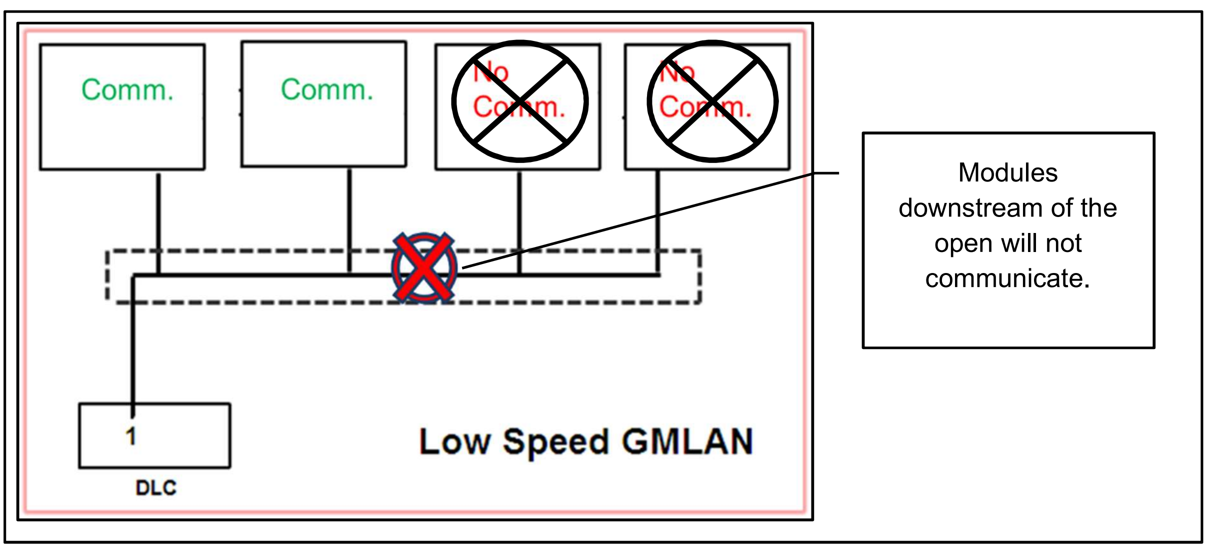


Figure 3-2, Example of Open Fault

Low Speed GMLAN (Shorts)

In a shorted circuit, the modules on the bus with the short will not communicate with other modules on that bus. If a short to ground is found, the voltage will be low and will not fluctuate. If the short is to voltage, the voltage will be high and will not fluctuate.

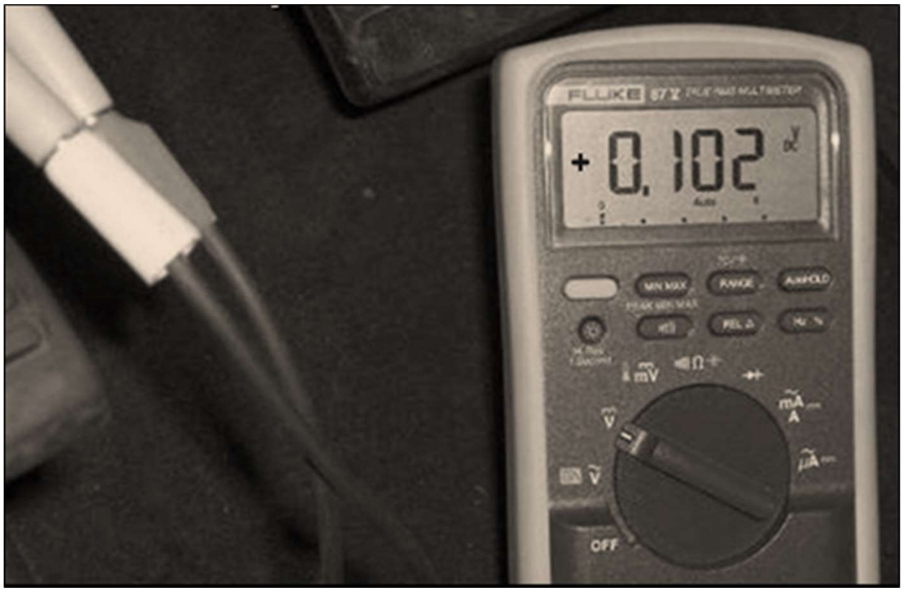


Figure 3-3, DMM Showing Pin 1 to Ground – Low and Not Fluctuating

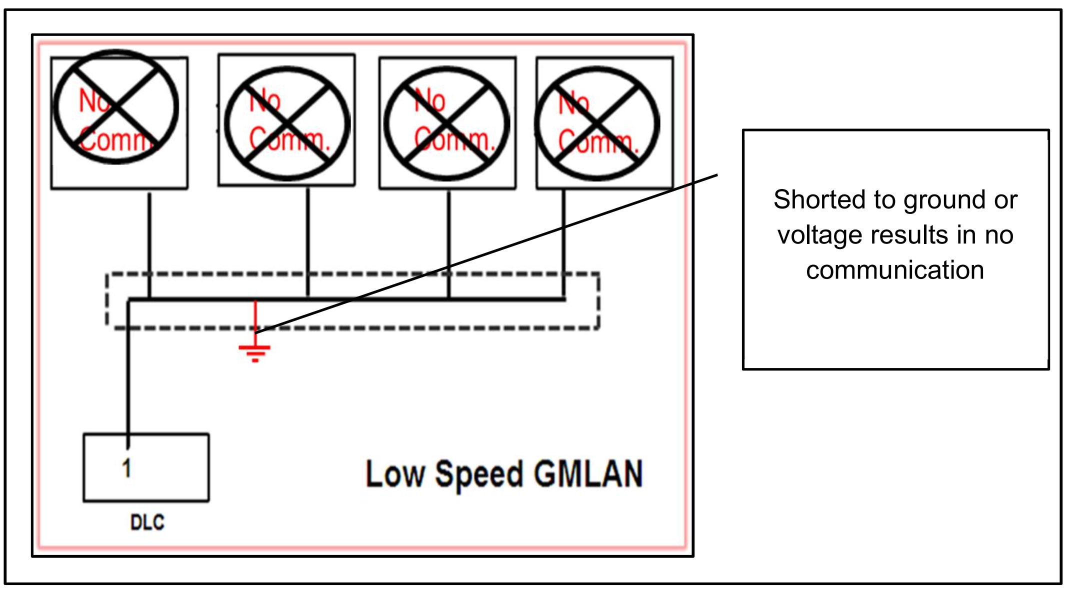


Figure 3-4, Example of Shorted to Ground

Single-Wire Data Circuit Testing – Oscilloscope

An oscilloscope provides a more detailed picture of the voltage signal on the network bus. The oscilloscope provides a higher sampling rate than the DMM, and displays the voltage signal graphically as a line trace on the screen.

Setting up the oscilloscope varies based on model. Use the following as basic guidelines for setting the oscilloscope:

1. Connect the channel probe to the serial data circuit (example: LS GMLAN = Pin 1 DLC).
2. Connect the channel ground to pin 4 or 5 of the DLC (ground reference).
3. Use terminal test probes, or a DLC break out box, to make connections.
4. Set the oscilloscope volts / division to 0.5 volt and time base to 50 milliseconds per division.
5. Check that the signal trace toggles from near 0 volts to approximately 5 volts in a LS GMLAN.

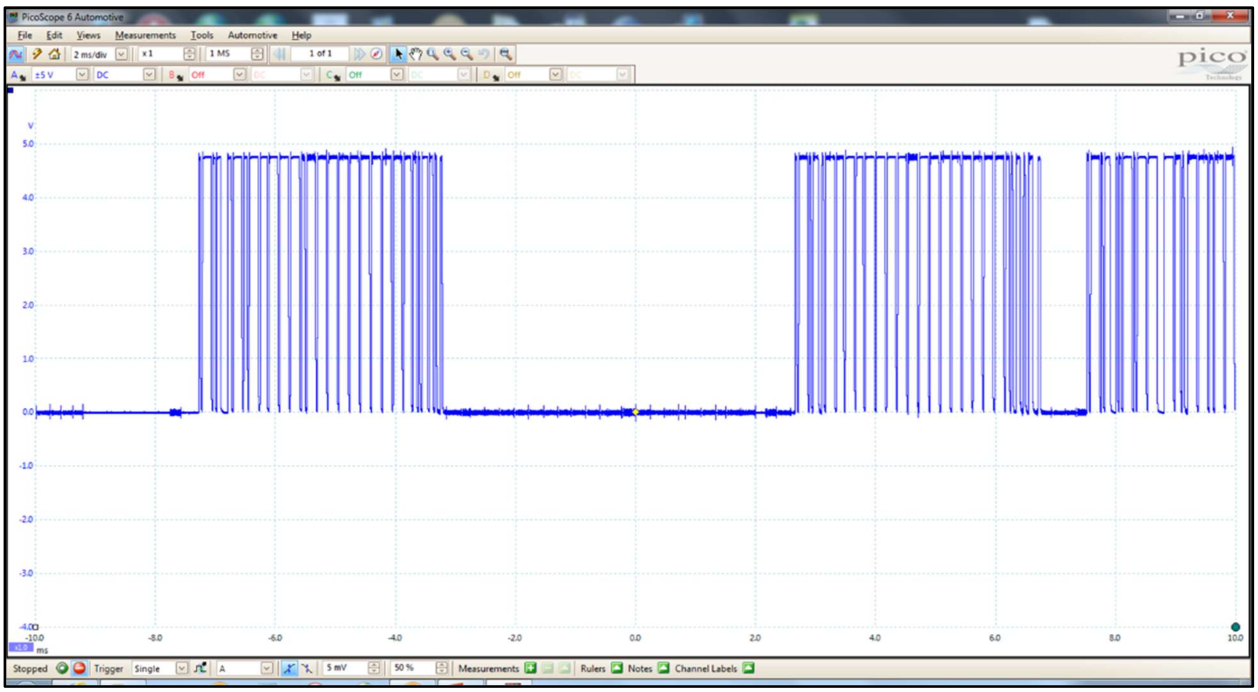


Figure 3-5, Oscilloscope – Single-Wire LS GMLAN Normal Activity

DUAL-WIRE SERIAL DATA CIRCUIT DIAGNOSIS

When faults occur on a dual-wire serial data circuit, loss of communication between control modules or to the scan tool can occur. There are several methods and tools to approach the diagnosis.

Dual-Wire Serial Data Circuit Testing – Digital Multimeter

As with the singe-wire LS GMLAN, the DMM can be used to check a dual-wire serial network. The testing principles are the same for other dual-wire serial data circuits. Voltage and resistance may vary between makes and models. Note that the GMLAN network is brought directly to the DLC. However, other vehicle manufacturers may have a diagnostic serial data circuit between the DLC and gateway module. So, in order to access the main networks, locate a splice pack / junction or test from a module connector. The manufacturer may also have published specific testing procedures for network communication issues, so be sure to refer to service information. It may prove useful to check various vehicles that come in the shop to get a baseline of normal readings from vehicles that are operating normally.

To check the circuit, place the key in the ON position, with the engine OFF. Use a DMM to check DC voltage between DLC pin 6 and ground, and then pin 14 and ground. The reading should be approximately 2.8 volts at pin 6, and approximately 2.2 volts at pin 14. If battery voltage is measured, there may be a short to voltage in that circuit. If the DMM measures 0 volts, there may be a short to ground in that circuit.

Next, with the battery disconnected, check resistance between pins 6 and 14 of the DLC. It should be about 60 ohms. If less than 60 ohms, check for a short between the wires. If more than 60 ohms, check for an open.

High Speed GMLAN Normal Operation

- DLC terminal 6 HS GMLAN (+) to ground: 2.5 to 3.5 volts and fluctuating
- DLC terminal 14 HS GMLAN (-) to ground: 1.5 to 2.5 volts and fluctuating
- Resistance between pins 6 and 14: approximately 60 ohms

Figure 3-6, Examples of DMM Showing Normal Voltage and Resistance

High Speed GMLAN Open

- Modules downstream of the open will not communicate with other modules
- Voltages at the DLC will be close to normal, unless the open is between the bus and the DLC
- If there is an open circuit, the resistance between pins 6 and 14 will be the resistance of one terminating resistor, as shown in Figure 3-7

Figure 3-7, DMM Showing Open Fault

High Speed GMLAN Short to Voltage or Ground

- Modules on the bus with the short will not communicate with other modules on that bus or the scan tool
- Voltage would be high if shorted to voltage
- Voltage would be low if shorted to ground
- Resistance across Pin 6 and Pin 14 would be low if the bus was shorted to ground

Figure 3-8, DMM Showing Short to Voltage

High Speed GMLAN Shorted Together

- Modules on the bus with the short will not communicate with other modules on that bus or the scan tool
- Voltage on pin 6 to ground, and from pin 14 to ground, will be the same
- Resistance across pins 6 and 14 will be low

Figure 3-9, Examples of DMM Showing Shorted Together Fault

Dual-Wire Serial Data Circuit Testing – Digital Storage Oscilloscope

Like DMM testing, the Digital Storage Oscilloscope (DSO) can also be used to perform electrical testing of vehicle networks. The benefit of the DSO is it provides a graphical representation of the network activity. The increased sampling rate can also help identify intermittent communication issues. Connecting the DSO to the network is similar to the DMM; however, the same probe ground reference is used for both channels. It may be necessary to experiment with the time base and voltage setting in the oscilloscope / software to get a good view of the network signal trace. As mentioned previously regarding DMM testing, it may prove useful to check various vehicles that come in the shop to capture a library of normal readings from vehicles that are operating correctly.

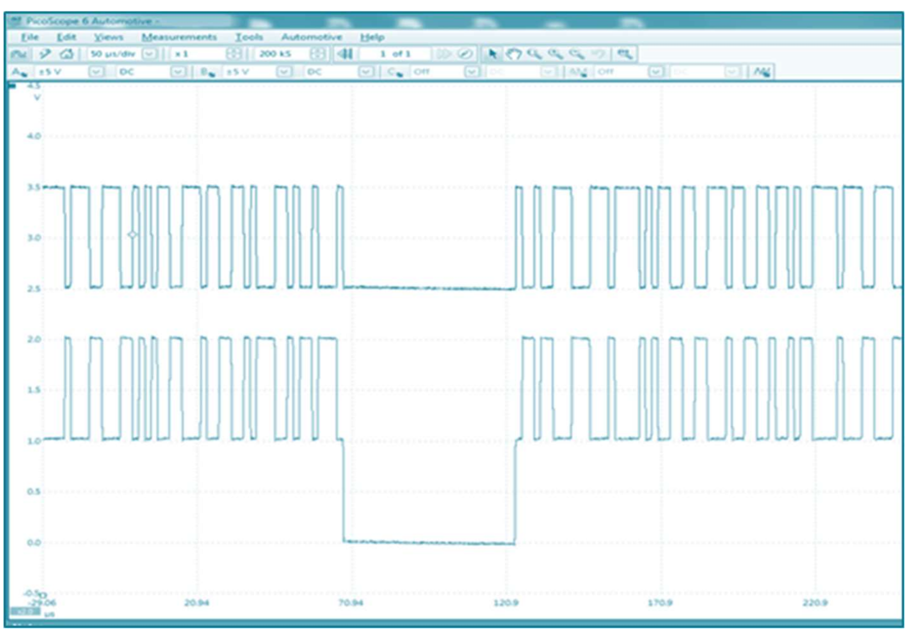


Figure 3-10, Oscilloscope Dual-Wire with Intermittent Short to Ground

DATA BUS DIAGNOSTIC TOOL

The Data Bus Diagnostic Tool is designed for use by technicians to specifically diagnose and repair data communications and connecting hardware systems. The information provided by the application can help identify a diagnostic starting point for a network fault.

Figure 3-11, Data Bus Diagnostic Tool Icon

A subscription to TIS2Web is needed in order to access the Data Bus Diagnostic Tool.

The Data Bus Diagnostic Tool becomes a smart module in the vehicle data communications network. It inquires how modules, connectors, and wires are working or not working. The Data Bus Diagnostic Tool, in conjunction with vehicle schematics, allows the technician to locate areas to investigate. It can:

- Determine what modules are on the serial data circuit, which will help locate an open / high resistance circuit fault
- Determine the physical serial data circuit's current state (OK, short to voltage, short to ground, open circuit condition, etc.)
- Provide a mechanism for passively monitoring low speed messages, which may help diagnose battery drain problems
- The vehicle data bus can be analyzed through the interactive use of the MDI, service information schematics, and vehicle control modules
- Use available features in the MDI through the DLC connector to verify data bus connections, verify if a fault is present, and attempt to identify (i.e. open, short, etc.)
- Identify a diagnostic starting point. Identify control modules that actively communicate and, in conjunction with vehicle schematics, identify control modules that are not communicating to define a starting point for repair
- Support all GM developed vehicles equipped with one or more serial data network

The Data Bus Diagnostic Tool does not diagnose individual sensors or vehicle components; it only analyzes serial data communication between vehicle control modules.

Installation

The Data Bus Diagnostic Tool installs when the GDS2 is launched from TIS2Web. See the GDS2 User Guide for Installation of GDS2. Click the icon to launch the tool.

Figure 3-12, TIS2Web

Data Circuit Selection

Upon selection of a Navigation Tab, Detected State, Measured Voltage, or Message Monitor, the Data Circuit Selection screen will open. The Data Circuit Selection screen (Figure 3-13) may also open when Start is selected if a circuit needs to be confirmed. The Data Circuit Selection screen shows the Data Circuits and DLC terminals that are active and available to analyze. The user may select multiple circuits from the available selections listed below:

- DLC terminal detection (single-wire) — this selection allows the technician to select a single-wire circuit in accordance with the DLC pin designation
- DLC terminal detection (two-wire) — this selection allows the technician to select a data bus circuit in accordance with the DLC pin designation
- Baud Rate (3) — when available, this selection sets the communication rate of serial data characters in correlation with vehicle capability
- Select the green check mark to enter selections

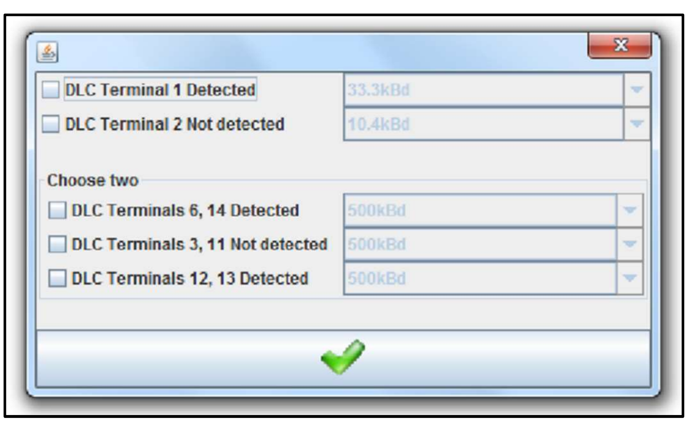


Figure 3-13, Data Circuit Selection Screen

Detected State

Detected states will be listed on the MDI 2 clearly (Figure 3-14). If the bus is determined to be working properly, OK will be clearly shown. Below the Detected State area, previous state conditions will be shown if previous tests were run during the current session.

There are eight detectable states that can result from a detected state test:

- OK
- Single-wire opens (for example, CAN (-) Open, CAN (+) Open)
- Double opens
- Single-wire shorts to power / ground
- Single-wire open / short (for example, the wire is broken and the far side is shorted)
- CAN (-) shorted to CAN (+)
- Ground offsets, for example, bad ECU grounds – The MDI 2 is able to determine which ECU(s) have a ground offset, if present
- Power faults, for example, open supply, blown fuse, broken enable line, etc.

The Responded column (2) indicates whether or not the module responded to the most recent request made by the Data Bus Diagnostic Tool. If a check mark is not present, the module has responded at some point in the test, but not to the most recent inquiry. If a green check mark appears, it indicates that the module has responded to the most recent request made by the Data Bus Diagnostic Tool.

MDI 2 functionality has enabled the Data Bus Diagnostic Tool to detect ground offset conditions with reliability. A ground offset is identified only when affected ECUs communicate. If the condition is recognized by the Data Bus Diagnostic Tool, the ground offset counter will add an increment to the Ground Offset Probability column. The count may increase slowly, providing evidence of the ECU with the highest probability of having a ground fault. Multiple ECUs may be present because they may share the same ground. The MDI does not have this capability. Currently, only the MDI 2 has this capability.

The Ground Offset Probability column is specific to the MDI 2. Detected Ground Offset increments will be displayed in this column. The numbers in the column will identify how many times the condition was recorded on the corresponding control module. If the Detected State is OK, the condition might be intermittent.

The Data Circuit column (4) indicates which circuit bus the control module (shown to the right) is on.

The Control Module column (5) displays the control module name. Modules will not be listed unless the module responds at least once. It is important to compare this list of control modules to the vehicle schematic to determine modules that are not responding.

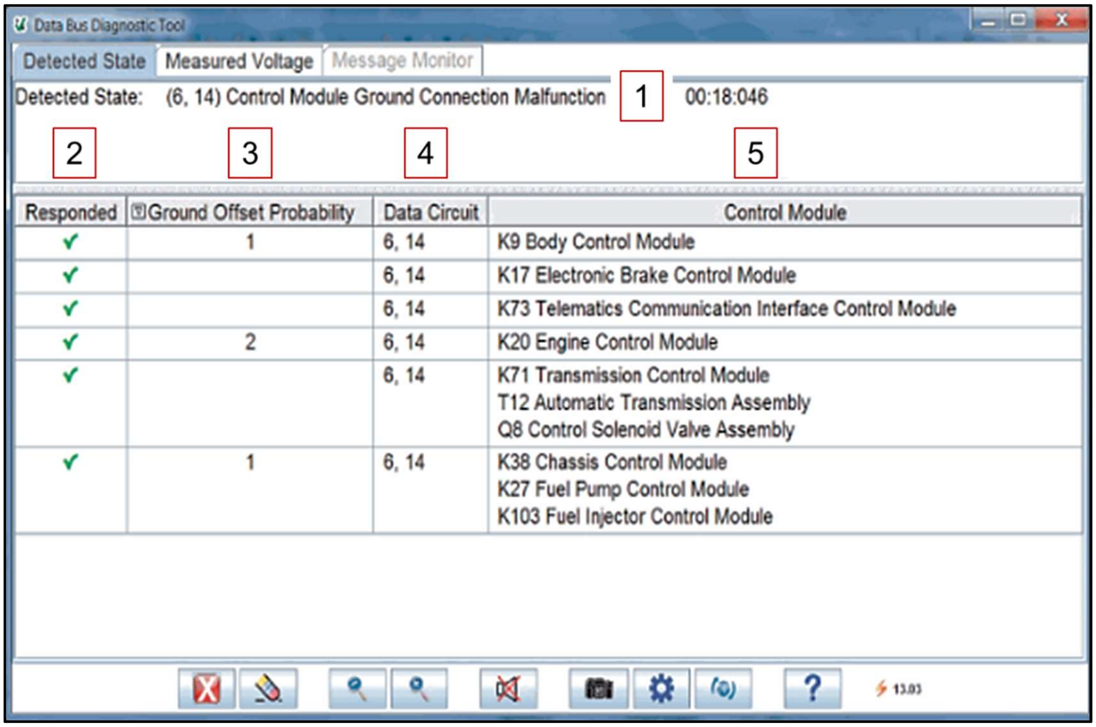


Figure 3-14, Detected State Tab

Localizing the Fault

Using the vehicle schematic from GM Service Information (SI), place a check mark on the modules corresponding to every module noted on the detected state test (Figure 3-15). Multiple data circuits may be tested at the same time. Refer to the Data Circuit column to identify to which data circuits the control modules belong. Take note of any modules that do not have a check mark. These are the modules that did not respond to recent inquires during the detected state procedure. Start by searching in the area on the vehicle after the last responding module on the tool and the first module not responding on the schematic. In many cases, the problem can be fixed by looking at the connectors and harness.

When attempting to locate a network fault, keep in mind that the Data Bus Diagnostic Tool application actively requests all possible diagnostic addresses to see what modules are on the bus. Modules that respond are on the good part of the bus, whereas modules that don't respond are on the bad part of the bus. The list of modules displayed in the application should be compared against that vehicle's network schematics. The application doesn't know what modules any vehicle is equipped with, so it can't report which modules are missing. Under a short to ground, no communication is possible, so no modules will be listed.

Please note the following tips:

- The localization of a fault is not possible if the bus is shorted (short to battery / ground, the speaker, a sensor wire, etc.), since no communication is possible. For hard short conditions, the technician may revert to a wiggle test
- Service information may identify the same module with a different name than the Data Bus Diagnostic Tool. As a result, all the names of possible components are provided on the Data Bus Diagnostic Tool. For example: Transmission Control Module, Automatic Transmission Assembly, and Control Solenoid Valve Assembly have a single check mark. Check the vehicle schematic to see which component of the three is present
- Compare vehicle Regular Production Option (RPO) tag to confirm modules not responding on the schematic are present RPO modules on the vehicle

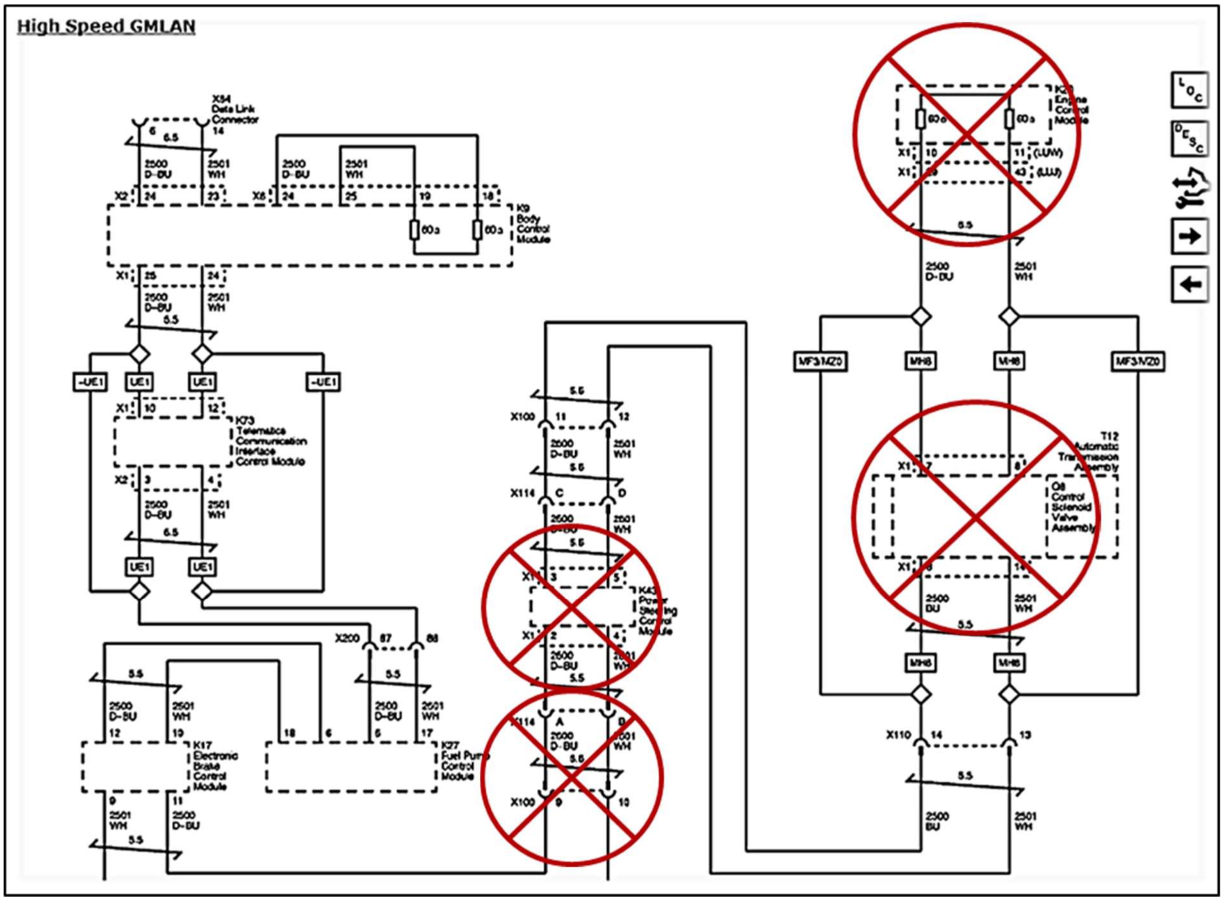


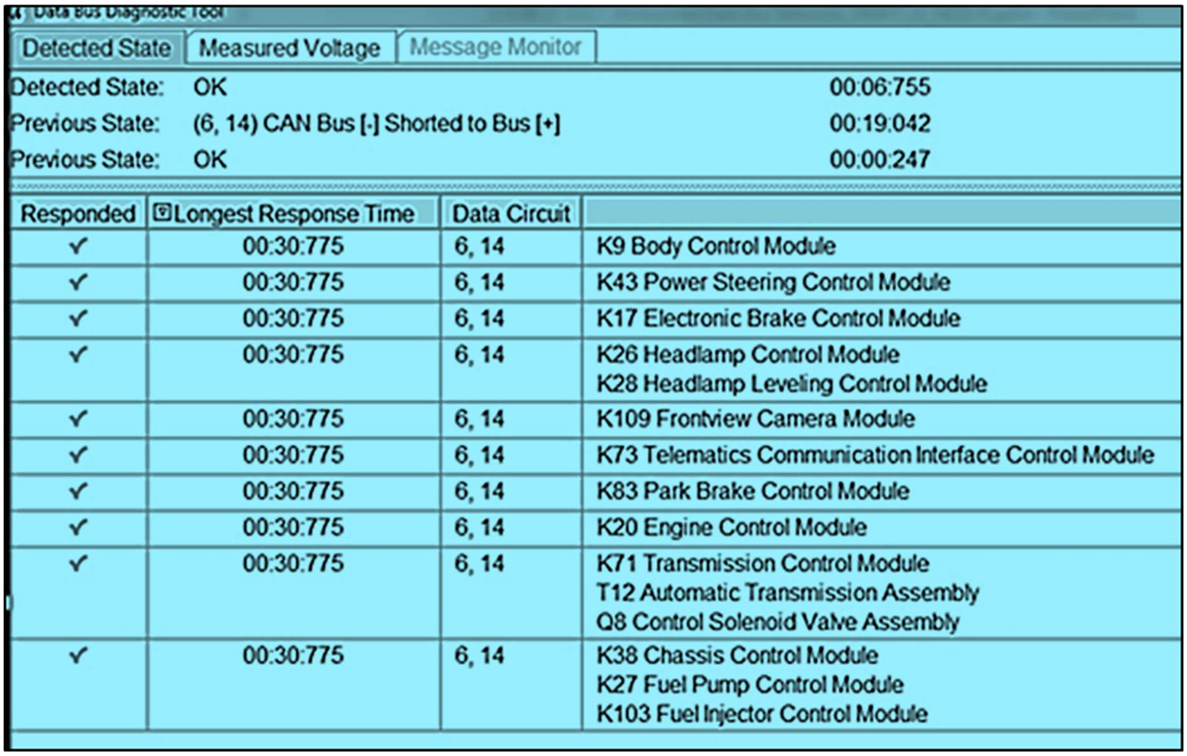
Figure 3-15, Network Schematic – Localizing Faults

Long Response Times

It is normal for some modules to briefly stop responding. For example, the BCM may stop responding intermittently. The BCM connects to both the LS GMLAN and HS GMLAN networks. The BCM primarily handles diagnostic requests, such as those sent by the Data Bus Diagnostic Tool and GDS 2 over HS GMLAN. By design, the BCM can handle diagnostic requests over low speed as well; however, other processes and LS GMLAN tasks take precedence over diagnostic requests. So it is normal for the BCM to ignore several diagnostic requests in a row before responding.

The application tracks the longest time it took for each control module to respond to a request. Control modules that took longer to respond than their peers are likely found on the faulted side of the bus. If the application is started on a faulted bus, and a module responds mid-way through the test, it will appear with a non-zero time value in this field. This number will not reset unless the reset (eraser) button is clicked, or the bus being tested is changed.

Some long response times are normal, particularly if there are no reported symptoms. Try viewing network activity on a like vehicle to determine if Data Bus Diagnostic Tool readings are normal for that particular vehicle and module.



Data Bus Diagnostic Tool

Detected State | Measured Voltage | Message Monitor

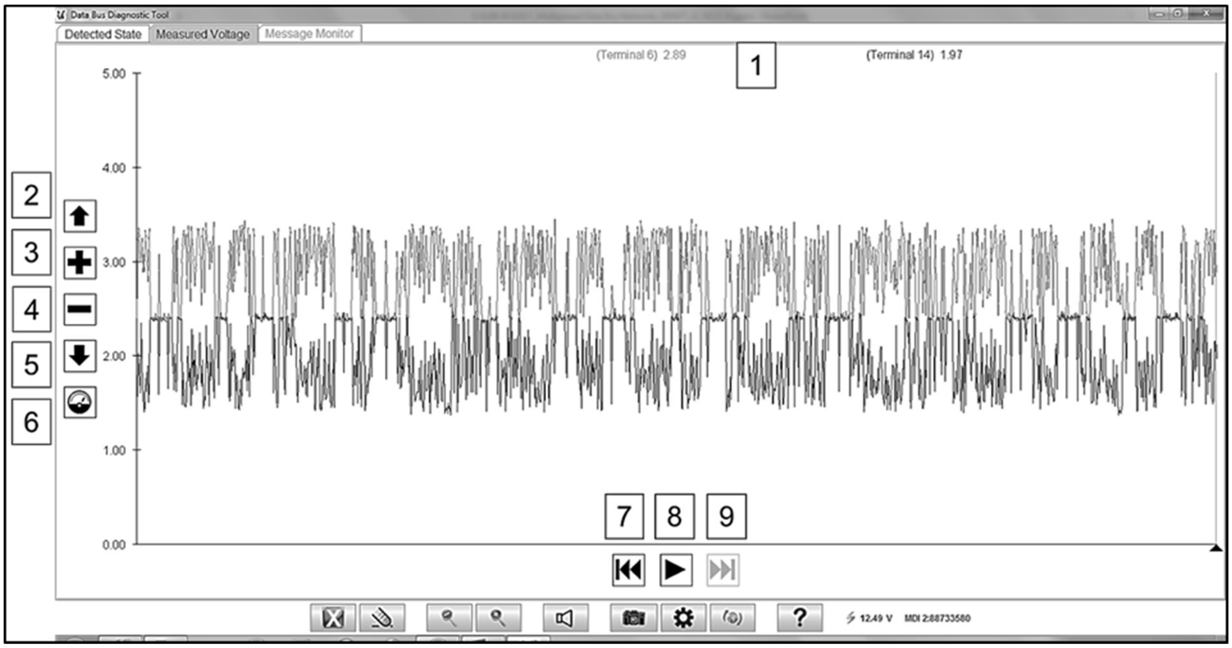
Detected State:	OK	00:06:755
Previous State:	(6, 14) CAN Bus [-] Shorted to Bus [+]	00:19:042
Previous State:	OK	00:00:247

Responded	Longest Response Time	Data Circuit	
✓	00:30:775	6, 14	K9 Body Control Module
✓	00:30:775	6, 14	K43 Power Steering Control Module
✓	00:30:775	6, 14	K17 Electronic Brake Control Module
✓	00:30:775	6, 14	K26 Headlamp Control Module K28 Headlamp Leveling Control Module
✓	00:30:775	6, 14	K109 Frontview Camera Module
✓	00:30:775	6, 14	K73 Telematics Communication Interface Control Module
✓	00:30:775	6, 14	K83 Park Brake Control Module
✓	00:30:775	6, 14	K20 Engine Control Module
✓	00:30:775	6, 14	K71 Transmission Control Module T12 Automatic Transmission Assembly Q8 Control Solenoid Valve Assembly
✓	00:30:775	6, 14	K38 Chassis Control Module K27 Fuel Pump Control Module K103 Fuel Injector Control Module

Figure 3-16, Long Response Times

Measured Voltage Tab

The Measured Voltage tab (Figure 3-17) provides a low frequency voltage trace, which measures voltage on two pins of a CAN bus. By recognizing the voltage trace range or signature of a good bus, a technician may identify a bad bus condition. The bad bus voltage trace signature may further be analyzed to identify a ground or a fault condition. The voltage trace may be analyzed by the technician to provide confirmation of output from the Detected State tab. Voltage patterns will vary between MDI and MDI 2 due to the increased capabilities of the MDI 2. The legend and graphic in Figure 3-17 detail the functions available on the tab.



1. Current values for the terminals being tested.
2. Up arrows move up the graph.
3. The plus sign zooms in the graph.
4. The minus sign zooms out the graph.
5. The down arrow moves the graph down.
6. The gauge displays the maximum, minimum, current, and average over the last 20 samples.
7. The step backward button allows the user to view backward recorded data.
8. The pause button pauses the data.
9. The step forward button allows the user to view forward recording data.

Figure 3-17, Measured Voltage Tab

Controller Area Network Voltages

The primary use of the Measured Voltage tab is to provide the technician with the ability to view low frequency voltage trace data. Identifying faults is difficult using Measured Voltage. Noting regular or irregular voltage patterns helps to determine whether or not a bus condition is regular or irregular. Voltage patterns that are normal will vary from vehicle to vehicle. Faulted voltage patterns generally have a more irregular pattern. Become familiar with voltage patterns, and use the examples provided here for future reference.

To perform the measured voltage test, follow these steps:

1. Turn the vehicle ignition key ON.
2. Select the Measured Voltage tab on the Data Bus Diagnostic Tool.
3. Select a data circuit.
4. Select the green Stop-Start selection icon to begin the test.
5. View the Measured Voltage Graph, and examine the CAN (+) in red and the CAN (-) in blue for inconsistencies.
6. Select the red Stop-Start with the X to stop the test.

Some characteristics of a good bus are:

- Not much overlap between CAN (-) and CAN (+)
- CAN (+) lies roughly between 2500 mV and 3000 mV
- CAN (-) lies roughly between 1900 mV and 2500 mV

Note: These are not exact numbers.

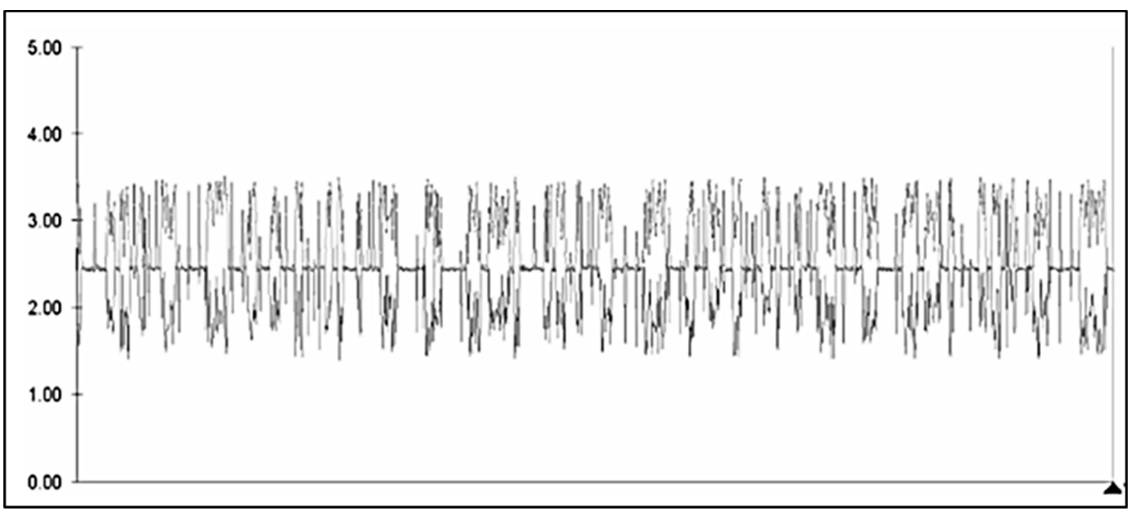


Figure 3-18, Good Bus Frequency Using an MDI 2

Power Fault vs Normal vs Ground Fault

Figure 3-19 shows a comparison of a module power fault and ground fault to normal network voltages. When a module loses B+, the network voltages tend to drift lower (negative offset), whereas when a module loses its ground, the network voltages tend to drift higher (positive offset).

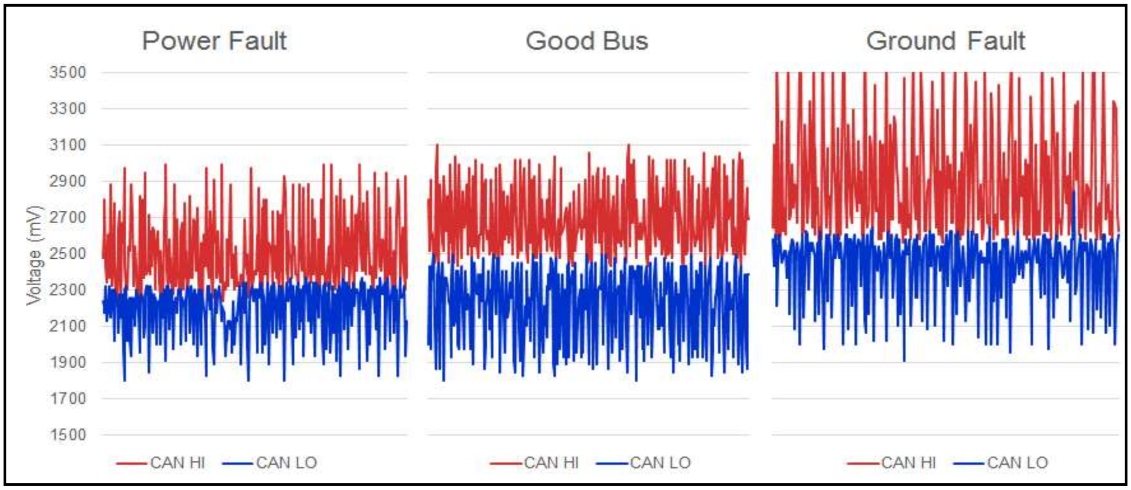


Figure 3-19, Comparison of Module Power Fault, Good Bus, and Ground Fault

CAN (-) Open vs Normal vs CAN (+) Open

When there is an open in either the high or low side of the network, there will be larger swings in the voltage's noise.

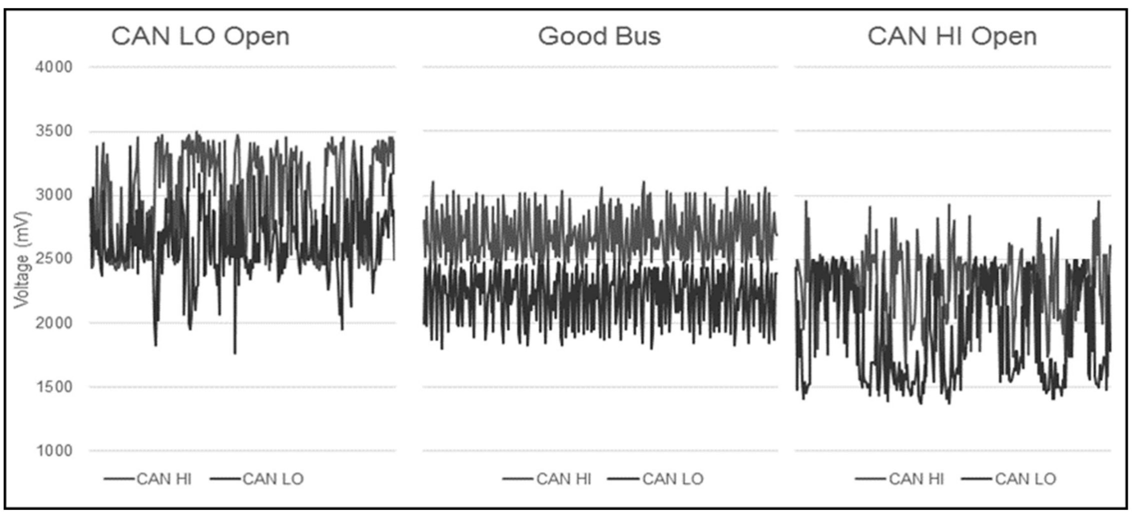


Figure 3-20, Comparison of CAN (-) Open, Good Bus, and CAN (+) Open

The Impact of Location

The distance of the fault from the DLC will impact the voltage signal. The further from the DLC the fault is the less voltage offset is observed in the pattern. This is due to the dampening effects of the modules between the fault and the DLC.

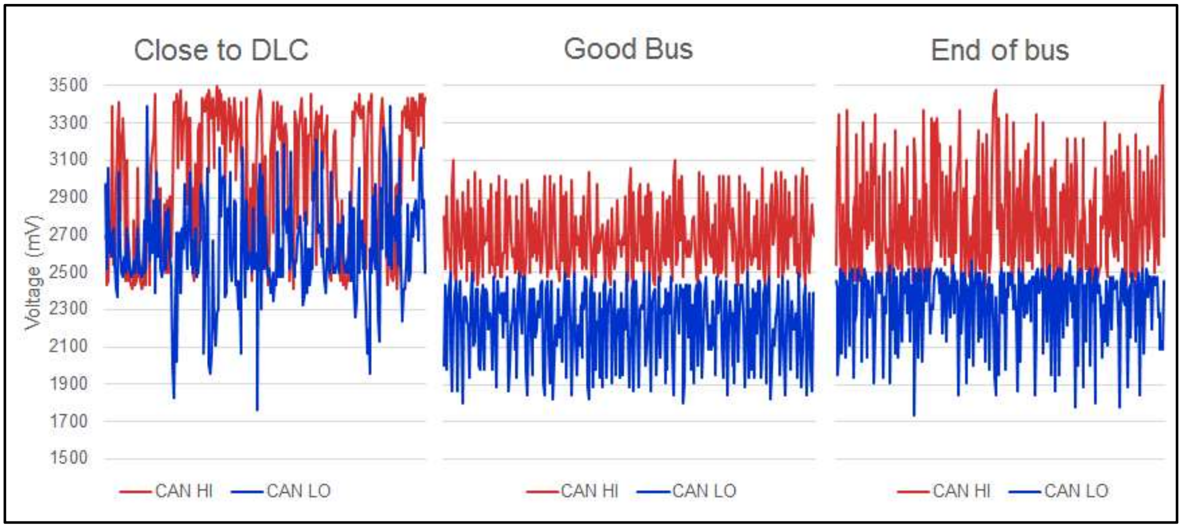


Figure 3-21, Fault Comparison

Message Monitor Tab

The Message Monitor tab is designed to diagnose battery voltage drain conditions. The Message Monitor tab passively monitors serial data circuits and displays information concerning which control modules are awake. This is different than the Detected State tab, which actively inquires of control modules on the bus. The data circuit must be designated DLC Terminal 1 (single-wire) to use the Message Monitor tab.

The Message Monitor tab works when the vehicle is in OFF mode. It may be required to run the test for a few minutes, an extended period of time, or it may be required to run overnight to simulate customer conditions. For this test to be valid, the vehicle needs to remain undisturbed (no doors opened, etc.). The Message Monitor tab will document control modules that have communicated during the test, the module idle time, and how many times the noted control module became active.

The key elements of the Message Monitor tab (Figure 3-22) are:

- Communicating (1) — If a green check mark is present in the Communicating column, this means the noted control modules have actively communicated in the past 1.5 seconds
- Idle Time (2) — Displays how long it has been since the control module's most recent communication, if more than 1.5 seconds have elapsed since that control module's last message
- First Active (3) — Counts the number of times each module was the first to communicate. The vehicle will go to sleep after 30 seconds under normal operating conditions; if the same control module awakens the vehicle again, the count will be 2. If a different module is the first to awake the vehicle, it will start with a count of 1
- Control Module (4) — Shows the corresponding control module's name

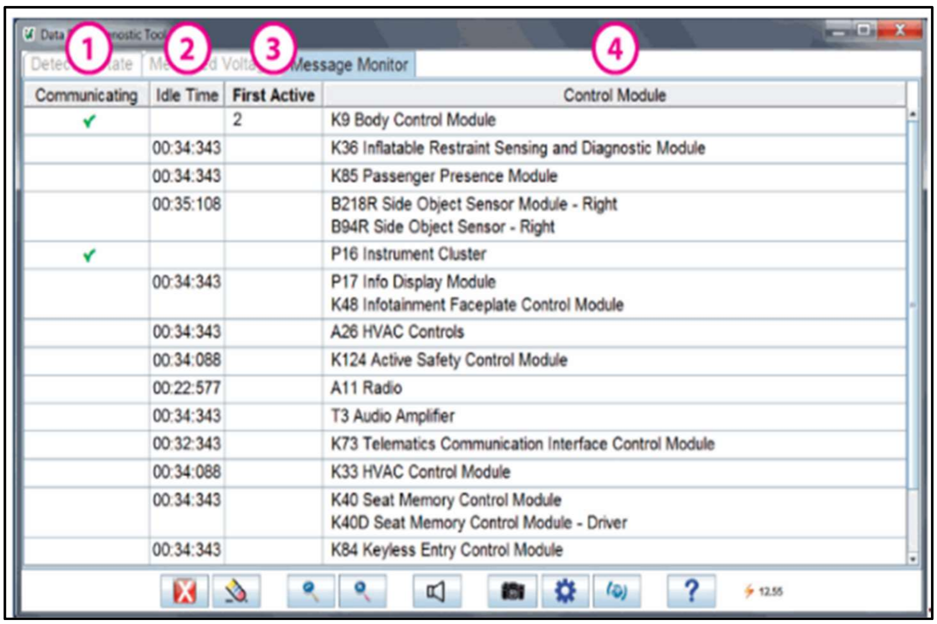


Figure 3-22, Message Monitor Tab

The Message Monitor provides a diagnostic starting point. It does not directly identify the cause of the concern.

To begin the test:

1. Ensure the ignition is in the OFF position.
2. Select the Message Monitor tab.
3. The Data Circuit Selection screen will open with the selection of the Message Monitor tab.
4. Select Data Circuit DLC Terminal 1 Detected (single-wire) only.
5. Select the Green Stop-Start selection with the Start icon on it.
6. Allow the vehicle to sit undisturbed for a predetermined amount of time.
7. When complete, select the Red Stop-Start selection with the X on it.
8. Analyze the data.

Intermittent Faults – Wiggle Test

When diagnosing intermittent network faults, concentrate on the Longest Response Time column, which tracks the amount of time it takes for a module to respond to a request. Once the suspect control modules have been identified, wiggling the suspect harness can help detect loose and poorly seated connector terminals, bad wire crimps, insulation problems, etc.

By selecting the settings function, an audio beep can be programmed to beep continuously when a fault is detected, or when the bus appears electrically okay. The application reacts rapidly to bus changes. To activate the beep function, follow these steps:

1. Unmute the PC speakers, and adjust the volume so the beeps are audible.
2. Confirm the Data Bus Diagnostic tool is not set on mute. See the speaker icon at the bottom of the Data Bus Diagnostic Tool screen.
3. Click on the Settings icon at the bottom of the Data Bus Diagnostic Tool page.
4. Select Beep on OK or Beep on Faults.
5. Set a Trigger Threshold Voltage, if needed. This will sound a beep when the measured voltage crosses the determined threshold range:
    - Select trigger
    - Enter a threshold voltage

There are two different beep strategies. If there is a continual faulted bus present, select Beep on OK so the application will beep when the bus is working properly. If a suspected bus fault may be present, select Beep on Faults so the application will beep when the fault presents itself.

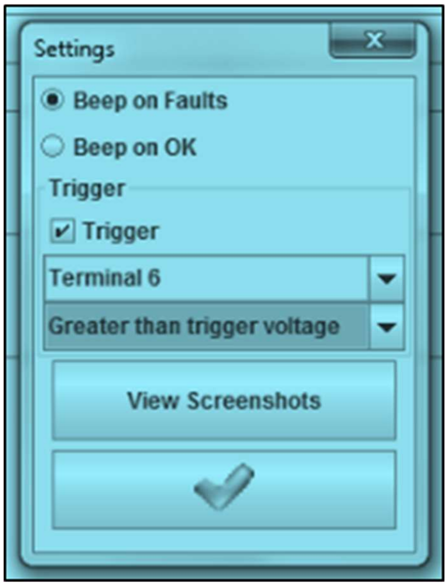


Figure 3-23, Setting Beep on Faults

DIAGNOSING AN OPTICAL MEDIA ORIENTED SYSTEMS TRANSPORT SYSTEM

When the flow of data in the MOST® bus is interrupted, it is called a ring break because of the network's ring topology. Causes of a ring break can include:

- A break in one of the optical fiber cables
- A voltage supply fault of the transmitting or receiving control module
- A malfunctioning transmitting or receiving control module

The symptoms of a ring break are:

- No sound or video
- No response from system controls
- DTC logged in the diagnosis manager for optical data bus interruption

Perform a ring break diagnostic to diagnose an inoperative MOST® network. The ring break diagnosis is a routine or test initiated by the diagnosis manager module using a scan tool. After the ring break diagnosis is started, the diagnosis manager will pull the diagnosis wire voltage low to notify the control modules to begin the ring break diagnostic. In response to this signal, all the control modules on the bus use their optic fiber transceivers to transmit light signals through the optical fiber cable. The control modules will check the following simultaneously:

- Module voltage supply and internal electrical functions
- Reception of the light signal from the preceding control module in the ring

Each control module of the MOST® bus will respond according to software programmed timing. Based on the time between the start of the ring break diagnosis and receipt of the answer, the diagnosis manager establishes which control module sent the answer. The control modules respond with two messages after the start of the ring break diagnosis:

- Control module is electrically OK indicating that the electrical function of the control module and voltage supply are okay
- Control module is optically OK indicates that the control module received the light signal from the preceding module in the ring

From this information, the diagnosis manager can determine:

- The presence of an electrical fault
- The presence of an optical data interruption and localization

A network interruption can be determined by using a wiring schematic to identify the installed order of the control modules, then noting the last control module to respond electrically and optically ok. The interruption will be after that module, and will be either in the optical fiber itself, or in the transmitter of the last module or receiver of the following module. Disconnect the optical fiber from the first non-responding module, and look at the end face of the fiber for a blinking red light. If there is no light, the optic fiber is either damaged or the transmitter of the previous module is inoperative.

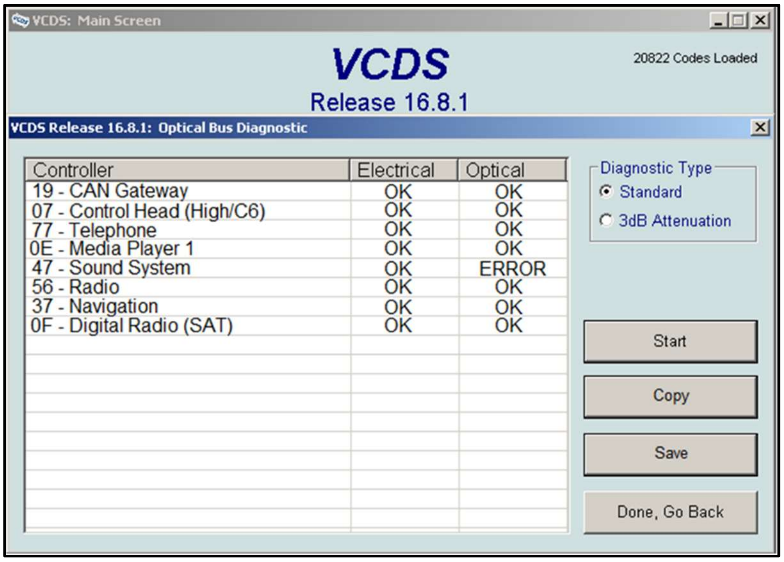


Figure 3-24, Optical Ring Break Test

An optical fiber loop tool can be used to substitute the suspected module. The loop tool allows the light signal to bypass the module, thereby verifying whether or not the problem is the module. Ring tools are available from OEM and aftermarket sources.

Figure 3-25, Optical Fiber Loop Tool

The ring break diagnosis process can only identify a complete interruption of the optical fiber. The diagnosis manager can also perform a ring break diagnosis with reduced light output to identify a reduction in the light transmission ability through the optical fiber cable known as increased attenuation. The ring break diagnosis with reduced output is nearly identical to the standard ring break; however, the control module transmitters output only half of their normal light output (3dB). If the optical fiber has increased attenuation, and the light signal is too faint as it reaches the receiver, the receiving module will then report optics not ok. These reduced optic failures are usually caused by kinked or damaged fiber, or loose, dirty, or damaged optical fiber connections.

DIAGNOSING A HARDWIRED MEDIA ORIENTED SYSTEMS TRANSPORT SYSTEM

Just like in an optical MOST® system, when the flow of data in a hardwired MOST® system is interrupted, it is called a ring break because of the network's ring topology.

Causes of a ring break include:

- An open / short in one of the twisted pair data wires
- A voltage supply fault of the transmitting or receiving control module
- A malfunctioning transmitting or receiving control module

The symptoms of a ring break are:

- No sound or video
- No response from system controls
- DTC U0028 logged in the diagnosis manager (radio)

The diagnosis of the MOST® 50 or hardwired MOST® system used in GM vehicles is as follows. The MOST® initialization consists of a short 100 millisecond low voltage pulse on the electronic control line connected to all devices contained on the MOST® ring. When the MOST® devices receive this wake up message, they will respond with a generic device response. Once these initial responses on the MOST® bus are reported successfully without error to the radio, the next responses will report the MOST® device addresses, their functionality requirements, and capabilities within. The radio will learn this information and also record the address node sequence on the MOST® bus at this point. This node address list will now be stored within the radio as the MOST® bus configuration (called Last Working MOST® ID of Node 1-9 on the scan tool data display.

Data List: Radio Data

Parameter Name	Control Mo...	Value
Rear USB Receptacle	Radio	Not Present
Front SD Card Receptacle	Radio	Not Present
Rear SD Card Receptacle	Radio	Not Present
Radio Theft Lock Armed	Radio	Armed
Radio Theft Lock Status	Radio	Inactive
Test Bench Mode	Radio	Inactive
Valet Mode Status	Radio	Inactive
XM Subscription Status	Radio	Invalid
High Definition Signal	Radio	Not Present
Digital Audio Signal	Radio	Not Present
Alternative Frequency Status	Radio	Inactive
Surrogate MOST Master Node Upstream Position	Radio	None
Number of MOST Communication Breaks	Radio	4
Last Working MOST ID of Node 1	Radio	Radio
Last Working MOST ID of Node 2	Radio	Amplifier
Last Working MOST ID of Node 3	Radio	Instrument Cluster
Last Working MOST ID of Node 4	Radio	Human Machine Interface ...
Last Working MOST ID of Node 5	Radio	UNRECOGNIZED STATE
Last Working MOST ID of Node 6	Radio	UNRECOGNIZED STATE
Last Working MOST ID of Node 7	Radio	UNRECOGNIZED STATE

Figure 3-26, MOST® 50 Scan Tool Data Parameters

When MOST® receive, transmit, or control line faults are detected, transmit / receive messages will not be received as expected from the wake up request. The radio and the Human Machine Interface (HMI) control module will then perform diagnostics to isolate these MOST® faults. If the MOST® control line is shorted low to 0 volts for excess amount of time, the radio will set a U2098 DTC, and HMI control module will set a U0029 02 DTC. At this point, the MOST® bus will be unable to communicate until the shorted MOST® control line is repaired.

Once the shorted MOST® control line diagnostics pass, the radio will attempt to resend the initial short pulse attempts up to three times on the MOST® control line. If the expired responses are not received, the radio continues into a failure mode, setting a U0028 DTC, and will continue to send 300 millisecond long pulses while DTC U0028 is current. This will enable the furthest upstream transmitting device to become the surrogate MOST® master in this MOST® fault / diagnostic mode.

DTC Display

Control Module	DTC	Symptom Byte	Description	Symptom Description	Status
Radio	U0028	00	MOST Bus	- - -	Current

Figure 3-27, U0028 Diagnostic Trouble Code

When the radio receives this new MOST® master identity, the surrogate MOST® master device can be identified based on scan tool data parameter, “Surrogate MOST® Master Node Upstream Position.” The scan tool and schematics will be used to determine the MOST® bus configuration and direction by utilizing the “Last Working MOST® ID of Node 1-9” parameters from the radio data display. When a fault is present, it will indicate the newly enabled “Surrogate MOST® Master Node Upstream Position” to the radio. This will assist in determining the location of the MOST® device / bus / control fault. The MOST® device and circuits upstream from the surrogate MOST® master device transmit, receive, or control lines will be the suspect areas for diagnostics. These faults can be associated with any of the MOST® transmit, receive, or control line twisted copper wires, or possibly an internal device fault.

DTC U0028 will take approximately 10 seconds for diagnostics to set in the radio with an active fault condition. With the latest software, the radio will report the surrogate MOST® Master Node Upstream Positon value when DTC U0028 is stored in history. When there is no MOST® bus fault, this value is None. The U0028 DTC state and the “Number of MOST® Communication Breaks” parameter must be used with the “Surrogate MOST® Master Mode Upstream Position parameter for a successful diagnosis. This is used to help capture surrogate information on intermittent fault conditions. The “Number of MOST® Communication Breaks” counter will increase each time the MOST® bus state transitions from Normal Operation (Lock Status) to Off State (Unlock status), and will accumulate from 0 to 65,535 failures. After the “Number of MOST® Communication Breaks” counter increments 10 times, DTC U0028 will be set. It is important to clear DTC U0028 and reset the Surrogate MOST® Master Node Upstream Position value to None after a successful repair. The Surrogate MOST® Master Node Upstream Position value can be reset to None by disconnecting the radio power, disconnecting the battery cables, or 50 ignition power down cycles. This will also reset the Number of MOST® Communication Breaks counter to 0.

The HMI control module will set a U0029 00 DTC when it diagnoses a MOST® bus not communicating properly after one attempt. When the DTC U0029 00 is set by the HMI control module without the corresponding DTC U0028 from the radio, it will be an indication of an intermittent wiring / device condition.

Surrogate Media Oriented Systems Transport Master

When diagnosing a MOST® network ring break, there are two ways to locate the break:

- Use the Surrogate MOST® Master Node Upstream Position parameter, or surrogate parameter for short
- Use the MOST® bus diagnostic starting point function of GDS 2

Some of the MOST® parameters in the radio data display are:

- The surrogate parameter is used to count out the position of the surrogate
- The Last Working MOST® ID of Node parameters indicate the position of the modules in the network ring
- Use the number displayed in the surrogate parameter to count the positions upstream of the radio. If the surrogate parameter is 4, count four positions upstream of the radio, starting with the last device listed

Radio Data		
Surrogate MOST Master Node Upstream Position	Radio	4
Last Working MOST ID of Node 1	Radio	Radio
Last Working MOST ID of Node 2	Radio	HMI Module
Last Working MOST ID of Node 3	Radio	Instrument Cluster
Last Working MOST ID of Node 4	Radio	Amplifier
Last Working MOST ID of Node 5	Radio	CD Player

Figure 3-28, Radio Data

- Figure 3-29 shows an example where the HMI control module will be the surrogate MOST® master

- It is important to note that the words, “UNSPECIFIED STATE” are displayed when optional devices are not installed. Do not count “UNSPECIFIED STATE” when counting out a surrogate position

- After locating the surrogate, bypass modules to find the cause of the ring break

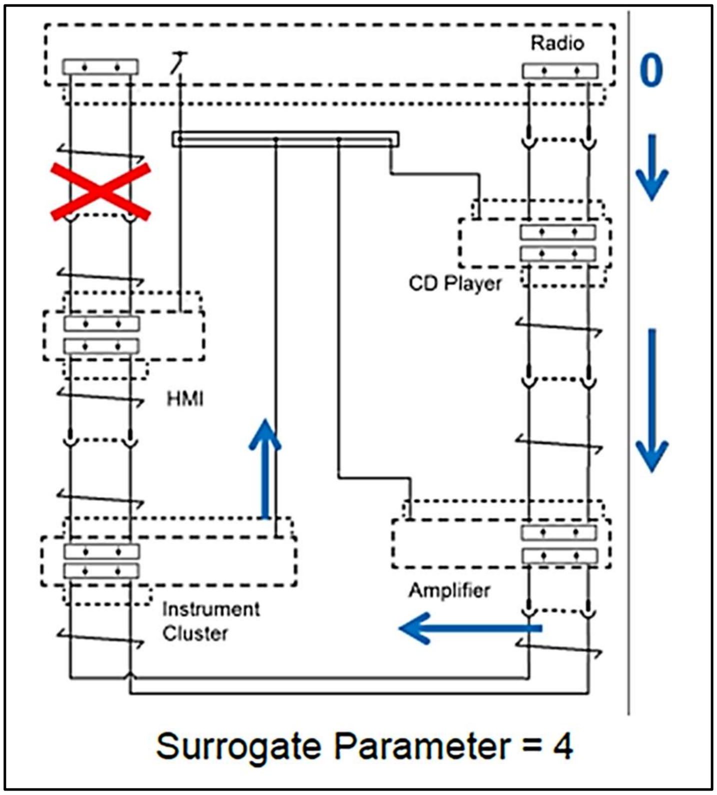


Figure 3-29, Ring Break Localization

Media Oriented Systems Transport Bus Diagnostic Starting Point

A feature in GDS 2 is the MOST® Bus Diagnostic Starting Point, located in the control functions menu of the radio. It provides the following information:

- The number of MOST® bus nodes equals the total number of modules on the MOST® network
- Node locations of MOST® communication break displays a range where the break occurs
- Last working MOST® ID of node identifies which modules and wiring need concentration in order to find the cause of the ring break

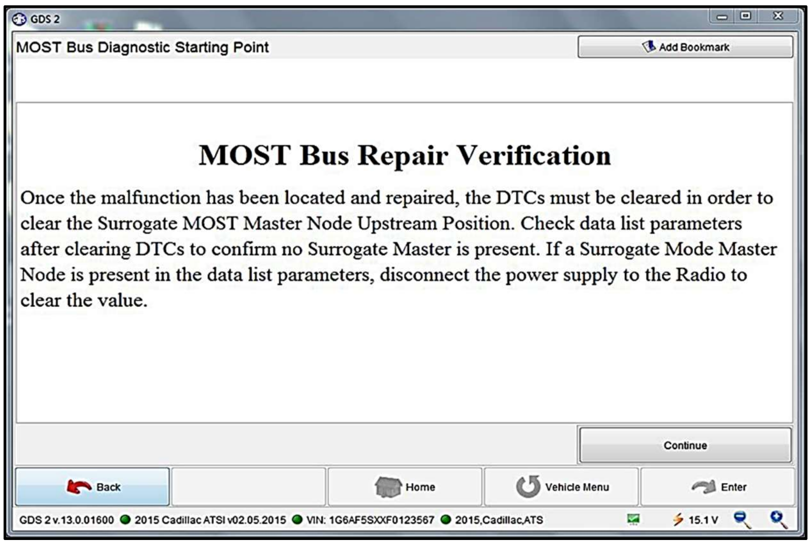


Figure 3-30, MOST® Bus Diagnostic Starting Point

Media Oriented Systems Transport Diagnostic Tool Kit

The MOST® Bus Diagnostic Tool Kit (EL-51578) consists of several test connectors that are connected in place of a module on the MOST® network. A test lead on each test connector provides an easy way to connect a DMM to check the MOST® control circuit voltage. As infotainment options are added to new vehicles, new test connectors may be added to the tool kit. The tool will help diagnose any of the following MOST® bus concerns and / or radio DTC U0028 00:

- Blank radio display
- Steering wheel controls inoperative
- DIC audio information page blank
- Audio inoperative with normal chime operation
- Radio controls inoperative

The diagnostic information below may be helpful if any of these concerns are encountered:

- Always perform Diagnostic System Check prior to diagnosing a radio U0028 00. If a MOST® bus module has a circuit or terminal fault, (power, ground, GMLAN / ECL wake up), this would be the probable cause of the radio U0028 00

- The EL-51589 MOST® Bus Diagnostic Tool Kit has to be released to aid in diagnosing MOST® bus concerns. The kit contains header connectors that are installed to bypass MOST® bus modules. The bypass connectors also contain a terminal for verifying ECL voltages (MOST® control circuit). The kit does not contain a bypass for the radio, which is the master of the bus

- The Radio U0028 00 will be used to determine MOST® bus state of health. If the module with the concern is bypassed, the Radio U0028 00 will report as history. Infotainment functions will return, with the exception of what the bypassed module controls. For example, if the amplifier is bypassed, and the DTC U0028 00 changes from current to history, ignore the symptom of no audio as the amplifier is bypassed. Other examples are that the display will be inoperative with HMI bypassed, and the DIC and steering wheel controls are inoperable with IPC bypassed

- Usually, there are one or two modules suspected with a current radio U0028 00 set, depending on which node positions are listed. If both of these suspect modules are bypassed, and the radio U0028 00 stays current, check the MOST® bus circuits and ECL for opens, shorts, high resistance, or terminal concerns

DIAGNOSTIC TECHNIQUES FOR GATEWAY EQUIPPED VEHICLES

Diagnosing communication network faults on busses isolated by the gateway module require a slightly different method of testing. Since the isolated bus, either dual-wire or single-wire, does not terminate at the DLC, the standard approach of testing from the DLC will not work. The gateway, along with the other module, will typically set DTCs for loss of communication with modules on the isolated bus. Attempt to communicate with each module on the isolated bus, and determine if it is just one or more, or all modules that are not communicating.

If only one device is not communicating, check the module’s ground, B+, ignition, and isolated serial data circuit terminals. If one or more devices are communicating, but not all, check the isolated serial data circuit for an open / high resistance. This does not apply to the gateway module. If none of the devices, except for the gateway module, are communicating, check the isolated serial data circuit for a shorted condition. To access the isolated serial data circuits, follow these steps:

1. Disconnect the connector to an easily accessed module on that isolated bus.

2. Review the vehicle schematic to determine which modules are on the isolated bus, to locate which modules have the terminating resistance, and how the serial data circuits are connected.

Resistance measurements may vary if the module that has been disconnected has a terminating resistor. Some isolated networks have more than one terminating resistor.

Each device may need to be disconnected in order to isolate a circuit fault. Use the schematic to identify the following:

- The gateway isolated HS GMLAN devices and terminating resistors
- The device locations on the gateway isolated HS GMLAN serial data circuits
- Each device's ground, B+, ignition, and gateway isolated HS GMLAN serial data circuit terminals

Some devices with an internal terminating resistor have a loop in the harness, which connects the internal resistor to the serial data circuit. When wired this way, test these loop circuits for the appropriate failure mode: short to voltage, short to ground, or open / high resistance, prior to replacing the device.

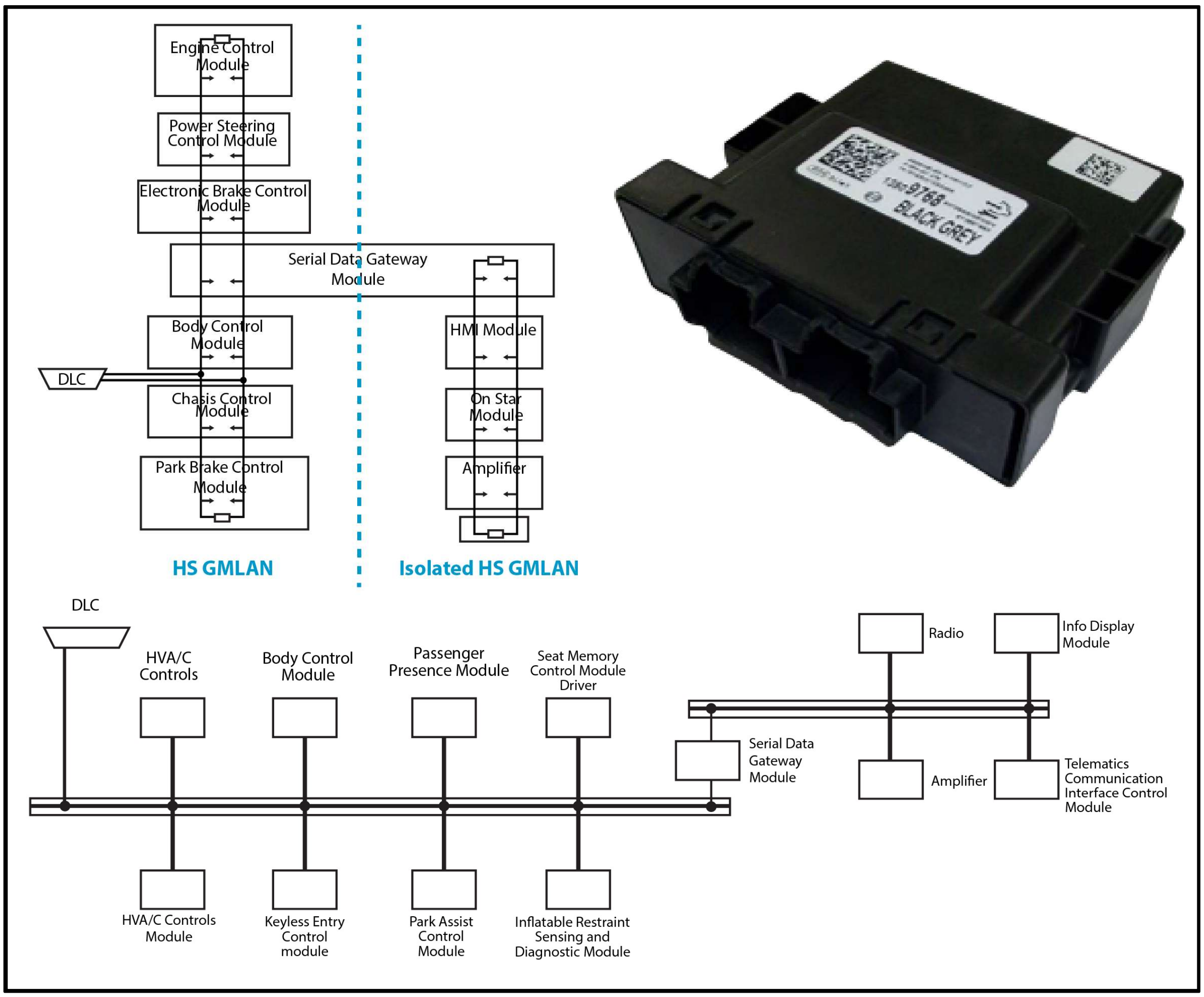


Figure 3-31, Serial Data Gateway Module and Secured Network

SERVICE AND REPAIR

REPAIR PROCEDURES FOR TERMINALS AND CONNECTORS

If the individual terminals are damaged on any GMLAN connection, use the appropriate connector repair procedure in order to repair the terminal. Knowing the connector manufacturer is helpful when trying to locate the correct connector repair procedure in GM Service Information. There are many different connector designs used by OEMs. When trying to determine the manufacturer of a connector, look for identifying marks that are unique to that connector supplier.

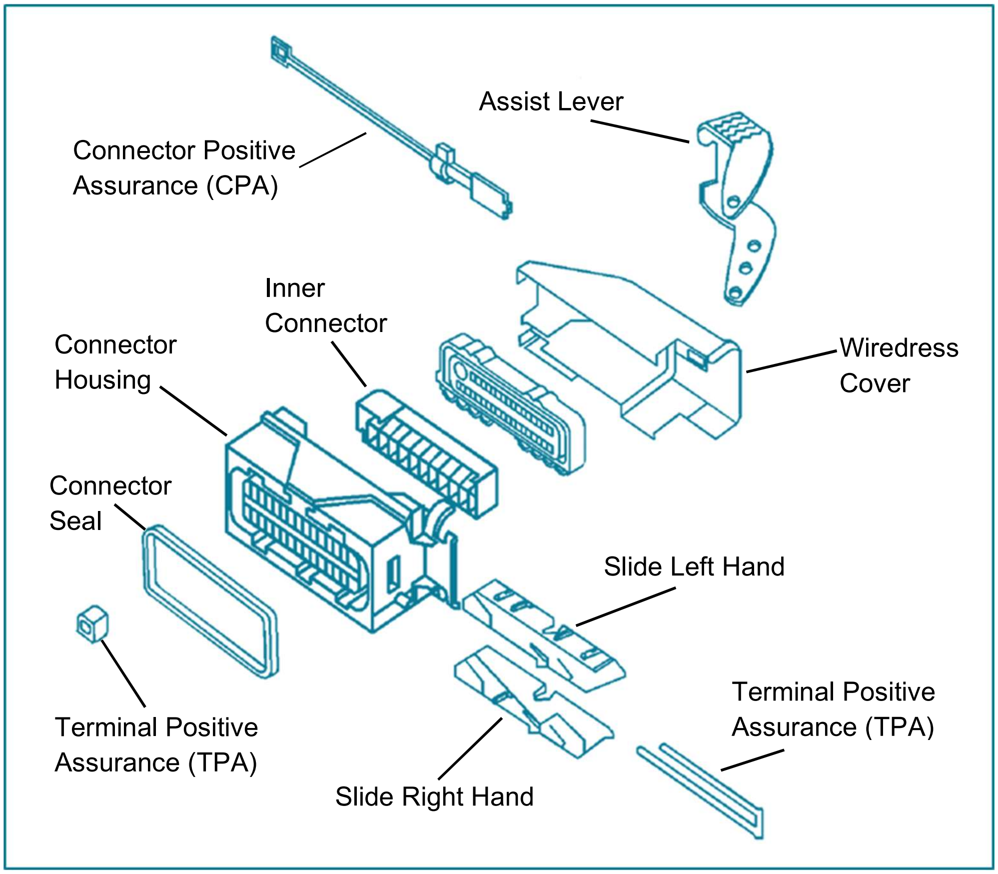
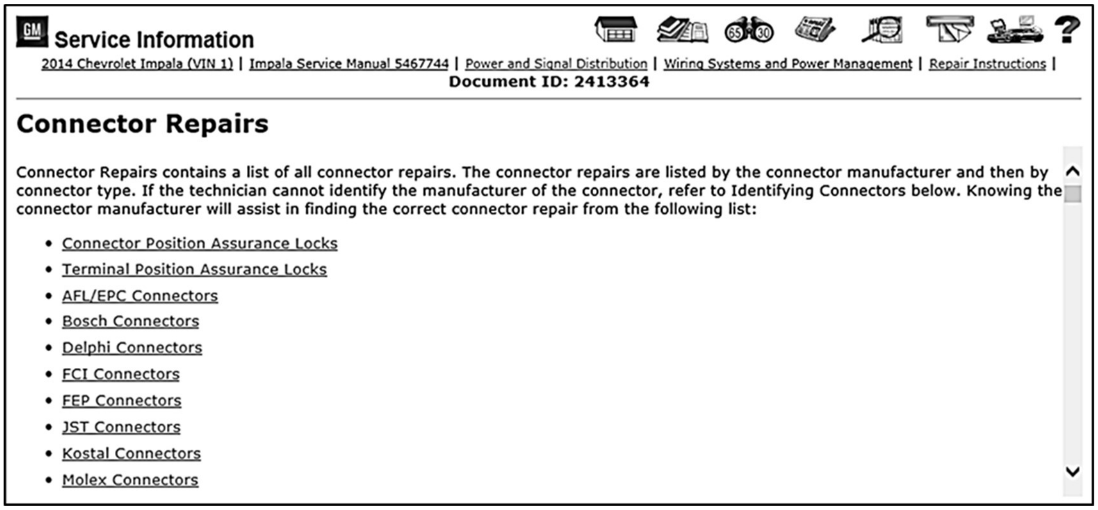


Figure 4-1, Connector Anatomy

GM Service Information provides connector repair documents for all of the connectors used in their vehicles. Use “connector repairs” in a keyword search to locate the repair document.



Service Information

2014 Chevrolet Impala (VIN 1) | Impala Service Manual 5467744 | Power and Signal Distribution | Wiring Systems and Power Management | Repair Instructions |
Document ID: 2413364

Connector Repairs

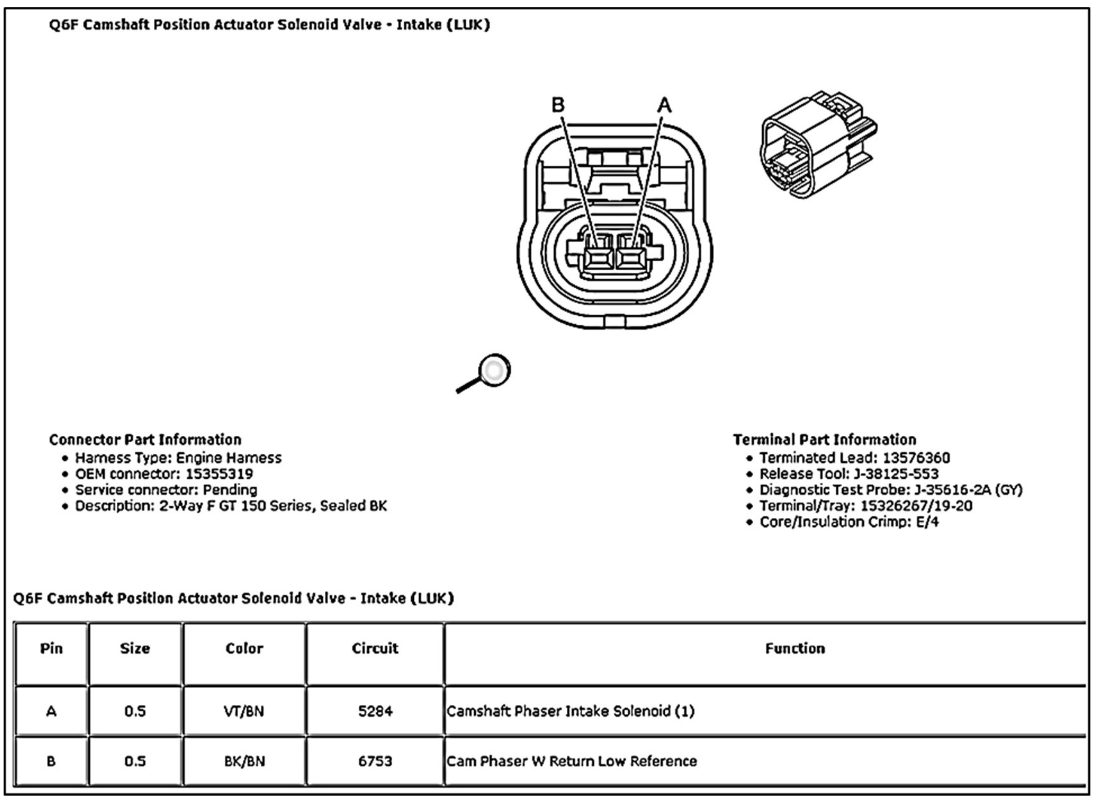
Connector Repairs contains a list of all connector repairs. The connector repairs are listed by the connector manufacturer and then by connector type. If the technician cannot identify the manufacturer of the connector, refer to Identifying Connectors below. Knowing the connector manufacturer will assist in finding the correct connector repair from the following list:

- Connector Position Assurance Locks
- Terminal Position Assurance Locks
- AFL/EPC Connectors
- Bosch Connectors
- Delphi Connectors
- FCI Connectors
- FEP Connectors
- JST Connectors
- Kostal Connectors
- Molex Connectors

Figure 4-2, Connector Repairs Keyword Search

Terminated Leads

Terminated leads are available to repair damaged terminals. Terminated leads can be used throughout the vehicle, as they are designed for temperatures up to 302°F (150°C).



Q6F Camshaft Position Actuator Solenoid Valve - Intake (LUK)

Connector Part Information
- Harness Type: Engine Harness
- OEM connector: 15355319
- Service connector: Pending
- Description: 2-Way F GT 150 Series, Sealed BK

Terminal Part Information
- Terminated Lead: 13576360
- Release Tool: J-38125-553
- Diagnostic Test Probe: J-35616-2A (GY)
- Terminal/Tray: 15326267/19-20
- Core/Insulation Crimp: E/4

Q6F Camshaft Position Actuator Solenoid Valve - Intake (LUK)

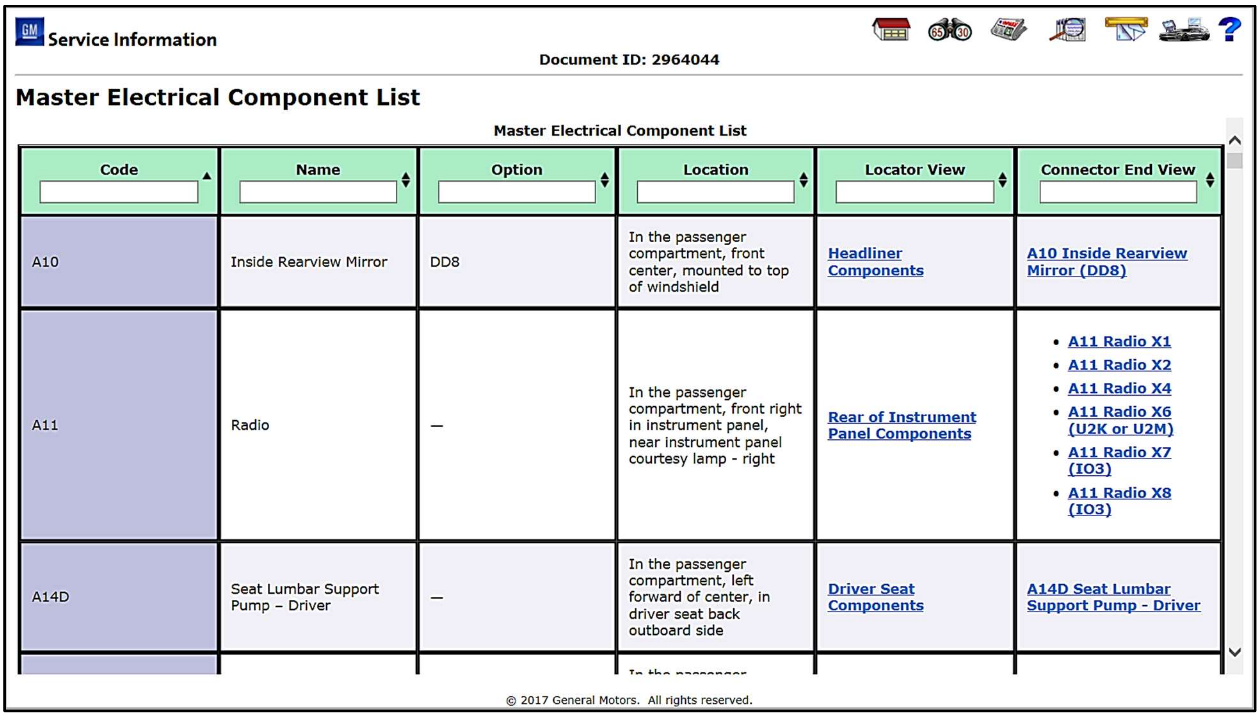
Pin	Size	Color	Circuit	Function
A	0.5	VT/BN	5284	Camshaft Phaser Intake Solenoid (1)
B	0.5	BK/BN	6753	Cam Phaser W Return Low Reference

Figure 4-3, Terminated Lead

The GM global wire repair strategy uses connector assemblies (pigtails) and terminated leads to repair wiring harnesses.

Connector Location

When diagnosing and repairing network faults, locate a connector in the vehicle to perform electrical tests or to repair a defective terminal, connector, or wire. Most vehicle manufacturers publish schematics and component location documents to assist in diagnosing and repairing the vehicle. GM Service Information provides links from the schematic to quickly get to a document illustrating the location of the connector selected.



Service Information

Document ID: 2964044

Master Electrical Component List

Master Electrical Component List

Code	Name	Option	Location	Locator View	Connector End View
A10	Inside Rearview Mirror	DD8	In the passenger compartment, front center, mounted to top of windshield	Headliner Components	A10 Inside Rearview Mirror (DD8)
A11	Radio	–	In the passenger compartment, front right in instrument panel, near instrument panel courtesy lamp - right	Rear of Instrument Panel Components	• A11 Radio X1 • A11 Radio X2 • A11 Radio X4 • A11 Radio X6 (U2K or U2M) • A11 Radio X7 (IO3) • A11 Radio X8 (IO3)
A14D	Seat Lumbar Support Pump – Driver	–	In the passenger compartment, left forward of center, in driver seat back outboard side	Driver Seat Components	A14D Seat Lumbar Support Pump - Driver

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Figure 4-4, GM Service Information Master Electrical Component List

GM electrical systems employ vehicle zoning to assist the technician in locating electrical grounding points, in-line harness connectors, and circuit splices within the vehicle. Other manufacturers may use a similar scheme to relate ground and connector locations. Figures 4-5 through 4-8 show a list of GM's passenger car and truck zone descriptions, utility zones, and the attendant numbers.

Callout Number	Zone Description – Passenger Car
100-199	Engine compartment (all forward of the instrument panel)
200-299	Within the instrument panel area (between the bulkhead and the front plane of the instrument panel)
300-399	Passenger compartment (from instrument panel to the back of the rear seats)
400-499	Luggage compartment (from the back of the rear seats to the rear of the vehicle)
500-599	Inline harness connectors to or within the driver door
600-699	Inline harness connectors to or within the front passenger door
700-799	Inline harness connectors to or within the left rear door
800-899	Inline harness connectors to or within the right rear door
900-999	Inline harness connectors to or within the luggage compartment lid or hatch

Figure 4-5, GM Zone Descriptions – Passenger Cars

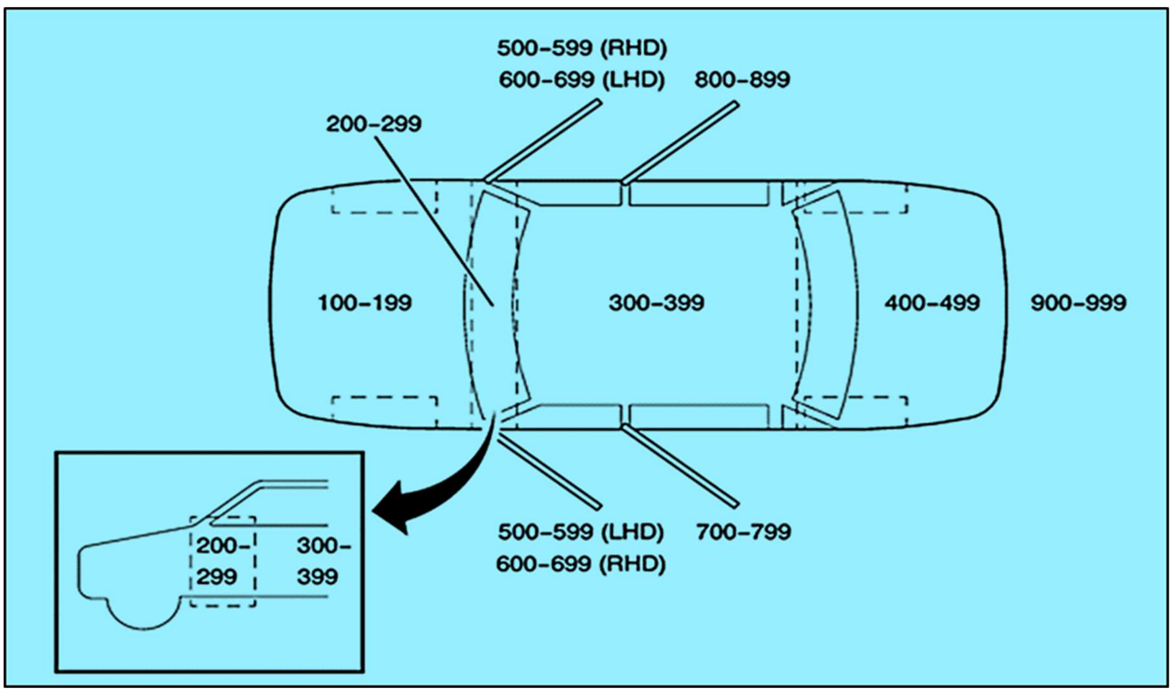


Figure 4-6, GM Zone Descriptions – Passenger Cars

Callout Number	Zone Description – Truck and Utility
100-199	Engine compartment (all forward of the instrument panel)
200-299	Within the instrument panel area (between the bulkhead and the front plane of the instrument panel)
300-399	Passenger compartment (from instrument panel to the back of the 2nd row seats)
400-499	Luggage compartment (from the back of the 2nd row seats to the rear of the vehicle, including any additional rows of seating rear of the 2nd row seats)
500-599	Inline harness connectors to or within the driver door
600-699	Inline harness connectors to or within the front passenger door
700-799	Inline harness connectors to or within the left rear door
800-899	Inline harness connectors to or within the right rear door
900-999	Inline harness connectors to or within the liftgate, lift window, endgate, or rear doors

Figure 4-7, GM Zone Descriptions – Truck and Utility

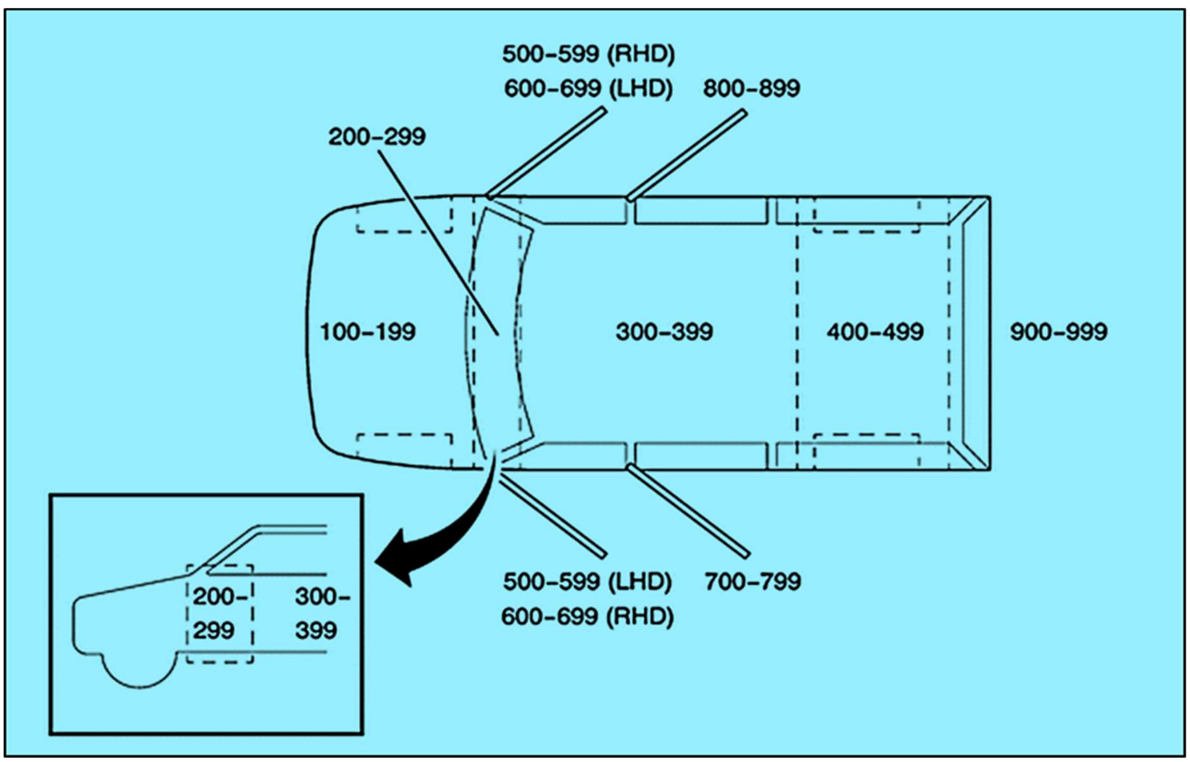


Figure 4-8, GM Zone Descriptions – Truck and Utility

PLASTIC OPTICAL CABLE REPAIR PROCEDURES

POF used in MOST® 25 and 150 systems require special repair processes and tools. The cables can be repaired and replaced if damaged. The tools are available through the OEM Dealer Tool programs or from the tool manufacturer by way of an aftermarket tool vendor. The MOST® connectors are generally standardized across manufacturers, as is the repair and servicing of the cables. More information on the tools needed to service these cables can be found at www.fiberfin.com.

Helpful hints for working with fiber optic cables include:

- Do not crush the optical fiber cable
- Avoid damage to the sheathing: chafing, perforation, cutting, pinching, etc.
- Do not kink or bend the cable to a radius of less than 1 inch (25 mm). Reduce the likelihood of kinks by covering the cable with split loom conduit
- Secure cable in original locations using appropriate fasteners or clips. Use the correct length when routing the optical fiber cables in the vehicle
- Protect the optical face of the cable ends from contamination with liquids, dust, fuel, etc.
- Protect the optical fiber cables from excessive heat from nearby soldering, heat bonding, or welding
- Do not use unapproved joining methods to connect optical fiber cables, such as gluing
- Do not twist two optical fiber cables together or with other wires

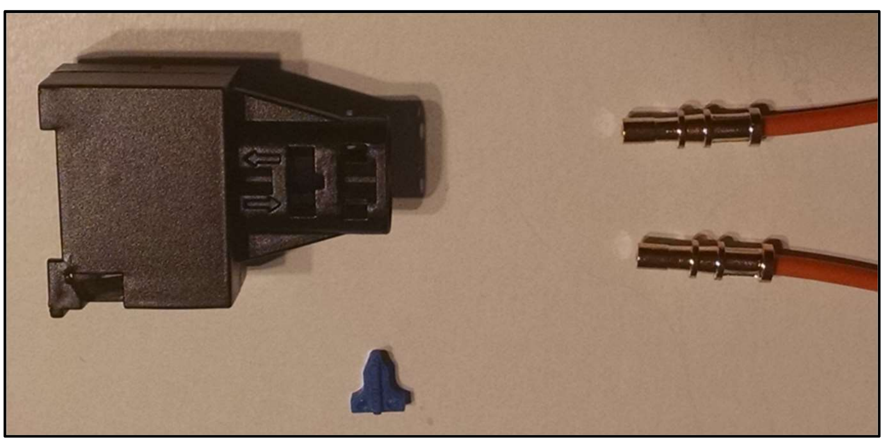


Figure 4-9, MOST® 25 Optical Connector

SPLICING TECHNIQUES FOR DATA COMMUNICATION WIRING

Serial data circuits require special wiring repair procedures due to the sensitive nature of the circuitry. The following are some basic GM repair recommendations that may be applicable to other vehicles, but check with the OEM service manual for exact information.

When making a repair to any GMLAN network, the original wire length after the repair must be the same length as before the repair. If the network is a twisted pair, the twist must be maintained after the repair is completed. If any wire except the pigtail is damaged, repair the wire by splicing in a new section of wire of the same gauge size (0.5 mm², 0.8 mm², 1.0 mm² etc.). Use the DuraSeal splice sleeves and EL-38125-10 crimping tool. DuraSeal splice sleeves have the following critical features:

- A special heat shrink sleeve contains a sealing adhesive inside and automatically seals the splice when heated
- A cross hatched (knurled) core crimp provides necessary contact integrity for sensitive, low-energy circuits
- Do not crimp with diagonal wire cutters

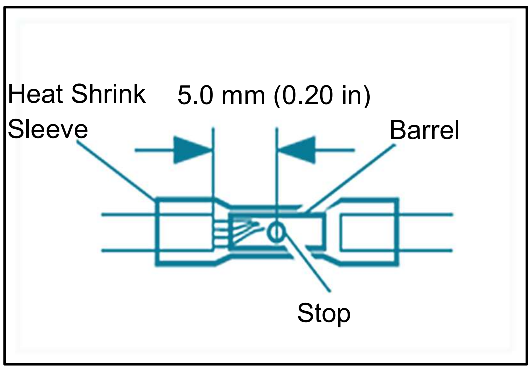


Figure 4-10, Wire Splicing

High Temperature Wire Repairs

Wiring that is exposed to high temperature, 275°F (135°C) or higher, for prolonged periods of time, needs special consideration when making repairs. Areas that may be exposed to higher temperatures can be identified by heat resistant materials used in those locations. These materials may include heat reflective tape or high temperature shrink tubing. Conduit and other protective coverings may also be used. Because conduit or similar coverings are used throughout the vehicle, regardless of the temperature, it may be necessary for the technician to determine if an area is exposed to excessive heat before making a wiring repair.

Please observe the following guidelines for high temperature repairs:

- Use high temperature bulk wire rated at 150°C (302°F) continuous temperature to replace any damaged wire
- Replace any heat shielding that is removed
- Cover any DuraSeal splice sleeves with shrink tubing
- After making a wiring repair, ensure that the location of the wiring is not moved closer to the heat source

Media Oriented Systems Transport Wiring Repairs

If the harness repair / analysis is performed, MOST® bus twisted pair unshielded wire should be 0.35 mm^2 (22 American Wire Gauge AWG) wire with at least one twist per each 1 45/64 inch (45 mm), and must not be untwisted for more than 3 15/16 of an inch (10 cm). The following conditions need to be met in order to ensure valid continuity:

- Untwisted length for all MOST® 50 circuits at each wire harness connector should be no longer than 50 mm max (25 mm is preferred)
- When wire repairs are made, a minimum of 25 twists per meter for all MOST® 50 circuits
- MOST® 50 has specific receive and transmit input / output
- The transmit of one module is connected to receive one of the next modules in the ring topology

Folded-Over Wire Repair

To reduce and manage GM Service Parts proliferation, service pigtails and terminated leads are designed with the largest wire gauge size that can be held by either the terminal or the connector housing. The folded-over wire repair technique, in which the copper wire strands are folded over before being installed into a splice sleeve, allows the service part to be used when repairing a smaller gauge size wire in a vehicle. This technique has passed all GM testing standards.

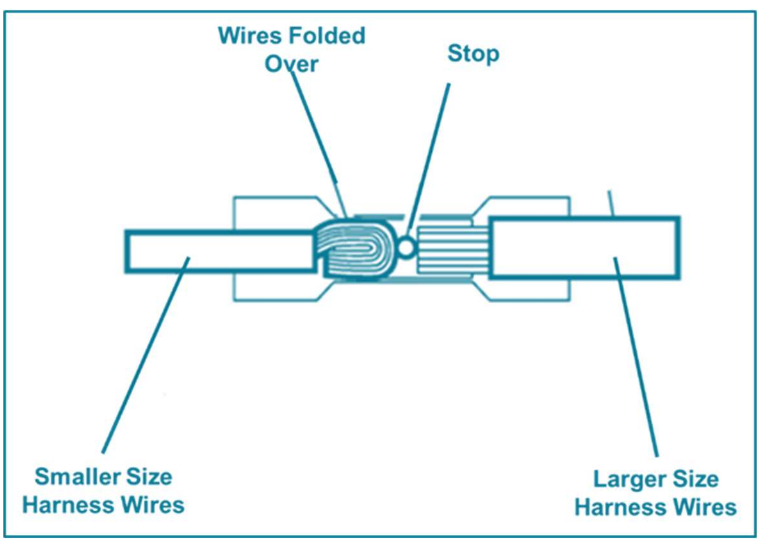


Figure 4-11, Folded-Over Wire Repair

Soldering is another method of splicing wires. Soldering involves heating the splice joint with a soldering iron, then applying solder wire to melt and fuse the joint together. Do not use an electric soldering iron on inflatable restraint circuits, as there is a risk of inducing an electric current in the circuit. However, a gas-heated soldering iron can be used on all circuits. It is recommended to use a 60:40 tin / lead rosin core solder for most general electrical work. Solder containing silver has a higher melting point and is used in special joining applications where increased mechanical strength is required. Do not use acid-core solders as they are for plumbing work and can damage the wire conductors or delicate electronic circuits. Solder clips can be used to mechanically join the wires before soldering to assist in forming the connection. Heat shrink tubing should be used to protect the soldered connection and should be placed on the wire before making the splice. Be sure to position it away from the joint to avoid activating it prematurely.

To solder a pair of wires, please use the instructions below:

1. Strip the insulation approximately ½ inch (13 mm).
2. Twist the conductors to compact them.
3. Insert the conductors into a splice clip, if available, and squeeze the clip closed.
4. A small alligator clip can also be used to temporarily hold the wires together.
5. Turn on the soldering iron, and allow it to reach operating temperature.
6. Apply solder to the tip of the iron, and wipe it clean using a wet sponge or towel. Reapply solder until the tip has a layer of solder on it.
7. Hold the iron in contact with the joint until solder touched to the joint begins to flow into the wires and joint.
8. Continue adding solder until the joint and wires have a shiny appearance and the joint is fully flowed out with solder.
9. Remove the solder, then the iron.
10. Cold solder joints appear dull and do not flow out onto the wires. Reheat the joint to correct.
11. When the joint has cooled, slide the shrink tubing over the joint and heat the shrink tubing to seal the joint.

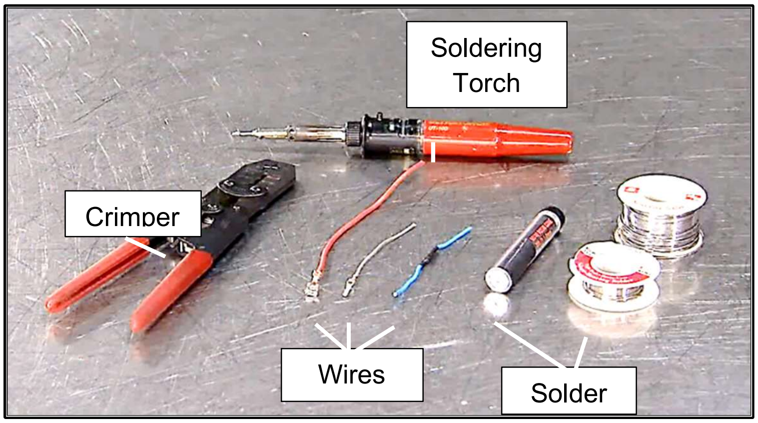


Figure 4-12, Soldering Supplies

MODULE PROGRAMMING AND SETUP PROCEDURES

Replacing a Control Module

If the diagnosis indicates that a failed control module is the root cause, replace it. Many control modules require service programming and setup when replaced. Some modules need service programming (SPS – TIS2WEB subscription), and others only require setup. To determine whether or not a module needs SPS, look at the label on the control module. There may be a computer programming symbol (double-ended arrow, computer monitor, and wrench). This icon identifies components that may need programming or setup upon replacement. This symbol is also located on GM electrical schematics found in GM Service Information. Clicking on the icon in the schematic will link to the control module references document in service information. However, on occasion, the SPS may not be an active link. Instead, navigate from the Service Manual page by clicking Diagnostic Overview, Starting Point, and Programming, Programming and Setup Diagnostic Information, Procedures, and finally Control Module References.

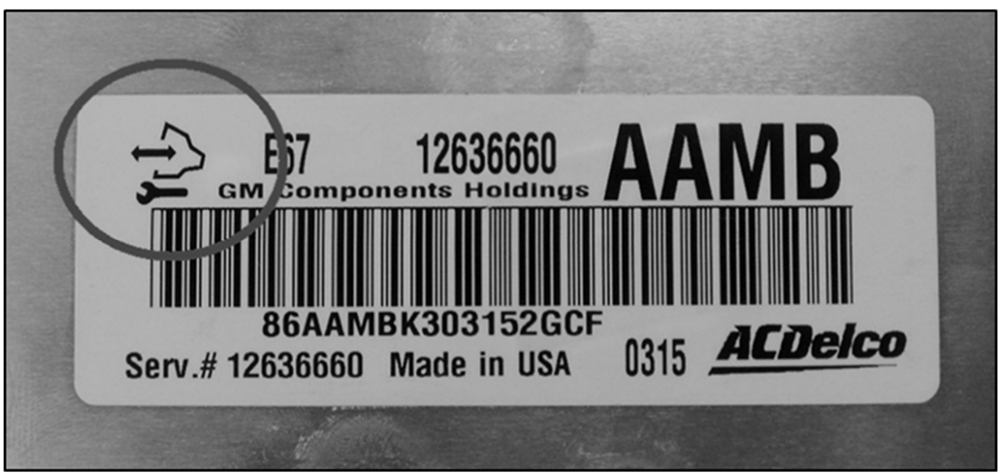
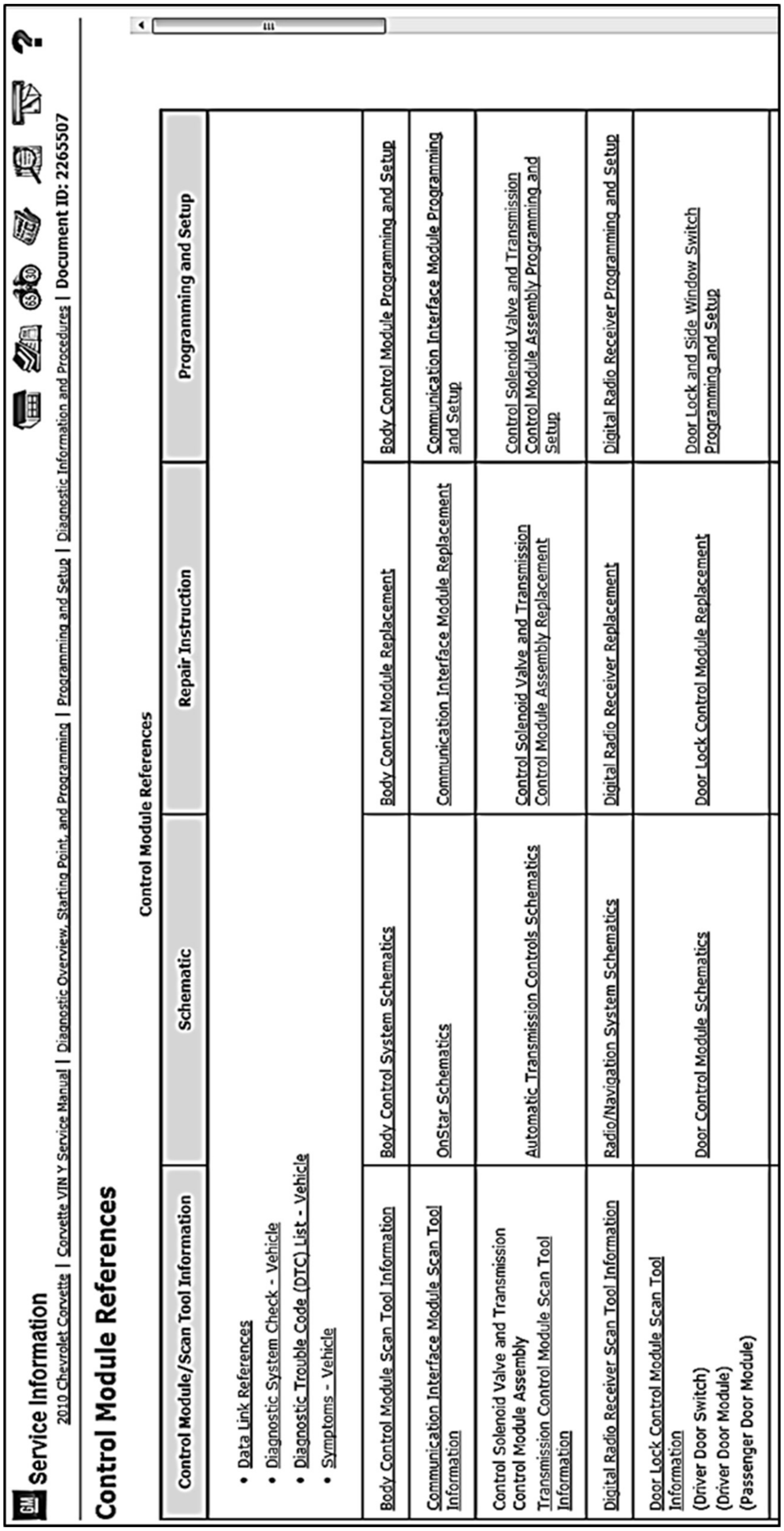


Figure 4-13, Example of Computer Programming Symbol

GM Service Information has a table called Control Module References that lists all of the selected vehicles' control modules. It provides a single location where technicians can find the information needed to diagnose, replace, and program a vehicle's modules. To locate the Control Module References document in Mitchell ProDemand, use the search function by entering the keywords "programming and setup – all systems." The Control Module References document is also located in the individual module replacement procedures. Each module replacement procedure has a link to the Control Module References table. Below are some tips for using the Control Module References table:

- The module name may also include the component code, which is an alphanumeric number used to identify a module in service information, most notably in schematics
- In the case that a module connector view or component location view is difficult to find in the Component Locator, it may be helpful to look for the module's component code instead of the model's name or function. Often, a module may be called something different in the component locator. However, its component code will be the same
- In the column marked Schematic, there is a link to the schematics that illustrate the module electrical connections
- In the column marked Repair Instruction, there is a link to the steps used to remove and install the module
- The links listed in Programming Setup provide the steps needed to program or reprogram the module. It is important to note that not all modules listed in the Control Module References table require reprogramming. Click on Programming Setup to determine if programming is needed, or if the module is a plug-and-play module and does not need programming



Service Information

2010 Chevrolet Corvette | Corvette VIN Y Service Manual | Diagnostic Overview, Starting Point, and Programming | Programming and Setup | Diagnostic Information and Procedures | Document ID: 2265507

Control Module References

Control Module References

Control Module/Scan Tool Information	Schematic	Repair Instruction	Programming and Setup
• Data Link References • Diagnostic System Check - Vehicle • Diagnostic Trouble Code (DTC) List - Vehicle • Symptoms - Vehicle			
Body Control Module Scan Tool Information	Body Control System Schematics	Body Control Module Replacement	Body Control Module Programming and Setup
Communication Interface Module Scan Tool Information	OnStar Schematics	Communication Interface Module Replacement	Communication Interface Module Programming and Setup
Control Solenoid Valve and Transmission Control Module Assembly Transmission Control Module Scan Tool Information	Automatic Transmission Controls Schematics	Control Solenoid Valve and Transmission Control Module Assembly Replacement	Control Solenoid Valve and Transmission Control Module Assembly Programming and Setup
Digital Radio Receiver Scan Tool Information	Radio/Navigation System Schematics	Digital Radio Receiver Replacement	Digital Radio Receiver Programming and Setup
Door Lock Control Module Scan Tool Information (Driver Door Switch) (Driver Door Module) (Passenger Door Module)	Door Control Module Schematics	Door Lock Control Module Replacement	Door Lock and Side Window Switch Programming and Setup

Figure 4-14, GM Control Module References Page

Swapping Modules

In the past, it was common practice to swap parts between vehicles to isolate service issues. However, with programmed modules, swapping a known good unit from another vehicle will not work.

A new vehicle security code protocol started with the 2010 model year GDS applications. The global architecture electrical system associated with these vehicles does not allow controller swaps between vehicles. Swapping ECMs or other modules (including radio, BCM, EBCM, Sensing Diagnostic Module [SDM], Transmission Control Module [TCM], Electronic Climate Control [ECC], Electronic Power Steering [EPS], Hybrid Powertrain Control Module [HPCM], and IPC) between two vehicles with the global architecture electrical system will result in damaging both controllers. A no-start condition will occur on both vehicles if these modules are swapped.

Some older vehicles may allow swapping some modules, but it is not a good practice. Some modules will not operate correctly, or at all, when the VIN stored in it does not match that of the vehicle. Best practice is to only use new parts when replacing the BCM and utilize the Service Exchange Centers when replacing the instrument column.

Programming Difficult Modules

With multiplex networks, there can be occasions where module programming is problematic. Often these situations are known and the manufacturer publishes a technical service bulletin to address the issue. It could involve a change in the programming sequence, including programming one module such as the gateway to allow programming of a module on the other side of the gateway. It could be that several modules must be updated in order to work together in the vehicle. In some situations, it may be necessary to remove fuses, use a special tool, or even fabricate a jumper harness to isolate a module from the network in order to program it successfully. Always review the technical service bulletins for the vehicle in question to help address any difficulties in programming.

GM issued two special tools originally for assisting in diagnosing Class 2 communication faults. The J 42236-A data bus diagnostic link box (Corvette) and J-45211 (Cadillac) is also used to isolate the PCM from the other modules on the Class 2 network during programming. While most shops will not have these special tools, there is another way to do the same thing: create a jumper wire between the DLC and the PCM connectors. This will provide an isolated Class 2 connection between the DLC and PCM during service programming. The terminals for the DLC are part #15317575 and for the PCM, they are #12084913. Assemble the jumper wire with sufficient length of wire to reach the DLC and the PCM. Remove the Class 2 wire from cavity 2 of the DLC, and insert the jumper wire terminal in its place. Repeat this at the PCM. Perform service programming and, when finished, remove the jumper wire. Reinstall the Class 2 terminals back in their respective places.

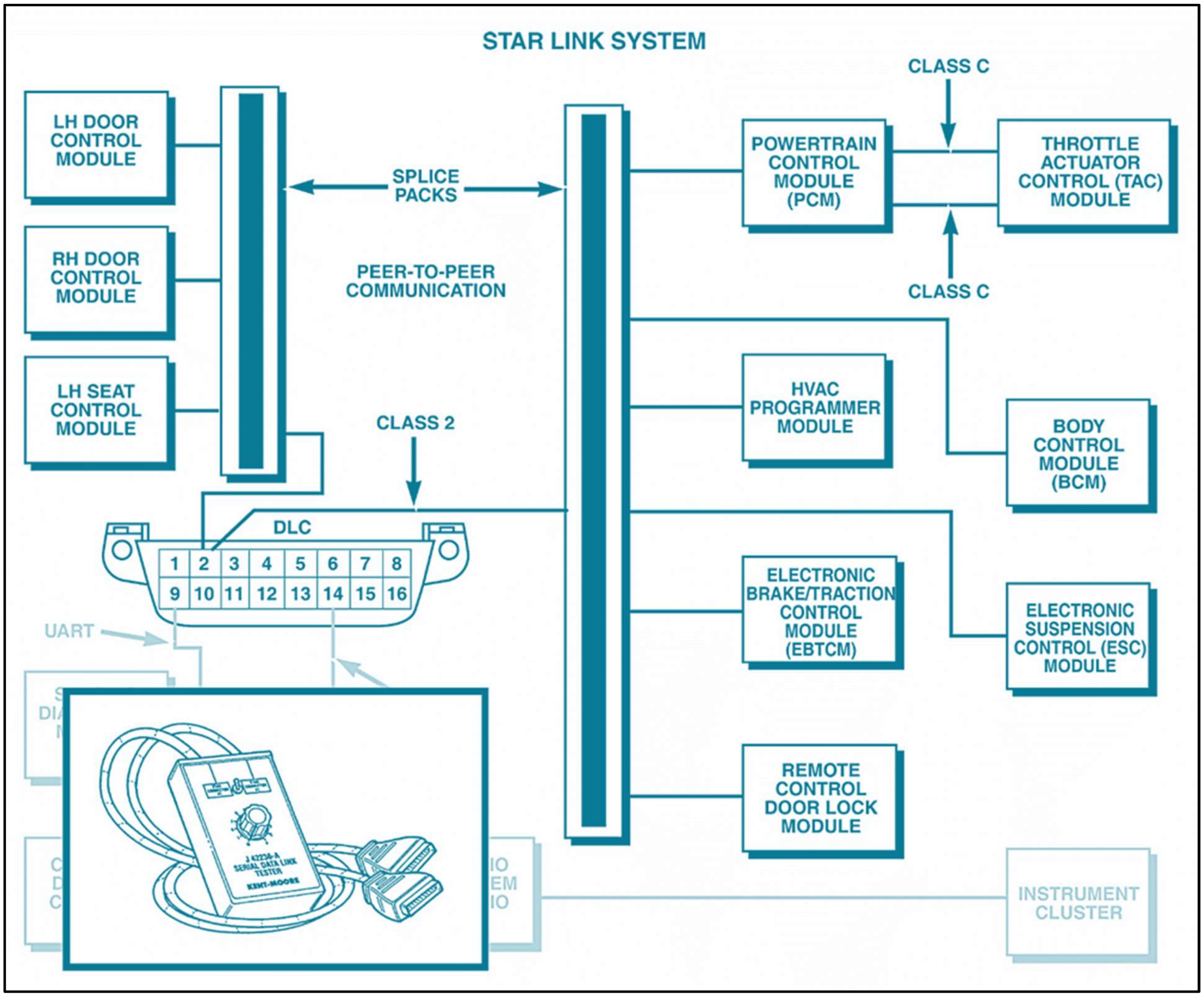


Figure 4-15, Isolating Modules for Programming

ADDITIONAL RESOURCES

PRODUCT VIDEOS

ACDelco product information videos help keep you in the know. From the latest in ACDelco innovations, to quick tips on product installation, there's always something new to learn.

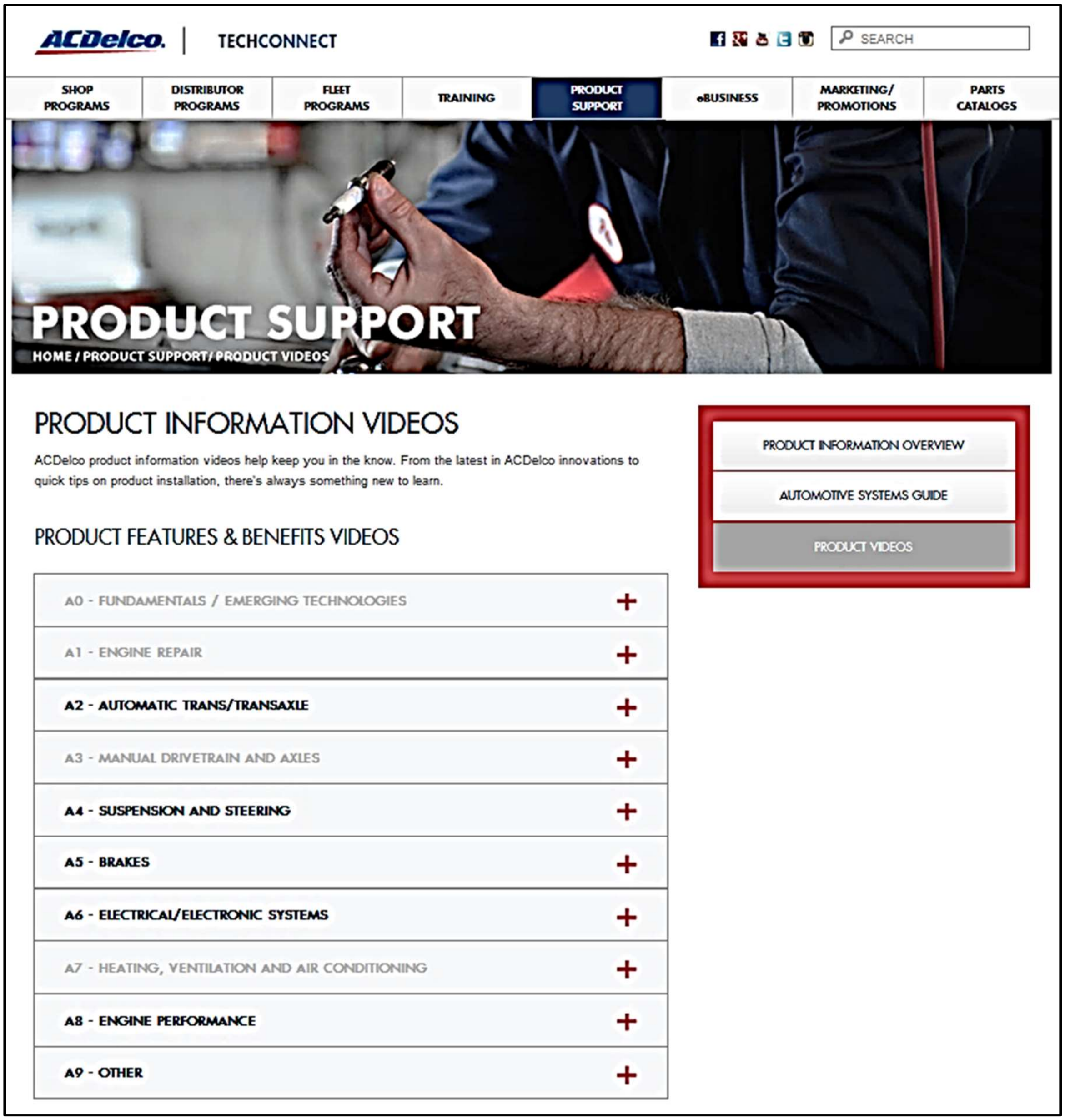


Figure 5-1, ACDelco.com

NEWSLETTERS

ACDelco Press Releases

From important updates to exciting ACDelco news, view the latest announcements from ACDelco.

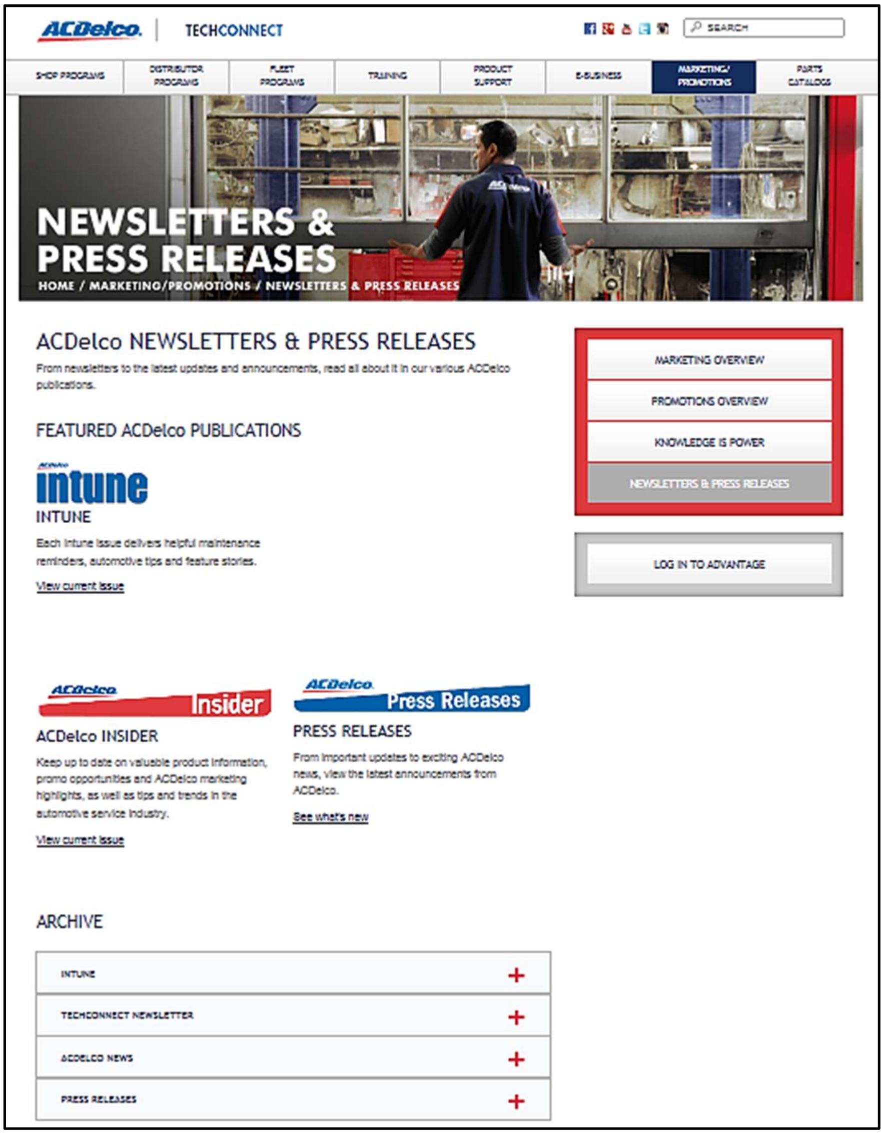


Figure 5-2, ACDelco TechConnect Newsletters and Press Releases

ACDELCO PRODUCT ASSISTANCE HOTLINES

- Brakes: 1-888-701-6169 (prompt #1)
- Chassis: 1-888-701-6169 (prompt #2)
- Lift support: 1-800-790-5438
- Shocks: 1-877-466-7752

- Starters and alternators: 1-800-228-9672
- Steering: 1-866-833-5567
- Wiper blades: 1-800-810-7097

SERVICE WEBSITES

- Acura — http://www.ServiceExpress.Honda.com
- Audi — http://www.ebahn.com/audi
- Bentley — http://www.bentleytechinfo.com
- BMW — http://www.bmwtechinfo.com
- Chrysler / Dodge / Eagle / Jeep / Plymouth — http://www.techauthority.com
- Ford / Lincoln / Mercury — http://www.motorcraft.com
- General Motors Buick / Cadillac / Chevrolet / Geo / GMC / Hummer / Oldsmobile / Pontiac / Saturn — http://www.gmtechinfo.com
- Honda — http://www.ServiceExpress.Honda.com
- Hyundai — http://www.hmaservice.com
- Infiniti — http://www.infinititechinfo.com
- Isuzu — http://www.isuzutechinfo.com
- Jaguar — http://www.jaguartechinfo.com
- Kia — http://www.kiatechinfo.com
- Land Rover — http://www.landrovertechinfo.com
- Lexus — http://techinfo.lexus.com
- Maserati — www.maseratitechinfo.com
- Mazda — http://www.mazdatechinfo.com
- Mercedes-Benz — http://www.startekinfo.com
- Mini — http://www.minitechinfo.com
- Mitsubishi — http://www.mitsubishitechinfo.com
- Nissan — http://www.nissantechinfo.com

- Porsche — https://www.techinfo.porsche.com
- Rolls Royce — http://www.rrtis.com
- Saab — http://www.saabtechinfo.com
- Subaru — http://techinfo.subaru.com
- Toyota — http://techinfo.toyota.com
- Volkswagen — http://www.ebahn.com/vw
- Volvo — http://www.volvotechinfo.com


GM GENUINE PARTS
ACDelco
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Like us at facebook.com/acdelco
Watch us at youtube.com/user/acdelcoofficialpage
ASE Accredited Training Provider