



ISO Cable Selection and Physical Harness Requirements for Vehicle Bus Data Transmission

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1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose.

This document describes cable selection, physical wire harness construction, and topology requirements for implementing serial data communication busses in GM vehicles. See the Classification section for the list of specific busses covered.

1.2 Applicability.

This standard consolidates wire harness requirements for serial data busses used in GM vehicles into a single document. All serial data bus wiring in GM vehicles shall meet the electrical and mechanical requirements identified in this document.

Complete requirements for GM vehicle wiring subsystems, including appearance, ambient environment, dependability, reliability, and serviceability, are given in the GM Power and Signal Distribution Subsystem Technical Specification (SSTS), CG1763 template (the supplier shall work with the GM Design Responsible Engineer to comprehend this requirement). The requirements in this document do not replace any requirements in the SSTS, but are additional requirements specific to serial data bus wiring in GM vehicles.

1.3 Remarks.

1.3.1 Classification.

The wired serial data busses in GM vehicles can be classified as follows:

- a. **Local Interconnect Network (LIN):** Local Interconnect Network, as defined in SAE J2602-1, a single wire serial data bus that operates at up to 19.2 kbit/s; there can be several independent instances of LIN networks on a GM vehicle.
- b. **SW CAN:** Single Wire Controller Area Network, as defined in GMW3089 that operates at 33.333 kbit/s during normal vehicle operation and 83.333 kbit/s during assembly or service programming. This bus is also known as Low Speed GM Local Area Network (LS GMLAN or LS LAN).
- c. **DW CAN:** Dual Wire Controller Area Network, as defined in GMW3122, that operates at one of two different speeds as follows:
 1. **MS CAN:** Mid Speed CAN that operates at 125 kbit/s, also known as Mid Speed GM Local Area Network (MS GMLAN or MS LAN). Future versions may utilize the Automotive Open System Architecture (AUTOSAR) messaging format, but the same physical layer.
 2. **HS CAN:** High Speed CAN that operates at 500 kbit/s. GM vehicles may have one or more instances of HS CAN busses.
 3. **CAN FD:** CAN with Flexible Data Rate, a variable speed DW CAN bus that operates at a base speed for bus arbitration and at 4x (Diagnostics CAN: 10x) the base speed for data transmission. CAN FD is being utilized for HS CAN (base speed 500 kbit/s) for Global B.
- d. **FlexRay:** A dual wire serial data bus, as defined in the FlexRay Communication System Electrical Physical Layer (FRCEPL) Specification and FlexRay Communication System Electrical Physical Layer Application Notes (FRCEPLAN), that operates at 10 Mbit/s and is typically used for chassis control functions.
- e. **MOST50:** Media Oriented Systems Transport, as defined in the MOST Physical Layer Specification (MOSTEPL) and MOST Specification (MOSTSPEC), a dual wire serial data bus that utilizes an electrical physical layer and that operates at 50 Mbit/s. It is typically used for "infotainment" functions per GIS-307. This bus may also be referred to as electrical MOST (eMOST). MOST50 is being replaced by Ethernet starting with the 2018 Model Year (MY).

Note: This document does not cover requirements for optical physical layer versions of MOST.

- f. **Ethernet:** A point to point serial data bus that can operate at variety of speeds. Currently GM is planning to implement Ethernet at a 100 Mbit/s data rate as defined in IEEE 802.3bw, 100BASE-T1 for "infotainment" or other "on board" functions over a single unshielded twisted pair (UTP). Ethernet for "off board" communications via the Data Link Connector (DLC) will utilize the 100BASE-TX protocol over two UTPs per ISO 13400-3. GM is planning to use IEEE802.3bp, 1000BASE-T1, on future programs over a single jacketed twisted pair (J-UTP or STP) with individual 2-pin connectors.

- g. **USB:** Universal Serial Bus used for communication to customer devices such as cell phones and music file (MPEG Layer 3 (MP3)) players is not included in this document at the current time but is reserved for future use.
- h. **LVDS:** Low-Voltage Differential Signaling, an analog bus used for communication of video signals (**not included in this document at the current time, but reserved for future use**).

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

Note: In the event of a conflict between the text of this specification and the documents cited herein, the text of this specification takes precedence.

2.1 External Standards/Specifications.

EIA-364-103	IEEE 802.3	ISO 13400-3	SAE J2602-1
EIA-364-108	ISO 7637-3	SAE J1962	SAE J3117

2.2 GM Standards/Specifications.

GMW3059	GMW3122	GMW15626
GMW3089	GMW3176	GMW15839

2.3 Additional References.

- CG1763 – GM Power and Signal Distribution Subsystem Technical Specification (SSTS) Template (The supplier shall work with the GM Design Responsible Engineer to comprehend this requirement)
- GIS-307 – Interface Testing Table
- J1962-007 – 16 Pin ALDL Connector, General Motors Terminal Definitions and Descriptions
- J1962-Global A – 16 Pin ALDL Connector, General Motors Terminal Definitions and Descriptions for Global A
- J1962-Global B – 16 Pin ALDL Connector, General Motors Terminal Definitions and Descriptions for Global B

3 Requirements

Note: In case of conflict between the electrical specification in this document and the platform-specific wiring harness specification, this document shall take precedence.

Note: All specifications in this standard apply over all ambient environment conditions, operating conditions, and product lifetime unless explicitly otherwise noted.

3.1 System/Subsystem/Component/Part Definition.

3.1.1 Appearance.

Not applicable, however, cable (wire) color requirements will be covered in 3.2.

3.1.2 Content.

3.1.2.1 Physical Content.

The serial data bus physical wire harness components covered by this document include cable (wire), connectors, terminals, splices, and other applicable wire harness sub-components. Serial data bus circuit traces in electrical centers are also covered.

3.1.2.2 Functional Content.

Not applicable.

3.1.3 Ambient Environment.

Serial data bus wire harness components shall meet all other requirements of this specification across the full range of temperature, humidity, and other environmental conditions that are defined in the GM Power and Signal Distribution Subsystem Technical Specification (SSTS), CG1763 template. The supplier shall work with the GM Design Responsible Engineer to comprehend this requirement.

3.1.4 Interfaces.

Connector, terminal, and other interface requirements will be discussed in their individual requirements sections.

3.1.5 Usage Definition.

Almost all current and future GM vehicles will utilize one or more dual wire CAN serial data busses. The single wire CAN serial data bus is currently used on most GM vehicles and is scheduled to be phased out starting with 2020 Model Year. One or more LIN busses are currently used on many GM vehicles. The MOST50 serial data bus is currently being used on some GM vehicles but usage is expected to be phased out starting in 2018 Model Year (2018MY). FlexRay and Ethernet started with 2018MY in GM vehicles. USB is currently used in many GM vehicles and LVDS is being used in some GM vehicles. Usage of both USB and LVDS is expected to continue for the foreseeable future.

3.2 Cable Selection Guidelines and Constraints.

3.2.1 Cable Type.

3.2.1.1 Single Wire Busses.

Cables used for all single wire serial data busses shall use copper conductors and meet all requirements of GMW15626 for single core stranded International Organization for Standardization (ISO) cables.

3.2.1.2 Dual Wire Busses.

Cables used for all dual wire serial data busses shall use copper conductors and meet all requirements of GMW15626 for single core stranded ISO cables or GMW15839 for sheathed, multi-core ISO cables.

Unless otherwise specified, dual wire busses may be constructed using either manually twisted single core cables or sheathed, twisted multi-core cables provided all other requirements in this document are met. For Ethernet 100BASE-T1 cable, which includes Unshielded Twisted Pair (UTP) and Jacketed Unshielded Twisted Pair (J-UTP), the cable shall meet the requirements of SAE J3117.

Note: It is expected that in most cases, manually twisted single core cables will be the lowest cost solution.

3.2.1.3 Shielded Cable.

LVDS requires shielded cable. For all other serial data busses shielded cable shall not be used unless electromagnetic compatibility (EMC) testing demonstrates such shielding resolves a noise coupling issue.

3.2.2 Cable Size.

Cables used for all serial data busses shall have conductor cross sections of either 0.35 mm² or 0.5 mm². For Ethernet cable, the usage of 0.13 mm² wire is allowed. However, the cable size and type shall be evaluated and approved by the Lead Power and Signal Distribution System (PSDS) Design Responsible Engineer (DRE) and the GM Materials Engineer. Determination of the proper size within these limits should be based upon other factors, including terminal crimp, splice construction, and/or durability requirements. This requirement is also specified in the Tables A1 through I1 in the corresponding Appendices.

Note: These cable sizes inherently meet the resistance requirements of all serial data busses.

3.2.2.1 Engine Applications.

All cable used for serial data wires in "on engine" locations shall be 0.5 mm² to withstand the increased engine vibration levels.

3.2.3 Cable Stranding.

Cable used for serial data circuits shall be symmetrical (ISO Type A). Asymmetrical Cable (ISO Type B) shall be prohibited. "High flex" cable (ISO Type C) may be used in locations that require additional fatigue resistance.

3.2.4 Cable Insulation.

3.2.4.1 Insulation Material.

3.2.4.1.1 Single Wire Busses.

The default cable insulation material for all single wire serial data bus circuits shall be cross-linked polyethylene (XLPE), but polyvinyl chloride (PVC) may be used if shorter bus length constraints are met.

3.2.4.1.2 Dual Wire Busses.

The default cable insulation material for all dual wire serial data bus circuits shall be XLPE, PP, or PE. Other insulation materials are allowed if they are demonstrated to meet all of the other requirements of this document.

3.2.4.2 Insulation Thickness.

The default insulation thickness for all serial data bus circuits shall be thin wall. Thick wall insulation may be used in locations requiring additional abrasion resistance, but must continue to meet all of the other requirements

of this document. Ultra-thin wall cable shall not be used for serial data circuits. Ethernet cable (UTP and JUTP) wall thickness are defined in SAE J3117.

3.2.4.2.1 Truck Chassis Applications.

If connector cavity sizes allow, thick wall insulation shall be used for serial data circuits in truck chassis locations to improve abrasion resistance when exposed to increased levels of grit and vibration.

3.2.4.3 Insulation Color.

The default insulation colors, including stripes, shall be as defined in GMW3176. All color deviations shall be documented in the vehicle electrical schematics. Color deviations may be allowed in the following two special situations.

3.2.4.3.1 Sheathed Cable Color Deviation.

To avoid the high cost of having special sheathed cables made, standard sheathed cable colors may be used. If options exist, select the standard colors closest to the defined GMW3176 colors.

3.2.4.3.2 Error Proofing Color Deviation.

In certain cases, bus wire color deviations may be requested to alleviate potential wire harness mis-builds. An example is when bus circuits in a ring topology share the same connectors at both ends within a wire harness. If error proofing color deviations are requested, the change should be limited to use of an alternative stripe color.

3.2.5 Circuit Twist Requirements.

3.2.5.1 Twist Length.

Dual wire bus circuits shall be twisted to prevent EMC coupling. The length of each 360 degree twist shall be constrained to the range of 11 mm to 40 mm. This requirement is also specified in Tables C1 through I1 in the corresponding Appendices.

Note 1: Alternatively, the twist rate may be defined as 25 twists/meter to 90 twists/meter.

Note 2: Testing has found that up to three Ethernet UTPs with a common twist length can share a wire harness bundle without creating cross talk issues.

3.2.5.2 Untwist Length at Ends.

When dual wire bus circuits terminate at a connector or splice, the untwisted length shall be constrained to 50 mm maximum, 30 mm maximum for Ethernet, with less preferred. The ends of the twisted wires shall be taped, if necessary, to ensure that the bus wires cannot untwist during lead prep or wire harness assembly. This requirement is also specified in Tables C1 through I1 in corresponding Appendices.

Note: For Ethernet if the untwisted length exceeds 10 mm, then the Ethernet circuit pair shall be taped or shrink wrapped together to within 10 mm of the back face of the connector.

3.2.5.3 Twisted Circuit Taping Requirements.

3.2.5.3.1 Ethernet, MOST50, and FlexRay.

If manually twisted single core cable is used for Ethernet, MOST50, and FlexRay serial data bus circuits, each twisted pair shall be covered in solid tape to within 50 mm, 30 mm for Ethernet, of each connector as defined in 3.4.6.1 Wire Harness Protection section of this document.

3.2.5.3.2 Dual Wire CAN.

If manually twisted single core cable is used for the Dual Wire CAN bus, spot tapes shall be used at the ends of the twisted sections to ensure that the ends do not untwist after lead preparation is complete.

3.2.5.4 Sheath Striping Restrictions.

If sheathed twisted pair cable is used for dual wire serial data circuits, the sheath strip length shall be 50 mm or less to ensure that the circuits remain twisted to within 50 mm, 30 mm for Ethernet, of each connector.

3.2.5.5 Twist Requirements at a "Looped Back" Connector.

FlexRay, MOST50, and Ethernet circuits that loop back to a common wire harness connector shall be twisted in a manner that meets all other requirements of this specification. Dual wire CAN circuits that loop back to a common wire harness connector may be taped together instead of twisting if they are < 150 mm in length and if they are held together by either solid over tape or three spot tapes equally spaced. See Figure 1 for illustrations of "looped back" connector circuits and twisting and taping options.

Note: "Looped back" connectors may be used to avoid wire harness proliferation when an optional module is not present in an interfacing wire harness.

3.2.6 Differential Characteristic Impedance.

To ensure maximum signal transmission integrity, the circuits that make up each dual wire bus must meet specific differential characteristic impedance requirements when tested according to the methodologies provided in Section 4. This parameter can also be called the "differential line impedance". See Tables C1 through I1 in the corresponding Appendices for the specific differential characteristic impedance requirements.

3.2.7 Capacitance.

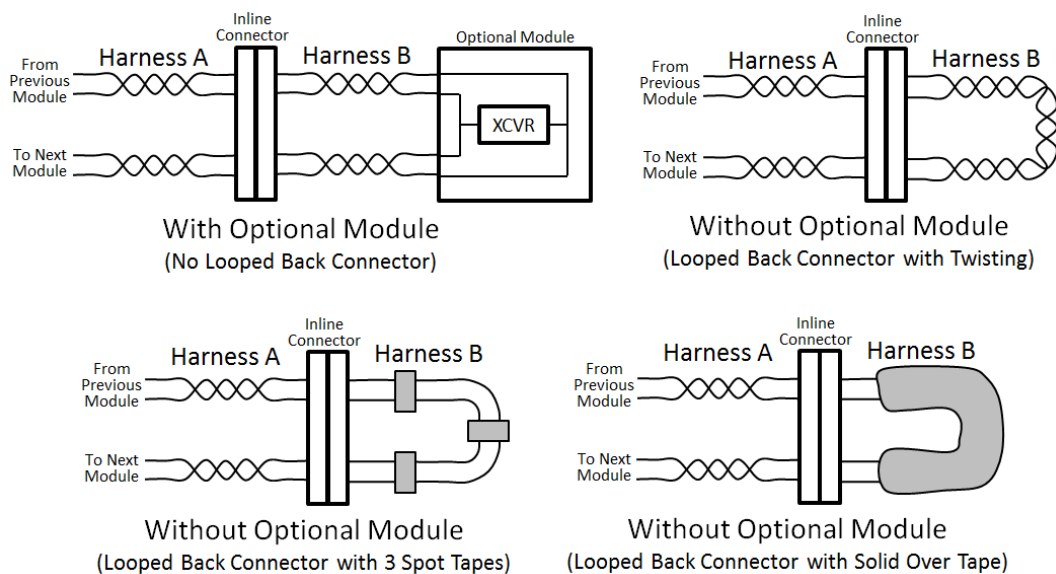
To ensure maximum signal transmission integrity, the circuits that make up each dual wire bus must also meet certain capacitance requirements.

3.2.7.1 Conductor to Ground.

The cable used for single wire busses shall meet certain limits for capacitance to ground when tested according to the methodology provided in Section 4. See Tables C1 through I1 in corresponding Appendices for the specific conductor to ground capacitance requirements.

3.2.7.2 Conductor to Conductor.

The cable used for the CAN and FlexRay dual wire busses shall meet certain limits for conductor to conductor capacitance when tested according to the methodology provided in Section 4. See Tables A1 and B1 in Appendices A and B for the specific conductor to conductor capacitance requirements.



XCVR Transceiver

Figure 1: Looped Back Connector Circuits

3.2.8 Propagation Delay.

The cable used for most serial data busses shall meet certain limits for the speed of signal transmission along bus wires, otherwise known as propagation delay, when tested according to the methodology provided in Section 4. See Tables A1 through I1 in the corresponding Appendices for the specific propagation delay requirements.

3.3 Connector Selection Guidelines and Constraints.

3.3.1 Connector Requirements.

3.3.1.1 Connector Sealing.

All device and inline connectors containing serial data circuits shall be sealed if they are located in a wet environment or are within 50 mm of the floor pan or are located under carpet.

3.3.1.2 Cavity Sizes.

All device and inline connectors containing serial data circuits shall, at a minimum, have cavities sized to accommodate cable sizes of 0.35 mm² to 0.5 mm² for ISO and SAE thin wall cable. Connectors expected to be

used in truck chassis or other high abrasion locations, should ideally have connector cavities that allow use of 0.5 mm² ISO thick wall cable. Jacketed cable may require unique connectors and cavity sizes.

3.3.1.3 Connector Position Assurance (CPA) devices.

CPA devices shall be used on all device and inline connectors containing serial data circuits.

3.3.2 Terminal Requirements.

3.3.2.1 Terminal Plating.

Serial data circuits have no inherent special terminal plating requirements; however, the same plating material shall be used on both halves of a mated terminal pair. Gold terminals should be avoided to reduce the chance of an inadvertent tin-gold interface being created.

Note: If a fretting corrosion issue arises with tin plated terminals due to excessive movement at the terminal interface, use of silver plated terminals is recommended.

3.3.3 Connector Pin Assignments.

3.3.3.1 Number of Required Pins.

The following connector pin count information is provided for reference only because it may impact wire harness design without being a wire harness requirement. See Figure 2 for example illustrations.

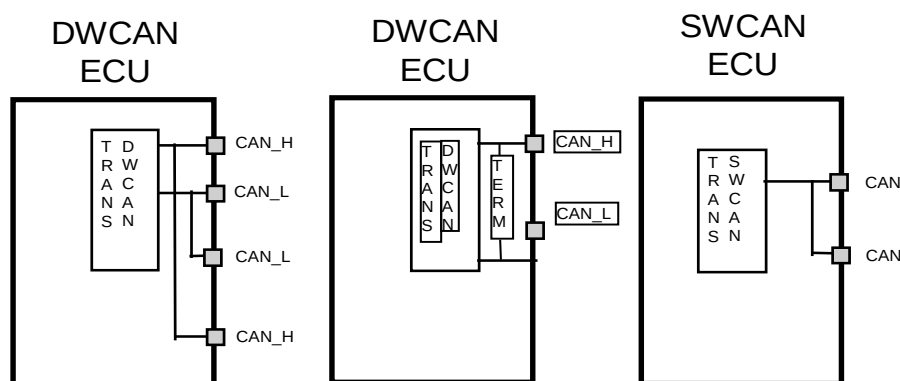


Figure 2: GMLAN Connections to Electronic Control Units (ECU)

- LIN.** Modules connected to a LIN bus will generally have a single pin for each LIN bus application, although two pins are allowed.
- SW CAN.** Modules connected to the SW CAN bus will generally have two bus pins to support linear, ring, star, and combination bus topologies.
- DW CAN.** Modules connected to the DW CAN will generally have two sets of internally spliced serial data bus pins to allow the wiring to be implemented as a module to module "daisy chain". Pin count exceptions may exist for modules that contain a terminating resistor or that utilize industry standard module hardware.
- FlexRay.** Modules connected to the FlexRay bus will have two sets of internally spliced serial data bus pins for each FlexRay channel to allow the wiring to be implemented in a module to module backbone.
- MOST50.** Modules for the MOST bus will have a single set of specific serial data bus pins for "transmit" (Tx) and "receive" (Rx) that are not internally connected and that are not interchangeable.
- Ethernet.** A gateway module will have specific Ethernet Tx and Rx pin pairs for the 100BASE-TX connection to the DLC. Modules that are part of an onboard OPEN (One-Pair Ether-Net) Alliance Special Interest Group (SIG) Ethernet network will only have one set of bidirectional bus pins if they do not contain an internal Ethernet switch, but may have two or more sets of bidirectional bus pins if they contain a switch.

3.3.3.2 Pin Assignment Locations.

Circuit pairs for dual wire serial data busses shall be located in adjacent cavities at device and inline connectors to minimize signal EMC coupling issues (see Figure 3).

If possible, serial data circuit connector cavities should be located as far away as possible from connector cavities for potential crosstalk with victim and threat circuits. Victim circuits are sensitive circuits that could be affected

by electrically and magnetically coupled "cross talk" from serial data circuits. Threat circuits are high current and/or high frequency circuits that could couple noise into serial data signals.

- Ethernet Pair.** Each Ethernet UTP, Unshielded Twisted Pair, shall occupy horizontally adjacent cavities within each connector assembly to reduce loop area and minimize the impact on characteristic impedance.
- Ethernet Pair to Ethernet Pair.** Different Ethernet UTPs shall not utilize adjacent connector cavities. The recommended minimum spacing of Ethernet pairs shall be diagonally adjacent using a "zig zag" pattern. If in the same row, a least one empty cavity shall be provided between Ethernet UTPs.
- Ethernet Pair to Other Circuits.** All connector cavities horizontally or vertically adjacent to Ethernet circuits should be empty. If non-empty cavities adjacent to Ethernet UTPs are unavoidable, additional testing is required to confirm RL, XT, and DBCI requirements are still met. However, adjacent cavities shall never contain a Ground or Low Reference circuit.

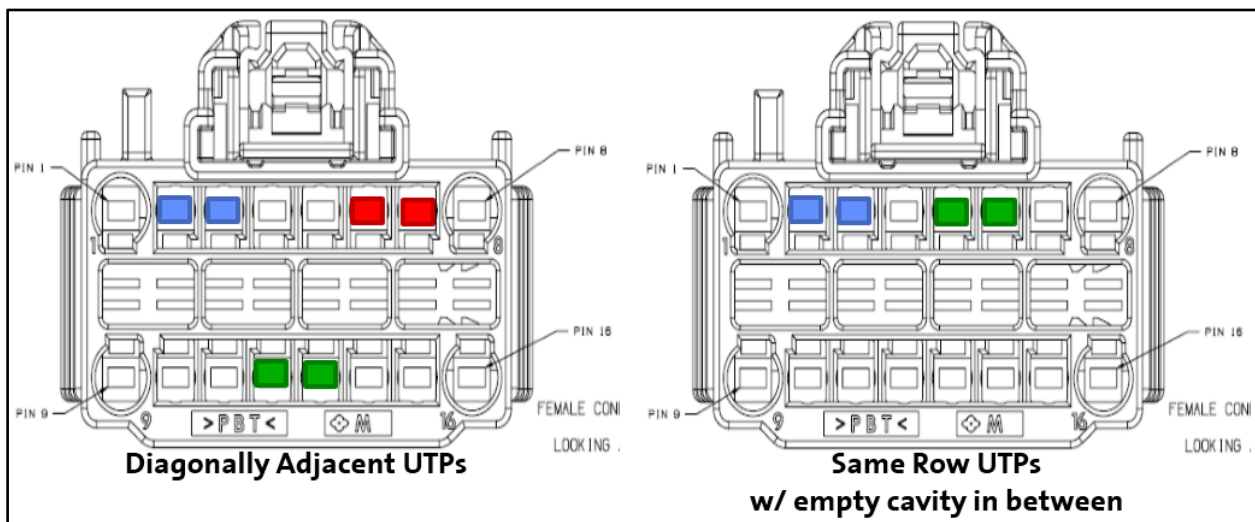


Figure 3: Ethernet Pair Pin Assignment Locations

3.4 Serial Data Bus Content Integration into Vehicle Wiring.

3.4.1 Topology Requirements.

3.4.1.1 Number of Nodes.

Each serial data bus is designed to support a different maximum number of nodes on the vehicle, not including a service tool. See the Tables A1 through I1 in corresponding Appendices for the specific node limit requirements.

3.4.1.1.1 Master and Slave Nodes.

Each instance of a LIN bus shall have a single Master node and shall support one or more Slave nodes as defined in Table A1 in Appendix A.

3.4.1.1.2 Unit and Primary Nodes.

The Single Wire Can bus shall be comprised of Unit and Primary Nodes that have different internal resistances as defined in GMW3089. The maximum number of total nodes shall be reduced by one for each Primary node used.

3.4.1.2 Topology.

Each serial data bus is designed to support one or more different wiring topologies as defined as follows. See the Topology Diagrams in Appendices A, B, D, E, F, G, H and I for the specific topology options and requirements for each serial data bus.

- Linear.** A "linear" serial data bus topology has the modules connected in series from one end to the other. Some serial data bus types require a linear topology.