MIL-STD-1553 Tutorial

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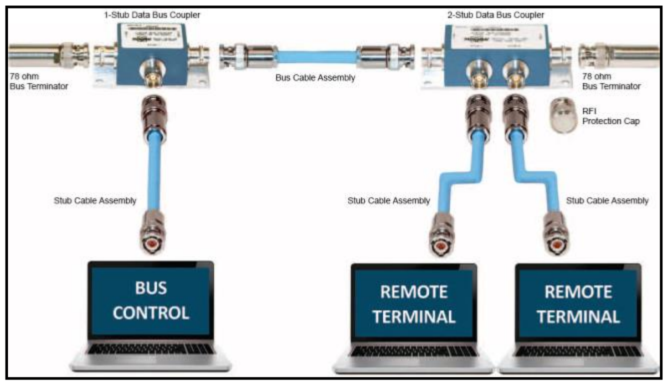
MIL-STD-1553 a Brief History

The digital data bus was designed in the early 1970’s to replace analog point-to-point wire bundles between electronic instrumentation. The latest version of the serial local area network (LAN) for military avionics, currently known as MIL-STD-1553B, was issued in 1978. After 35+ years of familiarity and reliable products, the data bus continues to be a popular militarized networking solution.

MIL-STD-1553B Bus Elements

A bus controller manages the information flow. Remote terminals interface with one or more simple subsystems to the data bus and respond to commands from that bus controller. A bus monitor is used for testing the data bus. The data bus is comprised of couplers, terminators, twinaxial cable assemblies and other accessories.

Data Bus LAN Topology



Bus couplers serve as coupling transformers with fault-isolation resistors. Bus and/or stub terminators are used either at the end of the bus, or on individual stubs. 78 ohm twinax cabling is used with concentric twinax connectors (with a center contact and an intermediate cylindrical contact) to create the connecting cable assemblies.

Box-Type Bus Coupler Configurations

- 1-8 stubs
- Single, dual or non-terminated
- Aluminum or steel casing

Inline-Type Bus Coupler Configurations

- 1-4 stubs via M17/176-00002 cable leads
- Single, dual or non-terminated

MIL-STD-1553B Data Bus Requirements

Communications Line	
Cable Type	Two-conductor twisted pair
Capacitance	30 pF/ft. max.
Twist	4 per ft. min.
Characteristic Ω (Z0)	70 to 85 ohms @ 1 MHz
Attenuation	1.5 dB/100 ft. @ 1 MHz max
Bus Length	Not specified
Termination	2 ends terminated in resistors = (Z0±2%)
Shielding	90% coverage minimum, 90% dual standby redundant
Cable Coupling	
Stub Length	Up to 20 ft. (may be exceeded)
Stub Voltage	1 to 14V p-p amplitude, line-to-line min. signal voltage, transformer coupled
Coupler Transformer	
Turns Ratio	1.41:1
Droop	<20% at 27V p-p 250 kHz square wave
Overshoot & Ringing	<+1V at 27V p-p 250 kHz square wave
Common Mode Rejection	>45 dB @ MHz at 27V p-p 250 kHz sq. wave
Fault Protection	Series resistors = 0.75 (Z0±2%)

Purpose & Application of Bus Couplers

The purpose of the bus coupler is to reduce reflections and maintain signal impedance levels. Since directly coupled devices (without couplers) do not provide any DC isolation or common mode rejection, direct connection to the bus should be avoided. Should these directly coupled devices have any shorting fault between the internal isolation resistors (which are usually found on the circuit board) and the main bus, the entire bus will experience failure because the device's internal isolation resistors are not sufficient to ensure against the bus shorting out.

The bus couplers have such built-in fault isolation resistors providing protection for the main bus in the event of a short circuit in the stub. All devices, including the bus controller, bus monitor and remote terminal, must be connected to the stub ends of the coupler.

Both ends of the bus must be terminated with 78 ohm terminators, whether it includes a single coupler or a series of couplers connected together. Some couplers have built-in terminators and are generally used at the end of the bus in multi-coupler applications. These types of couplers can be either single or dual-terminated, and are mainly for vehicle applications, as they limit the flexibility of lab test set-ups. In a lab application, the unused stub ports on the coupler do not need to be terminated since the stubs have a higher impedance than the bus. A high impedance terminator (1000 to 3000 ohms) may be used in vehicle applications to simulate a future load from an unspecified device. In both lab and vehicle applications, an RFI cap over the unused stub is a deterrent to interference and dust.

Bus Length Considerations

MIL-STD-1553B does not specify the length of the bus. That being said, the maximum length of the bus is directly related to the gauge of the cable conductor and time delay of the transmitted signal. A smaller conductor attenuates the signal more than a larger conductor. Typical propagation delay for a 1553B cable is 1.6 nanoseconds per foot. Thus, a 100 ft. (end-to-end) bus would have a 160 nanosecond propagation delay, which is equal to the average rise time of a 1553B signal. This delay time is proportional to the distance propagated. According to MIL-HDBK-1553A, when a signal's propagation delay time is more than 50% of the rise or fall time, it becomes necessary to consider transmission line effects.

Waveform Characteristics (varying distance)

Consideration must be given to the actual distance between the transmitter and receiver, as well as the individual waveform characteristics of said transmitters and receivers.

MIL-STD-1553B specifies that the longest stub length is 20 feet for transformer coupled stubs, but can be exceeded. With no stubs attached, the main bus acts as a transmission line with infinite length without disturbing reflections. When a stub is added, the bus is loaded and a mismatch occurs with resulting reflections.

The degree of mismatch and signal distortion due to reflections are a function of the impedance presented by the stub and terminal input impedances. To minimize signal distortion, it is desirable that the stub maintain high impedances. This impedance is reflected back to the main bus, so at the same time the impedances must be kept low so that an adequate amount of signal power can be delivered to the receiving end. For this reason, a trade-off between these conflicting requirements is necessary to achieve the specified signal-to-noise ratio and system error rate performance (for more information, refer to MIL-HDBK-155A).

Cable Type

Typically, the cable used to connect the bus and stub devices has a characteristic impedance of 78 ohms at 1 MHz. FEP and PFA jacket high-temperature cable are used in vehicles, while the PVC jacket cable is more suitable for lab use.

Connector Types

TRB - There are several types of connectors used on the bus and at the coupler stubs, the most common of which is the concentric twinax connector. These connectors typically have three bayonet coupling slots (plugs) or lugs (jacks) known as TRB type, which have the same envelope size as a coaxial BNC connector. The center contact is high (positive) connected to the twinax blue wire and the cylindrical contact is low (negative) connected to the twinax white wire. The body of the connector is the bus shield.

TRS - There is a subminiature version of the twinax concentric connector known as TRS type (same envelope size as TPS coaxial connectors).

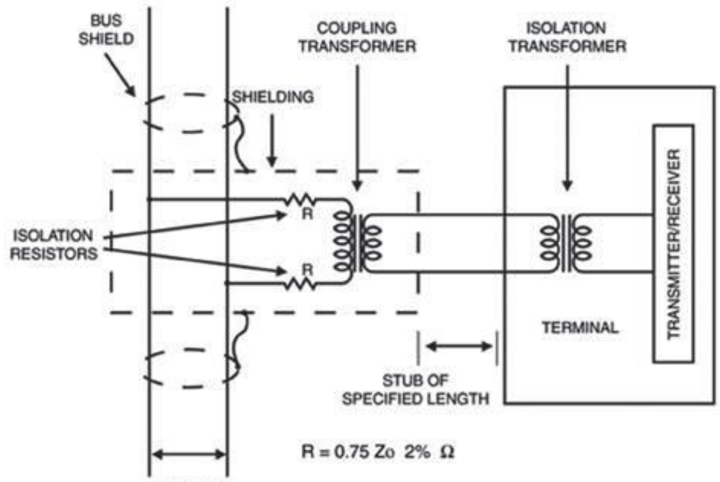
Common Mating Interface Types

Two-bayonet, three-bayonet, four-bayonet, and threaded.

Other Connector Options

D-subminiature, cylindrical, and proprietary.

Systems designers must be aware of cable compatibility of connectors and availability of components before finalizing the design of a data bus system.



Data Bus Interface Schematic

MilesTek designs and manufactures a broad range of MIL-STD-1553B products to address Military Avionics, Aerospace, Industrial and government applications. In addition to a wide selection of off the shelf products, MilesTek can custom manufacture cable assemblies and harnesses. MilesTek is headquartered in Lewisville, Texas and is AS9100C and ISO9001:2008 certified.

MilesTek is an Infinite Electronics company