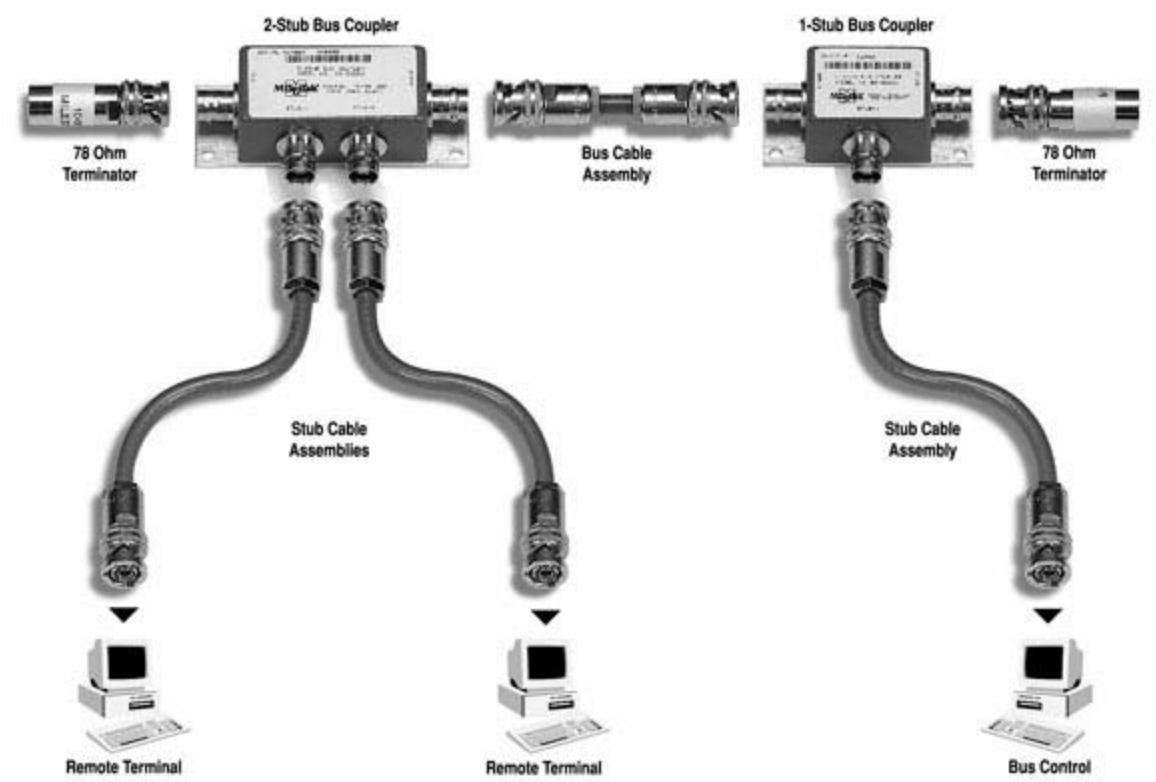
MIL-STD-1553B Introduction

The digital data bus MIL-STD-1553 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 known as MIL-STD-1553B was issued in 1978. After 20 years of familiarity and reliable products, the data bus continues to be the most popular militarized network.



The MIL-STD-1553B bus has four main elements: (1) a bus controller that manages the information flow; (2) remote terminals that interface one or more simple subsystems to the data bus and respond to commands from the bus controller; (3) the bus monitor that is used for data bus testing; (4) data bus components (bus couplers, cabling, terminators and connectors). Data is sequentially transmitted and received in a multiplexing scheme over two copper wires from computer to computer at a bit rate of 1 megabit per second. In most vehicle applications, redundant buses are employed.

From the data bus components hardware LAN point of view, the topology encompasses bus couplers (coupling transformers with fault-isolation resistors), terminators and cabling that includes twinax cable (twisted shielded pair) and concentric twinax connectors (with a center contact and an intermediate cylindrical contact).

Bus couplers are available in various configurations from single stub to multi-stub box type and in-line type. The in-line type is used in vehicles where light weight and small size are important. The purpose of the coupler is to reduce reflections and maintain signal impedance levels. Since direct coupled devices (without couplers) provide no DC isolation or common mode rejection, direct connection to the bus should be avoided. Without couplers, any shorting fault between the device's internal isolation resistors (usually found on the circuit board) and the main bus will cause failure of the entire bus. In other words, the device's internal isolation resistors are not sufficient enough to ensure against shorting out the bus. In addition to transformers, the bus couplers have built-in fault isolation resistors providing protection for the main bus in event of a short circuit in the stub. All devices such as the bus controller, bus monitor and remote terminal must be connected to the stub ends of the coupler.

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

MIL-STD-1553B does not specify length of the bus. However, the maximum length of 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 the end-to-end 100-ft. bus would have a 160 nanosecond propagation delay, which is equal to the average rise time of a 1553B signal. According to MIL-HDBK-1553A, when a signal's propagation delay time is more than 50% of the rise or fall time, it is necessary to consider transmission line effects. This delay time is proportional to the distance propagated. Also, consideration must be given to the actual distance between the transmitter and receiver, and the individual waveform characteristics of the transmitters and receivers. Similarly, the longest stub length is specified at 20 feet for transformer coupled stubs, but can be exceeded. With no stubs attached, the main bus looks like an infinite length transmission line with no 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 impedance. To minimize signal distortion, it is desirable that the stub maintain a high impedance. This impedance is reflected back to the main bus. At the same time, however, the impedance must be kept low so that adequate signal power will be delivered to the receiving end. Therefore, a tradeoff and compromise among 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-1553A.

MIL-STD-1553B Data Bus Requirements

Communications Line:

Cable Type:	Two-conductor twisted pair
Capacitance:	30 pF/ft. max.
Twist:	Four per foot min.
Char. Impedance:	(Zo) 70 to 85 ohms at 1 MHz
Attenuation:	1.5 dB/100 ft. @ 1 MHz max.
Bus Length:	Not specified
Termination:	Two ends terminated in resistors = (Zo) ± 2%
Shielding:	90% coverage min., 90% dual standby redundant

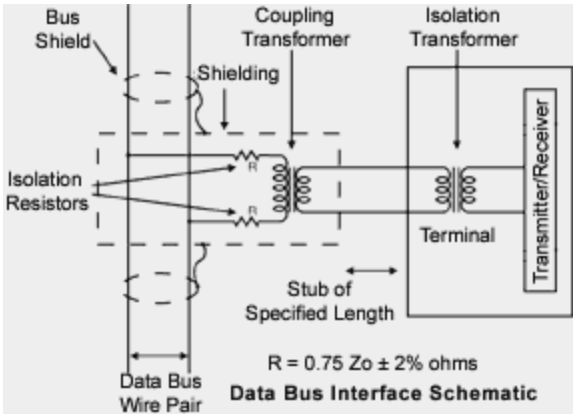
Cable Coupling:

Stub Length:	Up to 20 feet (may be exceeded).
Stub Voltage:	1-14V p-p amplitude, line-to-line min. signal voltage, transformer coupled
Coupler Transformer:	Turns Ratio 1.41:1 Droop <20% (1)
Overshoot/Ringing:	<+1V (1)
CMR:	>45 dB at 1 MHz (1)
Fault Protection:	Series resistors = 0.75 Zo ± 2% ohms

Notes:
(1) at 27 V p-p 250 kHz square wave.
CMR = Common Mode Rejection

Typically, the cable used to connect the bus and stub devices has a characteristic impedance of 78 Ohm at 1 MHz. Plenum rated cable is used in vehicles while the PVC jacket cable is suitable for lab uses.

The most commonly used connectors on the bus and at the coupler stubs generally are concentric twinax connectors, which have three bayonet coupling slots/lugs known as TRB type (same envelope size as a coaxial BNC connector). In concentric connector applications, 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 bus shield. However, sometimes coupling types on the bus and stubs may be the less common two-bayonet, four-bayonet and threaded styles. There is another type of twinax concentric connector known as TRS size, a subminiature size that is smaller than TRB and the same size as TPS coaxial types. Also one other less common subminiature connector is sometimes used; this type has a proprietary design with various keying and contact arrangements. Since bayonet type connectors do not require safety wiring and can withstand severe shock and vibration, they are preferred over threaded types. Furthermore, the connectors on bus controllers, bus testers and remote terminals may be D-subminiature or cylindrical type; in this case, a hybrid cable assembly must be built to interface to the coupler. Therefore, the systems designer must be aware of cable compatibility of connector and availability of these components before finalizing the design of a data bus system.



Data Bus Interface Schematic

MilesTek MIL-STD-1553B Components

The bus coupler is connected between MIL-STD-1553B bus and bus devices (controllers, monitors and terminals). The purpose of a bus coupler is to reduce reflections, protect the bus and maintain impedance of the bus by employing a transformer and a pair of fault-isolation resistors. The transformer with turns ratio of 1.41:1 maintains the 78 ohm impedance of the bus while the resistors protect the bus from potential shorts from devices on the stub. The MIL-STD-1553B standard recommends that coupling devices connected directly to the bus without bus couplers should be avoided because of the potential hazards of direct connections and very limited stub lengths (less than 1 foot). Terminators or self-terminating couplers must be used at both ends of the bus.
MilesTek bus couplers are available in 1- through 8-stub compact models. These bus couplers utilize off-the-shelf components resulting in quick delivery and reduced prices. Coupler transformers and resistors meet mil spec requirements. Superior in design to competitive models that use open coils, MilesTek bus couplers employ encapsulated transformers for maximum performance and reliability. Featured in the 2- through 8-stub bus couplers, printed circuit cards hold transformers, resistors and connector leads to prevent the possibility of shorting and breaking internal components during use. Furthermore, after couplers are assembled, a potting compound with low out-gassing characteristics permanently secures all components in place.

In accordance with MIL-HDBK-217F Military Handbook for Reliability Prediction of Electronic Equipment, two different mean time between failure (MTBF) values have been calculated for each bus coupler based on environmental conditions. For lab use, the benign ground calculation was based at 30°C. The second value is predicated on the employment of bus couplers in extreme conditions of 130°C in high-performance aircraft fighters such as the F-15, F-16, F-11, F/A 18 and A10. Values are expressed in hours.

Furthermore, MilesTek couplers have been tested by Test Systems, Inc. in accordance with SAE AS4117 to confirm meeting MIL-STD-1553B specifications.

General Specifications

Transformer Turns Ratio:	1.41:1
Fault Isolation Resistors (Non-Inductive):	59 Ohm, 2 Watt 1%
Operating Temperature:	-55°C to +130°C
Overshoot/Ringing:	±1.0V max.
Droop:	less than or equal to 20%
Min. Primary Open Impedance (Ohms):	1 Stub - 3000 2 Stub - 1500 3 Stub - 1000 4 Stub - 750 5 Stub - 600 6 Stub - 500 7 Stub - 430 8 Stub - 375
Connectors:	TRB 3-Lug Jacks

MTBF Ratings

Bus Coupler Type & Part Number	Benign Ground	Inhabited Air
1-Stub, 90-50201	26,282,590	3,604,240
2-Stub, 90-50202	14,625,870	1,906,970
3-Stub, 90-50203	10,144,045	1,301,702
4-Stub, 90-50204	7,764,699	1,002,667
5-Stub, 90-50205	6,289,466	802,574
6-Stub, 90-50206	5,246,920	672,710
7-Stub, 90-50207	4,557,636	579,020
8-Stub, 90-50208	4,006,089	508,236