MIL-STD-1553 Networks Made Simple

BETA TRANSFORMER TECHNOLOGY CORPORATION
A subsidiary of Data Device Corporation

Application Note

AN/252

A MIL-STD-1553 data bus network is simply a local area network originally conceived for aircraft and now used on satellites, rocket launchers, land vehicles, ships and ground stations.

The bus itself is a twisted shielded pair of conductors having a characteristic impedance of 77Ω1. Since it is a balanced transmission line optimized for 75 kHz to 1 MHz, each end must be terminated in a non inductive resistor of 77Ω1. If it is not terminated the signals will be reflected back down the bus causing distortions on the data waveform which can cause a high error rate. The longer the bus and the more stubs on it the more likely to be a higher error rate. Most commercial terminators are 78Ω since that is the closest standard value. The value of the resistor is not very critical, usually ± 1 or 2 %. The cable itself can vary from 70 to 85Ω. For worst case conditions, the terminator should be rated for at least 1/2 Watt and preferably 2 Watts for a good margin of safety at high duty cycles and temperatures. Carbon resistors should be avoided because of their high temperature coefficients.

The shield provides EMI protection–both susceptibility and radiated. For most applications a single shield is adequate but for flight critical applications double shielding may be used, or even double shielding with a mu-metal wrap for EMP protection. As you may surmise, the cable gets stiffer and more difficult to work with as more shields are added with weight and cost also increasing.

Notice 2 to the standard requires all USAF applications connect subsystems and equipment to the bus via a transformer and two resistors (called a coupler) to provide isolation from the bus. There is a transformer in the equipment and one in the coupler. The two resistors in the coupler are for fault isolation so a short circuit on the stub or in the equipment cannot drag down the whole network. See figure 1. These resistors vary from 52 to 59Ω depending on the manufacturer and system. Their value is not critical to the operation of the bus. There is one in each leg between the bus and the transformer. These also should be rated for at least 1 Watt and be non inductive.

There is no specified maximum length to the data bus but they are generally held to less than 300 feet. Maximum practical length is governed more by the number of stubs on the bus and the resistance of the conductors. There are buses that work at lengths of over 1000 feet and buses that barely work at 300 feet. The 1000+ foot buses generally have only 2 or 3 stubs. In general shortness is goodness and minimizing the number of stubs reduces the likelihood of having problems. For longer buses the use of 22 AWG or even 20 AWG wire is recommended to reduce resistive losses.

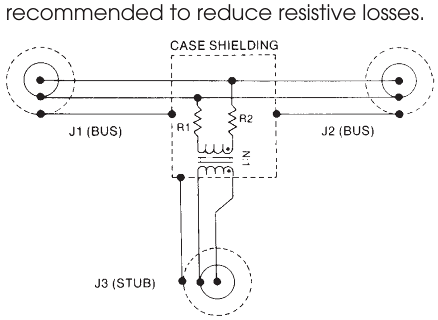


Fig. 1. Transformer-Coupled Data Bus Coupler Schematic.

Stub lengths should be held to 20 feet maximum. As with the bus, shortness is goodness. Short buses with few stubs can tolerate longer stubs better than long buses with many stubs. And, as with buses, there are networks that have excessive stub length and perform effectively, but as a general rule long buses, many stubs and long stub length usually lead to trouble because signal levels are reduced by the heavy load the total stubs present, the resistive drop of the conductors and the more reflections occurring at each coupler, splice connector and any other mismatch in the system. Higher reflection levels combined with low signal level is a recipe for problems.

It should be noted that triaxial connectors, although rated at 75Ω, do not have balanced capacitance and the bus is a balanced transmission line. The capacitance between the center pin and the outer shell (ground) is much less than the capacitance between the inner shell and the outer shell. For this reason the number of connectors on the bus or stubs should be kept to a minimum.

Many systems build in extra stubs, either as maintenance ports or for future growth. If this is done it is recommended all validation or qualification testing be performed with a dummy load on the unused stubs to present a worst case situation. The dummy load is usually between 1000 and 3000Ω but should be chosen to represent the actual impedance of the stub cable and equipment that may eventually be connected to it. Once the system has completed the verification testing the dummy load can be replaced with a dust cap. This will generally result in a slightly higher signal level giving an additional margin of performance. Again, the dummy load should be a non inductive resistor rated for at least 1/2 Watt. The dust cap is to keep EMI out and to keep the mating surfaces clean.

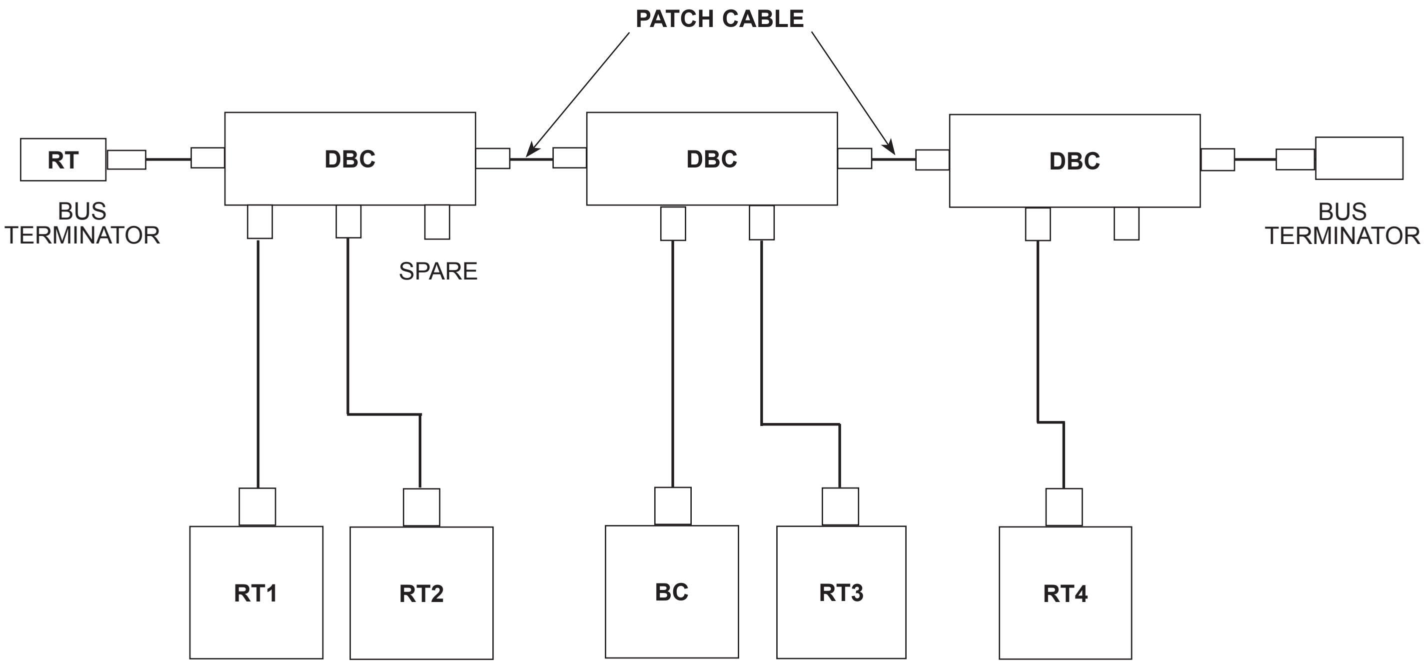
In the beginning, when 1553 was new and experience sparse, multi-stub couplers were avoided because it was thought the reflections due to the larger discontinuity (of 75Ω) would be too large. These fears have proven to be overstated and now 4 and 5 stub couplers are common and some systems use 10 stub couplers. Also becoming common in short bus systems with minimal stub count is the practice of using a multi-stub coupler with internal terminators and no external bus leads. The bus then appears as a star system. The advantages to this approach are lower parts count, lighter weight and improved reliability due to the elimination of bus connectors associated with the terminators.

When testing 1553 networks it must be kept in mind that the network has transformers and it is a balanced transmission line. Any test method must address these two facts. Neither an ohmmeter nor a TDR (time domain reflectometer) is entirely suitable. Even a properly working system does not mean the network is fault free. A conductor to shield short may only cause high error rates under certain EMI conditions, with the system working fine the rest of the time. With a short to shield in a balanced system the unshorted conductor will still carry the data (albeit at a reduced level) but it will no longer be shielded and will be susceptible to EMI.

North Hills™

As you can see, 1553 networks are deceptively simple. They are very robust and forgiving. But, as with most things, if you break too many rules or stretch too many parameters you can run into trouble. The best thing to do then is to look at what you have and decide how you can incrementally improve it by reducing the stretches while not breaking as many rules.

Typical Mil-Std 1553 Network



SAI GLOBAL AS9100 Aerospace
SAI GLOBAL ISO 9001 Quality

For ordering assistance and technical support,
E-Mail: service@BTTC-Beta.com
Visit: BTTC-Beta.com Data Device Corporation
Call: HQ, N.Y., U.S.A (631) 224-7393
UK +44-(0)1635-811140
France +33-(0)1-41-16-3424
Germany +49-(0)89-1500-12-11
Japan +81-(0)3-3814-7688
Asia +65-6489-4801
India +91 80 46797 0368