

## Finding Faults in MIL-STD-1553 Harnesses

In the past, many system problems have been investigated at the equipment and software level when the real culprit has been a faulty harness, either in a failed connector joint or kinked/crushed cable. Often the act of connecting and disconnecting the equipment or replacing the equipment is enough to disturb the harness enough to make the problem appear or disappear. Such a problem can be chased for many hours before the wiring technician decides to check the bus harness or cable itself.

Historically, MIL-STD-1553 networks and harnesses have been checked out using Time Domain Reflectometers (TDRs), ohmmeters, continuity checkers and the like, with varying degrees of success and lack thereof.

To understand the “lack thereof” let us review what we need to check to ensure that the network or harness is functioning properly. We need to check for:

1. Insertion loss from one stub to the next in the 75kHz-to-1MHz spectrum
2. Open Circuits
3. Short Circuits
4. Short to shield on the bus and on the stubs
5. Crossovers - i.e., miswiring of the high and low, resulting in a phase change.

Since access to the couplers and main bus itself may be difficult, it would also be useful to detect these problems and make the measurements from an end of the harness that is easily accessible. That end is usually the bus stub end where the stub connects to a line replaceable unit or other piece of equipment.

An ohmmeter, or continuity checker, can check for continuity of wires and shields. It cannot check for insertion loss or transformer integrity in the coupler. Because the ohmmeter is a DC instrument it cannot check the other side of the transformer or bus side of the harness, it can only check the portion of the stub circuit it is connected to. Hence ohmmeters or continuity checkers are of limited use. They also require direct access to every wire or cable. Since the measurements are DC, the confidence level is low even if everything checks out. So the results may not be worth the effort.

A TDR will give you more information than the continuity checker, since it is an AC tester. It works by transmitting pulses down the cable to be measured and looks for reflections caused by discontinuities in the cable's impedance. It works well on coaxial cables when you are trying to locate a break or short on a long line. But in a complex MIL-STD-1553 shielded twisted-pair cable network or harness, locating the discontinuity may be only of limited value. Also, as with the continuity tester, the TDR can only measure on single lengths of cable.

In a branch network or harness TDRs cannot:

1. Measure insertion loss between stub ends
2. Make measurements in the 75kHz-to-1MHz spectrum
3. Differentiate between closely located stubs
4. Differentiate between a 3K ohm terminator or equipment load and an open circuit at the connector
5. Detect a short to shield
6. Detect a crossover/miswiring
7. Detect a transformer or isolation resistance problem

Additionally, the reflections can be difficult to interpret in branched networks. They can be the source of some information, but the confidence level in finding anything other than a severe problem will be low.

### WHAT THE DBT500A OVERCOMES

In response to these problems, North Hills has developed a portable DBT500A MIL-STD-1553 harness tester, designed for use in rugged environments. The DBT500A is designed to test all the parameters necessary for high confidence in a 1553 network.

The DBT500A checks the following items:

1. Measures insertion loss from stub to stub from the equipment end of the stub leads. Measured at  $5.5V_{P-P}$  @ 200kHz. This read out is in dB's.
2. Detects shorts and opens in the stubs and main bus from stub ports
3. Detects shorts to shield in the bus and stubs from the stub ports

4. Detects missing, shorted or incorrect value terminators
5. Detects a crossover/miswiring

All these measurements are go/no go type tests, except for the insertion loss measurement, which reads out in dB on an LCD display

The DBT500A is battery powered and will run for 24 hours on an overnight charge. It has a separable transmitter section for measurements between remotely located stub ends. This enables one-man operation. A storage compartment is provided in the lid for the power cord and test cables.

All tests and checks are done with A/C, thereby checking for faults in the spectrum in which the bus operates, including checking the transformers in the couplers. The entire network can be A/C tested from the stub cable ends, including shorts to shield on the main bus.

In short, the DBT500A harness tester can check out a MIL-STD-1553 network with very high level of confidence in a minimum amount of time, since access to the main bus is not required.

### THE DBT500A OPERATION

In practice, the DBT500A is used to make a series of checks (go/no go) and insertion loss measurements from one stub to all the others, comparing the results in a simple look-up table that contains a "Golden" reference set of data (see Table 1). You can then pinpoint the nature and location of any problems sufficient to replace the faulty replaceable cable, harness section or coupler. The test results are clear an unambiguous. They do not call for "interpretation".

The DBT500A operates by means of menu-prompted software controlled by four push buttons on the receiver unit and offering three modes of operation:

**Automatic-** Performs all tests automatically, allowing the user to test the ENTIRE harness and display a Results Summary of conditions found.

**Manual-** Allows the user to perform an individual test on the harness.

**Continuous Monitor-** Also known as the "Wire Wiggle" mode, allows the user to perform an individual test while searching for the intermittent fault.

The Transmitter (TX) module has two modules of operation, Normal and screen, controlled by the toggle switch. In the "Screen Test" mode the DBT500A will check

for shorts to the screen/shield on the loop of the main bus and the stubs that are connected.

When Power is turned on, the DBT500A, using an advanced microprocessor design, performs a series of self tests and calculates the transmitter/receiver offset, before prompting the user for the mode of operation and eliminates the need for routine calibration.

### AUTOMATIC AND MANUAL MODES

In an actual test situation it is recommended that the first test to be performed be the screen/shield test, in the screen test mode, between the stubs at each extreme of the bus; thereby checking the entire main bus with one measurement. The unit can be then be put to into the "normal mode" (move the TX switch to NORM) to perform all the remaining tests without changing TX modes.

Should fault be found in the screen/shield test mode, it can be located to a particular cable segment by progressively moving the main instrument from one stub to another until the fault is isolated. For complex buses, a successive approximation type technique can speed things up. In this technique you have the TX section fixed at the last stub of the bus and move the main box (the receiver or RX) from the other end to the middle stub. If the problem is still detected, continue moving the box to the middle stub of the loop being tested. If the fault goes away go in the other direction.

Once the loop with the fault has been identified, the TX section can be switched to the normal mode (TX mode switch to NORM). If the fault cannot be detected in the normal mode, the short to shield is on the main bus segment of the loop. If it can be detected using the high, and low screen test mode on the receiver/main box, then the fault is on the stub connected to the input of the receiver/main box.

Don't forget to check the stub connected to the Tx section by reversing the input and output connections by using a known good stub as the Transmitter (Tx) and the original Transmitter stub as the Receiver (Rx). It should be remembered that in the normal mode the DBT500A screen/shield test results apply only to the stub line connected to the receiver, while in screen/shield test mode (TX screen switch ON) the result applies to the whole loop between the transmitter and receiver connections.

### CONTINUOUS MONITORING MODE

In both the automatic and manual modes of operation, the

DBT500A steps through a series of test on the cable harness, whereas in Continuous Monitoring Mode the user is able to identify the intermittent problem, which may only be apparent when the harness is flexed. In this mode the DBT500A will indicate with a PASS/FAIL display for each of the tests. To aid the user in searching for the intermittent problem, the FAIL indication may be “frozen” on the screen for up to 30 seconds after the fail condition has cleared. The DBT 500A also displays a FAIL COUNT, which is updated even with the display “frozen”.

### FAULT DISPLAYS

Should a fault be detected in the harness, the DBT500A will automatically display possible causes of the failure. In automatic mode, the user has the option of continuing with the testing of the harness or aborting the test fault to find the cause of the failure.

### USEFUL INFORMATION

Some other Items of interest that may be helpful in trouble shooting a harness are:

1. A normal insertion loss between two stub cable ends is  $12.1 \pm .3$  dB.

2. A missing or open terminator or dummy load (3K ohm), instead of a terminator, will drop the insertion loss by about 6 dB. If both are missing, open or the wrong value, the insertion loss will be even less.
3. A reading of more than 12.5 dB insertion loss usually means there is a short on the main bus some distance from the loop being measured. The higher the reading, the closer the short.
4. If your system uses dummy loads on unused stubs (they are usually 2k-3k terminators) and your bus traffic signals are on the high side with bad reflections, first check that one of the dummy loads wasn't inadvertently used as a bus terminator. A proper terminator should be  $78 + 10$  ohms.

### “GOLDEN” TEST RESULTS

When using the DBT500A it is recommended that you establish a “Golden” reading reference set, in dB for each bus, using Table 1 below. This set of readings is to be kept with the system.

**Table 1: “Golden” Reference Data Set**

Stub 1 to	dB Reading	Pass/Fail	Screen Tests		
			H	L	Bus
T1					
Stub 2					
Stub 3					
Stub 4					
Stub 5					
Stub 6					
Stub n					
T2					
Stub 2 to Stub 1					

Notes: Take readings with the system not powered. RTs and BCs may be connected or disconnected but note the condition under which the readings were taken to ensure repeatability in the future. Dual redundant buses should have similar readings