



AEROSPACE STANDARD

AS4115™

REV. A

Issued 1989-01
Reaffirmed 2011-11
Stabilized 2017-08

Superseding AS4115

Test Plan for the Digital Time Division Command/Response Multiplex Data Bus System

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1. SCOPE:

This test plan consists of two major sections for testing of MIL-STD-1553B data bus systems: Bus Network and System Integration Tests.

1.1 General: This test plan defines the test requirements for:

- a. Verifying that the bus network, (that is, cabling, couplers, connectors and terminators) when in the final system design configuration, complies with the requirements of MIL-STD-1553B.
- b. Ensuring that when the bus system (that is, bus network, remote terminals and bus controllers) is integrated, it meets the specific requirements of MIL-STD-1553B, and provides for reliable communications within its system environment.

1.2 Application: This is a general test plan for any data bus system designed to meet the requirements of MIL-STD-1553B. These requirements shall apply to the bus system when invoked in a specification or statement of work. The requirements of this test plan may be used in both design verification and production tests.

Tests specified herein may be performed in any order unless otherwise noted. For example, to minimize movement of test equipment, system tests may be combined with one another or combined with other tests of the system in which the data bus is used.

When this test plan is used for design verification, all remote terminal and bus controller designs should have been validated as per the "Validation Test Plan for the Digital Internal Time Division Command/Response Multiplex Data Bus Remote Terminals" and "Validation Test Plan for the Digital Internal Time Division Command/Response Multiplex Data Bus Bus Controllers."

When this test plan is used for production testing, all remote terminal and bus controller equipment should have been tested as per the "Production Test Plan for Digital Internal Time Division Command/Response Multiplex Data Bus Remote Terminals" and "Production Test Plan for the Digital Internal Time Division Command/Response Multiplex Data Bus Bus Controllers."

Special requirements such as those needed to meet armament bus requirements when specified in the individual system specification may, when within 1553B requirements, replace values or tolerances specified in this test plan for the purpose of generating a system test procedure.

2. APPLICABLE DOCUMENTS:

2.1 Standards, Military:

MIL-STD-1553 (USAF), Aircraft Internal Time Division Command/Response Multiplex Data Bus, 30 Aug. 1973

MIL-STD-1553A, 30 Apr. 1975

MIL-STD-1553B, 21 Sept. 1978 with Notice 1, 12 Feb. 1980 and with Notice 2, 8 Sept. 1986

2.2 Other Documents:

- a. SAE AS 4113, Validation Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Bus Controllers
- b. MIL-HDBK-1553 Notice 1, 24 September 1986, Validation Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Remote Terminals
- c. SAE AS 4114, Production Test Plan for the Time Division Command/Response Multiplex Data Bus Controllers
- d. SAE AS 4112, Production Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Remote Terminals

3. DEFINITIONS:

- 3.1 BC - Bus Controller: As defined in the paragraph titled "Bus Controller" of MIL-STD-1553.
- 3.2 RT - Remote Terminal: As defined in the paragraph titled "Remote Terminal" of MIL-STD-1553.
- 3.3 Message: A single message is the transmission of a command word, status word and data word(s) if they are specified. For the case of a remote terminal to remote terminal (RT-RT) transmission, the message shall include the two command words, status word(s) and data word(s).
- 3.4 Responses: The following are definitions of RT responses as used in this test plan. In each case, the status word must have the correct terminal address and unused status bits set to zero.
 - 3.4.1 CS - Clear Status: The status word may have the busy bit or service request bit set, or both. All other status code bits in the status word must be zero and the associated message must have the proper word count.
 - 3.4.2 Respond in Form: A remote terminal is said to "respond in form" if its response to an illegal command as defined in the "Illegal Commands" paragraph of MIL-STD-1553B consists of a response formatted as though it were a legal command.
- 3.5 Valid Word: A valid word is one which conforms to the criteria of the "Word Validation" paragraph of MIL-STD-1553B.
- 3.6 Illegal Bus Traffic: That traffic which consists of illegal commands and the data and responses associated with those commands.
- 3.7 Backup BC: Backup BC is here defined as a terminal on the bus that has the capability to become primary BC.

4. GENERAL TEST REQUIREMENTS:

The following paragraphs define the configurations, pass/fail criteria, and general procedures for testing data bus systems. Specifically, this document contains the test configurations and procedures for the Bus Network Tests (5.1) and the System Integration Tests (5.2) for MIL-STD-1553B data bus systems.

4.1 General Monitoring Requirements: In addition to the specific tests that follow, certain terminal parameters must be continuously monitored throughout all system integration tests. These parameters are:

- a. Remote terminal response time
- b. Contiguous data
- c. Proper Manchester encoding
- d. Proper bit count
- e. Odd parity
- f. Proper terminal addresses in the status word
- g. Proper word count
- h. Reserved status and instrumentation bits in the status word responses set to zero
- i. Proper sync
- j. Proper intermessage gap
- k. Illegal bus traffic

The data bus system shall have failed the test if, at any time during the test, any of these parameters fail to meet the requirements of MIL-STD-1553B.

4.2 Time Domain Reflectometry (TDR) Considerations: Although the individual tests do not require the use of a TDR, valuable network characterization data can be obtained by the proper use of a TDR. The TDR may prove even more useful in testing a bus network where stub connections or ends of the bus are not easily accessible to the test equipment. The TDR placed at one end of the bus would provide data on bus termination mismatch, stub impedance differences, and open and shorted stubs.

5. DETAILED REQUIREMENTS:

5.1 Bus Network Tests: The purpose of these tests is to verify the bus network as a separate entity, prior to bus controller and remote terminal integration. In the tests defined below, any reference to BC or RT refers to the use of test equipment simulating that function.

All tests shall be performed during validation testing. Production tests shall encompass as many of the tests as possible, but shall include the Data Path Integrity test of 5.1.8. It is recognized that some of the tests may not be possible due to lack of physical access to specific test points in the production configuration.

5.1 (Continued):

Unless otherwise noted, all terminal positions not under test shall be terminated at the terminal end of the stub as follows:

- a. 1000 Ω for transformer coupled stubs
- b. 2000 Ω for direct coupled stubs

When a terminal output amplitude is specified, its output level shall be verified when bus conditions change, that is, shorting a stub or removing a coupler. When directed to "short a stub," the stub shall be loaded at the terminal end of the stub as follows:

- a. 0 Ω for a transformer coupled stub
- b. 110 Ω for a direct coupled stub

5.1.1 Continuity: The purpose of this test is to perform DC continuity and resistance measurements on the bus network. This test is optional. It may be performed following the failure of the data integrity test in 5.1.8 to aid in isolation of a problem area. It may also be performed as an aid in isolating simple continuity problems prior to other bus network tests if continuity measurement points are easily accessible. The following tests in this section shall be undertaken with all stubs open circuit at the terminal end of the stub.

5.1.1.1 Shield Continuity: Continuity of the shield shall be measured at each connection point on the bus network. The measurement point may be the shield braid or the outer metal shell of the bus network components. The measurement shall be made at each bus terminator and each terminal connection. Continuity measurements may be made between adjacent points along the bus network to minimize the length of test measurement cables. All measurements shall be less than 0.012 Ω /ft. In order to ensure that measurements reflect actual shield continuity figures, and not continuity through system ground, the bus network must be isolated from the system ground. Should this not be possible, then either the bus harness shall be tested prior to installation or point-to-point measurements shall be taken on stubs and bus sections.

5.1.1.2 Bus Continuity: This test may be omitted in installations where the two bus terminators are an integral part of the bus network (that is, the terminators are not easily removable and access to the high or low side of the main bus is not provided). To perform the test, the bus terminators at each end of the bus network shall be removed, a short applied between the high side of the bus and the shield at one end, and continuity measured between the high side of the bus and the shield at the opposite end of the bus. If there are direct-coupled connections on the bus network, with a short still applied at one end of the bus network, continuity shall be measured between the high side and the shield for each direct-coupled connection. The maximum resistance measured for these continuity tests shall be a function of the distance between the measurement point and the short, and shall be less than 0.052 Ω /ft (assumes 26 gage wire or larger). Repeat the test between the low side of the bus and the shield. In addition to the 0.052 Ω /ft

5.1.1.2 (Continued):

requirement, each measurement between the high side of the bus and the shield shall be within 10% of the corresponding measurement between the low side of the bus and the shield. These tests should be performed with transformer couplers removed from the bus network, if possible. If the transformer couplers are an integral part of the bus, and not easily removable, the measurements shall be made with the short placed on the cable's end nearest the majority of transformer-coupled connections.

5.1.1.3 Bus Isolation: This test may be omitted in installations where either bus terminators or transformer-coupled connections are an integral part of the bus network. To perform the test, all bus terminators and transformer couplers shall be removed from the bus network. An isolation resistance of greater than 1 MΩ shall be measured between the high and low sides of the bus. An isolation resistance of greater than 1 MΩ shall be measured between the shield and the high side of the bus, and between the shield and the low side of the bus.

5.1.1.4 Transformer-Coupled Stubs: The maximum DC resistance between the high and low sides of each transformer-coupled stub termination (point A-A, Fig. 1) shall be measured. This test shall be made with the transformer couplers installed on the bus. The value measured shall be less than 5Ω.

5.1.1.5 Transformer-Coupled Fault Isolation Resistance: This test may be omitted if the transformer couplers are an integral part of the bus. The maximum DC resistance of each transformer coupler on the bus shall be measured. This test shall be performed with both terminators disconnected. The measurement is to be made between the high and low sides of the coupler bus connector. One transformer coupler at a time shall be disconnected from the bus, and the DC resistance measured. The value measured for each coupler shall be between 102 and 132 Ω for single couplers. These values should be divided by N for multiple stub couplers where N is the number of stubs in each coupler.

5.1.1.6 Transformer-Coupled Isolation: This test may be omitted if the high or low side of the bus or of the transformer coupler is not accessible. The minimum resistance between the high side of the main bus and the high side of each transformer-coupled stub termination shall be measured. The test shall be repeated for the low side of the bus and the low side of each stub termination. Each value measured shall be greater than 10 MΩ.

- 5.1.2 **Impedance:** The purpose of this test is to characterize, for future reference, the impedance of the bus in the system configuration. In addition, the impedance of the stubs, as seen from an RT, will be characterized.

The following steps shall be used for the impedance tests as specified.

- Step 1. The stubs not under test shall be loaded as defined in 5.1.
- Step 2. Begin with the configuration in Step 1, then progressively open all stubs one at a time. Each stub, when opened, shall remain open until completion of step. Record the impedance after each stub is open.
- Step 3. Begin with the configuration in Step 1, then short each stub, one at a time. Record the impedance while stub is shorted. Replace the load after each measurement so that only one stub is shorted for each measurement.

- 5.1.2.1 **Bus Impedance:** The test equipment shall be connected as shown in Fig. 2 with the stubs open. The bus impedance, Z_B , shall be measured with a sinusoidal waveform with an amplitude between 1 and 2 Vrms at 75.0 kHz and 1.0 MHz. Record Z_B for each frequency. Perform the test for each step in 5.1.2. Repeat this test for all stubs.

- 5.1.2.2 **Stub Impedance for Transformer Coupled Stubs:** The test configuration in Fig. 3 shall be used for this test with all other stubs terminated as indicated. The stub input impedance, Z_S , shall be measured with a sinusoidal waveform that has an amplitude between 1 and 2 Vrms at 75.0 kHz and 1.0 MHz. Record Z_S for each frequency. Perform the test for each step in 5.1.2. Repeat this test for all stubs.

- 5.1.3 **Dynamic Fault Effects:** This test verifies the ability of the bus network to operate reliably in the presence of intermittent short circuit conditions at any stub position. It requires the use of a high speed electronic switch with an "on" resistance of less than 5 Ω and a switching speed of less than 1 μ s.

Connect a bus controller and remote terminal at positions close to the opposite ends of the bus network. Establish communication between the bus controller and remote terminal.

Connect the electronic switch at any other terminal position of the bus network. For transformer coupled stubs, place the switch directly across the standard load (as specified in 5.1). For direct coupled stubs, place the switch in series with 110 Ω across the standard load (as specified in 5.1). Cause the switch to operate at a frequency of 30 ± 3 kHz with equal on/off times. This ensures at least one switch closure or one switch opening for every transmitted word. The switch must run continuously for the duration of the test.