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Production Test Plan for the Digital Time Division Command/Response Multiplex Data
Bus Remote Terminals

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1. SCOPE:

This test plan is broken into two major sections for the production testing of remote terminals: Electrical and Protocol.

1.1 General: This production test plan defines the test requirements for verifying that Remote Terminals meet the requirements of MIL-STD-1553B, "Digital Time Division Command/Response Multiplex Data Bus."

1.2 Application: This is a general test plan for any remote terminal designed to meet the requirements of MIL-STD-1553B. These requirements shall apply to the remote terminal under test, when invoked in a specification or statement of work.

Tests specified may be performed in any order, combined with one another or combined with other tests of the subsystem in which the Remote Terminal may be embedded.

The Remote Terminal which is under test must also have its design validated per the "Validation Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Remote Terminals."

The tests specified are to be used in production test of a remote terminal chip, module or function within an equipment. It is intended that all stimuli and measurements be made via external connections and/or test points. No required access to any other points is intended.

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

2. APPLICABLE DOCUMENTS:

2.1 Standards, Military: MIL-STD-1553B, 21 Sep 1978, "Aircraft Internal Time Division Command/Response Multiplex Data Bus" with Notice 2, 8 September 1986.

2.2 Other Documents: MIL-HDBK-1553, Notice 1, 24 September 1986 "Validation Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Remote Terminals."

3. DEFINITIONS:

3.1 Responses: The following are definitions of the responses of the RT 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.

3.1.1 BCR - Broadcast Command Received: The broadcast command received bit (bit time 15) is set in status word.

3.1.2 BUSY - Busy: The busy bit (bit time 16) is set in the status word.

- 3.1.3 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.
- 3.1.4 DBA - Dynamic Bus Acceptance: The dynamic bus control acceptance bit (bit time 18) is set in the status word.
- 3.1.5 ME - Message Error: The message error bit (bit time 9) is set in the status word.
- 3.1.6 NR - No Response: The addressed terminal does not produce any response to the command.
- 3.1.7 Respond in Form: A terminal is said to "respond in form" if its response to an illegal command as defined in 4.4.3.4 of MIL-STD-1553B consists of a response formatted as though it were a legal command.
- 3.1.8 SF - Subsystem Flag: The subsystem flag bit (bit time 17) is set in the status word.
- 3.1.9 TF - Terminal Flag: The terminal flag bit (bit time 19) is set in the status word.
- 3.2 Other Definitions:
- 3.2.1 UUT - Unit Under Test.
- 3.2.2 RT - Remote Terminal.
- 3.2.3 BC - Bus Controller.
4. GENERAL TEST REQUIREMENTS:

The following paragraphs define the configurations, pass/fail criteria, and general procedures for testing remote terminals. Specifically, this document contains the test configurations and procedures for the Electrical Tests (5.1) and the Protocol Tests (5.2) for MIL-STD-1553B remote terminals. The remote terminal under test is referred to as the unit under test (UUT). Proper terminal responses are defined in each test paragraph.

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

1. response time
2. contiguous data
3. proper Manchester encoding
4. proper bit count
5. odd parity
6. proper word count
7. proper terminal address in the status word
8. reserved status and instrumentation bits in the status word are set to zero
9. proper sync

The UUT 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.

5. DETAILED REQUIREMENTS:

5.1 Electrical Tests: All tests shall use Fig. 1, General Test Configuration, with all measurements taken at point "A", unless otherwise noted. Each test paragraph contains the requirements for both transformer and direct coupled stubs. A UUT which provides both transformer and direct coupled stubs must be tested on both stubs. Electrical tests shall be performed on all buses for UUTs with redundant bus configurations.

5.1.1 Output Characteristics: The following tests are designed to verify that all UUT output characteristics comply with MIL-STD-1553B. These tests shall be performed after establishing communications between the test equipment and the UUT.

If necessary, use the Optional Test Configuration, Fig. 2, in order to isolate the UUT output from any reactive load presented by the Tester.

5.1.1.1 Amplitude: A valid, legal transmit command shall be transmitted to the UUT, requesting the maximum number of words that it is capable of sending. The amplitude of the waveform transmitted by the UUT shall be measured, peak-to-peak, as shown in Fig. 3. The pass criteria for V_{pp} for transformer coupled stubs shall be 18.0 V minimum and 27.0 V maximum. The pass criteria for V_{pp} for direct coupled stubs shall be 6.0 V minimum and 9.0 V maximum.

5.1.1.2 Rise and Fall Times: A valid, legal transmit command shall be sent to the UUT, requesting at least one data word. The rise and fall time of the UUT waveform shall be measured between the 10 and 90% points of the waveform as shown in Fig. 3. The measurements shall be taken at both the rising and falling edges of a sync waveform and a data bit waveform. The rise time (T_R) and the fall time (T_F) shall be measured. The pass criteria shall be $100 \text{ ns} \leq T_R < 300 \text{ ns}$ and $100 \text{ ns} \leq T_F < 300 \text{ ns}$.

5.1.1.2 (Continued):

Note: The rise time of the sync waveform shall be measured at the mid-crossing of a data word sync, and the fall time of the sync waveform shall be measured at the mid-crossing of the status word sync. The rise and fall times of the data bit waveform shall be measured at a zero crossing where the prior zero crossing and next zero crossing are at 500 ns intervals from the measured zero crossing.

5.1.1.3 Zero Crossing Stability: Selected valid legal transmit commands shall be sent to the UUT, requesting the UUT to transmit words having zero crossing time intervals of 500, 1000, 1500 and 2000 ns. The zero crossing time (T_{ZC}) shall be measured for both the positive to negative and the negative to positive waveforms as shown in Fig. 4. The pass criteria shall be that $T_{ZC} = 500 \pm 25$, 1000 ± 25 , 1500 ± 25 and 2000 ± 25 ns.

5.1.1.4 Distortion, Overshoot and Ringing: A valid legal transmit command shall be sent to the UUT, requesting the UUT to transmit at least one data word. The distortion of the waveform, distortion voltage (V_D), shall be measured as indicated in Fig. 3. Pass criterion shall be $V_D \leq 900$ mV, for transformer coupled stubs and $V_D \leq 300$ mV, for direct coupled stubs.

5.1.1.5 Output Symmetry: A valid legal transmit command shall be sent to the UUT requesting the maximum number of data words that the UUT is capable of transmitting. The output symmetry is determined by measuring the waveform tail-off at the end of each message. The maximum residual voltage (V_R) shall be measured as shown in Fig. 3. The intermessage gap time shall be a minimum of 1 ms. The pass criterion shall be $V_R \leq 250$ mV peak for transformer coupled stubs and $V_R \leq 90$ mV peak for direct coupled stubs after time T_T (the time beginning 2.5 μ s after the mid-bit zero crossing of the last parity bit). This test shall be run six times with each data word in the message having the same bit pattern.

The six data word patterns that shall be used are:

8000(HEX), 7FFF(HEX), 0000(HEX), FFFF(HEX),
5555(HEX), and AAAA(HEX)

Note: For terminals that cannot transmit data words, the output symmetry test shall be performed on the status word response to a receive command or mode command.

5.1.1.6 Output Noise: The test configuration shown in Fig. 5 shall be used to test the UUT inactive bus output noise levels. The test shall be conducted while the UUT is in the power-on receive state. The output noise (V_{rms}) shall be measured at point "A" as shown in Fig. 5. Measurements shall be made with an instrument that has a minimum frequency bandwidth of from DC to 10 MHz. The pass criterion shall be $V_{rms} \leq 14$ mV for transformer coupled stubs and $V_{rms} \leq 5.0$ mV for direct coupled stubs.

- 5.1.1.7 Power On/Off Noise: A UUT shall not emit any spurious differential output during a power-up or power-down sequence. Power shall be applied to the UUT and any outputs from the UUT to the bus shall be measured. Power shall be removed from the UUT and any output to the bus from the UUT shall be measured.

The pass criterion shall be:

1. For transformer coupled stubs, any spurious noise pulses produced shall be less than ± 250 mV peak.
2. For direct coupled stubs, any spurious noise pulses produced shall be less than ± 90 mV peak.

NOTE: Use normal on/off power sequence of UUT.

- 5.1.2 Input Characteristics: The input tests are designed to verify that multiplex devices can properly decode bi-phase data.

5.1.2.1 Input Waveform Compatibility:

- 5.1.2.1.1 Amplitude Variations: A sequence of valid legal receive commands shall be transmitted to the UUT. The test shall be performed for input voltage levels of 0.20, 0.86, and 6.0 Vpp for transformer coupled stubs, and at 0.28, 1.2, and 9.0 Vpp for direct coupled stubs. A minimum of 1000 commands shall be transmitted to the UUT at each input level. The response of the UUT shall be monitored for every message at each input level.

The pass criteria shall be:

1. NR for transformer coupled stub inputs of 0.20 Vpp.
2. CS for transformer coupled stub inputs of 0.86 Vpp.
3. CS for transformer coupled stub inputs of 6.0 Vpp.
4. NR for direct coupled stub inputs of 0.28 Vpp.
5. CS for direct coupled stub inputs of 1.2 Vpp.
6. CS for direct coupled stub inputs of 9.0 Vpp.

- 5.1.2.1.2 Input Impedance: The input impedance of the UUT shall be measured first with the power on and repeated with the UUT power off. The input impedance, Z_{in} , shall be measured with a sinusoidal waveform having an amplitude 1.0 to 2.0 Vrms, at a frequency of 1.0 MHz. The pass criterion shall be $Z_{in} \geq 1000 \Omega$ for transformer coupled stubs and $Z_{in} \geq 2000 \Omega$ for direct coupled stubs.

For this test, do not use Fig. 1; remove all loads from UUT.

- 5.2 Protocol Tests: All tests in this section shall use the test configuration shown in Fig. 1. The test signal amplitude shall be 3.0 Vpp for direct coupled stubs and 2.1 Vpp for transformer coupled stubs measured at point A. For UUTs having both direct and transformer coupled stubs, the protocol tests need only be performed on one stub type per bus. Any condition, which causes the UUT to respond other than as called out in MIL-STD 1553B, to lock up or require a power cycle in order to recover from a failure, shall automatically cause that UUT to fail the test. The protocol tests shall be performed on all buses for UUTs with redundant bus configurations.

5.2.1 RT Response to Command Words:

5.2.1.1 RT Address: The purpose of this test is to verify that the UUT responds only to valid legal commands, that is, those that contain the address of the UUT.

5.2.1.1.1 Valid RT Address: The test equipment shall transmit to the UUT one valid legal transmit command and one valid legal receive command with the minimum word count for the UUT. Associated data may be random or controlled depending on UUT requirements. The pass criteria shall be that the UUT responds with CS for each command. If the UUT has variable address capability, this test shall be repeated for the following addresses:

00001, 00010, 00100, 01000, 10000, 00000

5.2.1.1.2 Invalid RT Address: The test equipment shall transmit to the UUT receive commands and transmit commands using all RT addresses not assigned to the UUT (with the exception of address 11111). Subaddress and word count fields shall be identical to those used in 5.2.1.1.1. The pass criteria shall be NR for each command.

5.2.1.2 Word Count: The purpose of the test is to verify that the UUT responds properly to all word counts implemented. During the test, the test equipment will transmit one valid, legal, non-mode transmit command and one valid, legal, non-mode receive command for each implemented word count. Only one subaddress is needed for any word count. The pass criteria shall be CS for each command.

5.2.1.3 Subaddress: The purpose of this test is to verify that the UUT responds properly to all subaddresses implemented. During this test, the test equipment shall transmit one valid, legal, non-mode transmit command and one valid, legal, non-mode receive command for each implemented subaddress. Only one word count is needed for any subaddress. The pass criteria shall be CS for each command.

5.2.1.4 Error Injection: These tests are intended to examine the UUT response when specific errors are forced into the message stream. The UUT shall not respond with a status word. If the data words it decodes fail any of the validity tests, the UUT should internally set the message error bit in its status word buffer. If the command word it decodes fails any of the validity tests, it shall ignore the command and wait for the next command (the ME bit should not be internally set in this case). For this test, valid legal commands will be sent to the UUT for Steps 1 and 3 in the test sequence below. Each error condition listed in Table 1 shall be injected in Step 2 of the test sequence. One error per test sequence shall be implemented.

1. Transmit a valid, legal command to the UUT.
2. Transmit to the UUT a message which contains one of the error conditions listed in Table 1.
3. Transmit a valid, legal command to the UUT.

5.2.1.4 (Continued):

The pass criteria shall be:

1. The UUT shall respond with CS for Steps 1 and 3 in the test sequence above.
2. The UUT shall not respond to commands for Step 2 in the test sequence above.

5.2.2 Optional Operation: This section provides for testing the optional requirements of MIL-STD-1553B. If a remote terminal implements any of the options, it shall be tested in accordance with the test identified for the option.

5.2.2.1 Dual Redundant Operation: This test shall be performed only if the UUT is configured with dual redundant buses. The requirements are as follows:

1. The UUT is required to accept a valid command received on the alternate bus while responding to a command on the original bus.
2. The UUT is required to respond to the valid command occurring later in time when overlapping valid commands are received on both buses.
3. When Step 1 or 2 occurs, the UUT shall reset and respond to the new command on the alternate bus.

Legal messages shall be used in this test. The following test sequence shall be performed twice for each interrupting command, once for each redundant bus:

- Step 1. Send a valid command to the UUT requesting the maximum number of data words that the UUT is designed to transmit.
- Step 2. Send the interrupting command on the alternate bus beginning no sooner than 4.0 µs after the beginning of the first command.
- Step 3. Send a valid "Transmit Status" mode command on the first bus after the messages on both buses have been completed. (If "Transmit Status" is not used, delete this step.)

The pass criteria shall be: Step 1 - NR, truncated message or CS, Step 2 - CS, and Step 3 - CS if transmit status is implemented.

5.2.2.2 Mode Commands: The purpose of these tests is to verify that the UUT responds properly to implemented mode commands. The tests are not intended to verify the mission aspects stated in the equipment specification. The UUT shall be tested for each mode code implemented with a subaddress field mode code indicator of all zeros and repeated with a subaddress field of all ones. The pass criteria are defined in each test paragraph.