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

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1. SCOPE:

This test plan is broken into three major sections for the testing of bus controllers Electrical, Protocol and Noise tests.

- 1.1 General: This validation test plan defines the test requirements for verifying that the design of bus controllers meets 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 first article, prototype, or engineering preproduction bus controller designed to meet the requirements of MIL-STD-1553B. These requirements shall apply to the bus controller under test, when invoked in a specification or statement of work.

This document deals only with bus controller functions that are explicitly described in MIL-STD-1553B. This document does not specify tests that check the integrity of data from the subsystem to the bus, nor does it attempt to address the system test requirements.

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.

3. DEFINITIONS:

- 3.1 Message: A single message is the transmission of a command word, status word, and data words if they are specified. For the case of a remote terminal to remote terminal (RT to RT) transmission, the message shall include the two command words, the two status words, and data words. All messages are divided into two message segments: a command message segment and a status message segment.
 - 3.1.1 CMS - Command Message Segment: A command message segment consists of a command word and associated data words, if any. In the case of RT to RT transfer, the command message segment includes both the receive command word and the transmit command word.
 - 3.1.2 SMS - Status Message Segment: A status message segment consists of a status word and associated data words, if any. In the case of RT to RT transfer, the status message segment includes the status word of the transmitting RT, its associated data words, and the status word of the receiving RT.
- 3.2 Bus Conditions: The following are definitions of bus conditions that bus controllers are required to detect. A description of the actual signal, state, or action taken within the bus controller, which is used during test procedures to indicate the detection of each of the following bus conditions, shall be attached to the test results. Bus controller states may or may not be distinguishable; that is, a single bus controller signal may indicate both NR and ISMS.

- 3.2.1 VSMS - Valid Status Message Segment: A VSMS condition occurs within a bus controller when it determines that a SMS contains only a CS and valid data words, the data words are contiguous to the status word and each other, and the response time is as specified in MIL-STD-1553.
- 3.2.2 ISMS - Invalid Status Message Segment: An ISMS condition occurs within a bus controller when it determines that a SMS is not a VSMS.
- 3.2.3 NR - No Response: A no response condition occurs if a bus controller determines that there has been no response to a command.
- 3.2.4 CS -Clear Status: The status word may have the busy bit or service request bit set, or both. The status word must have the correct terminal address, all other status code bits in the status word must be zero and the associated message segment must have the proper word count.
- 3.3 Other Definitions:
- 3.3.1 VW - Valid Word: A valid word conforms to the following minimum criteria:
- a. The word begins with a valid sync field.
 - b. The bits are in a valid Manchester II code.
 - c. The information field has 16 bits plus parity.
 - d. The word parity is odd.
- 3.3.2 UUT - Unit Under Test: For the purposes of this test plan, UUT refers to the bus controller under test.
- 3.3.3 BC - Bus Controller:
- 3.3.4 RT - Remote Terminal:
- 3.3.5 MCX - Mode Code: For the purposes of this test plan, mode codes are tabulated in Table 1.
- 3.3.6 DBACC - Dynamic Bus Control Acceptance Bit: The status word bit at bit time 18.

4. GENERAL TEST REQUIREMENTS:

The following paragraphs define the configurations, pass/fail criteria, and general procedures for testing bus controllers. Specifically, this document contains the test configurations and procedures for the Electrical Tests (5.1), the Protocol Tests (5.2), and the Noise Rejection Test (5.3) for MIL-STD-1553 bus controllers. Bus controllers that can be deployed in more than one configuration, depending upon the choice of stored program or hardware option, shall be tested using all specified configurations such that the test program exercises all of the bus controller's capabilities. Before performing each test, the UUT shall be cleared of any preexisting error conditions to ensure that all test results are independent of previous results.

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

1. contiguous data
2. proper Manchester encoding
3. proper bit count
4. odd parity
5. proper word count
6. proper intermessage gap times
7. proper sync
8. proper CMS transmission

This general monitoring requirement shall include the verification that the CMS transmitted by the UUT is the CMS specified to be transmitted by the procedure.

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-1553. Record the parameters for all failures.

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-1553.

5.1.1.1 Amplitude: A receive command shall be transmitted by the UUT, with 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. 2.

The pass criterion for V_{pp} for transformer coupled stubs is 18.0 V minimum and 27.0 V maximum.

The pass criteria for V_{pp} for direct coupled stubs are 6.0 V minimum and 9.0 V maximum.

- 5.1.1.2 Rise Time/Fall Time: A receive command shall be sent by the UUT with 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. 2. 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 are $100 \text{ ns} \leq T_R \leq 300 \text{ ns}$ and $100 \text{ ns} \leq T_F \leq 300 \text{ ns}$.

The measured parameters, T_R and T_F , shall be recorded.

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 command 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: A receive command shall be sent by the UUT, with at least one data word 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. 3.

The pass criteria are that $T_{ZC} = 500 + 25 \text{ ns}$, $1000 + 25 \text{ ns}$, $1500 + 25 \text{ ns}$ and $2000 + 25 \text{ ns}$.

The measured parameters, T_{ZC} , shall be recorded for each case.

- 5.1.1.4 Distortion, Overshoot and Ringing: A receive command shall be sent by the UUT with at least 1 data word. The distortion of the waveform, distortion voltage (V_D), shall be measured as indicated in Fig. 2.

The pass criteria are $V_D \leq 900 \text{ mV}$, for transformer coupled stubs or $V_D \leq 300 \text{ mV}$, for direct coupled stubs.

The worst measured parameter, V_D , shall be recorded.

- 5.1.1.5 Output Symmetry: A receive command shall be sent by the UUT with 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. 2. The minimum intermessage gap time shall be 1 Ms.

The pass criteria are $V_R \leq 250 \text{ W peak}$ for transformer coupled stubs and $V_R \leq 90 \text{ W peak}$ for direct coupled stubs after time T_T (the time beginning 2.5 μs after the midbit zero crossing of the last parity bit)

5.1.1.5 (Continued):

This test shall be run six times with each data word in the message having the same bit pattern. The six data word bit patterns that shall be used are:

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

The measured parameter, VR, shall be recorded for each bit pattern.

5.1.1.6 Output Noise: The test configuration shown in Fig. 4 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 and the power-off state. The output noise (Vrms) shall be measured at point "A" as shown in Fig. 4 for both states. Measurements shall be made with an instrument that has a minimum frequency bandwidth of from DC to 10 MHz.

The pass criteria are Vrms $\leq$ 14.0 mV for transformer coupled stubs and Vrms $\leq$ 5.0 mV for direct coupled stubs.

The measured parameter, Vrms, shall be recorded for each case.

5.1.1.7 Output Isolation: This test shall be performed only if the UUT is configured with redundant buses. A receive command shall be sent by the UUT with the maximum number of data words that it is capable of sending. The voltage of the output waveform transmitted by the UUT shall be measured on the active and redundant bus (or buses). Each data bus shall be alternately activated and measurements taken.

The pass criterion is that the ratio in dB between the output voltage on the active bus and the output voltage on all inactive buses shall be greater than or equal to 45 dB (Fig. 5).

The measured parameter, output isolation, expressed as a ratio in dB, shall be recorded for each bus combination.

5.1.1.8 Power On/Off Noise: A UUT shall limit 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 onto the bus shall be measured. Power shall be removed from the UUT and any output onto the bus from the UUT shall be measured. Repeat the test ten times.

The pass-criteria are:

- a. For transformer coupled stubs, any spurious noise pulses produced shall be less than +250 mV peak.
- b. For direct coupled stubs, any spurious noise pulses produced shall be less than +90 W peak.

All measured parameters, output noise amplitudes and pulse widths, shall be recorded.

Note: This test shall be performed using the normal on/off power sequence to the 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 Zero Crossing Distortion: A transmit message shall be transmitted by the UUT and the test equipment shall respond appropriately. Positive and negative zero crossing distortions equal to 150 ns minimum, with respect to the previous zero crossing, shall then be introduced individually to each zero crossing of each word transmitted to the UUT in response to the transmit command.

The transmitted signal amplitude at point "A", Fig. 1, shall be 2.1 Vpp for transformer coupled stubs and 3.0 Vpp for direct coupled stubs. Each zero crossing distortion shall be transmitted to the UUT a minimum of 1000 times. There shall be only one zero crossing deviation per message.

The pass criterion is the detection of a VSMS by the UUT for each SMS with a zero crossing distortion.

Positive and negative zero crossing distortions shall then be applied in turn to a single zero crossing and adjusted to determine the values at which the first ISMS is detected by the UUT. Record these values.

5.1.2.1.2 Amplitude Variations: A transmit command requesting the maximum number of data words specified by the UUT shall be transmitted by the UUT to the test equipment. The voltage of the test equipment response shall be decremented from 6.0 Vpp to 0.1 Vpp for transformer coupled stubs and from 9.0 Vpp to 0.1 Vpp for direct coupled stubs in steps no greater than 0.1 Vpp. A minimum of 1000 words shall be transmitted for each setting.

The pass criteria are:

- a. A VSMS for each SMS with $0.86 \leq V_{pp} \leq 6.0$ for transformer coupled stubs and $1.2 \leq V_{pp} \leq 9.0$ for direct coupled stubs
- b. A NR for each SMS with $V_{pp} \leq 0.20$ for transformer coupled stubs and $V_{pp} \leq 0.28$ for direct coupled stubs

The measured parameter, Vpp, at which NR first occurs shall be recorded.

5.1.2.1.3 Rise and Fall Time:

5.1.2.1.3.1 Trapezoidal: A transmit message involving one or more data words shall be sent by the UUT. The test equipment shall respond with a signal amplitude of 2.1 Vpp for the transformer coupled stub and 3.0 Vpp for the direct coupled stub. The rise and fall times shall be less than or equal to 100 ns, as shown in Fig. 2.

The pass criterion is a VSMS by the UUT for each SMS transmitted.

- 5.1.2.1.3.2 Sinusoidal: A transmit message involving one or more data words shall be sent by the UUT. The test equipment shall respond with a signal amplitude of 2.1 Vpp for the transformer coupled stub and 3.0 Vpp for the direct coupled stub. The rise and fall times of the signal shall approximate that of a 1 MHz sinusoidal signal.

The pass criterion is a VSMS by the UUT for each SMS transmitted.

- 5.1.2.2 Common Mode Rejection: The Common Mode Test Configuration, Fig. 6A and Fig. 6B, shall be used for this test. Transmit commands with the UUT's maximum word count shall be transmitted by the UUT at the maximum rate consistent with the minimum intermessage gap defined in 4.3.3.7 of MIL-STD-1553. The test equipment shall respond with a common mode voltage injected at point "C", and the UUT response observed. The voltage of the transmitted message measured at point "A" shall be 0.86 Vpp for transformer coupled stubs and 1.2 Vpp for direct coupled stubs. The following common mode voltage levels shall be applied in turn; +10.0 V.D.C. to ground, -10.0 V.D.C. to ground and a ± 10 Vp line to ground sinusoidal signal that is swept through the range of 1 Hz to 2 MHz. Each test condition shall be present for a minimum time period of 90 S.

The pass criterion is a VSMS by the UUT for each SMS transmitted at each setting.

If a failure occurs, the frequency of the common mode signal injected shall be recorded.

- 5.1.2.3 Input Impedance: The input impedance of the UUT shall be measured with the UUT power on and with the UUT power off. The input impedance, Z_{in} , shall be measured with a sinusoidal waveform having an amplitude 1.0 Vrms to 2.0 Vrms, at the following frequencies: 75.0 kHz, 100.0 kHz, 250.0 kHz, 500.0 kHz and 1.0 MHz.

The pass criteria are $Z_{in} \geq 1000 \Omega$ for transformer coupled stubs and $Z_{in} \geq 2000 \Omega$ for direct coupled stubs.

The measured parameter, Z_{in} , shall be recorded at each frequency.

- 5.2 Protocol Tests: All tests in this section shall use the test configuration shown in Fig. 1. The test signal amplitude shall be $3.0 \text{ Vpp} \pm 0.1 \text{ Vpp}$ for direct coupled stubs and $2.1 \text{ Vpp} \pm 0.1 \text{ Vpp}$ 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-1553, 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 Required Bus Controller Operation: The following tests verify all required operations of a BC:

5.2.1.1 Command Vocabulary Verification: This test verifies that the UUT is capable of transmitting every command word required by its design. The UUT shall transmit each unique command word that it is designed to transmit. Receive command words shall be followed by the correct number of data words. The pass criterion is the verification of the UUT's transmission of all command words required by its design.

5.2.1.2 Identification of Correct Address Field in Response: This test verifies that the UUT accepts valid message responses with the correct address field and identifies illegal message responses. Remote terminal address field "31" (11111) shall not be transmitted by the UUT for this test.

5.2.1.2.1 Correct Address Field with Controller-Remote Terminal Message Transfers: This test verifies that the UUT detects an error when the address field in a SMS does not match the address in its associated CMS. The UUT shall send 32 receive commands and 32 transmit commands all with the same RT address to the test equipment. The test equipment shall respond to each CMS with an SMS. Each SMS will have a status word with a different RT address so that each one of the 32 possible addresses is used once in response to a receive command, and once in response to a transmit command. The above procedure shall be performed for each implemented RT address in the command word, so that each RT address (except "11111") is used once. This test requires that the UUT send a total of $N*64$ CMSs where N is the number of RT addresses implemented by the UUT.

The pass criteria are an ISMS for each SMS with an incorrect address in the status word and a VSMS for each SMS with the correct address in the status word.

5.2.1.2.2 Correct Address Field with Remote Terminal-Remote Terminal Message Transfers: This test verifies that the UUT detects an error when the address field in a SMS does not match the address in its associated CMS for RT-RT message transfers. The UUT shall send $(31*31)-31=930$ unique, RT-RT command pairs so that every possible combination of transmitting and receiving addresses is used. The test equipment shall respond to each command pair with the correct address in the transmitting RT's status word, and each possible address in the receiving RT's status word. The above procedure shall be performed so that each implemented incorrect address and the single correct address are used in the receiving RT's status word. The above test shall then be repeated using the correct address in the receiving RT's status word, and each implemented address in each transmitting RT's status word. This test requires that the UUT shall send a total of $930*N*2$ command pairs, where N is the number of RT addresses implemented by the UUT.

The pass criteria are an ISMS for each SMS with an incorrect address in a status word and a VSMS for each SMS with correct status word addresses.

5.2.1.3 Minimum Response Time: This test verifies that the UUT validates responses with minimum response times.

5.2.1.3.1 Minimum Response Time: BC-RT Transfers: The UUT shall send a transmit command. The test equipment shall respond with a valid status and the number of valid data words requested at time T equal to 4.0 μ s maximum after the transmit command as shown in Fig. 7. A minimum of 1000 messages shall be sent during this test. The UUT shall then send a valid receive command with the correct number of valid data words. The test equipment shall respond with a valid status word starting with time T equal to 4.0 μ s after the last data word as shown in Fig. 7. A minimum of 1000 messages shall be sent during this test.

The pass criterion is a VSMS for each SMS transmitted.

5.2.1.3.2 Minimum Response Time: RT-RT Transfers: The UUT shall send an RT-RT CMS. The test equipment shall respond with a status word and the number of data words requested at time T equal to 4.0 μ s maximum after the receive command as shown in Fig. 7. The test equipment shall send a second status word for the receiving terminal at time T equal to 4.0 μ s maximum after the last data word associated with the transmitting RT's response as shown in Fig. 7. A minimum of 1000 messages shall be sent during this test.

The pass criterion is a VSMS after each SMS transmitted.

5.2.1.4 Minimum No-Response Time-Out: This test verifies that the UUT does not indicate a no-response before the minimum no-response time.

5.2.1.4.1 Minimum No-Response BC-RT Transfer: The UUT shall send a transmit command. The test equipment shall respond with a valid status and the number of valid data words requested, at time T equal to 14.0 μ s minimum after the transmit command as shown in Fig. 7. A minimum of 1000 messages shall be sent during this test. The UUT shall then send a valid receive command with the correct number of valid data words. The test equipment shall respond with a valid status word at time T equal to 14.0 μ s minimum after the last data word. The UUT shall detect correct test equipment response. A minimum of 1000 messages shall be sent during this test.

The pass criterion is a VSMS after each SMS transmitted.

5.2.1.4.2 Minimum No-Response Time-Out: RT-RT Transfers: The UUT shall send an RT-RT CMS. The test equipment shall respond with a status word and the number of data words requested at time T equal to 14.0 μ s minimum after the transmit command as shown in Fig. 7. The test equipment shall send a second status word for the receiving terminal at time T equal to 14.0 μ s minimum after the last data word associated with the transmitting RT's response, as shown in Fig. 7. A minimum of 1000 messages shall be sent during this test.

The pass criterion is a VSMS after each SMS transmitted.