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PRODUCTION TEST PLAN FOR THE TIME DIVISION COMMAND/RESPONSE MULTIPLEX DATA BUS BUS CONTROLLERS

RATIONALE

This document has been reaffirmed to comply with the SAE 5-year Review policy.

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1. SCOPE:

This test plan consists of two major sections for the production testing of bus controllers: Electrical tests and Protocol tests.

1.1 General: This production test plan defines the test requirements for determining that bus controllers 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 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.

The primary intent of this test plan is to test those requirements of MIL-STD-1553 for bus controllers that have been implemented in hardware, software, or firmware. However, it is recognized that some additional software may be required to meet this intent and that this software may be the operational software (or some portion thereof), special test software, or some combination of these.

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

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

This document deals only with bus controller functions which 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.

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: SAE Aerospace Standard, AS 4113, "Validation Test Plan for the Digital Time Division Command/Response Multiplex Data Bus Bus Controllers."

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 CS - Clear Status: The status word may have the busy bit or service request bit set, or both. The status word shall 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.

3.2.2 NR - No Response: A no response condition occurs if a bus controller determines that there has been no response to a command.

3.2.3 ISMS - Invalid Status Message Segment: An ISMS condition occurs within a bus controller when it determines that an SMS is not a VSMS.

3.2.4 VSMS - Valid Status Message Segment: A VSMS condition occurs within a bus controller when it determines that an SMS contains only a CS, a valid status word, and valid data words, that the data words are contiguous to the status word and each other, and that the response time is as specified in MIL-STD-1553.

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: As defined in the paragraph titled Bus Controller of MIL-STD-1553.

3.3.4 RT - Remote Terminal: As defined in the paragraph titled Remote Terminal of MIL-STD-1553.

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 production testing of bus controllers. Specifically, this document contains the test configurations and procedures for the electrical tests (5.1) and for the protocol tests (5.2) for MIL-STD-1553 bus controllers. Bus controllers which 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 pre-existing error conditions to insure that all test results from a given test are independent of previous test results. The bus controller under test is referred to as the UUT. Proper terminal responses are defined in each paragraph.

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.

5. DETAILED REQUIREMENTS:

5.1 Electrical Tests: Each test paragraph contains the requirements for both transformer and direct coupled stubs. A UUT which provides both transformer and direct coupled stubs shall 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. All output characteristic tests shall use Fig. 1A, with all measurements taken at point "A", unless otherwise noted.

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 criteria for transformer coupled stubs are 18.0 Vpp minimum and 27.0 Vpp maximum. The pass criteria for direct coupled stubs are 6.0 Vpp minimum and 9.0 Vpp 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 ns <= T_R <= 300 ns and 100 ns <= T_F <= 300 ns.

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: T_{ZC} = 500 ± 25 ns, 1000 ± 25 ns, 1500 ± 25 ns and 2000 ± 25 ns.

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 <= 900 mV for transformer coupled stubs, or V_D <= 300 mV for direct coupled stubs.

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 <= 250 mV peak for transformer coupled stubs and V_R <= 90 mV peak for direct coupled stubs after time T_T (the time beginning 2.5 µs 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 bit patterns that shall be used are:

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

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 <= 14.0 mV for transformer coupled stubs and Vrms <= 5.0 mV for direct coupled stubs.

5.1.1.7 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 mV peak.

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. All input characteristic electrical tests shall use Fig. 1A or 1B, with all measurements taken at point "A" unless otherwise noted.

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. 1A or 1B, 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 100 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.

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's response shall be set to 0.20 Vpp, 0.86 Vpp, and 6.0 Vpp for transformer coupled stubs; and to 0.28 Vpp, 1.2 Vpp, and 9.0 Vpp for direct coupled stubs. A minimum of 1000 words shall be transmitted for each setting.

The pass criteria are:

a. A VSMS for each SMS at 0.86 Vpp and 6.0 Vpp for transformer coupled stubs; a VSMS for each SMS at 1.2 Vpp and 9.0 Vpp for direct coupled stubs.

b. A NR for each SMS with Vpp at 0.20 for transformer coupled stubs and Vpp at 0.28 for direct coupled stubs.

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 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, Zin, 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 Zin >= 1000 Ω for transformer coupled stubs and Zin >= 2000 Ω for direct coupled stubs.

Note: Do not use Fig. 1A or 1B for this test; remove all loads from UUT.

5.2 Protocol Tests: All tests in this section shall use the test configuration shown in Fig. 1A or 1B. The test signal amplitude shall be 3.0 Vpp ± 0.1 Vpp for direct coupled stubs and 2.1 Vpp ± 0.1 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 that causes the UUT to respond other than as called out in MIL-STD-1553, or 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 test 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: These tests verify 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 an SMS does not match the address in its associated CMS. The UUT shall send two receive commands and two transmit commands with the same RT address to the test equipment. The test equipment shall respond to each CMS with an SMS. One SMS shall have a status word with a proper RT address, while the other SMS shall have an improper RT address in response to the receive commands. Similarly, one SMS shall have a status word with a proper RT address, while the other SMS shall have an improper RT address in response to

5.2.1.2.1 (Continued):

the transmit commands. 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.

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 RT-RT Message Transfers: This test verifies that the UUT detects an error when the address field in the transmitting RT's status word does not match the address in the transmit command word, or the address in the receiving RT's status word does not match the address in the receive command word. The UUT shall send a sequence of RT-RT command pairs with fixed unique addresses in the transmit and receive command words. The test equipment shall respond with correct address in the transmitting RT's status word and every possible address in the receiving RT's status word. The test sequence shall be repeated using the same command words. The test equipment shall now respond with the correct address in the receiving RT's status word, and every possible address in the transmitting RT's status word. The two sequences comprise a total of 64 identical command pairs with two valid and 62 invalid responses.

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

5.2.1.3 Minimum Response Time: These tests verify 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 word, and the number of valid data words requested, at time T equal to 4.0 µs maximum after the transmit command as shown in Fig. 5. A minimum of 100 messages shall be sent during this test. The UUT shall then send a valid receive command, together 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 µs maximum after the last data word as shown in Fig. 5. A minimum of 100 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 µs maximum after the transmit command as shown in Fig. 5. The test equipment shall send a second status word for the receiving terminal at time T equal to 4.0 µs maximum after the last data word associated with the transmitting RT's response as shown in Fig. 5. A minimum of 100 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: These tests verify 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 word, and the number of valid data words requested, at time T equal to 14.0 µs minimum after the transmit command as shown in Fig. 5. A minimum of 100 messages shall be sent during this test. The UUT shall then send a valid receive command, together 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 µs minimum after the last data word. The UUT shall detect correct test equipment response. A minimum of 100 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 µs minimum after the transmit command as shown in Fig. 5. The test equipment shall send a second status word for the receiving terminal at time T equal to 14.0 µs minimum after the last data word associated with the transmitting RT's response, as shown in Fig. 5. A minimum of 100 messages shall be sent during this test.

The pass criterion is a VSMS after each SMS transmitted.

5.2.1.5 No-Response Time-Out: These tests verify that the UUT detects a no-response when an RT does not respond.

5.2.1.5.1 No-Response Time-Out: BC-RT Transfers: The UUT shall send a minimum of six CMSs, three with receive commands and data and three with transmit commands. The test equipment shall not respond to any of the messages.

The pass criterion is an NR for each expected SMS.

5.2.1.5.2 No-Response Time-Out: RT-RT Transfers: The UUT shall send a minimum of nine RT-RT CMSs. The test equipment shall not respond to either command of the first three CMSs. The test equipment shall respond to the transmit command but not the receive command of the next three CMSs, and finally the test equipment shall not respond to the transmit command but shall respond to the receive command of the last three CMSs.

The pass criterion is an NR for each expected SMS.

5.2.1.6 Error Injection: BC-RT/RT-BC: The purpose of these tests is to examine the UUT's response to specific errors in the message stream. Unless otherwise noted, the test sequence described below shall be used for all error injection tests. The error to be encoded in Step 2 for a given message is specified in each test paragraph.

The pass criteria is also defined in each test paragraph.

Test sequence:

Step 1: A CMS shall be sent by the UUT as specified in each paragraph.
Step 2: A SMS containing the specified error shall be sent to the UUT.

5.2.1.6.1 Parity: The purpose of these tests is to verify the UUT's capability of detecting parity errors embedded in different words within a message.

5.2.1.6.1.1 Status Word Validation for Transmit Commands: This test verifies the ability of the UUT to detect a parity error occurring in a status response to a transmit command word. The test sequence as defined in 5.2.1.6 shall be performed with a transmit command in Step 1 and a parity error encoded into the test equipment status word for test Step 2.

The pass criterion for this test is an ISMS for the transmitted SMS.

5.2.1.6.1.2 Status Word Validation for Receive Commands: This test verifies the ability of the UUT to recognize a parity error occurring in a status response to a receive command word. The test sequence as defined in 5.2.1.6 shall be performed with a receive command in Step 1 and a parity error encoded in the test equipment status word for test Step 2.

The pass criterion for this test is an ISMS for the transmitted SMS.

5.2.1.6.1.3 Data Word Validation: This test verifies the ability of the UUT to recognize a parity error occurring in a data word. The test sequence as defined in 5.2.1.6 shall be performed with a transmit command in Step 1 and a parity error encoded in a data word for Step 2. The SMS shall have the maximum number of data words that the UUT is designed to receive. The test sequence shall be sent N times, where N equals the number of data words sent. Each data word shall have the parity bit inverted in turn, but only one parity error is allowed per message.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.6.2 Word Length: These tests verify the ability of the UUT to recognize an error in word length occurring within a message. The test plan excludes testing of high bit count errors at the end of any message segment.

5.2.1.6.2.1 Status Word Validation for Transmit Commands: This test verifies the ability of the UUT to recognize word length errors in a status response to transmit commands. The test sequence as defined in 5.2.1.6 shall be performed with a transmit command in Step 1 and with the status response word defined below for Step 2. Repeat this test with each of the status words defined below.

a. Shorten the status word by one bit.
b. Shorten the status word by two bits.
c. Lengthen the status word by two bits.
d. Lengthen the status word by three bits.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.6.2.2 Status Word Validation for Receive Commands: This test verifies the ability of the UUT to recognize word length errors occurring in a status response to receive commands. The test sequence as defined in 5.2.1.6 shall be performed with a receive command in Step 1 and with the response word as defined below for Step 2. Repeat this test with each of the status words defined below.

a. Shorten the status word by one bit.
b. Shorten the status word by two bits.

The pass criterion for this test is an ISMS for each SMS transmitted.

5.2.1.6.2.3 Data Word Validation: This test verifies the ability of the UUT to recognize data word length errors. The test sequence as defined in 5.2.1.6 shall be performed with a transmit command in Step 1 and as defined below for Step 2. The response message shall be a status word with the maximum number of data words that the UUT is designed to receive. Repeat this test with each of the data words defined below.

a. Shorten the data word by one bit.
b. Shorten the data word by two bits.
c. Lengthen the data word by two bits.
d. Lengthen the data word by three bits.

The test sequence of 5.2.1.6 shall be performed N times for A and B, and N-1 times for C and D, where N equals the number of data words sent. High bit count errors shall not be tested in the last data word of the response. Only one data word shall be altered at a time in a given message. Steps A and B shall be performed in turn for each data word in the message. Steps C and D shall be performed in turn for each data word except the last.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.6.3 Bi-Phase Encoding: This test verifies the ability of the UUT to recognize bi-phase errors. A bi-phase encoding error is defined to be the lack of a zero crossing in the center of a bit time. A bi-phase error occurs as either a logic high or low for the duration of a bit time. Each bit location, except the sync period, of each word shall have a single bi-phase error encoded into it in turn. Only a single bi-phase error shall be injected for each message.

5.2.1.6.3.1 Status Word Validation for Transmit Commands: This test verifies the ability of the UUT to recognize bi-phase encoding errors in response to transmit commands. The test sequence as defined in paragraph 5.2.1.6 shall be performed with a transmit command in Step 1 and a bi-phase encoding error encoded into the status word for test Step 2. Only one bi-phase error is allowed per status word. A complete test involves performing the test sequence 17 times, once for each bit location. A complete test requires two test sets to be performed, once for high bi-phase errors and once for low bi-phase errors.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.6.3.2 Status Word Validation for Receive Commands: This test verifies the ability of the UUT to recognize bi-phase encoding errors in response to receive commands. The test sequence as defined in 5.2.1.6 shall be performed with a receive command in Step 1 and a bi-phase error encoded into a status word for test Step 2. Only one bi-phase error is allowed per command word. A test set involves performing the test sequence 17 times, once for each bit location. A complete test requires two test sets to be performed, once for high bi-phase errors and once for low bi-phase errors.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.6.3.3 Data Word Validation: This test verifies the ability of the UUT to recognize bi-phase encoding errors in data words. The test sequence as defined in 5.2.1.6 shall be performed with a transmit command requesting the maximum number of data words that the UUT is designed to receive in Step 1 and a bi-phase error encoded into each data word in the response for Step 2. Individually, each bit location of each data word shall have a bi-phase error encoded into it in turn; only one bi-phase error is allowed for each message. A complete test involves performing the sequence 17 times. The test set shall be repeated N times, where N equals the number of data words sent. A complete test requires two test sets to be performed, once for high bi-phase errors and once for low bi-phase errors.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.6.4 Sync Encoding: This test verifies the ability of the UUT to recognize sync errors. The sync pattern, as defined for this test, is a waveform with six 0.5 µs divisions. The divisions are represented as a 1 or 0 to indicate the polarity of the division on the data bus. A proper status sync is represented as 111000 and a proper data sync is represented as 000111.

5.2.1.6.4.1 Status Word Sync Validation: This test verifies that the UUT rejects status words with invalid waveforms. The test sequence as defined in 5.2.1.6 shall be performed with a transmit command requesting the maximum number of data words the UUT is designed to receive for Step 1 and a sync error encoded in a status word for Step 2. The following invalid sync patterns shall be used:

111100, 110000, 111001, 011000, 000111

The test sequence shall be performed for each of the above invalid sync patterns.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.6.4.2 Data Word Sync Validation: This test verifies that the UUT rejects invalid data sync waveforms. The test sequence shall be performed as defined in 5.2.1.6 with a transmit command requesting the maximum number of data words that the UUT is designed to receive in Step 1 and with a sync error encoded into each data word for Step 2. Only one data word per message shall have an invalid sync encoded into it. The following invalid sync patterns shall be used:

000011, 001111, 000110, 100111, 111000

The test sequence shall be performed N times for each of the above invalid sync patterns, where N equals the maximum number of data words in the message. The test shall be performed so that each sync error shall occur with each data word.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.6.5 Response Message Length: These tests verify that the UUT properly detects an error when an incorrect number of data words is received.

5.2.1.6.5.1 Response to Receive Command: This test verifies the ability of the UUT to detect an error condition if a data word is contiguous to a status word in response to a receive command. Perform the test sequence as defined in 5.2.1.6 with a receive command in Step 1 and a data word contiguously following a status word for Step 2.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.6.5.2 Response to Transmit Commands: This test verifies that the UUT recognizes an error in the number of data words that are sent. Perform the test sequence as defined in 5.2.1.6 with a transmit command requesting the maximum number of data words in Step 1 and a data word count error in the SMS for Step 2. This response is a valid status word with different number of data words than specified in the command word. The test sequence shall be performed N+1 times, where N equals the maximum number of data words the BC can request. The first sequence shall have N+1 data words. The second sequence shall have N-1 data words and each of the remaining sequences shall remove one additional data word until the number of data words equals zero.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.6.6 Discontiguous Data: This test verifies that the UUT recognizes discontiguous data in a message. Perform the test sequence as defined in 5.2.1.6 with a transmit command in Step 1 with a 4.0 µs data word gap error in a status response to a transmit command for Step 2. The gap is measured as in Fig. 5. This response shall be a status word with the maximum number of data words that the UUT is designed to receive with a gap between the status word and the first data word or between a data word pair. The test sequence shall be performed N times, where N equals the maximum number of data words. Each test sequence shall be performed with the gap appearing before a different data word. Only one gap time insertion is allowed per message.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.7 Error Injection: RT to RT Transfers: These tests verify the UUT's response to specific errors in an RT to RT message stream. Unless otherwise noted, the following test sequence shall be used for all RT-RT error injection tests. The no-response condition or encoding error for a given message is specified in each test paragraph.

The pass criteria are defined in each test paragraph.

Test Sequence:

Step 1: A valid legal RT to RT command pair shall be sent by the UUT as specified in each paragraph.
Step 2: An RT response to the transmit command shall contain the specified error (if any) and shall be sent to the UUT by the test equipment.
Step 3: The specified RT response (if any) to the receive command shall be sent to the UUT by the test equipment.

Note that in the case of an RT to RT transfer, the SMS consists of an RT response to the transmit command followed by an RT response to the receive command.

5.2.1.7.1 Parity: These tests verify the ability of the UUT to detect parity errors embedded in different words within an RT to RT SMS.

5.2.1.7.1.1 Status Word Validation for Responses to RT to RT Transmit Commands: This test verifies the ability of the UUT to detect a parity error occurring in the status response to the transmit command in an RT to RT command. The test sequence as defined in 5.2.1.7 shall be performed twice. The first test sequence shall be performed with a parity error encoded in the test equipment status word response to the transmit command for Step 2 and a CS in Step 3.

The test sequence shall be performed the second time with a parity error encoded in the test equipment status word response to the transmit command for Step 2 and no response in Step 3.

In both cases, the pass criterion is an ISMS for each SMS transmitted.

5.2.1.7.1.2 Status Word Validation for Responses to RT to RT Receive Commands: This test verifies the ability of the UUT to recognize a parity error occurring in the status response to a receive command in an RT to RT command. The test sequence as defined in 5.2.1.7 shall be performed with no errors in Step 2, and a parity error in the test equipment status word response to the receive command for Step 3.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.7.1.3 RT to RT Data Word Validation: This test verifies the ability of the UUT to recognize a parity error occurring in a data word in an RT to RT SMS. The test sequence as defined in 5.2.1.7 shall be performed twice. The first sequence shall be performed with the RT to RT command pair requesting the maximum number of data words allowable by the UUT's design in Step 1, a parity error encoded in a data word for Step 2, and a CS in Step 3.

The test sequence shall be performed the second time with a parity error in a data word for Step 2 and no response in Step 3.

Each test sequence of 5.2.1.7 must be sent N times, where N equals the number of data words sent. Only one data word shall have the parity bit inverted for each message sent, with a different data word being altered for each execution of the test sequence.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.7.2 Word Length: These tests verify the ability of the UUT to recognize word length errors within any word in an RT to RT SMS. The test plan excludes testing of high bit count errors at the end of any word sequence.

5.2.1.7.2.1 Status Word Validation for Responses to RT to RT Transmit Commands: This test verifies the ability of the UUT to recognize word length errors occurring in the status response to an RT to RT transmit command. The test sequence as defined in 5.2.1.7 shall be performed twice. The first test sequence shall be performed with the status response word defined below for Step 2 and a CS for Step 3. The test sequence shall be performed a second time with a no-response in Step 3. Repeat those sequences with each of the status words defined below.

a. Shorten status word by one bit.
b. Shorten status word by two bits.
c. Lengthen status word by two bits.
d. Lengthen status word by three bits.

The pass criterion for this test is an ISMS for each SMS transmitted.

5.2.1.7.2.2 Status Word Validation for Responses to RT to RT Receive Commands: This test verifies the ability of the UUT to recognize word length errors occurring in the status response to an RT to RT receive command. The test sequence as defined in 5.2.1.7 shall be performed with no errors in Step 2, and with the status word defined below used for Step 3. Repeat this test with each of the status words defined below.

a. Shorten status word by one bit.
b. Shorten status word by two bits.

The pass criterion for this test is an ISMS for each SMS transmitted.

5.2.1.7.2.3 Data Word Validation: This test verifies the ability of the UUT to recognize data word length errors. The test sequence as defined in 5.2.1.7 shall be performed twice. The first test sequence shall be performed with the RT to RT command pair requesting the maximum number of data words allowable by the UUT's design in Step 1, a data word from the list below in Step 2, and a CS in Step 3.

The test sequence shall be performed a second time with no response in Step 3. Repeat these sequences using each data word shown below.

a. Shorten data word by one bit.
b. Shorten data word by two bits.
c. Lengthen data word by two bits.
d. Lengthen data word by three bits.

Each test sequence of 5.2.1.7 shall be performed N times for A and B and N-1 times for C and D, where N equals the number of data words sent. High bit count errors shall not be tested in the last data word of the response. Only one data word shall be altered at a time in a given message. Steps A and B shall be performed for each data word in the message. Steps C and D shall be performed for each data word except the last.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.7.3 Bi-Phase Encoding: These tests verify the ability of the UUT to recognize bi-phase errors within any word in an RT to RT SMS. A bi-phase error is defined to be the lack of a zero crossing in the center of a bit time. A bi-phase error occurs as either a logic high or low for the duration of a bit time. Each bit location, except the sync period, of each word shall have a single bi-phase error encoded into it. Only a single bi-phase error shall be injected for each message.

5.2.1.7.3.1 Status Word Validation for Responses to RT to RT Transmit Command: This test verifies the ability of the UUT to detect bi-phase encoding errors occurring in the status response to an RT to RT transmit command. The test sequence as defined in 5.2.1.7 shall be performed twice. The first test sequence shall be performed with a bi-phase error encoded in the status word for test Step 2 and a CS in test Step 3.

The test sequence shall be performed the second time with a no-response in Step 3. Only one bi-phase error is allowed per status word. A test set involves performing each test sequence 17 times, once for each bit location. A complete test requires two test sets to be performed, once for high bi-phase errors and once for low bi-phase errors.

The pass criterion is an ISMS for the SMS transmitted.

5.2.1.7.3.2 Status Word Validation for Responses to RT to RT Receive Commands: This test verifies the ability of the UUT to recognize bi-phase encoding errors occurring in the status response to an RT to RT receive command. The test sequence as defined in 5.2.1.7 shall be performed with no errors in Step 2 and a bi-phase error in the status word for Step 3. Only one bi-phase error is allowed per status word. A test set involves performing the test sequence 17 times, once for each bit location. A complete test requires two test sets, once for high bi-phase errors and once for low bi-phase errors.

The pass criterion is an ISMS for the SMS transmitted.

5.2.1.7.3.3 Data Word Validation: This test verifies the ability of the UUT to recognize bi-phase encoding errors occurring in a data word in an RT to RT SMS. The test sequence as defined in 5.2.1.7 shall be performed twice. The first test sequence shall be performed with the RT to RT command pair requesting the maximum number of data words allowable by the UUT's design in Step 1, a bi-phase error encoded in a data word for Step 2, and a CS in Step 3. A complete test requires 2 X N tests. Sets to be performed, once for high bi-phase errors and once for low bi-phase errors.

The test sequence shall be performed the second time with a no-response in Step 3.

5.2.1.7.3.3 (Continued):

Each test sequence of 5.2.1.7 must be sent N times, where N equals the number of data words sent. Only one data word shall have a bi-phase encoding error for each message sent, with a different data word being altered for each execution of the test sequence.

The pass criterion is an ISMS for the SMS transmitted.

5.2.1.7.4 Sync Encoding: This test verifies the ability of the UUT to recognize sync errors in the status and data word syncs in an RT to RT SMS. The sync pattern, as defined for this test, is a waveform with six 0.5 us divisions. Each division is represented as a 1 or 0 to indicate the polarity of the divisions on the data bus. A proper status sync is represented as 111000 and a proper data sync is represented as 000111.

5.2.1.7.4.1 Status Word Sync Validation for Response to RT to RT Transmit Commands: This test verifies the ability of the UUT to recognize sync waveforms in the status response to an RT to RT transmit command. The test sequence as defined in 5.2.1.7 shall be performed twice. The first test sequence shall be performed with a sync error (as shown below) encoded in the status word for Step 2, and a CS in Step 3. The second test sequence shall be performed with a no-response in Step 3.

The following invalid sync patterns shall be used:

111100, 110000, 111001, 011000, 000111

Each test sequence shall be performed for each of the above invalid sync patterns.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.7.4.2 Status Word Sync Validation for Response to RT to RT Receive Commands: This test verifies the ability of the UUT to recognize invalid sync waveforms in the status response to an RT to RT receive command. The test sequence as defined in 5.2.1.7 shall be performed with no errors in Step 2, and a sync error (as shown below) encoded in the status word for Step 3.

The following invalid sync patterns shall be used:

111100, 110000, 111001, 011000, 000111

The test sequence shall be performed for each of the above invalid sync patterns.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.7.4.3 Data Word Sync Validation: This test verifies the ability of the UUT to recognize invalid data sync waveforms in an RT to RT SMS. The test sequence as defined in 5.2.1.7 shall be performed twice. The first test sequence shall be performed with the RT to RT command pair requesting the maximum number of data words allowable by the UUT's design. A sync error shall be encoded into each data word for Step 2, and a CS in Step 3. The test sequence shall be performed the second time with a no response in Step 3. Only one data word per SMS shall have an invalid sync encoded into it.

The following invalid sync patterns shall be used:

000011, 001111, 000110, 100111, 111000

Each test sequence shall be performed N times for each of the above invalid sync patterns, where N equals the maximum number of data words in the message.

The test shall be performed so that each sync error shall occur with each data word.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.7.5 Response Message Length: This test verifies the ability of the UUT to recognize message length errors, when an incorrect number of data words are transmitted by either RT in an RT to RT SMS.

5.2.1.7.5.1 Message Length Validation for RT to RT Transmit Commands: This test verifies the ability of the UUT to detect an error condition when an incorrect number of data words are transmitted in response to an RT to RT transmit command. The test sequence as defined in 5.2.1.7 shall be performed twice. The first test sequence shall be performed with the RT to RT command pair requesting the maximum number of data words allowable by the UUT's design. A data word count error shall be injected into the SMS for Step 2, and a CS in Step 3.

The test sequence shall be performed the second time with a no-response in Step 3.

Each test sequence shall be performed N+1 times, where N equals the maximum number of data words. The first sequence shall have N+1 data words, the second sequence shall have N-1 data words and each of the remaining sequences shall remove one additional data word until the number of data words equals zero.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.7.5.2 Message Length Validation for RT to RT Receive Commands: This test verifies the ability of the UUT to detect an error condition if a data word is contiguous to a status word in response to the RT to RT receive command. The test sequence as defined in 5.2.1.7 shall be performed with no errors in Step 2 and one data word contiguously following the status word for Step 3.

The pass criterion is an ISMS for each SMS transmitted.

5.2.1.7.6 Discontiguous Data: This test verifies that the UUT recognizes discontiguous data in an RT to RT SMS. The test sequence as defined in 5.2.1.7 shall be performed with the transmit command in the RT to RT command pair requesting the maximum number of data words allowable by the UUT's design. A 4.0 us gap shall be injected either between the status word and the first data word or between a data word pair for Step 2 with no errors in Step 3. The gap is measured as in Fig. 5.

The test sequence shall be performed N times, where N equals the maximum number of data words. Each test sequence shall be performed with the gap appearing before a different data word. Only one gap time insertion is allowed per message. The test sequence shall be performed the second time with a no-response in Step 3.

The pass criterion is an ISMS for each SMS transmitted.

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

5.2.2.1 Mode Commands: This section verifies that the UUT properly implements the processing of mode commands. All optional mode commands defined in MIL-STD-1553 shall be tested both with normal responses from the test equipment and with selected error responses. (Reference Table 1.)

5.2.2.1.1 Dynamic Bus Control: This test verifies the ability of the UUT to initiate a dynamic bus control mode code sequence, identify the RT response, and take appropriate action.

1. Cause the UUT to send an MCO. The test equipment shall respond with a valid status word with the DBACC bit set to zero.

   The pass criteria are a VSMS and verification that the UUT detects that the DBACC bit was not set.

2. Cause the UUT to send an MCO. The test equipment shall respond with a valid status word with the DBACC bit set to one.

   The pass criteria are a VSMS and verification that the UUT detects that the DBACC bit was set.

5.2.2.1.2 Mode Commands Without Data Words: In the following tests, each mode command from MC1 through MC8, as defined in Table 1, shall be tested as follows:

Cause the UUT to send the selected mode command. The test equipment shall respond with a valid, legal status word.

The pass criterion is a VSMS for the SMS.

5.2.2.1.3 Transmit Mode Commands With Data Words: In this test, each of the mode commands, MC16, MC18, and MC19, as shown in Table 1, shall be tested as follows:

Cause the UUT to send the selected mode command. The test equipment shall respond with a valid, status word and one contiguous data word.

The pass criterion is a VSMS.

5.2.2.1.4 Receive Mode Commands With Data Words: In this test, each of the mode commands, MC17, MC20, and MC21, as shown in Table 1, shall be tested as follows:

Cause the UUT to send the selected mode command and contiguous data word. The test equipment shall respond with a valid status word.

The pass criterion is a VSMS.

5.2.2.2 Status Word: The following tests are intended to confirm that the UUT is capable of detecting all of the bits of the status word for each message format. The bits shall be tested one at a time by successively setting each of the eleven status code bits (bits 9-19) to a logic one with the remaining status code bits set to a logic zero. In each case, verify the ability of the UUT to detect each bit and verify any special function associated with the bit that the UUT supports in accordance with the requirements of MIL-STD-1553.

5.2.2.2.1 Status Bits, Receive Commands: Cause the UUT to send a sequence of eleven receive commands with the appropriate number of data words. Cause the test equipment to respond to each of the commands in the sequence with a valid status word with a different bit set in each status code field.

The pass criterion is the verification of bit detection.

5.2.2.2.2 Status Bits, Transmit Commands: Cause the UUT to send a sequence of eleven transmit commands. Cause the test equipment to respond to each of the commands in the sequence with a valid status word, and the appropriate number of data words. The status words shall have a different bit set in each status code field.

The pass criterion is the verification of bit detection.

5.2.2.2.3 Status Bits, RT to RT Commands, Transmitter Status: Cause the UUT to send a sequence of eleven RT to RT command pairs. Cause the test equipment to respond to each of the transmit commands in the sequence with a valid status word and the appropriate number of data words. The status word for the transmitter response shall have a different bit set in each status code field. The test equipment shall also respond to the receive command with a valid status word with all eleven status code bits set to a logic zero.

The pass criterion is the verification of bit detection.

5.2.2.2.4 Status Bits, RT to RT Commands, Receiver Status: Cause the UUT to send a sequence of eleven RT to RT command pairs. Cause the test equipment to respond to each of the transmit commands in the sequence with a valid status word with all eleven status code bits set to a logic zero, and the appropriate number of data words. The test equipment shall also respond to each of the receive commands in the sequence with a status word with a different bit set in each status code field.

The pass criterion is the verification of bit detection.

5.2.2.2.5 Status Bits, Mode Command: For this test, cause the UUT to send a sequence of eleven mode commands. Cause the test equipment to respond to each of the mode commands in the sequence with a valid status word, and valid data word if required. The status words shall have a different bit set in each status code field.

The pass criterion is the verification of bit detection. Repeat this test for each mode command supported by the UUT.

5.2.2.3 Broadcast Command: This test verifies that the UUT does not expect a response to a broadcast command, a command with the RT address field set to all ones, or that the UUT's operation is not disrupted if a status response occurs. Each type of broadcast command shall be tested.

5.2.2.3.1 Broadcast Receive Commands: Cause the UUT to send a receive broadcast command. The test equipment shall not respond to this command.

The pass criterion is verification that the UUT registered an NR as the correct response.

5.2.2.3.2 Broadcast Receive Command With Response: Cause the UUT to send a receive broadcast command. Cause the test equipment to respond to this command with a valid status word.

The pass criterion is an ISMS detected by the UUT.

5.2.2.3.3 Broadcast RT-RT Command: This test verifies that the UUT does not expect a response from receiving RT in broadcast RT-RT transfer.

5.2.2.3.3.1 Broadcast RT-RT Command With No-Response: Cause the UUT to send a broadcast RT-RT command. The test equipment shall not respond.

The pass criterion is the verification that the UUT registered an NR.

5.2.2.3.3.2 Broadcast RT-RT Command With Response: Cause the UUT to send a broadcast RT-RT command. Cause the test equipment to respond with a status word and the appropriate number of data words representing the transmitting RT's response. Cause the test equipment to follow this with a status word representing a response from a receiving RT.

The pass criterion is an ISMS by the UUT.

5.2.2.3.3.3 Normal Broadcast RT-RT Command: Cause the UUT to send a broadcast RT-RT command. Cause the test equipment to respond with a status word and the appropriate number of data words representing the transmitting RT's response.

The pass criterion is a VSMS by the UUT.

5.2.2.3.4 Broadcast Mode Commands: Perform this test for each of the following mode commands that can be sent by the UUT: MC1, MC3, MC4, MC5, MC6, MC7, MC8, MC17, MC20, MC21. Let the UUT send each broadcast mode command. The test equipment shall not respond to these commands.

The pass criterion is verification that the UUT registered an NR as the correct response.

5.2.2.3.5 Broadcast Mode Command With Response: Cause the UUT to send each of the following legal broadcast mode commands that are supported by the UUT design specification: MC1, MC3, MC4, MC5, MC6, MC7, MC8, MC17, MC20, MC21. Cause the test equipment to respond to each command with a valid status response.

The pass criteria shall be an ISMS detected by the UUT for each command.

5.2.2.4 Response On Alternate Bus: This test verifies that the UUT detects a response to a command on the opposite bus from which the command was issued as an erroneous response. During this test, the UUT shall send out a command and the test equipment shall respond to the command on each alternate bus. This test shall be conducted with a transmit command, a receive command, and an RT-RT command pair. The RT-RT case shall be conducted for each bus, first for the transmitter response on each alternate bus, then for the receiver response on each alternate bus. The UUT shall not accept a response on an alternate bus.

The pass criterion for each case is an NR or ISMS for each SMS on an alternate bus.