Herschel	Herschel-Planck CDMS-interface test-requirements specification	**Hifi no.: SRON-U/HIFI-SP-2000-5 .** **Inst.no.: n** **Issue: Issue 1.0** **Date: 14 June 2001** **Category: -**

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1. Introduction

This document describes the test-requirements for terminals to be connected to the spacecraft bus on the FIRST or PLANCK spacecraft. In particular, these requirements apply to the CDMS simulator and the instruments Remote Terminal.

The CDMS simulator is part of the test-equipment used for the Instrument Level Test (ILT). During the ILT the CDMS-sim will only be connected to one instrument.

To get a comprehensive document the applicable requirements as listed in the Packet Structure ICD and in the MIL-STD are copied here in an annex.

Notice that test described in this document are applicable to the instrument-level tests. The tables in this document with the requirement-identification numbering may be used in the verification processes of the instruments.

1.1. Used acronyms:

BC Bus controller

CS Clear Status

ME Message error bit

NR No Response

RT Remote Terminal

BIT Built-in Test

UUT Unit under Test

1.2. Response definitions

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.

Broadcast command received (BCR). The broadcast command received bit (bit time fifteen) is set in status word (and no data words in response to a transmit status mode command or a single data word in response to a transmit last command mode command).

Busy bit (BUSY). CS with the busy bit (bit time sixteen) set in the status word, and no data words.

Clear status (CS). The status word may have the busy bit and/or service request bit set. All other status code bits in the status word must be zero and the associated message must have the proper word count.

Dynamic bus acceptance by (DBA). CS with the dynamic bus control acceptance bit (bit time eighteen) set in the status word.

Service request bit (SRB). CS with the service request bit (bit time eleven) set in the status word.

Message error bit (ME). The message error bit (bit time nine) is set in the status word and no data words (except in response to a transmit last command mode command which requires on data word).

No response (NR). The addressed terminal does not produce any response to the command.

Respond in form. A terminal is said to ”respond in form” if its response to an illegal command as defined in the paragraph titled “illegal command” of MIL-STD-1553 consists of a response formatted as though it were a legal command.

Subsystem flag bit (SF). CS with the subsystem flag bit (bit time seventeen) set in the status word.

Terminal flag bit (TF). CS with the terminal flag bit (bit time nineteen) set in the status word.

2. Applicable documents

AD-#1 SRON-U/HIFI/SP/2000-004 CDMS simulator requirements specification document

AD-#2 SCI-PT-ICD-07527 version 1 Packet Structure ICD

AD-#3 MIL-STD-1553B, Notice 2, 8.9.1986

Digital time division command/response multiplex data bus

3. Reference Documents

RD.1. MIL HDBK 1553A, 1 November 1988

Multiplex Application Handbook

4. Test overview

This section lists the requirements that will be verified by tests. The tests may be carried out in three configurations:

1. Instrument, connected to standard test-equipment
2. CDMS-sim, connected to standard test-equipment
3. Instrument connected to CDMS-sim.

An x indicates which configuration shall be used to test the requirement.

The requirements originate from AD-#2 and AD-#3. Where a test is described in RD.1 a reference is made in the right-most column.

Test		Applicable to			Req nr	MIL HDBK
		instrument	CDMS sim	Integrated		
4.1.	**Output characteristics**					5.1.1
4.1.1	Amplitude	x	x		2045.1	5.1.1.1
4.1.2	Risetime/falltime.	x	x		2045.2	5.1.1.2
4.1.3	Zero crossing stability	x	x		2045.2	5.1.1.3
4.1.4	Distortion, overshoot and ringing.	x	x		2045	5.1.1.4
4.1.5	Output symmetry.	x	x		2045.4	5.1.1.5
4.1.6	Output noise.	x	x		2045.3	5.1.1.6
4.1.7	Output isolation.	x	x		2045.12	5.1.1.7
4.1.8	Power on/off noise.	x	x		2045.11	5.1.1.8.1
4.1.9	Power on response.	x			2045.	5.1.1.8.2
4.1.10	Terminal response time.	x			2045.	5.1.1.9
4.1.11	Frequency stability	x	x		2045.	5.1.1.10
4.2.	**Input characteristics.**					5.1.2
4.2.1	Zero crossing distortion.	x			2045.5	5.1.2.1.1
4.2.2	Amplitude variations.	x			2045.6	5.1.2.1.2
4.2.3	Rise and fall time.	x			2045	5.1.2.1.3
4.2.4	Common mode rejection	x			2045.8	5.1.2.2
4.2.5	Input impedance.	x	x		2045.9	5.1.2.3
4.3.	**Protocol tests.**					5.2
4.3.1	Response to command words.	x				5.2.1.1
4.3.2	Intermessage gap (Minimum time)	x			3080	5.2.1.2.1
4.3.3	Intermessage gap (Transmission rate)	x			3080	5.2.1.2.2
4.4.	**Error Injection.**	x				5.2.1.3
4.4.1	Parity.	x				5.2.1.3.1

Test		Applicable to			Req nr	MIL HDBK
		instrument	CDMS sim	Integrated		
4.4.2	Word Length.	x				5.2.1.3.2
4.4.3	Bi-Phase Encoding	x				5.2.1.3.3
4.4.4	Sync Encoding.	x				5.2.1.3.4
4.4.5	Message Length.	x				5.2.1.3.5
4.4.6	Contiguous Data.	x				5.2.1.3.6
4.4.7	Terminal fail-safe.	x				5.2.1.3.7
4.4.8	Superseding Commands.	x				5.2.1.4
4.4.9	Required Mode Commands.	x	x	x		5.2.1.5
	Transmit Status	x	x	x		5.2.1.5.1
	Transmitter Shutdown and Override	x	x	x		5.2.1.5.2
	Reset Remote Terminal.	x	x	x		5.2.1.5.3
4.4.10	Data Wrap-Around	?				5.2.1.6
4.4.11	Bus Switching.	x				5.2.1.7
4.4.12	Unique Address	x				5.2.1.9
4.4.13	Optional Operation.	x				5.2.2
	Optional Mode commands	x				5.2.2.1
	Synchronize with/without data word	x				5.2.2.1.2
	Initiate self-test	x				5.2.2.1.3
	Transmit BIT word	?				5.2.2.1.4
	Selective transmitter shutdown & override	x				5.2.2.1.5
	Terminal flag inhibit and override	?				5.2.2.1.6
	Transmit Vector word	?				5.2.2.1.7
	Transmit last command	x				5.2.2.1.8
	Status word bits	x				5.2.2.2
	Service request	?				5.2.2.2.1
	Broadcast command received	x				5.2.2.2.2
	Busy	?				5.2.2.2.3
	Subsystem flag	x				5.2.2.2.4
	Terminal flag	?				5.2.2.2.5
	Illegal command	x				5.2.2.3
	Broadcast mode command	x				5.2.2.4
	Error injection broadcast messages	x				5.2.2.5
4.5.	**Noise rejection test**	x				5.3
4.6.	**CDMS sim Data Link support**					

Test		**Applicable to**			**Req nr**	**MIL HDBK**
		instrument	CDMS sim	Integrated		
4.6.1	Mode commands		x	x		
4.6.2	No response timeout		x			
4.6.3	Receive message:	x	x	x		
4.6.4	Broadcast message:	x	x	x		
4.6.5	Transmit message:	x	x	x		
4.6.6	Receive low-level command	x	x	x		
4.7.	**Satellite data-bus protocol**					
4.7.1	EGSE connection		x			
4.7.2	Basic protocol without TM or TC transfer		x			
4.7.3	Transfer of TC-packet.			x		
4.7.4	RT error-conditions during data-transfer.		x			
4.7.5	TM-packet transfer.			x		
4.7.6	CDMS-sim error conditions during data transfer.			x		
4.7.7	Nominal mode			x		
4.7.8	Burst mode			x		

4.1. Output characteristics

The following tests are designed to verify that all UUT output characteristics comply with MIL-STD-1553. These tests shall be performed after establishing communications between the test equipment and the UUT. All output electrical tests shall use figure 1A (RD.1), General Resistor Pad Configuration, with all measurements taken at point "A", unless otherwise noted.

Notice that the UUT in the figure below may be either the CDMS-sim or the Instrument.

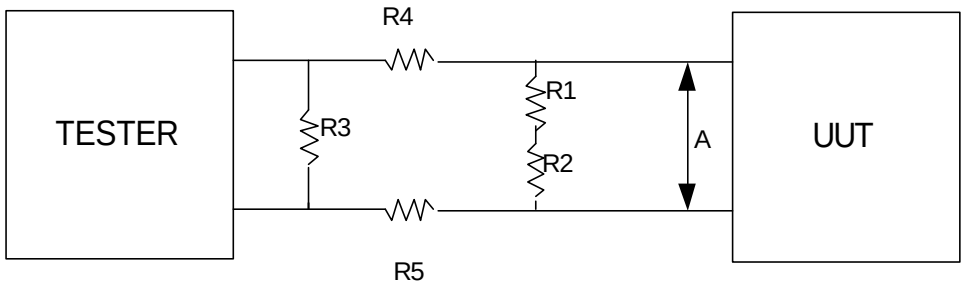


Figure 4.1. -1 General resistor pad configuration (Fig 1A in RD.1)

4.1.1. Amplitude

A valid, legal transmit command shall be sent 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 on figure 2 (RD.1), The pass criteria for Vpp for transformer coupled stubs shall be 18.0 V minimum, and 27.0 V maximum. The maximum and minimum measured parameters, Vpp, shall be recorded.

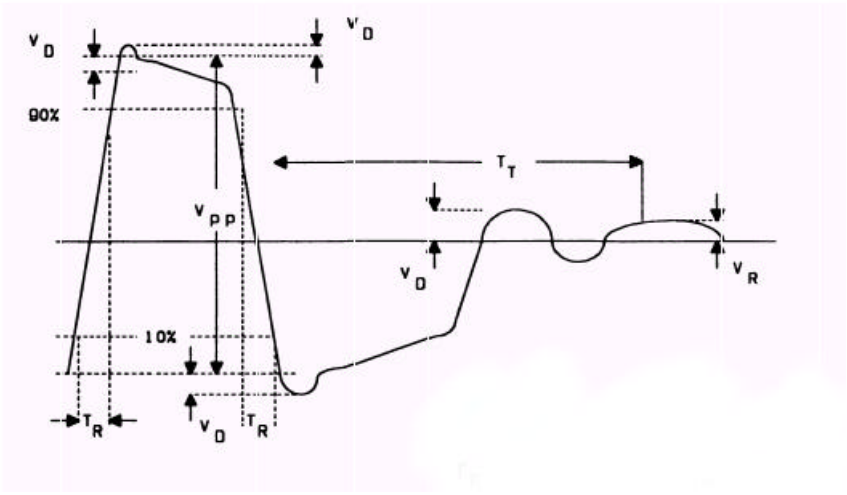


Figure 4.1.1-1 Waveform measurement (Fig 2 in RD.1),

4.1.2. Risetime/falltime.

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 on figure 2 (RD.1). The measurements shall be taken at both the rising and falling edges of a sync waveform and a data bit waveform. The risetime (Tr) and the falltime (Tf) shall be recorded.

The pass criteria shall be 100 ns < Tr < 300 ns and 100 ns < Tf < 300 ns. The measured parameters, Tr and Tf, shall be recorded.

Note: The risetime 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.

4.1.3. Zero crossing stability

A valid legal transmit command shall be sent to the UUT, requesting the UUT to transmit words having zero crossing time intervals of 500 ns, 1000 ns, 1500 ns and 2000 ns. The zero crossing time shall be measured for both the positive (Tzcp) and the negative (Tzcn) waveforms as shown on figure 3, RD.1.

The pass criteria for each case shall be that Tzcp and Tzcn = 500 ±25 ns, 1000 ±25 ns, 1500 ±25 ns and 2000 ±25 ns. The measured parameters, Tzcp and Tzcn shall be recorded for each case.

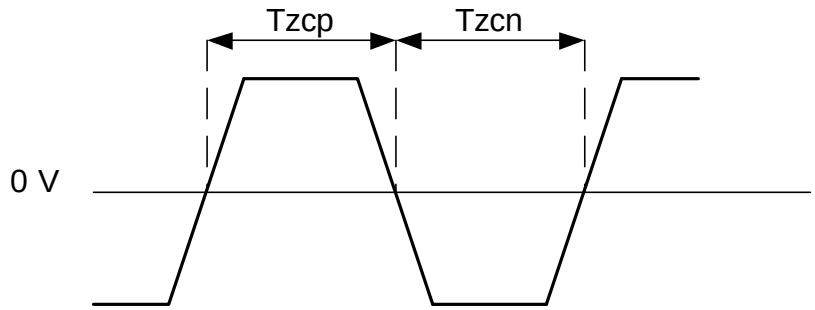


Figure 4.1.3-1 Zero-crossing interval measurements (Fig 3 in RD.1)

4.1.4. 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 (VD) shall be measured as indicated on figure 2, RD.1.

Pass criteria shall be VD <+ 900 mV peak, line-to-line, for transformer coupled stubs. The worst measured parameter, VD, shall be recorded.

4.1.5. 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 (Vr) shall be measured as shown on figure 2 RD.1. 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

The pass criteria shall be Vr <+ 250 mV peak, line-to-line, for transformer coupled stubs after time Tt (the time beginning 2.5 us after the mid-bit zero crossing of the last parity bit). The measured parameter, Vr, shall be recorded for each bit pattern.

4.1.6. Output noise.

The test configuration shown on figure 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 on figure 4, RD.1 for both states. Measurements shall be made with an instrument that has a minimum frequency bandwidth of DC to 10 MHz.

The pass criteria shall be Vrms < 14.0 mV for transformer coupled stubs. The measured parameters, Vrms, shall be recorded for each case.

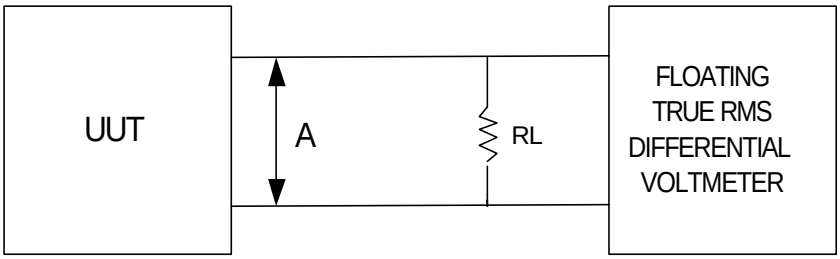


Figure 4.1.6-1 Output noise configuration (R_L=70.0 ohms $\pm$ 2%; Fig 4 in RD.1)

4.1.7. Output isolation.

A valid legal transmit command shall be sent to the UUT requesting 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 criteria shall be that the ratio in dB between the output peak-to-peak voltage on the active bus and the output peak-to-peak voltage on all inactive buses shall be greater than or equal to 45 dB (figure 5, RD.1). The measured parameters, output isolation, expressed as a ratio in dB, shall be recorded for each bus combination.

Notice that the UUT in the figure below may be either the CDMS-sim or the Instrument.

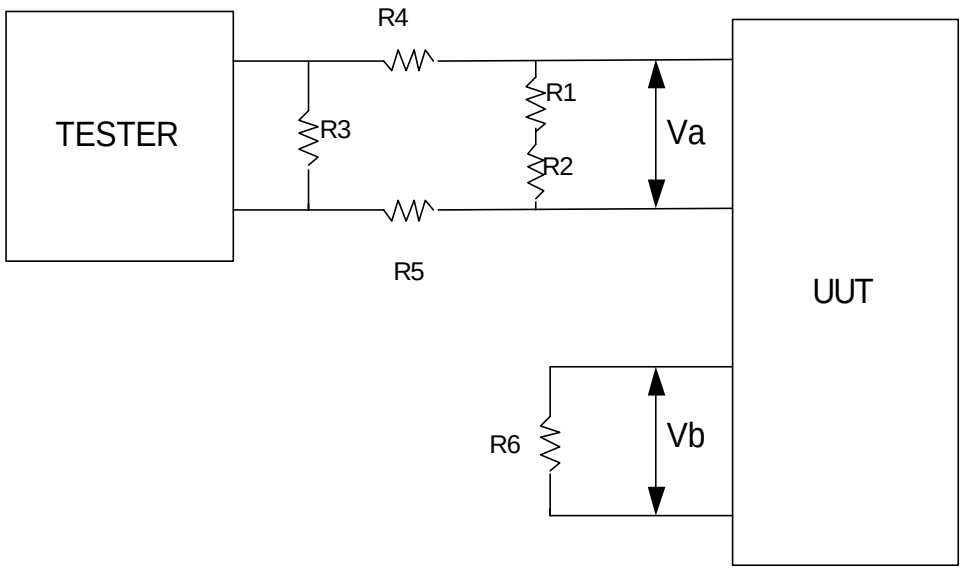


Figure 4.1.7-1 Output isolation (Fig 5 in RD.1)

4.1.8. 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 shall be measured. Power shall be removed from the UUT and any output from the UUT shall be measured. Repeat the test ten times.

The pass criteria shall be: For transformer coupled stubs any spurious noise pulses produced shall be less than or equal to ±250 mV peak, line-to-line.

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 of the UUT.

4.1.9. Power on response.

The purpose of this test is to verify that the UUT responds correctly to commands after power is applied to the UUT. Using the normal power on sequence for the UUT, repeat the following test sequence a minimum of ten times.

Step 1. Power the UUT off.

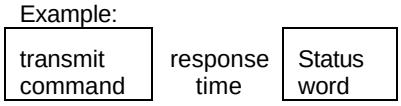
Step 2. Send valid, legal, non-broadcast, non-mode commands to the UUT with a maximum intermessage gap of 1 ms.

Step 3. Power on the UUT and observe all the responses for a minimum of 2 s from the first transmission of the UUT after power on.

The pass criteria shall be: step 3 - NR until the first UUT transmission, and CS for the first transmission and all responses thereafter.

4.1.10. Terminal response time.

Example:



The purpose of this test is to verify that the UUT responds to messages within the proper response time. The test sequence shown below shall be performed.

Step 1. A valid legal transmit command shall be sent to the UUT and the response time measured.

Step 2. A valid legal receive command shall be sent to the UUT and the response time measured.

Step 3. Not Applicable

Step 4. A valid legal mode command shall be sent to the UUT and the response time measured.

The pass criteria for step 1, step 2, step 3, and step 4 shall be a response time between 4.0 and 12.0 us at point A of figure 1A and measured as shown on figure 7 (RD.1). The command words used and the response times shall be recorded.

4.1.11. Frequency stability

The purpose of this test is to verify that the transmitter clock in the UUT has the proper accuracy and long term stability and proper short term stability. The transmitter clock measured shall be either the main oscillator output or an appropriate derivative of that clock (e.g., either the 16 MHz oscillator or the 1-2 MHz transmitter shift clock). The test sequence shown below shall be performed on the clock output whose ideal frequency is Fi.

Step 1. The short term transmitter clock frequency shall be measured for a single period of the waveform.

Step 2. Repeat step 1 for at least 10,000 samples and record the minimum (Fsmin) and the maximum (Fsmax) frequency from the samples taken.

Step 3. The transmitter clock frequency shall be measured with a gate time of 0.1s and the mean frequency for at least 1,000 samples (Fav) shall be recorded.

The pass criteria shall be:

Step 1 and Step 2 -Ss1 = 100 (Fsmax - Fav)/Fav < 0.01 and Ss2 = 100 (Fav-Fsmin)/Fav < 0.01;

Step 3- the magnitude of S1 = 100 (Fav-Fi)/Fi < 0.1. Record Ss1, Ss2 and S1.

4.2. Input characteristics.

The input tests are designed to verify that multiplex devices can properly decode bi-phase data. All input electrical tests shall use figure 1A or figure 1B of RD.1 with all measurements taken at point “A,” unless otherwise noted.

Notice that the UUT in the figure below may be either the CDMS-sim or the Instrument.

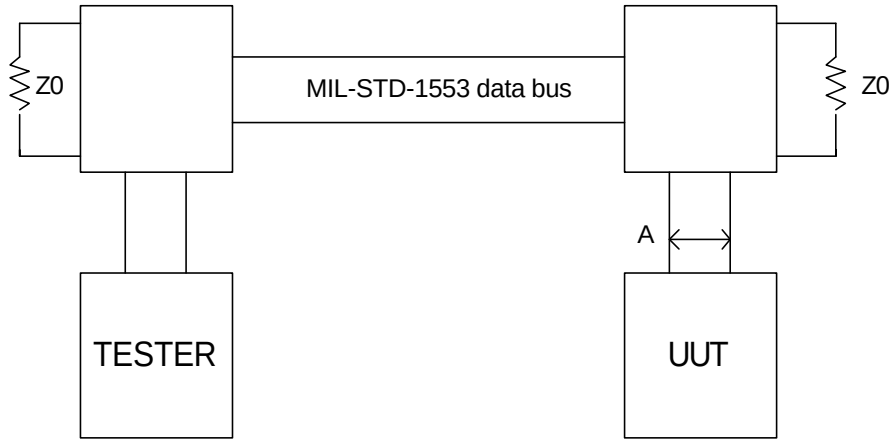


Figure 4.2-1 General bus configuration (Fig 1B in RD.1). Notice that the standard resistor pad configuration is shown in section 4.1.

4.2.1. Zero crossing distortion.

A legal valid receive message shall be sent to the UUT and the proper response verified. Positive and negative zero crossing distortions equal to N ns, with respect to the previous ideal zero crossing shall be introduced individually to each zero crossing of each word transmitted to the UUT.

The transmitted signal amplitude at point “A” shall be 2.1 Vpp for transformer coupled stubs. The rise and fall time of the transmitted message (measured at a data bit zero crossing with the prior zero crossing and the next zero crossing at 500 ns intervals from the measured zero crossing) measured at point “A” shall be 200 ns $\pm$20 ns. Each zero crossing distortion shall be transmitted to the UUT a minimum of 1000 times.

The pass criteria is the transmission of a CS by the UUT for each zero crossing distortion sent with N > 150 ns. 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 NR of the UUT occurs; these values shall be recorded.

The fail criteria is the transmission of a NR by the UUT for any zero crossing distortion sent with N < 150 ns.

4.2.2. Amplitude variations.

A legal valid receive message shall be sent to the UUT. The transmitter's voltage, as measured at point “A” of figure 1A or figure 1 B of RD.1, shall be decremented from 6.0 Vpp to 0.1 Vpp for transformer coupled stubs in steps no greater than 0.1 Vpp. The rise and fall time of the transmitted message (measured at a data bit zero crossing with the prior zero crossing and the next zero crossing at 500 ns intervals from the measured zero crossing) measured at point “A” shall be 200 ns $\pm$ 20 ns. The response of the UUT shall be observed at each step. A minimum of 1000 messages shall be transmitted for each setting.

The pass criteria shall be:

a. A CS for 0.86 , < Vpp < 6.0 for transformer coupled stubs

b. A NR for Vpp < 0.20 for transformer coupled stubs

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

4.2.3. Rise and fall time.

Trapezoidal.

A minimum of 1000 valid receive messages shall be sent to the UUT with a signal amplitude of 2.1 Vpp for the transformer coupled stub. The rise and fall times of the signal shall be less than or equal to 100 ns.

The pass criteria shall be CS by the UUT for each message.

Sinusoidal.

A minimum of 1000 valid receive messages shall be sent to the UUT with a signal amplitude of 2.1 Vpp for the transformer coupled stub. The rise and fall times of the signal shall approximate that of a 1 MHz sinusoidal signal.

The pass criteria shall be CS by the UUT for each message.

4.2.4. Common mode rejection

The common mode test configuration, figure 6A or figure 6B of RD.1, shall be used for this test. Legal valid receive messages with the UUT'S maximum word count shall be sent to the UUT at a repetition rate which generates a bus activity duty cycle of 50% $\pm$10% 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. The rise and fall time of the transmitted message (measured at a data bit zero crossing with the prior zero crossing and the next zero crossing at 500 ns intervals from the measured zero crossing) measured at point “A shall be 200 ns $\pm$ 20 ns. The following common mode voltage levels shall be applied in turn: +10.0 V.D.C. line-to-ground, -10.0 V DC line-to-ground and $\pm$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 seconds.

The pass criteria shall be a CS by the UUT for all messages at each setting. If a failure occurs, the measured parameters, common mode signal injected shall be recorded.

4.2.5. Input impedance.

The input impedance of the UUT in a stand alone configuration (i.e., disconnected from figure 1A or 1B of RD.1) 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 shall be Zin > 1000 ohms for transformer coupled stubs. The measured parameter, Zin, shall be recorded at each frequency.

4.3. Protocol tests.

All tests in this section shall use the test configuration as shown on figure 1A or figure 1B of RD.1. The test signal amplitude shall be 2.1 Vpp ± 0.1 Vpp for transformer coupled stubs measured at point A. The protocol tests shall be performed on all buses for UUTS with redundant bus configurations.

Required remote terminal operation.

The following tests verify required operations of a remote terminal.

4.3.1. Response to command words.

The purpose of this test is to verify that the UUT responds properly to all commands.

RT response to command words.

All possible command words (65, 536 combinations) meeting the criteria of the paragraph on “Word validation” of MIL-STD-1553 shall be sent to the UUT. Mode commands tested in 4.4.9,4.4.13 (see 5.2.1.5, 5.2.2.1, or 5.2.2.4 of RD.1) may be omitted from this test since they are tested separately. Each command word shall be followed by the proper number of contiguous valid data words as defined in the paragraph on “Message formats” of MIL-STD-1553. Refer to table 4.3.1-1 for undefined mode commands. The associated data may be either random or controlled, depending on the UUT requirements.

The following sequence shall be executed for all combinations of command words where the varying command word is sent as step 2.

Step 1. Send a valid legal non-broadcast non-mode command to the UUT.

Step 2. Send the variable command word to the UUT.

Step 3. Send a transmit last command mode command to the UUT. (If this mode command is not implemented, then transmit status mode command shall be used and the data word associated with transmit last command mode command shall be deleted from the pass criteria.)

The pass criteria given below is contingent on the type of command sent. All commands which cause the UUT to fail shall be recorded.

Non-Broadcast Commands (including mode commands):

a. Valid legal commands: step 1- CS; step 2- CS; step 3- CS and the data word contains the command word bit pattern from step 2 (except for transmit last command mode command where the data word contains the command word bit pattern from step 1).

b. Valid illegal commands:

   (1) If illegal command detection option is implemented: step 1 -CS; step 2- ME with no data words; step 3-ME and the data word contains the command word bit pattern from step 2.

   (2) If the illegal command detection option is not implemented: step 1- CS; step 2- CS; step 3- CS and the data word contains the command word bit pattern from step 2.

c. Invalid command (wrong RT address): step 1- CS; step 2- NR; step 3- CS and the data word contains the command word bit pattern from step 1.

d. Undefined mode commands (see table 1) (for any one undefined mode command, any single set (1), (2), (3), (4), is acceptable):

   (1) step 1- CS; step 2- CS; step 3- CS and the data word contains the command word bit pattern addressed to the UUT from step 2.

   (2) step 1- CS; step 2- ME; step 3- ME and the data word contains the command word bit pattern addressed to the UUT from step 2.

   (3) step 1- CS; step 2- NR; step 3- CS and the data word contains the command word bit pattern addressed to the UUT from step 1.

(4) step 1- CS; step 2- NR; step 3- ME and the data word contains the command word bit pattern addressed to the UUT from step 2.

Table 4.3.1-1. MIL-STD-1553B Undefined Mode Codes

T/R	MODE CODE	ASSOCIATED DATA WORD
0	00000	No
0	01111	No
0	10000	Yes
0	10010	Yes
0	10011	Yes
1	10001	Yes
1	10100	Yes
1	10101	Yes

Broadcast Commands (including mode commands):

e. If there are any broadcast commands that are considered as valid commands:

(1) Legal commands: step 1 -CS; step 2- NR; step 3- BCR and the data word contains the commands word bit pattern from step 2.

(2) Illegal commands (if illegal command detection is implemented): step 1- CS; step 2- NR; step 3- BCR and ME and the data word contains the command word bit pattern from step 2.

(3) Illegal commands (if illegal command detection is not implemented): step 1- CS; step 2- NR; step 3- BCR and the data word contains the command word bit pattern from step 2.

f. If there are no broadcast commands that are considered as valid commands: step 1 -CS; step 2-NR; step 3-CS and the data word contains the command word bit pattern from step 1.

g. Undefined broadcast mode commands (see table 1) (for anyone undefined mode command, any single set (1), (2), (3) is acceptable):

(1) step 1 - CS; step 2- NR; step 3- BCR and the data word contains the command word bit pattern from step 2.

(2) step 1 - CS; step 2- NR; step 3-ME and BCR and the data word contains the command word bit pattern from step 2.

(3) step 1 - CS; step 2- NR; step 3- CS and the data word contains the command word bit pattern from step 1.

4.3.2. Intermessage gap (Minimum time)

Example

receive command	data word	data word	...	data word	response time	Status word	intermessage-gap	Next Command

The purpose of this test is to verify that the UUT responds properly to messages with a minimum intermessage gap. The message pairs listed in table below shall be sent to the UUT with the minimum intermessage gaps as defined in the paragraph on “Intermessage gap” of MIL-STD-1553. Each message pair shall be sent to the UUT a minimum of 1,000 times. Message pairs which include commands not implemented by the UUT shall be deleted from the test. Each message pair shall have an intermessage gap time (T) of 4.0 us as shown on figure 7.

The pass criteria for this test is CS for each message. All message pairs used shall be recorded and message pairs which cause the UUT to fail the test shall be indicated.

4.3.3. Intermessage gap (Transmission rate)

The purpose of this test is to verify that the UUT responds properly to messages sent for a sustained period with a minimum intermessage gap. The message listed in each step shall be sent with an intermessage gap of 7 us $\pm$3 us, i.e. a burst of messages with an intermessage gap of 7 us $\pm$3 us between each message as shown on figure 7 of RD.1. Each step shall be performed for a minimum of 30 s.

Step 1. A valid legal transmit message followed by a valid legal transmit message.

Step 2. A valid legal receive message followed by a valid legal receive message.

Table 4.3.3-1 Intermessage gap messages.

	Command types	
A)	BC to UUT Transfer (maximum word count)	
B)	UUT to BC Transfer (maximum word count)	
C)	UUT/RT (maximum word count)	NA
D)	RT/RT (maximum word count)	NA
E)	Mode Command Without Data Word	
F)	Mode Command With Data Word (Transmit)	
G)	Mode Command With Data Word (Receive)	
H)	BC to UUT Transfer (Broadcast) (maximum word count)	
I)	UUT/RT (Broadcast) (maximum word count)	NA
J)	RT/UUT (Broadcast) (maximum word count)	NA
K)	Mode Command Without Data Word (Broadcast)	
L)	Mode Command With Data Word (Broadcast)	

MESSAGE PAIRS

1)	A (GAP) A	
2)	B (GAP) A	
3)	C (GAP) A	NA
4)	D (GAP) A	NA
5)	E (GAP) A	
6)	F (GAP) A	
7)	G (GAP) A	
8)	H (GAP) A	
9)	I (GAP) A	NA

10)	J (GAP) A	NA
11)	K (GAP)A	
12)	L (GAP) A	

Note: This table defines the types and combinations of messages to be used e.g., pair number 2 specifies a transmit command with the maximum word count to be followed (after the minimum intermessage gap time specified in the paragraph on “Intermessage gap” of MIL-STD-1553) by a receive command with the maximum word count.

Step *3* A valid legal transmit message followed by a valid legal receive message. The pass criteria for this test is a CS for each message. All messages which cause the UUT to fail the test shall be recorded.

Note: If the busy bit gets set, then increase the intermessage gap until the busy bit is reset. At this time record the intermessage gap and repeat steps 1 through 3 until the test is completed without the busy bit getting set.

4.4. Error Injection.

The purpose of these tests is to examine the UUT'S response to specific errors in the message stream. Unless otherwise noted, the following test sequence 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.

Test sequence:

Step 1. A valid legal message shall be sent to the UUT. A mode command shall not be used.

Step 2. A legal message containing the specified error shall be sent to the UUT.

Step 3. A transmit status mode command shall be sent to the UUT.

The pass criteria is defined in each test paragraph. All commands and responses shall be recorded.

4.4.1. Parity.

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

Transmit Command Word.

This test verifies the ability of the UUT to detect a parity error occurring in a transmit command word. The test sequence as defined above shall be performed with a parity error encoded into a transmit command word for test step 2.

The pass criteria for this test shall be: step 1 -CS; step 2- NR; step 3- CS.

Receive Command Word.

This test verifies the ability of the UUT to recognize a parity error occurring in a receive command word. The test sequence as defined above shall be performed with a parity error encoded in a receive command word for test step 2.

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3-CS.

Receive Data Words.

This test verifies the ability of UUT to recognize a parity error occurring in a data word. The test sequence as defined above shall be performed with a parity error encoded in a data word for test step 2. The message shall be a receive command with the maximum number of data words that the UUT is designed to receive. The test sequence must be sent N times, where N equals the number of data words sent.

Individually each data word must have the parity bit inverted. Only one parity error is allowed per message.

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3- ME.

4.4.2. Word Length.

This test verifies the ability of the UUT to recognize transmit command word length errors. The test sequence as defined above shall be performed with the command word shortened as defined below for test step 2.

a. Transmit command shortened by one bit

b. Transmit command shortened by two bits

The pass criteria for this test shall be: step 1- CS, step 2- NR; step 3- CS.

Receive Command Word.

This test verifies the ability of the UUT to recognize receive command word length errors. The test sequence as defined above shall be performed with the command word as defined below for test step 2.

a. Shorten the receive command word by one bit

b. Shorten the receive command word by two bits

c. Lengthen the receive command word by two bits

d. Lengthen the receive command word by three bits

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3- CS, or alternately for c and d only, the pass criteria may be: step 1- CS; step 2- NR; step 3- ME.

Receive Data Words.

This test verifies the ability of the UUT to recognize data word length errors.

The test sequence as defined above shall be performed as defined below for test step 2. The message

shall be a receive command with the maximum number of data words that the UUT is designed to received.

a. Shortened the data word by one bit

b. Shortened 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 5.2.1.3 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 errors shall not be tested in the last data word of a receive message.

Only one data word shall be altered at a time. Steps a through d shall be performed for each data word in the message.

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3- ME.

4.4.3. 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. Only a single bi-phase error shall be injected for each message.

Transit Command Word.

This test verifies the ability of the UUT to recognize bi-phase encoding errors in transmit command words. The test sequence as defined above shall be performed with a bi-phase encoding error encoded into a transmit command word for test step 2. Each bit location shall have each of the bi-phase errors injected into it. 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, one for injecting high bi-phase errors and another for injecting low bi-phase errors.

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3- CS.

Receive Command Word.

This test verifies the ability of the UUT to recognize bi-phase encoding errors in receive command words. The test sequence as defined above shall be performed with a bi-phase error encoded into a receive command word for test step 2. Each bit location must have each of the bi-phase errors injected into it. 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 one for injecting high bi-phase errors and another for injecting low bi-phase errors.

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3- CS.

Receive Data Words.

This test verifies the ability of the UUT to recognize bi-phase encoding errors in data words. The test sequence as defined above shall be performed with a bi-phase error encoded into each data word in the message for test step 2. The message shall be a receive command and the maximum number of data words that the UUT is designed to receive. Individually each bit location of each data word shall have a bi-phase error encoded into it. Only one bi-phase error is allowed for each message.

A test set 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 2*N test sets to be performed, once for high bi-phase errors and once for low bi-phase errors.

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3- ME.

4.4.4. 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 us divisions. The divisions are represented as a 1 or 0 to indicate the polarity of each division of each division on the data bus. A proper command sync is represented as 111000 and a proper data sync is represented as 000111.

Transmit Command Word.

This test shall verify that the UUT rejects transmit commands with invalid sync waveforms. The test sequence as defined above shall be performed with a sync error encoded in a transmit command word for test step 2. The test sequence shall be performed for each of the following invalid sync patterns:

111100,110000,111001,000111

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3- CS.

Receive Command Word.

This test shall verify that the UUT rejects receive commands with invalid sync waveforms. The test sequence as defined above shall be performed with a sync error encoded in a receive command word for test step 2. The test sequence shall be performed for each of the following invalid sync patterns:

111100,110000,111001,011000,000111

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3-CS.

Data Word

This test shall verify that the UUT rejects invalid data sync waveforms. Perform the test sequence as defined above with a sync error encoded into each data word for test step 2. The message is a valid receive command word and the maximum number of data words that the UUT is designed to receive.

Only one data word per message shall have an invalid sync encoded into it. The test sequence shall be performed N times for each of the following invalid sync patterns: where N equals the maximum number of data words in the message.

000011,001111,000110,100111,111000

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3- ME.

Note: Data words shall not be encoded such that bit times 4 through 8 match the terminal address of the UUT or be 11111 when the invalid data sync pattern 111000 is being used.

4.4.5. Message Length.

These tests shall verify that the UUT properly detects an error when an incorrect number of data words are received.

Transmit Command.

This test verifies the ability of the UUT to respond properly if the data word is contiguous to a transmit command word. perform the test sequence as defined above with a data word contiguously following a transmit command word for test step 2.

The pass criteria for this test shall be: step 1- CS; step 2- NR; step 3- ME.

Receive Command.

This test shall verify that the UUT recognizes an error in the number of data words that are received. Perform the test sequence as defined above with a data word count error in a receive message for test step 2. This message is a valid legal receive command word with the word count field equal to the maximum number of data words that the

UUT is designed to receive but with a 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 first sequence shall have N+1 data words. The second sequence shall have N-1 data words and each of the remaining sequence shall remove one additional data word until the number of data words equals zero.

The pass criteria shall be: step 1- CS; step 2- NR; step 3- ME.

Mode command Word Count Error.

This test verifies the ability of the UUT to respond properly when an incorrect number of words are sent with a mode command. Perform the test sequence defined above using valid receive mode command in step 2 which would normally have an associated data word transmitted with it, but send the number of data words equal to the mode code value used. Repeat the test sequence with the same mode command but with no data word in step 2. Repeat the test sequence using a valid transmit mode command except send a data word contiguously following the command word.

In all three cases the pass criteria shall be: step 1 -Cs; step 2- NR; step 3- ME.

4.4.6. Contiguous Data.

This test verifies that the UUT recognizes discontinuous data in a message.

Perform the test sequence as defined above with a 4.0 us data word gap error in a receive message for test step 2. The gap is measured as on figure 7. The receive message shall be a receive command with the maximum number of data words that the UUT is designed to receive with a gap between the command 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. Only one gap time insertion is allowed per message.

The pass criteria for this test shall be: step 1 -CS; step 2- NR; step 3- ME.

4.4.7. Terminal fail-safe.

The purpose of this testis to verify that the terminal fail-safe timer is properly implemented in the UUT. The UUT is required to contain a hardware implemented timer that will cause the transmitter to shutdown if the UUT transmits a message longer than 800.0 us. A fail-safe time-out occurring on one bus shall not affect the transmitter on any other bus. The reception of a valid command on the bus on which the time-out has occurred shall enable the transmitter. The test sequence below shall be performed for each bus:

Step 1. Initiate a condition in the UUT which causes the fail-safe timer to timeout. Measure the duration of the transmission

Step 2. Remove the condition initiated in step 1.

Step 3. Send the UUT a valid legal message over the bus on which the time-out has occurred.

The pass criteria shall be that the timeout in step 1 occurs and the transmitter is shut down allowing the total transmission time to be between 660.0 us and 800.0 us. The response of the UUT in step 3 shall be CS. Record the measured parameter at which the fail-safe time-out occurs. For test failures, record the test parameters at which the failure occurred.

4.4.8. Superseding Commands.

This test verifies that the UUT will not malfunction and responds properly to possible occurrences of superseding commands. The following test sequence shall be used for this test.

Step 1. A valid legal receive message shall be sent to the UUT with the maximum number of words that the UUT is designed to receive encoded in the word count field.

Step 2. Before step 1 is completed, a superseding message shall be sent to the UUT.

Step 3. A transmit status mode command shall be sent to the UUT.

Record the UUT's response to each step when the test is performed with the following superseding command formats (step 2):

a. After at least one data word is transmitted in step 1, but before the last data word is transmitted, follow the selected data word with a gap of 4.0 us (reference figure 7), then a valid legal transmit command requesting the maximum number of data words that the UUT is designed to transmits.

b. Proceed as in “a” above, except transmit a valid legal transmit status mode command as the superseding command.

c. After at least one data word is transmitted in step 1, but before the last data word is transmitted, follow the selected data word contiguously with a valid legal transmit command requesting the maximum number of data words that the UUT is designed to transmit.

d. After the last data word is transmitted in step 1 follow it contiguously with a valid legal transmit command requesting the maximum number of data words that the UUT is designed to transmit.

The pass criteria shall be:

For a, step 1- NR, step 2- CS, step 3- CS

For b, step 1- NR, step 2- ME, step3 -ME

For e, step 1- NR, step 2- NR, step 3 -ME or, step 1- NR, step 2- CS, step 3- CS

For d, step 1- NR, step 2- CS, step 3- CS or, step 1- NR, step 2- NR, step 3- ME

For test failures, record the test parameters for which the failure occurred.

4.4.9. Required Mode Commands.

The purpose of these tests is to verify that the UUT responds properly to the required mode commands. The tests are not intended to verify the mission aspects stated in the equipment specification. The UUT shall be tested for each required mode code with a subaddress field mode code indicator of all zeros and repeated with a subaddress field of all ones.

The pass criteria is defined in each test paragraph. If any test fails, record the UUT response to that test.

Transmit Status

The purpose of this test is to verify that the UUT has the ability to recognize the transmit status mode command and to transmit its last status word. The following sequence shall be performed:

Step 1. A valid legal message shall be sent to the UUT on the primary bus.

Step 3. A valid legal message shall be sent to the UUT on the alternate bus.

Step 4. A transmit status mode command shall be sent to the UUT on the alternate bus.

Step 5. A valid legal receive command with a parity error is a data word shall be sent on the primary bus.

Step 6. A transmit status mode command shall be sent to the UUT on the primary bus.

Step 7. Repeat step 6.

Step 8. Repeat step 4.

Step 9 Repeat step 1.

Step 10. Repeat step 2.

Step 11. Repeat step 4.

The pass criteria for each of the above steps shall be as follows: step 1- CS; step 2- CS; step 3- CS; step 4-

CS; step *5*- NR; step 6- ME; step 7- ME; step 8- ME; step 9- CS; step 10- CS; step 11- CS.

Transmitter Shutdown and Override

This test shall verify that the UUT recognizes the dual redundant mode commands to shutdown the alternate bus transmitter and to override the shutdown. In a dual redundant system each bus must be tested as the alternate bus and as the primary bus. A valid legal transmitter shutdown mode command shall be sent to the UUT to cause an alternate bus transmitter shutdown. A valid legal override transmitter shutdown mode command shall be sent to the

UUT to cause an override of the transmitter shut-down. The following test sequence shall be used for each case including verification of the UUT response indicated.

Step 1. A valid legal command shall be sent on the primary bus to the UUT.

Step 2. A valid legal command shall be sent on the alternate bus to the UUT.

Step *3.* A valid legal transmitter shutdown mode command shall be sent to the UUT on the primary bus.

Step 4. A valid legal command shall be sent on the alternate bus to the UUT.

Step 5. A valid legal command shall be sent on the primary bus to the UUT.

Step 6. A valid legal override transmitter shutdown mode command shall be sent to the UUT on the alternate bus.

Step 7. A valid legal command shall be sent to the UUT on the alternate bus.

Step 8. A valid legal override transmitter shutdown mode command shall be sent to the UUT on the primary bus.

Step 9. A valid legal command shall be sent on the alternate bus to the UUT.

Step 10. A valid legal command shall be sent on the primary bus to the UUT.

The pass criteria for each of the above steps shall be as follows: step 1- CS; step 2- CS; step 3- CS; step 4- NR; step 5- CS; step 6- NR; step 7- NR; step 8- CS; step 9- CS; step 10- CS.

Reset Remote Terminal.

The purpose of this test is to verify that the UUT has the ability to recognize and properly operate when the reset remote terminal mode command is received. Note that this test provides characterization of reset time as a first step. If the reset time is variable, the test must be performed with conditions in the UUT set such that a maximum reset time results. The following sequence shall be performed.

Step 1. A reset remote terminal mode command shall be sent to the UUT on one bus.

Step 2. After time T from step 1, as measured per figure 7 of RD.1, a valid legal command shall be sent to the UUT on the same bus.

Starting with time TR not less than 5 ms, repeat step 1 and step 2 while decreasing time T to 4.0 us in steps no greater than 10.0 us.

The minimum time, TR , between step 1 and step 2, as measured per figure 7, in which the UUT's response to step 2 is CS (with busy bit reset), shall be recorded.

Step 3. A valid legal transmitter shutdown mode command shall be sent to the UUT on the same bus.

Step 4. A valid legal command shall be sent to the UUT on the alternate bus.

Step 5. A reset remote terminal mode command shall be sent to the UUT on the first bus.

Step 6. After an intermessage gap to TR , a valid legal command shall be sent to the UUT on the alternate bus.

The pass criteria for each of the above steps shall be as follows: step 1- CS; step 2- CS (with BUSY bit reset) for all time T >5.0 ms, and CS or NR for T <5.0 ms; step 3-CS; step 4- NR; step 5- CS; step 6- CS.

Having established the time, TR , that the UUT requires in order to complete its reset function, the following sequence shall be performed.

Step 7. A reset remote terminal mode command shall be sent to the UUT on one bus.

Step 8. Send a valid legal receive command to the UUT on the same bus time T after the status response in step 7, where (TR -40.0 us < T < (TR -20.0 us), but not less than 4 us, as measured in figure 7

Step 9. Send a valid legal command to the UUT on the same bus time T after the status response in step 8 (if the response of the UUT during the reset period is NR, then time T shall be measured after the last data word of step 8), where 4.0 us< T < 5.0 us, as measured in figure 7.

The pass criteria for each of the above steps shall be as follows: step 7- CS; step 8- CS or NR, step 9- CS (with BUSY bit reset).

4.4.10. Data Wrap-Around

The purpose of this test is to verify that the UUT properly implements the data wrap-around capability. The following sequence shall be performed 10,000 times, with random data patterns for each data word in each sequence. The messages used shall contain the maximum number of data words that the RT is capable of transmitting or receiving, i.e., Record the number of correct responses and the number of incorrect responses.

Step 1. Send a receive message to the UUT at subaddress 30 (11110) or the appropriate receive wrap-around subaddress defined for the UUT.

Step 2. Send a transmit command to the UUT with the appropriate transmit wrap-around subaddress and with the same word count as step 1.

The pass criteria shall be: step 1- CS; step 2- CS with each data word having the same bit pattern as the corresponding data word in step 1.

4.4.11. Bus Switching.

This test shall be performed only if the UUT is configured with dual redundant buses.

This test verifies that the dual redundant remote terminal properly performs the bus switching requirements of MIL-STD-1553 (para on “Data Bus Activity”). The requirements are as follows:

a. If the UUT is receiving or operating on a message on one bus, and another valid, legal command to the UUT occurs on the opposite bus later in time, then the UUT is required to reset and respond appropriately to the later command on the opposite bus.

b. An invalid command on the alternate bus shall not affect the response of the UUT to commands on the original bus.

Unless otherwise specified, legal messages are used in this test. The interrupting message on the alternate bus shall be swept through the command word, the response time gap, the UUT’s status word, and the UUT’s data transmission on the first bus. For all tests, record the command words used. The following test sequences shall be performed twice for each interrupting command, once for each redundant bus.

RT transmitting:

Step 1. Send a valid transmit 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 4.0 us after the beginning of the first command.

Step 3. Send a valid transmit status mode command after the messages on both buses have been completed.

Step 4. Repeat step 1 through step 3 increasing the time between step 1 and step 2 in no greater than 0.25 us increments until the messages no longer overlap.

Perform the test with the following interrupting messages for step 2.

a. A valid legal message

b. A message with a parity error in the command word.

c. A valid message with a terminal address different than that of the UUT.

The pass criteria shall be: for a, step 1- NR, truncated message or CS, step 2- CS and step 3- CS; and for b and c, step 1 CS; step 2- NR and step 3- CS. For test failures, record the test parameters at which the failure occurred.

4.4.12. Unique Address

The purpose of this test is to verify that the UUT can be assigned any unique address from an external connector on the UUT. The following sequence shall be performed for the UUT:

Step 1. Send a valid, legal command to the UUT.

Step 2. Repeat step 1 thirty-one times with the same command word except use all other possible bit combinations in the RT address field of the command word.

Step 3. Repeat step 1 and step 2 after externally changing the RT address for all possible combinations from 00000 through 11110.

Step 4. After externally changing the RT address to simulate a single point address validation failure (e.g., parity error on the address lines), repeat step 1 and step 2.

The pass criteria shall be: step 1- CS; step 2- NR for each combinations; step 3- same as step 1 and step 2; step 4- NR for each combination.

Note: Power cycling may be required after externally changing the RT address.

4.4.13. Optional Operation.

This section provides for testing the optional requirements of MIL-STD-1553. If a remote terminal implements any of the options, it shall be tested in accordance with the test herein identified for the option. If the transmit status mode command shall be used.

Optional 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 is defined in each test paragraph. If any test fails, record the UUT response to that test.

Dynamic Bus Control

Not applicable

Synchronize.

The following paragraphs provide the test criteria for the synchronize mode commands.

Synchronize (without data word). The purpose of this test is to verify that the UUT has the ability to recognize a synchronization mode command without using a data word. A valid legal synchronize (without data word) mode command shall be sent to the UUT.

The pass criteria shall be that the UUT respond with CS.

Synchronize (with data word)

The purpose of this test is to verify that the UUT has the ability to recognize a synchronization mode command which uses a data word. A valid legal synchronize (with data word) mode command shall be sent to the UUT.

The pass criteria shall be that the UUT respond with CS.

Initiate Self-Test.

The purpose of this test is to verify that the UUT has the ability to recognize and properly operate when the initiate self-test mode command is received. Note that this test provides characterization of self-test time as a first step. If the self-test time is variable, the test must be performed with conditions in the UUT set such that a maximum self test time results. The following sequences shall be performed:

Step 1. An initiate self-test mode command shall be sent to the UUT on one bus.

Step 2. After time T from step 1, as measured per figure 7 of RD.1, a valid legal command shall be sent to the UUT on the same bus.

Starting with time T not less than 100 ms, repeat step 1 and step 2 while decreasing time T to 4.0 us in steps no greater than 1.0 ms. Finer granularity, 10.0 us maximum steps, shall be used to more accurately determine the self-test time when the time of self-test is determined using the coarser steps.

The minimum time Ts between step 1 and step 2, as measured per figure 7 of RD.1 in which the UUT's response to step 2 is CS (with BUSY bit reset), shall be recorded.

The pass criteria for each of the above steps shall be as follows: step 1- CS; step 2- CS (with BUSY bit reset) for all time T > 100 ms, and CS or NR for time T < 100 ms.

Having established the time, Ts , that the UUT requires in order to complete its self-test function, the following sequence shall be performed.

Step 3. An initiate self-test mode command shall be sent to the UUT on one bus.

Step 4. Send a valid legal receive command to the UUT on the same bus time T after the status response in step 3, where (Ts -40.0 us) < T < (Ts -20.0 us), but not less than 4.0 us, as measured in figure 7.

Step 5. Send a valid legal command to the UUT on the same bus time T after the status response in step 4 (if the response of the UUT during the reset period is NR, then time T shall be measured after the last data word of step 4), where 4.0 us < T < 5.0 us, as measured in figure 7.

The pass criteria for each of the above steps shall be as follows: step 3- CS, step 4- CS or NR, step 5- CS (with BUSY bit reset).

Transmit BIT Word.

The purpose of this test is to verify that the UUT has the ability to recognize this mode command. A valid legal transmit BIT mode command shall be sent to the UUT.

The pass criteria shall be that the UUT respond with CS.

Selective Transmitter shutdown and Override.

This test shall verify that the UUT recognizes the multi-redundant mode code commands to shut down a selected bus transmitter and to override the shutdown in a multi-redundant system, each bus must be tested as the primary bus with the remaining busses as alternate busses. A valid legal selected transmitter shutdown mode command shall be sent to the UUT accompanied by the appropriate data word to cause a selective bus transmitter shutdown. A valid legal override selected transmitter shutdown mode command shall be sent to the UUT accompanied by the appropriate data word to cause an override of the selected bus transmitter shutdown. The following test sequence shall be performed using each bus as the primary bus and each of the remaining busses in turn as the alternate bus, including verification of the UUT response indicated.

Step 1. A valid legal command shall be sent on the first bus to the UUT.

Step 2. A valid legal command shall be sent on the alternate bus to the UUT.

Step 3. A valid legal selected transmitter shutdown mode command shall be sent to the UUT on the first bus with the data word encoded to shutdown the alternate bus.

Step 4. A valid legal command shall be sent on the alternate bus to the UUT.

Step 5. A valid legal command shall be sent on the first bus to the UUT.

Step 6. A valid legal override selected transmitter shutdown mode command shall be sent to the UUT on the alternate bus with the same data word as sent in step 3.

Step 7. A valid legal command shall be sent to the UUT on the alternate bus.

Step 8. A valid legal override selected transmitter shutdown mode command shall be sent to the UUT on the first bus with the same data word as sent in step 3.

Step 9. A valid legal command shall be sent on the alternate bus to the UUT.

Step 10. A valid legal command shall be sent on the first bus to the UUT.

Step 11. Repeat step 3 except that the data word shall be encoded with a bit pattern that would normally shutdown the first bus if it was sent on the alternate bus.

Step 12. Repeat step 4.

Step 13. Repeat step 5.

The data words associated with step 3 and step 11 for each bus shall be recorded.

The pass criteria for each of the above steps shall be as follows: step 1- CS, step 2- CS, step 3- CS, step 4- NR, step 5- CS, step 6- NR, step 7- NR, step 8- CS, step 9- CS, step 10- CS, step 11- CS, step 12—CS, step 13- CS.

Terminal Flag Bit Inhibit and Override.

This test verifies that the UUT recognizes and responds properly to the mode code commands of inhibit terminal flag bit and override inhibit terminal flag bit. Beginning in step 2 of the test sequence below, the UUT shall be caused to set the terminal flag bit.

Step 1. A valid legal receive command with at least one data word shall be sent to the UUT.

Step 2. Procedures as defined for the UUT, shall be performed that will set the terminal flag in the UUT status response. Send a valid legal receive command with at least one data word to the UUT.

Step 3. A valid legal inhibit terminal flag mode code command shall be sent to the UUT.

Step 4. Repeat step 1.

Step 5. A valid legal override inhibit terminal flag mode code command shall be sent to the UUT.

Step 6. A valid legal receive command with at least one data word shall be sent to the UUT.

Step 7. Procedures, as defined for the UUT, shall be performed which resets the TF bit.

Step 8. Repeat step 1.

The pass criteria for each of the above steps shall be as follows: step 1- CS, step 2- TF, step 3- CS or TF, step 4- CS, step 5- CS or TF, step 6- TF, step 8- CS.

Transmit Vector Word.

This test verifies the capability of the UUT to recognize and respond properly to a transmit vector word mode code command. A valid legal transmit vector word mode code command shall be sent to the UUT.

The pass criteria shall be that the UUT respond with CS.

Transmit Last Command

This test verifies that the UUT recognizes and responds properly to a transmit last command mode code. The following test sequence shall be used:

Step 1. A valid legal receive command with at least one data word shall be sent to the UUT.

Step 2. A valid legal receive command different from that used in step 1 above with at least one data word shall be sent to the UUT and a parity error shall be encoded into the first data word.

Step 3. A valid transmit last command mode command shall be sent to the UUT.

Step 4. A valid transmit status mode command shall be sent to the UUT.

Step 5. A valid legal transmit last command mode command shall be sent to the UUT.

Step 6. A valid legal transmit last command mode command shall be sent to the UUT.

Step 7. A valid legal receive command with at least one data word shall be sent to the UUT.

Step 8. A valid legal transmit last command shall be sent to the UUT.

Step 9. A valid legal transmit command shall be sent to the UUT.

Step 10. A valid legal transmit last command mode command shall be sent to the UUT.

The pass criteria for each of the above steps shall be as follows: step 1- CS; step 2- NR; step 3- ME, followed by a data word containing the command word from step 2; step 4-ME; step 5- ME, followed by a data word containing the command word form step 4; step 6- ME, followed by a data word containing the command word from step 4; step 7- CS; step 8- CS, followed by a data word containing the command word form step 7; step 9- CS; step 10- CS, followed by a data word containing the command word from step 9.

Status Word Bits

The following tests verify that all implemented status code bits are properly used and cleared. Implementation of all status code bits in the status word except the ME bit is optional. In addition to the separate tests, for each of the following status bits: service request, busy, subsystem flag, and terminal flag, provide the analysis as listed below.

a. What conditions set the status bit in the status word transmitted on the data bus.

b. What conditions reset the status bit in the status word transmitted on the data bus.

c. If the condition specified in item a. occurred and disappeared without intervening commands to the UUT, list the cases where the status bit is set and reset in response to a valid, non-mode command to the UUT.

d. Given that the status bit was set, and the condition which set the bit has gone away, list the cases where the status bit is still set in response to the second valid, non-mode command to the UUT.

The UUT has failed a test sequence if it does not respond as indicated in each of the separate tests below.

Service Request

This test verifies that the UUT sets the service request bit as necessary and clears it when appropriate. The UUT shall set bit time eleven of the status word when a condition in the UUT warrants the RT to be serviced. A reset of the bit shall occur as defined by each RT. The following steps shall be performed and the appropriate responses verified.

Step 1. A valid legal receive command with at least one data word shall be sent to the UUT.

Step 2. A condition which causes the service request bit to be set shall be introduced into the UUT. A valid legal command that does not service the request shall be sent to the UUT.

Step 3. A valid legal command that does not service the request shall be sent to the UUT.

Step 4. Procedures, as defined for the UUT, shall be performed which resets the service request bit.

Step 5. A valid legal receive command with at least one data word shall be sent to the UUT.

The pass criteria for each of the above steps shall be as follows: step 1- CS, with the service request bit reset; step 2- SRB; step 3- SRB; step 5- CS, with the service request bit reset. All commands and UUT responses shall be recorded.

Broadcast command Received

This test verifies that the UUT sets the broadcast command received bit of the status word after receiving a broadcast command. The UUT shall set status bit fifteen to a logic one after receiving the broadcast command. The following test sequence shall be performed using either the transmit last command or transmit status mode code command to verify the bit condition.

Step 1. A valid legal broadcast receive message shall be sent to the UUT.

Step 2. A valid legal transmit last command shall be sent to the UUT.

Step 3. A valid, legal, non-broadcast command shall be sent to the UUT.

Step 4. Repeat step 1.

Step 5. Repeat step 3.

Step 6. Deleted.

Step 7. Deleted.

The pass criteria for each of the above steps shall be as follows: step 1- NR; step 2- BCR, and the data word contains the bit pattern of the command word in step 1; step 3- CS; step 4- NR; step 5- CS; step 6- NR; step 7-ME and BCR, and the data word contains the bit pattern of the command word in step 6. All commands and UUT responses shall be recorded.

Busy

This test verifies the capability of the UUT to set the busy bit of the status word. Bit time sixteen of the status word shall be set when the UUT is busy. Prior to performing the test sequence below, a condition which sets the busy bit must be received.

Step 1. A valid legal transmit command shall be sent to the UUT.

Step 2. Procedures, as defined for the UUT, shall be performed which resets the busy bit.

Step 3. A valid legal transmit command shall be sent to the UUT.

The pass criteria for each of the above steps shall be as follows: step 1- BUSY; step 3- CS. All commands and UUT responses shall be recorded.

Subsystem Flag

This test verifies the capability of the UUT to set the subsystem flag of the status word. Bit time seventeen of the status word shall be set to a logic one when a subsystem fault has been determined fault has been determined. Prior to performing the test sequence below, a condition which sets the subsystem flag bit must be activated.

Step 1. A valid legal transmit command shall be sent to the UUT.

Step 2. Remove the condition which sets the subsystem flag bit. Cycling power to the UUT shall not be part of these procedures to reset the SF bit.

Step 3. A valid legal transmit command shall be sent to the UUT.

Step 4. Repeat step 3.

The pass criteria for each of the above steps shall be as follows: step 1- SF; step 3- CS; step 4- CS. All commands and UUT responses shall be recorded.

Terminal Flag

This test verifies that the UUT sets the terminal flag bit as necessary and clears it when appropriate. The UUT shall set bit time nineteen of the status word when an occurrence in the UUT shall set causes a terminal fault condition. Prior to performing the test sequence below, a condition which sets the terminal flag bit must be activated.

Step 1. A valid legal receive command with at least one data word shall be sent to the UUT.

Step 2. Remove the condition which sets the terminal flag bit. Cycling power to the UUT shall not be part of this procedure.

Step 3. A valid legal transmit command shall be sent to the UUT.

Step 4. Repeat step 3.

The pass criteria for each of the above steps shall be as follows: step 1- TF; step 3- CS or TF; step 4- CS.

All commands and UUT responses shall be recorded.

Illegal Command

This test verifies that the UUT recognizes and responds properly to illegal commands when the illegal command detection option is implemented. The following sequence shall be performed:

Step 1. Send an illegal receive command to the UUT.

Step 2. Send a transmit status mode command to the UUT.

Step 3. Send a valid legal transmit command to the UUT.

Step 4. Send an illegal receive command to the UUT with a parity error in one of the data words.

Step 5. Send a transmit status mode command to the UUT

Step 6. Repeat step 3.

Step 7. Send an illegal transmit command to the UUT.

Step 8 Send a transmit status mode command to the UUT.

Step 9 Repeat step 3.

Step 10 Send an illegal command to the UUT with a parity error in the command word.

Step 11 Send a transmit last command mode command to the UUT. If the transmit last command mode command is not implemented in the RT, send a transmit status mode command instead.

The pass criteria shall be: step 1- ME; step 2- ME; step 3- CS; step 4- NR; step 5- ME; step 6- CS; step 7- status only with ME bit set; step 8- ME; step 9- CS; step 10- NR; step 11- CS, if the transmit last command mode command was used, the data word shall be the command word sent in step 9.

Broadcast Mode Command. The purpose of this testis to verify that the UUT responds properly to implemented broadcast mode commands. This test is 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. Use the following test sequence unless otherwise noted.

Step 1. A valid receive message shall be sent to the UUT.

Step 2. A valid legal broadcast message shall be sent to the UUT.

Step 3. A transmit last command mode command shall be sent to the UUT.

4.5. Noise Rejection Test.

This test verifies the RT's ability cooperate in the presence of noise.

The maximum word error rate for a RT is one part in 10^7. While performing this test, all words received by the UUT shall be in presence of an additive white Gaussian noise distributed over a bandwidth of 1.0 kHz to 4.0 MHz at an RMS amplitude of 140 mV for transformer could stubs measured at point A of figure 9A or figure 10A of RD.1. This test shall be conducted with a signal level of 2.1 V peak-to-peak, line-to-line, for transformer coupled stubs.

The rise and fall time of the transmitted message (measured at a data bit zero crossing with the prior zero crossing and the next zero crossing at 500 ns intervals from the ensured zero crossing) measured at point "A" shall be 200.0 ns. Figure 9A and figure 10A depict the configurations for conducting the noise rejection test.

Figure 9B and figure 10B depict suggest configurations for the noise rejection test. The noise test shall run continuously with intermessage gaps of > 100.0 us until the total number of all words received by the UUT exceeds the required number for acceptance of the UUT or is less than the required number for rejection of the terminal, as specified in table Ill, of RD.1. All data words used in the tests shall contain random bit patterns. These bit patterns shall be unique for each data word in a message and shall change randomly from message to message. The noise test shall be performed on all buses for UUTs with redundant bus configurations

4.6. CDMS sim Data Link support

The following tests demonstrate that the CDMS sim can support the data-link to the RTs

4.6.1. Mode commands

The purpose of the test is to demonstrate that the CDMS-sim complies with requirements: 3045

The configuration is as shown in section 5.3.

All mode commands in Table 1 shall be tested.

A valid mode command is sent to the RT.

The following data are checked

- Correct effect of RT on mode command
- Status word

The test will be performed on the CDMS-sim with appropriate test-equipment and on the CDMS-sim connected to the DPU/ICU

4.6.2. No response timeout

The purpose of this test is to demonstarte that the CDMS-sim complies with requirement 3085

The configuration is as shown in section 5.2.

Measure the minimum no-response time-out of the CDMS-sim.

4.6.3. Receive message:

The purpose of the test is to demonstrate that the CDMS-sim and the RT comply with requirements: 3025 and 3065

The configuration is as shown in section 5.3.

A valid transmit command is used to send a TBD number of words to the RT. Use TBD SAs

The following data are checked

- Correct use of T/R bit (Requirement 3125)
- Correctness of transmitted data
- Status word

The test will be performed on the CDMS-sim with appropriate test-equipment and on the CDMS-sim connected to the DPU/ICU

4.6.4. Broadcast message:

The purpose of the test is to demonstrate that the CDMS-sim and the RT comply with requirements: 3075

The configuration is as shown in section 5.3.

A valid broadcast command is used to send a TBD number of words

The following data are checked

- Correct use of T/R bit (Requirement 3125)
- Correctness of broadcasted data
- Status word

The test will be performed on the CDMS-sim with appropriate test-equipment and on the CDMS-sim connected to the DPU/ICU

4.6.5. Transmit message:

The purpose of the test is to demonstrate that the CDMS-sim and the RT comply with requirements: 3065

The configuration is as shown in section 5.3.

A valid transmit command is used to get a TBD number of words to the RT. Use TBD SAs

The following data are checked:

- Correct use of T/R bit (Requirement 3125)
- Correctness of transmitted data
- Status word

4.6.6. Receive low-level command

The purpose of the test is to demonstrate that the CDMS-sim and the RT comply with requirements: 4365, 4370, 4375, 4390, 4395.

The configuration is as shown in section 5.3.

The low-level commands implemented on each individual instrument are TBD.

4.7. Satellite data-bus protocol

The following tests demonstrate that the CDMS sim can operate the databus protocol.

4.7.1. EGSE connection

These tests demonstrate that the CDMSsim can connect properly to the EGSE to pass packets and to receive commands.

The configuration is as shown in section 5.3.

Accept configuration commands from EGSE

Pass TC-packet from EGSE to instrument

Pass TM-packet from instrument to EGSE

Test-description TBW

4.7.2. Basic protocol without TM or TC transfer

The purpose of this test is to check the timing of the protocol and the proper appearance of the poll-commands.

4.7.3. Transfer of TC-packet.

The purpose of the test is to demonstrate that the Combination RT and BC complies with requirements: 3200, 3205, 3210, 3245, 4195, 4240, 4250, 4400, 4415, 4420, 4425, 4430.

- The configuration is as shown in section 5.3.

The complete TC packet transfer mechanism is

1. As required: Receive-commands to RT-SA 11,12,13,14 R; RT replies with status word;
2. Receive command to RT-SA 27 R; RT replies with status word
3. RT updates RT-SA 27 T
4. Transmit command to RT-SA 27 T (No timing specified)
5. Assemble TC-packet.

Measurement condition:

Send one TC-packet to the connected RT

The following data are checked:

- Check all status words
- Are all messages in the same subframe
- Check if TC-packet is split up correctly over the messages

The test will be performed on the CDMS-sim with appropriate test-equipment and on the CDMS-sim connected to the DPU/ICU

4.7.4. RT error-conditions during data-transfer.

The purpose of the test is to demonstrate the packet transfer handshake, (i.e. demonstrate that the CDMS-sim complains when the confirmation is omitted):

The configuration is as shown in section 5.2.

Send a TC packet to the RT. The RT does not write confirmation.

Send a TM packet to the RT without updated sequence counter

4.7.5. TM-packet transfer.

The purpose of the test is to demonstrate that the Combination RT and BC complies with requirements: 3185, 3190, 3195, 3245, 4195, 4240, 4250, 4500,4505,4510, 4515, 4545, 4550, 4555, 4560, 4570, 4625, 4630, 4635, 4640, 4645, 4655, 4665, 4685, 4690, 4695.

The complete TM packet transfer mechanism is:

1. Transmit command: read 2 words from RT-SA10T;

   RT replies with status word plus TM packet transfer control words;

   These words contain: N_{msg} and N_{wrds};
2. Mode command synchronise with data-word;
3. A sequence of N_{msg} transmit commands followed by the same number of replies;
4. Receive command: receive 2 words at RT-SA10R. RT replies with status word.
5. Assemble TM-packet;

The following data are checked:

- Check the TM packet transfer control word, written by RT on SA 10T and read by BC
- Check the transmit command, sent by BC
- Is the number of messages correct (as requested by RT)
- Check all status words
- Are the messages in the same sub-frame?
- Is the number of data-words correct for each message
- Check the confirmation at SA 10R
- Is the new value of the transfer control word written in time (within 2 +2 ms after beginning of next subframe)
- Check if TM-packet is split up correctly over the messages

4.7.6. CDMS-sim error conditions during data transfer.

The purpose of the test is to demonstrate the transfer handshake, (i.e. demonstrate that the RT complains when the confirmation is omitted). 4605

The configuration is as shown in section 5.1.

Receive a TM packet. Do not write confirmation Check error message of RT

Do not update the sequence counter of TC packet.

4.7.7. Nominal mode

The purpose of the test is to demonstrate that the BC can operate a profile in the nominal mode. Refer to requirements 3160, 3161, 3180, 4015, 4050, 4060, 4065, 4085, 4090, 4185, 4260, 4125, 4155, 4160, 4265, 4270, 4275, 4290, 4295, 4350, 4355, 4360, 4410, 4585, 4590, 4595

The configuration is as shown in section 5.3.

The RT produces TM-data with data-rate = 100kbps

The BC generates 2 TC-packets per second, 2 asynchronous TC packets per second and 1 time-synchronisation per second

Measurement	**Requirement**
Measure latency between packet transfers	4015
Check the timing of frames (1 frame per second)	
Create a list of mode commands	4155
Create a list of status words issued during packet-transfer	
Demonstrate that timing is according to Table 4	
Create listing of status as polled during transfer	
Create a list of TM packet counter • start at 0 upon reset • drop to 1 after 255	4585, 4590
Create a list of TC packet counter • start at 0 upon reset • drop to 1 after 255	4410

4.7.8. Burst mode

The purpose of the test is to demonstrate that the BC can operate a profile in the burst mode. Refer to requirements 4045, 4185,4190 and 4700

The configuration is as shown in section 5.3.

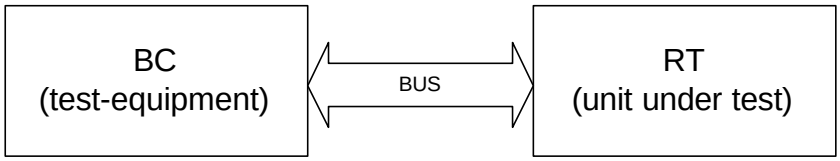
The RT produces TM-data with data-rate = 400kbps

Rest: TBD

5. Configurations overview

5.1. Test Data-link properties of RT

This configuration is used to test the Data-Link properties of the remote terminal.



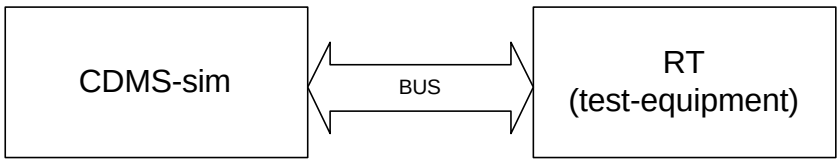
The BC and the RT shall be connected with a Databus interface that complies with requirement 2005.

The tests listed in section 4 of this documents imply the following requirements for the BC used in this configuration to test the RT:

- The response time can be measured
- Signal level from BC-output can be regulated
- Signal can be monitored
- BC can generate command word with parity error.
- BC can transmit TC-packets with wrong sequence counter
- BC can omit TC transfer confirmation

5.2. Test Data-link properties of BC

This configuration is used to test the properties of the CDMS-sim



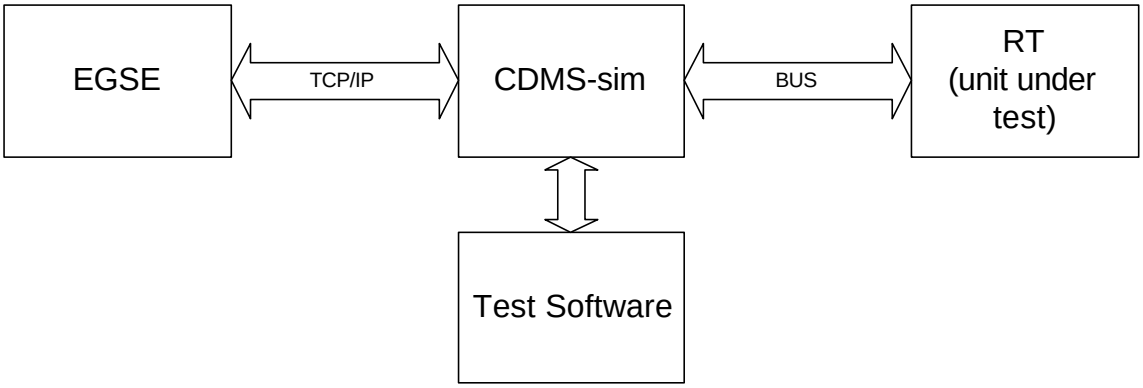
The BC and the RT shall be connected with a Databus interface that complies with requirement 2005.

The tests listed in section 4 of this documents imply the following requirements for the BC used in this configuration to test the RT:

- RT can modify response time
- RT can request TM-packets with wrong sequence counter
- RT can omit TC transfer confirmation

5.3. Test configuration EGSE, CDMS-sim and RT

This configuration is used to test the communication between BC and RT, in combination with the EGSE.



The BC and the RT shall be connected with a Databus interface that complies with requirement 2005.

The BC shall be embedded in or connected to a package of test-software.

The tests listed in section 4 of this documents imply the following requirements for the BC used in this configuration to test the RT:

- The RT shall be able to generate TM-packets at a rate of 100 kbps in nominal mode
- The RT shall be able to generate TM-packets at a rate of 350 kbps in burst mode
- A signal can be injected onto the bus
- The output signal of BC can be adjusted.
- The error-rate can be monitored on both the BC side and the RT side.
- The test-SW shall allow to check the timing of the mode-commands.
- The test-SW shall allow to test the timing of individual messages
- The test-SW shall allow to list all status-words

Annex A. Requirements overview

Physical layer

Req nr	Ver	Description	Test
		data bus topology	
2005	R,T	The data bus topology shall be in accordance to AD-#3, see paragraph §4.5, §30.10.	
2005.1		4.5.1.1 wire to wire capacitance < 30.0 pF/ft; Not less than 4 twist per foot; Shield provides a minimum of 75 % coverage	
2005.2		4.5.1.2 Z_0 in range (70,0 – 85.0 Ohm) @ 1.0 MHz sine	
2005.3		4.1.1.3 Cable power loss is less than1.5 dB/100ft	
2005.4		4.1.1.4 Cables shall be terminated with resistance equal to the cable's nominal impedance $Z_0 \pm 2\%$	
2005.5		4.5.1.5.1 Length of the stub should not exceed 20 ft.	
2005.6		4.5.1.5.1.1 Turns ratio of transformer = 1:1.41 $\pm$ 3.0%, with the higher turns on the isolation resistor side	
2005.7		4.5.1.5.1.1.1 Open circuit impedance at B > 3kOhm in freq. range 75.0 kHz – 1.0 MHz with 1.0 V RMS sine wave	
2005.8		4.5.1.5.1.1.2 Droop shall not exceed 20%; Overshoot and ringing shall be less than $\pm$1V peak. For this test R=360.0 Ohm $\pm$5%, with input 250.0 kHz square wave, 27.0 V peak-peak, rise and fall time no greater than 100 ns.	
2005.9		4.5.1.5.1.1.3 Coupling transformer CMRR > 45.0 dB at 1 MHz	
2005.10		4.5.1.5.1.2 isolation resistors shall be equal to 75 % of the cable's nominal impedance $Z_0 \pm 2\%$	
2005.11		The impedance placed across the cable bus shall be no less than 1.5 Z_0	
2005.12		4.5.1.5.1.3 coupling transformers and isolation resistors shall have continuous shielding with minimum of 75 % coverage	
2005.13		4.5.1.5.1.4 Refer to figure 9. Point A shall have peak-to-peak amplitude, line to line within the range of 1V and 14 V	
2010	T	The physical characteristics of the Bus interfaces shall be in accordance to AD-#3 MIL STD 1553 B,	
2015	R,I	All terminals shall use transformer coupled stubs.	
2020	R,I	The BC shall use transformer coupled stubs.	
2025		Further details are TBD.	
		Data Bus Medium	
2030	R,T	The data bus medium shall be a TSP cable with 75 Ohms TBC.	
2035	R,T	See AD-#3, paragraph §4.5, §30.10.	
		Stubs, Connectors, Shielding	
2040	R,T	See AD-#3, paragraph §4.5, §30.10.	

Req nr	Ver	Description	Test
2040.1		30.10.1 Cable shielding minimum 90 % coverage	
2040.2		30.10.2 connector junctions cable terminations and bus-stub junctions 360^0 shielding with 75 % coverage	
2040.3		30.10.3 center pin is used for the high Manchester bi-phase signal. Inner ring for low signal.	
2040.4		30.10.4 The actual characteristic impedance of the data bus cable shall be in the range of 70.0 to 85 Ohms @ 1MHz sine.	
2040.5		30.10.5 NA	
		Electrical Signal Characteristics	
2045	R,T	See AD-#3, paragraph §4.5, §30.10.	
2045.1.		R_L= 70 Ohm $\pm$ 2% 4.5.2.1.1.1 Output level on A shall be within the range of 18.0 – 27.0 V peak-peak.	4.1.1
2045.2.		4.5.2.1.1.2 Waveform at A shall have zero-crossing deviation less than 25 ns from ideal crossing points; Refer to figure 13. rise and fall times shall be from 100.0 to 300.0 ns when measured from 10-90 % of full waveform peak-to peak, line to line. Any distortion shall not exceed $\pm$900.0 mV peak, line to line.	4.1.3
2045.3.		4.5.2.1.1.3Any noise transmitted when the terminal is receiving or has power removed shall not exceed 14.0 mV RMS line to line	4.1.8
2045.4.		4.5.2.1.1.4 From the time beginning 2.5 microsecond after the mid-bit crossing of the parity bit of the last word transmitted by a terminal the maximum voltage at point A shall be no greater than 250.0 mV peak, line to line.	4.1.5
		4.5.2.1.2 The terminal shall be able to operate with signals:	
2045.5.		zero crossing deviation = $\pm$ 150 ns from ideal	4.2.1
2045.6.		peak-to peak amplitude line-to-line is in the range of 0.86 to 14 V	4.2.2
2045.7.		the terminal should not respond to signals within the range of 0-0.2 V	4.2.2
2045.8.		4.5.2.1.2.2 Any signal from DC to 2.0 MHz, with amplitude equal or less than 10 V line to ground shall not degrade the performance of the receiver.	4.2.4
2045.9.		4.5.2.1.2.3 Input impedance is minimum 1kOhm, @ 75.0 kHz-1MHz	4.2.5
2045.10.		4.5.2.1.2.4 word error rate is less than 1 in 10^7 , with noise added.	4.5.
2045.11.		30.10.6 Output noise during power up or power down sequence shall be lower than $\pm$250mV peak, line-to-line.	4.1.8
2045.12.		4.6.1 Terminals shall have a minimum of 45 dB isolation between databuses.	4.1.7
2045.13.		4.6.3 both buses are standby Either bus may receive a command.	4.4.11

Data link layer

General

Req nr	Ver	Description	Test
		Bus controller functions	
3005	R,T	The Command and Data Management System Simulator (CDMS-sim) shall act as Bus Controller (BC).	
3010	R,T	Automated message repetition by the BC in case of transmission errors is not foreseen	-
3015	R	RT to RT transmissions are not foreseen.	-
3020	R	The usage of broadcast messages is allowed.	-
3025	R,T	The BC shall be able to send MIL-Bus messages to the units or instruments working as RTs on the bus	4.6.3 4.6.4 4.6.5
3030	R,T	The BC shall support Mode Commands as shown in Table 1	4.6.
3035	R,T	The BC shall support the RT SA allocation as shown Table 2	
		Remote terminal functions	
3040	R,T	All spacecraft units or instruments connected to the data bus shall act as Remote Terminals (RT).	
3045	R,T	The RT shall support Mode Commands as shown **Error! Reference source not found.**.	4.6.
3050	R,T	Each RT shall support this SA allocation as shown **Error! Reference source not found.**	
3052	R	The RT shall support broadcast messages.	4.6.4
		word formats	
3055	R,T	The used word formats shall be in accordance to AD-#3. See fig 3.1.5-1 in AD-#2	
		message formats	
3060	D	The MIL Bus transfer formats to be utilized are shown in figure 3.1.3.2-1 AD-#2. There are three basic types of messages, which are always initiated by a specific Command of the BC :	
3065	D	Receive messages: These messages are sent from the BC to the addressed RT (and/or attached equipment / subsystem), which responds with dedicated actions. There is always a Status Word reply but no Data reply.	4.6.3
3070	D	Transmit messages These messages are sent from the addressed RT or equipment / subsystems to the BC; they carry the requested data.	4.6.5
3075	D	Broadcast messages These messages are used by the BC to send Commands (with or without data) to all RTs in parallel, which initiate dedicated actions at the RTs (e.g. synchronization). There is no status or data reply allowed.	4.6.4
		Message timing	
3080	T	The timing of messages shall be in accordance to AD-#3. Further details of	

		Intermessage Gap and Response Time are TBD.	
3085	R, T	The BC No Response Timeout shall be adjusted to TBD microsecond.	4.6.2

Command word

Req nr	Ver	Description	Test
3090	D	See figure 3.1.5-1AD-#2: Word formats	
3095	T	The utilization of the Command Word shall be in compliance to AD-#3, § 4.3.3.5.1.	
		RT address field	
3100	N	Each Remote Terminal (RT) connected to a MIL Bus has a unique address, which allows the Bus Controller (BC) to communicate with selected equipment. The address range for equipment is 1 to 30. Address 0 is reserved. Address 31 is used for broadcast.	
3105	R,T	The RT Address shall be configurable via an external connector of the RT unit, see AD-#3 § 30.3.	
3110	R	The RT Address of all onboard units shall be in accordance to Table 3.2.1-1 in AD-#2: RT Address assignment.	
3115	D	AD-#2: Table 3.2.1-1: RT Address assignment TBD:	
3120	N	Notes: - One RT Address must be reserved for BC, because of H/W and testing needs. - An implementation example of an address connector is shown in Figure 3.2.1 -1 all Address and Parity lines have pull up resistors, so that a ‚0' on a line is coded by connecting it to common secondary return (secondary zero volt), as shown below. The type of Parity is odd.	
		T/R Bit Field	
3125	T	The usage of this bit shall be in accordance to AD-#3 § 4.3.3.5.1.3.	4.6.3, 4.6.5
3130	N	A logic zero indicates that the RT shall receive data from the BC and a logic one indicates that the RT shall transmit data to the BC.	
		Subaddress/Mode field	
3135	R,T	The allocation of Subaddresses (SAs) shall be as shown Table 2	
3140	D	See AD-#2 table 3.2.3-1, or Table 2	
		Usage of sub-addresses	
3145	T	Mode command(SA 0, 31) Compliant to the MIL STD 1553B, see AD-#3.	
3150	R, T	Unit status data (SA 1T) Via this SA the RT shall provide H/K data and status data about the RT/ unit.	
3155	T	Unit control (SA 1R) Via this SA the RT shall receive unit related Low Level commands.	

3160	T	Asynchronous Short Command 1, 2(SA 3R, 4R) Small Asynchronous Telecommand Packets, with a maximum length of 64 octets (one message), are sent to these SAs.	4.7.7
3161	T	The RT shall support the reception of Small Asynchronous Telecommands, as needed by the RT.	4.7.7
3165	T	If the RT generates Event TM Packets with a maximum length of 64 octets (one message), these SAs shall be used for the exchange.	Not applicable
3170	T	Event Message TM The BC shall inform the RT about the event messages acquisition by sending an acknowledge message to these SAs.	Not applicable
3175	R,T	Internal Time(SA 8T) This SA is reserved for a read of the internal time and clock status of a unit. (Note: Details are TBD, for unit initialization or test and troubleshooting purpose.)	Not applicable
3180	T	Time messages(SA 8R) By using this SA the BC shall distribute time information on the bus. The time message shall be sent as broadcast message to all RTs	4.7.7
3185	T	TM Packet Transfer Request (SA 10T) The RT provides via this SA its request for a TM packet transfer.	4.7.5
3190	T	TM Packet Transfer Confirmation (SA 10R)The BC shall place here, after reading the TM packet from the RT, the Confirmation message.	4.7.5
3195	T	TM Data send(SA 11-26T) This SA contains the nominal TM packet data.	4.7.5
3200	T	TC Data receive (SA 11-14R) This SA contains the nominal TC packet data.	4.7.3
3205	T	TC Packet Transfer Descriptor (SA 27R) To this SA the BC shall send the Control words to inform the RT about the presence of a new TC packet	4.7.3
3210	T	TC Packet Transfer Confirmation (SA 27T) The RT shall place here, after reading the TC packet from the BC, the Confirmation message.	4.7.3
3215	T	Low Level Command (SA 28T) This SA is reserved for low level commanding of RTs.	4.6.6
3220	T	Low Level Command-status This SA is reserved for supporting a low level command execution status.	4.6.6
3225	R	Data send (SA 2,3,4,7,9,29T) Unused Transmit SA.	
3230	R	Data receive (SA 2,7,9,15 – 26,29R) Unused Receive SA.	
3235	T	Data Wrap read (SA 30T) SA used for test purpose, see AD-#3 and AD-#2. The implementation of this feature is mandatory for the RT.	
3240	T	Data Wrap write (SA 30R) SA used for test purpose, see AD-#3 and AD-	

		#2. The implementation of this feature is mandatory for the RT Data Word Count/ Mode Code Field	
		Data word count / mode code field	
3245	T	The Data Word Count Field indicates the quantity of data words to be transferred to/ from the BC. It shall be used according to AD-#3 § 4.3.3.5.1.5.	4.7.3, 4.7.5
3250	D	In case the Data Word Count Field is set to ´00000´or ´11111´ the BC and RTs shall support Mode Commands as follows: Table 1	
3255	N	Certain functions of mode commands are used within the Data Bus Protocol, details are specified AD-#2. Further Mode Command usage is unit specific and currently TBD.	
		Status Word structure	
		Status Word bits	
3260	T	After the reception of any MIL Bus message (except a MIL Bus broadcast message), a RT responds with a status word which shall be in accordance with AD-#3, § 4.3.3.5.3.	
3265	D	The status word has content shown in Table 3	
3270	T	The RT shall support the Status Word Flags as shown in Table 3	
3275	R	The RT shall support at least the Status word bit as required by AD-#3§ 30.5.2., further details are TBD	
3280	N	**Data word structure** Word format shall be according to AD-#2 figure 3.1.5-1	
		Data Link Layer FDIR	Not applicable

Transfer layer

Req nr	Ver	Description	Test
		Functional and performance	
4005	R	BC MIL-Bus messages and RT response messages shall be assigned to predefined time slots.	
4010	T	Maximum throughput for all users shall be at least 350 kbps on TM/TC packet level.	
		This can be tested in the burst mode	
		Maximum throughput may be lower in nominal mode	

Req nr	Ver	Description	Test
4015	T	The minimum latency for a single user between the end of a packet transfer and the start of a new transfer of the same type (TM or TC) shall be 2,5 milliseconds.	4.7.7
4020	R	The maximum size of TM-Packets shall be 1024 octets.	
4025	R	The maximum size of TC-Packets shall be 248 octets.	
4030	T	The BC and RT shall support the transfer of TM/TC-Packets with variable length.	
4040	R	One complete packet shall be exchanged with a user without interruptions for the user (RT).	
4045	T	~~The BC shall support each second the exchange of at least 50 TM-Packets.~~ The BC shall support each second the exchange of at least 25 TM packets from a single instrument that is not in burst mode. The BC shall support each second the exchange of at least 50 TM packets from a single instrument that is in burst mode.	
4050	T	~~The BC shall support each second the exchange of at least 16 TC-Packets.~~ The BC shall support each second the exchange of at least 4 TC-Packets to one single instrument. (*Subframes 1, 17,33 and 49 are reserved for TC. In each subframe 4 TC packets to different RT can be delivered. For the single RT-configuration the number of TC packets per second should be reduced to 4 See Astrium TN p 44.)*	4.7.7
4060	T	The BC shall support each second the exchange of at least 1 time synchronization.	4.7.7
4065	T	The BC shall support each second the exchange of at least 2 Asynchronous Short TC-Packets, with a maximum length of 64 octets, addressed independently to dedicated buffers within RTs.	4.7.7
4070	T	The accuracy for timing and synchronization across all on-board systems up to the data interface of users shall be better than 100 microseconds TBC	?
4075	T	The routing latency of an Asynchronous Short TC-Packet from the BC to the input buffer of a RT shall be below 1 millisecond.	?
4080	T	~~The BC shall control the TM data rate of a maximum of ten users by adjusting the actual data rates according to allocated bandwidths on a 2 second time scale.~~ The BC shall control the TM data rate according to predefined bus-profiles.	NA
4085	T	Each on-board user shall be served in a periodic way for at least two times per second.	4.7.7
4090	N	Note: The actual data traffic may be a combination of all data types described above.	4.7.7
		Cyclic transfer protocol	
4100	R, T	The cyclic Satellite Data Bus Protocol (SDBP) shall have a deterministic,	

Req nr	Ver	Description	Test
		periodic structure, which is synchronized with the central on-board time, implemented in the CDMS	
4105	R, T	The SDBP shall be based on a 1 second period called Frame. This frame is divided into 64 subframes, each containing a number of MILSTD 1553B messages These messages shall occur in a Subframe within a defined timing structure called Message Slots	
4110	R, T	The TM Packet transfer from a RT (Instrument) to the CDMU shall be Subframe allocated. This means that any Instrument TM Packet shall fit into the Subframe boundaries.	
		Frame timing	
4120	R	One second / one Frame shall be divided into 64 Subframes.	
4125	R, T	The first Subframe every second shall start with the Mode Command "Sync without Data word" in the first message slot.	4.7.7
4130	R, T	This Subframe is reserved and no instrument TM data transfer is allowed (TC packets may be sent).	
4135	N	Note: This provides time for the instrument internal processes like clock (time) maintenance, etc.	
4140	R, T	Subframes 1, 17, 33,49 shall be reserved for TC Packet transfer.	
4145	T	In Subframe 33 the time information shall be distributed.	
4150	R, T	The remaining Subframes (60 out of 64) shall be used for TM packet transfers (TC packets may be send also).	
4155	R, T	The Mode Command "Sync with Data word" is inserted into the first message slot of Subframes 2 to 64.	4.7.7
		Subframe timing	
4160	R, T	Subframe synchronization: In the first Subframe every second the Mode Command Sync distributed as broadcast message will be used. In all other Subframes the broadcast message Mode Command Sync with Data Word will be utilized.	4.7.7
4165	R, T	Regulation Slot: The remaining slot time is sufficient to provide one asynchronous command insertion between any other slot without discarding the following slots. The slot time of slot No. 24 will be reduced in accordance to the asynchronous event.	
4170	T	The BC shall support the Slot Allocation according to Table 4.1.3.1-1 with respect to their timing constrains.	
		Data transfer	
4175	N	~~The BC will be commanded by ground to activate one of several predefined fixed Bus Profiles. Each Bus Profile defines the function of all 64 Subframes, which belong to a cyclic 1 second frame.~~ ~~Each set-up is static for a longer period of time (typically for up to some hours). All instruments will be commanded independently into modes, in which they will stay below their allocated maximum data rates.~~ The bus profile is configurable: • Nominal one instrument	

Req nr	Ver	Description	Test
		• Burst one instrument • Memory upload	
4180	T	~~The BC shall accept ground commands for activating, deactivating, and modifying predefined Bus Profiles for data transfer.~~	
4185	T	~~The BC shall support predefined Bus Profiles and shall adapt these Profiles dynamically to the RT needs.~~ The BC shall mimic predefined Bus Profiles and shall adapt these Profiles dynamically to the RT needs. The Bus profiles should be adapted to the presence of only one instrument.	4.7.7
4190	T	The RT shall accept ground commands which will start predefined operational modes.	
4195	T	Each packet transfer is controlled by the exchange of a Packet Transfer Request/Descriptor and a Packet Transfer Confirmation, which are providing the necessary (handshake) information about the transfer.	4.7.3, 4.7.5
4200	T	At the latest with the receiving of a next Subframe Sync Message the RT shall check the status of the packet transfer, that has taken place in the previous Subframe.	
4205	T	If the packet transfer was performed, then the RT shall update the TM packet data buffer within 2 msec.	
4210	T	If the packet transfer was performed, then the RT shall update the TM Packet Transfer Request Words within 2 msec.	
4220	R, T	Only one TM packet transfer from each RT at a time is allowed. If there is more than one packet to be send the RT shall queue the TM packets.	
4225	T	Event Messages are independent from TM transfers and their exchange shall be possible besides nominal TM packet transfers.	
4230	R, T	TM packets shall be transferred within one Subframe.	
4235	R, T	Transmission of multiple small TM Packets should be avoided and the RT should generate maximum length packets as much as possible for an optimized utilization of allocated RT data rate.	
		Packet transfer control commands	
4240	T	The BC and RT shall support Packet Transfer Requests via SA 10T and Packet Transfer Descriptors via SA 27R.	4.7.3, 4.7.5
4245	D	For control purposes Packet Transfer Requests and Descriptors are introduced. Each of them consists out of two words. Each sender, BC in case of TC packets or RT in case of TM packets, shall provide the following parameters with these words: - The number of needed messages - The number of words in the last message	
4250	R, T	Each receiver shall utilize this information to reassemble the TM or TC packet.	4.7.3, 4.7.5
		Frame synchronization by BC	
4260	T	In the first Subframe each second the BC shall issue the Broadcast Mode	4.7.7

Req nr	Ver	Description	Test
		Command Synchronize, transmitted in the first message slot .	
4265	T	The BC shall issue in all other Subframes the Broadcast Mode Command Synchronize with DataWord, transmitted in the first message slot .	4.7.7
4270	T	The distributed word formats shall be as shown in Figure 4.2-1: (Subframe Synchronize messages)	4.7.7
4275	T	In the Subframe User field the BC shall insert the RT address of the instrument, which is allowed to send its TM data in this Subframe.	4.7.7
4280	T	If this Subframe is not allocated to an specific RT/ Instrument, the BC shall insert ´00000´B in this field.	
4285	T	Any RT, which is not in Burst Mode, shall not interpret the field as a command or enable signal.	
4290	T	In the Subframe Count field the BC shall transmit the Subframe Count value.	4.7.7
4295	T	The RT shall support an internal Subframe Counter and shall provide the value for BC access TBC. See chapter 4.4.	4.7.7
4300	T	When receiving the first Subframe each second the Subframe Counter shall be set to 0 and the RT shall increment this value by one with every received Sync with Data Word command.	
		Time synchronization	
4305	T	The BC shall provide system time information (Central Time Reference) via the MIL Bus.	
4310	T	The time information shall be a broadcast message send to SA 8R.	
4315	R	The layout of this message is shown in figure 4.3	
4320	T	The BC shall send the time information in Subframe no. 33 (Subframe count: 32).	
4325	T	The value of the time information field shall be the time at the beginning of the next frame.	
4330	T	The relative accuracy of the time information shall be max. 100 microseconds with respect to the system time (CTR) of the BC	
4335	R, T	~~The BC shall provide the Central Time Reference signal to an external test I/F for verification purpose.~~ Not applicable for CDMS sim	
4340	T	The time format shall be CUC	
		Status polling	
4350	T	The BC shall acquire the RT status data from SA 1T at least once in a second.	4.7.2
4355	T	The RT shall provide its health status data and additional information.	4.7.2
4360	T	The RT status information shall be available via SA 1T using the layout shown in figure 4.4-1	4.7.2
4365	T	The RT shall be able to receive Low Level Commands at SA 1R. (e.g. Start of BIT, Reset, etc.)	4.6.6

Req nr	Ver	Description	Test
4370	T	reserved bits: These bits shall be set to zero.	4.6.6
4375	T	Subframe count: Here the RT shall provide either: - a fixed pattern or - a copy of the bus provided subframe count value (used for intelligent RT)	4.6.6
4385	T	Details are TBD.	4.6.6
4390	R, T	In the second data word the RT shall provide: - BIT information; - dynamic status (e.g. Watchdog); - other health information	4.6.6
4395	T	For layout see table 4.4	
		Telecommand packet delivery	
4400	T	The BC shall send in the same Subframe all messages belonging to a TC packet followed by the Packet Transfer Descriptor message.	4.7.3
4405	T	For TC Packet Descriptor command word layout see table 4.5.1-1.(AD-#2) Note: To provide bus throughput capability there are at least 4 Subframes reserved for commanding.	4.7.3
4410	T	The BC shall provide a circular TC Packet counter for command identification within the Transfer Layer.	4.7.7
4415	T	The TC packet shall be sent to TC Data receive SAs, beginning with SA 11R.	4.7.3
4420	T	The Packet Transfer Descriptor shall be send to SA 27R.	4.7.3
4425	T	The RT shall evaluate the TC Packet Transfer Descriptor at least after receiving of the next Subframe Sync.	4.7.3
4430	T	The RT shall store the TC packet and copy the associated words of the Packet Transfer Descriptor to SA 27T, see table 4.5.1-2 .	4.7.3
4435	N	For RT behavior description see figure 4.5.1-1.	
		Event driven TC packets	
4440	D	Event-driven TC Packets are Asynchronous Short TC Packets (max. 64 octets), which are on -board generated and serve for specific Instrument functions, which require a fast RT reaction time(e.g. On-Target Flag, Spin Reference Signal).	
4445	T	The BC shall be able to send Asynchronous Short TC	
4450	T	The RT shall support the receiving of Asynchronous Short TC-Packets for special instruments control functions, as required for a certain RT	
4455	T	The routing latency of an Asynchronous Short TC Packet from the CDMS to the input buffer of a RT shall be equal or below 1 millisecond	

Req nr	Ver	Description	Test
4460	T	The BC shall be able to insert Asynchronous Short TC packet messages in the ongoing message-sequence.	
4465	T	The insertion shall not interrupt or damage any of the other bus messages in the Subframe.	
4470	T	The BC shall send event-driven TC packets of type TBD to SA 3R	
4475	T	The BC shall sent event-driven TC packets of type TBD to SA 4R	
		Low level commanding (applicable to any FP instrument ?)	
4480	T	Sending of Low Level Commands to non-intelligent RTs shall be possible via a dedicated SA (Low Level command SA 28R)	4.6.6
4485	T	For low level command verification a separate Transmit SA (SA 28T) shall be supported.	4.6.6
4490	T	Sending of Low Level Commands to RTs for Unit Control purpose shall be possible via SA 1R.	4.6.6
4495	T	The BC shall support Low Level Commands according to table 4.5.1	4.6.6
		Periodic TM packets	
		RT TM packet transfer request	
4500	T	The RT shall request a TM packet transfer (RT to BC) by setting its TM Packet Transfer Request control words (SA 10T). Refer to Table 4.6.1.1-1 in AD-#1	4.7.5
4505	T	Bits 0,1,2,8,9 and 10 are reserved for later use. The bits shall be set to zero.	4.7.5
4510	T	This data field indicates the number of messages needed for the packet the RT is intending to send in the next Subframe. The first message of a TM Packet is always stored at SA 11T.	4.7.5
4515	T	This data field indicates the number of data words transmitted in the last message. In case of 32 words this field is set to "00000"B.	4.7.5
4520	D	Data packets always have a size of n x 16 Bit. Because they are built out of an even number of bytes there is no fill area foreseen.	4.7.5
4525	T	Event A 0 - no Event message pending	
4530	T	Event A 1 - Event message is pending BC is asked to read associated SA and to confirm.	Not applicable
4535	T	Event B 0 - no Event message pending	
4540	T	Event B 1- Event message is pending BC is asked to read associated SA and to confirm.	Not applicable
4545	T	Burst Mode 0 - Nominal Mode	4.7.5
4550	T	Burst Mode 1 - Burst Mode-	4.7.5
		Flow control	4.7.5
4555	T	Flow Control pattern 00 - No transfer pending	4.7.5
4560	T	Flow Control pattern 01 - Transfer is pending	4.7.5

Req nr	Ver	Description	Test
4565	T	Flow Control pattern 10 - reserved	4.7.5
4570	T	Flow Control pattern 11 - Transfer is finished (this pattern is used by BC only)	4.7.5
4575	D	This field is used to support a RT-generated counter. By using a counter, which is incremented with every new request, and which is returned to the RT after a successful transfer, the RT is able to detect the completion of a specific TM packet transfer, even if successive packets are identical in size. To avoid that after an RT initialization or reset an identical packet number will be used, there is one number foreseen for that case. This number does never appear in the cyclical transmission, it is skipped in the normal sequence.	
4580	T	No check on (the completeness of) the sequence will be performed by the BC depending on the Packet Count value.	
4585	T	The RT shall support a circular Packet Counter (increment counter).	4.7.7
4590	T	The allowed range during nominal operation is 1 to 255 decimal.	4.7.7
4595	T	After initialization or restart the RT shall set the counter value to 0 for the first TM Packet Transfer.	
4600	R, T	The RT is not allowed to use this counter for any other purpose than defined in this chapter (Packet Count).	
4605	T	The BC shall identify a new TM Packet Transfer Request by comparing the Packet Counter value with the previous one.	4.7.6
4610	T	If these values are identical the BC shall ignore the request	4.7.6
		TM packet confirmation from the BC	
4625	D	The RT, which has requested a TM packet transfer, must be able to determine, if the packet transfer was performed and the next packet data can be loaded to the message buffers. After a successful packet transfer the BC sends a handshake signal to the sending RT (TM Packet Confirmation). This handshake informs the RT which packet was the last one transmitted, by returning a modification of the Packet Transfer Request including the last Packet Count value and a transfer status.	4.7.5
4630	T	The BC shall support a TM packet transfer handshake by using the TM Packet Transfer Confirmation.	4.7.5
4635	T	The BC shall send this Command to SA 10R.	4.7.5
4640	T	The layout is shown in the table 4.6.1.2-1, AD-#2	4.7.5
4645	T	The BC shall send the TM Packet Confirmation in the same Subframe in which the TM Packet transfer was performed.	4.7.5
4650	D	The first data word is a duplication of the first Packet Transfer Request control word acquired from the RT:	4.7.5
4655	T	The second data word shall contain all necessary information for the handshake purpose The Packet Count field shall be identical to the packet count field of the TM	4.7.5

Req nr	Ver	Description	Test
		packet which was acquired last.	
4660	R	The packet count value itself is with no further meaning.	4.7.5
4665	T	Flow Control is set by the BC to:11 - Meaning of Flow Control pattern: Transfer is finished.	4.7.5
4670	D	Note: No handling of Event packets is performed via this data word. All other bits are set to zero.	
4675	N	Figure 4.6.1.2-1 illustrates the logical flow of BC Sequence behavior.	
		TM packet transfer mechanism	
4685	T	**Initialization** After the BC has been commanded by ground to execute a predefined bus traffic profile (or the BC makes use of a default profile after initialization/ reset) it shall starts the polling of the RTs. The RT shall request a TM packet transfer (RT to BC) by setting its TM Packet transfer control words (SA 10 Transmit). At least one Subframe before the next scheduled TM packet transfer for a certain RT, the BC shall poll the RT for a need of transfer. This will be done by reading the RT TM Packet Transfer Request words from SA 10T.	
4690-	T	**Packet Delivery** If there was a packet transfer request, the BC shall acquire this TM Packet within the next Subframes by using as much transmit message commands as requested by the RT. After the valid transmission (no error occurred) the BC sends the Transfer Confirmation message to the RT, see chapter 4.6.1.2 . The RT shall check the content of the Confirmation message at the latest after receiving of the next Mode Command Synchronize .If the transfer is confirmed by the BC, the RT shall prepare the next data packet transfer. If a new TM packet shall be sent, the RT shall load the new TM Packet Data and the new TM Packet Request Command within 2 m sec after beginning of the Subframe.	4.7.5
4695	T	**End of Transfer** In case there is no new TM packet pending the RT shall set the first word of the TM Packet Transfer Request to ´0000 0000´B, and the Packet Count value of the second word shall stay unchanged. The Flow Control field bits shall be set to ´00´.	4.7.5
		Burst Mode Burst Mode is used in the case that the needed data throughput for one RT is so high that several consecutive Subframes have to be used to acquire the TM Packet data from this RT.	
4700-1	T	The RT in Burst Mode shall use fixed TM Packet sizes. The TM Packets shall have their maximum size of 1024 octets.	
4700-2		The Burst Mode shall be indicated by the RT by setting the bit in the Burst Mode Field of the TM Packet Transfer Request Words.	

Req nr	Ver	Description	Test
4700-3		After the BC has acquired the RT´s TM Packet Transfer Request message, the BC shall acquire in one of the following Subframes the TM Packet (SA 11T to SA 26T), and shall send TM Packet Transfer Confirmation Command words belonging to this TM Packet to SA 10R.	
4700-4		The BC shall perform the polling of the RT in burst mode by reading the RT TM Packet Transfer Request Words (SA 10T) immediately after the acquisition and confirmation of the TM Packet.	
4700-5		The BC shall not check the validity of a last packet transfer and shall not support any retry on packet level.	
4700-6		In the Burst Mode the RT shall provide an update of the TM Packet Transfer Request (SA 10T) according to following timing: In the Burst Mode the TM Packet Transfer Request SA is updated either after: - The Subframe has started and the RT address of the RT in Burst Mode was transmitted in the Data word of the Synchronization message TBC. or after - The requested TM Packet Transfer has actually started in this Subframe. This is detected by the BC-access to SA 11T.	
4700-7		In the Burst Mode the RT shall provide an update of the TM Packet Transfer messages (SA 11T to SA 26T) according to following timing: In the Burst Mode the TM Packet output buffers (SA 11T to SA 26T) shall be updated either after - Receiving of the BC TM Packet Transfer Confirmation message (SA 10R) or after - The next Subframe is started and the RT address of the RT in Burst Mode was transmitted within the Synchronization message TBC.	
		Event driven TM-packets	Not applicable
4800	D	TM-Event packets are small TM data packets, which are used for Telecommand verification and for reporting asynchronous RT events; details are defined in the main part of RD 2. They fit into one MIL Bus message. These TM Event messages are handled independently from the nominal TM packet transfer.	Not applicable
4805	T	If the RT has to start a TM Event transfer it shall load the Event packet message into the buffers associated with Event message SA 5T or SA 6T (see Table 3.1-2) and shall set the corresponding Event Flag in the Packet Transfer Request control words.	Not applicable
4810	T	The Event transfer handshake is performed by a duplication of the Event message coming from the RT Transmit SA to the corresponding Receive SA by the BC.	Not applicable
4815	T	By comparing the contents of these SAs, the RT shall be able to detect that the BC has acquired a certain Event message	Not applicable
4820	T	The BC shall take care that an Event Flag, which is taken into account, will initialize only once the associated reading of an Event message.	Not applicable
4830	T	After the BC has started the transfer of an Event message in a certain Subframe, it shall ignore status changes of the associated Event Flag	Not applicable

Req nr	Ver	Description	Test
		during this Subframe and the next Subframe. Note: This provides time for the RT for resetting of this flag.	
4835	R, T	The RT shall check at least after every Subframe sync if the Event Packet Transfer is confirmed	Not applicable
4840	T	If the Event Packet Transfer is confirmed the RT shall reset the corresponding Event Flag	Not applicable
4845	R, T	A new Event Flag setting of the same kind (A or B) is only allowed after waiting 2 Subframes.	Not applicable
4850	R, T	The RT shall use Event TM-A messages (SA 5T) for TBD.	Not applicable
4855	R, T	The RT shall use Event TM-B messages (SA 6T)for TBD	Not applicable
4860	T	The BC shall poll a RT at least two times a second to detect an Event Flag setting	Not applicable
4865	N	Figure 4.6.2-1 illustrates the logical flow of the RT Event handling behavior	Not applicable

Transfer Layer FDIR (Not applicable to CDMS-sim)

4900-TFL-TBD

Data Rate Monitoring

4910-TFL- T

The BC bus protocol layers shall provide information to the higher application layers of the BC about the amount of acquired TM data per RT and per second.

4915-TFL- N

Annex B. Specification tables

Table 1. List of Mode Commands with the corresponding patterns.

Mode command	Pattern	SA	ref to AD-#3	BC	RT
Dynamic Bus Control	00000	00000	4.3.3.5.1.7.1	NO	NO
Synchronize (without data word) *)	00001	00000	4.3.3.5.1.7.2	YES	YES
Transmit Status Word	00010	00000	4.3.3.5.1.7.3	YES	YES
Initiate Self-test **)	00011	00000	4.3.3.5.1.7.4	YES	YES
Transmitter (TX) Shut-Down	00100	00000	4.3.3.5.1.7.5	YES	YES
Override TX Shut-Down	00101	00000	4.3.3.5.1.7.6	YES	YES
Inhibit Terminal Flag	00110	00000	4.3.3.5.1.7.7	YES	YES
Override Inhibit Terminal Flag Bit	00111	00000	4.3.3.5.1.7.8	YES	YES
Reset Remote Terminal **)	01000	00000	4.3.3.5.1.7.9	YES	YES
Transmit Vector Word	10000	00000	4.3.3.5.1.7.11	YES	YES
Synchronize (with data word) *)	10001	00000	4.3.3.5.1.7.12	YES	YES
Transmit Last Command	10010	00000	4.3.3.5.1.7.13	YES	YES
Transmit BIT (built-in Test data) Word **)	10011	00000	4.3.3.5.1.7.14	YES	YES
Selected TX Shut Down (SD)	10100	00000	4.3.3.5.1.7.15	NO	NO
Override Selected TX SD	10101	00000	4.3.3.5.1.7.16	NO	NO
Remaining Possible Command pattern (reserved for future use)	all other	00000	4.3.3.5.1.7.10	N/A	N/A

This table should be adopted in AD-#1, which is a specific copy of table 3.2.3-1 in AD-#2.

Table 2. SA utilization

Subaddress	Transmit	Receive
0	reserved for Mode command	reserved for Mode command
1	Unit status	data Unit control
2	*Data send*	*Data receive*
3	*Data send*	Asynchronous Short Command 1
4	*Data send*	Asynchronous Short Command 2
5	Event Message TM - A	Event Message TM - A acknowledge
6	Event Message TM - B	Event Message TM - B acknowledge
7	*Data send*	*Data receive*
8	Internal Time TBD	Time Messages
9	*Data send*	*Data receive*
10	TM Packet Transfer Request	TM Packet Transfer Confirmation
11	TM Data send	MSB TC Data receive MSB
12	TM Data send	TC Data receive
13	TM Data send	TC Data receive
14	TM Data send	TC Data receive LSB
15	TM Data send	*Data receive*
16	TM Data send	*Data receive*
17	TM Data send	*Data receive*
18	TM Data send	*Data receive*
19	TM Data send	*Data receive*
20	TM Data send	*Data receive*
21	TM Data send	*Data receive*
22	TM Data send	*Data receive*
23	TM Data send	*Data receive*
24	TM Data send	*Data receive*
25	TM Data send	*Data receive*
26	TM Data send LSB	*Data receive*
27	TC Packet Transfer Confirmation	TC Packet Transfer Descriptor
28	Low Level Command - Status	Low Level Command
29	*Data send*	*Data receive*
30	Data Wrap read	Data Wrap write
31	reserved for Mode command	reserved for Mode command

Table 3. MIL bus RT status word

Bit #	Meaning	Supported by RT	Status indication
0-4	Address of responding RT	YES	none
5	Message Error	YES ,	1=yes 0=no
6	Instrumentation	YES	set to zero
7	Service Request	YES ,	1=yes 0=no
8-10	Reserved	YES	set to zero = ´0´
11	Broadcast Command Received	YES ,	1=yes 0=no
12	Busy	YES ,	1=yes 0=no
13	Subsystem Flag	YES ,	1=fault 0=no fault
14	Dyn. Bus Control Acceptance	YES	set to zero
15	Terminal Flag (RT fault)	YES ,	1=fault 0=no fault

Table 4. subframe timing

Slot #	Purpose	Duration (micro seconds)
1	Subframe synchronization	150
2	Command/Acquisition	750
3	Command/Acquisition	750
4	Command/Acquisition	750
5	Packet transfer	750
6	Packet transfer	750
7	Packet transfer	750
8	Packet transfer	750
9	Packet transfer	750
10	Packet transfer	750
11	Packet transfer	750
12	Packet transfer	750
13	Packet transfer	750
14	Packet transfer	750
15	Packet transfer	750
16	Packet transfer	750
17	Packet transfer	750
18	Packet transfer	750
19	Packet transfer	750
20	Packet transfer	750
21	Packet control	150
22	Packet control	150
23	Packet control	150
24	Regulation slot	<= 775