

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

RATIONALE

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

FOREWORD

This document was developed as a companion standard to AS15531, Digital Time Division Command/Response Multiplex Data Bus. This standard is the result of a conversion of a military document to a commercial standard. This standard has been written to support both SAE AS15531 and MIL-STD-1553B. The lineage of this document is:

Appendix A, MIL-HDBK-1553, Multiplex Applications Handbook
Section 100, MIL-HDBK-1553A, Multiplex Applications Handbook

This document should be used as an aid in the development, test and verification of remote terminal designs. Interpretations and clarifications to AS15531 and MIL-STD-1553B have been made and are useful in understanding the intent of the standards' meaning.

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SAE AS4111

TABLE OF CONTENTS

1. SCOPE	6
1.1 General	6
1.2 Field of Application.....	6
2. REFERENCES	6
2.1 Applicable Documents	6
2.1.1 SAE Publications.....	6
2.1.2 U.S. Government Publications	7
3. DEFINITIONS	7
3.1 Responses	7
3.1.1 Broadcast Command Received	7
3.1.2 Clear Status	7
3.1.3 Busy Bit	7
3.1.4 Dynamic Bus Acceptance Bit	7
3.1.5 Service Request Bit.....	7
3.1.6 Message Error Bit	7
3.1.7 No Response	7
3.1.8 Respond In Form	7
3.1.9 Subsystem Flag Bit	7
3.1.10 Terminal Flag Bit	7
4. GENERAL REQUIREMENTS.....	8
4.1 General Test Requirements	8
4.2 Test for Optional Requirements.....	8
4.3 General Monitoring Requirement	8
5. DETAILED REQUIREMENTS.....	9
5.1 Electrical Tests	9
5.1.1 Output Characteristics.....	9
5.1.1.1 Amplitude	9
5.1.1.2 Risetime/Falltime.....	9
5.1.1.3 Zero Crossing Stability	9
5.1.1.4 Distortion, Overshoot and Ringing	10
5.1.1.5 Output Symmetry	10
5.1.1.6 Output Noise	10
5.1.1.7 Output Isolation	10
5.1.1.8 Power On/Off.....	11
5.1.1.8.1 Power On/Off Noise	11

SAE AS4111

TABLE OF CONTENTS (Continued)

5.1.1.8.2	Power On Response	11
5.1.1.9	Terminal Response Time.....	12
5.1.1.10	Transmission Bit Rate	12
5.1.2	Input Characteristics	12
5.1.2.1	Input Waveform Compatibility	13
5.1.2.1.1	Zero Crossing Distortion	13
5.1.2.1.2	Amplitude Variations.....	14
5.1.2.1.3	Rise and Fall Time	14
5.1.2.1.3.1	Trapezoidal.....	14
5.1.2.1.3.2	Sinusoidal.....	14
5.1.2.2	Common Mode Rejection.....	15
5.1.2.3	Input Impedance	15
5.2	Protocol Tests.....	15
5.2.1	Required Remote Terminal Operation.....	15
5.2.1.1	Response to Command Words	15
5.2.1.1.1	RT Response to Command Words	16
5.2.1.1.2	RT to RT Response to Command Words.....	19
5.2.1.2	Intermessage Gap.....	19
5.2.1.2.1	Minimum Time.....	19
5.2.1.2.2	Transmission Rate	21
5.2.1.3	Error Injection.....	21
5.2.1.3.1	Parity	21
5.2.1.3.1.1	Transmit Command Word	21
5.2.1.3.1.2	Receive Command Word	22
5.2.1.3.1.3	Receive Data Words	22
5.2.1.3.2	Word Length.....	22
5.2.1.3.2.1	Transmit Command Word	22
5.2.1.3.2.2	Receive Command Word	22
5.2.1.3.2.3	Receive Data Words	23
5.2.1.3.3	Bi-Phase Encoding.....	23
5.2.1.3.3.1	Transmit Command Word	23
5.2.1.3.3.2	Receive Command Word	23
5.2.1.3.3.3	Receive Data Words	24
5.2.1.3.4	Sync Encoding	24
5.2.1.3.4.1	Transmit Command Word	24
5.2.1.3.4.2	Receive Command Word	24
5.2.1.3.4.3	Data Word	24
5.2.1.3.5	Message Length.....	25
5.2.1.3.5.1	Transmit Command.....	25
5.2.1.3.5.2	Receive Command.....	25
5.2.1.3.5.3	Mode Command Word Count Error.....	25
5.2.1.3.5.4	RT to RT Word Count Error.....	26
5.2.1.3.6	Contiguous Data	26
5.2.1.3.7	Terminal Fail-Safe	26

SAE AS4111

TABLE OF CONTENTS (Continued)

5.2.1.4	Superseding Commands.....	27
5.2.1.4.1	RT Superseding Commands	27
5.2.1.4.2	RT to RT Superseding Command	28
5.2.1.5	Required Mode Commands	28
5.2.1.5.1	Transmit Status	29
5.2.1.5.2	Transmitter Shutdown and Override	30
5.2.1.5.3	Reset Remote Terminal.....	31
5.2.1.6	Data Wrap-Around	32
5.2.1.7	RT to RT Message Errors	32
5.2.1.7.1	RT to RT Timeout.....	33
5.2.1.7.2	RT to RT Message Format Errors	33
5.2.1.7.3	Transmitting RT Errors	34
5.2.1.8	Bus Switching.....	35
5.2.1.9	Unique Address.....	37
5.2.2	Optional Operation	37
5.2.2.1	Optional Mode Commands.....	37
5.2.2.1.1	Dynamic Bus Control	37
5.2.2.1.2	Synchronize	38
5.2.2.1.2.1	Synchronize (Without Data Word).....	38
5.2.2.1.2.2	Synchronize (With Data Word).....	38
5.2.2.1.3	Initiate Self-Test.....	38
5.2.2.1.4	Transmit BIT Word	38
5.2.2.1.5	Selected Transmitter Shutdown and Override	39
5.2.2.1.6	Terminal Flag Bit Inhibit and Override	40
5.2.2.1.7	Transmit Vector Word.....	40
5.2.2.1.8	Transmit Last Command.....	41
5.2.2.2	Status Word Bits.....	42
5.2.2.2.1	Service Request.....	42
5.2.2.2.2	Broadcast Command Received	43
5.2.2.2.3	Busy	43
5.2.2.2.4	Subsystem Flag	44
5.2.2.2.5	Terminal Flag.....	44
5.2.2.3	Illegal Command	45
5.2.2.4	Broadcast Mode Commands.....	46
5.2.2.4.1	Broadcast Synchronize (Without Data Word).....	46
5.2.2.4.2	Broadcast Synchronize (With Data Word).....	46
5.2.2.4.3	Broadcast Initiate Self-Test	47
5.2.2.4.4	Broadcast Transmitter Shutdown and Override	47
5.2.2.4.5	Broadcast Selected Transmitter Shutdown and Override	48
5.2.2.4.6	Broadcast Terminal Flag Bit Inhibit and Override	50
5.2.2.4.7	Broadcast Reset Remote Terminal	51
5.2.2.4.8	Broadcast Dynamic Bus Control	52
5.2.2.5	Error Injection - Broadcast Messages	52
5.2.2.5.1	Parity - BC-RT Broadcast.....	53

SAE AS4111

TABLE OF CONTENTS (Continued)

5.2.2.5.1.1	Command Word Error	53
5.2.2.5.1.2	Data Word Error	53
5.2.2.5.2	Message Length, BC to RT Broadcast	53
5.3	Noise Rejection Test	54
APPENDIX A	TEST PLAN TO AS15531 AND MIL-STD-1553B CROSS REFERENCE	68
APPENDIX B	MIL-STD-1553B TO TEST PLAN CROSS REFERENCE	73
APPENDIX C	AS15531 TO TEST PLAN CROSS REFERENCE	77
APPENDIX D	TEST PLAN CHANGES FOR MIL-STD-1553B ONLY RTS	80
APPENDIX E	TEST PLAN CHANGES FOR MIL-STD-1553B, NOTICE 1 RTS	81
TABLE 1	Undefined Mode Codes	17
TABLE 2	Intermessage Gap Messages	20
TABLE 3	Criteria for Acceptance or Rejection of a Terminal for the Noise Rejection Tests	55
FIGURE 1A	Resistor Pad Configuration	56
FIGURE 1B	Bus Configuration	56
FIGURE 2	Waveform Measurements	57
FIGURE 3	Zero Crossing Interval Measurements	58
FIGURE 4	Output Noise Configuration	58
FIGURE 5	Output Isolation	59
FIGURE 6A	Transformer Coupled Common Mode Configuration	60
FIGURE 6B	Direct Coupled Common Mode Configuration	61
FIGURE 7	Gap Measurement Time	62
FIGURE 8	RT - RT Timeout Measurement	63
FIGURE 9A	Configuration for Noise Rejection Test	64
FIGURE 9B	Suggested Configuration for Noise Rejection Test	65
FIGURE 10A	Configuration for Noise Rejection Test	66
FIGURE 10B	Suggested Configuration for Noise Rejection Test	67

SAE AS4111

1. SCOPE:

This SAE Aerospace Standard (AS) contains a sample test plan for AS15531 or MIL-STD-1553B Remote Terminals (RT) that may serve several different purposes. This document is intended to be contractually binding when specifically called out in a specification, Statement of Work (SOW), or when required by a Data Item Description (DID). Any and all contractor changes, alterations, or testing deviations to this section shall be separately listed for easy review.

1.1 General:

The purpose of these tests is to verify that the Unit Under Test (UUT) responds properly in accordance with the requirements of the governing standard. The tests are not intended to verify the mission aspects stated in the equipment specification.

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

1.2 Field of Application:

This general test plan is intended for design verification of remote terminals designed to meet the requirements of AS15531 and MIL-STD-1553B with Notice 2. Appendix A, B, and C provide cross references among this test plan, AS15531, and MIL-STD-1553B. For those remote terminals not required to meet Notice 2, Appendix D and E list the changes in this test plan for MIL-STD-1553B only and MIL-STD-1553B, Notice 1. The test plan requirements apply to the terminal under test, when invoked in a specification or statement of work.

When invoked in a specification or statement of work, these requirements apply to the remote terminal and associated equipment which is developed either alone or as a portion of a system or subsystem development. The contractor is responsible for invoking all the applicable requirements of this document on any and all subcontractors he/she may employ.

2. REFERENCES:

2.1 Applicable Documents:

The following publications form a part of this standard to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the contract. In the event of conflict between the text of this standard and references cited herein, the text of this standard takes precedence. Nothing in this standard, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications: Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AS15531 Digital Time Division Command/Response Multiplex Data Bus

SAE AS4111

2.1.2 U.S. Government Publications: Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-1553B Digital Time Division Command/Response Multiplex Data Bus
Notice 2

3. DEFINITIONS:

3.1 Responses:

The following are definitions of the responses of the RT as used in this test plan. In each case the status word must have the correct terminal address and unused status bits set to zero.

- 3.1.1 Broadcast Command Received (BCR): The broadcast command received bit (bit time fifteen) is set in the 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).
- 3.1.2 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.
- 3.1.3 Busy Bit (BUSY): CS with the busy bit (bit time sixteen) set in the status word, and no data words.
- 3.1.4 Dynamic Bus Acceptance Bit (DBA): CS with the dynamic bus control acceptance bit (bit time eighteen) set in the status word.
- 3.1.5 Service Request Bit (SRB): CS with the service request bit (bit time eleven) set in the status word.
- 3.1.6 Message Error Bit (ME): The message error bit (bit time nine) is set in the status word followed by no data words (except in response to a transmit last command mode command which requires one data word).
- 3.1.7 No Response (NR): The addressed terminal does not produce any response to the command.
- 3.1.8 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 AS15531 or MIL-STD-1553B consists of a response formatted as though it were a legal command.
- 3.1.9 Subsystem Flag Bit (SF): CS with the subsystem flag bit (bit time seventeen) set in the status word.
- 3.1.10 Terminal Flag Bit (TF): CS with the terminal flag bit (bit time nineteen) set in the status word.

SAE AS4111

4. GENERAL REQUIREMENTS:

4.1 General Test Requirements:

The following paragraphs define the configurations, pass/fail criteria, and general procedures for testing remote terminals (RT). Specifically, this document contains the test configurations and procedures for the Electrical Tests (5.1), the Protocol Tests (5.2), and the Noise Rejection Test (5.3) for AS15531 and MIL-STD-1553B remote terminals. The remote terminal under test is referred to as the Unit Under Test (UUT). Proper terminal responses are defined in each test paragraph. If the hardware/software design of the UUT does not permit a test to be performed, then adequate analysis shall be provided in place of the test results to demonstrate that the design meets the requirements of AS15531 or MIL-STD-1553B as stated in the test.

Any condition which causes the UUT to respond other than as called out in AS15531 or MIL-STD-1553B, to lock up, or require a power cycle in order to recover for any reason shall automatically cause that UUT to fail the test. All occurrences of responses with the busy bit set in the status word shall be recorded. If the UUT response does not match the pass criteria for a particular test, then the UUT has failed that test.

4.2 Test for Optional Requirements:

All tests for optional requirements defined in 5.2.2 shall be executed if that AS15531 or MIL-STD-1553B option is required by the subsystem specification or Interface Control Document (ICD). Any optional capabilities implemented in the RT should also be tested, if possible. Within the constraints imposed by the hardware/software design, optional capabilities must be tested prior to use by system integrators.

4.3 General Monitoring Requirement:

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

- a. response time
- b. contiguous data
- c. proper Manchester encoding
- d. proper bit count
- e. odd parity
- f. proper word count
- g. proper terminal address in the status word
- h. reserved status and instrumentation bits in the status word are set to zero
- i. proper sync

The UUT shall have failed the test if at any time during the test any of these parameters fail to meet the requirements of AS15531 or MIL-STD-1553B. Record the parameters for all failures.

SAE AS4111

5. DETAILED REQUIREMENTS:

5.1 Electrical Tests:

Each test paragraph contains the requirements for both transformer and direct coupled stubs. A UUT which provides both transformer and direct coupled stubs must be tested on both stubs. Electrical tests shall be performed on all buses for UUTs with redundant bus configurations.

5.1.1 Output Characteristics: The following tests are designed to verify that all UUT output characteristics comply with AS15531 or MIL-STD-1553B. These tests shall be performed after establishing communications between the test equipment and the UUT. All output electrical tests shall use Figure 1A, Resistor Pad Configuration, with all measurements taken at point 'A', unless otherwise noted.

5.1.1.1 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 maximum and minimum peak to peak amplitudes (V_{ppmax} , V_{ppmin}) over all words transmitted by the UUT in the message, shall be measured and recorded. For waveforms having overshoot, these measurements shall be taken as shown in Figure 2.

The pass criteria shall be $V_{ppmax} \leq 27.0$ V, $V_{ppmin} \geq 18.0$ V for transformer coupling; and the pass criteria shall be $V_{ppmax} \leq 9.0$ V, $V_{ppmin} \geq 6.0$ V for direct coupling.

5.1.1.2 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 percent and 90 percent points of the waveform as shown on Figure 2. The measurements shall be taken at both the rising and falling edges of a sync waveform and a data bit waveform. The risetime (T_R) and the falltime (T_F) shall be recorded.

The pass criteria shall be 100 ns $\leq T_R \leq 300$ ns and 100 ns $\leq T_F \leq 300$ ns. The measured parameters, T_R and T_F , 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.

5.1.1.3 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 (T_{zcp}) and the negative (T_{zcn}) waveforms as shown on Figure 3.

The pass criteria for each case shall be that T_{zcp} and $T_{zcn} = 500 \pm 25$ ns, 1000 ± 25 ns, 1500 ± 25 ns, and 2000 ± 25 ns. The measured parameters, T_{zcp} and T_{zcn} shall be recorded for each case.

SAE AS4111

- 5.1.1.4 Distortion, Overshoot and Ringing: A valid legal transmit command shall be sent to the UUT, requesting the UUT to transmit at least one data word. The distortion of the waveform, distortion voltage (V_D) shall be measured as indicated on Figure 2.

Pass criteria shall be $V_D \leq \pm 900$ mV peak, line-to-line, for transformer coupled stubs or $V_D \leq \pm 300$ mV peak, line-to-line, for direct coupled stubs. The worst measured parameter, V_D , shall be recorded.

- 5.1.1.5 Output Symmetry: A valid legal transmit command shall be sent to the UUT requesting the maximum number of data words that the UUT is capable of transmitting. The output symmetry is determined by measuring the waveform tailoff at the end of each message. The maximum residual voltage (V_R) shall be measured as shown on Figure 2. 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 $V_R \leq 250$ mV peak, line-to-line, for transformer coupled stubs, and $V_R \leq \pm 90$ mV peak, line-to-line, for direct coupled stubs, after time T_T (the time beginning 2.5 μ s after the mid-bit zero crossing of the last parity bit). The measured parameter, V_R , shall be recorded for each bit pattern.

- 5.1.1.6 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 (V_{RMS}) shall be measured at point 'A' as shown on Figure 4 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 $V_{RMS} \leq 14.0$ mV for transformer coupled stubs and $V_{RMS} \leq 5.0$ mV for direct coupled stubs. The measured parameters, V_{RMS} , shall be recorded for each case.

- 5.1.1.7 Output Isolation: This test shall be performed only if the UUT is configured with redundant buses. A 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). The measured parameter, output isolation, expressed as a ratio in dB, shall be recorded for each bus combination.

SAE AS4111

5.1.1.8 Power On/Off:

5.1.1.8.1 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:

- a. For transformer coupled stubs any spurious noise pulses produced shall be less than or equal to ± 250.0 mV peak, line-to-line.
- b. For direct coupled stubs any spurious noise pulses produced shall be less than or equal to ± 90.0 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. A 20 MHz bandwidth restriction shall be imposed on the measurement equipment.

5.1.1.8.2 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 seconds 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.

SAE AS4111

5.1.1.9 Terminal Response Time: 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 a minimum of 100 times.

- 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. A valid legal RT to RT command, with the UUT as the receiving terminal, shall be sent to the UUT and the response time measured.
- 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 μ s and 12.0 μ s at point A of Figure 1A and measured as shown on Figure 7. The command words used and the maximum response times shall be recorded.

5.1.1.10 Transmission Bit Rate: The transmission bit rate of the UUT shall be verified by analysis. Analysis may include component assembly or UUT test procedures and results sufficient to verify the UUT's transmission bit rate.

The pass criteria is that the transmission bit rate shall be 1.0 megabits per second with a combined accuracy and long-term stability of ± 0.1 percent (i.e. ± 1000 Hz), and a short-term stability over a 1.0 second interval shall be at least 0.01 percent (i.e. ± 100 Hz).

5.1.2 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 with all measurements taken at point 'A', unless otherwise noted. For Air Force applications, all input electrical tests, with the exception of 5.1.2.1.1, shall use Figure 1B, with all measurements taken at point 'A' unless otherwise noted.

SAE AS4111

5.1.2.1 Input Waveform Compatibility:

5.1.2.1.1 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 150 ns from the ideal, with respect to the previous ideal zero crossing, (i.e., $2.0 \mu\text{s} \pm 150 \text{ ns}$, $1.5 \mu\text{s} \pm 150 \text{ ns}$, $1.0 \mu\text{s} \pm 150 \text{ ns}$, $0.5 \mu\text{s} \pm 150 \text{ ns}$) shall be introduced individually to each zero crossing as follows:

- a. All zero crossings in the command word;
- b. All 35 zero crossings in a single data word where the data pattern is 0000H;
- c. The zero crossing between bit times 19 and 20 in a single data word where the data pattern is 8000H.
- d. The zero crossing in the middle at bit time 4 and the zero crossing between bit time 4 and 5 in a single data word where the pattern is C000H.

Each zero crossing distortion shall be transmitted to the UUT a minimum of 1000 times.

This test shall use Figure 1A or Figure 1B. The signal amplitude transmitted to the UUT, measured at point "A" shall be $2.1 V_{PP}$ for transformer coupled stubs and $3.0 V_{PP}$ for direct coupled stubs. The rise and fall time of this signal (measured at the 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 $200 \text{ ns} \pm 20 \text{ ns}$.

The pass criteria is CS for each message transmitted.

Positive and negative zero crossing distortions (equal to N ns) shall then be applied in turn to a single zero crossing. The zero crossings shall be increased in steps to determine the positive and negative values at which the first NR occurs. It is recommended that the steps be no greater than 5 ns. The value at which the first NR occurs, for both positive and negative zero crossing distortions, shall be recorded.

SAE AS4111

5.1.2.1.2 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 1B, shall be decremented from $6.0 V_{PP}$ to $0.1 V_{PP}$ for transformer coupled stubs and from $4.5 V_{PP}$ to $0.1 V_{PP}$ for direct coupled stubs in steps no greater than $0.1 V_{PP}$. 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 $200 \text{ ns} \pm 20 \text{ ns}$. 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 $0.86 \leq V_{PP} \leq 6.0$ for transformer coupled stubs and $1.2 \leq V_{PP} \leq 4.5$ for direct coupled stubs
- b. A NR for $V_{PP} \leq 0.20$ for transformer coupled stubs and $V_{PP} \leq 0.28$ for direct coupled stubs

The measured parameter, V_{PP} , at which NR first occurs shall be recorded.

5.1.2.1.3 Rise and Fall Time:

5.1.2.1.3.1 Trapezoidal: A minimum of 1000 valid receive messages shall be sent to the UUT with a signal amplitude of $2.1 V_{PP}$ for the transformer coupled stub and $3.0 V_{PP}$ for the direct 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.

5.1.2.1.3.2 Sinusoidal: A minimum of 1000 valid receive messages shall be sent to the UUT with a signal amplitude of $2.1 V_{PP}$ for the transformer coupled stub and $3.0 V_{PP}$ for the direct 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.

SAE AS4111

5.1.2.2 Common Mode Rejection: The common mode test configuration, Figure 6A or Figure 6B, 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 percent \pm 10 percent 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 $0.86 V_{PP}$ for transformer coupled stubs and $1.2 V_{PP}$ for direct 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 $200 \text{ ns} \pm 20 \text{ ns}$. The following common mode voltage levels shall be applied in turn: +10.0 Vdc line-to-ground, -10.0 Vdc line-to-ground, and $\pm 10 V_p$ 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.

NOTE: The design of the test fixture used for this test should consider, and if necessary compensate for, stray capacitance introduced by cable lengths, connectors, and adapters used to interface to the UUT. Any capacitance imbalances introduced may effect test results.

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

5.1.2.3 Input Impedance: The input impedance of the UUT in a stand alone configuration (i.e., disconnected from Figure 1A or Figure 1B) shall be measured with the UUT power on and with the UUT power off. The input impedance, Z_{in} , shall be measured with a sinusoidal waveform having an amplitude $1.0 V_{RMS}$ to $2.0 V_{RMS}$, 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 $Z_{in} \geq 1000$ ohms for transformer coupled stubs and $Z_{in} \geq 2000$ ohms for direct coupled stubs. The measured parameter, Z_{in} , shall be recorded at each frequency. For characterization of the UUT, the phase angle at each measured frequency shall also be recorded.

5.2 Protocol Tests:

All tests in this section shall use the test configuration as shown on Figure 1A or Figure 1B. The test signal amplitude shall be $3.0 V_{PP} \pm 0.1 V_{PP}$ for direct coupled stubs and $2.1 V_{PP} \pm 0.1 V_{PP}$ for transformer coupled stubs measured at point 'A'. For UUTs having both direct and transformer coupled stubs, the protocol tests need only be performed on one stub type per bus. The protocol tests shall be performed on all buses for UUTs with redundant bus configurations.

5.2.1 Required Remote Terminal Operation: The following tests verify required operations of a remote terminal.

5.2.1.1 Response to Command Words: The purpose of this test is to verify that the UUT responds properly to all commands.

SAE AS4111

5.2.1.1.1 RT Response to Command Words: All possible command words (65, 536 combinations) meeting the criteria of the paragraph on Word Validation (paragraph 4.4.1.1 of AS15531 or MIL-STD-1553B) shall be sent to the UUT. Mode commands tested in 5.2.1.5, 5.2.2.1, or 5.2.2.4 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 AS15531 or MIL-STD-1553B. Refer to Table 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 variable command word is sent as Step 2.

Where implemented by the UUT, mode commands tested in 5.2.1.5, 5.2.2.1, or 5.2.2.4 may be omitted from this test since their inclusion here may change the state of the UUT. For example, the Reset RT mode command may cause the UUT to cease responding to subsequent commands issued during this test. This action, though appropriate for the UUT, defeats the intent of this test paragraph.

- 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 a 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.

SAE AS4111

5.2.1.1.1 (Continued):

- 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 (except for Transmit Last Command mode commands where the data word may contain the Command Word bit pattern from Step 1).
 - (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 (except for Transmit Last Command mode commands where the data word may contain the Command Word bit pattern from Step 1).

TABLE 1 - Undefined Mode Codes

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

SAE AS4111

5.2.1.1.1 (Continued):

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 (except for broadcast transmit last command mode commands where the data word may contain the command word bit pattern from Step 1).
 - (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 (except for broadcast transmit last command mode commands where the data word may contain the command word bit pattern from Step 1).
- 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 may contain the command word bit pattern from Step 1.
- g. Undefined broadcast mode commands (see Table 1) (for any one 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.

SAE AS4111

5.2.1.1.2 RT to RT Response to Command Words: All possible command words (65,536 combinations) meeting the criteria of the paragraph on Word Validation (paragraph 4.4.1.1 of AS15531 or MIL-STD-1553B) shall be sent to the UUT embedded in an RT to RT message format. For the variable command, command combinations with the T/R bit = 0 shall be the first command of the RT to RT message and the command combinations with the T/R bit = 1 shall be the second command of the RT to RT message. The other command in the RT to RT message shall have the appropriate number of words as the variable command and shall be to a terminal address different than the variable command and not to the UUT terminal address. The appropriate response to the other command shall be simulated in order to complete the RT to RT message. Refer to Table 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 embedded in the RT to RT message format.

NOTE: For mode commands without data words, the other command of the RT to RT message shall be a mode command without data words which may be an undefined mode command.

Step 3. Send a transmit last command mode command to the UUT. (If this mode command is not implemented, then a 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 shall be as listed in 5.2.1.1.1, except the pass criteria for any RT to RT mode command is as specified in 5.2.1.1.1.d and the pass criteria for any broadcast RT to RT mode command shall be as specified in 5.2.1.1.1.g.

5.2.1.2 Intermessage Gap:

5.2.1.2.1 Minimum Time: The purpose of this test is to verify that the UUT responds properly to valid legal messages with a minimum intermessage gap. Valid legal messages of the message pairs listed in Table 2 shall be sent to the UUT with the minimum intermessage gap time (T) of 4.0 μ s as shown on Figure 7. 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.

The pass criteria shall be CS, CS for message pairs 1-7; and NR, CS for message pairs 8-12. All message pairs used shall be recorded and message pairs which cause the UUT to fail the test shall be indicated.

SAE AS4111

TABLE 2 - Intermessage Gap Messages

COMMAND TYPES	<ul style="list-style-type: none"> A) BC to UUT Transfer (maximum word count) - Receive Command (Note 3) B) UUT to BC Transfer (maximum word count) - Transmit Command (Note 3) C) UUT/RT (maximum word count) (Note 1) D) RT/UUT (maximum word count) (Note 2) E) Mode Command Without Data Word F) Mode Command With Data Word (Transmit) G) Mode Command With Data Word (Receive) H) Broadcast BC to UUT Transfer (maximum word count) (Note 3) I) Broadcast UUT/RT (maximum word count) (Notes 1, 3) J) Broadcast RT/UUT (maximum word count) (Notes 2, 3) K) Broadcast Mode Command Without Data Word L) Broadcast Mode Command With Data Word
MESSAGE PAIRS	<ul style="list-style-type: none"> 1) A (GAP) A 2) B (GAP) A 3) C (GAP) A 4) D (GAP) A 5) E (GAP) A 6) F (GAP) A 7) G (GAP) A 8) H (GAP) A 9) I (GAP) A 10) J (GAP) A 11) K (GAP) A 12) L (GAP) A
<p>This table defines the types and combinations of messages to be used in test 5.2.1.2.1, 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 AS15531 or MIL-STD-1553B) by a receive command with maximum word count.</p>	
<p>Notes:</p> <ul style="list-style-type: none"> 1. UUT/RT: Denotes RT to RT transfer with UUT receiving 2. RT/UUT: Denotes RT to RT transfer with UUT transmitting 3. Maximum word count shall be the maximum number of words the UUT is designed to receive/transmit 	

SAE AS4111

5.2.1.2.2 **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 $7 \mu\text{s} \pm 3 \mu\text{s}$ (i.e., a burst of messages with an intermessage gap of $7 \mu\text{s} \pm 3 \mu\text{s}$ between each message) as shown on Figure 7. Each step shall be performed for a minimum of 30 seconds.

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.

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 thru 3 until the test is completed without the busy bit getting set.

5.2.1.3 **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.

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

5.2.1.3.1.1 **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 in 5.2.1.3 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.

SAE AS4111

5.2.1.3.1.2 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 in 5.2.1.3 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.

5.2.1.3.1.3 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 in 5.2.1.3 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.

5.2.1.3.2 Word Length: This test verifies the ability of the UUT to recognize an error in word length occurring within a message. The test plan excludes testing of high bit errors on a transmit command and on the last data word of a receive message.

5.2.1.3.2.1 Transmit Command Word: This test verifies the ability of the UUT to recognize transmit command word length errors. The test sequence as defined in 5.2.1.3 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.

5.2.1.3.2.2 Receive Command Word: This test verifies the ability of the UUT to recognize receive command word length errors. The test sequence as defined in 5.2.1.3 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.

SAE AS4111

5.2.1.3.2.3 Receive Data Words: This test verifies the ability of the UUT to recognize data word length errors. The test sequence as defined in 5.2.1.3 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 receive.

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

The test sequence of 5.2.1.3 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.

5.2.1.3.3 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.

5.2.1.3.3.1 Transmit 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 in 5.2.1.3 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.

5.2.1.3.3.2 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 in 5.2.1.3 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.

SAE AS4111

5.2.1.3.3.3 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 in 5.2.1.3 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.

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

5.2.1.3.4.1 Transmit Command Word: This test shall verify that the UUT rejects transmit commands with invalid sync waveforms. The test sequence as defined in 5.2.1.3 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, 011000, 000111.

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

5.2.1.3.4.2 Receive Command Word: This test shall verify that the UUT rejects receive commands with invalid sync waveforms. The test sequence as defined in 5.2.1.3 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.

5.2.1.3.4.3 Data Word: This test shall verify that the UUT rejects invalid data sync waveforms. Perform the test sequence as defined in 5.2.1.3 with a sync error encoded into each data word for test Step 2. The message is a valid receive command word with 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 thru 8 match the terminal address of the UUT or be 11111 when the invalid data sync pattern 111000 is being used.

SAE AS4111

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

5.2.1.3.5.1 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 in 5.2.1.3 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.

5.2.1.3.5.2 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 in 5.2.1.3 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.

5.2.1.3.5.3 Mode Command Word Count Error: This test verifies the ability of the UUT to respond properly when an incorrect number of words is sent with a mode command. Perform the test sequence defined in 5.2.1.3 using a 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.

SAE AS4111

5.2.1.3.5.4 RT to RT Word Count Error: This test verifies the ability of the UUT to respond properly when an incorrect number of words is sent to it as a receiving RT during an RT to RT transfer. Perform the following test sequence.

Step 1 Send a valid legal RT to RT command pair followed in 4.0 μ s to 12.0 μ s by a valid status word and N data words to the UUT, where N is the number of data words requested in the transmit command.

Step 2 Send the same RT to RT command pair followed in 4.0 μ s to 12.0 μ s by a valid status word and N-1 data words.

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

Step 4 Repeat Steps 1 through 3 using a word count of N+1 in Step 2.

The pass criteria in both cases shall be that the receiving RT's status is: Step 1 - CS; Step 2 - NR; Step 3 - ME.

5.2.1.3.6 Contiguous Data: This test verifies that the UUT recognizes discontinuous data in a message. Perform the test sequence as defined in 5.2.1.3 with a 4.0 μ s 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.

5.2.1.3.7 Terminal Fail-Safe: The purpose of this test is 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 μ s. 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:

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 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 μ s and 800.0 μ s. 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.

SAE AS4111

5.2.1.4 Superseding Commands: The purpose of this test is to verify that the UUT responds properly to superseding commands.

5.2.1.4.1 RT 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 μ s (reference Figure 7), then a valid legal transmit command requesting the maximum number of data words that the UUT is designed to transmit.
- 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; Step 3 - ME

For c, 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.

SAE AS4111

5.2.1.4.2 RT to RT Superseding Command: The purpose of this test is to verify that the UUT will not malfunction and responds properly to a superseding command when operating as the receiving RT in a RT to RT transfer.

- Step 1. Send a valid legal RT to RT command pair followed in 4.0 μ s to 12.0 μ s by a valid status word and N data words to the UUT, where N is the number of data words indicated in the receive command.
- Step 2. Send the same RT to RT command pair followed in 4.0 μ s to 12.0 μ s by a valid legal transmit command addressed to the UUT.
- Step 3. A transmit status mode command shall be sent to the UUT.

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

5.2.1.5 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.

SAE AS4111

5.2.1.5.1 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 bus under test.
- Step 2. A transmit status mode command shall be sent to the UUT on the same bus used in Step 1.
- Step 3. A valid legal message shall be sent to the UUT on a bus other than that used in Step 1.
- Step 4. A transmit status mode command shall be sent to the UUT on the same bus used in Step 3.
- Step 5. A valid legal receive command with a parity error in a data word shall be sent on the same bus used in Step 1.
- Step 6. A transmit status mode command shall be sent to the UUT on the same bus used in Step 1.
- 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.

SAE AS4111

5.2.1.5.2 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. 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 to the UUT on the bus under test.
- Step 2. A valid legal command shall be sent to the UUT on a bus other than that used in Step 1.
- Step 3. A valid legal transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 1.
- Step 4. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 5. A valid legal command shall be sent to the UUT on the same bus used in Step 1.
- Step 6. A valid legal override transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 2.
- Step 7. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 8. A valid legal override transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 1.
- Step 9. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 10. A valid legal command shall be sent to the UUT on the same bus used in Step 1.

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.

SAE AS4111

5.2.1.5.3 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 the reset time (T_{RST}) 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 the bus under test.

Step 2. After time T from Step 1, as measured per Figure 7, a valid legal command shall be sent to the UUT on the same bus used in Step 1.

Starting with time T at 100.0 ms repeat Step 1 and Step 2 while decreasing time T from 100.0 ms down to 4.0 μ s in the following steps: from 100.0 ms to 6.0 ms in no greater than 1.0 ms steps, and from 6.0 ms to 4.0 μ s in no greater than 10.0 μ s steps.

The minimum time, T_{RST} , 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 bus used in Step 1.

Step 4. A valid legal command shall be sent to the UUT on a bus other than that used in Step 1.

Step 5. A reset remote terminal mode command shall be sent to the UUT on the bus used in Step 1.

Step 6. After an intermessage gap equal to T_{RST} , a valid legal command shall be sent to the UUT on a bus other than that used in Step 1.

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 $T \geq 5.0$ ms, and CS or NR for $T < 5.0$ ms; Step 3 - CS; Step 4 - NR; Step 5 - CS; Step 6 - CS (with busy bit reset).

SAE AS4111

5.2.1.6 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., the maximum word count from the set of all messages defined for that RT). 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 wraparound 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.

NOTE: It is important to consider the following during implementation of this test:

- a. The UUT may require time to move the data from the receive subaddress to the transmit subaddress. To avoid misleading test results, sufficient time should be allowed, if required, for the UUT to transfer data from the receive subaddress buffer to the transmit subaddress buffer.
- b. Steps should be taken to avoid the busy condition prior to test execution as "busy" may alter test results causing inappropriate failures.

5.2.1.7 RT to RT Message Errors: The purpose of this test is to examine the UUT's response to specific errors in the message stream when operating as the receiving RT in an RT to RT transfer. For these tests, the bus tester shall act as the bus controller and the transmitting remote terminal as required.

SAE AS4111

5.2.1.7.1 RT to RT Timeout: The purpose of this test is to verify that the UUT times out properly when operating as a receiving RT in an RT to RT transfer. Time T, as shown in Figure 8, is measured from the zero crossing of the parity bit of the receive command to the mid sync zero crossing of the first data word. The following test sequence shall be performed.

Step 1. Send a valid legal RT to RT command pair followed in 4.0 μ s to 12.0 μ s by a valid status word with the RT address of the transmit command and the proper number of data words shall be sent to the UUT.

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

Repeat Step 1 and Step 2 incrementing the time in Step 1 between the transmit command and the status word in no greater than 0.5 μ s increments until the time is equal to 30.0 μ s.

When the UUT (receiving RT) stops responding, the time T, as specified in Figure 8, shall be measured and recorded.

The pass criteria shall be: Step 1 - CS for $T \leq 54.0 \mu$ s, CS or NR for $54.0 < T \leq 60.0 \mu$ s, and NR to $T > 60.0 \mu$ s; Step 2 - CS if Step 1 is CS, ME if Step 1 is NR.

5.2.1.7.2 RT to RT Message Format Errors: The purpose of this test is to verify that the UUT will not malfunction and responds properly to errors in the message stream associated with the transmitting RT when the UUT is the receiving RT in a RT to RT transfer. The following test sequence shall be used:

Step 1. Send a valid legal RT to RT command pair followed in 4.0 μ s to 12.0 μ s by a valid status word and N data words to the UUT, where N is the number of data words indicated in the receive command.

Step 2. Send the same RT to RT message as in Step 1 injecting one of the errors indicated below.

Step 3. Send a transmit status mode command to the UUT.

SAE AS4111

5.2.1.7.2 (Continued):

Record the UUT's response to each step when the test is performed with each of the following format errors (Step 2):

- a. Invalid transmit command word. Inject an invalid sync pattern in the transmit command word followed in 4.0 μ s to 12.0 μ s with a receive command with the same address as the transmit command followed by N data words and no status response. This command combination will appear to the UUT as the same message format in Step 1 with an invalid transmitting RT's command word.
- b. Invalid transmitting RT's status word. Inject an invalid sync pattern in the transmitting RT's status word.
- c. Wrong sync type in the transmitting RT's status word. Send the same RT to RT command pair as in Step 1 followed in 4.0 μ s to 12.0 μ s by N+1 data words.

The pass criteria for each of the test formats shall be as follows: Step 1 - CS; Step 2 - NR, Step 3 - ME.

5.2.1.7.3 Transmitting RT Errors: The purpose of this test is to verify proper occurrence of the transmitting RT's command and status words. The purpose of this test is twofold: first to determine whether the UUT verifies the proper occurrence of the transmitting RT's command and status word and, secondly, to verify that the UUT will not malfunction and responds properly to errors in the message stream associated with the transmitting RT when the UUT is the receiving RT in an RT to RT transfer. Although recommended by Notice 2, the standard does not require the receiving RT to verify the proper occurrence of the transmitting RT's command and status word. Therefore, the first purpose of this test is for characterization of the UUT only. The following test sequence shall be used:

- Step 1. Send a valid legal RT to RT command pair followed in 4.0 μ s to 12.0 μ s by a valid status word and N data words to the UUT, where N is the number of data words indicated in the receive command.
- Step 2. Send the same RT to RT command pair as in Step 1 followed in 4.0 μ s to 12.0 μ s by a status word containing a terminal address different from both the transmit command and the UUT, followed by N data words.
- Step 3. A transmit status mode command shall be sent to the UUT.

The pass criteria shall be the following: Step 1 - CS; Step 2 - CS or NR, Step 3 - CS if Step 2 is CS; ME if Step 2 is NR.

SAE AS4111

5.2.1.8 Bus Switching: This test verifies that the dual redundant remote terminal properly performs the bus switching requirements of AS15531 or MIL-STD-1553B (paragraph 4.6.3.1 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 opposite 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 for each interrupting command.

RT Transmitting:

- Step 1. Send a valid transmit command to the UUT on the bus under test requesting the maximum number of data words that the UUT is designed to transmit.
- Step 2. Send the interrupting command to the UUT on a bus other than that used in Step 1 beginning 4.0 μ s after the beginning of the first command.
- Step 3. After the messages on both buses have been completed, send a valid legal transmit status mode command to the UUT on the same bus used in Step 2.
- Step 4. Send a valid legal transmit status mode command to the UUT on the same bus used in Step 1.

Repeat Step 1 through Step 4 increasing the gap time between Step 1 and Step 2 in increments no greater than 250.0 ns 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; Step 3 - CS; Step 4 - CS and for b and c, Step 1 - CS; Step 2 - NR; Step 3 - CS; Step 4 - CS. For test failures, record the test parameters at which the failure occurred.

SAE AS4111

5.2.1.8 (Continued):

RT Receiving:

- Step 1. Send a valid RT to RT message command to the UUT and a second RT on the bus under test with the UUT the receiving terminal with the maximum number of data words that the UUT is designed to receive.
- Step 2. Send the interrupting command to the UUT on a bus other than that used in Step 1 beginning 4.0 μ s after the beginning of the first command.
- Step 3. After the messages on both buses have been completed, send a valid legal transmit status mode command to the UUT on the same bus used in Step 2.
- Step 4. Send a valid legal transmit status mode command to the UUT on the same bus used in Step 1.

Repeat Step 1 through Step 4 increasing the gap time between Step 1 and Step 2 in increments no greater than 250.0 ns until the messages no longer overlap.

- 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 status or CS; Step 2 - CS; Step 3 - CS; Step 4 - CS and for b and c, Step 1 - CS; Step 2 - NR; Step 3 - CS; Step 4 - CS. For test failures, record the test parameters at which the failure occurred.

SAE AS4111

5.2.1.9 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 thru 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.

5.2.2 Optional Operation: This section provides for testing the optional requirements of AS15531 or MIL-STD-1553B. 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 last command mode command is not implemented in the UUT, then the transmit status mode command shall be used.

5.2.2.1 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.

5.2.2.1.1 Dynamic Bus Control: The purpose of this test is to verify that the UUT has the ability to recognize the dynamic bus control mode command and to take control of the data bus. A valid legal dynamic bus control mode command shall be sent to the UUT. The UUT shall take control of the data bus when its response is DBA as required in the UUT's design specification.

The pass criteria shall be that the UUT responds with a DBA upon acceptance of bus control or a CS upon rejection of bus control.

NOTE: Upon completion of this test, it may be necessary to reconfigure the UUT as a remote terminal.

SAE AS4111

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

5.2.2.1.2.1 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 responds with CS.

5.2.2.1.2.2 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 responds with CS.

5.2.2.1.3 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 initiated 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, a valid legal command shall be sent to the UUT on the same bus.

Starting with time T not less than 200.0 ms, repeat Step 1 and Step 2 while decreasing time T to 4.0 μ s in no greater than 1.0 ms steps. Finer granularity, 10.0 μ s maximum steps may 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 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.

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 $T \geq 100.0$ ms, and CS or NR for time $T < 100.0$ ms.

5.2.2.1.4 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 BIT word transmitted by the UUT shall be recorded.

The pass criteria shall be that the UUT responds with CS followed by a valid BIT Word.

SAE AS4111

5.2.2.1.5 Selected Transmitter Shutdown and Override: This test shall verify that the UUT recognizes the multi-redundant mode commands to shut down a selected bus transmitter and to override the shutdown. A valid legal selected transmitter shutdown mode command shall be sent to the UUT accompanied by the appropriate data word to cause a selected 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.

- Step 1. A valid legal command shall be sent to the UUT on the bus under test.
- Step 2. A valid legal command shall be sent to the UUT on a bus other than that used in Step 1.
- Step 3. A valid legal selected transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 1 with the data word encoded to shut down the bus used in Step 2.
- Step 4. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 5. A valid legal command shall be sent to the UUT on the same bus used in Step 1.
- Step 6. A valid legal override selected transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 2 with the same data word as sent in Step 3.
- Step 7. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 8. A valid legal override selected transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 1 with the same data word as sent in Step 3.
- Step 9. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 10. A valid legal command shall be sent to the UUT on the same bus used in Step 1.
- Step 11. Repeat Step 3 except that the data word shall be encoded with a bit pattern that would normally shut down the same bus used in Step 1 if it was sent on the same bus used in Step 2.
- Step 12. Repeat Step 4.
- Step 13. Repeat Step 5.

SAE AS4111

5.2.2.1.5 (Continued):

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.

5.2.2.1.6 Terminal Flag Bit Inhibit and Override: This test verifies that the UUT recognizes and responds properly to the mode command(s) of inhibit terminal flag bit and override inhibit 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 command shall be sent to the UUT.
- Step 4. Repeat Step 1.
- Step 5. A valid legal override inhibit terminal flag mode 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.

5.2.2.1.7 Transmit Vector Word: This test verifies the capability of the UUT to recognize and respond properly to a transmit vector word mode command. A valid legal transmit vector word mode command shall be sent to the UUT. The vector word transmitted by the UUT shall be recorded.

The pass criteria shall be that the UUT responds with CS followed by a valid Vector Word.

SAE AS4111

5.2.2.1.8 Transmit Last Command: This test verifies that the UUT recognizes and responds properly to a transmit last command mode command. 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 mode 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 from 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 from Step 7; Step 9 - CS; Step 10 - CS, followed by a data word containing the command word from Step 9.

SAE AS4111

- 5.2.2.2 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.
- What conditions set the status bit in the status word transmitted on the data bus.
 - What conditions reset the status bit in the status word transmitted on the data bus.
 - 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.
 - 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.

- 5.2.2.2.1 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 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 reset 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.

SAE AS4111

5.2.2.2.2 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 used:

- 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. If this mode command is not implemented, then a transmit status mode command shall be used, and the data word associated with the transmit last command mode command shall be deleted from the pass criteria.
- Step 3. A valid, legal, non-broadcast command shall be sent to the UUT.
- Step 4. Repeat Step 1.
- Step 5. Repeat Step 3.

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. All commands and UUT responses shall be recorded.

5.2.2.2.3 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.

- Step 1. A condition which sets the busy bit must be activated.
- Step 2. A valid legal transmit command shall be sent to the UUT.
- Step 3. Procedures, as defined for the UUT, shall be performed which reset the busy bit.
- Step 4. A valid legal transmit command shall be sent to the UUT.
- Step 5. A condition which sets the busy bit must be activated.
- Step 6. A valid receive command shall be sent to the UUT.
- Step 7. Procedures, as defined by the UUT, shall be performed which reset the busy bit.
- Step 8. A valid legal receive command shall be sent to the UUT.

The pass criteria for each of the above steps shall be as follows: Step 2 - BUSY; Step 4 - CS (with the busy bit reset); Step 6 - BUSY; Step 8 - CS (with the busy bit reset). All commands and UUT responses shall be recorded.

SAE AS4111

5.2.2.2.4 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. 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.

5.2.2.2.5 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 cause 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.

SAE AS4111

5.2.2.3 **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 word 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 be 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.

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5.2.2.4 Broadcast Mode Commands: The purpose of this test is 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. If this mode command is not implemented, then a transmit status mode command shall be used, and the data word associated with the transmit last command mode command shall be deleted from the pass criteria.

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

5.2.2.4.1 Broadcast Synchronize (Without Data Word): The purpose of this test is to verify that the UUT has the ability to recognize a broadcast synchronize (without data word) mode command. The test sequence defined in 5.2.2.4 shall be used with a broadcast synchronize (without data word) mode command in Step 2.

The pass criteria for each of the above steps shall be as follows: Step 1 - CS; Step 2 - NR; Step 3 - BCR and the data word contains the broadcast command sent in Step 2.

5.2.2.4.2 Broadcast Synchronize (With Data Word): The purpose of this test is to verify that the UUT has the ability to recognize a broadcast synchronize (with data word) mode command. The test sequence defined in 5.2.2.4 shall be used with a broadcast synchronize (with data word) mode command in Step 2.

The pass criteria for each of the above steps shall be as follows: Step 1 - CS; Step 2 - NR; Step 3 - BCR and the data word contains the broadcast command sent in Step 2.

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5.2.2.4.3 Broadcast Initiate Self-Test: The purpose of this test is to verify that the UUT has the ability to recognize the broadcast initiate self-test mode command. The following sequence shall be performed:

Step 1. A broadcast initiate self-test mode command shall be sent to the UUT on the bus under test.

Step 2. After time T from Step 1, as measured per Figure 7, a valid, legal non-broadcast, non-mode command shall be sent to the UUT on the same bus used in Step 1.

Starting with time T not less than 200.0 ms, repeat Step 1 and Step 2 while decreasing T to 4.0 μ s in steps no greater than 1.0 ms. Finer granularity, 10.0 μ s steps, may be used to more accurately determine the self-test time when the time of self-test is determined using the courses steps.

The minimum time 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.

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

5.2.2.4.4 Broadcast Transmitter Shutdown and Override: The purpose of this test is to verify that the UUT has the ability to recognize and properly execute these broadcast mode commands.

The following sequence shall be performed:

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

Step 2. A valid legal command shall be sent to the UUT on a bus other than that used in Step 1.

Step 3. A valid legal broadcast transmitter shutdown command shall be sent to the UUT on the same bus used in Step 1.

Step 4. A transmit last command mode command shall be sent to the UUT on the same bus used in Step 1. If this mode command is not implemented, then a transmit status mode command shall be used, and the data word associated with the transmit last command mode command shall be deleted from the pass criteria.

Step 5. A valid legal command shall be sent to the UUT on the same bus used in Step 2.

Step 6. A valid legal command shall be sent to the UUT on the same bus used in Step 1.

Step 7. A valid legal broadcast override transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 2.

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5.2.2.4.4 (Continued):

- Step 8. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 9. A valid legal broadcast override transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 1.
- Step 10. A transmit last command mode command shall be sent on the same bus used in Step 1 to the UUT. If this mode command is not implemented, then a transmit status mode command shall be used, and the data word associated with the transmit last command mode command shall be deleted from the pass criteria.
- Step 11. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 12. A valid legal command shall be sent to the UUT on the same bus used in Step 1.

The pass criteria for each of the above steps shall be as follows: Step 1 - CS; Step 2 - CS; Step 3 - NR; Step 4 - BCR (and the data word contains the command word of Step 3); Step 5 - NR; Step 6 - CS; Step 7 - NR; Step 8 - NR; Step 9 - NR; Step 10 - BCR (and the data word contains the command word of Step 9); Step 11 - CS; Step 12 - CS.

5.2.2.4.5 Broadcast Selected Transmitter Shutdown and Override: This test shall verify that the UUT recognizes the multi-redundant broadcast mode commands to shut down a selected bus transmitter and to override the shutdown. A valid legal broadcast selected transmitter shutdown mode command shall be sent accompanied by the appropriate data word to cause a selective bus transmitter shutdown. A valid legal broadcast override selected transmitter shutdown mode command shall be sent accompanied by the appropriate data word to cause an override of the selected bus transmitter shutdown.

- Step 1. A valid legal command shall be sent to the UUT on the bus under test.
- Step 2. A valid legal command shall be sent to the UUT on a bus other than that used in Step 1.
- Step 3. A valid legal broadcast selected transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 1 with the data word encoded to shut down the bus used in Step 2.
- Step 4. A transmit last command mode command shall be sent to the UUT on the same bus used in Step 1. If this mode command is not implemented, then a transmit status mode command shall be used, and the data word associated with the transmit last command mode command shall be deleted from the pass criteria.
- Step 5. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 6. A valid legal command shall be sent to the UUT on the same bus used in Step 1.

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5.2.2.4.5 (Continued):

- Step 7. A valid legal broadcast override selected transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 2 with the same data word as sent in Step 3.
- Step 8. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 9. A valid legal broadcast override selected transmitter shutdown mode command shall be sent to the UUT on the same bus used in Step 1 with the same data as sent in Step 3.
- Step 10. Repeat Step 4.
- Step 11. A valid legal command shall be sent to the UUT on the same bus used in Step 2.
- Step 12. A valid legal command shall be sent to the UUT on the same bus used in Step 1.
- Step 13. Repeat Step 3 except that the data word shall be encoded with a bit pattern that would normally shut down the bus used in Step 1 if it was sent on the same bus used in Step 2.
- Step 14. Repeat Step 4.
- Step 15. Repeat Step 5.
- Step 16. Repeat Step 6.

The data words associated with Step 3 and Step 13 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 - NR; Step 4 - BCR (and the data word contains the command word of Step 3); Step 5 - NR; Step 6 - CS; Step 7 - NR; Step 8 - NR; Step 9 - NR; Step 10 - BCR (and the data word contains the command word of Step 9); Step 11 - CS; Step 12 - CS; Step 13 - NR; Step 14 - BCR (and the data word contains the command word of Step 13); Step 15 - CS; Step 16 - CS.

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5.2.2.4.6 Broadcast Terminal Flag Bit Inhibit and Override: This test verifies that the UUT recognizes and responds properly to the broadcast mode command(s) 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 broadcast inhibit terminal flag mode command shall be sent to the UUT.
- Step 4. A transmit last command mode command shall be sent to the UUT. If this mode command is not implemented, then a transmit status mode command shall be used, and the data word associated with the transmit last command mode command shall be deleted from the pass criteria.
- Step 5. Repeat Step 1.
- Step 6. A valid legal broadcast override inhibit terminal flag mode command shall be sent to the UUT.
- Step 7. A transmit last command mode command shall be sent to the UUT. If this mode command is not implemented, then a transmit status mode command shall be used, and the data word associated with the transmit last command mode command shall be deleted from the pass criteria.
- Step 8. A valid legal receive command with at least one data word shall be sent to the UUT.
- Step 9. Procedures, as defined for the UUT, shall be performed which reset the TF bit.
- Step 10. Repeat Step 1.

The pass criteria for each of the above steps shall be as follows: Step 1 - CS; Step 2 - TF; Step 3 - NR; Step 4 - BCR or (BCR and TF) and in either case the data word contains the command word of Step 3; Step 5 - CS; Step 6 - NR; Step 7 - BCR or (BCR and TF) and in either case the data word contains the command word of Step 6; Step 8 - TF; Step 10 - CS.

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5.2.2.4.7 Broadcast Reset Remote Terminal: The purpose of this test is to verify that the UUT has the ability to recognize the broadcast mode command to reset itself to a power up initialized state. The following sequence shall be performed:

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

Step 2. After time T from Step 1, as measured per Figure 7, a valid legal transmit command shall be sent to the UUT on the same bus used in Step 1.

Starting with time T at 100.0 ms repeat Step 1 and Step 2 while decreasing time T from 100.0 ms down to 4.0 μ s in the following steps: from 100.0 ms to 6.0 ms in no greater than 1.0 ms steps, and from 6.0 ms to 4.0 μ s in no greater than 10.0 μ s steps.

The minimum reset time, T_{RST} , 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 used in Step 1.

Step 4. A valid legal command shall be sent to the UUT on a bus other than that used in Step 1.

Step 5. A valid legal broadcast reset remote terminal mode command shall be sent to the UUT on the same bus used in Step 1.

Step 6. After an intermessage gap equal to T_{RST} , a valid legal command shall be sent to the UUT on a bus other than used in Step 1.

The minimum time 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.

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

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5.2.2.4.8 Broadcast Dynamic Bus Control: The purpose of this test is to insure that the UUT does not take over bus control function in response to a broadcast mode command. The following sequence shall be performed:

Step 1. A broadcast dynamic bus control mode command shall be sent to the UUT.

Step 2. A transmit status mode command shall be sent to the UUT.

The pass criteria shall be: Step 1 - NR; Step 2 - CS (the BCR bit shall be set, ME bit may be set, but the DBA bit shall not be set).

5.2.2.5 Error Injection - Broadcast Messages: The purpose of this test is to verify the UUT's response to data specific errors in broadcast messages. Unless otherwise noted, the following test sequence shall be used for all error injection tests. The error to be encoded in Step 4 for a given message is specified in each test paragraph. The pass criteria is defined in each test paragraph. All responses shall be recorded.

Test sequence:

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

Step 2. A transmit last command mode command shall be sent to the UUT. If this mode command is not implemented, then a transmit status mode command shall be used, and the data word associated with the transmit last command mode command shall be deleted from the pass criteria.

Step 3. A valid legal receive message shall be sent to the UUT.

Step 4. A broadcast message containing the specified error shall be sent to the UUT.

Step 5. A transmit last command mode command shall be sent to the UUT. If this mode command is not implemented, then a transmit status mode command shall be used, and the data word associated with the transmit last command mode command shall be deleted from the pass criteria.

Step 6. Repeat Step 3.

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5.2.2.5.1 Parity - BC-RT Broadcast: The purpose of this test is to verify the UUT's capability to detect parity errors embedded in different words within a message.

5.2.2.5.1.1 Command Word Error: This test verifies the ability of the UUT to recognize a parity error in the broadcast command. The test sequence as defined in 5.2.2.5 shall be performed with a parity error encoded in a broadcast command for test Step 4.

The pass criteria for this test shall be: Step 1 - NR; Step 2 - BCR and the data word contains the command word of Step 1; Step 3 - CS; Step 4 - NR; Step 5 - CS and the data word contains the command word of Step 3; Step 6 - CS.

5.2.2.5.1.2 Data Word Error: This test verifies the ability of the UUT to recognize a parity error occurring in a data word. The test sequence as defined in 5.2.2.5 shall be performed with a parity error encoded in a data word for Step 4. The message shall be a BC-RT (broadcast) command with the maximum number of data words that the UUT is designed to receive. The test sequence must be executed N times, where N equals the number of data words in the message. Each data word in the message will be transmitted with a parity error. Only one parity error is allowed per message.

The pass criteria for this test shall be: Step 1 - NR; Step 2 - BCR and the data word contains the command word of Step 1; Step 3 - CS; Step 4 - NR; Step 5 - ME (BCR may be set) and the data word contains the command word of Step 4; Step 6 - CS.

5.2.2.5.2 Message Length, BC to RT Broadcast: 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 in 5.2.2.5 with the data word count error in a BC - RT (broadcast) message for test Step 4. The message is a valid legal broadcast command word with the word count field equal to the maximum number of data words that the UUT is designed to receive and 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. Other sequences shall remove one additional data word until the number of data words equals zero.

The pass criteria for this test shall be: Step 1 - NR; Step 2 - BCR and the data word contains the command word of Step 1; Step 3 - CS; Step 4 - NR; Step 5 - ME (BCR may be set) and the data word contains the command word of Step 4; Step 6 - CS.

5.3 Noise Rejection Test:

This test verifies the RT's ability to operate 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 140.0 mV for transformer coupled stubs or 200.0 mV for direct coupled stubs measured at point A of Figure 9A or Figure 10A. This test shall be conducted with a signal level of 2.1 V peak-to-peak, line-to-line, for transformer coupled stubs or 3.0 V peak-to-peak, line-to-line, for direct coupled stubs measured at point 'A' of Figure 9A or Figure 10A. 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 500.0 ns intervals from the measured zero crossing) measured at point 'A' shall be 200.0 ns + 20.0 ns. Figure 9A and Figure 10A depict the configurations for conducting the noise rejection test. Air Force applications shall use only the configuration in Figure 10A. Figure 9B and Figure 10B depict suggested configurations for the noise rejection test. The noise test shall run continuously with intermessage gaps of $\geq 100.0 \mu\text{s}$ 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 3. 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. A unit under test that provides transformer and direct coupled stubs shall be tested on both stubs. The noise test shall be performed on all buses for UUTs with redundant bus configurations.

The pass criteria shall be in conformance with the word error rate defined in Table 3. An error for this test is defined as any response other than CS (with busy bit and SR reset).

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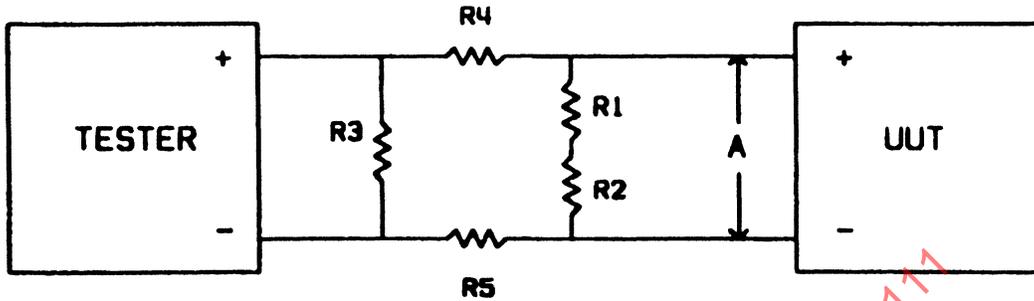
TABLE 3 - Criteria for Acceptance or Rejection of a Terminal for the Noise Rejection Tests

Total number of words received by the terminal (in multiples of 10^7)

NO. OF ERRORS	REJECT (EQUAL OR LESS)	ACCEPT (EQUAL OR LESS)
0	N/A	4.40
1	N/A	5.21
2	N/A	6.02
3	N/A	6.83
4	N/A	7.64
5	N/A	8.45
6	0.45	9.27
7	1.26	10.08
8	2.07	10.89
9	2.88	11.70
10	3.69	12.51
11	4.50	13.32
12	5.31	14.13
13	6.12	14.94
14	6.93	15.75
15	7.74	16.56
16	8.55	17.37
17	9.37	18.19
18	10.18	19.00
19	10.99	19.81
20	11.80	20.62
21	12.61	21.43
22	13.42	22.24
23	14.23	23.05
24	REJECT	REJECT

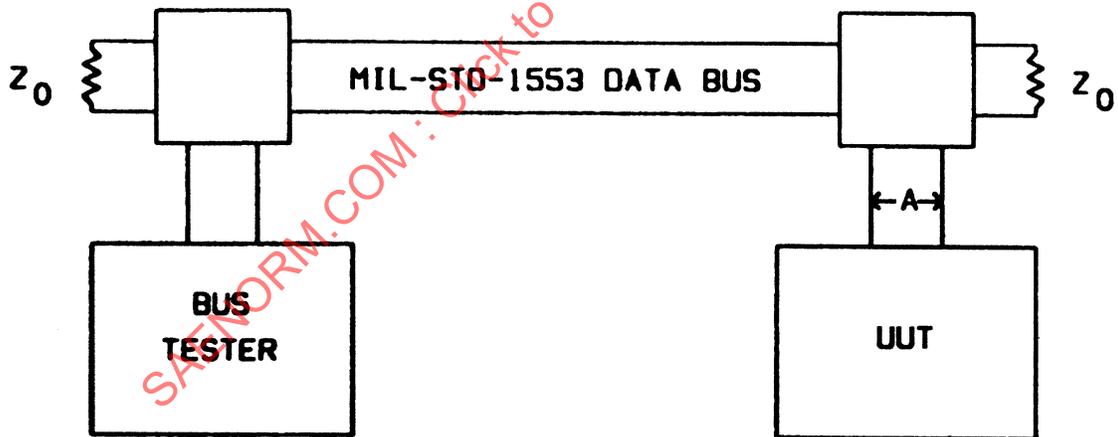
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	<u>DIRECT COUPLED</u>	<u>TRANSFORMER COUPLED</u>
UUT LOAD	35 ohms \pm 2 %	70 ohms \pm 2 %
R1, R2	20 ohms \pm 1 %	46.5 ohms \pm 1 %
R3, R4, R5	100 ohms \pm 1 %	93.1 ohms \pm 1 %

FIGURE 1A - Resistor Pad Configuration



NOTE 1 Reference Figures 5 and 6 of AS15531, or Figures 9 and 10 of MIL-STD-1553B for Data Bus Interface Coupling

NOTE 2 Reference Figure 10B of this Test Plan for suggested cable type, bus and stub lengths, etc.

FIGURE 1B - Bus Configuration

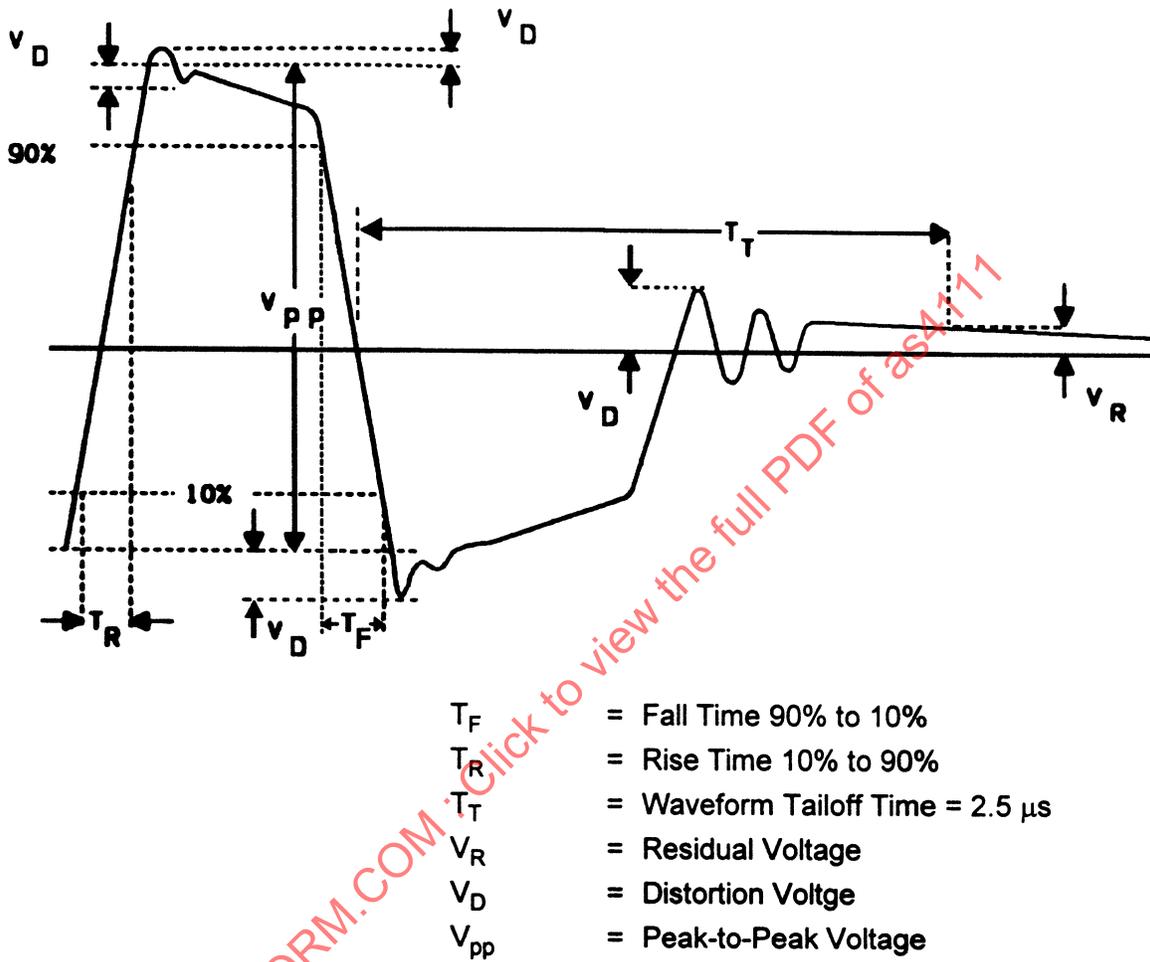


FIGURE 2 - Waveform Measurements

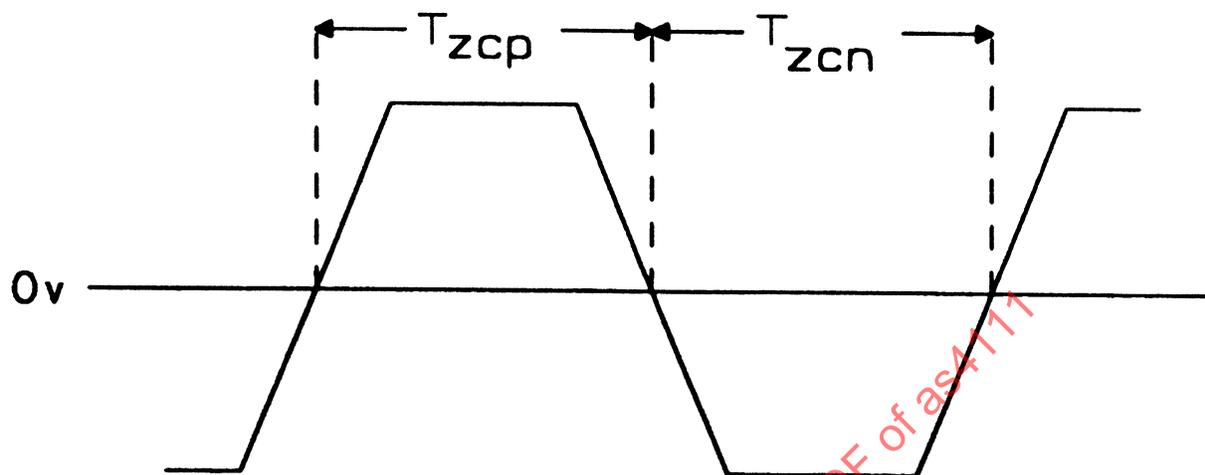
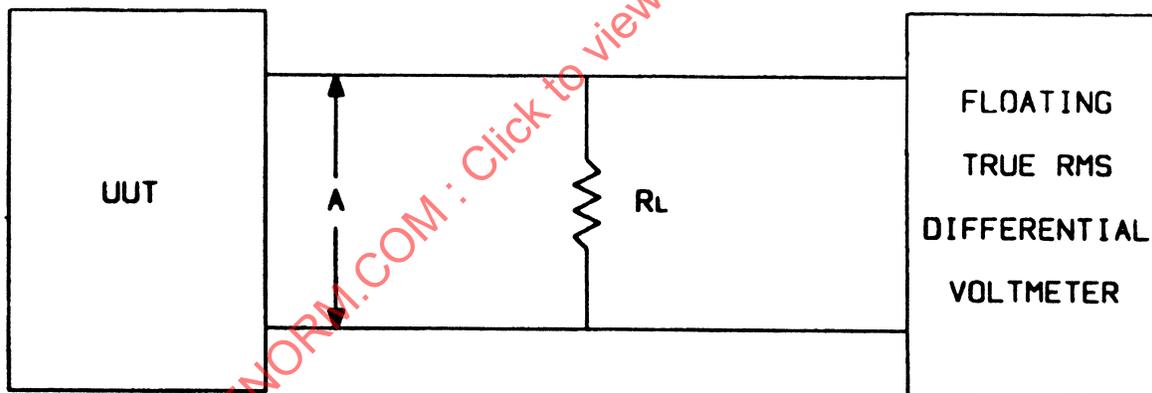


FIGURE 3 - Zero Crossing Interval Measurements



TRANSFORMER COUPLED

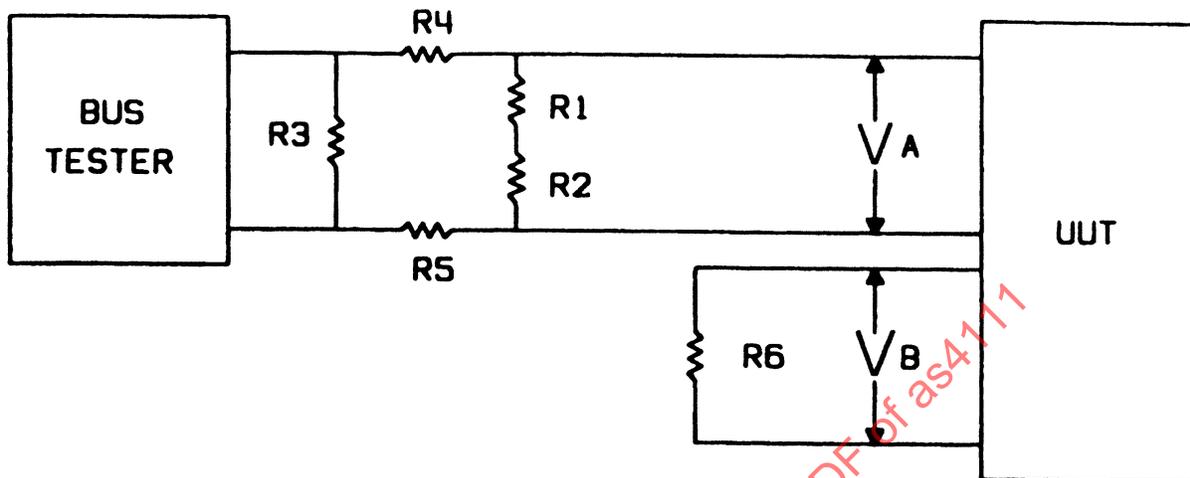
$R_L = 70.0 \text{ ohms} \pm 2\%$

DIRECT COUPLED

$R_L = 35.0 \text{ ohms} \pm 2\%$

FIGURE 4 - Output Noise Configuration

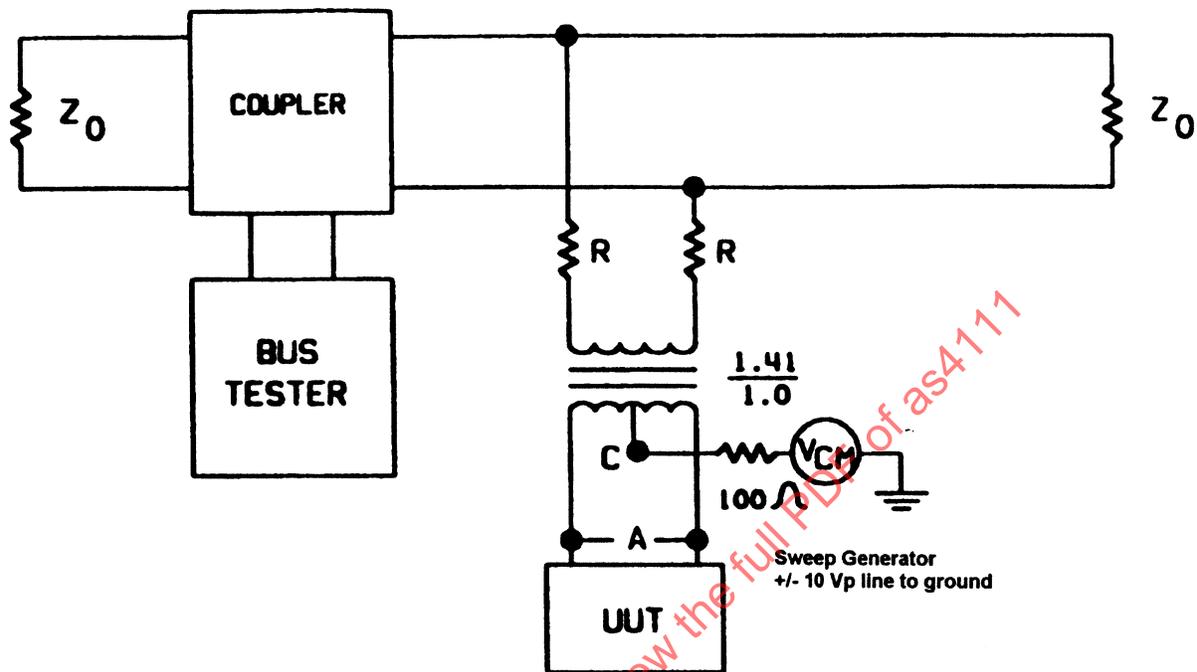
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	<u>DIRECT COUPLED</u>	<u>TRANSFORMER COUPLED</u>
UUT LOAD	35 ohms ± 2 %	70 ohms ± 2 %
R1, R2	20 ohms ± 1 %	46.5 ohms ± 1 %
R3, R4, R5	100 ohms ± 1 %	93.1 ohms ± 1 %
R6	35 ohms ± 2 %	70 ohms ± 2 %

$$db = 20 \log (V_A / V_B)$$

FIGURE 5 - Output Isolation

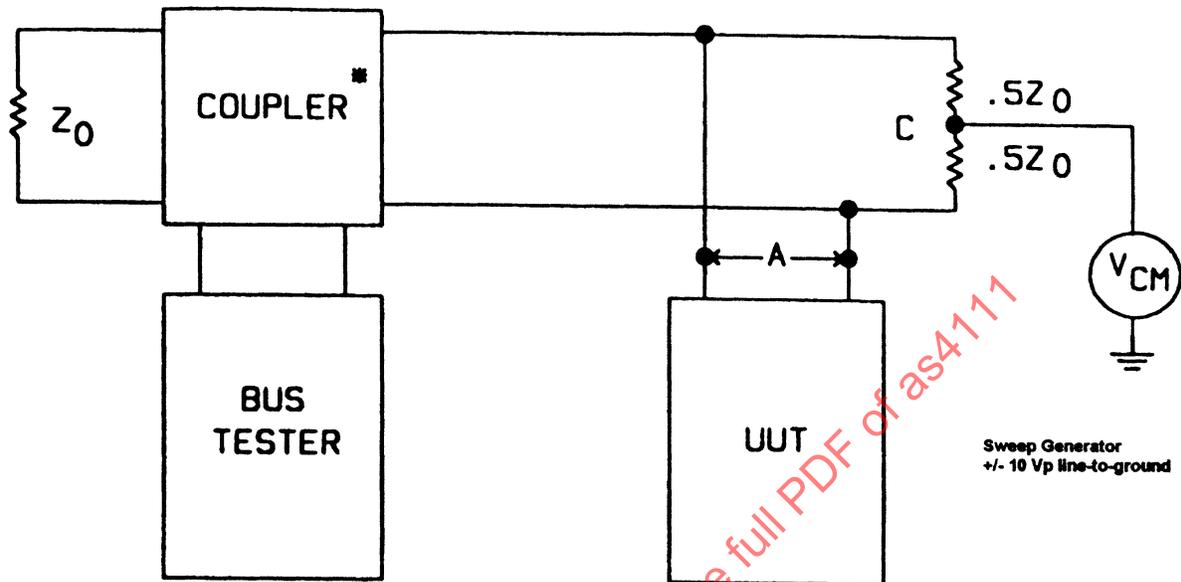


$$R = 0.75 Z_0 \pm 2\%$$

Z_0 = Selected Cable Nominal Characteristic Impedance

NOTE: UUT stub length shall be ≤ 3.0 feet

FIGURE 6A - Transformer Coupled Common Mode Configuration



* = Transformer Coupled Stub must be used
 Z_0 = Selected Cable Nominal Characteristics Impedance

NOTE: UUT stub length shall be ≤ 1.0 feet

FIGURE 6B - Direct Coupled Common Mode Configuration

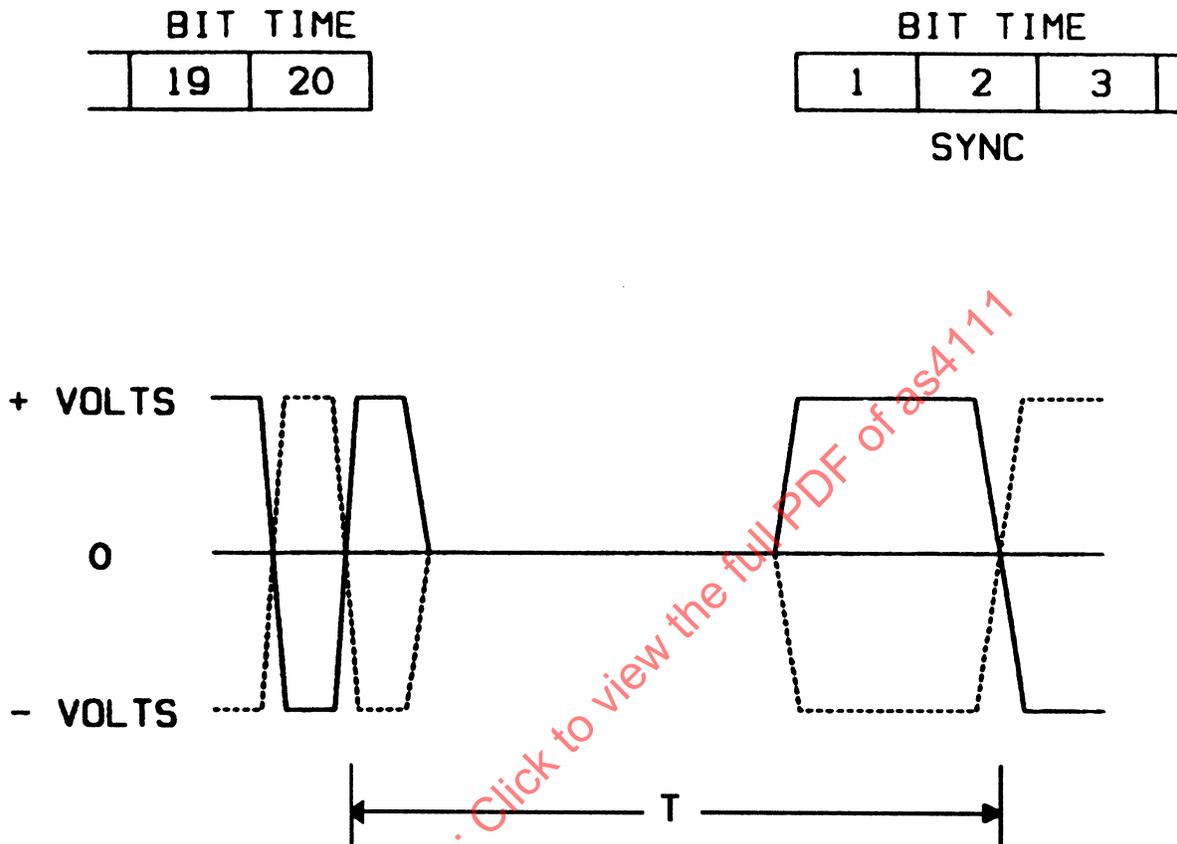


FIGURE 7 - Gap Measurement Time

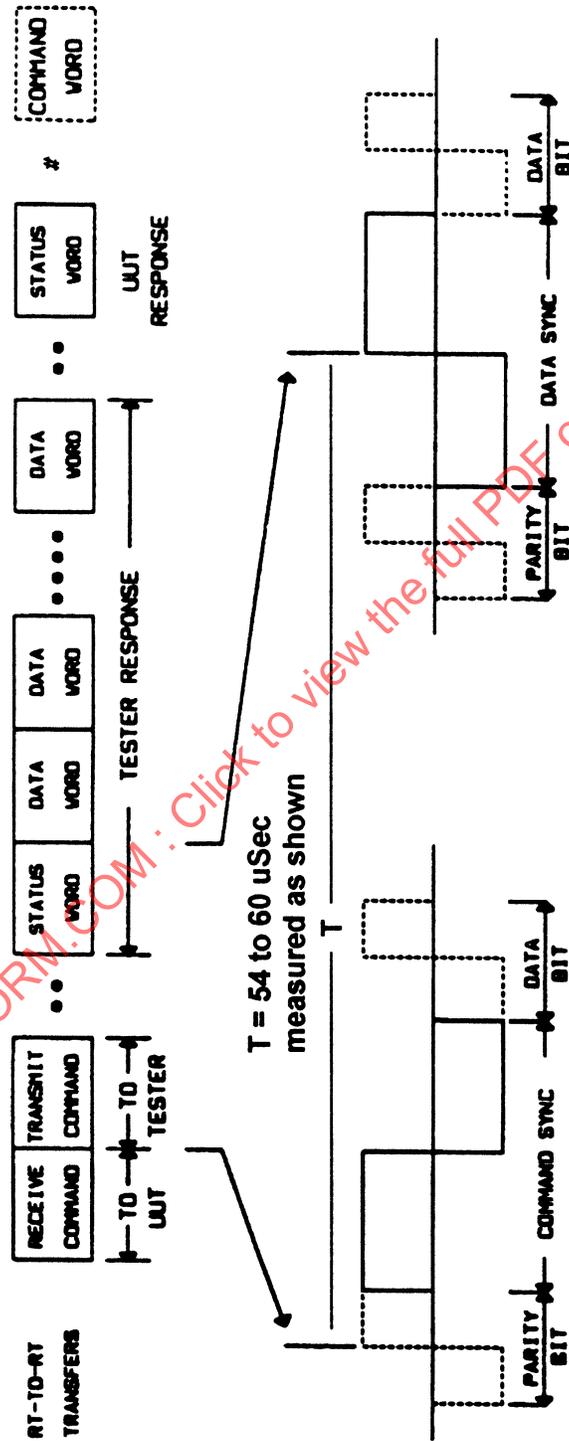
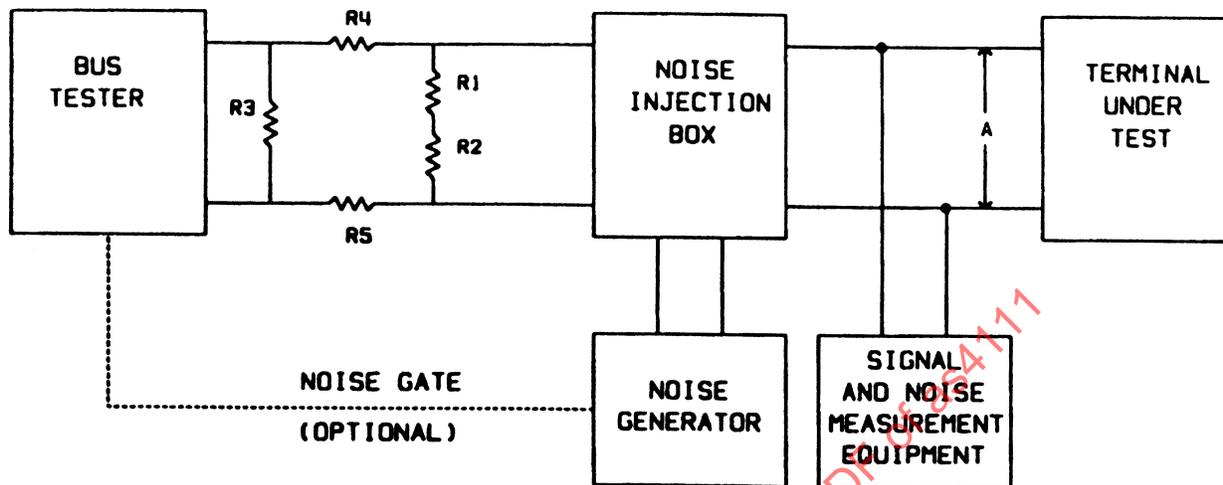


FIGURE 8 - RT - RT Timeout Measurement

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	<u>DIRECT COUPLED</u>	<u>TRANSFORMER COUPLED</u>
UUT LOAD	35 ohms ± 2 %	70 ohms ± 2 %
R1, R2	20 ohms ± 1 %	46.5 ohms ± 1 %
R3, R4, R5	100 ohms ± 1 %	93.1 ohms ± 1 %

FIGURE 9A - Configuration for Noise Rejection Test