BCM Display Test Plan
Oshkosh Corporation
Product Test Plan
Wednesday October 11, 2023

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Revision	Description of Changes	Date	Author
1.0	Initial Release of Test Plan	20230214	Benjamin Patri
1.1	Section 11.4 – Added Vibration Profile to be used for Offroad Simulation.	20230221	Benjamin Patri
1.2	Section 11.18 – Changed Starting Profile Temperature to -40 from -45C to match lower end of operating temperature range. Section 11.29 – Changed the harness length from 1.5 to 2m to match MIL Spec and corrected a reference to the MIL Spec from revision F to revision G. Section 11.30 – Changed the harness length from 1.5 to 2m to match MIL Spec.	20230227	Benjamin Patri
1.3	Section 11.7 – Removed the 2011 year from the referenced spec. Section 11.5 – Updated to state 1 Cycle. Section 11.3 – Added 28VDC as voltage to run test at. Section 11.24 – Added location of thermocouple for testing. Section 11.6 – Added Note stating maximum is 85C. Section 11.8 – Updated Spec reference to 'G' from 'H'. Changed units to all be shown in mm. Section 11.36 – Added a depth of 150mm from top of DUT for test.	20230313	Benjamin Patri
1.4	Section 11.4 – Added a call out to section 11.1 specifically. Section 11.36 – Added a call out to section 11.1 specifically. Section 11.43 – Added a Power Cycle Test section. Section 11.3 – Updated to only run 3 profiles concurrently since the Vibration test in 11.1 is basically a repeat of the other 3 profiles.	20230320	Benjamin Patri
1.5	Section 2 – Added Power Cycle Test to Test Sequence.	20230327	Benjamin Patri
1.6	Section 11.14 – Updated to be 10-15 second spacing between pulses due to Advantech test equipment limitation of 15s. Section 11.1 – Changed the reference to revision G to be revision H and updated to use the table and graph from revision H.	20230403	Benjamin Patri
1.7	Section 2, 11.23 – Removed Thermal Storage Reliability Custom Test as it is equivalent to Section 11.5 Temperature Cycle Test. Section 11.40 – Removed duplicate Dust and Sand section, already exists in this document as Section 11.38.	20230515	Benjamin Patri
1.8	Section 11.11 – Added clarification on tests to run and voltage levels. Section 11.20 – Added clarification on how to test the different cables.	20230816	Benjamin Patri
1.9	Section 11.11 – Remove DCC Testing as J1113-12 does not require testing multiple test methods for slow and fast transient pulses.	20230828	Benjamin Patri
1.10	Section 11.33 – Updated field strength from 100mA to 200mA to match ISO.	20230919	Benjamin Patri
1.11	Sections 2, 11.5, 11.6, 11.23, 11.24, 11.38, 11.41 – Modified to Split into Test Round 1 and 2 for temperature range change of -40 to 70C for Operating	20230925	Benjamin Patri

	Temperature and -40 to 85C for Storage Temperature due to limitations of components.		

Table of Contents

1. INTRODUCTION

This Product Test (PT) Plan will establish the tests that will be performed on the DUT to verify the design meets the requirements. This test procedure is limited to the hardware/environmental tests. This test procedure does not include software testing and will define the environments applied, the mode of operation of the device under test (DUT), and the acceptance criteria for each test.

The population used for testing shall henceforth referred to as the DUT. Successful completion of all of the following tests will be the criteria for evaluating design integrity.

2. PRODUCT TEST SEQUENCE

Testing should be done from the top down using the table below. The Functional Test should be performed before starting any tests and after each test at a minimum. Some tests require Functional Test to be performed additionally as specified in the specific tests.

Visual Inspection and Functional Test at 25°C					
LOT A (3 DUT)	**Lot B (3 DUT)**	**Lot D (3 DUT)**	**Lot E (3 DUT)**	**Lot F (2 DUT)**	**Lot G (10 DUT)**
Spares	Vibration	Random Vibration	Vibration	Vibration	Thermal Shock (Test Round 1)
	Temperature Cycle (Test Round 1)	Vibration Profiles	Mutual Coupling	Radiated Electromagnetic Emissions	Thermal Cycle Reliability (Test Round 1)
	Humidity Cycle (Test Round 1)	1800 Hours Simulated Offroad Vibration	Positive Switching Spikes	RE102, Radiated Emissions	
	Altitude (Test Round 1)	Operational Shock	Negative Switching Spikes	RS103, Radiated Susceptibility-Radiated	
	Salt Spray	Transit Drop	Parallel Inductive Load Switching	RS105, Radiated Susceptibility, Transient Electromagnetic Field	
	Immersion and Splash		Load Dump - Unsuppressed	EMI Component Susceptibility-Radiated	
	Steam Cleaning and Pressure Washing		Direct Current Motor acting as a Generator	CS101, Conducted Susceptibility, power leads	
	Dust and Sand		Transient Immunity	CS114, Conducted Susceptibility, BCI	
			Starter Motor Engagement Disturbance	CS115, Conducted Susceptibility, BCI, Impulse Excitation	
			Starting Profile	EMI Component Susceptibility-Bulk Current Injection	
			Reversed Voltage		
			Over Voltage Protection		
			Over Voltage Protection 50V		
			Power Cycle (Test Round 1)		
			Wiring Harness Inductance Switching		
			Short Circuit Protection		
			Electrostatic Discharge, Handling		
			Electrostatic Discharge, Powered		
Visual Inspection and Functional Test at 25°C					

3. REFERENCE DOCUMENTS

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the listed revision of each publication shall apply.

Document	Version	Description
SAE J1211	November 2012	Handbook for Robustness Validation of Automotive Electrical/Electronic Modules
SAE J1455	March 2017	Recommended Environmental Practices for Electronic Equipment Design in Heavy-Duty Vehicle Applications
SAE J1812	September 2018	Function Performance Status Classification for EMC Immunity Testing
SAE J1113-1	October 2018	Electromagnetic Compatibility Measurement Procedures and Limits for Components of Vehicles, Boats (up to 15 m), and Machines (Except Aircraft) (16.6 Hz to 18 GHz)
SAE J1113-11	December 2018	Immunity to Conducted Transients on Power Leads
SAE J1113-12	November 2017	Electrical Interference by Conduction and Coupling - Capacitive and Inductive Coupling via Lines Other than Supply Lines
SAE J1113-13	February 2015	Electromagnetic Compatibility Measurement Procedure for Vehicle Components - Part 13: Immunity to Electrostatic Discharge
SAE J1113-21	October 2005	Electronmagnetic Compatibility Measurement Procedure for Vehicle Components— Part 21: Immunity to Electromagnetic Fields, 30 MHz to 18 GHz, Absorber-Lined Chamber
MIL-STD-202-107	April 2015	Test Method Standard, Method 107, Thermal Shock
MIL-STD-461G	December 2015	Requirements For The Control Of Electromagnetic Interference Characteristics Of Subsystems And Equipment
MIL-STD-810H	January 2019	Environmental Engineering Considerations and Laboratory Tests
IEC CISPR 25	December 2021	Vehicles, boats, and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers
ISO 11452-2	January 2019	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 2: Absorber-lined shielded enclosure
ISO 11452-4	April 2020	Road vehicles – Component test methods for electrical disturbances from narrowband radiated electromagnetic energy – Part 4: Harness excitation methods
ISO 16750-2	November 2012	Road vehicles — Environmental conditions and testing for electrical and electronic equipment — Part 2: Electrical loads
ISO 7637-2	March 2011	Road vehicles — Electrical disturbances from conduction and coupling — Part 2: Electrical transient conduction along supply lines only
ISO 10605	July 2008	Road vehicles — Test methods for electrical disturbances from electrostatic discharge
ASAE EP455	December 1990	Environmental Considerations in Development of Mobile Agricultural Electrical/Electronic Components

4. DEFINITIONS

Term	Definition
amps	Amperes
CAN	Controller Area Network
DUT	Device(s) Under Test
ED	Electronic Design
EMC	Electromagnetic Compatibility
g	gravity force (9.81m/s^2)
GHz	Gigahertz
Hz	Hertz
I/O	Inputs and Outputs
kHz	Kilohertz
kV	kilovolt
MD	Mechanic Design
mm	millimeters
PT	Product Test
SAE	Society of Automotive Engineers
V	Volt
VDC	Volts Direct Current
°C	Degrees Celsius
°F	Degrees Fahrenheit

5. EXPECTATIONS

The following is expected from the entity that is carrying out the test of this product:

• This entire test plan will be read and understood by one or more cognizant test engineers prior to the start of testing

• The cognizant test engineer(s) shall have the responsibility to assure that this test plan is followed by the person or persons actually performing the test

• Detailed performance/failure logs will be maintained

• Weekly progress reports will be provided to engineer(s) at Oshkosh

• Oshkosh must approve any deviation from this test plan before the change is made

• Oshkosh will be notified upon finding any failures

6. RESPONSIBILITIES

6.1 Testing Facility

All DUT will be serialized and all test data will be maintained on each individual DUT. A functional test will be conducted on all units before starting the qualification test sequence and after each test unless otherwise specified in the document. Unless otherwise agreed upon by Oshkosh, all units must be from the same build.

The testing facility will be responsible to conduct the tests in accordance to this test plan and to read and understand the entire test procedure before starting any test. They will also be responsible for documenting all tests, reporting any failures to Oshkosh, providing weekly summaries, and providing a complete report as to the results of all tests listed within this document.

Upon completion of qualification testing or final testing, the group responsible for performing the test shall generate a test report within ten business days. The summary shall include the analysis of data, deviations from procedure and review of all failures with respect to cause, degree and proposed corrective action.

Test procedure and test equipment must be recorded with the test data and attached to the summary as supporting documentation. The supplier shall retain the report until transmission to Oshkosh is confirmed.

6.2 Oshkosh

Oshkosh will be responsible to provide a detailed test plan for all tests to be completed and provide technical support, upon request, for all parts that are designed by Oshkosh.

7. PASS/FAIL CRITERIA

For the DUT to pass the test, all visual inspections must be satisfactory and all indicated functional tests must pass without discrepancy. If the functional test does not pass, then all output from the functional test must be captured and documented.

All test failures shall be reported to Oshkosh within one business day. For each failure, Oshkosh Engineering, Manufacturing and Test organizations shall meet to determine what failure analysis and corrective action recommendations shall be used. Oshkosh will determine the amount of re-qualification testing.

8. DEVIATIONS

Oshkosh must approve deviations from this test plan before implementing.

9. TEST EQUIPMENT

9.1 Test Equipment Minimum Requirements

As a minimum, the following test equipment is required. All available model, serial number, and calibration information must be recorded and included in the test report. This information will be filled in form the database and displayed as below.

• DC Power Supply with minimum voltage range of 8V to 32V and with a current capability of at least 20A for the entire current range. Voltage tolerance (measured at the DUT connector) must be maintained within ±0.1V of the specified voltage for all voltage levels required during testing.

• DC Power Supply capable of supplying 50V ± 0.1V and 300A (for DC Overvoltage testing)

• Instrumentation to generate transient waveforms per SAE and MIL Standards

• Instrumentation to measure voltage and current with accuracy of ± 2%

• Environmental chamber with temperature (±3°C) control per SAE and MIL Standards

• Instrumentation to measure temperature with ±3°C accuracy

• A test fixture to support and operate the DUT on the vibration table

• A test fixture to support and operate the DUT in the environmental chamber under maximum load

• A test fixture to support and operate the DUT in the HALT chamber under maximum load

• A functional tester to test the DUT after completion of each test and to monitor tests

• One or more computers with USB and Ethernet to support communication testing with DUT

• Supporting harnesses and test boxes

9.2 Test Instrumentation Accuracy

Unless otherwise specified for a particular test, instrumentation accuracy shall be as follows:

Temperature	± 3°C
Frequency	± 2%
Electromagnetic Field Strength	± 3dB
Time	± 5%
DC Voltages and Currents	± 2%
Electrical Parameters	± 2%
AC and Transient Voltages	± 5%
Pressure	± 5%
All Others (not listed above)	± 10%

10. FUNCTIONAL TEST DESCRIPTION

10.1 Visual Inspection

A visual inspection is required as part of the evaluation of many of the individual environmental tests. This visual inspection requires that the DUT is inspected for “no detrimental damage.” This term shall be used to describe a physical condition of the DUT where minor deformations are permissible if such deformations will not affect or interfere with the mechanical or electrical functions of the DUT, the mating and sealing of connectors, or the integrity of the seal of the DUT.

Although not visual in nature, this test shall also checked for any sound of loose components within the DUT. Visual aids (i.e. magnifier) may be utilized as necessary to properly perform the visual inspection.

Deviations from this visual inspection and the visual inspection requirements will be detailed in the individual test report.

The functional test procedure described herein shall be used to evaluate correct DUT operation before and after product testing. For those tests requiring monitoring during the test, this test or a modified version of this test may be used as needed. Unless otherwise specified, all functional tests are to be performed at 25°C ± 5°C.

10.2 Functional Test

TBD = Should Test all IO for proper functionality

11. ENVIRONMENTAL AND ELECTRICAL TEST DESCRIPTIONS

11.1 Vibration Test (MIL-STD 810H - Section Method 514.8)

11.1.1 Test Connectors

The DUT will not have harnessing mated.

The DUT will not be powered or monitored for functionality during the test.

11.1.2 Test Purpose

To verify the product can withstand and operate during vibration that can occur in vehicle operation.

11.1.3 Test Procedure

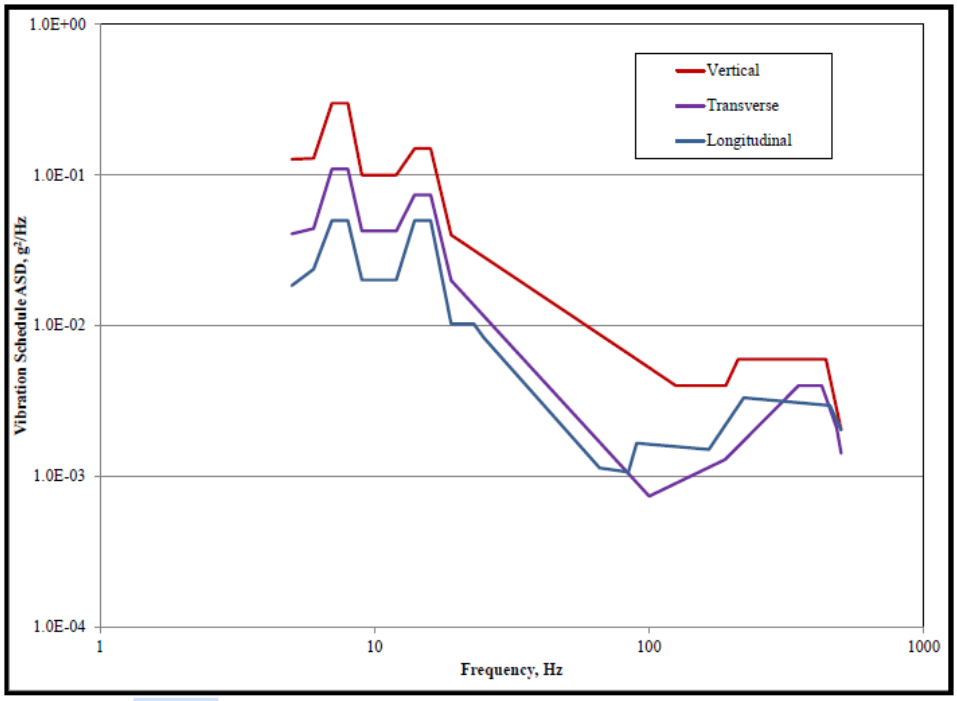
8 DUT shall be subjected to the Vibration Test, as specified in MIL-STD 810H, Method 514.8.

The DUT will be rigidly mounted to a vibration fixture which will adequately transfer vibration to the DUT. Two accelerometers will be placed at opposite corners within 12 inches of the DUT which will be used to the control the vibration. The DUT fasteners should be tightened to a torque of 30Nm.

The Vibration test will consist of the DUT being subjected to the vibration profile as specified. The DUT will be subjected to this profile for 4 hours in each axis for a total test time of 12 hours.

DUT profile will be based on the following parameters per:

Table 514.8-I Vibration Environment Categories
Life Phase: Transportation
Platform: Trucks and Trailers
Category: 6. Large Assembly Transport
Annex: C
Test: III



Composite Wheeled Vehicle Vibration Exposure (from MIL-STD-810H)

Vertical		Transverse		Longitudinal	
Frequency, Hz	ASD, g^2/Hz	Frequency, Hz	ASD, g^2/Hz	Frequency, Hz	ASD, g^2/Hz
5	0.12765	5	0.04070	5	0.01848
6	0.12926	6	0.04415	6	0.02373
7	0.30000	7	0.11000	7	0.05000
8	0.30000	8	0.11000	8	0.05000
9	0.10000	9	0.04250	9	0.02016
12	0.10000	12	0.04250	12	0.02016
14	0.15000	14	0.07400	14	0.05000
16	0.15000	16	0.07400	16	0.05000
19	0.04000	19	0.02000	19	0.01030
90	0.00600	100	0.00074	23	0.01030
125	0.00400	189	0.00130	25	0.00833
190	0.00400	350	0.00400	66	0.00114
211	0.00600	425	0.00400	84	0.00107
440	0.00600	482	0.00210	90	0.00167
500	0.00204	500	0.00142	165	0.00151
				221	0.00333
				455	0.00296
				500	0.00204
rms = 2.24 g		rms = 1.45 g		rms = 1.32 g	

Vibration Profile (from MIL-STD-810H)

11.1.4 Test Evaluation

DUT will be inspected post test for any loose parts or other damage as a result of the sinusoidal vibration. Impaired function for this test shall be defined as failing functional test after test completion or any sign of loose components.

11.2 Random Vibration (ASAE EP455 - Section 5.15.1)

11.2.1 Test Connectors

The DUT will have harnesses mated.

One DUT will be powered to 28V and monitored for functionality throughout the duration of the test. The other DUTs will be unpowered with harnesses mated and functionally tested after vibration on each axis.

11.2.2 Test Purpose

To verify the product can withstand and operate during vibration that can occur in vehicle operation.

11.2.3 Test Procedure

DUT shall be subjected to the Random Vibration Test as specified in ASAE EP455, section 5.15.1.

Mount the DUT in its normal mounting configuration. Vibrate for a minimum of 8 hours in each of 3 orthogonal axes at 52.4 m/s2 RMS overall acceleration and power spectral density of 2 m2/s3 from 50 Hz to 2000 Hz. Spectral density curve shall conform to profile illustrated in the figure below.

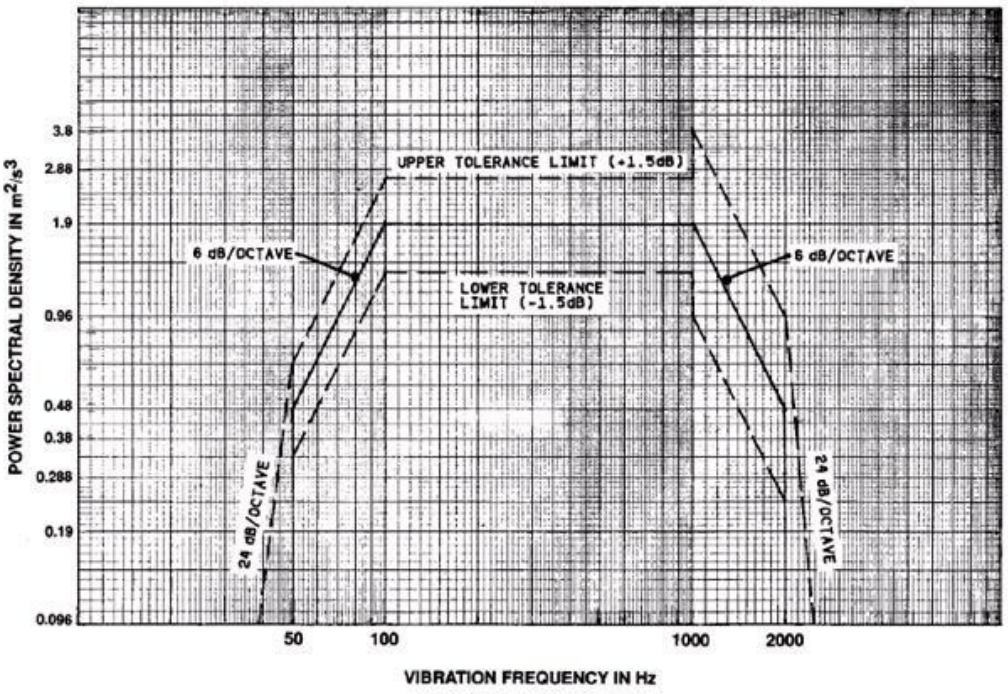


Figure 4 – Random vibration

Random Vibration Profile

11.2.4 Test Evaluation

DUT will be inspected post test for any lose parts or other damage as a result of the shock. Impaired function for this test shall be defined as failing functional test after test completion or any evidence of loose components.

11.3 Vibration Profiles Test (SAE J1455 Section 4.10)

11.3.1 Test Connections

The DUT will be powered to 28V and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be monitored for functionality throughout the duration of the test.

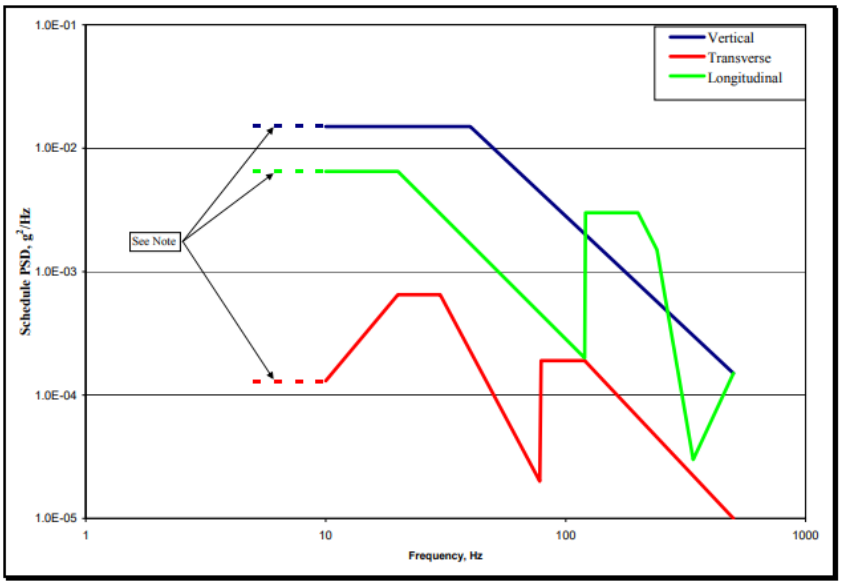
11.3.2 Test Purpose

To verify the product can withstand and operate during vibration that can occur in on-road vehicle operation.

11.3.3 Test Procedure

DUT shall be subjected to the Vibration Profiles as specified in SAE J1455, Section 4.10.

The DUT should run all profiles shown from Figure 6 to Figure 8 in Section 4.10. The profiles in Figures 6 to 8 should be run concurrently. Vibrate for a minimum of 8 hours in each of 3 orthogonal axes for each set of profiles for a total of 24 hours test time.



Combined Vibration Profiles Graph (from MIL-STD-810G)

Vertical		Transverse		Longitudinal	
Frequency, Hz	PSD, g^2/Hz	Frequency, Hz	PSD, g^2/Hz	Frequency, Hz	PSD, g^2/Hz
10	0.01500	10	0.00013	10	0.00650
40	0.01500	20	0.00065	20	0.00650
500	0.00015	30	0.00065	120	0.00020
rms = 1.04 g		78	0.00002	121	0.00300
		79	0.00019	200	0.00300
		120	0.00019	240	0.00150
		500	0.00001	340	0.00003
		rms = 0.20 g		500	0.00015
				rms = 0.74 g	

Combined Vibration Profiles Table (from MIL-STD-810G)

11.3.4 Test Evaluation

DUT will be inspected post test for any loose parts or other damage as a result of the vibration test. Impaired function for this test shall be defined as failing functional test after test completion or any sign of loose components.

11.4 Simulated Offroad 1800 Hour Vibration Test (Custom)

11.4.1 Test Connections

The DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be monitored for functionality throughout the duration of the test.

11.4.2 Test Purpose

To verify the product can withstand and operate during vibration that can occur in offroad vehicle operation.

11.4.3 Test Procedure

The DUT will be cycle through voltage levels, changing the voltage every 10 hours. The voltages to run at will include 8V, 12V, 18V, 24V, and 32V. Use the same Vibration Profile as used in the Vibration Test (Section 11.1) for the duration of this test. Test for a total of 1800 hours. Every 600 hours, change the orientation of the DUT so that it is tested in all three axis orientations.

11.4.4 Test Evaluation

DUT will be inspected post test for any loose parts or other damage as a result of the vibration test. Impaired function for this test shall be defined as failing functional test after test completion or any sign of loose components.

11.5 Temperature Cycle (SAE J1455 - Section 4.1.3.1)

11.5.1 Test Connectors

The DUT will not have harnesses mated.

The DUT will not be powered or monitored for functionality during the test.

11.5.2 Test Purpose

To verify the product's ability to operate under extreme temperature transitions without any detrimental effects.

11.5.3 Test Procedure

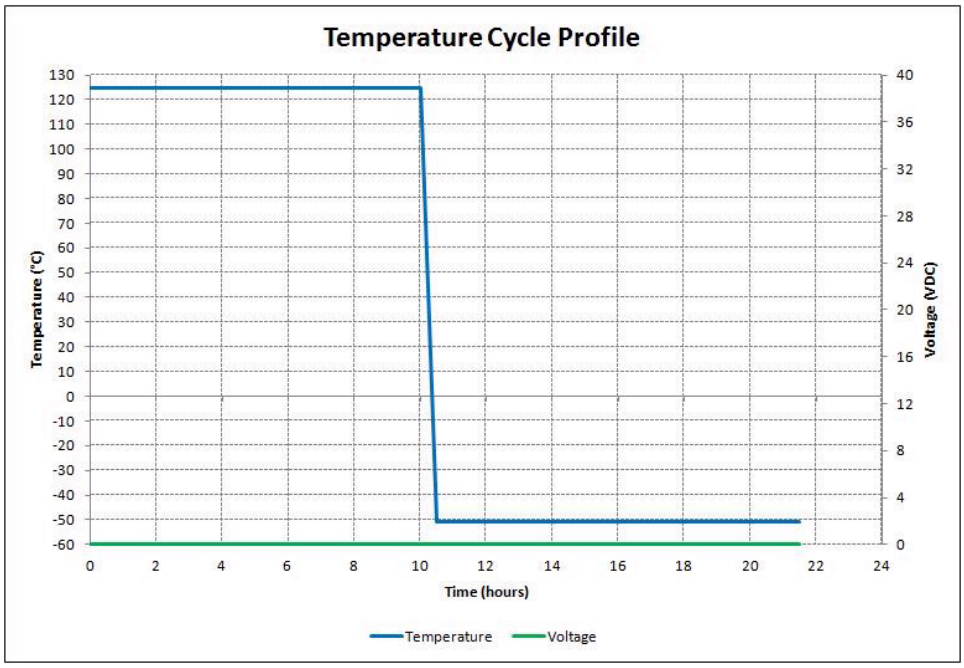
DUT will be subjected to a temperature cycle test as specified in SAE J1455, section 4.1.3.

The temperature cycle test shall follow the profile defined below. DUT shall dwell at each of the temperature extremes for 10 hours. The test shall be run for 1 full cycle as shown in the profile below. Stabilization should be verified by actual measurements with thermocouples or other means. It is important that all parts of the test specimen be held at the specified maximum and minimum temperatures for at least 10 hours, after reaching stability at that temperature.

During the transition between the two extremes, the temperature change shall not exceed 4.5°C per minute and should be at least 1.5°C per minute.

For Test Round 1, the two temperature extremes shall be -40°C and +85°C.

For Test Round 2, the two temperature extremes shall be -51°C and +125°C.



Temperature Cycle

11.5.4 Test Evaluation

DUT will be inspected post test for any visible damage such as cracking, distorting, or discoloring as a result of the temperature profile. Impaired function for this test shall be defined as failing functional test after test completion.

11.6 Humidity Cycle (SAE J1455 - Section 4.2)

11.6.1 Test Connectors

The DUT will have harnesses mated.

The DUT will be powered to 24V and monitored for functionality throughout the duration of the test. See section 14.2.2 for detailed information about DUT monitoring.

11.6.2 Test Purpose

To evaluate the ability of the product to operate in conditions where the DUT is subjected to humidity changes as they many occur in normal operation.

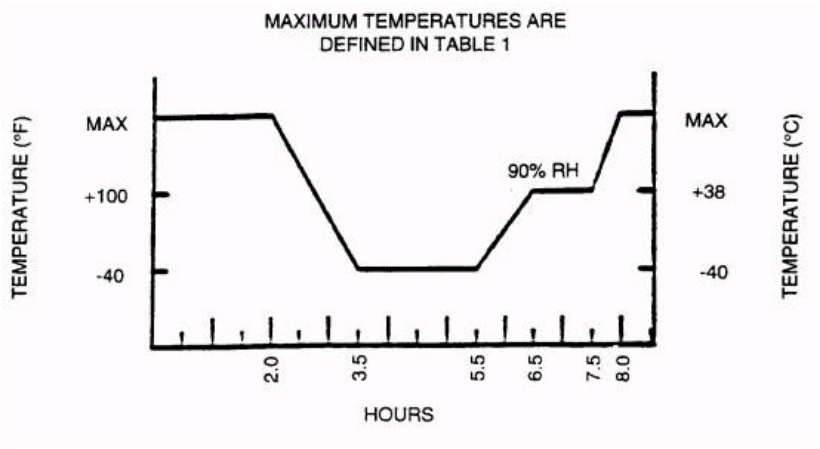
11.6.3 Test Procedure

DUT will be subjected to the effect of the Humidity test as specified in SAE J1455:2011, section 4.2.

The most common way to determine the effect of humidity on vehicle electronics is to over test and examine any failure for relevance to the more moderate actual operating conditions. The test is an 8 hour active temperature humidity cycling under accelerated conditions according to the Humidity Cycle below. This is a quick and effective method for uncovering defects in plastic encapsulated semiconductors. Ten humidity cycles should be completed.

For Test Round 1, the maximum temperature should be an operating temperature of 70°C.

For Test Round 2, the maximum temperature should be an operating temperature of 85°C.



Humidity Cycle

11.6.4 Test Evaluation

DUT will be inspected post test for any visible damage such as cracking, distorting, or discoloring as a result of the temperature and humidity profile. Impaired function for this test shall be defined as failing functional test during or after test completion.

The DUT will be given to an Advanced Tech Lab at the conclusion of the test to be opened and inspected for moisture ingress. Results of this test shall be included as an attachment to the test report.

11.7 Operating Shock (SAE J1455 - Section 4.11.3.4)

11.7.1 Test Connectors

The DUT will have harnesses mated.

One DUT will be powered to 28V and monitored for functionality throughout the duration of the test with the engineering test box. The others DUT will be unpowered with harnesses mated.

11.7.2 Test Purpose

To verify the product can withstand and operate during extreme mechanical shocks that can occur during vehicle operation.

11.7.3 Test Procedure

DUTs will be subjected to the Operating Shock Test, as specified in SAE J1455, section 4.11.3.4.

The DUT will be rigidly mounted to a fixture which will adequately transfer energy to the DUT. An accelerometer will be placed near the DUT which will be used to the control the shock pulses. The DUT fasteners should be tightened to a torque of 30Nm.

The DUT will be subjected to eighteen 50g, 11 msec half-sine shock pulses. Six pulses shall be applied to each axis, 3 positive and 3 negative shock pulses. The duration between each pulse will be 10 seconds.

Type of Pulse	Half-Sine Pulse
Peak Pulse Amplitude	490 m/sec2
Pulse Duration	11 ms
Number of Axes	3
Pulses per Axis	6 total; 3 in each direction

Total Shock Pulses	18
Duration Between Pulses	10 seconds
DUT Orientation	Normal operating orientation

11.7.4 Test Evaluation

DUT will be inspected post test for any loose parts or other damage as a result of the shock. Impaired function for this test shall be defined as failing functional test during or after test completion.

11.8 Transit Drop (MIL-STD 810H - Section Method 516.6)

11.8.1 Test Connectors

The DUT will not have harnesses mated.

The DUT will not be powered or monitored for functionality during the test.

11.8.2 Test Purpose

To verify the product can withstand mechanical shocks that can occur during the transportation of the product in their shipping container.

11.8.3 Test Procedure

The DUT shall be subjected to the Transit Drop Test, as specified in MIL-STD 810H, Method 516.8, Section 4.6.5.

The DUT will be placed in its normal shipping container, raised to a height of 1200 mm and released to free fall onto a two inch thick plywood surface backed by a concrete floor. The test will consist of a sequence of 26 drops.

If additional DUT are not available to fill the shipping container, material of equivalent weight can be used. In this case the DUT will be placed in the location which will receive the most stress during the drops.

Test Basis	DUT < 45.4 lbs
DUT Surfaces	As described below
Drop Height	1200 mm (± 50 mm)
Drop Surface	Plywood
Number of Drops	26

Identify each surface of the DUT as follows: Top #1, Right side #2, Bottom # 3, Left side #4, Front (closest edge,) #5, Far end (farthest edge) #6.

The DUT shall be dropped on each face, edge, and corner.

11.8.4 Test Evaluation

DUT will be inspected post test for any loose parts or other damage as a result of the shock. Impaired function for this test shall be defined as failing functional test after test completion.

11.9 Negative Switching Spikes (SAE J1113-11 - Section 8)

11.9.1 Test Connectors

The DUT will have harnesses mated. The PC CAN bus should be isolated from the DUT's CAN bus.

The DUT will be powered per the table in the test procedure and monitored for functionality throughout the duration of the test.

11.9.2 Test Purpose

To evaluate the ability of the product to operate when subjected to transients occurring as a result of switching processes.

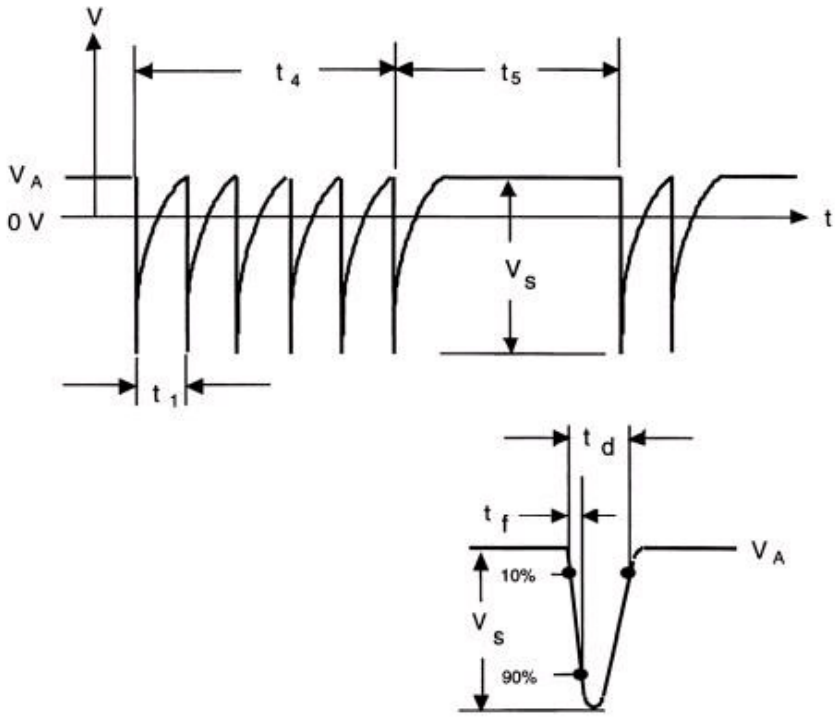
11.9.3 Test Procedure

The DUT shall be subjected to the Negative Switching Spikes Test, as specified in SAE J1113-11 (2018), Section 8, Test Pulse 3A.

The Negative Switching Spikes test will be applied to the power and ground connections of the DUT. The test setup shall be placed at a height of 50 mm above the ground plane. Test each unit first at 12V with 12V parameters and then at 24V with 24V parameters.

Note: There will be some DC voltage drop across the source resistance, Rs. The DC source voltage Va must be adjusted to compensate for this voltage drop across Rs such that the DC voltage measured between +BAT and GND (measured at the DUT) is the value specified in the table above. Failure to do this may prevent the DUT from operating during the test. Non-operation due to DC voltage drop will not be considered a failure of the DUT.

Parameters	12V System	24V System
V_A	13 V +/- 1V	27 V +/- 1V
V_S (from V_A)	-150 V	-200 V
R_i	50Ω	50Ω
t_d	0.1 µs +100/-0%	0.1 µs +100/-0%
t_f	5 ns ± 30%	5 ns ± 30%
t_1	100 µs	100 µs
t_4	10 ms	10 ms
t_5	90 ms	90 ms
Duration	1 hour	1 hour



Test Pulse

11.9.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test during or after test completion.

11.10 Positive Switching Spikes (SAE J1113-11 - Section 8)

11.10.1 Test Connectors

The DUT will have harnesses mated. The PC CAN bus should be isolated from the DUT's CAN bus.

The DUT will be powered per the table in the test procedure, connected to the engineering test box, and monitored for functionality throughout the duration of the test.

11.10.2 Test Purpose

To evaluate the ability of the product to operate when subjected to transients occurring as a result of switching processes.

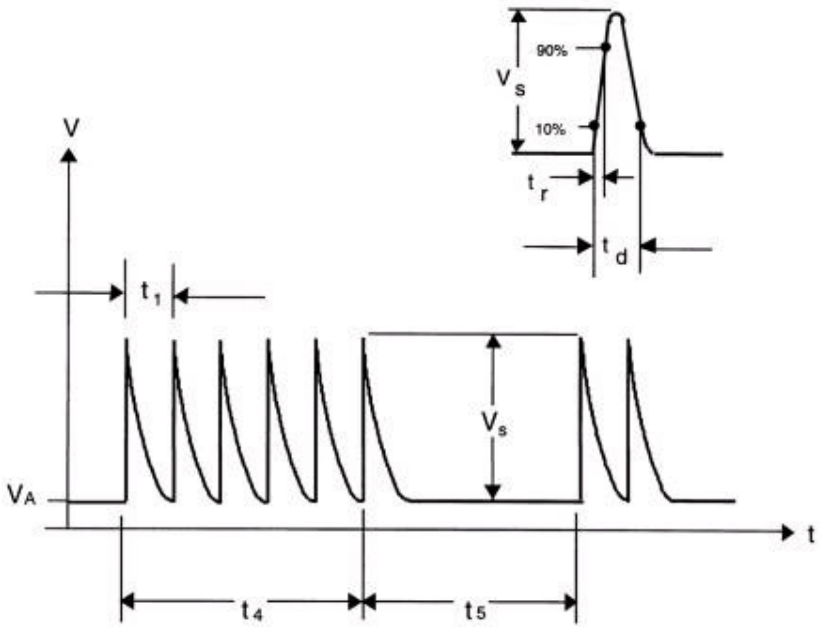
11.10.3 Test Procedure

The DUT shall be subjected to the Positive Switching Spikes Test, as specified in SAE J1113-11 (2018), Section 8, Test Pulse 3B.

The Positive Switching Spikes test will be applied to the power and ground connections of the DUT. The following parameters will be used to perform the Switching Spikes transient as shown in the table below. The test setup shall be placed at a height of 50 mm above the ground plane.

Parameters	12V System	24V System
V_A	13 V +/- 1V	27 V +/- 1V
V_S	+150 V	+200 V
R_i	50Ω	50Ω
t_d	0.1 µs +100/-0%	0.1 µs +100/-0%
t_f	5 ns ± 30%	5 ns ± 30%
t_1	100 µs	100 µs
t_4	10 ms	10 ms
t_5	90 ms	90 ms
Duration	1 hour	1 hour

Note: There will be some DC voltage drop across the source resistance, Rs. The DC source voltage Va must be adjusted to compensate for this voltage drop across Rs such that the DC voltage measured between +BAT and GND (measured at the DUT) is the value specified in the table above. Failure to do this may prevent the DUT from operating during the test. Non-operation due to DC voltage drop will not be considered a failure of the DUT.



Test Pulse

11.10.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test during or after test completion.

11.11 Mutual Coupling (SAE J1113-12 - Section 4, 5)

11.11.1 Test Connectors

The DUT will have harnesses mated.

The DUT will be powered per the table in the test procedure, connected to simulated loads, and monitored for functionality throughout the duration of the test. Test at all 4 Test levels for each test. For CCC and ICC, Test Level IV should be tested at both 12V and then 24V test level for each DUT. For all other tests, test at 24V only.

11.11.2 Test Purpose

To evaluate the ability of the product to operate in the presence of transients resulting from switching processes.

11.11.3 Test Procedure

The DUT shall be subjected to the Mutual Coupling Tests, as specified in SAE J1113-12 (2017), Section 4, 5.

The Mutual Coupling test will be applied to the entire wiring harness of the DUT. The following four methods should be tested:

- The capacitive coupling clamp (CCC) method
- The inductive coupling clamp (ICC) method
- The capacitive/inductive coupling (CIC) method

The tests to be run are listed in Table 1 of Section 4.1 from SAE J113-12 and shown below.

Table 1 - Test method applicability

Transient Type	Test Method			
	CCC	DCC	ICC	CIC
Slow transient pulses 2a of 5.3.2		✓	✓	
Fast transient pulses 3a and 3b of 5.3.3	✓	✓		
Pulses A and B of 5.4.3				✓

Transient pulses test [a]	Selected test level [b]	Test levels U_s [c] V				Test time min
		I min.	II	III	IV max.	
Fast 3a (DCC and CCC)		– 30	– 60	– 80	– 110	10
Fast 3b (DCC and CCC)		+ 18	+ 37	+ 60	+ 75	10
DCC slow +		+ 8	+15	+ 23	+ 30	5
DCC slow –		– 8	– 15	– 23	– 30	5
ICC slow +		+ 3	+ 4	+ 5	+ 6	5
ICC slow –		– 3	– 4	– 5	– 6	5

a Transient pulses tests as in 5.3.
b Values agreed to between vehicle manufacturer and supplier.
c The amplitudes in the table are the values of Us, as defined for each transient pulse in 5.3. Us is referenced
- at the output of the CCC for the CCC method;
- at the output of the capacitor for the DCC method;
- at the calibration jig output for ICC method.

12V Test Levels

Transient pulses test [a]	Selected test level [b]	Test levels U_s [c] V				Test time min
		I Min	II	III	IV Max	
Fast 3a (DCC and CCC)		– 37	– 75	– 110	– 150	10
Fast 3b (DCC and CCC)		+ 37	+ 75	+ 110	+ 150	10
DCC slow +		+ 15	+25	+ 35	+ 45	5
DCC slow –		– 15	– 25	– 35	– 45	5
ICC slow +		+ 4	+ 6	+ 8	+ 10	5
ICC slow –		– 4	– 6	– 8	– 10	5

[a] Transient pulses tests as in 5.3.

[b] Values agreed to between vehicle manufacturer and supplier.

[c] The amplitudes in the table are the values of Us, as defined for each transient pulses in 5.3. Us is referenced
- at the output of the CCC for the CCC method;
- at the output of the capacitor for the DCC method;
- at the calibration jig output for ICC method.

24V Test Levels

11.11.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test during or after test completion.

11.12 Parallel Inductive Load Switching (SAE J1113-11 - Section 8)

11.12.1 Test Connectors

The DUT will have harnesses mated. The PC CAN bus should be isolated from the DUT's CAN bus.

The DUT will be powered throughout the duration of the test.

11.12.2 Test Purpose

To evaluate the ability of the product to operate when subjected to inductive load switching transients.

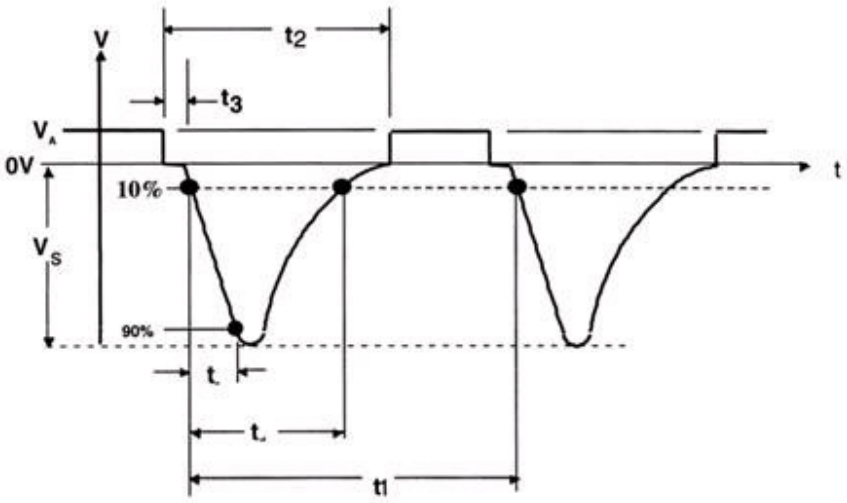
11.12.3 Test Procedure

The DUT shall be subjected to the Inductive Load Switching Test, as specified in SAE J1113-11, Section 8, Figure 2.

The Inductive Load Switching test will be applied to the +BAT connections of the DUT. The following parameters will be used to perform the Inductive Load Switching transient as shown in the table below. The test setup shall be placed at a height of 50 mm above the ground plane.

Do NOT stop the test until all pulses are completed. The DUT will be functionally verified after the test is completed. Use the test parameters below for testing.

Parameters	12V System	24V System
V_A	14 V	28 V
V_S	-600 V	-600 V
R_i	20Ω	50Ω
t_d	1 ms	1 ms
t_r	1 µs +0/–50%	3 µs +0/–50%
t_1	4 s	4 s
T_2	200 ms	200 ms
t_3	<100 µs	<100 µs
Number of Pulses	500	500



Parallel Inductive Load Switching Transient

11.12.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test after test completion.

11.13 Wiring Harness Inductance Switching (SAE J1113-11 - Section 8)

11.13.1 Test Connectors

The DUT will have harnesses mated. The PC CAN bus should be isolated from the DUT's CAN bus.

The DUT will be powered per the table in the test procedure and monitored for functionality throughout the duration of the test.

11.13.2 Test Purpose

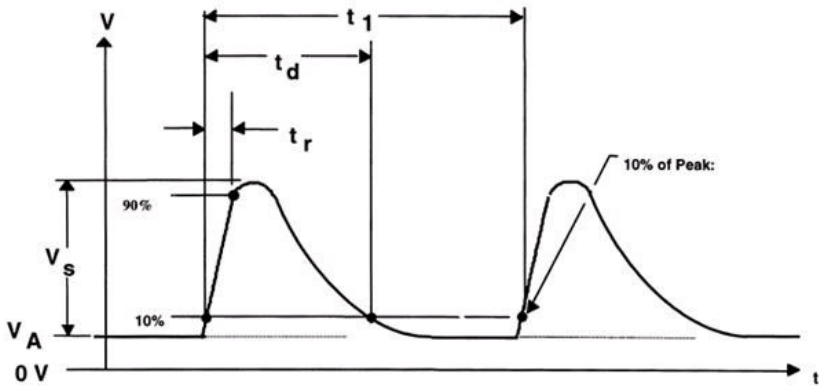
To evaluate the ability of the product to operate when subjected to transients caused by the sudden interruption of current through the inductance of the wiring harness.

11.13.3 Test Procedure

The DUT shall be subjected to the Wiring Harness Inductance Switching Test, as specified in SAE J1113-11, Section 8, Figure 3.

The Wiring Harness Inductance Switching test will be applied to the +BAT terminals of the DUT. The test setup shall be placed at a height of 50 mm above the ground plane.

Parameters	12V System	24V System
V_A	13 V +/- 1V	27 V +/- 1V
V_S	50 V	50 V
R_i	2Ω	2Ω
t_d	0.05 ms	0.05 ms
t_r	1 µs +0/–50%	1 µs +0/–50%
t_1	2 s	2 s
Number of Pulses	5000	5000



Wire Harness Inductive Switching Transient

11.13.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test after test completion.

11.14 Load Dump - Unsuppressed (SAE J1113-11 - Section 8)

11.14.1 Test Connectors

The DUT will have harnesses mated.

The DUT will be powered per the table in the test procedure and monitored for functionality throughout the duration of the test.

11.14.2 Test Purpose

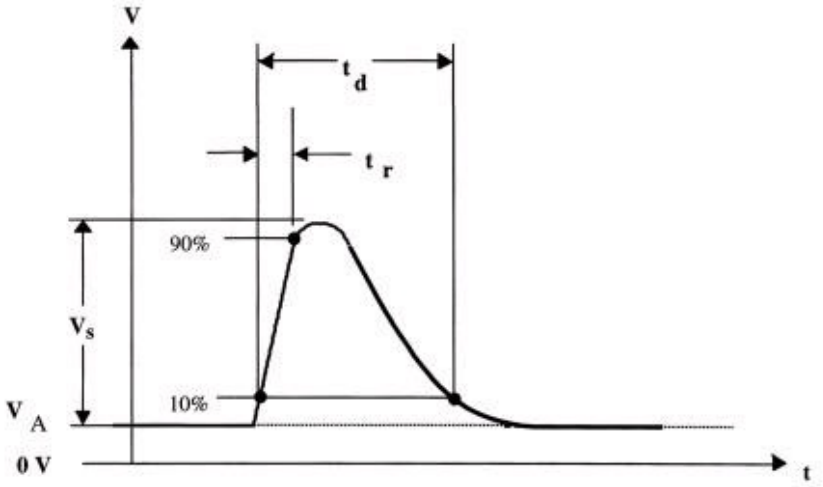
To verify that the product can withstand an electrical pulse that can occur when the vehicle alternator electrical load is abruptly reduced or removed from the vehicle electrical system.

11.14.3 Test Procedure

The DUT shall be subjected to the Load Dump Test, as specified in SAE J1113-11, Section 8, Test Pulse 5A.

The Unsuppressed Load Dump test will be applied to the power and ground connections of the DUT. The parameters or the Load Dump transient are shown in the table below. The test setup shall be placed at a height of 50 mm above the ground plane.

Parameters	12V System	24V System
V_A	14 V	28 V
V_S	75 V	150 V
R_i	4Ω	2Ω
t_d	200 ms	200 ms
t_r	10 ms	10 ms
Pulse Rate	10-15 s intervals	10-15 s intervals
Number of Pulses	5	5



Test Pulse

11.14.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test after test completion.

11.15 Direct Current Motor acting as a Generator (SAE J1113-11 - Section 8)

11.15.1 Test Connectors

The DUT will have harnesses mated. The PC CAN bus should be isolated from the DUT's CAN bus.

The DUT will be powered per the table in the test procedure, connected to the engineering test box, and monitored for functionality throughout the duration of the test.

11.15.2 Test Purpose

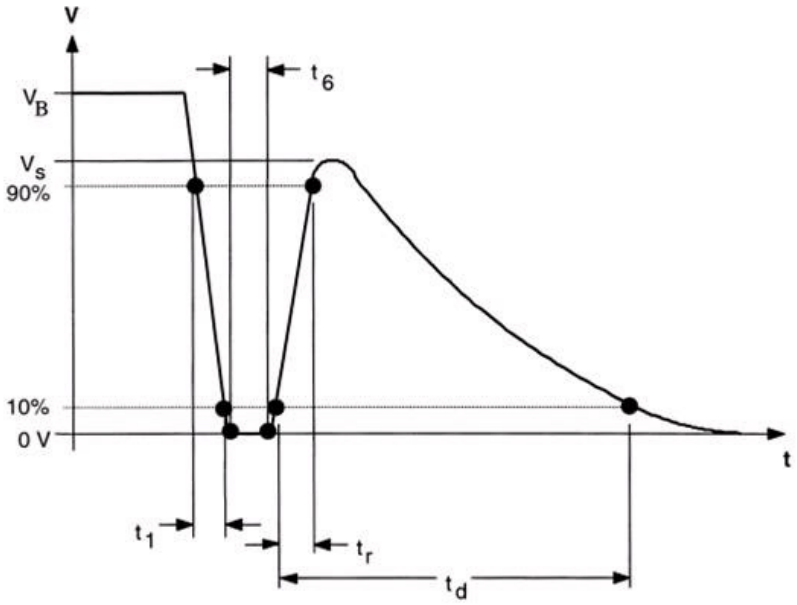
To verify that the product performs a in predictable manner during DC Motors Acting as Generators Transient, and not suffer damage as a result of the transient.

11.15.3 Test Procedure

The DUT shall be subjected to the Direct Current Motors Acting as a Generator Test, as specified in SAE J1113-11, Section 8, Figure 4.

The Direct Current Motors Acting as a Generator test will be applied to the power and ground terminals of the DUT. The parameters of the DC Motors Acting as Generators Transient test shall be applied per the table below.

Parameters	12V System	24V System
V_B	12 V	24 V
V_S	10 V	20 V
R_i	0.02Ω	0.02Ω
t_d	2 s	2 s
t_1	1 ms ± 0.5 ms	1 ms ± 0.5 ms
t_r	1 ms ± 0.5 ms	1 ms ± 0.5 ms
t_6	1 ms ± 0.5 ms	1 ms ± 0.5 ms
Pulse Cycle Time	5 s	5 s
Number of Pulses	10	10



DC Motor Acting as a Generator Transient

11.15.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test after test completion.

11.16 Starter Motor Engagement Disturbance Test (SAE J1113-11 - Section 8)

11.16.1 Test Connectors

The DUT will have harnesses mated. The PC CAN bus should be isolated from the DUT's CAN bus.

The DUT will be powered per the table in the test procedure and monitored for functionality throughout the duration of the test.

11.16.2 Test Purpose

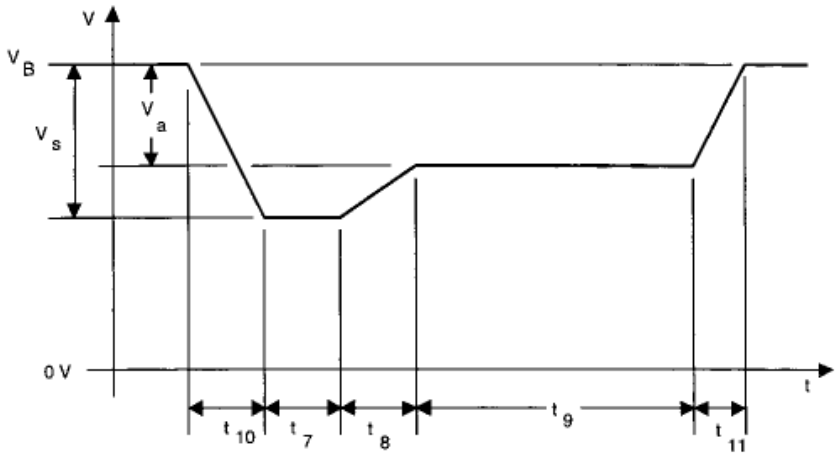
To evaluate the ability of the product to operate when subjected to transients occurring as a result of switching processes.

11.16.3 Test Procedure

The DUT shall be subjected to the Starter Motor Engagement Disturbance Test, as specified in SAE J1113-11 (2018), Section 8, Figure 7, Test Pulse 4.

The Starter Motor Engagement Disturbance test will be applied to the power and ground connections of the DUT. Test each unit first at 12V with both sets of 12V parameters and then at 24V with both sets of 24V parameters. There will be a total of 4 tests run per each DUT.

Parameters	12V System	24V System
V_S (from V_B)	-7 V	-16 V
V_a (from V_B)	-6 V	-12 V
R_i	0.02 Ω	0.02 Ω
t_7	40 ms	100 ms
t_8	≤ 50 ms	≤ 50 ms
t_9	20 s	20 s
t_{10}	5 ms	10 ms
t_{11}	5 and 100 ms	10 and 100 ms



Test Pulse

11.16.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test during or after test completion.

11.17 Transient Immunity (ISO 7637-2, Section 4)

11.17.1 Test Connections

For powered testing, the DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals. The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

11.17.2 Test Purpose

To provide an enhanced analysis of mechanical stress due to pressure changes.

11.17.3 Test Procedure

The DUT shall be subjected to the Transient Immunity Test, as specified in ISO 7637-2, Section 4.

The DUT shall be tested at Severity Level IV following the table below for Test Pulses 1, 2a, 2b, 3a, and 3b.

Test pulse[a]	Selected test level[b]	Test pulse severity level, U_S^{cd} V			Min. number of pulses or test time	Burst cycle/ pulse repetition time	
		IV	III	I / II		min.	max.
1		–600	–450	–300	500 pulses	0,5 s	[e]
2a		+112	+55	+37	500 pulses	0,2 s	5 s
2b		+20	+20	+20	10 pulses	0,5 s	5 s
3a		–300	–220	–150	1 h	90 ms	100 ms
3b		+300	+220	+150	1 h	90 ms	100 ms

[a] Test pulses as in 5.6.

[b] Values agreed between vehicle manufacturer and equipment supplier.

[c] The amplitudes are the values of U_s as defined for each test pulse in 5.6.

[d] The former levels I and II are revised because they did not ensure sufficient immunity in subsequent road vehicles' design.

[e] The maximum pulse repetition time shall be chosen such that it is the minimum time for the DUT to be correctly initialized before the application of the next pulse and shall be ⩾0,5 s.

11.17.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test after test completion.

11.18 Starting Profile (ISO 16750-2 - Section 4.6.3)

11.18.1 Test Connectors

The DUT will have harnesses mated.

The DUT will be powered per the table in the test procedure and monitored for functionality throughout the duration of the test.

11.18.2 Test Purpose

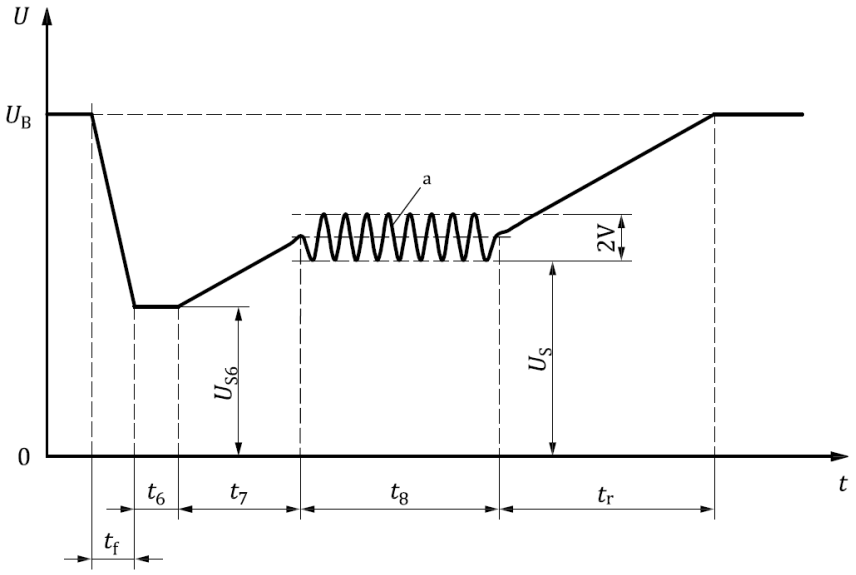
To evaluate the ability of the product to survive a voltage waveform that occurs during the starting of the vehicle.

11.18.3 Test Procedure

The DUT shall be subjected to the Level IV Starting Profile Test for a 12 V system and Level III for a 24 V system, as specified in ISO 16750-2, Section 4.6.3.

The Starting Profile test will be applied to the +BAT connections of the DUT. This test will be performed at a voltage of US. Apply the transient to the DUT 10 times with a 1 minute break in between each application while keeping the DUT at -40°C. The DUT will be allowed to soak at -40°C for at least 40 minutes prior to the test. The parameters for the Starting Profile test are listed below in the table below.

Parameters	12V System	24V System
U_{S6}	6 V	6V
U_S	6.5 V	10 V
t_f	5 ms	10 ms
t_6	15 ms	50 ms
t_7	50 ms	50 ms
t_8	30 s	30 s
t_r	100 ms	40 ms
f	2Hz and 50Hz	2Hz and 50Hz
Number of Pulses	10	10



Starting Profile Transient

11.18.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test during or after test completion.

11.19 Reversed Voltage (ISO 16750-2 - Section 4.7)

11.19.1 Test Connectors

The DUT will have harnesses mated.

The DUT will be powered during the test. The DUT will not be monitored.

11.19.2 Test Purpose

To verify that the product can withstand high negative voltage conditions that may be due to installation of incorrect types of batteries or a faulty cable harness in the power supply lines.

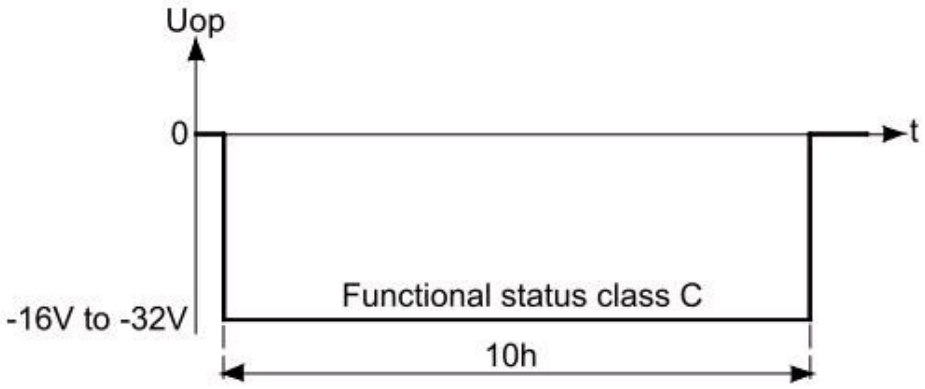
11.19.3 Test Procedure

The DUT shall be subjected to the Reversed Operating Voltage Test, as specified in ISO 16750-2, section 4.7.

The Reversed Operating Voltage test shall apply a negative voltage to the BAT supply pins of the DUT. The voltage shall be applied for a duration of 5 minutes. The test shall be repeated 5 times. The parameters to be used should first be for a 12V system and then for a 24V system. The current shall be applied through a breaker such as a 20 amp SnapAction VB3 breaker or a Mechanical Products PN 1600-206-200-3220-A CB.

The power supply circuit current capacity shall be at least five times the current rating of the protection fuse.

Parameters	12V System	24V System
U_A	-16V	-32V
Test Temperature	23°C ± 5°C	23°C ± 5°C
Duration	5 min	5 min
Cycles	5	5



Reversed Operating Voltage

11.19.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test after test completion.

11.20 Short Circuit Protection (ISO 16750-2 - Section 4.10)

11.20.1 Test Connectors

The DUT will have harnesses mated.

The DUT will be powered per the table in the test procedure and monitored for functionality throughout the duration of the test.

11.20.2 Test Purpose

To verify that the product can withstand electrical fault conditions which can occur when wires are inadvertently connected to circuits that they were not intended to contact.

11.20.3 Test Procedure

The DUT shall be subjected to the Short Circuit Protection Test, as specified in ISO 16750-2, section 4.10

The DUT will be tested with a 20 amp protection fuse inserted on the shorting line. Each non-excluded pin will be shorted to USmax and then to ground for 1 minute each. The DUT will be powered throughout the test. The power supply circuit current capacity shall be at least five times the current rating of the protection fuse. The power supply shall be capable of supplying a minimum of 500A. The test shall be run at 23°C.

<u>Direct Shorts to BAT: (CAN and Digital IO)</u>

1) Power the DUT at 16.0V +/- 0.1V.
2) Verify with external equipment that all Inputs and Outputs function correctly.
3) Set all Outputs on DUT to a Low State.
4) Verify with external equipment that the Outputs are in a Low State.
5) Connect each Input and Output pin to BAT with an in-line 20 amp breaker for 1 minute.
6) Disable all Outputs.
7) Connect each Output pin to BAT with an in-line 20 amp breaker for 1 minute.

8) Disconnect supply power from the DUT.
9) Connect each Input and Output pin to BAT with an in-line 20 amp breaker for 1 minute.
10) Apply Power back to the DUT.
11) Verify with external equipment that all Inputs and Outputs function correctly. The unit shall pass the test without discrepancy.
12) Repeat test at 32.0V +/- 0.1V.

Direct Shorts to GND: (CAN and Digital IO)

1) Power the DUT at 16.0V +/- 0.1V.
2) Verify with external equipment that all Inputs and Outputs function correctly.
3) Set all Outputs on DUT to a High State.
4) Verify with external equipment that the Outputs are in a High State.
5) Connect each Input and Output pin to GND with an in-line 20 amp breaker for 1 minute.
6) Disable all Outputs.
7) Connect each Output pin to GND with an in-line 20 amp breaker for 1 minute.
8) Verify with external equipment that all Inputs and Outputs function correctly. The unit shall pass the test without discrepancy.
9) Repeat test at 32.0V +/- 0.1V.

Direct Shorts to BAT: (All Others)

1) Power the DUT at 16.0V +/- 0.1V.
2) Verify with external equipment that all Inputs and Outputs function correctly.
3) Test each cable individually by connecting all non-GND pins on each cable to BAT with an in-line 20 amp breaker for 1 minute.
4) Test each cable individually by connecting all GND pins on each cable to BAT with an in-line 20 amp breaker for 1 minute.
5) Disconnect supply power from the DUT.
6) Test each cable individually by connecting all non-GND pins on each cable to BAT with an in-line 20 amp breaker for 1 minute.
7) Test each cable individually by connecting all GND pins on each cable to BAT with an in-line 20 amp breaker for 1 minute.
8) Apply Power back to the DUT.
9) Verify with external equipment that all Inputs and Outputs function correctly. The unit shall pass the test without discrepancy.
10) Repeat test at 32.0V +/- 0.1V.

Direct Shorts to GND:

1) Power the DUT at 16.0V +/- 0.1V.
2) Verify with external equipment that all Inputs and Outputs function correctly.
3) Test each cable individually by connecting all non-GND pins on each cable to GND with an in-line 20 amp breaker for 1 minute.
4) Test each cable individually by connecting all GND pins on each cable to GND with an in-line 20 amp breaker for 1 minute.
5) Disable all Outputs.
6) Test each cable individually by connecting all non-GND pins on each cable to GND with an in-line 20 amp breaker for 1 minute.
7) Test each cable individually by connecting all GND pins on each cable to GND with an in-line 20 amp breaker for 1 minute.
8) Verify with external equipment that all Inputs and Outputs function correctly. The unit shall pass the test without discrepancy.
9) Repeat test at 32.0V +/- 0.1V.

11.20.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test during or after test completion.

11.21 Electrostatic Discharge, Handling (SAE J1113-13 - Section 5)

11.21.1 Test Connectors

The DUT will not be powered or monitored for functionality during the test.

11.21.2 Test Purpose

To verify that the product can withstand an electrostatic discharge from the human body or from nearby objects which have been electrically charged.

11.21.3 Test Procedure

The DUT shall be subjected to the Electrostatic Discharge Test, as specified in SAE J1113-13, section 5.

The Electrostatic Discharge test will be conducted with the DUT in a non-operational (handling) state. The non-operational setup, which simulates handling of the DUT, will subject the DUT to the sequence below. Each pin and designated enclosure locations will be subjected to 3 discharges of each polarity with an interval of 5 seconds between each pulse. Dissipation of residual charge shall be drained by connecting a 1MegaOhm resistor to ground and then to the discharge points. The DUT will be placed on an ESD mat while the test is conducted. The test shall be performed at 23°C ± 3°C, and a relative humidity of 20% to 50%.

Sequence	Type	Level	Discharge Network
1	Contact	+ 8 kV	C = 150 pF R = 2 kOhm
2	Contact	- 8 kV	
3	Air	+ 25 kV	
4	Air	- 25 kV	

Note: Sequences 3-4 are applied to the Case only.

TBD

Designated Enclosure Locations Diagram #1

11.21.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test after any of the test sequences.

11.22 Electrostatic Discharge, Powered (SAE J1113-13 - Section 4)

11.22.1 Test Connectors

The DUT will have harnessing mated.

The DUT will be powered per the table in the test procedure, connected to simulated signals/loads, and monitored for functionality throughout the duration of the test.

11.22.2 Test Purpose

To verify that the product can withstand an electrostatic discharge from the human body or from nearby objects which have been electrically charged.

11.22.3 Test Procedure

The DUT shall be subjected to the Electrostatic Discharge Test, as specified in SAE J1113-13, section 4.

The Electrostatic Discharge test will be conducted with the DUT in an operational (powered) state. The operational setup, which simulates operation of the DUT, will subject the DUT to the test sequence shown below while the DUT is powered. Each pin and designated enclosure locations will be subjected to 3 discharges of each polarity with an interval of 5 seconds between each pulse. The Designated Enclosure Locations can be found in the Electrostatic Discharge, Handling section of this document. The DUT will be grounded during the test. The test shall be performed at 23°C ± 5°C, and between 30% to 50% relative humidity.

Sequence	Type	Level	Discharge Network
1	Contact	+ 8 kV	C = 150 pF R = 2 kOhm
2	Contact	- 8 kV	
3	Air	+ 15 kV	
4	Air	- 15 kV	

Note: Sequences 3-4 are applied to the Case only.

11.22.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test during or after any of the test sequences.

11.23 Thermal Cycling Reliability (Custom Test)

11.23.1 Test Connectors

The DUT will have harnessing connected.

The DUT will be power per the graph in the test procedure, monitored, and electrically loaded throughout the duration of the test.

11.23.2 Test Purpose

To evaluate the ability of the product to operate in conditions where the DUT is subjected to temperature and voltage changes as they many occur in normal operation.

11.23.3 Test Procedure

The DUT shall be subjected to the Thermal Cycle Reliability Test.

The Thermal Cycling Reliability Test shall be performed to prove the reliability goal for B10 of 23,200 hours with 90% level of confidence. The test shall include combined profiles for temperature and voltage. The test shall consist of 6 cycles (6 weeks). These conditions are intended to run simultaneously in a temperature/humidity chamber that is outfitted to allow continuous operation of all DUT.

The combined temperature/voltage profiles shall be per the table below throughout the test. The actual voltage and chamber temperature shall be measured and logged during the test. Additionally, the temperature on the surface of one DUT shall be measured and logged.

All Inputs/Outputs should be connected and monitored with simulated loads and signals.

For Test Round 1, use the following table:

Step	Voltage	Temperature Change	Temperature Target	Time (hr)
1	8V	1.5C-3.0C Per Minute	-40C	12
2	12V	1.5C-3.0C Per Minute	-40C	11
3	18V	1.5C-3.0C Per Minute	-40C	11
4	24V	1.5C-3.0C Per Minute	-40C	11
5	32V	1.5C-3.0C Per Minute	-40C	11
6	8V	1.5C-4.5C Per Minute	70C	12
7	12V	1.5C-4.5C Per Minute	70C	11
8	18V	1.5C-4.5C Per Minute	70C	11
9	24V	1.5C-4.5C Per Minute	70C	11
10	32V	1.5C-4.5C Per Minute	70C	11
11	8V	1.5C-4.5C Per Minute	70C	11
12	12V	1.5C-4.5C Per Minute	70C	11
13	18V	1.5C-4.5C Per Minute	70C	11
14	24V	1.5C-4.5C Per Minute	70C	11
15	32V	1.5C-4.5C Per Minute	70C	11

For Test Round 2, use the following table:

Step	Voltage	Temperature Change	Temperature Target	Time (hr)
1	8V	1.5C-3.0C Per Minute	-40C	12
2	12V	1.5C-3.0C Per Minute	-40C	11
3	18V	1.5C-3.0C Per Minute	-40C	11
4	24V	1.5C-3.0C Per Minute	-40C	11
5	32V	1.5C-3.0C Per Minute	-40C	11
6	8V	1.5C-4.5C Per Minute	70C	12
7	12V	1.5C-4.5C Per Minute	70C	11
8	18V	1.5C-4.5C Per Minute	70C	11
9	24V	1.5C-4.5C Per Minute	70C	11
10	32V	1.5C-4.5C Per Minute	70C	11
11	8V	1.5C-4.5C Per Minute	85C	12
12	12V	1.5C-4.5C Per Minute	85C	11
13	18V	1.5C-4.5C Per Minute	85C	11
14	24V	1.5C-4.5C Per Minute	85C	11
15	32V	1.5C-4.5C Per Minute	85C	11

11.23.4 Test Evaluation

DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing functional test during or after any of the test sequences.

11.24 Thermal Shock (SAE J1455 - Section 4.1.3.2)

11.24.1 Test Connectors

The DUT will have harnesses mated.

The DUT will not be powered or monitored for functionality during the test.

11.24.2 Test Purpose

To verify the product's ability to operate under extreme temperature transitions without any detrimental effects.

11.24.3 Test Procedure

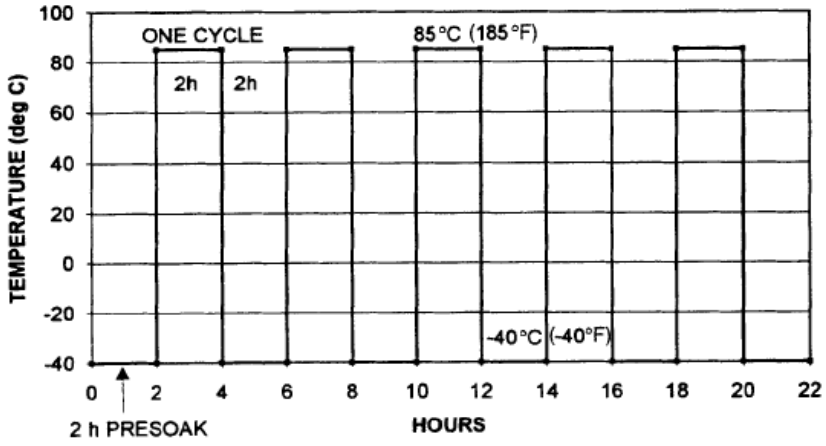
The DUT will be subjected to the Thermal shock test as specified in SAE J1455, section 4.1.3.2.

The thermal shock test should begin with a two hour presoak at –40°C. The test item should be transferred to the hot chamber (For Test Round 1 = 70°C, For Test Round 2 = 85°C) where it should remain for two hours, then transferred back to the cold chamber (–40°C) where it should remain for an additional two hours. Each transfer should be accomplished in 1 minute or less. The two hour dwell in the hot chamber and two hour dwell in the cold chamber constitute one thermal shock cycle.

Subject the DUT to 267 thermal shock cycles.

The DUT shall be functionally tested at the completion of every 100 cycles.

Cycle Stage	Dwell Time
Cold Dwell	2 hours
Transition to Hot	< 1 minute
Hot Dwell	2 hours
Transition to Cold	< 1 minute
Cycles	267



Thermal Shock Profile

11.24.4 Test Evaluation

DUT will be inspected post test for any visible damage such as cracking, distorting, or discoloring as a result of the temperature profile. Impaired function for this test shall be defined as failing functional test after test completion.

11.25 Radiated Electromagnetic Emissions (IEC CISPR 25 - Section 6.4)

11.25.1 Test Connectors

The DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be powered to 28V.

11.25.2 Test Purpose

To measure the levels of radiated electromagnetic emissions of the DUT and verify they do not exceed specified limits.

11.25.3 Test Procedure

The DUT shall be subjected to the Radiated Emissions Test, as specified in IEC CISPR 25, Section 6.4.

The Radiated Electromagnetic Emissions test shall consist of measuring the narrowband and broadband radiated emissions of the DUT. The frequency range of the measured emissions will be 150kHz-1GHz. The narrowband emissions will be measured using the peak detector of the spectrum analyzer. Narrowband emissions that exceed the narrowband limits will be remeasured using the average detector of the spectrum analyzer. If the difference between the peak and average measurements are less than 6dB the signal will be considered narrowband. If the difference between the peak and average measurements are greater than 6dB the signal will be considered broadband. If necessary, the broadband emissions will be remeasured using the quasi peak detector of the spectrum analyzer. The DUT will be placed inside the anechoic chamber 50mm above the ground plane and 200mm back from the front edge of the ground plane. 1.5m of harness will be placed 50mm above the ground plane and 100mm back from the front edge of the ground plane.

An active rod antenna will be used to measure emissions from 150kHz-30MHz. A Biconical antenna will be used to measure emissions from 30MHz-200MHz in both horizontal and vertical polarities. A Log Periodic antenna will be used to measure emissions from 200MHz-1GHz in both horizontal and vertical polarities Line Impedance Stabilization Networks (LISN's) will be used on VBAT and GND lines to provide proper impedance.

11.25.4 Test Evaluation

Impaired function for this test shall be defined as radiated electromagnetic emissions exceeding Class 4 limit lines.

11.26 RE102, Radiated Emissions (MIL-STD 461G - Section 5.17)

11.26.1 Test Connectors

The DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

11.26.2 Test Purpose

To measure the levels of radiated electromagnetic emissions of the DUT and verify they do not exceed specified limits.

11.26.3 Test Procedure

The DUT shall be subjected to the Radiated Emissions Test, as specified in MIL-STD 461G, Section 5.17.

The Radiated Electromagnetic Emissions test shall consist of measuring the radiated emissions of the DUT. The frequency range of the measured emissions will be 10kHz-4GHz. The emissions will be measured using the peak detector of the spectrum analyzer. The DUT will be placed inside the anechoic chamber 50mm above the ground plane and 200mm back from the front edge of the ground plane. 2m of harness will be placed 50mm above the ground plane and 100mm back from the front edge of the ground plane.

An active rod antenna will be used to measure emissions from 10kHz-30MHz. A Biconical antenna will be used to measure emissions from 30MHz-200MHz in both horizontal and vertical polarities. A Double ridge horn antenna with a 69.0 by 94.5cm opening will be used to measure emissions from 200MHz-1GHz in both horizontal and vertical polarities. A Double ridge horn antenna with a 24.2 by 13.6cm opening will be used to measure emissions from 1GHz-4GHz in both horizontal and vertical polarities. Line impedance stabilization networks (LISN's) will be used on VBAT and GND lines to provide proper impedance.

Frequency Range	6 dB Resolution Bandwidth	Minimum Dwell Time		Minimum Measurement Time Analog-Tuned Measurement Receiver 1/
		Stepped-Tuned Receiver 1/ (Seconds)	FFT Receiver 2/ (Seconds/ Measurement Bandwidth)	
30 Hz - 1 kHz	10 Hz	0.15	1	0.015 sec/Hz
1 kHz - 10 kHz	100 Hz	0.015	1	0.15 sec/kHz
10 kHz - 150 kHz	1 kHz	0.015	1	0.015 sec/kHz
150 kHz - 10 MHz	10 kHz	0.015	1	1.5 sec/MHz
10 MHz - 30 MHz	10 kHz	0.015	0.15	1.5 sec/MHz
30 MHz - 1 GHz	100 kHz	0.015	0.15	0.15 sec/MHz
Above 1 GHz	1 MHz	0.015	0.015	15 sec/GHz

Emissions Frequency Ranges

11.26.4 Test Evaluation

Impaired function for this test shall be defined as radiated electromagnetic emissions exceeding specified limits for army ground applications.

11.27 CS101, Conducted Susceptibility, Power Leads (MIL-STD 461G - Section 5.7)

11.27.1 Test Connectors

The DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

11.27.2 Test Purpose

To verify proper operation in the presence of conducted electromagnetic interference.

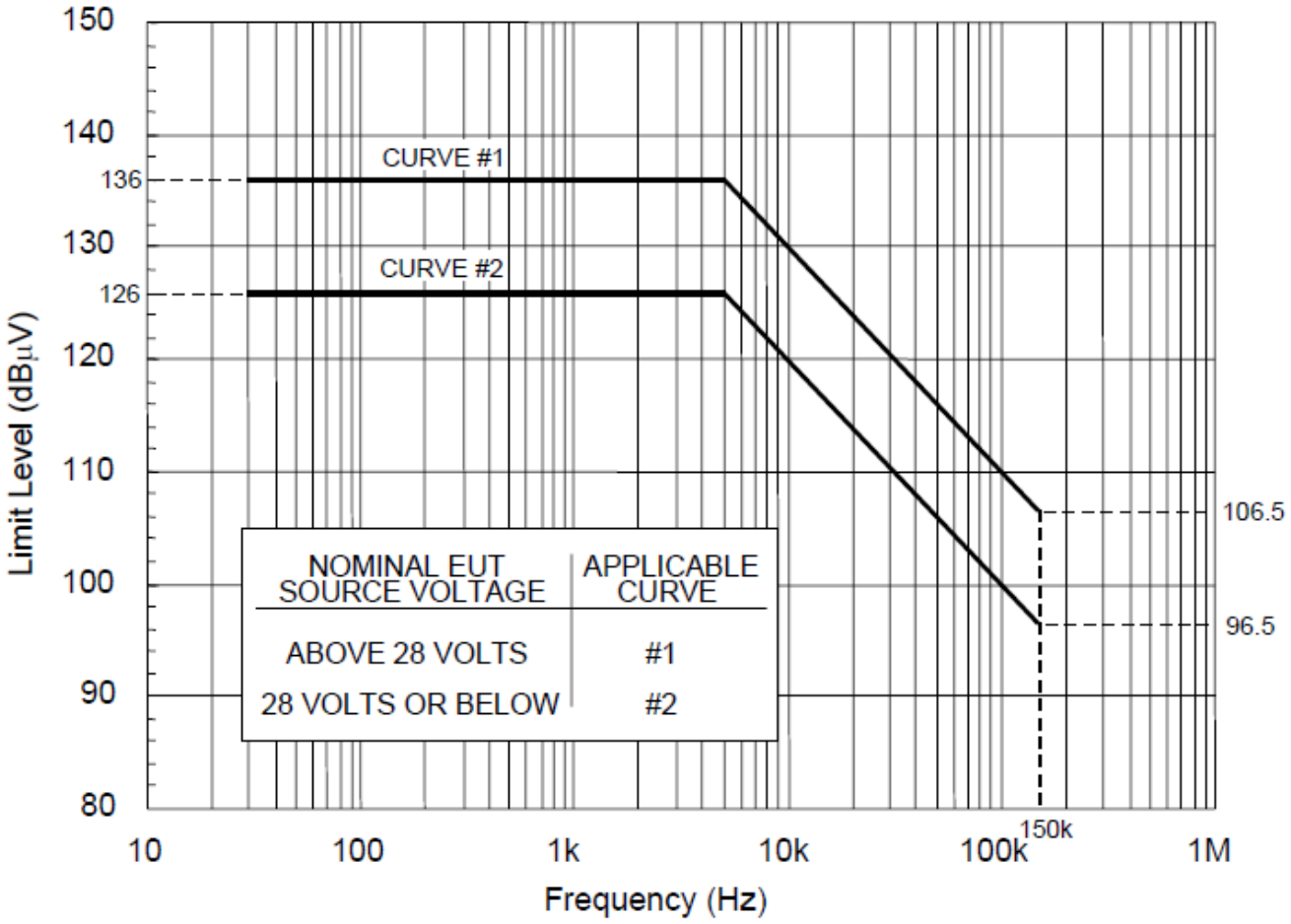
11.27.3 Test Procedure

The DUT shall be subjected to the CS101, Conducted Susceptibility, Power Leads Test, as specified in MIL-STD 461G, section 5.7.

The Conducted Susceptibility test will consist of the DUT power leads being subjected to electromagnetic interference from 30Hz to 250kHz through a coupling transformer. Field strengths shall follow Figure CS101-1: Curve #2. The DUT will be placed inside an anechoic chamber 50mm above the ground plane and 200mm back from the front edge of the ground plane. 1.5m of harness will be placed 50mm above the ground plane and 100mm back from the front edge of the ground plane. Line impedance stabilization networks (LISN's) will be used on VBAT and GND lines to provide proper impedance.

Frequency Range	Analog Scans Maximum Scan Rates	Stepped Scans Maximum Step Size
30 Hz - 1 MHz	0.0333 f_o/sec	0.05 f_o
1 MHz – 30 MHz	0.00667 f_o/sec	0.01 f_o
30 MHz - 1 GHz	0.00333 f_o/sec	0.005 f_o
1 GHz - 40 GHz	0.00167 f_o/sec	0.0025 f_o

Frequency Step Sizes



CS101 Voltage Limits

11.27.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.28 CS114, Conducted Susceptibility, BCI (MIL-STD 461G - Section 5.13)

11.28.1 Test Connectors

The DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

11.28.2 Test Purpose

To verify proper operation in the presence of conducted electromagnetic interference.

11.28.3 Test Procedure

The DUT shall be subjected to the CS114, Conducted Susceptibility, Bulk Current Injection Test, as specified in MIL-STD 461G, section 5.13.

The Conducted Susceptibility test will consist of the DUT being subjected to Bulk Current Injection from 10kHz to 200MHz. Field strengths shall follow Figure CS114-1: Curve #3 from 10kHz to 2MHz and Curve #4 from 2MHz to 200MHz. Sweeps will be run with a pulse modulated signal at a 1kHz rate with a 50% duty cycle. The dwell time at each frequency step will be based upon the test time of the DUT.

The DUT will be placed inside an anechoic chamber 50mm above the ground plane and 200mm back from the front edge of the ground plane. 2m of harness will be placed 50mm above the ground plane and 100mm back from the front edge of the ground plane. Line impedance stabilization networks (LISN's) will be used on VBAT and GND lines to provide proper impedance.

Frequency Range	Analog Scans Maximum Scan Rates	Stepped Scans Maximum Step Size
30 Hz - 1 MHz	0.0333 f_o/sec	0.05 f_o
1 MHz – 30 MHz	0.00667 f_o/sec	0.01 f_o
30 MHz - 1 GHz	0.00333 f_o/sec	0.005 f_o
1 GHz - 40 GHz	0.00167 f_o/sec	0.0025 f_o

Frequency Step Sizes

11.28.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.29 CS115, Conducted Susceptibility, BCI, Impulse Excitation (MIL-STD 461G - Section 5.14)

11.29.1 Test Connectors

The DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

11.29.2 Test Purpose

To verify proper operation in the presence of impulse signals coupled onto the DUT associated cabling.

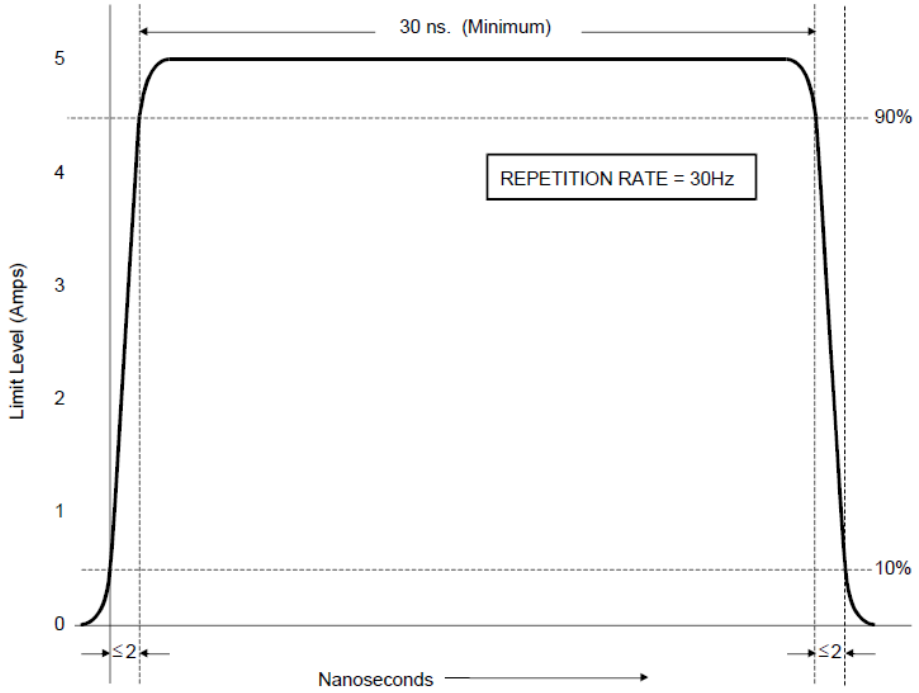
11.29.3 Test Procedure

The DUT shall be subjected to the CS115, Conducted Susceptibility, Bulk Cable Injection, Impulse Excitation Test, as specified in MIL-STD 461G, Section 5.14.

The Conducted Susceptibility test will consist of the DUT being subjected to bulk current injection, impulse excitation using a current injection probe. Field strengths will be 5A with a repetition rate of 30Hz for 1 minute.

The monitor probe shall be placed 5 cm from the DUT connector and the injection probe shall be placed 5 cm from the monitor probe.

The DUT will be placed inside an anechoic chamber 50mm above the ground plane and 200mm back from the front edge of the ground plane. 2m of harness will be placed 50mm above the ground plane and 100mm back from the front edge of the ground plane. Line impedance stabilization networks (LISN's) will be used on VBAT and GND lines to provide proper impedance.



CS115 Signal Characteristics

11.29.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.30 RS103, Radiated Susceptibility (MIL-STD 461G - Section 5.20)

11.30.1 Test Connectors

The DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

11.30.2 Test Purpose

To verify proper operation in the presence of radiated electromagnetic interference.

11.30.3 Test Procedure

The DUT shall be subjected to the RS103, Radiated Susceptibility Test, as specified in MIL-STD 461G, section 5.20.

The Radiated Susceptibility test will consist of the DUT being subjected to electromagnetic interference from 10 kHz to 4GHz. Field strengths will be 20V/m from 10kHz to 2MHz and 50V/m from 2MHz to 4GHz. Sweeps will be run with a pulse modulated signal at a 1kHz rate with a 50% duty cycle. The dwell time at each frequency step will be based on the test time of the DUT.

The DUT will be placed inside an anechoic chamber 50mm above the ground plane and 200mm back from the front edge of the ground plane. 2m of harness will be placed 50mm above the ground plane and 100mm back from the front edge of the ground plane. Line impedance stabilization networks (LISN's) will be used on VBAT and GND lines to provide proper impedance.

Frequency Range	Analog Scans Maximum Scan Rates	Stepped Scans Maximum Step Size
30 Hz - 1 MHz	0.0333 f_o/sec	0.05 f_o
1 MHz – 30 MHz	0.00667 f_o/sec	0.01 f_o
30 MHz - 1 GHz	0.00333 f_o/sec	0.005 f_o
1 GHz - 40 GHz	0.00167 f_o/sec	0.0025 f_o

Frequency Step Sizes

11.30.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.31 RS105, Radiated Susceptibility, Transient Electromagnetic Field (MIL-STD 461G – Section 5.22)

11.31.1 Test Connectors

The DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

11.31.2 Test Purpose

To verify the ability of the DUT enclosure to withstand a transient electromagnetic field.

11.31.3 Test Procedure

The DUT shall be subjected to the RS105, Radiated Susceptibility, Transient Electromagnetic Field Test, as specified in MIL-STD 461G, section 5.22.

The Radiated Susceptibility, Transient Electromagnetic Field test will consist of the DUT being subjected to a transient electromagnetic field. Follow the test procedure to calibrate the levels and test as specified in the standard.

11.31.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.32 EMI Component Susceptibility-Radiated (ISO 11452-2 - Section 8)

11.32.1 Test Connections

The DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

11.32.2 Test Purpose

To verify proper operation in the presence of electromagnetic interference.

11.32.3 Test Procedure

The DUT shall be subjected to the Level 4 EMI Component Susceptibility Test, as specified in ISO 11452-2, Section 8.

The Susceptibility test will consist of the DUT being subjected to electromagnetic interference using the free-field method from 80MHz to 1GHz. The field strength shall be based on the three status levels below. The frequency steps for each frequency band are defined in the table below. Sweeps will be run with and without 80% amplitude modulation with a 1kHz modulating signal. Measurements will be taken with a Biconical antenna in both the horizontal and vertical polarizations. Vertical polarization measurements shall be performed from 80MHz-1GHz and horizontal polarization measurements shall be performed from 400MHz-1GHz. The dwell time at each frequency step will be based upon the test time of the DUT. The test program used to automate the test will be Immunity Test.vi.

The DUT will be placed inside an anechoic chamber 50mm above the ground plane and 200mm back from the front edge of the ground plane. 1.5m of harness will be placed 50mm above the ground plane and 100mm back from the front edge of the ground plane. Line impedance stabilization networks (LISN's) will be used on VBAT and GND lines to provide proper impedance.

Frequency Band MHz	Linear Steps MHz	Logarithmic Steps %
0.01 to 0.1	0.01	10
> 0.1 to 1	0.1	10
> 1 to 10	1	10
> 10 to 200	5	5
> 200 to 400	10	5
> 400 to 1000	20	2
> 1000 to 18000	40	2

11.32.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.33 EMI Component Susceptibility - Bulk Current Injection (ISO 11452-4 - Section 8)

11.33.1 Test Connections

The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

11.33.2 Test Purpose

To verify proper operation in the presence of electromagnetic interference.

11.33.3 Test Procedure

The DUT shall be subjected to the Level 4 EMI Component Susceptibility Test, as specified in ISO 11452-4, Section 8.

The Susceptibility test will consist of the DUT being subjected to electromagnetic interference from 1MHz to 400MHz using Bulk Current Injection and the substitution method. The field strength shall be 200mA. The frequency steps for each frequency band are defined in the table below. The test shall be conducted with current injection probe shall be placed on the harness at 150mm, 450mm, and 750mm from the connector on the DUT. The dwell time at each frequency step will be based upon the test time of the DUT.

The DUT will be placed inside an anechoic chamber 50mm above the ground plane and 200mm back from the front edge of the ground plane. 1m of harness will be placed 50mm above the ground plane and 100mm back from the front edge of the ground plane. Line impedance stabilization networks (LISN's) will be used on VBAT and GND lines to provide proper impedance.

Frequency Band MHz	Linear Steps MHz	Logarithmic Steps %
0.01 to 0.1	0.01	10
> 0.1 to 1	0.1	10

> 1 to 10	1	10
> 10 to 200	5	5
> 200 to 400	10	5
> 400 to 1000	20	2
> 1000 to 18000	40	2

11.33.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.34 Salt Fog Spray Test (MIL-STD-810H Method 509.7)

11.34.1 Test Connections

The DUT will have harnesses mated.

The DUT will not be powered or monitored for functionality during the test.

11.34.2 Test Purpose

To determine the effectiveness of the DUT body to protect against the effects of salt deposits.

11.34.3 Test Procedure

The DUT shall be subjected to the Salt Fog Spray Test as specified in MIL-STD-810H, Method 509.7.

Maintain the temperature in the chamber at 35 ±2 °C (95 ±3.6 °F). Use water with a 5 ± 1% salt solution concentration. Alternate 24-hour periods of salt fog exposure and drying conditions for a minimum of four 24-hour periods (two wet and two dry). The air velocity in test chambers should be minimal (essentially zero). The temperature of the chamber should be continuously monitored during the test.

11.34.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.35 Immersion Test (SAE J1455 Section 4.3.3.2)

11.35.1 Test Connections

The DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals.

The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

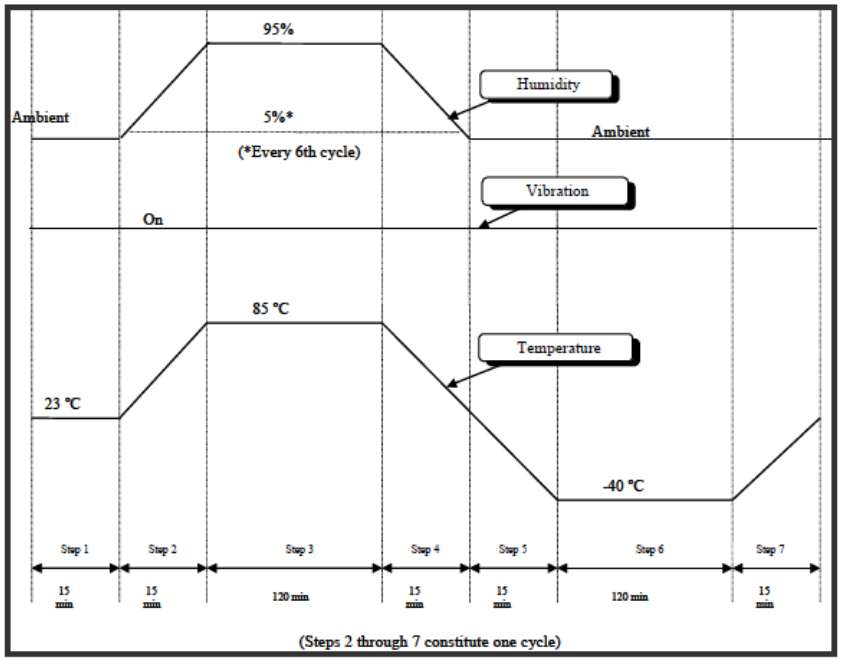
11.35.2 Test Purpose

To provide an enhanced analysis of sealed connector and sealed enclosure integrity.

11.35.3 Test Procedure

The DUT shall be subjected to the Immersion Test as specified in SAE J1455, Section 4.3.3.2.

Use water with a 5 ± 1% salt solution concentration. Immerse the DUT in salt water at 74 ±2 °C (165 ±3.6 °F). The DUT should be completed covered by the salt water at a depth of 150mm from the top of the DUT and remain immersed for a period of 1 hour. The DUT shall then be transferred to a salt water solution maintained at 0 ±2 °C (32 ±3.6 °F) within 2 minutes of leaving the hot salt water bath. The unit shall be left to soak in the cold bath for a period of 1 hour. Repeat this sequence to have a total of 3 hot baths and 3 cold baths taking care to transfer between baths within 2 minutes each time. After all baths have been completed, the DUT should then be immediately placed in a chamber to follow the Test Profile shown in the chart below for a total of 5 cycles, also found as Figure 14 in J1455. The vibration profile should match what is done in the Vibration Test (Section 11.1) of this test plan document with each DUT mounted in a different axis orientation.



Combined Test Profile

11.35.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.36 Steam Cleaning and Pressure Washing Test (SAE J1455 Section 4.5)

11.36.1 Test Connections

The DUT will have harnesses mated.

The DUT will not be powered or monitored for functionality during the test.

11.36.2 Test Purpose

To provide an enhanced analysis of sealed connector and sealed enclosure integrity from high heat, extreme water pressure, and caustic detergents.

11.36.3 Test Procedure

The DUT shall be subjected to the Steam Cleaning and Pressure Washing Test as specified in SAE J1455, Section 4.5.

Testing should be performed in the following order: Level 1 (Standard Test), Level 2 (Standard Test w/Detergent), Level 3 (Harsh Test), and finally Level 4 (Extreme Test).

11.36.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.37 Dust and Sand Test (SAE J1455 Section 4.7)

11.37.1 Test Connections

The DUT will have harnesses mated.

The DUT will not be powered or monitored for functionality during the test.

11.37.2 Test Purpose

To provide an enhanced analysis of sealed connector and sealed enclosure integrity from exposure to dust and sand.

11.37.3 Test Procedure

The DUT shall be subjected to the Dust and Sand Test as specified in SAE J1455, Section 4.7.

Test shall be run at room temperature. ISO 5011 Coarse or Equivalent 70% dust shall be used. Components should be placed in a dust chamber with sufficient dry air movement to maintain a concentration of 0.88 g/m3 (0.025 g/ft3) for a period of 24 hours.

11.37.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.38 Altitude Test (SAE J1455 Section 4.9 and MIL-STD-810H Method 500)

11.38.1 Test Connections

For powered testing, the DUT will be powered and placed in an operating mode with all inputs and output connected with simulated loads and signals. The DUT will be powered to 28V and monitored for functionality throughout the duration of the test.

For unpowered testing, the DUT will have harnesses mated, but will not be monitored for functionality during the test.

11.38.2 Test Purpose

To provide an enhanced analysis of mechanical stress due to pressure changes.

11.38.3 Test Procedure

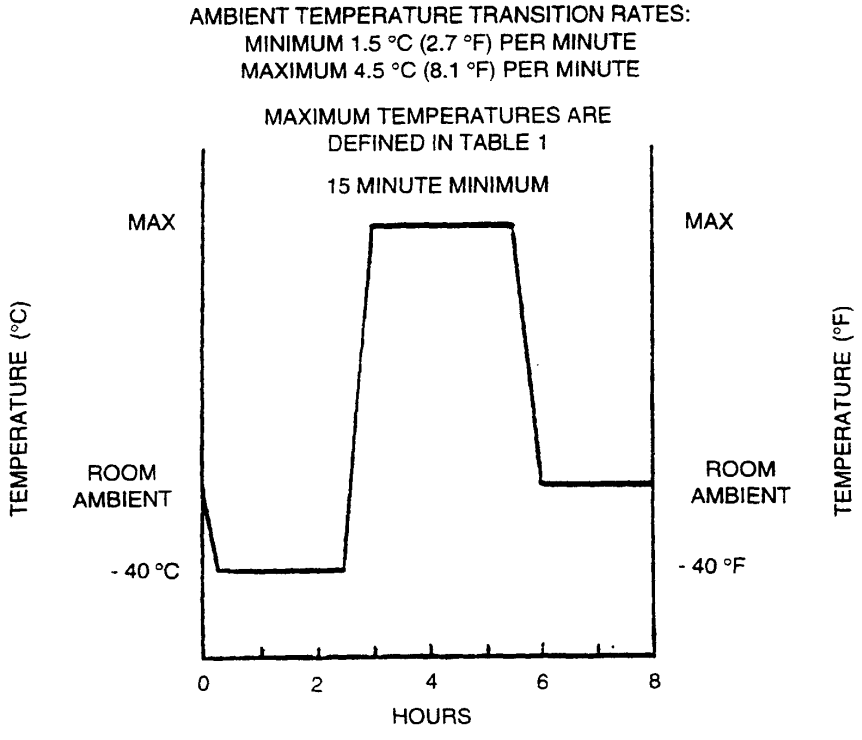
The DUT shall be subjected to the Altitude Test as specified in SAE J1455, Section 4.9 and MIL-STD-810H, Method 500.

For unpowered testing, the DUT will be tested at 18.6 kPa absolute pressure at -50 ±3 °C (±5 °F) for 10 hours.

For powered testing, the DUT will first be tested at 62.0 kPa absolute pressure at ±3 °C (±5 °F) following the chart below. The DUT will then be tested at 106.0 kPa absolute pressure at ±3 °C (±5 °F) following the chart below. This chart below shows 1 cycle of the test. The DUT should run 3 cycles at each pressure.

For Test Round 1, the maximum temperature should be set to 70 °C.

For Test Round 2, the maximum temperature should be set to 85 °C.



8 Hour Thermal Cycle

11.38.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.39 Over Voltage Protection Test (ISO 16750-2)

11.39.1 Test Connections

The DUT will be powered to the test voltage and monitored for functionality throughout the duration of the test.

11.39.2 Test Purpose

To simulate the condition where voltage regulation fails.

11.39.3 Test Procedure

The DUT shall be subjected to the Over Voltage Protection Test as specified in ISO 16750-2, Section 4.3.2.

The test shall be run at 65 ±3 °C in a chamber. A voltage of 36 V shall be applied for 60 minutes to all inputs of the DUT.

11.39.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.40 Over Voltage Protection 50V Test (Custom)

11.40.1 Test Connections

The DUT will be powered to the test voltage and monitored for functionality throughout the duration of the test.

11.40.2 Test Purpose

To simulate the condition where voltage regulation fails.

11.40.3 Test Procedure

The DUT shall be subjected to the Over Voltage Protection 50V Test.

The test shall be run at 65 ±3 °C in a chamber. A voltage of 50 V shall be applied for 5 minutes to all inputs of the DUT.

11.40.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

11.41 Power Cycle Test (Custom)

11.41.1 Test Connections

The DUT will be powered to the test voltages and monitored for functionality throughout the duration of the test.

11.41.2 Test Purpose

To simulate the condition where power supply fluctuations occur.

11.41.3 Test Procedure

The DUT shall be subjected to the Power Cycle Test.

The test shall be run 1000 cycles for each temperature and voltage combination in the table below. One Cycle is defined as 25 seconds power supply ON and 20 seconds power supply OFF to the DUT.

For Test Round 1, use the following table:

Temperature	Voltage
-40 ±3 °C	8V
-40 ±3 °C	32V
70 ±3 °C	8V
70 ±3 °C	32V

For Test Round 2, use the following table:

Temperature	Voltage
-40 ±3 °C	8V
-40 ±3 °C	32V
85 ±3 °C	8V
85 ±3 °C	32V

11.41.4 Test Evaluation

The DUT will be inspected post test for any visible damage. Impaired function for this test shall be defined as failing the functional test after test completion.

12. Post-Test Unit Teardown

12.1 Lot D and G Teardown Inspection

Lots D and G units will have been subjected to mechanical shocks. Some items for inspection may include:

- Manually shake the unit and listen for any rattling sound associated with loose parts.

- Remove the back cover and visually inspect that side of the board for any loose components.

- Remove screws that retain the PCB; record the torque required to loosen.

- Remove the PCB from the housing and visually inspect the board for loose components.