SAE International

SURFACE VEHICLE RECOMMENDED PRACTICE

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Superseding J1113-13 NOV2004

Electromagnetic Compatibility Measurement Procedure for Vehicle Components - Part 13: Immunity to Electrostatic Discharge

RATIONALE

EMC committee is requesting a 28 days re-affirmation ballot for J1113-13 as part of the systematic review process. The committee is considering a 2 year plan to determine if J1113-13 would be

1. maintained as a stand alone standard or
2. as an exceptional document while referencing to ISO 10605 or
3. canceled in favor of using ISO 10605

TABLE OF CONTENTS

1. Scope

This SAE Standard specifies the test methods and procedures necessary to evaluate electrical components intended for automotive use to the threat of Electrostatic Discharges (ESDs). It describes test procedures for evaluating electrical components on the bench in the powered mode and for the packaging and handling non-powered mode.

A procedure for calibrating the simulator that is used for electrostatic discharges is given in Appendix A.

An example of how to calculate the RC Time Constant is given in Appendix B

Functional Performance Status Classifications for immunity to ESD and Sensitivity classifications for ESD sensitive devices are given in Appendix C.

1.1 Measurement Philosophy

The familiar static charge generated and discharged when moving about inside a vehicle or exiting from a vehicle has assumed greater significance with the increase of vehicular electronic components. Tests simulating the electrostatic discharge of humans, in common use by non-automotive industries, were examined and it was determined that they were not applicable to the automotive environment. As a consequence, tests tailored to the automotive environment were developed.

Tests that simulate an electrostatic discharge (ESD) into a vehicular electrical system are based on the human ESD model. The ESD model consists essentially of a capacitor formed by a person to his surroundings and discharged through a path that includes that person's resistance as well as vehicle loads. Sensitive electrical devices can be adversely affected by energy either injected or coupled from electrostatic discharges.

ESD generates transient coupled EM fields as a result of the rapid high-voltage charge transfer. These EM fields are an inherent part of the discharge event and are not simulated separately.

Components can also be damaged by ESD during handling and they should therefore be evaluated for ESD sensitivity in a non-powered mode. The test procedures to evaluate the ESD sensitivity classification of components in a non-powered mode is detailed in Section 5 of this document.

2. References

2.1 Applicable Publications

The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest revision of SAE publications shall apply.

2.1.1 SAE Publication

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

SAE J1113-1—Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft) (60 Hz to 18 GHz)

2.1.2 IEC Publication

Available from International Electrotechnical Commission, 3, rue de Verambe, P.O. Box 131, 1211 Geneva 20, Switzerland.

IEC 61000-4-2:2001-04—Electromagnetic compatibility (EMC)—Part 4-2: Testing and measurement techniques—Electrostatic discharge immunity test

2.1.3 ISO Publication

Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO 10605—Road vehicles—Electrical disturbances from electrostatic discharges

3. *Test Equipment*

This section describes test equipment that is applicable to all parts of this document.

3.1 An ESD simulator that simulates the Human Body ESD model (see Figures 1A and 1B) having the following characteristics shall be used:

a. Voltage Range—Variable from –25 to +25 kV
b. Capacitance—330 pF ± 10%, 150 pF ± 10% (Multiple Probes)
c. Resistance—2000 Ω ± 10%
d. Risetime
   1. Direct Contact—0.7 to 1.0 ns (into a 2Ω load)
   2. Air Discharge ≤20 ns (into a 2Ω load)
e. Tip—(see Figure 2)—IEC Standard 61000-4-2

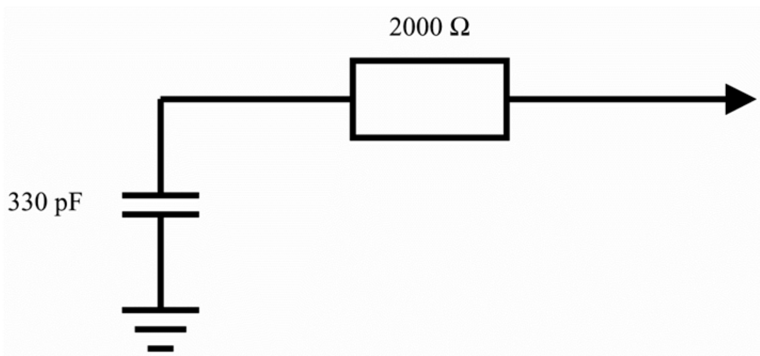

FIGURE 1A—POWERED MODE TEST SIMULATOR PARAMETERS

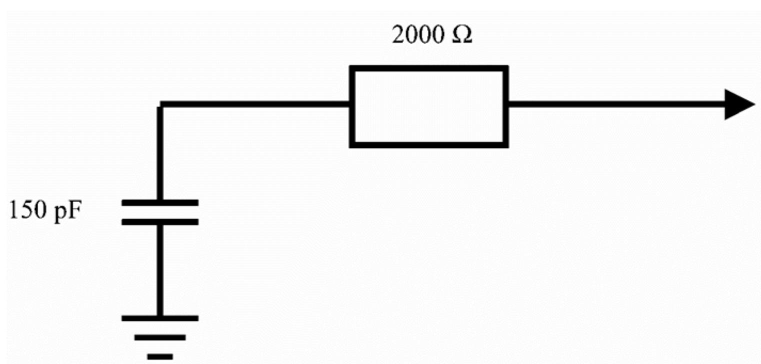

FIGURE 1B—PACKAGING AND HANDLING TEST SIMULATOR PARAMETERS

FIGURE 1—ESD HUMAN BODY MODEL PARAMETERS

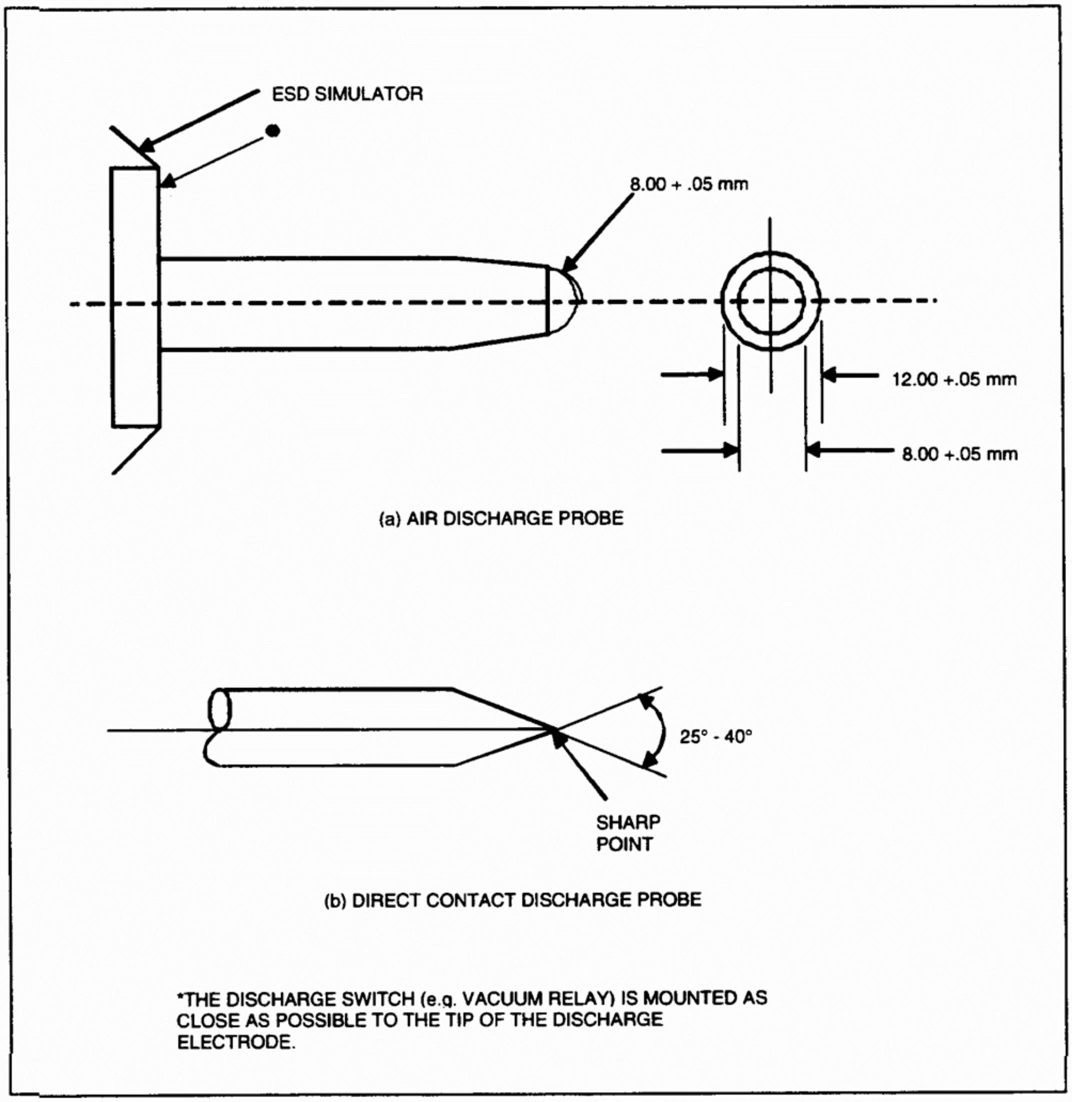

FIGURE 2—ESD SIMULATOR DISCHARGE TIP PROBES

3.1.1 The ESD simulator shall be designed so that the discharge capacitance is fully charged to the desired voltage before the energy can be switched to the DUT and shall not allow bleed off prior to discharge.

3.1.2 The ESD Simulator is commercially available.

3.2 Ground Plane

The ground plane shall be a conductive metallic sheet (i.e., copper, brass or galvanized steel)[1] as defined in SAE J1113-1. The ground plane shall be connected to the facility earth ground by a ground strap as short as possible. Length less than 2 m suggested.

3.3 Isolation Blocks

Isolation blocks, if used, shall be constructed of clean, non-hygroscopic, insulating material. The blocks are to be 25 mm ± 2.5 mm in height and project beyond the DUT by at least 20 mm on all sides.

3.4 Coaxial Target

A coaxial target specified by the International Electrotechnical Commission IEC 61000-4-2 shall be used during the ESD simulator verification of Appendix A.

3.5 20 dB Attenuator

A 50 Ω, 20 dB wideband attenuator (bandwidth 18 GHz) may be needed at the output of the coaxial target during the simulator verification of Appendix A.

3.6 Measurement Instrumentation

Verification of the risetime for the ESD simulator requires an analog measurement device with a minimum effective single shot bandwidth of 1 GHz or a digital measurement device with a minimum sampling rates of 4 Gigasamples per second and a single shot bandwidth of at least 1 GHz. Each instrument shall have 50 Ω input impedance. The use of a Faraday Shield, to separate the target from the measurement instrumentation, is highly recommended.

3.7 Voltage Probe (Electrometer)

The ESD simulator charging voltage shall be verified using an electrometer (input resistance 100 Gigohm minimum).

3.8 Test Equipment used to verify the requirements of the DUT shall not be sensitive to ESD.

3.9 Static Dissipative Mat

The surface resistivity of this mat shall be between 10^5 to 10^{12} Ω per square and placed on and connected to a ground plane if required by the Mat manufacturer.

4. Test Setup and Procedure for Powered Mode Component Tests

4.1 Prior to performing the test, a test plan shall be generated which shall include interface test points, component mode of operation, module orientation requirements, number of test units, and any special instructions and changes from the standard test.

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[1] Aluminum ground planes are not recommended because aluminum oxide buildup causes a nonconductive layer.

4.1.1 The test plan may specify DUT's other than those used for non-powered mode testing.

4.2 Before application of any discharges to the DUT, verify that the ESD Simulator Discharge Verification procedure of Appendix A has been performed.

4.2.1 For this test (powered mode test), the ESD simulator shall be configured with the 330 pF capacitor probe shown in Figure 1A.

4.3 Test Environment

4.3.1 TEMPERATURE RANGE

23 °C ± 3 °C; 20 °C preferred.

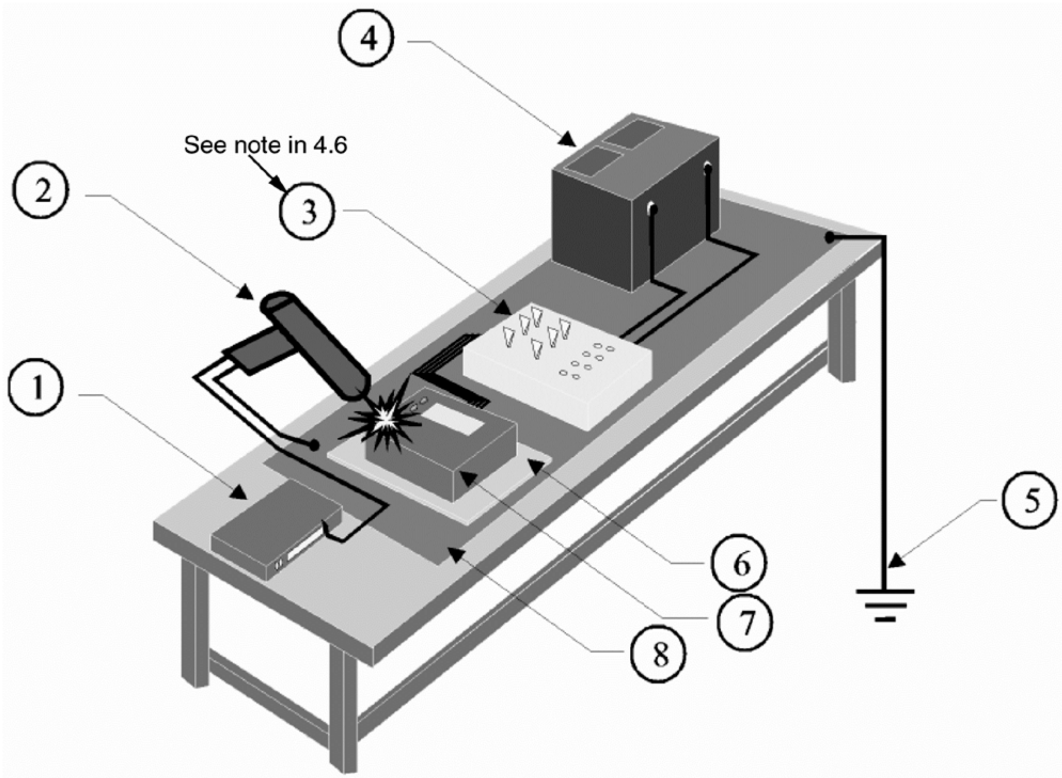
4.3.2 RELATIVE HUMIDITY

20 to 50%; 30% preferred.

4.3.3 IONIZER

Charge dissipation between discharges of some modules (instrument panels, large plastic modules, etc.) may require use of an ionizer.

4.4 The test setup shall be configured in accordance with Figure 3.



Key

1. Simulator power supply
2. ESD simulator
3. Exerciser
4. Battery
5. Ground Strap
6. Insulation block (if necessary)
7. Device under test
8. Ground plane

FIGURE 3—TEST SETUP FOR POWERED MODE COMPONENT TEST

4.5 The ESD simulator high voltage ground shall be directly connected to the ground plane by an insulated grounding strap less than 2 m long. For all discharge return cable lengths used, the simulator shall meet the requirements of Appendix A.

4.5.1 The connection of the simulator return cable to the Ground Reference plane and all bonding should be of low impedance at high frequencies. The discharge return cable of the simulator (if required) should be positioned at least 0.2 m from the DUT while the discharge is being applied. This measure is needed to reduce radiation from this cable from affecting the test results. The end of the discharge return cable connected to the simulator may be closer to the DUT.

4.6 The DUT shall be placed on the ground plane (see Figure 3). Chassis-mounted components are to be placed directly on the ground plane. Components which will be isolated from ground in normal installation shall be tested with an insulator between the components and the ground plane using the isolation blocks defined in 3.3. All voltage supply pins shall be connected to an appropriate power source (automotive battery). All other pins shall have inputs applied as necessary to put the DUT into a simulated mode of operation.

NOTE—Test equipment susceptibility to ESD may limit the ability to conduct testing using normal operational inputs; at a minimum the DUT shall be in a powered, idling mode.

4.7 Each exposed shaft, button, switch, or surface of the DUT, which will be accessible to the occupant from inside the vehicle, shall be tested at each of the voltage levels as defined in Appendix C or as specified in the test plan in accordance with the following two methods.

4.7.1 DIRECT CONTACT DISCHARGE

Use the direct contact probe (Figure 2b). The ESD simulator shall be placed in direct contact with all accessible discharge points. Each discharge point shall be tested to the contact discharge voltage levels in Appendix A.

4.7.2 AIR DISCHARGE

Use the air discharge probe (Figure 2a). The ESD simulator shall be placed at a minimum distance of 15 mm away from the DUT.

The simulator fingertip probe shall be held perpendicular (±15 degrees) to the discharge location. The simulator fingertip probe shall very slowly be moved towards the DUT at 5 mm/s or less until a discharge is obtained. Each point shall be tested to the air discharge voltage levels in Appendix A.

NOTE—If no discharge occurs, continue moving the probe towards the DUT until the simulator discharge tip is in contact with the discharge point. If the simulator makes contact with discharge point and no discharge has occurred, discontinue testing at that voltage level and location.

4.8 Each discharge point shall be subjected to a minimum of three positive polarity and three negative polarity discharges at each voltage level. The time duration between discharges shall be a minimum of 5 s.

NOTE—At each voltage level, all discharge points of a device may be tested first at a single polarity and then tested with the alternate polarity.

4.9 During and after each series of three discharges, the DUT shall meet all applicable performance requirements.

4.10 Record all deviations noted (visible, audible, failures, etc.) on a data sheet such as the example Data Sheet 1 (Figure 4).

DATA SHEET 1

ELECTROSTATIC DISCHARGE TEST RECORD FOR COMPONENTS

COMPONENT DESCRIPTION ____________________ TEST NO. ____________________

PART NO. ____________________________________ PAGE ________ OF ____________

COMPONENT FUNCTIONS ____

____

TEMPERATURE ______________________________ RELATIVE HUMIDITY ____________

SPECIAL TEST CONDITIONS ____

TEST FACILITY ____

REQUESTED BY ______________________________ PHONE ______________________

TESTED BY _________________________________ DATE _______________________

DISCHARGE POINT	VOLTAGE/POLARITY	PERFORMANCE DEVIATION

FIGURE 4—DATA SHEET 1—ELECTROSTATIC DISCHARGE TEST RECORD FOR COMPONENTS

5. Test Setup and Procedure for Packaging and Handling Sensitivity Classification Test (Non-Powered Mode Test)

5.1 Prior to performing the test, generate a test plan including interface test points, DUT mode of operation, module orientation requirements, number of modules to be tested, any special instructions and changes from the standard test.

5.1.1 The test plan may specify DUT’s other than those used for powered mode testing.

5.1.2 The test plan may allow different DUT’s for each Test Sequence shown in Table 1.

5.2 Before applying any discharges to the DUT, verify that the ESD simulator discharge verification procedures of Appendix A had been performed.

5.2.1 For this test (Non-powered mode test), the ESD Simulator shall be configured with the 150 pF capacitor probe shown in Figure 1B.

5.3 Test Environment

5.3.1 Temperature range 23 °C ± 3 °C; 20 °C preferred.

5.3.2 Relative humidity 20 to 50%; 30% preferred.

5.3.3 IONIZER

Charge dissipation between discharges of some modules (instrument panels, large plastic modules etc.) may require use of an ionizer.

5.4 The test setup shall be configured according to Figure 5.

5.5 Connect the ESD simulator high voltage ground directly to the ground plane (if used) or to the facility ground, by an insulated grounding strap less than 2 m long. For all discharge return cable lengths used, the simulator shall meet the requirements of Appendix A. The connection of the simulator return cable to the Ground Reference plane and all bonding should be of low impedance at high frequencies. The discharge return cable of the simulator should be positioned at least 0.2 m from the DUT while the discharge is being applied. This measure is needed to reduce radiation from this cable from affecting the test results. The end of the discharge return cable connected to the simulator may be closer to the DUT.

5.6 Perform a full functional test of the DUT prior to any application of ESD checking for rise time, current leakage, etc.

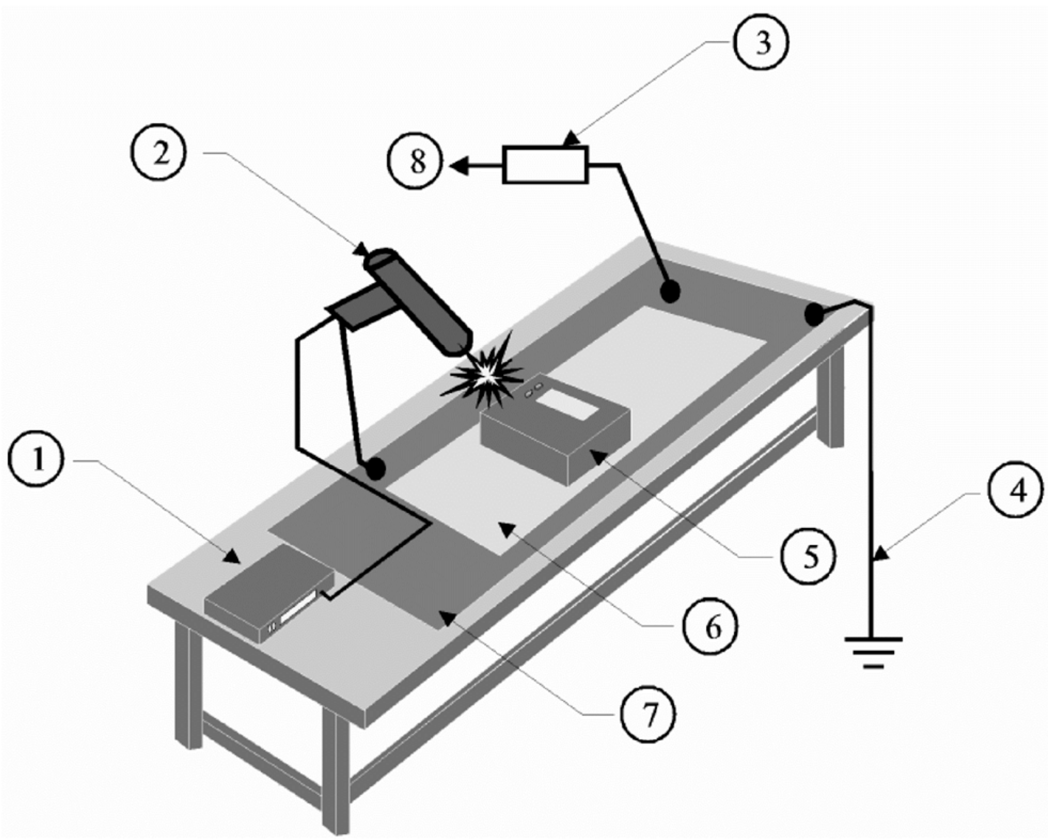
5.7 Place the DUT on a static dissipative mat as described in 3.9 to bleed-off any accumulated charge of the DUT housing.

5.7.1 Remove the DUT power source.

5.8 DUTs shall be step stressed according to the test sequence shown in Table 1.

5.9 Apply the ESD at, but not limited to, each connector pin, case, button, switch display, case screw, and case opening of the DUT that is accessible during handling.

5.9.1 Perform an evaluation test on all connector pins using the Air Discharge Probe and the maximum Test Voltage Level to determine if a discharge event occurs to any pin. If a discharge event does not occur then connector pins are not required to be tested further. If a discharge event does occur to any pin within a connector then all pins within that connector will be tested further according to the test sequence shown in Table 1.



Key

1. Simulator power supply
2. ESD simulator
3. 1 MΩ bleed-off resistor
4. Ground strap
5. Device under test
6. Static Dissipative Mat
7. Ground plane (if required by the manufacturer of the Mat)
8. See 5.10 for use of bleed-off resistor

FIGURE 5—TEST SETUP FOR PACKAGING AND HANDLING CLASSIFICATION TEST

5.9.2 Use a mating terminal crimped to a wire with gage 14 AWG to 20 AWG (2 mm^2 to 0.5 mm^2) to access recessed connector pins if further testing is required as specified in 5.9.1. The wire shall be solid (not stranded) and ≤25 mm long.

5.9.3 A connector with closely-spaced pins may result in a crowding of the lead wires. This makes it difficult to discharge to the intended wire. If this occurs, use multiple connectors with reduced number of lead wires in each. Evaluate each connector configuration separately.

5.10 Direct Contact Discharge

Place the ESD simulator in direct contact with all selected discharge points and test at the direct contact discharge voltages specified in Table 1 using the probe of Figure 2b. After each discharge to the DUT, residual charge remaining on the DUT shall be drained by one of the following methods:

a. Briefly connecting a 1 MΩ resistor (see Figure 5) in the following sequence, (1) between the discharge location and ground, and (2) between the ground point of the DUT and ground.
b. Extend the time between successive discharges to allow natural decay of the charge from the DUT surface.
c. Activate an air ionizer. If used, the air ionizer must be turned off and removed when each discharge is applied.

5.10.1 A minimum of six discharges shall be applied to each test point at each voltage level, three with a positive polarity and three with a negative polarity.

5.11 Air Discharge

Test each discharge point at the air discharge voltages specified in Table 1 using the air discharge probe of Figure 2a. Place the ESD simulator a minimum of 15 mm away from the DUT. Place the simulator air discharge probe perpendicular (±15 degrees) to the discharge location. Move it very slowly, at 5 mm/s or less, toward the DUT until a single discharge is obtained. After each discharge to the DUT, residual charge remaining on the DUT shall be drained by one of the following methods:

a. Briefly connecting a 1 MΩ resistor (see Figure 5) in the following sequence, (1) between the discharge location and ground, and (2) between the ground point of the DUT and ground.
b. Extend the time between successive discharges to allow natural decay of the charge from the DUT surface.
c. Activate an air ionizer. If used, the air ionizer must be turned off and removed when each discharge is applied.

5.11.1 A minimum of six discharges shall be applied to each test point at each voltage level, three with a positive polarity and three with a negative polarity.

5.11.2 If no discharge occurs, continue moving the probe towards the DUT until the simulator discharge probe contacts the discharge point. If still no discharge occurs, discontinue testing at that voltage level and location.

5.12 When testing inaccessible points (non-connector), slowly move the probe tip close enough to generate a discharge.

NOTE—Points shall be considered inaccessible when the ESD simulator probe cannot touch them directly.

5.13 After discharging to all the points of the DUT at one of the specified positive and negative voltage levels, the DUT shall meet all applicable functional tests as in 5.6. (After each positive and negative voltage level).

TABLE 1—ESD TEST SEQUENCE AND VOLTAGE LEVELS

Test Sequence	Type of Discharge	Test Voltage Level	Minimum number of discharges at each polarity
1	Contact Discharge	±4 kV	3
2	Contact Discharge	±6 kV	3
3	Air Discharge	±8 kV	3
4	Contact Discharge	±8 kV	3
5	Air Discharge	±15 kV	3
6	Air Discharge	±25 kV	3

5.14 Record deviations on a data sheet such as the example Data Sheet 1 (see Figure 4).

5.15 Use Section C.2 in Appendix C to determine the ESD sensitivity classification.

NOTE—It is recommended that all DUT's survive ±4 kV direct contact discharge, otherwise, they may be difficult to protect against ESD damage due to handling.

5.16 All CONTAINERS of ESD Sensitive (ESDS) devices and some ESDS devices themselves shall be clearly marked with a standard ESD warning label.

6. Test Severity Levels

6.1 A full description and discussion of the Function Performance Status Classification including Test Severity Levels are given in SAE J1113-1, Appendix A. Please review it prior to using the suggested Test Severity Levels presented in Appendix C.

7. Notes

7.1 Marginal Indicia

The change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. An (R) symbol to the left of the document title indicates a complete revision of the report.

PREPARED BY THE SAE EMI STANDARDS COMMITTEE

REAFFIRMED BY THE SAE ELECTROMAGNETIC COMPATIBILITY (EMC) STANDARDS COMMITTEE

APPENDIX A
(NORMATIVE)
ELECTROSTATIC DISCHARGE SIMULATOR VERIFICATION PROCEDURE

A.1 Scope and Field of Application

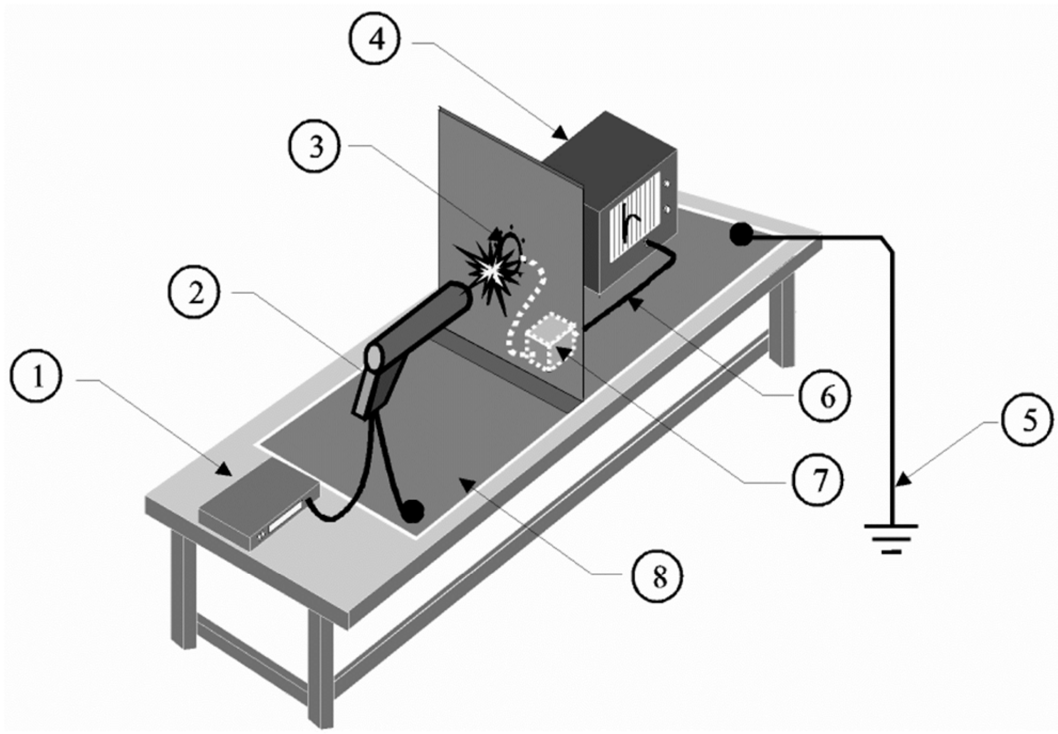
This Appendix defines a test method for verifying the operation of an ESD simulator that is used for testing automotive electronic components and systems.

Two verification procedures are specified each using two probes. Method A.2 is to be performed at least annually and method A.3 is to be performed before a test or at time intervals specified by the test facility or the customer.

A.2 ESD Simulator Full Verification Setup and Procedure

Shall be performed at least annually and more frequently with heavy usage.

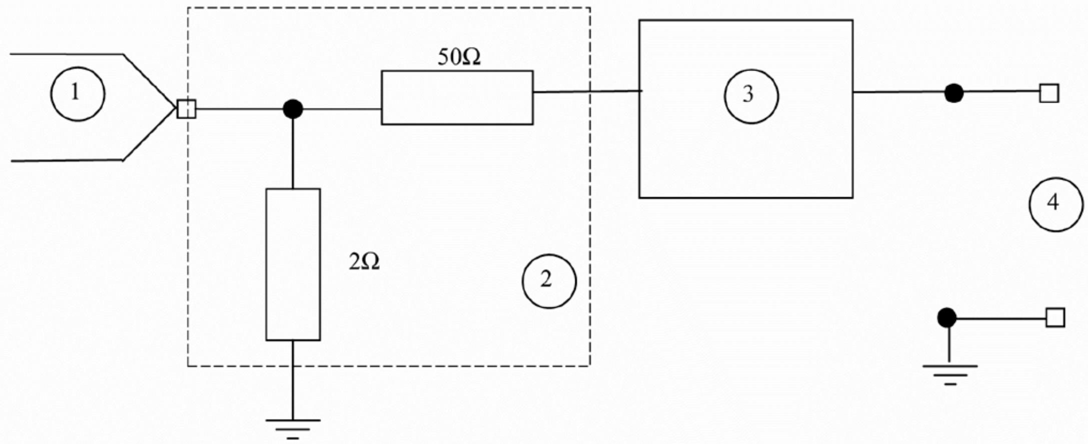
A.2.1 The test setup shall be configured according to Figure A1. Figure A2 shows an equivalent schematic of the setup. Note that a 20 dB wideband attenuator may be required as shown in Figure A1 depending on the vertical sensitivity of the oscilloscope.



NOTE—The use of a full faraday cage is allowed.

1. Simulator power supply
2. ESD simulator
3. Coaxial target
4. Oscilloscope
5. Ground Strap
6. Double shielded coaxial cable
7. 20 dB attenuator (optional)
8. Ground plane

FIGURE A1—ESD SIMULATOR VERIFICATION TEST SETUP CONFIGURATION



Key

1 ESD simulator

2 Coaxial target

3 20 dB attenuator (optional)

4 Oscilloscope input

FIGURE A2—EQUIVALENT SCHEMATIC

A.2.2 The Coaxial target as specified in IEC 61000-4-2:2001-04 shall be located on and bonded to the ground plane. The target output shall be connected to the oscilloscope through a 50 Ω double-shielded, high-frequency, cable ≤1 m long.

A.2.3 The cable shall not be looped and shall be insulated from the ground plane.

A.2.4 The ESD simulator high voltage ground shall be directly connected to the ground plane by an insulated grounding strap less than 2 m long. For all discharge return cable lengths used, the simulator shall meet the requirements of Appendix A.

A.2.5 The connection of the simulator return cable to the Ground Reference plane and all bonding should be of low impedance at high frequencies. The discharge return cable of the simulator should be positioned at least 0.2 m from the DUT while the discharge is being applied. This measure is needed to reduce radiation from this cable from affecting the test results. The end of the discharge return cable connected to the simulator may be closer to the DUT.

A.2.6 The ESD simulator shall be set up and operated according to its instruction manual.

A.2.7 To calibrate the display voltage of the ESD simulator, first adjust the ESD simulator voltage to the desired level and polarity. Next, verify the voltage setting using the voltage probe of 3.7 at levels of ±2 kV, ±4 kV, ±6 kV, ±8 kV, ±15 kV, and ±25 kV. The electrometer reading shall be within ±500 V for voltages ≤±5 kV and ±10% for voltages >±5 kV to ≤±25 kV.

A.2.8 ESD Simulator Risetime Verification Procedure

A.2.8.1 The horizontal time base and vertical amplifier level of the oscilloscope shall be configured in order to view the risetime of the ESD waveform. The horizontal sweep shall be set to single event trigger.

A.2.8.2 DIRECT CONTACT DISCHARGE VERIFICATION (SEE FIGURE 2B)

Discharge to the target at each test level and polarity shown in Table A1 and verify the risetime and first peak current parameters specified in Table A1. Figure A3 illustrates a typical waveform shape.

A.2.8.3 AIR DISCHARGE VERIFICATION (PERFORMED AT ±15 kV ONLY) (SEE FIGURE 2A)

The ESD simulator shall be placed a minimum distance of 15 mm from the coaxial target. The ESD simulator with air discharge probe attached, shall be held perpendicular (±15 degrees) to the target. From this position the simulator air discharge probe shall be slowly moved towards the target at 5 mm/s or less until a single discharge occurs. Only single event discharge waveforms are acceptable. Figure A3 illustrates a typical waveform shape.

NOTE—The slow approach method specified previously minimizes multiple discharges, discharges at lower voltage levels, and ringing in measurement equipment.

A.2.8.3.1 Record the waveform shape and parameters on Data Sheet 2 (see Figure A4).

A.2.8.3.2 Verify that the air discharge risetime at each polarity is ≤20 ns.

A.2.8.4 Acceptable ESD waveforms must be repeatable a minimum of six times in 10 attempts for both direct contact discharge and air discharge.

A.2.9 ESD Simulator RC Time Constant Verification Procedure

A.2.9.1 Configure the horizontal time base and vertical amplifier level of the oscilloscope to show the complete ESD waveform. Set the horizontal sweep to single event trigger.

A.2.9.2 RC time constant verification of the ESD simulator is performed at ±15 kV (air discharge) only.

A.2.9.3 The ESD simulator, with air discharge probe attached, shall be held perpendicular (±15 degrees) to the target. From this position the simulator air discharge probe shall be slowly moved towards the target at 5 mm/s or less until a single discharge occurs. Only single event discharge waveforms are acceptable. Figure A3 illustrates a typical waveform shape.

A.2.9.4 Record the waveform shape and parameters on Data Sheet 2 (see Figure A4).

A.2.9.5 Determine the RC time constant from the discharge curve starting after the second current peak (IP_2) and/or ringing and ending when the waveform has decayed 63%.

NOTE 1—In determining the RC time constant, where there is no second current peak (Ip_2) or when there is ringing in the measured waveform, calculate the RC time constant after the leading edge and/or ringing (where the waveform is stable).

NOTE 2—An example of how to find the RC Time Constant is found in Appendix B - ESD Simulator RC Time Constant Verification

TABLE A1—DIRECT CONTACT DISCHARGE VERIFICATION PARAMETERS

Level	Indicated Voltage (±kV)	First Peak Current (±A)	Rise Time With Discharge Switch (ns)
1	2 ± 0.5	7.5 + 2.25/–0	0.7 - 1
2	4 ± 0.5	15 + 4.5/–0	0.7 - 1
3	6 ± 0.6	22.5 + 6.75/–0	0.7 - 1
4	8 ± 0.8	30 + 9.0/–0	0.7 - 1

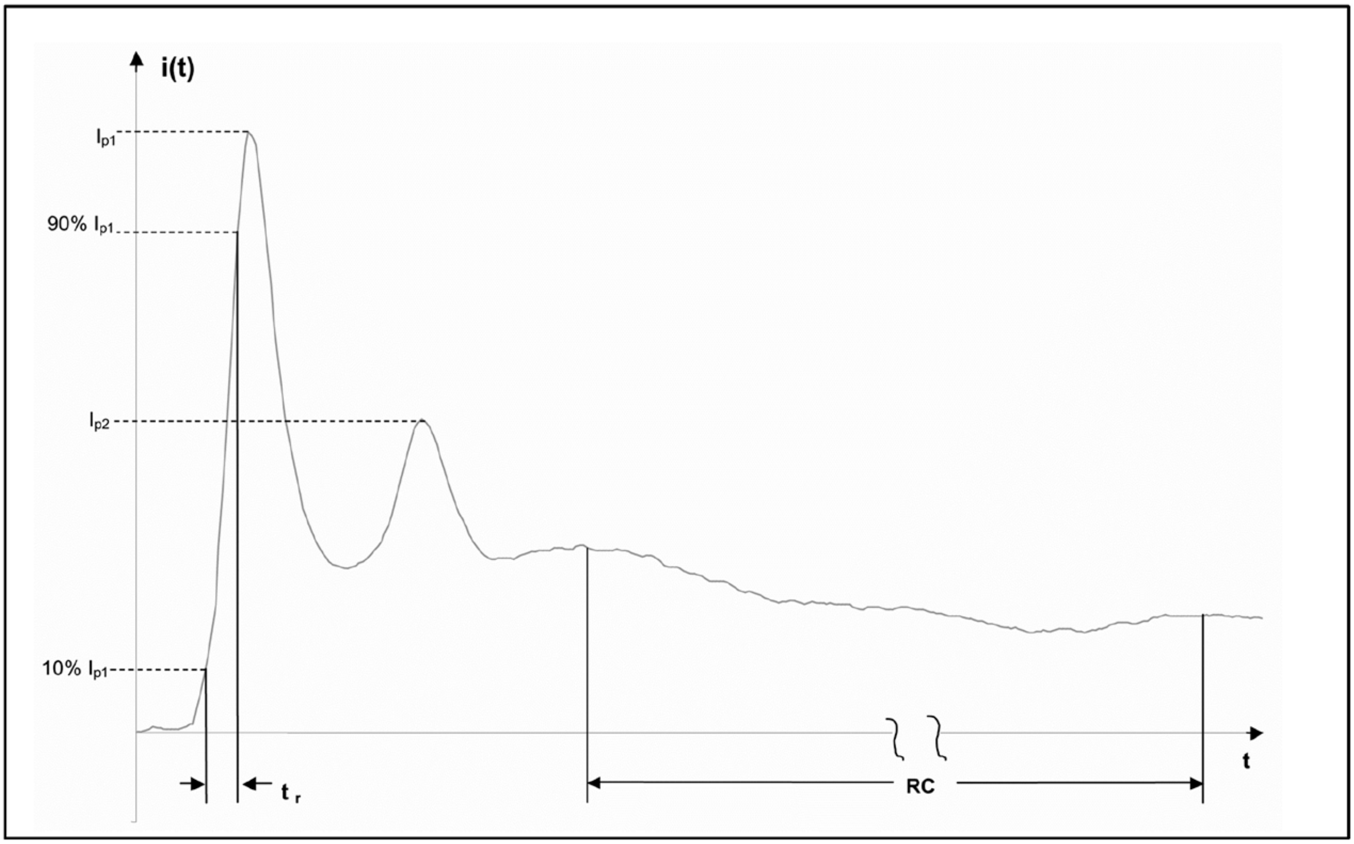


FIGURE A3—TYPICAL WAVEFORM SHAPE

ESD Simulator Waveshape Record

I_{p1}	______ Amps
I_{p2}	______ Amps
Risetime (10% to 90%) I_{p1}	______ ns
RC Time Constant	______ ns
Temperature	______ F or C
Relative Humidity	______ %
Simulator Voltage	______ kV
Polarity	______ + or -
Technician	______________________
Date	______________________

FIGURE A4—DATA SHEET 2—ESD SIMULATOR WAVESHAPE RECORD

A.2.9.6 Verify that the RC time constant value is 600 ns ± 120 ns, for the 330 pF probe, and 300 ns ± 60 ns for the 150 pF probe.

A.2.9.7 Acceptable ESD waveforms are those that are repeatable a minimum of six times in 10 attempts.

A.3 ESD Simulator Voltage Verification Procedure

A.3.1 Perform the ESD simulator Voltage verification before performing an ESD test or at the time intervals specified by the laboratory or customer.

A.3.2 To calibrate the display voltage of the ESD simulator, first adjust the ESD simulator voltage to the desired level and polarity. Use the electrometer to verify the voltages. Verify the voltage setting at voltage levels of ±2 kV, ±4 kV, ±6 kV, ±8 kV, ±15 kV, and ±25 kV. The electrometer reading shall be within ±500 V for voltages ≤±5 kV and ±10% for voltages >±5 kV to ≤±25 kV.

APPENDIX B
(INFORMATIVE)
ESD SIMULATOR RC TIME CONSTANT VERIFICATION

B.1 RC Time Constant

An acceptable ESD RC Time Constant Verification Waveform shall be a waveform that can be shown through demonstration to be:

a. Repeatable a minimum of six discharges out of 10 discharge attempts and
b. Has only a single event air discharge.

B.1.1 Connect the ESD simulator high voltage ground directly to the ground plane. Set the ESD simulator up and turn it on per manufacturer instructions (i.e.. Power cord, ground wire…).

B.1.2 Configure the oscilloscope using either the positive or negative setup. Ensure that the horizontal time scale of the scope is sufficient so as to observe enough of the exponential decay to measure the time constant.

B.1.3 Set the ESD Simulator voltage for ±15kv.

B.1.4 Position the ESD Simulator ground wire as far from the target and ground plane as possible.

B.1.5 Place the ESD simulator a minimum of 15 mm away from the device under test. Place the simulator air discharge probe perpendicular (± 15°) to the discharge location. Move it very slowly, i.e., 5 mm/s or less, toward the target until a single acceptable waveform discharge is obtained.

B.1.6 Record the RC Time constant and I_{p1} Risetime waveform values on Data Sheet 2 (Figure A4).

B.1.7 Figure B1 shows the measurement marker position when determining the RC Time constant.

B.1.8 The *RC* time constant is determined in the following manner:

a. Determine the waveform voltage value at the end of the waveform as displayed on the screen.
b. Divide the above value by 0.37 and set the oscilloscope markers (a_y and b_y) to read both this value and the voltage value found above.
c. Read the Δt value. This is the RC Time constant
d. Verify that the *RC* time constant value is (600 ± 120) ns for the 330 pf probe and (300 ± 60) ns for the 150 pf probe.
e. Continue until all test voltages and capacitance values have been tested.

FIGURE B1—RC TIME CONSTANT MEASUREMENT

APPENDIX C
(INFORMATIVE)
FUNCTION PERFORMANCE STATUS CLASSIFICATIONS

C.1 The test severity levels shown in Figure C1 are the recommended Performance Objective for the powered mode component test of Section 4.

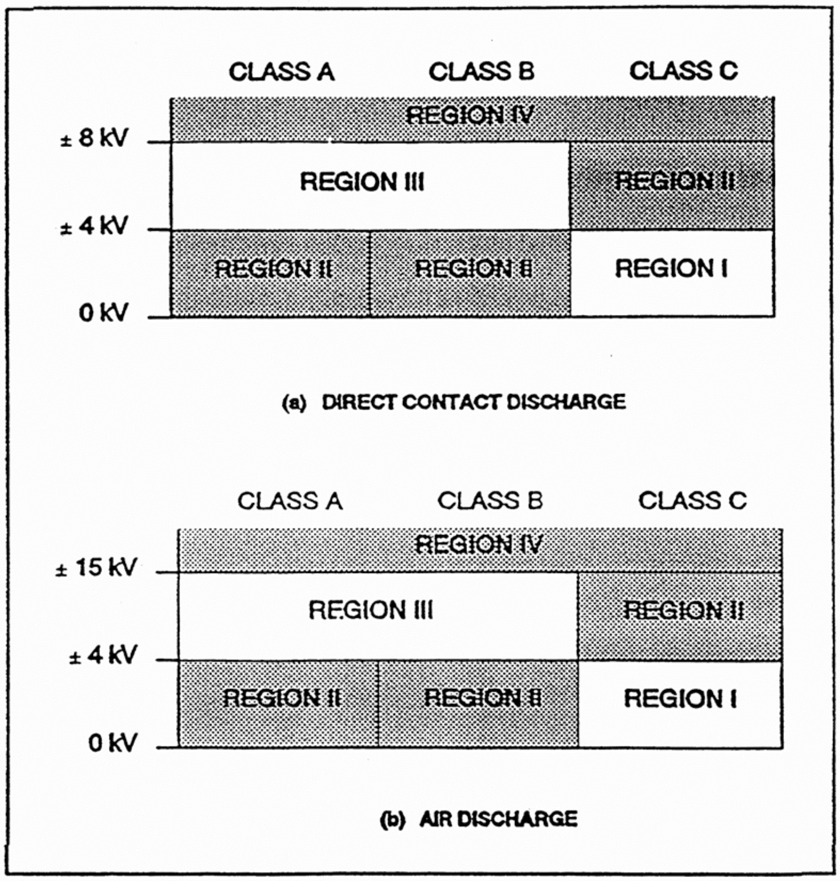


FIGURE C1—SUGGESTED TEST SEVERITY LEVELS

C.2 Figure C2 provides ESD Sensitivity Classification for the Packaging and Handling Sensitivity Classification test of Section 5.

ESD VOLTAGE (± kV)	TEST MODE	CLASSIFICATION
$0 < V \leq 4^*$	CONTACT DISCHARGE	EXTREMELY SENSITIVE
* RECOMMENDED MINIMUM ACCEPTANCE LEVEL = ±4 kV		
$4 < V \leq 6$	CONTACT DISCHARGE	HIGHLY SENSITIVE
$4 < V \leq 8$	AIR DISCHARGE	
$6 < V \leq 8$	CONTACT DISCHARGE	MODERATELY SENSITIVE
$8 < V \leq 15$	AIR DISCHARGE	
$15 < V \leq 25$	AIR DISCHARGE	SLIGHTLY SENSITIVE
$V > 25$	NOT TESTED	NOT SENSITIVE

FIGURE C2—ESD SENSITIVE COMPONENT CLASSIFICATION FOR PACKAGING AND HANDLING