SURFACE VEHICLE RECOMMENDED PRACTICE

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Vehicle Electromagnetic Immunity - Electrostatic Discharge (ESD)

RATIONALE

This document has been determined to contain basic and stable technology which is not dynamic in nature.

1. SCOPE

This SAE Standard specifies the ESD test methods and procedures necessary to evaluate electronic modules intended for vehicle use. It describes test procedures for evaluating electronic modules in complete vehicles.

A procedure for verifying the simulator that is used to generate the electrostatic discharges is given in Appendix A.

Functional status classifications for immunity to ESD are given in Appendix B.

2. REFERENCES

2.1 Applicable Documents

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

2.1.1 IEC Publication

Copies of these documents are available online at http://webstore.ansi.org/

IEC 61000-4-2 (2001-04) Electromagnetic Compatibility (EMC) - Part 4-2: Testing and Measurement Techniques - Electrostatic Discharge Immunity Test

2.1.2 ISO Publication

Copies of these documents are available online at http://webstore.ansi.org/

ISO 10605 Road Vehicles - Test Methods for Electrical Disturbances from Electrostatic Discharge

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3. DEFINITIONS

3.1 ELECTROSTATIC DISCHARGE (ESD)

A transfer of electrostatic charge between bodies at different potentials occurring prior to contact or induced by an electrostatic field.

3.2 HUMAN ESD MODEL FOR VEHICLE OCCUPANTS

The capacity, voltage, and resistance that characterize a person as a source of an electrostatic charge for automobile conditions. Figure 1 defines the model of capacitance and resistance network. The resistances are 330 Ohm or 2000 Ohm. The capacitance is 150 pF for an occupant outside vehicle. The capacitance is 330 pF for an occupant inside vehicle.

3.3 DUT

Device under test.

3.4 ESD SIMULATOR

An instrument that simulates the human ESD model for vehicle occupants.

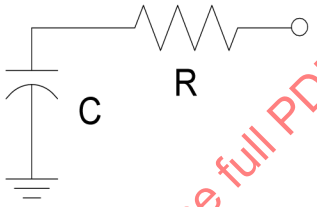


Figure 1 - Human body model

4. TEST EQUIPMENT

This section describes test equipment that is applicable to all parts of this procedure, including Appendix A.

4.1 An ESD simulator that simulates the Human Body ESD model having the following characteristics shall be used:

a. Voltage Range - Variable from -25 to +25 kV

b. Capacitance - 330 pF ± 10%, 150 pF ± 10%

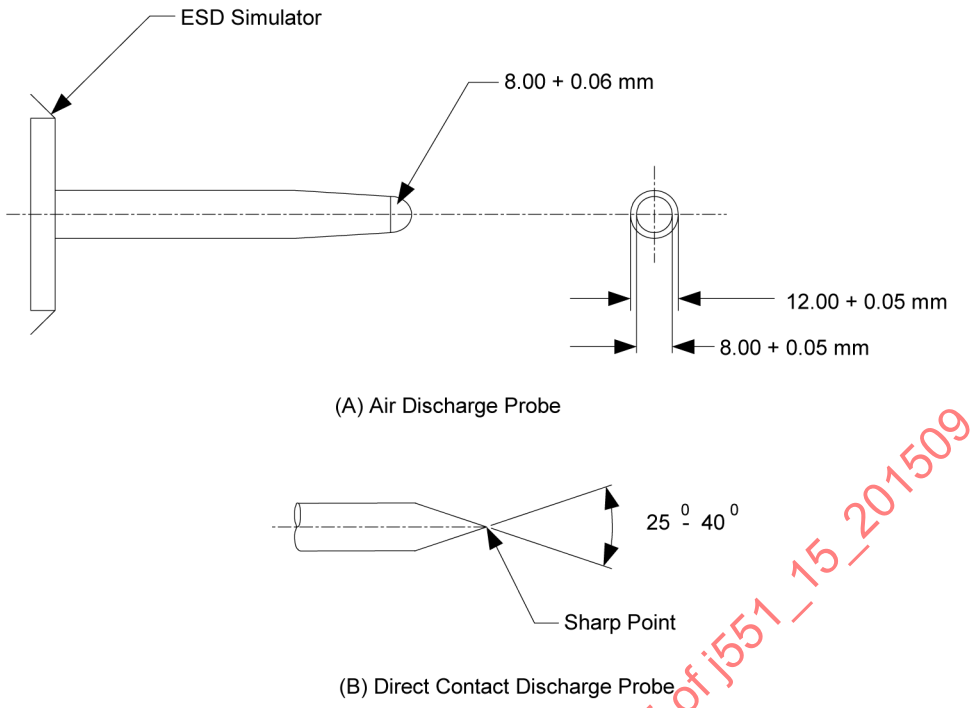
c. Resistance - 330 Ohm ± 10%, 2000 Ohm ± 10%

d. Risetime

   1. Direct Contact: 0.7 to 1.0 ns (into a 2 Ohm load)

   2. Air Discharge: less than 20 ns (into a 2 Ohm load)

e. Tip - (see Figure 2) - IEC 61000-4-2



NOTE 1: The discharge switch (e.g., vacuum relay shall be mounted as close as possible to the tip of the discharge electrode. Dimensions in millimeters

Figure 2 - ESD Simulator discharge tip probes

4.2 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 device under test and shall not allow bleed-off prior to discharge.

4.3 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 rate of 4 Gigasamples per second and a single shot bandwidth of 1 GHz. The instrument shall have 50 Ohm input impedance. The use of a Faraday shield, to separate the target from the measurement instrumentation, is highly recommended.

4.4 Voltage Probe (Electrometer)

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

5. TEST PROCEDURE

5.1 Record the pertinent test vehicle information or any specific test conditions in the test report.

5.2 Prior to performing the tests, a test plan shall be generated which shall include all the interface test points and respective test levels for each interface to be tested; the vehicle modes of operation such as drive/idle, cruise; and any special instructions and changes from the standard test.

5.2.1 The discharge points, at a minimum, shall include all accessible points, i.e., electrical switches and controls that can be interfaced by an occupant within the passenger compartment. Also any knobs, levers, or handles which would be actuated in the normal operation of the vehicle should be included.

5.2.2 In a standard test sequence, the vehicle's engine is to be running in idle mode.

5.2.3 Before the application of any discharges to the vehicle, the ESD Simulator Discharge Verification procedure of Appendix A shall be performed.

5.3 Test Environment

5.3.1 Temperature Range

Maintain the ambient temperature during the test at 25 °C ± 10 °C.

5.3.2 Relative Humidity

The relative humidity between 20% and 60% (20 °C and 30% relative humidity preferred).

5.4 ESD Operation Test Procedure

WARNING: For the safety of lab personnel, live airbags shall be DISABLED (mechanics install INERT airbags instead) when performing the test.

5.4.1 The ESD test simulator ground wire shall be electrically connected to the vehicle body inside the passenger compartment (see Figure 3). The steel seat adjustment rail or chassis is recommended. Similar approach may be used for underhood and trunk Locations if required. DC resistance shall be less than 1 Ohm.

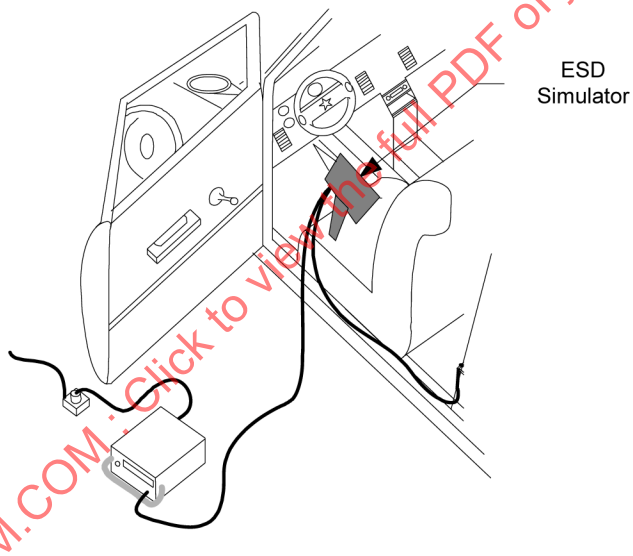


Figure 3 - Vehicle ESD test setup

5.4.2 All discharge points that can be accessed from inside the vehicle shall be tested with the 330 pF 330 Ohm (prefer) or 2000 Ohm probe at ±4, ±8, and ±15 kV. Only those discharge points that can be conveniently accessed when standing outside the vehicle (this in effect lowers a person's capacitance) and reaching inside, such as the headlight switch or the ignition switch, shall be additionally tested with the 150 pF 330 Ohm (prefer) or 2000 Ohm probe at ±25 kV. In this process, the ESD simulator shall be moved towards the discharge point as quickly as possible until either discharge occurs or the electrode touches the discharge point.

NOTE: Should failures occur when testing with air method, re-check by pulling and releasing the gun trigger only when gun is moved at least 0.5 m away from the discharge point. This will avoid any failures due to the radiated transient field induced by the gun relay.

5.4.3 Apply contact discharges to occupant entry or exit discharge locations, specifically the door handles, door window sills and a-pillars with the 330 pF 330 Ohm (prefer) or 2000 Ohm probe at ±4, ±8, ±15 and ±25 kV.

5.4.4 Each discharge point shall be subjected to a minimum of ten (10) positive polarity and ten (10) negative polarity discharges at each voltage level. The time duration between discharges shall at least 1 s for conductive surfaces with a conductive path to vehicle ground and 5 s for nonconductive surfaces. If the material unknown, 5 s shall be used. Alternatively, the discharge points can be discharged by touching with a grounded resistor (approx. 1 megohm) in case of conductive surfaces or with a grounded brush or sheet in case of nonconductive surfaces.

NOTE 1: At each voltage level, the discharge may be tested first at a single polarity and then tested with the alternate polarity.

NOTE 2: Multiple discharges to the same non-conductive area (e.g., radio bezel) may create a static charge where-upon subsequent full discharges are not possible (i.e., ESD simulator voltage is at similar potential as test object). For those cases, neutralize the DUT static charge between discharges (e.g., air ionizer).

NOTE 3: The connection of the simulator return cable to the Ground Reference and all bonding should be of low impedance. The discharge return cable of the simulator should be positioned at least 0.5 m from the DUT while the discharge is being applied. This space will minimize the influence of radiation from this cable to the test results.

5.4.5 Record all deviations noted from normal vehicle operation (visible, audible, anomalies, etc.) in the test report. Various operating systems such as heater controls, air conditioner controls, radio controls, and digital displays shall be exercised periodically during the test to demonstrate normal response.

5.5 Vehicle RF Impulse Test

Vehicle Electronic Components may be affected by ESD events by two ways:

1. ESD directly discharges to DUT or its Interface

2. ESD discharges to vehicle body and is radiated out through vehicle structure or human body. Then RF noises may coupe to vehicle electronic system(s) and affect its normal operation.

The RF Impulse Test is to simulate RF radiation through vehicle structure or human body. This is intended to be performed in addition to the normal ESD test, which subjects electronic modules to direct ES discharges. Real life ESD radiation events can occur in many situations, such as when a charged passenger moves away from a seating surface and/or exits the vehicle.

5.5.1 Test Environment

5.5.1.1 Temperature Range

Maintain the ambient temperature during the test at 25 °C ± 10 °C.

5.5.1.2 Relative Humidity

The relative humidity between 20% and 60% (20 °C and 30% relative humidity preferred).

5.5.2 Equipment Setup for the ESD RF Impulse Test (example)

Magnetic Field Adaptor: 15 cm ± 1.0 cm diameter. The Figure 4 shows the adaptor manufactured from Noise Ken (03-00049A). A similar adaptor could be developed for other ESD simulators.

Figure 4 - An example of the magnetic field adaptor for rf impulse test

5.5.3 ESD Gun Setup Parameters

Dwell Time:	Two (2) seconds (minimum)
Number of Discharges:	Five (5) at each location
Network:	330 pF / 330 Ohm
Polarity:	Positive
Mode:	Contact Discharge Mode

5.5.4 Verification Procedure

The ESD simulator shall be verified using the Direct Contact verification procedure in Appendix A. After the verification, the Direct Contact Discharge Probe is replaced by the magnetic field adaptor (15 cm ± 1.0 cm diameter conductive loop). One end of the magnetic field adaptor is connected to the ESD simulator and another end of the magnetic field adaptor is connected to the EMC simulator ground point.

5.5.5 ESD RF Radiated Impulse Test Procedure

WARNING: For the safety of lab personnel, live airbags shall be DISABLED (mechanics install INERT airbags instead) when performing the test.

5.5.5.1 Requirement

No effect to normal performance (Status I) of the DUT or vehicle E/E systems. Refer to Appendix B for the test level requirements.

5.5.5.2 ESD Gun Grounding

The ESD Gun does not need to be grounded to vehicle for this test.

5.5.5.3 Procedure

Place the Magnetic Field Adaptor in parallel to the test objects. Keep about 300 to 400 mm distance between the adaptor and the test object. Trig the ESD simulator for five (5) times at each location and observe the vehicle functional performance. The test locations shall be defined in the test plan (i.e., the driver entrance areas, cluster, radio, display, etc).

5.5.5.4 Test Report

The test results shall be written complete and legible. If any anomalies are observed during the test, the following information shall be included:

1. ESD Gun Adaptor position

2. Specific Anomalies

3. Humidity and Temperature

****Photos may be taken to help documenting the test setup and ESD Gun's positions.****

6. NOTES

6.1 Revision Indicator

A change bar (I) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE EMI 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 modules and systems.

Method A.2 is to be performed at least annually and the Method A.3 is to be performed before a test or at time intervals specified by the test facility or the customer.

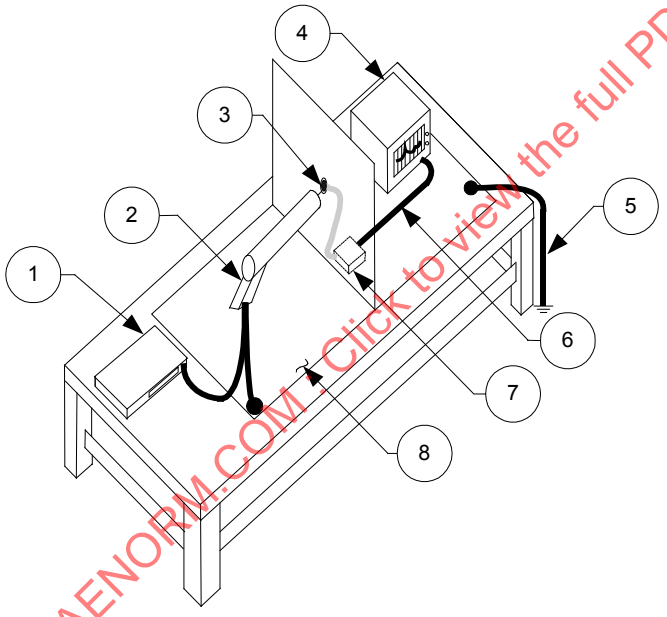
A.2 ESD SIMULATOR FULL VERIFICATION SETUP AND PROCEDURE

This procedure shall be performed at least annually by the user and more frequently with heavy usage.

A.2.1 The test setup shall be configured in accordance with Figure A1. Figure A2 shows an equivalent schematic of the setup.

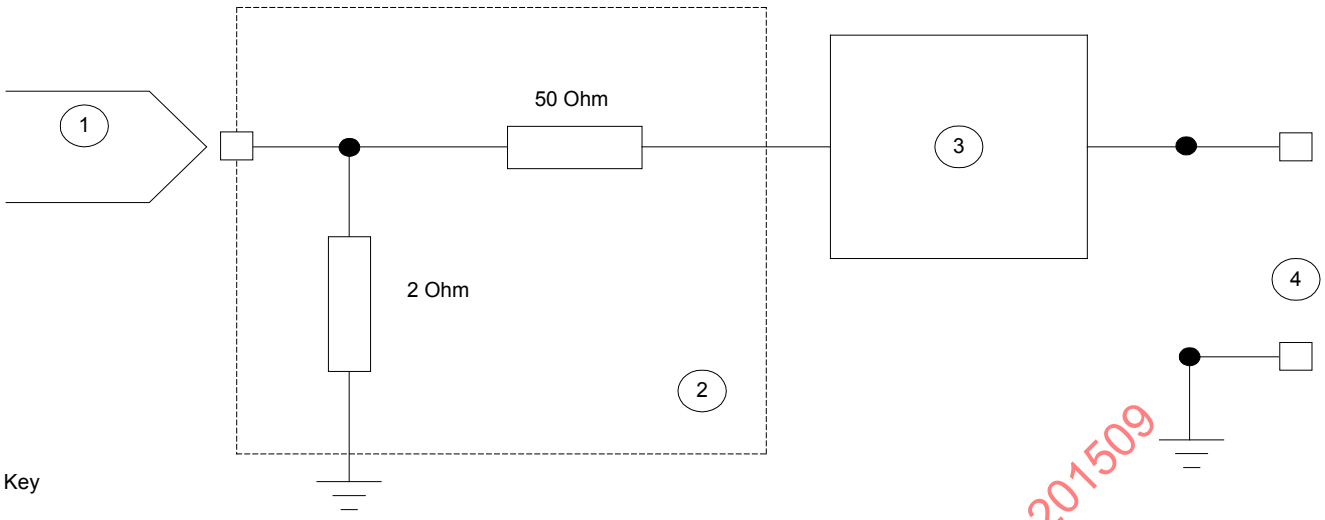
Note that a 20 dB wideband (18 GHz) attenuator shall be required as shown in Figure A1 depending on the vertical sensitivity of the oscilloscope.

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



Key:
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 20dB attenuator (optional)

4 Oscilloscope input

Figure A2 - Equivalent schematic

A.2.2 The ground plane shall be a conductive metallic sheet (i.e., copper, brass, or galvanized steel) with a minimum thickness of 1.0 mm and with an area of at least 1 m^2. 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.)

A.2.3 The coaxial target shall be located on and bonded to the ground plane. A 50 Ohm coaxial target specified by IEC 61000-4-2 shall be used during the ESD simulator verification. The target output shall be connected to the oscilloscope through a 50 Ohm double-shielded high frequency cable ≤1 m long. 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 or the grounding strap provided by manufacturer.

A.2.5 The ESD simulator shall be set up and operated according to its instruction manual.

A.2.6 To verify the display voltage of the ESD simulator, first adjust the ESD simulator voltage to the desired level and polarity. Use the electrometer of 4.6 to verify the voltage setting at voltage levels of ±4 kV, ±6 kV, ±8 kV, ±15 kV, and ±25 kV. The electrometer reading shall be within ±500 V for voltages ≤±8 kV and ±10% for voltages >±8 kV to ≤±25 kV.

A.2.7 ESD Simulator Risetime Verification Procedure

A.2.7.1 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.2.7.2 Direct Contact Discharge Verification

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.

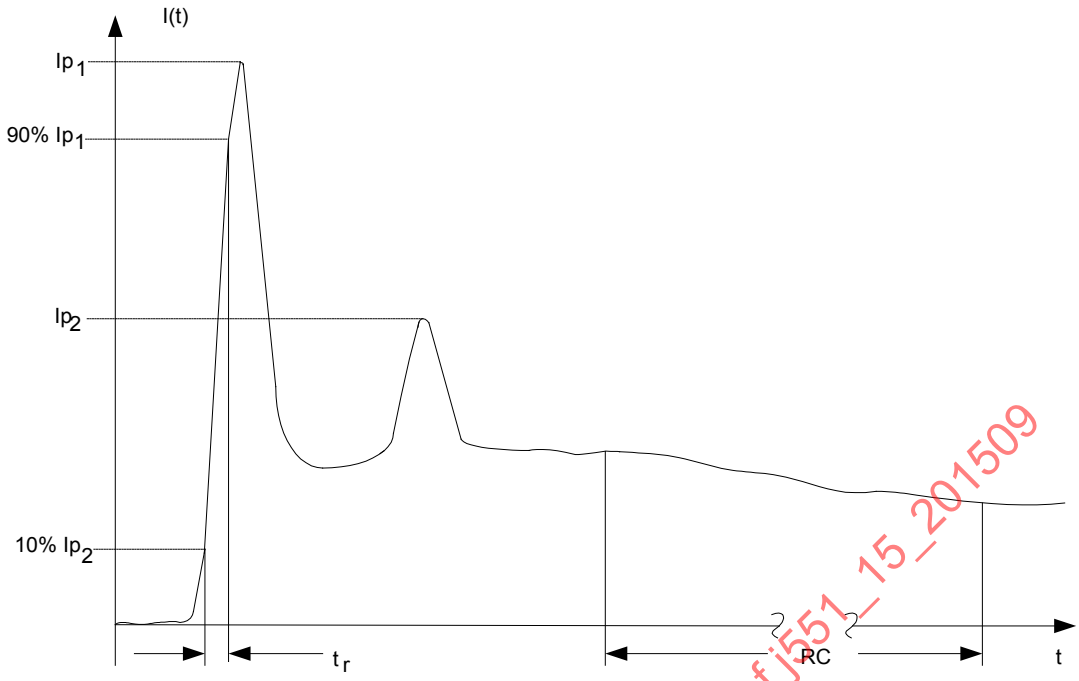


Figure A3 - Typical output waveform of the ESD simulator

A.2.7.3 Air Discharge Verification (performed at ±15 kV only)

The ESD simulator shall be placed a minimum distance of 15 cm 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.2.7.3.1 Record the waveform shape and parameters on Data Sheet (see Figure A4.)

A.2.7.3.2 Verify that the air discharge risetime at each polarity is ≤20 ns.

Table A1 - Direct discharge verification parameters

Level	Indicated Voltage	First Peak Current	Risetime With Discharge Switch
1	2 (kV) ± 10%	7.5 A +2.25 A –0 A	0.7 to 1 ns
2	4 (kV) ± 10%	15.0 A +4.5 A –0 A	0.7 to 1 ns
3	6 (kV) ± 10%	22.5 A +6.75 A –0 A	0.7 to 1 ns
4	8 (kV) ± 10%	30.0 A +9.0 A –0 A	0.7 to 1 ns