SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
400 Commonwealth Drive, Warrendale, PA 15096-0001

SURFACE VEHICLE STANDARD

SAE J1113-4 | REV. MAY97

Issued 1995-04
Revised 1997-05

Superseding J1113-4 APR95

Submitted for recognition as an American National Standard

IMMUNITY TO RADIATED ELECTROMAGNETIC FIELDS—BULK CURRENT INJECTION (BCI) METHOD

1. ***Scope***—This SAE Standard defines a method for evaluating the immunity of automotive electrical/electronic devices to radiated electromagnetic fields coupled to the vehicle wiring harness. The method, called Bulk Current Injection (BCI), uses a current probe to inject RF current from 1 to 400 MHz into the wiring harness of automotive devices. BCI is one of a number of test methods that can be used to simulate the electromagnetic field. For a list of others, see SAE J1113/1.

1.1 **Measurement Philosophy**—As a vehicle is driven near high power transmitting antennas or when a mobile transmitter is used on a vehicle, the radiated electric field couples, either directly or through the wiring harness, into electronic devices on the vehicle. In the frequency range of 1 to 400 MHz, coupling occurs mostly through the wiring harness. To simulate this coupling, BCI can be used. BCI provides a method of compatibility evaluation by inducing high-frequency current into the wiring harness. It is a nonintrusive method since the wiring harness is not broken. BCI lends itself to the case of devices with many interconnecting wires.

2. ***References***—General information regarding this document, including definitions, references, and general safety considerations is found in SAE J1113/1.

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 ANSI PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ANSI C95.1—American National Standards for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, [3 kHz to 300 GHz]

2.1.3 ISO PUBLICATION—Available from ANSI, 11 West 42nd Street, New York, NY 10036-8002.

ISO 11452-4—Road vehicles—Electrical disturbances by narrowband radiated electromagnetic energy—Component test methods: Bulk current injection (BCI)

QUESTIONS REGARDING THIS DOCUMENT: (412) 772-8512 FAX: (412) 776-0243
TO PLACE A DOCUMENT ORDER; (412) 776-4970 FAX: (412) 776-0790

2.1.4 MILITARY PUBLICATION—Available from the U. S. Government, DOD SSP, Subscription Service Division, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094

MIL-STD-462D-CS114—Conducted Susceptibility, Bulk Cable Injection, 10 kH to 400 MHz

3. Test Equipment

3.1 RF Signal Generator—1 to 400 MHz.

3.2 Broadband Power Amplifier—1 to 400 MHz, 50 W minimum. The amplifier should be able to drive a load of any impedance mismatch without damage to itself.

3.3 Current Injection Probe—1 to 400 MHz high power capability. More than one type of probe may be required.

3.4 Current Monitoring Probe—1 to 400 MHz. The monitor probe output voltage (V_{out}) should be converted to the induced current (I_{ind}) by the following relationship:

$$I_{ind}[dBmA] = V_{out}[dBmV] - Z_t[dB\Omega] \quad \text{(Eq. 1)}$$

where:

Z_t = Current probe transfer impedance

The transfer impedance of the current monitoring probes shall be verified and/or updated yearly.

3.5 Spectrum Analyzer or Equivalent—(For use with monitoring probe.)

3.6 Directional Coupler (Optional)

3.7 Power Meter

3.8 Computer Control (Optional)

4. Test Setup

4.1 The test setup is shown in Figure 1.

NOTE 1—If a regulated power supply is used to power the DUT, then a LISN shall be used in the supply line. This network (LISN) is specified in SAE J1113/1.

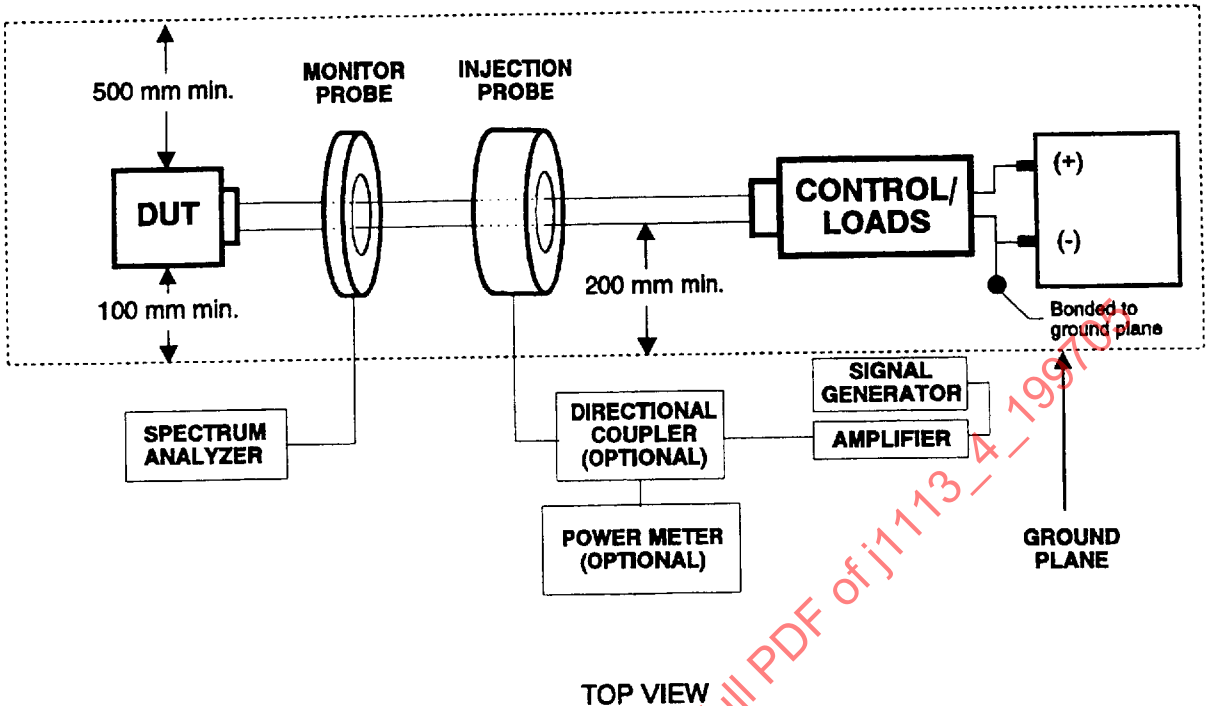
NOTE 2—When a battery is used, a charging source may be required to maintain the specified supply voltage.

4.2 The test shall be performed in a shielded room.

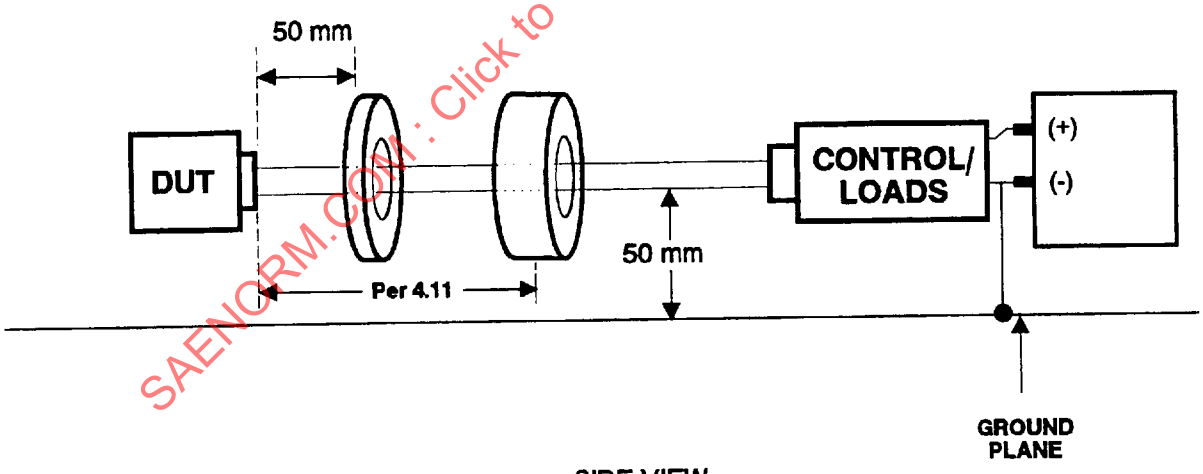
4.3 The ground plane requirements are specified in SAE J1113/1.

4.4 The grounding of the DUT and/or its outer case depends on its application in the vehicle. If the DUT will be grounded when installed in the vehicle, then it must be bonded to the ground plane in the bench test the same way it will be attached in the vehicle. If not, the DUT shall be placed on an insulated support.

4.5 A 1 m test harness including any permanently attached pigtail shall be used unless otherwise specified in the test plan. Any variance from the standard harness shall be described in the test report.



TOP VIEW



SIDE VIEW

ALL DIMENSIONS ± 5 mm TOLERANCE

FIGURE 1—BCI TEST SETUP

4.6 The bottom of the wiring harness bundle must be maintained 50 mm above the ground plane along its entire length.

4.7 The grounding of the battery polarity depends on its application in the vehicle. The battery terminal that is used as reference shall be bonded to the ground plane using a low resistance ground strap of less than 2.5 mW.

4.8 The harness ground at the simulator end must be attached to the ground plane.

4.9 The current injection and current monitoring probes shall be insulated from the ground plane and supported (if needed) to keep the probes concentric about the harness.

4.10 The current monitoring probe shall be located 50 mm ± 5 mm from the outermost edge of the DUT connector (measured from the center of the probe) as shown in Figure 1.

4.11 The current injection probe shall be positioned 120 mm ± 5 mm from the outermost edge of the DUT connector (measured from the center of the probe) as shown in Figure 1. The test shall be repeated with the injection probe at 450 mm ± 5 mm and 570 mm ± 5 mm from the connector.

NOTE—Performing the measurements at 3 locations minimizes wiring harness resonance effects.

4.12 The DUT is to be operated in its designed modes. Therefore, appropriate control signals should be provided and actual or simulated loads used.

4.13 DUT performance criteria should be accurately defined. Appropriate instrumentation to monitor for anomalies shall be provided.

4.14 Proper steps should be taken to prevent the RF energy from coupling into control and/or monitoring equipment.

5. Test Procedure

5.1 **Test Plan**—Prior to performing the tests, a test plan shall be generated which shall include interface test points, DUT mode of operation, DUT acceptance criteria, and any special instructions and changes from the standard test. Every DUT shall be verified under the most significant situations; i.e., at least in stand-by and in a mode where all the actuators can be excited. The Function Performance Status Classification of SAE J1113/1 Appendix A shall be reviewed.

5.2 **Test Conditions**—The test conditions specifying: Test temperature and supply voltage, Modulation, Dwell time and Frequency steps are given in 6.1 of SAE J1113/1.

5.2.1 FREQUENCY RANGE—The frequency range of the BCI test method is 1 to 400 MHz. The frequency range of the BCI test method is a direct function of the current probe characteristic. More than one type of current probe may be required.

5.3 There are two test methods for the BCI test: the current monitoring probe method (closed-loop) and the calibrated injection probe method (substitution). For both tests, the test equipment shall be connected in a similar manner to that shown in Figure 1.

NOTE—HAZARDOUS VOLTAGES AND FIELDS MAY EXIST WITHIN THE TEST AREA. CARE SHOULD BE TAKEN TO ENSURE THAT THE REQUIREMENTS FOR LIMITING THE EXPOSURE OF HUMANS TO RF-ENERGY ARE MET. (i.e., ANSI C95.1)

5.3.1 CURRENT MONITORING PROBE METHOD (CLOSED-LOOP METHOD)

5.3.1.1 Mount the injection probe around the harness at each of the three (3) positions defined in 4.11.

5.3.1.2 At each probe position, a search for performance anomalies (see 4.13) shall be conducted over the frequency range of the injection probe using CW with ON-TO-OFF and OFF-TO-ON transitions. All performance anomalies found during the transitions and during the CW dwell time shall be recorded.

NOTE—Avoid overshoots during the OFF-TO-ON transitions.

5.3.1.3 For each anomaly, the lowest induced current measured by the Current Monitoring Probe shall be recorded as the threshold of immunity.

5.3.1.4 The search for performance anomalies shall continue by incrementing the power level until either one of the following stop criteria is met:

a. The specified maximum induced current level is achieved,
b. The maximum forward power to the injection probe of 50 W ± 0.5 W is achieved, or
c. Any of the first 5 harmonics (up to 400 MHz) is within 9 dB of the fundamental frequency.

5.3.2 CALIBRATED INJECTION PROBE METHOD (SUBSTITUTION METHOD)

5.3.2.1 Calibrate the injection probe according to the method described in Appendix B.

5.3.2.2 Mount the current injection probe around the harness as defined in 4.11. Where the harness contains a number of branches, the test shall be repeated with the current probe(s) clamped around each of the branches. Under these test conditions, the monitoring probe, if used, shall be left at its previous distance from the DUT.

5.3.2.3 Using either the pre-calibrated level of net power or a relatively high level of fixed net power, a search for anomalies shall be conducted over the frequency range of the injection probe.

5.3.2.4 For each event, the lowest net power to the probe shall be recorded as the threshold of immunity even if this is found with the injection probe in different positions at different frequencies. The use of a current monitoring probe as defined in 4.10 is optional.

5.4 Test Reports—When required in the test plan, a test report should be submitted detailing information regarding the test equipment, test site, systems tested, length of test harness used, frequencies, power levels, system interactions, and any other relevant information regarding the test.

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 A.

7. Notes

7.1 Marginal Indicia—The change bar (I) 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 AND TEST METHODS STANDARDS COMMITTEE

APPENDIX A

TEST SEVERITY LEVELS

A.1 The test levels in Figure A1 are the recommended performance objectives for this test.

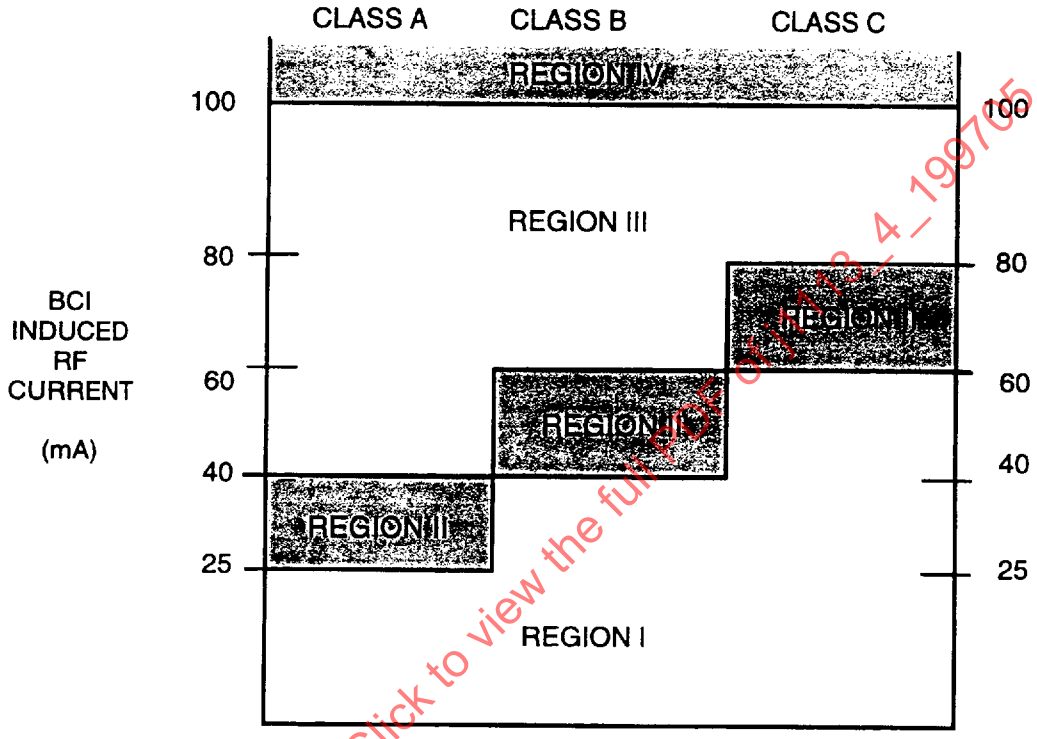


FIGURE A1—SUGGESTED TEST SEVERITY LEVELS