SAE International™

SURFACE VEHICLE STANDARD

SAE J1113-22

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Electromagnetic Compatibility Measurement Procedure for Vehicle Components—Part 22—Immunity to Radiated Magnetic Fields

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1. Scope

This SAE Standard specifies the test methods and procedures for vehicle components to determine the components immunity to radiated magnetic fields.

2. References

2.1 Applicable Publications

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

2.1.1 SAE PUBLICATIONS

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

SAE J1113-1—Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft)
SAE J1812—Function Performance Status Classification for EMC Immunity Testing

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: custsvc@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

2.1.2 IEEE PUBLICATION

Available from Institute of Electrical and Electronic Engineers, 445 Hoes Lane, Piscataway, NJ 08854.

Bronaugh, Edwin L., "Helmholz Coils for EMI Immunity Testing: Stretching the Uniform Field Area," IEEE, 7th International Conference on EMC, York, England, 28–31, August 1990.

2.1.3 MILITARY PUBLICATIONS

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

MIL STD 461E—Department of Defense Interface Standard; Requirements for the Control of Electromagnetic Interface Characteristics of Subsystems and Equipment, 1999

3. Definitions

See SAE J1113-1.

4. Measurement Philosophy

See SAE J1812.

5. Essential Elements of Function Performance Status Classification

See SAE J1812.

6. Test Equipment, Test Setup and Test Procedure

Prior to performing the tests, a test plan shall be generated which shall include:

Test method

Test points for the radiating loop method if used

DUT axes (X, Y and Z) for the Helmholtz coil method if used

6.1 Test Equipment

The instrumentation shall be immune to the generated magnetic fields at its test location.

6.1.1 FUNCTION GENERATOR/LF GENERATOR

Capable of producing sinusoidal and square wave signals from 15 Hz to 30 KHz.

6.1.2 AUDIO POWER AMPLIFIER/LF AMPLIFIER

15 Hz to 30 KHz bandwidth minimum (approximately 200 W).

6.1.3 CURRENT MONITOR/PROBE

15 Hz to 30 kHz bandwidth minimum, true rms AC voltmeter or current meter.

6.1.4 MAGNETIC FIELD INTENSITY MONITOR/PROBE

15 Hz to 30 KHz bandwidth minimum with DC rejection to reject the earth's magnetic field.

6.1.5 MAGNETIC FIELD PROBE (HELMHOLTZ METHOD ONLY)

0 to 100 μT minimum.

NOTE—The field has to be monitored only if the coils are separated more than one radius (R). If a Helmholtz coil system is constructed accurately, then the field produced can be calculated with high accuracy and a field intensity monitor is not required.

6.2 Test Setup

The test harness shall be placed on a non-conductive, low permeability support.

6.2.1 RADIATING LOOP (FIGURE 1)

The radiating loop method is based on the use of coil current as the reference parameter for calibration and test.

For this method, the radiating loop of MIL STD 461E is recommended, but any similar coil may be used. The MIL STD 461E coil has the following characteristics:

Diameter: 120 mm
Number of turns: 20
Wire: Approx. 2.0 mm (AWG12)

The flux density (B) at a distance of 50 mm from the plane of the loop is given by Equation 1:

$$B = \mu_0 * H = 9.5x10^{-5} * I \text{ (Tesla)} \quad \text{(Eq. 1)}$$

The unperturbed magnetic field (H) at a distance of 50 mm from the plane of the loop is given by Equation 2:

$$H = 75.6 * I \text{ (A/m)} \quad \text{(Eq. 2)}$$

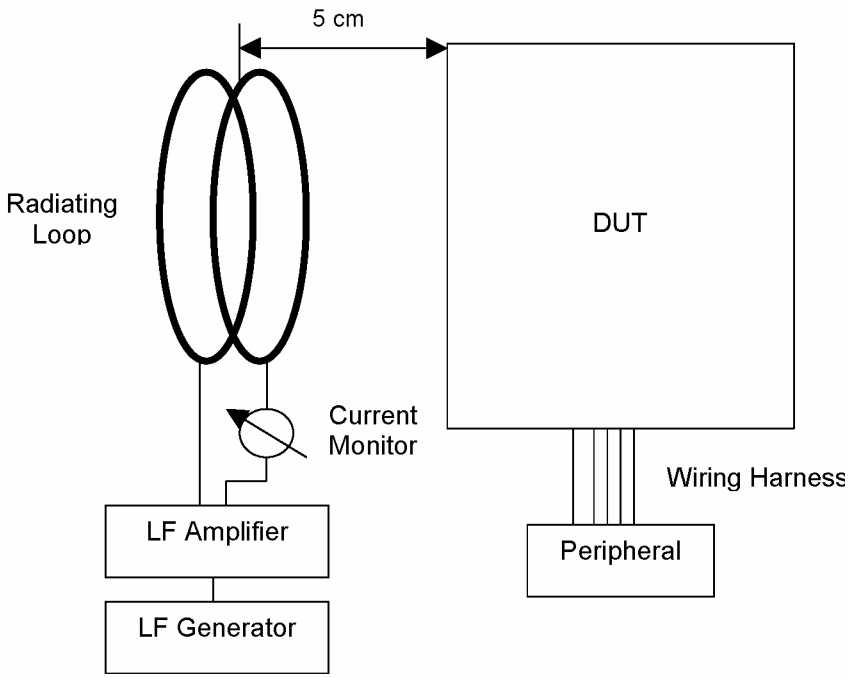

FIGURE 1—RADIATING LOOP TEST SETUP

6.2.2 HELMHOLTZ COIL METHOD (FIGURE 2)

The radius of the coil will be determined by the size of the DUT. In order to obtain a uniform magnetic field (+10%, -0%), the relationship between the DUT and the coil, shown in Figure 3, should be met. The uniform field region shown in Figure 3 is for a cube shaped DUT. For differently shaped DUTs and information on how to trade off field uniformity for DUT size, refer to the published article by Mr. Bronaugh in the listed references

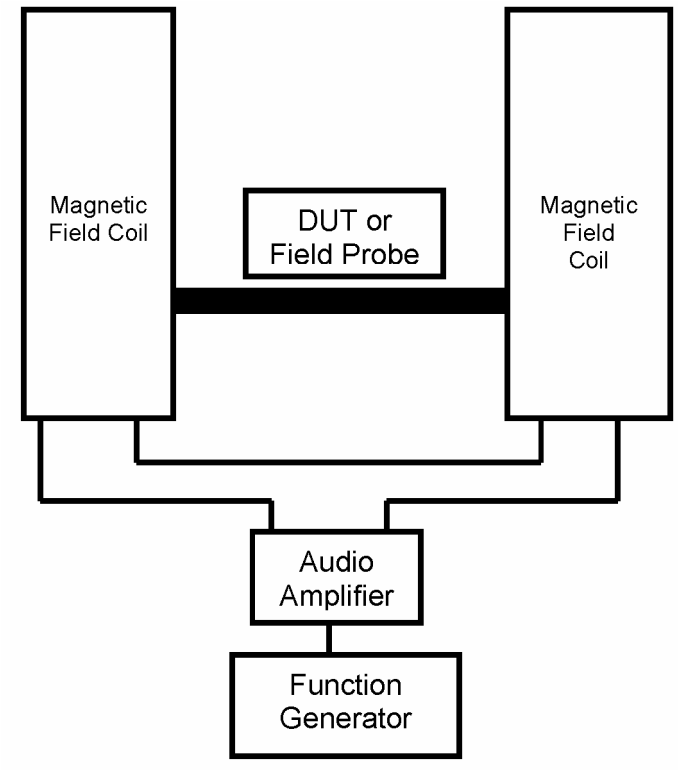

FIGURE 2—HELMHOLTZ COIL TEST SETUP

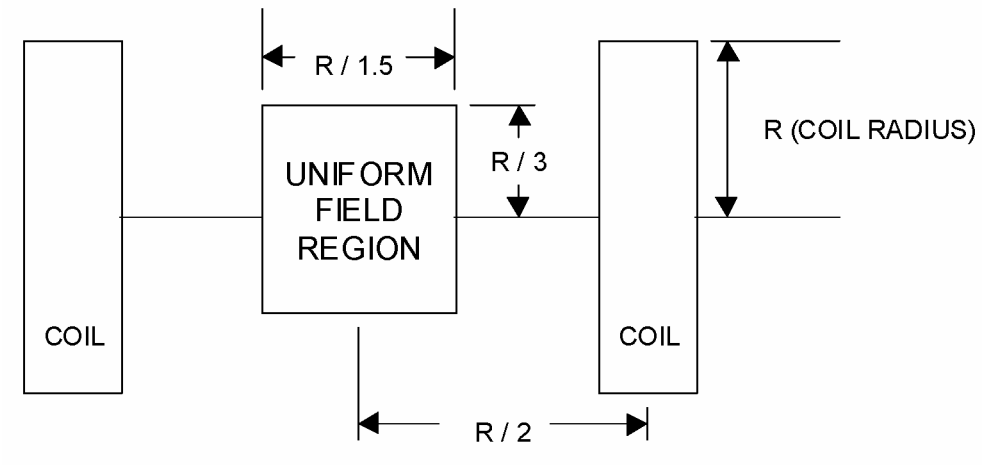

FIGURE 3 HELMHOLTZ COIL CONFIGURATION

For a pair of Helmholtz coils spaced one radius apart, the magnetic flux density at the center of the system is given by Equation 3:

$$B = \mu_0 * H = (8.991*10^{-7} * N * I)/ R, \text{ (Tesla)} \qquad \text{(Eq. 3)}$$

where:

N is number of wire turns on a coil
R is coil radius (m)
I is coil current (A)

The unperturbed magnetic field at the center of the system is given by Equation 4:

$$H = (0.7155*N*I)/R, \quad (A/m) \qquad \text{(Eq. 4)}$$

where:

N is number of wire turns on a coil
R is coil radius (m)
I is coil current (A)

The current carrying capability and number of turns of the coil should be selected such that the test specification can be met. The coil should not have a self resonant frequency at or lower than the upper harmonic frequency of 30 kHz. Helmholtz coils can be purchased commercially.

6.3 Test Procedure

The test is conducted by subjecting the device under test and the associated harness to the test signal based on the calculated or calibrated value as defined in the test plan.

The DUT shall be made to operate under typical loading and other conditions as in the vehicle. These operating conditions must be clearly defined in the test plan to ensure that the test is repeatable.

6.3.1 RADIATING LOOP

Prior to the actual test with the DUT present, the coil current required to generate a specific field strength (measured with a magnetic field intensity monitor) shall be determined for each frequency.

6.3.1.1 Test frequency steps are found in Table III of MIL-STD-461E except extended down to 15 Hz.

6.3.1.2 Connect the setup according to Figure 4 for calibration purposes.

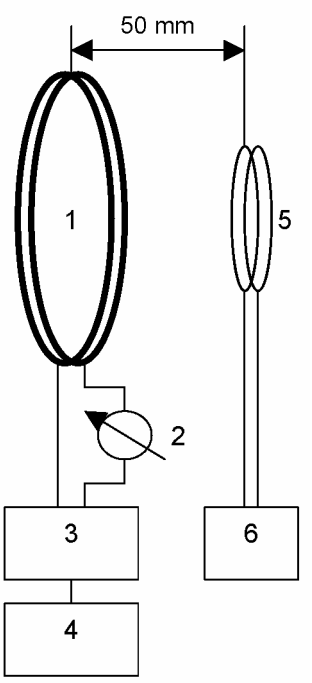

FIGURE 4—RADIATING LOOP CALIBRATION

Key
1 Radiating loop
2 Current monitor
3 LF Amplifier
4 LF generator
5 Sensor coil
6 Voltmeter

6.3.1.3 Without the DUT present and using the Magnetic Field Intensity Monitor- calibrate the magnetic field at 10 A/m. Record the RMS current through the magnetic coils versus field values for each test frequency.

6.3.1.4 Connect the setup according to Figure 1 for testing of the DUT.

6.3.1.5 Each face of the DUT shall be partitioned into equal areas of 100 mm X 100 mm or less. The radiating loop shall be positioned 50 mm from the center of each of these areas and parallel to the face of the DUT.

6.3.1.6 In addition the radiating loop shall be placed at each electrical interface connector, and harness, and at any attached magnetic sensor(s). The radiating loop shall be placed so that maximum coupling occurs between it and any attached magnetic sensor(s).

6.3.1.7 All wires in the harness shall be terminated or open according to the vehicle application. If possible, the actual loads and actuators shall be used.

6.3.1.8 Place the radiating coil 50 mm from a test point on the operating DUT (see Figure 1).

6.3.1.9 Generate the defined magnetic field levels, either from the calculated or calibration values, (see 6.2.1).

6.3.1.10 At each frequency, expose the DUT for a minimum of 2 s.

6.3.1.11 Monitor the DUT and record the respective field intensity for:

a) malfunction
b) degradation of performance, or
c) deviation from predefined tolerances

Repeat 6.3.1.7 thru 6.3.1.10 for the other test points of the DUT.

6.3.2 HEMLHOLTZ COIL

6.3.2.1 For a properly constructed Helmholtz coil, calibration is not required. If calibration is required, see note after 6.1.5 and proceed to 6.3.2.2. If Calibration is not required, proceed to 6.3.2.4.

6.3.2.2 Connect the calibration setup according to Figure 5.

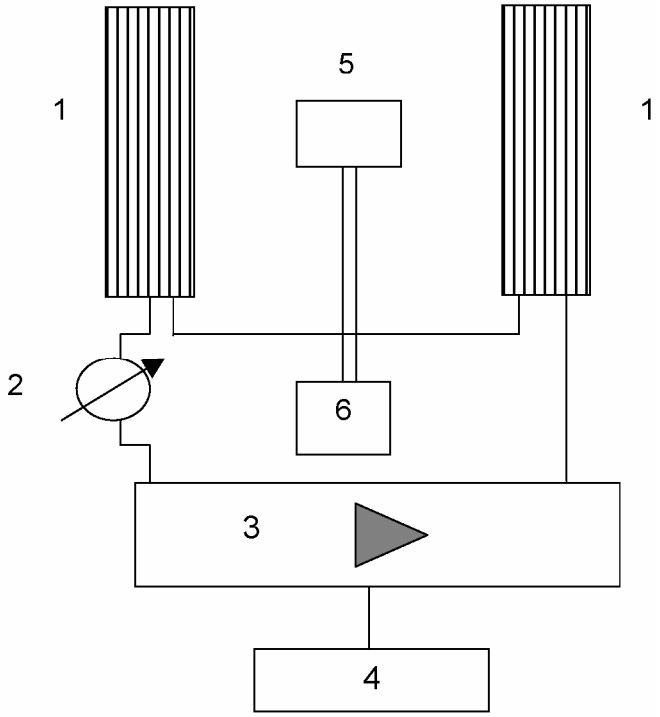

FIGURE 5 —HELMHOLTZ COIL CALIBRATION

Key
1 Coil(s)
2 Current Monitor
3 LF amplifier
4 LF generator
5 Magnetic Field Probe
6 Magnetic Field Monitor

6.3.2.3 Calibrate the system by generating the magnetic field, measuring the field using the intensity monitor, and recording the coil current versus field values.

6.3.2.4 Place the operating DUT in the uniform field region of the Helmholtz coil.

6.3.2.5 Generate the desired magnetic field levels either from calibration or calculated values.

6.3.2.6 At each field strength level, expose the DUT for a minimum of 2 s.

6.3.2.7 Monitor the DUT and record the respective magnetic field intensity for: (a) malfunction, (b) degradation of performance, or (c) deviation of parameters beyond tolerances up to the performance levels defined in Appendix A.

6.3.2.8 Repeat steps 6.3.2.5 thru 6.3.2.7 for the other two orientations of the DUT.

NOTE—Caution must be exercised when operating high power amplifiers to avoid hazards to personnel and instrumentation. Instrumentation in the near vicinity of the coils must be shielded to prevent interference from radiated fields. Care should be exercised not to operate the coils near large metal objects to prevent movement or heating of the metal object.

7. Notes

7.1 Marginal Indicia

The change bar (l) is the convenience of the user in locating areas where technical changes have been made to the previous issue of the report. If the (R) symbol is next to the report title, it indicates a complete revision of the report.

PREPARED BY THE SAE EMI STANDARDS COMMITTEE

APPENDIX A
(INFORMATIVE)
FUNCTIONAL STATUS CLASSIFICATION, REGION OF PERFORMANCE, AND TEST SIGNAL SEVERITY LEVEL FOR IMMUNITY TESTING

A.1 The test levels in Figure A1 are the Suggested Performance Objectives for this test.

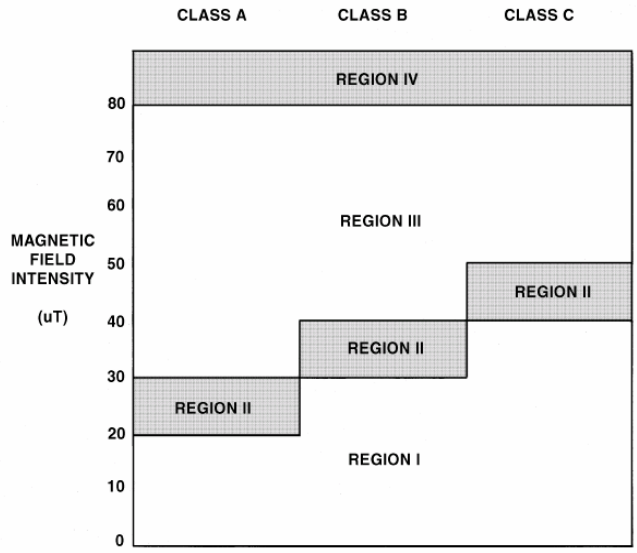

FIGURE A1—SUGGESTED TEST SEVERITY LEVELS

Rationale

This test method has been in use for over 20 years in the industry and is now included in the SAE J1113 series.

Relationship of SAE Standard to ISO Standard

A corresponding standard (ISO 11452-8) is currently under development.

Application

This SAE Standard covers the recommended testing technique for determining the immunity of automotive electronic devices to magnetic fields.

Reference Section

SAE J1113-1—Electromagnetic Compatibility Measurement Procedures and Limits for Vehicle Components (Except Aircraft)

SAE J1812—Function Performance Status Classification for EMC Immunity Testing

MIL STD 461E—Department of Defense Interface Standard; Requirements for the Control of Electromagnetic Interface Characteristics of Subsystems and Equipment, 1999

Bronaugh, Edwin L., "Helmholz Coils for EMI Immunity Testing: Stretching the Uniform Field Area," IEEE, 7th International Conference on EMC, York, England, 28–31, August 1990.

Developed by the SAE EMI Standards Committee