The Engineering Society For Advancing Mobility Land Sea Air and Space®
INTERNATIONAL
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SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J1113/22

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ELECTROMAGNETIC COMPATIBILITY MEASUREMENT PROCEDURE FOR VEHICLE COMPONENTS—PART 22—IMMUNITY TO RADIATED MAGNETIC FIELDS FROM POWER LINES

*1. **Scope***—This SAE Recommended Practice covers the recommended testing technique for determining the immunity of automotive electronic devices to magnetic fields generated by power transmission lines and generating stations.

1.1 **Measurement Philosophy**—Electronic systems may be affected when immersed in a magnetic field. These fields are found near high-power transmission lines and power generating stations. The fields consist of the fundamental (60 Hz signal) and its odd harmonics. Consequently, devices in vehicles that are driven near these sources may be subjected to these fields.

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

2.1 **Applicable Documents**—The following publications form a part of this specification to the extent specified herein. The latest issue 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)

2.1.2 IEE PUBLICATION—Available from Institute of Electrical Engineers, 445 Hose Lane, Piscataway, NJ 08854.

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

*3. **Test Equipment***

3.1 The following section describes a typical test setup that could be used to generate a uniform magnetic field. Figure 1 illustrates this setup.

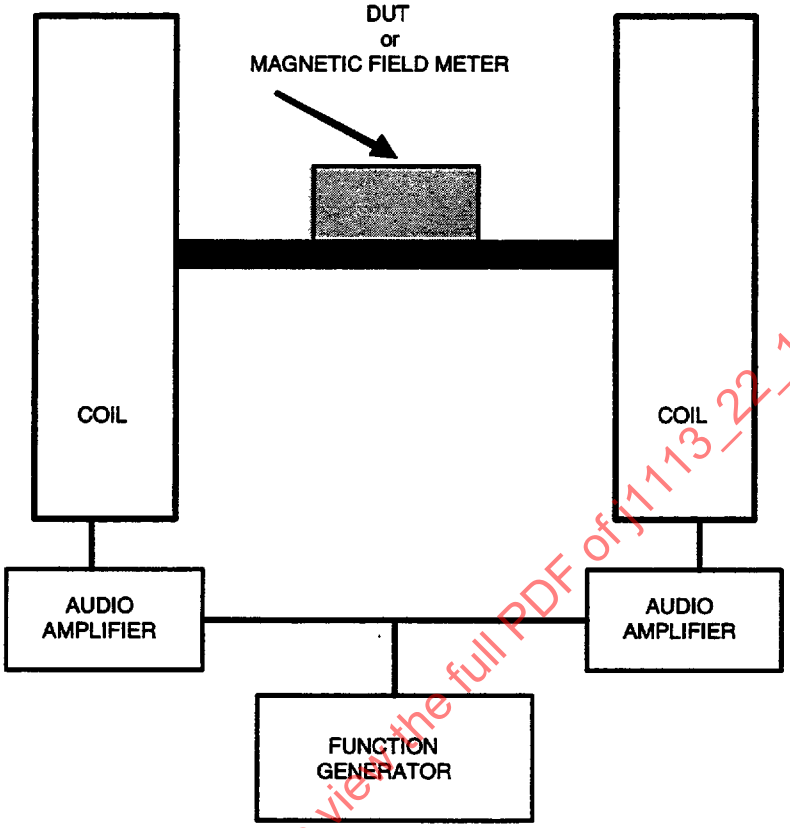

FIGURE 1—MAGNETIC FIELD TEST SETUP

3.2 Helmholtz Coil—The radius of the coil will be determined by the size of the DUT. In order to obtain a uniform magnetic field (+10%), the relationship between the DUT and the coil, shown in Figure 2, should be met. The uniform field region shown in Figure 2 is for a cube shaped DUT. For differently shaped DUTs and information on how to trade off field uniformity for DUT size, the reader is referred to Bronaugh.[1]

The coil should be capable of producing a frequency-dependent magnetic field intensity of 160 dBpT (100 μT) at 60 Hz, decreasing at a rate of 12 dB/octave for odd harmonics of 60 Hz up to 30 kHz (see Figure 3). For a pair of Helmholtz coils spaced one radius apart, the magnetic flux density at the center of the system is given by Equation 1:

$$B = \mu_0 H = (8.991 \times 10^{-7} \, N \, I)/R, \text{ (Teslas)} \qquad \text{(Eq. 1)}$$

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

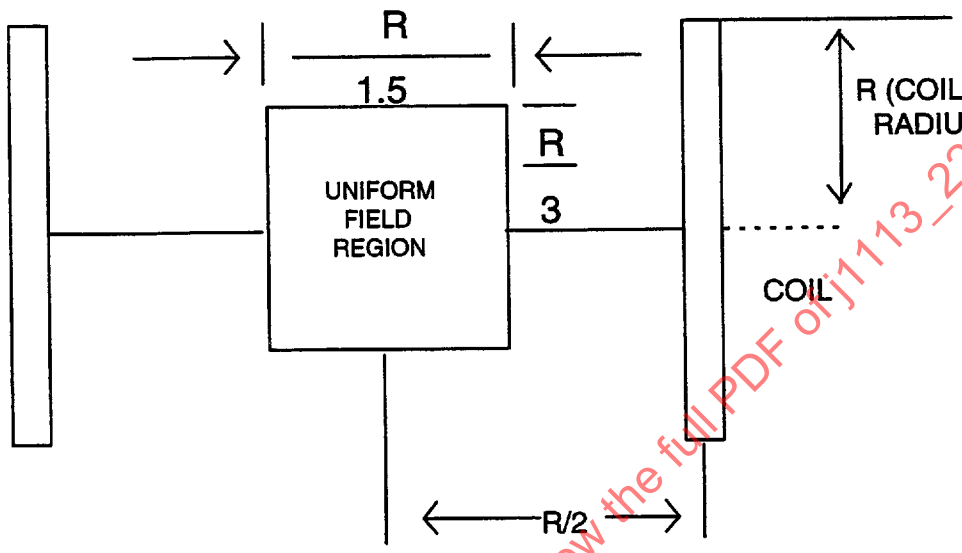

FIGURE 2—HELMHOLTZ COIL CONFIGURATION

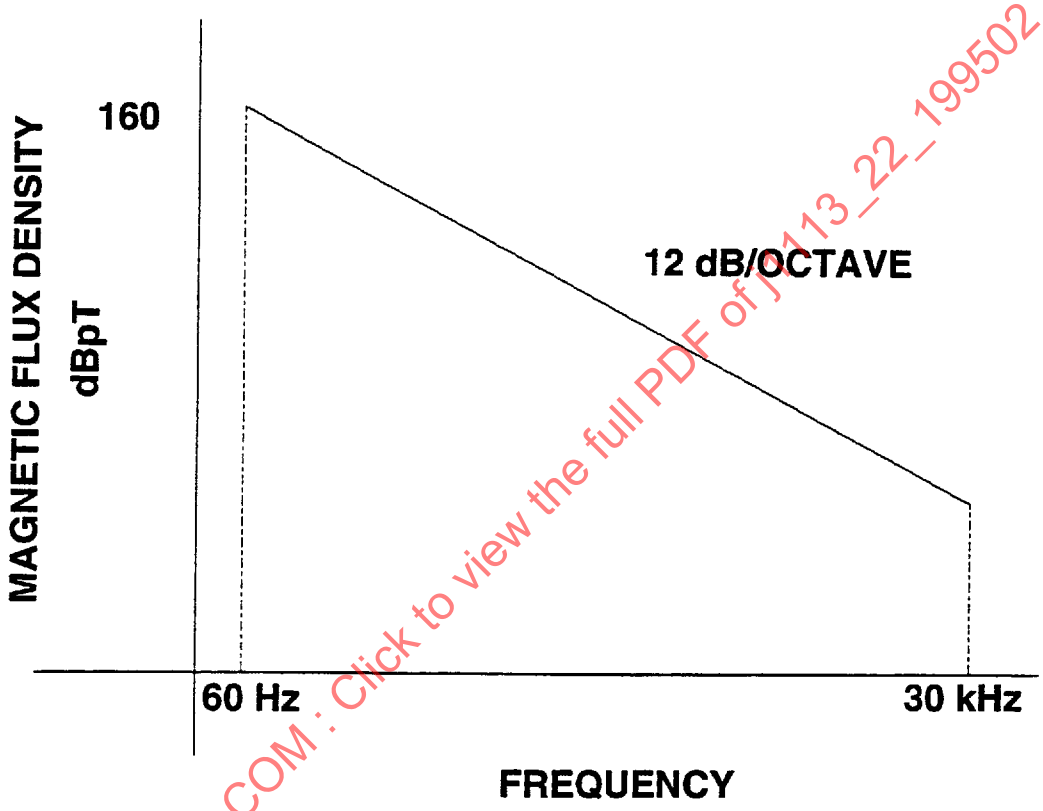

FIGURE 3—MAGNETIC FLUX DENSITY VERSUS FREQUENCY

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 2:

$$H = \frac{0.7155\,N\,I}{R} \cdot (A/m) \qquad \text{(Eq.2)}$$

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.

3.3 Function Generator—Capable of producing 60 Hz square wave signals.

3.4 Audio Power Amplifier—30 Hz to 30 kHz bandwidth minimum (approximately 200 W). Should be capable of delivering power to the coil to generate the specified magnetic field intensities as shown in Figure 3.

3.5 Current Monitor—30 to 2500 Hz bandwidth minimum, true rms AC voltmeter or current meter.

3.6 Magnetic Field Intensity Monitor—30 to 2500 Hz bandwidth minimum with DC rejection to reject the earth's magnetic field.

3.6.1 MAGNETIC FIELD PROBE—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 Helmholz coil system is constructed accurately, then the field produced can be calculated with high accuracy and a field intensity monitor is not required.

4. Test Setup and Procedure

NOTE—Caution should be exercised to avoid long exposures to the magnetic fields. For long exposures, personnel should stay 0.5 m away from the coils.

4.1 If calibration is required, see note after 3.6.

4.1.1 Connect the test setup according to Figure 1 without the DUT.

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

4.2 For a properly constructed Helmholz coil, calibrating is not required.

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

NOTE—The Helmholtz coil criteria of 3.2 should be met.

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

4.5 At each field strength level, expose the DUT for a minimum of 30 s.

4.6 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 Section 5 and Appendix A.

4.7 Repeat steps 4.3 thru 4.6 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.

5. Test Severity Levels

5.1 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.

PREPARED BY THE SAE EMI STANDARDS COMMITTEE