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EIA STANDARD

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EMI Shielding Effectiveness Test Procedure for Electrical Connectors

EIA-364-66A

(Revision of EIA 364-66)

May 2000



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TEST PROCEDURE No. 66A

EMI SHIELDING EFFECTIVENESS TEST PROCEDURE
FOR
ELECTRICAL CONNECTORS

(From EIA Standards Proposal No. 4730, formulated under the cognizance EIA CE-2.0 Committee on National Connector Standards, and previously published in EIA-364-66.)

1 Introduction**1.1 Scope**

This standard establishes test methods for the measurement of the EMI shielding effectiveness of electrical connectors over the frequency range of 1.0 GHz to 10.0 GHz using the mode-stirred technique. The procedure applies to both circular and rectangular connectors.

1.2 Object**1.2.1 General**

1.2.1.1 The mode-stirred method for the measurement of connector shielding effectiveness consists of exposing the Connector Under Test (CUT) and a reference antenna to an electromagnetic field and comparing the ratio of the signal levels induced into each unit.

1.2.1.2 The electromagnetic field within the mode-stirred test chamber is continuously perturbed by the operation of a rotating reflective element called a mode-stirrer (or tuner).

1.2.1.3 With the proper size test chamber and appropriate antennas, the mode-stirred technique can be used over the frequency range of 200 MHz to 40 GHz.

1.2.2 Mode-stirred test chamber

1.2.2.1 The mode-stirred chamber is a large cavity (in terms of a wavelength) with a high quality factor (Q) whose boundary conditions are continuously perturbed by a rotating reflective surface (tuner or mode-stirrer) mounted within the chamber. Electromagnetic power is established inside the chamber by means of an input or transmitting antenna; see figure 1.

1.2.2.2 The time-averaged electromagnetic fields within the chamber are approximately equal in amplitude spatially, and are formed by uniformly distributed plane waves. The field distribution at each point in the chamber is then a composite of randomly polarized plane waves; therefore, the average response for the effective aperture of a receiving antenna (or the connector under test) placed inside the chamber approaches a value equivalent to a gain of unity.^{1), 2)}

1.2.3 Measurement of connector Shielding Effectiveness (SE)

1.2.3.1 The measurement of SE is based on the comparison of the rf power induced into the CUT on the rf power induced into a reference antenna; see figure 1. The shielding effectiveness of the CUT (expressed in dB) is then defined as:

$$SE = 10 \log \left(\frac{P_{\text{ref}}}{P_{\text{cut}}} \right) \text{ (dB)}$$

where:

P_{cut} = Power coupled to the connector under test

P_{ref} = Power coupled to the reference antenna

1.2.3.2 Both the value of P_{cut} and P_{ref} are determined statistically as a function of tuner position and are determined for the same net input power applied to the chamber.

1.2.3.3 The leakage to be measured is principally that which enters the connector shells under test at the main point of interface. Leakage at the accessory joints is to be prevented by appropriate fixturing.

1) M. L. Crawford, G. H. Koepke, “*Design, Evaluation, and Use of a Reverberation Chamber for Performing Electromagnetic Susceptibility/Vulnerability Measurements*,” Technical Note 1092, National Bureau of Standard.

2) M. L. Crawford and J. M. Ladbury, “*Mode-Stirred Chamber for Measuring Shielding Effectiveness of Cables and Connectors*,” IEEE August 1988 International Symposium on Electromagnetic compatibility, Seattle, Washington, pp. 30-36.

1.2.4 Methods of measurements

There are two basic methods of operating the mode-tuner while performing the measurement of the output levels from the reference antenna and the CUT:

- discrete tuning: step positioning of the mode-tuner,
- continuous tuning: constant rotation of the mode-tuner.

NOTE — It shall be acceptable to use either the discrete-tuned or the continuous tuned method in the measurement of connector shielding effectiveness as described in this test procedure.

1.2.4.1 Discrete tuning

1.2.3.1.1 Discrete tuning provides the optimum accuracy at test frequencies less than or equal to 2 GHz. The mode-tuner is incremented in discrete steps of 1.8 degrees (200 steps) for one full revolution of the tuner, and measurements are performed at each tuner position.

1.2.4.1.2 This method permits the measurement of the net input power supplied to the transmitting antenna, the power from the reference antenna and the power from the CUT at each tuner position. Corrections can then be made to normalize the reference antenna and CUT received power measurements for an equivalent constant net input power as needed to correct for changes in the transmitting antenna's input impedance as a function of tuner position.

1.2.4.1.3 This technique also allows corrections to be made for impedance mismatch between the CUT, the reference antenna and the power measuring instrumentation as described in annex D.

1.2.4.2 Continuous tuning

1.2.4.2.1 At test frequencies above 2 GHz, the changes in the VSWR of the input antenna vs. tuner position are less significant than at the lower frequencies. This results in improved stability of the net input power to the test chamber, and enables measurements to be made using continuous stepping (or slow rotation) of the mode-tuner position with a minimum of error.

1.2.4.2.2 The output signal levels from the reference antenna and the CUT are measured continuously at a data rate that is very fast in comparison to the rate of rotation of the mode-tuner. The large amount of data acquired results in improved measurement accuracy.

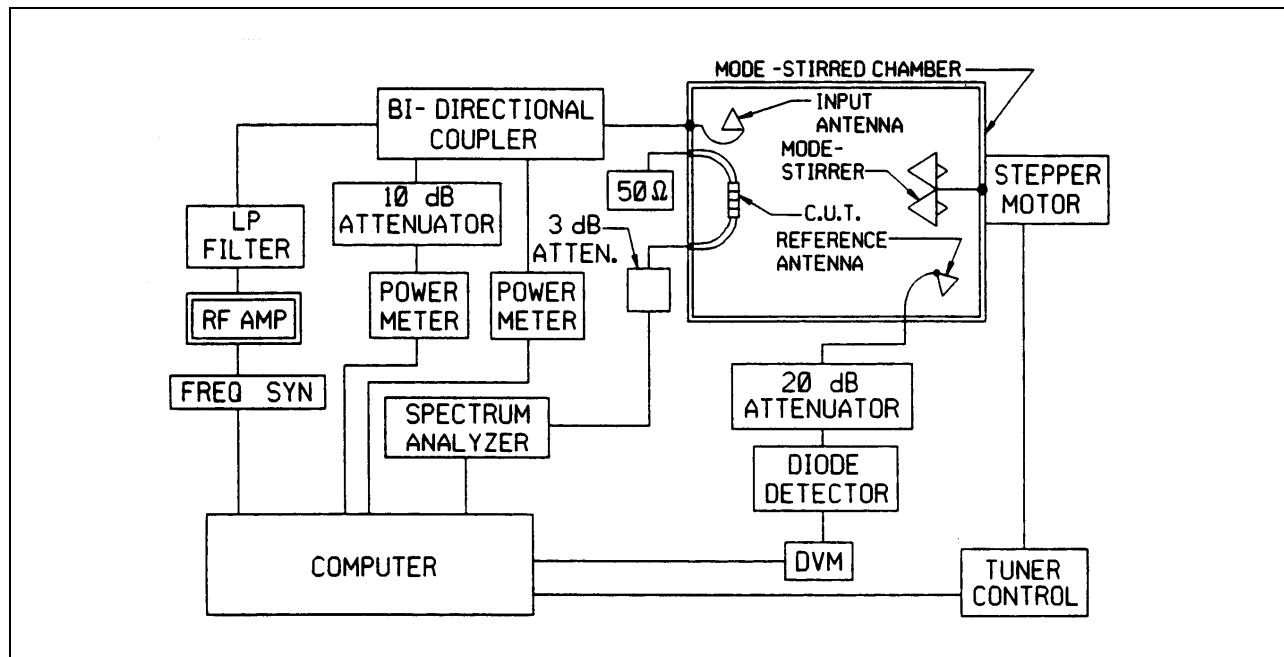


Figure 1 – Mode stirred shielding effectiveness measurement system

2 Test resources

2.1 Equipment

The essential test equipment and components required for an automated mode-stirred shielding effectiveness measurement system are shown in figure 1. The desired performance criteria for each primary item are summarized in annex C.

2.1.1 Test chamber

2.1.1.1 Mode-stirred shielded enclosure

2.1.1.1.1 Details of recommended test chamber design and construction are given in annex A, together with a description of the mode-tuner and the ridged horn antennas.

2.1.1.1.2 The minimum of any chamber internal dimension shall be greater than three wavelengths at the lowest test frequency. For optimum chamber performance at the lower frequencies, the volume of the chamber should be as large (with respect to a wavelength) as possible. The ratio of the squares of the chamber's linear dimensions should be as non-rational as possible.¹⁾ The test chamber is described further in annex A.

2.1.1.1.3 The chamber should have a shielding effectiveness of at least 100 dB as measured by MIL-STD-285. This level of shielding will enable the measurement of CUT shielding effectiveness levels of greater than 100 dB. As a minimum, the test chamber and the test instrumentation shall have a combined shielding effectiveness at each test frequency that is 10 dB greater than the minimum shielding requirements of the CUT.

2.1.1.2 Mode-tuner

The mode-tuner should be large with respect to a wavelength and be bent at angles to the walls of the chamber. The tuner should be at least two wavelengths from tip to tip at the lowest test frequency. The mode-tuner is further described in annex B.

2.1.1.3 Antennas

The input and reference horn antennas should be placed in different corners of the chamber and located so that they face into the corners. This orientation will minimize possible direct-path coupling from the input antenna to the reference antenna or to the CUT. The preferred relative placement of the antennas and the CUT within the test chamber are shown in figure 1.

2.1.2 Input power monitoring

The incident-signal power meter, see figure 1, is used to monitor the level and stability of the incident power to the input antenna. The reflected power meter enables the determination of the new input power to the chamber.

2.1.3 VSWR of components and cables

2.1.3.1 The individual components of the measurement system should be of good quality, with an input and output VSWR of 1.3:1 or less. This applies especially to all components, cables, and instrumentation in the signal paths from both the reference antenna and the CUT assembly. This precaution will minimize the magnitude of mismatch uncertainties, and facilitate measurement error analysis; see annex D for further discussion on corrections for mismatch errors.

2.1.3.2 The range of mismatch uncertainty in dB can be found from the following:

$$\text{Maximum mismatch loss} = -10 \log [1 - (|\Gamma_S| + |\Gamma_L|)^2] \quad (\text{dB})$$

$$\text{Minimum mismatch loss} = -10 \log [1 - (|\Gamma_S| - |\Gamma_L|)^2] \quad (\text{dB})$$

where:

Γ_S = Reflection coefficient of the source (reference antenna or CUT)

Γ_L = Reflection coefficient of the load (detector or receiver/spectrum analyzer)

The magnitudes, $|\Gamma_S|$ and $|\Gamma_L|$ can be obtained from the appropriate VSWR by the equation:

$$|\Gamma_i| = \frac{\text{VSWR} - 1}{\text{VSWR} + 1}$$

where:

i = S or L

2.1.3.3 Cable and component losses

Characterize all cables, attenuators, directional couplers, and switches for VSWR and attenuation (or coupling factor) at each test frequency prior to beginning the test.

2.1.3.3.1 This data will be used to correct the measurement system readings of reference antenna and CUT output levels, and if desired, the input power to the test chamber. These corrections can be made part of the test program for an automated mode-stirred system.

NOTE — All individual data that is to be averaged later should be stored in units of power (milliwatts), not in dBm or other measurement units.