IEC 61726

Edition 4.0 2022-07

INTERNATIONAL STANDARD

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colour inside

Cable assemblies, cables, connectors and passive microwave components – Screening attenuation measurement by the reverberation chamber method

Cordons, câbles, connecteurs et composants hyperfréquence passifs – Mesurage de l'affaiblissement d'écran par la méthode de la chambre réverbérante

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CABLE ASSEMBLIES, CABLES, CONNECTORS AND PASSIVE MICROWAVE COMPONENTS – SCREENING ATTENUATION MEASUREMENT BY THE REVERBERATION CHAMBER METHOD

FOREWORD

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IEC 61726 has been prepared by IEC technical committee 46: Cables, wires, waveguides, RF connectors, RF and microwave passive components and accessories. It is an International Standard.

This fourth edition cancels and replaces the third edition published in 2015. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

a) reworded Clause 1 "Scope";
b) replaced IEC TS 62153-4-1 by IEC 62153 (all parts) in Clause 2;
c) added the definition of screening attenuation in 3.1;
d) added Clause 4 "Principle of screening attenuation measurement";
e) added the descriptions of some test set-ups, such as frequency synthesizer, spectrum analyser, stepper motor, linking devices and the sampling system, etc. in Clause 5;
f) added Clause 6 "DUT";

g) reworded Clause 7 "Measurement procedure";

h) added Clause 8 "Caution notes";

i) added Clause 9 "Acceptance criterion";

j) added Clause 10 "Information to be given in the relevant specification".

The text of this International Standard is based on the following documents:

Draft	Report on voting
46/847/CDV	46/877/RVC

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications.

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CABLE ASSEMBLIES, CABLES, CONNECTORS AND PASSIVE MICROWAVE COMPONENTS – SCREENING ATTENUATION MEASUREMENT BY THE REVERBERATION CHAMBER METHOD

1 Scope

This document describes the measurement of screening attenuation by the reverberation chamber measurement method, also called mode stirred chamber method.

This document is applicable to screening attenuation measurements of cable assemblies, cables, connectors, and passive microwave components, such as waveguides, phase shifters, diplexers/multiplexers, power dividers/combiners, etc.

Modern electronic equipment has shown a demand for methods for testing screening attenuation performance of microwave components over their whole frequency range. Convenient measurement methods have existed for lower frequencies and components of regular shape. These measurement methods are described in the IEC 62153 series. For much higher frequencies and for components of irregular shape, the reverberation chamber method can be used. Theoretically, the reverberation chamber method has no upper limit of the measurement frequency, but it is limited by the quality and sensitivity of the measurement system, and the lower limit of the measurement frequency is restricted by the size of the reverberation chamber.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 61000-4-21:2011, *Electromagnetic compatibility (EMC) – Part 4-21: Testing and measurement techniques – Reverberation chamber test methods*

IEC 61196-1, *Coaxial communication cables – Part 1: Generic specification – General, definitions and requirements*

IEC 62153 (all parts), *Metallic communication cable test methods*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61196-1, IEC 61000-4-21 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- IEC Electropedia: available at https://www.electropedia.org/
- ISO Online browsing platform: available at https://www.iso.org/obp

3.1
screening attenuation
ratio of the electromagnetic field power coupled to the reference antenna to the electromagnetic field power coupled to the device under test (DUT), expressed by a_s in Formula (1):

$$a_s = 10 \log_{10}\left(\frac{P_{REF}}{P_{DUT}}\right) \tag{1}$$

where

a_s is the screening attenuation of DUT, in dB;

P_{REF} is the power coupled to the reference antenna, in W;

P_{DUT} is the power coupled to the DUT, in W.

4 Principle of screening attenuation measurement

The reverberation chamber is an electrically large screening cavity with high quality factor, which is equipped with mode stirrer(s), input antenna and reference antenna. A system configuration example of screening attenuation measurement by reverberation chamber method is shown in Figure 1.

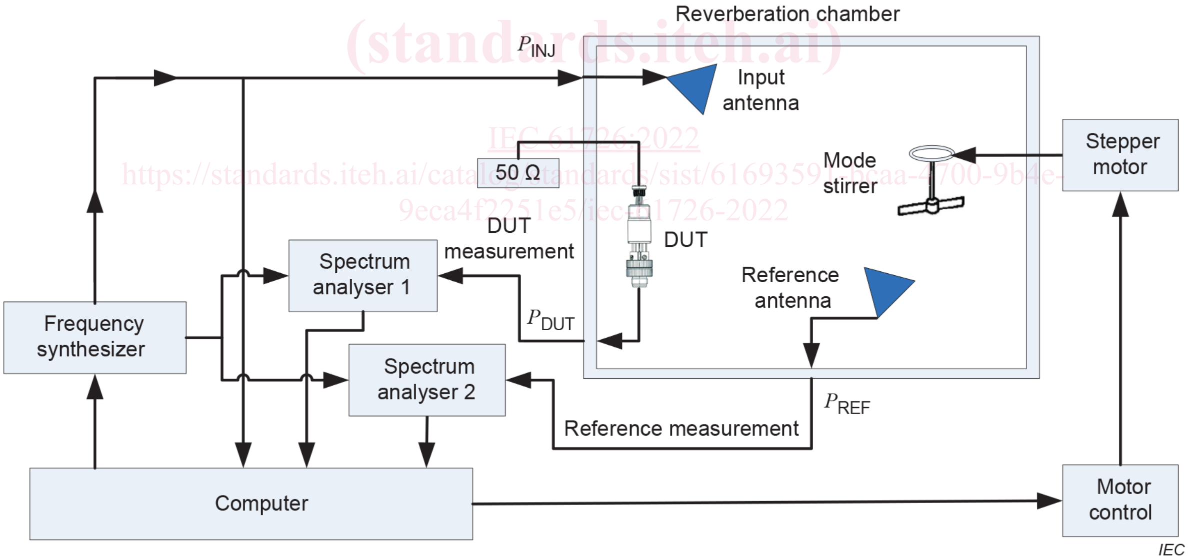

Figure 1 – System configuration example of screening attenuation by reverberation chamber

The electromagnetic wave power P_{INJ} emitted by the frequency synthesizer is transmitted to the reverberation chamber through the input antenna in the cavity. The electromagnetic wave will excite the multi-mode electromagnetic field in the reverberation chamber. The boundary conditions of these electromagnetic fields change with the rotation and stirring of the mode stirrer, and the electromagnetic field distribution in the cavity is nearly uniform, isotropic and randomly polarized in the sense of statistical average. When the DUT is placed in the reverberation chamber, the approximately uniformly distributed electromagnetic power P_{REF} in the reverberation chamber received by the reference antenna is equivalent to the external input power of the DUT, and the electromagnetic power P_{DUT} coupled into the DUT can be obtained by the spectrum analyser outside the reverberation chamber.

According to the definition Formula (1), the screening attenuation of DUT can be calculated from Formula (2):

$$
\begin{aligned}
a_{\mathrm{s}} &= 10\log_{10}\left(\frac{P_{\mathrm{REF}}}{P_{\mathrm{DUT}}}\right) \\
&= 10\log_{10}\left[\left(\frac{P_{\mathrm{INJ}}}{P_{\mathrm{DUT}}}\right)\times\left(\frac{P_{\mathrm{REF}}}{P_{\mathrm{INJ}}}\right)\right] \\
&= 10\log_{10}\left(\frac{P_{\mathrm{INJ}}}{P_{\mathrm{DUT}}}\right) - 10\log_{10}\left(\frac{P_{\mathrm{INJ}}}{P_{\mathrm{REF}}}\right) \\
&= 10\log_{10}\left(\frac{P_{\mathrm{INJ}}}{\mathrm{P}_{\mathrm{DUT}}}\right) - \Delta_{\mathrm{ins}}
\end{aligned}
\tag{2}
$$

where

a_{s} is the screening attenuation of DUT, in dB;

P_{REF} is the power coupled to the reference antenna, in W;

P_{DUT} is the power coupled to the DUT, in W;

P_{INJ} is the power injected into the chamber, in W;

Δ_{ins} is the insertion loss of the chamber, in decibels (dB).

In Formula (2), the first term represents the total screening attenuation of the system which can be obtained by measuring the power of DUT connected with a load by spectrum analyser 1. The second term represents the insertion loss of the reverberation chamber which can be obtained by measuring the power of the reference antenna by spectrum analyser 2. Measurements of the total screening attenuation and the insertion loss can be carried out simultaneously.

When only one spectrum analyser is configured, the DUT and reference antenna can be connected to the spectrum analyser separately by using a switch, and the total screening attenuation of the system and the insertion loss of the reverberation chamber can be measured separately (also known as time-division measurement), as shown in Figure 2.

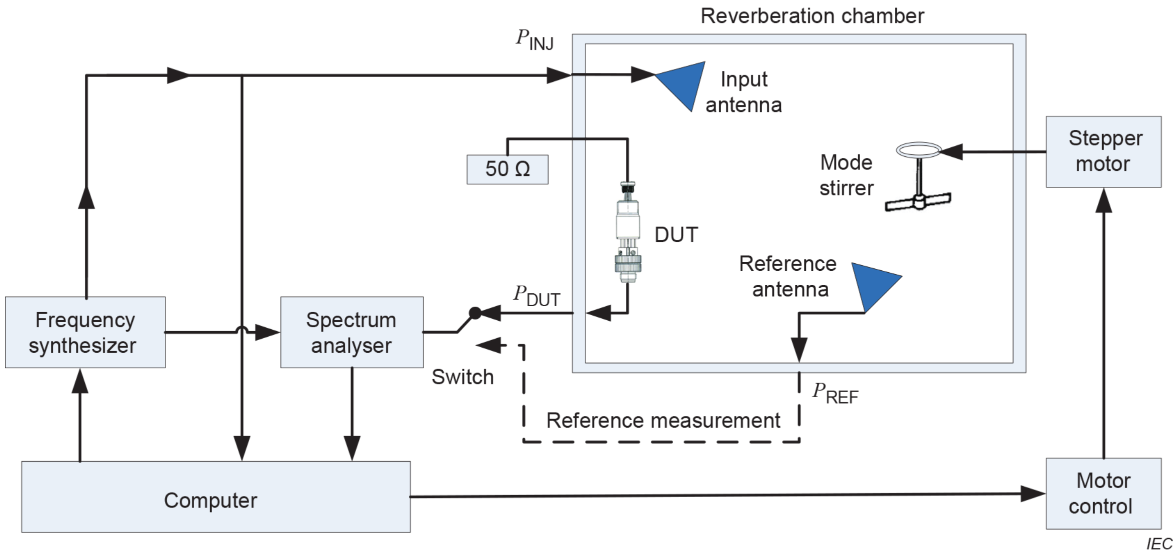

Figure 2 – System configuration example of screening attenuation by reverberation chamber with only one spectrum analyser

5 Measurement equipment

5.1 General test instruments

5.1.1 Frequency synthesizer

Frequency synthesizer or other frequency source shall be used, and its output power, frequency range and transmission bandwidth shall meet the measurement requirements. In order to ensure the repeatability of measurement, the frequency stability of frequency synthesizer or other frequency source should be better than 10^{-6}.

5.1.2 Spectrum analyser

The frequency range, resolution bandwidth and sensitivity of the spectrum analyser should meet the measurement requirements. Other equipment that offers the same function, such as EMI test receiver, can also be used.

5.1.3 Reverberation chamber

The reverberation chamber shall comply with IEC 61000-4-21.

In general, the reverberation chamber is a shielded enclosure having any shape; however, a perfect cubic shape should be avoided for optimum performance at lower frequencies. It shall be made of conductive materials (copper, aluminium or steel) and shall not contain lossy materials.

The upper frequency limit depends on the quality of the shielded enclosure and cables. Furthermore, the sensitivity of the used measurement instruments also limits the maximum frequency. There is no upper limit theoretically for the measurement frequency of the reverberation chamber when its quality is disregarded.

In general, the reverberation chamber is required to work with sufficient modes, and the working frequency should be greater than the cavity mode frequency as calculated from Formula (3):

$$f > f_{\mathrm{mnp}} = \frac{c_0}{2}\sqrt{\left(\frac{m}{l}\right)^2 + \left(\frac{n}{w}\right)^2 + \left(\frac{p}{h}\right)^2} \tag{3}$$

where l, w and h are the length, width and height of reverberation chamber respectively, m, n and p are integers, and the value range is up to the number of modes of reverberation chamber.

It can be drawn from Formula (3) that the lowest usable frequency (LUF) of the reverberation chamber is limited by the size of the reverberation chamber. The larger the volume is, the lower LUF is; and the number of modes of the reverberation chamber is directly proportional to the measurement frequency and the size of the reverberation chamber. Increasing the size of the reverberation chamber and raising the test frequency can both expand the number of modes of the reverberation chamber. Therefore, the size of reverberation chamber should be large enough to meet the requirements for mode frequency and mode number when measuring at lower frequencies.

For more detailed requirements and instructions for reverberation chambers, reference to IEC 61000-4-21.

5.1.4 Mode stirrer

The mode stirrer shall be large with respect to wavelength and be at an angle to the walls of the chamber. The mode stirrer shall be at least two wavelengths at the lowest measurement frequency from tip to tip. When needed, more than one mode stirrer can be provided.

5.1.5 Input antenna

The input antenna shall be a broadband antenna capable of covering the operating frequency range, and its transmitting direction shall be towards the corner of the reverberation chamber or the mode stirrer to avoid direct exposure to the reference antenna. The antenna should exhibit limited resonances in the frequency range and not introduce losses.

The recommended antennas for different frequency bands are given in Table 1.

Table 1 – Recommended antennas

Frequency range	Antenna type
≤1 GHz	Dipole antenna
≥1 GHz	Horn antenna

5.1.6 Reference antenna

The reference antenna shall be of the same type as the input antenna, and its polarization direction shall be orthogonal to that of the input antenna.

5.1.7 Stepper motor

The stepper motor should be driven with enough torque to control the angle and speed.

5.1.8 Linking devices

Low loss semi-rigid coaxial cables with good screening attenuation shall be used as the test cables to connect the spectrum analyser to the DUT. To avoid resonances, the DUT is inserted into a test cable loop having a length of more than four wavelengths at minimum frequency. The cable connecting the spectrum analyser to the reference antenna should be consistent with the length and quality of the test cable connecting the spectrum analyser to the DUT. It is required that the test cables, related connectors, adapters, loads, etc. having a screening attenuation at least 10 dB better than the DUT, so as to ensure that the measured leakage is caused by DUT.

5.1.9 Other instruments

In order to improve the performance of the measurement system, the power meter, directional coupler, power amplifier and other control equipment can be used. These instruments should meet the measurement requirements.

5.2 Return loss requirements for linking devices

The individual components of the measurement system should be of good quality, with an input and output return loss of 15 dB or better. This applies especially to all components, cables and instrumentation in the signal paths between the reference antenna and the spectrum analyser, as well as between the DUT and the spectrum analyser, they shall meet this requirement.

This requirement can be difficult to achieve for some DUTs. In this case, a graph of return loss against frequency shall be included in the documentation.

5.3 Sampling system

5.3.1 General

The sampling system shall acquire the power values of the signals from the reference antenna and the DUT on one revolution of the mode stirrer. The receiver can be connected with the computer through the control interface, and the samples can be acquired and processed by software.

Different approaches are acceptable depending on the performance of the equipment:

- discrete tuning (step positioning of the mode stirrer);
- continuous tuning (constant rotation of the stirrer);
- peak power acquisition on one revolution of the mode stirrer;
- averaged power calculation on one rotation of the mode stirrer.

When choosing a measurement mode, it shall be recognized that:

- discrete tuning is slow and requires a large number of sample measurements to be taken per revolution of the mode stirrer. This does, however, result in the acquisition of more accurate measurements;
- continuous tuning can continuously rotate and stir to acquire data, and is very economical in time, but requires a modern and stable receiver.

Therefore, the following two data sampling methods can be used to complete the signal power sampling:

a) normal sampling system;
b) fast sampling system.

5.3.2 Normal sampling system

The normal sampling system offers a high dynamic range, especially if power controlled amplifiers are used at the output of the generator.

The mode stirrer rotates to different positions (e.g. 50) per a fixed step size. The number of the positions depends on the LUF of the chamber, as recommended in IEC 61000-4-21 and shown in Table 2. The spectrum analyser samples the signals separately, and then stores each power