CISPR 17

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

Methods of measurement of the suppression characteristics of passive EMC filtering devices

Méthodes de mesure des caractéristiques d'antiparasitage des dispositifs de filtrage CEM passifs

CISPR 17:2011

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METHODS OF MEASUREMENT OF THE SUPPRESSION CHARACTERISTICS OF PASSIVE EMC FILTERING DEVICES

FOREWORD

International Standard CISPR 17 has been prepared by CISPR subcommittee A: Radio interference measurements and statistical methods.

This second edition cancels and replaces the first edition published in 1981. It is a technical revision.

This edition includes the following significant technical change with respect to the previous edition: new measurement methods are added to characterize the more technologically sophisticated EMC filtering devices currently available.

The text of this standard is based on the following documents:

FDIS	Report on voting
CISPR/A/941/FDIS	CISPR/A/951/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

The suppression characteristics of EMC filters and components used for the suppression of EM disturbances, referred to in this standard as EMC filtering devices, are a function of numerous variables such as impedance of the circuits to which they connect, operating voltage and current, and ambient temperature. This standard specifies uniform test methods that will enable comparison of filtering and suppression characteristics determined by test laboratories or specified by manufacturers.

The first edition of CISPR 17 (1981) prescribed the measurement methods of insertion loss mainly for power-line filters. Today, however, many types of sophisticated EMC filters and suppression components can be found in various electronic devices. Those filters need to be characterized using standardized measurement methods. New methods for measurement of impedance and S-parameters for such EMI devices are included in this second edition.

In addition, the following insertion loss measurement methods from the first edition have been deleted because they are no longer in use in the industry:

- measurement method with a bias voltage for insertion loss measurement,
- in situ method, and
- worst-case methods.

METHODS OF MEASUREMENT OF THE SUPPRESSION CHARACTERISTICS OF PASSIVE EMC FILTERING DEVICES

1 Scope

This International standard specifies methods to measure the radio interference suppression characteristics of passive EMC filtering devices used in power and signal lines, and in other circuits.

The defined methods may also be applied to combinations of over-voltage protection devices and EMC filtering devices.

The measurement method covers the frequency range from 9 kHz to several GHz depending on the device and test circuit.

NOTE Measurement methods in this standard may be applied up to 40 GHz.

The standard describes procedures for laboratory tests (type tests) as well as factory tests. Test methods with and without bias conditions are defined.

Measurement procedures are provided for unbiased and bias conditions. Measurements under bias conditions are performed to determine potential non-linear behaviour of the EMC filtering devices such as saturation effects in inductors with magnetic cores. This testing serves to show the usability in a specific application (such as frequency converters that produce high amplitudes of common mode pulse current and thus may drive inductors into saturation). Measurement under bias conditions may be omitted if the non-linear behaviour can be determined by other methods (e.g. separate saturation measurement of the inductors used).

2 Normative references

The following referenced documents are indispensable for the application 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 60050-161, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

3 Terms, definitions and abbreviations

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions, as well as those given in IEC 60050-161, apply.

3.1.1
bias current
d.c. or a.c. mains (power) frequency current flowing through the current conductor(s) of the EMC filtering device under test

3.1.2
bias voltage
d.c. or a.c. mains (power) frequency voltage applied between specified parts of the EMC filtering device under test

3.1.3
device under test
EMC filtering device subjected to measurement, calibration and test according to this standard

3.1.4
EMC filtering device
a generic term within this standard to describe any kind of suppression circuit, whether a single component or a complex circuit

3.1.5
filter
composition of single components such as inductors and capacitors that can suppress electromagnetic disturbance

3.1.6
impedance
Z
ratio of an a.c. electric current I to an a.c. voltage V (at frequency f), which may be represented by a complex number expressed as $Z = V/I$, indicating the total opposition to the passage of a.c. current; used as a parameter to represent the characteristics of two-terminal devices such as inductors, capacitors, and resistors, as well as those of four-terminal devices such as common-mode choke coils (CMCC)

NOTE Consists of ohmic resistance R and reactance X, usually represented in complex notation as $Z = R + jX$; alternatively represented in the polar coordinates as $|Z| \exp(j\theta)$ (absolute value $|Z|$ and phase angle θ); may imply the performance of an EMC filtering device; Z is expressed in Ω.

3.1.7
insertion loss
for a filter connected into a given transmission system, the ratio of voltages appearing across the line immediately beyond the point of insertion, before and after insertion of the EMC filtering device under test

NOTE Insertion loss is expressed in dB.

3.1.8
impedances of the test circuit
impedance across the terminals of the test circuit without the filter connected

NOTE For insertion loss measurement shown in Figure 4, impedances are designated Z_0, Z_{11}, Z_{12} and Z_2 referenced to 50 Ω; in special cases the impedances may be changed to other values that reflect the environmental conditions of certain applications.

3.1.9
receiver
selective or non-selective instrument, such as a broadband voltmeter, a tunable voltmeter, a spectrum analyzer or the receiving part of a network analyzer

NOTE See 5.2.2 for details.

3.1.10
reference impedance
impedance of a line or port at the point where the insertion loss or S-parameters are measured or evaluated, specified when results are reported

NOTE The reference impedance is usually 50 Ω.

3.1.11
reference potential
reference for voltage measurement to which the ground connections of the test equipment and the filter are connected, normally provided by a metallic plane of sufficient size

3.1.12
single component
basic component used for EMC purposes such as capacitors or inductors

3.1.13
***S*-parameter**
scattering parameter
S_{ij}
an element of the S-matrix expressing the transmission and reflection coefficients of a device

NOTE 1 As most commonly used, each S-parameter relates the complex electric field strength (or voltage) of a reflected or transmitted wave to that of an incident wave; the subscripts of a typical S-parameter S_{ij} refer to the output and input ports related by the S-parameter, which may vary with frequency and apply at a specified set of input and output reference planes; may imply the performance of an EMC filtering device.

EXAMPLE The S-parameters for a two-port circuit are defined as follows:

$$S = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

where

S_{11} and S_{22} are the reflection coefficients at port 1 or 2 of a circuit component, respectively, where the opposite port is terminated with a port reference impedance (for example 50 Ω); and

S_{21} and S_{12} are the transmission coefficients representing the ratio of the signal transmitted to port 2 to that incident from port 1, and vice versa, respectively. The value of S_{21} is a good indicator of the noise suppression for a signal passing through this component.

NOTE 2 It is important to evaluate the degradation of a signal waveform caused by variation in the S-parameters with the frequency.

3.1.14
test circuits

3.1.14.1
asymmetrical (common mode) test circuit
test circuit in which all input lines of a filter under test are connected to a signal generator with all output lines being connected to a receiver

NOTE The test circuit used to measure the asymmetrical (common mode) insertion loss of a filter is shown in Figure 5.

3.1.14.2
symmetrical (differential mode) test circuit
test circuit in which the signal is fed across a pair of input lines of a filter under test, and the corresponding pair of output lines is connected to a receiver; the other lines are not terminated

NOTE An example of the test circuit used to measure the symmetrical (differential mode) insertion loss of a filter is shown in Figure 6; all combinations of each two lines of the filter are measured; ground or PE (protective earth) terminals are not considered.

3.1.14.3
unsymmetrical test circuit
test circuit in which the signal is fed to an input line of a filter under test, and the corresponding output line is connected to a receiver; the other input and output lines are terminated in specified impedances

NOTE An example of the test circuit used to measure the unsymmetrical insertion loss of a filter is shown in Figure 7; each line of the filter is measured with all unused lines terminated to reference potential with Z_{11} or Z_{12}.

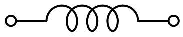
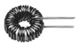
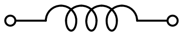
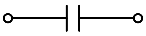
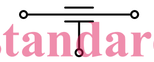
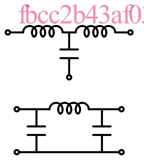
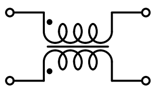
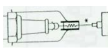
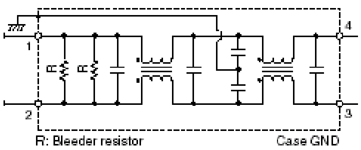
3.2 Abbreviations

CMCC	Common-mode choke coils
DUT	Device under test
EM	Electromagnetic
EMC	Electromagnetic compatibility
e.m.f.	Electromotive force
GND	Ground
HPF	High-pass filter
L	Line
N	Neutral
PE	Protective earth
RF	Radio frequency
SMD	Surface mount device
TRL	Thru/Reflect/Line
VNA	Vector network analyzer
VSWR	Voltage-standing wave ratio

4 Classification of EMC filtering devices

Examples of EMC filtering devices and their applicable measurement methods are shown in Table 1.

Table 1 – Examples of EMC filtering devices

Filter type	Examples	Symbol or circuit diagram	Parameters to be measured and measurement method		
	Outer view		Insertion loss	Impedance	*S*-parameter
Ferrite cores and absorbing clamps			Clause 5	Clause 6	Clause 7
Chokes, inductors and beads	 		Clause 5	Clause 6	Clause 7
Non-feedthrough capacitors	 		Clause 5	Clause 6	Clause 7
Feedthrough capacitors	 		Clause 5	–	Clause 7
Three-terminal capacitors	 		Clause 5	–	Clause 7
Common mode choke coils	 		Clause 7	Clause 6	Clause 7
Resistors			Annex E of CISPR 12:2007	–	–
Filter (multiple lines[a] with GND)			Clause 5	–	–

[a] one line without neutral, multiple lines with or without neutral.