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ข้อกำหนดสำหรับอุปกรณ์และวิธีการวัดสัญญาณรบกวนวิทยุและภูมิคุ้มกัน

เล่ม 2–2 วิธีการวัดของสัญญาณรบกวนและภูมิคุ้มกัน – การวัดกำลังไฟฟ้ารบกวน

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS–

PART 2–2 : METHODS OF MEASUREMENT OF DISTURBANCES AND IMMUNITY – MEASUREMENT OF DISTURBANCE POWER

สำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม

กระทรวงอุตสาหกรรม

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มาตรฐานผลิตภัณฑ์อุตสาหกรรม
ข้อกำหนดสำหรับอุปกรณ์และวิธีการวัดสัญญาณรบกวนวิทยุและภูมิคุ้มกัน
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มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นโดยรับ CISPR 16-2-2(2005-09) Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-2 : Methods of measurement of disturbances of and immunity- Measurement of disturbance power มาใช้ในระดับเหมือนกันทุกประการ (identical) โดยใช้ CISPR ฉบับภาษาอังกฤษเป็นหลัก

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นเพื่อใช้ในการอ้างอิง และเพื่อให้ทันกับความต้องการของผู้ใช้มาตรฐาน ซึ่งจะได้แปลเป็นภาษาไทยในโอกาสอันสมควรต่อไป หากมีข้อสงสัยโปรดติดต่อสอบถามสำนักงานมาตรฐานผลิตภัณฑ์อุตสาหกรรม

คณะกรรมการมาตรฐานผลิตภัณฑ์อุตสาหกรรมได้พิจารณามาตรฐานนี้แล้ว เห็นสมควรเสนอรัฐมนตรีประกาศตามมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511

ประกาศกระทรวงอุตสาหกรรม

ฉบับที่ 3497 (พ.ศ. 2549)

ออกตามความในพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม

พ.ศ. 2511

เรื่อง กำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม

ข้อกำหนดสำหรับอุปกรณ์และวิธีการวัดสัญญาณรบกวนวิทยุและภูมิคุ้มกัน

เล่ม 2-2 วิธีการวัดของสัญญาณรบกวนและภูมิคุ้มกัน -

การวัดกำลังไฟฟ้ารบกวน

อาศัยอำนาจตามความในมาตรา 15 แห่งพระราชบัญญัติมาตรฐานผลิตภัณฑ์อุตสาหกรรม พ.ศ. 2511 รัฐมนตรีว่าการกระทรวงอุตสาหกรรมออกประกาศกำหนดมาตรฐานผลิตภัณฑ์อุตสาหกรรม ข้อกำหนดสำหรับอุปกรณ์และวิธีการวัดสัญญาณรบกวนวิทยุและภูมิคุ้มกัน เล่ม 2-2 วิธีการวัดของสัญญาณรบกวนและภูมิคุ้มกัน - การวัดกำลังไฟฟ้ารบกวน มาตรฐานเลขที่ มอก. 2092 เล่ม 2-2549 ไว้ ดังมีรายละเอียดต่อท้ายประกาศนี้

ประกาศ ณ วันที่ 4 พฤษภาคม พ.ศ. 2549

สุริยะ จึงรุ่งเรืองกิจ

รัฐมนตรีว่าการกระทรวงอุตสาหกรรม

มาตรฐานผลิตภัณฑ์อุตสาหกรรม
ข้อกำหนดสำหรับอุปกรณ์และวิธีการวัดสัญญาณรบกวนวิทยุและภูมิคุ้มกัน
เล่ม 2-2 วิธีการวัดของสัญญาณรบกวนและภูมิคุ้มกัน - การวัดกำลังไฟฟ้ารบกวน

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้กำหนดขึ้นโดยรับ CISPR 16-2-2(2005-09) Specification for radio disturbance and immunity measuring apparatus and methods- Part 2-2 : Methods of measurement of disturbances and immunity - Measurement of disturbance power มาใช้ในระดับเหมือนกันทุกประการ(identical) โดยใช้ CISPR ฉบับภาษาอังกฤษเป็นหลัก

มาตรฐานผลิตภัณฑ์อุตสาหกรรมนี้ได้รับการระบุให้เป็นมาตรฐานพื้นฐาน ซึ่งกำหนดวิธีการวัดกำลังไฟฟ้ารบกวนโดยใช้ประกับดูดกลืน ในพิสัยความถี่ 30 เมกะเฮิรตซ์ ถึง 1 000 เมกะเฮิรตซ์

รายละเอียดให้เป็นไปตาม CISPR 16-2-2 (2005-09)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 2-2: Methods of measurement of disturbances and immunity – Measurement of disturbance power

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard CISPR 16-2-2 has been prepared by CISPR subcommittee A: Radio interference measurements and statistical methods.

This consolidated version of CISPR 16-2-2 is based on the first edition (2003), its amendment 1 (2004) [documents CISPR/A/506/FDIS and CISPR/A/524/RVD] and its amendment 2 (2005) [documents CISPR/A/583/FDIS and CISPR/A/598/RVD].

It bears the edition number 1.2.

A vertical line in the margin shows where the base publication has been modified by amendments 1 and 2.

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

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result 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.

INTRODUCTION

CISPR 16-1, CISPR 16-2, CISPR 16-3 and CISPR 16-4 have been reorganised into 14 parts, to accommodate growth and easier maintenance. The new parts have also been renumbered. See the list given below.

Old CISPR 16 publications

CISPR 16-1	Radio disturbance and immunity measuring apparatus
CISPR 16-2	Methods of measurement of disturbances and immunity
CISPR 16-3	Reports and recommendations of CISPR
CISPR 16-4	Uncertainty in EMC measurements

New CISPR 16 publications

CISPR 16-1-1	Measuring apparatus
CISPR 16-1-2	Ancillary equipment – Conducted disturbances
CISPR 16-1-3	Ancillary equipment – Disturbance power
CISPR 16-1-4	Ancillary equipment – Radiated disturbances
CISPR 16-1-5	Antenna calibration test sites for 30 MHz to 1 000 MHz
CISPR 16-2-1	Conducted disturbance measurements
CISPR 16-2-2	Measurement of disturbance power
CISPR 16-2-3	Radiated disturbance measurements
CISPR 16-2-4	Immunity measurements
CISPR 16-3	CISPR technical reports
CISPR 16-4-1	Uncertainties in standardised EMC tests
CISPR 16-4-2	Measurement instrumentation uncertainty
CISPR 16-4-3	Statistical considerations in the determination of EMC compliance of mass-produced products
CISPR 16-4-4	Statistics of complaints and a model for the calculation of limits

More specific information on the relation between the 'old' CISPR 16-2 and the present 'new' CISPR 16-2-2 is given in the table after this introduction (TABLE RECAPITULATING CROSS REFERENCES).

Measurement instrumentation specifications are given in five new parts of CISPR 16-1, while the methods of measurement are covered now in four new parts of CISPR 16-2. Various reports with further information and background on CISPR and radio disturbances in general are given in CISPR 16-3. CISPR 16-4 contains information related to uncertainties, statistics and limit modelling.

CISPR 16-2 consists of the following parts, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods – Methods of measurement of disturbances and immunity:*

- Part 2-1: Conducted disturbance measurements,
- Part 2-2: Measurement of disturbance power,
- Part 2-3: Radiated disturbance measurements,
- Part 2-4: Immunity measurements.

TABLE RECAPITULATING CROSS-REFERENCES

Second edition of CISPR 16-2 Clauses, subclauses	First edition of CISPR 16-2-2 Clauses, subclauses
1.1	1
1.2	2
1.3	3
2.1	4
2.2	5
2.3	6
2.5	7
4.1	8
Annexes	Annexes
C	A
B	B
Figures	Figures
1,…, 4	1,…, 4
17	5

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 2-2: Methods of measurement of disturbances and immunity – Measurement of disturbance power

1 Scope

This part of CISPR 16 is designated a basic standard, which specifies the methods of measurement of disturbance power using the absorbing clamp in the frequency range 30 MHz to 1 000 MHz.

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.

CISPR 13:2001, *Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement*

CISPR 14-1:2000, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 16-1-1:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-3:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-3: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Disturbance power*

CISPR 16-2-1:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

CISPR 16-2-3:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

CISPR 16-2-4: 2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Immunity measurements*

CISPR 16-3:2003, *Specification for radio disturbance and Immunity measuring apparatus and methods – Part 3: CISPR technical reports*

CISPR 16-4-1:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests*

CISPR 16-4-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainties*

CISPR 16-4-3:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-3: Uncertainties, statistics and limit modelling – Statistical considerations in the determination of EMC compliance of mass-produced products*

ITU-R Recommendation BS.468-4: *Measurement of audio-frequency noise voltage level in sound broadcasting*

3 Terms and definitions

For the purpose of this part of CISPR 16, the definitions of IEC 60050(161) apply, as well as the following:

3.1
associated equipment

1) Transducers (e.g. probes, networks and antennas) connected to a measuring receiver or test generator
2) Transducers (e.g. probes, networks, antennas) which are used in the signal or disturbance transfer between an EUT and measuring equipment or a (test-) signal generator

3.2
EUT
the equipment (devices, appliances and systems) subjected to EMC (emission) compliance tests

3.3
product publication
publication specifying EMC requirements for a product or product family, taking into account specific aspects of such a product or product family

3.4
emission limit (from a disturbing source)
the specified maximum emission level of a source of electromagnetic disturbance

[IEV 161-03-12]

3.5
ground reference
a connection that constitutes a defined parasitic capacitance to the surrounding of an EUT and serves as reference potential

NOTE See also IEV 161-04-36.

3.6
(electromagnetic) emission
the phenomenon by which electromagnetic energy emanates from a source

[IEV 161-01-08]

3.7
coaxial cable
a cable containing one or more coaxial lines, typically used for a matched connection of associated equipment to the measuring equipment or (test-)signal generator providing a specified characteristic impedance and a specified maximum allowable cable transfer impedance

3.8
common mode (asymmetrical disturbance voltage)
the RF voltage between the artificial midpoint of a two-conductor line and reference ground, or in case of a bundle of lines, the effective RF disturbance voltage of the whole bundle (vector sum of the unsymmetrical voltages) against the reference ground measured with a clamp (current transformer) at a defined terminating impedance

NOTE See also IEV 161-04-09.

3.9
common mode current
the vector sum of the currents flowing through two or more conductors at a specified cross-section of a "mathematical" plane intersected by these conductors

3.10
measuring receiver
a receiver for the measurement of disturbances with different detectors

NOTE The receiver is specified according to CISPR 16-1-1.

3.11
test configuration
gives the specified measurement arrangement of the EUT in which an emission level is measured

NOTE The emission level is measured as required by IEV 161-03-11, IEV 161-03-12, IEV 161-03-14 and IEV 161-03-15, definitions of emission level.

3.12
weighting (quasi-peak detection)
the repetition-rate dependent conversion of the peak-detected pulse voltages to an indication corresponding to the psychophysical annoyance of pulsive disturbances (acoustically or visually) according to the weighting characteristics, or alternatively gives the specified manner in which an emission level or an immunity level is evaluated

NOTE 1 The weighting characteristics are specified in CISPR 16-1-1.

NOTE 2 The emission level or immunity level is evaluated as required by IEC 60050(161) definitions of level (see IEV 161-03-01, IEV 161-03-11 and IEV 161-03-14).

3.13
continuous disturbance
RF disturbance with a duration of more than 200 ms at the IF-output of a measuring receiver, which causes a deflection on the meter of a measuring receiver in quasi-peak detection mode which does not decrease immediately

[IEV 161-02-11, modified]

NOTE The measuring receiver is specified in CISPR 16-1-1.

3.14
discontinuous disturbance
for counted clicks, disturbance with a duration of less than 200 ms at the IF-output of a measuring receiver, which causes a transient deflection on the meter of a measuring receiver in quasi-peak detection mode

NOTE 1 For impulsive disturbance, see IEV 161-02-08.

NOTE 2 The measuring receiver is specified in CISPR 16-1-1.

3.15
measurement time
T_m
the effective, coherent time for a measurement result at a single frequency (in some areas also called dwell time)

- for the peak detector, the effective time to detect the maximum of the signal envelope,
- for the quasi-peak detector, the effective time to measure the maximum of the weighted envelope
- for the average detector, the effective time to average the signal envelope
- for the r.m.s. detector, the effective time to determine the r.m.s. of the signal envelope

3.16
sweep
a continuous frequency variation over a given frequency span

3.17
scan
a continuous or stepped frequency variation over a given frequency span

3.18
sweep or scan time
T_s
the time between start and stop frequencies of a sweep or scan

3.19
span
Δf
difference between stop and start frequencies of a sweep or scan

3.20
sweep or scan rate
the frequency span divided by the sweep or scan time

3.21
number of sweeps per time unit (e.g. per second)
n_s
1/(sweep time + retrace time)

3.22
observation time
T_o
the sum of measurement times T_m on a certain frequency in case of multiple sweeps. If n is the number of sweeps or scans, then $T_o = n \times T_m$

3.23
total observation time
T_{tot}
the effective time for an overview of the spectrum (either single or multiple sweeps). If c is the number of channels within a scan or sweep, then $T_{tot} = c \times n \times T_m$

3.24
lead under test
LUT
lead, associated with a EUT, that is the subject of an emission or an immunity test

NOTE In general, a EUT may have one or more leads that are used for interconnections to the mains supply, or other networks, or for interconnection to auxiliary equipment. These leads are generally electrical cables such as mains cables, coaxial cables, data bus cables, etc..

3.25
absorbing clamp measurement method
ACMM
method for measurement of disturbance power of an equipment under test (EUT) by using an absorbing clamp device that is clamped around the lead(s) of the EUT

3.26
absorbing clamp test site
ACTS
test site that is validated to perform disturbance power measurements by using the absorbing clamp measurement method (ACMM)

3.27
clamp factor
CF
ratio of the disturbance power of an EUT to the received voltage at the output of the absorbing clamp

NOTE The clamp factor is a transducer factor of the absorbing clamp.

3.28
clamp reference point
CRP
indication on the outside of the absorbing clamp that is related to the longitudinal position of the front edge of the current transformer within the clamp and is used to define the horizontal position of the clamp during the measurement

3.29
slide reference point
SRP
end of the clamp slide where the EUT is located and which is used to define the horizontal distance to the clamp reference point (CRP) of the absorbing clamp during the measurement procedure

4 Types of disturbance to be measured

This clause describes the classification of different types of disturbance and the detectors appropriate for their measurement.

4.1 Types of disturbance

For physical and psychophysical reasons, dependent on the spectral distribution, measuring receiver bandwidth, the duration, rate of occurrence, and degree of annoyance during the assessment and measurement of radio disturbance, distinction is made between the following types of disturbance:

a) *narrowband continuous disturbance*, i.e. disturbance on discrete frequencies as, for example, the fundamentals and harmonics generated with the intentional application of RF energy with ISM equipment, constituting a frequency spectrum consisting only of individual spectral lines whose separation is greater than the bandwidth of the measuring receiver so that during the measurement only one line falls into the bandwidth in contrast to b);

b) *broadband continuous disturbance,* which normally is unintentionally produced by the repeated impulses of, for example, commutator motors, and which have a repetition frequency which is lower than the bandwidth of the measuring receiver so that during the measurement more than one spectral line falls into the bandwidth; and

c) *broadband discontinuous disturbance* is also generated unintentionally by mechanical or electronic switching procedures, for example by thermostats or programme controls with a repetition rate lower than 1 Hz (click-rate less than 30/min).

The frequency spectra of b) and c) are characterized by having a continuous spectrum in the case of individual (single) impulses and a discontinuous spectrum in case of repeated impulses, both spectra being characterized by having a frequency range which is wider than the bandwidth of the measuring receiver specified in CISPR 16-1-1.

4.2 Detector functions

Depending on the types of disturbance, measurements may be carried out using a measuring receiver with:

a) an average detector generally used in the measurement of narrowband disturbance and signals, and particularly to discriminate between narrowband and broadband disturbance;

b) a quasi-peak detector provided for the weighted measurement of broadband disturbance for the assessment of audio annoyance to a radio listener, but also usable for narrowband disturbance;

c) a peak detector which may be used for either broadband or narrowband disturbance measurement.

Measuring receivers incorporating these detectors are specified in CISPR 16-1-1.

5 Connection of measuring equipment

This subclause describes the connection of measuring equipment, measuring receivers and associated equipment such as artificial networks, voltage and current probes, absorbing clamps and antennas.

5.1 Connection of associated equipment

The connecting cable between the measuring receiver and the associated equipment shall be shielded and its characteristic impedance shall be matched to the input impedance of the measuring receiver.

The output of the associated equipment shall be terminated with the prescribed impedance.

5.2 Connections to RF reference ground

The artificial mains network (AMN) shall be connected to the reference ground by a low RF impedance, e.g. by direct bonding of the case of the AMN to the reference ground or reference wall of a shielded room, or with a low impedance conductor as short and as wide as practical (maximum length to width ratio is 3:1).

Terminal voltage measurements shall be referenced only to the reference ground. Ground loops (common impedance coupling) shall be avoided. This should also be observed for measuring apparatus (e.g. measuring receivers and connected associated equipment, such as oscilloscopes, analyzers, recorders, etc.) fitted with a protective earth conductor (PE) of Protection Class I equipment. If the PE connection of the measuring apparatus and the PE connection of the power mains to the reference ground do not have RF isolation from the reference ground, the necessary RF isolation shall be provided by means such as RF chokes and isolation transformers, or if applicable, by powering the measuring apparatus from batteries, so that the RF connection of the measuring apparatus to the reference ground is made via only one route.

For the treatment of PE connection of the EUT to the reference ground, see clause A.4 of CISPR 16-2-1.

Stationary test configurations do not require a connection with the protective earth conductor if the reference ground is connected directly and meets the safety requirements for protective earth conductors (PE connections).

5.3 Connection between the EUT and the artificial mains network

General guidelines for the selection of grounded and non-grounded connections of the EUT to the AMN are discussed in annex A of CISPR 16-2-1.

6 General measurement requirements and conditions

Radio disturbance measurements shall be:

a) reproducible, i.e. independent of the measurement location and environmental conditions, especially ambient noise;

b) free from interactions, i.e. the connection of the EUT to the measuring equipment shall neither influence the function of the EUT nor the accuracy of the measurement equipment.

These requirements may be met by observing the following conditions:

c) existence of a sufficient signal-to-noise ratio at the desired measurement level, e.g. the level of the relevant disturbance limit;

d) having a defined measuring set-up, termination and operating conditions of the EUT;

e) having a sufficiently high impedance of the probe at the measuring point, in the case of voltage probe measurements;

f) when using a spectrum analyzer or scanning receiver due considerations shall be given to its particular operating and calibration requirements.

6.1 Disturbance not produced by the equipment under test

The measurement signal-to-noise ratio with respect to ambient noise shall meet the following requirements. Should the spurious noise level exceed the required level, it shall be recorded in the test report.

6.1.1 Compliance testing

A test site shall permit emissions from the EUT to be distinguished from ambient noise. The ambient noise level should preferably be 20 dB, but at least be 6 dB below the desired measurement level. For the 6 dB condition, the apparent disturbance level from the EUT is increased by up to 3,5 dB. The suitability of the site for required ambient level may be determined by measuring the ambient noise level with the test unit in place but not operating.

In the case of compliance measurement according to a limit, the ambient noise level is permitted to exceed the preferred –6 dB level provided that the level of both ambient noise and source emanation combined does not exceed the specified limit. The EUT is then considered to meet the limit. Other actions can also be taken; for example, reduce the bandwidth for narrowband signals and/or move the antenna closer to the EUT.

NOTE If both the ambient field strength and field strength of ambient and EUT are measured separately, it may be possible to provide an estimate of the EUT field strength to a quantifiable level of uncertainty. Reference is made in this respect in annex C of CISPR 11.

6.2 Measurement of continuous disturbance

6.2.1 Narrowband continuous disturbance

The measuring set shall be kept tuned to the discrete frequency under investigation and returned if the frequency fluctuates.

6.2.2 Broadband continuous disturbance

For the assessment of broadband continuous disturbance the level of which is not steady, the maximum reproducible measurement value shall be found. See 6.4.1 for further details.

6.2.3 Use of spectrum analyzers and scanning receivers

Spectrum analyzers and scanning receivers are useful for disturbance measurements, particularly in order to reduce measuring time. However, special consideration must be given to certain characteristics of these instruments, which include: overload, linearity, selectivity, normal response to pulses, frequency scan rate, signal interception, sensitivity, amplitude accuracy and peak, average and quasi-peak detection. These characteristics are considered in annex B.

6.3 Operating conditions of the EUT

The EUT shall be operated under the following conditions:

6.3.1 Normal load conditions

The normal load conditions shall be as defined in the product specification relevant to the EUT, and for EUTs not so covered, as indicated in the manufacturer's instructions.

6.3.2 The time of operation

The time of operation shall be, in the case of EUTs with a given rated operating time, in accordance with the marking; in all other cases, the time is not restricted.

6.3.3 Running-in time

No specific running-in time, prior to testing, is given, but the EUT shall be operated for a sufficient period to ensure that the modes and conditions of operation are typical of those during the life of the equipment. For some EUTs, special test conditions may be prescribed in the relevant equipment publications.

6.3.4 Supply

The EUT shall be operated from a supply having the rated voltage of the EUT. If the level of disturbance varies considerably with the supply voltage, the measurements shall be repeated for supply voltages over the range of 0,9 to 1,1 times the rated voltage. EUTs with more than one rated voltage shall be tested at the rated voltage which causes maximum disturbance.

6.3.5 Mode of operation

The EUT shall be operated under practical conditions which cause the maximum disturbance at the measurement frequency.

6.4 Interpretation of measuring results

6.4.1 Continuous disturbance

a) If the level of disturbance is not steady, the reading on the measuring receiver is observed for at least 15 s for each measurement; the highest readings shall be recorded, with the exception of any isolated clicks, which shall be ignored (see 4.2 of CISPR 14-1).

b) If the general level of the disturbance is not steady, but shows a continuous rise or fall of more than 2 dB in the 15 s period, then the disturbance voltage levels shall be observed for a further period and the levels shall be interpreted according to the conditions of normal use of the EUT, as follows:

   1) if the EUT is one which may be switched on and off frequently, or the direction of rotation of which can be reversed, then at each frequency of measurement the EUT should be switched on or reversed just before each measurement, and switched off just after each measurement. The maximum level obtained during the first minute at each frequency of measurement shall be recorded;

   2) if the EUT is one which in normal use runs for longer periods, then it should remain switched on for the period of the complete test, and at each frequency the level of disturbance shall be recorded only after a steady reading (subject to the provision that item a) has been obtained).

c) If the pattern of the disturbance from the EUT changes from a steady to a random character part way through a test, then that EUT shall be tested in accordance with item b).

d) Measurements are taken throughout the complete spectrum and are recorded at least at the frequency with maximum reading and as required by the relevant CISPR publication.

6.4.2 Discontinuous disturbance

Measurement of discontinuous disturbance may be performed at a restricted number of frequencies. For further details, see CISPR 14-1.

6.4.3 Measurement of the duration of disturbances

The EUT is connected to the relevant artificial mains network. If a measuring set is available, it is connected to the network and a cathode-ray oscilloscope is connected to the i.f. output of the measuring set. If a receiver is not available, the oscilloscope is connected directly to the network. The time base of the oscilloscope can be started by the disturbances to be tested; the time base is set to a value of 1 ms/div –10 ms/div for EUT with instantaneous switching and 10 ms/div – 200 ms/div for other EUT. The duration of the disturbance can either be recorded directly by a storage oscilloscope or digital oscilloscope or by photograph or hard copy recording of the screen.

6.5 Measurement times and scan rates for continuous disturbance

Both for manual measurements and automated or semiautomated measurements, measurement times and scan rates of measuring and scanning receivers shall be set so as to measure the maximum emission. Especially, where a peak detector is used for prescans, the measurement times and scan rates have to take the timing of the emission under test into account. More detailed guidance on the execution of automated measurements can be found in 8.

6.5.1 Minimum measurement times

Clause B.7 of the present standard gives a table of the minimum sweep times or the fastest – practically achievable – scan rates. From this table the following minimum scan times for each whole CISPR band have been derived:

Table 1 – Minimum scan times for the three CISPR bands with peak and quasi-peak detectors

Frequency band		Scan time T_s for peak detection	Scan time T_s for quasi-peak detection
A	9 kHz – 150 kHz	14,1 s	2820 s = 47 min
B	0,15 MHz – 30 MHz	2,985 s	5 970 s = 99,5 min = 1 h 39 min
C/D	30 MHz – 1 000 MHz	0,97 s	19 400 s = 323,3 min = 5 h 23 min

The scan times in Table 1 apply for CW signals. Depending on the type of disturbance, the scan time may have to be increased – even for quasi-peak measurements. In extreme cases, the measurement time T_m at a certain frequency may have to be increased to 15 s, if the level of the observed emission is not steady (see 6.4.1). However isolated clicks are excluded.

Scan rates and measurement times for use with the average detector will be found in Annex C.

Most product standards call out quasi-peak detection for compliance measurements which is very time consuming, if no time-saving procedures are applied (see 8). Before time-saving procedures can be applied, the emission has to be detected in a prescan. In order to ensure that e.g. intermittent signals are not overlooked during an automatic scan, the considerations in 6.5.2 to 6.5.4 need to be taken into account.

6.5.2 Scan rates for scanning receivers and spectrum analyzers

One of two conditions need to be met to ensure that signals are not missed during automatic scans over frequency spans:

1) for a single sweep: the measurement time at each frequency must be larger than the intervals between pulses for intermittent signals;
2) for multiple sweeps with maximum hold: the observation time at each frequency should be sufficient for intercepting intermittent signals.

The frequency scan rate is limited by the instrument's resolution bandwidth and the video bandwidth setting. If the scan rate is chosen too fast for the given instrument state, erroneous measurement results will be obtained. Therefore, a sufficiently long sweep time needs to be chosen for the selected frequency span. Intermittent signals may be intercepted by either a single sweep with sufficient observation time at each frequency or by multiple sweeps with maximum hold. Usually for an overview over unknown emissions, the latter will be highly efficient: as long as the spectrum display changes, there may still be intermittent signals to discover. The observation time has to be selected according to the periodicity at which interfering signals occur. In some cases, the sweep time may have to be varied in order to avoid synchronization effects.

When determining the minimum sweep time for measurements with a spectrum analyzer or scanning EMI receiver, based on a given instrument setting and using peak detection, two different cases have to be distinguished. If the video bandwidth is selected to be **wider** than the resolution bandwidth, the following expression can be used to calculate the minimum sweep time:

$$T_{\mathrm{s\ min}} = (\mathrm{k} \times \Delta f) / (B_{\mathrm{res}})^2 \qquad (1)$$

where

$T_{\mathrm{s\ min}}$ = Minimum sweep time

Δf = Frequency span

B_{res} = Resolution bandwidth

k = Constant of proportionality, related to the shape of the resolution filter; this constant assumes a value between 2 and 3 for synchronously-tuned, near-Gaussian filters. For nearly rectangular, stagger-tuned filters, k has a value between 10 and 15.

If the video bandwidth is selected to be equal to or smaller than the resolution bandwidth, the following expression can be used to calculate the minimum sweep time:

$$T_{\mathrm{s\ min}} = (\mathrm{k} \times \Delta f) / (B_{\mathrm{res}} \times B_{\mathrm{video}}) \qquad (2)$$

where B_{video} = Video bandwidth

Most spectrum analyzers and scanning EMI receivers automatically couple the sweep time to the selected frequency span and the bandwidth settings. Sweep time is adjusted to maintain a calibrated display. The automatic sweep time selection can be overwritten if longer observation times are required, e.g., to intercept slowly varying signals.

In addition, for repetitive sweeps, the number of sweeps per second will be determined by the sweep time $T_{s\ min}$ and the retrace time (time needed to retune the local oscillator and to store the measurement results, etc.).

6.5.3 Scan times for stepping receivers

Stepping EMI receivers are consecutively tuned to single frequencies using predefined step sizes. While covering the frequency range of interest in discrete frequency steps, a minimum dwell time at each frequency is required for the instrument to accurately measure the input signal.

For the actual measurement, a frequency step size of roughly 50 % of the resolution bandwidth used or less (depending on the resolution filter shape) is required to reduce measurement uncertainty for narrowband signals due to the stepwidth. Under these assumptions the scan time $T_{s\ min}$ for a stepping receiver can be calculated using the following equation:

$$T_{s\ min} = T_{m\ min} \times \Delta f/(B_{res} \times 0{,}5) \qquad (3)$$

where $T_{m\ min}$ = Minimum measurement (dwell) time at each frequency

In addition to the measurement time, some time has to be taken into consideration for the synthesizer to switch to the next frequency and for the firmware to store the measurement result, which in most measuring receivers is automatically done so that the selected measurement time is the effective time for the measurement result. Furthermore, the selected detector, e.g. peak or quasi-peak, determines this time period as well.

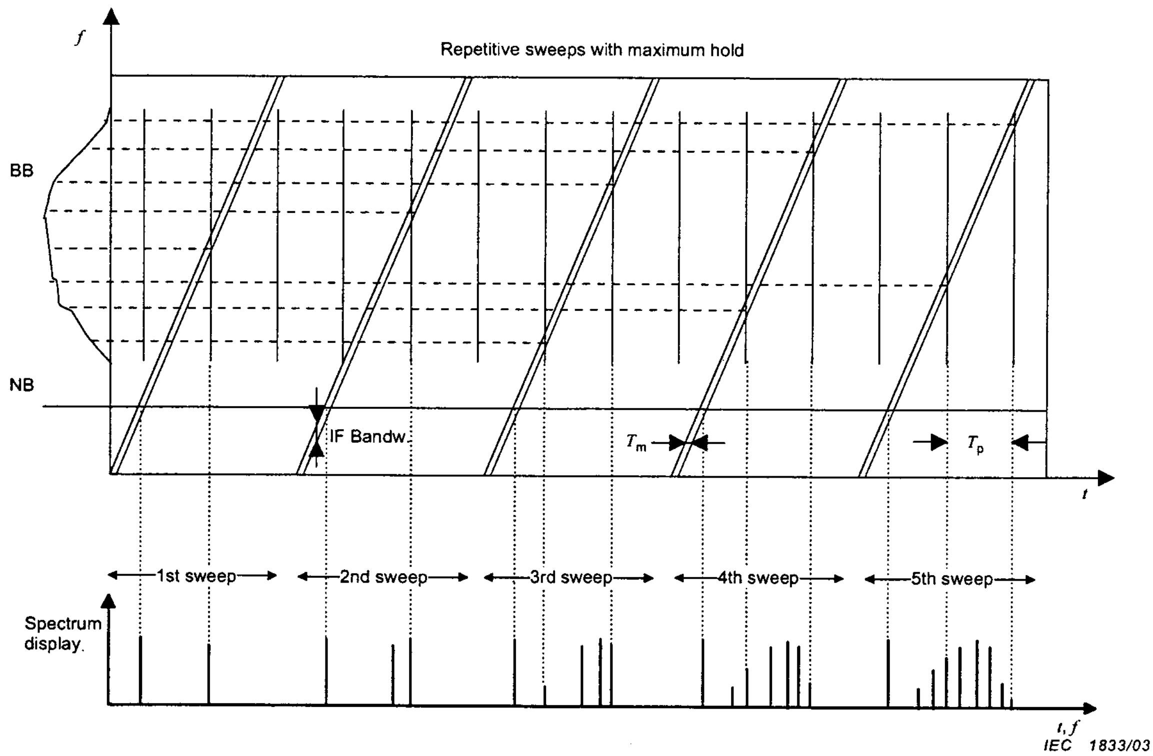
For purely broadband emissions, the frequency step size may be increased. In this case the objective is to find the maxima of the emission spectrum only.

6.5.4 Strategies for a spectrum overview using the peak detector

For each prescan measurement, the probability of intercepting all critical spectral components of the EUT spectrum shall be equal to 100 % or as close to 100 % as possible. Depending on the type of measuring receiver and the characteristics of the disturbance, which may contain narrowband and broadband elements, two general approaches are proposed:

- stepped scan: the measurement (dwell) time shall be long enough at each frequency to measure the signal peak, e.g. for an impulsive signal the measurement (dwell) time should be longer than the reciprocal of the repetition frequency of the signal.
- swept scan: the measurement time must be larger than the intervals between intermittent signals (single sweep) and the number of frequency scans during the observation time should be maximized to increase the probability of signal interception.

Figures 1, 2 and 3 show examples of the relationship between various time-varying emission spectra and the corresponding display on a measuring receiver. In each case the upper part of the figure shows the position of the receiver bandwidth as it either sweeps or steps through the spectrum.

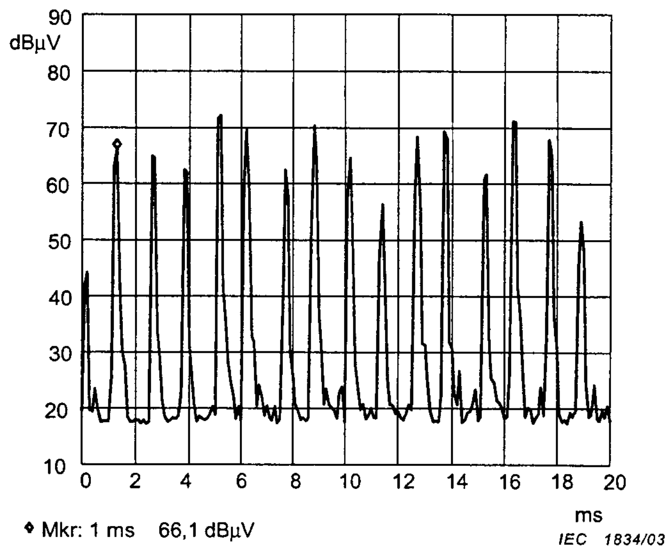


T_p is the pulse-repetition interval of the impulsive signal. A pulse occurs at each vertical line of the spectrum-vs.-time display (upper part of the figure).

Figure 1 – Measurement of a combination of a CW signal ("NB") and an impulsive signal ("BB") using multiple sweeps with maximum hold

If the type of emission is unknown, multiple sweeps with the shortest possible sweep time and peak detection allow to determine the spectrum envelope. A short single sweep is sufficient to measure the continuous narrowband signal content of the EUT spectrum. For continuous broadband and intermittent narrowband signals, multiple sweeps at various scan rates using a "maximum hold" function may be necessary to determine the spectrum envelope. For low repetition impulsive signals, many sweeps will be necessary to fill up the spectrum envelope of the broadband component.

The reduction of measurement time requires a timing analysis of the signals to be measured. This can be done either with a measuring receiver which provides a graphical signal display, used in zero-span mode or using an oscilloscope connected to the receiver's IF or video output as e.g. shown in Figure 2.



Disturbance from a DC collector motor: due to the number of collector segments the pulse repetition frequency is high (approx. 800 Hz) and the pulse amplitude varies strongly. Therefore for this example, the recommended measurement (dwell) time with the peak detector is > 10 ms.

Figure 2 – Example of a timing analysis

This way pulse durations and pulse repetition frequencies can be determined and scan rates or dwell times selected accordingly:

- for **continuous unmodulated narrowband** disturbances the fastest scan time possible for the selected instrument settings may be used;
- for **pure continuous broadband** disturbances, e.g. from ignition motors, arc welding equipment, and collector motors, a stepped scan (with peak or even quasi-peak detection) for sampling of the emission spectrum may be used. In this case the knowledge of the type of disturbance is used to draw a polyline curve as the spectrum envelope (see Figure 3). The step size has to be chosen so that no significant variations in the spectrum envelope are missed. A single swept measurement – if performed slowly enough – will also yield the spectrum envelope;
- for **intermittent narrowband** disturbances with unknown frequencies either fast short sweeps involving a "maximum hold" function (see Figure 4) or a slow single sweep may be used. A timing analysis may be required prior to the actual measurement to ensure proper signal interception.

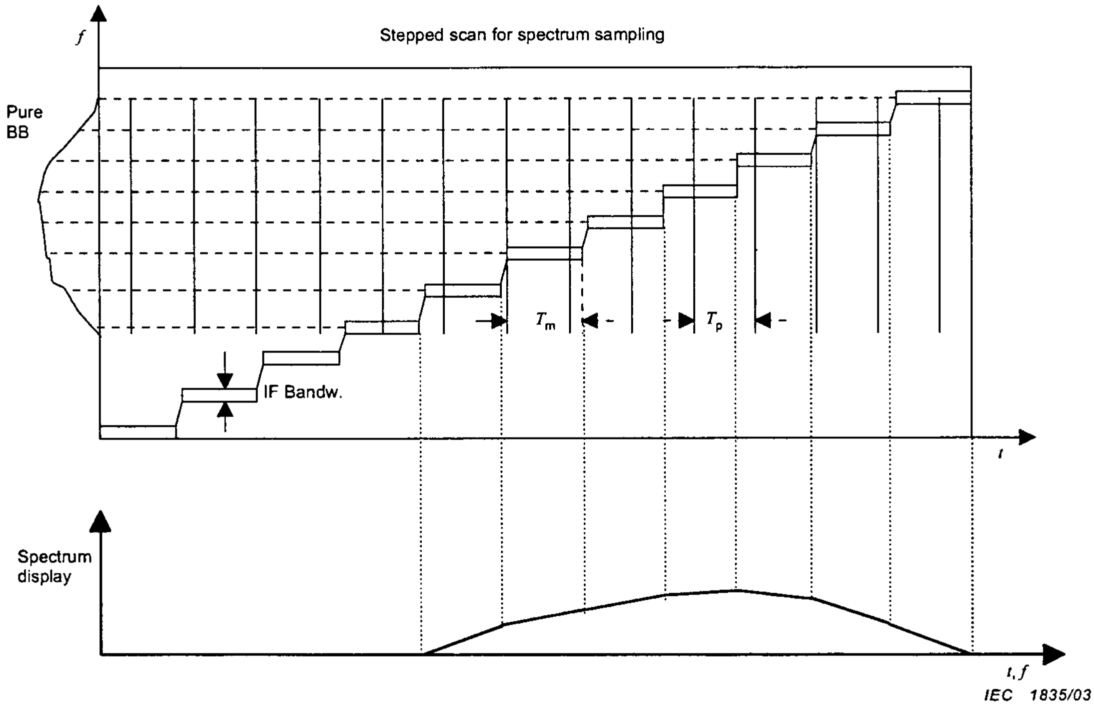


Figure 3 – A broadband spectrum measured with a stepped receiver

The measurement (dwell) time T_m should be longer than the pulse repetition interval T_p, which is the inverse of the pulse repetition frequency.

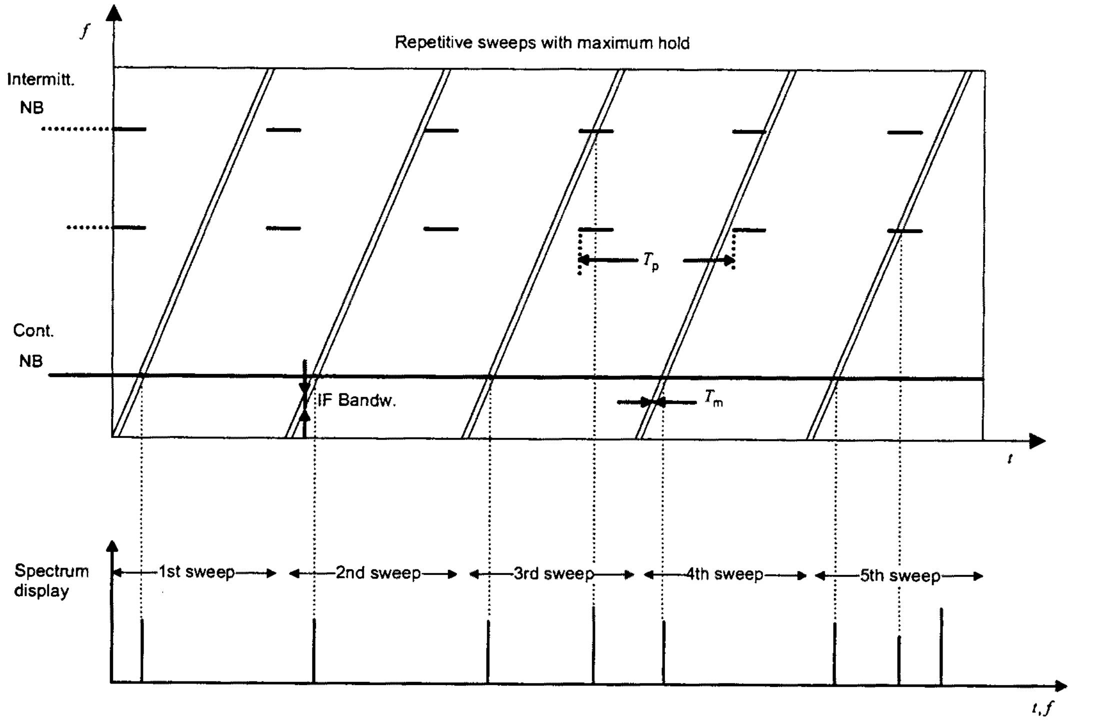


Figure 4 – Intermittent narrowband disturbances measured using fast short repetitive sweeps with maximum hold function to obtain an overview of the emission spectrum

NOTE In the example above, 5 sweeps are required until all spectral components are intercepted. The number of sweeps required or the sweeptime may have to be increased, depending on pulse duration and pulse repetition interval.

Intermittent broadband disturbances have to be measured with discontinuous disturbance analysis procedures, as described in CISPR 16-1-1.

7 Measurements using the absorbing clamp

7.1 Introduction

For small equipments under test (EUTs) connected only by one mains lead, or another type of lead, the absorbing clamp measurement method (ACMM) offers an alternative to the radiated emission measurement method. The ACMM determines the disturbance power by using an absorbing clamp. The advantages of the ACMM with respect to the radiated emission test are mainly the reduced measurement time and reduced cost of the test site.

The basis of the ACMM is the recognition that radiated emissions from electrically small equipment (see 7.2.2) can primarily be attributed to common mode currents flowing on e.g., the mains lead attached to the equipment. The disturbance potential of an EUT having one external lead may be taken as the power it could supply to its lead acting as a radiating antenna. This power is assumed to be nearly equal to that supplied by the EUT to the absorbing clamp placed around the lead under test (LUT) at the position where the measured common mode current is maximum. An exact model of the ACMM is not available. This makes the uncertainty considerations and the comparison between the radiated emission measurement method and the ACMM difficult. The historical background of the absorbing clamp is described in detail in Annex A.

This clause establishes the general requirements for the measurement of disturbance power produced at the leads of a EUT. For specific products, more specific measurement procedures and operating conditions may be necessary. The limitations of the ACMM are stated in 7.2. The calibration and validation methods related to the ACMM are given in Clause 4 of CISPR 16-1-3. Measurement instrumentation uncertainty considerations on the ACMM are described in CISPR 16-4-2.

7.2 Application of the absorbing clamp measurement method

The applicability (scope) of this ACMM is limited. The applicability of the ACMM for certain categories of products shall be decided by the product committees, by taking into account the limitations given in the following subclauses. The precise measuring procedure and its applicability has to be specified for each category of products in the product standard.

7.2.1 Frequency range

The ACMM as described in this clause may be applied to measure the disturbance power of an EUT between 30 MHz and 1 000 MHz.

7.2.2 EUT unit dimensions

The EUT unit is the housing of the EUT without its connecting leads. The ACMM is most accurate for EUT units having dimensions typically smaller than a quarter of a wavelength of the highest measured frequency and with one or more leads as the main source of disturbance radiation. If the dimensions of the EUT unit approach a quarter of a wavelength of the highest measuring frequency, then direct radiation of the EUT unit may occur. Then, the ACMM may not be suitable to assess the full radiation properties of the EUT. In general, the method is most useful for small EUTs and in the frequency range of 30 MHz to 300 MHz. The ACMM is applicable to both tabletop and floor standing EUTs.

7.2.3 LUT requirements

Initially, the ACMM is applied for EUTs with a single mains lead (see Annex A). When the EUT has external leads other than a mains lead, also those leads can radiate disturbances. These auxiliary leads may be connected to an auxiliary unit. The ACMM can also be used to measure these leads. The disturbance contribution of such auxiliary leads connected to auxiliary apparatus depends on the length of the auxiliary lead with respect to the wavelength. If length of the auxiliary lead is larger than half a wavelength of the highest measurement frequency, then the contribution of this auxiliary lead shall be taken into account in the measurement procedure. Product standards shall give specific information on the treatment of auxiliary leads (like extension of these leads), the set-up of these auxiliary leads and auxiliary apparatus in order to enable reproducibility of the disturbance measurement.

If the auxiliary lead is permanently attached to the appliance and to the auxiliary apparatus and if the length of the auxiliary lead is less than a half wavelength at the highest frequency, then measurements are not to be made on these leads.

7.3 Requirements for measurements instrumentation and test site

A schematic drawing of the ACMM is given in Figure 5. The following requirements apply for the various parts of the instrumentation and for the test site.

7.3.1 Measuring receiver

The measuring receiver shall comply with the requirements of CISPR 16-1-1. When using spectrum analyzers or scanning receivers, the recommendations given in Annex B shall be considered.

7.3.2 Absorbing clamp assembly

The absorbing clamp assembly consists of the following parts:

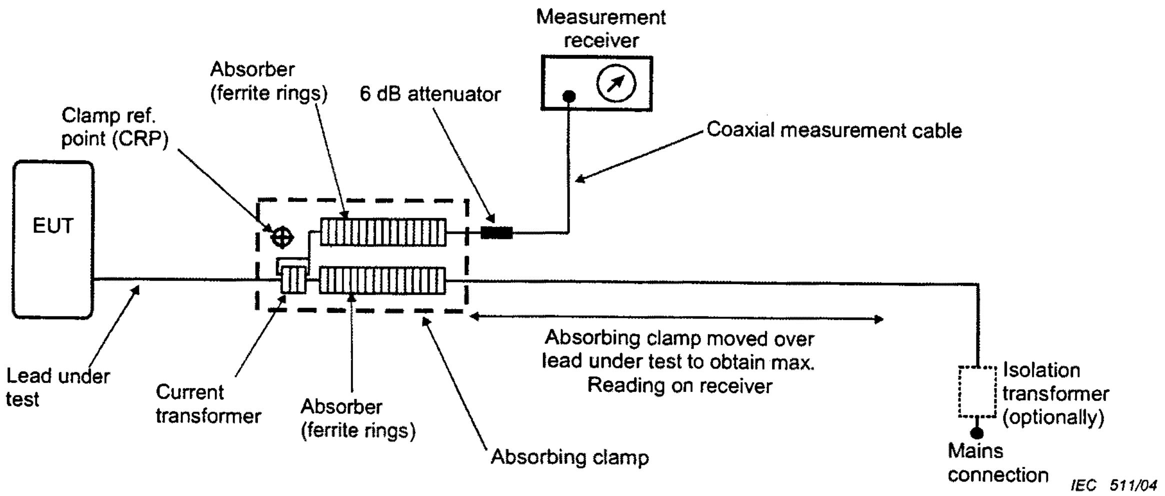
a) absorbing clamp (includes internally the current transformer and absorbers along the LUT and measurement cable; see Figure 5);

b) 6 dB attenuator;

c) measurement cable.

The absorbing clamp assembly shall comply with the requirements given in Clause 4 of CISPR 16-1-3. The clamp factor (CF) of this absorbing clamp assembly shall be determined in accordance with the measurement procedure given in Clause 4 of CISPR 16-1-3. Also the decoupling factors of the absorbing clamp assembly shall be checked in accordance with the measurement procedures given in Clause 4 of CISPR 16-1-3.

The clamp reference point (CRP) indicates the longitudinal position of the front edge of the current transformer within the clamp. This reference point is used to define the position of the clamp during the measurement procedure. The CRP shall be indicated on the outside housing of the absorbing clamp.



NOTE 1 The 6-dB attenuator and the measurement cable are integral parts of the absorbing clamp and shall be calibrated together.

NOTE 2 The 6-dB attenuator may be located inside the absorbing clamp unit.

Figure 5 – Schematic drawing of the absorbing clamp measurement method

7.3.3 Absorbing clamp test site requirements

The absorbing clamp test site (ACTS) is a site that is used for application of the ACMM. The ACTS is specified in detail in Clause 4 of CISPR 16-1-3, and its performance shall be validated in accordance with the procedure given in CISPR 16-1-3. The ACTS can be either an outdoor or indoor facility and includes the following elements (Figure 6):

- a non-metallic table for support of the EUT unit;
- the clamp slide to support the LUT and the absorbing clamp;
- a moveable support or hook system for the absorbing clamp measurement cable;
- auxiliary means such as a rope to move the absorbing clamp.

The above ACTS elements shall be included in the ACTS validation procedure.

The near end of the clamp slide (at the side of the EUT) is denoted as the slide reference point (SRP, see Figure 6). This SRP is used to define the horizontal distance to the CRP. Some of the requirements for the above mentioned elements of the ACTS that are specified in detail in Clause 4 of CISPR 16-1-3 are repeated below for convenience.

a) The length of the clamp slide shall ensure that the absorbing clamp can be moved over such a distance that the maximum disturbance power is measured at the lowest frequency of 30 MHz. The length of the clamp slide shall be (6 ± 0,05) m.

   NOTE 1 In theory, the length of the clamp slide is determined by the sum of the theoretical maximum scanning length (over a half wavelength = 5 m at 30 MHz), the distance between the SRP and the CRP (0,1 m), and the length of the absorbing clamp (0,7 m) and a margin to accommodate lead fixtures at the end (0,1 m). This gives a total length of 5,9 m for the clamp slide. For reproducibility reasons, the length of clamp slide is fixed to 6 m (and not minimally 6 m).

b) The scanning distance of the absorbing clamp shall be 5 m. Consequently, the CRP shall move between 0,1 m and 5,1 m from the SRP.

c) The height of the clamp slide shall be 0,8 m ± 0,05 m for both tabletop and floor standing EUTs. Consequently, the height of the LUT shall be nearly 0,8 m above the floor of the site. It should be noted that within the absorbing clamp, the height of the LUT above the floor will be a few centimetres larger.

d) The EUT table, the clamp slide and the auxiliary means (rope) shall be non-reflecting, non-conducting and the dielectric properties shall be close to the dielectric properties of air. In this way, these items (EUT table, clamp slide and other auxiliary means close to the EUT and LUT) are electromagnetically transparent (neutral). In addition to material properties, the material (thickness and construction) is of importance as well. Typically, dry wood is an adequate material for the construction of the EUT table and the clamp slide between 30 MHz and 300 MHz.

   NOTE 2 The requirements and validation methods for EUT positioning tables and antenna masts are presented in CISPR 16-1-3 Ed.2[1]. It is suggested to apply material with a relative permittivity $\varepsilon_r < 1,5$. The influence of the material and construction of the EUT table and the clamp slide may be significant for frequencies above 300 MHz. See CISPR 16-1-3 Ed.2 for further information and guidance.

[1] CISPR 16-1-3:2004, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-3: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Disturbance power*

7.4 Ambient requirements

The ambient noise level present at the ACTS shall comply with the requirements given in 6.1.

The ambient disturbance power shall be evaluated in accordance with 7.8.1. The ambient noise level shall be at least 6 dB below the applicable limit.

7.5 EUT leads requirements

The disturbance power shall be measured for each of the leads (see also 7.2.3), one at a time. The measurement procedure is given in 7.8. The requirements for the leads are as follows.

7.5.1 Lead under test

The length of the LUT shall be at least a half-wavelength at the lowest frequency of measurement, plus an additional length to connect the lead to a mains connection on the floor. This means that the lead length shall be typically at least 7,5 m.

NOTE 1 The lead length is determined by the minimum length of the clamp slide 6 m + 1 m (drop of the LUT to floor) + 0,5 m margin = 7,5 m. Additional length may be required for the LUT section between the EUT and the clamp reference point.

NOTE 2 In general, the original leads connected to the EUT are much shorter than 7,5 m, and the lead must be extended or completely replaced by a lead of the required length and of the same type and construction as the original lead of the EUT. Extension of leads is generally not practical, because in general the extension plugs will not pass through the absorbing clamp.

NOTE 3 The type of low voltage distribution may differ in different countries, and test laboratories may have different mains network topologies or different mains connection philosophies. For certain EUTs, the disturbance properties may depend very much on the type of mains connection. The mains connection may be asymmetric (phase to ground) or symmetric (using an isolation transformer). This may be the reason for significant reproducibility problems. It is noted here that these 'mains-connection induced' reproducibility problems are generic, and are not specific to the ACMM. The reproducibility problem can be evaluated by connection of the mains through an isolating transformer.

7.5.2 Leads not under test

If the EUT has more than one lead (see 7.2.3), the leads that are not subject to measurement (including the connected auxiliary apparatus) shall be removed if operationally possible, at the time when another lead is measured. A lead that cannot be removed shall be isolated by means of a common-mode absorbing device (CMAD). A CMAD may consist of a number of lossy ferrite rings or another absorbing device put around the lead immediately adjacent to the housing of the EUT. The isolated leads shall be positioned near the EUT on the EUT table. The performance requirements for the CMAD are under consideration.

7.6 Test set-up requirements

7.6.1 General

The following general requirements for the test set-up apply:

a) the test set-up of the EUT and the LUT on the ACTS are shown in Figures 6 and 7;

b) the distance between the clamp test set-up (EUT, LUT, clamp) and any objects (including persons, walls and ceiling, but floor excluded) shall be at least 0,8 m;

c) the configuration of the ACTS shall be the same as during the ACTS performance validation.

7.6.2 EUT set-up

The set-up of the EUT shall comply with the following requirements:

a) the EUT shall be placed on a support table. The height of the table shall be 0,8 m ± 0,05 m for table top EUTs. The support for equipment designed for use primarily on a floor, shall be (0,1 ± 0,01) m high;

b) the EUT shall be positioned on the EUT table in its normal operating position as far as possible. The LUT shall run directly towards the SRP of the clamp slide. In case a normal position is not defined, the EUT shall be positioned such that its LUT runs directly towards the clamp slide. The distance from EUT unit to the SRP shall be as short as possible.

NOTE For certain types of products like a washing machine or a coffee maker, the normal operating position is obvious. However, for products like a hairdryer or a drill, this is less obvious and the EUT will just be laid on the table. The importance of this subclause is to enhance the reproducibility of the test. Product committees may decide to give specific guidance to assure reproducible positioning of the EUT.

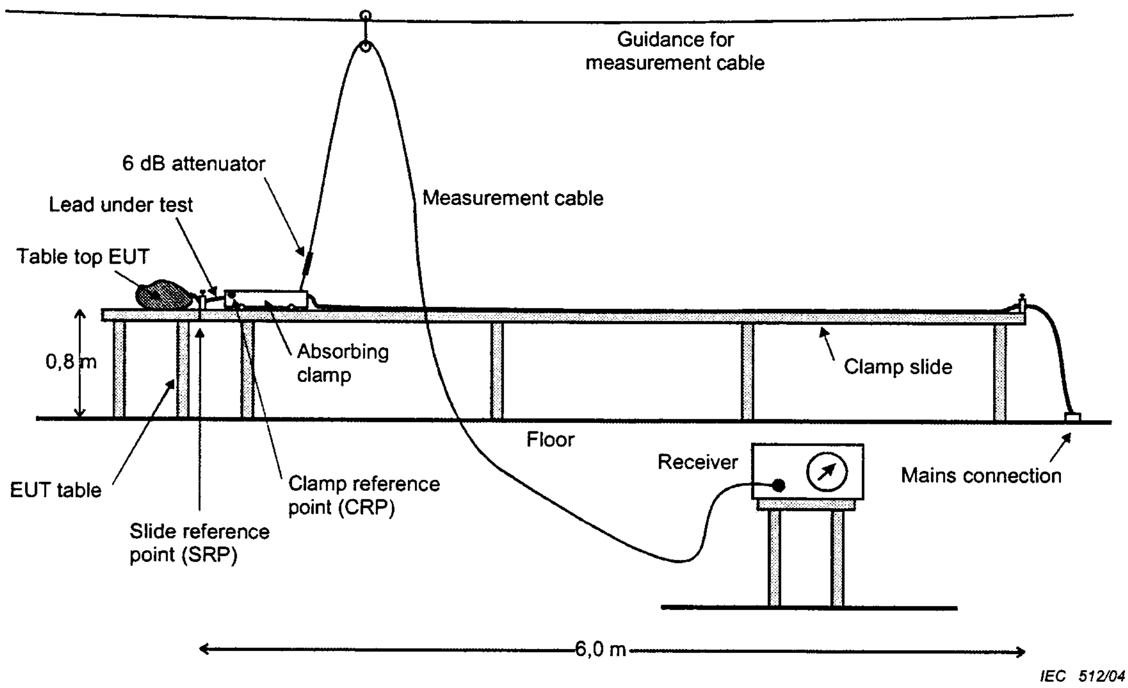


Figure 6 – Side view of the absorbing clamp measurement set-up for table top EUTs

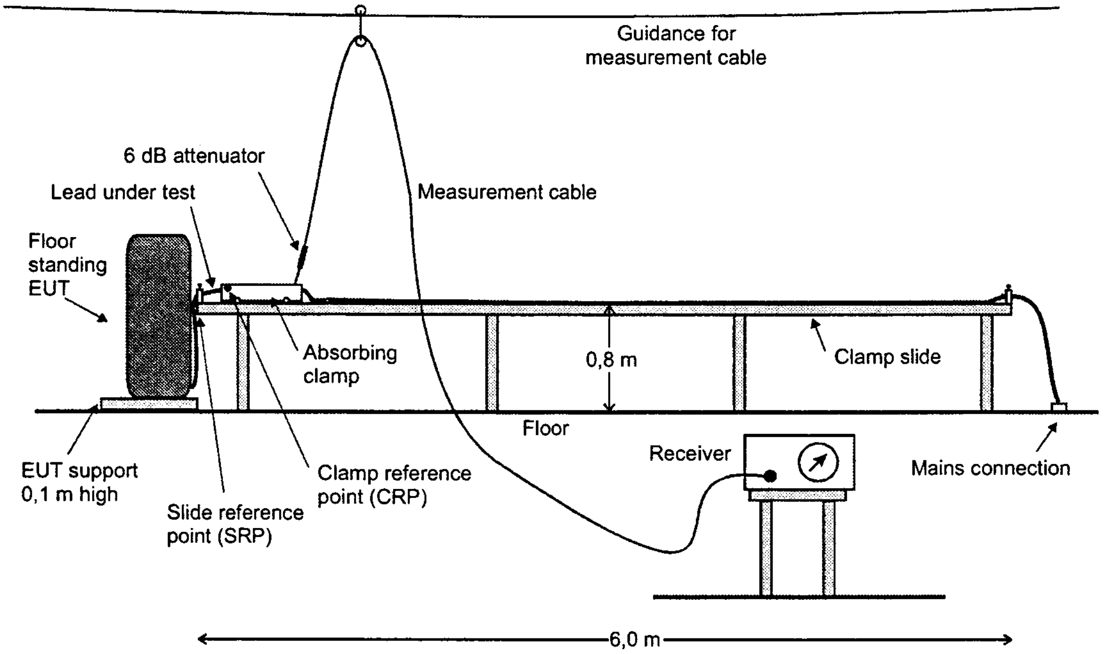


Figure 7 – Side view of the absorbing clamp measurement set-up for floor standing EUTs

7.6.3 LUT set-up

The LUT is positioned horizontally straight above the clamp slide, to permit variation of the position of the absorbing clamp along the lead to find the maximum reading. Outside the absorbing clamp, the height of the LUT above the floor shall be as close to 0,8 m as possible. For better attachment of the LUT during the clamp sliding procedure, it is convenient to fix the LUT at the near end and the far end of the clamp slide by using quick release locks.

7.6.4 Absorbing clamp

The following positioning requirements relating to the absorbing clamp apply.

a) The absorbing clamp is placed around the LUT as shown in Figure 6. The absorbing clamp shall be positioned on the clamp slide with the current transformer facing the EUT.

b) During the clamp scanning, the minimal horizontal distance between the CRP and the SRP shall be (10 ± 1) cm. This distance of 10 cm is required to accommodate different types of clamps, due to the possible different positions of the CRP. The test results very much depend on this initial position. For reproducibility purposes, it is essential to include this additional specification to ensure that all initial positions can be identical.

c) The LUT shall be kept in the centre of the absorbing clamp at the location of the current transformer, i.e., at the CRP. Most clamps have a centering support for this purpose.

7.6.5 Measurement cable

The absorbing clamp measurement cable shall meet the following requirements.

a) In case the 6 dB attenuator is not integrated into the absorbing clamp assembly, it is important to connect the separate 6 dB attenuator close to the measurement connector of the clamp. Note that the 6 dB attenuator shall be a coaxial attenuator with a maximum VSWR of 1,12 and a maximum attenuation tolerance of ± 0,3 dB (see Clause 4 of CISPR 16-1-3).
b) The measurement cable is connected to the measuring receiver or spectrum analyzer.
c) The measurement cable shall run over a gliding pulley such that the measurement cable runs at almost a right angle to the absorbing clamp and does not touch the ground.

7.7 Operating conditions of the EUT

When measurements of the disturbance power are performed, the EUT shall be operated in its normal modes of operation, including the standby mode. A pre-scan procedure (7.8.2 a)) is used to determine the mode of operation that causes the highest emission. The general operating conditions of the EUT as given in Clause 6 shall be met. Additional product-specific conditions may be necessary. If applicable, product-specific operational conditions shall be specified in the product standard.

7.8 Measurement procedure

7.8.1 Ambient measurement procedure

Ambient signals shall be measured prior to the actual test of the EUT by using the LUT (the main lead, or, if not applicable, another lead). The ambient disturbance power is measured while the EUT is switched off. Ambient signals shall be measured while the absorbing clamp is moved in accordance with the final scan procedure described in 7.8.2 b). The ambient disturbance power calculated using Equation (4), shall be at least 6 dB below the applicable limit.

7.8.2 EUT measurement procedure

For each lead connected to the EUT (see 7.5), the following measurement procedure shall be applied.

a) Pre-scan at a fixed position

   The clamp shall be positioned at a horizontal distance of 0,1 m from the SRP. The EUT shall be switched on and the operating conditions shall be as specified in 7.7. For this fixed position and for each of the relevant operating modes of the EUT, a frequency scan shall be performed to find the operating modes that yield the highest emission levels. For the mode of operation at which the maximum emission occurs, the final-scan procedure shall be performed. A peak detector may be used in this pre-scan procedure. The pre-scan procedure is also used to gain information about the type of disturbances (narrowband, broadband).

b) Final scan

The procedure for the final scan will depend on the type of disturbance found during the pre-scan. Guidance on the procedures for narrowband, broadband, continuous and discontinuous disturbances can be found in 6.2 and 6.4 and in CISPR 14-1. Depending on the type of disturbance found during the pre-scan procedure, the following two alternative procedures can be applied for the final scan.

1) Measurement at fixed frequencies and clamp scanning continuously

The position of the CRP of the absorbing clamp along the lead shall be varied continuously over a distance corresponding to at least a half-wavelength (free space) of the frequency in question. At each frequency, the maximum indication obtained on the measurement receiver connected to the absorbing clamp shall be determined. The speed of movement of the clamp shall be such that the measurement time at a certain frequency corresponds to a distance step size of the clamp of less than 1/15 wavelength.

2) Measurement at fixed clamp positions and receiver scanning over the frequency band

It may be more convenient to position the absorbing clamp along the clamp slide at a sufficient number of discrete positions depending on the upper frequency applied. For instance, a distance step size of 0,02 m is sufficient if the maximum frequency is 1 000 MHz (step size is 1/15 wavelength). The measurement receiver shall perform a frequency scan at each clamp position. The measurement receiver shall maintain the maximum reading for all positions. A constant distance step size along the whole lead under test would increase the measurement time significantly. As the distance between the EUT and the absorbing clamp increases, a progressively larger step size may be used. This reduces the number of steps considerably. Tables 2 and 3 show the sample schemes that can be applied depending on the upper frequency used. A further reduction of test time may be achieved by limiting the frequency scan as a function of the position of the clamp. The upper frequency limit for the receiver can be calculated from the clamp position that corresponds to a half wavelength.

Table 2 – Sample scheme for an absorbing clamp measurement with an upper frequency bound of 300 MHz

Range of positions of the absorbing clamp (CRP with respect to the SRP)	Distance step size m	Number of samples
SRP + 0,1 m to SRP + 0,40 m	0,06	5
SRP + 0,40 m to SRP + 0,90 m	0,10	5
SRP + 0,90 m to SRP + 1,8 m	0,15	6
SRP + 1,8 m to SRP + 3,0 m	0,20	6
SRP + 3,0 m to SRP + 5,1 m	0,30	8 (incl. end point)
Total number of samples along lead under test		30

Table 3 – Sample scheme for an absorbing clamp measurement with an upper frequency bound of 1 000 MHz

Range of positions of the absorbing clamp (CRP with respect to the SRP)	Distance step size m	Number of samples
SRP + 0,1 m to SRP + 0,2 m	0,02	5
SRP + 0,2 m to SRP + 0,4 m	0,04	5
SRP + 0,4 m to SRP + 0,8 m	0,05	8
SRP + 0,8 m to SRP + 1,4 m	0,10	6
SRP + 1,4 m to SRP + 3,0 m	0,20	8
SRP + 3,0 m to SRP + 5,1 m	0,30	8 (incl. end point)
Total number of samples along lead under test		40

7.9 Determination of disturbance power

From the measurement data for each of the LUTs, the disturbance power shall be calculated using equation (4). The disturbance power P corresponding to the maximum measured voltage V at each test frequency is determined by using the clamp factor (CF) obtained from the absorbing clamp calibration procedure described in Clause 4 of CISPR 16-1-3.

$$P = V + CF \tag{4}$$

where

P is the disturbance power in dB(pW);

V is the measured voltage in dB(μV);

CF is the clamp factor in dB(pW/μV).

NOTE The clamp factor is derived with the 6 dB factor of the attenuator included (see 7.3.2).

7.10 Determination of the measurement uncertainty

For each absorbing clamp test facility, the actual measurement instrumentation uncertainty value U_{lab} shall be determined using the guidance given in CISPR 16-4-2.

The measurement instrumentation uncertainties up to a certain level must be taken into account in the compliance criterion (7.11). This means that uncertainties in excess of an agreed value U_{cispr} shall be incorporated in the compliance criterion. The U_{cispr} value for the absorbing clamp test method is 4,5 dB (4.1 of CISPR 16-4-2).

7.11 Compliance criteria

At each frequency, the disturbance power P obtained for each of the LUTs shall be checked for compliance against the applicable limit P_L. The compliance criterion shall incorporate the measurement instrumentation uncertainty in excess of U_{cispr} = 4,5 dB. Guidance on the application of the compliance criterion is given in CISPR 16-4-2.

8 Automated measurement of emissions

8.1 Introduction: Precautions for automating measurements

Much of the tedium of making repeated EMI measurements can be removed by automation. Operator errors in reading and recording measurement values are minimized. By using a computer to collect data, however, new forms of error can be introduced that may have been detected by an operator. Automated testing can lead, in some situations, to greater measurement uncertainty in the collected data than manual measurements performed by a skilled operator. Fundamentally, there is no difference in the accuracy with which an emission value is measured whether manually or under software control. In both cases the measurement uncertainty is based on the accuracy specifications of the equipment used in the test set-up. Difficulties may arise, however, when the current measurement situation is different from the scenarios the software was configured for.

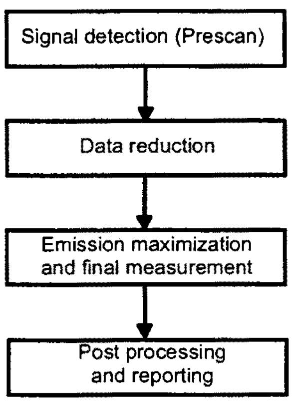
For example, an EUT emission adjacent in frequency to a high level ambient signal may not be measured accurately, if the ambient signal is present during the time of the automated test. A knowledgeable tester, however, is more likely to distinguish between the actual interference and the ambient signal; therefore the method for measuring the EUT emission can be adapted as required. However, valuable test time can be saved by performing ambient scans prior to the actual emission measurement with the EUT turned off to record ambient signals present on the OATS. In this case the software may be able to warn the operator of the potential presence of ambient signals at certain frequencies by applying appropriate signal identification algorithms.

Operator interaction is recommended if the EUT emission is slowly varying, if the EUT emission has a low on-off cycle or when transient ambient signals (e.g. arc welding transients) may occur.

8.2 Generic measurement procedure

Signals need to be intercepted by the EMI receiver before they can be maximized and measured. The use of the quasi-peak detector during the emission maximization process for all frequencies in the spectrum of interest leads to excessive test times (see 6.5.1). Time-consuming processes like antenna height scans are not required for each emission frequency. They should be limited to frequencies at which the measured peak amplitude of the emission is above or near the emission limit. Therefore, only the emissions at critical frequencies whose amplitudes are close to or exceed the limit will be maximized and measured.

The following generic process will yield a reduction in measurement time:



IEC 1867/03

8.3 Prescan measurements

This initial step in the overall measurement procedure serves multiple purposes. Prescan places the least number of restrictions and requirements upon the test system since its main purpose is to gather a minimal amount of information upon which the parameters of additional testing or scanning will be based. This measurement mode can be used to test a new product, where the familiarity with its emission spectrum is very low. In general, prescan is a data acquisition procedure used to determine where in the frequency range of interest, significant signals are located. Depending on the goal of this measurement, antenna tower and turntable movement may be necessary (for the radiated emission test) as well as improved frequency accuracy (e.g. for further processing on an OATS) and data reduction through amplitude comparison. These factors define the measurement sequence during the execution of prescan. In any case, the results will be stored in a signal list for further processing.

When a prescan measurement is made to quickly obtain information on an EUT's unknown emission spectrum, frequency scanning can be performed by applying the considerations of section 6.5.

- Determination of the required measurement time

If the emission spectrum and especially the maximum pulse repetition interval T_p of the EUT is not known, this has to be investigated to assure the measurement time T_m is not shorter than T_p. The intermittent character of the EUT's emission is especially relevant for critical peaks of the emission spectrum. First should be determined at which frequencies the amplitude of the emission is not steady. This can be done by comparing the max-hold with a min-hold or clear/write function of the measuring equipment or software, and observing the emission for a period of 15 s. During this period no change in the set-up should be made (no change of lead in case of conducted emission, no movement of absorbing clamp, no movement of turntable or antenna in case of radiated emission). Signals with e.g. more than 2 dB difference between the max-hold result and min-hold result are marked as intermittent signals. (Care should be taken not to mark noise as intermittent signals.) In case of radiated emission the polarisation of the antenna is changed and the measurement is repeated, to reduce the risk that certain intermittent peaks are not found because they remain below noise level. From each intermittent signal the pulse repetition period T_p can be measured, by applying zero span or using an oscilloscope connected to the IF-output of the measurement receiver. The correct measurement time can also be determined by increasing it until the difference between max-hold and clear/write displays is below e.g. 2 dB. During further measurements (maximization and final measurement) it has to be assured for each part of the frequency range that the measuring time T_m is not smaller than the applicable pulse repetition period T_p.

The **type of measurement** determines the definition of a prescan measurement in the following way.

- For measurements **using the absorbing clamp**, prescan may be performed with the absorbing clamp close to the EUT.

  For conducted emissions or emissions measured with the absorbing clamp, two limits, for quasi-peak and average detector, may be called out. In this case, prescan can include a measurement with the average detector if the peak data exceeds the average limit, before data reduction is applied. Otherwise narrowband emissions which exceed the average limit, may be hidden by broadband emission which are below the Quasi-Peak limit; therefore a non-compliance situation cannot be detected. It should be noted that narrowband responses do not necessarily correspond with broadband emission peaks.

8.4 Data reduction

The second step in the overall measurement procedure is used to reduce the number of signals collected during prescan and thus aimed at further reduction of the overall measurement time. These processes can accomplish different tasks, e.g., determination of significant signals in the spectrum, discrimination between ambient or auxiliary equipment signals and EUT emissions, comparison of signals to limit lines, or data reduction based on user-definable rules. Another example of data-reduction methods involving the sequential use of different detectors and amplitude versus limit comparisons is given by the decision tree in Annex C of CISPR 16-2-1. Data reduction may be performed fully automated or interactively, involving software tools or manual operator interaction. It need not be a separate section of the automated test, i.e. it may be part of a prescan.

In certain frequency ranges, especially the FM band, an acoustic ambient discrimination is very effective. This requires signals to be demodulated to be able to listen to their modulation content. If an output list of prescan contains a large number of signals and acoustic discrimination is needed, it can be a rather lengthy process. However, if the frequency ranges for tuning and listening can be specified, only signals within these ranges will be demodulated. The results of the data reduction process are stored in a separate signal list for further processing.

8.5 Emission maximization and final measurement

During the final test the emissions are maximized to determine their highest level. After the maximization of the signals, the emission amplitude is measured using quasi-peak detection and/or average detection, allowing for the appropriate measurement time (at least 15 s if the reading shows fluctuations close to the limit).

The **type of the measurement** defines the maximization process yielding the highest signal amplitudes:

– for measurements with the **absorbing clamp**: amplitude maximization by variation of the clamp position along the leads.

8.6 Post processing and reporting

The last part of the test procedure addresses documentation requirements. The functionality for defining sorting and comparison routines which then can be automatically or interactively applied to signal lists supports a user in compiling the necessary reports and documentation. The corrected peak, quasi-peak or average signal amplitudes should be available as sorting or selection criteria. The results of these processes are stored in separate output lists or can be combined in a single list and are available for documentation or further processing.

Results shall be available in tabular and graphics format for use in a test report. Furthermore, information about the test system itself, e.g. transducers used, measuring instrumentation, and documentation of the EUT set-up as required by the product standard should also be part of the test report.

Annex A
(informative)

Historical background to the method of measurement of the interference power produced by electrical household and similar appliances in the VHF range
(see subclause 7.1)

A.1 Historical detail

Although measurement of field strength is, in theory, the most suitable method for determining the interference capability of all types of appliances at frequencies higher than 30 MHz, the methods involved together with the precautions to be taken prove troublesome in application. Consequently, engineers have for a long time used the terminal voltage method, while waiting for something more satisfactory. Several methods have been envisaged to replace those involving field measurements in open air by radiation measurements in the laboratory. Among the most interesting are the stop filter method and the ground current method. These are substitution methods, in which a slotted coaxial filter having negligible losses is used to adjust the radiating length of the supply lead of the source of interference in such a way as to obtain maximum radiation. In these methods, the interference capability of an appliance is defined as the power which a standard generator must inject into a simple aerial of known characteristics in order to obtain the same effect on an aerial connected to the measuring apparatus as that produced by the source of interference. Several more convenient methods have been developed from those just mentioned.

The measurement of terminal voltages has been considerably improved by replacing the artificial mains V-network by a Y-network, so as to obtain the true common mode voltage produced by the source of interference. A similar method using a reactive slotted coaxial filter was developed. A method for measuring the power which the source of interference may inject into the supply lead has also been proposed. This method is based on the measurement of the current at the input of an *absorbent* coaxial device.

The advantage of the latter over the terminal voltage method is that it is not necessary to disconnect the supply lead. It indicates values of the interference power corresponding closely with those obtained by the methods in which the radiation of the supply lead is measured in the resonant condition.

Although, through their ease of operation, the terminal voltage and the absorbing coaxial device methods were preferable to the stop filter and the ground current methods, it remained to be shown that the results which they gave conformed with those obtained in practice.

Statistical measurements on the disturbance sources have shown that the interference measured by the stop filter method agrees more closely than that measured by the terminal voltage method, with the effect of the same sources measured at the input of receivers located in the same building. Measurements made by the absorbent device method gave results intermediate between the two previous ones. Other methods have been compared.

A.2 Development of the method

In the stop filter method, a value directly related to the current at the centre of a resonant half-wave aerial is measured. The most important thing is not the radiating system but the power that the source of interference is capable of transmitting to the radiating system. The same principle applies to the ground current method. If it were possible to measure this power without measuring a field, all the disadvantages arising from the influence of surrounding objects on the propagation between the radiating elements and the receiving aerial would be removed. The attempt to replace the coaxial stop filter by a ferrite tube showed that a large part of the energy produced by the source of interference was dissipated in this tube. It was then thought that the measurement of the current at the input of the ferrite tube might replace, at least in part, the measurement of the field by the stop filter method. This gave rise to the devices described in annex B of CISPR 16-1-3.

The following question was then studied: how do the different methods of measurement compare in the particular case of a *shielded source* of interference of given available power, with a purely resistive internal impedance when transmitting all its interference energy to the supply lead in the common mode when the size of this source is varied? Experimental investigations showed the remarkable fact that the new device gave results which were practically independent of the dimensions of the source of interference (3,5 dm^3 to 1700 dm^3) and which were also more consistent than those obtained by other methods.

In fact, one can reduce the absorbing device measuring system to the following circuit: a source of interference of internal impedance Z_S supplying a load Z_C through a low-loss line of characteristic impedance Z_L. If the length of the line is varied from zero, the power absorbed by the load Z_C passes (when Z_C is different from Z_L) through maxima and minima corresponding to resonance and anti-resonance of the system.

Neglecting the radiation and other losses of the line and discussing the case in which the load is located at a distance corresponding to the first maximum, we consider the point in the line at which the source and the load appear as pure resistance R_S and R_C. It can thus be shown that if P_d is the available power of the source, P_C the power absorbed by the load and

$$m = \frac{R_s}{R_c}$$

then

$$\frac{P_c}{P_d} = \frac{4m}{(m+1)^2}$$

This gives for

m =	0,1	0,2	0,5	1	2	5	10	20	30
$M = 10 \lg \frac{P_c}{P_d}$ =	–4,8	–2,5	–0,5	0	–0,5	–2,5	–4,8	–7,4	–9 dB

It will be seen that the matching of the source to the lead is not very critical and that, if an absorbent clamp is used to constitute a load, for example of the order of 200 Ω, the results obtained will not be very different from those obtained if a load is applied to the output of the source of interference in the form of a line brought to resonance by means of a coaxial stop filter.

More details on the development and theory of operation of the absorbing clamp are described in [1] [2].

A.3 Reasons for improvement of the clamp measurement method

The absorbing clamp measurement method has proven to be a convenient method for compliance testing and is widely used for several types of commercial electronic equipment (CISPR 13 and CISPR 14-1). However, the method is not without critics. For instance in [2] several drawbacks of the method and suggestions for improvement have been described. The validity of the 'transmission line model' of the clamp measurement method at higher frequencies is criticized in this paper as well.

The clamp measurement method is also useful for pre-compliance testing purposes. However, the relationship between absorbing clamp and radiated emission measurement results cannot always easily be determined, due to relatively large uncertainties and different types of uncertainty sources associated with both methods.

In the past decade, the uncertainties and repeatability of EMC measurement methods in general has become a very important issue. This was driven by the fact that EMC measurements suffer a relatively large intrinsic uncertainty and by the fact that accreditation bodies require inclusion of uncertainties in the compliance criteria. For the clamp calibration and clamp measurement method, this was also the impetus for improvements i.e., to reduce the uncertainties associated with the clamp measurement method and clamp calibration method.

In [3], the results of an extensive study on the uncertainties of the calibration and use of absorbing clamps are reported. Various influence quantities were investigated experimentally and suggestions for improvement were given, such as

- the application of a secondary absorbing device (SAD);
- keeping the lead under test central within the clamp;
- removal of objects and personnel 1 m away from the set-up;
- application of a 6 dB attenuator directly at the output of the clamp.

The latter three suggestions are incorporated in the clamp measurement method and in the clamp calibration method. The secondary absorbing device is applied for the clamp calibration and for the clamp test site validation.

Finally, it should be noted that the absence of a valid model of the clamp measurement method and the lack of knowledge of the true sensitivity coefficients associated with each influence quantity makes a model-based uncertainty assessment very difficult.

[2] Figures in brackets refer to the reference documents in Clause A.4 at the end of this annex.

A.4 Reference documents

[1] MEYER DE STADELHOFEN, J. *A new device for radio interference measurements at VHF: the absorbing clamp.* Proceedings, IEEE Int. EMC Symposium, 1969, p.189-193.

[2] KWAN, HK. *A theory of operation of the CISPR absorbing clamp.* Proceedings of the IEE Symposium on EMC, 1988, p. 141-143.

[3] WILLIAMS, T. *Calibration and use of the CISPR absorbing clamp.* EMC Europe Symposium, Brugge, 2000, pp. 527-532.

Annex B
(informative)

Use of spectrum analyzers and scanning receivers
(see clause 6)

B.1 Introduction

When using spectrum analyzers and scanning measuring sets, the following characteristics should be taken into account:

B.2 Overload

Most spectrum analyzers have no RF preselection in the frequency range up to 2000 MHz; that is, the input signal is directly fed to a broadband mixer. To avoid overload, to prevent damage and to operate a spectrum analyzer linearly, the signal amplitude at the mixer should typically be less than 150 mV peak. RF attenuation or additional RF preselection may be required to reduce the input signal to this level.

B.3 Linearity test

Linearity can be measured by measuring the level of the specific signal under investigation and repeating this measurement after an X dB attenuator has been inserted at the input of the measuring set or, if used, the preamplifier ($X \geq 6$ dB). The new reading of the measuring set display should differ by X dB not more than ± 0,5 dB from the first reading when the measuring system is linear.

B.4 Selectivity

The spectrum analyzer and scanning measuring set must have the bandwidth specified in CISPR 16-1-1 to correctly measure broadband and impulsive signals and narrowband disturbance with several spectrum components within the standardized bandwidth.

B.5 Normal response to pulses

The response of a spectrum analyzer and scanning measuring set with quasi-peak detection can be verified with the calibration test pulses specified in CISPR 16-1-1. The large peak voltage of the calibration test pulses typically requires an insertion of RF attenuation of 40 dB or more to satisfy the linearity requirements. This decreases the sensitivity and makes the measurement of low repetition rate and isolated calibration test pulses impossible for bands B, C and D. If a preselecting filter is used ahead of the measuring set, then the RF attenuation can be decreased. The filter limits the spectrum width of the calibration test pulse as seen by the mixer.

B.6 Peak detection

The normal (peak) detection mode of spectrum analyzers provides a display indication which, in principal, is never less than the quasi-peak indication. It is convenient to measure emissions using peak-detection because it allows faster frequency scans than quasi-peak detection. Then those signals which are close to the emission limits need to be remeasured using quasi-peak detection to record quasi-peak amplitudes.

B.7 Frequency scan rate

The scan rate of a spectrum analyzer or a scanning measuring set should be adjusted for the CISPR frequency band and the detection mode used. The minimum sweep time/frequency or the fastest scan rate is listed in the following table:

Band	Peak-detection	Quasi-peak detection
A	100 ms/kHz	20 s/kHz
B	100 ms/MHz	200 s/MHz
C&D	1 ms/MHz	20 s/MHz

For a spectrum analyzer or scanning measuring set used in a fixed tuned non-scanning mode, the display sweep time may be adjusted independently of the detection mode and according to the needs for observing the behaviour of the emission. If the level of disturbance is not steady, the reading on the measuring set must be observed for at least 15 s to determine the maximum (see 6.4.1).

B.8 Signal interception

The spectrum of intermittent emissions may be captured with peak-detection and digital display storage if provided. Multiple, fast frequency scans reduce the time to intercept an emission compared to a single, slow frequency scan. The starting time of the scans should be varied to avoid any synchronism with the emission and thereby hiding it. The total observation time for a given frequency range must be longer than the time between the emissions. Depending upon the kind of disturbance being measured, the peak detection measurements can replace all or part of the measurements needed using quasi-peak detection. Re-tests using a quasi-peak detector should then be made at frequencies where emission maxima have been found.

B.9 Average detection

Average detection with a spectrum analyzer is obtained by reducing the video bandwidth until no further smoothing of the displayed signal is observed. The sweep time must be increased with reductions in video bandwidth to maintain amplitude calibration. For such measurements, the measuring set shall be used in the linear mode of the detector. After linear detection is made, the signal may be processed logarithmically for display, in which case the value is corrected even though it is the logarithm of the linearly detected signal.

A logarithmic amplitude display mode may be used, for example, to distinguish more easily between narrowband and broadband signals. The displayed value is the average of the logarithmically distorted IF signal envelope. It results in a larger attenuation of broadband signals than in the linear detection mode without affecting the display of narrowband signals. Video filtering in log-mode is, therefore, especially useful for estimating the narrowband component in a spectrum containing both.

B.10 Sensitivity

Sensitivity can be increased with low noise RF pre-amplification ahead of the spectrum analyzer. The input signal level to the amplifier should be adjustable with an attenuator to test the linearity of the overall system for the signal under examination.

The sensitivity to extremely broadband emissions which require large RF attenuation for system linearity is increased with RF pre-selecting filters ahead of the spectrum analyzer. The filters reduce the peak amplitude of the broadband emissions and less RF attenuation can be used. Such filters may also be necessary to reject or attenuate strong out-of-band signals and the intermodulation products they cause. If such filters are used they must be calibrated with broadband signals.

B.11 Amplitude accuracy

The amplitude accuracy of a spectrum analyzer or a scanning measuring set may be verified by using a signal generator, power meter and precision attenuator. The characteristics of these instruments, cable and mismatch losses have to be analyzed to estimate the errors in the verification test.

Annex C
(informative)

Scan rates and measurement times for use with the average detector

C.1 General

This annex is intended to give guidance on the selection of scan rates and measurement times when measuring impulsive disturbance with the average detector.

The average detector serves the following purposes:

a) to suppress impulsive noise and thus to enhance the measurement of CW components in disturbance signals to be measured

b) to suppress amplitude modulation (AM) in order to measure the carrier level of amplitude modulated signals

c) to show the weighted peak reading for intermittent, unsteady or drifting narrowband disturbances using a standardized meter time constant.

Clause 6 of CISPR 16-2-2 defines the average measuring receiver for the frequency range 9 kHz to 1 GHz.

In order to select the proper video bandwidth and the corresponding scan rate or measurement time, the following considerations apply:

C.1.1 Suppression of impulsive disturbance

The pulse duration T_p of impulsive disturbance is often determined by the IF bandwidth B_{res}: $T_p = 1/B_{res}$. For the suppression of such noise, the suppression factor a is then determined by the video bandwidth B_{video} relative to the IF bandwidth: $a = 20 \lg (B_{res}/B_{video})$. B_{video} is determined by the bandwidth of the lowpass filter following the envelope detector. For longer pulses, the suppression factor will be lower than a. The minimum scan time $T_{s\,min}$ (and max. scan rate $R_{s\,max}$) is determined using:

$$T_{s\,min} = (k \cdot \Delta f)/(B_{res} \cdot B_{video}) \qquad \text{(C.1)}$$

$$R_{smax} = \Delta f / T_{smin} = (B_{res} \cdot B_{video})/k \qquad \text{(C.2)}$$

where Δf is the frequency span and k is a proportionality factor, which depends on the speed of the measuring receiver/spectrum analyzer.

For the longer scan times, k is very close to 1. If a video bandwidth of 100 Hz is selected, the maximum scan rates and pulse suppression factors in Table C.1 will be obtained.

Table C.1 – Pulse suppression factors and scan rates for a 100 Hz video bandwidth

	Band A	Band B	Bands C and D
Frequency range	9 kHz to 150 kHz	150 kHz to 30 MHz	30 MHz to 1 000 MHz
IF bandwidth B_{res}	200 Hz	9 kHz	120 kHz
Video bandwidth B_{video}	100 Hz	100 Hz	100 Hz
Maximum scan rate	17,4 kHz/s	0,9 MHz/s	12 MHz/s
Maximum suppression factor	6 dB	39 dB	61,5 dB

This can be applied for product standards calling out quasi-peak and average limits in bands B (and C) if short pulses are expected in the disturbance signal. Compliance of the EUT with both limits has to be demonstrated. If the pulse repetition frequency is greater than 100 Hz and the quasi-peak limit is not exceeded by the impulsive disturbance, then the short pulses are sufficiently suppressed for average detection with a video bandwidth of 100 Hz.

C.1.2 Suppression of impulsive disturbance by digital averaging

Average detection may be done by digital averaging of the signal amplitude. An equivalent suppression effect can be achieved if the averaging time is equal to the inverse of the video filter bandwidth. In this case, the suppression factor a = 20 lg (T_{av}*B_{res}), where T_{av} is the averaging (or measuring) time at a certain frequency. Consequently a measurement time of 10 ms will result in the same suppression factor as the video bandwidth of 100 Hz. Digital averaging has the advantage of zero delay time, when switching from one frequency to another. On the other hand, for averaging of a certain pulse repetition frequency f_p, the result may vary depending on whether n or n+1 pulses are averaged. This effect is less than 1 dB, if T_{av}*f_p > 10.

C.2 Suppression of amplitude modulation

In order to measure the carrier of a modulated signal, the modulation has to be suppressed by signal averaging over a sufficiently long time, or by using a video filter of sufficient attenuation at the lowest frequency. If f_m is the lowest modulation frequency and if we assume that the max. measurement error due to the 100 % modulation is limited to 1 dB, then the measurement time T_m should be $T_m = 10 / f_m$.

C.3 Measurement of slowly intermittent, unsteady or drifting narrowband disturbances

In subclause 6.4.3 of CISPR 16-1-1, the response to intermittent, unsteady or drifting narrowband disturbances is defined using the peak reading with meter time constants of 160 ms (for bands A and B) and 100 ms (for bands C and D). These time constants correspond to 2nd order video filter bandwidths of 0,64 Hz or 1 Hz respectively. For correct measurements, these bandwidths would require very long measurement times (see Table C.2).

Table C.2 – Meter time constants and the corresponding video bandwidths and maximum scan rates

	Band A	Band B	Bands C and D
Frequency range	9 kHz to 150 kHz	150 kHz to 30 MHz	30 MHz to 1 000 MHz
IF bandwidth B_{res}	200 Hz	9 kHz	120 kHz
Meter time constant	160 ms	160 ms	100 ms
Video bandwidth B_{video}	0,64 Hz	0,64 Hz	1 Hz
Maximum scan rate	8,9 s/kHz	172 s/MHz	8,3 s/MHz

This applies however only for pulse repetition frequencies of 5 Hz or less. For all higher pulse widths and modulation frequencies, higher video filter bandwidths may be used (see C.1.1). Figures C.1 and C.2 show the weighting function of a pulse with 10 ms pulse duration versus pulse repetition frequency f_p with peak reading ("CISPR AV") and with true averaging ("AV") for meter time constants of 160 ms (Figure C.1) and 100 ms (Figure C.2).

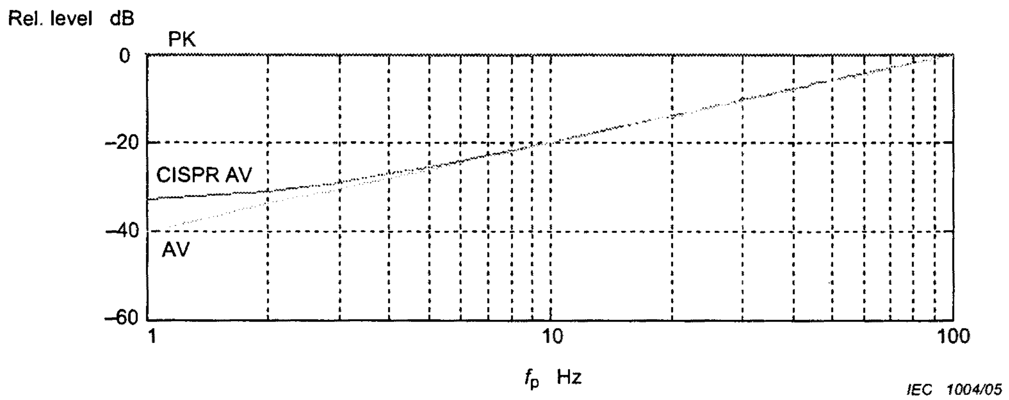


Figure C.1 – Weighting function of a 10 ms pulse for peak ("PK") and average detections with ("CISPR AV") and without ("AV") peak reading: meter time constant 160 ms

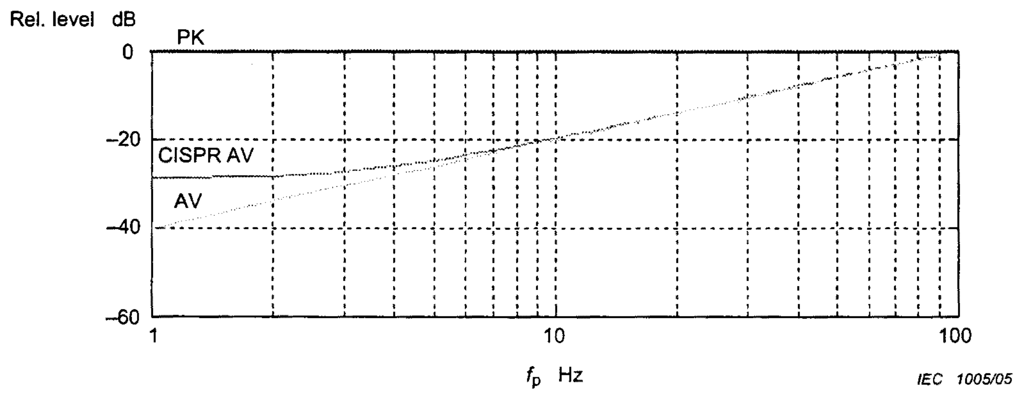


Figure C.2 – Weighting functions of a 10 ms pulse for peak ("PK") and average detections with ("CISPR AV") and without ("AV") peak reading: meter time constant 100 ms

Figures C.1 and C.2 imply that the difference between average with peak reading ("CISPR AV") and without peak reading ("AV") is increasing as the pulse repetition frequency fp decreases. Figures C.3 and C.4 show the difference for f_p = 1 Hz as a function of pulse width.

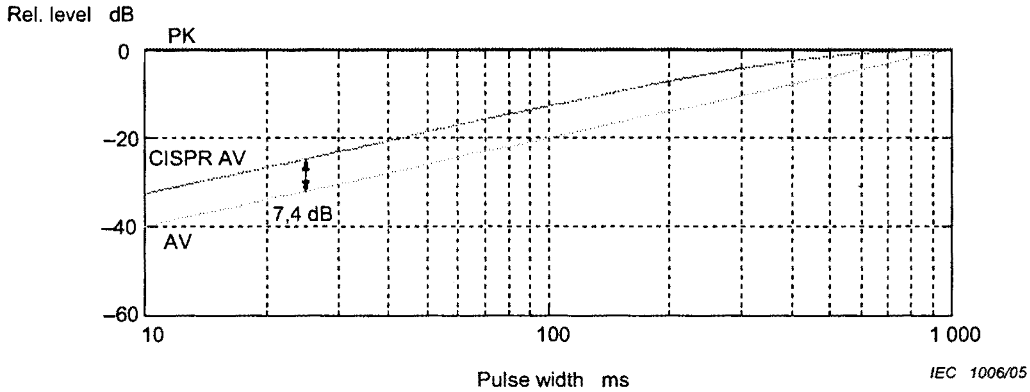


Figure C.3 – Example of weighting functions (of a 1 Hz pulse) for peak ("PK") and average detections as a function of pulse width: meter time constant 160 ms

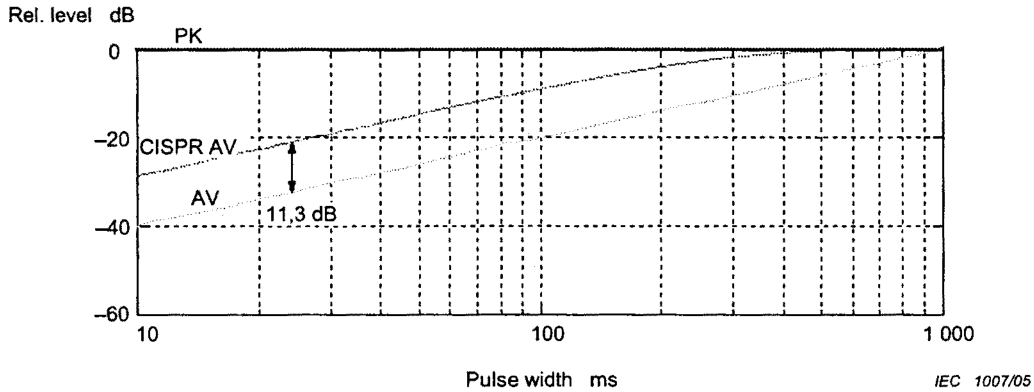


Figure C.4 – Example of weighting functions (of a 1 Hz pulse) for peak ("PK") and average detections as a function of pulse width: meter time constant 100 ms

C.4 Recommended procedure for automated or semi-automated measurements

When measuring EUTs which do not emit slowly intermittent, unsteady or drifting narrowband disturbances, it is recommended to measure with the average detector using a video filter bandwidth of e.g. 100 Hz, i.e. a short averaging time during a prescan procedure. At frequencies where the emission is found to be close to the average limit, it is recommended to make a final measurement using a lower video filter bandwidth, i.e. a longer averaging time. (For the prescan/final measurement procedure see also Clause 8 of this standard).

For slowly intermittent, unsteady or drifting narrowband disturbances, manual measurements are the preferred solution.