

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

**Specification for radio disturbance and
immunity measuring apparatus and methods –**

**Part 2:
Methods of measurement of
disturbances and immunity**

*Spécification pour les appareils et méthodes de mesure
des perturbations radioélectriques et de l'immunité –*

*Partie 2:
Méthodes de mesure des perturbations
et de l'immunité*



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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: Methods of measurement of
disturbances and immunity**

FOREWORD

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International Standard CISPR 16-2 has been prepared by CISPR, subcommittee A: Radio interference measurements and statistical methods.

This second edition cancels and replaces the first edition published in 1996, Amendment 1 (1999) and Amendment 2 (2002).

The document CISPR/A/443/FDIS, circulated to the National Committees as Amendment 3, led to the publication of the new edition.

The text of this standard is based on the first edition, its Amendment 1 and Amendment 2 and on the following documents:

FDIS	Report on voting
CISPR/A/443/FDIS	CISPR/A/463/RVD

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

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

This standard should be read in conjunction with CISPR 16-1.

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

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- withdrawn;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

Withdrawn

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 2: Methods of measurement of disturbances and immunity

Section 1: General

1.1 Scope

This part of CISPR 16 specifies the methods of measurement of EMC phenomena in the frequency range 9 kHz to 18 GHz.

1.2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60083:1997, *Plugs and socket-outlets for domestic and similar general use standardized in member countries of IEC – Standards*

IEC 60364-4: *Electrical installations of buildings – Part 4: Protection for safety*

CISPR 11:1997, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

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 16-1:1999, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

CISPR 22:1997, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

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

1.3 Definitions

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

1.3.1

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

1.3.2

EUT

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

1.3.3**product publication**

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

1.3.4**emission limit (from a disturbing source)**

the specified maximum emission level of a source of electromagnetic disturbance

[IEV 161-03-12]

1.3.5**immunity limit**

the specified minimum immunity level

[IEV 161-03-15]

1.3.6**ground reference**

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

NOTE See also IEC 161-04-36.

1.3.7**(electromagnetic) emission**

the phenomenon by which electromagnetic energy emanates from a source

[IEV 161-01-08]

1.3.8**Immunity (to a disturbance)**

the ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[IEV 161-01-20]

1.3.9**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

1.3.10**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 IEC 161-04-09.

1.3.11**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

1.3.12**differential mode voltage; symmetrical voltage**

the RF disturbance voltage between the wires of a two conductor line

[IEV 161-04-08, modified]

1.3.13

differential mode current

half the vector difference of the currents flowing in any two of a specified set of active conductors at a specified cross-section of a “mathematical” plane intersected by these conductors

1.3.14

unsymmetrical mode (V-terminal voltage)

the voltage between a conductor or terminal of a device, equipment or system and a specified ground reference. For the case of a two-port network, the two unsymmetrical voltages are given by:

- a) the vector sum of the asymmetrical voltage and half of the symmetrical voltage; and
- b) the vector difference between the asymmetrical voltage and half of the symmetrical voltage.

NOTE See also IEC 161-04-13.

1.3.15

measuring receiver

a receiver for the measurement of disturbances with different detectors

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

1.3.16

test configuration

gives the specified measurement arrangement of the EUT in which an emission or immunity level is measured

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

1.3.17

artificial network (AN)

an agreed reference load (simulation) impedance presented to the EUT by actual networks (e.g., extended power or communication lines) across which the RF disturbance voltage is measured

1.3.18

artificial mains network (AMN)

a network inserted in the supply mains lead of apparatus to be tested which provides, in a given frequency range, a specified load impedance for the measurement of disturbance voltages and which may isolate the apparatus from the supply mains in that frequency range

[IEC 161-04-05]

1.3.19

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.

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

1.3.20**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.

1.3.21**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.

1.3.22**fully anechoic chamber (FAC) or fully anechoic room (FAR)**

shielded enclosure, the internal surfaces of which are lined with radio frequency absorbing material (i.e. RF absorber), that absorbs electromagnetic energy in the frequency range of interest. The Fully Absorber-Lined Room is intended to simulate a free space environment where only the direct ray from the transmitting antenna reaches the receiving antenna. All indirect and reflected waves are minimised with the use of proper absorbing material on all walls, the ceiling and the floor of the FAR

1.3.23**measurement time**

T_m

the effective, coherent time for a measurement result at a single frequency (sometimes 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

1.3.24**sweep**

a continuous frequency variation over a given frequency span

1.3.25**scan**

a continuous or stepped frequency variation over a given frequency span

1.3.26**sweep or scan time**

T_s

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

1.3.27**span**

Δf

difference between stop and start frequencies of a sweep or scan

1.3.28

sweep or scan rate

the frequency span divided by the sweep or scan time

1.3.29

number of sweeps per time unit (e.g. per second)

n_s

$1/(\text{sweep time} + \text{retrace time})$

1.3.30

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 $T_o = n \times T_m$

1.3.31

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 $T_{tot} = c \times n \times T_m$

Section 2: Disturbance measurements

2.1 Types of disturbance to be measured

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

2.1.1 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.

2.1.2 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

2.2 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.

2.2.1 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.

2.2.2 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.

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).

2.2.3 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.

2.3 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.

2.3.1 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.

2.3.1.1 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 E of this standard and in Annex C of CISPR 11.

2.3.2 Measurement of continuous disturbance

2.3.2.1 Narrowband continuous disturbance

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

2.3.2.2 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 2.3.4.1 for further details.

2.3.2.3 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.

2.3.3 Operating conditions of the EUT

The EUT shall be operated under the following conditions:

2.3.3.1 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.

2.3.3.2 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.

2.3.3.3 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.

2.3.3.4 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.

2.3.3.5 Mode of operation

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

2.3.4 Interpretation of measuring results

2.3.4.1 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.

2.3.4.2 Discontinuous disturbance

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

2.3.4.3 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 intermediate frequency (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.

2.3.5 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 4.1.

2.3.5.1 Minimum measurement times

Clause B.7 of the present standard provides a table of the minimum sweep times or the fastest – practically achievable – scan rates. From this table the following minimum scan times for measurements over a complete 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 to the measurement of 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 2.3.4.1). However isolated clicks are excluded.

Most product standards call out quasi-peak detection for compliance measurements which is very time consuming, if no time-saving procedures are applied (see 4.1). 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 missed during an automatic scan, the considerations in 2.3.5.2 to 2.3.5.4 need to be taken into account.

2.3.5.2 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:

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

where

$T_{s \min}$ = 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:

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

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 overridden 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.).

2.3.5.3 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.

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

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.

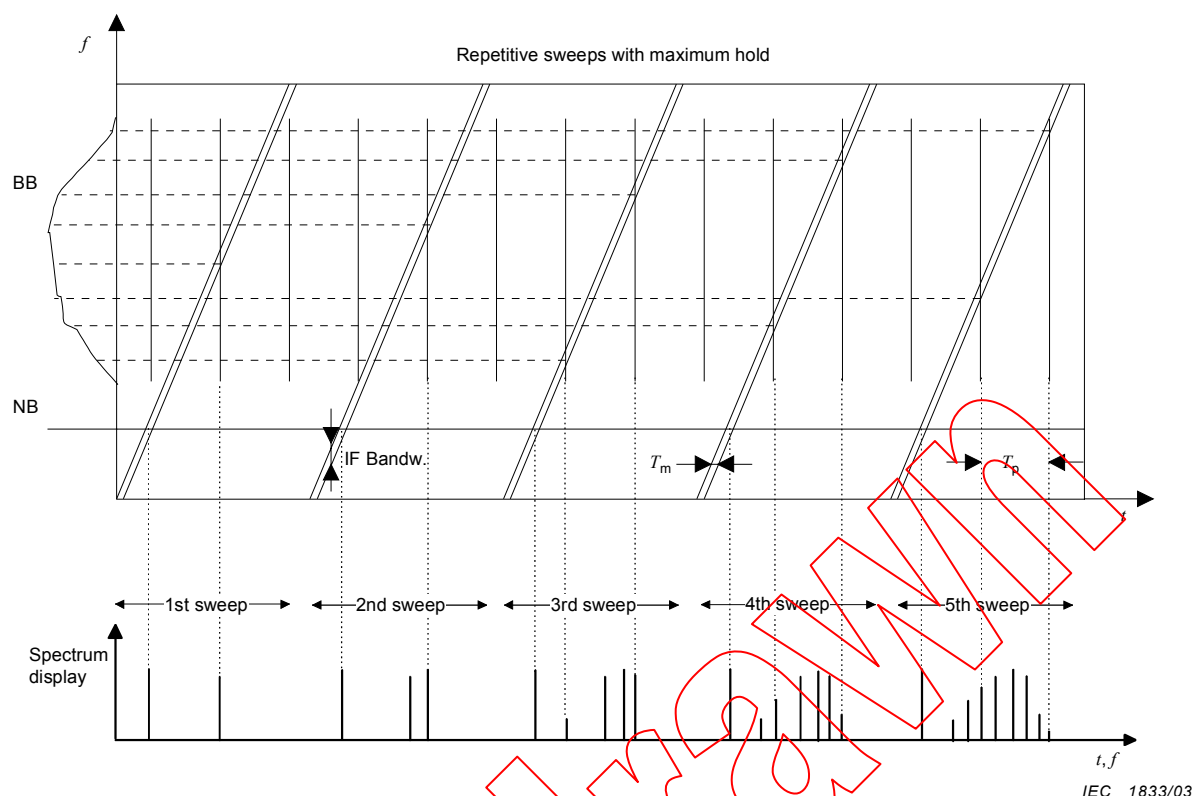
For purely broadband emissions, the frequency step size may be increased. In this case the objective is to find the maxima of the emission spectrum only.

2.3.5.4 Strategies for obtaining 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 components, 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.

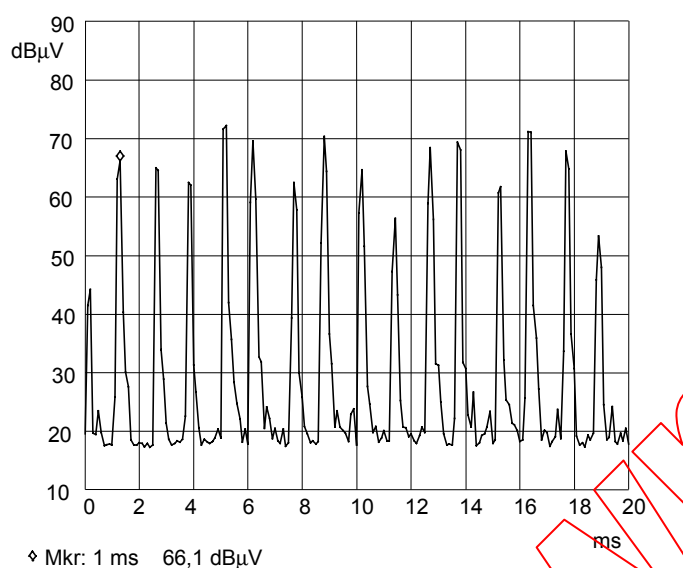


T_p is the pulse-repetition interval of the impulsive signal. A pulse occurs at each vertical line of the spectrum-vs.-time display (upper part of the figure).

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.

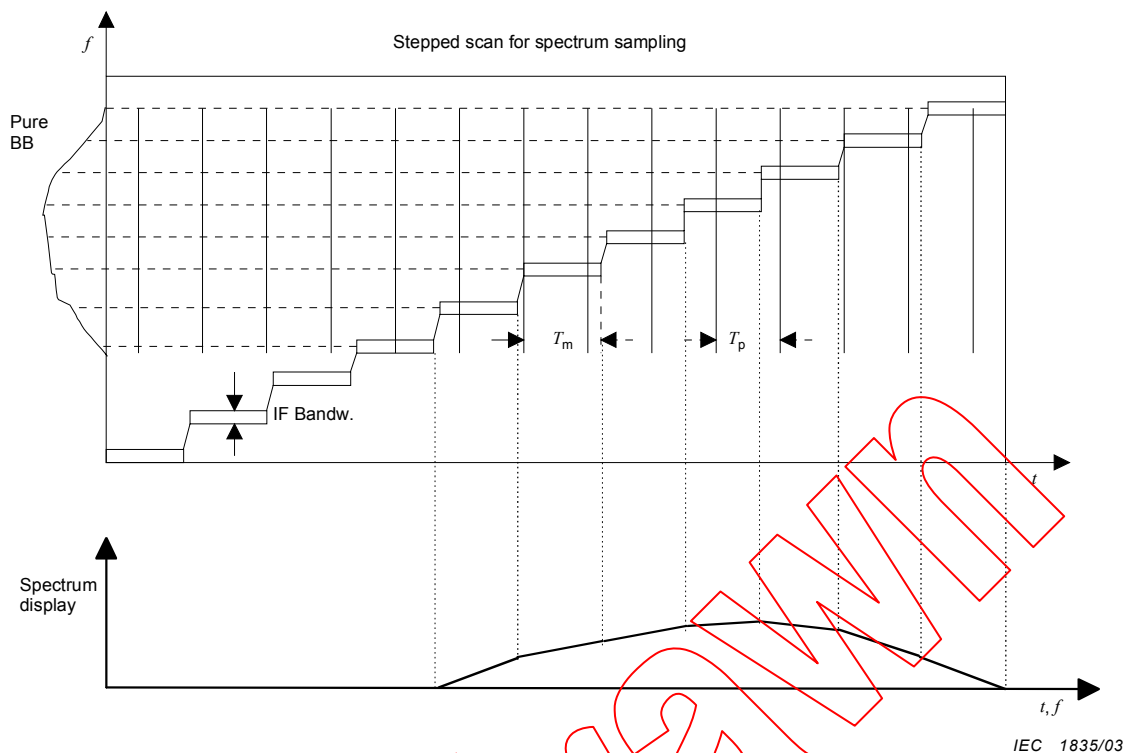


Figure 3 – A broadband spectrum measured with a stepped receiver

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.

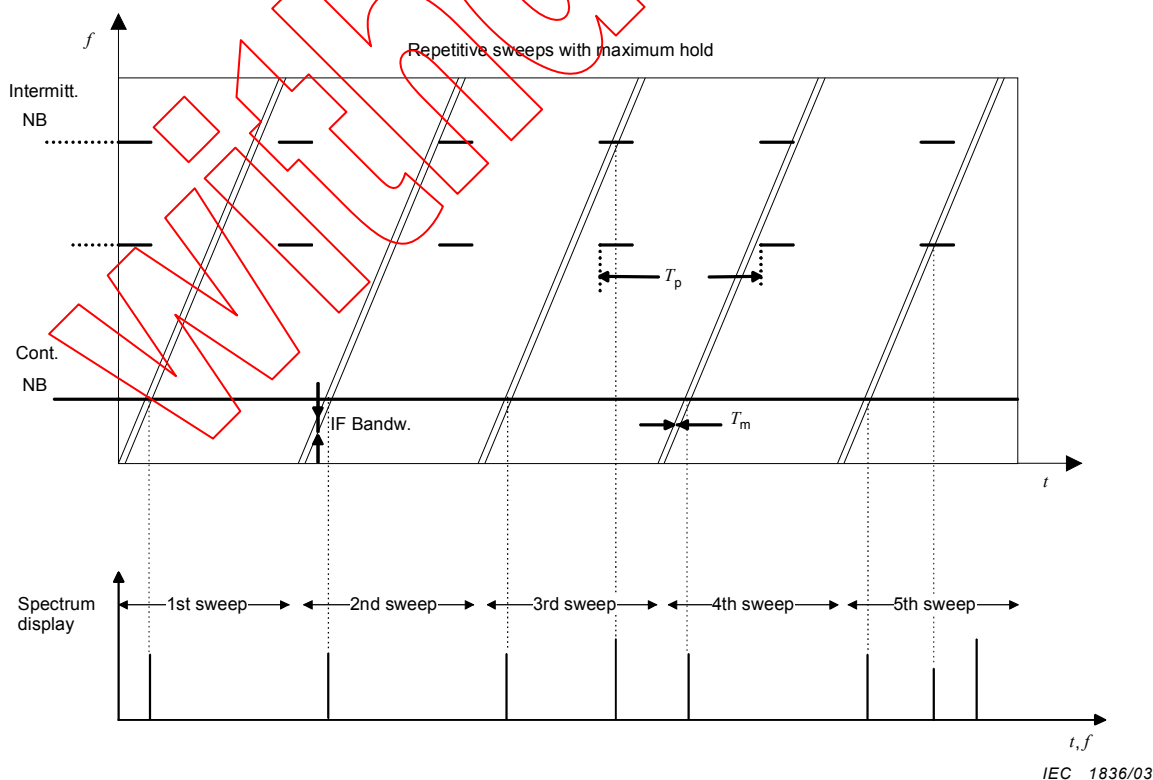


Figure 4 – Intermittent narrowband disturbances measured using fast short repetitive sweeps with maximum hold function to obtain an overview of the emission spectrum

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 Part 1 of this standard.

2.4 Measurement of disturbances conducted along leads, 9 kHz to 30 MHz

2.4.1 Introduction

When testing for compliance with emission limits for electromagnetic disturbances conducted along leads, the following items shall be considered as minimum, both in the standardized situation (type tests) and at the place of installation (*in situ* tests):

- a) *the types of disturbances*: there are two methods of measuring conducted disturbances, either as a voltage (prevailing method for CISPR measurements) or as a current. Both methods can be used to measure the three types of conducted disturbances, i.e.:
 - common mode (also called asymmetrical mode);
 - differential mode (also called symmetrical mode);
 - unsymmetrical mode;

NOTE The unsymmetrical mode voltage is primarily measured at the mains network. The common mode voltage (or current) is measured primarily for signal and control lines.

- b) *the measuring equipment*: the type of measuring equipment is chosen in relation to the disturbance properties to be determined (see 2.4.2);
- c) *the associated equipment*: the type of associated equipment, i.e., artificial networks, current probes or voltage probes, is chosen in accordance with the type of disturbance to be measured in accordance with 2.4.1 a). Each type of associated equipment presents RF loading to the measured signals and lines (see 2.4.3);
- d) *RF load conditions of the disturbance source*: the measuring set-up will present certain RF load impedances to the disturbance source(s) in the EUT. These impedances are standardized in type tests or might depend on the conditions at the place of installation in the case of *in situ* tests (see 2.4.3 and 2.4.4);
- e) *the test configuration of EUT*: a standardized test configuration shall specify the reference ground, the position of the EUT and associated measuring equipment with respect to that reference ground, connections to that reference ground and interconnections of the EUT with the associated equipment (see 2.4.4 and 2.4.5).

2.4.2 Measuring equipment (receivers, etc.)

In general, a distinction is drawn between continuous and discontinuous disturbances. Continuous radio-frequency disturbances are predominantly measured in terms of frequency domain parameters. Discontinuous disturbances are also measured in terms of frequency domain parameters but may need additional time domain measurements.

The measuring sets and other measuring equipment specified in CISPR 16-1 shall be used. For time domain measurements oscilloscopes etc. may be used.

2.4.2.1 Use of detectors for conducted disturbance measurements

CISPR 16-1 specifies the characteristics of detectors that are required to perform measurements per product specifications. Several of these product specifications require the use of both quasi-peak and average detectors for conducted disturbance measurements. The time constants of these two detectors are very long and make automated measurements time consuming.

A peak detector with shorter time constants may be used to make initial measurements and to determine compliance with a limit. But if the measured disturbance levels are above a limit they shall be followed by measurements with the quasi-peak and average detectors.

Annex D provides guidance on how these measurements may be performed efficiently.

2.4.3 Associated measuring equipment

Associated measuring equipment for conducted disturbance measurement is divided into two categories:

- a) voltage measuring sensors, such as artificial networks (AN) and voltage probes;

NOTE The artificial network is sometimes referred to as impedance simulation network (ISN).

- b) current measuring sensors, such as current probes.

2.4.3.1 Artificial networks (AN)

The common mode, differential and unsymmetrical mode impedances of actual networks, such as of power mains and telephones, are location dependent and, in general, time varying. Therefore, type testing of disturbance requires standardized impedance simulation networks, referred to as artificial networks (AN). The AN provides standardized RF load impedances to the EUT. For this purpose, the AN is inserted in series with the terminals of the EUT and the actual network or signal simulator. In this way the AN simulates extended networks (long lines) with defined impedances.

2.4.3.1.1 Types of artificial networks

The ANs specified in CISPR 16-1 shall be used, unless specific reasons call for another construction. In general three types of AN can be distinguished:

- a) *the V-type AN*: in a defined frequency range the RF impedances between each of the EUT terminals to be measured and the reference ground have a defined value, whereas no impedance component is connected directly between these terminals. The construction defines (indirectly) both the differential and common mode voltage measured. In principle, there is no limit for the number of EUT terminals, i.e. for the number of lines to be measured by V-type ANs;
- b) *the Delta-type AN*: in a defined frequency range the RF impedance between a pair of EUT terminals to be measured and between these terminals and the reference ground have a defined value. This construction defines directly both the differential and the common mode RF load impedances.

Addition of a balance/unbalance transformer makes it possible to measure the symmetric and asymmetric disturbance voltage;

- c) *the T-type AN*: in a defined frequency range the common mode RF impedance between a pair of EUT terminals to be measured and a reference ground has a defined value. In general, no defined differential load impedance is included in a T-type AN as such. The defined differential impedance must then be provided by the external circuit connected to the supply (line) terminals of the T-type AN. This type of AN is used to measure common mode disturbance voltages only.

2.4.3.1.2 Minimum requirements

The AN shall meet the following minimum requirements:

- a) in a defined frequency range the AN shall provide defined RF impedances between the terminals of the EUT to be measured and between these terminals and the reference ground. By meeting this requirement, the disturbance source to be measured is loaded in a defined manner if, in addition, the test configuration (see 2.4.4) is defined;
- b) if the AN is intended to separately measure common mode and/or differential mode disturbances (see 2.4.3.1.1), the rejection ratio of differential to common mode signals, and vice versa, shall be specified in the appropriate frequency range;
- c) in a defined frequency range there shall normally be an isolation between the defined RF impedances and the actual network (or a signal simulator) so that the loading of the AN by the actual network (or the signal simulator) does not unduly influence the value of any of the defined RF impedances;

- d) the AN shall provide a defined connection (connector) to which the defined measuring equipment can be connected, in order to make a defined test configuration possible. The input connector shall be suitable for measuring equipment with 50 Ω input impedance as defined in CISPR 16-1;
- e) the AN shall provide a defined connecting point to which the reference ground can be connected, in order to make a defined test configuration possible;
- f) the AN shall be calibrated according to a prescribed procedure.

2.4.3.1.3 Additional requirements

The AN shall have the following additional requirements:

- a) the AN shall contain a decoupling or blocking network to prevent:
 - damage of the components forming the defined RF impedances by the wanted line voltages of the network, such as the mains voltage,
 - damage of the components forming the defined RF impedances by peak voltages produced by the EUT, such as switching transients,
 - influence of the rated line voltages on the measuring results, for example overload of the input stage of the measuring equipment;
- b) the AN shall contain a filter to prevent intentional signals on the actual network or the signal simulator influencing the measuring results.

2.4.3.2 Voltage probes

For standardized voltage probes, see CISPR 16-1.

Disturbance voltages on terminals which are not to be measured with an AN can be measured with a voltage probe. Examples of such terminals are connecting jacks for antennas, control lines, signal lines and load lines. In general the voltage probe is used to measure the common mode disturbance voltage. The probe presents a high RF impedance between the terminal to be measured and the reference ground.

2.4.3.2.1 Minimum requirements

- a) In a defined frequency range the voltage probe shall provide a high RF impedance between its measuring tip and the reference ground so as not to affect the voltage to be measured.
- b) The voltage probe shall have a blocking capacitor of such a value to ensure that line voltage cannot damage the measuring receiver.
- c) The voltage probe shall provide a defined 50 Ω connection (connector) to which the standardized measuring receiver can be connected, in order to make a defined disturbance measurement.
- d) The voltage probe shall provide a defined connection point to which the reference ground can be connected in a defined manner via a lead of defined maximum length unless the reference ground is connected to the EUT in another specified way.

- e) The voltage probe shall be calibrated according to a prescribed procedure, where this procedure shall account for parasitic effects near the test point, for example unwanted capacitive coupling between the test point and the screening of the probe. The voltage division between probe impedance and input impedance of measuring equipment shall be independent of frequency or accounted for in the calibration process.
- f) The voltage probe name-plate shall state the maximum line voltage.

2.4.3.3 Current probes

Current probes or current transformers allow the measurement of all three types of disturbance current (see 2.4.1) on mains leads, signal lines, load lines etc. A clip-on construction of the probe will facilitate its use.

The common mode current on leads is measured when the current probe is clipped around those leads, regardless of the number of wires. In this situation, the differential mode currents on the leads will induce signals with equal magnitude but opposite sign, so that these signals cancel to a high degree. The latter effect allows the measurement of a common mode current with a small amplitude in the presence of differential mode (operating) currents with large amplitude.

For already defined (and standardized) current probes see CISPR 16-1.

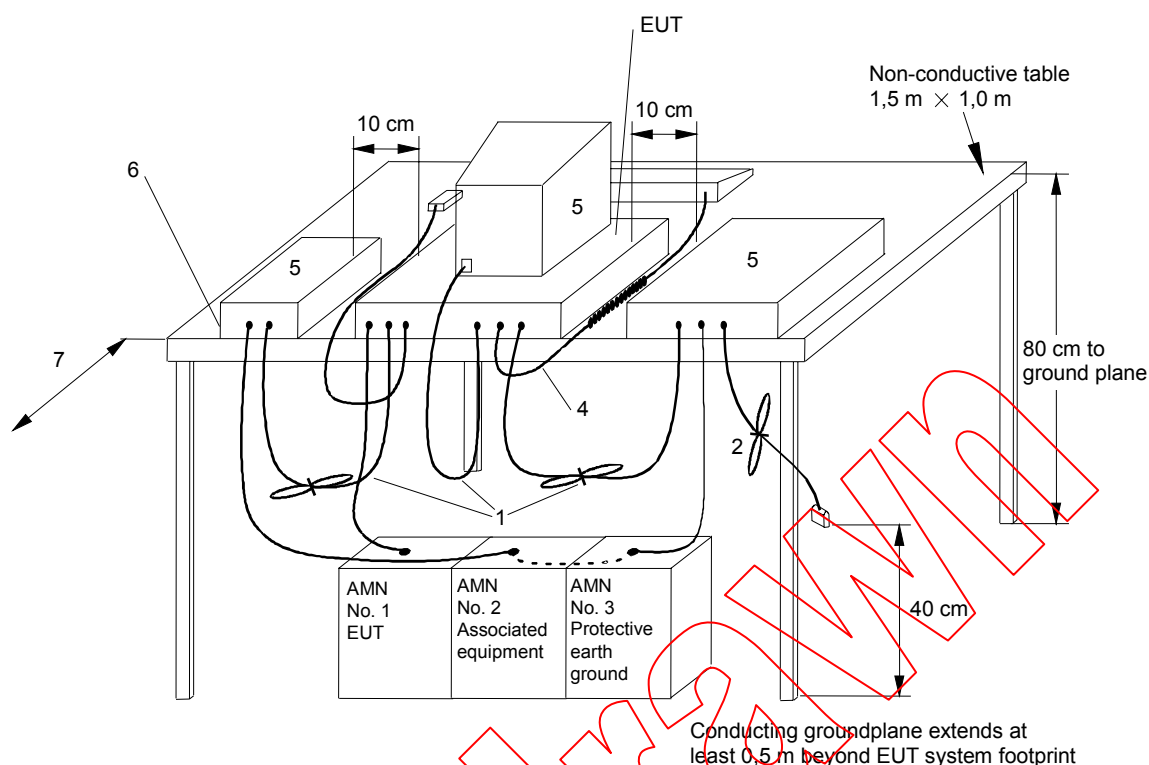
2.4.3.3.1 Minimum requirements

- a) In a defined frequency range the current probe shall have a defined transfer impedance, that is, a defined ratio of the RF voltage induced in the probe and the known RF current on a single wire running through the probe, as measured in a specified way.
- b) In a defined frequency range the insertion loss caused by the current probe, that is of the EUT, shall be less than 1 Ω.
- c) The current probe shall be constructed in such a way that the influence of electric fields on the measuring results can be neglected.
- d) The current probe shall provide a defined connection (connector) to which the defined (and standardized) measuring equipment can be connected, in order to make a defined test configuration possible. In addition, the input impedance of the measuring equipment to be used in connection with the current probe shall be indicated.
- e) The current probe specification shall include the maximum current rating before saturation effects will take place.
- f) The current probe shall be calibrated according to a prescribed procedure.

2.4.4 Equipment test configuration

2.4.4.1 Disposition of equipment under test and its connection to the artificial network

For measurement of the disturbance voltage the equipment under test (EUT) is connected to the power supply mains and any other extended network via one or more artificial network(s) (in general, the V-type network is used for this purpose) (see Figure 5), in accordance with the following requirements. Other CISPR publications supply additional test details relevant to particular EUTs.



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- 1 Interconnecting cables that hang closer than 40 cm to the ground plane shall be folded back and forth forming a bundle 30 cm to 40 cm long, hanging approximately in the middle between the ground plane and the table.
- 2 I/O cables that are connected to a peripheral shall be bundled in the centre. The end of the cable may be terminated if required using correct terminating impedance. The total length shall not exceed 1 m.
- 3 EUT is connected to AMN No. 1. Measurement terminals of AMNs must be terminated with 50 Ω . AMNs are placed directly on horizontal ground plane and 40 cm from vertical ground plane.
 - 3.1 All associated equipment is connected to AMN No. 2.
 - 3.2 Protective earth ground wires (green/yellow) from associated equipment are connected to AMN No. 3.
- 4 Cables of hand-operated devices, such as keyboards, mice, etc. shall be placed as close as possible to the host.
- 5 Non-EUT components being tested.
- 6 Rear of EUT, including peripherals, shall all be aligned and flush with rear of table top.
- 7 Rear of table top shall be 40 cm removed from a vertical conducting plane that is bonded to the floor ground plane.

Figure 5 – Test configuration: table-top equipment for conducted disturbance measurements on power mains (see 2.4.4.1 and 2.4.4.2)

An EUT, whether intended to be grounded or not, and which is to be used on a table is configured as follows:

- either the bottom or the rear of the EUT shall be at a controlled distance of 40 cm from a reference groundplane. This groundplane is normally the wall or floor of a shielded room. It may also be a grounded metal plane of at least 2 m by 2 m. This is physically accomplished as follows:
 - place the EUT on a table of non-conducting material which is at least 80 cm high. Place the EUT so that it is 40 cm from the wall of the shielded room, or
 - place the EUT on a table of non-conducting material which is 40 cm high so that the bottom of the EUT is 40 cm above the groundplane;
- all other conductive surfaces of the EUT shall be at least 80 cm from the reference groundplane;

- the ANs are placed on the floor as shown in Figure 5 in such a way that one side of the AN housings is 40 cm from the vertical reference ground plane and other metallic parts;
- the EUT cable connections shall be as shown in Figure 5;
- the optional test configuration for table-top EUT with only a power cord attached is shown in Figure 6.

Floor-standing EUTs are subject to the same provisions as above with the exception that they shall be placed on a floor, the points of contact being consistent with normal use. A ground-connected floor of metal shall be used but shall not make metallic contact with the floor support(s) of the EUT. The metal floor may be used as the reference ground plane and shall extend at least 50 cm beyond the boundaries of the EUT and have minimum dimensions of 2 m by 2 m. For examples of test configurations, see Figures 7 and 8.

The artificial network is RF bonded to the reference groundplane by a low radio-frequency impedance connection.

NOTE The “low” radio-frequency impedance value should preferably be less than $10\ \Omega$ at 30 MHz. This can, for example, be achieved if the housing of the artificial network is mounted directly to the reference ground plane or its connection strap has a length-to-width ratio not more than 3:1.

The EUT is located so that the distance between the boundary of it and the closest surface of the artificial network is 80 cm.

The power mains leads to an artificial network and the connecting cable from the network to the measuring receiver must be arranged in such a way that their locations do not influence the measurement results. EUTs, which are not equipped with fixed connecting leads, are connected to the artificial network with a 1 m long lead as specified in the relevant equipment documentation.

If the EUT is to be connected to a reference ground this shall be done by means of a lead running parallel to the EUT mains lead and of the same length at a distance of not more than 10 cm from it, unless a ground conductor is contained in the mains lead itself. If a fixed lead is attached to the EUT this shall be 1 m long, or if in excess of 1 m, part of the lead is folded back and forth in the shape of a meander, as far as possible so as to form a bundle not exceeding 40 cm in length, and arranged in the form of a non-inductive serpentine in such a way that the total length of the lead does not exceed 1 m (see also Figure 9). However, when the bundled lead may influence the measurement results, a shortening of the length to 1 m is recommended.

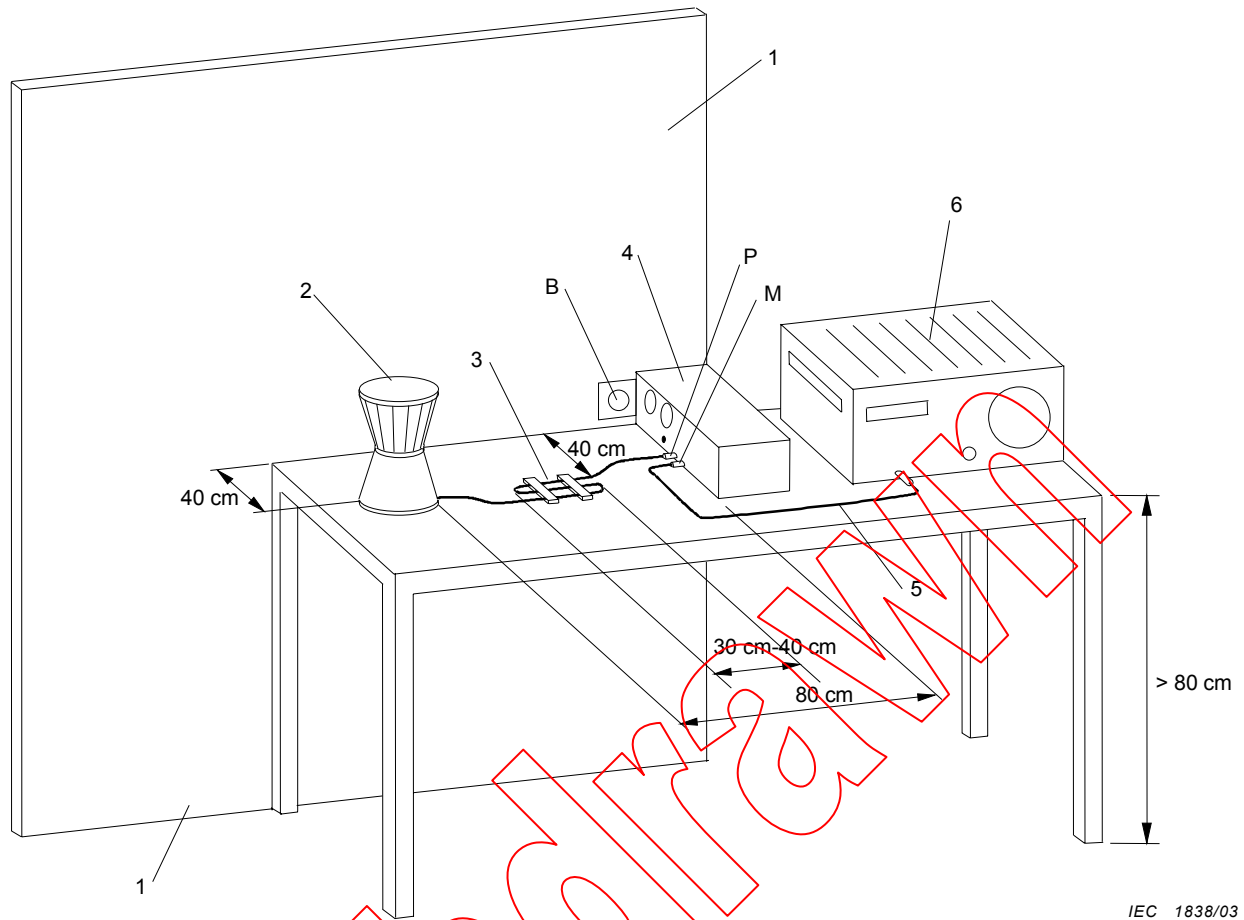
2.4.4.2 Procedure for the measurement of unsymmetric disturbance voltages with V-networks

2.4.4.2.1 Disposition of equipment with ground connection

For equipment under test which is required to be grounded during its operation, or the conductive housing of which can come into contact with ground, the unsymmetric radio interference voltage of the individual mains lead is measured with reference to the reference metal wall (general mass of the measuring equipment) to which the housing of the equipment under test is connected via its protective ground conductor and the ground connection of the artificial mains network (see the equivalent circuit in Figure 10).

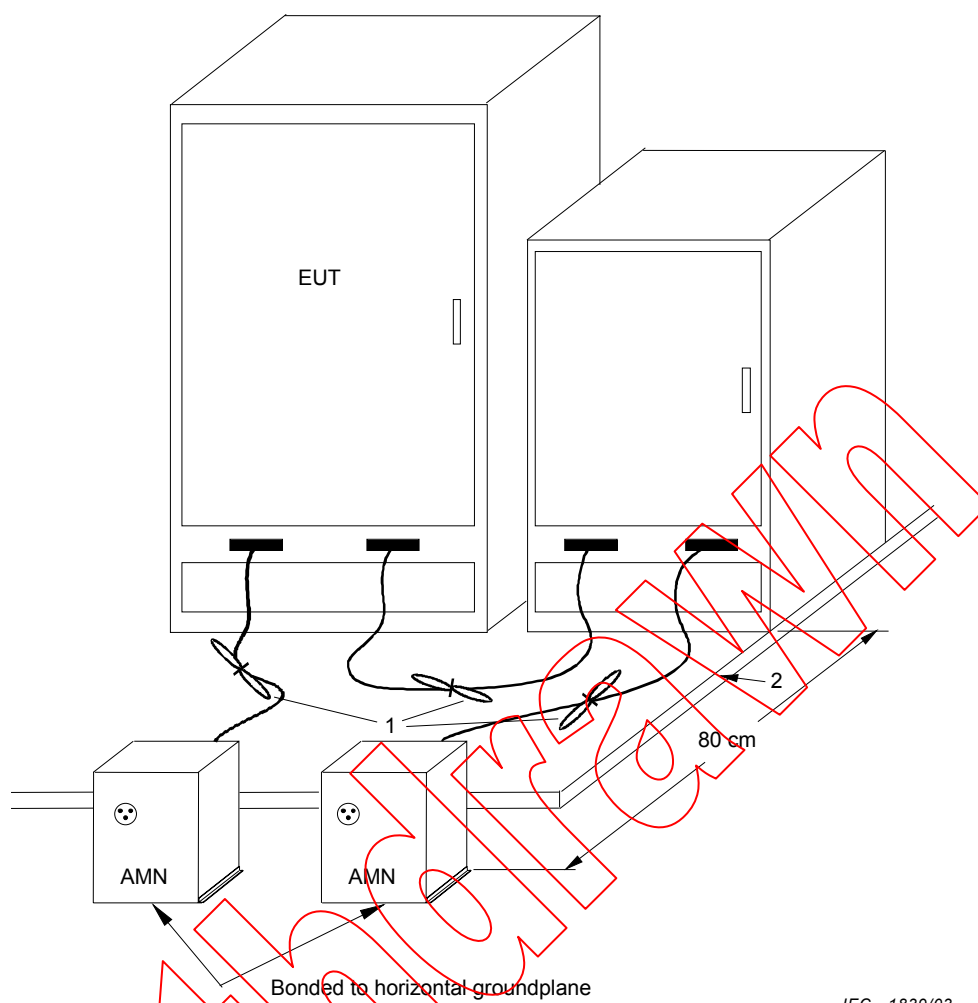
The parameters determining the interference potential of grounded test units are discussed in Clause A.3.

For EUTs with two or more power and safety conductors or special ground connections the measurement result depends much on the termination conditions of the mains terminals and the grounding conditions (refer also to 2.4.5 on measurement in systems).



- 1 Metallic wall 2 m × 2 m
- 2 EUT
- 3 Excess power cord (3 cm × 40 cm) (folded back and forth)
- 4 "V" mains network
- 5 Coaxial cable
- 6 Measuring receiver
- B Reference ground connection
- M Measuring receiver input
- P Power to EUT

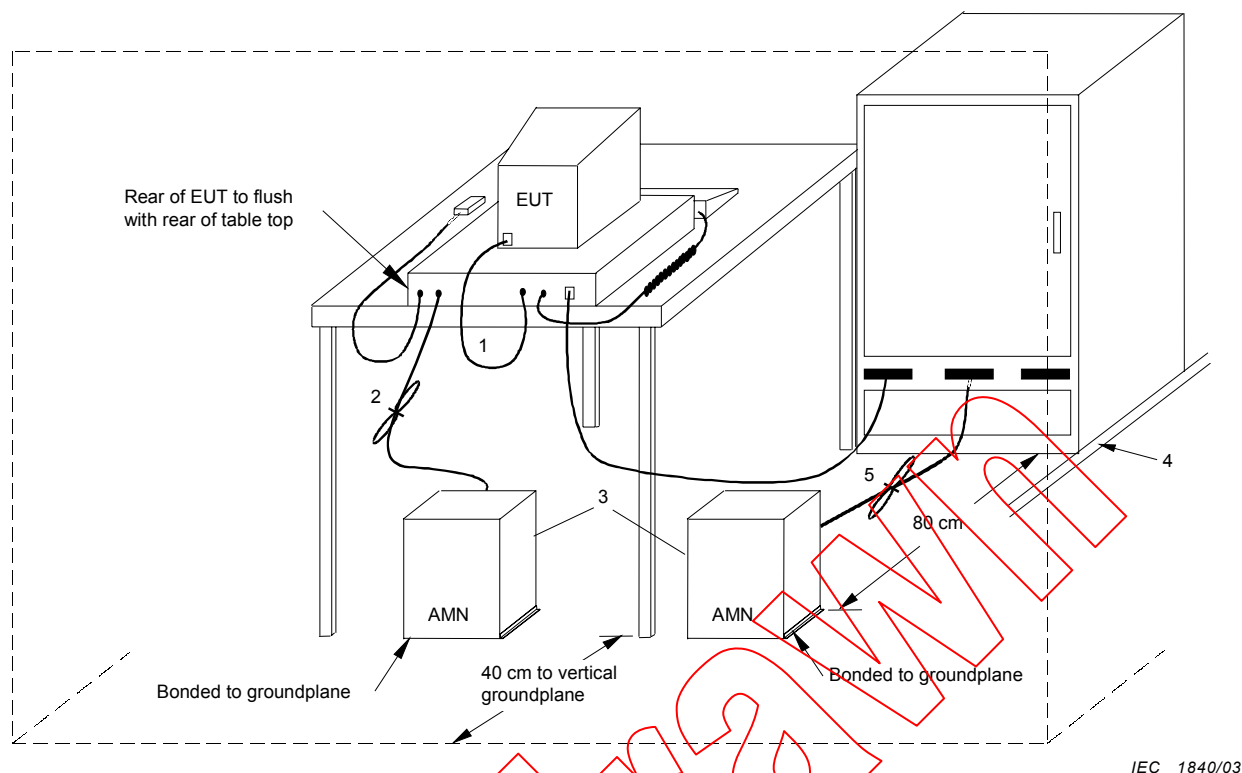
Figure 6 – Optional test configuration for an EUT with only a power cord attached
(see 2.4.4.1)



IEC 1839/03

- 1 Excess cables shall be bundled in the centre or shortened to appropriate length.
- 2 The EUT and cables shall be insulated (up to 12 mm) from the ground plane.
- 3 The EUT is connected to one AMN. The AMN can be placed on top of or immediately beneath the ground plane.
All other equipment is powered from the second AMN.

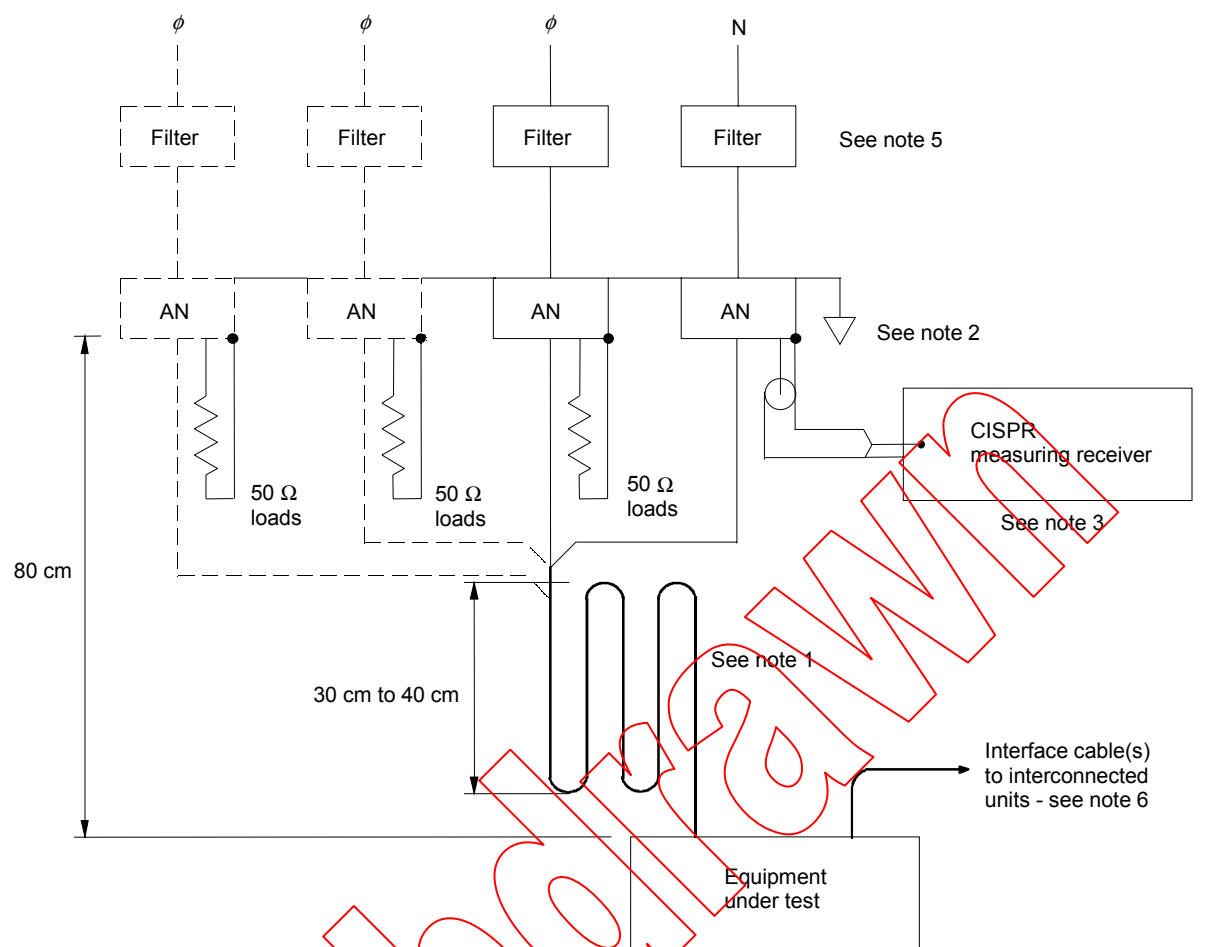
Figure 7 – Test configuration: floor-standing equipment (see 2.4.4.1 and 2.4.5.2.2)



IEC 1840/03

- 1 The interconnecting cables which hang closer than 40 cm to the ground plane shall be folded back and forth forming a bundle 30 cm – 40 cm long, hanging approximately in the middle between the ground plane and the table.
- 2 Excess power cords shall be bundled in the centre or shortened to appropriate length.
- 3 The EUT is connected to one AMN. The AMN may alternatively be connected to the vertical reference plane. All other equipment is powered from the second AMN.
- 4 The EUT and the cables shall be insulated (up to 12 mm) from the ground plane.
- 5 The I/O cable to the floor standing unit drapes to the ground plane and the excess is bundled. Cables not reaching the ground plane are dropped to the height of the connector or 40 cm, whichever is lower.

Figure 8 – Test configuration: floor-standing and table-top equipment
(see 2.4.4.1 and 2.4.5.2.2)



IEC 1841/03

- 1 The length of the EUT power cord in excess of 80 cm shall be folded into a serpentine-like bundle and not coiled.
- 2 Connection of the AN to the ground plane shall provide a low impedance path at high frequencies. It shall be made using a solid flat metal conductor that has a length-to-width ratio of not more than 5 to 1.
- 3 The CISPR measuring the set shall only be grounded to the reference ground plane via the outer conductor of the coaxial cable.
- 4 Dotted lines represent the test set-up for the three-phase power.
- 5 Optional filter hook-up; replace with shorts if not used.
- 6 Interconnected units may be attached to a single AN via a power junction strip or box.
- 7 A table mounted or handheld EUT must be 40 cm from any grounded conducting surface of at least 2 m square and at least 80 cm from any other conductive objects, including devices that are part of the system or instrumentation.

Figure 9 – Schematic of conducted disturbance voltage test configuration
(see 2.4.4.1 and 2.4.5.2.2)

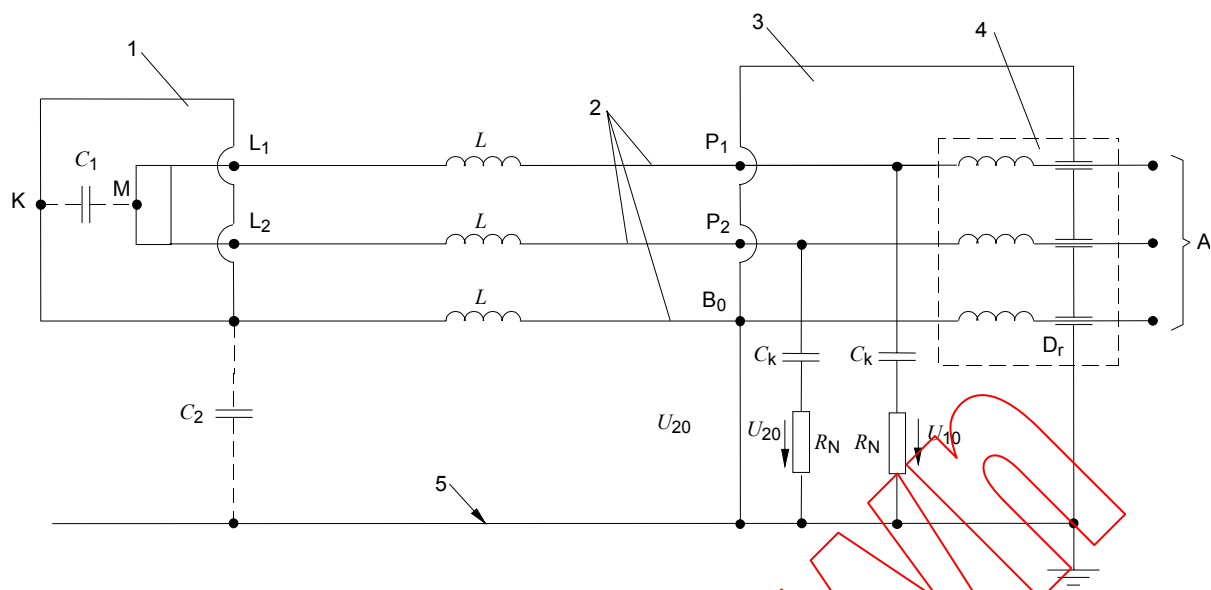
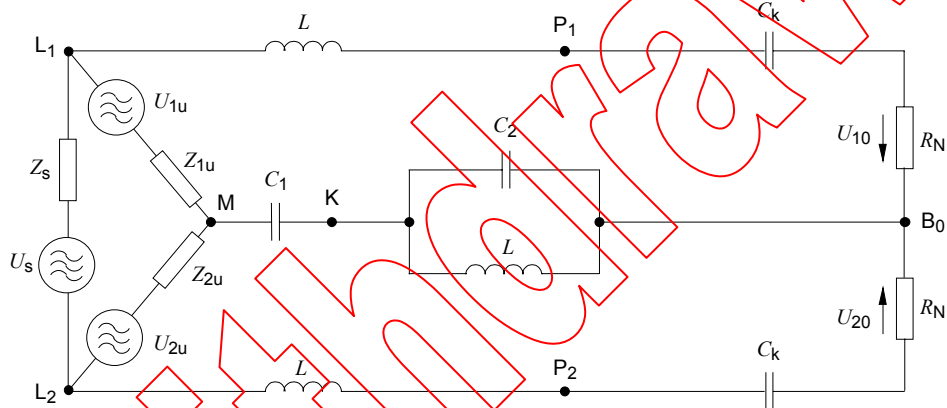


Figure 10a – Schematic for measurement and power circuit

IEC 1842/03



IEC 1843/03

Figure 10b – Equivalent voltage source and measurement circuit

- 1 Equipment under test (EUT)
- 2 Power cord
- 3 "V" power mains network
- 4 Decoupling circuit (filter)
- 5 Metallic wall
- A Power input
- B₀ Reference earth connection
- L₁, L₂ Power cord connection (100 cm)
- P₁, P₂ EUT plug to mains network
- C₁ Stray capacitance within EUT to metallic parts
- C₂ Stray capacitance of EUT to metallic wall (earth)
- C_K Coupling capacitors within mains network
- D_r Inductor (choke) for safety ground wire
- K Conductive structural parts of the EUT
- L Inductance of connecting wires
- M Fictitious mid-point of the internal common mode voltages
- R_N Simulation resistances (50 Ω or 150 Ω)
- Z_s Symmetric internal resistance of EUT
- Z_{1u}, Z_{2u} Common mode resistance of the EUT
- U_{1u}, U_{2u} Internal common mode voltage of the EUT
- U₁₀, U₂₀ External measurable common mode voltage

Figure 10 – Equivalent circuit for measurement of common mode disturbance voltage for Class I (grounded) EUT (see 2.4.4.2.1)

As the ground safety conductors in the actual mains power supply installation may have a considerable length, and therefore do not guarantee a ground impedance as low and effective as in the standard test set-up with only a 1 m long ground wire connection to the reference mass, and moreover, since safety conductors need not be used on every product per IEC 60364-4, disturbance voltage measurements on pluggable Class I appliances shall be carried out according to 2.4.4.2.2, also without the safety or ground wire being connected (non-grounded measurement). If however for safety reasons it is necessary to maintain the safety function of ground wires, this can be achieved by the use of an RF choke or impedance equal to the network impedance of a V-network in the safety wire path.

Exceptions may be made for non-radiating or well screened EUTs which have to be grounded according to special requirements or instructions (see A 2.1 and A 4.1).

2.4.4.2.2 Disposition of equipment without ground connection

Devices without ground connection comprise electrical devices with protective insulation (protection Class II) and devices which can be operated without ground or safety conductor (device of protection Class III) and also pluggable protection Class I devices connected via an isolating transformer. For these devices, the unsymmetrical disturbance voltage of the individual conductors must be measured with respect to the metal reference ground of the measurement arrangement as shown in the equivalent circuit of Figure 11.

Since in the long and medium wave bands (0,15 MHz to 2 MHz) the results of measurement can be considerably influenced by the low series capacitance C_2 between the EUT and the reference ground, and since it is determined by the specified distance, the arrangement must be exactly followed and other external influence such as body and hand capacitance, for example, should be avoided.

2.4.4.2.3 Disposition of handheld equipment without a ground connection

Measurements shall first be made in accordance with 2.4.4.2.2. Additional measurements shall then be made using the artificial hand described in CISPR 16-1.

The general principle to be followed in the application of the artificial hand is shown in Figure 13. Terminal M of the RC element shall be connected to any exposed non-rotating metal work and to metal foil wrapped around all handles, both fixed and detachable, supplied with the EUT. Metalwork which is covered with paint or lacquer is considered as exposed metalwork and shall be directly connected to the RC element.

The artificial hand shall consist of metal foil wrapped around the case, or part thereof, as specified below. The foil shall be connected to one terminal (terminal M) of an RC element (see Figure 12) consisting of a capacitor of $220 \text{ pF} \pm 20 \%$ in series with a resistor of $510 \Omega \pm 10 \%$; the other terminal of the RC element shall be connected to the reference earth of the measuring system.

The artificial hand is to be applied the following way:

- a) when the case of the EUT is entirely of metal, no metal foil is needed, but the terminal M of the RC element shall be connected directly to the body of the EUT;
- b) when the case of the EUT is of insulating material, metal foil shall be wrapped around the handle B (Figure 13), and also around the second handle D, if present. Metal foil 60 mm wide shall also be wrapped around the body C at that point where the iron core of the motor stator is located or around the gearbox if this gives a higher emission level. All these pieces of metal foil, and the ring or bushing A, if present, shall be connected together and to the terminal M of the RC element;

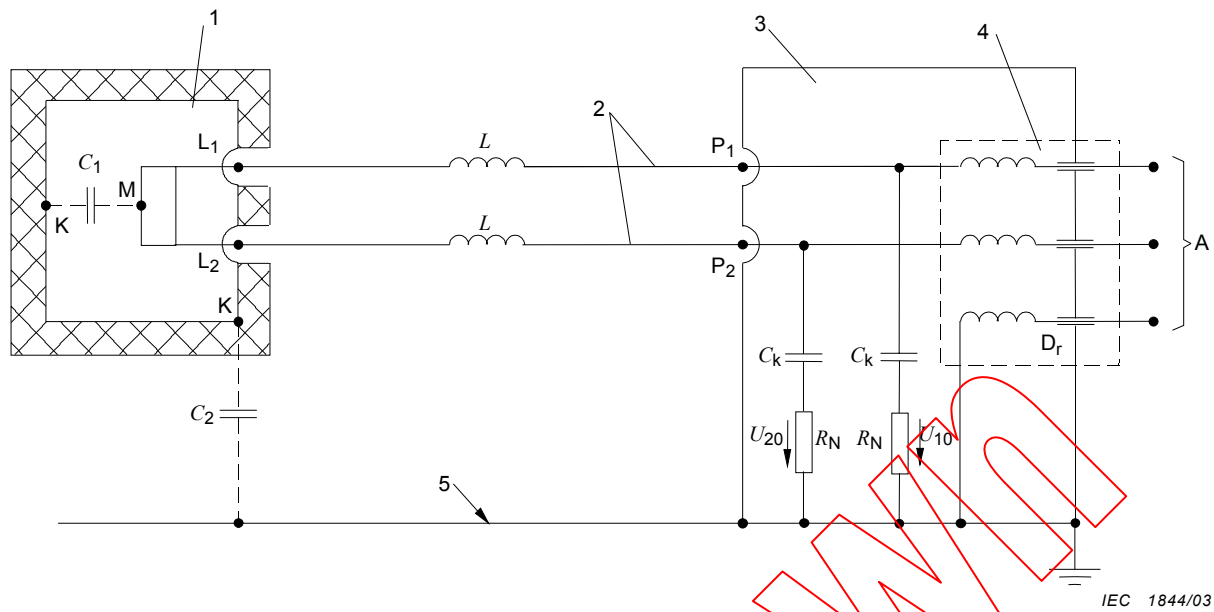


Figure 11a – Schematic for power and measurement circuit

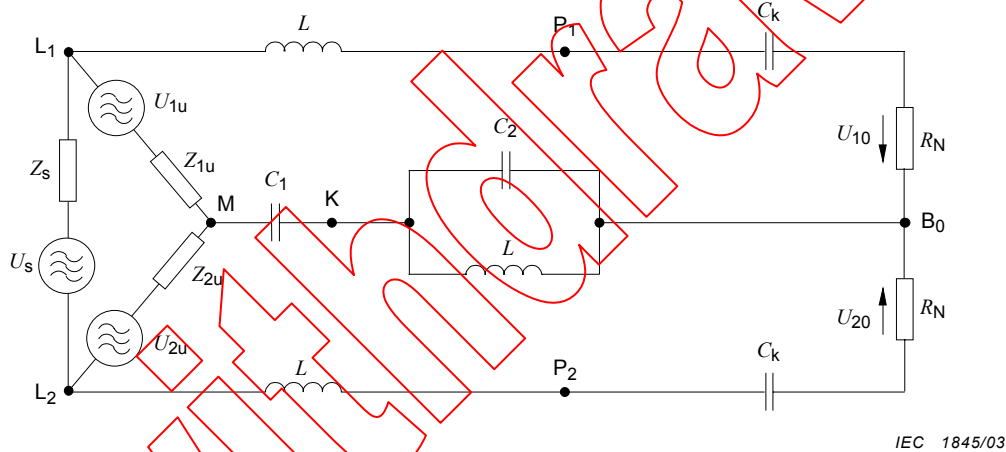


Figure 11b – Equivalent RFI source and measurement circuit

NOTE Refer to Figure 10 for symbols.

Figure 11 – Equivalent circuit for measurement of common mode disturbance voltage for Class II (grounded) EUT (see 2.4.4.2.2)

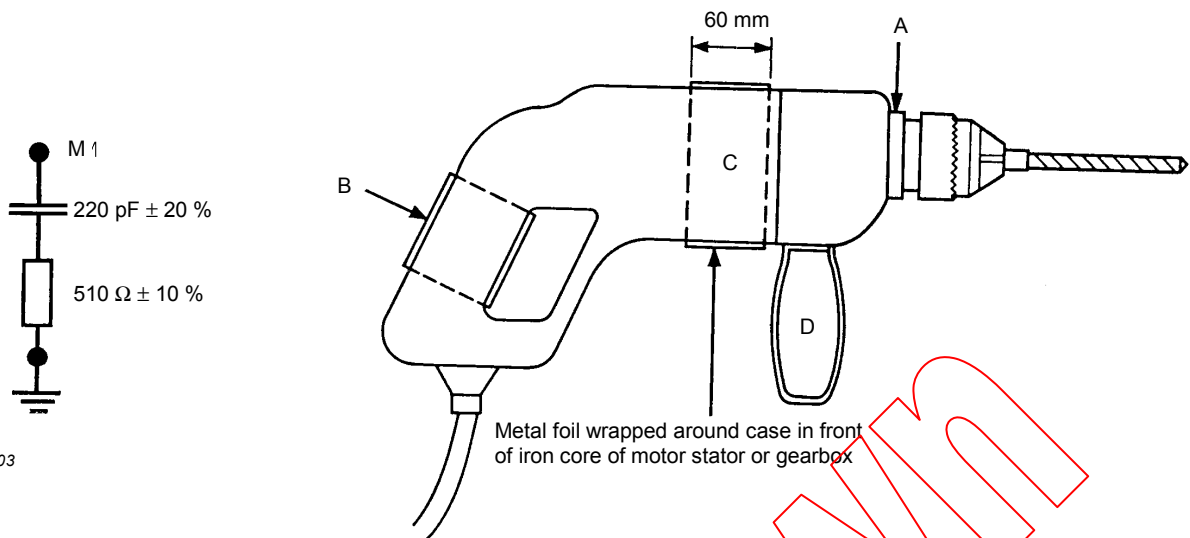


Figure 12 – RC element for artificial hand (see 2.4.4.2.3)

Figure 13 – Portable electric drill with artificial hand (see 2.4.4.2.3)

- c) when the case of the EUT is partly metal and partly insulating material, and has insulating handles, metal foil shall be wrapped around the handles B and D (Figure 13). If the case is non-metallic at the location of the motor, a metal foil 60 mm wide shall be wrapped around the body C at that point where the iron core of the motor stator is located, or alternatively around the gearbox, if this is of insulating material and a higher emission level is obtained. The metal part of the body, the point A, the metal foil round the handles B and D and the metal foil on the body C shall be connected together and to the terminal M of the RC element;
- d) when the EUT has two handles of insulating material A and B and a case of metal C, for example an electric saw (Figure 14), metal foil shall be wrapped around the handles A and B. The metal foil at A and B and the metal body C shall be connected together and to the terminal M of the RC element.

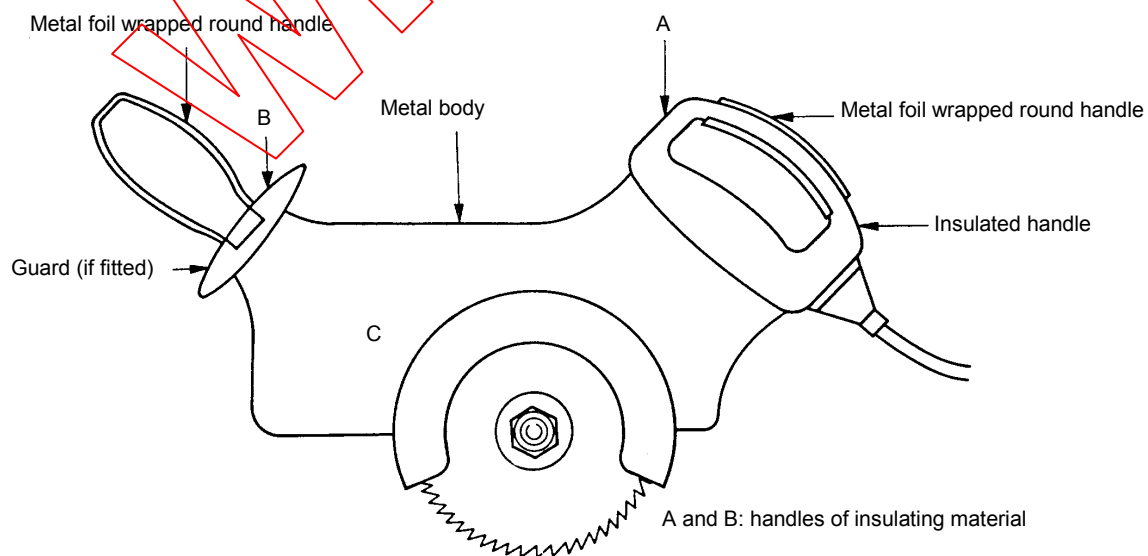


Figure 14 – Portable electric saw with artificial hand (see 2.4.4.2.3)

2.4.4.2.4 Disposition of keyboards, electrodes and other equipment sensitive to human touch

In the case of such equipment the artificial hand shall be applied as required by the product specifications and in general according to 2.4.4.2.3.

2.4.4.2.5 Disposition of equipment with external suppression components

If interference suppression devices are attached outside the EUT (e.g. in a plug device for connection to the mains) or as an element inserted in the connecting cable (power cord emission suppression device), or if shielded power cords are used, an additional 1 m long unshielded cable must be connected between the emission suppression device and the artificial network for measurement of the disturbance voltage. The line between the device and the emission suppression device must be placed in the direct proximity of the test object.

2.4.4.2.6 Disposition of equipment having auxiliary apparatus connected at the end of a lead other than the mains lead

NOTE 1 Regulating controls incorporating semiconductor devices are excluded from this subclause, the provisions of 2.4.4.4.1 shall apply.

NOTE 2 When the auxiliary apparatus is not essential to the operation of the EUT and has a separate test procedure specified elsewhere, this subclause does not apply. The main EUT is tested as an individual EUT.

NOTE 3 The ultimate decision whether to measure and apply limits is to be made in the relevant CISPR product publication.

Connecting leads exceeding 1 m in length shall be bundled in accordance with 2.4.4.1.

Measurements are not required when the connecting lead between EUT and auxiliary apparatus is permanently fixed on both ends and is either shorter than 2 m or shielded, provided that in the latter case the shielded lead is connected at both ends to the metal housing of the EUT and that of the auxiliary apparatus. Leads with removable plugs and sockets are considered to be extendable to a length of more than 2 m and measurements are required.

The equipment under test shall be arranged in accordance with previous parts of 2.4.4.2, with the following additional requirements:

- a) the auxiliary apparatus shall be placed at the same height as and at the same distance from the grounded conducted surface and if the lead is long enough, it is to be treated in accordance with 2.4.4.1. If the auxiliary lead is shorter than 0,8 m, its length shall be maintained, and the auxiliary apparatus shall be placed as far away as possible from the main apparatus. When the auxiliary apparatus is a control, the arrangements for its operation must not affect the level of disturbance;
- b) if an EUT having an auxiliary apparatus is grounded, no artificial hand shall be connected. If the EUT itself is made to be held in the hand, the artificial hand shall be connected to the EUT and not to any auxiliary apparatus;
- c) if the EUT is not made to be held in the hand, auxiliary apparatus which is not grounded and is made to be held in the hand must be connected to the artificial hand. If the auxiliary apparatus is not made to be held in the hand either, it shall be placed in relation to a grounded conducting surface as described in 2.4.4.1.

In addition to the measurement on the terminals for the mains connection, measurements are conducted on all other terminals for incoming and outgoing leads (e.g. control and load lines) using a voltage probe connected to the input of the measuring receiver.

The auxiliary apparatus, control or load is connected to allow measurements to be made under all provided operating conditions and during interactions between the EUT and the auxiliary apparatus.