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INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Specification for radio disturbance and immunity measuring apparatus and methods –

Part 1-5: Radio disturbance and immunity measuring apparatus – Antenna calibration test sites for 30 MHz to 1 000 MHz

*This **English-language** version is derived from the original **bilingual** publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.*

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FOREWORD

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International Standard CISPR 16-1-5 has been prepared by CISPR subcommittee A: Radio interference measurements and statistical methods.

This first edition of CISPR 16-1-5, together with CISPR 16-1-1, CISPR 16-1-2, CISPR 16-1-3 and CISPR 16-1-4, cancels and replaces the second edition of CISPR 16-1, published in 1999, amendment 1 (2002) and amendment 2 (2003). It contains the relevant clauses of CISPR 16-1 without technical changes.

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

The committee has decided that the contents of this publication will remain unchanged until 2005. 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- withdrawn;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 16-1 and the present ‘new’ CISPR 16-1-5 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 16-1 consists of the following parts, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods – Radio disturbance and immunity measuring apparatus:*

- Part 1-1: Measuring apparatus,
- Part 1-2: Ancillary equipment – Conducted disturbances,
- Part 1-3: Ancillary equipment – Disturbance power,
- Part 1-4: Ancillary equipment – Radiated disturbances,
- Part 1-5: Antenna calibration test sites for 30 MHz to 1 000 MHz.

TABLE RECAPITULATING CROSS REFERENCES

Second edition of CISPR 16-1 Clauses, subclauses	First edition of CISPR 16-1-5 Clauses, subclauses
1	1
2	2
3	3
5.13	4
Annexes	**Annexes**
R	A
S	B
T	C
U	D
V	E
W	F
Figures	**Figures**
55, 56, 57, 58, 59	1, 2, 3, 4, 5
S.1, S.2, S.3, S.4	B.1, B.2, B.3, B.4
T.1, T.2, T.3	C.1, C.2, C.3
Tables	**Tables**
19, 20	1, 2

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 1-5: Radio disturbance and immunity measuring apparatus – Antenna calibration test sites for 30 MHz to 1 000 MHz

1 Scope

This part of CISPR 16 is designated a basic standard which specifies the requirements for calibration test sites, used to perform antenna calibrations, as well as the test antenna characteristics, calibration site verification procedure and site compliance criteria. Further information on calibration site requirements, test antenna considerations and the theory of antennas and site attenuation is provided in informative annexes.

Measurement instrumentation specifications are given in CISPR 16-1-1 and CISPR 16-1-4. Further information and background on uncertainties in general is given in CISPR 16-4-1, which may be helpful in establishing uncertainty estimates for the calibration processes of antennas.

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 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 16-1-4:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment - Radiated disturbances*

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 standardised 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*

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

International Vocabulary of Basic and General Terms in Metrology, International Organization for Standardization, Geneva, 2nd edition, 1993

3 Definitions

For the purpose of this section of CISPR 16, the following definitions apply. Also see IEC 60050(161).

3.1
calibration test site (CALTS)
open area test site with metallic ground plane and tightly specified site attenuation performance in horizontal and vertical electric field polarization

A CALTS is used for determining the free-space antenna factor of an antenna.

Site attenuation measurements of a CALTS are used for comparison to corresponding site attenuation measurements of a compliance test site, in order to evaluate the performance of the compliance test site

3.2
compliance test site (COMTS)
environment which assures valid, repeatable measurement results of disturbance field strength from equipment under test for comparison to a compliance limit

3.3
antenna
that part of a transmitting or receiving system that is designed to radiate or to receive electromagnetic waves in a specified way

NOTE 1 In the context of this standard, the balun is a part of the antenna.

NOTE 2 See also the term "wire antenna".

3.4
balun
passive electrical network for the transformation from a balanced to an unbalanced transmission line or device or vice versa

3.5
free-space-resonant dipole
wire antenna consisting of two straight colinear conductors of equal length, placed end to end, separated by a small gap, with each conductor approximately a quarter-wavelength long such that at the specified frequency the input impedance of the wire antenna measured across the gap is pure real when the dipole is located in the free space

NOTE 1 In the context of this standard, this wire antenna connected to the balun is also called the "test antenna".

NOTE 2 This wire antenna is also referred to as "tuned dipole".

3.6
site attenuation
site attenuation between two specified positions on a test site is the insertion loss determined by a two-port measurement, when a direct electrical connection between the generator output and receiver input is replaced by transmitting and receiving antennae placed at the specified positions

3.7
test antenna
combination of the free-space-resonant dipole and the specified balun

NOTE For the purpose of this standard only.

3.8
wire antenna
a specified structure consisting of one or more metallic wires or rods for radiating or receiving electromagnetic waves

NOTE A wire antenna does not contain a balun.

4 Specifications and validation procedures for a test site to be used to calibrate antennas in the frequency range of 30 MHz to 1 000 MHz

Clause 5 of CISPR 16-1-4 specifies the requirements for a test site used to make radio disturbance field strength measurements in the frequency range of 30 MHz to 1 000 MHz. Such a test site may not be suitable for calibrating antennas. This clause specifies the requirements and validation procedure for a test site suitable for the calibration of antennas above a conducting, flat metal plane in the frequency range of 30 MHz to 1 000 MHz. A test site meeting these stringent requirements may also be used as a reference test site for comparison purposes in an alternative validation procedure to 5.6 of CISPR 16-1-4.

4.1 Introduction

A test site suitable for performing antenna calibration, referred to herein as CALTS, is intended to provide a suitable environment to calibrate an antenna for its free-space antenna factor. This calibration is performed most conveniently above a reflecting plane by using only horizontal polarization. Subclauses 4.3 through 4.6 specify the characteristics of a CALTS, the characteristics of a calculable test antenna and the CALTS verification (validation) procedure and performance criteria. The CALTS validation procedure given in 4.5 requires the use of a calculable dipole antenna as specified in 4.4, thus creating the possibility of comparing theoretically predicted site-attenuation to measured CALTS performance. Items to be reported in a CALTS validation report are summarized in 4.7. Annex A provides guidance for constructing a CALTS, which complies with validation criteria specified in 4.6.

In order for a CALTS to be used as a reference test site (REFSITE) for validating the performance of test sites according to clause 5 of CISPR 16-1-4, some additional requirements need to be specified. Subclause 4.7 specifies the additional characteristics and performance criteria. Test sites specified in clause 5 of CISPR 16-1-4, which are used for demonstrating compliance with radiated emission limits are referred to herein as a compliance test site (COMTS). Validation of a COMTS may be obtained by comparing it to the theoretical site attenuation given in clause 5 of CISPR 16-1-4 (which takes precedence) or by comparing site attenuation measurements of the REFSITE to corresponding site attenuation measurements of the COMTS, using the same measurement set-up and equipment (antennas, cables, generator, receiver, etc.).

The annexes to this standard contain informative specifications of a CALTS and of the calculable, free-space-resonant dipole (tuned dipole) to be used in the CALTS validation procedures. They also give a model for calculating theoretical site attenuation, numerical examples and a checklist for the validation procedure.

4.2 Antenna calibration test site (CALTS) specification

4.2.1 Introduction

The CALTS comprises the following main components:

– a good-conducting flat metal plane (the reflecting plane);

– an electromagnetically obstruction-free area surrounding the reflecting plane.

In addition, the following ancillary equipment is needed:

– two antenna masts carrying the antennas to be used in either the CALTS validation procedure or the antenna calibration procedure;

– the cables to be connected to these antennas; and

– electronic equipment, such as an RF generator and a measuring receiver.

The normative specification for a CALTS is given in 4.2.2, while annex A contains a number of informative specifications as a guidance to construct and place a CALTS in such a way that the validation criteria will normally be met.

4.2.2 Normative specification

For the calibration of antennas, the CALTS shall comply with the validation criteria given in 4.5.3, i.e.

a) site attenuation at fixed antenna heights, and

b) antenna heights for maximum site attenuation, or for maximum site attenuation, at all frequencies at which the antennas shall be calibrated.

NOTE 1 In the CALTS validation procedure, equipment is used which is also subject to normative specifications (see 4.3 and 4.4).

NOTE 2 The CALTS validation report (4.6) will contain information on how compliance with the requirements is maintained, so that the CALTS is deemed to comply with the requirements during its actual use.

4.3 Test antenna specification

4.3.1 Introduction

To allow (numerical) calculation of the theoretical site attenuation SA_c needed in the validation procedure, antennas are needed which can be accurately modelled. Therefore, the test antenna shall be a free-space resonant dipole connected to a balun with specified properties. The normative test antenna specifications are given in 4.3.2. An example of the construction of a test antenna is given in annex B.

The test antenna consists of a balun and two colinear wire elements (conductors) each having a diameter D_{we} and length L_{we}. These elements are connected to the two feed terminals (A and B in figure 1) at the balun. The gap between these feed terminals has a width W_g. The tip-to-tip length L_a of the antenna is given by $L_a = 2L_{we} + W_g$. The centre of the test antenna is in the middle of the feed-terminal gap on the centre-line of the two colinear wire elements.

The balun has an unbalanced input/output (transmitting/receiving antenna) port and a balanced port at the two feed terminals A and B. As an example, in figure 1 the purpose of the balun is indicated schematically by the balance/unbalance transformer.

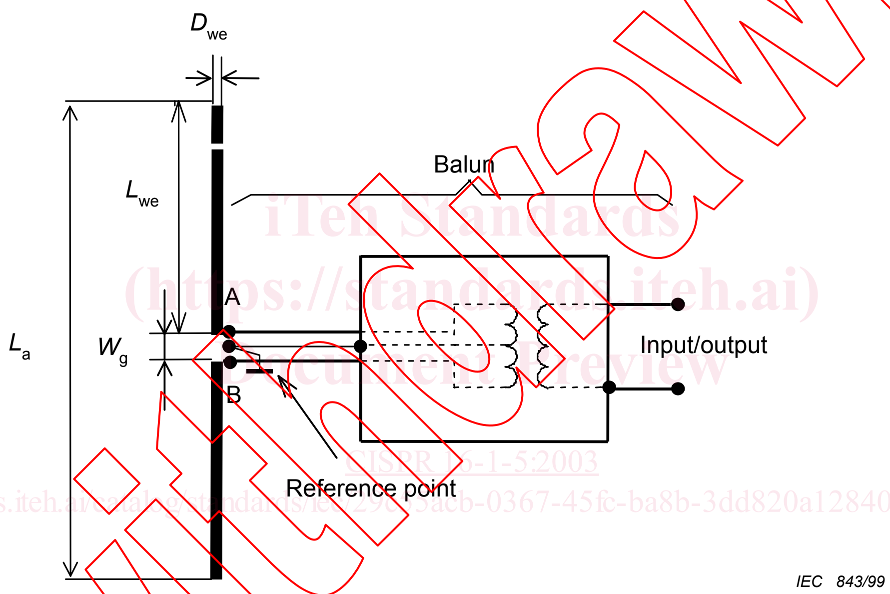
4.3.2 Normative specifications

4.3.2.1 The test antenna shall have identical wire elements of length L_{we} which can be disconnected from the balun to enable the balun parameters to be validated, and to allow the balun heads of the two antennas used in site attenuation measurements to be connected together.

4.3.2.2 The tip-to-tip length $L_a(f, D_{we})$ of the approximately $\lambda/2$ wire antenna is determined by the condition that, at the specified frequency f and in free space, the absolute value of the imaginary part of the input impedance at the feed terminals is smaller than 1 Ω.

NOTE 1 If the wire elements have a constant diameter and if $D_{we} << L_a$, then $L_a(f,D_{we})$ can be calculated from the equation (C.2) in subclause C.1.1. If the diameter is not a constant, e.g. when a telescopic antenna is used, $L_a(f)$ can only be calculated numerically, see C.2.2.

NOTE 2 When using a telescopic antenna, the telescopic elements should be tuned in such a way that the elements having the largest diameter are used first (see figure 2), and the numerical calculations should account for this approach.



NOTE – The centre of the test antenna is in the middle of the gap on the centre-line of the two wire elements.

Figure 1 – Schematic diagram of the test antenna

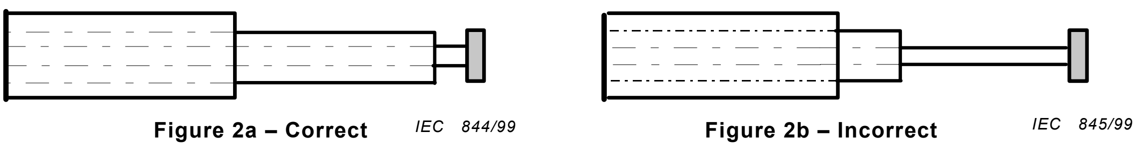


Figure 2a – Correct **Figure 2b – Incorrect**

Figure 2 – Adjustment of a telescopic wire element to the length L_{we}

Under consideration: At test frequencies between 30 MHz and 80 MHz, a fixed length dipole with $L_a = L_a$ (80 MHz) may be used.

4.3.2.3 The feed-terminal gap shall be $W_g \leq 15$ mm or $W_g \leq 0{,}03\ \lambda_{min}$, whichever is the smaller,

where

$\lambda_{min} = c_0/f_{max}$,

f_{max} is the highest test frequency at which the test antenna is used; and

c_0 is the velocity of the electromagnetic waves in vacuum.

4.3.2.4 If the tip-to-tip length $L_a(f)$ of the actual wire antenna is within ΔL_a of the length $L_a(f)$ specified for that antenna (see table 2), that length is presumed to be validated when the width of the feed-terminal gap complies with 4.3.2.3.

4.3.2.5 The balanced port of the balun shall have:

a) a specified impedance Z_{AB} with a specified maximum VSWR, see table 2, when the unbalanced port is terminated in the impedance Z_e presented to it by the external circuitry (the antenna feed cable);

b) an amplitude balance with respect to the balun reference point better than ΔA_b dB, see table 2, when both feed terminals are terminated in an impedance $Z_{AB}/2$ with respect to the balun reference point;

c) a phase balance of 180° ± $\Delta\phi_b$° (see table 2), when both feed terminals are terminated in an impedance $Z_{AB}/2$ with respect to the balun reference point.

NOTE 1 Connectors at the balun ports should enable RF measurements to be made at the three balun ports.

NOTE 2 The balanced port impedance Z_{AB} is the impedance between the feed terminals A and B in figure 1. The preferred value of this impedance is Z_{AB} = 100 Ω (real).

NOTE 3 The impedance Z_e presented by the external circuitry is usually 50 Ω, being the preferred value.

NOTE 4 The amplitude and phase balance requirements ensure that the signals at the feed terminals A and B are sufficiently equal in amplitude and opposite in phase with respect to the balun reference point. When the balanced port meets these requirements, the isolation between the two feed terminals will be more than 26 dB when the unbalanced port is terminated in the impedance Z_e.

NOTE 5 As far as practical, the balun components should be oriented to present the minimum co-polarized reflecting surface to the wire antenna.

NOTE 6 The components of the balun are electrically screened, so that their (parasitic) properties cannot be influenced by the surroundings. The balun reference point and the ground terminal of the output/input port are connected to that screen.

4.3.2.6 The balun properties required in 4.3.2.5 may be determined from S-parameter measurements and, partly, from injection measurements.

NOTE 1 The head-to-head connection of the baluns in 4.4.4.2 and 4.4.4.4 may be replaced by a cable-to-cable connection when the full set of balun S-parameters and the port impedances presented to the baluns by the generator and the receiver are known, provided the balun properties are incorporated in the SA_c calculation.

NOTE 2 S-parameter and injection measurements are described in annex B.