

Specification for radio disturbance and immunity measuring apparatus and methods

Part 1-5: Radio disturbance and immunity measuring apparatus — Specifications and validation procedures for CALTS and RFTS from 30 MHz to 1 000 MHz

ICS 33.100.10; 33.100.20

National foreword

This British Standard is the UK implementation of EN 55016-1-5:2004+A1:2012. It is identical to CISPR 16-1-5:2003+A1:2012. It supersedes BS EN 55016-1-5:2004, which will be withdrawn on 24 July 2015.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted by Technical Committee GEL/210, EMC — Policy, committee to Subcommittee GEL/210/12, EMC basic, generic and low frequency phenomena Standardization.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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**Specification for radio disturbance and immunity
measuring apparatus and methods
Part 1-5: Radio disturbance and immunity measuring apparatus –
Specifications and validation procedures for CALTS and RFTS
from 30 MHz to 1 000 MHz
(CISPR 16-1-5:2003)**

Spécifications des méthodes et des appareils
de mesure des perturbations radioélectriques
et de l'immunité
aux perturbations radioélectriques
Partie 1-5: Appareils de mesure
des perturbations radioélectriques
et de l'immunité aux perturbations
radioélectriques –
Emplacements d'essai pour l'étalonnage
des antennes de 30 MHz à 1 000 MHz
(CISPR 16-1-5:2003)

Anforderungen an Geräte und Einrichtungen
sowie Festlegung der Verfahren zur Messung
der hochfrequenten Störaussendung
(Funkstörungen) und Störfestigkeit
Teil 1-5: Geräte und Einrichtungen
zur Messung der hochfrequenten
Störaussendung (Funkstörungen)
und Störfestigkeit –
Messplätze für die Antennenkalibrierung
von 30 MHz bis 1 000 MHz
(CISPR 16-1-5:2003)

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of the International Standard CISPR 16-1-5:2003, prepared by CISPR SCA, Radio-interference measurements and statistical methods, was submitted to the formal vote and was approved by CENELEC as EN 55016-1-5 on 2004-09-01 without any modification.

The following dates were fixed:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2005-09-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2007-09-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard CISPR 16-1-5:2003 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document CISPR/A/994A/FDIS, future amendment 1 to edition 1 of CISPR 16-1-5, prepared by SC A "Radio-interference measurements and statistical methods" of IEC/TC CISPR "International special committee on radio interference" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 55016-1-5:2004/A1:2012.

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standards conflicting with the
document have to be withdrawn

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Endorsement notice

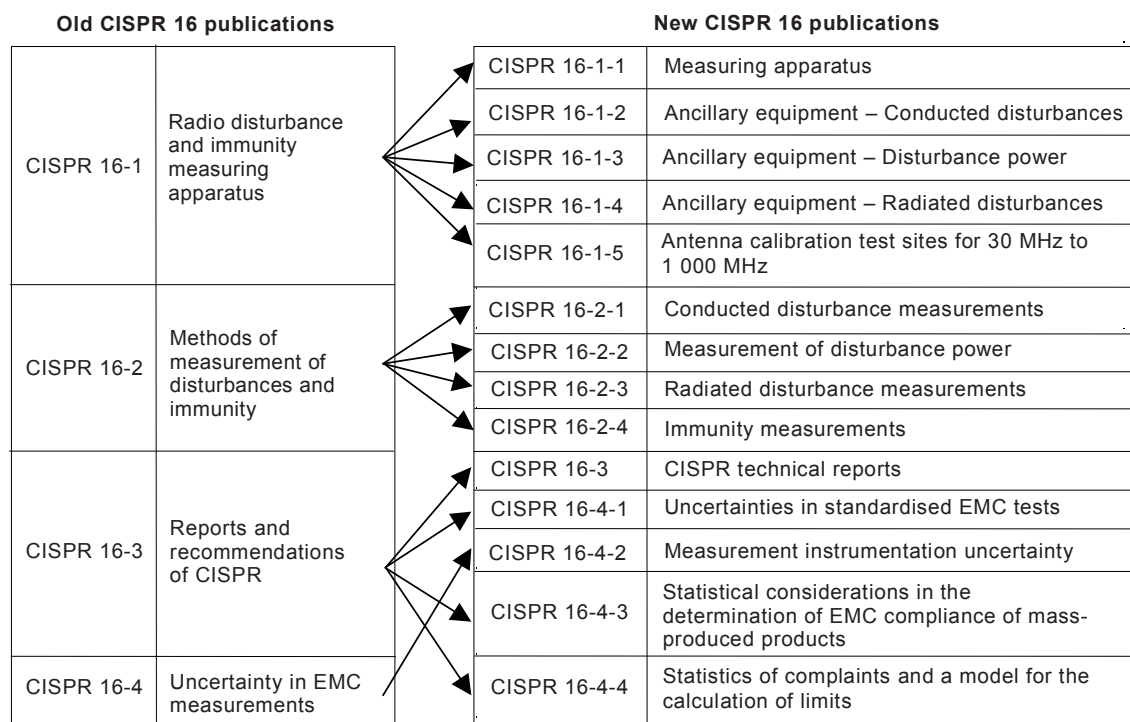
The text of the International Standard CISPR 16-1-5:2003/A1:2012 was approved by CENELEC as a European Standard without any modification.

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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.



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

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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 to 1000 MHz

1 Scope

A1 This part of CISPR 16 specifies the requirements for calibration test sites used to perform antenna calibrations and for reference test sites used to measure the antenna-pair reference site attenuation for compliance test site validations. It describes the test antenna characteristics, calibration and reference test site verification procedures 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 **A1**

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*

A1 CISPR 16-1-4:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements* **A1**

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)

A1 open-area test site with metallic ground plane and tightly specified site attenuation performance in horizontal electric field polarization

NOTE A CALTS is used for the measurement of height dependent AF, and by the standard site method to measure free-space AF. A CALTS can also be validated for vertical polarization via 4.7. See the related definition of a REFTS. **A1**

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

A1 site attenuation

SA

minimum site insertion loss measured between two polarization-matched antennas located on a test site when one antenna is moved vertically over a specified height range and the other is set at a fixed height **A1**

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.

A1 3.9**site insertion loss**

transmission loss between a pair of antennas placed at specified positions on a test site, when a direct electrical connection between the signal generator output and the measuring receiver input is replaced by transmitting and receiving antennas placed at the specified positions

3.10**reference test site****REFTS**

open-area test site with metallic ground plane and tightly specified site attenuation performance in horizontal and vertical electric field polarizations

NOTE Site attenuation measurements of a REFTS are used for comparison to corresponding site attenuation measurements of a COMTS to evaluate the performance of the COMTS. **A1**

4 A1 Specifications and validation procedures for CALTS and REFTS from 30 MHz to 1 000 MHz A1

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 **A1** 5.2.6 **A1** of CISPR 16-1-4.

4.1 A1 General A1

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.

A1 In order for a CALTS to be used as a reference test site for validating the performance of test sites according to Clause 5 of CISPR 16-1-4, the CALTS should be verified using both horizontal and vertical antenna polarizations, as described in 4.7, whereupon it qualifies for use as a REFTS. Test sites specified in Clause 5 of CISPR 16-1-4 that are used for demonstrating compliance with radiated emission limits are referred to herein as compliance test sites (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, or by comparing the site attenuation measured on a REFTS to the corresponding site attenuation measured on the COMTS, using the same antennas and the same antenna set-up geometry. **A1**

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

- A1** For the calibration of antennas, the CALTS shall comply with the validation criteria given in 4.5.3.1 at all frequencies at which the antennas shall be calibrated. The tests in 4.4.3.2 and their associated criteria in 4.5.3.2 and 4.5.3.3 are optional, but are included for those who want to confirm the achievement in 4.5.3.1 of $T_{SA}(f)$ to less than 0,7 dB. **A1**

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.

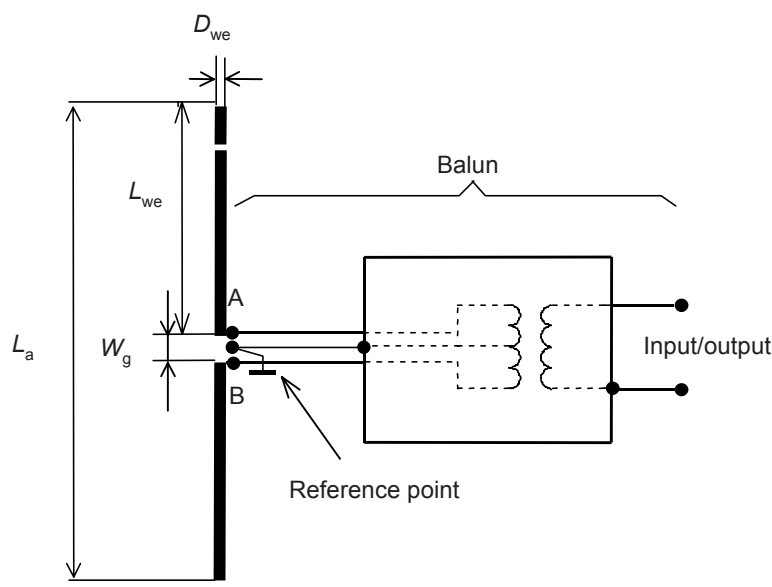
4.3.2 Normative specifications

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 1Ω .

NOTE 1 If the wire elements have a constant diameter and if $D_{we} \ll L_a$, 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

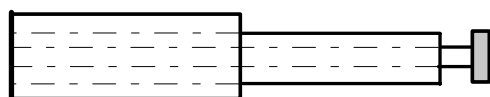


Figure 2a – Correct IEC 844/99

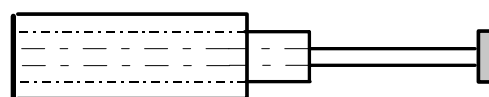


Figure 2b – Incorrect IEC 845/99

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 $W_g \leq 15 \text{ mm}$ 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 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);
- 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;
- a phase balance of $180^\circ \pm \Delta \phi_b$ (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 $Z_{AB} = 100 \Omega$ (real).

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

4.3.2.7 If, in the CALTS validation procedure, test antennas and/or test equipment is used with Z_{AB} and/or Z_e differing from the preferred values $100\ \Omega$ and $50\ \Omega$, respectively, then this should be explicitly mentioned in the validation report (4.6).

4.4 Antenna calibration test site validation procedure

4.4.1 Introduction

In the validation procedure, the measured site attenuation SA_m is compared with the theoretically calculated site attenuation SA_c . The procedure thus verifies whether the CALTS sufficiently meets the properties assumed in the SA calculations, i.e.:

- a) the plane is perfectly flat and infinitely large;
- b) the absolute value of the reflection coefficient of that plane is $r = 1$; and
- c) the phase difference of the incoming and reflected horizontally polarized EM waves at the plane is $\phi = \pi$ radians;
- d) the influence of the ancillary equipment and surroundings of the plane is negligible.

To verify the properties, two sets of measurements are required:

- 1) the properties a), b) and d) are verified simultaneously in a SA measurement procedure using fixed antenna heights (see 4.4.4), after which the measured and calculated SA are compared;
- 2) the properties a), c) and d) are verified simultaneously in a procedure in which the height of one of the test antennas is scanned for maximum SA after which the measured and calculated height of that antenna corresponding with that maximum are compared (see 4.4.5).

Alternatively, the latter set of properties may also be verified simultaneously in a scanned frequency measurement procedure (see 4.4.6).

Below, a quantity $\pm \Delta X$ represents the maximum tolerance of a parameter value X allowed in the validation procedure. The quantitative data for the tolerances are summarized in table 2.

4.4.2 Test set-up

4.4.2.1 The centres of the test antennas, the antenna masts and the antenna coaxial antenna cables are positioned in a plane perpendicular to the reflecting plane and centrally located on the reflecting plane.

NOTE The centre of the test antenna has been defined in 4.3.1

4.4.2.2 The colinear wire elements are positioned parallel to the reflecting plane (antenna in horizontal polarization) throughout, and perpendicular to the (vertical) plane mentioned in 4.4.2.1.

NOTE At the lower end of the frequency range, e.g. 30 MHz to 40 MHz, the relatively long wire elements may droop, thus influencing the measuring results. This influence can be eliminated by physically propping up the wire elements, or can be accounted for in the calculation of the theoretical site attenuation (see also 4.4.4.3 and 4.5.3.1).

4.4.2.3 The horizontal distance between the centres of the test antennas is

$$d = 10,00\text{ m} \pm \Delta d\text{ m (see table 2).}$$

4.4.2.4 The height of the centre of the transmitting antenna above the reflecting plane is

$$h_t = 2,00 \text{ m} \pm \Delta h_t \text{ m (see table 2).}$$

4.4.2.5 The height of the centre of the receiving antenna above the reflecting plane shall be adjustable to the heights $h_r \pm \Delta h_r$, as specified in table 1 and table 2, and shall be scannable over the height range $1,0 \text{ m} \leq h_r \leq 4,0 \text{ m}$ as required in 4.4.5.

4.4.2.6 The coaxial cables connected to the baluns of the transmitting and receiving antennas run perpendicular to the wire elements and parallel to the reflecting plane over a distance of at least 1 m from the wire elements. After that, the cables may drop onto the reflecting plane and (preferably) continue to run underneath the reflecting plane or on top of that plane perpendicularly to the wire elements until they reach the edge of the plane. To avoid common mode coupling, ferrite loading of the coaxial cables connected to the baluns is advised.

NOTE 1 The cables should have a low transfer impedance to avoid influence on the measured results of the induced cable sheet currents through that impedance.

NOTE 2 When the cables run partly underneath the reflecting plane, the sheath of the cable should be bonded (360° around) to the reflecting plane when penetrating that plane.

4.4.2.7 The RF generator and RF receiver shall not be elevated above the level of the reflecting plane if they are within 20 m from the plane.

4.4.2.8 The RF generator shall have a good frequency and output level stability throughout the duration of the site-attenuation measurements. See also 4.4.4.5.

NOTE It might be necessary to include a warm-up time (normally indicated by the equipment manufacturer) of the RF generator and RF receiver in the measuring procedure, to assure a sufficient long-term stability of these equipments.

4.4.2.9 The RF receiver shall have its linearity calibrated over a dynamic range of at least 50 dB. The uncertainty of the receiver linearity is denoted as ΔA_r (see 4.5.2.2). A reasonable value for the receiver linearity uncertainty is 0,2 dB.

NOTE If the linear dynamic range is less than 50 dB a substitution method may be followed, using a calibrated precision attenuator as described in 4.4.4.7.

4.4.3 Test frequencies and receiving antenna heights

4.4.3.1 With due observance to 4.2.2, the validation measurements described in 4.4.4 shall be carried out at least at the frequencies and the associated fixed heights of the centre of the receiving antenna h_r (m) above the reflecting plane given in table 1.

NOTE 1 Information concerning the CALTS performance at the intermediate frequencies can be obtained by using swept-frequency measurements as described in A.2.2.

NOTE 2 Care shall be taken in case of high-Q responses, especially for frequencies above 300 MHz. In such a case a swept-frequency procedure should be carried out around the specified frequencies and at the associated heights.

4.4.3.2 In addition to the validation measurements described in 4.4.4, either three receiving antenna height-scan measurements as described in 4.4.5 or three frequency-scan measurements as described in 4.4.6 shall be carried out.

- a) When choosing to perform receiving-antenna, height-scan measurements, these shall be carried out at the frequencies f_s : 300 MHz, 600 MHz and 900 MHz, with the test antennas tuned to the associated frequency f_s .

- b) When choosing to perform frequency-scan measurements, these shall be carried out with combinations $\{h_{rs}, f_s\}$: {2,65 m, 300 MHz}, {1,30 m, 600 MHz} and {1,70 m, 900 MHz} of the receiving antenna height h_{rs} and the test antenna tuned frequency f_s .

**Table 1 – Frequency and fixed receiving antenna height data for SA measurements
where $h_t = 2$ m and $d = 10$ m (4.4.2.3 and 4.4.2.4)**

Frequency MHz	h_r m	Frequency MHz	h_r m	Frequency MHz	h_r m
30	4,00	90	4,00	300	1,50
35	4,00	100	4,00	400	1,20
40	4,00	120	4,00	500	2,30
45	4,00	140	2,00	600	2,00
50	4,00	160	2,00	700	1,70
60	4,00	180	2,00	800	1,50
70	4,00	200	2,00	900	1,30
80	4,00	250	1,50	1 000	1,20

4.4.3.3 If narrow-band noise, such as that originating from broadcast transmitters, hinders accurate measurement at a frequency specified in 4.4.3.1 and 4.4.3.2, a usable test frequency as close as possible to that specified frequency shall be chosen.

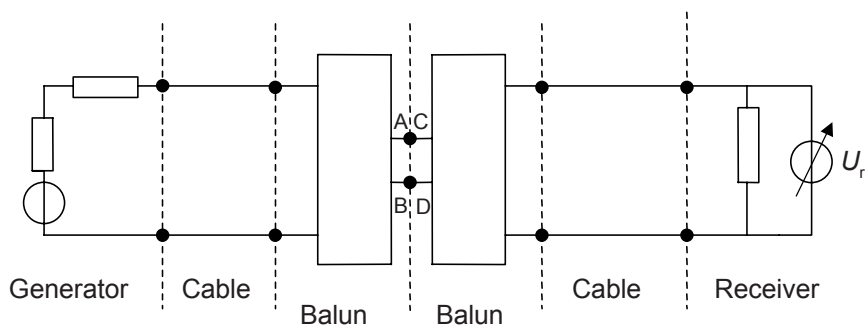
The rationale for a deviation from a specified frequency shall be recorded in the validation report (see 4.6).

4.4.3.4 The frequency of the RF generator providing the signal for the transmitting antenna shall be adjusted to within Δf (see table 2), of a test frequency specified in table 1 or in 4.4.3.2.

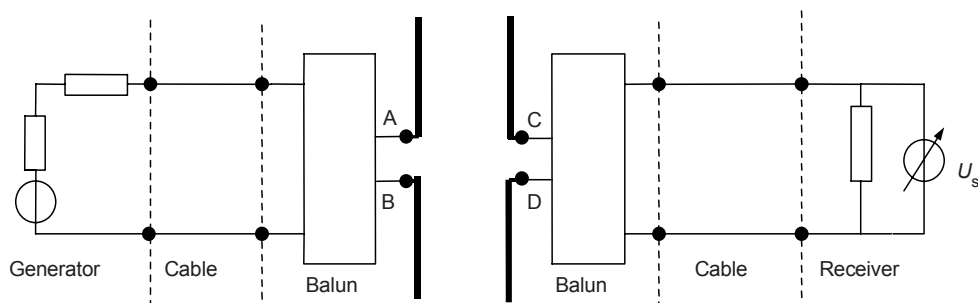
4.4.4 Site attenuation measurements

This subclause describes the three measurements needed to determine the measured site attenuation SA_m (see 4.5.3.1), at the specified frequencies. The site attenuation being considered is the SA between the feed terminals of the transmitting antenna (A and B in figures 3 and 4) and those of the receiving antenna (C and D in figures 3 and 4).

NOTE Where a full set of balun S-parameters is available (see 4.3.2.6), it is also possible to consider the SA between the two cable/balun interfaces provided the balun properties are incorporated in the calculation of the theoretical SA. In the description given below, the latter possibility will be indicated by a note, where appropriate.



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Figure 3 – Determination $U_{r1}(f)$ or $U_{r2}(f)$ 

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Figure 4 – Determination $U_s(f)$ with the wire antennas in their specified position

4.4.4.1 Measurement 1: At a specified frequency f , the reference voltage $U_{r1}(f)$ is determined. This voltage makes it possible to account for the attenuation of the signal between the RF generator output port and the feed terminals of the transmitting wire antenna and, similarly, between the feed terminals of the receiving wire antenna and the receiver input port.

$U_{r1}(f)$ is determined as follows (see figure 3). The wire elements of the test antennas are disconnected from their balun and the two baluns are connected head-to-head (see also note 4 below) with a connection which is as short as possible, preferably $< \lambda_{\min}/10$, where $\lambda_{\min}$ has been defined in 4.3.2.3.

The level of the RF generator is set to give a receiver reading at least 60 dB above the noise level of the receiver (see note 2 below). The receiver reading is recorded as $U_{r1}(f)$.

NOTE 1 The level of the emitted field should not exceed the local transmission permitted levels.

NOTE 2 In this subclause it is presumed that the RF receiver complies with 4.4.2.9. Where the note to 4.4.2.9 applies, the method given in 4.4.4.7 should be applied.

NOTE 3 The noise level of the receiver can be reduced by reducing the receiver bandwidth. However, if the RF generator and RF receiver are not frequency-locked, as in the case of a tracking generator and spectrum analyser, the receiver bandwidth should be sufficiently wide that a possible drift of the frequency of the RF generator signal does not influence the measuring results.

NOTE 4 If the method given in the note to 4.4.4 is followed, the complete test antennas are disconnected and the two antenna cables are interconnected when determining $U_{r1}(f)$ and $U_{r2}(f)$ in 4.4.4.4.

4.4.4.2 The amplitude setting of the RF generator used in 4.4.4.1 at a particular frequency remains unchanged throughout the measurements associated with 4.4.4.3 and 4.4.4.4.

4.4.4.3 Measurement 2: The baluns are disconnected from each other, the wire elements connected to their balun (see figure 4), and are adjusted to the specified length $L_a(f)$. The test antennas are brought into position as specified in 4.4.2 and 4.4.3. All other elements in the test set-up are the same as in 4.4.4.1. See also the notes to 4.4.2.2 and 4.4.4.5.

At the specified test frequency f , and with the antennas in their specified position, the receiver reading is recorded as $U_s(f)$.

4.4.4.4 Measurement 3: The measurement of the reference voltage (see 4.4.4.1), is repeated at the same specified frequency. The value is recorded as $U_{r2}(f)$.

4.4.4.5 If $U_{r1}(f)$ and $U_{r2}(f)$, expressed in logarithmic units, differ by more than 0,2 dB, the stability of the test set-up shall be improved and the aforementioned measurements 1, 2 and 3 repeated.

NOTE A cause of instability effects may also be the temperature dependence of the coaxial cable attenuation, especially under direct sunlight exposure.

4.4.4.6 The measured site attenuation $SA_m(f)$ is given by the following equation:

$$SA_m(f) = 20 \log_{10} \left\{ \frac{U_{ra}(f)}{U_s(f)} \right\} \quad (\text{dB}) \quad (1)$$

where $U_{ra}(f)$ is the average of $U_{r1}(f)$ and $U_{r2}(f)$.

NOTE If no provisions have been taken to avoid the droop of the wire elements of both test antennas at the lower frequencies 30 MHz, 35 MHz and 40 MHz, it might be necessary to correct the measured site attenuation SA_m (see 4.5.3.1).

4.4.4.7 Where the dynamic range of the RF receiver does not comply with 4.4.2.9, the following substitution method may be used provided the full set of balun S-parameters is available and the balun properties are incorporated in the calculation of the theoretical SA.

- Determine and record the receiver reading $U_s(f)$ as described in 4.4.4.3.
- Replace the test antennas by a calibrated precision attenuator and connect both antenna cables to this attenuator. Adjust the insertion loss caused by the attenuator to a level $A_{i1}(f)$ such that the same receiver reading $U_s(f)$ as determined under a) is found. Record $A_{i1}(f)$ and its associated measurement uncertainty $\Delta A_{i1}(f)$.
- To demonstrate the stability of the test set-up mentioned in 4.4.2.8, repeat step b) to determine $A_{i2}(f)$ after a period of time approximating the total time between the reading of $U_s(f)$ in step a) and $A_{i1}(f)$ in step b). If $A_{i2}(f)$ differs by more than 0,2 dB from $A_{i1}(f)$, the stability of the test set-up shall be improved and steps a), b) and c) repeated.
- If the test set-up is sufficiently stable, the measured site attenuation is given by

$$SA_m(f) = 20 \log_{10} \{A_{ia}\} \quad (\text{dB}) \quad (2)$$

where $A_{ia}(f)$ is the average value of $A_{i1}(f)$ and $A_{i2}(f)$ in linear units.