

INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

**Electromagnetic compatibility (EMC) –
Part 4-22: Testing and measurement techniques – Radiated emissions and
immunity measurements in fully anechoic rooms (FARs)**

**Compatibilité électromagnétique (CEM) –
Partie 4-22: Techniques d'essai et de mesure – Mesures de l'immunité et des
émissions rayonnées dans des enceintes complètement anéchoïques (FAR)**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2010 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester.

If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de la CEI ou du Comité national de la CEI du pays du demandeur.

Si vous avez des questions sur le copyright de la CEI ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de la CEI de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

- Catalogue of IEC publications: www.iec.ch/searchpub

The IEC on-line Catalogue enables you to search by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, withdrawn and replaced publications.

- IEC Just Published: www.iec.ch/online_news/justpub

Stay up to date on all new IEC publications. Just Published details twice a month all new publications released. Available on-line and also by email.

- Electropedia: www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing more than 20 000 terms and definitions in English and French, with equivalent terms in additional languages. Also known as the International Electrotechnical Vocabulary online.

- Customer Service Centre: www.iec.ch/webstore/custserv

If you wish to give us your feedback on this publication or need further assistance, please visit the Customer Service Centre FAQ or contact us:

Email: csc@iec.ch
Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00

A propos de la CEI

La Commission Electrotechnique Internationale (CEI) est la première organisation mondiale qui élabore et publie des normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications CEI

Le contenu technique des publications de la CEI est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

- Catalogue des publications de la CEI: www.iec.ch/searchpub/cur_fut-f.htm

Le Catalogue en-ligne de la CEI vous permet d'effectuer des recherches en utilisant différents critères (numéro de référence, texte, comité d'études,...). Il donne aussi des informations sur les projets et les publications retirées ou remplacées.

- Just Published CEI: www.iec.ch/online_news/justpub

Restez informé sur les nouvelles publications de la CEI. Just Published détaille deux fois par mois les nouvelles publications parues. Disponible en-ligne et aussi par email.

- Electropedia: www.electropedia.org

Le premier dictionnaire en ligne au monde de termes électroniques et électriques. Il contient plus de 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans les langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International en ligne.

- Service Clients: www.iec.ch/webstore/custserv/custserv_entry-f.htm

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions, visitez le FAQ du Service clients ou contactez-nous:

Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

**Electromagnetic compatibility (EMC) –
Part 4-22: Testing and measurement techniques – Radiated emissions and
immunity measurements in fully anechoic rooms (FARs)**

**Compatibilité électromagnétique (CEM) –
Partie 4-22: Techniques d'essai et de mesure – Mesures de l'immunité et des
émissions rayonnées dans des enceintes complètement anéchoïques (FAR)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX

XA

ICS 33.100.10; 33.100.20

ISBN 978-2-88912-229-5

CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope.....	8
2 Normative references	8
3 Terms and definitions	9
4 FAR applications	10
4.1 Measurand for radiated immunity testing	10
4.2 Measurand for radiated emission measurements	11
5 FAR validation/calibration procedure	11
5.1 General.....	11
5.2 Validation set-ups.....	11
5.3 Test facility description.....	15
5.3.1 General	15
5.3.2 Test volume.....	15
5.3.3 Broadband antenna	15
5.3.4 Antenna cables.....	15
5.3.5 Set-up table.....	15
5.3.6 Turntable.....	16
5.3.7 Automated antenna polarization changer.....	16
5.3.8 Absorber configuration	16
5.4 Definition of quantities to be determined by the FAR validation procedure.....	16
5.5 Required sampling positions for FAR validation.....	17
5.6 FAR validation procedure	18
5.6.1 General	18
5.6.2 Type 1 validation set-up	18
5.6.3 Type 2 validation set-up	19
5.6.4 Type 3 validation set-up	19
5.6.5 Type 4 validation set-up	20
5.6.6 Calculation of $\overline{C}_{dB}$ and $s_{dB,C}$ for all set-up types	20
5.7 Validation requirement	20
6 Test set-up	21
Annex A (normative) Radiated immunity tests	26
Annex B (normative) Radiated emission measurements.....	31
Annex C (informative) Background on the system transducer factor and simultaneous emissions/immunity validation method	34
Annex D (informative) Measurement uncertainties	37
Bibliography.....	50
Figure 1 – Type 1 validation block diagramme	12
Figure 2 – Type 2 validation block diagramme	12
Figure 3 – Type 3 validation block diagramme	13
Figure 4 – Type 4 validation block diagramme	13
Figure 5 – Locations of the sampling points for FAR validation	18
Figure 6 – Example test set-up for table-top equipment	23

Figure 7 – Example test set-up for table-top equipment, top view.....	24
Figure 8 – Example test set-up for floor-standing equipment.....	24
Figure 9 – Example test set-up for floor-standing equipment, top view	25
Figure A.1 – Definition of $d_{\text{measurement}}$ for immunity tests	28
Figure B.1 – Definition of $d_{\text{measurement}}$ for emission measurements.....	32
Figure D.1 – Example of influence factors for emission measurements	37
Figure D.2 – Example of influences upon the immunity test method	44
 Table 1 – Components required for the different validation set-up types	 15
Table 2 – Validation criteria	21
Table D.1 – Measurement instrumentation uncertainty in a FAR for radiated emission measurements in the frequency range 30 MHz to 1 000 MHz	38
Table D.2 – Measurement instrumentation uncertainty in a FAR for radiated emission measurements in the frequency range 1 GHz to 18 GHz	39
Table D.3 – Measurement instrumentation uncertainty in a FAR for level setting for immunity testing in the frequency range 30 MHz to 1 000 MHz	45
Table D.4 – Measurement instrumentation uncertainty in a FAR for level setting for immunity testing in the frequency range 1 GHz to 18 GHz	46

INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

ELECTROMAGNETIC COMPATIBILITY (EMC) –

**Part 4-22: Testing and measurement techniques –
Radiated emissions and immunity measurements
in fully anechoic rooms (FARs)**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61000-4-22 has been prepared by CISPR subcommittee A: Radio interference measurements and statistical methods, in cooperation with subcommittee 77B: High frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This standard has the status of a basic EMC publication in accordance with IEC Guide 107, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*.

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

Enquiry draft	Report on voting
CISPR/A/912/FDIS	CISPR/A/923/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.

A list of all parts of the IEC 61000 series can be found on the IEC website under the general title Electromagnetic compatibility (EMC), and of all parts of the CISPR 16 series under the general title Specification for radio disturbance and immunity measuring apparatus and methods.

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

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

INTRODUCTION

This standard is part of the IEC 61000 series of standards, according to the following structure:

Part 1: General

- General considerations (introduction, fundamental principles)
- Definitions, terminology

Part 2: Environment

- Description of the environment
- Classification of the environment
- Compatibility levels

Part 3: Limits

- Emission limits
- Immunity limits (in so far as they do not fall under the responsibility of the product committees)

Part 4: Testing and measurement techniques

- Measurement techniques
- Testing techniques

Part 5: Installation and mitigation guidelines

- Installation guidelines
- Mitigation methods and devices

Part 6: Test set-up

Part 9: Miscellaneous

Each part is further subdivided into several parts, published either as international standards, as technical specifications or technical reports, some of which have already been published as sections. Others will be published with the part number followed by a dash and a second number identifying the subdivision (example: IEC 61000-6-1).

This part is an international standard that establishes the required test procedures for using fully anechoic rooms for performing radiated immunity testing and radiated emission measurements.

The main text of this standard provides all information that is common to both radiated emission measurements and immunity tests in a FAR (fully anechoic room). This includes the description of a FAR, a common set-up for equipment under test (EUT), and a harmonized validation/calibration procedure. The test methods described in this standard are based on the harmonized validation/calibration which verifies a FAR as a measurement system, including the room, antenna and associated cables simultaneously. The validation procedure determines a combined transducer factor for a FAR measurement system that is later applied to both emission measurements and immunity tests. If different sets of antennas and/or cables are used for emission measurements and immunity tests the validation/calibration process is performed twice.

Annex A (normative) provides the measurement procedure and any special considerations for performing radiated immunity tests.

Annex B (normative) provides the measurement procedure and any special considerations for performing radiated emission measurements.

Annex C (informative) provides background on the system transducer factor and simultaneous emissions/immunity validation method.

Annex D (informative) provides guidance for calculation of the uncertainty of measurement results obtained using a FAR and instrumentation in accordance with ISO/IEC Guide 98-3 [4]¹⁾.

¹⁾ Numbers in square brackets refer to the Bibliography.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-22: Testing and measurement techniques – Radiated emissions and immunity measurements in fully anechoic rooms (FARs)

1 Scope

This part of IEC 61000 considers immunity tests and emission measurements for electric and/or electronic equipment. Only radiated phenomena are considered. It establishes the required test procedures for using fully anechoic rooms for performing radiated immunity testing and radiated emission measurements.

NOTE In accordance with IEC Guide 107 [1], IEC 61000-4-22 is a basic EMC publication for use by product committees of the IEC. As stated in Guide 107, product committees are responsible for determining the applicability of the EMC standards. TC 77 and CISPR and their sub-committees are prepared to cooperate with product committees in the determination of the value of particular EMC tests for specific products.

This part establishes a common validation procedure, equipment under test (EUT) set-up requirements, and measurement methods for fully anechoic rooms (FARs) when both radiated electromagnetic emission measurements and radiated electromagnetic immunity tests will be performed in the same FAR.

As a basic measurement standard, this part of IEC 61000 does not intend to specify the test levels or emission limits to be applied to particular apparatus or system(s). Its main goal is to provide general measurement procedures to all concerned product committees of IEC or CISPR. Specific product requirements and test conditions are defined by the responsible product committees.

The methods described in this standard are appropriate for radiated emission measurements and immunity tests in the frequency range of 30 MHz to 18 GHz.

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 16-1-1:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-4:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Radiated disturbances*

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

IEC 60050-394:2007, *International Electrotechnical Vocabulary (IEV) – Part 394: Nuclear instrumentation – Instruments, systems, equipment and detectors*

3 Terms and definitions

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

3.1

ancillary equipment

transducers (e.g. current and voltage probes and artificial networks) connected to a measuring receiver or (test) signal generator and used in the disturbance signal transfer between the EUT and the measuring or test equipment

3.2

associated equipment

AE

apparatus that is not part of the system under test, but needed to help exercise the EUT

3.3

average system transducer factor

$\overline{C}_{dB}$

factor that converts a voltage at the system source/receive termination point to field strength induced or received; this parameter is calculated from the FAR validation data separately for horizontal and vertical polarization

NOTE Average system transducer factor is expressed in dB(1/m).

3.4

calibration

set of operations that establish, under specified conditions, the relationship between values of quantities indicated by a measuring instrument or measuring system, or values represented by a material measure or a reference material, and the corresponding values realized by standards

[IEC 60050-394, 394-40-43]

3.5

forward power

$P_{f,x}$

power to a FAR test system, recorded during the measurement of the field at a single position, x , in the test volume

NOTE Forward power is expressed in watts (W).

3.6

fully anechoic room

FAR

shielded enclosure, the entire internal surface of which is lined with radio-frequency absorbing material (RF-absorber), which absorbs electromagnetic energy in the frequency range of interest

3.7

fully anechoic room test system

FAR test system

test system comprised of a FAR and a means to generate and/or measure electromagnetic fields

NOTE Most typically this is comprised of a FAR, an antenna and other ancillary equipment and cabling.

3.8 measurement distance

$d_{\text{measurement}}$
distance used for EUT measurement/testing and measured from the reference point of the transmit/receive antenna to the periphery of the EUT at its closest point on the measurement axis

NOTE Measurement distance is expressed in metres (m) and is illustrated in Figures A.1 and B.1.

3.9 normalized forward power

$P_{\text{fn},x}$
forward power required to generate an electric field strength of 1 V/m at a position, x , in the test volume

NOTE Normalized forward power is expressed in watts (W).

3.10 polarization

orientation of the electric field vector of a linearly polarized radiated field

3.11 reference distance

$d_{\text{reference}}$
distance at which a limit is specified

3.12 test volume

maximum volume in a FAR in which the EUT and its cabling may be positioned

NOTE See Clause 6 for additional details.

3.13 validation

process of confirming that a finalized instrumentation and control system (hardware and software) complies with all of its functional, performance and interface requirements

[IEC 60050-394, 394-40-42]

3.14 validation distance

$d_{\text{validation}}$
distance used for validation/calibration measurements and measured from the reference point of the transmit/receive antenna to the test volume at its closest point on the measurement axis

4 FAR applications

4.1 Measurand for radiated immunity testing

Most electronic equipment is, in some manner, affected by electromagnetic radiation. This radiation is frequently generated by such general-purpose sources as the small handheld radio transceivers that are used by operating, maintenance and security personnel, fixed-station radio and television transmitters, vehicle radio transmitters, and various industrial electromagnetic sources.

In the frequency range covered by this standard, far-field conditions cannot be established in all cases (e.g. at the lower frequencies), and therefore the disturbance quantity simulating the real electromagnetic phenomenon is defined by the quantity “electrical field strength” in this standard.

The measurand to establish the desired disturbance quantity for immunity tests is the electric field strength (carrier) established by using the average system transducer factor $\bar{C}_{dB}$ at $d_{\text{measurement}}$. The measurand is obtained separately for the horizontal and vertical polarizations.

4.2 Measurand for radiated emission measurements

The measurand in a FAR for radiated emission measurements is the field strength radiated by the EUT and obtained at the measurement distance $d_{\text{measurement}}$ by the use of a linearly-polarized antenna and applying the average system transducer factor, $\bar{C}_{dB}$, to the maximum voltage measured at the receive termination point. The measurand is obtained separately for the horizontal and vertical polarizations of the receiving antenna, and expressed as a result at the reference distance, $d_{\text{reference}}$, specified in product standards.

5 FAR validation/calibration procedure

5.1 General

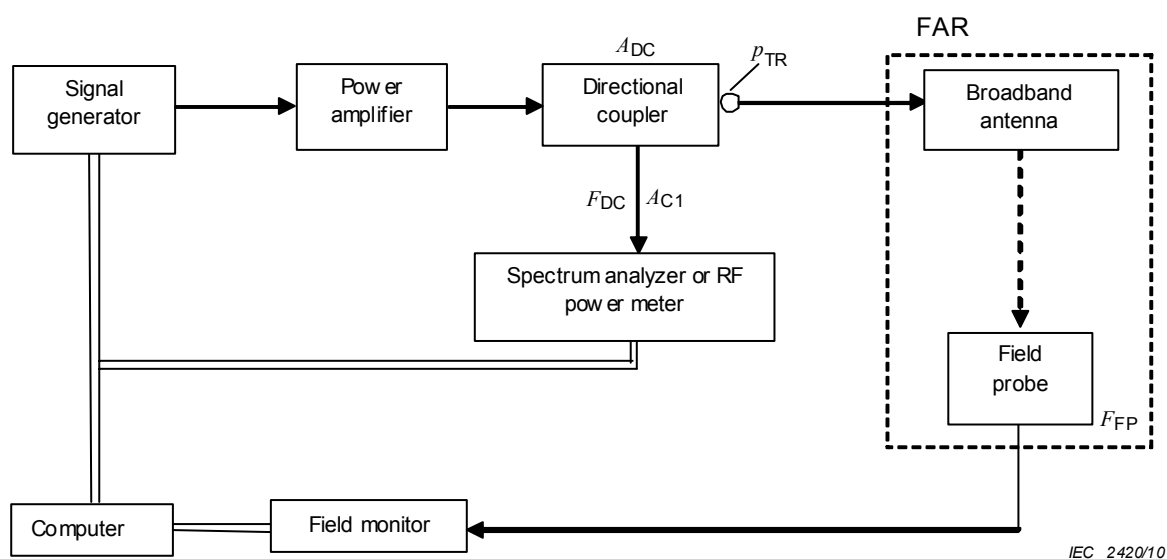
This clause provides the performance requirements and harmonized FAR validation procedure for both radiated emission measurements and radiated immunity tests.

5.2 Validation set-ups

Figures 1 to 4 show block diagrams of set-ups that can be used alternatively for the validation procedure. All set-up variants have a transducer reference point (p_{TR}) for which the average system transducer factor (see 5.4) is determined by the validation process.

The primary instrumentation required for each of these set-ups is summarized in the following bulleted list, and described further in the subsequent lettered list.

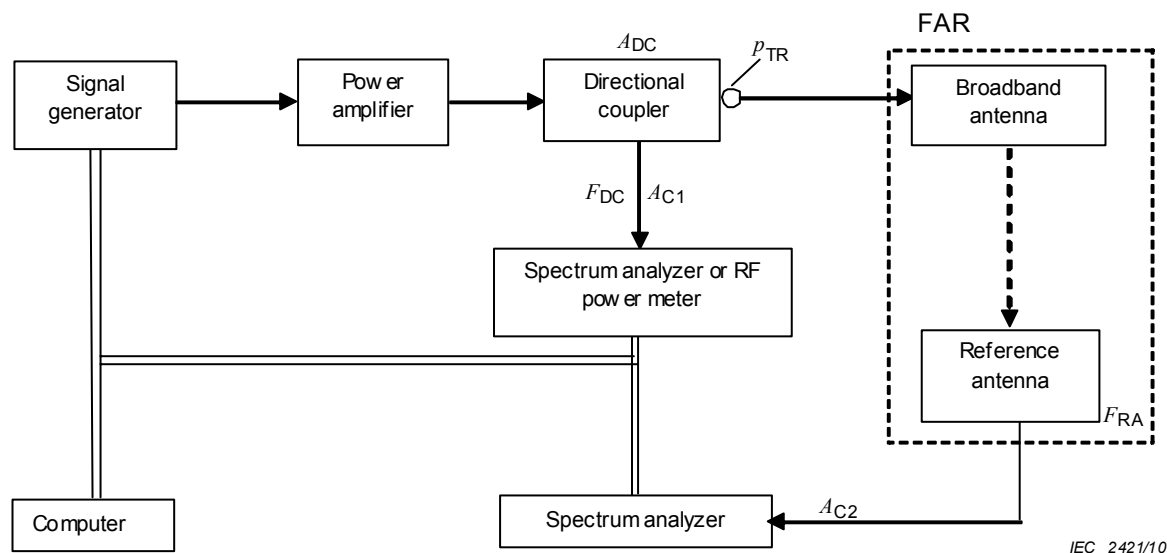
- Type 1 (Figure 1): signal generator, spectrum analyzer or power meter, field probe
- Type 2 (Figure 2): signal generator, spectrum analyzer or power meter, reference antenna
- Type 3 (Figure 3): network analyzer, reference antenna
- Type 4 (Figure 4): network analyzer, power amplifier, reference antenna



Key:

- A_{C1} Attenuation of the cable between the directional coupler and the spectrum analyzer or power meter (dB)
- F_{FP} Calibration factor of the field probe (in linear scale)
- A_{DC} Attenuation of the directional coupler between power input and power output (dB)
- F_{DC} Coupling loss of the directional coupler between power input and forward power output (dB)
- p_{TR} Transducer reference point

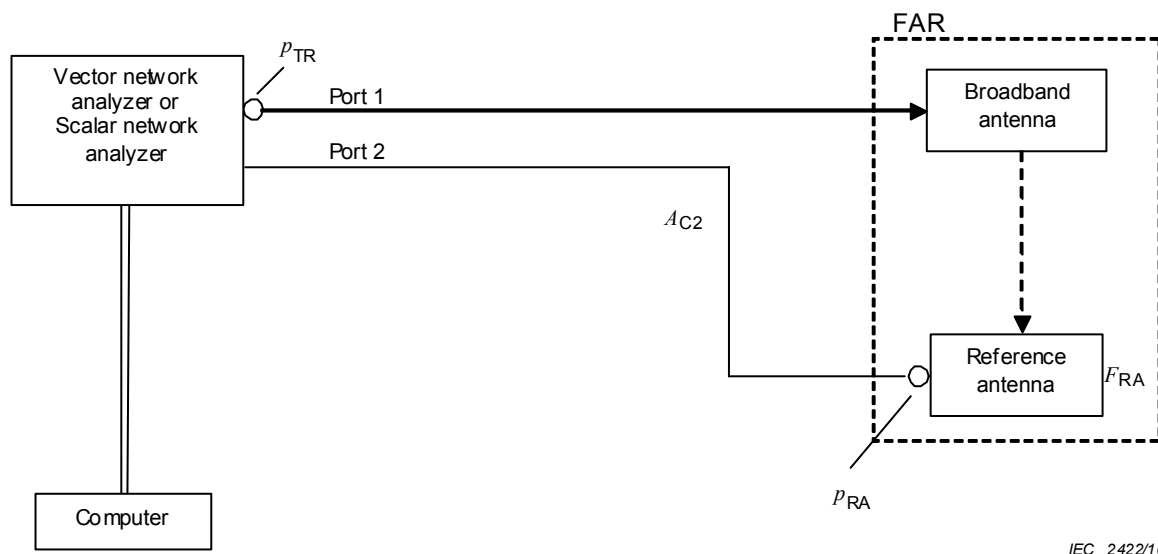
Figure 1 – Type 1 validation block diagramme



Key:

- A_{C1} Attenuation of the cable between the directional coupler and the spectrum analyzer or power meter (dB)
- A_{C2} Attenuation of the cable between the reference antenna and the spectrum analyzer (dB)
- F_{RA} Antenna factor of the reference antenna [dB(1/m)]
- A_{DC} Attenuation of the directional coupler between power input and power output (dB)
- F_{DC} Coupling loss of the directional coupler between power input and forward power output (dB)
- p_{TR} Transducer reference point

Figure 2 – Type 2 validation block diagramme



Key:

F_{RA} Antenna factor of the reference antenna [dB(1/m)]

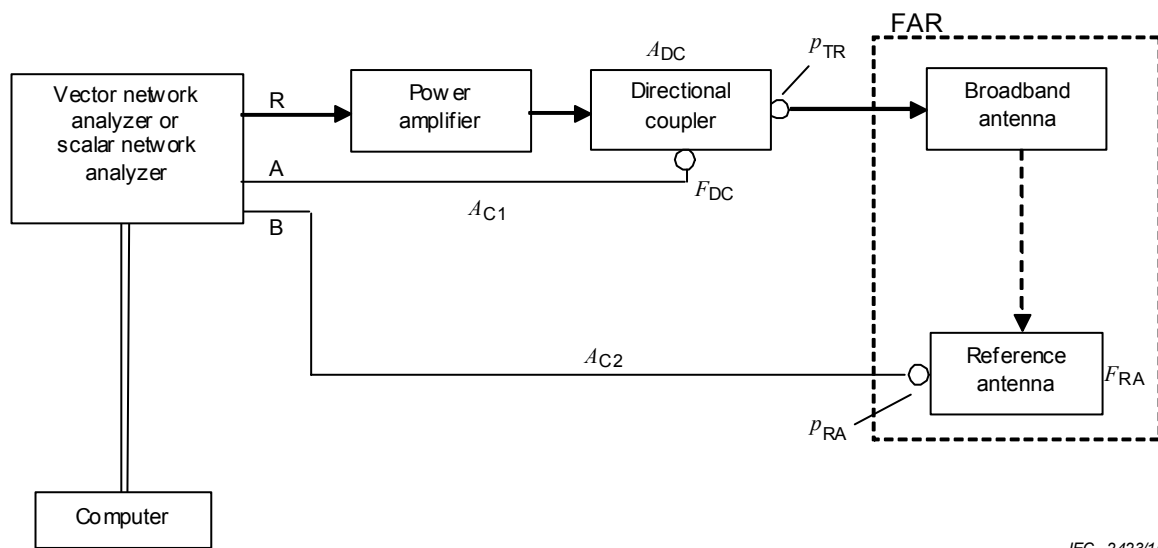
A_{C2} Attenuation of the cable between the reference antenna and the spectrum analyzer (dB)

p_{RA} Reference point of the reference antenna

p_{TR} Transducer reference point

NOTE Alternatively, the attenuation of the cable between the reference antenna and the network analyzer may be determined by normalization of the network analyzer (p_{TR} and p_{RA} are connected for normalization).

Figure 3 – Type 3 validation block diagramme



Key:

A_{C1} Attenuation of the cable between the directional coupler and the spectrum analyzer or power meter (dB)

A_{C2} Attenuation of the cable between the reference antenna and the spectrum analyzer (dB)

F_{RA} Antenna factor of the reference antenna [dB(1/m)]

A_{DC} Attenuation of the directional coupler between power input and power output (dB)

F_{DC} Coupling loss of the directional coupler between power input and forward power output (dB)

p_{TR} Transducer reference point

p_{RA} Reference point of the reference antenna

R,A,B Network analyzer ports – output port R, input ports A and B

Figure 4 – Type 4 validation block diagramme

The following components are part of a FAR validation set-up. A summary list of the components required for the different set-up types is given in Table 1.

a) Fully anechoic room (FAR)

The test volume and the validation distance shall be previously specified according to Figure 5 (see 5.5) and definitions 3.12, 3.14.

b) Broadband antenna

The position of the broadband antenna is fixed in the room.

NOTE 1 The antenna factor normally provided with the antenna is not required because it is determined as part of the FAR test system transducer factor during this validation/calibration.

c) RF power meter, frequency selective voltmeter, or spectrum analyzer

d) Directional coupler

e) Isotropic field probe and monitor

f) Reference antenna

The reference antenna shall conform to the specifications in 5.4.2.3 of CISPR 16-1-4 for the frequency range 30 MHz to 1 GHz and 8.3.3.1 of CISPR 16-1-4 for the frequency range 1 GHz to 18 GHz.

g) Cable to broadband antenna

Routing to the broadband antenna shall be fixed in the installation.

NOTE 2 The loss of the cable to the broadband antenna is determined as part of the FAR system transducer factor during this validation/calibration.

NOTE 3 The cable to the broadband antenna is typically recommended to be installed horizontally from the antenna to the absorbers lined on the back wall, then installed vertically against the absorbers to the floor. This is to minimize the influence of the cable.

h) Other RF cables

The characteristics of other RF cables shall be determined in previous calibration. Any differences between the cables utilized for this calibration and subsequent testing may be separately characterized.

i) Signal source

RF generator, able to produce a stable signal.

j) Power amplifier

The output power shall be monitored during this validation/calibration and during immunity tests (see 5.2 c) and d)). Refer to Annex A for consideration of harmonics and compression characteristics.

k) Scalar or vector network analyzer

Instrument for the measurement of the transfer function between two points (S_{21}) or the ratio of two signals (without bridge).

Table 1 – Components required for the different validation set-up types

Component ¹⁾	Validation set-up ²⁾			
	Type 1	Type 2	Type 3	Type 4
a) Fully anechoic room (FAR)	x	x	x	x
b) Broadband antenna	x	x	x	x
c) RF power meter	x	x	–	–
d) Directional coupler	x	x	–	x
e) Isotropic field probe and monitor	x	–	–	–
f) Reference antenna	–	x	x	x
g) Cable to broadband antenna	x	x	x	x
h) Other RF cables	x	x	x	x
i) Signal source	x	x	–	–
j) Power amplifier	x	x	–	x
k) Scalar or network analyzer	–	–	x	x
¹⁾ Letters preceding a component correspond with items detailed in 5.2.				
²⁾ “x” indicates component is required; “–” indicates component is not required.				

5.3 Test facility description

5.3.1 General

For the purposes of FAR validation, the parameters of 5.3.2 through 5.3.8 shall be specified and clearly documented using text descriptions and photographs in the validation report.

5.3.2 Test volume

The test volume is a cylinder that shall encompass the EUT maximum dimensions including its associated cables, as described in Clause 6. The following parameters of the specified test volume shall be clearly defined: diameter of volume, location of the centre of the volume bottom surface, and height.

5.3.3 Broadband antenna

The broadband antenna shall be located at a fixed position outside the test volume within a FAR. The antenna height is typically set to the height of the centre of the test volume. The broadband antenna is used as the receiving antenna for emission measurements and as the transmitting antenna for the validation/calibration tests and subsequent immunity tests. The validation/calibration process shall be performed for each set of antennas (e.g. to cover various frequency ranges) used for either immunity testing or emission measurements.

5.3.4 Antenna cables

Reflections from antenna cables can affect results obtained in FAR testing, so consideration should be given to their design and placement. The lengths of antenna cables located within a FAR and leading to the broadband antenna shall be laid out in the same manner during validation of a FAR as they are during product tests in a FAR. Any ferrites placed on the antenna cable shall be present for both validation testing and subsequent EUT testing.

5.3.5 Set-up table

Set-up tables made from nonconductive and low permittivity materials are recommended. A set-up table that is designed for installation in the test volume and is removable does not need to be in-place during the facility validation described in 5.6. A set-up table that is located

outside of the test volume and always used for EUT tests shall be considered as part of a FAR facility and shall be installed during the validation procedure of 5.6.

5.3.6 Turntable

The recommended minimum facility contains a remotely controlled turntable in the test volume. Validation/calibration of the facility shall be performed with the turntable, power feed and communication cabling in their typical locations, and as used for EUT testing.

5.3.7 Automated antenna polarization changer

A computer-controlled, automated antenna polarization changer is recommended, to reduce test time.

5.3.8 Absorber configuration

The absorber configuration used for the validation test must be the same as will be used for subsequent EUT testing.

5.4 Definition of quantities to be determined by the FAR validation procedure

The quantities to be determined for each sampling position from the FAR validation procedure are as described in this subclause. The system transducer factor, $C_{dB,x}$, in dB(1/m), for a single position denoted by x , is given by:

$$C_{dB,x} = 20\log(f_{MHz}) - 15 - 10\log\left(\frac{d_x^2}{P_{fn,x}}\right) \quad (1)$$

where

f_{MHz} is the frequency in MHz;

d_x is the distance between the reference point of the broadband antenna and the reference point of the field probe or reference antenna, in m (see 5.5 for additional details);

$P_{fn,x}$ is the normalized forward power in W, given by:

$$P_{fn,x} = \frac{P_{f,x}}{E_x^2} \quad (2)$$

where

$P_{f,x}$ is the forward power at the transducer reference point p_{TR} in W;

E_x is the corresponding electric field strength at location x in V/m.

NOTE Annex C gives background and rationale about the relationships shown in Equations (1) and (2).

From the individual system transducer factors, $C_{dB,x}$, the average system transducer factor, $\bar{C}_{dB}$, (as defined in 3.3) can be derived using Equation (3):

$$\bar{C}_{dB} = \sum_{x=1}^n \frac{C_{dB,x}}{n} \quad (3)$$

where n is the number of sampling points, as determined according to the procedure of 5.5.

The standard deviation of the collected samples is calculated using Equation (4), and for each antenna polarization separately. This quantity is used for comparison to the validation criteria of 5.7.

$$s_{dB,C} = \sqrt{\frac{1}{n-1} \times \sum_{x=1}^n (C_{dB,x} - \bar{C}_{dB})^2} \quad (4)$$

The standard deviation of the average system transducer factor, $s_{dB,\bar{C}}$, is calculated using Equation (5), for each antenna polarization. This quantity is important for the estimation of uncertainty for subsequent EUT testing [i.e. see item 8 of D.1.3 and item 9 of D.2.4)].

$$s_{dB,\bar{C}} = \frac{s_{dB,C}}{\sqrt{n}} \quad (5)$$

5.5 Required sampling positions for FAR validation

For the procedure described in this subclause, the characteristics of a FAR are to be measured at multiple positions in a test volume, and the results expressed as an average system transducer factor and a standard deviation (see 5.4), separately for each antenna polarization (horizontal and vertical).

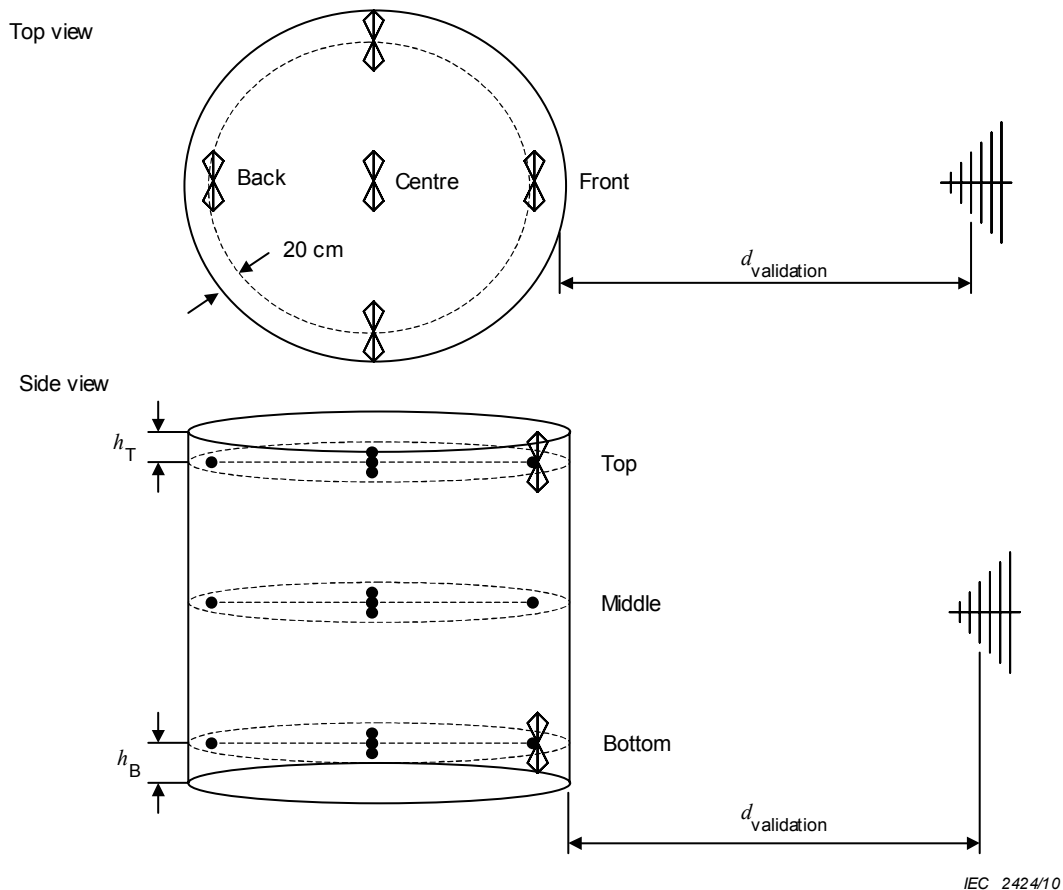
The FAR measurements and validation shall be performed for both horizontal and vertical antenna polarizations at the following positions (see Figure 5):

- a) At three heights of the test volume – bottom, middle and top:
 - 1) bottom height h_B , located at 25 % of the height of the test volume from the bottom. This height shall be a minimum of 20 cm when the test volume height is less than 80 cm, and shall be taken as 50 cm when the test volume height is more than 2 m;
 - 2) top height h_T , located at 25 % of the height of the test volume from the top; this height shall be a minimum of 20 cm when the test volume height is less than 80 cm, and shall be taken as 50 cm when the test volume height is more than 2 m;
 - 3) middle height, located at 50 % of the height of the test volume.
- b) At five positions in all three horizontal planes – centre, left, right, front, and rear positions, in each horizontal plane.

The position in height of the broadband antenna outside of the test volume shall be set and remain fixed at the centre height of the test volume, as shown in Figure 5. The broadband antenna shall not be tilted, i.e. the boresight axis of the broadband antenna shall remain aligned along the primary measurement axis for all measurements. The field probe or reference antenna located in the test volume shall be oriented or tilted to face the broadband antenna. The position of the broadband antenna (including height) shall be the same as will be used later for equipment testing.

The distance between the reference point of the broadband antenna and the front position of the test volume is $d_{\text{validation}}$. Any antenna masts and supporting floors or structures shall be in place during the validation procedure. Note that only the field probe or reference antenna is moved throughout the test volume with this procedure—the broadband antenna is not moved during the validation, therefore the actual separation distance between the broadband antenna and each sampling position, d_x , will vary depending on the sampling position. Note that the actual separation distance shall be recorded for each sampling position, and then used for d_x in Equation (1).

The sampling positions shall be located such that the phase centre of the reference antenna or field probe shall always be a minimum of 20 cm inside the test volume.



NOTE Parameters are described in 5.5. The cylinder formed by the solid lines represents the test volume.

Figure 5 – Locations of the sampling points for FAR validation

5.6 FAR validation procedure

5.6.1 General

Set up the measurement equipment as indicated in Figure 1, Figure 2, Figure 3 or Figure 4. Place the probe or reference antenna at one of the positions illustrated in Figure 5, and set the polarization of the broadband antenna to horizontal.

The specific steps used for each of the four set-up types of 5.2 are detailed in 5.6.2 to 5.6.5. Calculations of the average system transducer factor and standard deviation are covered in 5.6.6.

5.6.2 Type 1 validation set-up

The following steps shall be applied when using a Type 1 validation set-up.

- Set the field probe to a single-axis mode, in order to measure the appropriate polarization.
- Set the signal generator to the first frequency of interest.
- Set the signal generator or amplifier output power to a fixed CW level that will provide a suitable validation field strength E_x . The measurement results are independent of the absolute field strength and/or power level.

NOTE 1 The signal generator and/or amplifier shall be operated at a power level below its maximum output level, to limit the possible influence of harmonics on the measurement results.

d) Record the following parameters:

- power indicated at the power meter measurement point, $P_{f,ind,x}$, in dBm;
- indicated field strength from the isotropic field probe, $E_{ind,x}$, in V/m;
- distance, d_x , between the broadband antenna and the field probe.

e) Step the frequency in increments not to exceed 1 %, and repeat steps c) and d) until the last frequency is reached.

f) Compute the system transducer factor for position x and for each frequency using:

$$C_{dB,x} = 20\log(f_{MHz}) - 15 - 20\log(d_x) + P_{f,ind,x} - 30 + A_{C1} + F_{DC} - A_{DC} - 20\log(F_{FP} \times E_{ind,x}) \quad (6)$$

NOTE 2 The parameters are defined in Figure 1.

g) Repeat steps a) through f) for each sampling position.

h) Repeat steps a) through g) for vertical polarization.

5.6.3 Type 2 validation set-up

The following steps shall be applied when using a Type 2 validation set-up.

a) Set the signal generator to the first frequency of interest.

Set the signal generator or amplifier output power to a fixed CW level that will provide a suitable validation field strength E_x . The measurement results are independent of the absolute field strength and/or power level.

NOTE 1 The signal generator and/or amplifier shall be operated at a power level below its maximum output level, to limit the possible influence of harmonics on the measurement results.

b) Record the following parameters:

- power shown by the power meter, $P_{f,ind,x}$, in dBm;
- indicated voltage from the spectrum analyzer, $V_{ind,x}$, in dB(μV);
- distance, d_x , between the broadband antenna and the reference antenna.

c) Step the frequency in increments not to exceed 1 %, and repeat steps a) and b) until the last frequency is reached.

d) Compute the system transducer factor for position x and for each frequency using:

$$C_{dB,x} = 20\log(f_{MHz}) - 15 - 20\log(d_x) + P_{f,ind,x} - 30 + A_{C1} + F_{DC} - A_{DC} - E_{ind,x} \quad (7)$$

where

$$E_{ind,x} = V_{ind,x} + A_{C2} + F_{RA} - 120 \quad (8)$$

NOTE 2 The parameters are defined in Figure 2.

e) Repeat steps a) through d) for each sampling position.

f) Repeat steps a) through e) for vertical polarization.

5.6.4 Type 3 validation set-up

The following steps shall be applied when using a Type 3 validation set-up.

a) Prior to the measurement, do a normalization of the network analyzer.

b) Set the start and stop frequency of the network analyzer. The frequency stepping shall be:

- For 30 MHz to 80 MHz: $f_{step} \leq 1 \text{ MHz}$.
- For 80 MHz to 500 MHz: $f_{step} \leq 2 \text{ MHz}$.

- For 500 MHz to 1 GHz: $f_{\text{step}} \leq 5 \text{ MHz}$.
 - For 1 GHz to 18 GHz: $f_{\text{step}} \leq 50 \text{ MHz}$.
- c) Measure and record $S_{21,x}$, in dB.
- d) Compute the system transducer factor for position x and for each frequency:

$$C_{\text{dB},x} = 20\log(f_{\text{MHz}}) - 32 - 20\log(d_x) - S_{21,x} - A_{\text{C2}} - F_{\text{RA}} \quad (9)$$

NOTE The parameters are defined in Figure 3.

- e) Repeat steps a) through d) for each sampling position.
- f) Repeat steps a) through e) for vertical polarization.

5.6.5 Type 4 validation set-up

The following steps shall be applied when using a Type 4 validation set-up.

- a) Prior to the measurement, perform a normalization of the network analyzer.
- b) Set the start and stop frequency of the network analyzer. The frequency stepping shall be:
- For 30 MHz to 80 MHz: $f_{\text{step}} \leq 1 \text{ MHz}$.
 - For 80 MHz to 500 MHz: $f_{\text{step}} \leq 2 \text{ MHz}$.
 - For 500 MHz to 1 GHz: $f_{\text{step}} \leq 5 \text{ MHz}$.
 - For 1 GHz to 18 GHz: $f_{\text{step}} \leq 50 \text{ MHz}$.
- c) Select an output power of the network analyzer that will provide a suitable validation field strength E_x . The measurement results are independent of the absolute field strength and/or power level.
- d) Measure and record the signal ratio B/A ($R_{\text{BA},x}$, in dB).
- e) Compute the system transducer factor for position x and for each frequency:

$$C_{\text{dB},x} = 20\log(f_{\text{MHz}}) - 32 - 20\log(d_x) - R_{\text{BA},x} + A_{\text{C1}} + F_{\text{DC}} - A_{\text{DC}} - A_{\text{C2}} - F_{\text{RA}} \quad (10)$$

NOTE The parameters are defined in Figure 4.

- f) Repeat steps a) through e) for each location.
- g) Repeat steps a) through f) for vertical polarization.

5.6.6 Calculation of $\overline{C}_{\text{dB}}$ and $s_{\text{dB},C}$ for all set-up types

For each polarization and frequency, calculate the average system transducer factor using Equation (3), and the standard deviation of the collected samples using Equation (4).

5.7 Validation requirement

The FAR validation requirement is based on the standard deviation of the sampled system transducer factors. The standard deviation $s_{\text{dB},C}$ for each polarization shall satisfy the criteria listed in Table 2.

Table 2 – Validation criteria

Frequency range	Validation criteria
30 MHz to 1 GHz	$s_{dB,C} \leq 1,8$ dB for all 15 sampling points
1 GHz to 18 GHz	$s_{dB,C} \leq 1,8$ dB for all 15 sampling points OR both of the following criteria shall be met: $s_{dB,C} \leq 3$ dB for all 15 sampling points and $s_{dB,C} \leq 1,8$ dB for the 10 points in the top and middle planes of the test volume

The validation is applicable as long as the test set-up used remains unchanged for subsequent EUT testing. Therefore the validation set-up (antenna, absorber set-up, cables, etc.) shall be fully documented.

6 Test set-up

Tests shall be performed with the EUT configured as closely as possible to its typical, practical end-use operating conditions. Unless stated otherwise, cables and wiring shall be as specified by the manufacturer, and the equipment shall be within its housing (or cabinet) with all covers and access panels in place. Any deviation from normal EUT operating conditions shall be fully described in the test report. When possible, the EUT set-up per manufacturer's specifications shall take precedence. The set-up is to be documented in the test report.

The set-up table height for table-top equipment or floor-standing equipment is not limited, provided that the equipment under test is entirely located within the test volume and the cable layout satisfies the following requirements.

- a) Interface cables, loads, and devices should be connected to at least one of each type of the interface ports of the EUT and, where practical, each cable shall be terminated in a device typical for its actual use. Where there are multiple interface ports of the same type, a typical number of these ports shall be connected to devices or loads. It is sufficient to connect only one of the loads, provided that it can be shown, for example by preliminary testing, that the connection of further ports would not significantly increase the level of disturbance (that is, more than 2 dB) or significantly degrade the immunity level. The rationale for the configuration and loading of ports shall be documented in the test report.

The number of additional cables should be limited to the condition where the addition of another cable does not decrease the margin by 2 dB with respect to the limit.

NOTE In some cases the optimum arrangement of features, loads, interface types, and cables for emissions and immunity tests are different, which may result in the need for some reconfiguration of the EUT within the confines of the uniform EUT arrangement.

The cable layout and termination shall be according to the following requirements:

- 1) When a specific cable arrangement is required by the manufacturer installation instructions, the cables shall be routed in accordance with the installation requirements. When not specified, or in cases when the cables may be routed generally, the cables shall be oriented so that vertically and horizontally polarized radiation are not excluded.
- 2) A minimum cable length of 1,0 m shall be routed in the test volume (unless the manufacturer's specifications require shorter cables). Excess cable lengths shall be bundled in the approximate centre of the length of the cable to form a bundle 30 cm to

40 cm in length. If no information is provided by the manufacturer about typical cable layout for normal use, the following arrangement shall be applied:

- i) For a table-top EUT (Figures 6 and 7), the cables leaving the test volume (that is, those that connect the EUT to the “outside world”) shall be exposed to the electromagnetic field for a total length of at least 1 m.
 - ii) For a floor-standing EUT (Figures 8 and 9), cables leaving the test volume shall be arranged with a length of at least 0,3 m run horizontally within the test volume, and with a vertical run according to typical, normal use (depending on the height of the I/O port above the bottom of the test volume).
- b) Cables not connected to another device may be terminated as follows:
- 1) Coaxial shielded cables shall be terminated with a coaxial termination (usually 50 Ω or 75 Ω).
 - 2) Shielded cables with more than one inner conductor should have common and differential mode terminations according to the EUT manufacturer's specifications. The common mode termination shall be connected appropriately between the inner conductors, or their differential mode termination, and the cable shield.
 - 3) Unshielded cables shall have differential mode termination according to the manufacturer's specifications.
- c) The following additional items shall be considered for the EUT set-up:
- 1) If the EUT needs associated equipment (AE, see definition 3.2) to operate properly, special care shall be taken to ensure that AE does not affect either radiated emission measurements nor radiated immunity tests. AE may be located outside the FAR during testing, if proper connecting interfaces are available on the room shielding. Measures to prevent RF-signal leakage into or out of the FAR through interconnection cable(s) may be necessary.
- NOTE 2 A device that simulates a telecommunications network is an example of AE. AE may be physically located outside the test environment.
- 2) Other methods or equipment used to suppress unwanted emissions from AE shall be located outside the test room.
 - 3) The test set-up, including cable layout, specifications of attached cables and terminations, and other measures taken to suppress emissions from ancillary equipment outside the test volume, shall be clearly described in the test report.
 - 4) The EUT perimeter is drawn between the components of the EUT that are located in the test volume, i.e. where the validation requirement is satisfied. The EUT perimeter shall include the connecting cables between EUT components, but cables that leave the test volume shall not be considered as part of the EUT perimeter. Cables that leave the test volume must fulfil the layout requirements described in this subclause.

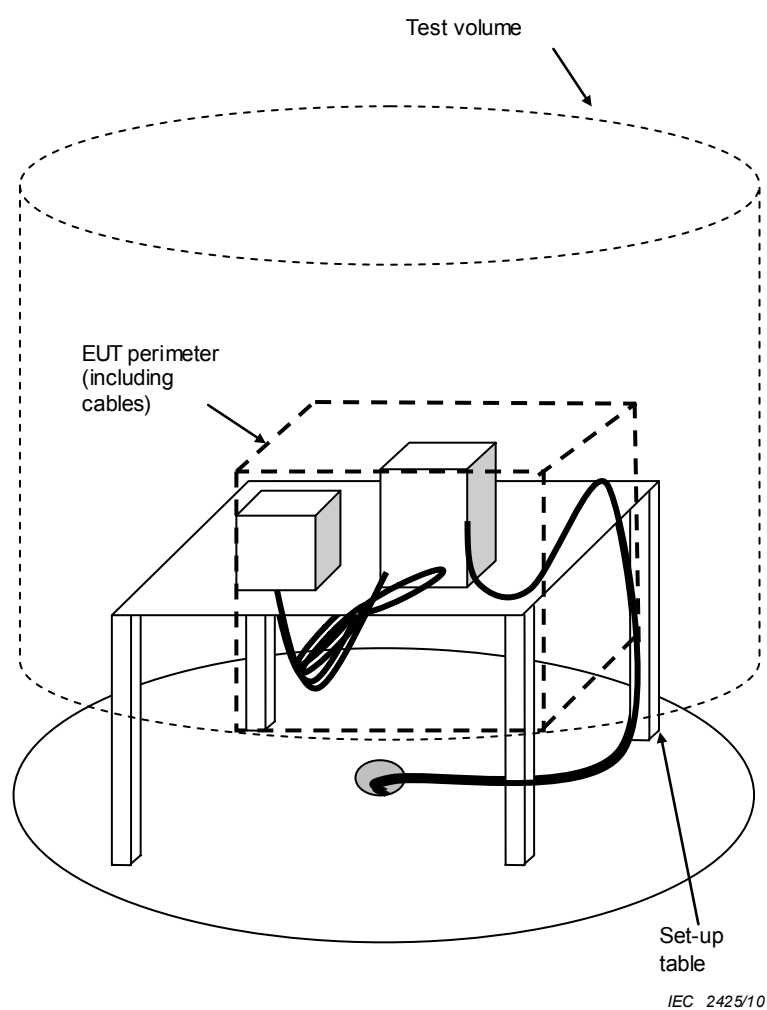


Figure 6 – Example test set-up for table-top equipment

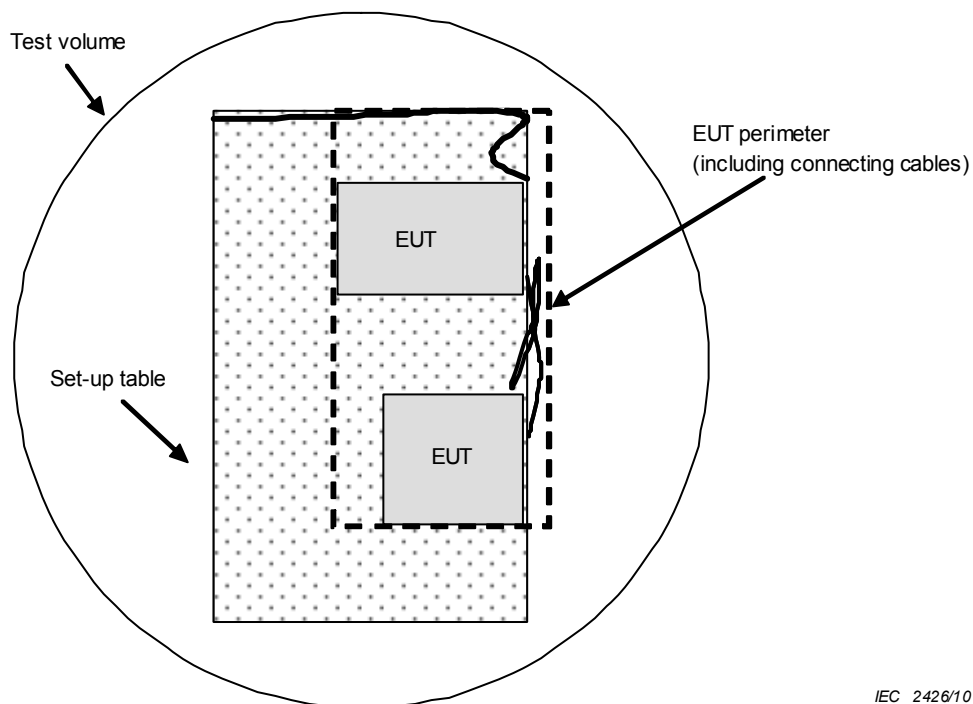


Figure 7 – Example test set-up for table-top equipment, top view

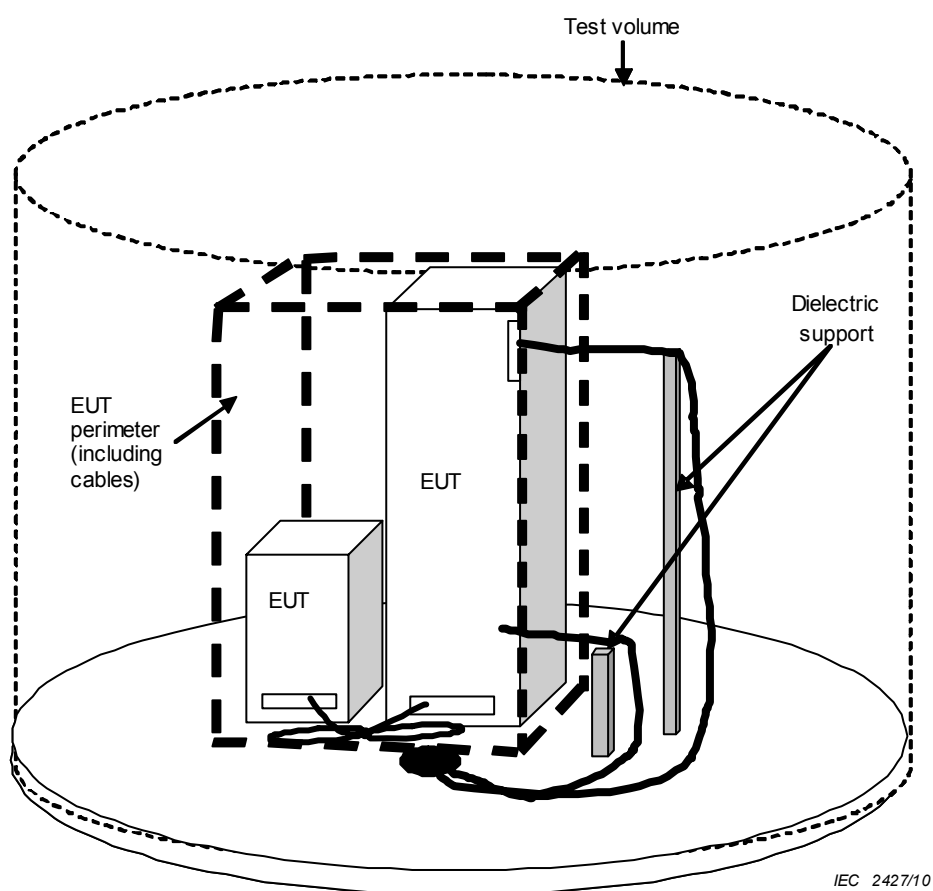


Figure 8 – Example test set-up for floor-standing equipment

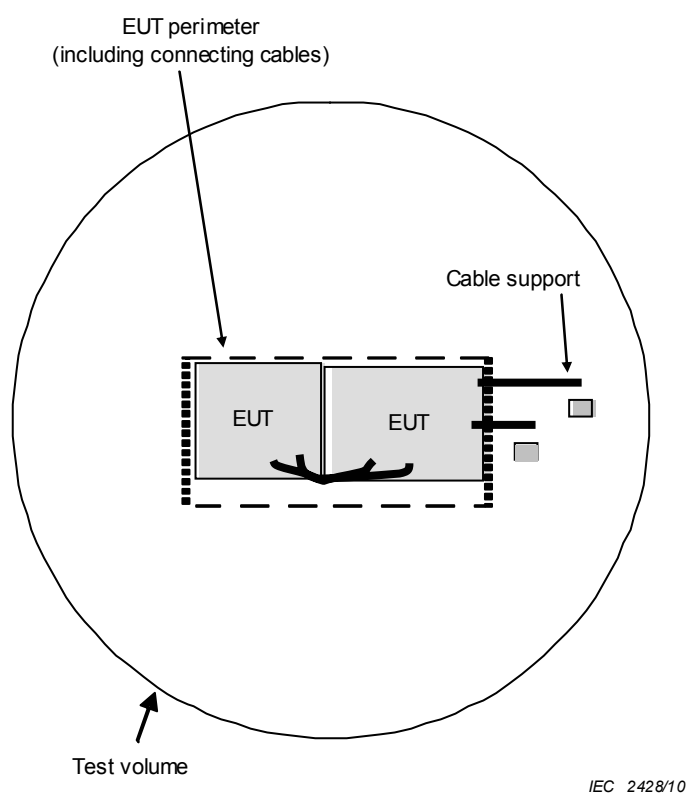


Figure 9 – Example test set-up for floor-standing equipment, top view

Annex A (normative)

Radiated immunity tests

A.1 General

This annex describes the procedures for performing radiated immunity tests in a FAR.

A.2 Test equipment

The equipment used for immunity tests is shown in Figures 1 and 2 (see 5.2). The field probe or reference antenna is not needed for immunity tests. Other specific parameters are given in the following list.

- *RF signal generator(s)*: capable of covering the frequency band of interest, and of being amplitude modulated by a 1 kHz sine wave with a modulation depth of 80 %, or the modulation specified by the product standard.
- *Power amplifiers*: to amplify signal (unmodulated and modulated) and provide antenna drive to the necessary field level. The harmonics generated by the power amplifier shall be such that any measured field strength produced in a FAR at each harmonic frequency shall be at least 6 dB below that of the fundamental frequency.
- *EMC filters*: may be placed between power amplifier and directional coupler to avoid problems caused by harmonics. Care shall be taken to ensure that the filters introduce no additional resonance effects on the connected lines.
- *Directional coupler*: needed to measure the forward power to the antenna and reverse power from the antenna. Normally only the forward power is used for validation/calibration as well as for immunity tests. Nevertheless, it is meaningful to measure also the reverse power in order to detect missing or bad connections to the antenna.
- *Forward and reverse power meter or spectrum analyzer*: used in connection with the directional coupler to measure forward and reverse power.
- *Broadband antenna(s)*: biconical, log periodic, horn or any other linearly polarized antenna system capable of satisfying frequency requirements.

To monitor the EUT during the test, additional equipment shall be used as necessary. Suitable equipment for monitoring includes:

- Video system;
- Microphone system;
- Probe for voltages and/or currents;
- Probe for digital signals (e.g. RS232, RS485, CAN, Ethernet).

Care shall be taken that the monitoring equipment will not be influenced by the electromagnetic field produced in a FAR, and that it does not influence the behaviour of the EUT. Optical fibre or cables with sufficient common-mode RF decoupling are highly recommended for the signal transmission. Monitoring equipment should be placed outside of a FAR, if at all possible.

A.3 Quick saturation check procedure

This quick check sequence shall be performed to determine that the amplifier saturation is sufficiently low. This procedure shall be performed at least once during the validation procedure.

NOTE This check needs to be performed only for the highest test level.

- a) Prepare the immunity test set-up as shown in Figure 1 or Figure 2 (see 5.2) starting with horizontal polarization of the broadband antenna.
- b) Set the signal generator to the first test frequency.
- c) Calculate the necessary forward power $P_{f,t,dBm}$ (at the transmit reference point) from the average system transducer factor:

$$P_{f,t,dBm} = 45 + 20\log(E_t) + 20\log(d_{\text{measurement}}) - 20\log(f_{\text{MHz}}) + \bar{C}_{dB} \quad (\text{A.1})$$

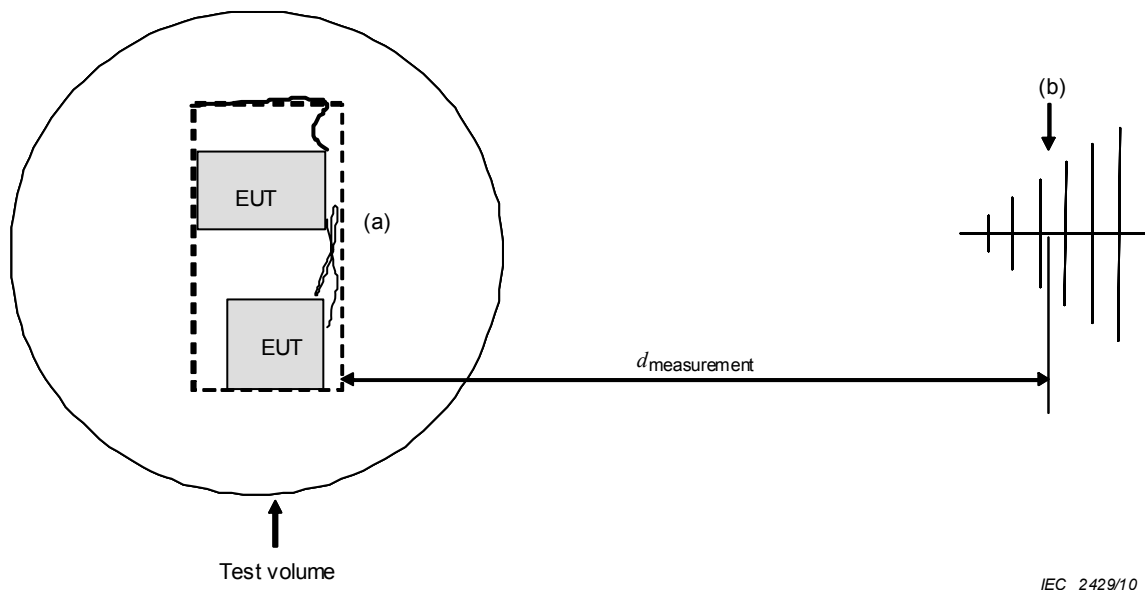
where

- | | |
|--------------------------|--|
| E_t | is the field strength intended as test level for the immunity test in V/m; |
| $d_{\text{measurement}}$ | is the distance between broadband antenna reference point and the nearest face of the EUT in m (see Figure A.1); |
| f_{MHz} | is the frequency in MHz; |
| $\bar{C}_{dB}$ | is the average system transducer factor (in dB/m) determined by the validation procedure. |

The forward power is the power injected into the transducer reference point (p_{TR} , see Figures 1 and 2, in 5.2). To adjust the instrumentation to that injection power, the attenuation of the cables, coupling of the directional coupler, etc. need to be taken into account.

Because the required forward power is maximum for the smallest EUT (largest $d_{\text{measurement}}$), the saturation check should be performed considering this worst-case situation.

- d) Set the RF generator output power until the power meter reading corresponds to the desired forward power calculated in step c), within a certain tolerance band. Immunity test control software typically does this step automatically.
- e) Record the power meter reading.
- f) Increase the RF generator output by 5,1 dB (this takes into account the increase of the peak envelope power of an 80 % AM modulated signal).
- g) Record the power meter reading and determine the difference from the power meter reading in step e). If this difference is within the interval 3,1 dB to 7,1 dB, the amplifier saturation is deemed to be acceptable. If the difference is less than 3,1 dB, or more than 7,1 dB, the amplifier is not suitable to produce the desired test field strength.
- h) Increment the frequency by 1 % and repeat steps c) to g) until the last frequency has been reached.
- i) Repeat steps b) to h) for vertical polarization of the broadband antenna.



Key

- (a) EUT periphery nearest face, including cables
- (b) Broadband antenna reference point

Figure A.1 – Definition of $d_{\text{measurement}}$ for immunity tests

A.4 Test procedure

A.4.1 General

The test shall be carried out on the basis of a test plan that shall include the relevant operating modes and verification of the performances of the EUT, as defined in the technical specification

The EUT shall be arranged as described in Clause 6, and shall be in one of the operating modes defined in the test plan.

A.4.2 Level setting process

The necessary forward power $P_{f,t,dBm}$ (rms, carrier, at p_{TR}) to produce the test field strength, E_t , for each individual frequency, shall be calculated from the average system transducer factor $\bar{C}_{dB}$, i.e. using

$$P_{f,t,dBm} = 45 + 20\log(E_t) + 20\log(d_{\text{measurement}}) - 20\log(f_{\text{MHz}}) + \bar{C}_{dB} \quad (\text{A.2})$$

where $d_{\text{measurement}}$ is the distance between the reference point of the antenna to the nearest face of the EUT.

The control equipment shall set the RF generator such that the calculated forward power is reached within a power tolerance range.

NOTE 1 This power tolerance range is normally specified by the test engineer. It is a compromise between uncertainty (see Annex D) and time needed to exactly establish the necessary power.

The EUT is successively illuminated at four faces by rotation of the EUT. If it is intended that the EUT be operated in other orientations, the illumination shall also include the bottom and top faces of the EUT.

NOTE 2 If an EUT consists of several components, it is not necessary to modify the position of each component within the EUT arrangement while illuminating it from different sides.

The frequency ranges to be considered are swept or scanned with the signal modulated (AM 80 % with 1 kHz sine wave, or as specified in the product standard), pausing to set the RF signal level or to switch signal generators and antennas as necessary. Where the frequency range is stepped incrementally, the step size shall not exceed 1 % of the preceding frequency value.

The dwell time of the amplitude modulated carrier at each frequency shall not be less than the time necessary for the EUT to be exercised and to respond, but shall in no case be less than 0,5 s. The sensitive frequencies (e.g. clock frequencies) shall be analyzed separately according to the requirements in product standards.

The polarization of the field generated by each antenna necessitates testing each EUT face twice, once with the antenna positioned vertically and again with the antenna positioned horizontally.

Attempts shall be made to fully exercise the EUT during testing, and to evaluate all the critical exercise modes selected for the immunity test, as stated in the test plan.

The use of special exercising programmes is recommended. These programmes (or reference to controlled programme descriptions) shall be documented in the test report.

A.4.3 Test plan

The test plan shall specify the following items:

- size of the EUT;
- representative operating modes of the EUT;
- type(s) and number of interconnecting cables used, and the interface port (of the EUT) to which these are to be connected;
- performance criteria;
- description of the method used to monitor the EUT;
- frequency range, dwell time and frequency steps;
- test level to be applied.

A.4.4 Evaluation of test results

The test results shall be classified in terms of the loss of function or degradation of performance of the EUT, relative to a performance level defined by its manufacturer or the requester of the test, or as agreed between the manufacturer and the purchaser of the product. The recommended classification is as follows:

- a) normal performance within limits specified by the manufacturer, requester or purchaser;
- b) temporary loss of function or degradation of performance which ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operator intervention;
- c) temporary loss of function or degradation of performance, the correction of which requires operator intervention;
- d) loss of function or degradation of performance which is not recoverable, due to damage to hardware or software, or loss of data.

The manufacturer's specification may define effects on the EUT that may be considered insignificant, and therefore acceptable.

This classification may be used as a guideline for formulating performance criteria, by committees responsible for generic, product and product-family standards, or as a framework

for the agreement on performance criteria between the manufacturer and the purchaser, for example where no suitable generic, product or product-family standard exists.

A.5 Test report

The test report shall contain all the information necessary to reproduce the test. In particular, the following items shall be documented.

- items specified in the test plan required by A.4.3;
- identification of the EUT and any associated equipment, for example, brand name, product type, serial number;
- any specific conditions necessary to enable the test to be performed;
- any specific conditions of use, for example cable length or type, shielding or grounding, or EUT operating conditions, which are required to achieve compliance;
- complete description of the cabling and equipment position and orientation (this can be accomplished using photographs of the arrangement);
- performance level defined by the manufacturer, requester or purchaser;
- performance criterion specified in the generic, product or product-family standard;
- any effects on the EUT observed during or after the application of the test disturbance, and the duration for which these effects persist;
- a clear statement as to whether the EUT is judged to pass or fail, and rationale for the pass or fail decision (based on the performance criterion specified in the generic, product or product-family standard, or agreed between the manufacturer and the purchaser);
- identification of the test equipment, for example, brand name, product type, serial number;
- any special environmental conditions under which the test was performed.

Annex B (normative)

Radiated emission measurements

B.1 General

This annex provides details for radiated emission measurement methods in a FAR.

B.2 Test equipment

The equipment used for the test is a FAR test system as used for a FAR validation done using the procedure of Clause 5, except that power amplifiers are not required for emission measurements. The measurement receiver used for emission measurements shall comply with CISPR 16-1-1.

The following equipment is required for emission measurement:

- a spectrum analyzer or receiver conforming to CISPR 16-1-1;
- a broadband antenna, cabling and FAR, as utilized during the determination of the average system transducer factor, $\overline{C}_{dB}$.

The measurement result (field strength) is calculated as:

$$E_{dB(\mu V/m)} = V_{pTR,dB(\mu V)} + \overline{C}_{dB} + 20 \log \left(\frac{d_{\text{measurement}}}{d_{\text{reference}}} \right) \quad (\text{B.1})$$

where

$V_{pTR,dB(\mu V)}$ is the voltage at the transducer reference point, p_{TR} (see Figures 1, 2, 3 and 4) in dB(μV);

$d_{\text{measurement}}$ is the distance between reference point of the antenna to the nearest face of the EUT (see Figure B.1);

$d_{\text{reference}}$ is the measurement distance as specified in the product standard.

Note that the average system transducer factor includes cable loss, antenna factor, and the average site influence as determined during the validation/calibration process, but does not include loss/gain of any equipment not used during the common emissions/immunity validation/calibration procedure. Thus, it may be necessary to further correct the reading for additional associated cabling or switches, including a broadband preamplifier where used for emissions tests, if these components were not included during the determination of $\overline{C}_{dB}$.