CISPR 16-4-2

Edition 2.0 2018-08

INTERNATIONAL STANDARD

NORME INTERNATIONALE

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE
COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

BASIC EMC PUBLICATION
PUBLICATION FONDAMENTALE EN CEM

AMENDMENT 2
AMENDEMENT 2

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

**Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques –
Partie 4-2: Incertitudes, statistiques et modélisation des limites – Incertitudes de mesure de l'instrumentation**

CISPR 16-4-2:2011-06/AMD2:2018-08(en-fr)

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INTERNATIONAL
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INTERNATIONALE

ICS 33.100.10; 33.100.20

ISBN 978-2-8322-5920-7

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FOREWORD

This amendment has been prepared by subcommittee CISPR subcommittee A: Radio-interference measurements and statistical methods, of IEC CISPR committee: International special committee on radio interference.

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

FDIS	Report on voting
CISPR/A/1257/FDIS	CISPR/A/1259/RVD

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

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the stability date indicated on the IEC website 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- withdrawn,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.

The contents of the corrigendum of January 2019 have been included in this copy.

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2 Normative references

Replace the dated reference CISPR 16-2-3:2010, by the following new reference:

CISPR 16-2-3:2016, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

3.1 Terms and definitions

Add, after the existing term and definition 3.1.1, the following new term and definition:

3.1.2
small EUT
equipment, either positioned on a table top or standing on the floor that, including its cables, fits in a cylindrical test volume of 1,5 m in diameter and 1,5 m in height measured from the floor

3.3 Abbreviations

Add, to the existing list modified by Amendment 1, the following new abbreviations:

AN artificial network

Δ-AN artificial Δ-network ('Δ' is pronounced 'delta')

LLAS large loop antenna system

LV low voltage

V-AMN artificial mains V-network

Table 1 – Values of U_{cispr}

Replace the first three lines of this table, modified by Amendment 1, by the following new lines:

Conducted disturbance at AC mains and other power ports using a V-AMN	(9 kHz to 150 kHz)	3,8 dB	B.1
	(150 kHz to 30 MHz)	3,4 dB	B.2
Conducted disturbance at AC mains ports using a voltage probe	(9 kHz to 30 MHz)	2,9 dB	B.3

Add, after the measurement method "Conducted disturbance at telecommunication port using CP", *the following new line:*

Conducted disturbance at telecommunication port using CP and CVP	(150 kHz to 30 MHz)	4,0 dB	B.5

Add before "Radiated disturbance (electric field strength at an OATS or in a SAC)" *the following new line:*

Radiated disturbance (disturbance current in a LLAS)	(9 kHz to 30 MHz)	3,3 dB	F.1

Add, after the existing NOTE 2, the following new notes:

NOTE 3 The value of U_{cispr} for conducted disturbances at telecommunication ports using CP and CVP is based on the expanded uncertainty in Table B.5 with consideration of additional uncertainties attributed to the CP transfer admittance Y_T and mismatch uncertainty CP-receiver δM; see comment B18).

NOTE 4 The values of U_{cispr} for the OATS, SAC and FAR are based on a small EUT – an EUT fitting in a cylindrical test volume of 1,5 m in diameter and 1,5 m in height – for a 3 m measurement distance (per 3.1.2).

5.1 Conducted disturbance measurements at a mains port using an AMN

Replace, in the title, the phrase "an AMN" *by the phrase* "a V-AMN".

5.1.1 Measurand for measurements using an AMN

Replace, in the title, the phrase "an AMN" *by the phrase* "a V-AMN".

5.1.2 Symbols of input quantities specific to measurements using an AMN

Replace in the title the phrase "an AMN" *by the phrase* "a V-AMN".

Replace the line starting with δD_{mains} *by the following new line:*

δD_{mains} Correction for the error caused by AC mains and other power supply disturbances, in dB

5.1.3 Input quantities to be considered for conducted disturbance measurements at a mains port using an AMN

Replace, in the title, the phrase "an AMN" *by the phrase* "a V-AMN".

Replace the eighth dashed item by the following new text:

– Effect of disturbances originating from the laboratory AC mains or other power supply

Add, after the existing Subclause 5.6.3 added by Amendment 1, the following new Subclause 5.7:

5.7 Conducted disturbance measurements at AC mains and other power ports using a Δ-AN

5.7.1 Measurand for measurements using a Δ-AN

V Asymmetric voltage in dB(μV), measured at the EUT port of the Δ-AN relative to the reference ground plane, and also symmetric voltage between two terminals at the EUT port of the Δ-AN not including reference ground; optionally also the unsymmetric voltage in dB(μV), measured at the EUT port of the Δ-AN relative to the reference ground plane, if the Δ-AN is furnished with a respective port for connection of the measuring receiver

5.7.2 Symbols of input quantities specific to measurements using a Δ-AN

F_{AN} Voltage division factor (asymmetric resp. symmetric) of the Δ-AN, in dB

$\delta F_{\text{AN}f}$ Correction for voltage division factor (VDF) frequency interpolation error, in dB

δD_{mains} Correction for the error caused by AC mains and other power supply disturbances, in dB

δV_{env} Correction for the effect of the environment, in dB

δZ_{AN} Correction for imperfect asymmetric or symmetric Δ-AN impedance, in dB

5.7.3 Input quantities to be considered for conducted disturbance measurements at AC mains and other power ports using a Δ-AN

– Receiver reading
– Attenuation of the connection between AN and receiver
– AN voltage division factor (asymmetric and symmetric)
– AN VDF frequency interpolation
– Receiver related input quantities:
  • Receiver sine-wave voltage accuracy
  • Receiver pulse amplitude response

- Receiver pulse response variation with repetition frequency
- Receiver noise floor

– Mismatch effects between the AN's receiver port and receiver
– AN impedance
– Effect of disturbances originating from the laboratory AC mains or other power supply
– Effect of environment

Add, after the existing Clause 8, the following new Clause 9:

9 Radiated disturbance measurements in the frequency range 9 kHz to 30 MHz

9.1 Magnetic field disturbance measurements using the LLAS in the frequency range 9 kHz to 30 MHz (see also Clause F.1)

9.1.1 Measurand for LLAS measurements

I Current in dB(µA), measured in each of the three loops of the LLAS

9.1.2 Symbols of input quantities specific for LLAS measurements

δZ_{vf} Correction for validation factor deviation, in dB

δZ_{fi} Correction for validation factor frequency interpolation, in dB

9.1.3 Input quantities to be considered for LLAS measurements

– Receiver reading
– Attenuation of connecting cable between LLAS and receiver
– Validation factor deviation
– Validation factor frequency interpolation
– Receiver related input quantities:
  - Receiver sine-wave voltage accuracy
  - Receiver pulse amplitude response
  - Receiver pulse response variation with repetition frequency
  - Receiver noise floor
– Mismatch between LLAS and receiver

9.2 Magnetic field disturbance measurement in the frequency range 9 kHz to 30 MHz using a loop antenna at various distances from the EUT

(Void)

Annex A – Basis for U_{cispr} values in Table 1, general information and rationale for input quantities common to all measurement methods

A.2 Rationale for the estimates of input quantities common to all disturbance measurements (“A” comments)

Replace, in the existing item A2) modified by Amendment 1, the abbreviation "AMN" *by the abbreviation* "V-AMN"*.*

Add in the first paragraph of A2), after “AMN, AAN, CDNE, CP, CVP, VP” *added by Amendment 1, the abbreviation* “LLAS”.

Add, in the first sentence of the first paragraph of item A6), the abbreviation "AN" *between the abbreviations* "AMN" *and* "AAN"*. Add, in the second paragraph, the term* "$\delta F_{\mathrm{AN}\,f}$" *between respective terms for* "$\delta F_{\mathrm{AMN}f}$" *and* "$\delta F_{\mathrm{VP}f}$"*.*

Replace in the first paragraph of A6), the phrase “absorbing clamp factor and antenna factor”, *by the new phrase* “absorbing clamp factor, LLAS validation factor and antenna factor”.

Replace, in item A7) a), the abbreviation "AMN" *by the abbreviation* "AN"*.*

Replace, in item A7) c) Note 12, the abbreviation "AMN" *by the abbreviation* "AN"*.*

Annex B – Basis for U_{cispr} values in Table 1, uncertainty budgets and rationale for conducted disturbance measurements

B.1 Uncertainty budget for conducted disturbance measurements at a mains port using an artificial mains network (AMN)

Replace the existing title by the following new title:

B.1 Uncertainty budget for conducted disturbance measurements at AC mains ports using a V-AMN

Replace the existing Equation (B.1) by the following new equation:

$$V = V_{\mathrm{r}} + A_{\mathrm{c}} + F_{\mathrm{AN}} + \delta F_{\mathrm{ANf}} + \delta V_{\mathrm{sw}} + \delta V_{\mathrm{pa}} + \delta V_{\mathrm{pr}} + \delta V_{\mathrm{nf}} + \delta M + \delta Z_{\mathrm{AN}} + \delta D_{\mathrm{mains}} + \delta E \qquad \text{(B.1)}$$

Table B.1 − Conducted disturbance measurements from 9 kHz to 150 kHz using a 50 Ω/50 µH + 5 Ω AMN

Replace, in the existing title, the abbreviation "AMN" *by the new abbreviation* "V-AMN".

Table B.2 − Conducted disturbance measurements from 150 kHz to 30 MHz using a 50 Ω/50 µH AMN

Replace, in the existing title, the abbreviation "AMN" *by the new abbreviation* "V-AMN".

B.6 Rationale for the estimates of input quantities specific to conducted disturbance measurement methods

Replace the existing comment B10) by the following new comment:

B10) An estimate of the CVP voltage division factor F_{CVP} is assumed to be available from a calibration report for the cable type to be measured, along with an expanded uncertainty and a coverage factor. The uncertainty includes the calibration setup.

Add, after the phrase "C.1.3 of CISPR 22:2008" *in the existing comment B18), the new phrase* "and in C.4.1.6.4 of CISPR 32:2015 [19]".

Add, after the existing Clause B.8 added by Amendment 1, the following new Clauses B.9 and B.10:

B.9 Basis for U_{cispr} values in Table 1, uncertainty budgets and rationale for conducted disturbance measurements at mains and other ports using a Δ-AN

The measurand V is calculated using:

$$V = V_{\text{r}} + a_{\text{c}} + F_{\text{AN}} + \delta F_{\text{AN}f} + \delta V_{\text{sw}} + \delta V_{\text{pa}} + \delta V_{\text{pr}} + \delta V_{\text{nf}} + \delta Z_{\text{AN}} + \delta M + \delta D_{\text{mains}} + \delta V_{\text{env}} \quad \text{(B.7)}$$

Table B.8 – Conducted disturbances measurements from 150 kHz to 30 MHz using a 150 Ω Δ-AN

Input quantity [a]	X_i	Uncertainty of x_i		$c_i\,u(x_i)$ [b]
		dB	Probability distribution function	dB
Receiver reading A1)	V_{r}	± 0,1	k = 1	0,10
Cable attenuation: AN-receiver A2)	a_{c}	± 0,1	k = 2	0,05
AN voltage division factor B25)	F_{AN}	± 0,2	k = 2	0,10
Receiver corrections:				
Sine wave voltage A3)	δV_{sw}	± 1,0	k = 2	0,50
Pulse amplitude response A4)	δV_{pa}	± 1,5	Rectangular	0,87
Pulse repetition rate response A4)	δV_{pr}	± 1,5	Rectangular	0,87
Noise floor proximity A5)	δV_{nf}	± 0,0	Rectangular	0,00
AN VDF frequency interpolation A6)	$\delta F_{\text{AN}f}$	± 0,1	Rectangular	0,06
Mismatch AN-receiver A7)	δM	± 0,07	U-shaped	0,05
AN Impedance (CM) tolerances B26)	$\delta Z_{\text{AN-CM}}$	+5,37/-3,67	Triangular	1,84
AN Impedance (DM) tolerances B26)	$\delta Z_{\text{AN-DM}}$	+5,37/–1,94	Triangular	1,49
Effect of mains disturbances B27)	δD_{mains}	± 0,0		0,00
Effect of the environment B19)	δV_{env}			
Combined standard uncertainty	u_{c}			2,93
Expanded uncertainty (U_{CISPR})	**$2\,u_{\text{c}}$**			**5,86**

a Superscripts refer to numbered comments in A.2 and in this annex.

b All sensitivity coefficients c_i are assumed to be equal to 1, see A.2.

B.10 Rationale for the estimates of input quantities specific to the measurement method using a Δ-AN

B25) Estimates of the Δ-AN voltage division factors F_{AN} ($F_{AN\_asymmetric}$ and $F_{AN\_symmetric}$) are assumed to be available from a calibration report, along with their expanded uncertainties and coverage factors.

B26) CISPR 16-1-2 defines the CM impedance of the 150 Ω Δ-AN as 150 Ω with a magnitude tolerance of ±30 Ω and a phase tolerance of ± 40°. Taking the extremes of all combinations of the constrained AN CM impedance and the unconstrained EUT impedance the estimate of the correction $\delta Z_{AN\text{-}CM}$ is zero with a deviation of +5,37/-3,67 dB. A triangular probability distribution is assumed because there is only a small chance of encountering the particular combinations of AN impedance and EUT impedance needed to produce those extremes. The triangular distribution is assumed to be symmetric.

The actual uncertainty will be reduced if the actual CM impedance does not reach the tolerance limits.

CISPR 16-1-2 defines the DM impedance of the 150 Ω Δ-AN as 150 Ω with a magnitude tolerance of ± 30 Ω and a phase tolerance of ±40°. Taking the extremes of all combinations of the constrained AN differential mode impedance and the unconstrained EUT impedance the estimate of the correction $\delta Z_{AN\text{-}DM}$ is zero with a deviation of +5,37/–1,94 dB. A triangular probability distribution is assumed because there is only a small chance of encountering the particular combinations of AN impedance and EUT impedance needed to produce those extremes. The triangular distribution is assumed to be symmetric.

The actual uncertainty will be reduced if the actual DM impedance does not reach the tolerance limits.

B27) For measurements using a Δ-AN, disturbances from the AC mains, other kind of power supply or from an external load are assumed to be suppressed by the Δ-AN itself or by additional filters inserted in the power supply line – if necessary.

Annex D – Basis for U_{cispr} values in Table 1 – Radiated disturbance measurements from 30 MHz to 1 000 MHz

Table D.1 – Horizontally polarized radiated disturbances from 30 MHz to 200 MHz using a biconical antenna at a distance of 3 m, 10 m or 30 m

Replace the table title by the following new title:

Table D.1 – Horizontally polarized radiated disturbances from 30 MHz to 200 MHz using a biconical antenna at an OATS/SAC at a distance of 3 m, 10 m or 30 m

Table D.2 – Vertically polarized radiated disturbances from 30 MHz to 200 MHz using a biconical antenna at a distance of 3 m, 10 m or 30 m

Replace the table title by the following new title:

Table D.2 – Vertically polarized radiated disturbances from 30 MHz to 200 MHz using a biconical antenna at an OATS/SAC at a distance of 3 m, 10 m or 30 m

Table D.3 – Horizontally polarized radiated disturbances from 200 MHz to 1 GHz using an LPDA antenna at a distance of 3 m, 10 m or 30 m

Replace the table title by the following new title:

Table D.3 – Horizontally polarized radiated disturbances from 200 MHz to 1 GHz using an LPDA antenna at an OATS/SAC at a distance of 3 m, 10 m or 30 m

Replace, in the "LPDA antenna corrections" *section of the table, the* "Phase centre location D4)" *details as follows*:

Phase centre location D4) at	3 m	δF_{aph}	± 0,20	Rectangular	0,12
	or 10 m	δF_{aph}	± 0,06	Rectangular	0,03
	or 30 m	δF_{aph}	± 0,02	Rectangular	0,01

Replace the expanded uncertainty details located just below Table D.3 by the following:

Hence, expanded uncertainty
$$U(E) = 2u_c(E) = \begin{cases} 5{,}12\ \text{dB, at a separation of 3 m (with tilting)} \\ 5{,}21\ \text{dB, at a separation of 3 m (without tilting)} \\ 5{,}20\ \text{dB, at a separation of 10 m} \\ 5{,}19\ \text{dB, at a separation of 30 m} \end{cases}$$

Table D.4 – Vertically polarized radiated disturbances from 200 MHz to 1 GHz using an LPDA antenna at a distance of 3 m, 10 m or 30 m

Replace the table title by the following new title:

Table D.4 – Vertically polarized radiated disturbances from 200 MHz to 1 GHz using an LPDA antenna at an OATS/SAC at a distance of 3 m, 10 m or 30 m

Replace, in the "LPDA antenna corrections" *section of the table, the* "Phase centre location D4)" *details as follows*:

Phase centre location D4) at	3 m	δF_{aph}	± 0,20	Rectangular	0,12
	or 10 m	δF_{aph}	± 0,06	Rectangular	0,03
	or 30 m	δF_{aph}	± 0,02	Rectangular	0,01

Replace the expanded uncertainty details located just below Table D.4 by the following:

Hence, expanded uncertainty
$$U(E) = 2u_c(E) = \begin{cases} 5{,}14\ \text{dB, at a separation of 3 m (with tilting)} \\ 6{,}21\ \text{dB, at a separation of 3 m (without tilting)} \\ 5{,}21\ \text{dB, at a separation of 10 m} \\ 5{,}18\ \text{dB, at a separation of 30 m} \end{cases}$$

D.3 Rationale for the estimates of input quantities specific to radiated disturbance measurement methods from 30 MHz to 1 000 MHz

Replace, in comment D4), all of the existing text and notes by the following new text and notes:

D4) The correction δF_{aph} for phase centre location is negligible for a biconical antenna. The variation in phase-centre location with frequency for an LPDA antenna can be corrected as recommended in CISPR 16-2-3.

For an LPDA antenna, the correction δF_{aph} was assumed to be applied e.g. by equivalent corrections of the AFs for the specified measurement distance (see CISPR 16-2-3). The remaining reduced uncertainty is given in Tables D.3 and D.4 with a rectangular probability distribution, having a half-width evaluated by considering the effect of an error of ± 0,07 m in the separation, and assuming that field strength is inversely proportional to separation. For example for d = 10 m, 20 lg(1 + 0,07/10) = 0,06 dB.

NOTE 4 If a tuned dipole is the measuring antenna, the correction δF_{aph} is negligible.

NOTE 5 For hybrid antennas, the correction δF_{aph} for the systematic effect is more complicated [see comment D12)].

Replace, in comment D11) 2nd paragraph, the existing text "Subclause 7.2.3 of CISPR 16-2-3:2010", *by the following new text:*

Subclause 7.3.4 of CISPR 16-2-3:2016

Replace, in comment D12), all of the existing text, equations and notes by the following new text, equations, notes and tables:

D12) Hybrid antennas are taken into account in the calculation of Tables D.7, D.8 and D.9. Hybrid antennas, used for radiated disturbance measurements in the frequency range 30 MHz to 1 000 MHz and consisting of a broadband dipole section and an LPDA antenna section, typically have the following characteristics (different parameters for specific designs may be provided by antenna manufacturers):

– a frequency range up to about 100 MHz, where the antenna acts like a biconical antenna (see Tables D.1, D.2 and D.5);

– a transition frequency range from about 100 MHz up to about 200 MHz (see below within this comment); and

– a frequency range above about 200 MHz where the antenna acts like an LPDA antenna (see Tables D.3, D.4 and D.6). For the correction δF_{adir} it is considered that the LPDA part is usually closer to the EUT than above in comment D3), which means that the correction factors are slightly higher and the uncertainties are slightly larger.

In the frequency range up to 100 MHz, the following is assumed:

– the AF variation relative to F_{a} for horizontal polarization at a height of 1 m reaches a maximum vs. frequency of ± 2 dB around 60 MHz and at a height of 4 m the variation is around ± 0,5 dB (data specific for individual antenna types need to be supplied by the antenna manufacturer). Since at horizontal polarization the antenna height for OATS/SAC measurements in the frequency range below 100 MHz is at its maximum, the lower AF height deviation has been assumed.

In the transition frequency range, the following may be assumed for uncertainty considerations:

– the antenna gain (in dBi) and, by association, the pattern directivity (in dB), increase linearly with the frequency (detailed antenna patterns for the correction δF_{adir} may be obtained from the manufacturer);

– as the frequency increases, the active phase centre travels linearly from the broadband dipole elements to the 200 MHz elements of the LPDA part [a detailed calculation of the AF correction δF_{aph} is given below in Equation (D.4)];

– the cross polarization suppression is equal to or above 20 dB; and

– the balun imbalance will normally be as low as that of the broadband dipole elements.

It is assumed that the antenna is provided with free-space AFs. Free-space AFs apply to the location of the phase centre. Because the phase centre location on the antenna is frequency dependent, the distance from a fixed EUT is also frequency dependent.

Equation (8) of CISPR 16-2-3:2016, as well as Equation (A.1) of CISPR 16-1-6:2014 [18], suggests a field-strength correction. For a given frequency, the following correction, ΔE in dB, is added to the measured electric field strength:

$$\Delta E = 20\lg\left(\frac{d_{\text{phase}}}{d}\right) = 20\lg\left(\frac{d + \Delta d}{d}\right) \tag{D.3}$$

According to a note in CISPR 16-2-3 this correction can also be done using distance-dependent AFs. In order to correct for the deviation from the reference distance, e.g. 10 m or 3 m, the AF is assumed to be corrected. A marker is assumed to be provided on the antenna midpoint, which is used to define the EUT-to-antenna distance d. Then, the actual AF $F_{\text{a act}}$ is calculated using the following equations:

$$F_{\text{a act}} = F_{\text{a}} + \delta F_{\text{aph}} \tag{D.4}$$

where $\delta F_{\text{aph}} = 20\lg\left(\frac{d + \Delta d}{d}\right)$

and

$F_{\text{a act}}$ is the actual (corrected) AF in dB(m^{-1});

F_{a} is the free-space AF in dB(m^{-1});

δF_{aph} is the correction for phase centre variation in dB;

d is the EUT-to-antenna midpoint distance in m;

d_{phase} is the EUT-to-phase-centre distance in m;