CISPR 16-1-4

Edition 4.0 2020-06

INTERNATIONAL STANDARD

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

AMENDMENT 1
AMENDEMENT 1

**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**

**Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques –
Partie 1-4: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Antennes et emplacements d'essai pour les mesures des perturbations rayonnées**

CISPR 16-1-4:2019-01/AMD1:2020-06(en-fr)

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FOREWORD

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

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

FDIS	Report on voting
CIS/A/1316/FDIS	CIS/A/1320/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- withdrawn,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.

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3.2 Abbreviated terms

Add the following new abbreviated terms to the existing list:

DRH double ridged horn

XP cross polarization

PDF probability density function

4.5.5 Cross-polar response of antenna

Delete, in the first sentence of the existing last paragraph, the cross-reference to [21].

4.7 Special antenna arrangements – large-loop antenna system

Replace the first sentence of the third paragraph with the following new sentence:

The EUT shall be positioned in the centre of the LLAS on a non-conductive support table.

Replace the third sentence of the third paragraph with the following new sentence:

Guidelines for routing of EUT cables are given in C.3 and Figure C.6.

Add, after the existing third paragraph, the following new paragraph:

The LLAS may be placed in any environment. Placement inside a shielded room, SAC, FAR, or weather-protected OATS is permitted. Placement in a shielded environment is recommended to eliminate ambient signals allowing for better sensitivity to EUT emissions. A minimum distance of 0,5 m between the LLAS and any metallic plane is recommended. The validation of the LLAS shall be performed at the location where the LLAS measurements normally take place to take into account the effect of the environment (see C.4).

Replace, in the NOTE, "Correction factors" *with* "Conversion factors".

C.3 Construction of a large-loop antenna (LLA)

Replace the existing third paragraph with the following paragraph:

The standard diameter of each LLA is defined as D = 2 m (i.e. the reference diameter). If necessary, e.g. in the case of a large EUT, D may be increased. However, in the frequency range up to 30 MHz, the maximum diameter allowed is 4 m. Further increase of the diameter can result in non-reproducible resonances of the LLAS response at the high-frequency end of the measuring range. The validation method specified in C.4 applies for LLAS loops with diameters of 2 m, 3 m, or 4 m.

Replace the second sentence of the seventh paragraph "The insertion loss of the current probe shall be sufficiently low (see NOTE 1)." *with "*The insertion impedance of the current probe should be sufficiently low (see NOTE).*"*

Delete the existing NOTE 1 and NOTE 2.

Add, between the seventh and eighth paragraphs, the following new NOTE:

NOTE To obtain a flat frequency response for each LLA at the lower end of the 9 kHz to 30 MHz frequency range, the resistive part of the insertion impedance, R_c, of the current probe is designed to be much smaller than $2\pi f L_c$ at f = 9 kHz, where L_c represents the inductance of the current probe. In addition, $R_c + R_i$ is to be less than or equal to $X_i/10 = (2\pi f L)/10$ at 9 kHz, where R_i is the resistance of the inner conductor of the loop and L is the loop inductance. This inductance is about 1,5 µH/m along the circumference; thus, for each standard LLA whose diameter is 2 m, $X_i \approx 0,5\ \Omega$ at f = 9 kHz.

Add, at the end of the existing text (before Figure C.1), the following new paragraph:

To avoid unwanted capacitive coupling between the EUT and the LLAS, the distance between the EUT and components of the LLAS shall be at least 0,10 times the loop diameter. Particular attention should be paid to the leads of an EUT. Cables shall be routed together and leave the test volume in the same octant of the LLAS, no closer than 0,4 m to any of the LLAS loops (see Figure C.6).

C.4 Validation of an LLA

Replace the existing title of this clause with the following new title:

C.4 Validation of the LLAS

Replace the first paragraph of this clause with the following three new paragraphs:

The validation of the LLAS shall be carried out by measuring the current induced in each of the three LLAs by means of the LLAS verification dipole connected to a 50 Ω RF generator, as described in C.5. The magnetic field emitted by the dipole allows verification of the magnetic field sensitivity of the LLAS. The electric field emitted by the LLAS verification dipole is intended to verify that the electric field sensitivity of the LLAS is sufficiently low.

The validation of an LLAS shall be performed at the site where the LLAS measurements normally take place. This is to account for the effect of the floor, walls, and similar objects or surfaces in the specific environment of the LLAS.

Validation measurements shall be performed at least at the following frequencies: 9 kHz, 100 kHz, 1 MHz, 2 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, 20 MHz, 25 MHz, and 30 MHz.

Replace the existing second and third paragraphs with the following new paragraphs:

The induced current shall be measured as a function of frequency in the range of 9 kHz to 30 MHz at the eight positions of the LLAS verification dipole shown in Figure C.7. During this measurement, the LLAS verification dipole shall be in the plane of the LLA under test.

In each of the eight positions, the measured validation factor, expressed in dB(Ω) as $20\ \lg(V_{go}/I_l)$, where V_{go} is the open circuit voltage of the RF generator and I_l is the measured current, shall not deviate by more than ±3 dB from the applicable reference validation factor given in Figure C.8 and Table C.1.

Delete the existing fourth paragraph.

Add, before Figure C.7, three new paragraphs as follows:

The reference validation factors given in Figure C.8 and Table C.1 are valid for an LLAS with circular loops having diameters of D = 2 m, 3 m, or 4 m.

Tabular values of the curves presented in Figure C.8 are given in Table C.1. These tabular values shall be used for the LLAS validation.

Background material and the equations for calculating the reference validation factors are given in CISPR TR 16-3:2020 [23].

Figure C.7 – The eight positions of the LLAS verification dipole during validation of an LLA

Replace the existing figure with the following new figure:

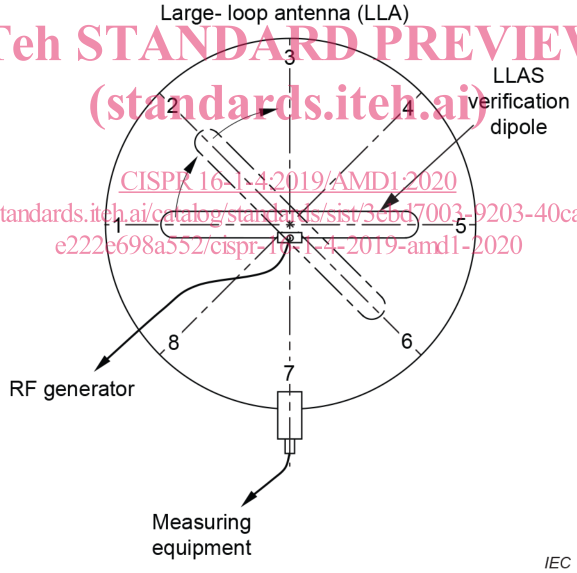


Figure C.7 – The eight positions of the LLAS verification dipole during validation of an LLA

Figure C.8 – Validation factor for an LLA of 2 m diameter

Replace the existing figure, including its title, with the following new figure:

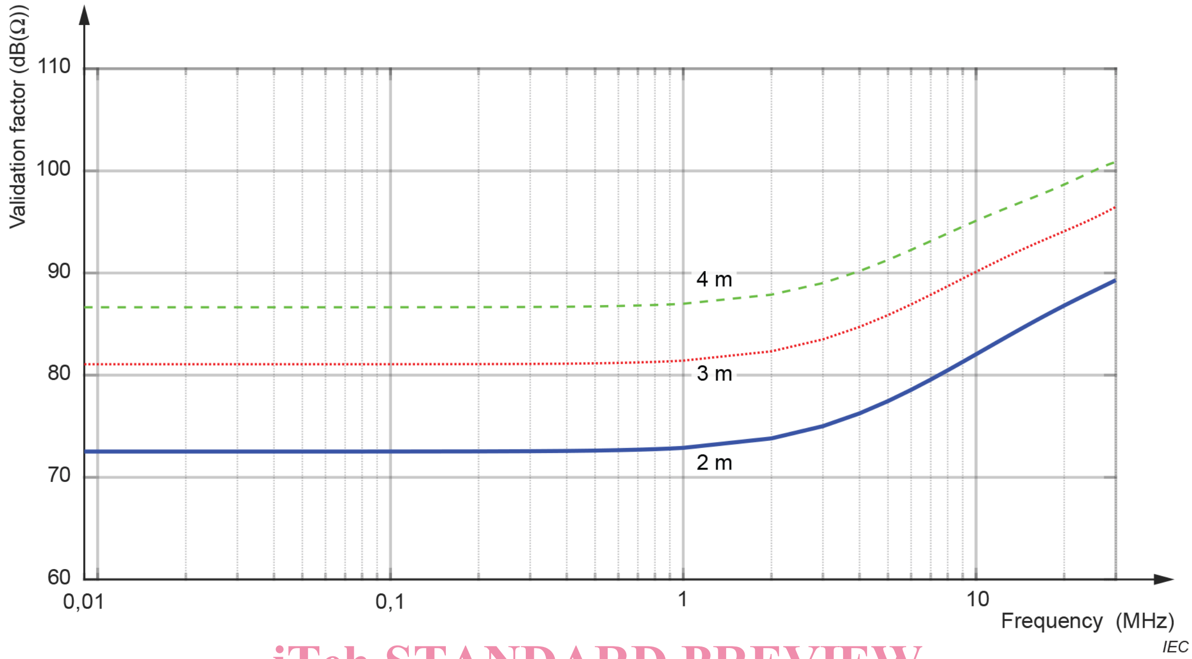


Figure C.8 – Reference validation factors for loops of 2 m, 3 m, and 4 m diameters

Add, after the new Figure C.8, the following new table:

Table C.1 – Reference validation factors of Figure C.8 for loops of 2 m, 3 m, and 4 m diameters

Frequency	Reference validation factor			Frequency	Reference validation factor		
	2 m LLAS	3 m LLAS	4 m LLAS		2 m LLAS	3 m LLAS	4 m LLAS
MHz	dB(Ω)			MHz	dB(Ω)		
0,009	72,52	81,07	86,64	7	79,57	87,87	93,13
0,01	72,52	81,07	86,64	8	80,47	88,71	93,88
0,02	72,52	81,07	86,64	9	81,30	89,45	94,54
0,03	72,52	81,07	86,64	10	82,04	90,12	95,11
0,04	72,52	81,07	86,64	11	82,72	90,71	95,62
0,05	72,52	81,07	86,64	12	83,34	91,24	96,07
0,06	72,52	81,07	86,65	13	83,90	91,72	96,47
0,07	72,52	81,07	86,65	14	84,42	92,15	96,84
0,08	72,52	81,07	86,65	15	84,90	92,54	97,18
0,09	72,52	81,07	86,65	16	85,34	92,89	97,50
0,1	72,52	81,07	86,65	17	85,75	93,22	97,80
0,2	72,54	81,08	86,66	18	86,13	93,53	98,10
0,3	72,55	81,10	86,68	19	86,48	93,82	98,39
0,4	72,58	81,13	86,70	20	86,81	94,09	98,67
0,5	72,61	81,16	86,73	21	87,12	94,35	98,94
0,6	72,65	81,20	86,77	22	87,41	94,60	99,21
0,7	72,70	81,24	86,82	23	87,68	94,85	99,47
0,8	72,75	81,30	86,87	24	87,94	95,09	99,72
0,9	72,81	81,36	86,93	25	88,19	95,32	99,96
1	72,88	81,42	86,99	26	88,43	95,56	100,18
2	73,81	82,33	87,88	27	88,66	95,79	100,38
3	75,01	83,51	89,02	28	88,88	96,02	100,57
4	76,26	84,72	90,19	29	89,09	96,25	100,73
5	77,46	85,88	91,28	30	89,30	96,47	100,88
6	78,56	86,93	92,26	-	-	-	-

C.5 Construction of the LLAS verification dipole antenna

Replace the first paragraph with the following paragraph:

The LLAS verification dipole, shown in Figure C.9, has been designed to emit simultaneously a magnetic field, which should be measured by the LLAS, and an electric field, which should be rejected by the LLAS.

Replace the existing second and third paragraphs with the following two paragraphs:

The LLAS verification dipole antenna shall be constructed in accordance with Figure C.9, using RG-223/U or similar type of coaxial cable. It shall have a width W = 150 cm and a spacing s = 10 cm (cable centre to cable centre distances), as depicted in Figure C.9. A slit in the outer conductor of the coaxial cable shall separate the dipole into two halves. One half of the dipole (the right-hand half in Figure C.9) shall be short-circuited near the connector as well as near the slit opposite from the connector. Short-circuited means that the inner and outer conductors of the coaxial cable shall be electrically bonded together. This half shall be connected to the reference-ground of the coaxial connector (BNC or similar type). The inner conductor of the coaxial cable, forming the left-hand half of the dipole in Figure C.9, shall be connected to the centre-pin of the coaxial connector, and its outer conductor connected to the reference ground of that coaxial connector.

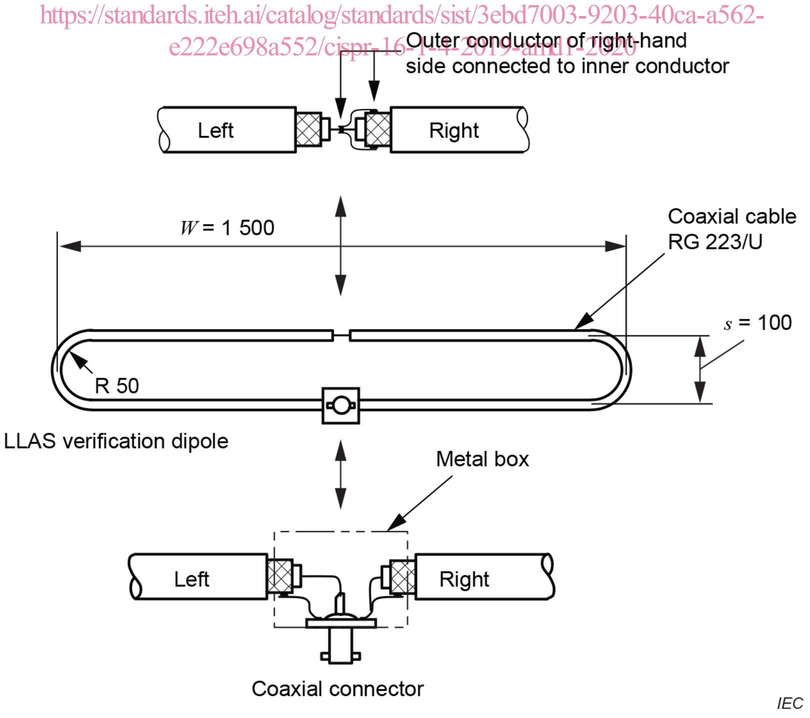
A small metal box shall be used to screen the connections near the coaxial connector. The outer conductor of the two halves of the dipole coaxial cable and the reference ground of the coaxial connector shall be bonded to this box.

Replace, in the existing fourth paragraph, "is used" *with* "may be used".

Figure C.9 – Construction of the LLAS verification dipole antenna

Replace the existing figure with the following new figure, without modifying its title:

Dimensions in millimetres



NOTE Distances indicated are cable centre to cable centre distances.

C.6 Conversion factors

Replace the existing text this clause, including Figure C.10 and Figure C.11, by the following new Clauses C.6 and C.7.

C.6 Conversion factors

C.6.1 General

This subclause deals with the factor that converts the current measured in an LLA with a non-standard diameter to a current that would have been measured using an LLA with the standard diameter of D = 2 m (see Figure C.10 and Table C.2). It also deals with the factor that converts the current (I) induced in an LLA by an EUT into a magnetic field strength H at a specified distance from the EUT (see Figure C.11 and Table C.3). Background material and the equations for calculating these conversion factors are given in CISPR TR 16-3:2020 [23].

C.6.2 Current conversion factors for an LLAS with non-standard diameter

The difference S_{D} in decibels, between the current measured in an LLA with diameter D, in m, and the current that would be measured using an LLA having the standard diameter D = 2 m, expressed in logarithmic units (such as dB(µA)), is given in Figure C.10 (and Table C.2) for several values of D, as determined using Equation (C.1):

$$S_{\mathrm{D}} = I_{D\,\mathrm{m}} - I_{2\,\mathrm{m}} \tag{C.1}$$

where $I_{D\,\mathrm{m}}$ and $I_{2\,\mathrm{m}}$ are the values of the induced currents in an LLA with diameter D and the standard 2 m diameter LLA, respectively, both expressed in logarithmic units (such as dB(µA)).

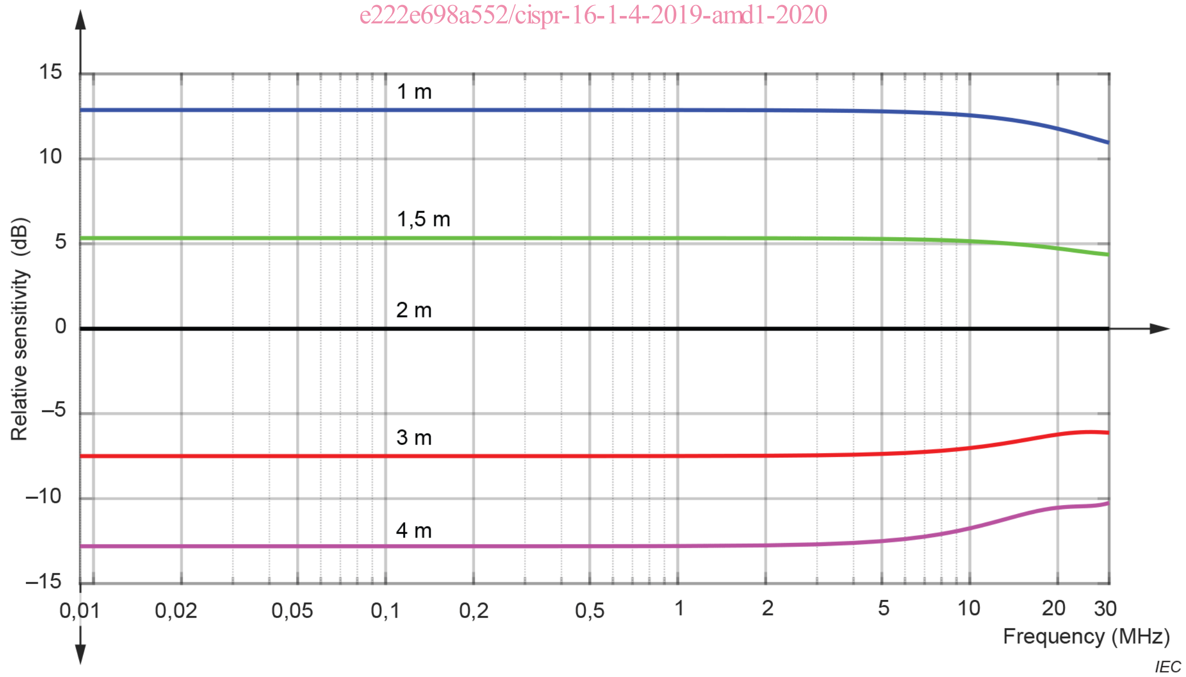


Figure C.10 – Sensitivity S_{D} of an LLA with diameter D relative to an LLA with 2 m diameter

Table C.2 – Sensitivity S_D of an LLA with diameter D relative to an LLA with 2 m diameter (Figure C.10)

Frequency MHz	LLAS diameter D				Frequency MHz	LLAS diameter D			
	1 m	1,5 m	3 m	4 m		1 m	1,5 m	3 m	4 m
	dB	dB	dB	dB		dB	dB	dB	dB
0,009	12,88	5,34	-7,50	-12,80	7	12,72	5,24	-7,25	-12,24
0,01	12,88	5,34	-7,50	-12,80	8	12,67	5,22	-7,18	-12,08
0,02	12,88	5,34	-7,50	-12,80	9	12,62	5,19	-7,11	-11,92
0,03	12,88	5,34	-7,50	-12,80	10	12,56	5,16	-7,02	-11,75
0,04	12,88	5,34	-7,50	-12,80	11	12,50	5,12	-6,94	-11,58
0,05	12,88	5,34	-7,50	-12,80	12	12,43	5,08	-6,85	-11,41
0,06	12,88	5,34	-7,50	-12,80	13	12,36	5,04	-6,76	-11,25
0,07	12,88	5,34	-7,50	-12,80	14	12,29	5,00	-6,67	-11,09
0,08	12,88	5,34	-7,50	-12,80	15	12,21	4,96	-6,58	-10,96
0,09	12,88	5,34	-7,50	-12,80	16	12,12	4,91	-6,50	-10,84
0,1	12,88	5,34	-7,50	-12,80	17	12,04	4,87	-6,42	-10,73
0,2	12,88	5,33	-7,50	-12,80	18	11,95	4,82	-6,35	-10,65
0,3	12,88	5,33	-7,50	-12,80	19	11,86	4,77	-6,28	-10,58
0,4	12,88	5,33	-7,50	-12,80	20	11,77	4,73	-6,23	-10,53
0,5	12,88	5,33	-7,50	-12,80	21	11,68	4,68	-6,18	-10,50
0,6	12,88	5,33	-7,50	-12,80	22	11,60	4,64	-6,14	-10,48
0,7	12,88	5,33	-7,50	-12,80	23	11,51	4,60	-6,11	-10,46
0,8	12,88	5,33	-7,49	-12,80	24	11,42	4,55	-6,09	-10,45
0,9	12,88	5,33	-7,49	-12,79	25	11,33	4,52	-6,08	-10,44
1	12,87	5,33	-7,49	-12,79	26	11,25	4,48	-6,08	-10,43
2	12,86	5,33	-7,48	-12,75	27	11,17	4,45	-6,08	-10,40
3	12,85	5,32	-7,45	-12,69	28	11,09	4,41	-6,09	-10,37
4	12,83	5,30	-7,41	-12,61	29	11,02	4,39	-6,10	-10,32
5	12,80	5,29	-7,37	-12,50	30	10,95	4,36	-6,12	-10,25
6	12,76	5,27	-7,31	-12,38	-	-	-	-	-

C.6.3 Conversion of LLAS measured current to magnetic field strength

The conversion factor in Figure C.11 and Table C.3 represent the worst-case (highest) of all three polarizations when considering a source of magnetic field positioned in the centre of an LLA with its magnetic dipole moment perpendicular to the plane of that LLA, for all three loops of an LLAS. As such, this conversion factor may be used to estimate the worst-case magnetic field strength that would be measured with the loop antenna specified in 4.3, at a specific measurement distance (3 m, 10 m, or 30 m) from the EUT periphery, with the loop antenna centre at 1,3 m above the metallic ground plane of a test site, with the EUT's lowest surface positioned at 80 cm above the ground plane, and with the EUT rotated through all azimuth angles, for all three loop antenna polarizations. This field strength estimation may be obtained by adding the conversion factor of Figure C.11 and Table C.3 to the worst-case induced current level measured from the EUT with the three loops of the LLAS, at the frequency of measurement.

NOTE 1 Often, traditional magnetic field strength test methods (e.g. from CISPR 11 [24]) apply a loop antenna as specified in 4.3 and positioned in a vertical plane only while the EUT is rotated only around its vertical axis. In that case only the horizontal dipole moments, i.e. the dipole moments parallel to the ground plane, are measured. Consequently, in case the EUT also generates vertical dipole moments, the LLAS conversion factor cannot be used to compare the results of both measurement methods. However, the LLAS conversion factor can be used for comparisons with the magnetic field strength measurement method results when the loop antenna of 4.3 is positioned in a horizontal plane, in addition to the two vertical loop plane polarizations.

If the actual position of a disturbance source within an EUT is at a distance less than 0,5 m from the centre of the standard LLAS, the measurement results differ by less than 3 dB from those with that source in the centre of the LLAS.

The relation between the magnetic field strength H in dB(μA/m) measured at a distance d and the LLA current I in dB(μA) is per Equation (C.2):

$$H = I + C_{\mathrm{dA}} \tag{C.2}$$

where C_{dA} is the current-to-field conversion factor in dB(m^{-1}) for a certain distance d when expressing H in dB(μA/m) (see also NOTE 2).

In general, the conversion factor is frequency-dependent; Figure C.11 (and Table C.3) present C_{dA} for standard measurement distances of 3 m, 10 m, and 30 m.

If the current is measured in an LLAS with a non-standard diameter D, Equation (C.2) can be written as Equation (C.3):

$$H = I - S_{\mathrm{D}} + C_{\mathrm{dA}} \tag{C.3}$$

where H is expressed in dB(μA/m), I in dB(μA), S_{D} in dB, and C_{dA} in dB(m^{-1}).

NOTE 2 For disturbance level calculations, CISPR uses the magnetic field strength H in dB(μA/m) instead of electric field strength E in dB(μV/m). In this context, the relation between H and E is given by Equation (C.4):

$$E = H + 51{,}5 \tag{C.4}$$

where E is expressed in dB(μV/m) and H in dB(μA/m). The constant 51,5, in dB(Ω) in Equation (C.4), is explained in the NOTE in 4.3.2.

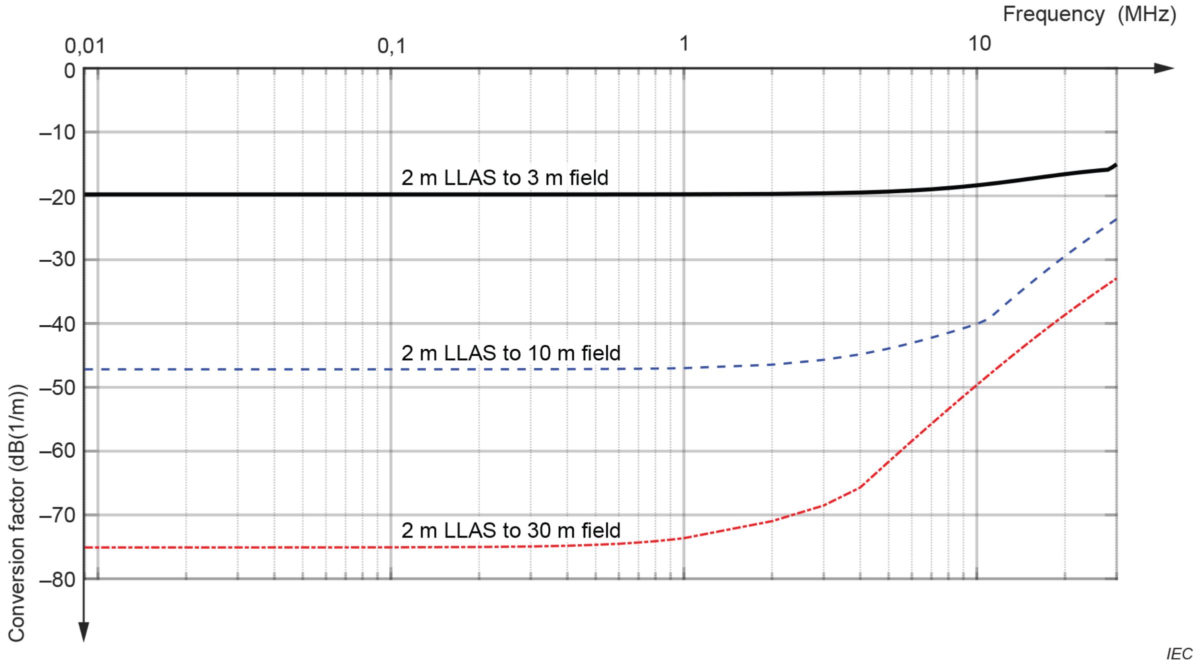


Figure C.11 – Conversion factor C_{dA} [for conversion into dB(μA/m)] for three standard measurement distances d