CISPR 16-1-6

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INTERNATIONAL STANDARD

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

BASIC EMC PUBLICATION
PUBLICATION FONDAMENTALE EN CEM

AMENDMENT 1
AMENDEMENT 1

**Specification for radio disturbance and immunity measuring apparatus and methods –
Part 1-6: Radio disturbance and immunity measuring apparatus – EMC antenna calibration**

**Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques –
Partie 1-6: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Étalonnage des antennes CEM**

CISPR 16-1-6:2014-12/AMD1:2017-01(en-fr)

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FOREWORD

This amendment has been prepared by CISPR subcommittee 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
CISPR/A/1195/FDIS	CISPR/A/1204/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- withdrawn,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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6.3.4 Radiation patterns of an antenna

Add, after the last paragraph of this subclause, the following new paragraph:

Annex I introduces a method for antenna pattern measurement in the frequency range above 1 GHz.

Add, after the existing Annex H, the following new Annex I:

Annex I
(normative)

Antenna pattern measurement method in the frequency range above 1 GHz, with measurement uncertainty budget

I.1 General

All measurement methods in the CISPR 16 series need an estimation of the measurement uncertainty. A common approach is to list all contributions and to determine the influence of each one. This works very well if the uncertainty contributions are <u>independent</u> from the EUT itself. In case of antenna pattern measurements above 1 GHz uncertainty contributions are NOT independent from the EUT.

The major uncertainty contributions are:

a) reflections inside the antenna chamber;

b) reflections from the transmit antenna mast and the receive antenna mast;

c) positioning uncertainty of the turntable leading to azimuth drift;

d) alignment of the antennas;

e) reflections between antennas.

All of these contributions are <u>dependent</u> on the antenna pattern to be measured as follows:

1) The nature of the pattern of omnidirectional antennas will lead to stronger reflections from objects around the antenna and from all surfaces of the anechoic chamber.

2) Coupling with the antenna mast is more significant if omnidirectional antennas or directional antennas with a strong back lobe are measured.

3) Uncertainty of the turntable positioning can be seen if directional antennas with a high-gradient antenna pattern are measured.

4) Alignment is more critical if directive antennas are measured.

5) Unwanted coupling between measurement antennas exists if the dimensions of the antennas are electrically large.

To account for these effects on uncertainty this measurement method includes a statistical estimation of the measurement uncertainty. The following subclauses describe the set-up and test method. Because a combined method is used, the problem of separately performing site validation and antenna mast validation is solved. It is easy for calibration labs to implement, and the effort is reasonable because the procedure is applied for the following cases:

a) for a new and/or modified chamber and/or turntable;

b) if the receive antenna model is changed;

c) for each manufacturer and model of AUC.

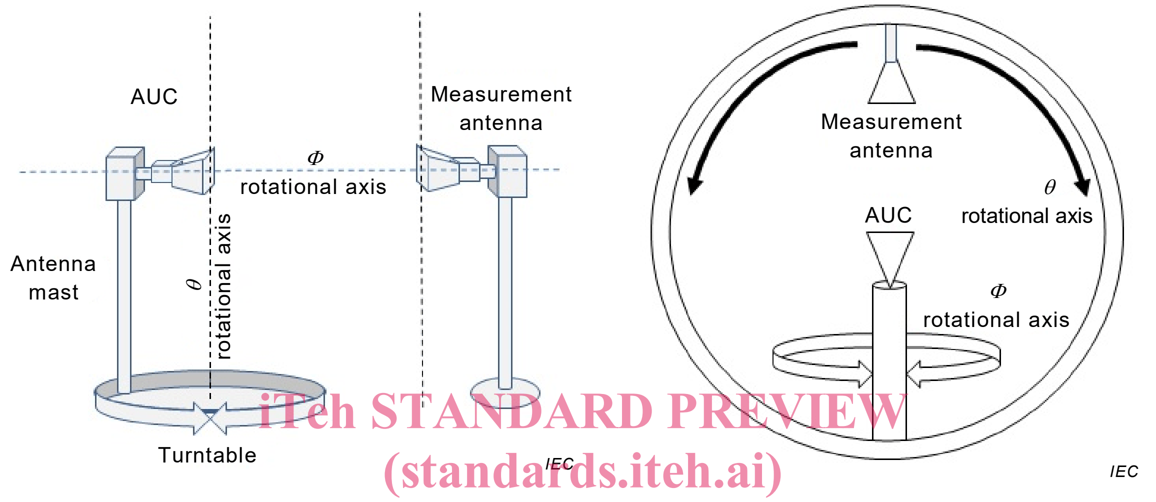
This method is similar to the method given in 5.3.3 of CISPR 16-1-5:2014.

I.2 Test set-up

In a typical test set-up, the receive or transmit antenna under test is mounted in front of a vertical mast placed on a turntable. A change between the E-plane and the H-plane is easily done by rotating the antenna by 90°.

For the purposes of these tests, two principal categories of positioning systems are defined based on known methods of performing spherical antenna pattern tests. These are the distributed-axis system and the combined-axis system.

Combined-axis systems mount the Φ-axis positioner on the θ-axis, as shown in Figure I.1 a), to rotate the AUC around two axes, while the distributed axis systems move the measurement antenna about the AUC on the Φ-axis positioner, as shown in Figure I.1 b). With the combined axis system the height is not critical but half the chamber height is recommended. With the distributed axis system the radius of the ring is determined by using the maximum size of the AUC and calculating the far-field criteria.

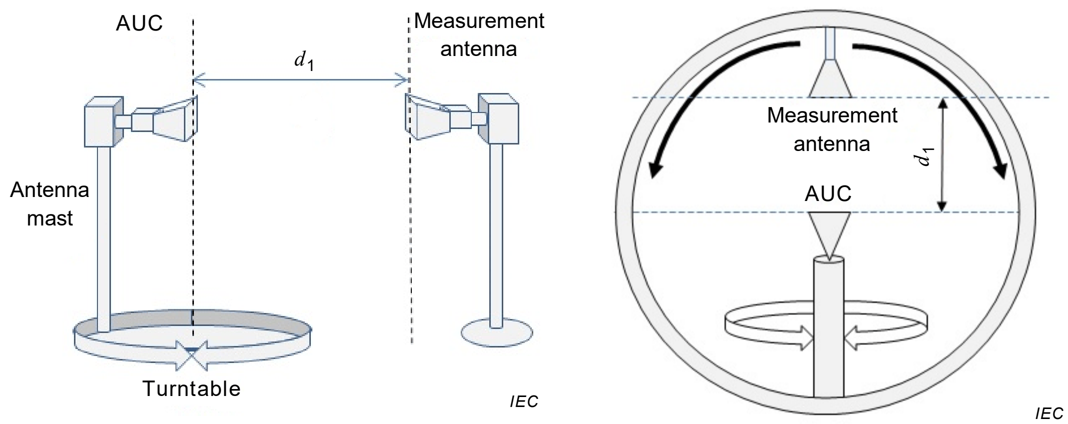


a) Combined axis system b) Distributed axis system

Figure I.1 – Typical set-up for antenna pattern measurement

Two distances are defined as follows:

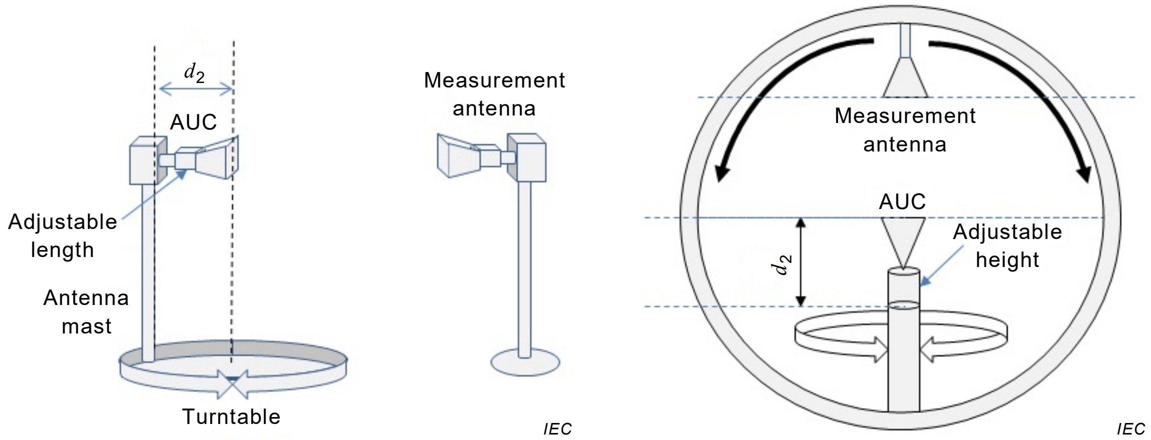
d_1 is the distance between the centre of the turntable and the reference point of the measurement antenna; a distance of 3 m or longer is recommended (see Figure I.2);



a) Combined axis system b) Distributed axis system

Figure I.2 − Definition of d_1

d_2 is the distance between the antenna mast and the reference point of the AUC (see Figure I.3); because only the antenna can be moved, and not the positioner. Adjustment of d_2 is possible using for example different length adaptors.



a) Combined axis system b) Distributed axis system

Figure I.3 – Definition of d_2

The AUC is the antenna mounted on the rotational positioner of the combined axis system and on the rotating pedestal for the distributed axis system. Only one of either system needs to be used.

For an element type antenna, see 7.5.2.1.

I.3 Test method

The test method is based on changing the phase condition of direct and reflected waves, similar to S_{VSWR} (see CISPR 16-1-4).

The antenna pattern is measured a total of 12 times while the distances d_1 and d_2 are varied as follows.

a) Influence of the antenna mast – with d_1 held constant, d_2 is increased in the following steps (see Figure I.4):

1) d_2 + 0,0 cm,
2) d_2 + 0,3 cm,
3) d_2 + 3,0 cm,
4) d_2 + 6,0 cm,
5) d_2 + 7,5 cm,
6) d_2 + 9,0 cm.

The spacing between d_2 positions above is unequal, i.e. similar to S_{VSWR}. The physical lower limit is defined by the lowest frequency used, at least $\lambda/4$.

NOTE The reference point and phase centre in this case mean the same thing. The phase centre can change as a function of frequency and has to be known for the application of the antenna, i.e. the antenna factor, to be valid. For LPDA antennas either the manufacturer's mark or the antenna midpoint for calibration is used. For DRG horn antennas the plane of the aperture is used.

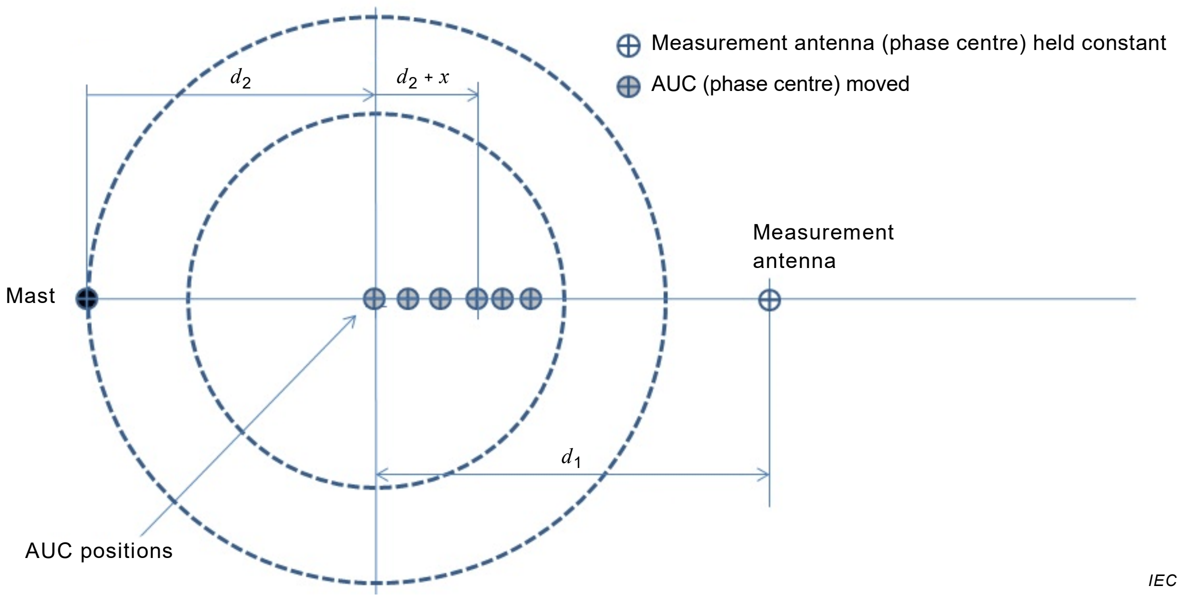


Figure I.4 – With d_1 held constant, d_2 is increased in x cm steps

b) Influence of the chamber – with d_2 held constant, d_1 is increased in the following steps (see Figure I.5):

1) d_1 + 0 cm,
2) d_1 + 2 cm,
3) d_1 + 10 cm,
4) d_1 + 18 cm,
5) d_1 + 30 cm,
6) d_1 + 40 cm.

The spacing between d_1 positions above is unequal. The distances listed above are equal to those used in measuring S_{VSWR}, so commercially available antenna positioners can be used for an automated procedure.

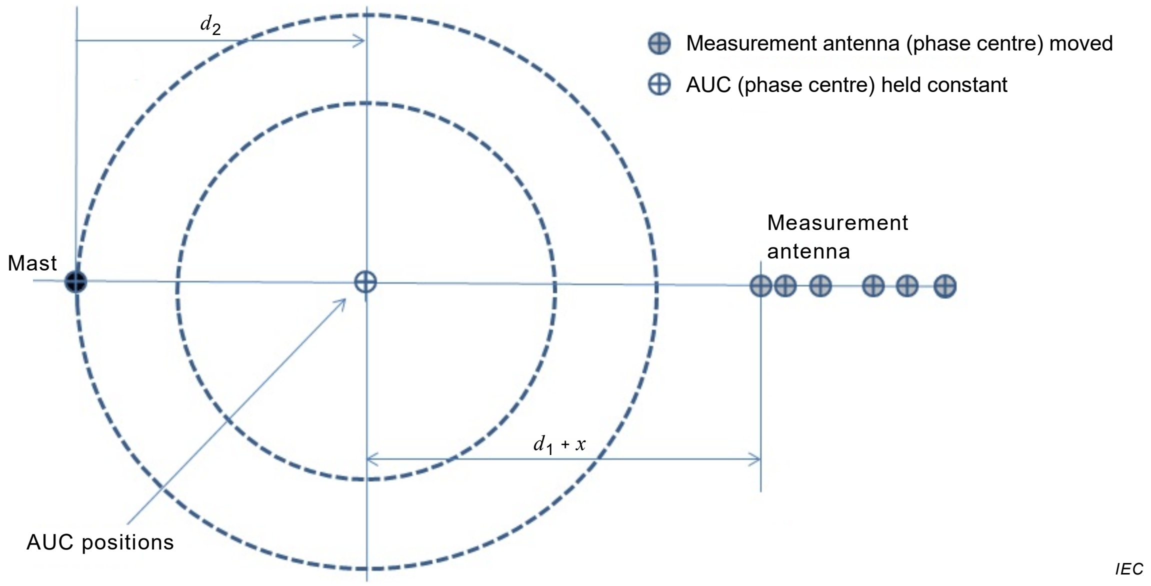


Figure I.5 – With d_2 held constant, d_1 is increased in x cm steps

When the change in d_2 causes the AUC to move away from the axis of rotation, the distance between the transmit and the receive antennas is dependent on the angle, and a distance correction is required (see Figure I.6 and Equation (I.1)).

To get an estimate for the measurement uncertainty contributions due to reflections of the test site and antenna positioner the standard deviations of combined and distributed systems are calculated separately from the measured antenna pattern. See Table I.2.

Measurements shall be performed at a single frequency in steps of 500 MHz or smaller. The turntable shall be stepped from 0° to 360° with a maximum angular resolution of 2°. The measurement at 360° shall be compared to the 0° value for completion of the pattern.

A radiation pattern correction is required for d_2 when the axes of both antennas do not coincide due to the turntable rotation (see Table I.1).

Due to the required correction of the received level and the angle – see Equation (I.3) and Figure I.6 – the angular grid is not equally spaced; see Table I.1. To solve this issue the pattern shall be recalculated to an angular resolution of 0,5° via linear interpolation at each frequency using dB scale values for pattern data. After this alignment the standard deviation shall be calculated.

Table I.1 – Correction of angle α for a distance of d_1 = 3 m (refer to Figure I.6)

α (°)	α_{corr} (°) x = 0 (cm)	α_{corr} (°) x = 0,3 (cm)	α_{corr} (°) x = 3 (cm)	α_{corr} (°) x = 6 (cm)	α_{corr} (°) x = 7,5 (cm)	α_{corr} (°) x = 9 (cm)
0	0,000	0,000	0,000	0,000	0,000	0,000
2	2,000	2,002	2,020	2,041	2,051	2,062
4	4,000	4,004	4,040	4,082	4,102	4,124
6	6,000	6,006	6,060	6,122	6,154	6,185
8	8,000	8,008	8,081	8,163	8,204	8,247
10	10,000	10,010	10,100	10,203	10,255	10,308
…	…	…	…	…	…	…
90	90,000	90,057	90,573	91,146	91,432	91,718
…	…	…	…	…	…	…
180	180,000	180,000	180,000	180,000	180,000	180,000
…	…	…	…	…	…	…
270	270,000	269,943	269,427	268,854	268,568	268,282
…	…	…	…	…	…	…
360	360,000	360,000	360,000	360,000	360,000	360,000

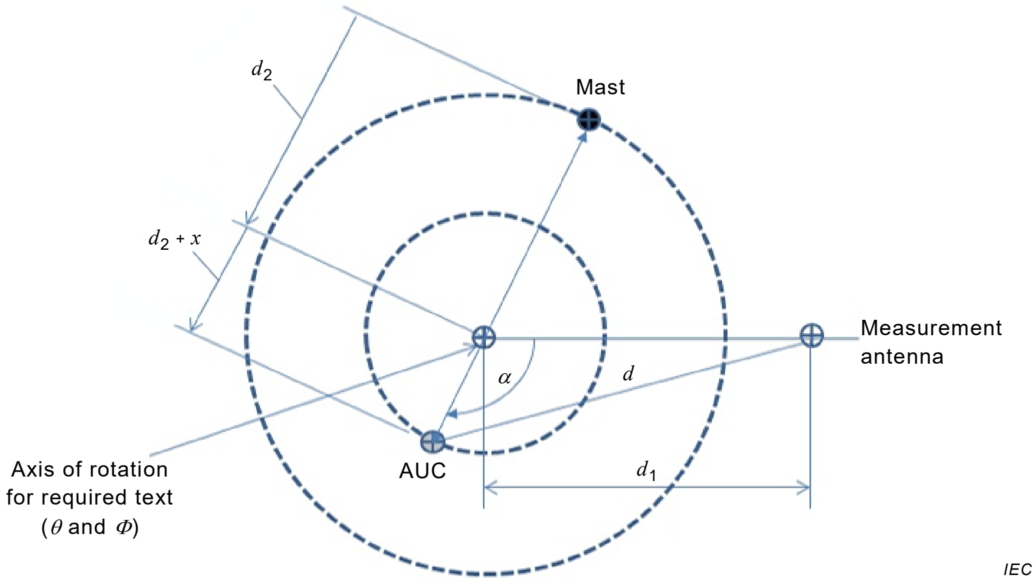


Figure I.6 – Distance and angle correction

The following equations support Figure I.6:

$$d^2 = d_1^2 + x^2 - 2d_1 x \cos\alpha \tag{I.1}$$

$$P_{\text{corr}} = P_{\text{meas}} + 20\lg\frac{d}{d_1} \tag{I.2}$$

$$\alpha_{\text{corr}} = \alpha + \arctan\left(\frac{x\sin\alpha}{d_1 - x\cos\alpha}\right) \tag{I.3}$$

I.4 Test report

The test report shall include a description of the facility, the test equipment used and the measurement uncertainty.

I.5 Uncertainty budget

An example uncertainty budget for antenna pattern measurement is provided in Table I.2.

Table I.2 – Example measurement uncertainty budget for antenna pattern measurement above 1 GHz

Source of uncertainty or quantity X_i	Value dB	Probability distribution	Divisor	Sensitivity	u_i dB
Repeatability of S_{21} value[a]	0,20	Normal	2	1	0,10
Reflections of site[b]	0,21	Normal	2	1	0,11
Reflections of positioner and cable[b]	0,35	Normal	2	1	0,18
Antenna height error[c]	0,1	Rectangular	$\sqrt{3}$	1	0,06
Antenna orientation error[d]	0,2	Rectangular	$\sqrt{3}$	1	0,12
Polarization mismatch[e]	0,02	Rectangular	$\sqrt{3}$	1	0,01
Combined standard uncertainty, u_c					0,27
Expanded uncertainty, U (k = 2)					**0,54**

This table is for 3 m distance; for other distances other values will need to be calculated.

NOTE Further guidance on uncertainty can be found in CISPR 16-4-2.

[a] The influence of the noise dominates the repeatability of S_{21} measurements on a network analyser. The number is determined by repeated measurements at several angular positions without turning the positioner between the measurements. The repeatability shall be checked at the main lobe position, a null and a side lobe position to get a reliable figure.

[b] The uncertainty associated with the reflections from positioner and site is determined by following procedure. If the uncertainty changes with frequency, the measurement estimation shall be done for proper frequency ranges.

1) Perform the measurement according to Clause I.3 by changing d_1 at the first frequency.
2) Calculate the standard deviation of these six traces for each angle.
3) Take the maximum value and fill it into the table (second line).
4) Perform the measurement according to Clause I.3 by changing d_2 at the first frequency.
5) Calculate the standard deviation of these six traces for each angle.
6) Take the maximum value and insert it into the table (third line).
7) Restart at a) with the next frequency.

[c] A typical value to place the antennas at the same height is 10 mm. Depending on the pattern of the antennas the uncertainty could be up to 0,1 dB.

[d] For precise alignment of the antennas, a laser based system is recommended. For high gain antennas alignment is more critical than for medium gain antennas. An uncertainty of 0,2 dB is estimated.

[e] Polarization mismatch uncertainty can be obtained using $\cos\phi$, where ϕ is an angular difference in polarization between transmit and receive antennas. For example, if the transmit and receive antennas are tilted by 2° in the opposite directions to each other, on the axes of their respective boresight directions, the polarization mismatch uncertainty becomes 0,02 dB [$= 20\lg\cos(2° \times 2)$].