

Methods of measurement on receiving antennas for satellite broadcast transmissions in the 12 GHz band —

Part 1: Electrical measurements on DBS receiving antennas

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- British Broadcasting Corporation
- British Educational Equipment Association
- British Radio and Electronic Equipment Manufacturers' Association
- British Telecommunications plc
- Consumers' Association
- Institution of Electrical Engineers
- International Consumer Electronics Association
- Radio, Electrical and Television Retailers' Association
- Radiocommunications Agency

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National foreword

This Part of BS EN 61114 has been prepared by Technical Committee EPL/12 and is the English language version of EN 61114-1:1993 *Methods of measurement on receiving antennas for satellite broadcast transmissions in the 12 GHz band — Part 1: Electrical measurements on DBS receiving antennas*, published by the European Committee for Electrotechnical Standardization (CENELEC). It is identical with IEC 1114-1:1992, published by the International Electrotechnical Commission (IEC).

It is anticipated that other parts of IEC Publication 1114 will be published as identical British Standards, subject to their harmonization by CENELEC.

This Part of BS EN 61114 defines the conditions and methods of measurement to be applied to receiving antennas for satellite broadcast transmissions in the 12 GHz band. The frequency ranges of the band are those defined by WARC BS-77 and RARC SAT-83. The receiving antenna constitutes the outdoor unit of a satellite receiver together with an SHF converter. Performance requirements are not specified.

Cross-references

Publications referred to	Corresponding British Standard
IEC (50)712:1992	BS 4727 <i>Glossary of electrotechnical, power, telecommunication, electronics, lighting and colour terms</i> Part 3 <i>Terms particular to telecommunications and electronics</i> Group 15:1992 <i>Antennas</i>
EN 61079-1:1993 (IEC 1079-1:1992)	BS EN 61079 <i>Methods of measurements on receivers for satellite broadcast transmissions in the 12 GHz band</i> Part 1:1995 <i>Radio-frequency measurements on outdoor units</i>

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, the EN title page, pages 2 to 26, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

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English version

Methods of measurement on receiving antennas for satellite broadcast transmissions on the 12 GHz band Part 1: Electrical measurements on DBS receiving antennas

(IEC 1114-1:1992)

Méthodes de mesure pour les antennes de
réception des émissions de radiodiffusion par
satellite dans la bande 12 GHz
Partie 1: Mesures électriques sur les antennes
de réception, des émissions de radiodiffusion
par satellite
(CEI 1114-1:1992)

Meßverfahren für Empfangsantennen für
Satelliten-Rundfunkübertragung im
12 GHz-Bereich
Teil 1: Elektrische Meßverfahren für
Satelliten-Empfangsantennen
(IEC 1114-1:1992)

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

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Foreword

The text of documents 12A(CO)152 and 152A, as prepared by sub-committee 12A: Receiving equipment, of IEC Technical Committee 12, Radiocommunications, was submitted to the IEC-CENELEC parallel vote in May 1991.

The reference document was approved by CENELEC as EN 61114-1 on 10 December 1991.

The following dates were fixed:

- latest date of publication of an identical national standard (dop) 1993-12-01
- latest date of withdrawal of conflicting national standards (dow) 1993-12-01

Annexes designated “normative” are part of the body of the standard. Annexes designated “informative” are given only for information. In this standard, Annex A, Annex C, Annex D and Annex E are informative, Annex B and Annex ZA are normative.

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1 Scope

This part of IEC 1114 applies to receiving antennas for satellite broadcast transmissions in the 12 GHz band. The frequency ranges of the band are those defined by WARC BS-77 and RARC SAT-83.

The object of this part is to define the conditions and methods of measurement to be applied. This part does not specify performance requirements.

The receiving antenna constitutes an outdoor unit of a satellite receiver together with an SHF converter. Methods of measurement of the SHF converter are described in Part 1 of IEC 1079.

In some measurements in this part it is assumed that the SHF converter will be removed from the antenna, leaving access to an RF port of the antenna.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of IEC 1114. At the time of publication of this standard, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this part of IEC 1114 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 50(712):1992, *International Electrotechnical Vocabulary (IEV) — Chapter 712: Antennas*.

IEC 169-15:1979, *Radio-frequency connectors — Part 15: R.F. coaxial connectors with inner diameter of outer conductor 4,13 mm (0,153 in) with screw coupling — Characteristic impedance 50 ohms (type SMA)*.

IEC 1079-1:1992, *Methods of measurement on receivers for satellite broadcast transmissions in the 12 GHz band — Part 1: Radio frequency measurements on outdoor units*.

WARC BS-77, *World Administrative Radio Conference for the Planning of the Broadcasting-Satellite Service (Geneva, 1977)*.

RARC SAT-83, *Regional Administrative Radio Conference for the Planning in Region 2 of the Broadcasting-Satellite Service (Geneva, 1983)*.

NOTE These two documents are available from the International Telecommunications Union (ITU).

3 General explanation of terms

For the purpose of this part of IEC 1114, the following definitions apply.

3.1

DBS receiving antenna

a small-sized SHF antenna intended for use in individual and collective reception of satellite broadcast signals

this part mainly applies to paraboloidal reflector antennas, which include offset paraboloidal reflector antennas, Cassegrain reflector antennas and other similar ones. However, it may also apply to planar array antennas

a paraboloidal reflector antenna usually comprises a main reflector, a primary radiator, a circular polarizer, an SHF converter, supporting structures for a primary radiator and pointing structures. The supporting structures, however, are not included in this part. A radome is also excluded

3.2

standard antenna

an antenna which is used as a gain reference for receiving antennas under test

3.3

source antenna

an antenna which is used as a transmitting antenna for measurements

4 General notes on measurements

4.1 General conditions

4.1.1 Introduction

Measurements should be carried out in accordance with the following conditions to ensure repeatable results.

4.1.2 Test site

Measurements shall be carried out at a facility where external radio interference and reflections from the ground and from surrounding structures have been minimized and their residual effects have been measured.

4.1.3 Environmental conditions

Under consideration.

4.1.4 Power supply

If an SHF converter is used as an integral part of the antenna, a power supply equivalent to the rated voltage of the converter shall be used. The fluctuation of the power supply voltage during the tests shall not exceed $\pm 2\%$.

4.1.5 Accuracy of measuring instruments

Requirements for the accuracy of measurements are not included in this part of IEC 1114 because they depend only on the purpose for which the measurements are required. The accuracy of the measuring instruments used, if known, shall either be stated as a percentage or in decibels, as appropriate. Alternatively, the precision class may be quoted as stated in relevant publications (under consideration).

4.1.6 Residual standing wave ratio (SWR) of test instruments

The residual SWR of the test instruments shall be less than 1,1 for measuring the antenna gain and the impedance matching and less than 1,5 for measuring the radiation pattern and the cross-polar pattern.

4.1.7 Stabilization period

Unless otherwise specified, measurements should be started once stabilization of the characteristics is obtained.

4.2 Test signal and test frequencies

Unless otherwise specified, the test signal shall be a c.w. signal and its frequency shall be the lowest, mid and highest frequencies in the 12 GHz band as specified by the standard of the country or countries for which the antenna under test was designed.

If there is interference at these frequencies, the test frequency can be shifted slightly to avoid disturbance.

If the characteristics of the antenna are strongly frequency-dependent, the measurements shall also be carried out at those frequencies where significant changes occur.

4.3 Arrangement of source and receiving antennas

4.3.1 Antenna distance

The distance R between the aperture planes of the source antenna and the antenna under test shall satisfy the following equations:

$$R > 2D_1^2/\lambda \quad (\text{m})$$

$$R > D_1 D_2 / 0,32 \lambda \quad (\text{m})$$

where

D_1 is the largest aperture diameter of the antenna under test (m);

D_2 is the largest aperture diameter of the source antenna (m);

λ is the free space wavelength at the test frequency (m).

4.3.2 Spatial variation of the field

The spatial variation of the field at the aperture plane of the antenna under test shall be minimized. The variation in the power received from a standard antenna shall be within $\pm 0,5$ dB on the aperture plane of the antenna. The method of measurement of the variation is described in 5.1.

If a larger variation is observed, the position and height of the antenna should be changed to obtain the value specified above.

4.3.3 Environmental conditions for G/T measurement

When the measurement of figure of merit G/T is made (see 5.6), the following conditions shall be maintained:

- the sky shall be clear;
- there shall be no noise sources such as the sun, a satellite, buildings and trees within 10° around the beam axis of the antenna under test.

4.4 Other conditions

If an SHF converter is used, the field intensity at the aperture plane shall be chosen so as not to overload the converter. The overload level of the converter is described in IEC 1079-1.

4.5 Measuring instruments

4.5.1 Standard antennas

A right-hand circularly polarized antenna and a left-hand circularly polarized antenna which have the same nominal gain of more than 20 dB shall be provided as standard antennas.

An example of a suitable antenna is described in Annex A.

The gain shall be calibrated at the test frequencies.

NOTE A linearly polarized horn antenna can be used as the standard antenna. However, the accuracy of the gain measurement may be slightly reduced.

4.5.2 Source antennas

A right-hand circularly polarized antenna and a left-hand circularly polarized antenna shall be provided as the source antennas. These antennas shall have the same nominal characteristics and a cross-polarization discrimination of more than 30 dB.

These values can be confirmed by the standard antenna (see Annex B).

4.5.3 Variable attenuator

A waveguide type precision attenuator having a variable range of 30 dB with an accuracy of better than $\pm 0,2$ dB is required.

4.5.4 Directional coupler

The directional coupler should have an SWR of less than 1,05, a coupling factor of about 10 dB and a directivity of better than 36 dB.

5 Methods of measurement

5.1 Calibration of field intensity

5.1.1 Introduction

Prior to measuring the characteristics of the antenna under test, calibration of the field intensity at the aperture plane of the antenna shall be carried out using a standard antenna.

5.1.2 Method of measurement

The arrangement of the test equipment is shown in Figure 1.

The measurement shall be made using the following procedure:

- a) set the source antenna and the antenna under test according to the measuring conditions described in clause 4;
- b) replace the antenna under test with the standard antenna;
- c) transmit the test signal from the source antenna at one of the test frequencies and move the standard antenna horizontally and vertically on the plane where the aperture plane of the antenna under test was located, and measure the received power at each point at a distance of two to four times the wavelength. The difference between the maximum and minimum measured values shall not exceed 1 dB. Then, calculate the average value from the measured values and note it as P_{HA} ;
- d) place the standard antenna on a plane in which the aperture of the antenna under test is included. The distance between the centre of the antenna under test and that of the standard antenna shall be greater than one and a half times the diameter of the antenna under test. Then, measure the received power and note it as P_H ;
- e) calculate the difference between P_H and P_{HA} and note it as:

$$\Delta\alpha = P_H - P_{HA}$$
- f) repeat b) to e) at other test frequencies.

5.2 Antenna gain

5.2.1 Introduction

Antenna gain is defined as the ratio, generally expressed in decibels, of the received power of an antenna which is oriented to a given direction in a uniform field of given polarization to that of a polarization-matched isotropic lossless antenna in the same field.

Unless otherwise specified, the direction shall be given so as to obtain maximum received power.

NOTE The term "antenna gain" is identical to "partial gain" as defined in IEV 712-02-44.

5.2.2 Method of measurement

The arrangement of the test equipment is shown in Figure 2.

Measurement shall be made using the following procedure:

- a) set the source antenna and the antenna under test according to the measuring conditions described in clause 4;
- b) locate the standard antenna at the same location described in 5.1.2 d);
- c) transmit a signal from the source antenna at one of the test frequencies, and set the received power at an appropriate level by adjusting the variable attenuator, and note the attenuation as L_o (dB);
- d) disconnect the receiver from the standard antenna and connect it to the antenna under test, and set the received power at the same level as that obtained in c) by adjusting the variable attenuator, and note the attenuation as L (dB);
- e) calculate the gain G by the following equation:

$$G = G_s + L - L_o + \Delta\alpha \text{ (dB)}$$
 where G_s is the antenna gain of the standard antenna;
- f) P_H should be monitored before and after the gain measurement, and its variation should not exceed 0,2 dB;
- g) Repeat b) to f) at other test frequencies.

NOTE If there are reflections in the test range, an alternative method of antenna gain measurement method may be applied (see Annex C).

5.2.3 Presentation of results

The results shall be listed in tables or presented graphically. A graphical example is shown in Figure 3.

5.3 Impedance matching

5.3.1 Introduction

This test measures the impedance matching of the antenna under test which should preferably be expressed in terms of the return loss ratio of the antenna, i.e. the amplitude of the reflection coefficient, in decibels; it may alternatively be expressed in terms of the standing wave ratio (SWR).

5.3.2 Method of measurement

The measurement shall be made by installing the antenna under test in an anechoic chamber or by directing its beam axis to the sky. The arrangement of the test equipment is shown in Figure 4.

Measurement shall be carried out as follows:

- calibrate the X axis of the X-Y recorder for the range of the frequency band by a sweep signal generator and the receiver;
- terminate the output port of the directional coupler with a short-circuit terminator, and measure the output level of the coupling port by the receiver and set it as 0 dB. Then sweep the frequency from the lowest to the highest frequency in the 12 GHz band as specified in 4.2, and calibrate the Y axis for the output level in the range of 0 dB to – 30 dB at the test frequencies, with the aid of the attenuator;
- replace the terminator with the antenna under test, and read the plot of the Y axis and note it as – L (dB). This will be the return loss ratio of the antenna.

NOTE 1 The impedance matching measurement can be made with a network analyzer.

NOTE 2 This method cannot be applied to the measurement of the receiving antenna including an SHF converter.

5.3.3 Presentation of results

The results shall be listed in a table or presented graphically. A graphical example is shown in Figure 5.

When the impedance matching is required to be expressed in terms of SWR, SWR can be calculated by the following equation:

$$\text{SWR} = (1 + 10^{-L/20}) / (1 - 10^{-L/20})$$

5.4 Radiation pattern

5.4.1 Introduction

The radiation pattern indicates the distribution of the ratio of the antenna gain as a function of the antenna direction to the maximum antenna gain on a given plane.

5.4.2 Method of measurement

The arrangement of the test equipment is shown in Figure 6.

Measurement shall be made using the following procedure:

- set the centre of rotation of the antenna under test at its aperture centre. If it is difficult to set the centre of rotation at the aperture centre, the difference between both the centres should be minimized;
- set the beam axis of the antenna under test as 0° of the X-axis;
- transmit a signal at one of the test frequencies, and set the received power at an appropriate level by adjusting the attenuator and note it as 0 dB. Then calibrate the Y axis of the X-Y recorder in the range of 0 dB to – 50 dB;
- set the pointers of the X axis and the Y axis at 0° and 0 dB, respectively by readjusting the direction and the signal level;
- rotate the antenna from – 180° to + 180° horizontally, and plot the curve of the received power relative to the rotating angle by the recorder;
- expand the scale of the X axis of the recorder by a factor of approximately ten, and rotate the antenna from – 18° to + 18° and plot the curve again;
- repeat d) to f) at other test frequencies.

NOTE 1 If there are reflections in the test range, an exact radiation pattern cannot be obtained. The pattern, however, can be measured with much improved accuracy even under these conditions by a method utilizing a network analyzer and a sweep signal generator (see Annex D).

NOTE 2 The pattern measurement plane should coincide with the geostationary orbit plane. Patterns may be measured in four planes, each intersecting the axis of the antenna main beam. Two planes should be orthogonal and the other two planes should be at 45° to the first two. If this measurement is used, it should be clearly stated in the measured results.

5.4.3 Presentation of results

The results shall be presented graphically. An example is shown in Figure 7.

5.5 Cross-polar radiation pattern

5.5.1 Introduction

The cross-polar radiation pattern indicates the distribution of the ratio of the antenna gain as a function of the antenna direction in the polarization orthogonal to that for which the antenna was designed, to the maximum antenna gain on a given plane.

5.5.2 Method of measurement

The arrangement of the test equipment is shown in Figure 8.

Measurement shall be made using the following procedure:

- set the antenna under test and calibrate the X-Y recorder as described in 5.4.2 a) to d);