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European Standard (Telecommunications series)

Fixed Radio Systems;
Characteristics and requirements
for point-to-point equipment and antennas;
Part 4-1: System-dependent requirements for antennas

Reference

REN/ATTM-04008

Keywords

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Contents

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Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM), and is now submitted for the ETSI standards One-step Approval Procedure.

The present document is part 4-1 of a multi-part deliverable. Full details of the entire series can be found in part 1 [3].

Proposed national transposition dates	
Date of latest announcement of this EN (doa):	3 months after ETSI publication
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Introduction

The purpose of the present document is to define antenna parameters, which are relevant to Fixed Radio Systems (FRS), including those considered essential for conformity to the R&TTE Directive [1]. Limits are set out in EN 302 217-4-2 [4].

Additional parameters appropriate to system implementation may be subject to agreement between the equipment purchaser and supplier. Further guidance is provided in annex B.

1 Scope

The present document summarizes all requirements for single main beam, linear polarization, directional antennas to be adopted in conjunction with Point-to-Point (PP) systems operating in the frequency range 1 GHz to 86 GHz.

Single polarization antennas, dual polarization antennas, dual band/single polarized antennas and dual band/dual polarization antennas are considered.

Description and limits for parameters relevant to essential requirements under article 3.2 of the R&TTE Directive [1] are given in EN 302 217-4-2 [4].

For other parameters and general information that does not affect the R&TTE Directive [1] "essential requirements" mentioned above, description and limits are set out in the present document.

There are a number of different antenna types for various applications, the principles by which they are classified are given in clause 5.

The present document does not cover aspects related to test procedures and test conditions, which are covered by the scope of EN 301 126-3-1 [2].

Guidance on the definition of radio parameters relevant to the essential requirements under article 3.2 of the R&TTE Directive [1] for DFRS may be found in TR 101 506 [i.1].

2 References

References are either specific (identified by date of publication and/or edition number or version number) or non-specific.

- For a specific reference, subsequent revisions do not apply.
- Non-specific reference may be made only to a complete document or a part thereof and only in the following cases:
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  - for informative references.

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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

[1] Directive 1999/5/EC of the European Parliament and of the Council of 9 March 1999 on radio equipment and telecommunications terminal equipment and the mutual recognition of their conformity (R&TTE Directive).

[2] ETSI EN 301 126-3-1: "Fixed Radio Systems; Conformance testing; Part 3-1: Point-to-Point antennas; Definitions, general requirements and test procedures".

[3] ETSI EN 302 217-1: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 1: Overview and system-independent common characteristics".

[4] ETSI EN 302 217-4-2: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4-2: Harmonized EN covering essential requirements of Article 3.2 of R&TTE Directive for antennas".

[5] IEC 60154-1: "Flanges for waveguides. Part 1: General requirements".

[6] IEC 60154-2: "Flanges for waveguides. Part 2: Relevant specifications for flanges for ordinary rectangular waveguides".

[7] IEC 60169-1: "Radio-frequency connectors. Part 1: General requirements and measuring methods".

2.2 Informative references

The following referenced documents are not essential to the use of the present document but they assist the user with regard to a particular subject area**.** For non-specific references, the latest version of the referenced document (including any amendments) applies.

[i.1] ETSI TR 101 506: "Fixed Radio Systems; Generic definitions, terminology and applicability of essential requirements under the article 3.2 of 1999/05/EC Directive to Fixed Radio Systems".

[i.2] ETSI EN 302 217-2-2: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2-2: Harmonized EN covering essential requirements of Article 3.2 of R&TTE Directive for digital systems operating in frequency bands where frequency co-ordination is applied".

[i.3] ETSI TR 102 243-1: "Fixed Radio Systems; Representative values for transmitter power and antenna gain to support inter- and intra-compatibility and sharing analysis; Part 1: Digital point-to-point systems".

[i.4] ETSI EN 302 217-2-1: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2-1: System-dependent requirements for digital systems operating in frequency bands where frequency co-ordination is applied".

[i.5] ITU-R Recommendation F.699: "Reference radiation patterns for fixed wireless system antennas for use in coordination studies and interference assessment in the frequency range from 100 MHz to about 70 GHz".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in EN 302 217-1 [3] apply.

3.2 Symbols

For the purposes of the present document, the symbols given in EN 302 217-1 [3] apply.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in EN 302 217-1 [3] apply.

4 Frequency bands

The present document defines the characteristics and requirements of antennas in the frequency range from 1 GHz to 86 GHz.

For technical commonalities that range is here divided into sub-ranges as follows:

Range 0: 1 GHz to 3 GHz;

Range 1: 3 GHz to 14 GHz;

Range 2: 14 GHz to 20 GHz;

Range 3: 20 GHz to 24 GHz;

Range 4: 24 GHz to 30 GHz;

Range 5: 30 GHz to 47 GHz;

Range 6: 47 GHz to 66 GHz;

Range 7: 66 GHz to 86 GHz.

5 Classification of antennas

Antenna classification presented in the present document is based on RPE and XPD parameters.

5.1 Templates for definition of Radiation Pattern Envelope (RPE) classes

The RPE directional characteristic (co-polar and cross-polar) impacts the interference situation in the network planning and a trade-off between a highly demanding RPE and the cost/size/weight of the antennas, compatible with the constraints given by present and future networks is then advisable.

With respect to the Radiation Pattern Envelope (RPE), four classes (RPE classes 1 to 4) have been identified according maximum co-polar limit templates for any actual RPE mask in significant range of off-axis azimuth angles. The templates for subdivision in those classes are also depending on given frequency ranges of operation according to figures 1 to 3 and table 1.

Figures 1 to 3 are intended only as templates for defining subdivision of antennas in directivity classes; actual limits options for declaration of conformance to essential requirements under article 3.2 of the R&TTE Directive [1] are defined only in EN 302 217-2-2 [i.2].

When more than one actual standardized RPE falls within the same class template, a sub-class indicative (A, B, C, etc.) will be used according their more demanding RPE limit in angles closer to the intended direction.

NOTE: Figures 1 to 3 report limit templates for any actual RPE mask of classes 2, 3 and 4 antennas; class 1 antennas are defined as those which actual RPE mask exceeds class 2 limit template.

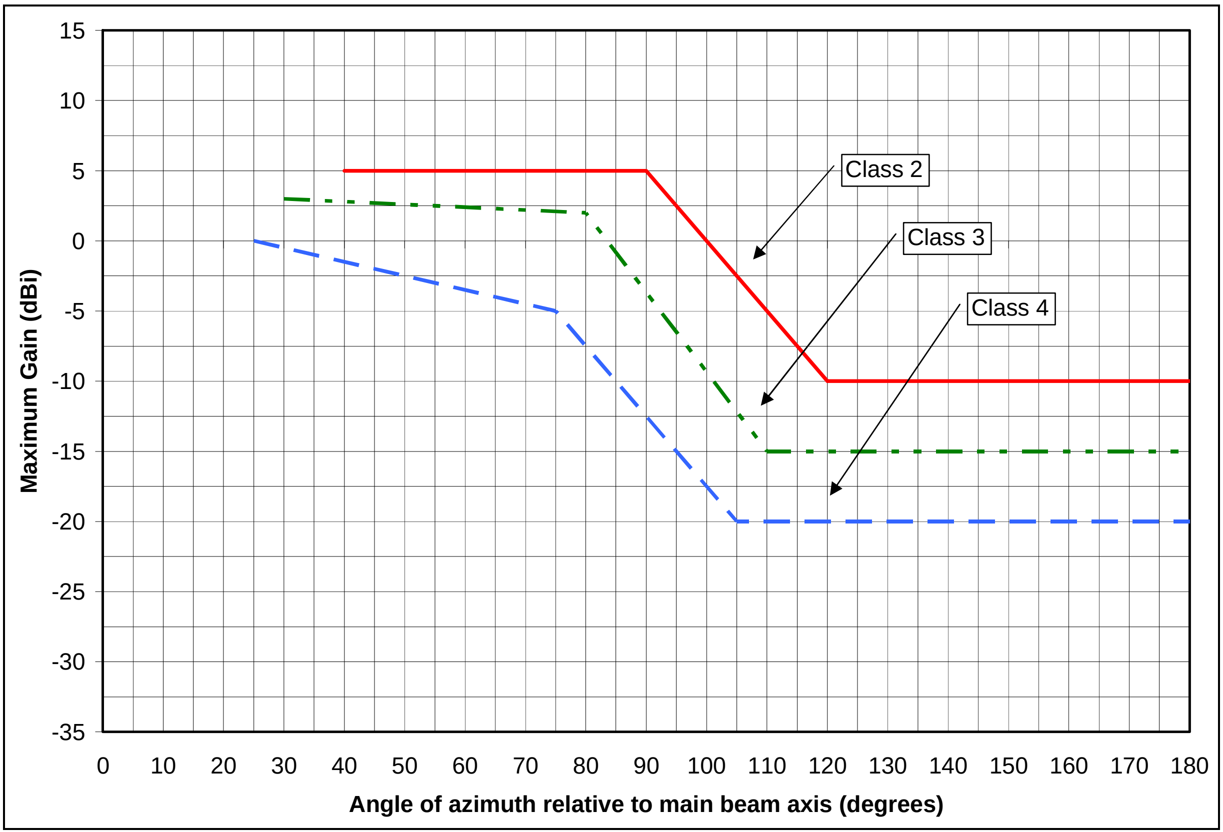


Figure 1: Co-polar limit templates for actual RPE masks of antenna classes in the range 1 GHz to 3 GHz (see table 1)

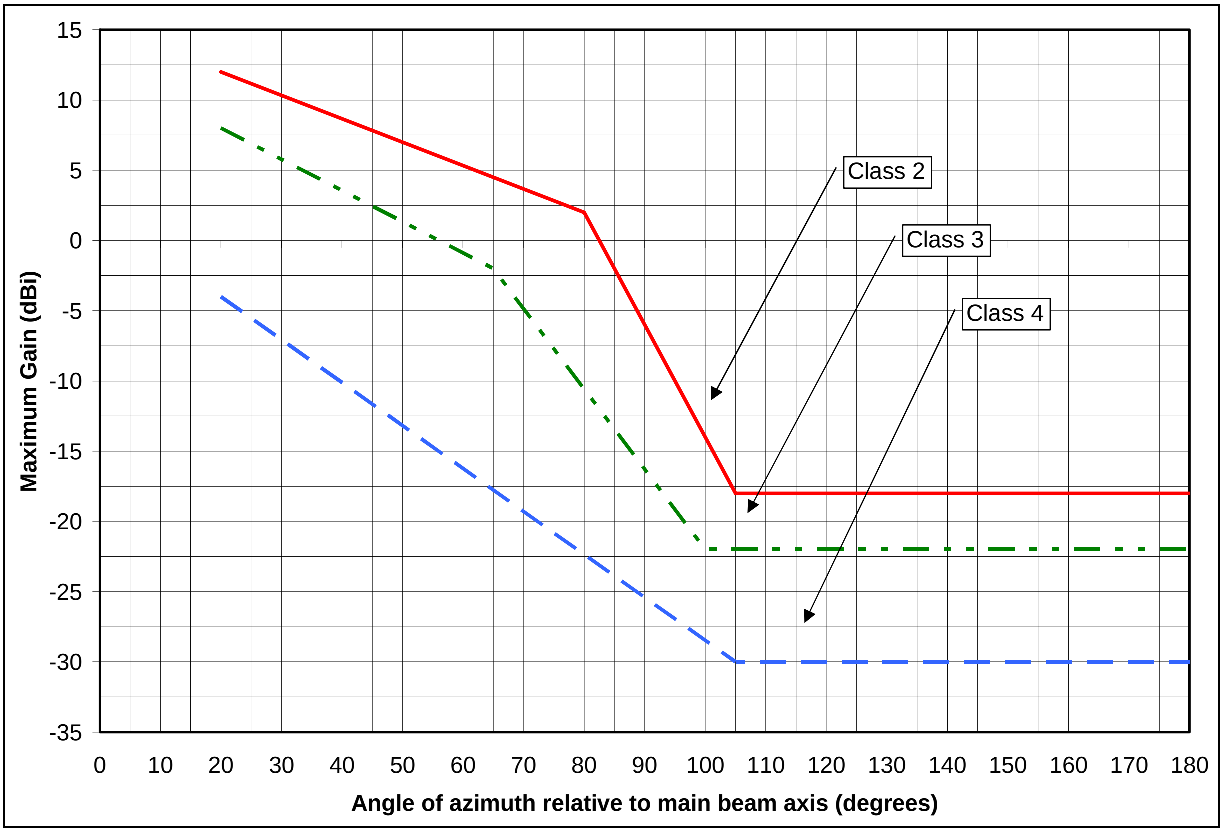


Figure 2: Co-polar limit templates for actual RPE masks of antenna classes in the range 3 GHz to 30 GHz (see table 1)

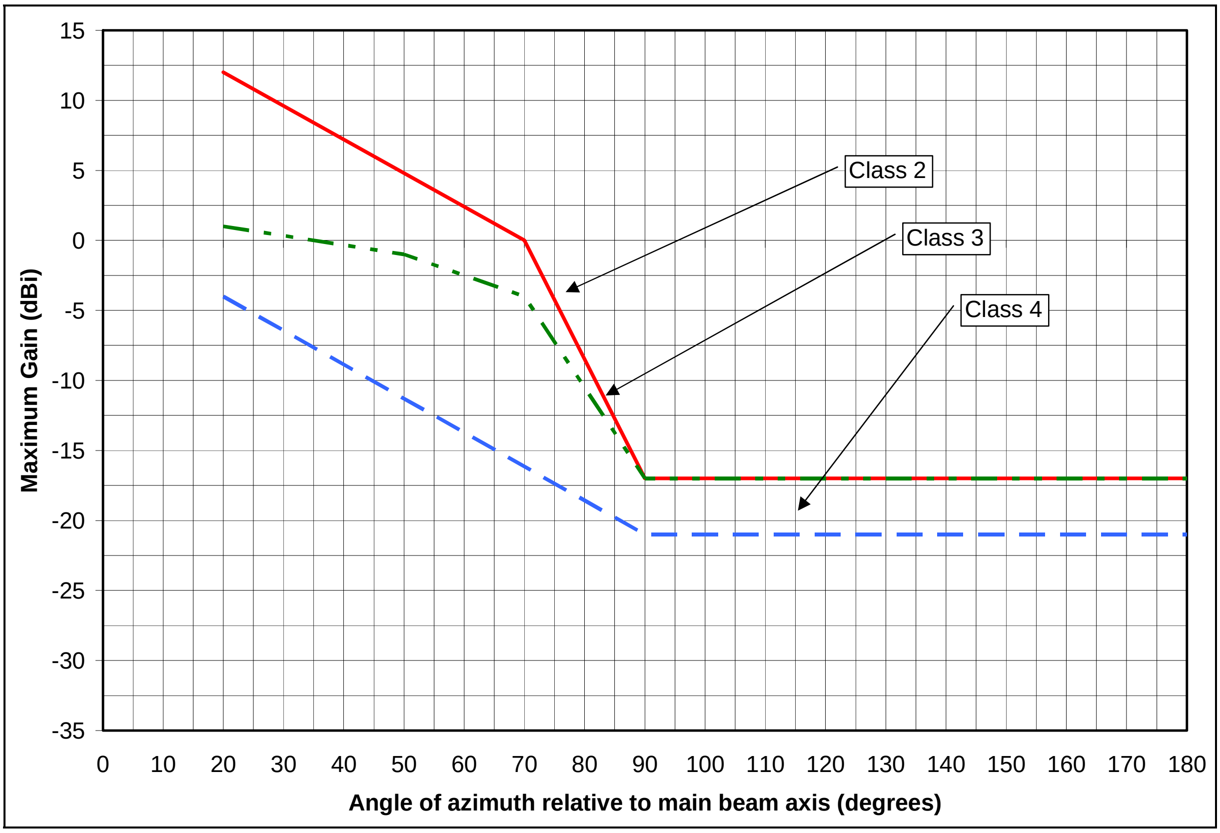


Figure 3: Co-polar limit templates for actual RPE masks of antenna classes in the range 30 GHz to 66 GHz (see table 1)

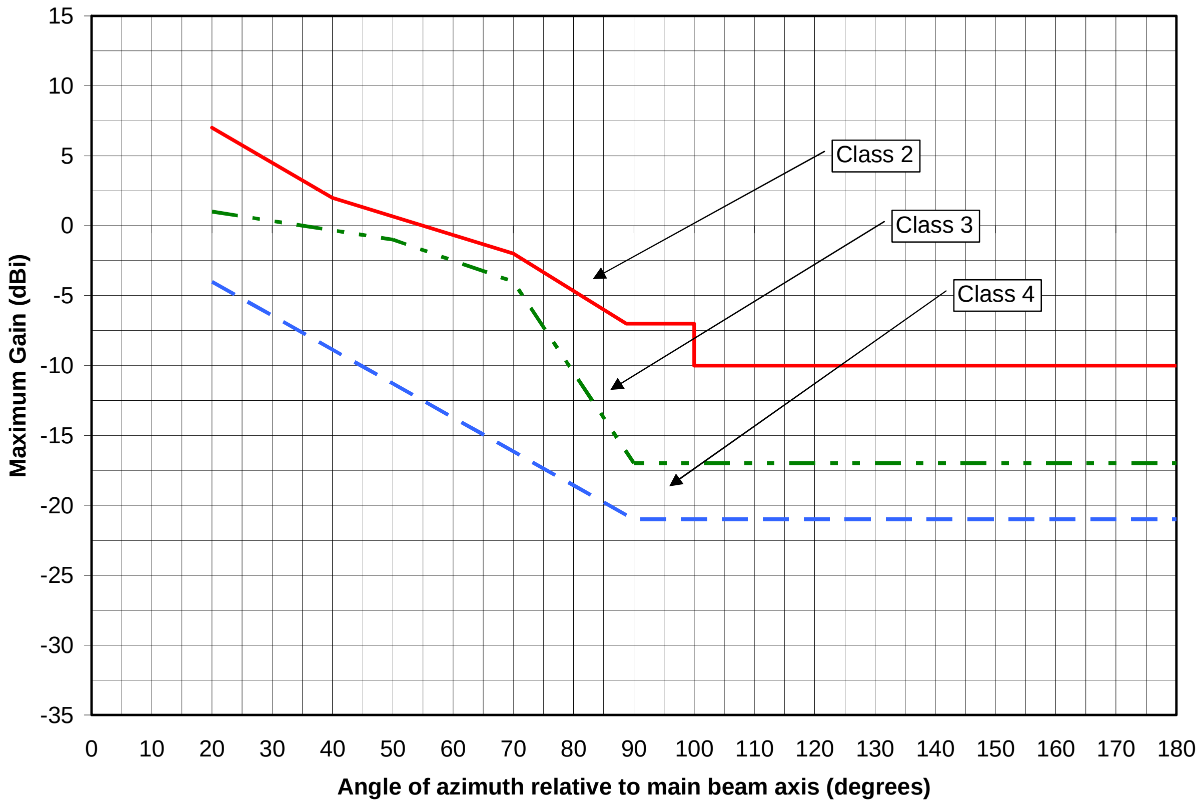


Figure 4: Co-polar limit templates for actual RPE masks of antenna classes in the range 66 GHz to 86 GHz (see table 1)

Table 1: Corner points of co-polar limits for actual RPE masks (see figures 1, 2 3 and 4)

RPE classes (see note 1)	Co-polar maximum limit templates for actual RPEs							
	Range 1 GHz to 3 GHz (see note 2)		Range 3 GHz to 30 GHz		Range 30 GHz to 66 GHz (see note 3)		Range 66 GHz to 86 GHz	
	Azimuth angle (°)	Maximum gain (dBi)	Azimuth angle (°)	Maximum gain (dBi)	Azimuth angle (°)	Maximum gain (dBi)	Azimuth angle (°)	Maximum gain (dBi)
2	40	5	20	12	20	12	20	7
	90	5	80	2	70	0	40	2
	120	-10	105	-18	90	-17	70	-2
	180	-10	180	-18	180	-17	88,75	-7
							100	-7
							100	-10
							180	-10
3	30	3	20	8	20	1	20	1
	80	2	65	-2	50	-1	50	-1
	110	-15	100	-22	70	-4	70	-4
	180	-15	180	-22	90	-17	90	-17
					180	-17	180	-17
4	25	0	20	-4	20	-4	20	-4
	75	-5	105	-30	90	-21	90	-21
	105	-20	180	-30	180	-21	180	-21
	180	-20						
NOTE 1: Class 1 antennas are defined as those which actual RPE exceeds class 2 template limit. NOTE 2: In EN 302 217-4-2 [4], no specific class 4 antenna RPE is defined for this frequency range; the corresponding limit template in table 1 is set for possible future use. NOTE 3: In EN 302 217-4-2 [4], no specific class 4 antenna RPE is defined for the frequency range 47 GHz to 66 GHz; the corresponding limit template in table 1 is set for possible future use.								

5.2 Cross-Polar Discrimination (XPD) categories

The XPD characteristics also have impact on frequency planning (e.g. minimum angle of nodal frequency reuse of cross polarized carriers) but also on the link performance (e.g. when CCDP or ACAP operation is foreseen for systems using high sensitive modulation formats).

With respect to cross-Polar Discrimination (XPD), three XPD performance categories (XPD categories 1 to 3) have been identified (refer to EN 302 217-4-2 [4]):

- XPD category 1: those antennas required to have standard cross-polar discrimination.
- XPD category 2: those antennas required to have high cross-polar discrimination.
- XPD category 3: those antennas required to have high cross-polar discrimination through an extended angular region.

6 Electrical characteristics

6.1 Radiation Pattern Envelope (RPE)

Co-polar and Cross-polar RPEs are relevant to the essential parameters under article 3.2 of the R&TTE Directive [1] and are stated in EN 302 217-4-2 [4].

NOTE 1: In bands where frequency co-ordination is not applied, cross-polar RPE is not considered relevant to essential requirements for R&TTE Directive [1] conformance, even if the antenna is actually dual polarized. Values are still given in EN 302 217-4-2 [4] but should be considered for reference purposes only. For definition of co-ordination in frequency bands, refer to definitions in EN 302 217-1 [3].

NOTE 2: RPEs are standardized as absolute worst-case envelope to be 100 % met by for conformance declaration purpose only. In addition, RPE masks, standardized in EN 302 217-4-2 [4] are not defined for angles close to the bore-sight direction. Therefore, information on typical main beam pattern and RPEs for common circularly-symmetric antenna types may be found in annex C.

In bands above 3 GHz, the RPEs proposed in EN 302 217-4-2 [4] are only of classes 2 or higher; class 1 antennas in those bands are no longer considered suitable for essential requirements under article 3.2 of the R&TTE within the European Community. Rationale is the fact that the increasing demand of spectrum in European Countries discourages the use of less demanding antenna RPEs. However, it is recognized that ETSI ENs have worldwide relevance and therefore, in other countries, there might be applications in lower density radio networks that justify a different trade-off in terms of performance and cost. Therefore, for such purposes in bands above 3 GHz, class 1 antenna RPEs are standardized in annex A.

6.2 Cross-Polar Discrimination (XPD)

XPD is relevant to the essential parameters under article 3.2 of the R&TTE Directive [1] and required values are defined in EN 302 217-4-2 [4].

NOTE: In bands where frequency co-ordination is not applied, XPD is not considered an essential requirement for R&TTE Directive [1] conformance, even if the antenna is actually dual polarized. Values are still given in EN 302 217-4-2 [4] but should be considered for reference purposes only. For definition of co-ordination in frequency bands, refer to definitions in EN 302 217-1 [3].

6.3 Antenna gain

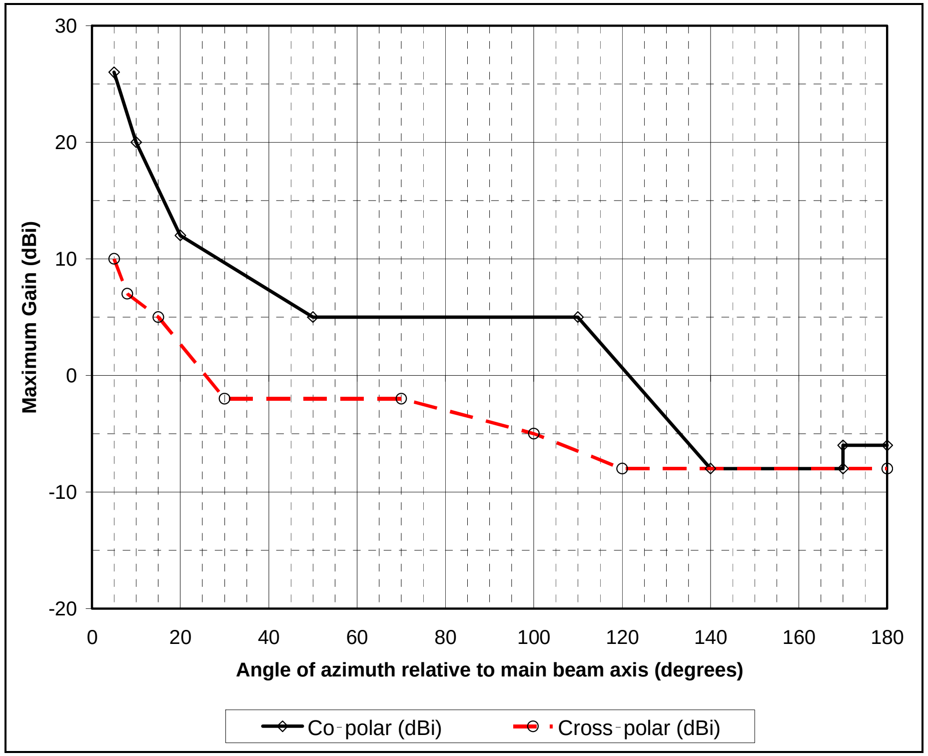
Antenna gain is relevant to the essential parameters under article 3.2 of the R&TTE Directive [1] and related requirements are defined in EN 302 217-4-2 [4].

Representative values for antenna gain and antenna diameter are provided for guidance in draft TR 102 243-1 [i.3] to support inter and intra-compatibility and sharing analysis.

NOTE: Regarding the antenna gain, it is here considered that only the declared gain is relevant to essential requirements for R&TTE Directive [1] article 3.2. Minimum gain requirement might be only a "National Interface" issue relevant to article 4.1 as long as it relates to off-axis E.I.R.P. limitation. Annex C gives some practical background on the impact and evaluation of typical gain for conventional and most popular circular symmetrical (parabolic) antennas; however, this does not preclude that other antenna types are applicable, provided that they met the specifications set in the present document.

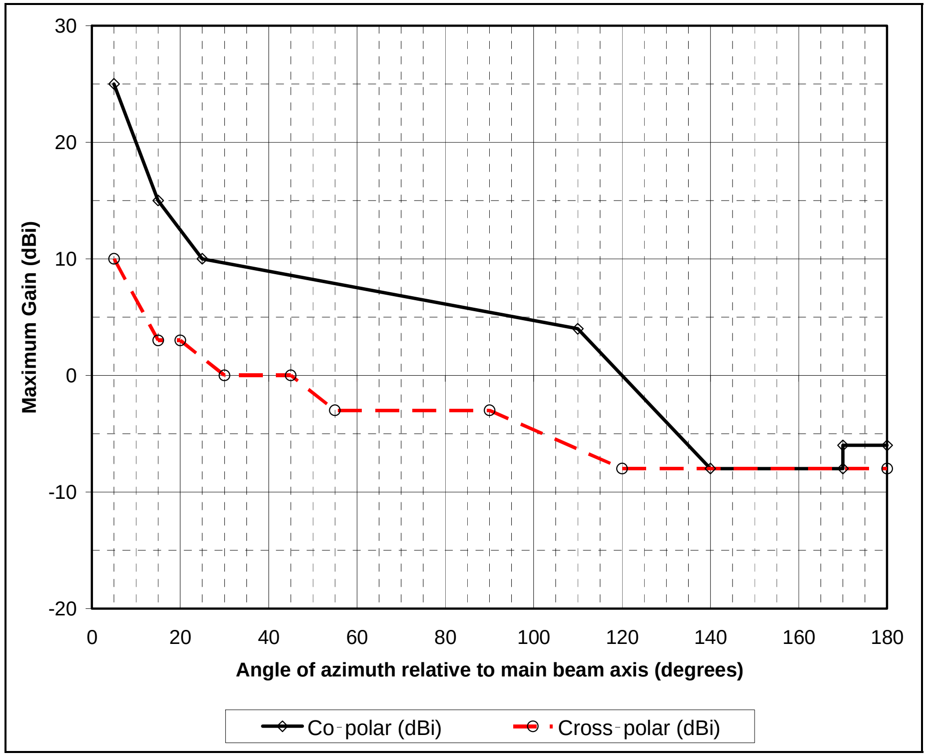
Annex A (normative): Standardized Radiation Pattern Envelopes for class 1 antennas in bands 3 GHz to 86 GHz

Standardized class 1 RPE in bands from 3 GHz to 86 GHz are reported in figures A.1 to A.7.



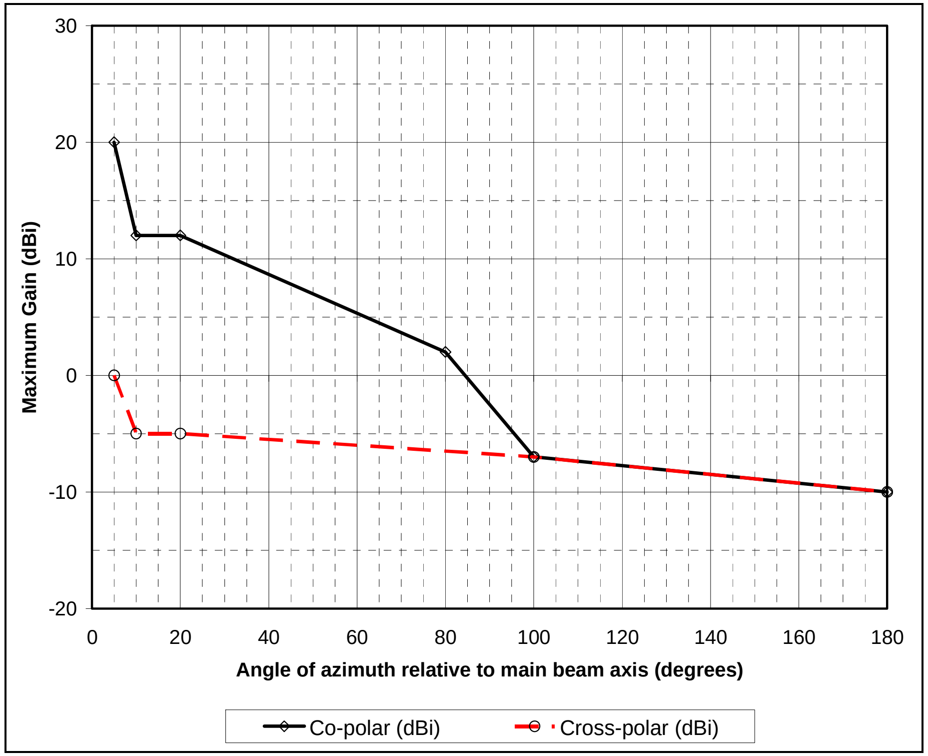
Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	26	5	10
10	20	8	7
20	12	15	5
50	5	30	-2
110	5	70	-2
140	-8	100	-5
170	-8	120	-8
170	-6	180	-8
180	-6		

Figure A.1: RPEs for class 1 antennas in the frequency range 3 GHz to 14 GHz



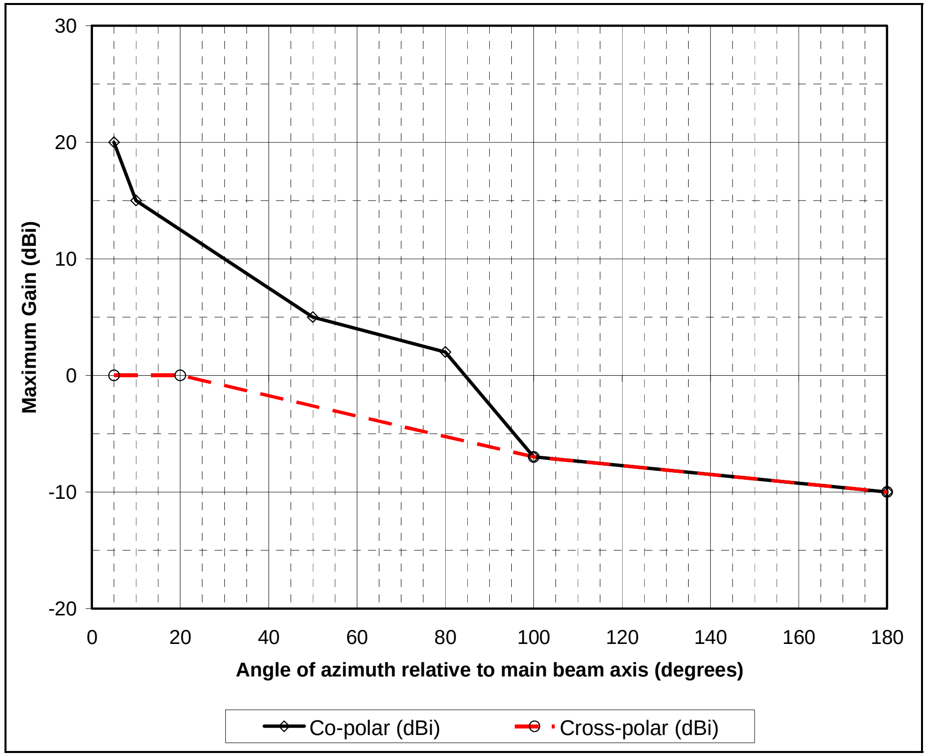
Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	25	5	10
15	15	15	3
25	10	20	3
110	4	30	0
140	-8	45	0
170	-8	55	-3
170	-6	90	-3
180	-6	120	-8
		180	-8

Figure A.2: RPEs for class 1 antennas in the frequency range 14 GHz to 20 GHz



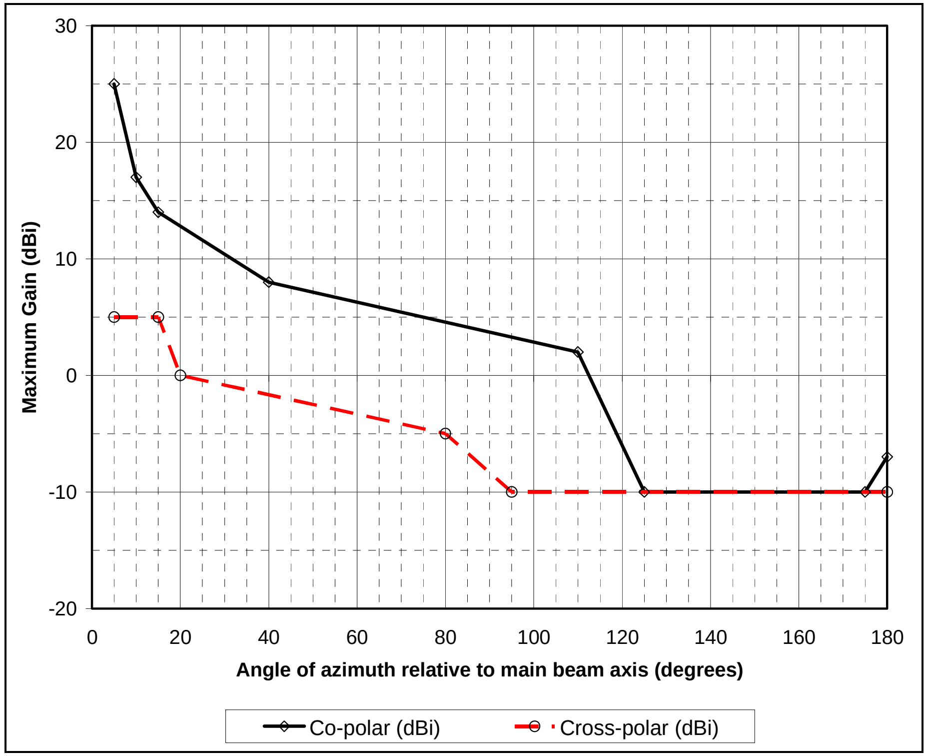
Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	20	5	0
10	12	10	-5
20	12	20	-5
80	2	100	-7
100	-7	180	-10
180	-10		

Figure A.3: RPEs for antennas class 1 in the frequency range 20 GHz to 24 GHz



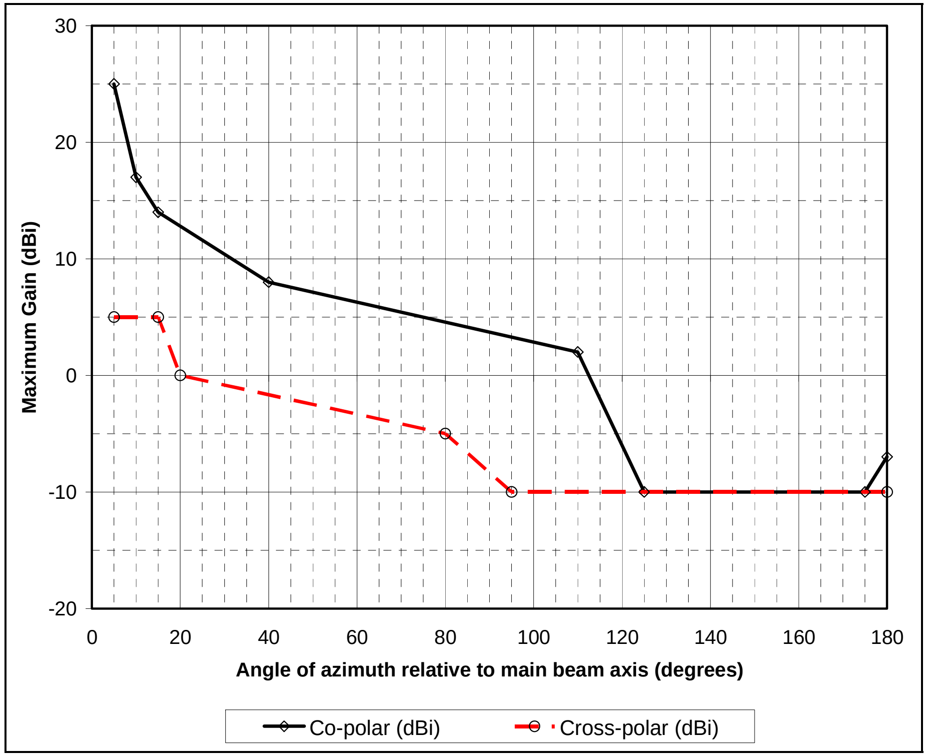
Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	20	5	0
10	15	20	0
50	5	100	-7
80	2	180	-10
100	-7		
180	-10		

Figure A.4: RPEs for class 1 antennas in the frequency range 24 GHz to 30 GHz



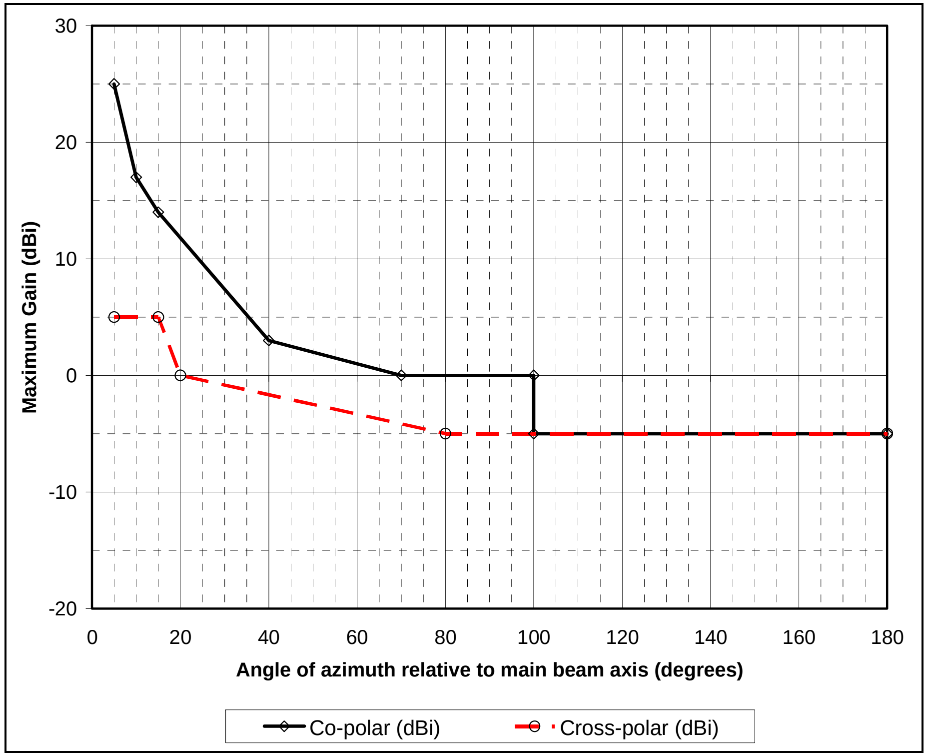
Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	25	5	5
10	17	15	5
15	14	20	0
40	8	80	-5
110	2	95	-10
125	-10	180	-10
175	-10		
180	-7		

Figure A.5: RPEs for class 1 antennas in the frequency range 30 GHz to 47 GHz



Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	25	5	5
10	17	15	5
15	14	20	0
40	8	80	-5
110	2	95	-10
125	-10	180	-10
175	-10		
180	-7		

Figure A.6: RPEs for class 1 antennas in the frequency range 47 GHz to 60 GHz



Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	25	5	5
10	17	15	5
15	14	20	0
40	3	80	-5
70 to 100	0	180	-5
100 to 180	-5		

Figure A.7: RPEs for class 1 antennas in the frequency range 71 GHz to 86 GHz

Annex B (informative): Additional information

B.1 Mechanical characteristics

B.1.1 Environmental characteristics

The principles for defining the operational environment profile are reported in EN 302 217-1 [3].

For commercially available antennas, the following additional information might be relevant.

The antennas are usually designed to operate within a temperature range of -45 °C to +45 °C with a relative humidity up to 100 % with salt mist, industrial atmosphere, solar and UV-radiation, etc.

The operational temperature range is sometimes divided into two parts for application in different climatic areas:

1) -33 °C to +40 °C;

2) -45 °C to +45 °C.

B.1.2 Wind ratings

The antennas should be designed to meet wind survival ratings specified in table B.1.

Table B.1

Antenna type	**Wind velocity m/s (km/h)**	**Ice load (density 7 kN/m^3)**
Normal duty	55 (200)	25 mm radial ice
Heavy duty	70 (252)	25 mm radial ice

B.1.3 Antenna stability

The antenna equipment should be stable under the most severe operational conditions at the site of intended application.

For installation on trellis or towers, this results in a maximum angular deviation of the antenna main beam axis not higher than 0,3 times the -3 dB beam width under the conditions specified in table B.2.

Table B.2

Antenna type	**Wind velocity m/s (km/h)**	**Ice load (density 7 kN/m^3)**
Normal duty	30 (110)	25 mm radial ice
Heavy duty	45 (164)	25 mm radial ice

B.2 Antenna input connectors

When flanges are provided at the input port of the antenna, they should be in accordance with IEC 60154-1 [5] and IEC 60154-2 [6].

For antennas, which are integrated to the radio equipment, proprietary connection designs may be utilized.

For antennas using coaxial input ports, the connectors should conform to IEC 60169-1 [7].

Other interconnection design should be agreed between the equipment supplier and purchaser in line with the overall system design requirements.

B.3 Return loss at the input ports

The minimum return loss should be agreed between the equipment and feeder supplier(s) and purchaser in line with the overall system design requirements. For guidance refer to equipment port return loss requirement in EN 302 217-2-1 [i.4], clause 6.1.2, for fully indoor digital systems, which are generally deployed with longer feeder connections to an external antenna, it is assumed that the return loss of the feeder + antenna assembly will be approximately of the same order.

For guidance, antennas with a Voltage Standing Wave Ratio (VSWR) in a range of 1,06 to 1,2 are typical.

B.4 Inter-port isolation

The isolation between the input ports of a dual polarized antenna should be agreed between the equipment supplier and purchaser in line with the overall system design requirements.

For guidance the isolation between ports may be between 25 dB and 35 dB (range 1 GHz to 3 GHz) and between 35 dB to 50 dB (3 GHz to 86 GHz).

B.5 Antenna labelling

It is recommended that the antennas should be clearly identified with a weather-proof and permanent label showing the suppliers name, antenna type, serial number and type approval reference number which identifies the country of origin.

For information on possible CE marking under the R&TTE Directive [1], please refer to the scope of EN 302 217-4-2 [4].

Annex C (informative): Antenna gain and radiation pattern information

C.1 Impact of antenna gain on the frequency planning

When frequency planning is applied, it generally results in setting the E.I.R.P. level required by a link for meeting the performance and availability objectives.

The longest possible hop length is limited by the technology adopted (i.e. maximum output power and maximum possible antenna gain); however most of the links are shorter and a trade-off between two parameters, output power and antenna gain, is possible for obtaining the same E.I.R.P. level.

From the frequency planning point of view it is obvious that, for each antenna RPE class selected, the best condition from the spectral use point of view (i.e. the higher protection to nearby links) is when the required E.I.R.P. is obtained with the highest antenna gain and the lowest output power.

However both parameters have physical and technological constraints:

- Power output may be reduced through RTPC function; however the range of attenuation available is limited by the requirement of meeting the spectrum mask through all RTPC range.
  Fixed RF attenuators might also be used; however the high integration sought today for fulfilling market requirements (i.e. size and cost) hardly allows room for such link-by-link RF attenuation selection.

- Antenna gain is related to reflector size that has become one of the most binding requirements in urban areas for their ambient impact.

For the above reason further trade-off has to be taken into account between maximizing efficiency in frequency planning and typical equipment and antenna technology available/imposed by external market constraint.

C.2 Gain and typical radiation pattern for circular-symmetric antennas

EN 302 217-4-2 [4] gives radiation pattern envelopes (RPE) intended for conformance to R&TTE Directive [1] and therefore are "absolute worst case" not to be exceeded in 100 % of cases; however the typical behaviour of antennas might be quite different. Also gain values are not standardized, due to the large variety of sizes required by the market and for keeping the standard open to potential new technologies; the gain is required only as declaration from the supplier.

Point-to-Point applications, in bands above 1 GHz, typically use antennas with circular symmetry (e.g. parabolic, horn, grid, etc.).

This annex wishes to add information on the typical gain and radiation pattern, in particular for the main lobe radiation, of these antenna types and is not intended to limit new technologies development, the characteristics of which might substantially diverge from the evaluation made in this annex.

The gain for circular antennas is strictly related to geometrical size of the reflector area and the construction technology has only marginal effect (sometimes referred to as "efficiency") on the actual gain value.

Side lobes attenuation of actual antennas depends on specific shielding (shroud) technology used, which in general impacts the size (deepness) of the antenna; however, ITU-R Recommendation F.699 [i.5] recommends formulas for defining typical gain and radiation pattern (in term of main lobe and peak envelope of side lobe patterns). These formulas are for use in sharing studies whenever the actual antenna RPE is not known and are currently valid from 1 GHz to 70 GHz.

ITU-R Recommendation F.699 [i.5] provides two sets of formulas, one for antennas with D/λ ratio higher than 100 and a second for antennas with D/λ ratio equal or less than 100.

This second case is, in practice, the one where the large majority of FS application falls and formulas are here reprinted for reader convenience and guidance on expected values from practical antennas.

In ITU-R Recommendation F.699 [i.5], the bore-sight gain is related to the antenna diameter by the simple relationship:

$$20 \log \frac{D}{\lambda} \approx G_{max} - 7{,}7$$

where G_{max} is the main lobe antenna gain (dBi).

For the radiation pattern, in cases where the ratio between the antenna diameter and the wavelength is less than or equal to 100 the following equations are recommended by ITU-R Recommendation F.699 [i.5]:

$$G(\varphi) = G_{max} - 2{,}5 \times 10^{-3} \left(\frac{D}{\lambda}\varphi\right)^2 \quad \text{for} \quad 0° < \varphi < \varphi_m;$$

$$G(\varphi) = G_1 \quad \text{for} \quad \varphi_m \le \varphi < 100\,\frac{\lambda}{D};$$

$$G(\varphi) = 52 - 10 \log \frac{D}{\lambda} - 25 \log \varphi \quad \text{for} \quad 100\,\frac{\lambda}{D} \le \varphi < 48°;$$

$$G(\varphi) = 10 - 10 \log \frac{D}{\lambda} \quad \text{for} \quad 48° \le \varphi \le 180°.$$

where $G_1 = 2 + 15 \log \frac{D}{\lambda}$, is the gain of the first side-lobe.

History

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