

ETSI EN 302 217-4 V2.1.1 (2017-05)



**Fixed Radio Systems;
Characteristics and requirements
for point-to-point equipment and antennas;
Part 4: Antennas**

Reference

DEN/ATTM-0435

Keywords

antenna, DFRS, DRRS, FWA, point-to-point,
radio, regulation, transmission

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Foreword

This European Standard (EN) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

The present document is part 4 of a multi-part deliverable covering the Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas. Full details of the entire series can be found in ETSI EN 302 217-1 [2].

National transposition dates	
Date of adoption of this EN:	15 September 2016
Date of latest announcement of this EN (doa):	31 December 2016
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	30 June 2017
Date of withdrawal of any conflicting National Standard (dow):	30 June 2018

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

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1 Scope

The present document defines the characteristics and requirements of antennas for point-to-point radio equipment operating in the frequency range from 1 GHz to 86 GHz falling within the scope of ETSI EN 302 217-2 [i.4].

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.

The present document is applicable to fixed radio equipment with *integral* or *dedicated antennas*, and to *stand-alone antennas*. In the latter case the present document may be used to provide guidance as to the information to be supplied by a manufacturer as required by article 10 paragraph 8 of Directive 2014/53/EU [i.2].

The main body of the present document specifies the characteristics that define the various antenna classes, whilst the annexes provide additional information that is useful to both antenna manufacturers and user/installers.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at <http://docbox.etsi.org/Reference>.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

- [1] ETSI EN 301 126-3-1 (V1.1.2): "Fixed Radio Systems; Conformance testing; Part 3-1: Point-to-Point antennas; Definitions, general requirements and test procedures".
- [2] ETSI EN 302 217-1 (V3.1.1): "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 1: Overview, common characteristics and system-independent requirements".
- [3] IEC 60154-1: "Flanges for waveguides. Part 1: General requirements".
- [4] IEC 60154-2: "Flanges for waveguides. Part 2: Relevant specifications for flanges for ordinary rectangular waveguides".
- [5] IEC 60169-1: "Radio-frequency connectors. Part 1: General requirements and measuring methods".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

- [i.1] Void.
- [i.2] Directive 2014/53/EU of the European Parliament and of the Council of 16 April 2014 on the harmonisation of the laws of the Member States relating to the making available on the market of radio equipment and repealing Directive 1999/5/EC.
- [i.3] Void.
- [i.4] ETSI EN 302 217-2 (V3.1.1): "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 2: Digital systems operating in frequency bands from 1 GHz to 86 GHz; Harmonised Standard covering the essential requirements of article 3.2 of Directive 2014/53/EU".
- [i.5] Void.
- [i.6] ETSI EN 301 126-1: "Fixed Radio Systems; Conformance testing; Part 1: Point-to-point equipment - Definitions, general requirements and test procedures".
- [i.7] Recommendation ITU-R 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 ETSI EN 302 217-1 [2] apply.

3.2 Symbols

For the purposes of the present document, the symbols given in ETSI EN 302 217-1 [2] apply.

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in ETSI EN 302 217-1 [2] apply.

4 Technical requirements specifications

4.1 Introduction

The electrical characteristics are given as function of specific classification of the antennas according to the principles referred to in clause 4.2.

The antenna manufacturer shall state, for each antenna type, the frequency band of operation and antenna gain at least at the frequency band edges and at mid-band. An antenna, which employs a radome, shall meet the requirements of the present document with the radome in place. The antenna system shall radiate a linear (single or dual) polarized wave.

4.2 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 4 and table 1.

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

NOTE: Figures 1 to 4 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.

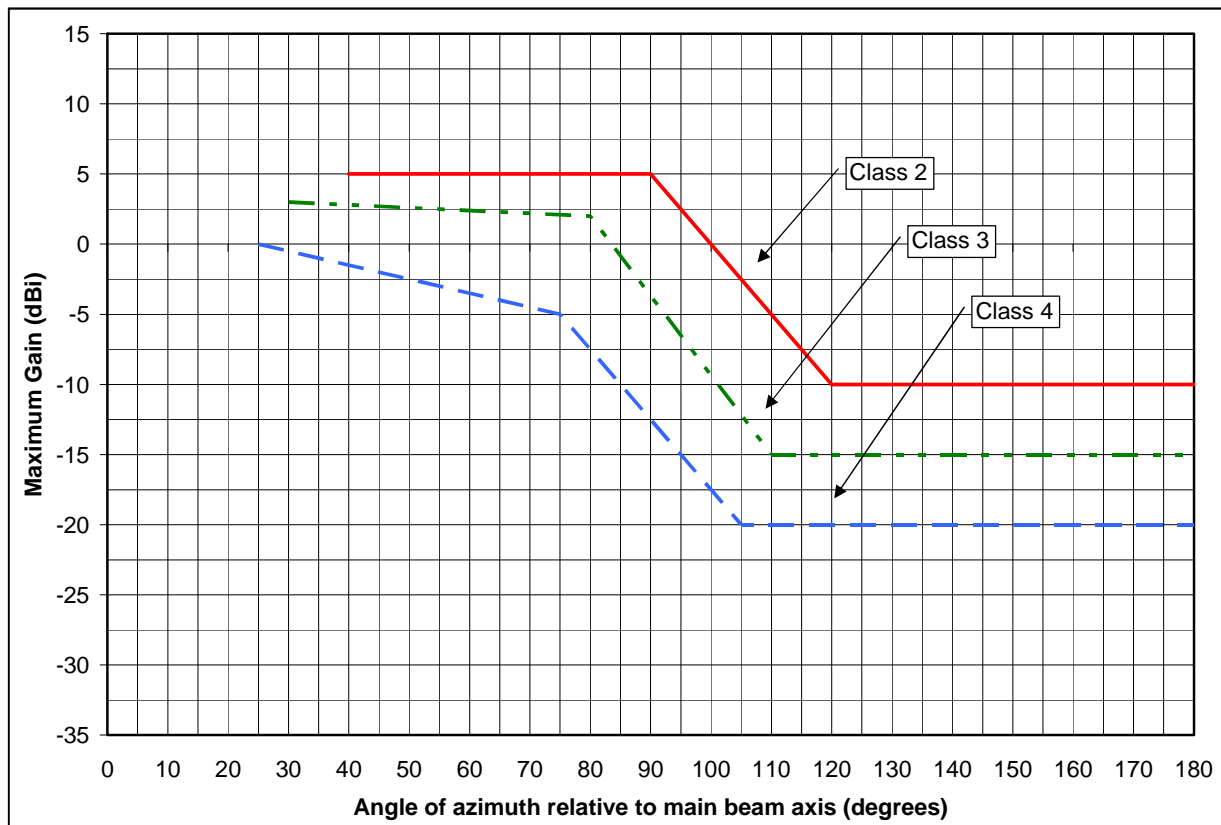


Figure 1: Co-polar limit templates for actual RPE masks of antenna classes in the range 1 GHz to 3 GHz (see table 1)

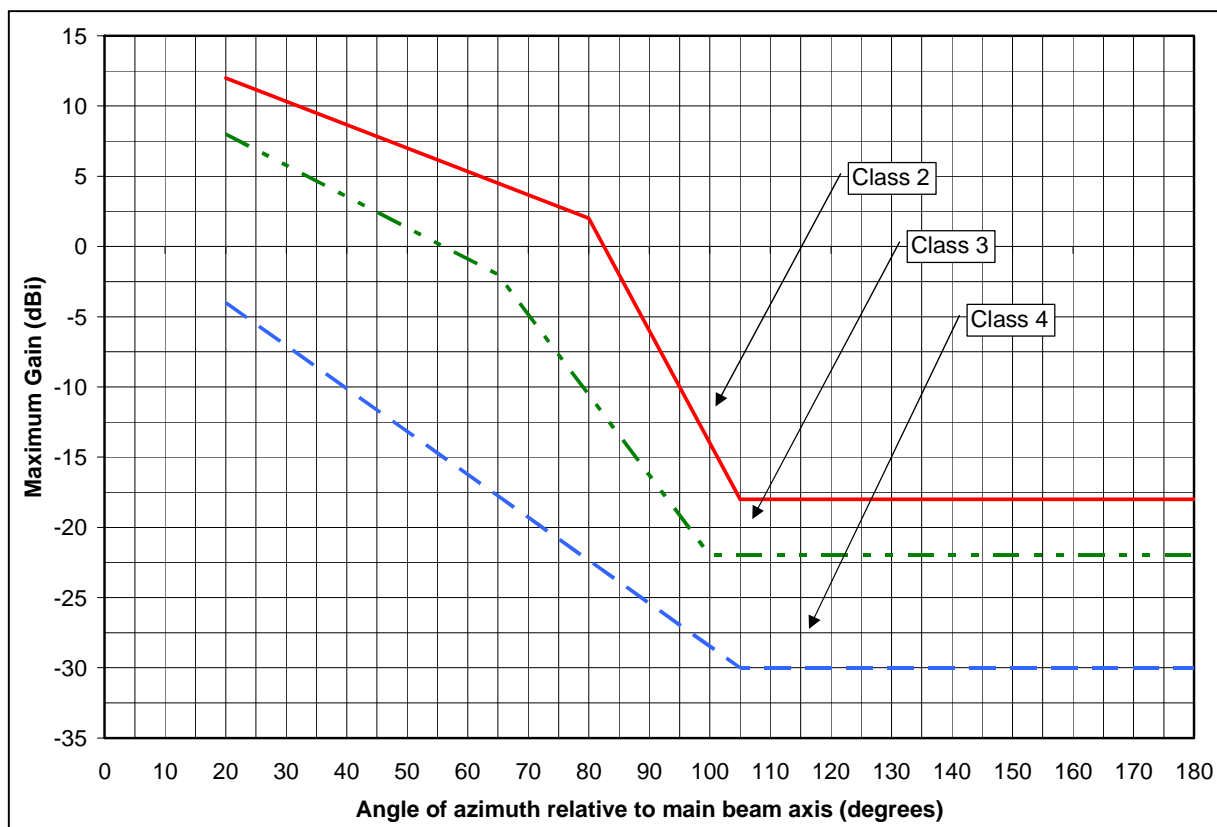


Figure 2: Co-polar limit templates for actual RPE masks of antenna classes in the range 3 GHz to 30 GHz (see table 1)

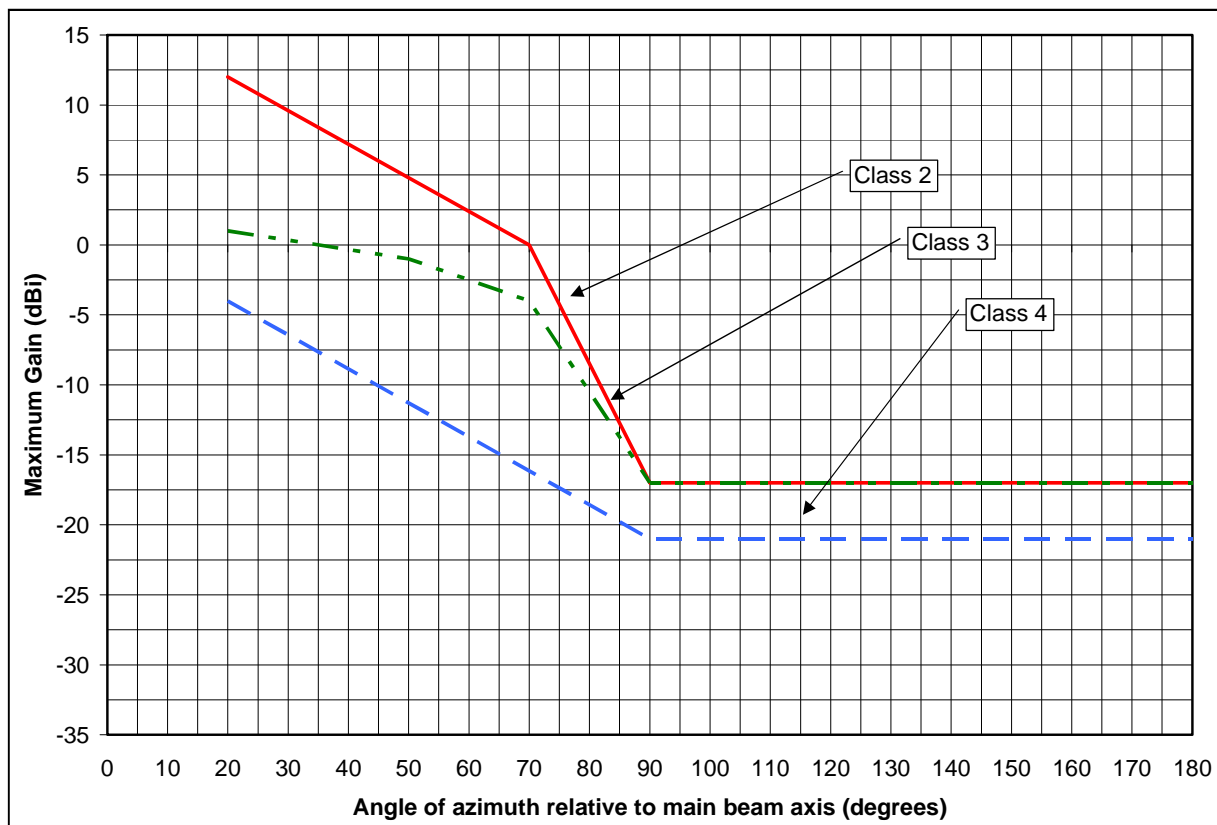


Figure 3: Co-polar limit templates for actual RPE masks of antenna classes in the range 30 GHz to 66 GHz (see table 1)

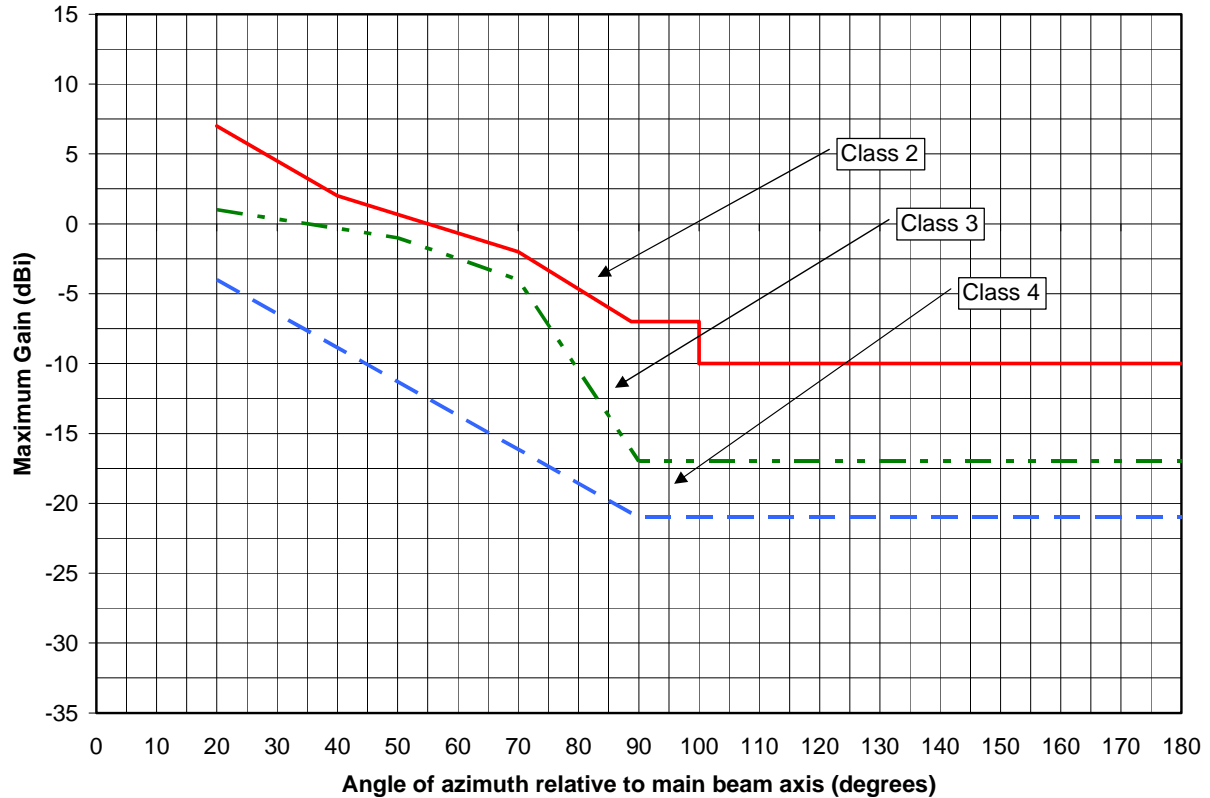


Figure 4: Co-polar limit templates for actual RPE masks of antenna classes in the range 66 GHz to 86 GHz (see table 1)

Table 1: Corner points of co-polar limits for actual RPE templates (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
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: 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: 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.

4.3 Environmental profile

The required environmental profile for operation of the antenna or the equipment-antenna assembly (in case of systems with integral antenna) shall be declared by the manufacturer. The antenna shall comply with all the technical requirements of the present document at all times when operating within the boundary limits of the declared operational environmental profile. For testing the compliance to technical requirements refer also to ETSI EN 301 126-3-1 [1] and clause 5 in the present document.

4.4 Radiation Pattern Envelope (RPE)

4.4.1 Introduction

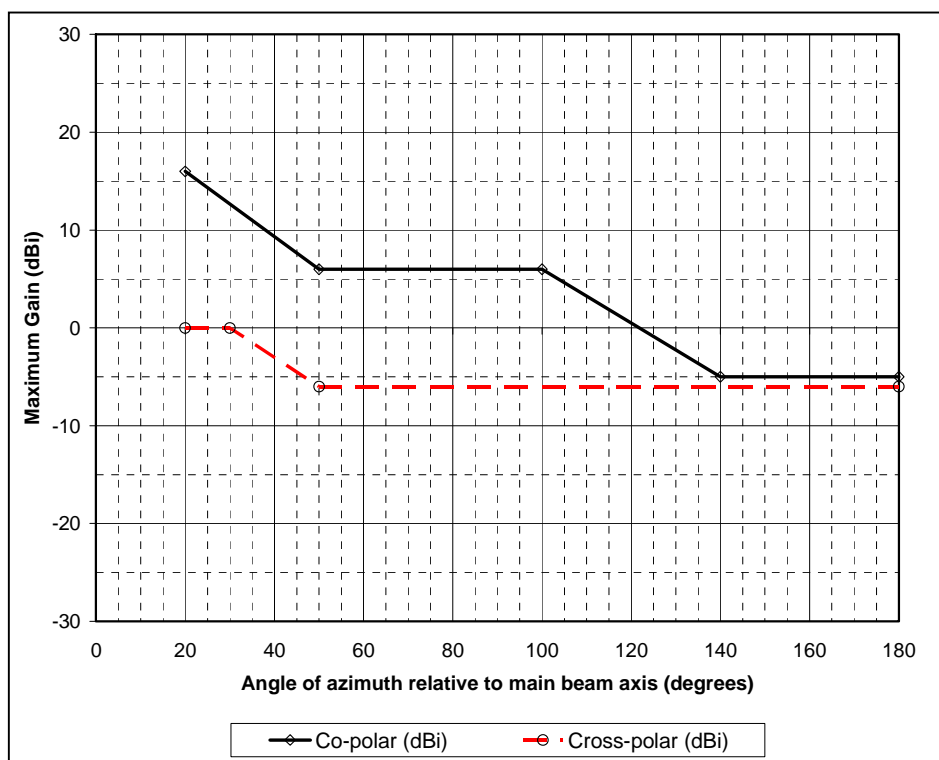
The present document defines all currently available Antenna RPE classes. An overview of which is given in table 2.

Table 2: Summary of RPE classes represented in the present document

Frequency range (GHz)	Antenna Radiation Pattern Envelope (RPE) class
1 to 3	1A, 1B, 1C, 2, 3
3 to 14	1, 2, 3, 4
14 to 20	1, 2, 3, 4
20 to 24	1, 2, 3, 4
24 to 30	1, 2, 3, 4
30 to 47	1, 2, 3A, 3B, 3C, 4
47 to 66	1, 2, 3A, 3B
66 to 86	1, 2, 3, 4

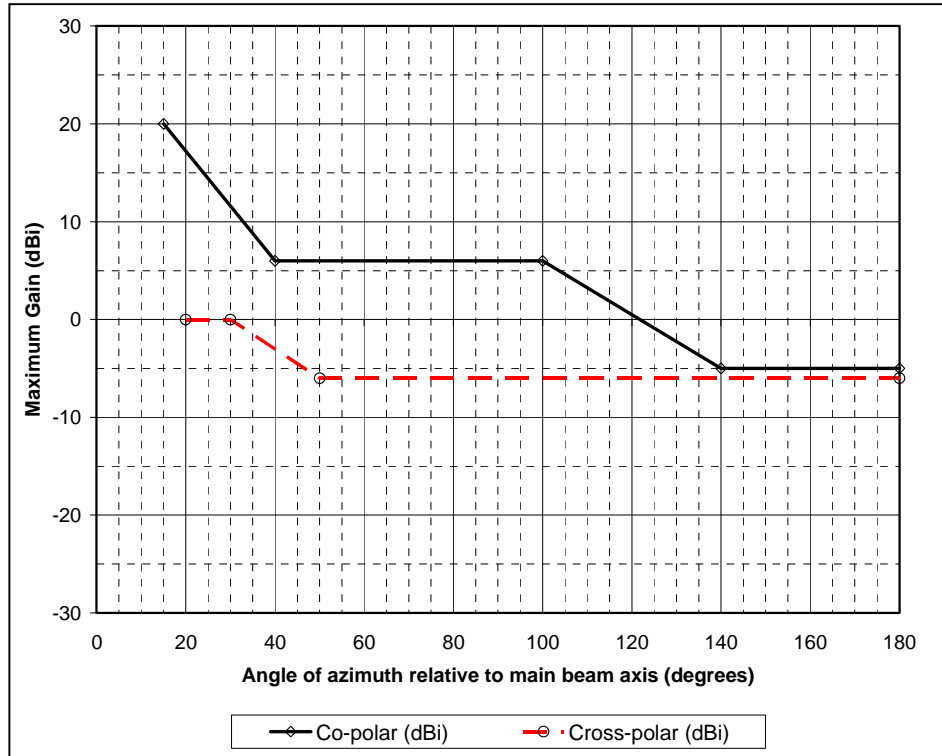
4.4.2 Frequency range 0: 1 GHz to 3 GHz

The choice of antenna depends on the application planned for this band, requirements of the operators and the responsible administration. Figures 5 to 10 give the RPEs for antenna classes 1, 2 and 3.



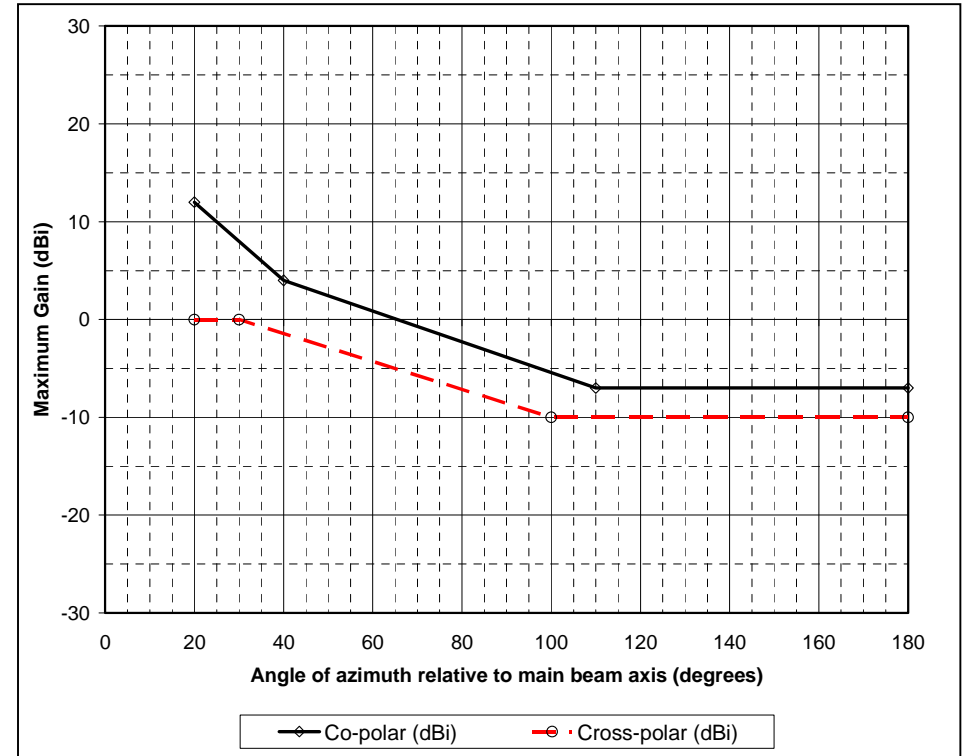
Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
20	16	20	0
50	6	30	0
100	6	50	-6
140	-5	180	-6
180	-5		

Figure 5: Class 1A antenna RPE (1 GHz to 3 GHz)



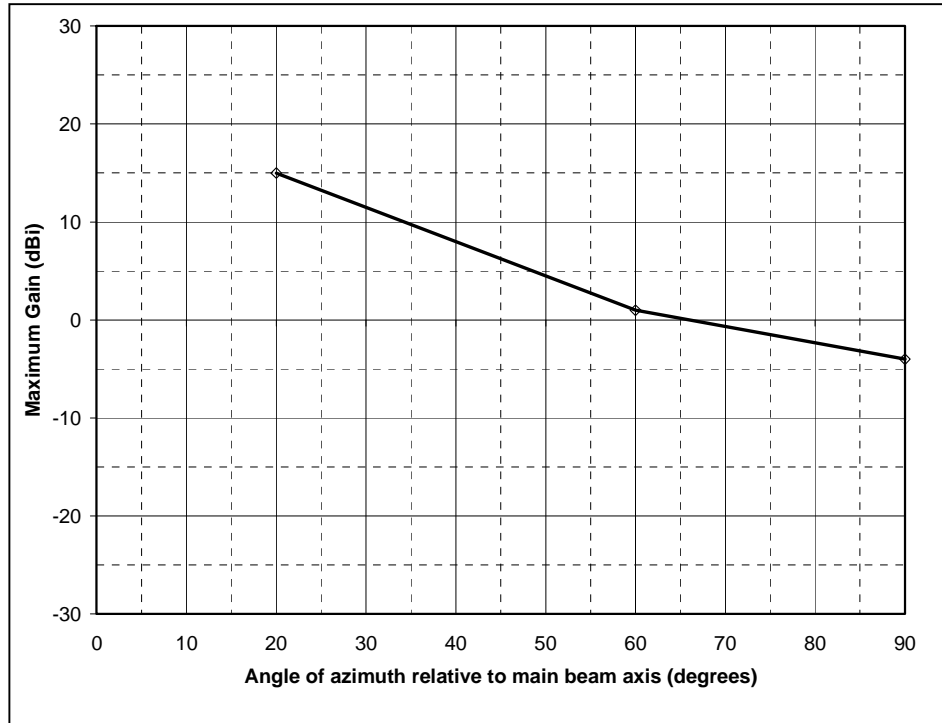
Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
15	20	20	0
40	6	30	0
100	6	50	-6
140	-5	180	-6
180	-5		

Figure 6: Class 1B antenna RPE (1 GHz to 3 GHz)



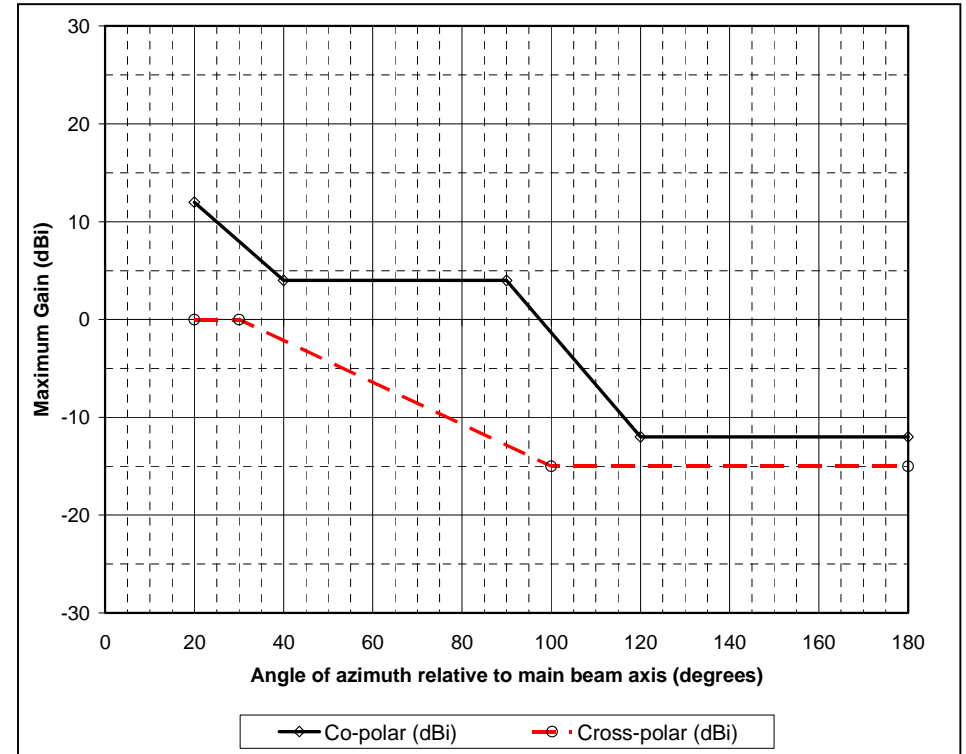
Azimuth angle (°)	Co-polar (dBi)	Azimuth angle (°)	Cross-polar (dBi)
20	12	20	0
40	4	30	0
110	-7	100	-10
180	-7	180	-10

Figure 7: Class 1C antenna RPE (1 GHz to 3 GHz, azimuth plane)



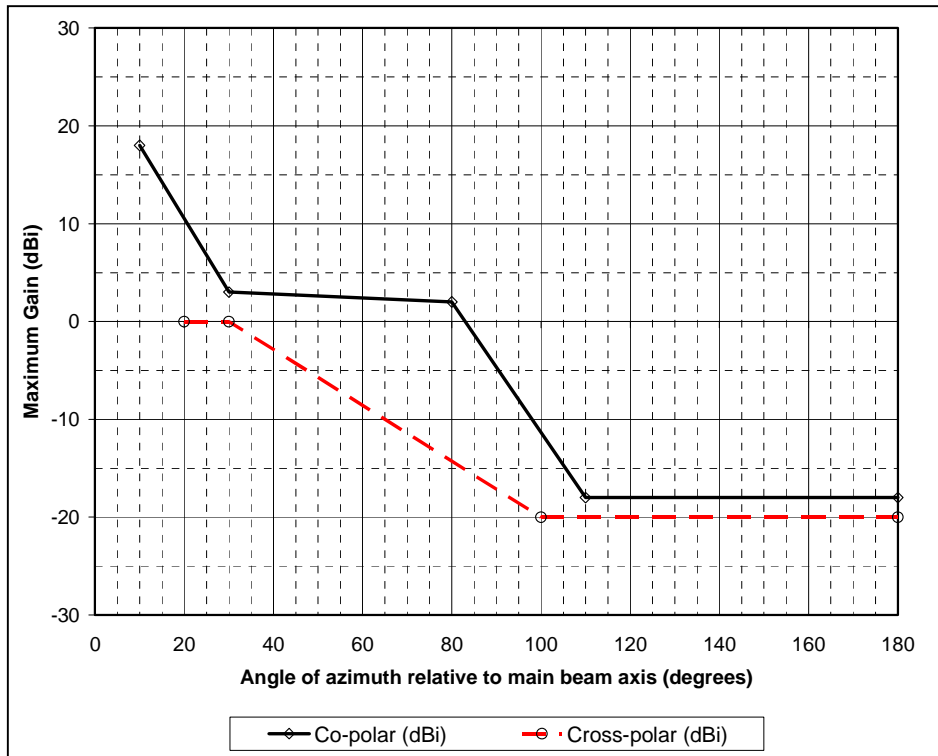
Elevation angle (°)	dBi
20	15
60	1
90	-4

Figure 8: Class 1C antennas RPE (1 GHz to 3 GHz, elevation plane)



Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
20	12	20	0
40	4	30	0
90	4	100	-15
120	-12	180	-15
180	-12		

Figure 9: Class 2 antenna RPE (1 GHz to 3 GHz)

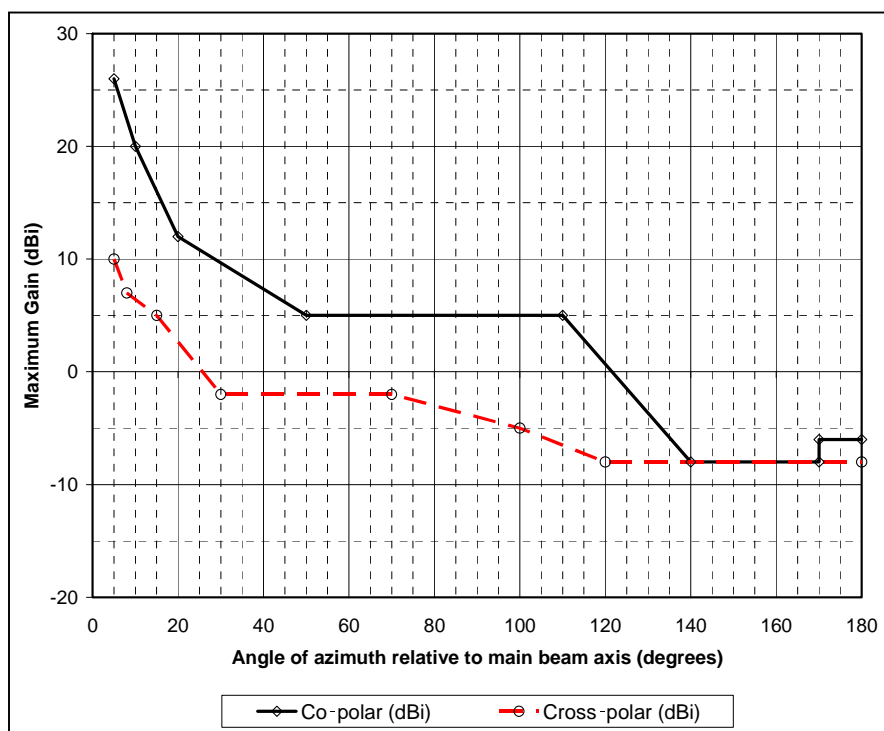


Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
10	18	20	0
30	3	30	0
80	2	100	-20
110	-18	180	-20
180	-18		

Figure 10: Class 3 antenna RPE (1 GHz to 3 GHz)

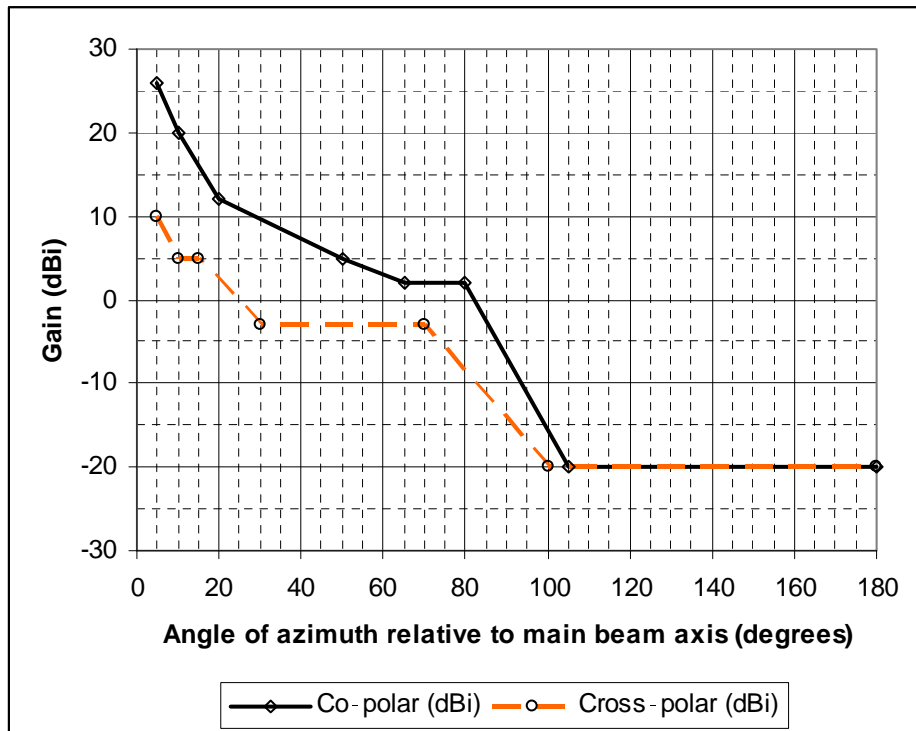
4.4.3 Frequency range 1: 3 GHz to 14 GHz

The choice of antenna depends on the application planned for this band, requirements of the operators and the responsible administration. Figures 11 to 14 give the RPEs for antenna classes 1, 2, 3 and 4.



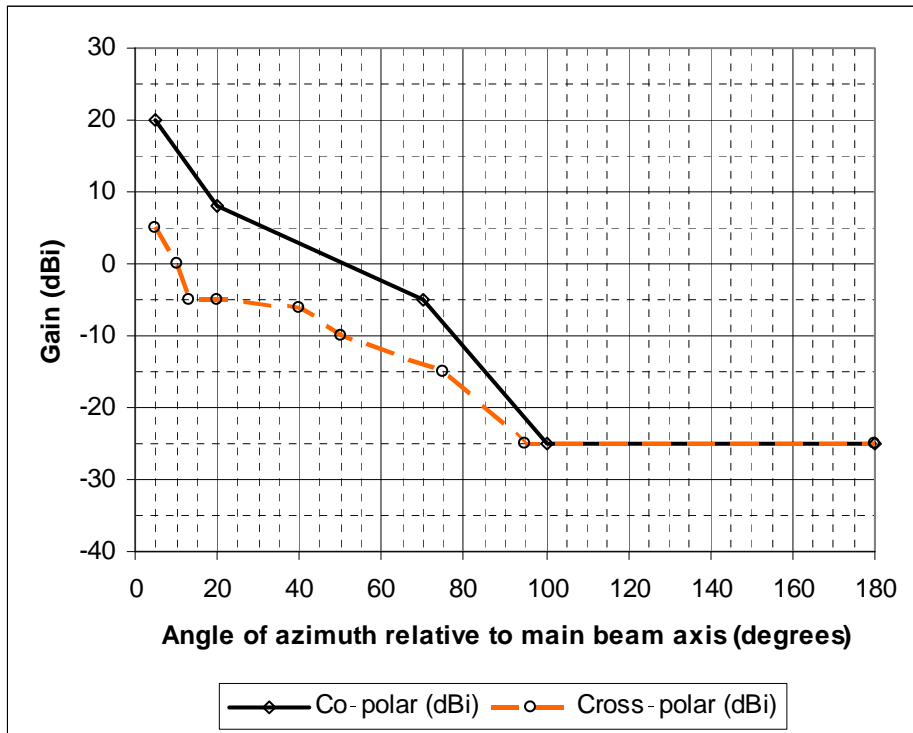
Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	26	5	10
10	20	8	7
20	12	15	5
50	5	30	-2
110	5	70	-2
140	-8	100	-5
170	-8	120	-8
170	-6	180	-8
180	-6		

Figure 11: RPEs for class 1 antennas in the frequency range 3 GHz to 14 GHz



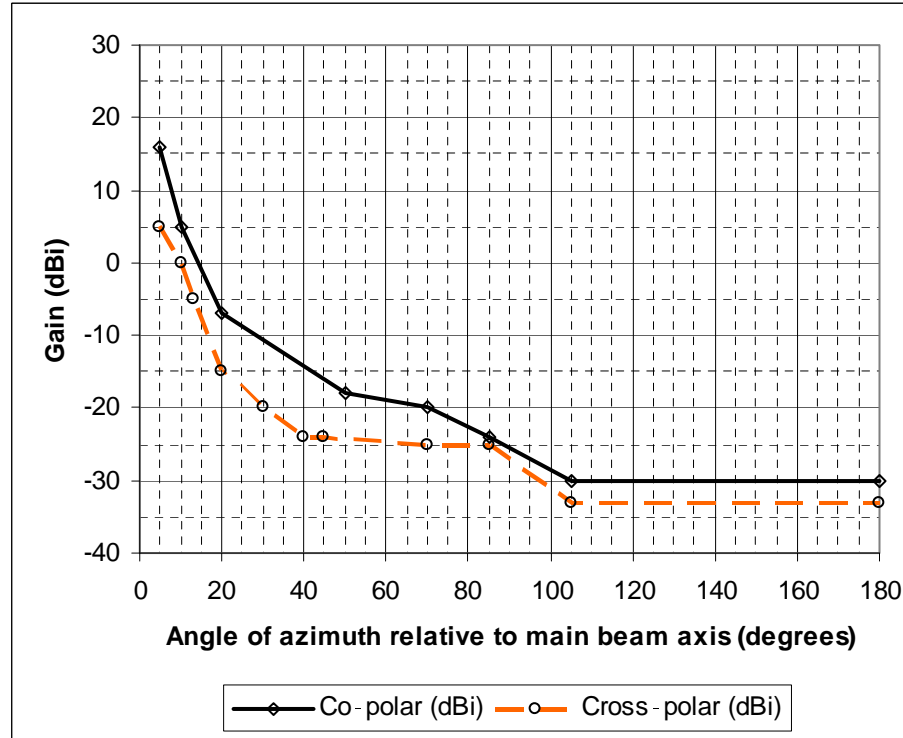
Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	26	5	10
10	20	10	5
20	12	15	5
50	5	30	-3
65	2	70	-3
80	2	100	-20
105	-20	180	-20
180	-20		

Figure 12: Class 2 antennas RPE (3 GHz to 14 GHz)



Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	20	5	5
20	8	10	0
70	-5	13	-5
100	-25	20	-5
180	-25	40	-6
		50	-10
		75	-15
		95	-25
		180	-25

Figure 13: Class 3 antennas RPE (3 GHz to 14 GHz)

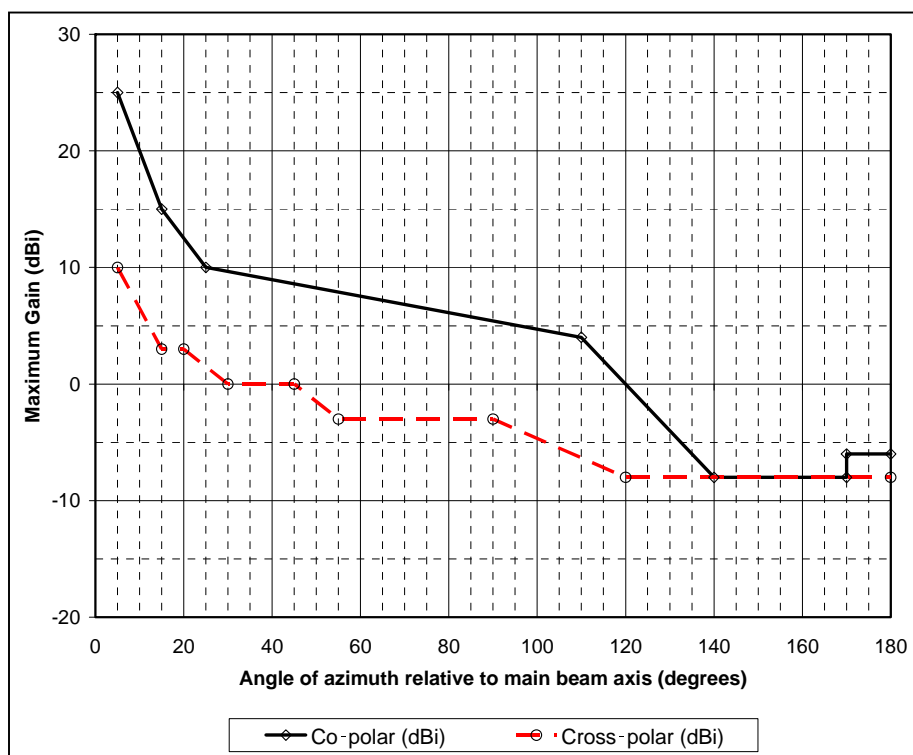


Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	16	5	5
10	5	10	0
20	-7	13	-5
50	-18	20	-15
70	-20	30	-20
85	-24	40	-24
105	-30	45	-24
180	-30	70	-25
		85	-25
		105	-33
		180	-33

Figure 14: Class 4 antennas RPE (3 GHz to 14 GHz)

4.4.4 Frequency range 2: 14 GHz to 20 GHz

The choice of antenna depends on the application planned for this band, requirements of the operators and the responsible administration. Figures 15 to 18 give the RPEs for antenna classes 1, 2, 3 and 4.



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 15: RPEs for class 1 antennas in the frequency range 14 GHz to 20 GHz

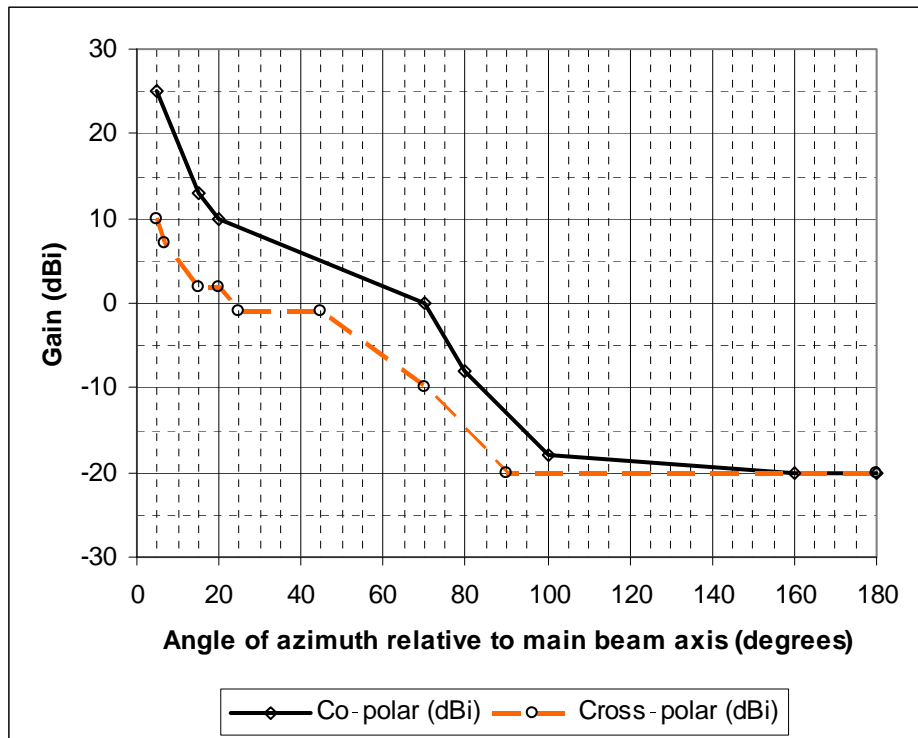


Figure 16: Class 2 antennas RPE (14 GHz to 20 GHz)

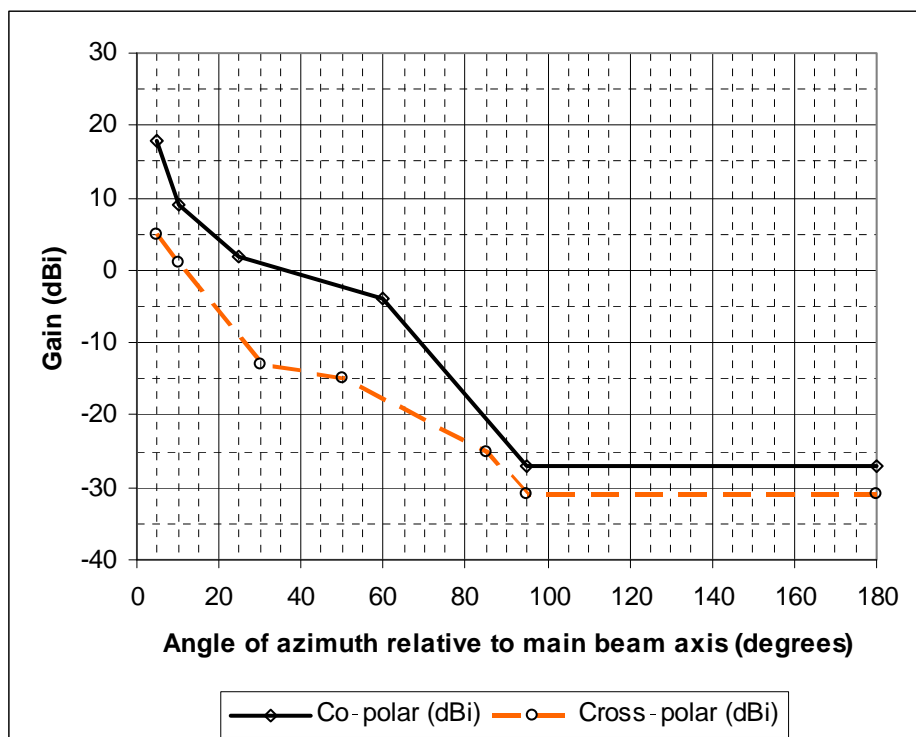


Figure 17: Class 3 antennas RPE (14 GHz to 20 GHz)

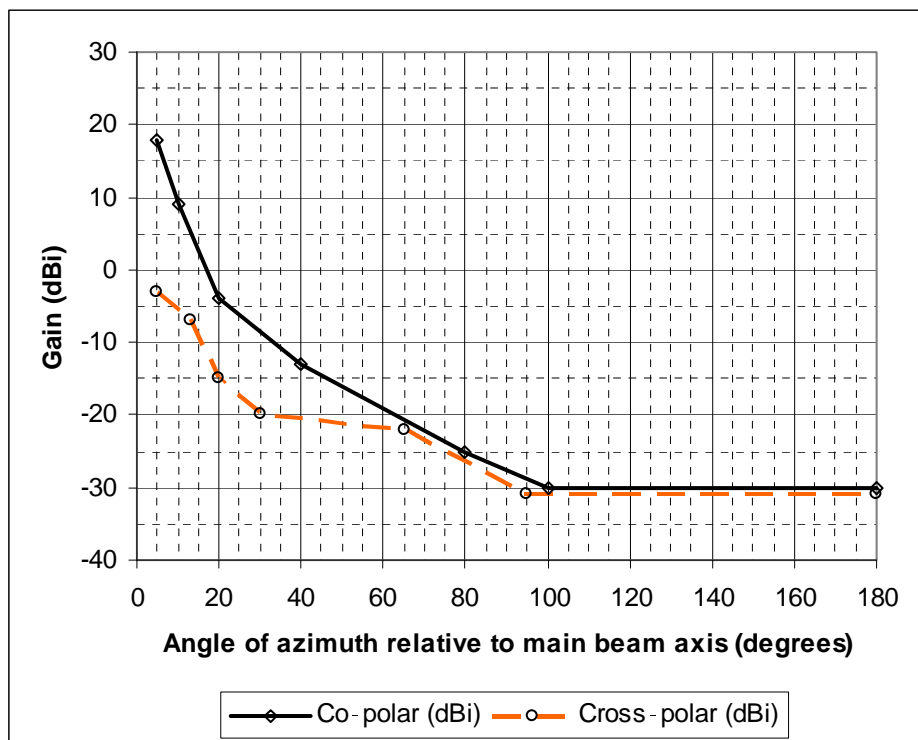
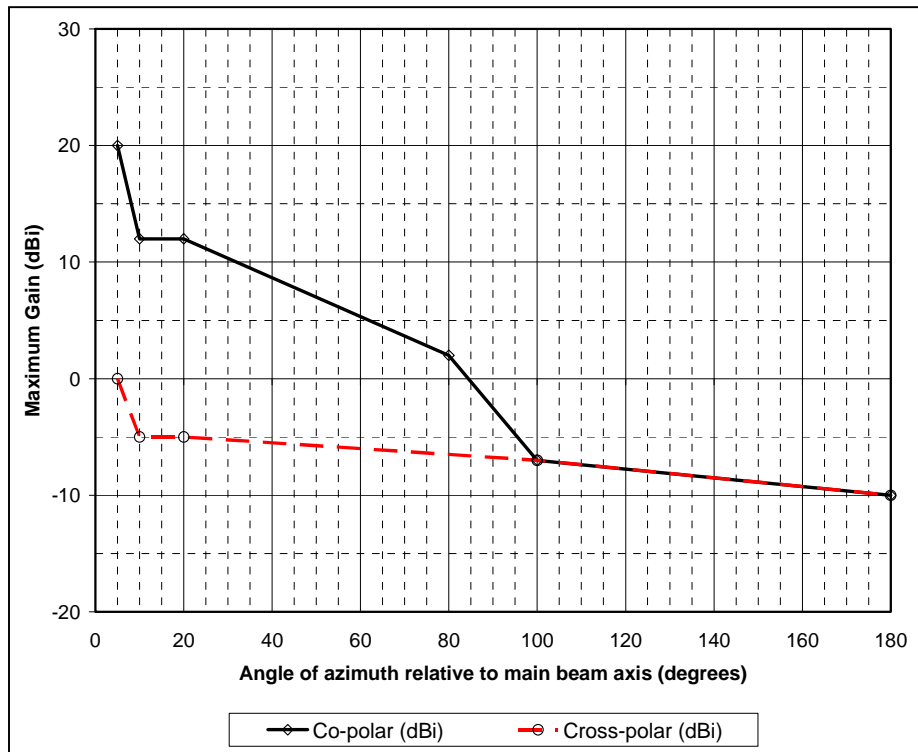


Figure 18: Class 4 antennas RPE (14 GHz to 20 GHz)

4.4.5 Frequency range 3: 20 GHz to 24 GHz

The choice of antenna depends on the application planned for this band, requirements of the operators and the responsible administration. Figures 19 to 22 give the RPEs for antenna classes 1, 2, 3 and 4.



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 19: RPEs for antennas class 1 in the frequency range 20 GHz to 24 GHz

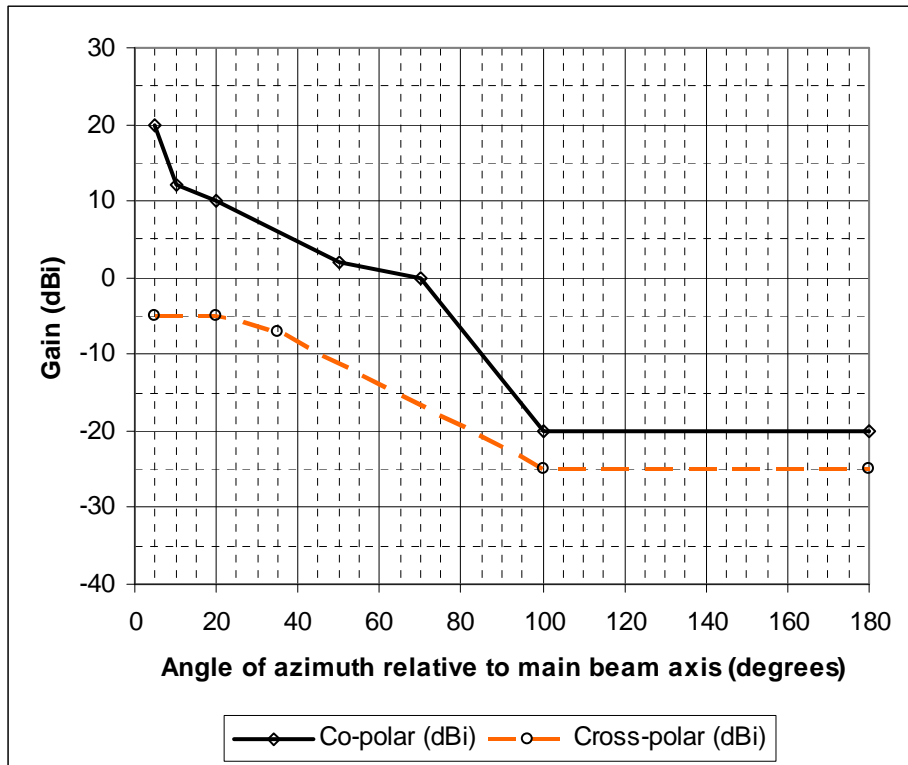


Figure 20: Class 2 antennas RPE (20 GHz to 24 GHz)

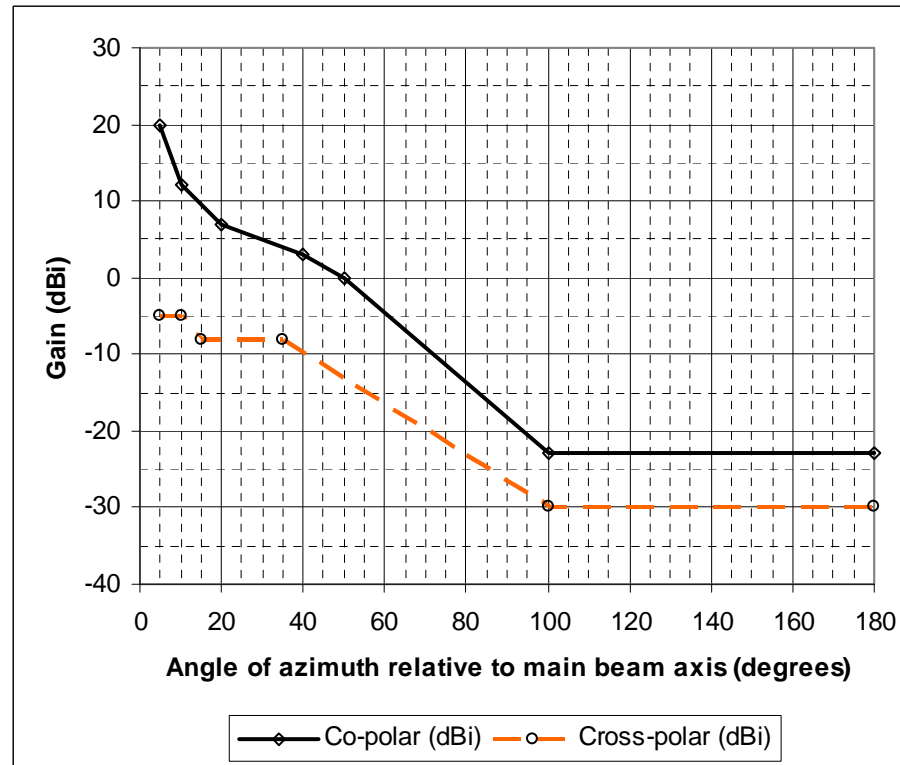
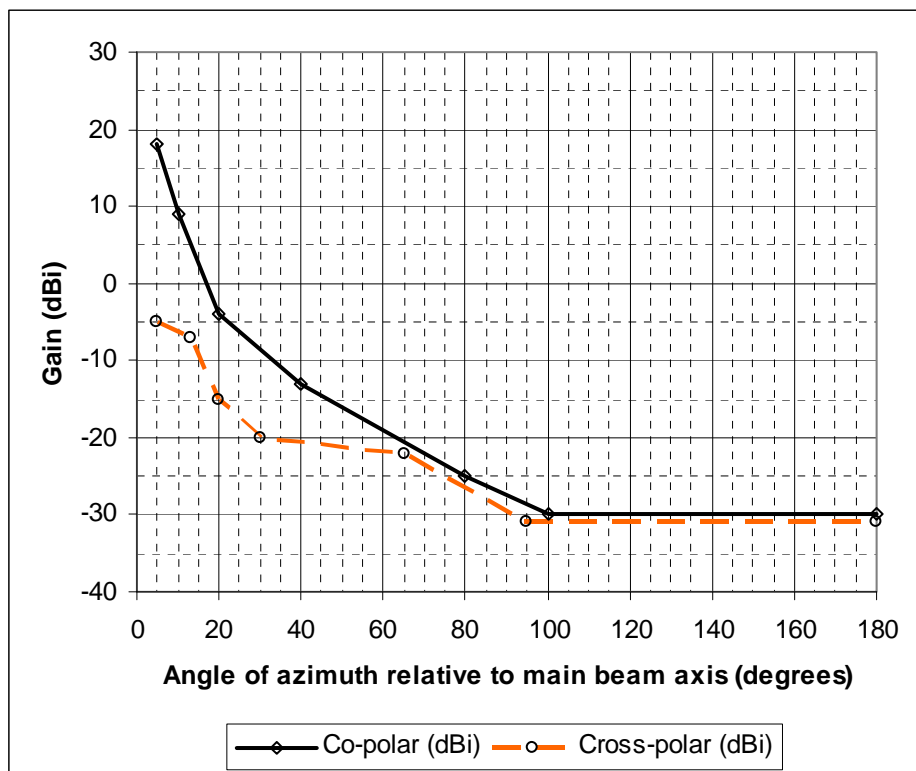


Figure 21: Class 3 antennas RPE (20 GHz to 24 GHz)

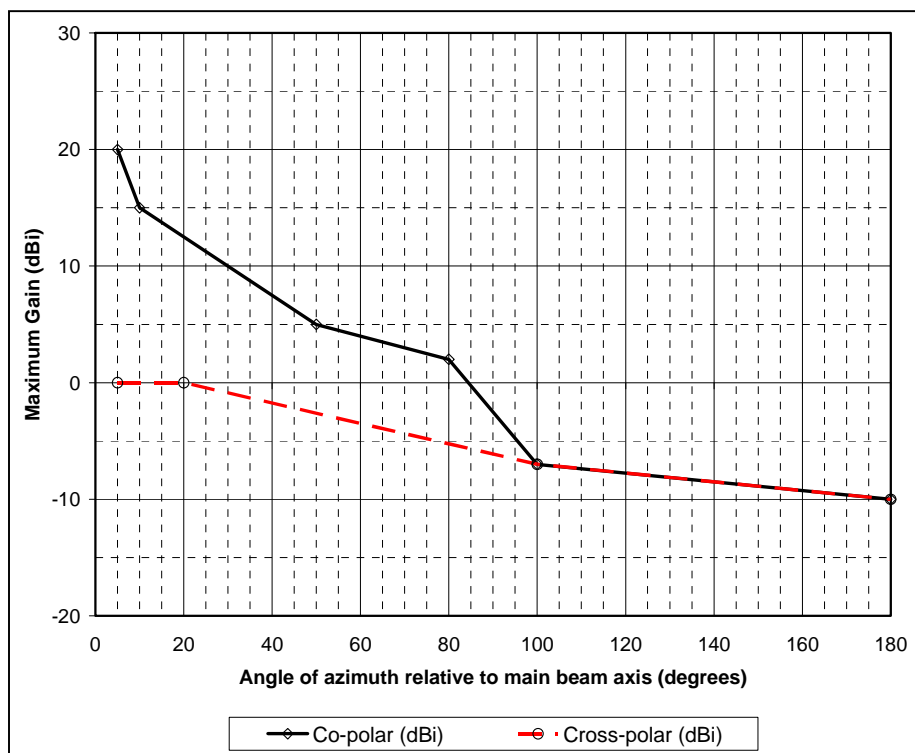


Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	18	5	-5
10	9	13	-7
20	-4	20	-15
40	-13	30	-20
80	-25	65	-22
100	-30	95	-31
180	-30	180	-31

Figure 22: Class 4 antennas RPE (20 GHz to 24 GHz)

4.4.6 Frequency range 4: 24 GHz to 30 GHz

The choice of antenna depends on the application planned for this band, requirements of the operators and the responsible administration. Figures 23 to 26 give the RPEs for antenna classes 1, 2, 3 and 4.



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 23: RPEs for class 1 antennas in the frequency range 24 GHz to 30 GHz

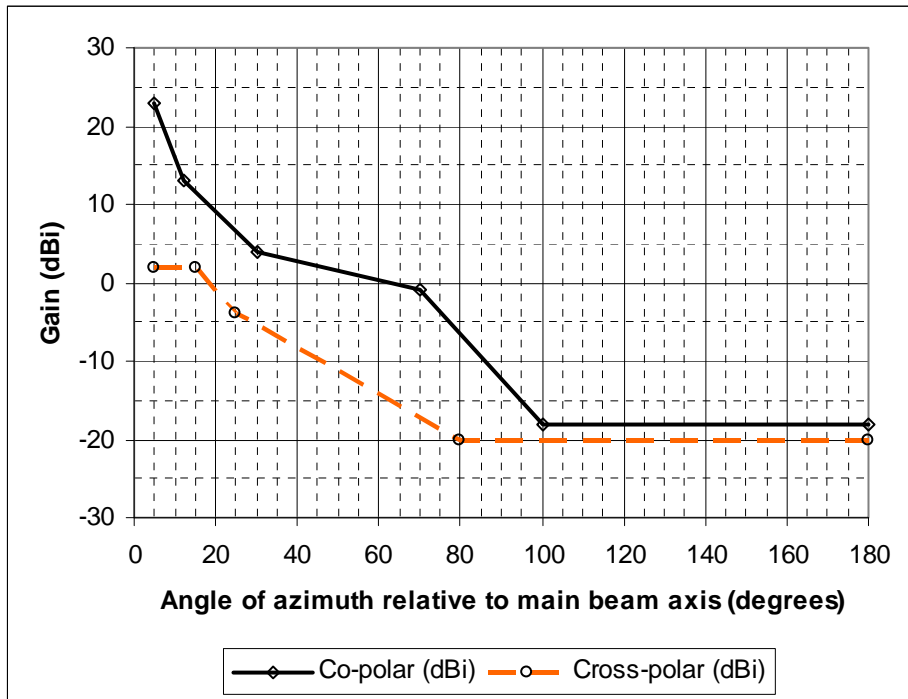


Figure 24: Class 2 antenna RPE (24 GHz to 30 GHz)

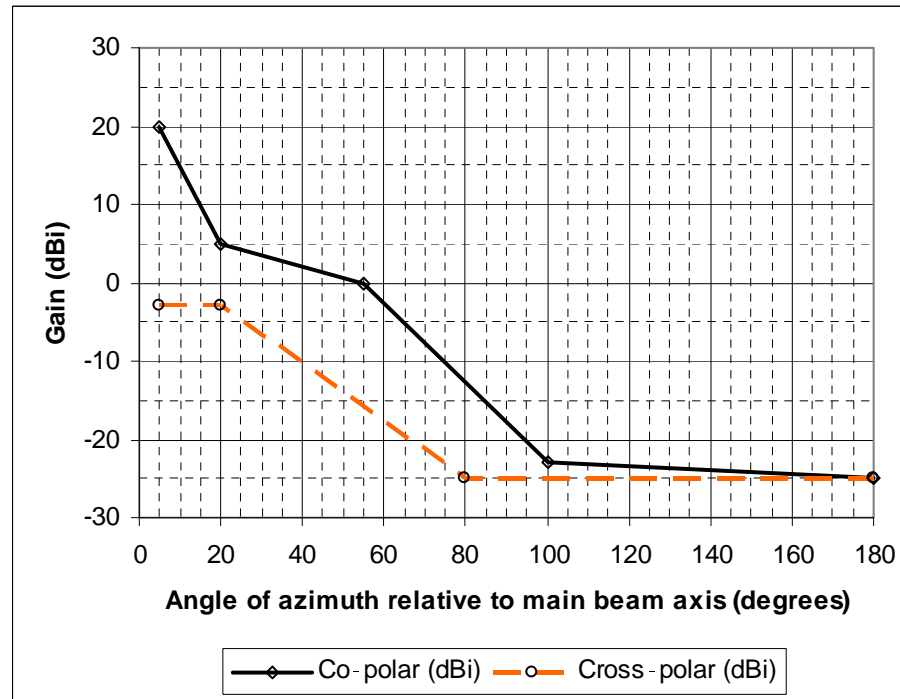


Figure 25: Class 3 antennas RPE (24 GHz to 30 GHz)

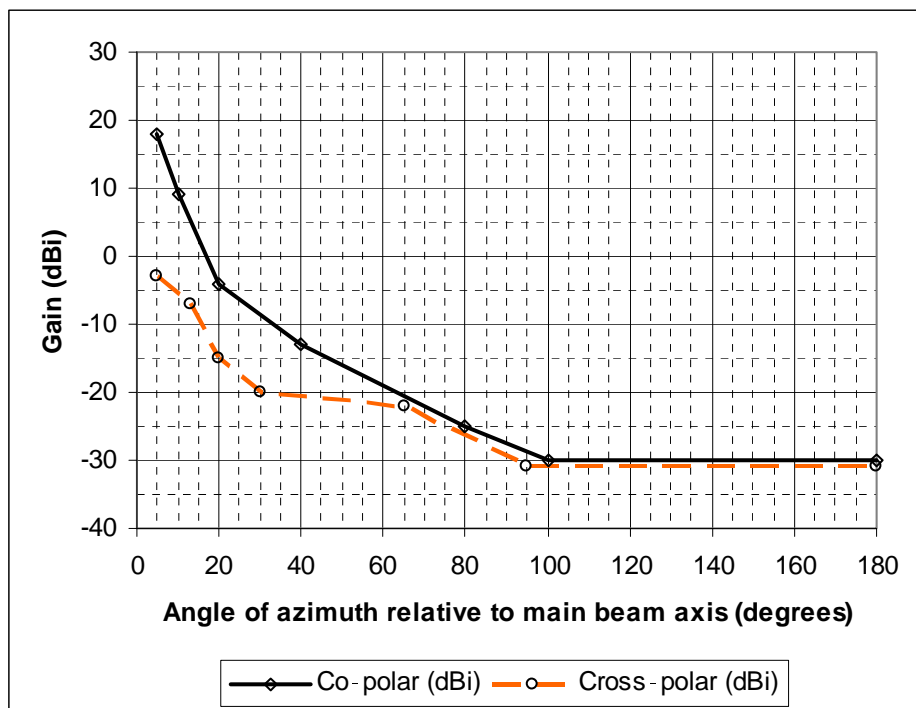
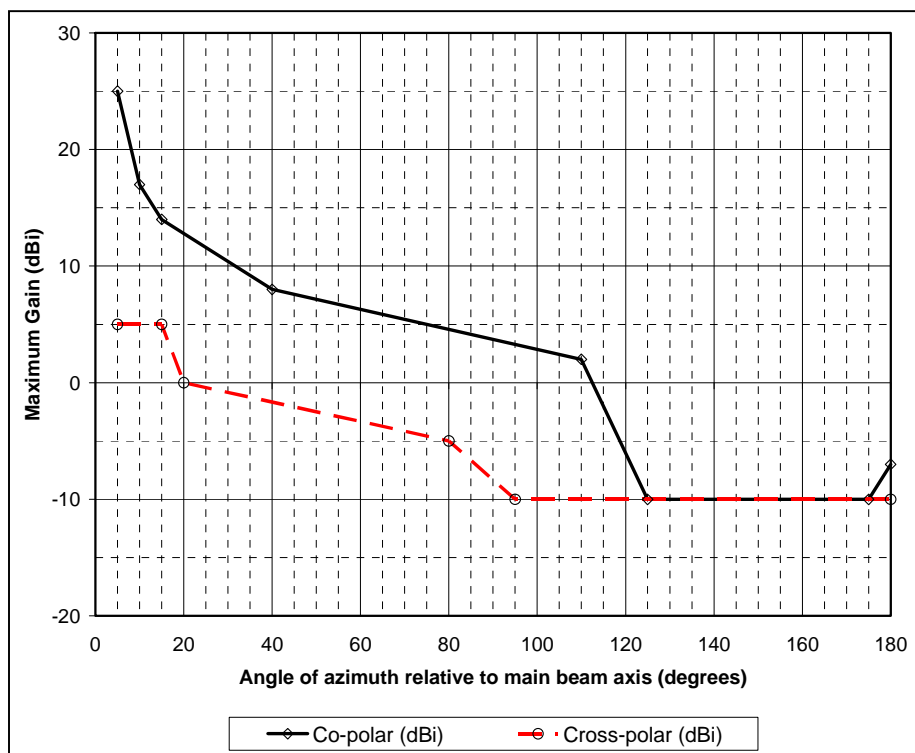


Figure 26: Class 4 antennas RPE (24 GHz to 30 GHz)

4.4.7 Frequency range 5: 30 GHz to 47 GHz

The choice of antenna depends on the application planned for this band, requirements of the operators and the responsible administration. Figures 27 to 32 give the RPEs for antenna classes 1, 2, 3 and 4.



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 27: RPEs for class 1 antennas in the frequency range 30 GHz to 47 GHz

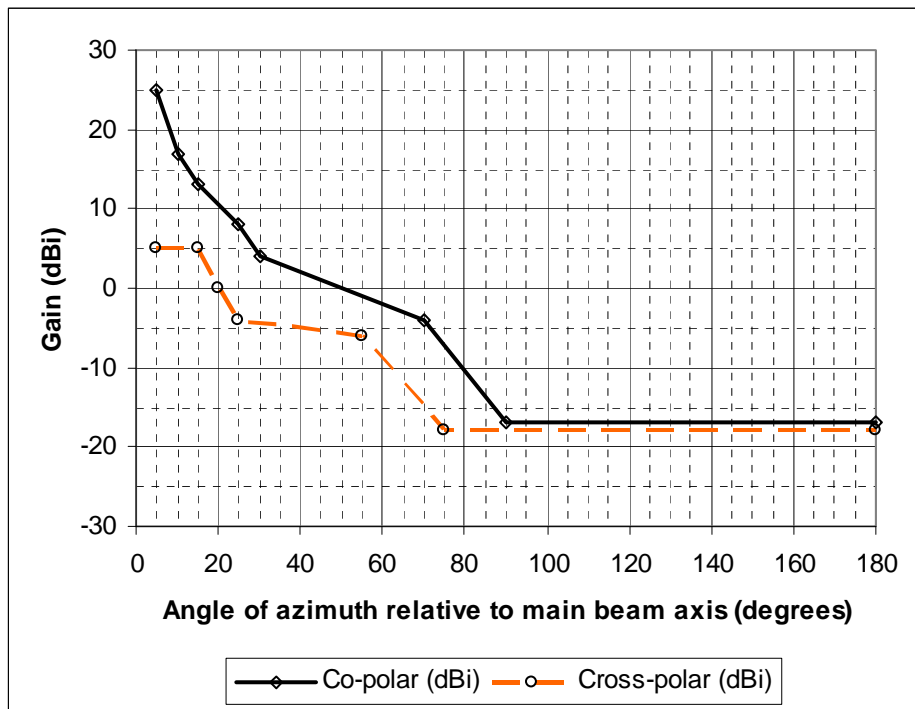


Figure 28: Class 2 antennas RPE (30 GHz to 47 GHz)

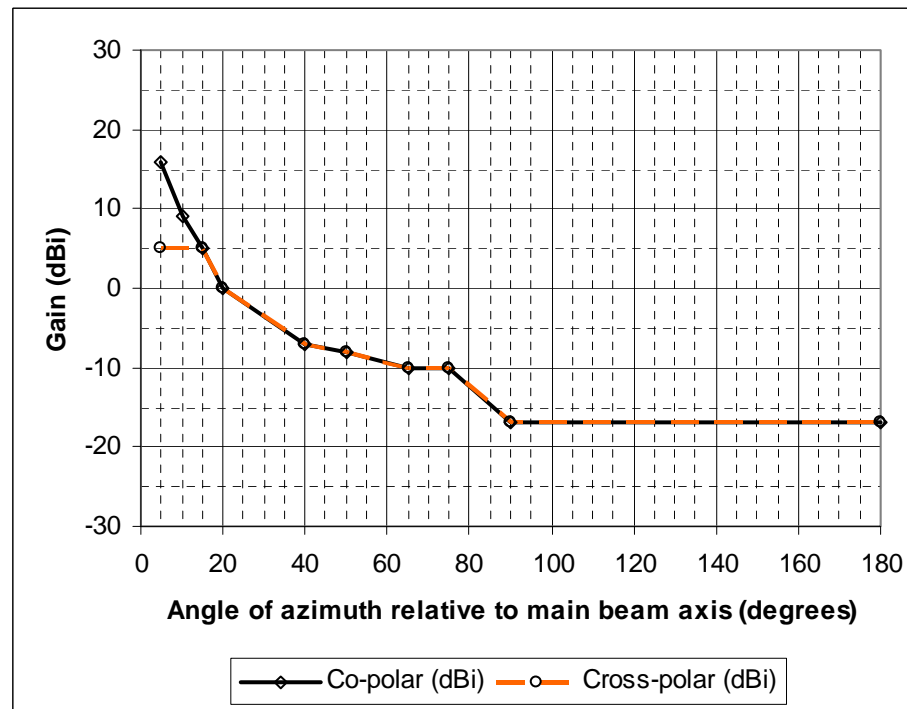


Figure 29: Class 3 A antennas RPE (30 GHz to 47 GHz, applicable to single vertical polarized antennas only)

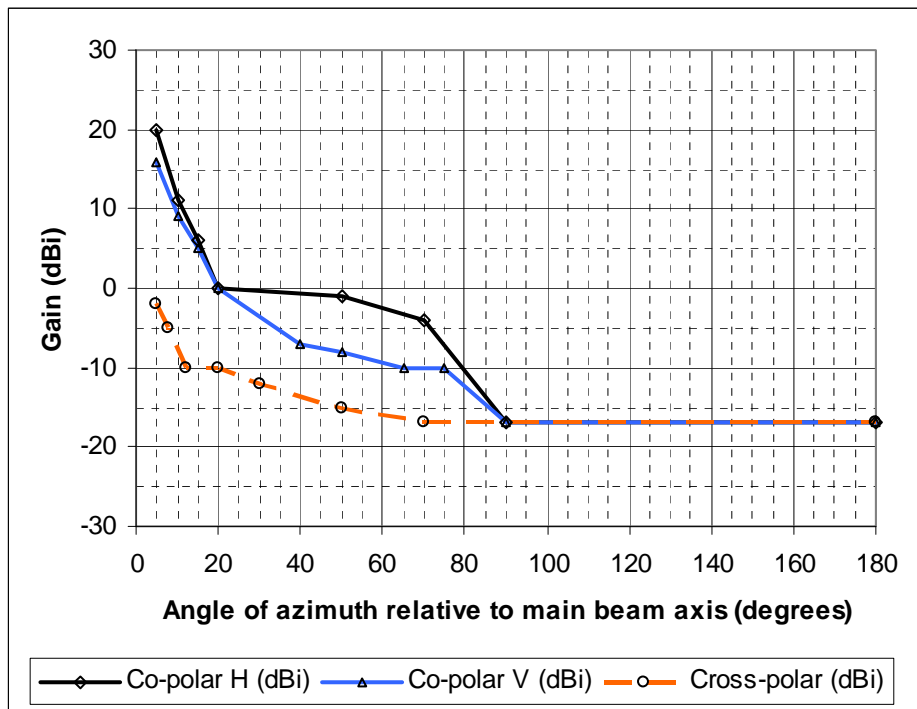


Figure 30: Class 3B antennas RPE (30 GHz to 47 GHz)

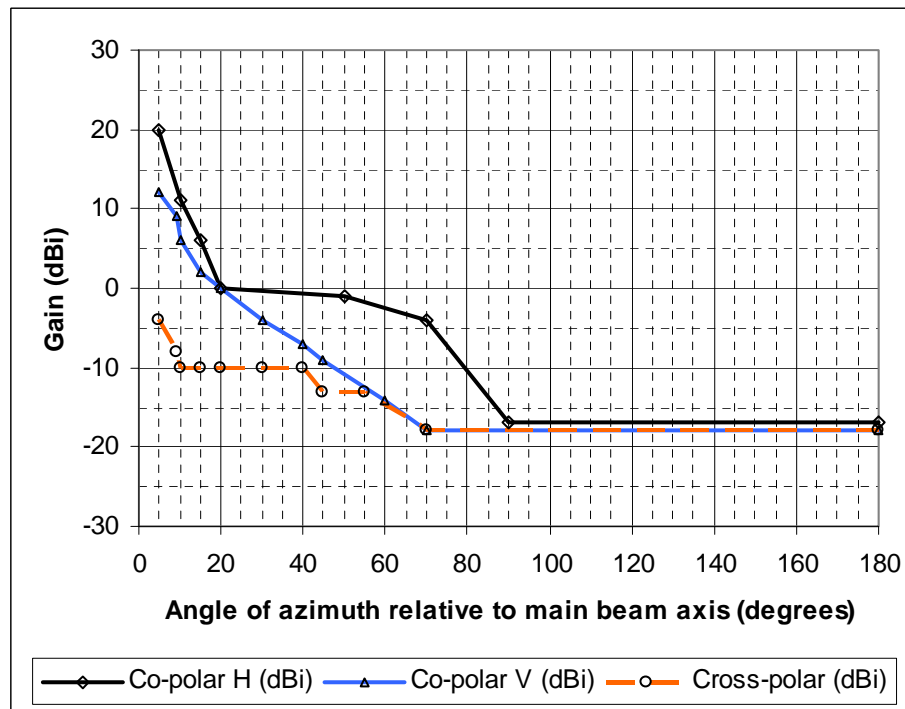


Figure 31: Class 3C antennas RPE (30 GHz to 47 GHz)

Angle (°)	Co-polar H (dBi)	Angle (°)	Co-polar V (dBi)	Angle (°)	Cross-polar (dBi)
5	20	5	16	5	-2
10	11	10	9	8	-5
15	6	15	5	12	-10
20	0	20	0	20	-10
50	-1	40	-7	30	-12
70	-4	50	-8	50	-15
90	-17	65	-10	70	-17
180	-17	75	-10	180	-17
		90	-17		
		180	-17		

Angle (°)	Co-polar H (dBi)	Angle (°)	Co-polar V (dBi)	Angle (°)	Cross-polar (dBi)
5	20	5	12	5	-4
10	11	9	9	9	-8
15	6	10	6	10	-10
20	0	15	2	15	-10
50	-1	20	0	20	-10
70	-4	30	-4	30	-10
90	-17	40	-7	40	-10
180	-17	45	-9	45	-13
		60	-14	55	-13
		70	-18	70	-18
		180	-18	180	-18

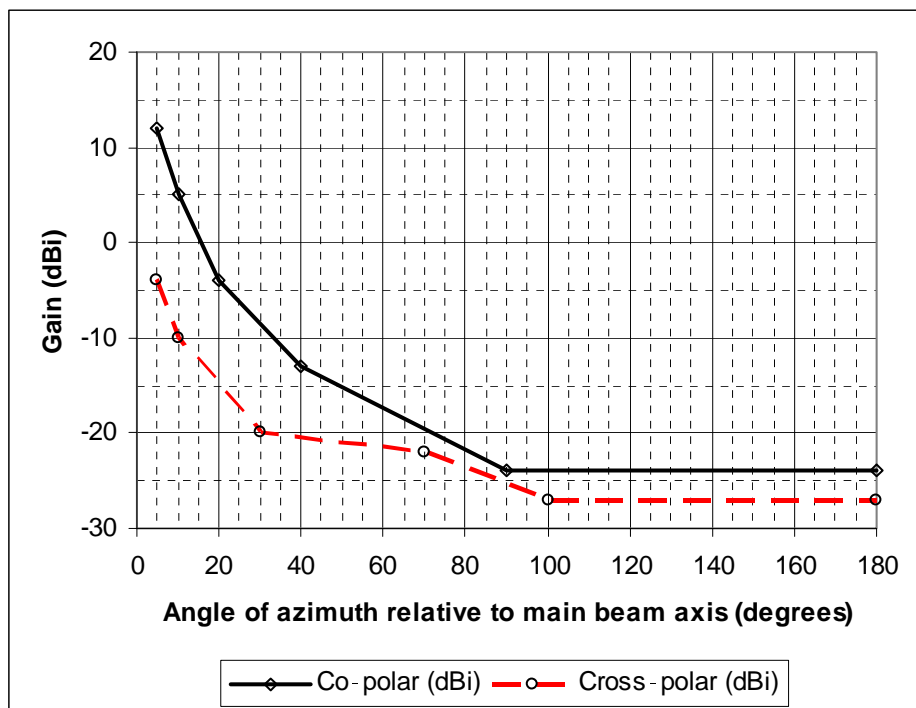
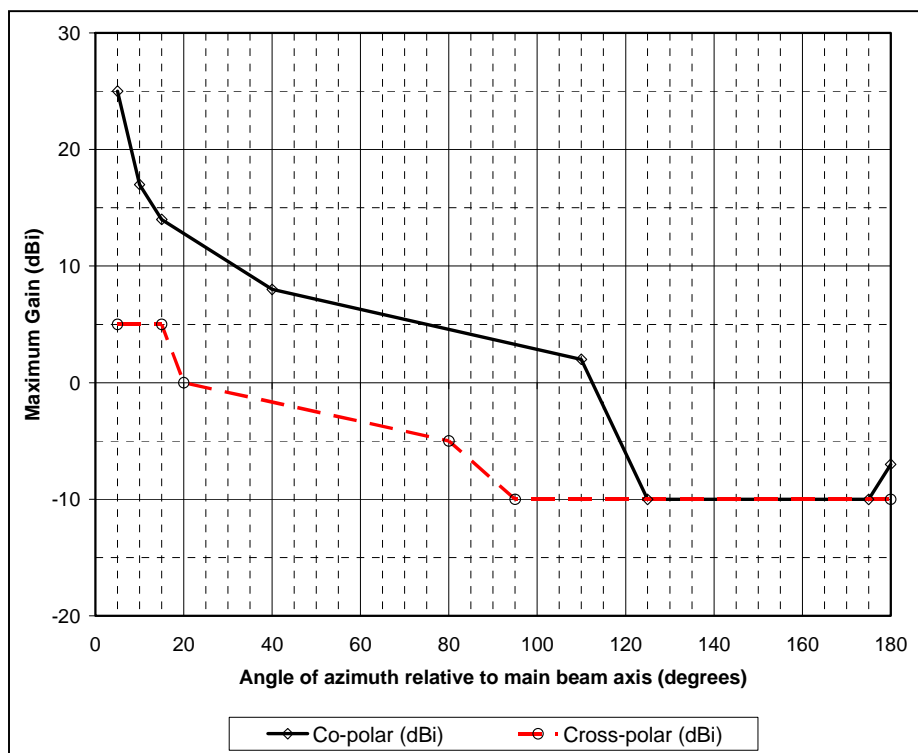


Figure 32: Class 4 antennas RPE (30 GHz to 47 GHz)

4.4.8 Frequency range 6: 47 GHz to 66 GHz

The choice of antenna depends on the application planned for this band, requirements of the operators and the responsible administration. Figures 33 to 36 give the RPEs for antenna classes 1, 2 and 3.



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 33: RPEs for class 1 antennas in the frequency range 47 GHz to 60 GHz

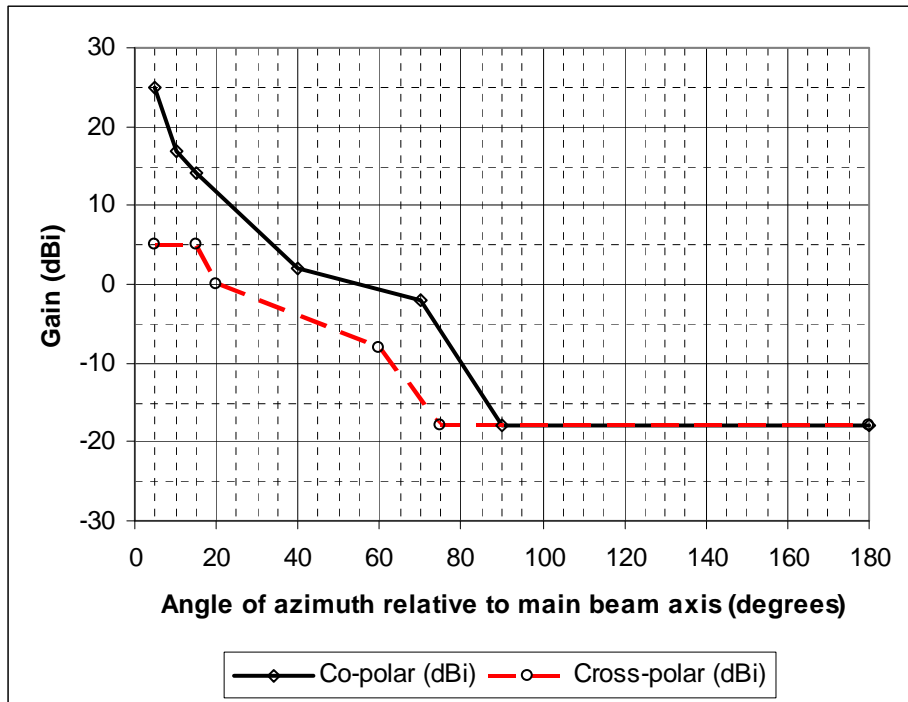


Figure 34: Class 2 antennas RPE (47 GHz to 66 GHz)

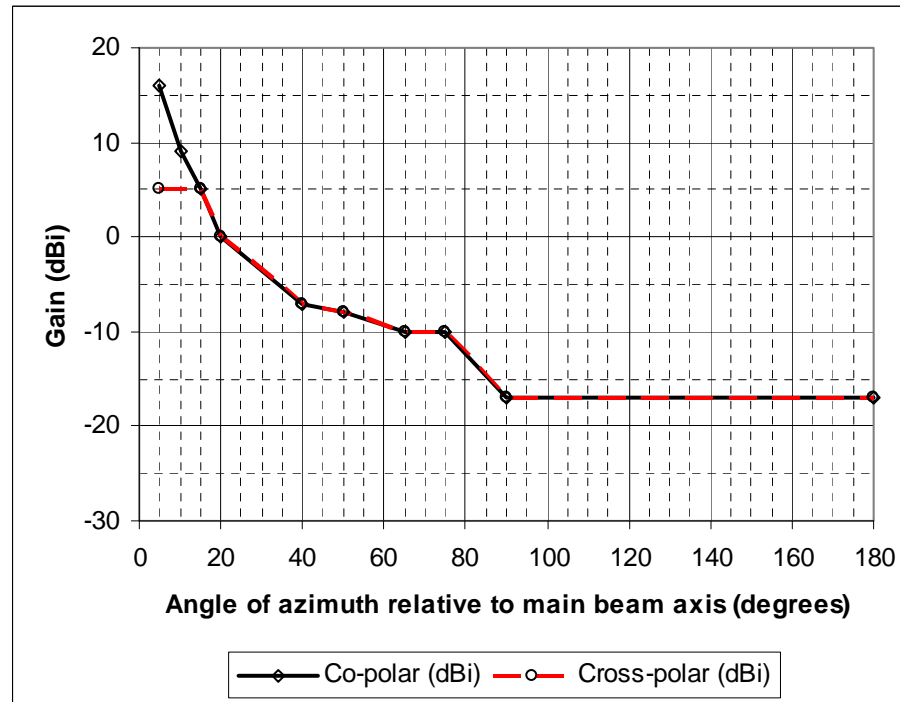


Figure 35: Class 3A antennas RPE (47 GHz to 66 GHz, vertically polarized only)

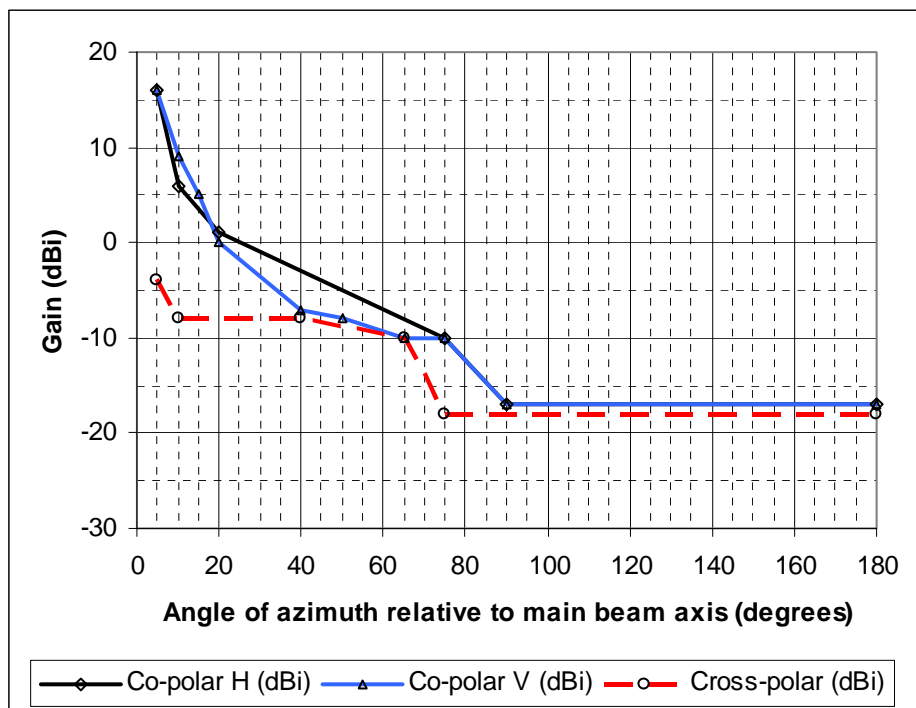
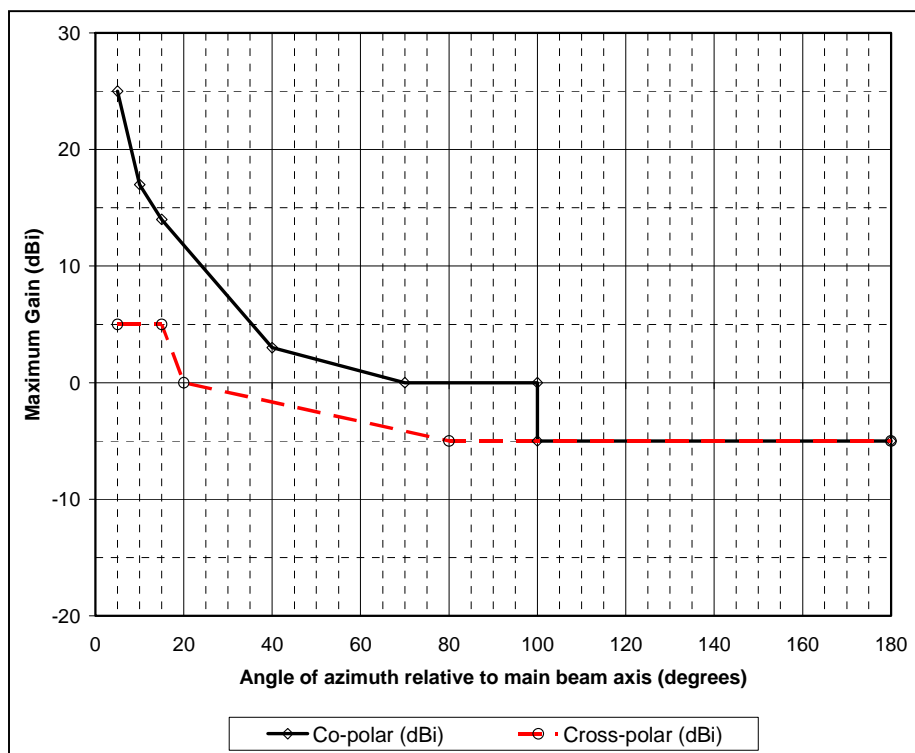


Figure 36: Class 3B antennas RPE (47 GHz to 66 GHz range)

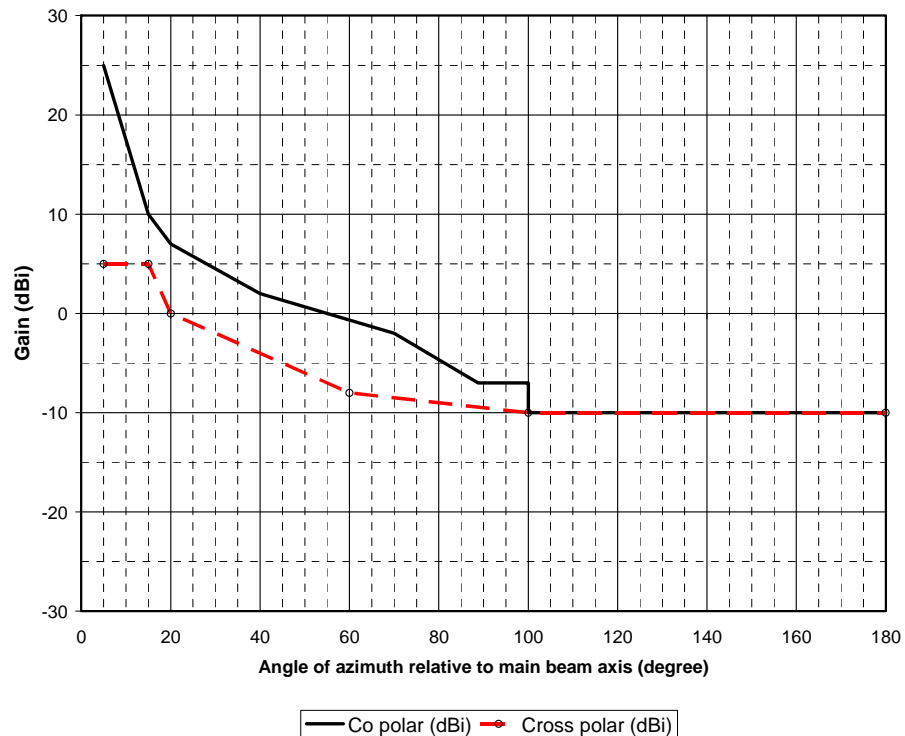
4.4.9 Frequency range 7: 66 GHz to 86 GHz

The choice of antenna depends on the application planned for this band, requirements of the operators and the responsible administration. Figures 37 to 40 give the RPEs for antenna classes 1, 2, 3 and 4.



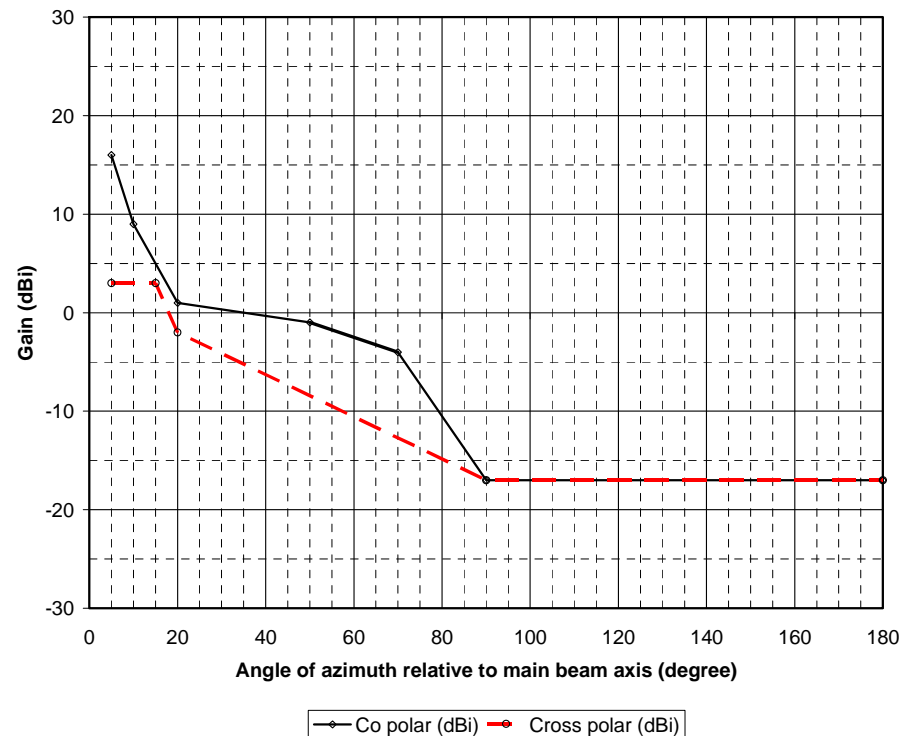
Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	25	5	5
10	17	15	5
15	14	20	0
40	3	80	-5
70 to 100	0	180	-5
100 to 180	-5		

Figure 37: RPEs for class 1 antennas in the frequency range 71 GHz to 86 GHz



Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	25	5	5
15	10	15	5
20	7	20	0
40	2	60	-8
70	-2	100	-10
88,75	-7	180	-10
100	-7		
100	-10		
180	-10		

Figure 38: Class 2 antenna RPE (71 GHz to 86 GHz)



Angle (°)	Co-polar (dBi)	Angle (°)	Cross-polar (dBi)
5	16	5	3
10	9	15	3
20	1	20	-2
50	-1	60	-10
70	-4	90	-17
90	-17	180	-17
180	-17		

Figure 39: Class 3 antenna RPE (71 GHz to 86 GHz)

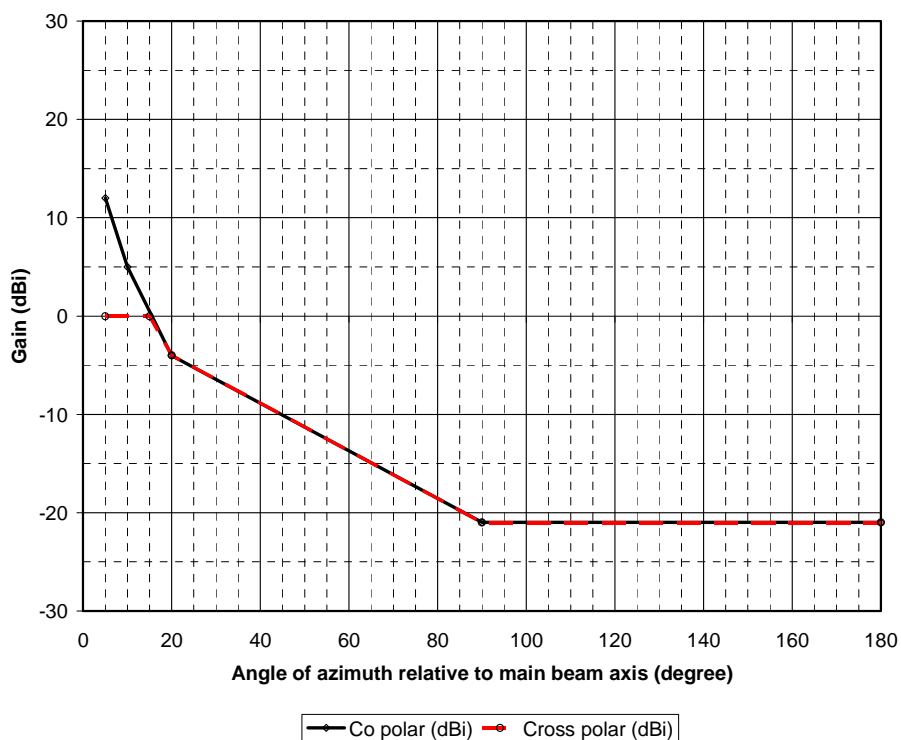


Figure 40: Class 4 antenna RPE (71 GHz to 86 GHz)

4.5 Cross-Polar Discrimination (XPD)

4.5.1 XPD categories

The XPD characteristics have impact 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:

- XPD category 1: those antennas required to have standard cross-polar discrimination. Limits are reported in clause 4.5.2.
- XPD category 2: those antennas required to have high cross-polar discrimination. Limits are reported in clause 4.5.3.
- XPD category 3: those antennas required to have high cross-polar discrimination through an extended angular region. Limits are reported in clause 4.5.3.

4.5.2 XPD category 1

Table 3 reports the XPD limits for all frequency ranges.

Table 3: Minimum XPD requirement per frequency range and category

Frequency ranges	Standard XPD
	Category 1 (dB) (see note)
Range 1 (3 GHz to 14 GHz)	27
Range 2 (14 GHz to 20 GHz)	27
Range 3 (20 GHz to 24 GHz)	27
Range 4 (24 GHz to 30 GHz)	27
Range 5 (30 GHz to 47 GHz)	27
Range 6 (47 GHz to 57 GHz)	27
Range 6 (57 GHz to 66 GHz)	No requirement
Range 7 (66 GHz to 86 GHz)	No requirement
NOTE: XPD values intended to be met with respect to the azimuth plane only and within the 1 dB beamwidth of the co-polarized main beam.	

4.5.3 XPD categories 2 and 3

4.5.3.1 Frequency range 1 GHz to 3 GHz

Category 2 is applicable to the frequency range 1 GHz to 3 GHz:

- Category 2: High XPD with 25 dB minimum requirement.
- Category 3 is not presently standardized for this frequency range.

The XPD corresponding to the RPEs classes referenced in clause 4.4 of the present document shall be equal to or higher than those values defined in table 4.

Table 4: Minimum XPD for each antenna class

Class	Minimum XPD (dB)
1A and 1B	25 (XPD category 2)
2	25 (XPD category 2)
3	25 (XPD category 2)
NOTE: XPD values are intended to be met with respect to the azimuth plane only and within an angle twice the half power beamwidth of the co-polarized main beam.	

4.5.3.2 Frequency range 3 GHz to 86 GHz

In the frequency range 3 GHz to 86 GHz, the two categories are defined according to sub-ranges of frequency and minimum requirements as defined in table 5. The manufacturer shall declare which XPD Category the antenna refers to.

The XPD shall be equal to or greater than those values defined in table 5.

In figures 41 and 42, masks are given for XPD measurements around the main beam axis.

Table 5: Minimum XPD requirement per frequency range and category

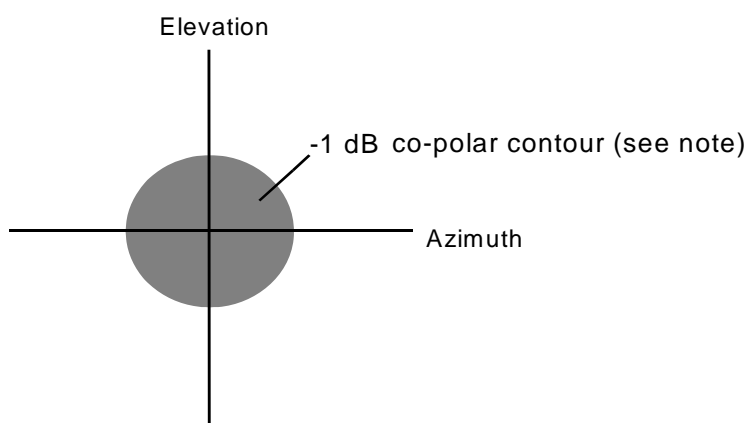
Frequency Ranges	High XPD	
	Category 2 (dB) (see note 1)	Category 3 (dB) (see note 2)
Range 1 (3 GHz to 14 GHz)	30	35 40 (see note 3)
Range 2 (14 GHz to 20 GHz)	27	30
Range 3 (20 GHz to 24 GHz)	27	30
Range 4 (24 GHz to 30 GHz)	27	30
Range 5 (30 GHz to 47 GHz)	27	30
Range 6 (47 GHz to 66 GHz)	Not applicable	Not applicable
Range 7 (66 GHz to 86 GHz)	Not applicable	Not applicable

NOTE 1: XPD values intended to be met within the 1 dB co-polar contour referred in figure 41.

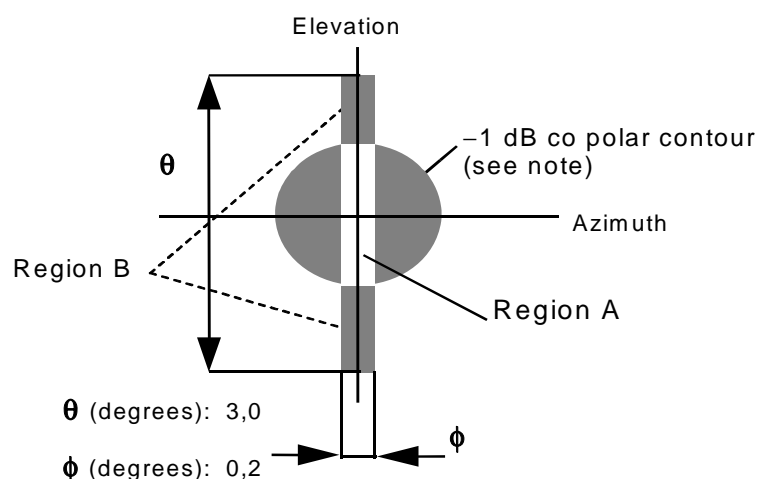
NOTE 2: XPD values intended to be met within the 1 dB co-polar contour and the region B referred in figure 42.

NOTE 3: Additional XPD values intended to be met within region A referred in figure 42.

In figures 41 and 42, masks are given for XPD measurements around the main beam axis.



NOTE: For the dual band antennas -1 dB contour for the highest frequency band shall be used.

Figure 41: Category 2 mask for XPD measurements around the main beam axis

NOTE: For the dual band antennas the -1 dB and other contours for the highest frequency band shall be used.

Figure 42: Category 3 mask for XPD measurements around the main beam axis

4.6 Antenna gain

The actual antenna gain contributes to the EIRP value, which is the basic parameter that shall be taken account of in order to control interference on the network. Therefore, the antenna manufacturer shall declare the nominal gain and its tolerance.

For frequency bands above 57 GHz there may be an impact in terms of minimum antenna gain when meeting the requirements of ETSI EN 302 217-2 [i.4].

5 Testing for compliance with technical requirements

5.1 Environmental conditions for testing

The technical requirements of the present document apply under the environmental profile for intended operation of the antenna, which shall be declared by the manufacturer.

The environmental profile may be determined by the environmental class of the equipment, intended for outdoor usage, according to the guidance given in clause 4.4 of ETSI EN 301 126-1 [i.6].

The antenna shall comply with all the requirements of the present document at all times when operating within the boundary limits of the declared operational environmental profile.

Any test, requested to generate the test report for assessment of point-to-point radio equipment, for integral, dedicated or stand-alone DFRS antennas (technical requirements of clause 4), shall be carried-out at reference environmental conditions of the test field according to clause 4.1 of ETSI EN 301 126-3-1 [1].

5.2 Wide radio-frequency band covering antennas specification and tests

DFRS antennas commonly cover an operating frequency range. The antenna parameters shall comply with all the requirements of the present document at any possible operating frequency.

The tests, requested to generate the test report shall be carried-out at the highest and the lowest possible operating frequency.

Annex A (informative): Additional information

A.1 Mechanical characteristics

A.1.1 Environmental characteristics

The principles for defining the operational environment profile are reported in ETSI EN 302 217-1 [2].

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.

A.1.2 Wind ratings

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

Table A.1

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

A.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 A.2.

Table A.2

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

A.2 Antenna input connectors

When flanges are provided at the input port of the antenna, they should be in accordance with IEC 60154-1 [3] and IEC 60154-2 [4].

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 [5].

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

A.3 Return loss at the input ports

The minimum return loss should be agreed between the equipment and feeder manufacturer(s) and purchaser in line with the overall system design requirements. For guidance refer to equipment port return loss requirement in ETSI EN 302 217-1 [2], clause 7.1.2, 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 is 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.

A.4 Inter-port isolation

The isolation between the input ports of a dual polarized antenna should be agreed between the equipment manufacturer 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).

A.5 Antenna labelling

It is recommended that the antennas should be clearly identified with a weather-proof and permanent label showing the manufacturers name, antenna type and serial number.

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

B.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.

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

The present document gives radiation pattern envelopes (RPE) that 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 manufacturer.

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 (depth) of the antenna; however, Recommendation ITU-R F.699 [i.7] 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 86 GHz.

Recommendation ITU-R F.699 [i.7] provides two sets of formulas, one for antennas with D/λ ratio greater than 100 and a second for antennas with D/λ ratio equal to 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 Recommendation ITU-R F.699 [i.7], 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 Recommendation ITU-R F.699 [i.7]:

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

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

$$G(\varphi) = 52 - 10 \times \log \frac{D}{\lambda} - 25 \log \varphi \quad \text{for } 100 \frac{\lambda}{D} \leq \varphi < 48^\circ;$$

$$G(\varphi) = 10 - 10 \times \log \frac{D}{\lambda} \quad \text{for } 48^\circ \leq \varphi \leq 180^\circ.$$

where φ : off-axis angle (degrees)

D : antenna diameter
 λ : wavelength } expressed in the same units

$$G_1: \text{ gain of the first side-lobe} = 2 + 15 \times \log \frac{D}{\lambda}$$

$$\varphi_m = \frac{20\lambda}{D} \sqrt{G_{max} - G_1} \quad \text{degrees}$$

History

Document history		
V1.1.3	December 2004	Publication as ETSI EN 302 217 parts 4-1 and 4-2
V1.2.1	June 2006	Publication as ETSI EN 302 217 part 4-2
V1.2.1	October 2007	Publication as ETSI EN 302 217 part 4-1
V1.3.1	October 2007	Publication as ETSI EN 302 217 part 4-2
V1.3.1	March 2009	Publication as ETSI EN 302 217 part 4-1
V1.4.1	March 2009	Publication as ETSI EN 302 217 part 4-2
V1.4.1	January 2010	Publication as ETSI EN 302 217 part 4-1
V1.5.1	January 2010	Publication as ETSI EN 302 217 part 4-2
V2.0.3	June 2016	EN Approval Procedure AP 20160915: 2016-06-17 to 2016-09-15
V2.1.1	May 2017	Publication