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Part 3: Multipoint Antennas

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Foreword

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

This multi-part deliverable covers characteristics and requirements for fixed multipoint radio equipment and antennas, using a variety of access and duplex methods and operating at a variety of bit rates in frequency bands as specified in the present document.

The present document is part 3 of a multi-part deliverable covering the Fixed Radio Systems; Multipoint Equipment and Antennas, as identified below:

Part 1: "Overview and Requirements for Digital Multipoint Radio Systems";

Part 2: "Harmonised Standard for access to radio spectrum";

Part 3: "Multipoint Antennas".

NOTE: Part 1 is no longer maintained and referenced in other parts of the series.

The present document includes requirements for antennas whether they are *integral* or *non-integral* (i.e. *dedicated* or *stand-alone* antennas).

National transposition dates	
Date of adoption of this EN:	30 August 2021
Date of latest announcement of this EN (doa):	30 November 2021
Date of latest publication of new National Standard or endorsement of this EN (dop/e):	31 May 2022
Date of withdrawal of any conflicting National Standard (dow):	31 May 2022

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).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

Introduction

For the general background, rationale and structure of the present document see also the clause "Introduction" in ETSI EN 302 326-2 [i.4].

1 Scope

1.1 General

The present document is applicable to antennas (*stand-alone*, *dedicated* or *integral* antennas according to the definitions of terms in clause 3.1) used in MultiPoint (MP) Digital Fixed Radio Systems (DFRS) (see note 1) intended for use in the frequency bands identified in ETSI EN 302 326-2 [i.4].

NOTE 1: Applications intended for offering in the bands 3,4 GHz to 3,8 GHz the option of Nomadic Wireless Access (NWA), according to the NWA definition in Recommendation ITU-R F.1399 [i.3], are also considered in the scope of the present document.

For Multipoint Fixed Radio Systems, antenna characteristics are not considered relevant to essential requirements under article 3.2 of Directive 2014/53/EU [i.1] (see note 2). Antenna characteristics in the present document are considered applicable whenever they are considered appropriate for the associated multipoint radio system.

NOTE 2: Rationale can be found in ETSI TR 101 506 [i.2].

1.2 Antenna types and operating frequency

The present document is applicable to multipoint radio system antennas of both linear (single or dual) polarization and circular (single or dual) polarization. Linear polarization antennas may support either or both of two mutually perpendicular planes of polarization. These planes are frequently, though not always, horizontal and vertical. Circular polarization antennas may support either *right hand* or *left hand* polarization or, for dual polarization, both.

The RPE directional characteristics and polarization characteristics (co-polar and cross-polar and for either linear or circular polarized antennas) impact on the interference has to be considered in network planning. A number of antenna options are defined in the present document.

Table 1 outlines the multipoint antenna types and their operating frequencies described in the present document.

NOTE: Antenna characteristics are not standardized at frequencies below 1 GHz.

Table 1: Antenna Types

Frequency Range (see note)	Types	Polarization	Notes
1 GHz to 3 GHz	Directional Sectored single beam Omnidirectional	Linear	The sectored and omnidirectional antennas may have a symmetric or asymmetric radiation pattern in the *elevation plane*.
3 GHz to 5,9 GHz, 5,9 GHz to 8,5 GHz and 8,5 GHz to 11 GHz	Directional Sectored single beam Sectored multi-beam (up to 5,9 GHz only) Omnidirectional	Linear	The sectored single and omnidirectional antennas may have a symmetric or asymmetric radiation pattern in the *elevation plane*. The sectored multi-beam antennas have a symmetric radiation pattern only.
1 GHz to 11 GHz	Directional Sectored single beam Omnidirectional	Circular	The sectored and omnidirectional antennas may have a symmetric or asymmetric radiation pattern in the *elevation plane*.
24,25 GHz to 30 GHz	Directional Sectored single beam	Linear	
30 GHz to 40,5 GHz and 40,5 GHZ to 43,5 GHz	Directional Sectored single beam Omnidirectional	Linear	The omnidirectional antennas may have a symmetric or asymmetric radiation pattern in the *elevation plane*.
NOTE: Attention is drawn to the fact that the specific operating bands are subject of CEPT or national licensing rules. Currently applicable Fixed Service bands and channel plans are described in ETSI EN 302 326-2 [i.4], although the applicability of these Fixed Service bands is at the discretion of the national administrations. Therefore, the present document applies only to those bands which are allocated to the Fixed Service and/or assigned by national regulations to MP applications on the date on which the EN was published.			

1.3 Profiles

The present document and associated ETSI EN 302 326-2 [i.4] for equipment and systems allows many distinct types of equipment, several different antenna types and several ways in which they might be interconnected to form a network. However, the applicability is limited to certain combinations of attributes and these combinations of attributes are called "profiles":

- Equipment profiles.
- Antenna profiles.
- System profiles.

Annex A discusses Equipment, Antennas and System Profiles for multipoint systems in the scope of this multi-part deliverable.

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 https://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 301 126-3-2: "Fixed Radio Systems; Conformance testing; Part 3-2: Point-to-Multipoint antennas - Definitions, general requirements and test procedures".

[2] ETSI EN 302 217-4: "Fixed Radio Systems; Characteristics and requirements for point-to-point equipment and antennas; Part 4: Antennas".

[3] Void.

[4] Void.

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.

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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] 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.2] ETSI TR 101 506 (V2.1.1): "Fixed Radio Systems; Generic definitions, terminology and applicability of essential requirements covering article 3.2 of Directive 2014/53/EU to Fixed Radio Systems".

[i.3] Recommendation ITU-R F.1399: "Vocabulary of terms for wireless access".

[i.4] ETSI EN 302 326-2 (V2.1.1): "Fixed Radio Systems; Multipoint Equipment and Antennas; Part 2: Harmonised Standard for access to radio spectrum".

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms (see note) apply:

NOTE: For the correct understanding and application of the requirements in the present document, the definitions below are identified, when relevant, with the use of *italic characters* (e.g. *azimuth plane*).

antenna: part of the transmitting or receiving system designed to transmit or receive electromagnetic radiation

azimuth plane: reference plane (see note) from which Radiation Pattern Envelopes are referenced

NOTE: This plane is nominally horizontal (see also *tilt*). The azimuth plane is generally mechanically identified by reference to the technical description for actual antennas for testing and deployment purposes. Sectorial and omnidirectional antennas might have intrinsic down-tilt of few degrees. In such cases, it would be more theoretically appropriate reference to a "conical" surface rather than a plane. However, *tilt* is generally compensated for by the test set antenna mounting (i.e. by tilting up the antenna test set mounting by an equivalent quantity) and the assessment is done by rotating the antenna rather than the receiving instrument. The test is thus performed in such a way that the measurements may be considered equivalent to those made in a true azimuth plane.

Central Station (CS): base station which communicates with Terminal Stations and in some cases Repeater Stations

co-polar: used to define parameters (such as gain or radiation pattern) applicable to radiated signals in the wanted plane of polarization (for linear polarization) or wanted direction of rotation (for circular polarization)

NOTE: The wanted plane or direction of rotation may be defined when the parameter is being measured by the plane or direction of rotation of the reference antenna.

co-polar pattern: diagram representing the co-polar radiation pattern of an antenna under test

NOTE: It is scaled in dBi or, as used in the present document, in dB relative to the measured antenna gain.

cross-polar: used to define parameters (such as gain or radiation pattern) applicable to radiated signals in the unwanted plane of polarization (for linear polarization) or unwanted direction of rotation (for circular polarization)

NOTE: The unwanted plane of polarization of a linear polarized antenna is defined as the plane which lies at right angles to the wanted plane. The unwanted direction of rotation of a circular polarized antenna is defined as that which is opposite to the wanted direction.

cross-polar pattern: diagram representing the cross-polar radiation pattern of an antenna under test

NOTE: It is scaled in dBi or, as used in the present document, in dB relative to the measured **co-polar** antenna gain.

dedicated antenna: antenna specifically designed for being attached to the radio equipment (i.e. with special mechanical fixing to the antenna port of the specific radio supplied), but can be separated from the equipment (typically for transport purpose) by using normal tools

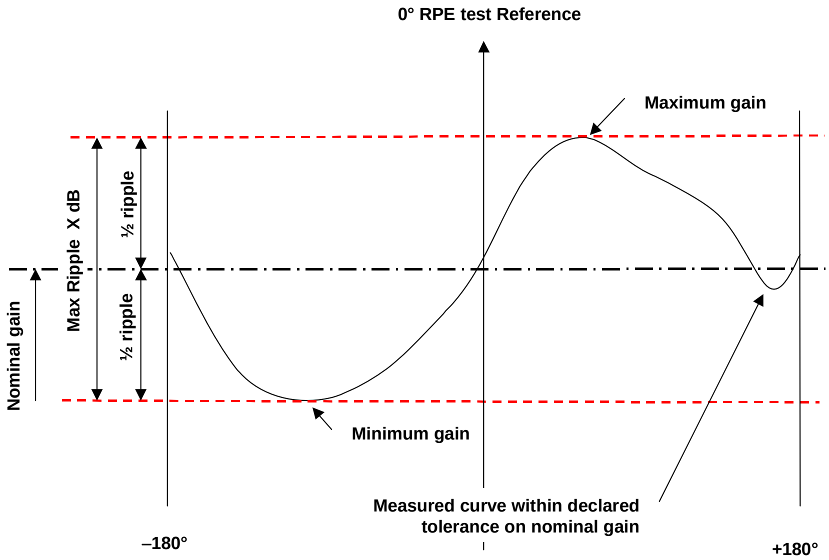
electrical tilt: angular shift in elevation of the direction of *maximum gain* of the antenna by a specific electrical design of the antenna

elevation plane: reference plane, orthogonal to the *azimuth plane*, to which Radiation Pattern Envelopes are referenced

NOTE: This plane is nominally vertical. For directional, single beam sectored and multi-beam sectored antennas, the *elevation plane* is centred to the azimuth *zero degree (0°) reference direction* (within each beam in multi-beam). For omnidirectional antennas, the *elevation plane* is not limited in the *azimuth plane* direction and is specific only to a given measurement.

gain: ratio of the radiation intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna was radiated isotropically

gain ripple: (for omnidirectional antennas) maximum variance of the gain in the *azimuth plane* around the actual gain of the antenna under test



NOTE: Figure 1 shows the relationship between the X dB gain ripple, measured minimum and *maximum gain*s in the *azimuth plane*, and the declared *nominal gain* and *gain tolerance* of an omnidirectional antenna.

Figure 1: Gain ripple for an omnidirectional antenna

gain tolerance: tolerance of the *nominal gain*, as declared by the supplier according to the principles shown in figures 1 and 2

integral (integrated) antenna: antenna which is declared as part of the radio equipment by the manufacturer; it is not physically separable from the equipment

isotropic radiator: hypothetical, lossless antenna with homogenous radiation intensity in all directions

left hand (anticlockwise) polarized wave: elliptically - or circularly - polarized wave, in which the electric field vector, observed in any fixed plane, normal to the direction of propagation, rotates in time in a left-hand or anticlockwise direction

maximum gain: highest gain (in any direction) of the antenna under test

mechanical tilt: angular shift in the *elevation plane* in the direction of *maximum gain* of the antenna when modifying the physical mounting of the antenna

Nomadic Wireless Access (NWA): "Wireless access" application in which the location of the "end-user termination" may be in different places but is stationary while in use

NOTE: See Recommendation ITU-R F.1399 [i.3].

nominal gain: gain declared by the supplier as a basis for the gain assessment:

- **For directional antennas:** it is related to the *maximum gain* through the *gain tolerance*.
- **For sectorial antennas:** the supplier should make a declaration of the gain for the antenna, together with maximum *gain tolerance* that should include the minimum gain within the declared sector. The gain of the antenna, as measured, should not, therefore, exceed the declared gain at the declared upper *gain tolerance* limit, nor should it be lower than the nominal gain at the declared lower *gain tolerance* limit (see figure 2).
- **For omnidirectional antennas:** it refers to the mean value of the gain ripple as shown in figure 1.

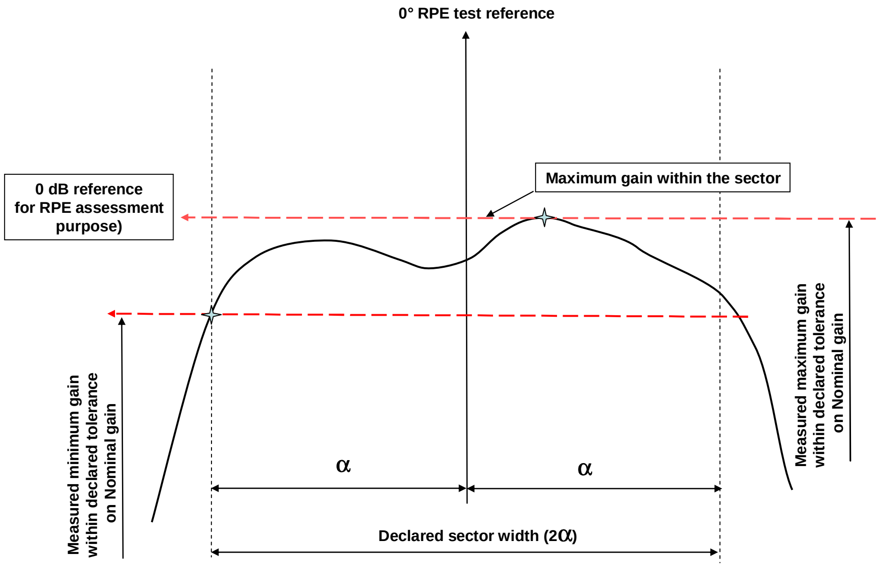


Figure 2: Gain ripple for a sectored antenna

radiation pattern: diagram describing the power flux density in a given plane and at a constant distance from the antenna as a function of the angle from the *zero degree (0°) reference direction*

Radiation Pattern Envelope (RPE): envelope of the radiation pattern

radome: cover of dielectric material, intended to protect an antenna from the effects of its physical environment

reference beam direction (ε°): direction, defined as ε°, defined by the manufacturer in relation to the mechanical characteristics of the antenna and used as reference for every beam RPE (applicable only to multi-beam antennas)

Repeater Station (RS): radio station providing the connection by air to the Central Station(s), the Terminal Stations and other Repeater Stations

NOTE: The Repeater Station may also provide the interfaces to the subscriber equipment if applicable.

right hand (clockwise) polarized wave: circularly (or, more generally, elliptically) polarized wave, in which the electric field vector, observed in any fixed plane, normal to the direction of propagation, rotates in time in a right-hand or clockwise direction

sector angle: angle of coverage in *azimuth plane* of a sectored antenna, defined as 2α° in the present document as declared by the manufacturer

NOTE: The sector angle may depend on the characteristics of the system to which the antenna will be connected and this may therefore result in the need for a different definition of the sector angle. Therefore no specific rule is given for such declaration although in general it is assumed that the sector angle may be close to the half-power (3 dB) beam-width.

stand-alone antenna: antenna designed independently from the fixed radio equipment, by the same or a different manufacturer and connected to the radio equipment in the field by standard cables and waveguides

Terminal Station (TS): remote (out) station, which communicates with a Central Station or Repeater Station

tilt: fixed angular shift of the direction of *maximum gain* of the antenna in the *elevation plane* by either electrical or mechanical means

Zero dB gain reference (*azimuth* and *elevation planes*):

- **For directional (DN) antennas:** corresponds to the *maximum gain* of the antenna. It is equal to the gain in the direction of the boresight (a term not used in the present document).
- **For sectored single beam antennas (SS):** corresponds to the *maximum gain* of the antenna within the declared sector (as in figure 2).
- **For sectored multi-beam antennas (MS):** corresponds to the *maximum gain* of the antenna within each beam (as in figure 2). It should therefore be noted that the multiple beams may have different zero dB gain references.
- **For omnidirectional antennas (OD):** corresponds to the *maximum gain* of the antenna in the *elevation plane* in which the radiation pattern is being measured. It is not defined for *azimuth plane*.

NOTE: It should be noted that except for directional antennas, the zero dB gain reference does not necessarily correspond to the gain in the *zero degree(0°) reference direction*.

Zero degree (0°) reference direction: direction used as the reference direction for the RPEs

NOTE 1: It is generally identified by the reference to the technical description for actual antennas for testing and deployment purposes and is declared by the manufacturer. It has a different geometrical relationship with the actual antenna type considered as follows:

- **For directional (DN) antennas:** corresponds to the direction of *maximum gain* in both axes of the antenna. It is equivalent to the boresight direction (term not used in the present document).
- **For sectored single beam antennas (SS):** the direction which, in the *azimuth plane*, is the centre of the declared *sector angle* and, in the *elevation plane*, corresponds to the direction of the *maximum gain*, nominally coincident to the *azimuth plane* intersection. (see figure 2 and note 2).
- **For sectored multi-beam antennas (MS):** corresponds, in the *azimuth plane*, to the *zero degree reference direction*; it is the common reference direction for the RPEs of all beams and is declared by the manufacturer. In the *elevation plane*, it is the direction of *maximum gain* of each beam (see note 2). It should therefore be noted that the multiple beams may have different *zero degree reference directions*.
- **For CS omnidirectional antennas (OD):** the *zero degree reference direction* for this omnidirectional antenna type is, in principle, not defined in the *azimuth plane* (i.e. only a 0° reference for actual test report should be identified according figure 2); In the *elevation plane* in which the radiation pattern is being measured, it is the direction of *maximum gain* (see note 2).
- **For NWA TS omnidirectional antennas (ODT):** *the zero degree reference direction* for this omnidirectional antenna type is, in principle, not defined in any plane (i.e. only a 0° reference for actual test report should be identified, for each plane, according figure 2).

NOTE 2: In practical tests, in particular for sector and CS omnidirectional antennas, the elevation RPE might have slight variation within a relatively large elevation angle and might lead to uncertainty in finding the *maximum gain* for the RPE assessment. In such cases the direction of the *azimuth plane* (including *tilts*, if any) should be used as *zero (0°) degree reference direction* in *elevation plane* even if actual slightly higher gain might be experienced in a slightly different direction. See also the note to "*azimuth plane*" definition.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

abs( )	Absolute value of the number
α	Alpha (= half of the sector angle)
dB	deciBel
dBi	deciBels relative to an isotropic source

ε	Epsilon (= beam reference direction)
f_0	Nominal centre frequency of declared antenna operating range
GHz	GigaHertz
θ	Theta (= angle from *zero degree reference direction*)

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CS	Central Station
DFRS	Digital Fixed Radio Systems
DN	DirectioNal (antenna)
EIRP	Equivalent Isotropically Radiated Power
EqC	Equipment Classification
LHCP	Left Hand Circular Polarization
MP	MultiPoint
MP-MP	MultiPoint-to-MultiPoint
MS	Multi-beam Sectorial (antenna)
NWA	Nomadic Wireless Access
OD	OmniDirectional (antenna) for CS use
ODT	OmniDirectional (antenna) for NWA TS use
pfd	power flux density
P-MP	Point-to-MultiPoint
RHCP	Right Hand Circular Polarization
RLAN	Radio Local Area Network
RPE	Radiation Pattern Envelope
RS	Repeater Station
SS	Single beam Sectorial (antenna)
TS	Terminal Station
XPD	Cross-Polar Discrimination

4 Technical requirements specifications

4.1 Classification of antennas

For each antenna type and frequency range, a number of different antenna classes are defined. The class of antenna selected will depend on operational requirements.

For each combination of antenna type and frequency range, several classes of antenna may be designated.

Directional antennas are designated as DN1, DN2 … DNn which are classified by increasingly demanding RPE according to the ranges defined in annex A.

Single beam sectored antennas are designated SS1, SS2 … SSn according to their increasingly demanding RPEs.

Multi-beam sectored antennas are designated MS1, MS2 … MSn according to their increasingly demanding RPEs.

Only one class of omnidirectional antenna for CS is currently specified. Should it occur that more than one class of omnidirectional antenna is designated, the designations OD1, OD2 … ODn may be used. A single case of omnidirectional antenna for TS intended for NWA application is considered and designated as ODT.

In few cases, when more than one standardized antenna parameters are close enough for being considered belonging to the same class, further alphabetical suffix (a, b, etc.) is used. For more information on antenna classes see annex A.

4.2 Characteristics description

4.2.1 General

Two characteristics are identified as applicable to antennas used in fixed multipoint radio systems:

- Radiation Pattern Envelope (RPE).
- Gain.

The RPE consists of different co-polar and cross polar envelopes.

For sectored (single beam or multi-beam) and omnidirectional CS antenna types the RPE is specified in different azimuth and elevation patterns. Different azimuth and elevation patterns are also specified in the case of linearly polarized directional antennas in the frequency range.

It should be noted that the method of specifying these characteristics is different for different antenna types. The characteristics are therefore separately specified for each antenna type.

A *zero degree (0°) reference direction* shall be defined for each antenna. The radiation characteristics in the present document are all referred to this *zero degree (0°) reference direction*.

For the purpose of the present document, an antenna is specific to a Type, Class, Polarization Type, the frequency range of operation. An antenna, which employs a *radome*, shall meet the requirements of the present document with the *radome* in place.

The following clauses specify the two characteristics for each antenna type, class and frequency range.

4.2.2 Radiation Pattern Envelope (RPE)

A *zero degree (0°) reference direction* shall be defined for each antenna and declared by the manufacturer. The radiation characteristics in the present document are all referred to this *zero degree (0°) reference direction*.

Elevation RPEs are defined at the azimuth *zero degree (0°) reference direction*. In the remaining directions slight variation may be expected (within 3 dB), however no specific tests are required.

The radiation pattern envelope is the envelope which the gain of the antenna shall not exceed, relative to its declared value, as a function of angle from the *zero degree (0°) reference direction*. The RPE is specified separately (for both co-polar and cross-polar values) for *azimuth plane* (the nominally horizontal plane) and *elevation plane* (the nominally vertical plane).

For the majority of antennas of type "Directional", the elevation and azimuth RPEs are identical and are thus specified in this way. For antennas of type "Omnidirectional", where the antenna performance is nominally uniform in the *azimuth plane*, the azimuth RPE is expressed as *gain ripple* in this plane.

Linearly polarized antennas radiate an electromagnetic wave which is nominally plane polarized. Radiation emitted which is in the wanted plane of polarization is referred to as co-polar. Radiation emitted in the unwanted plane of polarization (orthogonal to the wanted plane) is referred to as cross-polar.

Circularly polarized antennas radiate an electromagnetic wave which is nominally circularly polarized such that the plane of polarization rotates in either a *right hand* or *left hand* direction. Radiation emitted for which the plane of polarization rotates in the wanted direction is referred to as co-polar. Radiation emitted for which the plane of polarization rotates in the opposite direction to that wanted is referred to as cross-polar.

The RPE is specified separately for co-polar and cross-polar radiation.

NOTE 1: In some cases, typically where co-polar RPE is the more demanding, the cross polar RPE may be less stringent than the co-polar in the *azimuth plane* region around 180°. This is justified, for the Operators may take into account polarization decoupling in adjacent cell/sector planning. However, when inter-operator planning (e.g. for pfd boundary evaluation) is concerned, in general, unless polarization decoupling is also specifically taken into account, the "worst case envelope" of the co-polar and cross polar RPE should be considered.

For single beam sectored and omnidirectional antennas, two types of antenna elevation RPE are defined:

- one for antennas designed to exhibit symmetric RPEs about the *zero degree (0°) reference direction*; and
- one for antennas designed for asymmetric RPEs about the *zero degree (0°) reference direction*.

For single beam sectored and multibeam sectored antennas, the elevation RPE applies only to the *elevation plane* at the azimuth *zero degree (0°) reference direction* of each beam.

For omnidirectional CS antennas, the elevation RPE applies at any azimuth angle. Omnidirectional antennas for TS in NWA applications do not have specific requirements for RPE in either plane (limits apply only to the gain in any direction).

Single beam sectored, multibeam sectored and omnidirectional antennas may have an *electrical tilt*. The scope of the present document includes antennas with *electrical tilt* in the range of 0° to -10°, where a positive *tilt* is in the upward direction and a negative *tilt* is in the downward direction. Further *mechanical tilt* of up to ±10° may be suitable for deployment of single beam sectored and multibeam sectored antennas in some situations (see note 2).

NOTE 2: All RPEs are here defined referenced to a "nominal" *azimuth plane* that corresponds to the horizontal plane only when the antenna has no *tilt*. When a *tilt* is present, the effect of the *tilt* will be compensated for in the test process as described in the definition so that the tests will be conducted as if for an antenna with no *tilt*.

The antenna technical description shall provide information on the nominal *electrical tilt* of the antenna to be used for test report purposes.

The RPEs for the frequency range 1 GHz to 11 GHz apply to both linearly and circularly polarized antennas, except for sectored multibeam antennas, for which only linearly polarized antennas are within the scope of the present document.

The RPEs for the frequency range 30 GHz to 40,5 GHz apply only to linearly polarized antennas.

The applicability of each set of parameters to linear or circular polarization is indicated.

The parameters for a single linear polarized antenna shall apply equally to the wanted plane of polarization of an antenna of either plane. The parameters for a dual linear polarized antenna shall apply equally to both planes of the antenna.

The parameters for a single circular polarized antenna shall apply equally to antennas using *Left Hand* Circular Polarization (LHCP) and antennas using *Right Hand* Circular Polarization (RHCP). The parameters for a dual circular polarized antenna shall apply equally to both LHCP and RHCP.

4.2.3 Antenna Gain

The actual antenna gain is the reference for evaluating the EIRP, which is the basic parameter that is taken into account in order to control interference in the network.

With the exception of omnidirectional TS antennas for NWA applications (for which only the maximum limit applies), the supplier shall make a declaration of the gain for the antenna, together with maximum *gain tolerance* of the antenna. The gain of the antenna, as measured, shall not, therefore, exceed the declared gain at the declared upper *gain tolerance* limit, nor shall it be lower than the *nominal gain* at the declared lower *gain tolerance* limit.

The *nominal gain* of the antenna, the *gain tolerance* and their relationship to the RPE are defined in clause 3.1 according to the type of antenna to which they refer.

The minimum gain of the antenna shall also meet the requirements of clause 4.5.

4.3 Environmental specifications and test

The technical requirements of the present document apply under the environmental profile for operation of the antenna or the equipment-antenna assembly, with its *radome* (if applicable) in place, which shall be declared by the supplier.

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.

4.4 Radiation Pattern Envelope (RPE) requirements

4.4.1 Directional antennas (DN): co-polar and cross-polar RPEs

4.4.1.1 Antenna classes defined in the present document

Where several directional antenna classes are specified in a frequency band, these are designated as DN1, DN2, etc. The rationale for this classification is given in annex A.

The Radiation Pattern Envelope (RPE) is defined as a gain which may not be exceeded as a function of the angle from the *zero degree (0°) reference direction* of the antenna. This gain is expressed as a gain relative to the **maximum, actual** gain (0 dB reference defined in clause 3.1) at the measured frequency.

The RPEs for both co-polar and cross polar gain are specified in the tables below. There is a separate table for each range of frequencies and, within each table, two separate columns are given for each class of antenna, one for the co-polar RPE and one for the cross polar RPE. The co-polar column is headed "Co" and the cross polar column is headed "X". The RPE defined by each column is the envelope obtained by joining each of the points for which there is an entry in the column, the point being defined by the relative gain in the column and the angle from the *zero degree (0°) reference* direction given at the left of the table for that point. The number of points in each column is variable, depending on the number of turning points in the graph of the RPE. Unless otherwise stated, the RPE applies to both *elevation* and *azimuth planes*.

4.4.1.2 Bands from 1 GHz to 11 GHz and from 24,25 GHz to 40,5 GHz

Figure 3 is an example of the co-polar and cross polar RPEs for a class of antenna with six defined points in the co-polar RPE and four defined points in the cross polar RPE.

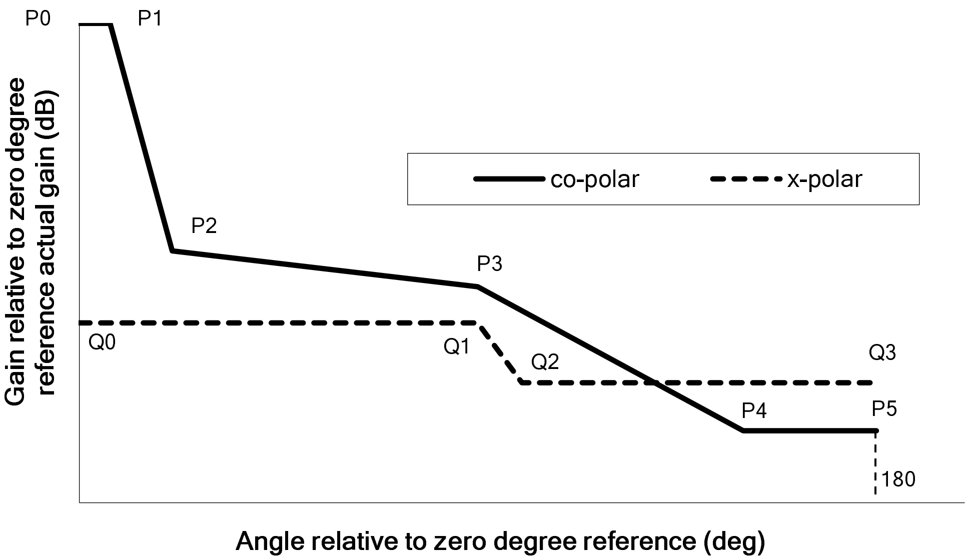


Figure 3: Normalized RPE for DN Azimuth and Elevation

The actual number and values of corner points for the standardized antennas are to be derived from the following tables.

Table 2: Directional antennas (linear polarization) from 1 GHz to 3 GHz, types DN1 to DN4

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)															
	DN1 (void)				DN2				DN3				DN4			
	Azimuth		Elevation		Azimuth		Elevation		Azimuth		Elevation		Azimuth		Elevation	
	Co	X	Co	X	Co	X	Co	X (see note)	Co	X	Co	X (see note)	Co	X	Co	X (see note)
0					0	-13	0	-13	0	-15	0	-15	0	-14	0	14
0																
10									0		0					
20													0		0	
30					0	-13	0		-8		-8					
40													-10	-14		
45											-8					
60					-5	-18	-5								-10	
90									-15	-15			-10			
90										-20					-10	
100														-29		
110					-14	-20	-14									
120													-26		-26	
150									-20		-20					
180					-16	-20	-16		-20	-20	-20		-26	-29	-26	

NOTE: There is no compliance or test report requirements for cross-polar elevation RPE; however at 0° reference the value should be the same as the cross-polar azimuth at 0° reference, while in other directions it should be no worse than the elevation co-polar RPE.

Table 3: Directional antennas (circular polarization) from 1 GHz to 3 GHz, types DN1 to DN4

Θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)															
	DN1 (void)				DN2				DN3				DN4			
	Azimuth		Elevation		Azimuth		Elevation		Azimuth		Elevation		Azimuth		Elevation	
	Co	X	Co	X	Co	X	Co	X (see note)	Co	X	Co	X (see note)	Co	X	Co	X (see note)
0					0	-13	0	-13	0	-15	0	-15	0	-14	0	-14
10									0							
20											0		0		0	
30					0	-13	0		-8		-8					
40													-10	-14	-10	
60					-5	-18	-5									
90									-15	-15	-15		-10			
90										-20						
100														-29		
110					-14	-20	-14									
120													-26		-26	
150									-20		-20					
180					-16	-20	-16		-20	-20	-20		-26	-29	-26	

NOTE: There is no compliance or test report requirements for cross-polar elevation RPE; however at 0° reference the value should be the same as the cross-polar azimuth at 0° reference, while in other directions it should be no worse than the elevation co-polar RPE.

Table 4: Directional antennas (either polarization type) from 3 GHz to 5,9 GHz, types DN1 to DN5

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)									
	DN1		DN2		DN3		DN4		DN5	
	Co	X	Co	X	Co	X	Co	X	Co	X
0	0	-15	0	-15	0	-19	0	-20	0	-20
10					0				0	
12			0				0			
20					-12					
30			-10				-17		-17	
70					-14					
90	0		-15	-15		-19	-17	-20	-17	-20
90	-10									
150			-20	-20	-29	-25	-30	-25	-30	-30
180	-10	-15	-20	-20	-29	-25	-30	-25	-30	-30

Table 5: Directional antennas (either polarization type) from 5,9 GHz to 8,5 GHz, types DN1 to DN5

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)									
	DN1 (void)		DN2		DN3		DN4		DN5 (void)	
	Co	X	Co	X	Co	X	Co	X	Co	X
0			0	-17	0	-25	0	-25		
8							0			
9			0		0					
20							-20			
22			-12		-18					
90			-17	-17	-21	-25	-22	-25		
100						-30				
150			-25	-25	-33		-35	-35		
180			-25	-25	-33	-30	-35	-35		

Table 6: Directional antennas (either polarization type) from 8,5 GHz to 11 GHz, types DN1 to DN5

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)											
	DN 1		DN2 (void)		DN3A		DN3b		DN4 (void)		DN5 (see note)	
	Co	X	Co	X	Co	X	Co	X	Co	X	Co	X
0	0	-12			0	-20	0	-28			0	-30
5											0	
6							0					
7					0							
10	0											
15					-13		-13				-20	
30	-10											
90	-15	-12			-20	-20	-24	-28			-30	-30
100								-33				
130		-17			-30	-30					-40	-40
150	-20						-36					
180	-20	-17			-30	-30	-36	-33			-40	-40
NOTE: DN5 is only defined for linear polarization.												

Table 7: Directional antennas (linear polarization) from 24,25 GHz to 30 GHz, types DN1 to DN5

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)											
	DN 1 (void)		DN2 (void)		DN3A		DN3b		DN4		DN5 (void)	
	Co	X	Co	X	Co	X	Co	X	Co	X	Co	X
0					0	-27	0	-30	0	-30		
2					0		0	-30				
2								-20				
2,5									0			
5						-27		-20				
8					-17		-17					
10						-30		-30	-17	-30		
20									-22	-45		
30					-22		-22					
90					-30	-30	-30	-30	-40			
100					-35	-35	-35	-35				
180					-37	-37	-40	-40	-40	-45		

Table 8: Directional antennas (linear polarization) from 30 GHz to 40,5 GHz, types DN1 to DN5

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)									
	DN1 (void)		DN2		DN3		DN4		DN5 (void)	
	Co	X	Co	X	Co	X	Co	X	Co	X
0			0	-30	0	-27	0	-30		
2					0					
2,5							0			
5			0	-30		-27				
5				-20						
8					-17					
10						-30	-17	-30		
12,5				-20						
15			-17							
20							-22	-45		
25				-30						
30			-22		-22					
90			-25		-30	-30	-40			
100			-30	-30	-35	-35				
180			-35	-35	-40	-40	-40	-45		

4.4.1.3 Band 40,5 GHz to 43,5 GHz

The co-polar and cross-polar radiation patterns for both *azimuth* and *elevation planes*, shall not exceed the RPE(s) defined in the following list:

Class DN1: see table 9 and figure 4.

The gain values defined are all relative to the maximum actual gain **at the measurement frequency**.

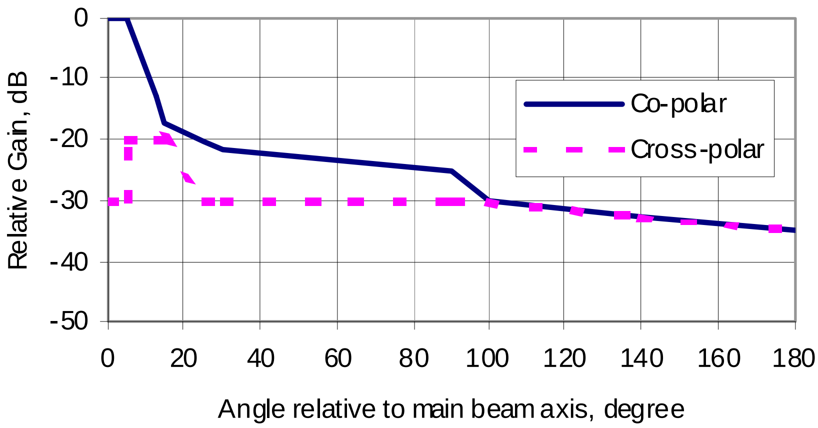


Figure 4: Class DN1 terminal station antenna

Table 9: Class DN1

Angle (degree)	Co-polar (dB)	Angle (degree)	Cross-polar (dB)
0	0	0	-30
5	0	5	-30
15	-17	5	-20
30	-22	12.5	-20
90	-25	25	-30
100	-30	100	-30
180	-35	180	-35

Class DN2: table 10 and figure 5.

The gain values defined are all relative to maximum, actual gain **at the measurement frequency**.

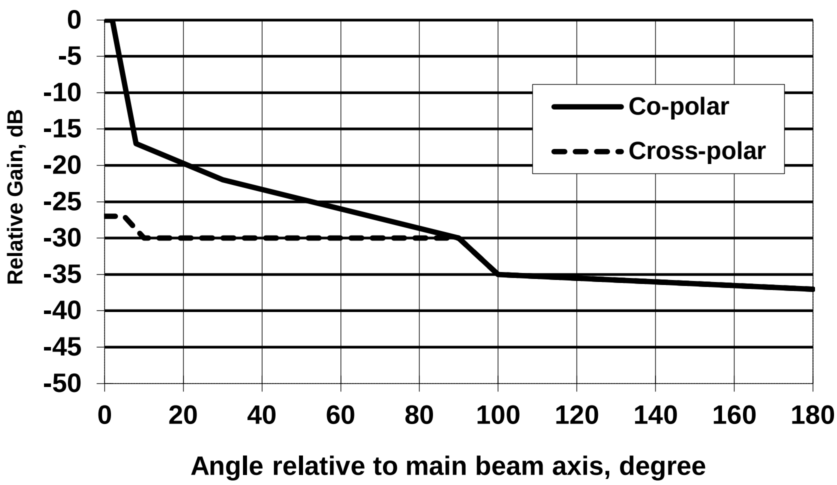


Figure 5: Class DN2 terminal station antenna

Table 10: Class DN2

Angle (degree)	Co-polar (dB)	Angle (degree)	Cross-polar (dB)
0	0	0	-27
2	0	5	-27
8	-17	10	-30
30	-22	90	-30
90	-30	100	-35
100	-35	180	-37
180	-37		

Class DN3: table 11 and figure 6.

The gain values defined are all relative to the maximum actual gain **at the measurement frequency**.

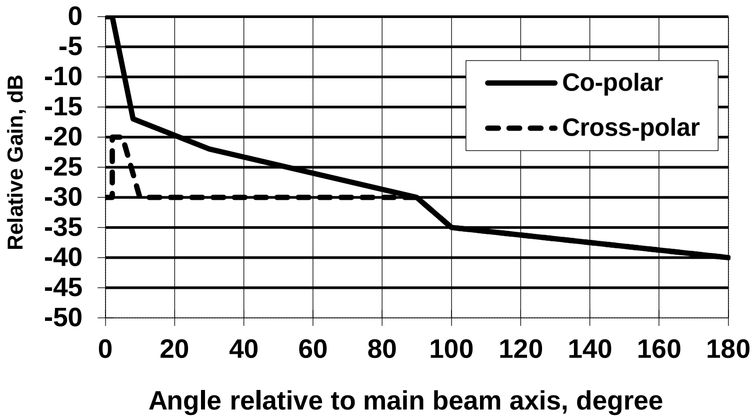


Figure 6: Class DN3 terminal station antenna

Table 11: Class DN3

Angle (degree)	Co-polar (dB)	Angle (degree)	Cross-polar (dB)
0	0	0	-30
2	0	2	-30
8	-17	2	-20
30	-22	5	-20
90	-30	10	-30
100	-35	90	-30
180	-40	100	-35
		180	-40

Class DN4: table 12 and figure 7.

The gain values defined are all relative to maximum, actual gain **at the measurement frequency**.

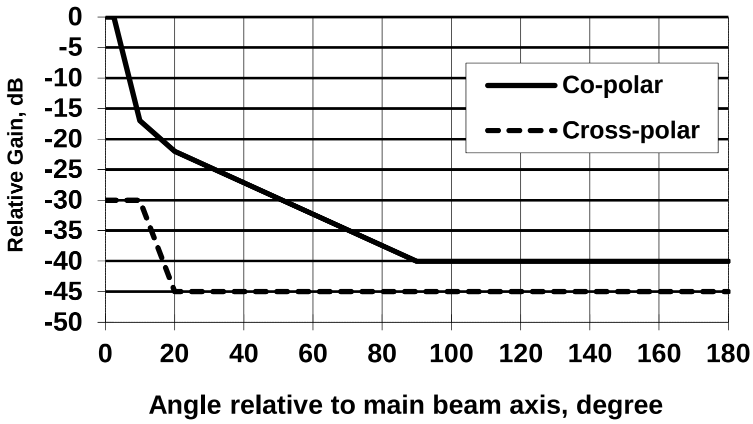


Figure 7: Class DN4 terminal station antenna

Table 12: Class DN4

Angle (degree)	Co-polar (dB)	Angle (degree)	Cross-polar (dB)
0	0	0	-30
2,5	0	10	-30
10	-17	20	-45
20	-22	180	-45
90	-40		
180	-40		

4.4.1.4 Directional antennas conforming to ETSI EN 302 217-4 [2]

Directional antenna, used for multipoint application, in any band in the scope of the present document, may alternatively conform to ETSI EN 302 217-4 [2].

4.4.2 Sectored Single beam (SS) antennas

4.4.2.1 Radiation Pattern Envelope (RPE), azimuth: co-polar and cross-polar

For single beam sectored antennas the co-polar and cross polar RPEs in tables 13 to 18 shall apply. The RPEs are constructed from the points in the table in the same way as the RPEs for directional antennas.

The sector width, defined here as 2α (see also clause 3.1) and otherwise referred to as sector angle, shall be declared by the supplier. The gain values are all relative to the actual *maximum gain* in the declared sector width (0 dB reference).

f_0 is defined as the centre frequency in GHz of the declared frequency range of operation of the antenna.

It should be noted that the positions of some of the points on the RPEs are calculated values from α and f_0. In these cases, the positions of the points are given as mathematical expressions in the table entries. Actual values derived from all expressions are rounded to the lower integer value in degrees or dB as appropriate. The azimuth patterns defined by such expressions apply for all combinations of frequency and sector angle within the ranges addressed by the relevant table.

Where more than one class of antenna is specified in a frequency range, these classes are designated as SS1, SS2, SS3, etc. according to their increasingly demanding RPE requirements.

The rationale for this classification is given in annex A.

The range of sector widths for which each antenna class is applicable is shown at the head of each table.

Sectored antennas with beamwidth < 15° shall conform to the specification otherwise applicable to a directional antenna.

Table 13: Azimuth RPEs for linear polarized single beam sector antennas 1 GHz to 3 GHz (applicable to sector widths (2α) of 15° to 180°)

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)	
	Co-polar	Cross Polar
0	0	-20
$\alpha + 5$	0	
$\alpha + (57{,}5 - 5f_0)$		-20
$\alpha + (105 - 7f_0)$	$-0{,}7f_0 - 16$	
$\alpha + (87{,}5 - 5f_0)$		$-1{,}4f_0 - 20$
$184{,}4 - 4{,}4f_0$	$-1{,}4f_0 - 20$	
180	$-1{,}4f_0 - 20$	$-1{,}4f_0 - 20$

Table 14: Azimuth RPEs for circularly polarized single beam sector antennas 1 GHz to 3 GHz (applicable to sector widths (2α) of 15° to 180°)

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)	
	Co-polar	Cross Polar
0	0	-10
$\alpha + 5$	0	
$\alpha + (57{,}5 - 5f_0)$		-10
$\alpha + (105 - 7f_0)$	$-0{,}7f_0 - 16$	
$\alpha + (87{,}5 - 5f_0)$		-15
$184{,}4 - 4{,}4f_0$	$-1{,}4f_0 - 20$	
180	$-1{,}4f_0 - 20$	-20

Table 15: Azimuth RPEs for linear polarized single beam sector antennas 3 GHz to 11 GHz (applicable to sector widths (2α) of 15° to 180°)

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)					
	SS1		SS2		SS3	
	Co	X	Co	X	Co	X
0	0	-12	0	-20	0	$-0{,}7\ f_0\ -17{,}5$
$\alpha + 5$	0	-15	0			
$\alpha + (20 - 1{,}4\ f_0)$					0	$-0{,}7\ f_0\ -17{,}5$
$\alpha + (57{,}5 - 5\ f_0)$				-20		
$\alpha + (75 - 4{,}3\ f_0)$					-23	$-1{,}4\ f_0\ -20$
$\alpha + (105 - 7\ f_0)$			-20			
$\alpha + (87{,}5 - 5\ f_0)$				-25		
$195 - 7\ f_0$			-20			
$165 - 4{,}3\ f_0$					-23	
$186 - 4{,}4\ f_0$			-25			
150					$-1{,}4\ f_0\ -20$	
160	-20	-20				
180	-20	-20	-25	-25	$-1{,}4\ f_0\ -20$	$-1{,}4\ f_0\ -20$

Table 16: Azimuth RPEs for circularly polarized single beam sector antennas 3 GHz to 11 GHz (applicable to sector widths (2α) of 15° to 180°)

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)					
	SS1		SS2		SS3	
	Co	X	Co	X	Co	X
0	0	-10	0	-10	0	-12
$\alpha + 5$	0	-10	0			
$\alpha + (20 - 1{,}4\ f_0)$					0	-12
$\alpha + (57{,}5 - 5\ f_0)$				-10		
$\alpha + (75 - 4{,}3\ f_0)$					-23	-20
$\alpha + (105 - 7\ f_0)$			-20			
$\alpha + (87{,}5 - 5\ f_0)$				-15		
$195 - 7\ f_0$			-20			
$165 - 4{,}3\ f_0$					-23	
$186 - 4{,}4\ f_0$			-25			
150					-30	
160	-20	-20				
180	-20	-20	-25	-25	-30	-30

Table 17: Azimuth RPEs for linear polarized single beam sector antennas 24 GHz to 40,5 GHz (applicable to sector widths (2α) of 15° to 130° for antenna class SS1 and of 15° to 180° for all other antenna classes)

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)									
	SS1		SS2a		SS2b		SS3		SS4	
	Co	X	Co	X	Co	X	Co	X	Co	X
0	0	-20	0	-20	0	-25	0	-25	0	-25
α		-20		-20				-25		-25
$\alpha + 5$	0		0		0	-25	0		0	
$\alpha + 15$		-25							-20	-30
$\alpha + 30$							-20	-30		
2α			-20	-25	-20	-30				
$2\alpha + 5$	-10									
105								-30		-30
110							-23		-23	
135	-12									
140							-35	-35	-35	-35
155	-15									
180	-25	-25	-30	-30	-30	-30	-35	-35	-35	-35

Table 18: Azimuth RPEs for linear polarized single beam sector antennas 40,5 GHz to 43,5 GHz (applicable to sector widths (2α) of 15° to 130° for antenna class SS1 and of 15° to 180° for all other antenna classes)

θ (°)	Gain relative to maximum actual gain at the measurement frequency (dB)					
	SS1		SS2		SS3	
	Co	X	Co	X	Co	X
0	0	-22	0	-25	0	-25
α		-22		-25		-25
α + 5	0		0		0	
α + 15		-25	-20	-30		
α + 30						
2α					-20	-30
2α + 5	-10					
105				-30		
110			-23			
135	-12					
140			-35	-35		
155	-15					
180	-25	-25	-35	-35	-30	-30

4.4.2.2 Radiation Pattern Envelope (RPE), elevation

4.4.2.2.1 Symmetric elevation RPEs: co-polar and cross-polar

For symmetric single beam sectored antennas, the co-polar RPE in the *elevation plane* shall conform to the RPEs given in table 19.

The angle θ° is relative to the 0 degree reference as defined in clause 3.1.

Since the co-polar RPE is symmetrical, the table applies equally to positive and negative values of θ.

Table 19: Symmetric elevation RPEs for single beam sector antennas

±θ (°)	Gain relative to maximum actual gain at the measurement frequency (dB)			
	1 GHz to 3 GHz	3 GHz to 11 GHz	24 GHz to 30 GHz and 40,5 GHz to 43,5 GHz	30 GHz to 40,5 GHz
0	0	0	0	0
6			0	0
10		0		-10
12	0			
12	-3			
14	-5			
15			-15	
20	-5			
25		-15		
60	-13			
60	-18			
90	-18	-19	-25	-20
From 90 to 180	See notes 1 and 2			
NOTE 1: The co-polar elevation limit in table 19 shall be linearly interpolated beyond the 90° point in table 19 to the point defined at 180° by the co-polar column in the appropriate azimuth RPE table (from tables 13 to 18) for the frequency range and class of antenna.				
NOTE 2: The cross polar limit shall be linearly interpolated between the 0° and the 180° points taken from the cross polar column in the appropriate azimuth RPE table (from tables 13 to 18) for the frequency range and class of antenna.				

4.4.2.2.2 Asymmetric elevation RPEs: co-polar and cross-polar (bands 1 GHz to 11 GHz only)

Two options, normal and improved elevation RPE are provided due to different intersystem deployment situations.

In frequency bands from 1 GHz to 11 GHz, between the angles of -30° (down) and +90° (up), for normal elevation RPE, and in frequency bands from 3 GHz to 11 GHz, between the angles of -90° (down) and +90° (up), for improved elevation RPE, single beam sectored antennas shall meet the co-polar and cross polar limits in table 20.

Table 20: Asymmetric elevation RPEs for single beam sector antennas for bands within the range 1 GHz to 11 GHz

Normal elevation RPE (1 GHz to 11 GHz)			Improved elevation RPE (3 GHz to 11 GHz)		
Angle (°)	Co-polar (dB)	Cross-polar (dB)	Angle (°)	Co-polar (dB)	Cross-polar (dB)
			-180 to -90	(see note 1)	(see note 2)
			-90	-16,0	-16
			-70	-9,0	-9
-180 to -30	(see note 1)	(see note 2)	-30	-3,0	-3
-30	-3	-3	-5	-3,0	-3
-5	-3	-3	-4	0,0	-3
-4	0	0	-4	0,0	-20
-4	0	-20	4	0,0	-20
4	0	-20	4	0,0	-3
4	0	0	10	-10,0	-10
10	-10	-10	45	-10,0	-10
45	-10	-10	45	-8,0	-8
45	-8	-8	70	-8,0	-8
90	-8	-8	90	-16,0	-16
90 to 180	(see note 3)	(see note 4)	90 to 180	(see note 3)	(see note 4)

NOTE 1: For angles more negative than -30° or -90° (down), for normal and improved patterns, respectively, the co-polar limit shall be linearly interpolated between the co-polar -30° / -3 dB (or -90° / -16 dB for improved pattern) point in table 20 out to the point defined at 180° by the co-polar column in the appropriate azimuth RPE table (from tables 13 to 17) for the frequency range and class of antenna.

NOTE 2: For angles more negative than -30° or -90° (down), for normal and improved patterns, respectively, the cross polar limit shall be linearly interpolated between the cross polar -30° / -3 dB (or -90° / -16 dB for improved pattern) point in table 20 out to the point defined at 180° by the cross polar column in the appropriate azimuth RPE table (from tables 13 to 17) for the frequency range and class of antenna.

NOTE 3: For angles more positive than +90° (up), the co-polar limit shall be linearly interpolated between the co-polar +90° / -8 dB (or +90° / -16 dB for improved pattern) point in table 20 out to the point defined at 180° by the co-polar column in the appropriate azimuth RPE table (from tables 13 to 17) for the frequency range and class of antenna.

NOTE 4: For angles more positive than +90° (up), the cross polar limit shall be linearly interpolated between the cross polar +90° / -8 dB (or +90° / -16 dB for improved pattern) point in table 20 out to the point defined at 180° by the cross polar column in the appropriate azimuth RPE table (from tables 13 to 17) for the frequency range and class of antenna.

4.4.3 Sectored multi-beam antennas (MS) (bands from 3 GHz to 5,9 GHz only)

4.4.3.1 General

A sector multi-beam antenna sharing a common aperture comprising of two or more beams at different azimuth angles.

Such antennas are provided with ports for each of the beams; all the beams may be active at the same time while using different frequencies. Each beam may be used as the central station covering a specific sector.

Such antennas are typically used to generate several narrow beams at a smaller form factor, for aesthetic, mechanical (such as space or wind loading) or cost reasons. This clause focuses on sectored multi-beam antennas in which the aggregate of all beams covers up to 180° in the frequency range 3 GHz to 5,9 GHz.

Sectored multi-beam antennas use only linear polarization. The parameters apply equally to linearly polarized antennas of either plane.

The co-polar and cross-polar radiation pattern envelopes for sectored multi-beam antennas are specified in tables 21 to 23.

4.4.3.2 Radiation Pattern Envelope (RPE), azimuth: co-polar and cross-polar

Where more than one class of antenna is specified in a frequency range, these classes are designated as MS1, MS2, etc., in order of increasing stringency.

It should be noted that the positions of some of the points on the RPEs are calculated values from α, ε and f_0. In these cases, the positions of the points are given as mathematical expressions in the table entries. All expressions are rounded to the lower integer value in degrees or dB, as appropriate.

The sector angle, the beamwidth (defined as 2α) and the *reference beam direction (ε)* shall be declared by the supplier for each beam. The azimuth patterns defined below in figure 8 and tables 21 and 22 apply for all combinations of frequency and sector angle within the ranges addressed by the present document. The gain values defined are all relative to the *maximum gain* in the considered *reference beam/sector angle*.

NOTE: MS1 antennas are defined only for abs(ε + 3 × α) ≤ 90°.
MS2 antennas are defined only for abs(ε + 6 × α) ≤ 60°.

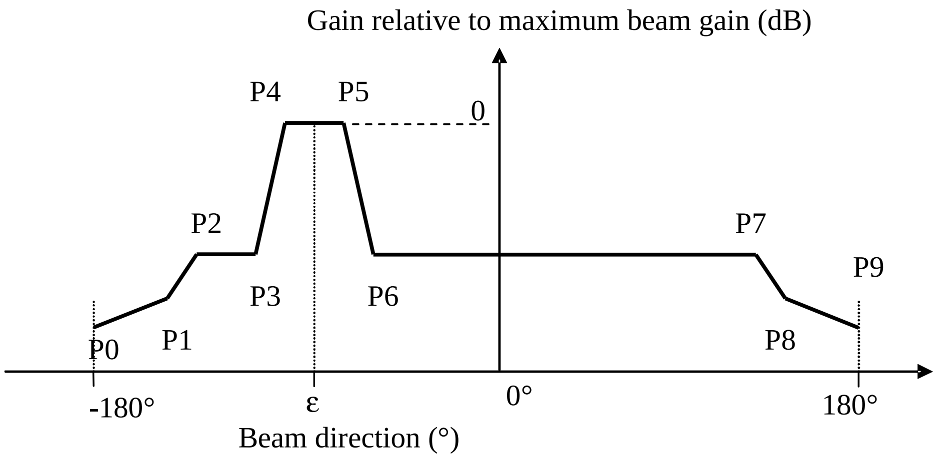


Figure 8: Azimuth RPEs for linear polarized multi-beam sector antennas 3 GHz to 5,9 GHz (defined for each beam)

Table 21: Co-polar, azimuth RPEs for linear polarized multi-beam sector antennas 3 GHz to 5,9 GHz

θ (º)	Gain relative to *maximum gain* in the considered *reference beam sector/angle* (dB)	
	MS1	**MS2**
	Co Polar	**Co Polar**
-180	-25	-35
-120	-20	
-135		-35
-90	-15	
-60		-20
ε - 6 × α		-20
ε - 5 × α		-17
ε - 3,3 × α		-17
ε - 3 × α	-15	
ε - 1,6 × α		0
ε - 1,5 × α	0	
ε		
ε + 1,5 × α	0	
ε + 1,6 × α		0
ε + 3 × α	-15	
ε + 3,3 × α		-17
ε + 5 × α		-17
ε + 6 × α		-20
60		-20
90	-15	
120	-20	-35
135		
180	-25	-35

Table 22: Cross-polar, azimuth RPEs for linear polarized multi-beam sector antennas 3 GHz to 5,9 GHz

θ (º)	Gain relative to *maximum gain* in the considered *reference beam sector/angle* (dB)	
	MS1	**MS2**
	Cross Polar	**Cross Polar**
ε - 180	-20	-20
ε – abs(α + 75 - 4,3 f_0)		-20
ε – abs(α + 57,5 - 5 f_0)	-20	
ε – abs(α + 57,5 - 5 f_0)	-15	
ε – abs(α + 20 - 1,4 f_0)		-15
ε	-15	-15
ε + abs(α + 20 - 1,4 f_0)		-15
ε + abs(α + 57,5 - 5 f_0)	-15	
ε + abs(α + 57,5 - 5 f_0)	-20	
ε + abs(α + 75 - 4,3 f_0)		-20
ε + 180	-20	-20

4.4.3.3 Radiation Pattern Envelope (RPE), elevation: co-polar and cross-polar

For multi-beam sectored antennas only symmetric RPEs are defined. The co-polar and cross-polar RPEs in the *elevation plane* shall conform, for all beams, with the RPEs given in table 23.

Since the co-polar RPE is symmetrical, the table applies equally to positive and negative values of θ.

Table 23: Elevation RPEs for multi-beam sector antennas

±θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)			
	MS1		MS2	
	Co-polar	Cross-polar	Co-polar	Cross-polar
0	0	-15	0	-15
10	0		0	
25	-15		-15	
90	-19		-19	
180	(see note)	-20	(see note)	-20
NOTE: The co-polar limit, for each beam, shall be linearly interpolated beyond 90° to the azimuth co-polar RPE value at (ε° + 180°) derived from table 21 for each MS 1 and MS 2 classes.				

4.4.4 Omnidirectional antennas (OD and ODT)

4.4.4.1 General

Omnidirectional antennas within the scope of the present document are either for CS applications (OD) or for NWA TS applications (ODT).

Omnidirectional antennas for TS applications (ODT) are limited to those for typically indoor deployment for NWA applications (e.g. desk antennas or lap-top RLAN-like antennas) in 3,4 GHz to 3,8 GHz bands. Outdoor antennas at fixed locations, as well as *integral* to handheld TS, are not considered within the scope of the present document.

NOTE: In the frequency range 24 GHz to 30 GHz, no omnidirectional antennas are currently defined.

For omnidirectional antennas, the co-polar radiation pattern in the *azimuth plane* is defined by the maximum *gain ripple,* which is defined in clause 3.1.

For both linear and circular polarization, the *gain ripple* shall not exceed 3 dB.

For omnidirectional antennas, the cross-polar radiation pattern in the *azimuth plane* is defined by the cross-polar gain relative to the measured gain at all azimuth angles.

The cross-polar radiation pattern in the *azimuth plane* shall not exceed -20 dB for linear polarization antennas and -12 dB for circular polarization antennas.

4.4.4.2 CS Radiation Pattern Envelope (RPE), elevation

4.4.4.2.1 Symmetric elevation RPEs: co-polar and cross-polar

For omnidirectional symmetric elevation antennas, the RPEs in table 24 shall apply. The RPEs are constructed from the points in the table in the same way as the RPEs for directional antennas.

Since the elevation pattern is symmetrical, the table applies equally to positive and negative values of θ.

Table 24: Elevation RPEs for symmetric elevation omnidirectional antennas

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)					
	1 GHz to 3 GHz		3 GHz to 11 GHz		30 GHz to 40,5 GHz and 40,5 GHz to 43,5 GHz	
	Co-polar	Cross-polar	Co-polar	Cross-polar	Co-polar	Cross-polar
0	0	XPD (see note 1)	0	XPD (see note 1)	0	-20
4	0	XPD (see note 1)		XPD (see note 1)		
4	0	0		0		
8					0	
10			0	0		
12	0	0				
12	-3	-3				
14	-5	-5				
20	-5	-5				
25			-15	-15		
30					-10	
60	-13	-13				
60	-18	-18				
90 (see note 2)	-18	-18	-19	-19	-20	-20

NOTE 1: XPD has the value -20 for linear polarization antennas and -12 for circular polarization antennas.

NOTE 2: For antennas with *electrical (down) tilt*, the +90º limit shall be extended up to $(90^\circ + |tilt^\circ|)$ and the -90° limited to $(-90^\circ + |tilt^\circ|)$ in order to cover the actual vertical direction.

4.4.4.2.2 Asymmetric elevation RPEs: co-polar and cross-polar

Omnidirectional antennas with an asymmetric elevation RPE and *electrical tilt* are included in the scope of the present document.

For omnidirectional asymmetric elevation antennas, the co-polar RPEs in table 25 shall apply. The RPEs are constructed from the points in the table in the same way as the RPEs for directional antennas.

Table 25: Elevation RPEs for asymmetric elevation omnidirectional antennas

θ (º)	Gain relative to maximum actual gain at the measurement frequency (dB)			
	1 GHz to 11 GHz		30 GHz to 40,5 GHz and 40,5 GHz to 43,5 GHz	
	Co-polar	Cross-polar	Co-polar	Cross-polar
-90	-3	-3	-20	-20
-30				
-20			-20	
-5	-3			
-4	0	-3		
-4	0	XPD (see note 1)		
0			0	-20
4	0	XPD (see note 1)		
4	0	0		
8			0	
10	-10	-10		
30			-10	
45	-10	-10		
45	-8	-8		
90 (see note 2)	-8	-8	-20	-20

NOTE 1: XPD has the value -20 for linear polarization antennas and -12 for circular polarization antennas.

NOTE 2: For antennas with *electrical (down) tilt*, the +90º limit shall be extended up to $(90^\circ + |tilt^\circ|)$ and the -90° limited to $(-90^\circ + |tilt^\circ|)$ in order to cover the actual vertical direction.

4.4.4.3 TS Radiation Pattern Envelope (RPE)

Standing that omnidirectional TS antennas, in the band 3,4 GHz to 3,8 GHz, in the scope of the present document are limited to typically indoor applications, no RPE requirements are foreseen.

4.5 Antenna gain requirements

4.5.1 General

For the purpose of the present document, an antenna is specific to a Type, Class, the frequency range of operation and the mid-band gain. An antenna, which employs a *radome*, shall meet the requirements of the present document with the *radome* in place.

The gain of the antenna is specified as the *maximum gain* of the antenna with reference to an *isotropic radiator* and is expressed in dBi. For some antenna types the gain is specified as a function of one or more declared design parameters (see the definitions of terms in clause 3.1).

The supplier shall declare the *nominal gain* and related *gain tolerances* according to the relevant definition and the minimum values set in following clauses; the actual antenna gain shall be in accordance to those declared values.

Antenna boresight (and associated gain) does not necessarily correspond to the 0° reference direction (and its associated gain).

The gain parameters apply for linearly polarized and circularly polarized antennas. The applicability of each set of parameters to linear or circular polarization is indicated for each set of parameters.

The parameters for linear polarized antennas apply equally to both horizontal and vertical linearly polarized antennas.

The parameters for circularly polarized antennas apply equally to antennas using either RHCP or LHCP.

4.5.2 Directional antennas

Where several directional antenna classes are specified in a frequency band, these are designated as DN1, DN2, etc.

The minimum declared gain of the directional antenna, expressed relative to an *isotropic radiator*, shall be as detailed in table 26.

Table 26: Minimum antenna gain for each frequency range and antenna class

Frequency band	Antenna class	Polarization type	Minimum declared gain (dBi)	Notes
1 GHz to 3 GHz	DN1 and DN2 DN3	Linear	8,0 14,0	
3 GHz to 11 GHz	All classes	Linear	ROUND (0,85 f_0 + 5)	ROUND ( ) means rounded up to the higher integer in dBi. f_0 is the nominal centre frequency
1 GHz to 11 GHz	All classes	Circular	ROUND (0,85 f_0 + 5)	As above
24,25 GHz to 30 GHz	All classes	Linear	22	
30 GHz to 40,5 GHz	All classes	Linear	24	
40,5 GHz to 43,5 GHz	All classes	Linear	Gain Category 1: 24	
			Gain Category 2: 28	

4.5.3 Sectored single beam antennas

The single beam sectored antenna declared gain shall exceed the values defined in figure 9 as a function of sector angle, 2α, in the range 15° to 180° and for all frequency ranges from 1 GHz to 11 GHz and from 24,25 GHz to 43,5 GHz.

Figure 9: CS Sector Antenna Minimum Declared *Nominal Gain* Limits

4.5.4 Sectored multi-beam antennas (bands from 3 GHz to 5,9 GHz only)

A sector multi-beam antenna sharing a common aperture comprising of two or more beams at different azimuth angles.

Such antennas are provided with ports for each of the beams; all the beams may be active at the same time while using different frequencies. Each beam may be used as the central station covering a specific sector.

Such antennas are typically used to generate several narrow beams at a smaller form factor, for aesthetic, mechanical (such as space or wind loading) or cost reasons. This clause focuses on sectored multi-beam antennas in which the aggregate of all beams covers up to 180° in the frequency range 3 GHz to 11 GHz.

Sectored multi-beam antennas use only linear polarization. The parameters apply equally to both horizontal and vertical linearly polarized antennas.

The declared *nominal gain*, for each beam of a multiple beam sectored antenna, shall exceed 11,5 dB for any beamwidth in the range 10° to 90°.

4.5.5 Omnidirectional antennas

4.5.5.1 CS OmniDirectional (OD)

The minimum declared *nominal gain* for omnidirectional antennas is specified in table 27.

Note that no omnidirectional antennas have been identified for the frequency range 24,25 GHz to 30 GHz.

The declared minimum gains for the frequency range 1 GHz to 11 GHz apply to both linearly and circularly polarized antennas.

The minimum declared gain for the frequency range 30 GHz to 40,5 GHz applies only to linearly polarized antennas.

Table 27: Minimum declared *nominal gain* for omnidirectional antennas

Frequency Range (GHz)	Minimum declared gain (dBi)
1 to 3	5
3 to 11	8
30 to 40,5	8
40,5 to 43,5	No requirement

4.5.5.2 TS omnidirectional (ODT)

Omnidirectional antennas for TS, in the band 3,4 GHz to 3,8 GHz, shall have a *maximum gain* of 6 dBi.

The limit applies including *gain tolerances* and in any direction within the three-dimensional 360° angle.

5 Testing for conformance with technical requirements

5.1 Void

This clause is left void.

5.2 Wide radio-frequency band covering antennas specification and test

Commonly, multipoint antennas cover an operating frequency range declared by the supplier. The antenna parameters shall comply with all the requirements of the present document within the declared operating frequency range.

The tests shall be carried out at the lowest, middle and highest frequency of the relevant frequency range to produce the test report and/or the appropriate declaration of conformity.

5.3 Environmental conditions for Testing

The technical requirements of the present document apply under the environmental profile for operation of the antenna or the equipment-antenna assembly, with its *radome* (if applicable) in place, which shall be declared by the supplier.

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.

Any test, carried out to generate the test report and/or declaration of conformity to the present document for *stand-alone*, *dedicated* or *integral* antennas, shall be carried-out at reference environmental conditions at the test field according to clause 4.1 of ETSI EN 301 126-3-2 [1].

5.4 Radiation Pattern Envelope (RPE)

For test antennas used for compliance testing, ETSI EN 301 126-3-2 [1], clause 6.1 shall apply.

The elevation RPE is measured at the *0° degrees RPE reference* as declared by the manufacturer (see figures 1 and 2 in clause 3.1).

In the remaining directions slight variation may be expected (within 3 dB), however no specific tests are required.

5.5 Antenna gain

For test antennas used for compliance testing, ETSI EN 301 126-3-2 [1], clause 6.2 shall apply.

The antenna gain shall be measured in accordance with the definitions of terms in clause 3.1 and consistent to the declaration of the supplier.

For test report purpose of omnidirectional TS antennas, the gain shall be measured along 360° over three perpendicular planes (one *azimuth plane* and two *elevation planes*).

Annex A (informative): Multipoint systems and Antenna profiles

A.1 General

According to their characteristics, Multipoint systems use different types of antennas: Directional, Sectorial and Omnidirectional.

Their RPE directional characteristics (co-polar and cross-polar and for either linear or circular polarized antennas) impact on the interference to be considered in network planning. A number of options (classes) are defined in the present document as trade-off between highly demanding RPE directivity and the cost/size/weight of the antennas. Their choice should take into account present and future network requirements and cost constraints.

The classes used in the present document supersede the classes used in previous standards (which were arbitrary in their sequence) and the relationship between the new classes and those previously used is defined in the tables of the following clauses.

A.2 Equipment profiles

This whole multi-part deliverable allows alternative consistent sets of recommendations and requirements, each for identified equipment profiles, which are defined in terms of their Equipment Classification (EqC), which classify equipments in terms of key characteristics. The profiles (or indeed any specific equipment) within the scope of this whole multi-part deliverable may be classified as discussed in normative annex C of ETSI EN 302 326-2 [i.4], which defines the permitted equipment profiles in terms of the various fields of EqC.

A.3 System profiles

This multi-part deliverable applies only to Multipoint systems using the following antenna type to station type combinations according to whether the network topology is P-MP or MP-MP (Mesh). Table A.1 indicates which system profiles are within the scope of this multi-part deliverable.

Table A.1: System Profiles within the scope of this multi-part deliverable: Antenna types - Station types combinations

		Antenna types		
Network topology	**Station types**	**Omnidirectional**	**Sectored**	**Directional**
P-MP	Central Station (CS)	Yes	Yes (see note 1)	No (see note 1)
	Repeater Station (RS) Facing CS Facing TS or further RS	 No Yes	 No Yes	 Yes Yes
	Terminal Station (TS)	Yes (see note 2)	No	Yes
MP-MP	Repeater Station (RS)	No	No	Yes

NOTE 1: Sectored antennas with beamwidth < 15° can conform to the specification otherwise applicable to a directional antenna.

NOTE 2: Omnidirectional TS antennas are limited to typically indoor deployment (e.g. desk antennas) for NWA applications in 3,4 GHz to 3,8 GHz bands. Outdoor antennas at fixed locations, as well as *integral* to handheld TS, are not considered antennas within the scope.

A.4 Directional antennas

The five directional antenna classes (classes DN1 to DN5) have been defined in line with the principle that the antennas with more demanding maximum combined co-polar and cross-polar RPEs have higher class numbers and antennas with closely related RPEs are assigned to sub-classes.

The subdivision of classes has been done setting practical RPE range steps differentiating the classes in order to accommodate, as much as possible, in logical and consistent order, across all frequency band. Whenever more than one RPE fall within the same step of RPE range, they have been distinguished with alphabetical suffix (a, b, etc.) within the same class, still according an increasing demand of their actual RPE. In order of maintaining the above consistencies also for possible future introduction of other RPE, some classes in some frequency ranges are actually kept void of parameters.

A.5 Sectorial and omnidirectional antennas

The antenna classes defined for single beam sectorial antennas in the frequency range 1 GHz to 11 GHz are defined in the present document as SS1 to SS3, respectively.

The antenna classes defined for single beam sectorial antennas in the frequency range 24,25 GHz to 43,5 GHz have been defined in line with the principle that the antennas with more demanding RPEs have higher class numbers and antennas with closely related RPEs are assigned to sub-classes.

The classes for multi-beam sectorial antennas are defined in the present document as MS1 and MS2.

There are no different omnidirectional antenna classes within the current scope of the present document; only a single specifications for CS OmniDirectional antennas (OD) and a single specifications for NWA TS OmniDirectional antennas (ODT) are presented.

Annex B (informative): Bibliography

- ETSI EN 301 215-1: "Fixed Radio Systems; Point to Multipoint Antennas; Antennas for point-to-multipoint fixed radio systems in the 11 GHz to 60 GHz band; Part 1: General aspects".

History

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