# ETSI EN 301 525 V1.1.1 (2000-06)

*European Standard (Telecommunications series)*

## Fixed Radio Systems;
## Point to Multipoint Antennas;
## Antennas for Point-to-Multipoint fixed radio systems in the 1 GHz to 3 GHz band

Reference

DEN/TM-04060

Keywords

antenna, CDMA, DRRS, FDMA, multipoint, radio, RLL, TDMA, transmission

***ETSI***

650 Route des Lucioles
F-06921 Sophia Antipolis Cedex - FRANCE

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C
Association à but non lucratif enregistrée à la
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# Contents

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# Foreword

This European Standard (Telecommunications series) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM).

The present document was firstly started as part 2 of EN 301 631. It has been decided by ETSI Technical Committee Transmission and Multiplexing to publish it as a standalone document under EN 301 525 V1.1.1.

The purpose of the present document is to define the antenna performance standards necessary to ensure optimum frequency co-ordination between like systems and/or different services by the Regulatory Authorities in the re-planned 1 GHz to 3 GHz band. The 3 GHz upper limit has been introduced making reference to the WARC '92 Final Acts [4] and the frequency plans as given in CEPT Recommendation T/R 13-01 [1], ITU-R Recommendation F.746-3 [2] and ITU-R Recommendation F.1098 [3].

Antennas as components for radio relay systems may need to meet environmental, mechanical and electrical characteristics not covered by the present document, in order that the systems will operate as intended. Characteristics to be considered are provided as guidance in Annex A.

The purpose of the present document is to define the requirements for antennas used in conjunction with point-to-multipoint (P-MP) systems necessary to facilitate frequency co-ordination between services in the frequency band 1 GHz to 3 GHz.

| National transposition dates | |
|---|---|
| Date of adoption of this EN: | 5 May 2000 |
| Date of latest announcement of this EN (doa): | 31 August 2000 |
| Date of latest publication of new National Standard or endorsement of this EN (dop/e): | 28 February 2001 |
| Date of withdrawal of any conflicting National Standard (dow): | 28 February 2001 |

# 1 Scope

The present document specifies the essential electrical requirements for linear polarization fixed beam antennas to be utilized with new Point-to-Multipoint (P-MP) systems, including central station and terminal station applications, operating in frequency bands from 1 GHz to 3 GHz. These systems use various multiple access schemes. Electronically steerable antennas, and circularly polarized antennas are not considered under the present document.

Only in exceptional circumstances, and after a consultation period with operators and manufacturers, the Regulatory Authority may impose the use of tighter requirements than the minimum values given in the present document, in order to maximize the use of scarce spectrum resources.

The application of these radio systems is anticipated to be for point-to-multipoint links in local access networks and customer access links.

For some high gain, point-to-multipoint requirements antennas may be used having performance as per the appropriate point-to-point antenna standard. For these antennas, minimum requirements are given in EN 300 631-1 [6].

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non-specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies.
- A non-specific reference to an ETS shall also be taken to refer to later versions published as an EN with the same number.

[1] CEPT Recommendation T/R 13-01: "Preferred channel arrangements for fixed services in the range 1-3 GHz".

[2] ITU-R Recommendation F.746-3 (1994): "Radio-frequency channel arrangements for radio-relay systems".

[3] ITU-R Recommendation F.1098 (1994): "Radio-frequency channel arrangements for radio-relay systems in the 1 900-2 300 MHz band".

[4] Final Acts of the World Radiocommunications Conference for dealing with frequency allocations in certain parts of the spectrum (WARC-92), Malaga-Torremolinas 1992.

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

[6] ETSI EN 300 631-1: "Transmission and Multiplexing (TM); Digital Radio Relay Systems (DRRS); Part 1: Antennas for Point-to-Point (P-P) radio links in the 1 GHz to 3 GHz band".

[7] ETSI ETS 300 019-1-4: "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-4: Classification of environmental conditions; Stationary use at non-weather protected locations".

[8] IEC Publication 60339-1: "General purpose rigid coaxial transmission lines and their associated flange connectors. Part 1: General requirements and measuring methods".

[9] IEC Publication 60339-2: "General purpose rigid coaxial transmission lines and their associated flange connectors - Part 2: Detail specifications".

[10] IEC Publication 60169-1: "Radio-frequency connectors. Part 1: General requirements and measuring methods", and applicable sub-parts.

[11] EN 122150: "Sectional Specification: Radio frequency coaxial connectors - Series EIA flange".

# 3 Definitions, symbols and abbreviations

## 3.1 Definitions

For the purposes of the present document, the following terms and definitions apply:

**antenna:** that part of the transmitting or receiving system that is designed to radiate or receive electromagnetic waves.

**boresight:** axis of the main beam in a directional antenna.

**central station:** base station which communicates each way with many terminal stations, and in some cases repeater stations.

**copolar pattern:** diagram representing the radiation pattern of a test antenna when the reference antenna is similarly polarized, scaled in dBi or dB relative to the measured antenna gain.

**crosspolar discrimination:** difference in dB between the peak of the copolarized main beam and the maximum crosspolarized signal over an angle measured within a defined region.

**crosspolar pattern:** diagram representing the radiation pattern of a test antenna when the reference antenna is orthogonally polarized, scaled in dBi or dB relative to the measured antenna gain.

**fixed beam:** radiation pattern in use is fixed relative to a defined mechanical reference plane

**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.

**half power beamwidth:** angle between the two directions at which the measured copolar pattern is 3 dB below the value on the main beam axis.

**input port(s):** flange(s) or connector(s) through which access to the antenna is provided.

**interport isolation:** ratio in dB of the power level applied to one port of a multi-port antenna to the power level received in any other port of the same antenna as a function of frequency.

**isotropic radiator:** hypothetical, lossless antenna having equal radiation intensity in all directions.

**main beam:** radiation lobe containing the direction of maximum radiation.

**main beam axis:** direction for which the radiation intensity is maximum.

**mechanical tilt**: fixed angular shift in elevation of the antenna main beam axis by a change to the physical mounting.

**radiation pattern:** diagram relating power flux density at a constant distance from the antenna to the direction relative to the antenna main beam axis.

**radiation pattern envelope (RPE):** envelope below which the radiation pattern shall fit.

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

**repeater station:** radio station providing the connection via the air to both the central station and the terminal stations. The repeater station may also provide the interfaces to the subscriber equipment if applicable.

**sector angle:** declared angle of coverage in azimuth of a sectored antenna, defined as $2\alpha$ in the present document.

**terminal station:** remote (out) station which communicates with a central station.

**tilt:** fixed, angular shift of the antenna main beam axis (boresight) in the elevation plane by either electrical, electronic or mechanical means.

**zero degree (0°) reference direction:** declared direction as reference to the antenna mechanical characteristics, used as reference for RPE.

## 3.2 Symbols

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

| | |
|---|---|
| $\alpha$ | Alpha (= half the sector angle) |
| dBi | Decibels relative to an isotropic source |
| fo | Nominal centre frequency of declared antenna operating range |
| GHz | GigaHertz |
| MHz | MegaHertz |

## 3.3 Abbreviations

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

| | |
|---|---|
| CS | Central Station |
| HPBW | Half Power BeamWidth |
| PIM | Passive InterModulation |
| P-MP | Point-to-Multipoint |
| RPE | Radiation Pattern Envelope |
| RS | Repeater Station |
| TS | Terminal Station |
| VSWR | Voltage Standing Wave Ratio |

# 4 Frequency bands

The present document applies to the frequency bands given in CEPT Recommendation T/R 13-01 [1], ITU-R Recommendation F.746-3 [2] and ITU-R Recommendation F.1098 [3].

# 5 Types of antennas

## 5.1 Antenna Types

The present document addresses fixed beam antennas used in the central (CS) and terminal (TS) stations including repeaters (RS).

The antennas are used in a system which can generally be described as in figure 1:

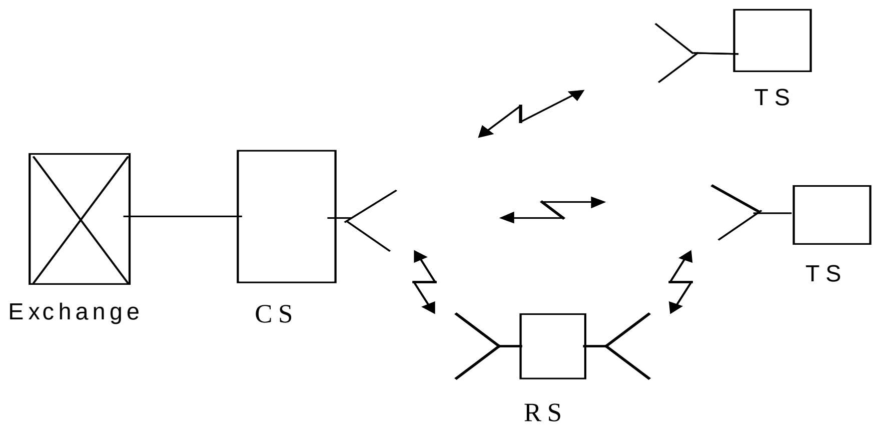


**Figure 1: General Point-to-Multipoint System Architecture**

**CS:** Central Station, which is linked to all remote stations (repeater or terminal stations) by microwave transmission paths.

**TS:** Terminal Station (outstation with subscriber interfaces).

**RS:** Repeater Station (radio repeater outstation with or without subscriber interfaces). A RS may serve one or more TSs.

These antennas shall be grouped into the following Types:

**Central and repeater stations:** Omnidirectional;

Sectored;

Directional, conforming to the requirements for TS antennas;

**Terminal stations:** Directional.

## 5.2 Antenna classifications

### 5.2.1 Central Station (CS) Classes

With respect to the azimuthal radiation pattern envelope (RPE), a number of Classes may be identified for central station (CS) sectored antennas, for example:

- Class CS 1;
- Class CS 2;
- Class CS 3.

Further Classes may be defined as required. These Classes allow flexibility for a variety of different systems, and may be generally appropriate for lower and higher density deployments. If appropriate, the definition of antenna Classes is given in subsequent parts of the present document.

With respect to the azimuthal RPE for omnidirectional CS antennas, no requirement for separate Classes has been identified.

### 5.2.2 Terminal Station (TS) Classes

With respect to the radiation pattern (RPE), a number of classes may be identified for terminal station (TS) directional antennas, for example:

- Class TS 1;
- Class TS 2;
- Class TS 3.

Further Classes may be defined as required. These Classes allow flexibility for a variety of different systems and deployment conditions. If appropriate, the definition of antenna Classes is given in subsequent parts of the present document.

# 6 Electrical characteristics

For the purpose of the present document, an antenna is specific to Type, Class, the frequency band 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.

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

## 6.1 Terminal Station (TS) Antennas

The RPEs and gain parameters apply for both horizontal and vertical linearly polarized antennas.

### 6.1.1 TS Radiation Pattern Envelopes (RPE)

The copolar and crosspolar radiation patterns for both azimuth and elevation shall not exceed the RPE's defined in the following list:

Class TS 1: table 1, figure 2a Azimuth

table 2, figure 2b Elevation

Class TS 2: table 3, figure 2c Azimuth

table 4, figure 2d Elevation

Class TS 3: table 5, figure 2e Azimuth

table 6, figure 2f Elevation

The gain values defined are all relative to maximum, actual gain.

**Class TS1**

**Table 1**

| Angle (degrees) | Copolar (dB) | Angle (degrees) | Crosspolar (dB) |
|---|---|---|---|
| 0 | 0 | 0 | -13 |
| 30 | 0 | 30 | -13 |
| 60 | -5 | 60 | -18 |
| 110 | -14 | 110 | -20 |
| 180 | -16 | 180 | -20 |

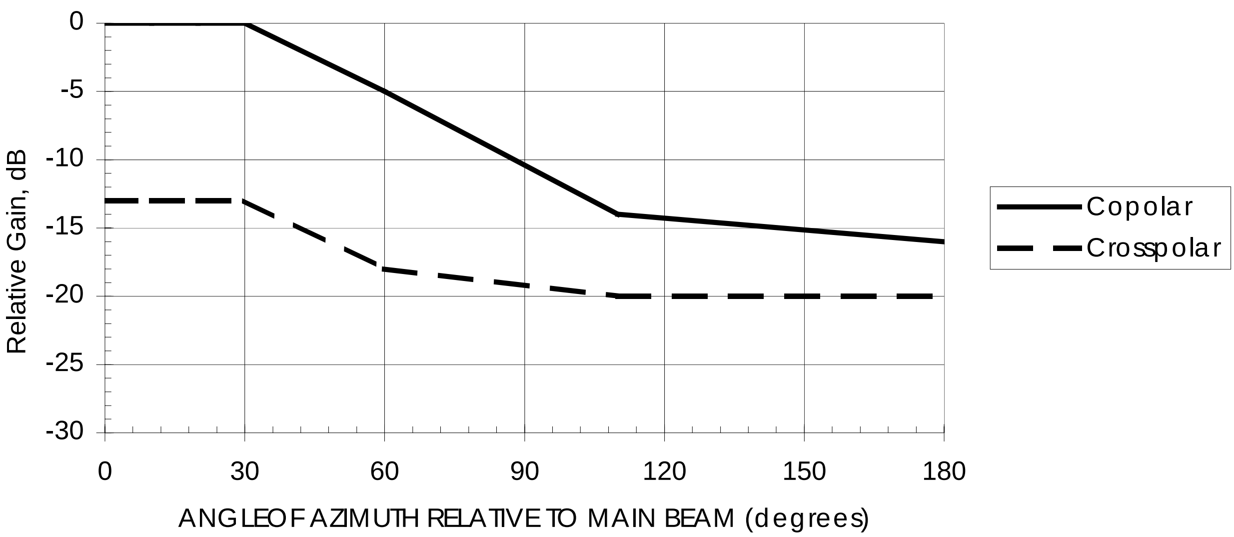


**Figure 2a: Class TS1 Terminal Station antenna azimuth RPE**

**Table 2**

| Angle (degrees) | Copolar (dB) |
|---|---|
| 0 | 0 |
| 30 | 0 |
| 60 | -5 |
| 110 | -14 |
| 180 | -16 |

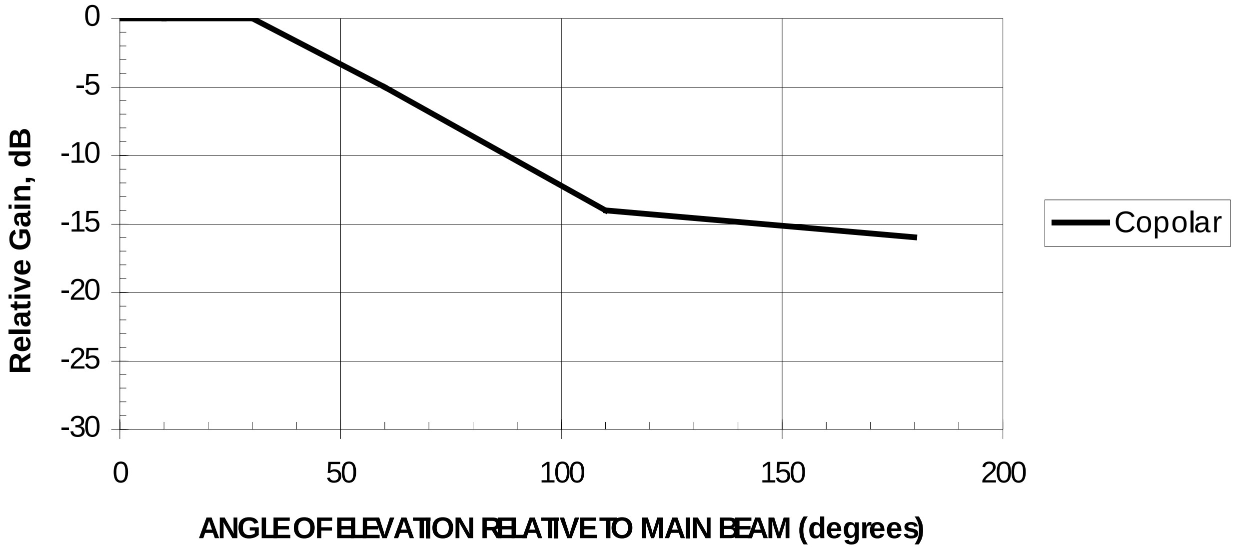


**Figure 2b: Class TS1 Terminal Station antenna elevation RPE**

**Class TS2**

**Table 3**

| Angle (degrees) | Copolar (dB) | Angle (degrees) | Crosspolar (dB) |
|---|---|---|---|
| 0 | 0 | 0 | -15 |
| 10 | 0 | 90 | -15 |
| 30 | -8 | 90 | -20 |
| 90 | -15 | 180 | -20 |
| 150 | -20 | | |
| 180 | -20 | | |

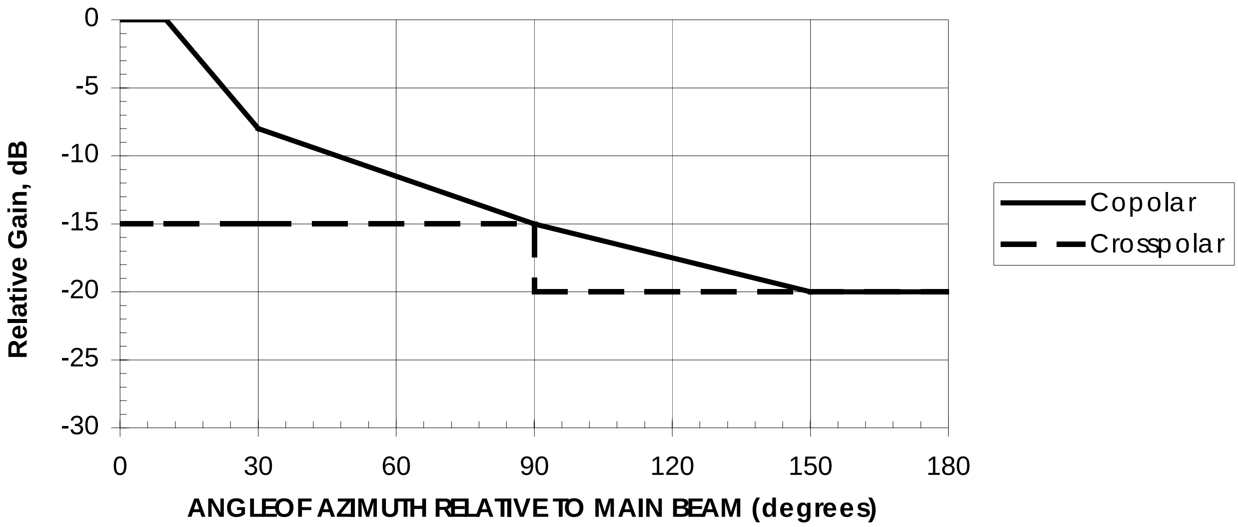


**Figure 2c: Class TS2 Terminal Station antenna azimuth RPE**

**Table 4**

| Angle (degrees) | Copolar (dB) |
|---|---|
| 0 | 0 |
| 10 | 0 |
| 30 | -8 |
| 45 | -8 |
| 150 | -20 |
| 180 | -20 |

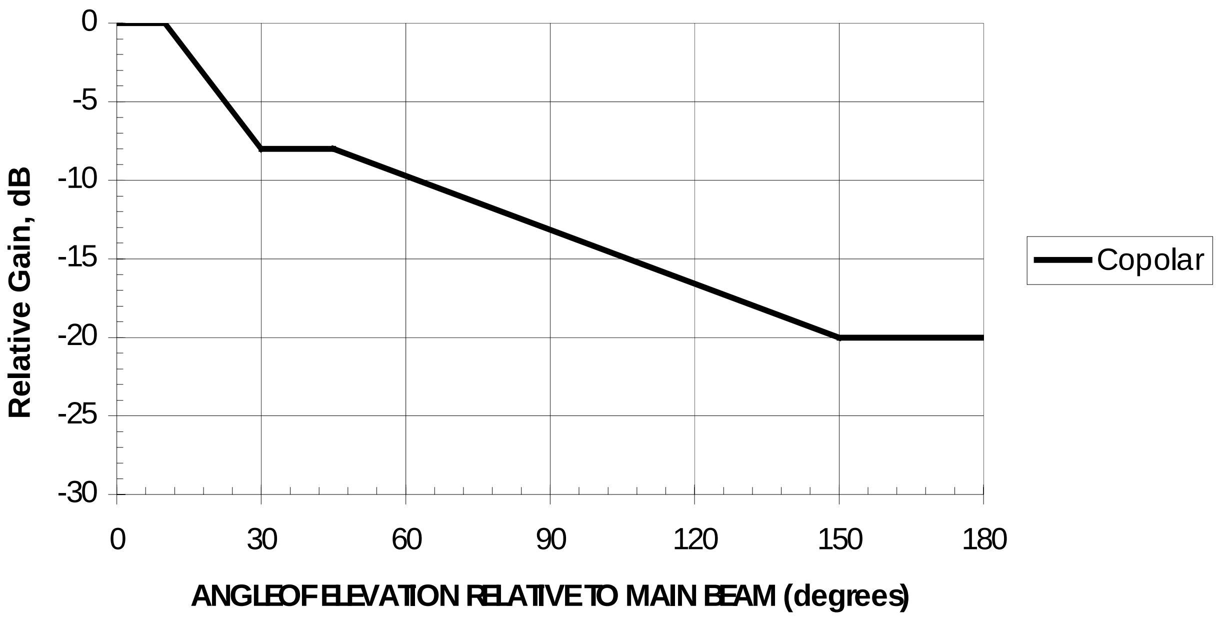


**Figure 2d: Class TS2 Terminal Station antenna elevation RPE**

**Class TS3**

**Table 5**

| Angle (degrees) | Copolar (dB) | Angle (degrees) | Crosspolar (dB) |
|---|---|---|---|
| 0 | 0 | 0 | -14 |
| 20 | 0 | | |
| 40 | -10 | 40 | -14 |
| 90 | -10 | 100 | -29 |
| 120 | -26 | 180 | -29 |
| 180 | -26 | | |

**Figure 2e: Class TS3 Terminal Station antenna azimuth RPE**

**Table 6**

| Angle (degrees) | Copolar (dB) |
|---|---|
| 0 | 0 |
| 20 | 0 |
| 60 | -10 |
| 90 | -10 |
| 120 | -26 |
| 180 | -26 |

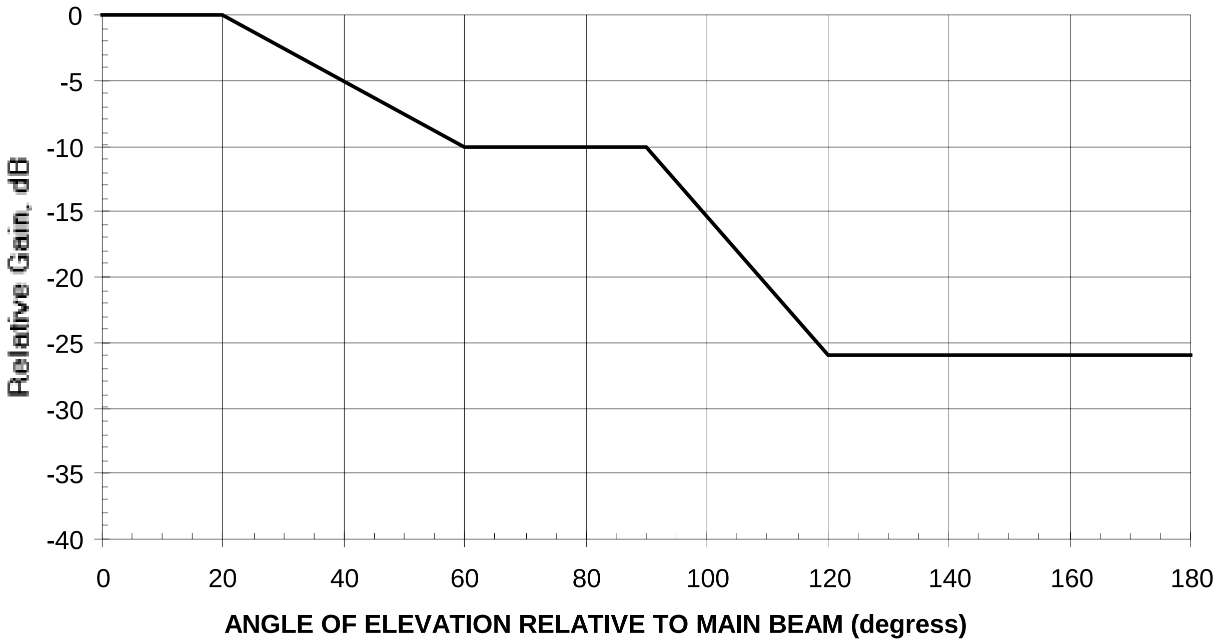


**Figure 2f: Class TS3 Terminal Station antenna elevation RPE**

### 6.1.2 Terminal Station (TS) minimum antenna boresight gain

The minimum gain of the TS Antenna, expressed relative to an isotropic radiator, shall be as detailed in table 7.

**Table 7: Minimum antenna gain for each antenna class**

| Type | Minimum Gain (dBi) |
|---|---|
| Class TS 1 and TS2 | 8,0 |
| Class TS 3 | 14,0 |

## 6.2 Central Station (CS) Sectored Antennas

### 6.2.1 CS Azimuth Elevation Pattern Envelopes (RPE), Sectored

The Central Station azimuth templates for sectored (i.e. not omnidirectional) antennas are given in figure 3 for sector widths in the range 15° to 180°. This template shall apply for all frequencies in the 1 GHz to 3 GHz band, and where fo refers to the centre frequency in GHz. Both copolar and crosspolar patterns are defined. The sector width, defined here as 2$\alpha$ and otherwise referred to as sector angle, has to be declared by the supplier. The gain values are all relative to the maximum gain in the declared sector width.

**a) Copolar RPE**

Point P0 is fixed whereas the positions of P1 to P4 are dependent on centre frequency and/or sector angle. Table 8 summarizes the expressions which describe all these copolar azimuth RPE points.

**b) Crosspolar RPE**

Table 9 summarizes the expressions which describe the four points which define the crosspolar azimuth RPE. Point Q0 is fixed, whereas the positions of Q1, Q2 and Q3 are dependent on centre frequency and/or sector angle.

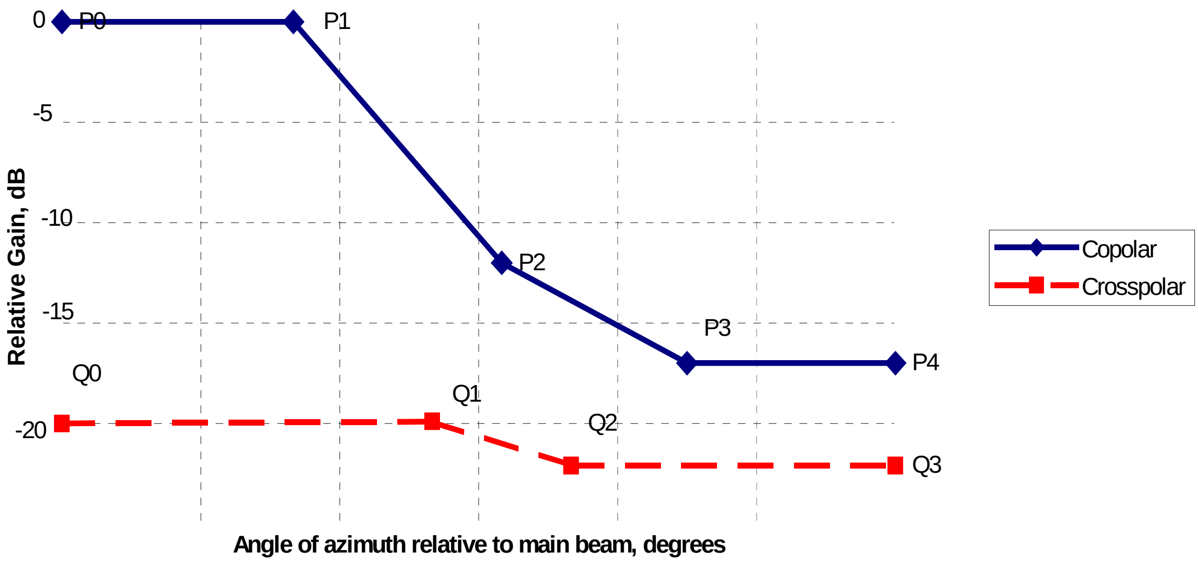


**Figure 3: Normalized CS Sector Antenna Template for azimuth**

The tables shall apply for all frequencies in the 1 GHz to 3 GHz band, and where fo is the nominal centre frequency in GHz and all expressions are rounded to the nearest integer value.

**Table 8**

| Copolar | Angle (degree) | Relative Gain (dB) |
|---|---|---|
| P0 | 0 | 0 |
| P1 | α + 5 | 0 |
| P2 | α + (105 - 7fo) | -0,7fo – 16 |
| P3 | 184,4 - 4,4fo | -1,4fo – 20 |
| P4 | 180 | -1,4fo – 20 |

**Table 9**

| Crosspolar | Angle (degree) | Relative Gain (dB) |
|---|---|---|
| Q0 | 0 | -20 |
| Q1 | α + (57,5 - 5fo) | -20 |
| Q2 | α + (87,5 - 5fo) | -1,4fo – 20 |
| Q3 | 180 | -1,4fo – 20 |

## 6.2.2 Minimum Boresight Gain, Sectored

The CS (Sectored) antenna boresight gain EN 301 126-3-2 [5] shall exceed the values defined in figure 4 as a function of sector angle, 2α, in the range 15° to 180° and for all frequencies in the 1 GHz to 3 GHz frequency band.

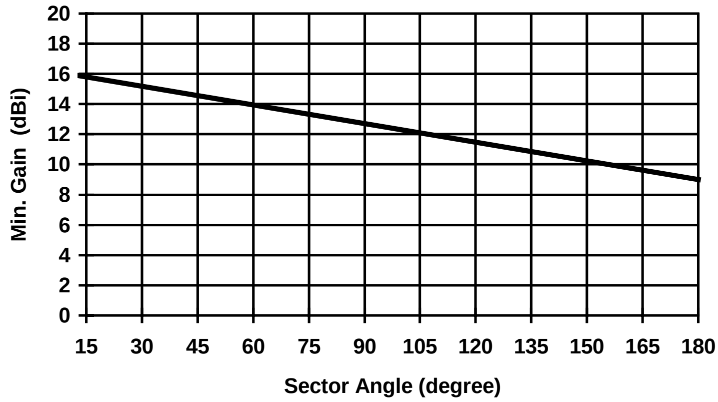


**Figure 4: CS Sector Antenna Minimum Boresight Gain Limits**

## 6.3 Central Station (CS) Omnidirectional Antennas

For omnidirectional CS antennas the following parameters shall apply for all frequencies in the 1 GHz to 3 GHz band:

Minimum nominal gain: 5 dBi;

Gain ripple (azimuth): 3 dB maximum (peak to peak);

Crosspolar discrimination: 20 dB minimum.

## 6.4 Central Station (CS) Omni and Sectored Elevation RPEs

Two CS antenna elevation RPEs are defined: one for antennas designed to exhibit symmetric RPEs about the 0° reference direction (figure 5) and one for antennas designed for asymmetric RPEs (figure 6). For antennas designed without any tilt the 0° reference direction normally corresponds to boresight.

It may be necessary in practical deployments to use electrical or mechanical tilt, or a combination of these two, to achieve the required cell coverage, taking into account the surrounding terrain, for example.

These elevation patterns are considered appropriate to the commonly used range of 0° to -10° for electrical downtilt. For sector antennas only further mechanical tilt of up to ±10° may be suitable for some situations.

An electrical tilt is translated onto the corresponding pattern as a ± shift along the elevation angle axis.

NOTE: Positive angles are for above boresight (up) and negative angles are for below (down).

### 6.4.1 Symmetric elevation RPEs

For **omni-symmetric** antennas the copolar limits in table 10 and figure 5 shall apply, with a uniform value of -20 dB for the crosspolar limit.

For **sectored symmetric** antennas only, the copolar limit in table 10 and figure 5 shall be linearly interpolated beyond the -18 dB, +90° point out to the point defined at 180° by the appropriate azimuth Class of antennas per table 8.

The crosspolar limit shall be linearly interpolated between the 0° and the 180° points taken from the appropriate azimuth Class of antennas as defined in table 9.

**Table 10**

| Angle (degree) | Copolar (dB) |
|---|---|
| 0 | 0 |
| 12 | 0 |
| 12 | -3 |
| 14 | -5 |
| 20 | -5 |
| 60 | -13 |
| 60 | -18 |
| 90 | -18 |

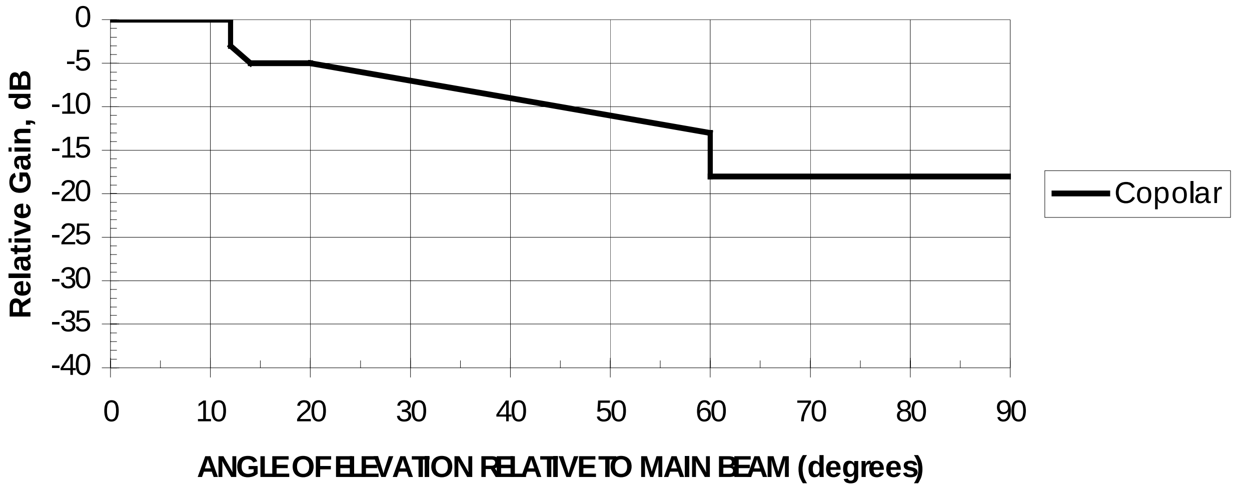


**Figure 5: Symmetric CS antenna elevation pattern**

## 6.4.2 Asymmetric elevation patterns

For **omni-asymmetric** antennas the copolar and crosspolar limits in figure 6 shall apply; outside the ± 4° range the crosspolar limit shall be taken as the same as the copolar limit.

For **sectored asymmetric** antennas only, the copolar limit in figure 6 shall be linearly interpolated:

a) beyond the -3 dB, -30° point (down) out to the point defined at 180° for the appropriate azimuth Class of antennas as taken from table 8; and

b) beyond the -8 dB, +90° point (up) out to the point defined at 180° for the appropriate azimuth Class of antennas as taken from table 8.

The crosspolar limit shall be linearly interpolated:

a) beyond the -8 dB, -30° point (down) out to the point defined at 180° for the appropriate azimuth Class of antennas as taken from table 9; and

b) beyond the -8 dB, +90° point (up) out to the point defined at 180° for the appropriate azimuth Class of antennas as taken from table 9.

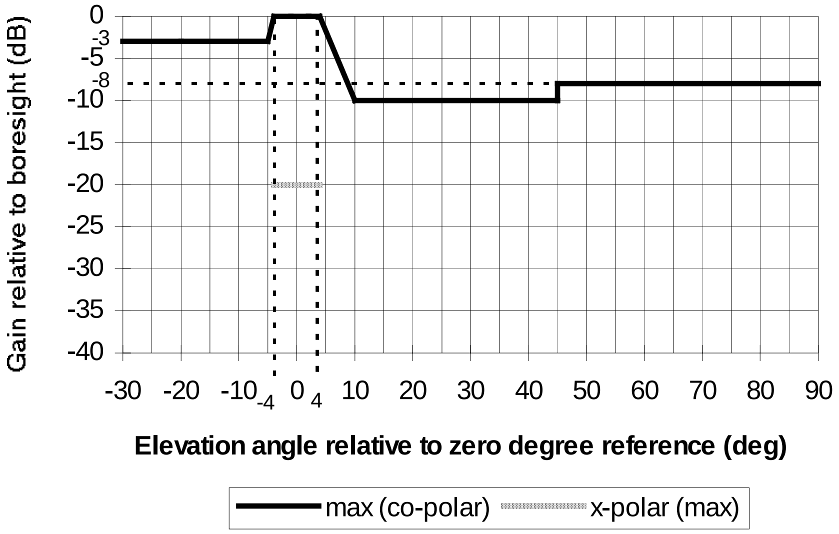


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**Figure 6: Asymmetric CS Antenna Elevation Patterns**

## 6.5 Radomes

Antenna adopting radomes shall conform to the absolute gain and radiation pattern values stipulated in the clauses above, with the radome in place.

## 6.6 Antenna polarization

The antenna system shall radiate linear (single or dual) polarization.

# 7 Conformance Tests

For antenna parameters EN 301 126-3-2 [5] shall apply.

# Annex A (informative): Antenna characteristics

## A.1 Mechanical characteristics

### A.1.1 Environmental characteristics

The antenna should be 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, UV-irradiation etc.

The temperature range could be divided in two parts where at least one of the following ranges should be covered:

1) -33°C to +40°C;

2) -45°C to +45°C.

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

**Table A.1: Wind survival ratings**

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

### A.1.2 Antenna stability

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

The deviation of the antenna main beam axis should not be more than 0,3 times the smaller of the two azimuthal and elevation HPBW, as a general guide, under the conditions specified in table A.2:

**Table A.2: Antenna stability**

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

Further guidance can be obtained from ETS 300 019-1-4 [7].

## A.2 Antenna input connectors

The input connector on the antenna should be mechanically compatible with the radio equipment, this should be agreed between the antenna supplier and the purchaser in line with the overall systems design requirements. For antennas which are integrated with the radio equipment proprietary connection designs may be utilized. In both cases, a suitable test fixture should be agreed and used for test purposes.

Attention is drawn to a range of coaxial connectors referred to in IEC Publication 339-1 [8] and IEC Publication 339-2 [9], IEC Publication 169-1 [10], and EN 122150 [11]. However, it should be noted that these standards are not exhaustive. The impedance of the input ports should be nominally 50 Ω coaxial.

# A.3 VSWR at the input ports

The maximum Voltage Standing Wave Ratio (VSWR) should be agreed between the equipment supplier and purchaser in line with the overall system design requirements. For guidance, antennas with a VSWR in the range 1,9 to 1,1 are typical.

# A.4 Interport isolation

Concerning dual polarized antennas, the isolation between the two inputs should be agreed between the equipment supplier and purchaser in line with the overall system design requirements. For guidance, interport isolation better than 25 dB is typical.

# A.5 Antenna labelling

Antennas should be clearly identified with a weatherproof and permanent label(s) showing the manufacturers name, antenna type, serial number(s), polarization(s) and where appropriate, the antenna should be identified with a label showing the type approval number. It should be noted that integrated antennas may share a common label with the outdoor equipment.

# A.6 Passive Intermodulation Performance

For some P-MP access methods the minimum Passive Intermodulation (PIM) performance of the antenna may need to be taken into account. In such cases the PIM performance should be agreed between the equipment supplier and the purchaser in line with the overall system design requirements.

For guidance PIM product limits can often exceed -100 dBc.

# Bibliography

The following material, though not specifically referenced in the body of the present document (or not publicly available), gives supporting information.


- ANSI/EIA Standard 195-C: "Electrical and Mechanical Characteristics for Terrestrial Microwave Relay System Antennas and Passive Reflector".

# History

| Document history | | | | |
|---|---|---|---|---|
| V1.1.1 | May 1999 | Public Enquiry | PE 9942: | 1999-05-19 to 1999-10-15 |
| V1.1.1 | March 2000 | Vote | V 20000505: | 2000-03-06 to 2000-05-05 |
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