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Technical Report

Fixed Radio Systems;
Multipoint Antennas;
Central and repeater station electronically steerable antennas for Multipoint (MP) fixed radio systems in the 3 GHz to 11 GHz band

Reference

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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Transmission and Multiplexing (TM).

The purpose of the present document is to define the antenna performance standards necessary to ensure optimum frequency co-ordination between the systems and/or different services by the Regulatory Authorities in the 3 GHz to 11 GHz band. These nominal frequency limits have been chosen to reflect the WARC '92 Final Acts [7] and the frequency plans as given in CEPT Recommendation T/R 13-02 [2] and ITU-R Recommendation F.748-1 [6].

Multipoint electronically steerable antennas, whether integrated within station equipment or not, may need to meet environmental, mechanical and electrical characteristics not covered by the present document, in order that the systems will operate as intended. Additional parameters and characteristics may be subject to agreement between the equipment purchaser and the supplier; these are considered and guidance is provided in annex A.

Introduction

The purpose of the present document is to define the requirements for electronically steerable antennas used in conjunction with multipoint (MP) systems necessary to facilitate frequency co-ordination between services in the frequency bands 3 GHz to 11 GHz.

1 Scope

The present document specifies the essential electrical requirements for linearly polarized electronically steerable antennas to be utilized with Multipoint (MP) systems, for central station and repeater station applications, operating in frequency bands from 3 GHz to 11 GHz. These systems use various multiple access schemes. A general description of electronically steerable antennas may be found in the present document.

Electronically steerable antennas for terminal stations are not considered in the present document.

Non steerable antennas for MP systems are covered in the standard EN 302 085 [1] that covers all the terminal station antennas.

Only in exceptional circumstances, and after a consultation period with operators and suppliers, 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.

2 References

For the purposes of this Technical Report (TR), the following references apply:

[1] ETSI EN 302 085: "Fixed Radio Systems; Point-to-Multipoint Antennas; Antennas for point-to-multipoint fixed radio systems in the 3 GHz to 11 GHz band".

[2] CEPT Recommendation T/R 13-02: "Preferred channel arrangements for fixed services in the range 22,0-29,5 GHz".

[3] CEPT/ERC/REC 12-05: "Harmonized radio frequency channel arrangements for digital terrestrial fixed systems operating in the band 10,0-10,68 GHz".

[4] CEPT/ERC/REC 14-03: "Harmonized radio frequency channel arrangements for low and medium capacity systems in the band 3 400 MHz to 3 600 MHz".

[5] ITU-R Recommendation F.747: "Radio-frequency channel arrangements for radio-relay systems operating in the 10 GHz band".

[6] ITU-R Recommendation F.748: "Radio-frequency channel arrangements for radio-relay systems operating in the 25, 26 and 28 GHz bands".

[7] Final Acts of the World Radiocommunications Conference (WRC-95) http://www.itu.int/ITU-R/conferences/wrc/wrc97-95/index.html.

[8] 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-weatherprotected locations".

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

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

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

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

3 Definitions, symbols and abbreviations

3.1 Definitions

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

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

boresight: axis of the main beam in a directional antenna

Central Station (CS): base station which communicates each way with many terminal stations and, in many cases, repeater stations

co-polar 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

cross-polar 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

cross-polar discrimination: difference between the peak of the co-polarized main beam and the maximum cross-polarized signal over an angle measured within a defined region

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 were radiated isotropically

Half Power BeamWidth (HPBW): angle, relative to boresight, between the two directions at which the measured co-polar pattern is 3 dB below the boresight gain

inter-port 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

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

main beam: radiation lobe containing the direction of boresight

mechanical tilt: fixed angular shift in elevation of the antenna boresight by a change to the physical mounting

Radiation Pattern Envelope (RPE): envelope within which the radiation pattern shall fit

radiation pattern: diagram relating power flux density at a constant distance from the antenna to the direction relative to the notional antenna boresight; specifically referenced in the present document to the zero degree reference direction

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

Repeater Station (RS): radio station providing the connection via the air to both the central station and the terminal station(s). The remote 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 2α in the present document. This angle may be covered by separate narrow beams in the case of electronically steerable antennas.

steerable antenna: antenna that covers different directions with separate narrow beams and high gain

Terminal Station (TS): remote (out) station which communicates with a central station

tilt: fixed, angular shift of the antenna boresight in the elevation plane by either electrical, electronic or mechanical means

zero degree (0°): declared direction as referenced to the antenna

reference direction: mechanical characteristics, used as reference for the RPE. See figure 1.

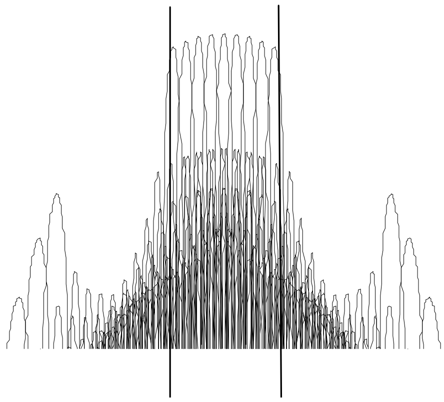


Figure 1

3.2 Symbols

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

α	Alpha (= half the sector angle)
dBi	DeciBels relative to an isotropic source
f_o	Nominal centre frequency of declared antenna operating range
GHz	GigaHertz
MHz	MegaHertz
ROUND ( )	Round up or down to nearest integer

3.3 Abbreviations

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

CS	Central Station
HPBW	Half Power BeamWidth
MP	MultiPoint
PIM	Passive InterModulation
RPE	Radiation Pattern Envelope
RS	Repeater Station
VSWR	Voltage Standing Wave Ratio

4 Frequency bands

The present document applies to a number of frequency ranges within the 3 GHz to 11 GHz frequency bands considered within CEPT/ERC and ETSI for allocation to the fixed services. Suitable sub-bands for allocation to multipoint use are subject to channel plans described in CEPT/ERC/REC 12-05[3], CEPT/ERC/REC 14-03 [4] and ITU-R Recommendation F.747 [5].

For the purpose of the present document, the overall frequency bands 3 GHz to 11 GHz are divided into three ranges as follows:

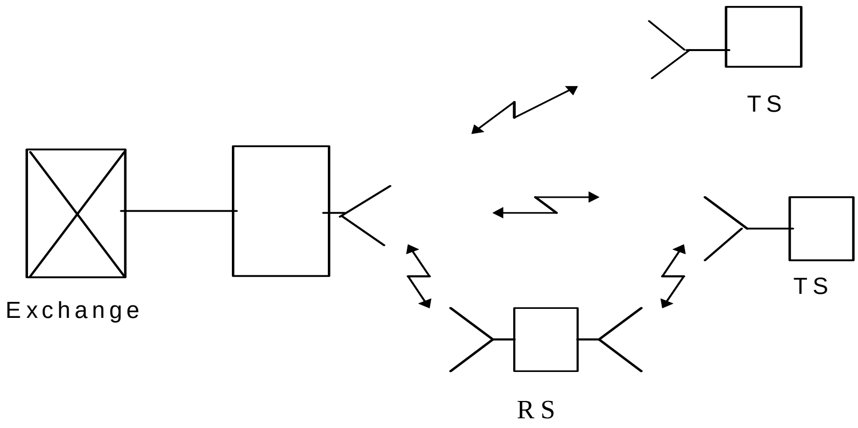
- range 1: 3,0 GHz to 5,9 GHz;
- range 2: 5,9 GHz to 8,5 GHz;
- range 3: 8,5 GHz to 11,0 GHz.

5 Types, characteristics and classification of antennas

5.1 Antenna types

The present document addresses electronically steerable antennas used in the Central (CS) and Repeater (RS) Stations.

The antennas are used in a system which can generally be described as in figure 2:



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.

Figure 2: General multipoint system architecture

These electronically steerable antennas shall be grouped into the following types:

Central and repeater stations: Omni-directional;

Sectored.

Electronically steerable antennas for repeater stations will be of Central (CS) station type.

5.2 Antenna characteristics

5.2.1 Merged radiation pattern envelope

The assumption is made that the electronically steerable antenna can point the beam in any of the available directions in the sector angle. By merging the radiation pattern of all available pointing directions into one plot an envelope of radiation patterns can be identified (see figure 3).

This envelope represents the highest attainable gain in each direction. This corresponds to the radiation pattern of a conventional antenna in terms of impact on coexistence issues. The term Radiation Pattern Envelope (RPE) is used in the present document to refer to the merged radiation pattern envelope.

The merged radiation pattern envelope method will be used for co-polar and cross-polar radiation patterns in both azimuth and elevation.

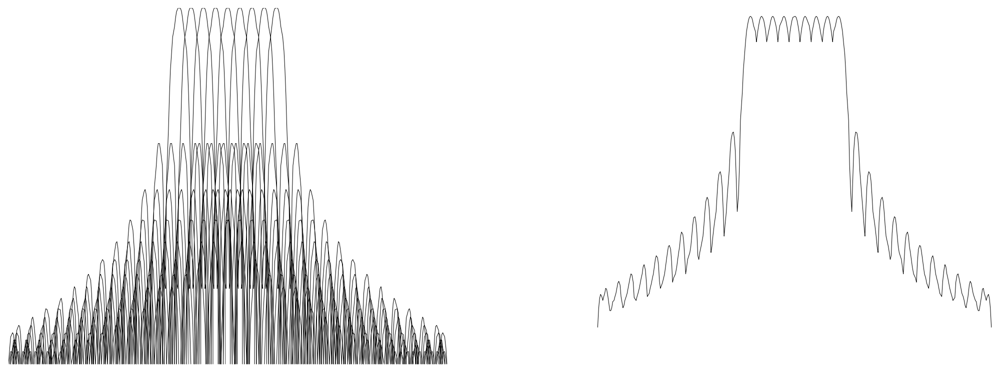


Figure 3: Illustration of merged radiation patterns (left) and their envelope (right) for a multiple beam antenna

5.2.2 Boresight gain

For a steerable antenna the boresight gain is defined as the gain of the antenna in the direction with the highest radiated intensity. This direction does not have to be in the middle of the sector angle.

5.2.3 Scan Sector

Scan sector refers to the sector angle which is declared by the Supplier. The beam can be pointed in different directions inside the scan sector.

The coverage in the scan sector can be either discrete or continuous. The number of beams and the type of coverage will be declared in the Supplier's declaration together with the time to switch between different beam positions.

Sidelobes of an electronically steerable antenna vary with the pointing angle. Sidelobes inside and outside the scan sector need to be considered separately. Sidelobes outside the scan sector may interfere with other systems working outside the declared sector angle, and the requirements on levels of these will be considered from an intersystem and interservice perspective. For interference on other systems the sidelobes inside the scan sector will be of less importance than the main lobes.

5.3 Antenna classifications

The switching process must not cause the antenna to radiate outside the spectrum mask, otherwise the RF power must be turned off.

5.3.1 CS Classes

With respect to the **azimuthal** Radiation Pattern Envelope (RPE), three classes may be identified in different frequency sub-ranges for Central Station (CS) **sectored** antennas:

- class CS 1;
- class CS 2;
- class CS 3.

These Classes allow flexibility for a variety of different systems, and may be generally appropriate for low, medium and higher density deployments respectively.

The sector in azimuth is covered by several positions of the beam and the antenna will exhibit always one beam in any one instant. Simultaneous beams are not considered in the present document. The position of the beam is controlled by an appropriate control signal driving the antenna's internal beam-forming network.

6 Electrical Characteristics

For the purpose of the present document, an antenna is specific to Type, Class, Range, 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 Central Station (CS) Sectored Antennas

6.1.1 CS Azimuth Radiation Pattern Envelope (RPE), Sectored

The Central Station **azimuth** RPEs for **sectored** (i.e. not omni-directional) antennas are defined in the following list for sector beamwidths in the range 15° to 180°:

- class CS 1: tables 1 and 2;
- class CS 2: tables 3 and 4;
- class CS 3: tables 5 and 6.

Both co-polar and cross-polar patterns are defined. The sector angle defined as 2α shall be declared by the supplier. The three azimuth patterns defined below 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 declared sector angle.

a) Co-Polar RPE

Point P0 is fixed whereas the positions of P1 to P5 are dependent on centre frequency and/or sector angle. Tables 1, 3 and 5 summarize the expressions which describe all these co-polar azimuth RPE points for classes 1 to 3 respectively.

b) Cross-Polar RPE

Tables 2, 4 and 6 summarize the expressions which describe the four points which define the cross-polar azimuth RPE. Point Q0 is fixed whereas the positions of Q1 to Q3 are dependent on centre frequency and/or sector angle.

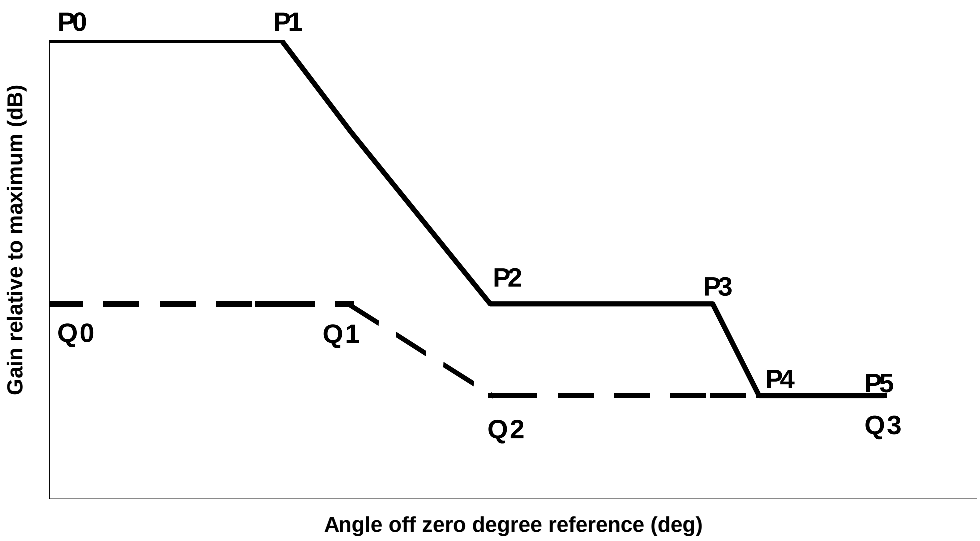


Figure 4: Normalized CS Sector Antenna Template for Azimuth

These tables shall apply for all frequencies in the 3 GHz to 11 GHz band, and where f_o is the nominal centre frequency in GHz and all expressions are rounded to the nearest integer value.

6.1.1.1 Class CS 1

Table 1: CS Class 1

Co-polar	Angle (deg)	Relative Gain (dB)
P0	0	0
P1	$\alpha + 5$	0
P2	160	-20
P3	160	-20
P4	160	-20
P5	180	-20

Table 2: CS Class 1

Cross-polar	Angle (deg)	Relative Gain (dB)
Q0	0	-12
Q1	$\alpha + 5$	-15
Q2	160	-20
Q3	180	-20

6.1.1.2 Class CS 2

Table 3: CS Class 2

Co-polar	Angle (deg)	Relative Gain (dB)
P0	0	0
P1	$\alpha + 5$	0
P2	$\alpha + (105 - 7f_o)$	-20
P3	$195 - 7f_o$	-20
P4	$186 - 4{,}4\ f_o$	-25
P5	180	-25

Table 4: CS Class 2

Cross-polar	Angle (deg)	Relative Gain (dB)
Q0	0	-20
Q1	$\alpha + (57{,}5 - 5f_o)$	-20
Q2	$\alpha + (87{,}5 - 5f_o)$	-25
Q3	180	-25

6.1.1.3 Class CS 3

Table 5: CS Class 3

Co-polar	Angle (deg)	Relative Gain (dB)
P0	0	0
P1	$\alpha + (20 - 1{,}4\ f_o)$	0
P2	$\alpha + (75 - 4{,}3\ f_o)$	-23
P3	$165 – 4{,}3\ f_o$	-23
P4	150	$-1{,}4\ f_o -20$
P5	180	$-1{,}4\ f_o -20$

Table 6: CS Class 3

Cross-polar	Angle (deg)	Relative Gain (dB)
Q0	0	$-0,7\ f_0\ -17,5$
Q1	$\alpha + (20 - 1,4\ f_0)$	$-0,7\ f_0\ -17,5$
Q2	$\alpha + (75 - 4,3\ f_0)$	$-1,4\ f_0\ -20$
Q3	180	$-1,4\ f_0\ -20$

6.1.2 Minimum Boresight Gain, Sectored

The CS antenna boresight gain 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 3 GHz to 11 GHz bands.

Antenna boresight gain does not necessarily correspond to the 0° reference gain.

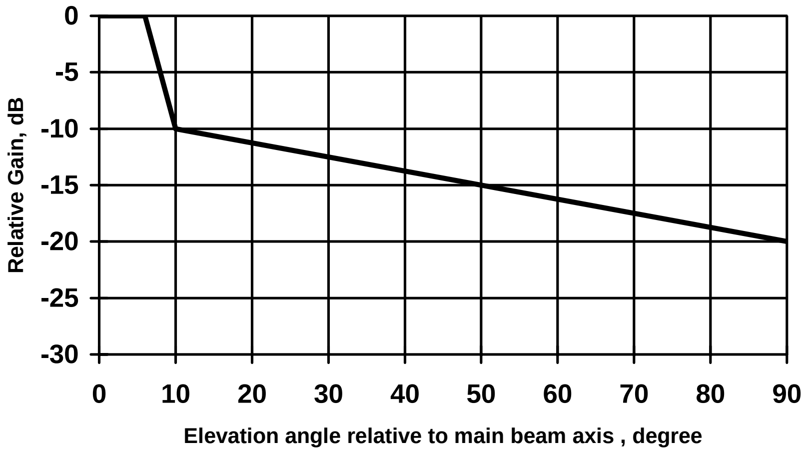


Figure 5: Symmetric CS antenna copolar elevation RPE

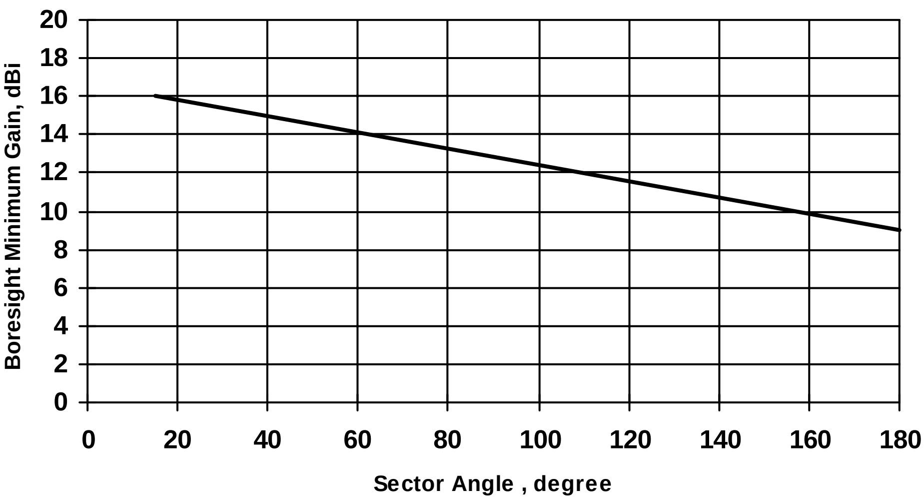


Figure 6: CS sector antenna boresight minimum gain

Table 7: Symmetric CS Antenna copolar elevation Pattern

Angle (degree)	Relative Gain (dB)
0	0
6	0
10	-10
90	-20

6.2 Polarization

The antenna shall radiate a linearly polarized wave.

6.3 Radomes

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

7 Conformance tests

EN 301 126-3-2 [9] shall apply.

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

Annex A: Antenna Characteristics

A.1 Mechanical Characteristics

A.1.1 Environmental characteristics

The antennas should be designed to operate within a temperature range of -45°C to +45°C with a relative humidity up to 100 % for environmental conditions specified in ETS 300 019-1-4 [8].

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

1) -33°C to +40°C;

2) -45°C to +45°C.

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

Table A.1

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

A.1.2 Antenna stability

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

For installation purposes, the deviation of the antenna boresight 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 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 [8].

A.2 Antenna input connectors

When flanges are provided at the input port of the antenna they should be in accordance with IEC 60154-1 [10] and IEC 60154-2 [11].

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

For antennas using coaxial input ports the impedance should be nominally 50 Ω and the connectors should conform to IEC 60169 [12].

The input connector on the antenna should be mechanically compatible with the radio equipment. This should be agreed between the equipment supplier and purchaser in line with the overall system design requirements. In such cases a suitable test fixture should be agreed and used for test purposes.

A.3 VSWR at the input port(s)

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

A.4 Inter-port isolation

The isolation between the input ports of a dual polarized antenna should be agreed between the equipment supplier and the purchaser in line with the overall system design requirements. For guidance inter-port isolation better than 25 dB is typical.

A.5 Antenna labelling

Antennas should be clearly identified with a weather-proof and permanent label(s) showing the manufacturer's name, antenna type, polarization direction, serial number(s) and type approval reference where appropriate.

NOTE: 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 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.

Annex B: Bibliography

- ETSI ETS 300 019-1-2: "Equipment Engineering (EE); Environmental conditions and environmental tests for telecommunications equipment; Part 1-2: Classification of environmental conditions; Transportation".
- CEPT/ERC/DEC/(95)04: "On the Procedures for Mutual Recognition of Type Approval of Radio (terminal) Equipment".
- IEC 60050-712: "International Electrotechnical Vocabulary - Chapter 712: Antennas".
- DIN 45.030, Part 1, Part 2: "Definitions/concepts, antennas".
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History

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