

Project	IEEE 802.16 Broadband Wireless Access Working Group		
Title	Recommended Antenna Specifications		
Date Submitted	2000-01-06		
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Re:	Call for contributions on antenna requirements for Broadband Wireless Access systems, meeting #3, Boulder, Colorado, September 17, 1999.		
Abstract	This document recommends general specifications for BTS and STS antennas and detailed specifications for STS antennas of a BWA system.		
Purpose	It is proposed that 802.16.2 (Coexistence Task Group) adopt the this document as Recommended Antenna Specifications within the Recommended Practices Document.		
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Recommended Antenna Specifications

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1 Frequency Ranges

Antenna design challenges vary from one frequency range to another. While achieving a certain level for a parameter might be easy at lower frequencies, it might prove to be difficult at higher frequencies or vice versa. Also, the number of coexisting systems varies from one frequency band to another. The amount of interference pollution, therefore, varies across the broad frequency range of interest of 802.16. Having said the above, in order to come up with antenna requirements for a more or less homogeneous environment, three frequency ranges are defined.

- Range 1: 10 GHz To 23.5 GHz
- Range 2: 23.5 GHz To 43.5 GHz
- Range 3: 43.5 GHz To 66 GHz

Most of the BWA systems will operate within the Range 2. Therefore, Range 2 is the focus of the Coexistence Task Group and this document.

2 Antenna Classes

Depending on the performance and the type of environment the antennas will be operating in, antennas are divided into electrical and mechanical classes. These classes help service providers in selection of antennas that are just right for the deployment environment without the excess cost of unnecessary high-performance antennas if the interference environment is a benign one.

2.1 Electrical Classes

In each of the three frequency ranges mentioned above, antennas are divided into three classes with respect to electrical performance. The main factor distinguishing among classes is the level and severity of interference in the environment. It should be noted here that the final decision on the selection of an antenna class is for the service provider to make. The following are only recommended guidelines.

2.1.1 Class 1

Class 1 antennas are meant for operation in environments in which interference levels are insignificant. This could be due to many factors including

- absence of coexisting systems in the same geographical area
- conservative reuse creating a benign self-interference environment
- coexisting systems being far enough such that the power spectral density flux density resulting from those systems is negligible

In such conditions, less complicated, low-cost antennas with minimum requirements specified in this document could be deployed.

2.1.2 Class 2

Class 2 antennas are meant for operation in environments in which interference levels could be potentially significant and cause problems under certain conditions. Factors contributing to the interference being upgraded from insignificant (in case of class 1) to potentially significant (in case of class 2) are

- Existence of at least one coexisting system in the same geographical area
- A reuse pattern which may cause self-interference problems in certain areas
- Proximity of coexisting systems such that the interferers' power spectral density flux density is not negligible.

In such conditions, antennas with higher levels of discrimination in side lobes and back lobes need to be deployed to guarantee the acceptable performance of the system.

2.1.3 Class 3

Class 3 antennas are meant for operation in environments in which interference levels are highly significant. Factors contributing to highly significant interference are

- Existence of several coexisting systems in the same geographical area
- Aggressive reuse pattern which creates significant self-interference levels throughout the network
- Extreme proximity to a coexisting system, e.g. adjacent cells.

In such conditions, highly efficient antennas with optimum pattern and very low side lobes and high front-to-back ratio need to be deployed to guarantee the performance of the system.

2.2 Mechanical Classes

In order to capture the environmental effects on antennas and their performance while operating within a BWA network, two mechanical classes are proposed. These two classes are heavy duty and normal duty. The use of high-gain, pencil-beam subscriber antennas at rooftops creates a unique situation in regard to vibrations and lateral movements of the antenna structure due to wind. Half a degree deviation from the orientation set by network planners could potentially lead to several dB losses in signal strength. However, while hurricane-prone areas require heavy-duty antenna systems, other areas could benefit from cheaper, normal-duty antennas.

2.3 Polarization

Rain attenuation is the dominant impairment in the frequency range of our focus; namely, range 2. Due to insignificant depolarizing effect of rain on vertical or horizontal polarization, only these two polarization states are considered for operation in BWA systems. The required polarization purity is captured in the specification of antenna XPD in the next section. Also, the AZ and EL RPEs shall be identical for vertically and horizontally polarized antennas.

2.4 VSWR

Voltage Standing Wave Ratio (VSWR) does not directly affect the coexistence of BWA systems. If not kept at a minimum level throughout the operation bandwidth, however, it reduces the radiated power out of the antenna below planned limits. A reduced carrier power leads to smaller $C/(I+N)$. A VSWR of 1.9 is equivalent to about

10% loss of power due to reflection. Therefore, it is recommended that the VSWR of the BWA antenna be kept below 1.9 across the entire target spectrum with 1.5 being the typical value (4% loss of power due to reflection).

2.5 Passive Intermodulation (PIM)

Passive intermodulation does not affect coexistence of BWA systems directly. However, when combined with other forms of coexistence-related interference, the additional noise added to the noise floor of the receiver due to passive intermodulation products could potentially affect the safe operation of a BWA system. It is recommended that the BWA antennas perform at 100 dBc or better in regards to passive intermodulation.

3 BTS Antenna

4 STS Antenna

It is assumed that STS antennas are high-gain, pencil-beam antennas mounted on rooftops of customers of a BWA system. The high gain of the antenna, and the discrimination it is expected to introduce against interference calls for certain performance levels that need to be addressed. The performance-related numbers and limits proposed in this document, however, are guidelines and should not prevent the utilization and deployment of future antenna technologies such as smart antennas.

4.1 Electrical Characteristics

STS antennas are highly directional, narrow-beam antennas. The specification defines two gain categories for STS antennas; standard-gain, and high-gain. While standard-gain antennas could be used for normal operation, high-gain type could be used for achieving greater range or better availability.

4.1.1 Minimum Cross-Polar Discrimination (XPD)

The STS antennas should follow the same guidelines set for BTS antennas in regards to XPD.

4.1.2 Minimum Cross-Polar Isolation (XPI)

The STS antennas should follow the same guidelines set for BTS antennas in regards to XPI.

4.1.3 Inter-Port Isolation

The STS antennas should follow the same guidelines set for BTS antennas in regards to inter-port isolation.

4.1.4 Gain Categories

Two gain categories are recommended for STS antennas: standard-gain and high-gain. While the standard-gain category is recommended for use under normal conditions, the high-gain category antenna should be used a) to provide additional dBs in the link budget for providing coverage to certain STSs and b) to control the level of interference given the smaller beamwidth of such antennas. The final choice of the gain category, however, is with the service provider.

4.1.4.1 Standard-gain STS Antenna

It is hereby recommended that standard-gain STS antenna should provide a maximum co-polar gain in the range of 35 to 40 dBi. The maximum cross-polar gain should follow the XPD guidelines in this document.

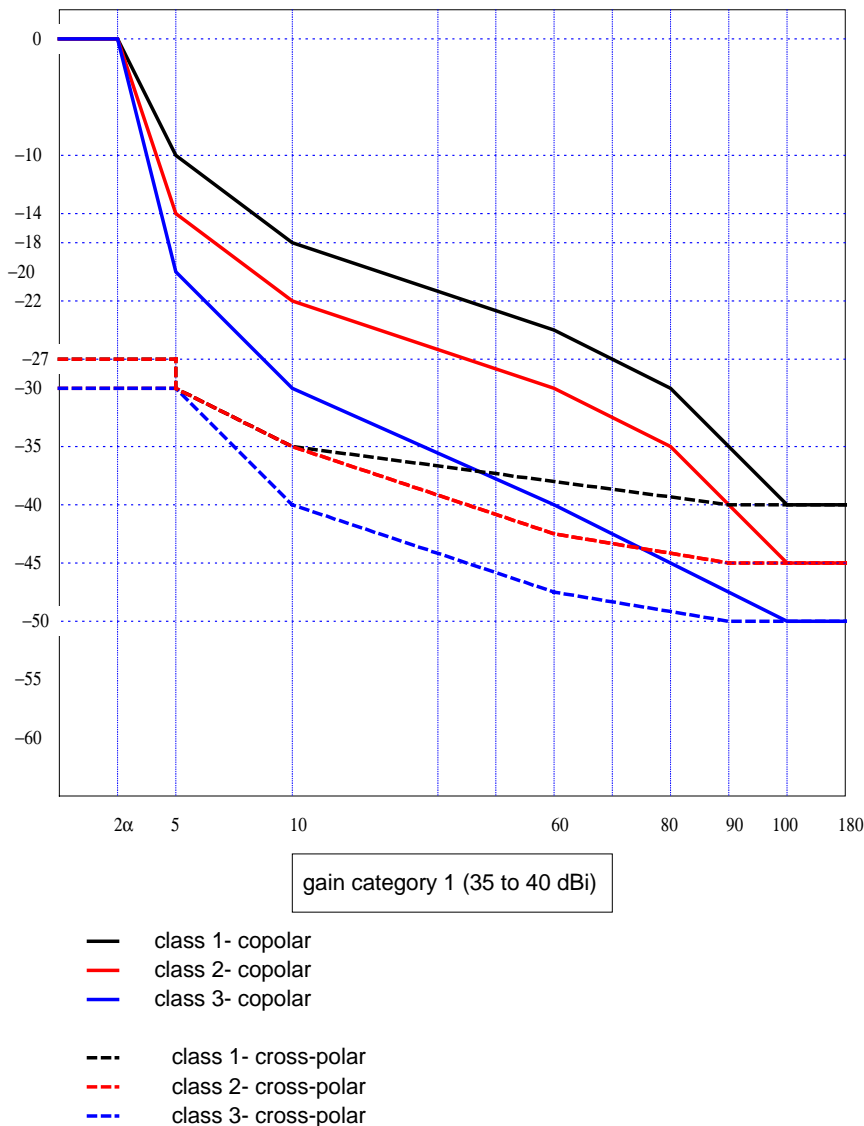
4.1.4.2 High-gain STS Antenna

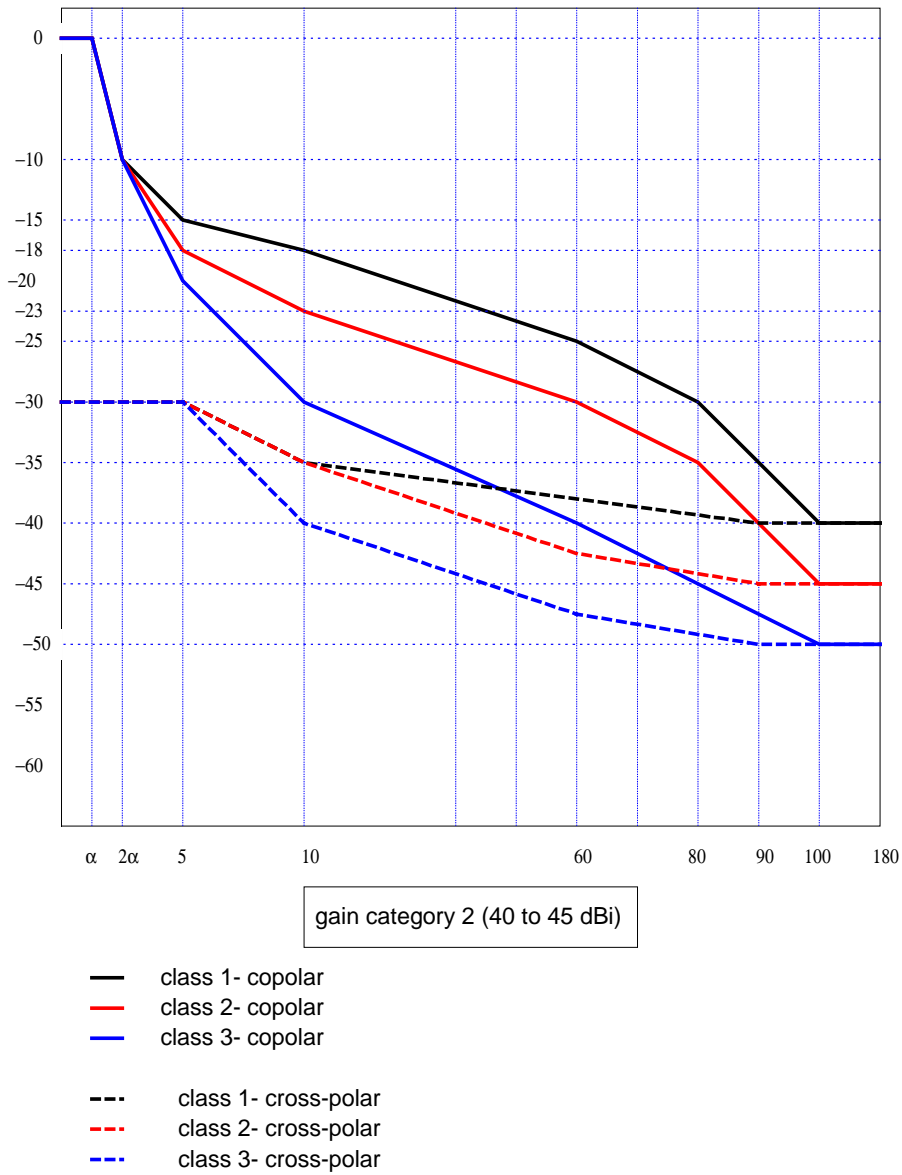
It is hereby recommended that high-gain STS antenna should provide a maximum co-polar gain in the range of 40 to 45 dBi. The maximum cross-polar gain should follow the XPD guidelines in this document.

4.1.5 Radiation Pattern Envelop (RPE)

The following tables show the RPEs of co- and cross-polar patterns for two gain categories. As described in a previous contribution 802.16cc-99/16, the required side lobe level and front-to-back ratio of the STS antenna depends on the coexistence scenario, C/I requirements of the radios, rain region, and the pattern of BTS antenna. It is recommended here that given the coexistence scenario, the required SLL and FBR be calculated by both the method described in 802.16cc-99/16 and the following RPEs for co- and cross-polar patterns, and the larger number be selected as the requirement for safe coexistence.

In the following graphs, α is one half of the half-power beamwidth of the antenna. It is also assumed that the same RPE should apply to both E- and H-plane.





4.1.5.1 Gain Category 1– Co-polar

Degree off bore axis	Class 1	Class 2	Class 3
0	0	0	0
2α	0	0	0
5	-10	-14	-20
10	-18	-22	-30
60	-25	-30	-40
80	-30	-35	-45
90	-35	-40	
100	-40	-45	-50
180	-40	-45	-50

4.1.5.2 Gain Category 1– Cross-polar

Degree off bore axis	Class 1	Class 2	Class 3
$0 \leq \text{angle} < 5$	-27	-27	-30
5	-30	-30	-30
10	-35	-35	-40
60		-43	-45
80			
90	-40	-45	-50
100	-40	-45	-50
180	-40	-45	-50

4.1.5.3 Gain Category 2– Co-polar

Degree off bore axis	Class 1	Class 2	Class 3
0	0	0	0
2α	0	0	0
4α	-10	-18	-20
5	-15	-14	-20
10	-18	-23	-30
60	-25	-30	-40
80	-30	-35	-45
90	-35	-40	
100	-40	-45	-50
180	-40	-45	-50

4.1.5.4 Gain Category 2– Cross-polar

Degree off bore axis	Class 1	Class 2	Class 3
0	-30	-30	-30
5	-30	-30	-30
10	-35	-35	-40
60		-43	-45
80			
90	-40	-45	-50
100	-40	-45	-50
180	-40	-45	-50

4.2 Mechanical Characteristics

The following mechanical characteristics of STS antennas, directly or indirectly, affect the coexistence of BWA systems.

4.2.1 Temperature and Humidity

The STS antennas should follow the same guidelines set for BTS antennas in regards to temperature and humidity.

4.2.2 Wind and Ice Loading

Due to narrow azimuth and elevation beamwidth, the STS antennas should be highly stable and undergo little mechanical deformation due to wind and other sources of vibrations. It is recommended that the maximum deviation of the antenna main beam axis due to any reason should be kept less than or equal to half of the beamwidth of the antenna at all times. This way, the power loss due to wind and other sources of vibration is guaranteed to be less than or equal to 3 dB. The following table shows the required operational wind and ice loading for normal and heavy-duty STS antennas.

	Normal Duty	Heavy Duty
Wind Velocity (mi/hr)	70	100
Ice Loading (in.)	1	1.5

4.2.3 Water Tightness

The STS antennas should follow the same guidelines set for BTS antennas in regards to water tightness.

4.3 Peripherals

4.3.1 Radomes

The STS antennas should follow the same guidelines set for BTS antennas in regards to radomes.

4.3.2 Heaters

The STS antennas should follow the same guidelines set for BTS antennas in regards to heaters.

4.3.3 Labeling

The STS antennas should follow the same guidelines set for BTS antennas in regards to labeling.