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Title	IEEE 802.16.2, Recommended Practices to Facilitate the Coexistence of Broadband Wireles Access (BWA) Systems: Working Document, Draft 5
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Re	IEEE PAR 802.16.2
Abstract	This document specifies the design, installation and test parameters for Broadband Wireless Access systems pertinent to coexistence. It provides coexistence support for systems designed to be compliant with IEEE 802.16.1.
Purpose	This draft is a working document for review by 802.16. This document will serve as the basis for our discussions at the next interim-working meeting in Montreal. **This working document has not been approved or voted upon.**
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IEEE 802.16.2, Recommended Practices to Facilitate the Coexistence of Broadband Wireless Access (BWA) Systems, Draft 5

1 Introduction

This document provides guidelines for minimizing interference in Broadband Wireless Access (BWA) systems. Pertinent coexistence issues are addressed and recommended engineering practices provide guidance for system design, deployment, co-ordination and frequency usage. The document covers the 10 to 66 GHz frequencies in general, but is focused on the range of 23.5-43.5 GHz.

1.1 Scope

This document provides recommended practices for the design and coordinated deployment of Broadband Wireless Access (BWA) systems to minimize interference so as to maximize system performance and/or service quality. The intent of this document is to define a set of consistent design and deployment recommendations for BWA systems. These recommendations, if followed by manufacturers and operators, will allow a wide range of equipment to coexist in a shared environment with acceptable mutual interference. This practice provides recommendations in three specific areas. First, it recommends limits for both in-band and out-of-band BWA emissions through parameters including radiated power, spectral masks and antenna patterns. Second, it recommends tolerance levels for certain receiver parameters, including noise floor degradation and blocking performance, for interference received from other BWA systems as well as from other terrestrial and satellite systems. Third, it recommends band plans, separation distances, and power spectral flux density limits to facilitate coordination and to enable successful deployment of BWA systems with tolerable interference.

The scope includes interference between systems deployed across geographic boundaries in the same frequency blocks and systems deployed in the same geographic area in adjacent frequency blocks. This document emphasizes coexistence practices for Point-to-Multipoint systems. The scope does not cover coexistence issues due to intra-system frequency re-use within the operator's authorized band, and it does not consider the impact of interference created by BWA systems on non-BWA terrestrial and satellite systems.

1.2 Order of Precedence and Assumptions

(a) In the event that local and/or ITU Radio Regulations have more stringent requirements than the recommendations contained within this document, then those regulations take precedence.

(b) This document was developed based on BWA equipment, which will conform to 802.16.1, but is intended to be generally applicable to all broadband wireless systems.

1.3 Definitions

Authorised Band: The band over which the regulator permits the license holder to operate transmitters.

Digital modulation: The process by which some characteristic (frequency, phase, amplitude or combinations thereof) of a carrier frequency is varied in accordance with a digital signal.Digital modulation is characterized by discrete changes of state for the carrier signal rather than continuous changes as in analog modulation.

Equivalent Isotropically Radiated Power (EIRP): The product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna. For purposes of this document, EIRP is expressed in decibels referenced to either 1 milliWatt (dBm) or one Watt (dBW) in the direction of the main antenna beam.

Frequency Block: A portion of radio spectrum assigned to an operator. A block would normally be considerably larger than any individual radio channel. This term is usually considered to be synonymous with authorized band.

Frequency Ranges: For purposes of this document, the following 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

[Frequency Slot: The smallest element of a frequency band plan that can be aggregated to form a block assignment.] [TBR (Barry input)]

Frequency Tolerance: Frequency tolerance is defined with respect to the carrier frequency in the air and is the maximum permissible departure with respect to the assigned frequency of the corresponding characteristic frequency of an emission.

Harmonics: Emissions which are integer multiples of a primary emission frequency. This includes baseband, IF and RF harmonics, which may all appear as sub-modulations of the main carrier.

Occupied Bandwidth B_o: For a single carrier, it is the width of a frequency band such that below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5% of the total mean power radiated by a given emission. This implies that 99% of the total mean emitted power is within this band, and hence this bandwidth is also known as the 99% bandwidth.

[When a multi-carrier transmission uses a common amplifier stage, the occupied bandwidth of this composite transmission is defined as the numeric sum of the individual carrier occupied bandwidths.

When a multi-carrier transmission uses a common amplifier stage, the occupied bandwidth of this composite transmission is defined by the following relationship:

$$B_{OM} = 1/2\ B_{OU} + 1/2\ B_{OL} + (F_{OU} - F_{OL})$$

Where:

B_{OM} = B_O of the multi-carrier system

B_{OU} = B_O of the uppermost sub-carrier

B_{OL} = B_O of the lowermost sub-carrier

F_{OU} = Centre frequency of the uppermost sub-carrier

F_{OL} = Centre frequency of the lowermost sub-carrier.]TBR

NOTE: This definition applies to most analog and simple digital emissions (QAM, QPSK, etc), but its applicability to other more complex modulation structures (e.g., OFDM, CDMA) is still to be determined.

Out-of-Band Emissions: Emissions from the edge of the authorized bandwidth up to 200% of the occupied bandwidth from the edge of the authorized bandwidth. These emissions occur both above and below the main emission

Power Flux Density (pfd): The radiated power flux per unit area expressed as Watts/m^2.

Power Spectral Flux Density (psfd): The radiated power flux per unit bandwidth per unit area. It is often expressed in Watts/MHz/m^2.

Repeaters: Repeaters are generally used to improve coverage to locations where the hub(s) have no line of sight within their normal coverage area(s), or alternatively to extend coverage of a particular hub beyond its normal range.

Service Area: A geographic area for which BWA licenses are issued.

Spectrum Disagregation: Some regulators allow a license holder to segregate their spectrum, to permit several operators access to sub-portions of the licensee's authorised band.

Spurious Emissions: Emissions greater than 200% of the occupied bandwidth from the edge of the authorized bandwidth.

Unwanted Emissions: Comprise out-of-band emissions, spurious emissions and harmonics.

Virtual Block Edge: A reference frequency used as a block edge frequency for testing of unwanted emissions, so as to avoid effects of RF block filters.

1.4 Related Standards and Documents

IEEE 802.16.1 “Telecommunications and Information Exchange Between Systems - LAN/MAN Specific Requirements - Air Interface for Fixed Broadband Wireless Access Systems”

ETSI BRAN HIPERACCESS “High PERformance Radio ACCESS System”

ETSI EN 301 213, parts 1-3 “Point to Multipoint DRRS in frequency bands in the range 24.5GHz to 29.5GHz”

ETSI EN 301 390 V1.1.1. (1999-07) “Spurious Emissions and Receiver immunity at Equipment/Antenna Port of Digital Fixed Radio Systems”

ETSI DEN/TM 04097 (work item) “Fixed Radio Systems; Radio equipment for use in Multimedia Wireless Systems (MWS) in the band 40.5GHz to 43.5GHz”

ETSI EN 301 215 – 1 “Point to Multipoint Antennas: Antennas for point-to multipoint fixed radio systems in the 11GHz to 60GHz band; Part 1: General aspects”

ETSI EN 301 215-2 “Point to Multipoint Antennas: Antennas for point-to-multipoint fixed radio systems in the 11GHz to 60GHz band; Part 2: 24GHz to 30GHz”

ETSI EN 301 215-3 “Characteristics of Multipoint Antennas for use in the Fixed Service in the band 40.5GHz to 43.5GHz”

Recommendation ITU-R P.530-8 “Propagation data and prediction methods required for the design of terrestrial line-of-sight systems”

Recommendation ITU-R P.837-1 “Characteristics of Precipitation for Propagation Modeling”

Recommendation ITU-R P.841-1 “Conversion of annual statistics to worst – month statistics”

Recommendation ITU-R P.840-3 “Attenuation due to clouds and fog”

Recommendation ITU-R P.526-6 “Propagation by diffraction”

Recommendation ITU-R P.676-4 "Attenuation by atmospheric gases"

ITU Recommendation F.746-1 "Radio Frequency channel arrangements for fixed services in the range 22.0 GHz to 29.5 GHz"

CEPT Rec. T/R 13-02 "Preferred channel arrangements for the Fixed Services in the range 22.0-29.5 GHz."

ITU-R Recommendation F.[AD/9D] "Maximum equivalent isotropically radiated power of transmitting stations in the Fixed Service operating in the frequency band 25.25-27.5 GHz shared with the Inter – Satellite Service."

IEC Publication 154-2 "Flanges for wave guides, rectangular"

ITU-R Rec. F.1191 "Bandwidths and unwanted emissions of digital radio relay systems"

ITU-R Document 7D-9D/68-E, dated 8 March 2000 "A proposed Draft New Recommendation on the Technical and Operational Requirements that Facilitate Sharing Between Point-to-Multipoint Systems in the Fixed Service and the Inter-Satellite Service in the Band 25.25-27.5GHz"

CEPT/ ERC Rec. 74-01 "Spurious Emissions"

Industry Canada RSS 191 "Local Multi Point Communication Systems In The 28 GHz Band; Point-To-Point And Point-To-Multipoint Broadband Communication Systems In The 24 GHz And 38 GHz Bands"

Industry Canada SRSP-324.25 "Technical Requirements for Fixed Radio Systems Operating in the Bands 24.25 - 24.45 GHz and 25.05 - 25.25 GHz"

Industry Canada SRSP-325.35 "Technical Requirements for Local Multipoint Communication Systems (LMCS) Operating in the Band 25.35 - 28.35 GHz"

Industry Canada SRSP-338.6 "Technical Requirements for Fixed Radio Systems Operating in the Band 38.6 - 40.0 GHz"

RABC "A Radio Advisory Board of Canada Supporting Study Leading to a Coordination Process For Point-To-Multipoint Broadband Fixed Wireless Access Systems in the 24, 28 and 38 GHz Bands"

2 System Overview

Broadband Wireless Access (BWA) is a term referring to a range of fixed radio systems, used primarily to convey broadband services between users' premises and core networks. The term "broadband" is usually taken to mean the capability to deliver significant bandwidth to each user (in ITU terminology, greater than around 1.5 Mbps, though many BWA networks support significantly higher data rates). The networks operate transparently, so users are not aware that services are delivered by radio. There is usually no direct user-to-user traffic. Such connections, if required, are made via a core network.

A typical BWA network supports connection to many user premises within a radio coverage area. It provides a pool of bandwidth, shared automatically amongst the users. Demand from different users is often statistically of low correlation, allowing the BWA network to deliver significant bandwidth-on-demand to many users, with a high level of spectrum efficiency. Significant frequency re-use is employed.

The range of applications is very wide and evolving quickly. It includes voice, data and entertainment services of many kinds. Each subscriber may require a different mix of services, which is likely to change rapidly as connections are established and terminated. Traffic flow may be unidirectional, asymmetrical or symmetrical, again changing with time. In some territories, systems delivering these services are referred to as Multimedia Wireless Systems (MWS) in order to reflect the convergence between traditional telecommunications services and entertainment services.

These radio systems compete with other wired and wireless delivery means for the "last mile" connection to services. Use of radio or wireless techniques result in a number of benefits, including rapid deployment and relatively low "up-front" costs.

2.1 Co-existence between systems

IEEE, through the 802.16.1, project is standardizing the air interface (Physical and MAC layers) of a BWA system. However, the allocation of spectrum is not uniquely associated with 802.16.1 systems and so other multipoint solutions are likely to share the various frequency bands set aside for these types of service. Thus, arrangements for satisfactory coexistence of like and unlike systems are required, meaning that the mutual interference between them is low enough to have an acceptably small effect on performance. This is particularly important when multiple systems having different characteristics operate across service area boundaries or across country borders.

Coexistence between the various like and unlike systems is a complex subject, requiring careful analysis on a case-by-case basis. Terrain effects are highly variable between system implementations. Fading due to rain and other atmospheric effects has to be taken into account. Statistical methods may be used to predict the probability that a certain level of interference will be exceeded. Despite these complexities, a number of recommendations and guidelines can be developed to assist planners to achieve acceptable levels of inter- system interference and make good use of the available spectrum. Such recommendations and guidelines are provided in this document.

The two main coexistence cases are:

a. Where two systems operate on the same radio frequency, but are deployed in adjacent or nearby geographic areas.

b. Where two systems are deployed in overlapping geographic areas, but operate on adjacent or near–adjacent frequencies.

2.2 Reference Diagram

Broadband Wireless Access systems typically include Base Transceiver Stations (BTS) or hubs, Subscriber Transceiver Stations (STS), subscriber terminals equipment, core network equipment, inter-cell links, repeaters and possibly other equipment. A reference BWA system diagram is provided in Figure 2-1. This diagram indicates the relationship between various pieces of the system. BWA systems may be much simpler and contain only some elements of the network shown in Figure 2-1. As a minimum, a BWA system will contain one BTS/Central Station (CS) and a number of STS units. In the figure, the wireless links are shown as zigzag lines connecting system elements.

Antennas with a variety of radiation patterns may be employed. In general, a subscriber station utilizes a highly directional antenna. Optional repeaters may be used to fill in coverage when a direct RF Line-of-Sight path cannot be established between a subscriber and a BTS. Inter-cell links are optional and may be used to interconnect two or more BTS/CS units using wireless techniques.

The boundary of the BWA network is at the interface points F and G. The F interfaces are generally standardized, being points of connection to core networks. The G interfaces, between terminal stations and terminal equipment may be either standardized or proprietary.

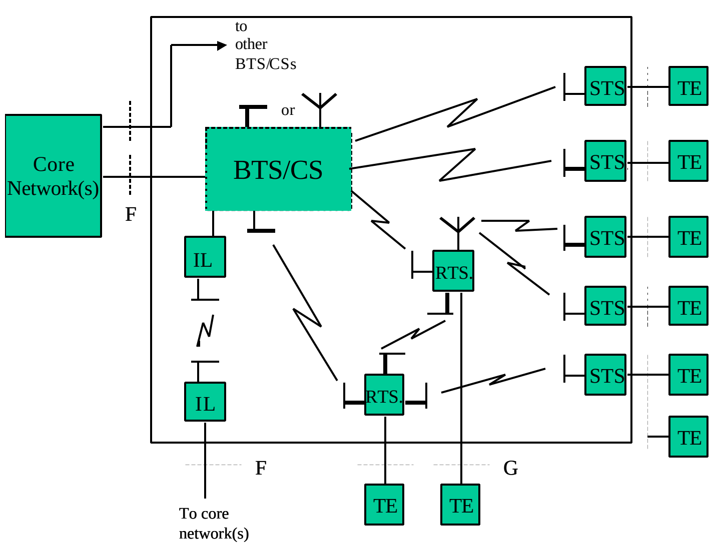


Figure 1 - Reference Diagram

Key to reference diagram

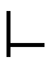
BTS/CS : The hub of a PMP system, or Central Station (access point) of a MP-MP system A BTS/CS may, optionally, be divided into two parts; – a control/ interface part and radio part. One control part could support one or a number of radio parts. The interface between the parts is not standardized.

STS: Subscriber Transceiver Station

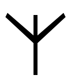
TE: The Terminal Equipment. A subscriber (STS) could be connected to more than one TE, dependent on the services required at the user's premises). The TE/STS interface could be standardized (e.g. telephone interface) or proprietary.

RPT: A Repeater Station, with optional connection to local terminal equipment.

IL: An In-band (Inter-cell) Link. Note that an in-band link could be used to connect a remote hub to a convenient access point of a core network or, alternatively, could provide a connection between two hubs.



Directional antenna



Omni-directional or sectored antenna

2.3 System Architecture

BWA systems often employ multipoint architectures. The term multipoint includes Point to Multipoint (PMP) and Multipoint-to-Multipoint (MP-MP). The 802.16.1 project will define a PMP system with hub stations and end user stations communicating over a fully specified air interface. A similar PMP standard is in preparation in Europe, in ETSI Project BRAN, which is producing an interoperability standard titled "Hiperaccess". Coexistence specifications for MWS (which will include the requirements for Hiperaccess) are being prepared by the ETSI TM4 committee. In addition, there are a number of proprietary BWA systems, for which the air interface is not standardized.

2.3.1 PMP Systems

PMP systems comprise Base Transceiver Stations (otherwise known as hubs), terminal stations and, in some cases, repeaters. Hubs have relatively wide beam antennas, divided into one or several sectors to provide 360-degree coverage. To achieve complete coverage of an area, more than one hub station may be required. The connection between hubs is not part of the BWA network itself, being achieved by use of radio links, fiber optic cable or equivalent means.

Links between hubs may sometimes use part of the same frequency allocation as the BWA itself. Routing to the appropriate hub is a function of the core network. Subscriber stations use directional antennas, facing a hub and sharing use of the radio channel. This may be achieved by various access methods, including frequency division, time division or code division.

2.3.2 MP-MP Systems

Multipoint-to-multipoint (MP-MP) systems have the same functionality as PMP systems. Hub stations are replaced by central stations (access points), which provide connections to core networks on one side and radio connection to other stations on the other. A subscriber station may be a radio terminal or (more typically) a repeater with local traffic access. Traffic may pass via one or more repeaters to reach a subscriber. Antennas

are generally narrow beam directional types. By providing means for remote alignment of antennas and suitable network configuration tools, it is possible to achieve high levels of coverage and spectrum efficiency.

2.3.3 Repeaters

Some systems deploy repeaters. In a PMP system, repeaters are generally used to improve coverage to locations where the hub(s) have no line of sight within their normal coverage area(s), or alternatively to extend coverage of a particular hub beyond its normal range. A repeater relays information from a hub to one or a group of subscribers. It may also provide a connection for a local subscriber. A repeater may operate on – frequency (i.e. using the same frequencies as those facing the hub) or it may use different frequencies (i.e. demodulate and re-modulate the traffic on different channels). In MP-MP systems, most stations are repeaters, which also provide connections for local subscribers.

2.4 Medium Overview

Electromagnetic propagation over Frequency Ranges 1 through 3 is characteristic of a relatively non-dispersive medium which is dominated by increasingly severe rain attenuation as frequency increases. Absorption of emissions by terrain and man-made structures is severe, leading to the normal requirement for optical line-of-sight between transmit and receive antennas for satisfactory performance. Radio systems in this frequency regime are typically thermal or interference noise-limited (as opposed to multipath-limited) and have operational ranges of a few kilometers due to the large free-space loss and the sizable link margin which has to be reserved for rain loss. At the same time, the desire to deliver sizable amounts of capacity promotes the use of higher-order modulation schemes with the attendant need for large C/I for satisfactory operation. Consequently, the radio systems are vulnerable to interference from emissions well beyond their operational range. This is compounded by the fact that the rain cells which produce the most severe rain losses are not uniformly distributed over the operational area thus creating the potential for scenarios where the desired signal is severely attenuated but the interfering signal is not.

3 Equipment Design Parameters

This section provides recommendations for equipment design parameters which significantly affect interference levels and hence co-existence. Recommendations are made for the following BWA equipment: base station equipment, subscriber equipment, repeaters and inter-cell links (including PTP equipment). Recommendations are for both transmitter and receiver portions of the equipment design. The recommended limits are applicable over the full range of environmental conditions for which the equipment is designed to operate including temperature, humidity, input voltage, etc.

3.1 Transmitter Design Parameters

This section provides recommendations for the design of both subscriber and base station transmitters, which are to be deployed in Broadband Wireless Access systems. Recommendation are also made for repeaters and inter-cell links.

3.1.1 Maximum EIRP Spectral Density

The amount of interference within a given area is often specified in terms of *power flux density.* This parameter is expressed in terms of Watts/square meter. However, because point-to-multipoint systems span very broad frequency bands and utilize many different channel bandwidths, a better measure of interference is *power spectral flux density* rather than power flux density. Since interference within a given area is directly related to the emissions from various transmitters, it is important to have some upper limits on transmitted power, or more accurately, limits for the equivalent isotropically radiated power spectral density. The following paragraphs recommend EIRP power spectral density limits. These limits apply to the mean EIRP spectral density produced over any continuous burst of transmission. The spectral density should be assessed with an integration bandwidth of 1 MHz; i.e. these limits apply over any 1 MHz bandwidth.

3.1.2 Base Station: Frequency Range 2 (23.5 – 43.5 GHz)

BWA base stations or hubs conforming to the recommendations of this practice should not produce an EIRP power spectral density exceeding 14 dBW/MHz. This limit applies to the mean EIRP spectral density produced over any continuous burst of transmission. (Any pulsed transmission duty factor does not apply.) The spectral density should be assessed with an integration bandwidth of 1 MHz; i.e. these limits apply over any 1 MHz bandwidth. Note for the specific sub-band 25.25-25.75 GHz, the recommended BTS EIRP limits may be further constrained, as defined by ITU-R Document 7D-9D/68-E, are as follows:

Transmitter of BTS:

The e.i.r.p. spectral density for each transmitter of a BTS in a BWA system should not exceed the following values in any 1 MHz band for the elevation angle θ above the local horizontal plane:

+14	dBW	for $0° \le \theta \le 5°$
$+14-10\log(\theta/5)$	dBW	for $5° < \theta \le 90°$

In the direction toward any geostationary (GSO) Data Relay Satellite (DRS) orbit location specified in ITU-R Recommendation ITU-R SA.1276[1], the e.i.r.p. spectral density limits[2] of a BTS shall not exceed +8dBW/MHz if the elevation angle above the local horizontal plane[3] is between 0° and 20°.

3.1.3 Subscriber: Frequency Range 2 (23.5 – 43.5 GHz)

BWA subscriber stations conforming to the recommendations of this practice should not produce an EIRP spectral density exceeding 30 dBW/MHz. This limit applies to the mean EIRP spectral density produced over any continuous burst of transmission. (Any pulsed transmission duty factor does not apply.) The spectral density should be assessed with an integration bandwidth of 1 MHz; i.e. these limits apply over any 1 MHz bandwidth. Note, the 30 dBW/MHz limit applies to the CPE operating under faded conditions (rain attenuation). A lower limit is specified for unfaded conditions, as described in 3.1.2. Note for the specific sub-band 25.25-25.75 GHz, the

[1] The ITU-R Recommendation ITU-R SA.1276 identifies the following geostationary DRS orbital positions: 16.4E°, 21.5°, 47°E, 59°E, 85°E 90°E, 95°E, 113°E, 121°E, 160°E, 177.5°E, 16°W, 32°W, 41°W, 44°W, 46°W, 49°W, 62°W, 139°W, 160°W, 170°W, 171°W, and 174°W.

[2] The e.i.r.p. spectral density radiated towards a geostationary DRS location should be calculated as the product of the transmitted power spectral density and the gain of the omnidirectional or sectoral antenna in the direction of the DRS. In the absence of a radiation pattern for the BTS antenna, the reference radiation pattern of Recommendation ITU-R F.1336 should be used. The calculation should take into account the effects of atmospheric refraction and the local horizon. A method for calculating the separation angles is given in Annex 2 to Recommendation ITU-R F.[PMP].

recommended subscriber EIRP limits may be further constrained, as defined by ITU-R Document 7D-9D/68-E, are as follows:

Transmitter of a STS in a BWA system or transmitters of point-to-point fixed stations:

> The e.i.r.p. spectral density for each transmitter of a STS of a BWA system, or transmitters of point-to-point fixed stations in the direction of any geostationary (GSO) Data Relay Satellite (DRS) orbit location specified in ITU-R Recommendation ITU-R SA.1276 should not exceed +24 dBW in any 1 MHz.

3.1.4 Repeater Stations: Frequency Range 2 (23.5 – 43.5 GHz)

There are several possible types of repeater (see system overview). From the point of view of EIRP limits, two recommendations are given, according to the direction faced by the repeater and type of antenna. The first recommended limit applies to situations where a repeater uses a sectored or omni directional antenna, typically facing a number of served subscribers. The second case applies where a repeater uses a highly directional antenna, typically facing a hub or single subscriber.

3.1.4.1 Repeaters (direction facing hub): 30 dBW/MHz

BWA repeater stations systems deploying directional antennas and conforming to the equipment requirements of this practice should not produce an EIRP spectral density exceeding 30dBW/ MHz. These limits apply to the mean EIRP spectral density produced over any continuous burst of transmission (Any pulsed transmission duty factor does not apply). The spectral density should be assessed with an integration bandwidth of 1MHz; i.e. these limits apply over any 1MHz bandwidth.

3.1.4.2 Repeaters (direction facing multiple subscribers): 14 dBW/MHz

BWA repeater stations deploying omni-directional or sectored antennas and conforming to the equipment requirements of this practice should not produce an EIRP spectral density exceeding 14dBW/ MHz. These limits apply to the mean EIRP spectral density produced over any continuous burst of transmission (Any pulsed transmission duty factor does not apply). The spectral density should be assessed with an integration bandwidth of 1MHz; i.e. these limits apply over any 1MHz bandwidth.

3.1.5 Inband Inter-cell Links: Frequency Range 2

Inband Inter-cell Links (ICLs) are point to point (PTP) radios that provide a wireless backhaul capability between base stations at rates ranging from DS-3 to OC-3. The advantage of ICLs is that they can share a common infrastructure as the PMP systems, e.g. the switch, to minimize overall network rollout costs. Additionally, ICL radios can operate under the auspices of the PMP license, thus avoiding the burden of additional licensing and cost associated with out of band PTP systems.

ICL radios typically employ high gain antennas to facilitate ranges that are at least twice the radius of a typical BWA/CS PMP system, e.g. 8-10 km. Based on this, the following typical parameters are assumed for a 28 GHz ICL transmitter:

G_{TX} = 42 dBi

P_{TX} = 0 dBW/carrier

Carrier BW = 50 MHz

Modulation = 16 QAM (data rate~150 Mb/s)

Power spectral density = $P_{TX} - 10 \text{ Log } (BW_{MHz}) = 0 - 10\text{Log}(50) = -17$ dBW/MHz

EIRPSD = $P_{TX} - 10 \text{ Log } (BW_{MHz}) + G_{TX} = -17 + 42 = 25$ dBW/MHz.

Allowing for some extra margin, the EIRPSD may be as high as 30 dBW/MHz.

Therefore, ICL radios conforming to the equipment recommendations of this practice should not produce an EIRP spectral density exceeding 30 dBW/MHz. This limit applies to the mean EIRP spectral density produced over any continuous burst of transmission. The spectral density should be assessed with an integration bandwidth of not more than 1 MHz.

3.1.6 Upstream Power Control

BWA subscriber stations conforming to the equipment design parameters recommended by this practice should not transmit an EIRP spectral density of more than 15 dBW/MHz under unfaded conditions, i.e. for clear sky conditions. This requirement is met if the maximum EIRP spectral density produced by the equipment is always less than 15 dBW/MHz, or it may be met by employing adaptive transmit power control to reduce EIRP spectral density below this limit during unfaded conditions, i.e. in clear or no-rain conditions. Note that a CPE can transmit up to a maximum EIRP value of 30 dBW/MHz during faded conditions (i.e. during rain fades) as described in section 3.1.1.2.

3.1.7 Down Stream Power Control

This practice assumes that no downstream power control is employed. However, it is recommended that the minimum power necessary to maintain the link be employed. And in all cases, the recommended limits given in paragraph 3.1.1.1 should be met.

3.1.8 Frequency Tolerance or Stability

The system should operate within a frequency stability of +/- 10 parts per million. [NOTE: This specification is only for the purposes of complying with *coexistence* requirements. The stability requirements contained in the PHY specifications may be more stringent, particularly for the base station. In addition, it is highly recommended that the CPE transmit frequency be controlled by using a signal from the downstream signal(s).]

3.2 Receiver Design Parameters

This section provides recommendations for the design of both subscriber and base station receivers, which are to be deployed in Broadband Wireless Access systems. The parameters for which recommendations are made are those which affect performance in the presence of interference from other BWA systems.

3.2.1 Base Station Selectivity and Interference Tolerance

The base station receiver is expected to be subjected to adjacent channel interference and co-channel interference from other BWA systems operating in close proximity to the reference system. Therefore the base station receivers must be designed with proper selectivity and tolerance to interference. The following paragraphs recommend minimum design standards to allow for interference.

3.2.1.1 Co-channel Interference Tolerance

The receiver should be capable of operating at the specified BER in the presence of a co-channel interference signal that is 6 dB below the receiver's noise floor, causing a total noise floor degradation of 1.0 dB. The minimum allowable degradation in the receivers effective noise floor of 1.0 dB was chosen as an acceptable degradation level upon which to operate a BWA system while allowing interference levels to be specified in an acceptable manner.

3.2.1.2 Adjacent Channel Interference Tolerance

The receiver must be capable of operating at the specified BER in the presence of an adjacent channel interference signal that is equal in power to the desired signal, i.e. C/I_{adj} = 0 dB.

3.2.1.3 CW Interference Tolerance

A CW interferer, at a level of +30 dB with respect to the wanted signal and at any frequency up to 60 GHz, excluding frequencies within ± 250% [or ± 500%] of the Occupied [channel] bandwidth centred around the centre frequency of the wanted signal, should not cause a degradation of more than 1 dB of the BER threshold.

3.2.2 Subscriber Station Selectivity and Interference Tolerance

The subscriber receiver is expected to be subjected to adjacent channel interference and co-channel interference from other BWA systems operating in the close proximity to the reference system. Therefore, the receivers intended for subscriber terminal applications should be designed with the proper selectivity and tolerance to interference. The following paragraphs recommend minimum design standards to allow for interference.

3.2.2.1 Co-channel Interference Tolerance

The receiver should be capable of operating at the specified BER in the presence of a co-channel interference signal that is 6 dB below the receiver's noise floor, causing a total noise floor degradation of 1.0 dB. The minimum allowable degradation in the receivers effective noise floor of 1.0 dB was chosen as an acceptable degradation level upon which to operate a BWA system while allowing interference levels to be specified in an acceptable manner. (See paragraph 4.4.)

3.2.2.2 Adjacent Channel Interference Tolerance

The receiver should be capable of operating at the specified BER in the presence of an adjacent channel interference signal that is equal in power to the desired signal, i.e. $C/I_{adj} = 0$ dB.

3.2.2.3 CW Interference Tolerance

A CW interferer, at a level of +30 dB with respect to the wanted signal and at any frequency up to 60 GHz, excluding frequencies within 500% of the center frequency of the wanted signal, should not cause a degradation of more than 1 dB of the BER threshold.

3.3 Unwanted Emissions

Unwanted emissions produced by the operator's equipment and occuring totally within an operator's authorised band are only relevent for that operator and not covered in this practice. Unwanted emissions from an operator into adjacent bands must be constrained to avoid giving unacceptable interferrence to users of adjacent spectrum and recommended emission limits are given in the following section.

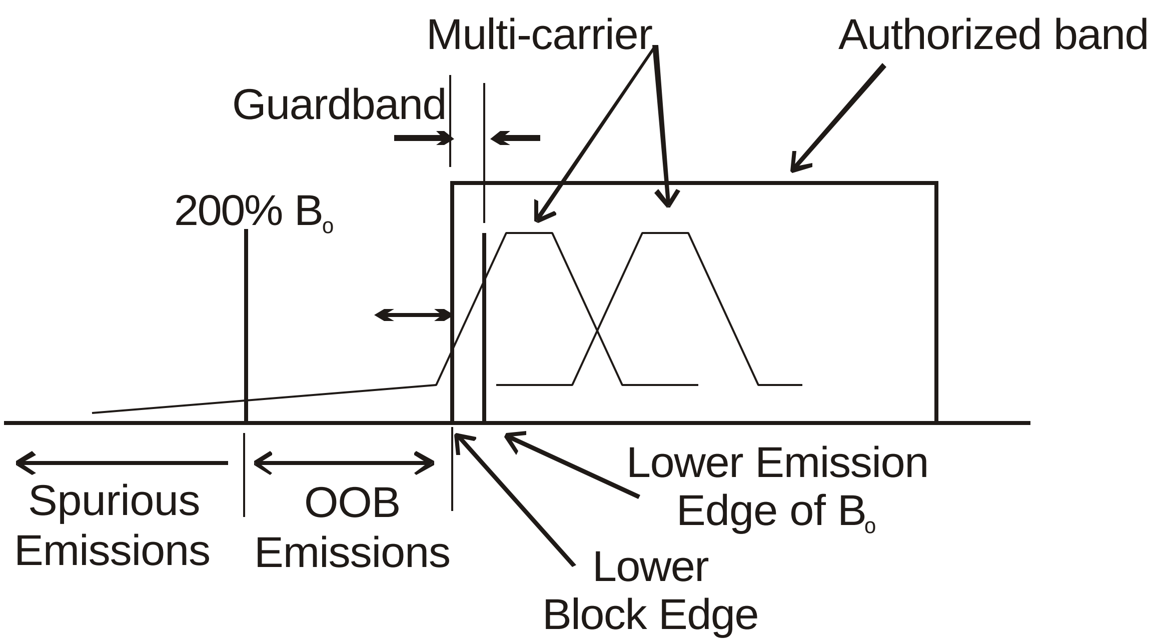


Figure 2 - Unwanted Emissions

As indicated in Figure 3.1, single carrier or multi-carrier transmissions, whose occupied bandwidth is totally within the authorized band, will emit some power into adjacent bands.These unwanted emissions include out-of-band (OOB) emissions (within 200% of the emission occupied bandwidth (B_o) of the authorised band edge) and spurious emissions (beyond this 200% point).

3.3.1 Unwanted Emission Limit

Unwanted emissions spectral density should be attenuated by at least A (dB) below the total mean output power P_{mean} as follows:

(1) For a single carrier transmitter (see section A.1.2) :

In any 1.0 MHz reference bandwidth, outside the virtual block edge, and removed from the virtual block edge frequency by up to and including $\pm$200% of the occupied bandwidth (i.e. 2 B_o): at least A = 11 + 40 f_{offset}/B_o + 10 $\log_{10}(B_o)$, dB, where B_o is in MHz and f_{offset} = frequency offset (in MHz) from the virtual block edge. Attenuation greater than 56 + 10 $\log_{10}$ (B_o) dB, or to an absolute level lower than -43 dBW/MHz, is not required. For emissions in which the occupied bandwidth is less than 1 MHz, the required attenuation is to be calculated using A= 11 + 40 f_{offset}/B_o dB. Guard bands, if used in the equipment design, must also be used in testing the spectrum mask.

(2) For a multi-carrier transmitter or multi-transmitters (not OFDM) into a common final stage amplifier (see section A.1.3):

The mask is to be the same as in (1), using the *occupied* bandwidth that is defined for multi-carrier transmitters in section 1.3. The total mean power is to be the sum of the individual carrier/transmitter powers. Guard bands, if used in the equipment design, must also be used in testing the spectrum mask.

Note: Several transmitters into a common non-active antenna cannot use the multi-carrier mask for the composite signal. In this case the appropriate mask applies to the individual transmitter.

(3) In any 1.0 MHz band which is removed from the identified edge frequency by more than $\pm$200% of the occupied bandwidth:

At least 43 + 10 $\log_{10}$ (P_{mean}) dB (i.e. –43 dBW), or 80 dB below P_{mean}, whichever is less stringent. P_{mean} is the mean output power of the transmitter (or, in the case of multi-carriers/multi-transmitters, the sum of the individual carrier/transmitter powers) in watts.

3.3.1.1 Unwanted Emission in Europe

Within Europe the CEPT/ETSI limits of Draft EN 301 390 should be applied which has limits that are 10 dB more stringent than CEPT/ERC Recommendation 74-01 for noise-like emissions over certain frequency bands. (FURTHER INTRO. INFO needed – e.g. Single Carrier)

The following is extracted from Draft EN301-390 V1.1.1 (1999-07):

> *"Spurious Emissions and Receiver immunity at Equipment / Antenna Port of Digital Fixed Radio Systems"*
>
> *4.1.3 Point-to-Multipoint equipments with fundamental emission above 21.2 GHz*
>
> > *The CEPT/ERC Recommendation 74-01 [4] shall apply for spurious emissions in the frequency range 9 kHz to 21.2 GHz and above 43.5 GHz.*
> >
> > *For spurios emissions falling in the range 21.2 GHz to 43.5 GHz the tighter limits shown in Figures 1 and 2 shall apply:*
> >
> > *In the same Figures, for comparison, the less stringent limits from CEPT/ERC Recommendation 74-01 [4] are also shown.*

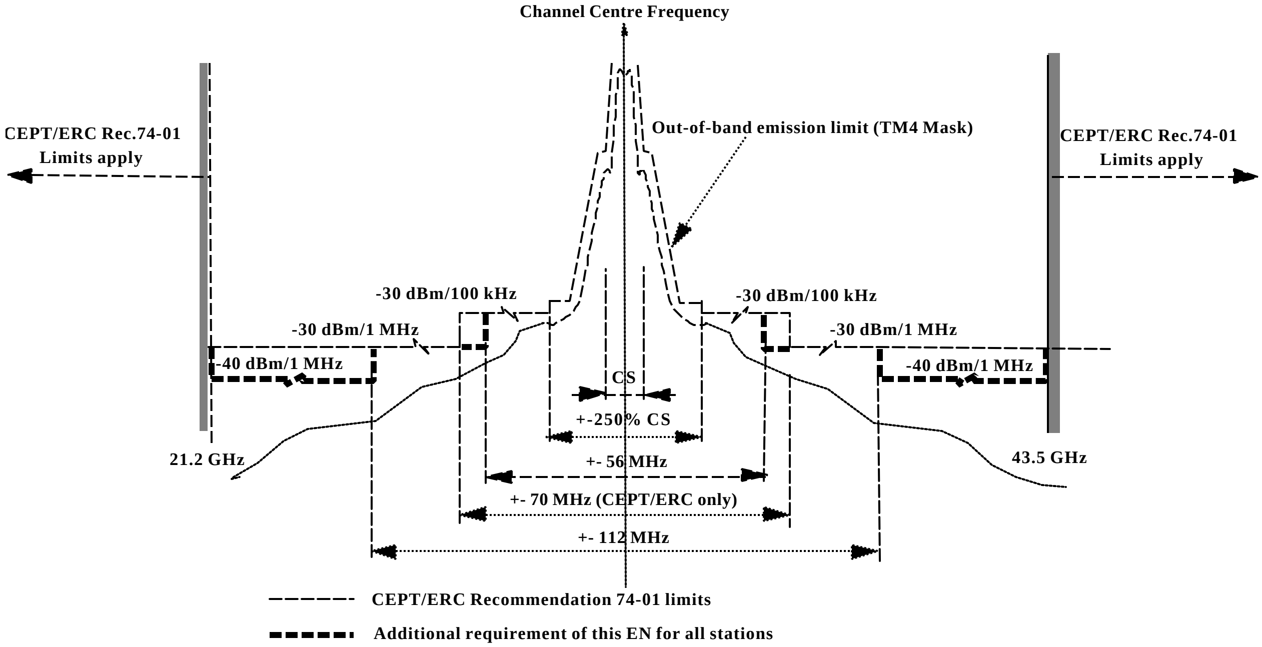


Figure 3 - Systems for Channel separation 1<CS≤10 MHz

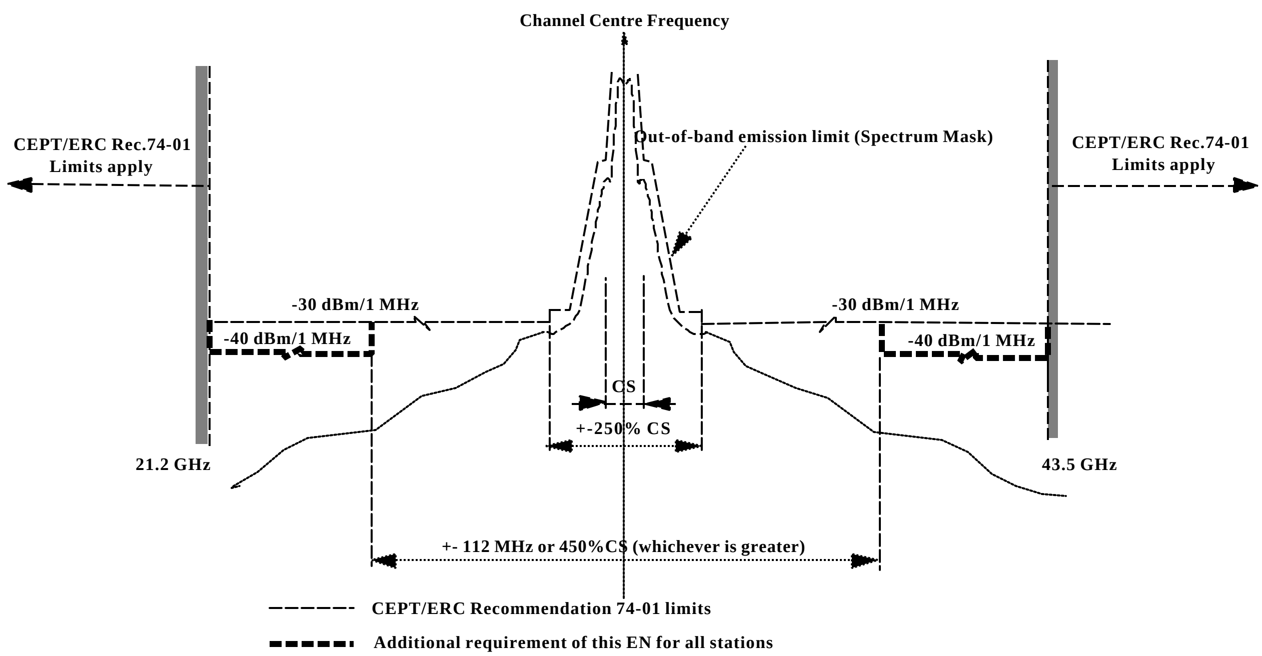


Figure 4 - Equipment for Channel separation CS>10 MHz

3.4 Antenna

The following antenna recommendations apply to frequency Range 2 (23.5-43.5 GHz), unless otherwise indicated.

3.4.1 Antenna Classes

The performance of the antenna is divided into three electrical classes, which can be paired in any combination depending on the specific electrical requirements. These classes help in the selection of antennas that are sufficient for the deployment environment.

The distinguishing factor among classes is the severity of interference in the environment. Although it is outside the scope of this paper to address intra-system interference, selection of antennas may be principally determined by interference arising from within the operator's own network rather than from external sources.

	Electrical Class 1 – Low Interference Environment	Electrical Class 2 – Moderate to High Interference Environment	Electrical Class 3 – Very High Interference Environment
User Density	Low	Higher	highest
Overlap (with adjacent sectors)	Minimal	Increasing	most
Buffer Distance (between potential interfering cells)	Large	Limited	none
Concurrent Signals	smallest number	multiple in each sector	most
Frequency Reuse	minimal, if any	Some	significant
Polarization Differentiation	not required	Important	critical

3.4.1.1 Electrical Class 1

Electrical Class 1 antennas, which are characterized by relatively poor sidelobe performance, 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 frequency re-use creating a benign self-interference environment
- sufficiently geographically separated coexisting systems such that the power spectral flux density resulting from those systems is negligible

In such conditions, antennas with the minimum requirements specified in this document could be deployed. The minimum recommended antenna is Electrical Class 1.

3.4.1.2 Electrical Class 2

Electrical 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 insignificance (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 frequency re-use pattern which may cause self-interference problems in certain areas
- Proximity of coexisting systems such that the interferer's power spectral 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 provide acceptable performance of the system.

3.4.1.3 Electrical Class 3

Electrical 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 frequency re-use pattern which creates significant interference throughout the network
- Extreme proximity of coexisting systems

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 provide acceptable performance of the system.

3.4.2 Common Antenna Parameters

The following antenna parameters affecting the coexistence of BWA systems apply to both BTS and STS antennas.

3.4.2.1 Polarization

Two polarization orientations are recommended, horizontal and vertical. The required polarization purity is captured in the specification of antenna XPD in the next section. Also, the Radiation Pattern Envelopes (RPEs) of this recommendation, described later, are independent of polarization.

3.4.2.2 Voltage Standing Wave Ratio (VSWR)

A Voltage Standing Wave Ratio (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).

3.4.2.3 Passive Intermodulation (PIM)

It is recommended that the passive intermodulation products due to antenna artifacts should be less than -100 dBc..

3.4.3 Base Transceiver Station (BTS) Antenna

3.4.3.1 Electrical Characteristics

This document only addresses sector BTS antenna. Three classes of operation are considered and involve low, moderate, and high interference environments.

3.4.3.1.1 Linear Polarization

Only horizontal and vertical polarization RPEs are included in this recommended practice.

3.4.3.1.1.1 Effect on Radiation Pattern Envelope (RPE)

In considering coexistence, the purchaser/system provider needs to factor the AZ and EL RPE’s into the required coverage footprint. For purposes of consistency and ease of implementation, the ability to select either horizontal or vertical polarization without the need for concern for differences in the RPE’s is considered very important. Hence, the AZ and EL RPE’s are independent of polarization..

3.4.3.2 Minimum Cross-Polar Discrimination (XPD)

The cross-polar discrimination (XPD) is the difference in dB between the peak of the copolarized main beam and the maximum cross-polarized signal on the principal planes of the antenna. The principal planes are defined as an azimuth plane for zero degree elevation and an elevation plane at zero degree azimuth. The polarization discrimination is specified in the tabular form in Appendix C and summarized in graphical form below.

3.4.3.3 Minimum Cross-Polar Isolation (XPI)

Specification of a minimum cross-polar isolation (XPI) for the BTS antenna implies that the antenna is a dual polarized antenna. The actual value of XPI should be the same as the value of XPD, defined in preceding section 3.4.3.1.1.2.

3.4.3.4 Radiation Pattern Envelope (RPE)

This section describes radiation pattern envelopes for the three Electrical Classes of antenna. [add definition of RPE-Bob]

The radiation pattern envelope is specified in terms of a variable α that is half the -3dB beamwidth of the antenna. Sector sizes for these RPE tables range from 15^o to 135^o.

3.4.3.5 Azimuth Radiation Pattern Envelopes

The following figures illustrate the recommended copolar and crosspolar RPEs for the three Electrical Classes of antenna. [Bob to change figures-express alpha+x as a percentage, and delete –3dB lower limit line]

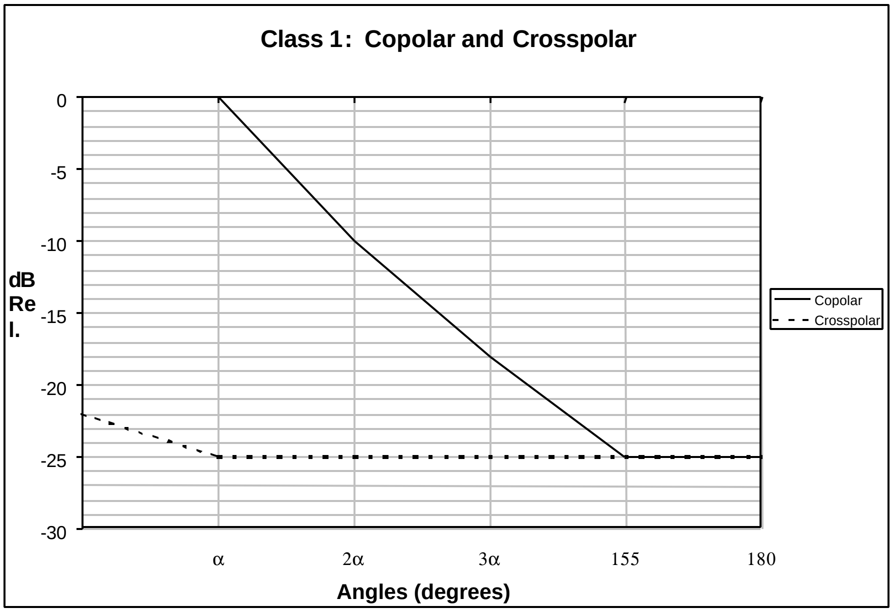


Figure 5 - Class 1 Co-polar and Cross-polar RPE

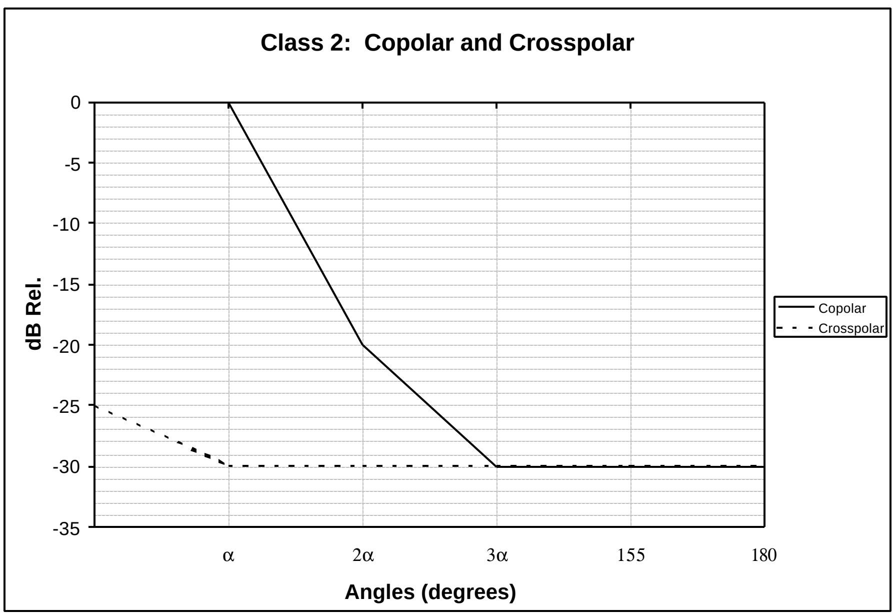


Figure 6 - Class 2 Co-polar and Cross-polar RPE

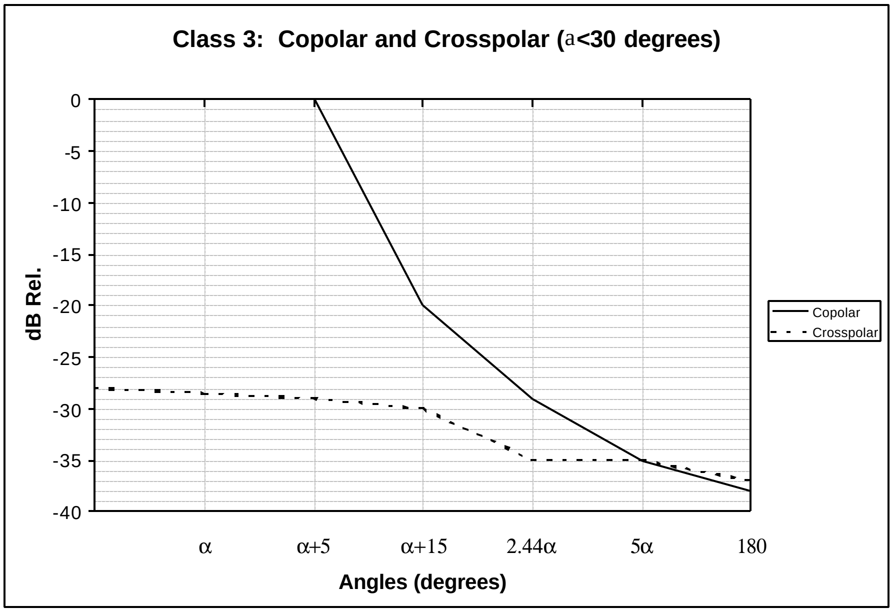


Figure 7 - Class 3 Co-polar and Cross-polar (α < 30 degrees) RPE

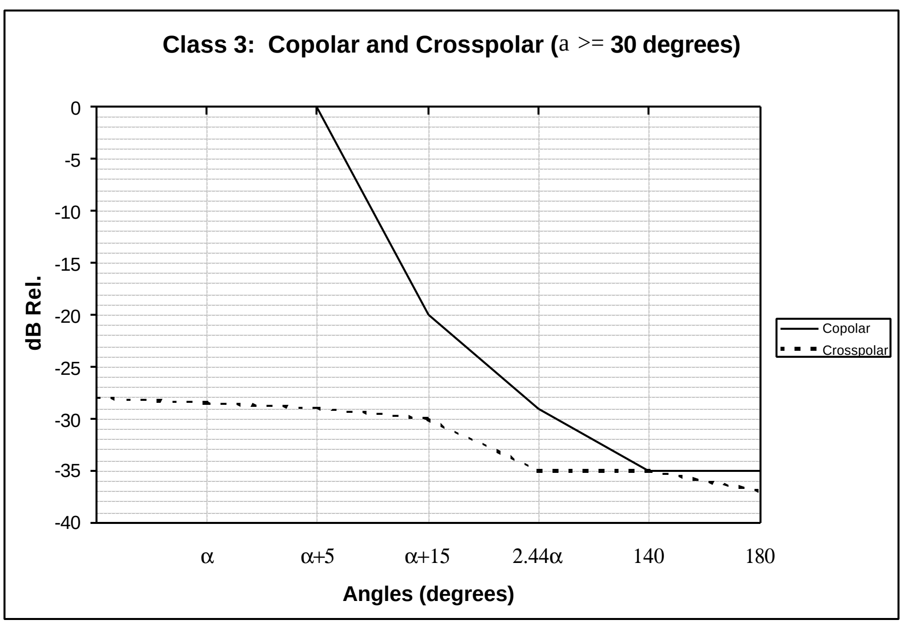


Figure 8 – Class 3 Co-polar and Cross-polar (α >= 30 degrees) RPE

3.4.3.6 Elevation Radiation Mask

3.4.3.6.1 Coexistence Issues

The elevation pattern should be specified both above and below the local horizon, to provide isolation, improve coexistence, and to ensure efficient use of radiated power.

3.4.3.6.2 Reference Directions

This specification will follow accepted practices for the specification of elevation radiation pattern envelopes that provide for the 0° angle to be directed at the local horizon, the 90° angle directed overhead, and the -90° angle directed downward.

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

3.4.3.6.2.1 Class-1 Elevation Mask.

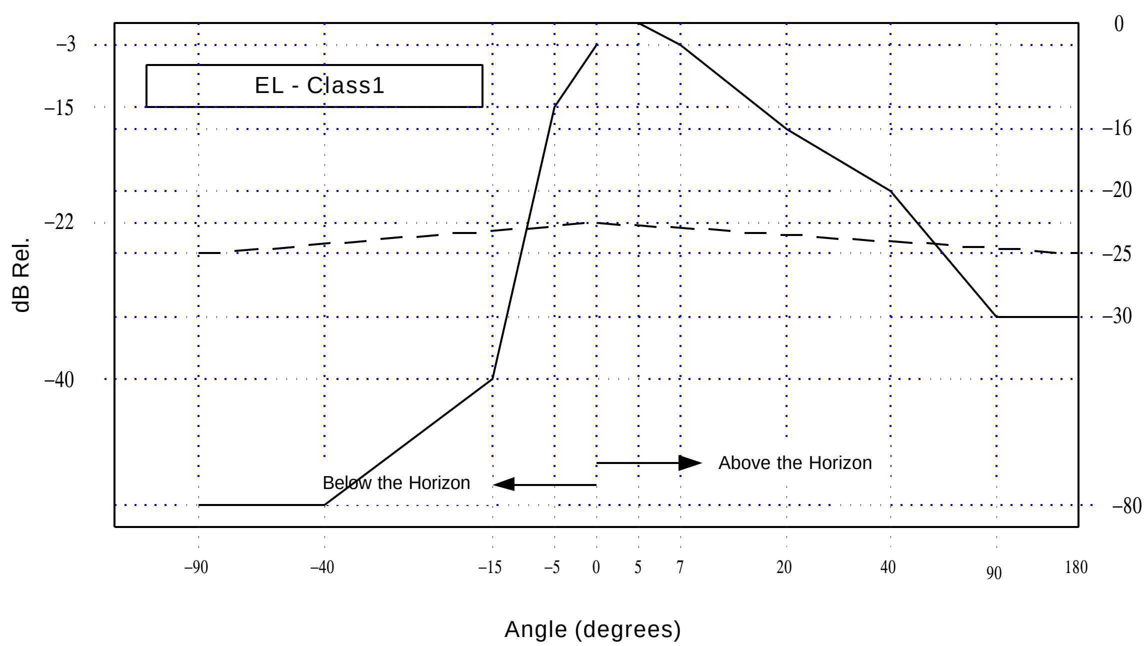


Figure 9 – Class 1 Elevation Mask

3.4.3.6.2.2 Class-2 Elevation Mask.

[NOTE XP mask should be –30 at left end]

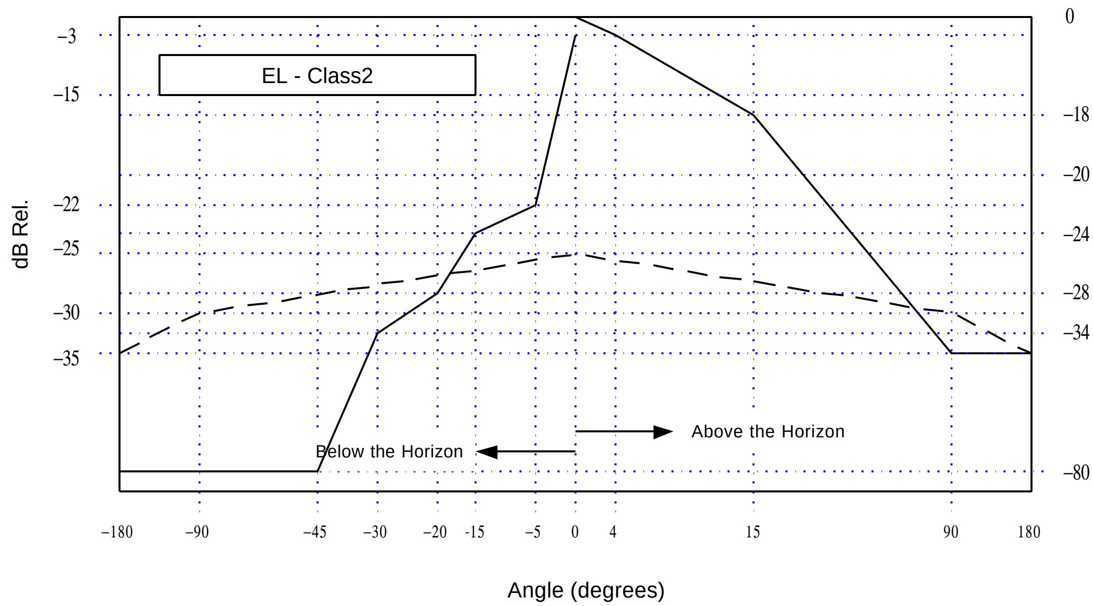


Figure 10 – Class 2 Elevation Mask

3.4.3.6.2.3 Class-3 Elevation Mask

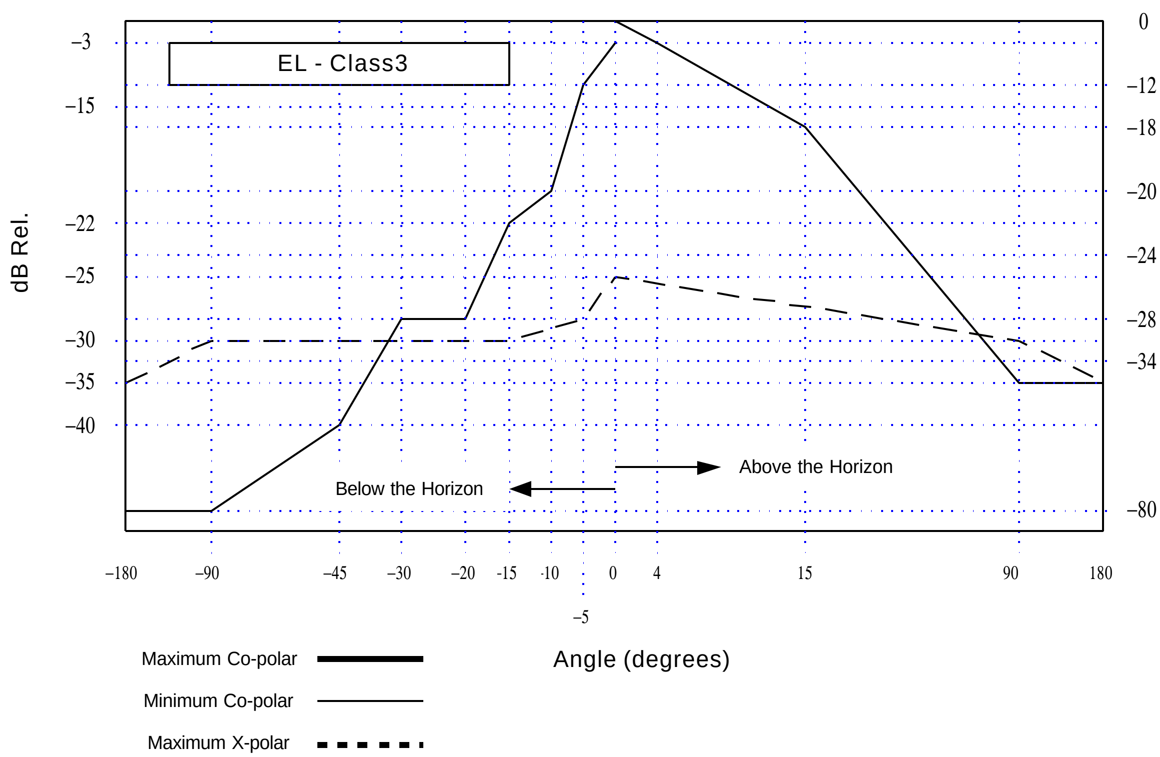


Figure 11 – Class 3 Elevation Mask

3.4.3.7 Mechanical Characteristics

This section discusses the recommended minimum requirements regarding antenna mechanical requirements for typical environments. However, for harsher environments e.g. hurricane-prone areas, a more robust antenna systems may be required.

3.4.3.7.1 Wind and Ice Loading

Wind loading as specified in this document for the BTS results in mechanical deformation or misalignment that would cause the radiated pattern to be altered and, hence, affect the coexistence characteristics. Antennas should meet the system operational requirements while subjected to the expected wind and ice loading in the geographical installation area. The angular deviation of the antenna main beam axis during specified operational conditions should not be more than 0.5 degrees. The antenna can exceed this deviation during survival conditions, but should return to its original pointing direction after the survival condition ceases. In any case, the minimum design operational wind load should be 70 mph (112 kph), and the minimum design survival wind load should be 100mph (160 kph). These minimum specified loads may be increased substantially in many geographical areas. If potential ice buildup is a factor, the ice thickness should be considered radial with the density assumed to be 44lb/ft^3 (705 kg/m^3). Consideration of ice buildup on the radome face depends on the material of the radome and whether a heater is utilized. Radome ice should be considered on a case by case basis.

3.4.3.7.2 Water Tightness

Water tightness is important in eliminating unwanted attenuation that would not necessarily be uniform over the antenna aperture and could change the pattern and non-uniformly reduce the distance over which the BTS would operate. In this regard, the antenna should be designed to ensure water ingress is negligible.

3.4.3.7.3 Temperature and Humidity

The antennas must not suffer performance degradation when subjected to temperature or humidity extremes, which could potentially cause interference. Therefore, antennas should be designed to operate within the recommendation of this document over the full temperature and humidity range for which the system is intended to be deployed.

3.5 Additional Consideration

3.5.1 Radomes and Heaters

If radomes are used, all recommended antenna limits included in this practice should be met i.e. with the radomes installed. This includes radome heaters where they are required.

3.5.2 Labeling

With respect to coexistence, labeling aids in the proper installation of the antenna. Proper labeling aids in installing the correct antenna with the correct radiation characteristics. Antennas should be clearly identified with a weatherproof and permanent label(s) showing the antenna type, antenna frequency range, antenna polarization, and, serial number(s). It should be noted that integrated antennas may share a common label with the outdoor equipment.

3.5.3 Mechanical Adjustment Assembly

The sector antennas described in this specification typically have a wide azimuth pattern and a narrow elevation pattern. The mechanical tilting assembly should accommodate adjustments in elevation and azimuth, consistent with the overall system design requirements.

3.5.4 Subscriber Transceiver Station (STS) Antenna

STS antennas are highly directional, narrow-beam antennas. The specification defines three directivity categories for STS antennas; category one through three. While category two antennas could be used for normal operation, category 3 could be used for achieving greater range or better availability.

3.5.5 Electrical Characteristics

3.5.5.1 Linear Polarization

The XPD, XPI and Inter-port Isolation should follow the same recommendations determined for BTS unless otherwise specified by the relevant RPEs.

3.5.5.2 Beamwidth Categories

Two beamwidth categories are recommended for STS antennas: category 2 and category 3. While category 1 should be used under special circumstances, category 2 is recommended for use under normal conditions. Category 3 antenna should be used a) to provide additional gain in the link budget for providing coverage to certain Subscriber Stations, and b) to control the level of interference given the smaller beamwidth of such antennas.

STS antennas should provide a maximum co-polar beamwidth in the ranges specified below.

[need to convert to beamwidths]

- Beamwidth category 1: 26 to 34 dBi
- Beamwidth category 2: 34 to 42 dBi
- Beamwidth category 3: 42 to 48 dBi

The maximum cross-polar discrimination should follow the minimum XPD recommendations as stated in this document.

3.5.6 Radiation Pattern Envelop (RPE)

The following figures show the RPEs of co- and cross-polar patterns for directivity categories 1, 2 and 3. 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 all of the above-mentioned parameters be taken into consideration in choosing the right class of antenna.

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. There is, however, no requirement on the symmetry of the antenna patterns as long as they meet the following RPEs. Please refer to Appendix C for a tabular listing of RPEs.

[figure missing]Figure 12 – Category 1 Antenna Directivity

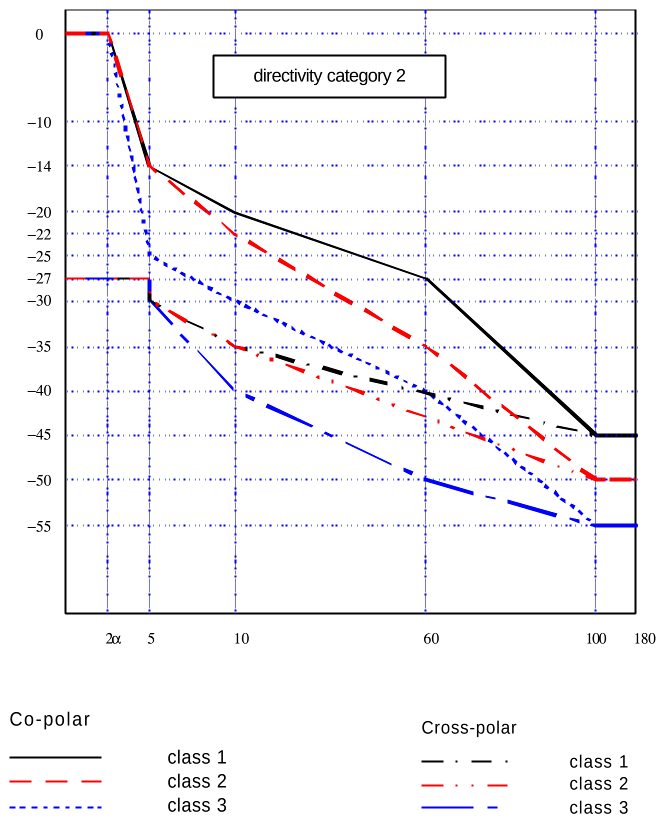


Figure 13 - Category 2 Antenna Directivity

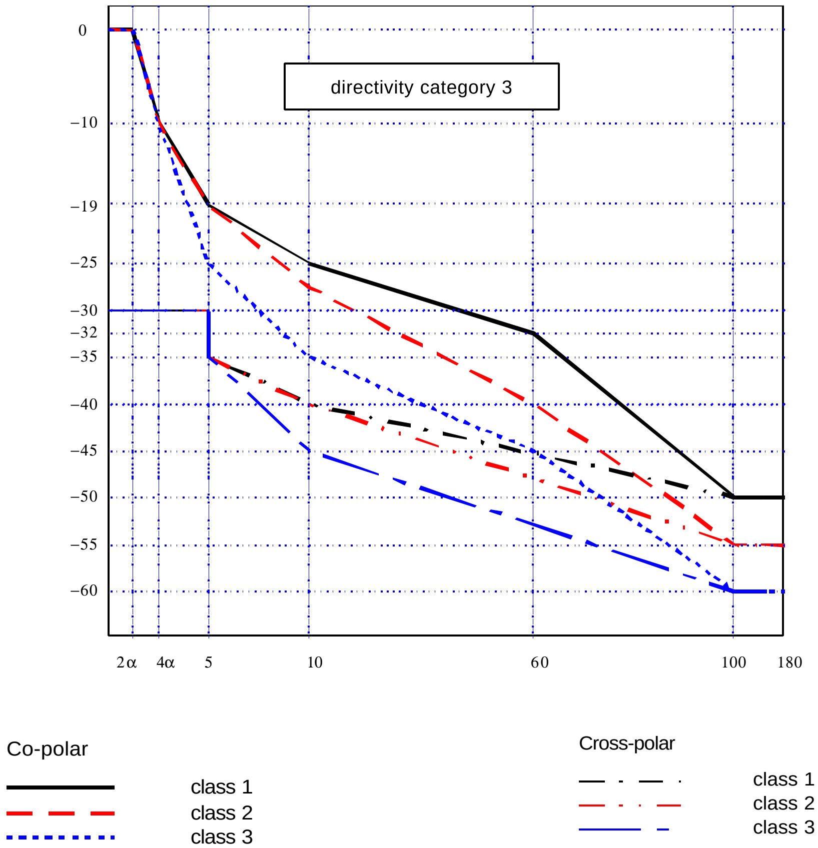


Figure 14 - Category 3 Antenna Directivity

[need to verify spec is acceptable – Keith/Bob/Reza]

3.5.7 [need category 3 figure]Mechanical Characteristics

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

3.5.8 Vibration

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 over the designed environmental conditions.

3.6 Other

3.4.3 EMI/EMC Parameter

4 System Design

4.1 Receiver Sensitivity Degradation Tolerance

Receiver sensitivity determines the minimum detectable signal and is a key factor in any link design. However, as the level of receiver noise floor increases, the sensitivity degrades. This, in turn, causes reduction in cell coverage, degradation in link availability, and loss of revenues. The factors contributing to the increase in noise power divide into two groups, internal and external. The Internal factors include, but are not limited to, the noise generated by various components within the receiver, intermodulation noise, and intra-network co- and adjacent-channel interference. The external factor is caused by inter-network interference due to coexistence.

The amount of degradation in receiver sensitivity is directly proportional to the total noise power added to the thermal noise, *S I,* consisting of intra- and inter-network (coexistence) components.

$$S\ I = P_{\text{intra}} + P_{\text{coex.}}$$

In order to reduce the contribution of coexistence in *S I*, it is recommended that the effect of any BWA network on any other coexisting BWA network should not degrade the receiver sensitivity of that BWA network by more than 1 dB. This is the level that triggers the coordination process described in section 7.1.

4.2 Subscriber TX lock to prevent transmissions when no received signal present –Erol

In the absence of a correctly received signal, the subscriber transmitter should be disabled. This is intended to prevent unwanted transmission from creating inference that would prevent normal system operation due to antenna mis-alignment. The subscriber should continuously monitor the received signal and if a loss of received signal is detected, no further transmissions are allowed until the received signal is restored. If the received signal is lost *while the unit is transmitting* the unit is permitted to complete the current transmission. This gives the subscriber a mechanism to notify the base station of the system fault.

4.2.1 Fail-safe

It is recommended that the subscriber and base station equipment have the ability to detect and react to failures, either software or hardware, in a manner to prevent unwanted emissions and interference. The following is an example list of items the equipment should monitor:

- TX PLL lock status
- Power Amplifier drain voltage/current
- Main power supply
- Microprocessor watchdog

The implementation of which items to monitor and preventive and/or corrective actions are considered to be vendor specific and not intended to increase system cost. However, the intent is to prevent transmissions, which may result in system interference due to individual CPE failures.

5 Interference and Propagation Evaluation

5.1 Develop Interference Scenarios [TBD]

5.2 Description of model and simulation to evaluate interference [TBD]

5.3 Results of modeling and simulation for example scenarios [TBD]

6 Frequency Plans

6.1 WRC-2000

[outcomes of WRC-2000 issues]

6.2 Band Plans [resolution needed]

This document addresses coexistence issues in multiple bands. The following paragraphs provide instantiations for some of these bands.

6.2.1 US 28 GHz Band Plan

The following reference band plan will be used for coexistence for FDD systems using the US LMDS band.

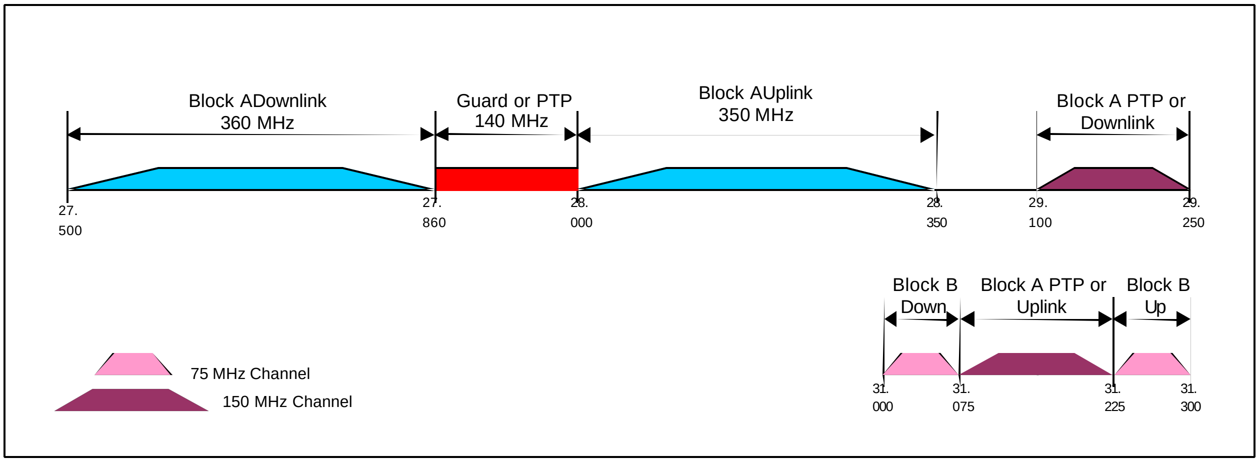


Figure 15 - Proposed Reference Bandplan for FDD systems within the U.S. LMDS band.

i. Within the 27.5 to 28.35 GHz band, no FDD downstream transmitters will radiate more than –30 dBm/MHz power above 27.925 GHz and no upstream FDD transmitters will radiate more than -30 dBm/MHz power below 27.925 GHz.

ii. Within the 27.5 – 28.35 GHz band, the power input to an FDD BST will be less than or equal to – 40 dBm/MHz above 27.925 GHz.

iii. Within the 27.5 – 28.35 GHz band, the power input to an FDD CPE will be less than or equal to – 70 dBm/MHz below 27.925 GHz.

iv. Within the 27.5 to 28.35 GHz band, no FDD system BTS will transmit on frequencies greater than 27.925 GHz..

v. Within the 27.5 to 28.35 GHz band, no FDD system CPE will transmit on frequencies below 27.925 GHz.

vi. For FDD systems, Block B downstream is 31.0 to 31.075 GHz and upstream is 31.225 to 31.3 GHz for BST to CPE systems.

vii. TDD PMP systems may operate in any band not specifically reserved for PTP use.

6.2.2 Canadian Band Plan for the 24 GHz

The following reference band plan will be used for coexistence for the 24 GHz band:

Block	Lower block (MHz)	Upper block (MHz)
A/A’	24250-24290	25050-25090
B/B’	24290-24330	25090-25130
C/C’	24330-24370	25130-25170
D/D’	24370-24410	25170-25210

E/E'	24410-24450	25210-25250

Frequency division duplex (FDD) systems: the base to subscriber links are preferred in the lower frequency blocks; the subscriber to base links are preferred in the upper frequency blocks.

Time division duplex (TDD) systems: may operate in both the lower and upper sub-bands.

6.2.3 Canadian Band Plan for the 38 GHz [add us and others—leland]

The following reference band plan will be used for coexistence for the 38 GHz band:

Block	Lower Block (MHz)	Upper Block (MHz)	Usage
A/A'	38600 – 38650	39300 – 39350	P-P
B/B'	38650 – 38700	39350 – 39400	P-P
C/C'	38700 – 38750	39400 – 39450	P-P, P-MP
D/D'	38750 – 38800	39450 – 39500	P-P, P-MP
E/E'	38800 – 38850	39500 – 39550	P-P, P-MP
F/F'	38850 – 38900	39550 – 39600	P-P, P-MP
G/G'	38900 – 38950	39600 – 39650	P-P, P-MP
H/H'	38950 – 39000	39650 – 39700	P-P, P-MP
I/I'	39000 – 39050	39700 – 39750	P-P, P-MP
J/J'	39050 – 39100	39750 – 39800	P-P, P-MP
K/K'	39100 – 39150	39800 – 39850	P-P
L/L'	39150 – 39200	39850 – 39900	P-P
M/M'	39200 – 39250	39900 – 39950	P-P
N/N'	39250 – 39300	39950 – 40000	P-P

Frequency division duplex (FDD) systems: the base to subscriber links are preferred in the upper frequency blocks; the subscriber to base links are preferred in the lower frequency blocks. Time division duplex (TDD) systems: may operate in both the lower and upper frequency blocks.

6.2.4 Japanese Bandplan for the 26 GHz, and 38 GHz Band

[to be included]

6.2.5 Eurpoean Bandplans for the 40.5-43.5 GHz Band

Within Europe a frequency plan is under development for Multimedia Wireless Systems (MWS) in the band 40.5-43.5GHz. Consideration is being given to a number of points in order to develop a so-called “slot” frequency plan which provides the basis for block assignments to a number of potentially competing operators within the band for MWS. The key points under consideration are:

- Accommodation of systems supporting both asymmetric and/or symmetric traffic.
- Digital MVDS.
- Make provision for both FDD and TDD operation.
- Accommodation of more than one operator must be possible in the same geographical area.
- Criteria for inter-operator protection.
- Where FDD is required duplex spacing needs to be practicable.
- Duplex spacing has to be chosen to allow efficient band planning.
- Accommodate legacy services, e.g analogue MVDS.
- Planning for growth.
- Need to protect Radio Astronomy service.
- The impact of possible band sharing with satellite services.

Frequency plan slots would be aggregated in a contiguous manner to form block assignments which can be consistent with the MWS technology to be deployed. The plan slots would have no relationship with equipment channelisation and be expected to be something smaller than the narrowest anticipated channel width associated with any MWS system. A figure of either 1MHz or 2MHz is under consideration at present. Once assigned the slot boundaries would become meaningless and have no significance regarding equipment channelisation or the way the operator makes use of the band. This allocation plan consists of 1500 adjacent 2 MHz slots starting at 40.5 GHz as per Figure 1. Any number of these slots may be aggregated to form a block assignment. Assignments may be paired in a contiguous or non-contiguous manner for FDD operation or unpaired for TDD operation.

This concept is illustrated for 2MHz slots in the figure below:

1	2	3	4	5	6	7	8	9	10	11	12	…	1500

40.500 40.504 40.508 40.512 40.516 40.520 40.524 43.500

40.502 40.506 40.510 40.514 40.518 40.522 43.498

Slot start frequency can be identified by the following relationship:

For slot number n = 1 to 1500;

Slot start frequency = (40.498 + n* 0.002) GHz

Once assigned, the slot boundaries become meaningless other than those coincident with the frequency block boundaries.

7 IFL Interference (J. Leland Langston)

8 Deployment & Co-ordination

The following paragraphs provide a recommended structure process to be used to co-ordinate deployment of BWA systems in order to minimize interference problems.

8.1 Methodology

Coordination is required between licensed service areas where the shortest distance between the respective service boundaries is less than[4] 60 km and both systems are operating co-channel, i.e. over the same BWA frequencies. The rationale for 60 km is given in the next section. The operators are encouraged to arrive at mutually acceptable sharing agreements that would allow for the provision of service by each licensee within its service area to the maximum extent possible.

Under the circumstances where a sharing agreement between operators does not exist or has not been concluded, and whose service areas are less than 60 km apart, the following coordination process should be employed (refer to Figure 7-1 for a graphical representation of the process):

BWA operators are required to calculate the power spectral flux density (psfd) at the service area boundary of the neighboring service area(s) for the BWA transmitting facilities. Power flux density is calculated using good engineering practices, taking into account such factors as propagation loss,

[4] In the event an operator using sites of very high elevations relative to local terrain that could produce interference to BWA service areas beyond 60 km, this operator should coordinate with the affected licensee(s).

atmospheric loss, antenna directivity toward the service area boundary, curvature of Earth. It is the maximum value for elevation points up to 500 m above local terrain elevation. Refer to the next section below for a rationale behind the psfd levels presented in this process.

Deployment of facilities which generate a psfd less than or equal to -114 dBW/m^2 in any 1 MHz (psfd A) at the other BWA service area boundaries is not subject to any coordination requirements. (It should be noted that the psfd values referred to in this section applies to systems operating in the 20-30 GHz frequency range. A table (Table 7-1), showing the corresponding psfd limits, is given below to address systems operating outside of this range.)

Deployment of facilities which generate a psfd greater than psfd A (-114 dBW/m^2 in any 1 MHz), but less than or equal to -94 dBW/m^2 in any 1 MHz (psfd B) at the other BWA service area boundaries are subject to successful coordination between the affected licensees in accordance with the following coordination process:

The operator must notify the respective licensee(s) of its intention to deploy the facility(ies) along with the appropriate information necessary to conduct an interference analysis.

The recipient of the notification must respond within 30 calendar days to indicate any objection to the deployment. Objection may be based on harmful interference to existing systems[5] only.

If there is no objection raised, then the deployment may proceed.

If an objection is raised, then the respective licensee(s) must work in collaboration to develop a suitable agreement between the licensee(s) before the deployment of facilities. It is expected that the time frame to develop such an agreement should not exceed 30 calendar days.

Proposed facilities must be deployed within 120 calendar days of the conclusion of coordination, otherwise, coordination must be reinitiated.

Deployment of facilities which generate a psfd greater than - 94 dBW/m^2 in any 1 MHz) (psfd B) at the other BWA service area boundaries is subject to successful co-ordination between the affected licensees.

[5] Existing systems include systems that are operational prior to receipt of the notification, or systems that have previously been co-ordinated successfully.

In any event, licensees are expected to take full advantage of interference mitigation techniques such as antenna discrimination, polarization, frequency offset, shielding, site selection, or power control to facilitate the co-ordination of systems.

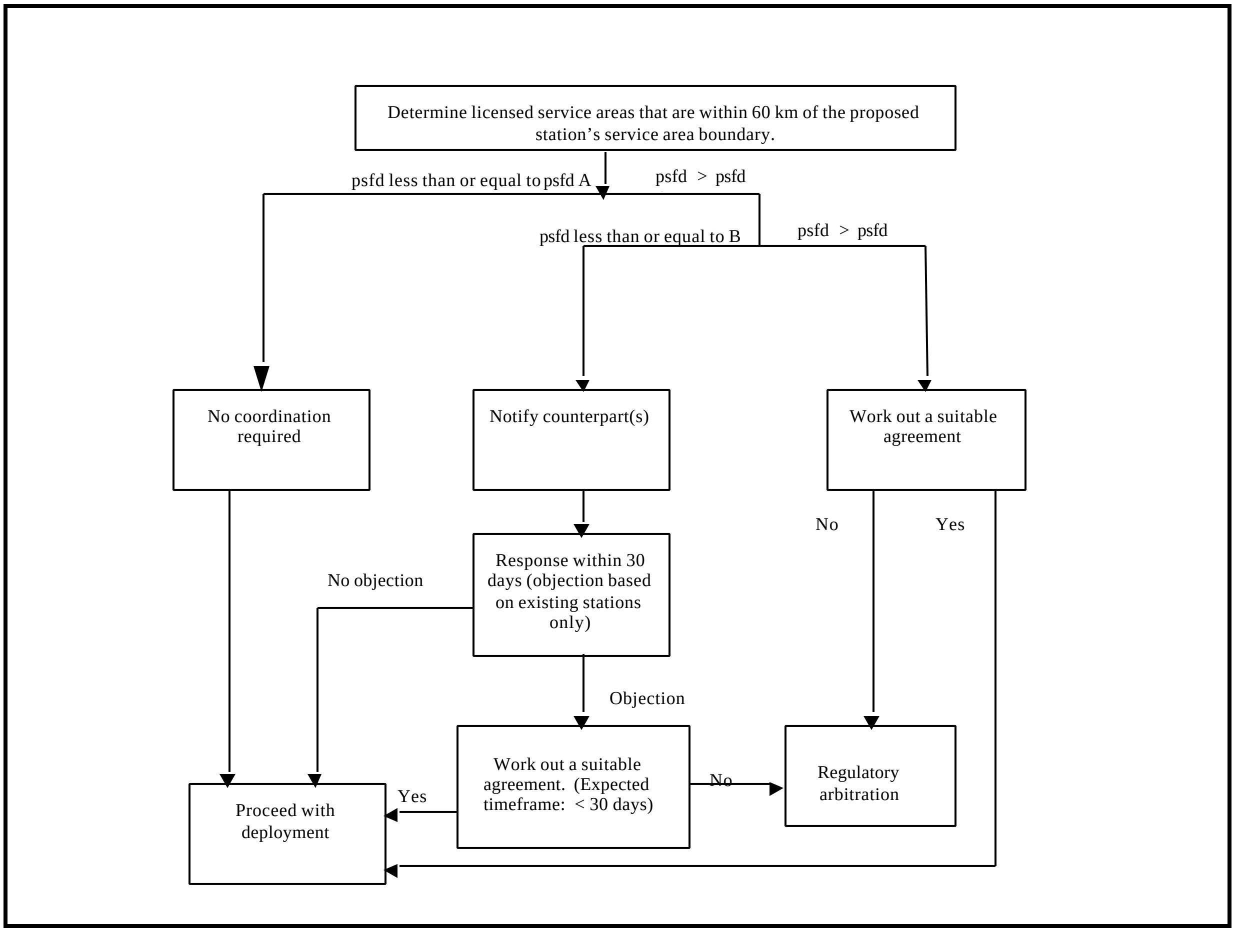


Figure 16 - Coordination process for adjacent area co-channel BWA Systems

All results of analysis on psfd, or agreements made between licensees must be retained by the licensees and be made available to the regulatory body upon request.

If a licence is transferred, the sharing agreement(s) developed between the former licensees should remain in effect until superseded by a new agreement between licensees.

In the event a satisfactory agreement or a successful co-ordination between the licensees is not reached, the regulatory body should be informed.

[While coordination between adjacent block licensees operating in the same vicinity may not be required in most cases, licensees may agree to coordinate certain installations to avoid interference.] new text – not discussed yet.

The table below summarizes the psfd levels for systems operating in the 20-30 GHz and 30-40 GHz bands.

Frequency Band	PSFD A ($dBW/MHz\text{-}m^2$)	PSFD B ($dBW/MHz\text{-}m^2$)
20-30 GHz	-114	-94
30-40 GHz	-125	-105

Table 7-1. Maximum psfd Limits

8.2 Co-ordination Distance

As described above, distance is used as the first trigger mechanism for co-ordination between adjacent licensed operators. If the boundaries of two service areas are within 60 km of each other, then the co-ordination process is invoked.

The rationale for 60 km is based upon several considerations including radio horizon calculations, propagation effects, and power flux density levels (the latter is discussed in the next section).

The radio horizon is defined as:

$$R_h=4.12(\sqrt{h_1} + \sqrt{h_2})$$

where:

R_h = Radio Horizon (km)

h_1 = Height of radio 1 above clutter (m)

h_2 = Height of radio 2 above clutter (m).

The table below presents the horizon range for different radio heights above average clutter.

	Height of Radio 1 (m)								
Height of Radio 2 (m)	10	20	30	40	50	60	70	80	90
10	26	31	36	39	42	45	47	50	52
20	31	37	41	44	48	50	53	55	58
30	36	41	45	49	52	54	57	59	62
40	39	44	49	52	55	58	61	63	65
50	42	48	52	55	58	61	64	66	68
60	45	50	54	58	61	64	66	69	71
70	47	53	57	61	64	66	69	71	74
80	50	55	59	63	66	69	71	74	76
90	52	58	62	65	68	71	74	76	78

Table 7-2. Horizon range for different radio heights (in kilometers).

The worst case interference scenario involves two base stations, as they are typically located on relatively high buildings/infrastructures and hence have greater radio horizon distances. A typical height for a base station is 65 m above ground level, or 55 m above clutter, assuming an average clutter height of 10 m. This produces a radio horizon of 60 km. There will be cases where the base station equipment may be located on higher buildings, which would produce a greater radio horizon. However, these base stations tend to tilt their antennas downward which effectively reduces the amount of power (interference) that can be directed towards the adjacent base station. The next section examines power levels in more detail.

8.3 Use of Power Spectral Flux Density (psfd) as a Coexistence Metric

This section addresses the maximum power flux density that can be tolerated as a result of co-channel interference originating from an adjacent licensed operator. The amount of interference generally considered acceptable or tolerable is one which produces a degradation of 0.5 dB to the system's C/N (this degradation

is usually taken into consideration during the original link budget exercise). For the noise floor to increase by 0.5 dB, the interference power level must be 6 dB below the receiver's thermal noise floor. Assuming a typical receiver noise figure of 6 dB, then the thermal noise power spectral density of the receiver is calculated as follows:

$$N_o = 10\,Log(kT_o) + N_F$$

$$N_o = -144 + 6 = -138 \text{ dBW/MHz}$$

where,

No = Receiver thermal noise power spectral density (dBW/MHz)

kT_o = Equipartition Law (-144 dBW/MHz)

N_F = Receiver noise figure (6 dB)

At 6 dB below N_o, the interference power level (I_{tol}) into the receiver is -144 dBW/MHz (-138 – 6).

The spectral power flux density (psfd) at the antenna aperture is calculated as follows:

$$psfd = \frac{\Pr}{Ae} = \frac{\Pr}{l^2 \frac{G}{4p}} = \Pr - 10Log(l^2) - G + 10Log(4p)$$

where:

Pr = interference power level into receiver (-144 dBW/MHz)

Ae = effective antenna aperture

λ = wavelength

G = antenna gain.

Assuming an operating frequency of 28 GHz (λ=.011m) and a typical base station antenna gain of 20 dBi, then the tolerable interference level is given as:

$$\text{Psfd}_{BTS} = -144 - 10\text{Log}(.011^2) - 20 + 10 \text{ Log}(4\pi) = -144 + 39 - 20 + 11 = -114 \text{ dBW/MHz-m}^2$$

Note that the base station receiver is considered only in this analysis (not the subscriber). This is primarily due to the fact that BTS' are typically located on high buildings/structures with omni directional coverage which tend to increase their probability of achieving line of sight (LOS) to adjacent licensed area transmitters. Subscribers, on the other hand, tend to be situated at low altitudes (~15 m) which significantly reduces the probability of LOS (due to obstacles/clutter) to adjacent area systems. Furthermore, subscribers have highly directional antennas (narrow beamwidths) which further reduces the probability that they will align with an interference source from an adjacent area.

The –114 dBW/MHz-m^2 represents psfd A in the 20-30 GHz range of the co-ordination process described above.

The psfd limits for the 30-40 GHz frequency range were derived in a similar manner.

A sample calculation is given below to determine the feasibility of meeting the psfd limit between a BTS transmitter and BTS victim receiver.. The formula for psfd is as follows:

$$psfd_{victim} = P_{TX} + G_{TX} - 10\log(4\pi) - 20\log(R) - A_{losses}$$

where;

P_{TX} = transmitter power (- 25 dBW/MHz)

G_{TX} = transmitter antenna gain in the direction of the victim receiver (18 dBi)

R = range (60000 m)

A_{losses} = atmospheric losses, ~ 0.1 dB/km

The values given in brackets represent typical BWA parameters.

Using the radio horizon range of 60 km from above, the psfd at the victim base station receiver antenna is:

$$psfd_{victim} = -25 + 18 – 10\log(4\pi) – 20\log(60000) – 60*.1$$

$$= -120 \text{ dBW/MHz-m}^2$$

The –120 value is lower than the –114 tolerable level, therefore, the 60 km range is considered reasonable as a first level trigger point. Note that the above psfd calculation assumes free space propagation and clear line of sight, i.e. complete first Fresnel zone clearance.

While spectral psfd A (-114) allows for quick deployment, it is based on fairly conservative assumptions that may unnecessarily limit system performance. Spectral psfd level B is set 20 dB higher on the basis that extra propagation losses will occur in reality, as much as 15 dB from diffraction, and that the operator will be able to resort to basic mitigation techniques including using cross-polarization, placing BTS transmitter at the same frequency as interfering BTS transmitter, etc.

[Licensees shall ensure that the psfd at the boundary of unlicensed neighboring service areas does not exceed psfd B.][new text-needs discussion]

8.4 Deployment Procedure

This section describes a process for an operator to follow in deploying an BWA system to promote coexistence. The process is essentially a ‘turn-on’ procedural list that should be followed before the operators activate their transmitter(s) to ensure they do not inadvertently interfere with or cause performance degradation to an existing system operating either co-located or in an adjacent area. The operator is highly encouraged to communicate with other known operators who may be potentially affected, since the slightest interference could severely affect their business.

The ‘turn on’ procedure is as follows:

a. Follow the coordination procedure described above and where applicable, take the necessary mitigation steps accordingly.

b. Scan the rooftop with a detector or spectrum analyzer to determine if any interference is present that may adversely affect the performance of the system to be deployed.

c. Ensure the antennas are properly installed in terms of main beam direction (AZ and El) and polarization (for the latter, labeling on the antenna to clearly indicate polarization is highly recommended). The antennas should also be sufficiently mechanically supported to withstand the worst case local wind conditions such that the antennas only deviate from their original alignment to within [+/- 0.5] degrees.

d. Before turning on the transmitter verify the proper tests have been performed to ensure EIRP and OOB emissions fall within the regulated/ recommended limits.

e. Verify the transmitter EIRP does not exceed safety limits as specified by local regulations.

f. Verify the transmitter or its IF cables do not interfere with IF cables or receivers from other co-located systems.

g. Verify the transmitter will automatically turn off in the event that it becomes rogue i.e. it loses lock and begins to transmit randomly in power and spectrum.

9 Mitigation

9.1 Antennas

9.1.1 BTS Antenna-to-Antenna Isolation

In practice, sector antennas are being co-located that are directed to the same sector. Such co-location involves two primary configurations. In one case, there are multiple antennas mounted at the same site on the same mounting structure that are directed to the same sector angle. In the second case, there are multiple antennas mounted at the same site on different mounting structures that are directed to the same sector.

Antenna-to-antenna isolation is dependent on factors like site location, mounting configurations, and other system level issues. Even with seemingly uncontrollable factors, there is a need for isolation between the antennas directed to the same sector. For guidance, the antenna-to-antenna isolation for antennas, which are co-pointed to the same sector with sector sizes of 90^o and less should be minimally 60 dB.

9.2 [NEEDS REVIEW]General

This section describes some of the mitigation techniques that could be employed in case of co-channel interference between systems operating in adjacent areas. As each situation may be unique, no single technique can be effective for all cases, and in certain circumstances, the application of more than one mitigation technique may be more effective.

In general, analyses to evaluate the potential for interference as well as any possible mitigation solution should be performed prior to systems implementation. Coordination with adjacent operators could significantly lower the potential for interference.

9.3 Separation distance/Power

One of the most effective mitigation techniques that can be employed is to increase the distance between the interfering transmitter and the victim receiver, thus lowering the interfering effect to an acceptable level. If the distance between the interferer and the victim cannot be increased, then the transmitter power can be lowered to achieve the same effect. However, both options are not always viable due to local terrain, intended coverage, network design, or other factors.

Another possible, but less desirable, option is to increase the transmit power levels of the customer premise equipment (CPEs) within a cell or sector in a given service area to improve the signal to interference level into the base station receiver. Operating the CPEs ‘hot’ at all times may help to address the adjacent area interference, however, it may introduce other interference scenarios that are equally undesirable, therefore, caution should be exercised if this approach is taken.

9.4 Antenna

9.4.1 Orientation

In certain system deployments, sectorized antennae will be used. A slight change in antenna orientation by the interfering transmitter or victim receiver can help to minimize interference. This technique is especially effective in the case of interference arising from main-beam coupling. However, as before with separation distance, although to a lesser degree, this mitigation technique may not be practical in certain deployment scenarios.

9.4.2 Tilting

Similar to changing the main-beam orientation, the downtilt of either the transmitting antenna or receiving antenna can also minimize the interfering effect. A small change in downtilt could significantly change the coverage of a transmitter, hence reducing interference to the victim receiver. However, in some systems, the downtilt range could be quite limited either due to technical reasons, or economic reasons, rendering this technique impractical.

9.4.3 Directivity

In problematic areas near the service area boundaries where interference is of concern, consideration can be given to using high performance antenna with high directivity as opposed to a broader range sectorized antenna or omni-directional antenna.

Another possible option is to place the base station at the edge of the service area or boundary, and deploy sectors facing away from the adjacent licensed area. Interference is then avoided through the front to back lobe isolation of the base station antennas, which can exceed 30 dB, to accommodate QPSK and 16 QAM modulation.

9.4.4 Antenna Heights

In circumstances where adjacent licensed base stations are relatively close to each other, another possible technique to avoid interference is to place the base station antennae at lower heights to indirectly create LOS blockages to neighboring base stations. This solution will not be practical in many cases, as it will significantly cause a reduction in coverage area (i.e. mini-cell), however, under certain conditions, it may be the best option available for addressing the interference issue.

9.4.5 Future Schemes

Future schemes may be available such as adaptive arrays or beam-steering antennas, which focus a narrow, beam towards individual users throughout the service area in real-time to avoid or minimize coupling with interfering signals. Beam shaping arrays, which create a null in the main beam towards the interfering source, represents another possible approach towards addressing interference.

9.5 Polarization

Cross polarization can be effective in mitigating interference between adjacent systems. A typical cross-polarization isolation of 25-30 dB can be achieved with most antennas today, which is sufficient to counter co-channel interference for QPSK and 16 QAM modulation schemes. As with other mitigation techniques, cross polarization is most effective when coordination is carried out prior to implementation of networks to accommodate all possible affected systems.

9.6 Blockage

Natural shielding, such as high ground terrain between boundaries, should be used to mitigate interference where possible. When natural shielding is not available, the use of artificial shielding, such as screens, can be considered.

9.7 Frequency plan

A similar frequency plan for the up- and downlink could help to reduce interference for FDD systems. The most problematic interference occurs between base stations primarily for the following reasons:

i) Base stations are typically located on high buildings/structures, therefore, they tend to have good clear line of sight (LOS) with neighboring base stations,

ii) Base stations typically operate over 360 degrees, and

iii) Base stations are always transmitting.

By transmitting at the same frequencies, co-channel interference between base stations is completely avoided. Frequency exclusion provides another, albeit very undesirable, approach for avoiding interference. This involves dividing or segregating the spectrum so that neighboring licensees operate in exclusive frequencies, thus avoiding any possibility for interference. This should and must be considered an absolute last resort, where all other remedial opportunities have been completely exhausted between the licensed operators.

9.8 Modulation and Encoding

Using more robust modulation and encoding schemes can help in deployment scenarios where the potential for interference is high. Future schemes being considered to help overcome cellular interference are spread spectrum and COFDM.

9.9 Shielding

9.10 Frequency

9.11 Spatial Separation

Appendix A - Test and Measurement / Hardware parameter summary

A.1 Testing of Unwanted Emissions

Some transmitters may be frequency agile to cover several authorized bands and may deploy a band edge RF filter only at the extremities. The option for Spectrum Segregation implies that operator segregation edge frequencies may also occur within an authorized band. Thus unwanted emissions at authorized band edges or at segregation band edges well inside the agility range of the transceiver may not benefit from the band edge RF filter and may be more severe (or "worst-case") compared to emissions at the extreme upper or lower edges.

This practice proposes a test methodology, which should therefore be applied at mid band segregation or authorized edge and the equipment performance is assumed to be equivalent (or better) at the extremity authorised band edges.

To facilitate assessing emissions at a generic mid-band segregation or authorized band edge, a virtual block edge is defined and testing (the results are assumed to be valid across the complete operational band) should be implemented at this virtual block edge. Unwanted emissions should be measured at the output of the final amplifier stage or referenced to that point. In additon to active amplifiers, the final amplifier *stage* may contain filters, isolators, diplexers, OMT, etc. as needed to meet emission requirements.

A.1.1 Methodology

Single-carrier and multi-carrier requirements are described below. If multicarrier operations are intended, then both requirements must be met. "Multicarrier" refers to multiple independent signals (QAM, QPSK, …) and does NOT refer to techniques such as OFDM.

Single carrier and multi-carrier tests should be carried out relative to a virtual block edge (defined in the Table A-1). The virtual block edge is located within the assigned band (see Figure A-1 below). When a transmitter is designed to only operate in part of a band (e.g. because of Frequency Division Duplexing), the virtual block edge should be inside the designed band of operation. The occupied bandwidth of the carrier(s) must be closer to the center of the block than the virtual block edge. The virtual block edge is only to be used for testing and does not impact an actual implementation in any way. One virtual block edge (at frequency f_{vl}) should be inside the lower edge of the designed or assigned band and the other virtual block edge (at frequency f_{vu}) should be inside the upper edge of the designed or assigned band.

Band	Minimum Separation between Actual and Virtual Block Edge
24/26 GHz	10 MHz
28 GHz	40 MHz
38 GHz	10 MHz

Table A-1. Minimum Separation between Actual and Virtual Band Edge for Different Bands

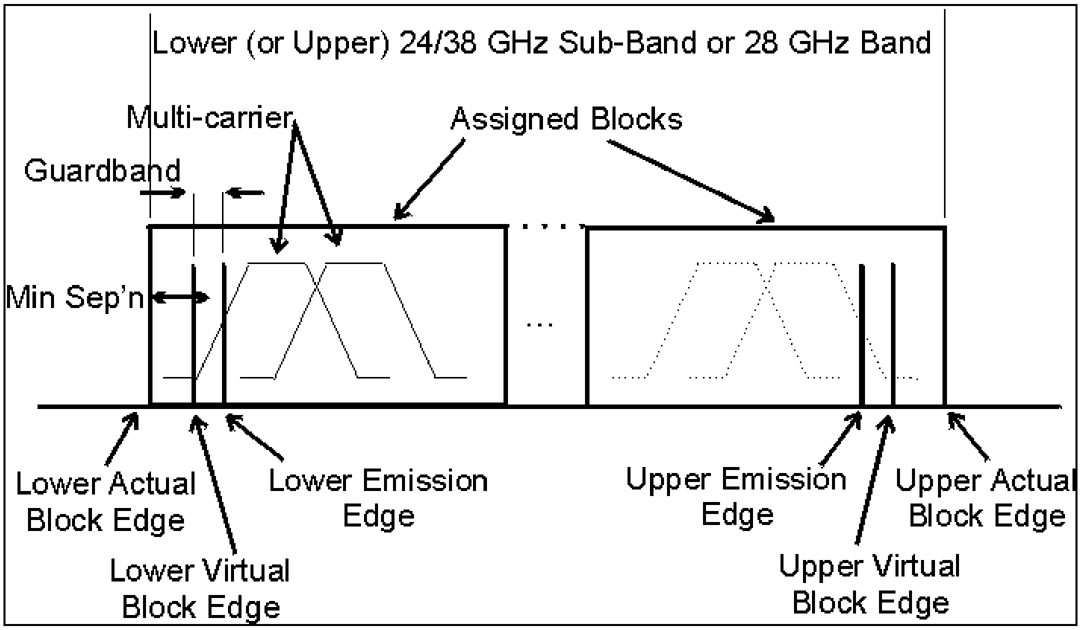


Figure A-1. Band Edge Definitions

Unwanted emissions should be measured when the transmitter is operating at the manufacturer's rated power and modulated with signals representative of those encountered in a real system operation. Unwanted emissions should be measured at the output of the final amplifier stage or referenced to that point. The measurement can be done at the transmitter's antenna connector as long as there is no frequency combiner in the equipment under test. It is important however that the point of measurement for this test be the same as the one used for the output power test. The point of measurement and the *occupied* bandwidth (B_o) should be stated in the test report

Single-carrier and multi-carrier requirements are described below. If multicarrier operations are intended, then both requirements must be met. "Multicarrier" refers to multiple independent signals (QAM, QPSK, …) and does NOT refer to techniques such as OFDM.

The purpose of specifying the tests relative to the virtual block edges is to avoid the attenuating effects of any RF filters that may be included in the transmitter design, so that the spectrum mask limits of section [[3.1.2.1] needs fixing] are applicable to any channel block.

Note that although testing is specified relative to the virtual block edges, the transmitter is expected to perform similarly for all frequencies within the designed band. Therefore, to reduce the number of test runs, the Lower Virtual Block Edge can be in one assigned band and the Upper Virtual Block Edge can be in another assigned band.

The search for unwanted emissions should be from the lowest frequency internally generated or used in the device (local oscillator, intermediate or carrier frequency), or from 30 MHz, whichever is the lowest frequency, to the 5th harmonic of the highest frequency generated or used, without exceeding 40 GHz.

A.1.2 Single carrier test

For testing nearest the lower virtual block edge, set the carrier frequency f_L closest to the lower virtual block edge, taking into account any guardband used in the design of the equipment, record the carrier frequency f_L, the virtual block edge frequency f_{VL}, the guardband (f_{LG}) and plot the RF spectrum. Likewise, perform the highest frequency test with the carrier frequency, f_U, nearest the upper virtual block edge. Record the carrier frequency, the virtual block edge frequency (f_{VU}), the guardband (f_{UG}) and the RF spectrum plot. The guardband is the frequency separation between the virtual block edge and the edge (99%) of the occupied emission.

The user manual should contain instructions, such as details on the minimum guardband sizes required to ensure that the radios remain compliant to the certification process.

It is to be noted that the regulations may permit licensees to have more than one frequency block for their systems. Equipment intended to have an occupied bandwidth wider than one frequency block per carrier should be tested using such a wideband test signal for the section [3.1.2.1(1) fix section #]requirement.

A.1.3 Multi-carrier test.

This test is applicable for multi-carrier modulation (not OFDM). It applies equally to multi-transmitters into a common power amplifier. Note that the multi-carrier transmitter must be subjected to the single carrier testing, described above, in addition to the tests specified below.

For multi-carrier testing, the single carrier test method of A.1.2 is to be used except that the single carrier is replaced by a multi-carrier modulated signal that is representative of an actual transmitter. The number of carriers should be representative of the maximum number expected from the transmitter, and be grouped side by side nearest the lower virtual block edge, with lower guardband, f_{LG}, if required by the design of the equipment. Likewise test nearest the upper virtual block edge. Record their spectrum plots, the number of carriers used and the guardband sizes (f_{LG}, f_{UG}), the carrier frequencies and the virtual block edge frequencies.

Notwithstanding the requirements in the TableA.1 "Minimum Separation between Actual and Virtual Block Edge", any equipment which uses the complete block or multiple blocks for a single licensee can include the attenuating effect of any RF filters in the transmitter design within the multi-carrier test , in which case the Virtual and Actual block edge frequencies will be the same.

The user manual should contain instructions, such as details on the minimum guardband sizes required and the maximum number of carriers or multi-transmitters permitted, to ensure that the radios remain compliant to the testing process.

A.2 Measuring Frequency Stability.

As discussed in section 3.1.3, the RF carrier frequency should not depart from the reference frequency (reference frequency is the frequency at 20^{o}C and rated supply voltage) in excess of $\pm$ 10 ppm. The RF frequency of the transmitter should be measured:

(a) At temperatures over which the system is designed to operate and at the manufacturer's rated supply voltage. The frequency stability can be tested to a lesser temperature range provided that the transmitter is automatically inhibited from operating outside the lesser temperature range. If automatic inhibition of operation is not provided the manufacturer’s lesser temperature range intended for the equipment is allowed provided that it is specified in the user manual.

(b) At 85% and at 115% of rated supply voltage, with temperature at +20^{o} C .

In lieu of meeting the above stability value, the test report may show that the frequency stability is sufficient to ensure that the occupied bandwidth emission mask stays within the licensee’s frequency band, when tested to the temperature and supply voltage variations specified above. The emission tests should be performed using the outermost assignable frequencies that should be stated in the test report.

Appendix B – Abbreviations and Glossary

This appendix contains a list of definitions and abbreviations contained in this document.

ABBREVIATIONS

BTA	Basic Trading Area
BTS	Base Transceiver Station
BWA	Broadband Wireless Access
CPE	Customer Premise Equipment
DL	Downlink
FDD	Frequency Division Duplex
EIRP	Effective Isotropic Radiated Power
EIRPSD	Effective Isotropic Radiated Power Spectral Density
ETSI	European Telecommunications Standards Institute
FDMA	Frequency Division Multiple Access
ICL	Inband Inter-cell Links
LMCS	Local Multipoint Communication System (Canadian version of LMDS)
LMDS	Local Multipoint Distribution Service (U.S. FCC Definition)
LOS	Line of Sight
Mbits/s	Megabits per second
MP	Multipoint
OFDM	Orthogonal Frequency Division Multiplexing
PMP	Point-to-Multipoint
ppm	Part per Million (10^{-6})
PTP	Point-to-Point
RX	Receive
QAM	Quadrature Amplitude Modulation
RS	Repeater Station
SRSP	Standard Radio Systems Plan
TDD	Time Division Duplex
TDM	Time Division Multiplexing
TDMA	Time Division Multiple Access
TX	Transmit
UL	Uplink

GLOSSARY

Base Station	The assemblage of hardware including antenna(s), transmitters, receivers, modem functions, network functions, control functions, etc. at a geographic point within a BWA network which provides network access to multiple subscribers located within the service region of the base station in a PMP system.
Broadband	Having instantaneous bandwidths greater than around 1 MHz and supporting data rates greater than 1.5 Mbps.
Broadband Wireless Access	The delivery of broadband service from a BTS to CPE using wireless technology.
Downlink	RF transmissions from the BS to the CPE
DS-3	A North American Common Carrier Multiplex Level in a TDM system having a line rate of 44.736 Mbps.
Frequency Division Duplex	A duplex scheme where transmission occurs simultaneously on the Uplink and Downlink path using different frequencies.
Guardband	The difference between the upper (lower) edge of the band containing the Upstream frequency channel(s) and the lower (upper) edge of the band containing the downstream channel(s) in an FDD system. This guard band is used in an FDD system to provide adequate frequency separation between the two paths.
Multi-Carrier System	The use of two or more carriers to provide service from a single transmitter.
Multipoint	A wireless topology where a single base station provides service to multiple subscribers located within the coverage area of the base station, and the subscribers are in geographically different locations with respect to each other. The sharing of resources may occur in the time domain, frequency domain, or both.
OC-3	One hierarchical level in the Synchronous Optical Network (SONET) transmission standard. The line rate for this level is 155.52 Mbps.
Power Control	A technique used BWA systems to actively adjust the transmit power of a transmitter to maintain the received signal level within some desired range.
Repeater	A device used to receive, amplify and retransmit information along a communications channel. In BWA systems, a repeater may be used to either extend the range of a link or compensate for non-LOS conditions.
Time Division Duplex	A duplex scheme where Uplink and Downlink transmissions occur at different times while sharing the same frequency.
Uplink	The transmissions of information from the subscriber to the Base Station.

Appendix C—Antenna Parameter Charts

C.1 Base Station Antenna Parameters

Table C-1. Class 1 - Azimuth RPE

Angle off-boresight (deg)	COPOL Recommended Maximum Relative Gain (dB)	COPOL Recommended Minimum Relative Gain (dB)	CROSSPOL Recommended Maximum Relative Gain (dB)
0	0	-3	-25
α	0	-3	
α+5			
α+15			
2*α	-20		
2.44*α			
3*α	-30		
155	-30		
180	-30		-30

Use linear interpolation between limits.

Table C-2. Class 2 - Azimuth RPE

In terms of α, where α equals ½ the 3 dB beamwidth:

Angle off-boresight (deg)	COPOL Recommended Maximum Relative Gain (dB)	COPOL Recommended Minimum Relative Gain (dB)	CROSSPOL Recommended Maximum Relative Gain (dB)
0	0	-3	-28
α	0	-3	
α+5			
α+15	-20		-30
2.44*α	-29		-35
140	-35		-35
180	-35		-37

Use linear interpolation between limits.

Table C-3. Class 3 Azimuth RPE

In terms of α, where α equals ½ the 3 dB beamwidth:

For $\alpha \geq 30$ degrees:

Angle off-boresight (deg)	COPOL Recommended Maximum Relative Gain (dB)	COPOL Recommended Minimum Relative Gain (dB)	CROSSPOL Recommended Maximum Relative Gain (dB)
0	0	-3	-28
α		-3	
α+5	0		
α+15	-20		-30
2.44*α	-29		-35
5*α	-35		-35
180	-40		-37

Use linear interpolation between limits.

For $\alpha < 30$ degrees:

Angle off-boresight (deg)	COPOL Recommended Maximum Relative Gain (dB)	COPOL Recommended Minimum Relative Gain (dB)	CROSSPOL Recommended Maximum Relative Gain (dB)
0	0	-3	-28
α		-3	
α+5	0		
α+15	-20		-30
2.44*α	-29		-35
5*α	-35		-35
180	-40		-37

Use linear interpolation between limits.

Table C-4. Class 1 Elevation RPE.

Angle (deg)	Above the Horizon COPOL Recommended Maximum Relative Gain (dB)	Below the Horizon COPOL Recommended Minimum Relative Gain (dB)	Above and Below the Horizon CROSSPOL Recommended Maximum Relative Gain (dB)
-90		-80	-25
-40		-80	
-15		-40	
-5		-15	
0	0	-3	-22
5	0		
7	-3		
20	-16		
40	-20		
90	-30		
180	-30		-25

Use linear interpolation between limits.

Table C-5. Class 2 Elevation RPE

In terms of α, where α equals ½ the 3 dB beamwidth:

Angle (deg)	Above the Horizon COPOL Recommended Maximum Relative Gain (dB)	Below the Horizon COPOL Recommended Minimum Relative Gain (dB)	Above and Below the Horizon CROSSPOL Recommended Maximum Relative Gain (dB)
-180		-80	-35
-90		-80	-30
-45		-80	
-30		-34	
-20		-28	
-15		-24	

-5		-22	
0	0	-3	-25
4	-3		
15	-18		
90	-35		-30
180	-35		-35

Use linear interpolation between limits.

Table C-6. Class 3 Elevation RPE

Angle (deg)	Above the Horizon COPOL Recommended Maximum Relative Gain (dB)	Below the Horizon COPOL Recommended Minimum Relative Gain (dB)	Above and Below the Horizon CROSSPOL Recommended Maximum Relative Gain (dB)
-180		-80	-35
-90		-80	-30
-45		-40	
-30		-28	
-20		-28	
-15		-22	-30
-10		-20	
-5		-12	-28
0	0	-3	-25
4	-3		
15	-18		
90	-35		-30
180	-35		-35

Use linear interpolation between limits.

C.2 CPE Antenna Parameters

Table C-7. Directivity 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

Table C-8. Directivity Category 1– Cross-polar

Degree off bore axis	Class 1	Class 2	Class 3
0≤ 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

Table C-9. Directivity Category 2– Co-polar

Degree off boresight axis	Class 1	Class 2	Class 3
0	0	0	0

2α	0	0	0
5	-14	-14	-25
10	-20	-22	-30
60	-27	-35	-40
100	-45	-50	-55
180	-45	-50	-55

Table C-10. Directivity Category 2– Cross-polar

Degree off boresight axis	Class 1	Class 2	Class 3
0≤ angle <5	-27	-27	-27
5	-30	-30	-30
10	-35	-35	-40
60			-50
100	-45	-50	-55
180	-45	-50	-55

Table C-11. Directivity Category 3– Co-polar

Degree off boresight axis	Class 1	Class 2	Class 3
0	0	0	0
2α	0	0	0
4α	-10	-10	-10
5	-19	-19	-25
10	-25	-27	-35
60	-32	-40	-45
100	-50	-55	-60
180	-50	-55	-60

Table C-12. Directivity Category 3– Cross-polar

Degree off boresight axis	Class 1	Class 2	Class 3
0≤ angle <5	-30	-30	-30
5	-35	-35	-35

10	-40	-40	-45
100	-50	-55	-60
180	-50	-55	-60