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Technical Report

Broadband Radio Access Networks (BRAN); Consideration of requirements for Mobile Terminal Station (TS) in Broadband Wireless Access Systems (BWA) in the 3 400 MHz to 3 800 MHz Frequency Band

Reference

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ETSI

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

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

Siret N° 348 623 562 00017 - NAF 742 C
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Foreword

This Technical Report (TR) has been produced by ETSI Technical Committee Broadband Radio Access Networks (BRAN).

Introduction

The present report deals with the consideration of requirements for mobile terminal stations in broadband wireless systems in the frequency band 3 400 MHz to 3 800 MHz. The detailed scope of the present document can be found in clause 1.

In November 2006 CEPT SE19 finalized its studies on the co-existence between mobile and fixed/nomadic broadband wireless systems in the 3 400 MHz to 3 800 MHz band. The outcome of SE19 [6] lead to the decision to open this band also for mobile use, which is reflected in ECC/DEC/(07)02 [1].

For fixed broadband wireless systems in this band it has to be noted that there exists already a harmonized European standard EN 302 326-2 [3] developed within ETSI.

1 Scope

The present document is a technical report of the "Broadband Radio Access Network (BRAN); Consideration of requirements for Mobile Terminal Station (TS) in Broadband Wireless Access Systems (BWA) in the 3 400 MHz to 3 800 MHz Frequency Band" work item. This work item was adopted at ETSI BRAN#50.

The purpose of this work item is to detail the technical and operational conditions with Terminal Stations operating in the 3 400 MHz to 3 800 MHz frequency range implemented under the flexible usage mode conditions identified in ECC Decision(07)02 [1]. It particularly focuses on the developments required within the standards framework to support the MWA aspects identified in the Decision.

2 References

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2.1 Normative references

The following referenced documents are indispensable for the application of the present document. For dated references, only the edition cited applies. For non-specific references, the latest edition of the referenced document (including any amendments) applies.

Not Applicable.

2.2 Informative references

[1] ECC/DEC/(07)02: Electronic Communications Committee, "ECC Decision of 30 March 2007 on availability of frequency bands between 3400-3800 MHz for the harmonized implementation of Broadband Wireless Access systems(BWA)".

[2] CEPT/ERC/REC 74-01E: "Unwanted Emissions in the Spurious Domain", October 2005.

[3] ETSI EN 302 326-2: "Fixed Radio Systems; Multipoint Equipment and Antennas; Part 2: Harmonized EN covering the essential requirements of article 3.2 of the R&TTE Directive for Digital Multipoint Radio Equipment".

[4]   ETSI EN 301 908-6 (V3.2.1): "Electromagnetic compatibility and Radio spectrum Matters (ERM); Base Stations (BS), Repeaters and User Equipment (UE) for IMT-2000 Third-Generation cellular networks; Part 6: Harmonized EN for IMT-2000, CDMA TDD (UTRA TDD) (UE) covering essential requirements of article 3.2 of the R&TTE Directive".

[5]   BRAN50d035r1: "Broadband Radio Access Networks (BRAN); Broadband Data Transmission Systems in 2500-2690 MHz, Harmonized EN covering essential requirements of article 3.2 of the R&TTE 1999/5/EC", April 2007.

[6]   SE19(06)74: "Final Summary of the 37th SE19 meeting", 21-22 Nov. 2006.

[7]   SE19(06)70: "Inter-System MWA MS to MWA MS Coexistence Analysis in 3.5 GHz Band for Unsynchronized TDD Systems or TDD Adjacent to FDD Systems", Motorola, UK Broadband, Clearwire Denmark, WiMax Telecom Europe 22-22 November 2006.

[8]   ETSI TS 125 102 (V7.2.0): "Universal Mobile Telecommunications System (UMTS); User Equipment (UE) radio transmission and reception (TDD) (3GPP TS 25.102 version 7.2.0 Release 7)".

[9]   3GPP TR 25.889 (V6.0.0): "Feasibility study considering the viable deployment of UTRA in additional and diverse spectrum arrangements".

[10]   ECC/REC/(04)05: "ECC Recommendation (04)05 Guidelines for Accommodation and Assignment of Multipoint Fixed Wireless Systems in Frequency Bands 3.4-3.6 GHz and 3.6-3.8 GHz".

[11]   IEEE 802.16.3c-01: "Channel Models for Fixed Wireless Applications".

[12]   SE19(06)54, Motorola: "MWA Systems for FWA/NWA Systems Coexistence Analysis in 3.5 GHz Band", 6-8 September 2006.

[13]   R4-061076(V0.4.0): "E-UTRA Radio Frequency (RF) system scenarios," 3GPP TSG RAN WG4#40, Tallinn, Estonia, August 28 - September 1, 2006.

[14]   WiMAX Forum: "Sharing studies in the 2 500-2 690 MHz band between IMT-2000 and broadband wireless access (BWA) systems," ITU-R WP8F/597, October 2005.

[15]   ITU-T Report M.2030: "Coexistence between IMT-2000 time division duplex and frequency division duplex terrestrial radio interface technologies around 2 600 MHz operating in adjacent bands and in the same geographical area".

NOTE: Available at http://www.itu.int/publ/R-REP-M.2030/en.

[16]   IEEE 802.16e: "IEEE Standard for Local and Metropolitan Area Networks - Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems - Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands".

[17]   ETSI TS 125 101: "Universal Mobile Telecommunications System (UMTS); User Equipment (UE) radio transmission and reception (FDD) (3GPP TS 25.101 version 8.1.0 Release 8)".

3   Definitions, symbols and abbreviations

3.1   Definitions

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

Automatic Transmit Power Control (ATPC): function implemented to offer a dynamic power control

maximum radiated output power: maximum mean radiated output power (EIRP) declared by the manufacturer

maximum radiated power density: maximum mean radiated output power (EIRP) density, defined as dBm/MHz

3.2 Symbols

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

dB	deciBel
dBc	deciBel relative to carrier
dBm	deciBel relative to 1 mW
f_c	center frequency
GHz	GigaHertz
kHz	kiloHertz
MHz	MegaHertz

3.3 Abbreviations

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

ACIR	Adjacent Channel Interference Ratio
ACLR	Adjacent Channel Leakage power Ratio
ACS	Adjacent Channel Selectivity
AMC	Adaptative Modulation and Coding
ATPC	Automatic Transmit Power Control
BER	Bit Error Rate
BW	BandWidth
BWA	Broadband Wireless Access
CDF	Cumulative Distribution Function
EIRP	Equivalent Isotropically Radiated Power
FDD	Frequency Division Duplex
FER	Frame Error Rate
LOS	Line Of Sight
MWA	Mobile Wireless Access
OFDM	Orthogonal Frequency Division Multiplexing
OFDMA	Orthogonal Frequency Division Multiplexing Access
PA	Power Amplifier
PER	Packet Error Rate
PL	PathLoss
PSD	Power Spectrum Density
PUSC	Partial Usage of SubCarriers
SINR	Signal to Interference and Noise Ratio
TDD	Time Division Duplex
TPC	Transmit Power Control
TS	Terminal Station
UE	User Equipment
WCDMA	Wideband Code Division Multiple Access

4 Study of Tx and Rx requirements

4.1 Transmitter maximum radiated output power

4.1.1 Definition

The maximum power of the transmitter has to be defined in terms of maximum radiated power. The term maximum radiated power density and maximum radiated output power are defined in clause 3.1.

4.1.2 Limits

The limit of the maximum radiated power density is 25 dBm/MHz according to ECC/DEC/(07)02 [1].

This leads to different maximum radiated output power figures for the different channel bandwidth. Table 4.1 shows as example these different figures for a number of channel bandwidths.

Table 4.1: Maximum radiated output power for different channel bandwidth

Channel bandwidth	Maximum radiated output power
5 MHz	32 dBm
7 MHz	33,5 dBm
10 MHz	35 dBm

4.1.3   Output Power tolerance

The maximum radiated output power should be declared by the supplier. The error of the maximum radiated output power should be within a tolerance of ±2 dB under normal conditions.

4.2   Emission discussion

The question of feasible emission limits for OFDMA systems has been raised in many forums. The final establishment of one or more mask limits will have important impact to handset performance. This clause addresses some measured data on an OFDM transmitter and describes the impact to the handset due to emission masks.

The limiting element for close-in emissions of a typical transmitter system at high power is the power amplifier. Figure 4.1 shows spectrum data captured from a 3G WCDMA PA, using a 10 MHz OFDMA modulated signal, at different levels of output power (5 MHz and 7 MHz OFDMA results would be similar). It also compares the spectrum data with the emission limits of several proposals. The output powers at which the different masks are satisfied are determined by visual inspection and do not represent any final determination of compliance but can be used for first order comparison reasons.

Spectral Emissions vs. Output Power
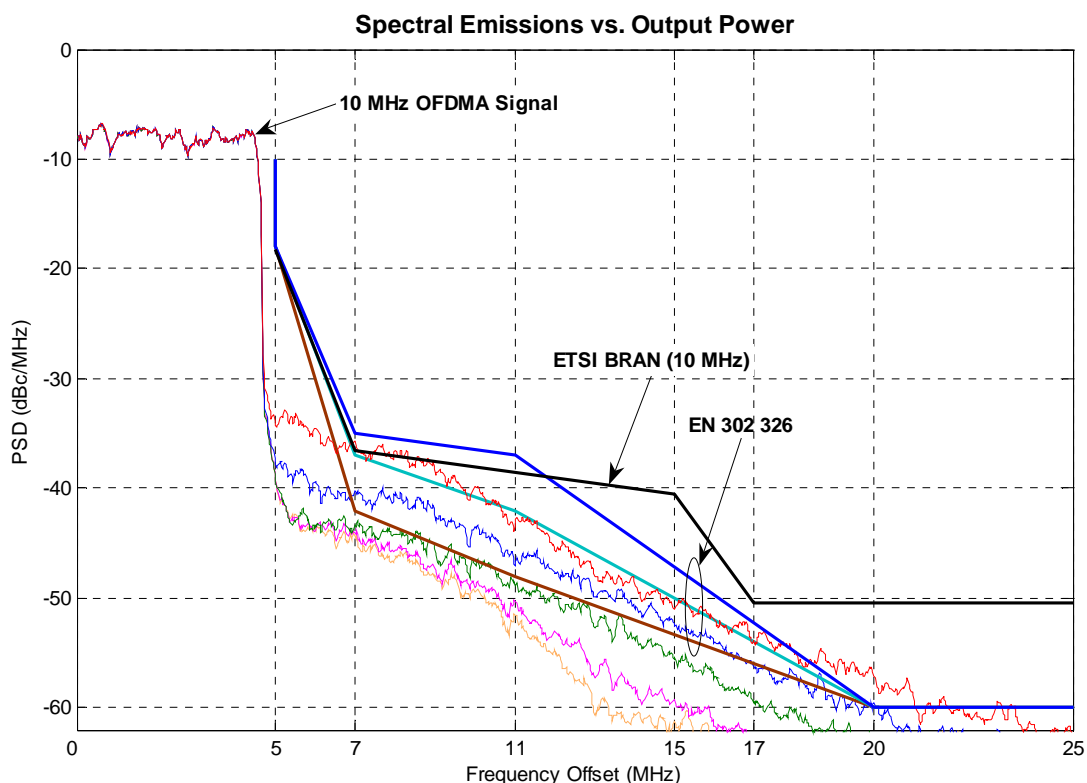
NOTE: The units of this plot are in dBc/MHz; the output power is normalized to 0 dB such that the attenuation of
out-of-band emissions relative to the output power is shown.

Figure 4.1: Transmitter Emissions vs Output Power

Table 4.2 summarizes the difference in output power at which the PA meets each mask relative to the TFES emission
mask [4] (10 MHz spectrum emission mask scaled version of 5 MHz option, which is also proposed in [5]). The
proposed TFES mask is very similar to the 3GPP WCDMA mask (from TS 125 101 [17]), the main difference being
scaling offsets to accommodate a 10 MHz channel bandwidth. The power amplifier used to collect this data of course
can be redesigned such that each mask is met at the desired output power however the resized device will consume
additional power as the mask gets more restrictive (shown in tables 4.2 and 4.3, column 3).

NOTE: Task Force for ERM and MSG for Harmonized Standards for IMT2000 (ERM: Electromagnetic
Compatibility and Radio Spectrum Matters; MSG: ETSI Mobile Standards Group).

Table 4.2: Emissions Mask Impact on TDD Transmitter

TDD (Duty Cycle = 45 %; Post PA Loss = 2,5 dB)		
Emission Mask	**Power Backoff (dB)**	**Increase in Current (to reach 24 dBm)**
ETSI BRAN (10 MHz)	0,0 (24,0 dBm)	1,00 x
EN 302 326-2 [3] (EMO = 2)	0,5 (23,5 dBm)	1,10 x
EN 302 326-2 [3] (EMO = 4)	1,2 (22,8 dBm)	1,18 x
FCC (Part 27)	2,3 (21,7 dBm)	1,37 x
EN 302 326-2 [3] (EMO = 6)	2,9 (21,1 dBm)	1,49 x
802.16 (WirelessHUMAN)	5,0 (19,0 dBm)	2,13 x

Table 4.3: Emissions Mask Impact on FDD Transmitter

FDD (Duty Cycle = 100 %; Post PA Loss = 4,5 dB)		
Emission Mask	**Power Backoff (dB)**	**Increase in Current (to reach 24 dBm)**
BRAN (10 MHz Option)	0,0 (24,0 dBm)	1,00 x
EN 302 326-2 [3] (EMO = 2)	0,5 (23,5 dBm)	1,10 x
EN 302 326-2 [3] (EMO = 4)	1,2 (22,8 dBm)	1,18 x
FCC (Part 27)	2,3 (21,7 dBm)	1,37 x
EN 302 326-2 [3] (EMO = 6)	2,9 (21,1 dBm)	1,49 x
802.16 (WirelessHUMAN)	5,0 (19,0 dBm)	2,13 x

NOTE: Absolute PA power is shown in parenthesis next to the amount of power reduction.

For a TDD transmitter to achieve 24 dBm of power at the antenna and using an assumption of 2,5 dB loss between the PA and antenna, the PA power is 26,5 dBm. To comply with the more restrictive masks at 24 dBm antenna power the power amplifier has to be modified. Table 4.2 reports the average amount of current required by the modified PA, and the increase in current drain over the reference case, to meet the required antenna power.

An FDD transmitter has an estimated 2 dB of extra post PA loss because of the duplex filter; the PA power is 28,5 dBm. The increase in PA power and the increase in duty cycle result in higher current drain and higher power dissipation in the FDD transmitter compared to TDD. Again, to comply with the more restrictive masks at 24 dBm antenna power, the power amplifier has to be modified. At a certain point, highlighted in yellow in table 4.3, the high PA current creates more heat than a handset can safely handle.

The tradeoff between emissions and PA power consumption is clear: compliance with the 802.16 mask will cost more than twice as much current as compliance with the TFES mask. For the 3,5 GHz band the TFES mask is presently the only mask that may allow for power consumption (and corresponding battery life) of TDD and especially FDD mobile terminal stations to be competitive with mobile handsets deployed in the 2,5 GHz band.

Figure 4.2 shows the TFES mask for the three channel bandwidth options 5 MHz, 7 MHz and 10 MHz in the 3,5 GHz band. The 5 MHz option is exactly the same like TFES [4]. For the 7 MHz and 10 MHz option the mask is slightly adapted to facilitate the shape of the OFDMA signal and to achieve the same ACLR figure as for the 5 MHz case. The actual limits for all 3 channel bandwidth options are shown in annex A.
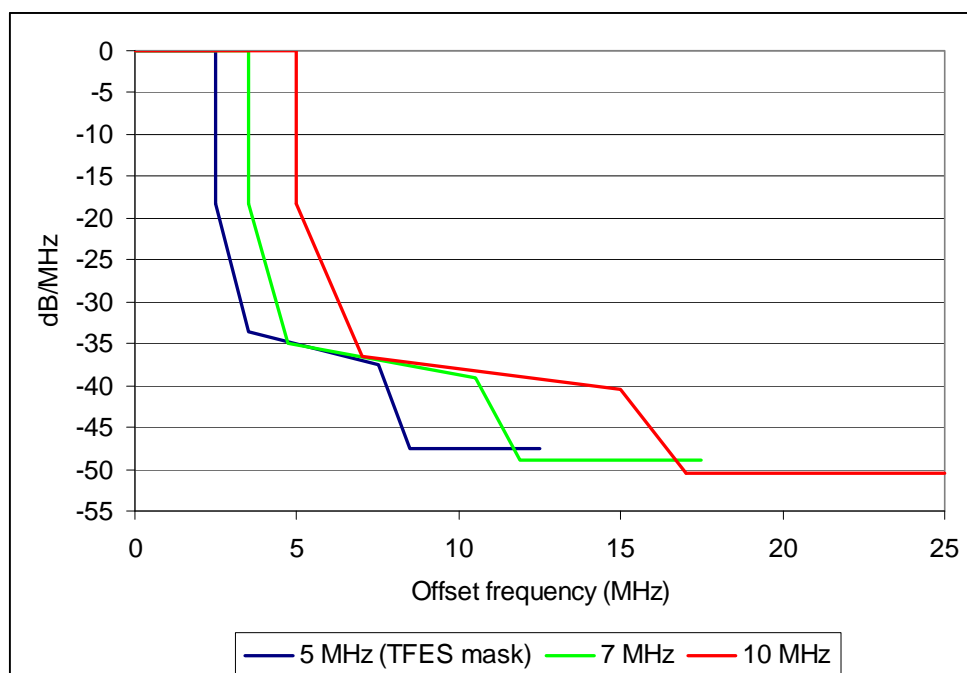

Figure 4.2: Mask for 5 MHz, 7 MHz and 10 MHz option

4.3 Transmitter Adjacent Channel Leakage power Ratio (ACLR)

4.3.1 Definition

Adjacent Channel Leakage power Ratio (ACLR) is the ratio of the mean power centred on the assigned channel frequency to the mean power centred on a first or second adjacent channel. The first adjacent and second adjacent channel centre offsets relative to the assigned channel centre frequency are exactly one channel bandwidth and two channel bandwidths. The measurement on the assigned and victim channel is performed using a rectangular filter with a bandwidth of 95 % of the channel bandwidth.

4.3.2 Limits

If the adjacent channel mean power is greater than -55 dBm then the ACLR should be equal to or greater than the limits specified in table 4.4.

Table 4.4: Mobile Terminal Station ACLR limits

Adjacent channel	ACLR limit relative to assigned channel frequency [dB]
1st adjacent channel	32,2
2nd adjacent channel	42,2
NOTE: The values in this table include already a measurement uncertainty of 0,8 dB.	

4.4 Transmitter power control

4.4.1 Definition

Transmit Power Control (TPC) is a mechanism that should be used by the equipment to ensure a mitigation factor on the aggregate power from a large number of devices to improve the spectrum sharing conditions. Automatic Transmit Power Control (ATPC) is defined in clause 3.1.

4.4.2 Limits

For mobile TS ATPC has to be implemented with a minimum power range of 15 dB. The ATPC should be implemented so that the minimum level is equal or less the 10 dBm/MHz.

4.5 Receiver adjacent and alternate channel rejection

4.5.1 Definition

The receiver adjacent and alternate channel rejection is a measure of the receiver's ability to receive a wanted signal at its assigned channel frequency in the presence of an unwanted interferer at a given frequency offset from the centre frequency of the assigned channel, either at the adjacent or alternate channel, without this unwanted input signal causing a degradation of the performance of the receiver beyond a specified limit.

To reference the receiver adjacent and alternate channel rejection values, a sensitivity level is defined as the signal level for Bit Error Rate (BER) $\leq 10^{-6}$ performance, over the channel bandwidth, corresponding to the most robust modulation and coding rate supported by the technology.

4.5.2   Limits

Table 4.5 lists the receiver adjacent and alternate channel rejection. For the interferer the same channel bandwidth has to be used as for the assigned channel bandwidth. All the measurements are done over 95 % of the channel. The compliant system should be able to meet a Bit Error Rate (BER) $< 10^{-6}$ with the interference levels specified in the tables. Please note that depending on some assumed packet sizes, equivalent Packet Error Rate (PER) criteria can be used alternatively.

Table 4.5: Receiver adjacent and non-adjacent channel rejection

Adjacent channel rejection (dB)	Alternate channelrejection (dB)
20	39

5   UE-UE Co-existence Studies

5.1   Introduction

When a TDD MWA system coexists with a FDD MWA system or an unsynchronized TDD MWA system in adjacent frequency blocks and the same geographic area, the UE to UE interference occurs when two UEs, one from each system, move close to each other while active. This situation usually happens in high user density areas, or hotspots, such as train stations, stadiums, and coffee shops.

This analysis addresses the UE to UE interference scenario for coexistence analysis of introducing Mobile Wireless Access (MWA) systems in the 3,5 GHz band. The following study is based on an input to ECC SE19 (SE19(06)70 [7]), which led to the decision to open the 3 400 MHz to 3 800 MHz band also for mobile use [6]. In SE19(06)70 results are presented assuming that equipment meets the EN 302 326-2 [3] requirements (ETSI mask from EN 302 326-2 [3] EqC-PET=O and EqC-EMO=4). This study presents further results for the case that equipment meets the TS 125 102 [8] requirements for unwanted emission.

A statistical UE to UE interference model based on certain hotspot definitions is used. The proposed statistical UE to UE interference simulation considers the high user density areas (hotspots) instead of assuming uniform user distribution throughout the whole sector. It models the UE to UE interference problem in a more balanced manner than deterministic worst case analysis and statistical analysis using uniform distribution. In particular, this methodology effectively captures the two major intrinsic aspects of the UE to UE interference:

   i.)   the event that two terminal stations come close to each other occurs with certain probability and mostly happens in high user density areas,

   ii.)   the power control scheme can scale down the Tx power of the interfering UE depending on its location relative to the base station.

Similar to the SE19 studies we consider a 7 MHz channel bandwidth along with the EN 302 326-2 [3] standard as the base for technical specifications of MWA UE since it represents the most current harmonized standard for BWA systems in this band. As mentioned earlier we are also using the TS 125 102 [8] beside the EN 302 326-2 [3] for the emission requirements.

5.2   UE to UE Results

In this clause, we present the simulation results for UE to UE statistical simulation with hotspot modeling. We note that the results are dependent upon the parameters and assumptions used in the study, which were chosen according to typical OFDMA based MWA systems in a micro cell setting. We simulated both outdoor hotspots and indoor hotspots scenarios. For both cases, a hotspot radius of 15 m and a guard band of 7 MHz (1 channel) is used.

Results are shown for two different sets of ACLR values, which are detailed in table 5.1. Further analysis and details on the interference mechanisms used in this study can be found in clause C.4.

Table 5.1 ACLR of MWA UE

Emission requirement for MWA UE	ACLR (dB)		
	1st Adjacent	2nd Adjacent	3rd Adjacent and up
EN 302 326-2 [3]	20,9	46,3	60
3GPP ACLR	33	43	53

Due to the probabilistic nature of UE to UE interference, we are mainly interested in the probability of the user experiencing less than 1 dB or 3 dB degradation in SINR due to UE to UE interference and the probability of the user experiencing less than 5 % or 10 % spectral efficiency loss. These quantitative results are summarized in table 5.2.

We assumed that the maximum number of simultaneous active users per sector is 16 to be consistent with the assumptions made in SE19. Normally active users are defined in the sense of users active in a communication session (like in a VoIP call). However, for the purpose of simulation, the concept of simultaneous active users is different. What we are modeling for each snapshot are users who are active simultaneously on a very fine time granularity, i.e., those users that are scheduled to tx/rx within the same frame (or even symbol). In this study, values representing the WiMAX system are assumed. This number is upper-bounded by the total number of available subchannels in the WiMAX system (30 for Partial Usage of Subcarriers (PUSC), and 16 for Adaptive Modulation and Coding (AMC)). A detailed description of the Methodology and Parameters can be found in annex C.

The 1x4x2 frequency reuse pattern used is illustrated below in the frequency domain. Both the interfering and victim systems use 2 consecutive blocks of frequency, each occupies one channel bandwidth.
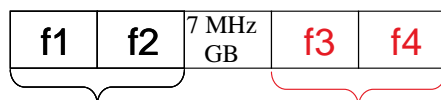

Table 5.2 summarizes the results for a cell radius of 250 m.

Table 5.2: Percentage of the users experiencing "< 1 dB SINR degradation" or "< 3 dB SINR degradation" or "< 5 % spectral efficiency loss" or "< 10 % spectral efficiency loss" for 1 channel (7 MHz) guard band

Emission requirement for UE	Outdoor hotspots				Indoor hotspots			
	< 1 dB SINR degradation	< 3 dB SINR degradation	< 5 % SE loss	< 10 % SE loss	< 1 dB SINR degradation	< 3 dB SINR degradation	< 5 % SE loss	< 10 % SE loss
EN 302 326-2 [3]	96 %	99 %	94 %	97 %	80 %	92 %	76 %	84 %
3GPP ACLR	89 %	97 %	89 %	94 %	52 %	78 %	66 %	75 %

It can be seen from the above results that indoor hotspots have more severe UE to UE interference problem. That is because the users at an indoor hotspot receive weaker desired signal due to penetration loss while the interfering mobile nearby has higher transmitting power to compensate the penetration loss. In our simulation, we assume the hotspots are either all indoor or all outdoor. A hybrid of both indoor and outdoor hotspots could also occur and would give results somewhere between the two scenarios we considered. Further, we also see that the results using 3GPP ACLR values are quite similar to the results using the EN 302 326-2 [3] emission requirements for the outdoor hotspot case. For the indoor case the 3GPP ACLR values show slightly worse results.

The detailed results in the form of cumulative distribution function (CDF) of the SINR degradation (in dB) and CDF of the spectral efficiency degradation (in percentage) for these system settings are presented below. Each figure contains two CDF curves which are plotted in different colors: black curve for ACLR values based on EN 302 326-2 [3] EMO=4 and a red curve for the ACLR values defined in 3GPP.

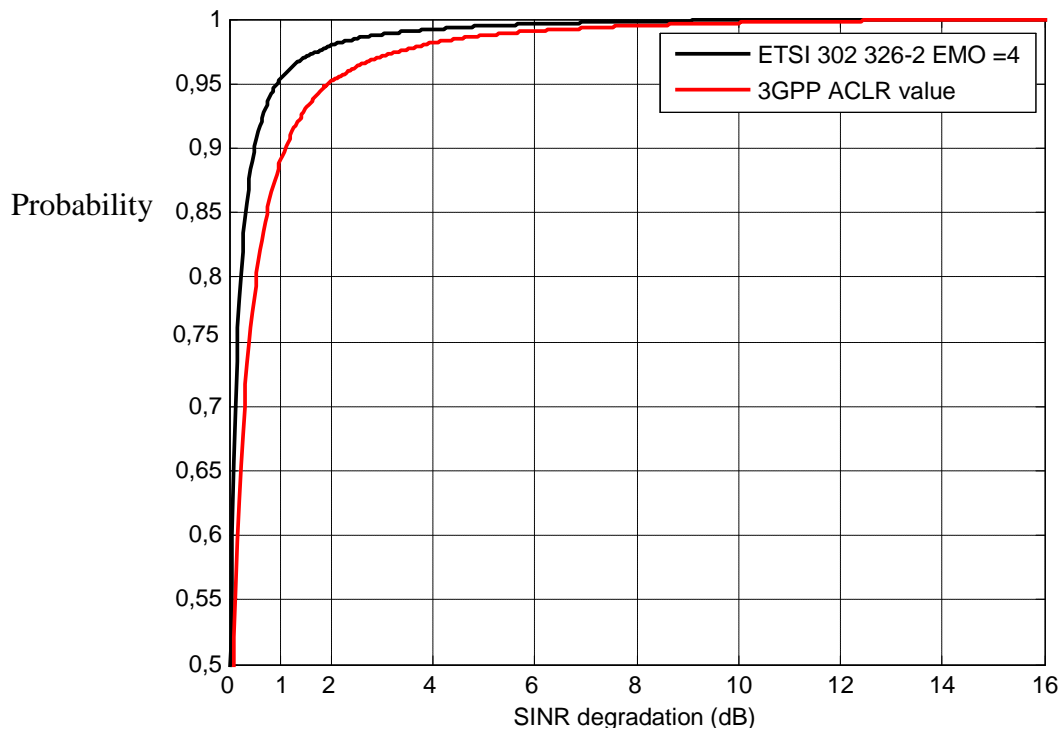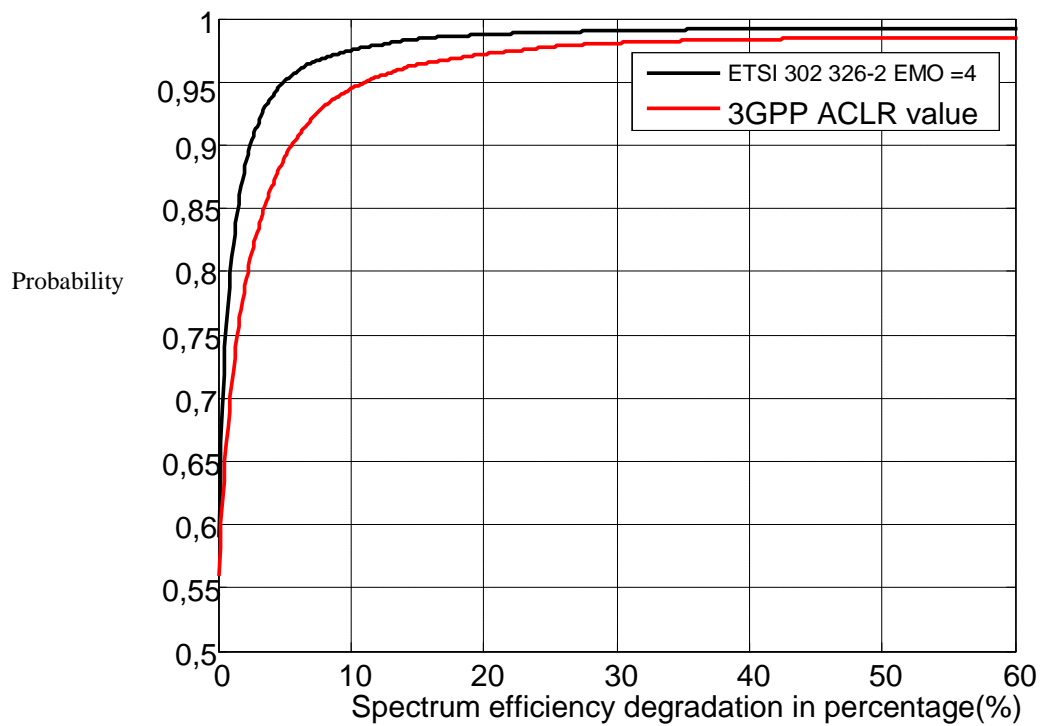## 5.2.1   Outdoor hotspots with 250 m sector radius and 7 MHz guard band

Figure 5.1

Figure 5.2

5.2.2   Indoor hotspots with 250 m sector radius and 7 MHz guard band
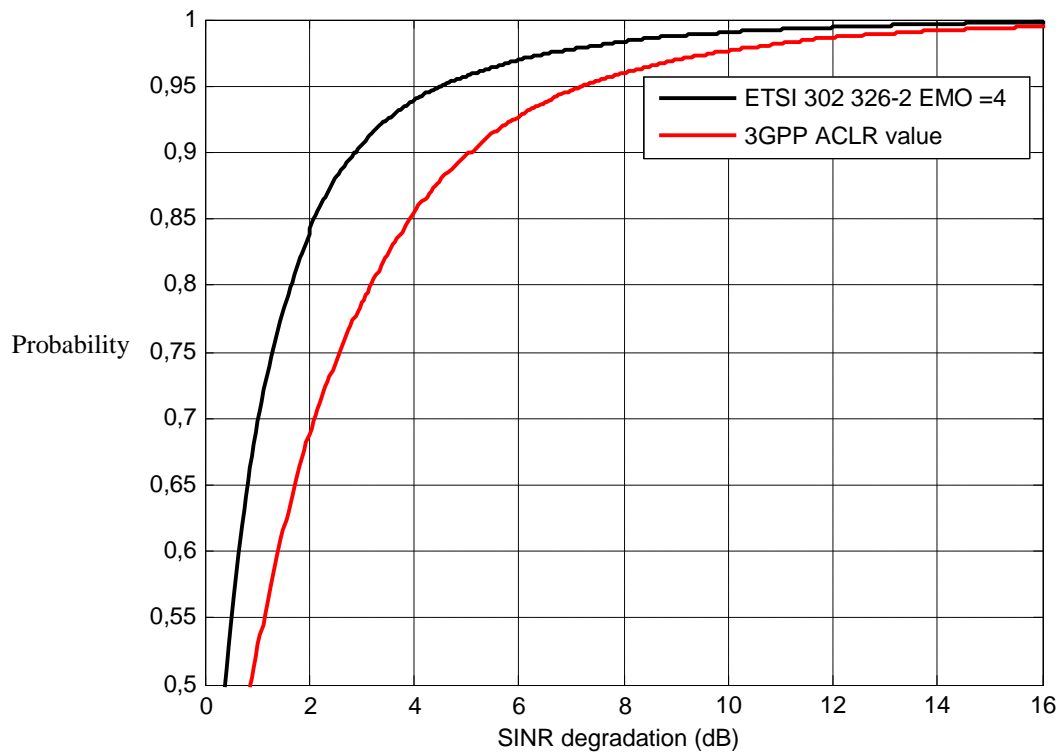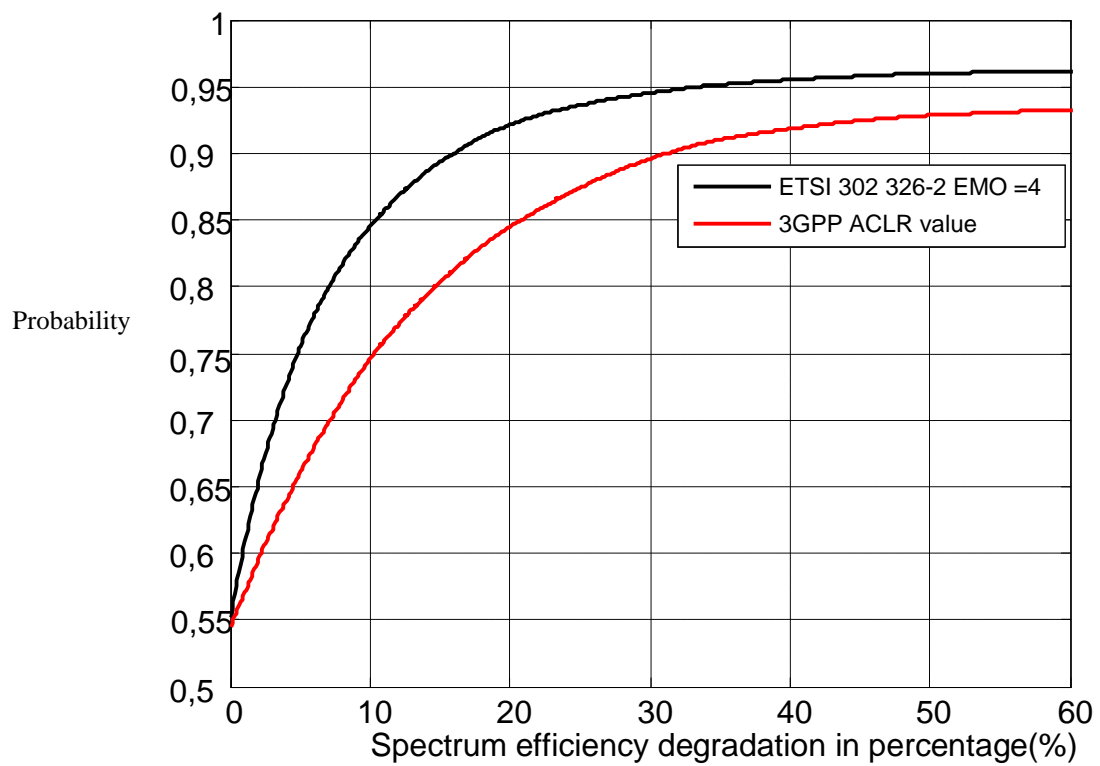

Figure 5.3

Figure 5.4

5.3   Additional Results for a sector radius of 1 000 m - outdoor hotspots

The sector radius of 1 000 m is used to model the situation in suburban area. While we keep the same number of hotspots per sector (3 hotspots) and the same number of users in the hotspot (75 % of users are in the hotspots), it is assumed that the hotspots are located less than 0,8xSector Radius from the base station to consider the effect of cell planning which usually puts the base station closer to high user density areas. Results are shown for outdoor hotspots, again for a 7 MHz guard band. It can be seen that for larger sector radius the UE interference problem gets worse. That is because the victim UEs are more probable to receive lower desired signal due to its distance from the base station and there is also more chance that the interfering UEs transmit at higher power due to power control. Again, like for the 250 m case 3GPP ACLR values give similar results like the emission requirements from EN 302 326-2 [3].
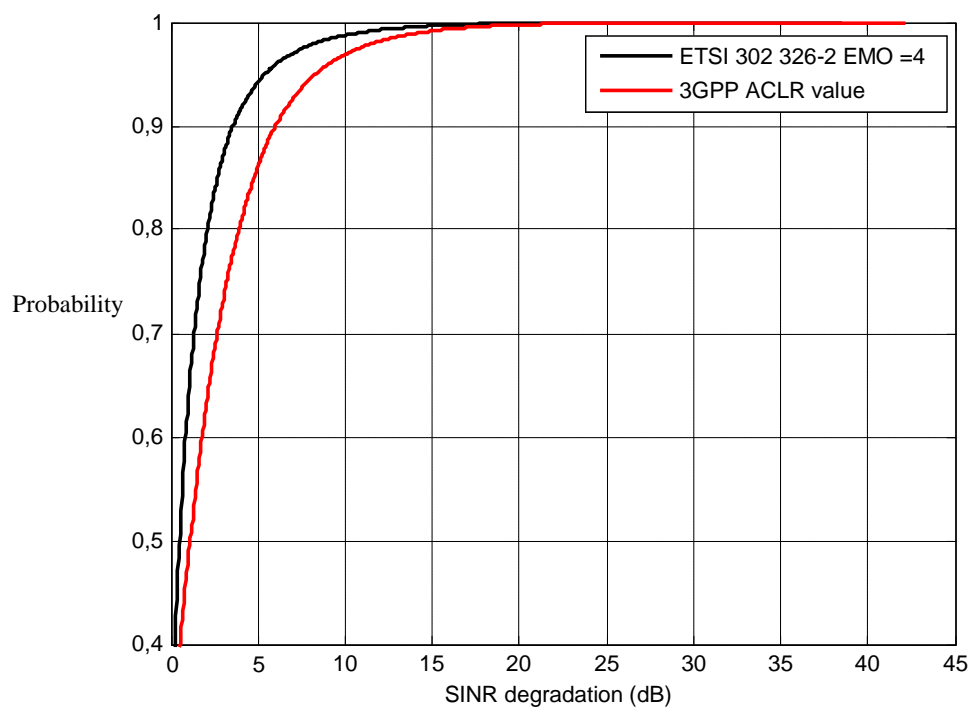
Figure 5.5
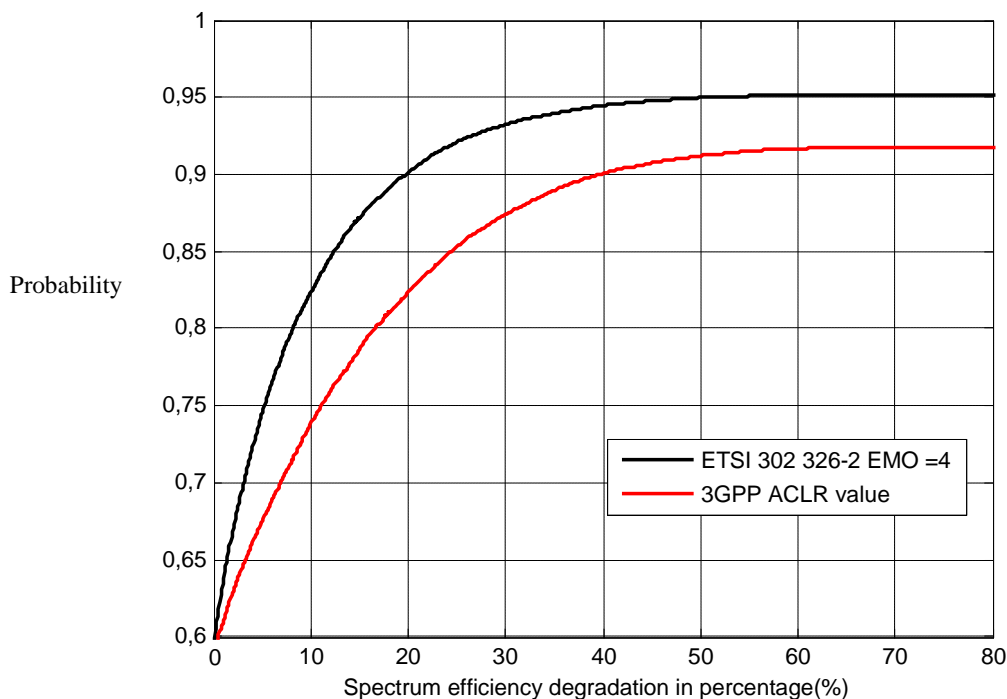
Figure 5.6

5.4   Summary of UE to UE studies

In this clause UE to UE interference studies have been presented, which are from the UE perspective the most critical scenario between two unsynchonized TDD MWA operators or a TDD MWA operator adjacent to an FDD MWA operator.

The presented results are based on the studies done in SE19 [6], [7], however also including results for emission requirements defined in TS 125 102 [8]. Results have been presented for outdoor as well as indoor scenarios assuming a guard band of 7 MHz (1 channel, ECC/REC(04)05 [10]).

From the results we see that using 3GPP ACLR values are quite similar to the results using the EN 302 326-2 [3] emission requirements for the outdoor hotspot case, even for a larger cell radius. For the indoor case the 3GPP ACLR values show slightly worse results.

Annex A:
Transmitter spectrum emission mask

A.1   Definition

Spectrum emission mask defines an out of band emission requirement for the transmitter. These out of band emissions are unwanted emissions outside the channel bandwidth resulting from the modulation process and non-linearity in the transmitter but excluding spurious emissions.

A.2   Limits

A.2.1   Spectrum emission mask for 5 MHz bandwidth

The spectrum emission mask of the TS applies to frequency offsets between 2,5 MHz and 12,5 MHz on both sides of the TS center carrier frequency. The out-of-channel emission is specified as power level measured over the specified measurement bandwidth but relative to the total mean power of the UE carrier measured in the 5 MHz band.

The power of any TS emission should not exceed the levels specified in Table A.1.

Table A.1: Spectrum emission mask requirement (5 MHz option)

Frequency offset Δf	Minimum requirement	Measurement bandwidth
2,5 MHz to 3,5 MHz	$\left\{-33,5-15\times\left(\frac{\Delta f}{MHz}-2,5\right)\right\}dBc$	30 kHz
3,5 MHz to 7,5 MHz	$\left\{-33,5-1\times\left(\frac{\Delta f}{MHz}-3,5\right)\right\}dBc$	1 MHz
7,5 MHz to 8,5 MHz	$\left\{-37,5-10\times\left(\frac{\Delta f}{MHz}-7,5\right)\right\}dBc$	1 MHz
8,5 to 12,5 MHz	-47,5 dBc	1 MHz

NOTE 1: Δf is the separation between the carrier frequency and the centre of the measuring filter.
NOTE 2: The first measurement position with a 30 kHz filter is at Δf equals to 2,515 MHz; the last is at Δf equals to 3,485 MHz.
NOTE 3: The first measurement position with a 1 MHz filter is at Δf equals to 4 MHz; the last is at Δf equals to 12 MHz. As a general rule, the resolution bandwidth of the measuring equipment should be equal to the measurement bandwidth. To improve measurement accuracy, sensitivity and efficiency, the resolution bandwidth can be different from the measurement bandwidth. When the resolution bandwidth is smaller than the measurement bandwidth, the result should be integrated over the measurement bandwidth in order to obtain the equivalent noise bandwidth of the measurement bandwidth.
NOTE 4: Note that equivalent PSD type mask can be derived by applying 10×log (5 MHz/30 kHz) = 22,2 dB and 10×log(5 MHz/1 MHz)= 7 dB scaling factor for 30 kHz and 1 MHz measurement bandwidth respectively.

A.2.2   Spectrum emission mask for 7 MHz bandwidth

The spectrum emission mask of the TS applies to frequency offsets between 3,5 MHz and 17,5 MHz on both sides of the TS center carrier frequency. The out-of-channel emission is specified as power level measured over the specified measurement bandwidth but relative to the total mean power of the TS carrier measured in the 7 MHz band.

The power of any TS emission should not exceed the levels specified in Table A.2.

Table A.2: Spectrum emission mask requirement (7 MHz option)

Frequency offset Δf	Minimum requirement	Measurement bandwidth
3,5 MHz to 4,75 MHz	$\left\{-33,5 - 13.5 \times \left(\dfrac{\Delta f}{MHz} - 3,5\right)\right\}$dBc	30 kHz
4,75 MHz to 10,5 MHz	$\left\{-35,0 - 0.7 \times \left(\dfrac{\Delta f}{MHz} - 4,75\right)\right\}$dBc	1 MHz
10,5 MHz to 11,9 MHz	$\left\{-39,0 - 7 \times \left(\dfrac{\Delta f}{MHz} - 10,5\right)\right\}$dBc	1 MHz
11,9 MHz to 17,5 MHz	-49,0 dBc	1 MHz

NOTE 1: Δf is the separation between the carrier frequency and the centre of the measuring filter.
NOTE 2: The first measurement position with a 30 kHz filter is at Δf equals to 3,515 MHz; the last is at Δf equals to 4,735 MHz.
NOTE 3: The first measurement position with a 1 MHz filter is at Δf equals to 5,25 MHz; the last is at Δf equals to 17 MHz. As a general rule, the resolution bandwidth of the measuring equipment should be equal to the measurement bandwidth. To improve measurement accuracy, sensitivity and efficiency, the resolution bandwidth can be different from the measurement bandwidth. When the resolution bandwidth is smaller than the measurement bandwidth, the result should be integrated over the measurement bandwidth in order to obtain the equivalent noise bandwidth of the measurement bandwidth.
NOTE 4: Note that equivalent PSD type mask can be derived by applying 10×log (5 MHz/30 kHz)= 23,7 dB and 10×log(5 MHz/1 MHz)= 8,5 dB scaling factor for 30 kHz and 1 MHz measurement bandwidth respectively.

A.2.3   Spectrum emission mask for 10 MHz bandwidth

The spectrum emission mask of the TS applies to frequency offsets between 5 MHz and 25 MHz on both sides of the TS center carrier frequency. The out-of-channel emission is specified as a power level relative to the total mean power of the TS carrier measured in the 10 MHz band.

The power of any TS emission should not exceed the levels specified in Table A.3.

Table A.3: Spectrum emission mask requirement (10 MHz option)

Frequency offset Δf	Minimum requirement	Measurement bandwidth
5,0 MHz to 7,0 MHz	$\left\{-33,5 - 9 \times \left(\dfrac{\Delta f}{MHz} - 5,0\right)\right\}$dBc	30 kHz
7,0 MHz to 15,0 MHz	$\left\{-36,5 - 0.5 \times \left(\dfrac{\Delta f}{MHz} - 7,0\right)\right\}$dBc	1 MHz
15,0 MHz to 17,0 MHz	$\left\{-40,5 - 5 \times \left(\dfrac{\Delta f}{MHz} - 15,0\right)\right\}$dBc	1 MHz
17,0 to 25,0 MHz	-50,5 dBc	1 MHz

NOTE 1: Δf is the separation between the carrier frequency and the centre of the measuring filter.
NOTE 2: The first measurement position with a 30 kHz filter is at Δf equals to 10,015 MHz; the last is at Δf equals to 6,985 MHz.
NOTE 3: The first measurement position with a 1 MHz filter is at Δf equals to 7,5 MHz; the last is at Δf equals to 24,5 MHz. As a general rule, the resolution bandwidth of the measuring equipment should be equal to the measurement bandwidth. To improve measurement accuracy, sensitivity and efficiency, the resolution bandwidth can be different from the measurement bandwidth. When the resolution bandwidth is smaller than the measurement bandwidth, the result should be integrated over the measurement bandwidth in order to obtain the equivalent noise bandwidth of the measurement bandwidth.
NOTE 4: Equivalent PSD type mask can be derived by applying 10×log (10 MHz/30 kHz)= 25,2 dB and 10×log(10 MHz/1 MHz)= 10 dB scaling factor for 30 kHz and 1 MHz measurement bandwidth respectively.

Annex B:
General requirements

B.1 Transmitter spurious emissions

B.1.1 Definition

Transmitter spurious emissions are emissions which are caused by unwanted transmitter effects such as harmonics emission, parasitic emission, intermodulation products and frequency conversion products, but exclude Out-of-band emissions.

B.1.2 Limits

Spurious emissions are defined by CEPT/ERC/REC 74-01 [2]. Note, that ITU-R prefer the phrase "unwanted emissions in the spurious domain" instead of "spurious emissions". Both definitions are technically the same.

The following requirements are only applicable for frequencies, which are greater than 250 % of the channel bandwidth (e.g. 12,5 MHz for the 5 MHz, 17,5 MHz for the 7 MHz and 25 MHz for the 10 MHz channel bandwidth) away from the TS centre carrier frequency.

Table B.1: General transmitter spurious emissions requirements

Frequency Band	Measurement Bandwidth	Minimum Requirements
30 MHz $\leq$ f < 1 GHz	100 kHz	-36 dBm
1 GHz < f < 19 GHz	30 kHz If 2,5 x BW $\leq$ $|f_C\text{-}f|$ < 10 x BW	-30 dBm
	300 kHz If 10 x BW $\leq$ $|f_C\text{-}f|$ < 12 x BW	-30 dBm
	1 MHz If 12 x BW $\leq$ $|f_C\text{-}f|$	-30 dBm

B.2 Receiver spurious emissions

B.2.1 Definition

Receiver spurious emissions are emissions at any frequency, when the equipment is in receive mode. The spurious receiver emissions power is the power of emissions generated or amplified in a receiver that appear at the TS antenna connector.

B.2.2   Limits

Receiver spurious emissions are defined by CEPT/ERC/REC 74-01 [2] and defined for the whole frequency range, also within the 250 % of the channel bandwidth across the TS centre carrier frequency.

The power of any spurious emissions should not exceed the limits given in table B.2.

Table B.2: Receiver spurious emission requirements

Frequency Band	Measurement Bandwidth	Minimum Requirements
30 MHz ≤f < 1 GHz	100 kHz	-57 dBm
1 GHz < f < 19 GHz	30 kHz If 2,5 x BW ≤ $|f_C$-f$|$ < 10 x BW	-47 dBm
	300 kHz If 10 x BW ≤ $|f_C$-f$|$ < 12 x BW	-47 dBm
	1 MHz If 12 x BW ≤ $|f_C$-f$|$	-47 dBm

Annex C:
Methodology and Parameters for UE to UE studies

C.1   Methodology

Using the deterministic methodology for UE to UE interference analysis, the worst-case interference scenario is modeled, as i) the mobiles are assumed to operate at maximum transmit power, while in reality, some power control scheme should be in effect so that the mobile scales down its power transmission if it has a good channel to the desired base station; ii) the event that two mobiles come within 1 meter of each other occurs with certain probability, so that the interference problem based on 1 meter separation distance and "1dB desensitization" do not happen all the time and to every mobile.

On the other hand, using the traditional Monte-Carlo simulation assuming uniform user distribution within a cell such as the one used in 3GPP [9] to evaluate UE to UE interference often gives optimistic results. The probability of 2 mobiles coming close to each other under the uniform distribution assumption is very low, resulting in often negligible performance degradation in terms of capacity loss. However, this approach does not take into account some real concerns of the operators - the "hotspot" phenomenon, i.e. high user density areas such as a coffee shop or a sports stadium.

In the following, we develop a statistical model that takes into account the above aspects, including power control and hotspot considerations. The results are expected to give a more realistic, or balanced, picture on UE to UE coexistence.

The statistical methodology is depicted at a high-level in the following flow chart (see figure C.1). The interfering system is denoted as system A. The victim system is denoted system B.
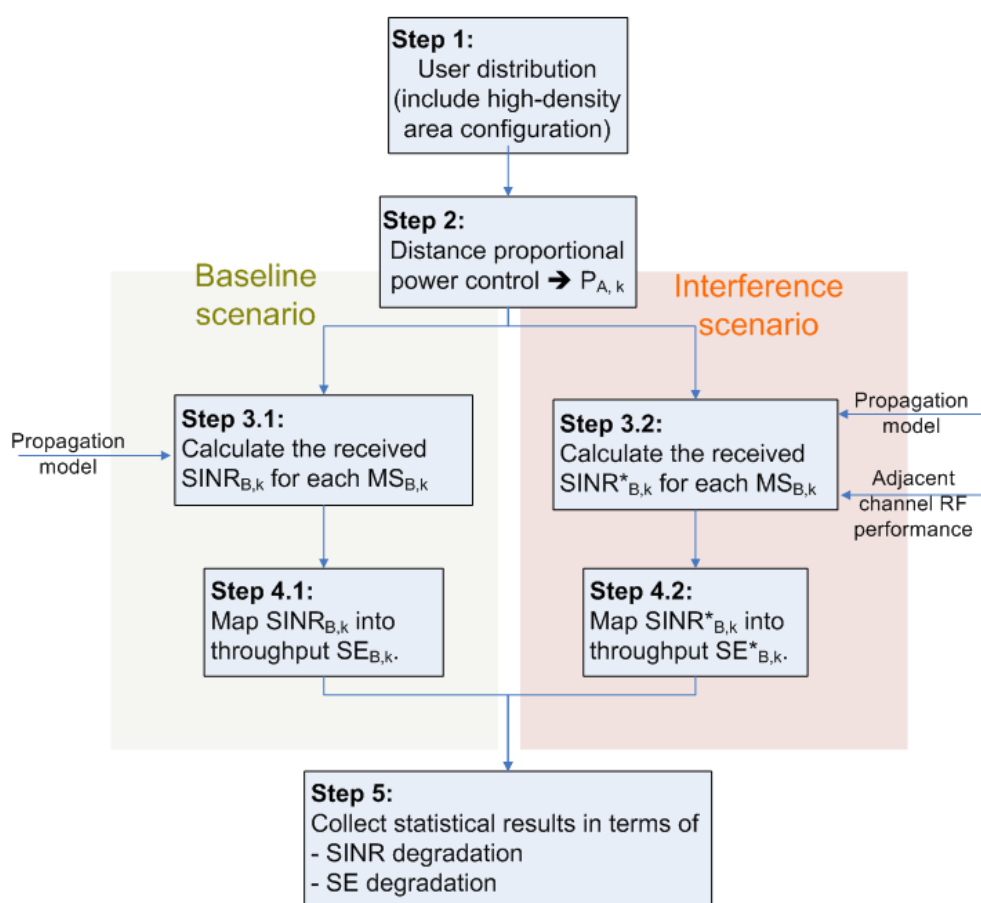

Figure C.1: UE to UE Statistical Methodology

Next, we explain each process box in more detail.

C.1.1   User distribution

First, cells and high-density areas are laid out. For both the interfering system A and the victim system B, cells are square with 1x4x2 reuse pattern, each square has side of $2*R_{cell-A}$ or $2*R_{cell-B}$. The cell radii are denoted as R_{cell-A} and R_{cell-B}, respectively. It is assumed $R_{cell} = R_{cell-A} = R_{cell-B}$ for the time being. It is further assumed for the time being that the base stations of the two systems are co-located so that the cells completely overlap each other, as shown in figure C.2. The victim cell simulated is shown as the red dashed center cell. Nine interfering cells surrounding the victim cell are simulated. The 1x4x2 frequency reuse pattern is illustrated in figure C.3 in the frequency domain. Both the interfering and victim systems use 2 consecutive blocks of frequency, each occupies one channel bandwidth. The guard band between the two systems is assumed to be 7 MHz (1 channel) according to REC(04)05 [10].
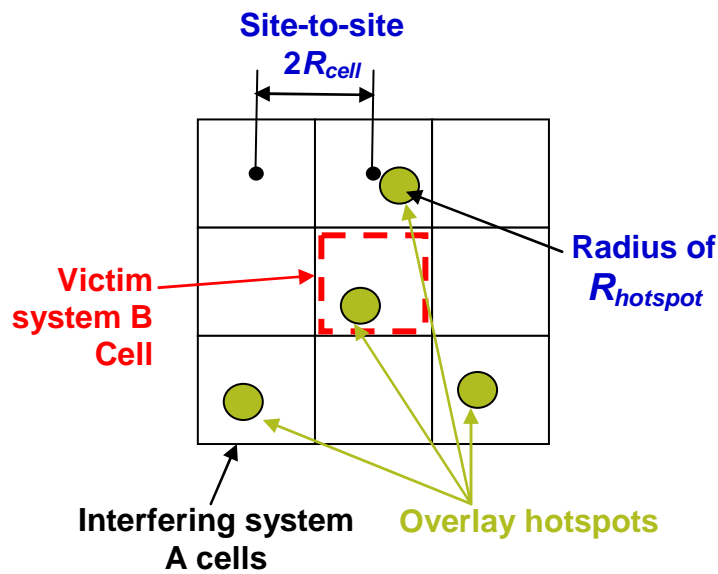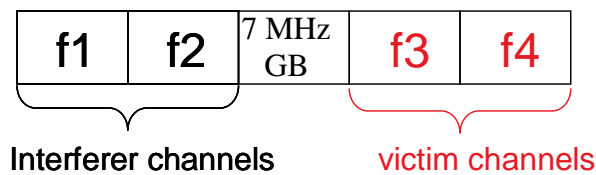
Figure C.2: Cell and hotspot layout

Figure C.3: 1x4x2 cell reuse

Hotspots, or high user density areas, are dispersed randomly throughout the cell as explained next. Let $R_{Hotspot}$ denote the hotspot radius. It is assumed that all hotspots have a circular shape (completely defined by $R_{Hotspot}$) for the time being. It is assumed that N_h hotspots are dispersed within each sector. Notice that these high density areas are by definition areas where cellular users congregate, such as a coffee shop or sports stadium. Hotspots are common to both systems, i.e., both the interfering system and the victim system serve users within the hotspot at the same time. Hotspots can be indoor (coffee shop) or outdoor (stadium).

The center of each hotspot is randomly distributed within the *eligible area* within a sector. An example eligible area (shaded) is depicted in figure C.4. The boundary lines exist so that hotspots will not be partially outside of the sector area or ride across sectors.
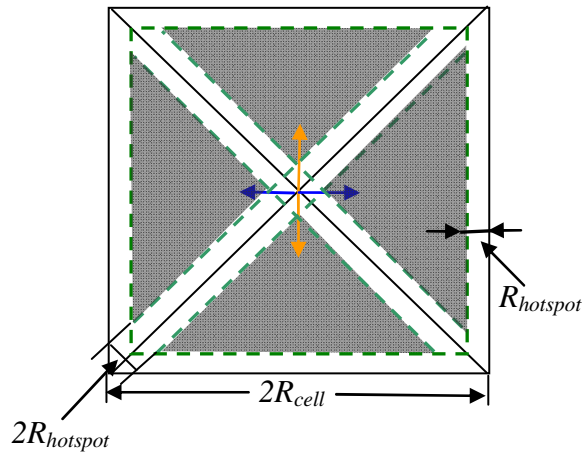
Figure C.4: Eligible area for hotspot center

Let N_{max} be the maximum number of simultaneously active users in one system. We assume N_{max} =16 to be consistent with the assumptions made in SE19. Out of the N_{max} users, we assume that *p%* of them are in the hotspot, while the remaining 1- *p%* are in the non-hotspot region of the sector. Users are distributed randomly within the hotspot/sector based on these numbers. Users within an indoor hotspot are indoor users, and users within an outdoor hotpot are outdoor users. This has an impact on the propagation modeling used for these hotspot users.

C.1.2   Distance proportional power control

Power control is only simulated for all the UEs in the interfering system A (uplink). It is not necessary for the UEs in the victim system B (downlink assuming always use BS full power). The result of the power control procedure is each terminal station's transmit power $P_{A,k}$. Distance proportional power control is assumed and its procedure can be described as follows:

1)   Set $P_{A,k}$ the transmit power of each UE as Max_Tx_power.

2)   Calculate C/I based on transmission loss which combines both path loss and antenna gains.

3)   If C/I > target C/I (in dB), reduce $P_{A,k}$ by Δ = C/I – target C/I (in dB).

The Erceg model type B [11] is used for the UE to BS path loss.

C.1.3   Calculate received SINR for each victim UE

In this step, the received $SINR_{B,k}$ for each victim $MS_{B,k}$ is calculated. Step 3.1 considers a baseline scenario where only system B operates. In Step 3.2, inter-system interference is introduced by turning system A on as well. These are described in more detail below.

C.1.3.1   Baseline Scenario (no inter-system interference)

For the baseline scenario, a single system is simulated which is the victim system.

The objective is to calculate the received $SINR_{B,k}$ for each victim terminal station. In order to do this, the received signal strength and received interference plus noise are both calculated.

The received signal strength is calculated using the following equation:

$$P_r \text{ (dBm)} = P_T \text{ (dBm)} - PL \text{ (dB)} - X_\sigma \text{ (dB)} + G_A \text{ (dB)} - ML \text{ (dB)}$$

where P_T is the base station transmit power, PL is the distance-based pathloss based on the Erceg model type B as described in clause C.3, and X_σ is the log-normal shadowing correction term with σ=8 dB. G_A is the sum of the two antenna gains. ML is the total miscellaneous losses at both ends (cable loss, body loss, etc.).

The received interference plus noise is calculated using the following equation:

$$I = \sum_{\text{all BS in system B}} I_{BS_i,B} + \text{noise.}$$

Notice that in the cell-layout shown in figure C.2, only 1 victim cell is modeled so that the intra-system interference from other base stations is not explicitly modeled. However, the value for intra-system interference derived from a separate single system simulation with 5-by-5 25-cell layout and presented in SE19(06)54 [12] is used as an input to this simulation. Again, the Erceg model type B and the log-normal shadowing correction term are both considered when considering the interference from other base stations.

C.1.3.2 Interference Scenario (with inter-system interference)

In this scenario, when calculating interference received by $MS_{B,k}$, the inter-system interference is considered in addition to the intra-system interference as considered in the baseline scenario.

For each victim $MS_{B,k}$, an interference circle is defined to be a circle centered at the mobile itself with radius r_{interf}. It is assumed that any interfering terminal station $MS_{A,k}$ causes inter-system interference to $MS_{B,k}$ if and only if it falls within the interference circle. In other words, for $MS_{A,k}$ outside the interference circle the interference is negligible. For the time being, it is assumed that the interference circle has a radius of 20 meters for all victim terminal stations.

Therefore, the inter-system interference is calculated by adding up all the interference from $MS_{A,k}$ which lies within the interference circle. This would require changing the equation for computing received interference plus noise to:

$$I = \sum_{\text{all BS in system B}} I_{BS_i,B} + \sum_{\text{all } MS_{A,k} \text{ in interference circle}} I_{MS_k,A} + \text{noise}$$

In particular, the inter-system interference term can be further expanded to

$$\sum_{\text{all } MS_{A,k} \text{ in interference circle}} I_{MS_k,A} = \sum_{\text{all } MS_{A,k} \text{ in interference circle}} (P_{A,k} - PL + G_A - ML - ACIR)$$

where G_A is the sum of the two antenna gains. ML is the total miscellaneous losses at both ends (cable loss, body loss, etc.). $P_{A,k}$ is the interfering station's transmit power as derived by step 2, and ACIR is the Adjacent/Alternate Channel Interference Ratio, which characterizes the adjacent/alternate channel RF performance and is a function of the amount of guard band (see clause C.4 for more details). To calculate pathloss PL, the free-space propagation model is used. This is a reasonable model for the LOS condition that typical holds when evaluating the interference from $MS_{A,k}$ within the interference circle.

In particular, ACIR is calculated following the methodology used by ITU-R:

$$ACIR = \frac{1}{\dfrac{1}{ACLR} + \dfrac{1}{ACS}}$$

where ACLR is the Adjacent Channel Leakage Ratio for the adjacent channel, and ACS is the Adjacent Channel Selectivity for the adjacent channel.

C.1.4 Map SINR into throughput

In this step, the received SINR level is mapped into an achievable spectral efficiency based on the spectral efficiency vs. SINR curve (figure C.5).
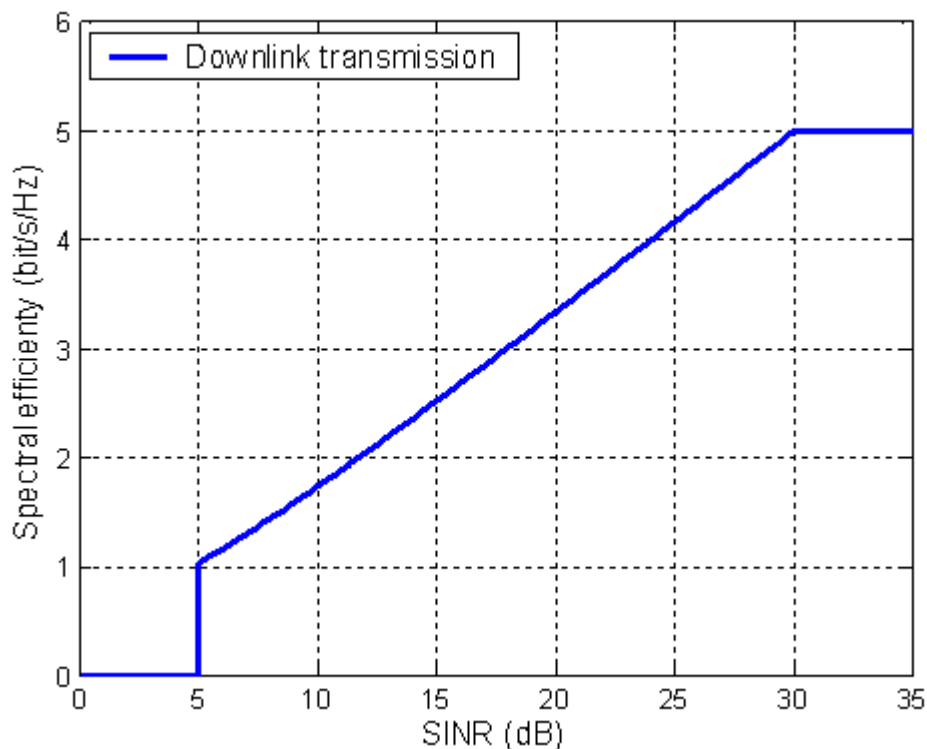
Figure C.5: Spectral efficiency vs. SINR curves

The spectral efficiency vs. SINR curve shown in figure C.5 uses the following truncated and shifted Shannon equation:

$$\text{Spectral Efficiency (b/s/Hz)} = \begin{cases} 0 & \text{for SINR} < \text{SINR}_{\text{MIN}} \\ \alpha.\log_2(1+10^{\text{SINR/10}}) & \text{for SINR}_{\text{min}} < \text{SINR} < \text{SINR}_{\text{MAX}} \\ \text{SE}_{\text{MAX}} & \text{for SINR} > \text{SINR}_{\text{MAX}} \end{cases}$$

Where: α Attenuation factor, representing implementation losses
        SINR_{MIN} Minimum SINR, dB
        SE_{MAX} Maximum throughput, b/s/Hz
        SINR_{MAX} SINR at which max spectral efficiency is reached, dB

The link level simulation of spectral efficiency vs. SINR is simulated for different coding and modulation schemes. The parameters of the modified Shannon equation are then obtained by approximating the curve to the link level simulation curve.

Parameter	Downlink BS → UE
	0,5
SINR_{MIN} (dB)	5
SINR_{MAX} (dB)	30
SE_{MAX}, (b/s/Hz)	5,0

The curve is also used in 3GPP for EUTRA coexistence studies [13].

C.1.5   Collect statistical results

By this time, associated with each victim $MS_{B,\,k}$ are its baseline SINR, $SINR_{B,\,k}$, and the SINR with inter-system interference, $SINR^*_{B,k}$, as well as the baseline spectrum efficiency, $SE_{B,k}$, and the spectrum efficiency with inter-system interference, $SE^*_{B,k}$. Let D_{SINR} be the degradation in SINR for each terminal station, and $X_{deg}\%$ be the degradation in spectrum efficiency for each mobile, which are given by:

$$D_{SINR}(\text{dB}) = \left| SINR^*_{B,k} - SINR_{B,k} \right|$$

$$SE_{\text{deg}}(\%) = \frac{\left| SE^*_{B,k} - SE_{B,k} \right|}{SE_{B,k}} \bullet 100\%$$

The Cumulative Distribution Function (CDF) of the degradation in SINR (D_{SINR}) and in spectrum efficiency ($SE_{deg}\%$) can then be derived over the entire victim mobile population.

C.2   System Parameters

Table C.1 shows the system parameters for MWA systems.

Table C.1: System parameters of MWA systems

	Base Station	User Equipment
Carrier frequency	3,5 GHz	
Channel Bandwidth	7 MHz	
Multiple Access	OFDMA	
FFT size	1024	
Subcarrier spacing	7,81 kHz	
Used number of subcarriers	864	
Number of subchannels	16 (Adaptive Modulation and Coding (AMC) mode in IEEE 802.16e [16])	
Number of active users Per sector	16	
System layout	90°-sector layout	
Frequency reuse	1x4x2	
Cell radius	250 m	
Max Tx Power	33 dBm	24 dBm
Antenna pattern	60 deg (-3 dB) 30 dB front-to-end attenuation (see note 1)	Omni-directional
Antenna height	30 meters	1,5 meter
Antenna gain	16 dBi	-2 dBi
Body Loss	N/A	-2 dBi
Noise figure	4 dB	7 dB
Critical C/I (UL ATPC Target)	14 dB	14 dB
Unwanted emission	EN 302 326-2 [3] (see note 2)	EN 302 326-2 [3] and TS 125 102 [8] (see note 2)

NOTE 1: For MWA systems, the terminal stations have omni-directional antennas and the following antenna pattern [14] is used for base station.

$$A(\theta) = -\min\left[12\left(\frac{\theta}{\theta_{3dB}}\right)^2, \ A_m\right] \quad \text{where} \quad -180 \le \theta \le 180$$

$\theta_{3dB} = 60^0$ is the 3dB beam width, and $A_m = 30dB$ is the maximum attenuation. Figure C.6 shows the antenna pattern.
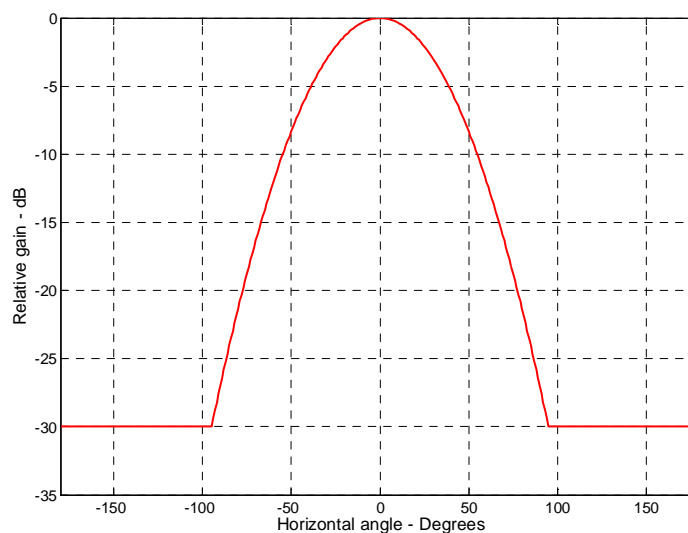

Figure C.6: Antenna pattern for MWA BS

NOTE 2: For MWA base station, the ETSI mask (EN 302 326-2 [3] EqC-PET = O and EqC-EMO = 6) is assumed. For MWA UE, it is assumed that the equipment meets either the ETSI 302 326-2 requirement (EqC-PET = O and EqC-EMO = 4) or the TS 125 102 [8] requirements for unwanted emission.

Parameters related to cell/hotspot layout and user distribution are listed in table C.1a:

Table C.1a

Parameter	Suggested value	Note
Rcell-A	250 m	Sector radius of system A
Rcell-B	250 m	Sector radius of system B
RHotspot	15 m	Hotspot radius
Nh	3 hotspots/sector	Number of hotspots/sector
Nmax	16 users	Maximum number of simultaneously active users/sector
p%	25 % in each hotspot and 75 % in all hotspots	Percentage of active users in all hotspots
C/Itarget	14 dB	Target signal strength for UL power control (same target for system A and B)
rinterf	20 m	Radius of interference circle Freespace pathloss assumed within the interference circle

C.3 Propagation Models

The Erceg model type B [11] is used for the path loss between MWA base station and MWA UE.

$$PL(d \text{ in m}) = A + 10 (a - b\, h_b + c/h_b) \log(d/d_0) + \Delta PL_f + \Delta PL_h + s, \text{ for } d > d_0,$$

where:

- $A = 20 \log(4 \pi d_0 / \lambda)$, λ in m;

- h_b: the height of base station antenna in m (between 10 m to 80 m);

- $d_0 = 100$ m;

- s: lognormal shadowing (std. dev. 8,2~ 10,6 dB);

- Model parameters:

Model parameters	Type A	Type B	Type C
A	4,6	4	3,6
B	0,0075	0,0065	0,005
C	12,6	17,1	20

- ΔPL_f: frequency correction term, $\Delta PL_f = 6 \log(f \text{ in MHz})/2\,000)$;

- ΔPL_h: receive antenna height correction term, h in m:

$$\Delta PL_h = -10,8 \log(h/2) \quad \text{(type A and B)};$$

$$= -20 \log(h/2) \quad \text{(type C)}.$$

It should be mentioned that when the UE is indoor, a 10 dB penetration loss is added to the path loss.

The free space propagation model is used for the path loss between interfering UE and victim UE. Let *f* be the operating frequency in MHz, and *d* be the separation distance between the transmitter and receiver in km. We will use the free-space pathloss formula assuming LOS conditions:

$$PL(dB) = 20\log(d) + 20\log(f) - 27,56$$

Using f = 3 500 MHz, we get   *PL (dB)* = 43,3 + 20×log(*d*), where *d* is in m.

C.4 Interference Mechanisms Considered

Two interference mechanisms can be considered: interfering transmitter unwanted emission and receiver filtering imperfection.

To analyze the combined effect of these two interference mechanism, the analytical methodology that is widely used by ITU-R and 3GPP [14] and [15] were adopted. First, the two interference mechanisms are modeled by the following two parameters:

- Adjacent Channel Leakage Ratio (ACLR) (transmitter unwanted emission mechanism) is the portion of interfering Tx power which leaks into the victim Rx channel (integrated over the Rx channel bandwidth). ACLR is thus a measure of the transmitter performance. Power received by the victim receiver due to unwanted emission = Transmit Power *P*/*ACLR*.

- Adjacent Channel Selectivity (ACS) (receiver filtering mechanism) is the portion of Tx power which is picked up from the interferer Tx by the overlap of the victim receiver filter with the Tx bandwidth. ACS is thus a measure of the receiver performance. Power received by the victim receiver due to receiver filtering imperfection = Transmit Power *P*/*ACS*.
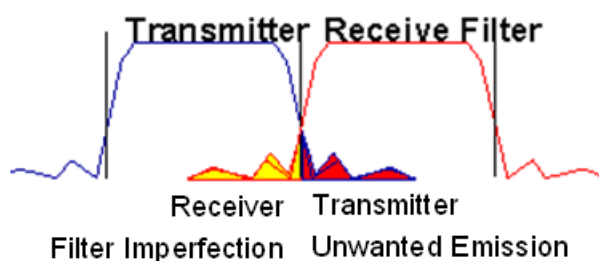

Figure C.7: Two interference mechanisms

The combined interference power of these two mechanisms, *I*, can be written as:

$$I = P/ACLR + P/ACS = P (1/ACLR + 1/ACS).$$

Therefore, $P/I = 1/(1/ACLR + 1/ACS)$.

This ratio is termed Adjacent Channel Interference Ratio (ACIR) and can be expressed as:

$$ACIR = \frac{P}{I} = \frac{1}{\frac{1}{ACLR} + \frac{1}{ACS}}$$

ACIR is therefore defined as the ratio of the transmission power to the interference power measured after a receiver filter in the victim channels. It should be emphasized that when one of the two factors is much smaller than the other, *ACIR* will be dominated by the smaller one. In such case, the larger factor can be omitted.

C.4.1 Derivation of ACLR from Unwanted Emissions

ACLR is defined as the ratio of transmit power over transmit leakage power on the victim receiver bandwidth. Therefore, given the unwanted emission and the frequency separation between the interfering transmitter bandwidth and the victim receiver bandwidth, the transmit leakage power can be obtained by integrating the emission power density over the victim bandwidth. Once we have the transmit leakage power, ACLR can be derived according to

ACLR = Transmit power / Transmit leakage power.

For MWA UE, the ACLR values are calculated for EN 302 326-2 [3] emission requirement. Further the ACLR values from the TS 125 102 [8] specifications are used. Notice that we made the assumption that the emission level further decreases by 10 dB for more than 2 channels away (3rd adjacent channel and up) which gives us an ACLR of 60 dB for 3rd adjacent channel and up.

Table C.2: ACLR of MWA UE

Emission requirement for MWA UE	ACLR (dB)		
	1st Adjacent	2nd Adjacent	3rd Adjacent and up
EN 302 326-2 [3]	20,9	46,3	60
3GPP ACLR	33	43	53

In the simulation, since victim UE is allocated one subchannel instead of using the whole channel bandwidth, the ACLR value needs to increased accordingly by 10 log(Num of Subchannels) when calculating the intersystem interference level for victim UE.

C.4.2 Derivation of ACS from Adjacent/Alternate Channel Rejection (ACR) Performance

The adjacent/alternate channel rejection performance is typically measured using the following procedure. First, the BER performance is measured at receiver sensitivity without any interference. Then the desired signal strength is raised 3 dB above the rate dependent receiver sensitivity, and power level of the interfering signal is raised until the same BER is obtained. The power difference between the interfering signal and the desired channel is the corresponding adjacent/alternate channel rejection depending on the frequency location of the interference signal. In other words, we want to obtain same performance (e.g. BER, FER) when operating at Sensitivity without interference, and when operating at Sensitivity +3dB in presence of interference. Therefore, the following Equation holds:

$$SNR_{\min} = \frac{Sensitivity}{N} = \frac{[Sensitivity + 3dB]}{N + \frac{P}{ACS}} = \frac{2 \times Sensitivity}{N + \frac{P}{ACS}}$$

where P = interference power and N is the noise power.

Based on the above Equation, ACS can be expressed as:

$$ACS = \frac{P}{N}$$
$$= SNR_{\min} + 3dB + Adjacent/Alternate\,Channel\,Rejection$$

The relationship between ACS, SINR$_{\min}$, and Adjacent/alternate channel rejection are illustrated in figure C.8.
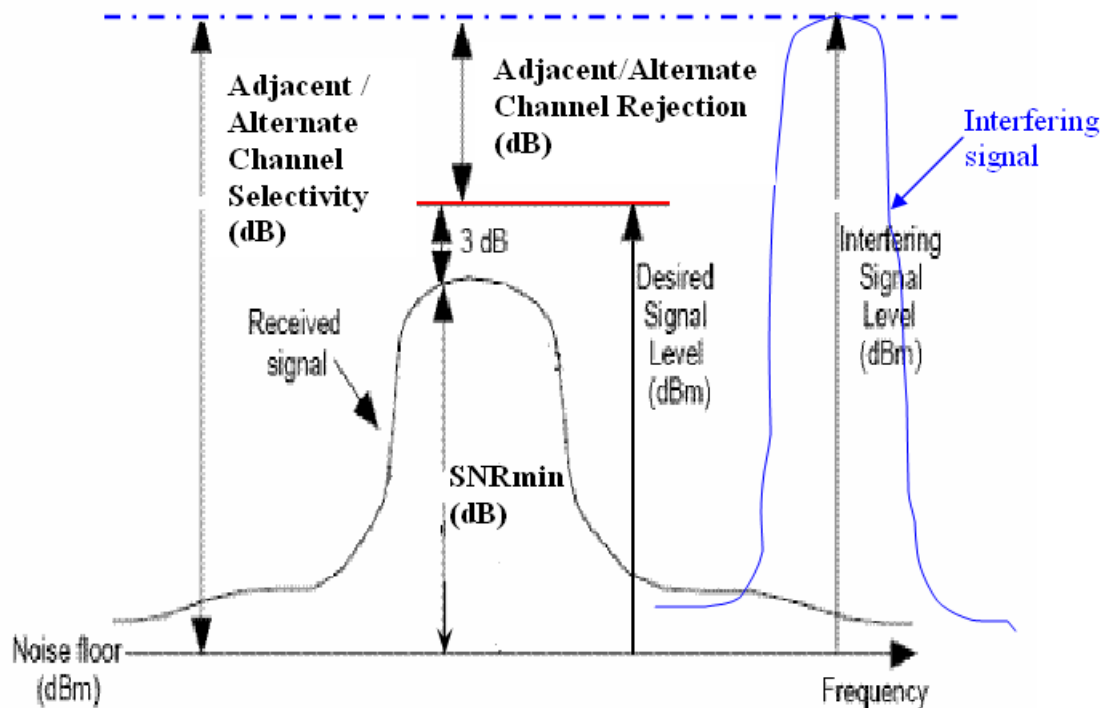
Figure C.8: The illustration of ACS, SINR$_{min}$, and Adjacent/alternate channel rejection

For MWA UE, the ACS values are derived from the ACR specification in IEEE 802.16e [16] standard, which are shown in table C.4. We assumed the ACS performance for more than 2nd adjacent channel is 10 dB better than that for 2nd adjacent channel.

Table C.3: ACS of MWA MS

ACS (dB)		
1st Adjacent	2nd Adjacent	3rd Adjacent and up
28	47	57

Table C.4: Adjacent and Alternate Channel Rejection - OFDMA

Modulation/coding	Adjacent channel rejection (dB)	Alternate channel rejection (dB)
16QAM-3/4	11	30
64QAM-3/4	4	23

History

Document history		
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