CEPT ECC
Electronic Communications Committee

ECC Report 191

Adjacent band compatibility between MFCN and PMSE audio applications in the 1785-1805 MHz frequency range

September 2013

0 EXECUTIVE SUMMARY

0.1 STUDIES INCLUDED IN THE REPORT

The purpose of this Report is to find conditions for operation of PMSE audio equipment (wireless microphones) in the frequency band 1785-1805 MHz. This frequency range corresponds to the duplex gap of the 1710-1785/1805-1880 MHz mobile band.

This report considers interference in both directions between PMSE equipment operating in the band 1785-1805 MHz and public mobile network equipment operating in the bands 1710-1785 MHz and 1805-1880 MHz. The studies in this report consider mainly the interference scenarios where audio PMSE equipment interferes with mobile network equipment, i.e. PMSE equipment interferes with mobile base station receiving below 1785 MHz and PMSE equipment interferes with mobile terminal receiving above 1805 MHz. The report considers a total of 16 scenarios corresponding to a specific combination of the following options:

- Indoor/outdoor;
- PMSE interferes MFCN or MFCN interferes PMSE;
- MFCN BS or MFCN UE;
- MFCN equipment is LTE or GSM.

0.2 METHODS CARRIED OUT IN THE REPORT

The report is based on several methods.

- Method 1: Monte-Carlo simulations carried out with the SEAMCAT tool, provided in ANNEX 1:
- Method 2: Minimum Coupling Loss (MCL) analysis, provided in ANNEX 2:
- Method 3: Analysis based on the method adopted in CEPT Report 30 [3], provided in ANNEX 3:

0.3 RESULTS

0.3.1 Results of the studies

The Method 1 (Monte-Carlo simulations, ANNEX 1:) assumes specific PMSE equipment parameters (e.g. spectrum emission mask, power, system bandwidth) and aims at deriving the needed restricted frequency range between the audio PMSE equipment and the mobile equipment in adjacent bands for PMSE using these parameters.

The methods in ANNEX 2: and ANNEX 3: aim at deriving a Block Edge Mask, with specific in-band and out of band allowed emission levels, without preliminary assumption on PMSE power, spectrum emission mask or system bandwidth.

It was shown that PMSE is able to find an operational channel with sufficient QoS with the assumption of certain spatial distances (see section A2.2) between the PMSE equipment and the MFCN equipment.

However, it should be noted that the analyses are limited to cases where there is an interference risk (both audio PMSE equipment and mobile terminal/base station are in operation), without taking into account the probability of such scenario which is related to the market penetration of audio PMSE equipment and mobile systems. The analyses also consider MFCN equipment operating at the edge of their band, which may not always be the case, especially in the case of GSM.

Additionally, scenarios corresponding to LTE mobile system equipment are based on 10 MHz channel bandwidth. The PMSE system is based on 200 kHz channel bandwidth. Impact of LTE bandwidths other than 10 MHz has not been studied in this report.

For the scenarios corresponding to mobile equipment (both terminals and base stations) interfering with audio PMSE equipment, duplex filters in the LTE macro base station and in the user equipment.are considered.The conclusions of this report do not guarantee that audio PMSE equipment will be able to operate in all the compatibility scenarios, but identifies the scenarios and technical conditions under which PMSE could be operated with sufficient QoS, whilst not creating interference to mobile systems in adjacent bands. These studies contain only analogue PMSE devices but the conclusions might be applied also for digital PMSE devices with low audio latency requirements.

0.3.2 BEM[1] proposal for PMSE audio applications in the frequency band 1785-1805 MHz

Table 1: BEM for handheld microphone

	Frequency Range	Handheld e.i.r.p.	Reasoning
OOB	< 1785 MHz	-17 dBm/200kHz	LTE UE spectrum emission mask
Restricted frequency range	1785-1785,2 MHz	4 dBm/200kHz	Blocking of GSM BS
	1785,2-1803,6 MHz	13 dBm/channel	
	1803,6-1804,8 MHz	10 dBm/200kHz*	Slow increase of LTE UE selectivity
Restricted frequency range	1804,8-1805 MHz	-14 dBm/200kHz	Blocking of GSM UE
OOB	> 1805 MHz	-37 dBm/200kHz	OOB calculation, in line with ERC/REC 74-01

* with a limit of 13 dBm/channel

Table 2: BEM for body worn microphone

	Frequency Range	Body worn e.i.r.p.	Reasoning
OOB	< 1785 MHz	-17 dBm/200kHz	LTE UE spectrum emission mask
	1785-1804,8 MHz	17 dBm/channel	
Restricted frequency range	1804,8-1805 MHz	0 dBm/200kHz	Blocking of GSM UE
OOB	> 1805 MHz	-23 dBm/200kHz	OOB calculation*

* For the body worn case the body loss is 14 higher than for the handheld case, therefore the -23 dBm for body worn is equivalent to -37 dBm for handheld.

0.3.3 Impact on PMSE

The studies regarding the impact on PMSE show that PMSE is able to find an operational channel with a sufficient QoS. To show the impact of the out-of-band emissions of the LTE equipment, the probability of interference was determined. Details see in Table 25 in ANNEX 1:, section A1.3.

For the case that the MFCN LTE macro BS and PMSE are located both outdoor a separation distance of 100 m is sufficed to ensure that PMSE has the possibility to find an operational channel. The operation of PMSE equipment in the same room/hall where a MCFN LTE pico station is used should be avoided, unless additional mitigation techniques are applied. For frequency offsets larger than 1 MHz and 100m separation, the impact of the MFCN LTE base station can be neglected. The probability of interference is considerably relaxed, if PMSE is operated indoor and the MFCN LTE base station is located outdoor due to the wall attenuation. In that case PMSE could find an operational channel with a sufficient QoS.

[1] In this case BEM is taken to be specific to audio PMSE applications under study.

If the frequency separation between LTE UE and the PMSE receiver is more than 10 MHz the probability of interference from the LTE UE is negligible. The probability of interference from the LTE macro BS increases if the frequency separation to the LTE macro BS decreases.

It is important to note that the studied interference scenarios may not happen in most cases where PMSE is looking to be deployed if relevant setup procedures (see Annex 5) are applied by PMSE users.

The most critical case is if the PMSE receiver is close to a transmitting MFCN pico BS. If this separation distance is increased, the probability of interference decreases accordingly. Concerning the impact from MFCN UE into PMSE, real UE will have better out-of-band emission performance than in the published ETSI standards (e.g. through the implementation of duplex filtering) and this will significantly reduce the probability of interference into PMSE receivers.

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LIST OF ABBREVIATIONS

Abbreviation	Explanation
3GPP	3rd Generation Partner Project
ACLR	Adjacent Channel Leakage power Ratio
ACS	Adjacent Channel Selectivity
ARFCN	Absolute Radio-Frequency Channel Number
BEM	Block Edge Mask
BS	Base Station
BTS	Base Transceiver Station
BW	Bandwidth
CEPT	European Conference of Postal and Telecommunications Administrations
DEC	Decision
DL	Downlink
ECC	Electronic Communications Committee
e.i.r.p.	equivalent isotropically radiated power
EN	European Norm
ERC	European Radiocommunications Committee
ETSI	European Telecommunications Standards Institute
EUTRA	Evolved Universal Terrestrial Radio Access
FDD	Frequency Division Duplex
FFT	Fast Fourier Transform
FSPL	Free Space Propagation Loss
GSM	Global System for Mobile communications
IB	In-Band
IEEE	Institute of Electrical and Electronics Engineers
IMT	International Mobile Telecommunication
INR	Interference to Noise Ratio
ITU	International Telecommunication Union
LTE	Long Term Evolution
MCL	Minimum Coupling Loss
MFCN	Mobile/Fixed Communications Networks
MS	Mobile Station
N/A	Not Available
NF	Noise Figure
OOB	Out-Of-Band
PI	Power of Interference
PMSE	Programme Making and Special Events
QoS	Quality of Service
RB	Resource Block
REC	Recommendation
RF	Radiofrequency
RFR	Restricted Frequency Range
RR	Radio Regulations
SEAMCAT	Spectrum Engineering Advanced Monte Carlo Analysis Tool

SINR	Signal to Interference and Noise Ratio
SM	Spectrum Management
TR	Technical Report
TS	Technical Specification
TS	Terminal Station
UE	User Equipment
UL	Uplink
UMTS	Universal Mobile Telecommunications System

1 INTRODUCTION

In Europe, the band 1785-1800 MHz is harmonised for radio microphones, as detailed in the ERC/REC 70-03 Annex 10 [1], with limitations for the in-band power: 20 mW/ 13 dBm for handheld microphones and 50 mW / 17 dBm for body worn microphones. The European Commission has mandated CEPT to study the extension of this band by another 5 MHz to 1805 MHz.

The report considers 16 scenarios corresponding to different interference cases: indoor/outdoor, PMSE interfering with MFCN (LTE and GSM) and MFCN (LTE) interfering with PMSE.

Studies have been performed with 3 different methods, including Monte-Carlo simulations (using SEAMCAT) and Minimum Coupling Loss (MCL) analyses.

The Report is structured as follows:

- In Chapter 2, the frequency usages are described;
- In Chapter 3, the assumptions, scenarios considered and simulation environments are presented;
- In Chapter 4, the results are provided;
- In Chapter 5, conclusions are drawn;
- In Annexes, simulation and calculation results are presented for different methods, considerations about Mobile UE emission limits are provided, setup procedure for PMSE is described, the impact of MFCN bandwidth on studies is analysed and methods to derive receiver blocking response and receiver blocking level are specified.

2 FREQUENCY USAGE AND ASSOCIATED TECHNICAL CONDITIONS

2.1 FREQUENCY USAGE

Table 3 shows an overview of main band usage in and around the 1710-1880 MHz band. More details about the European Common Allocations and the relation to European Standards are found in subsequent sections.

Table 3: Overview of band usage in and around the 1785-1805 MHz band

	1710 MHz	1785 MHz	1800 MHz	1805 MHz 1880 MHz
RR Region 1 Allocation and RR footnotes relevant to CEPT and Frequency Band	FIXED MOBILE 5.384A 5.149 5.341 5.385 5.386 5.387	FIXED MOBILE 5.384A 5.386 5.387	FIXED MOBILE 5.384A 5.386	FIXED MOBILE 5.384A 5.386
European Common Allocation	FIXED MOBILE 5.384A 5.149 5.341 5.385	FIXED MOBILE	MOBILE Fixed	FIXED MOBILE 5.384A
Major Utilisation	GSM 1800 ERC/DEC/(95)03 ECC/REC/(05)08 EN 301 502 EN 301 511 IMT ECC/DEC/(06)13 ECC/REC/(08)02 EN 301 908 MCV ECC/DEC/(08)08 MCA ECC/DEC/(06)07 EN 302 480	Radio microphones and Assistive Listening devices ERC/REC 70-03 EN 300 422 Wireless Audio Applications ERC/REC 70-03 EN 300 422 Mobile applications See NOTE 1	See NOTE 1	GSM 1800 ERC/DEC/(95)03 ECC/REC/(05)08 EN 301 502 EN 301 511 IMT ECC/DEC/(06)13 ECC/REC/(08)02 EN 301 908 MCV ECC/DEC/(08)08 MCA ECC/DEC/(06)07 EN 302 480

NOTE 1: This band is identified for IMT in the RR, but within CEPT this band is not planned for the harmonised introduction of IMT

2.2 FREQUENCY ENVIRONMENT

The FDD duplex gap extends from 1785 MHz to 1805 MHz as illustrated in Figure 1.

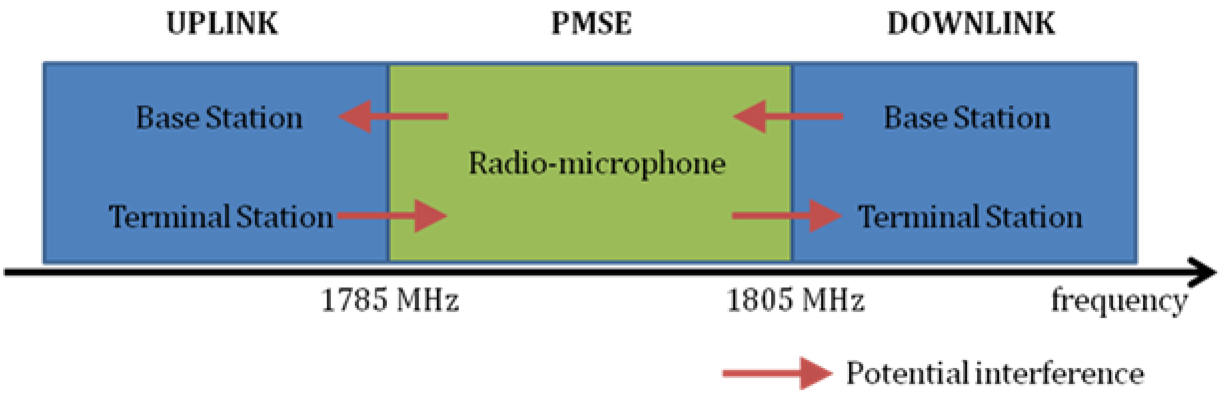


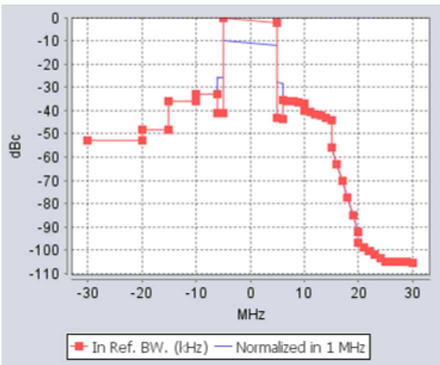
Figure 1: The FDD duplex gap and potential interference

Different interference scenarios are proved in this band and the potential interferences are to be investigated. In the next section the different scenarios are described and technical parameters are listed.

3 PARAMETERS AND SCENARIOS FOR STUDIES

3.1 MFCN AND PMSE PARAMETERS

Table 4: Parameters for an LTE UE

Parameter	Unit	Value	Comment
Channel Bandwidth	MHz	10	
Transmission bandwidth (BW)	MHz	9	ETSI TS 136.101, Table 7.3.1-2 → Sensitivity for a 10 MHz channel is defined for 50 Resource Blocks (RB). ETSI TS 136.211, Section 6.2.3 → 1 Resource Block corresponds to 180 kHz
Reference Sensitivity	dBm	-94	ETSI TS 136.101, Table 7.3.1-1
Noise Figure (NF)	dB	9	3GPP TR 36.824
Noise Floor (N, after FFT processing)	dBm	-95.4	10·log(k·T·BW·1000) + NF[2] This is the noise floor at the output of the FFT, i.e. affecting the transmission bandwidth. (See ANNEX 6:)
Standard Desensitization $D_{STANDARD}$	dB	13	ETSI TS 136.101, Table 7.6.3.1-1
Standard Narrow-band Blocking Level $I_{OOB-STANDARD}$	dBm	-55	ETSI TS 136.101, Table 7.6.3.1-1 at 212.5 kHz from the channel edge
Blocking Response	dB	-27.7 then decrease by 0.8 dB every 200 kHz	CEPT Report 30, Section A5.2.2 → decrease of 8 dB at 2 MHz offset assumed
Target Desensitization D_{TARGET}	dB	3	SE7(12)061
Target Narrow-band Blocking Level $I_{OOB-TARGET}$	dBm	-67.8 then increase by 0.8 dB every 200 kHz	at 212.5 kHz from the channel edge
Antenna height	m	1.5	
Body loss	dB	3	
Antenna gain	dBi	-4	Average value Omni directional
Maximum transmit power	dBm	23	ETSI TS 136.101, Table 6.2.2-1
Out-of-band emissions (Monte-Carlo Simulations)	dB		ETSI TS 136.101, Table 6.6.2.1.1-1 → values relative to 23 dBm Including the attenuation of the UE duplex filter (see Figure 13 in section A1.3.3.3)

[2] k = Boltzmann constant; T = 290 K; BW = Bandwidth; NF = Noise figure

Duplexer impact			Typical duplexer filter

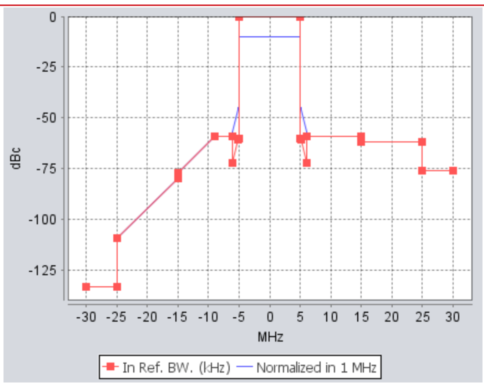
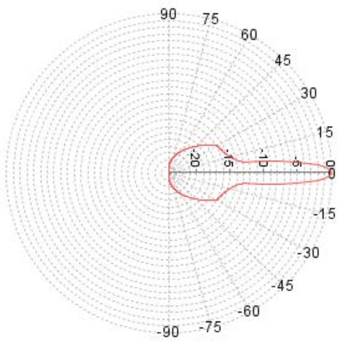
Note: The combination of the spectrum emission mask and the additional duplex filter leads to a spectrum emission mask with reduced OOB emissions. The adopted mask was used to simulate the impact of LTE on PMSE.

Table 5: Parameters for a GSM UE

Parameter	Unit	Value	Comment
Bandwidth (BW)	MHz	0.2	ETSI TS 145.005, Section 2 → channel spacing is 200 kHz
Reference Sensitivity	dBm	-102	ETSI TS 145.005, Table 6.2-1a
Noise Figure (NF)	dB	8	3GPP TR 45.050
Noise Floor (N)	dBm	-113	10.log(k.T.BW.1000) + NF
Standard Desensitization $D_{STANDARD}$	dB	3	ETSI TS 145.005, Section 5.1.3 $D_{TARGET} = D_{STANDARD}$
Blocking Protection Ratio	dB	-9 for 1804.8-1805 MHz -41 for 1804.6-1804.8 MHz -49 for 1804.4-1804.6 MHz	ETSI TS 145.005, Table 6.3-1
Standard Blocking Level $I_{OOB-STANDARD}$	dBm	-90 for 1804.8-1805 MHz -58 for 1804.6-1804.8 MHz -50 for 1804.4-1804.6 MHz	$I_{OOB-STANDARD}$ = Sens + D - Protection_Ratio
Blocking Response	dB	-23 for 1804.8-1805 MHz -55 for 1804.6-1804.8 MHz -63 for 1804.4-1804.6 MHz	
Antenna height	m	1.5	
Body loss	dB	3	
Antenna gain	dBi	-4	Average value Omni directional

Table 6: Parameters for an LTE macro BS (wide area)

Parameter	Unit	Value	Comment
Channel Bandwidth	MHz	10	
Transmission bandwidth (BW)	MHz	4.5	ETSI TS 136.104, Table 7.2.1-1 → Sensitivity for a 10 MHz channel is defined for 25 Resource Blocks (RB) ETSI TS 136.211, Section 6.2.3 → 1 Resource Block corresponds to 180 kHz
Reference Sensitivity	dBm	-101.5	ETSI TS 136.104, Table 7.2.1-1
Noise Figure (NF)	dB	5	3GPP TR 36.824
Noise Floor (N, after FFT processing)	dBm	-102.4	10·log(k·T·BW·1000) + NF over 25 RB This is the noise floor at the output of the FFT, i.e. affecting the transmission bandwidth. (See ANNEX 6:)
Standard	dB	6	ETSI TS 136.104,

Parameter	Unit	Value	Comment
Desensitization $D_{STANDARD}$			Table 7.5.1-1
Standard Narrow-band Blocking Level $I_{OOB-STANDARD}$	dBm	-49	ETSI TS 136.104, Table 7.5.1-1
Blocking Response	dB	-48.7	
Target Desensitization D_{TARGET}	dB	1	
Target Narrow-band Blocking Level $I_{OOB-TARGET}$	dBm	-59.7	
Antenna height	m	30	
Antenna gain (with cable loss)	dBi	15	
Maximum transmit power	dBm	46	
Out-of-band emissions (Monte-Carlo Simulations)	dB		ETSI TS 136.104, Table 6.6.3.2.2-1 → values relative to 46 dBm Including the attenuation of the BS duplex filter (see Figure 7 in section A1.3.2)
BS duplex filter impact		< 1785 MHz = -48 dB 1785 – 1801 MHz = +3 dB per MHz 1801 – 1805 MHz = 0 dB > 1805 MHz = 0 dB	
Vertical antenna pattern (Monte-Carlo Simulations)	dB	 A down-tilt of 3° is assumed	SEAMCAT 4.0.0, Library Antenna, 3GPP Tri-Sector Antenna
Horizontal antenna pattern	dB	Omni directional	Envelope of a 3-sector-antenna

Note: The combination of the spectrum emission mask and the additional duplex filter leads to a spectrum emission mask with reduced OOB emissions. The adopted mask was used to simulate the impact of LTE on PMSE.

Table 7: Parameters for a GSM macro BS

Parameter	Unit	Value	Comment
Bandwidth (BW)	MHz	0.2	ETSI TS 145.005, Section 2 → channel spacing is 200 kHz
Reference Sensitivity	dBm	-104	ETSI TS 145.005, Table 6.2-1b
Noise Figure (NF)	dB	8	3GPP TR 45.050
Noise Floor (N)	dBm	-113	10.log(k.T.BW.1000) + NF

Parameter	Unit	Value	Comment
Standard Desensitization $D_{STANDARD}$	dB	3	ETSI TS 145.005, Section 5.1.2
Blocking Protection Ratio	dB	-9 for 1804.8-1805 MHz -41 for 1804.6-1804.8 MHz -49 for 1804.4-1804.6 MHz	ETSI TS 145.005, Table 6.3-1
Standard Blocking Level $I_{OOB-STANDARD}$	dBm	-92 for 1804.8-1805 MHz -60 for 1804.6-1804.8 MHz -52 for 1804.4-1804.6 MHz	$I_{OOB-STANDARD}$ = Sens + D - Protection_Ratio
Blocking Response	dB	-21 for 1804.8-1805 MHz -53 for 1804.6-1804.8 MHz -61 for 1804.4-1804.6 MHz	
Target Desensitization D_{TARGET}	dB	1	
Target Blocking Level $I_{OOB-TARGET}$	dBm	-98 for 1804.8-1805 MHz -66 for 1804.6-1804.8 MHz -58 for 1804.4-1804.6 MHz	
Antenna height	m	30	
Antenna gain (with cable loss)	dBi	15	

Table 8: Parameters for an LTE pico BS (local area)

Parameter	Unit	Value	Comment
Channel Bandwidth	MHz	10	
Transmission bandwidth (BW)	MHz	4.5	ETSI TS 136.104, Table 7.2.1-2 → Sensitivity for a 10 MHz channel is defined for 25 Resource Blocks (RB). ETSI TS 136.211, Section 6.2.3 → 1 Resource Block corresponds to 180 kHz
Reference Sensitivity	dBm	-93.5	ETSI TS 136.104, Table 7.2.1-2
Noise Figure (NF)	dB	13	3GPP TR 36.931
Noise Floor (N, after FFT processing)	dBm	-94.4	10.log(k.T.BW.1000) + NF over 25 RB This is the noise floor at the output of the FFT, i.e. affecting the transmission bandwidth. (See ANNEX 6:)
Standard Desensitization $D_{STANDARD}$	dB	6	ETSI TS 136.104, Table 7.5.1-1
Standard Narrow-band Blocking Level $I_{OOB-STANDARD}$	dBm	-41	ETSI TS 136.104, Table 7.5.1-1
Blocking Response	dB	-48.7	
Target Desensitization D_{TARGET}	dB	1	
Target Narrow-band Blocking Level $I_{OOB-TARGET}$	dBm	-51.7	
Antenna height	m	3	
Antenna gain (with cable loss)	dBi	0	
Maximum transmit power	dBm	24	ETSI TS 136.104, Table 6.2-1

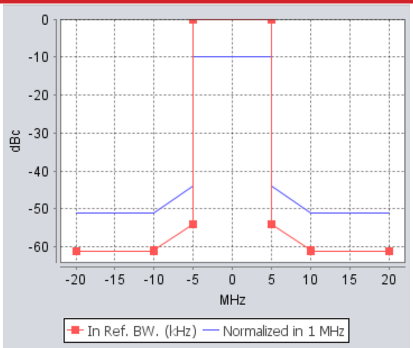
Parameter	Unit	Value	Comment
Out-of-band emissions (Monte-Carlo Simulations)	dB		ETSI TS 136.104, Table 6.6.3.2A-1 → values relative to 24 dBm
BS filter impact			Not taken into account
Vertical antenna pattern	dB	Omni directional	
Horizontal antenna pattern	dB	Omni directional	

Table 9: Parameters for a GSM pico BS

Parameter	Unit	Value	Comment
Bandwidth (BW)	MHz	0.2	ETSI TS 145.005, Section 2 → channel spacing is 200 kHz
Reference Sensitivity	dBm	-95	ETSI TS 145.005, Table 6.2-1b
Noise Figure (NF)	dB	8	3GPP TR 45.050
Noise Floor (N)	dBm	-113	10.log(k·T·BW·1000) + NF
Standard Desensitization $D_{STANDARD}$	dB	3	ETSI TS 145.005, Section 5.1.2
Blocking Protection Ratio	dB	-9 for 1804.8-1805 MHz -41 for 1804.6-1804.8 MHz -49 for 1804.4-1804.6 MHz	ETSI TS 145.005, Table 6.3-1
Standard Blocking Level $I_{OOB-STANDARD}$	dBm	-83 for 1804.8-1805 MHz -51 for 1804.6-1804.8 MHz -43 for 1804.4-1804.6 MHz	$I_{OOB-STANDARD}$ = Sens + D - Protection_Ratio
Blocking Response	dB	-30 for 1804.8-1805 MHz -62 for 1804.6-1804.8 MHz -70 for 1804.4-1804.6 MHz	
Target Desensitization D_{TARGET}	dB	1	
Target Blocking Level $I_{OOB-TARGET}$	dBm	-89 for 1804.8-1805 MHz -57 for 1804.6-1804.8 MHz -49 for 1804.4-1804.6 MHz	
Antenna height	m	3	
Antenna gain (with cable loss)	dBi	0	

Table 10: Parameters for handheld PMSE

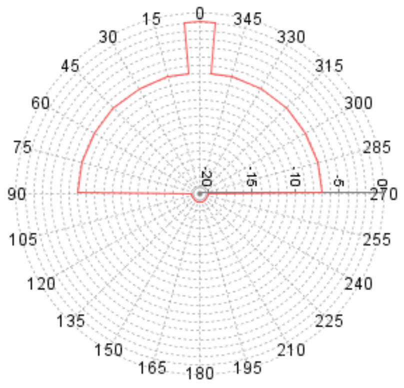
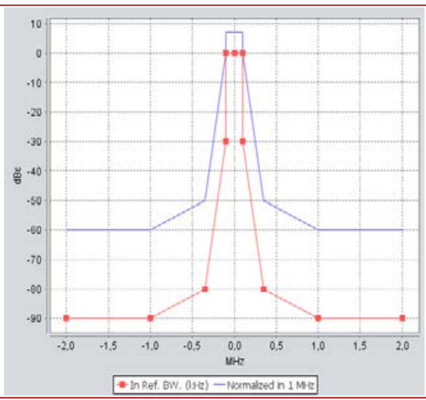
Parameter	Unit	Value	Comment
Bandwidth (BW)	MHz	0.2	
Antenna height	m	1.5	
Body loss	dB	1 around 0° 7 elsewhere 	
Maximum e.i.r.p.	dBm	13	ERC/REC 70-03, Annex 10
Transmitter mask (Monte-Carlo Simulations)	dBm		ETSI EN 300 422 (revised)

Table 11: Parameters for body worn PMSE

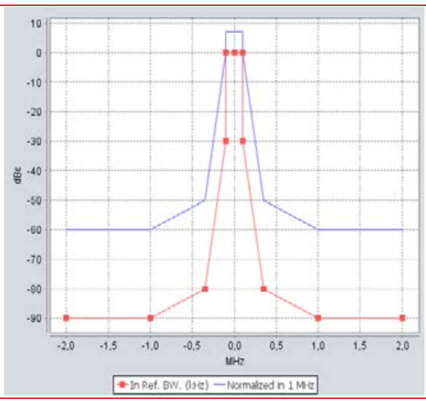
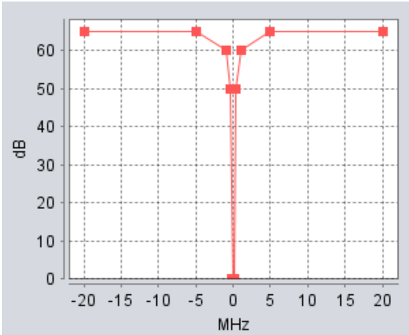
Parameter	Unit	Value	Comment
Bandwidth (BW)	MHz	0.2	
Antenna height	m	1.5	
Body loss	dB	15	
Maximum e.i.r.p.	dBm	17	ERC/REC 70-03, Annex 10
Transmitter mask (Monte-Carlo Simulations)	dBm		ETSI EN 300 422 (revised)

Table 12: Parameters for PMSE receivers

Parameter	Unit	Value	Comment
Bandwidth (BW)	MHz	0.2	
Reference Sensitivity	dBm	-90	ETSI TR 102 546, Section B.4.1.3
Noise Figure (NF)	dB	6	ETSI TR 102 546, Section B.3.1
Noise Floor (N)	dBm	-115	10·log(k·T·BW·1000) + NF
Standard Desensitization $D_{STANDARD}$	dB	3	$D_{TARGET} = D_{STANDARD}$
Blocking Response	dB		ETSI TR 102 546 Attachment 2, Applicable Receiver Parameter for PWMS below 1 GHz
Antenna height	m	3	
Antenna gain	dBi	0	Omni directional

Note 1: The calculation of the receiver blocking response and the target receiver blocking level is described in ANNEX 7:.
Note 2: For the SEAMCAT simulations the minimum required signal of -90 dBm (sensitivity) with a location probability of 95 % has been used. The fading conditions on a stage are simulated with a Gaussian distribution with a standard deviation of 12 dB. The distribution of the wanted signal is described in ANNEX 1:, section A1.3.1.

3.2 SCENARIOS

In the following table the relevant scenarios are listed.

Table 13: Overview of scenarios

Scenario	Outdoor/ Indoor	Interferer	Victim	Distance (MCL)	Distance range (Monte-Carlo Simulations)	Propagation model
1	Outdoor	PMSE	GSM UE	15	15..100 m	IEEE 802.11 Model C, break-point at 5m
2		PMSE	LTE UE			
3		GSM UE	PMSE			
4		LTE UE	PMSE			
5		PMSE	GSM macro BS	100	100..350 m	Extended Hata, Urban
6		PMSE	LTE macro BS			
7		GSM macro BS	PMSE			
8		LTE macro BS	PMSE			
8a	Mixed	LTE macro BS (outdoor)	PMSE (indoor)	100	100..350 m	Extended Hata, Urban Wall attenuation 10 dB
9	Indoor	PMSE	GSM UE	5	5..50 m	IEEE 802.11 Model C, break-point at 5m
10		PMSE	LTE UE			
11		GSM UE	PMSE			
12		LTE UE	PMSE			

Scenario	Outdoor/ Indoor	Interferer	Victim	Distance (MCL)	Distance range (Monte-Carlo Simulations)	Propagation model
13		PMSE	GSM pico BS	5	5..50 m	IEEE 802.11 Model C, break-point at 5m
14		PMSE	LTE pico BS			
15		GSM pico BS	PMSE			
16		LTE pico BS	PMSE			

Note 1: In the distance range of an event area, e.g. theatre or outdoor show, people are present across the propagation link between a transmitter and a receiver and may cause additional loss (of up to 20 to 30 dB), as a result of body loss or multi-path interference due to body scattering[3]. Thus, the propagation model IEEE 802.11 (Model C) is used as in ECC Report 131 [5].
Note 2: An outdoor show is typically a concert performance.

A part from the indoor and the outdoor scenarios, a comprehensive mixed scenario for a densely populated urban environment is given for information, see ANNEX 8:. Based on scenario 8 also a mixed scenario (scenario 8a) has been simulated, with PMSE indoor and the LTE macro BS outdoor (see A1.3).

The set-up of distance ranges in the table above in the simulations is illustrated in Figure 2 below.

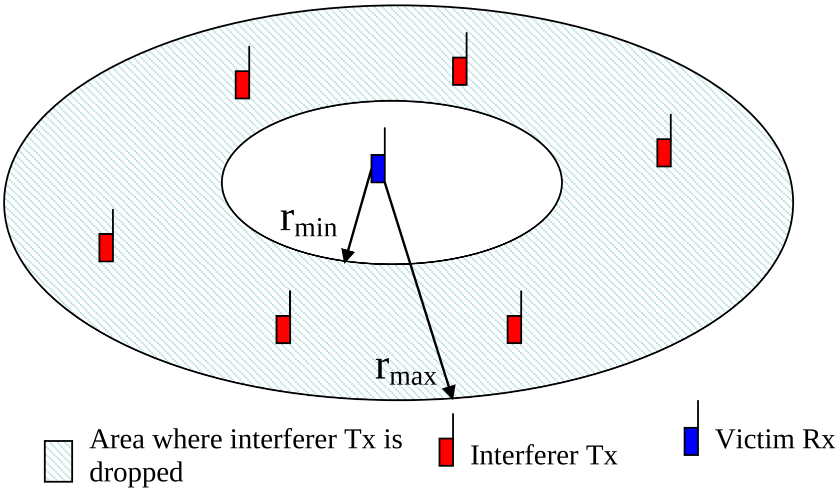


Figure 2: Illustration of the distance range

PMSE should be operated only if a check of quality of service in the radio environment is performed before and resulted in sufficient quality. The PMSE setup indicates whether enough PMSE channels with no interference are available to guarantee the needed quality of service. This procedure is described in ANNEX 5:

[3] See ECC Report 131 Annex 2 [5]

Figure 3 and Figure 4 below illustrate the outdoor and indoor scenarios.

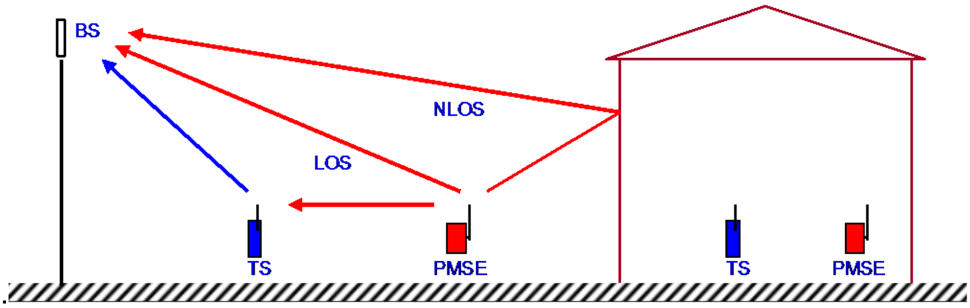


Figure 3: Outdoor interference scenario

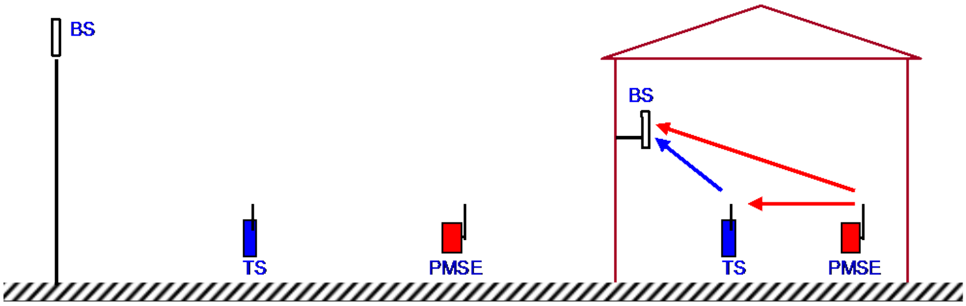


Figure 4: Indoor interference scenario

4 RESULTS OF COMPATIBILITY STUDIES

4.1 METHODOLOGY

In order to address a compatibility study for PMSE in the 1785-1805 MHz band different methods have been used:

- Method 1 - Simulations: Given that PMSE applications will be used in very different environments, it is impossible to predict in advance in which radio environmental PMSE is operated, as well as the spatial location of the devices to each other and the number of different devices. Therefore, a Monte Carlo analysis is applied using the simulator tool SEAMCAT (version 4.0.0).
- Method 2 - Minimum Coupling Loss (MCL) calculation: It is simple to use and does not require a computer for implementation in order to have the results for the worst case analysis. The result generated is isolation in dB, which are converted into the required physical separation between PMSE and MFCN systems.
- Method 3 - Analysis based on the method adopted in CEPT Report 30 [3].

The full descriptions of Methods 1 to 3, including derivations, can be found in Annexes 1 to 3. In addition, Annex 4 identifies the current emission limits in the band considered for terminals with similar characteristics as audio PMSE devices.

4.2 RESULTS

4.2.1 Handheld PMSE interference into MFCN

The results provided by Methods 1, 2 and 3 for handheld PMSE are summarised in Table 14.

Table 14: Summary of results for different scenarios, Handheld PMSE

Scenario	Indoor /Outdoor	Interferer	Victim	Method 1 Unwanted/Blocking (%)	Method 2	Method 3
1	Outdoor	PMSE	GSM UE	Not available	RFR: 1804.8-1805 MHz OOB: -37 dBm/200kHz	Not available
2	Outdoor	PMSE	LTE UE	0/1.05	RFR: 1803.6-1805 MHz OOB: -36 dBm/200kHz	RFR: 1803.8-1805 MHz OOB: -42 dBm/200kHz
3	Outdoor	GSM UE	PMSE	Not available	Not available	Not available
5	Outdoor	PMSE	GSM macro BS	0.09/0.13	RFR: 1785-1785.2 MHz OOB: -20 dBm/200kHz	Not available
6	Outdoor	PMSE	LTE macro BS	0.01/0.03	RFR: None required OOB: -17 dBm/200kHz	RFR: 1785-1785.2 MHz OOB: -29 dBm/200kHz
7	Outdoor	GSM macro BS	PMSE	Not available	Not available	Not available
9	Indoor	PMSE	GSM UE, indoor	Not available	RFR: 1804.4-1805 MHz	Not available

Scenario	Indoor /Outdoor	Interferer	Victim	Method 1 Unwanted/Blocking (%)	Method 2	Method 3
					OOB: -53.5 dBm/200kHz	
10	Indoor	PMSE	LTE UE, indoor	0/5.92	RFR: 1800-1805 MHz OOB: -52.5 dBm/200kHz	Not available
11	Indoor	GSM UE	PMSE	Not available	Not available	Not available
13	Indoor	PMSE	GSM pico BS	22.56/0.01	RFR: 1785-1786.6 MHz OOB: -60 dBm /200kHz	Not available
14	Indoor	PMSE	LTE pico BS	2.27/3.17	Not allowed in the band (RFR > 20 MHz)	Not available
15	Indoor	GSM pico BS	PMSE	Not available	Not available	Not available

4.2.2 Body Worn PMSE interference into MFCN

The results provided by Methods 1, 2 and 3 for Body Worn PMSE are summarized in Table 15.

Table 15: Summary of results for different scenarios, Body Worn PMSE

Scenario	Indoor /Outdoor	Interferer	Victim	Method 1 Unwanted/Blocking (%)	Method 2	Method 3
1	Outdoor	PMSE	GSM UE	Not available	RFR: 1804.8-1805 MHz OOB: -23 dBm /200kHz	Not available
2	Outdoor	PMSE	LTE UE	0/0.37	RFR: none required OOB: -22 dBm /200kHz	RFR: 1804.8-1805 MHz OOB: -35 dBm/200kHz
3	Outdoor	GSM UE	PMSE	Not available	Not available	N/A
5	Outdoor	PMSE	GSM macro BS	0.01/0.02	RFR: none required OOB: -6 dBm /200kHz	Not available
6	Outdoor	PMSE	LTE macro BS	0.02/0.07	RFR: none required OOB: -3 dBm /200kHz	RFR: 1785-1785.2 MHz OOB: -21 dBm/200kHz
7	Outdoor	GSM macro BS	PMSE	Not available	Not available	Not available
9	Indoor	PMSE	GSM UE, indoor	Not available	RFR: 1804.6-1805 MHz OOB: -39.5	Not available

Scenario	Indoor /Outdoor	Interferer	Victim	Method 1 Unwanted/Blocking (%)	Method 2	Method 3
					dBm/200kHz	
10	Indoor	PMSE	LTE UE, indoor	0/5.84	RFR: 1802.4-1805 MHz OOB: -38.5 dBm/200kHz	Not available
11	Indoor	GSM UE	PMSE	Not available	Not available	Not available
13	Indoor	PMSE	GSM pico BS	66.29/33.56	RFR: 1785-1785.4 MHz OOB: -46 dBm/200kHz	Not available
14	Indoor	PMSE	LTE pico BS	0.15/1.47	RFR: None required but e.i.r.p. limited to 15 dBm OOB: -41 dBm/200kHz	Not available
15	Indoor	GSM pico BS	PMSE	Not available	Not available	Not available

4.2.3 MFCN interference into PMSE

The results provided by Method 1 for PMSE receivers are summarized in Table 16.

Table 16: Summary of results for different scenarios, PMSE receiver

Scenario	Indoor/ Outdoor	Interferer	Victim	Method 1 Unwanted/Blocking (%) 1.4 MHz separation	Method 1 Unwanted/ Blocking (%) 11.8 MHz separation	Method 2	Method 3
4	Outdoor	LTE UE	PMSE	25.07/0.0	Not available	Not available	Not available
8	Outdoor	LTE macro BS	PMSE	14.73/0.04	Not available	Not available	Not available
8a	Outdoor/ Indoor	LTE macro BS	PMSE	5.67/0.02	0.1/0.01	Not available	Not available
12	Indoor	LTE UE	PMSE	54.15/0.0	0.35/0	Not available	Not available
16	Indoor	LTE pico BS	PMSE	27.17/0.07	Not available	Not available	Not available

5 CONCLUSION

5.1 STUDIES INCLUDED IN THE REPORT

The present report studies the conditions for operation of PMSE audio equipment (wireless microphones) in the frequency band 1785-1805 MHz. This frequency range corresponds to the duplex gap of the 1710-1785/1805-1880 MHz mobile band.

This report considers interference in both directions between PMSE equipment operating in the band 1785-1805 MHz and public mobile network equipment operating in the bands 1710-1785 MHz and 1805-1880 MHz. The studies in this report consider mainly the interference scenarios where audio PMSE equipment interferes with mobile network equipment, i.e. PMSE equipment interferes with mobile base station receiving below 1785 MHz and PMSE equipment interferes with mobile terminal receiving above 1805 MHz. The report considers a total of 16 scenarios corresponding to a specific combination of the following options:

- Indoor/outdoor;
- PMSE interferes MFCN or MFCN interferes PMSE;
- MFCN BS or MFCN UE;
- MFCN equipment is LTE or GSM.

5.2 METHODS CARRIED OUT IN THE REPORT

The report is based on several methods.

- Method 1: Monte-Carlo simulations carried out with the SEAMCAT tool, provided in ANNEX 1:
- Method 2: Minimum Coupling Loss (MCL) analysis, provided in ANNEX 2:
- Method 3: Analysis based on the method adopted in CEPT Report 30 [3], provided in ANNEX 3:

5.3 RESULTS

5.3.1 Results of the studies

The Method 1 (Monte-Carlo simulations, ANNEX 1:) assumes specific PMSE equipment parameters (e.g. spectrum emission mask, power, system bandwidth) and aims at deriving the needed restricted frequency range between the audio PMSE equipment and the mobile equipment in adjacent bands for PMSE using these parameters.

The methods in ANNEX 2: and ANNEX 3: aim at deriving a Block Edge Mask, with specific in-band and out of band allowed emission levels, without preliminary assumption on PMSE power, spectrum emission mask or system bandwidth.

It was shown that PMSE is able to find an operational channel with sufficient QoS with the assumption of certain spatial distances (see section A2.2) between the PMSE equipment and the MFCN equipment.

However, it should be noted that the analyses are limited to cases where there is an interference risk (both audio PMSE equipment and mobile terminal/base station are in operation), without taking into account the probability of such scenario which is related to the market penetration of audio PMSE equipment and mobile systems. The analyses also consider MFCN equipment operating at the edge of their band, which may not always be the case, especially in the case of GSM.

Additionally, scenarios corresponding to LTE mobile system equipment are based on 10 MHz channel bandwidth. The PMSE system is based on 200 kHz channel bandwidth.Impact of the LTE bandwidths other than 10 MHz has not been studied in this report.

For the scenarios corresponding to mobile equipment (both terminals and base stations) interfering with audio PMSE equipment, duplex filters in the LTE macro base station and in the user equipment are considered.

The conclusions of this report do not guarantee that audio PMSE equipment will be able to operate in all the compatibility scenarios, but identifies the scenarios and technical conditions under which PMSE could be operated with sufficient QoS, whilst not creating interference to mobile systems in adjacent bands. These studies contain only analogue PMSE devices but the conclusions might be applied also for digital PMSE devices with low audio latency requirements.

5.3.2 BEM proposal for PMSE audio applications in the frequency band 1785-1805 MHz

Table 17: BEM for handheld microphone

	Frequency Range	Handheld e.i.r.p.	Reasoning
OOB	< 1785 MHz	-17 dBm/200kHz	LTE UE spectrum emission mask
Restricted frequency range	1785-1785,2 MHz	4 dBm/200kHz	Blocking of GSM BS
	1785.2-1803.6 MHz	13 dBm/channel	
	1803.6-1804.8 MHz	10 dBm/200kHz*	Slow increase of LTE UE selectivity
Restricted frequency range	1804.8-1805 MHz	-14 dBm/200kHz	Blocking of GSM UE
OOB	> 1805 MHz	-37 dBm/200kHz	OOB calculation, in line with ERC/REC 74-01

* with a limit of 13 dBm/channel

Table 18: BEM for body worn microphone

	Frequency Range	Body worn e.i.r.p.	Reasoning
OOB	< 1785 MHz	-17 dBm/200kHz	LTE UE spectrum emission mask
	1785-1804.8 MHz	17 dBm/channel	
Restricted frequency range	1804.8-1805 MHz	0 dBm/200kHz	Blocking of GSM UE
OOB	> 1805 MHz	-23 dBm/200kHz	OOB calculation*

* For the body worn case the body loss is 14 higher than for the handheld case, therefore the -23 dBm for body worn is equivalent to -37 dBm for handheld.

5.3.3 Impact on PMSE

The studies regarding the impact on PMSE show that PMSE is able to find an operational channel with a sufficient QoS. To show the impact of the out-of-band emissions of the LTE equipment, the probability of interference was determined. Details see in Table 25 in ANNEX 1:, section A1.3.

For the case that the MFCN LTE macro BS and PMSE are located both outdoor a separation distance of 100 m is sufficed to ensure that PMSE has the possibility to find an operational channel. The operation of PMSE equipment in the same room/hall where a MCFN LTE pico station is used should be avoided, unless additional mitigation techniques are applied. For frequency offsets larger than 1 MHz and 100m separation, the impact of the MFCN LTE base station can be neglected. he probability of interference is considerably relaxed, if PMSE is operated indoor and the MFCN LTE base station is located outdoor due to the wall attenuation. In that case PMSE could find an operational channel with a sufficient QoS.

If the frequency separation between LTE UE and the PMSE receiver is more than 10 MHz the probability of interference from the LTE UE is negligible. The probability of interference from the LTE macro BS increases if the frequency separation to the LTE macro BS decreases.

It is important to note that the studied interference scenarios may not happen in most cases where PMSE is looking to be deployed if relevant setup procedures (see Annex 5) are applied by PMSE users.

The most critical case is if the PMSE receiver is close to a transmitting MFCN pico BS. If this separation distance is increased, the probability of interference decreases accordingly. Concerning the impact from MFCN UE into PMSE, real UE will have better out-of-band emission performance than in the published ETSI standards (e.g. through the implementation of duplex filtering) and this will significantly reduce the probability of interference into PMSE receivers.

ANNEX 1: SEAMCAT SIMULATION FOR INDOOR AND OUTDOOR ENVIRONMENT

The relevant scenarios used for PMSE can be classified into 2 basic types: outdoor and indoor. The analyses were based on Monte Carlo simulation (with SEAMCAT version 4.0.0) to cover the various deployment situations of PMSE in the different environments. The parameters used for the studies are presented in chapter 3. These results compared with the MCL analyses gives the possibility to derive a BEM for PMSE, therefore the same assumptions was made for this Annex and ANNEX 2:. All Scenarios does not consider power control of the UE, this means it is always assumed that the MFCN receive only the minimum amount of power and transmit always the maximum power.

A1.1 PMSE HAND HELD

The Scenarios 6 and 14 are only made with one frequency separation, because there is no additional selectivity for the BS receiver in the PMSE band. The results do not change, if the frequency separation is increased.

Table 19: PMSE Hand held

Unwanted/Blocking (exceedance probability) [%]											
				Frequency distance between the PMSE channel edge and the band edge of the MFCN [kHz]							
Scenario	Interferer	Victim	I/N [dB]	200	400	600	800	1000	1200	1400	
2	PMSE	LTE UE(10MHz)	0	0/1.05	0/0.74	0/0.67	0/0.40	0/0.37	0/0.32	0/0.13	Outdoor
2	PMSE	LTE UE(5MHz)	0	0/2.08	0/1.59	0/1.15	0/0.87	0/0.79	0/0.51	0/0.48	
6	PMSE	LTE BS	-6	0.01/0.03	-	-	-	-	-	-	
5	PMSE	GSM BS	-6	0.09/0.13	0.02/0.2	0/0	-	-	-	-	
10	PMSE	LTE UE	0	0/11.28	0/10.01	0/8.93	0/7,99	0/7.26	0/6.65	0/5.92	Indoor
14	PMSE	LTE Pico BS	-6	2.27/3.17	-	-	-	-	-	-	
13	PMSE	GSM Pico BS	-6	58.05/30.24	39.98/16.76	30.94/0.01	23.47/0	22.93/0	22.79/0	22.56/0.01	

A1.2 PMSE BODY WORN

The Scenarios 6 and 14 are only made with one frequency separation, because there is no additional selectivity for the BS receiver in the PMSE band. The results do not change, if the frequency separation is increased.

Table 20: PMSE Body worn

Unwanted/Blocking (exceedance probability) [%]											
				Frequency distance between the PMSE channel edge and the band edge of the MFCN [kHz]							
Scenario	Interferer	Victim	I/N [dB]	200	400	600	800	1000	1200	1400	
2	PMSE	LTE UE(10MHz)	0	0/0.37	0/0.12	0/0	-	-	-	-	Outdoor
2	PMSE	LTE UE(5MHz)	0	0/0.81	0/0.41	0/0.26	0/0.13	0/0	-	-	
6	PMSE	LTE BS	-6	0.02/0.07	-	-	-	-	-	-	
5	PMSE	GSM BS	-6	0.01/0.02	0/0	-	-	-	-	-	
10	PMSE	LTE UE	0	0/13.50	0/11.95	0/10.18	0/9.25	0/8.43	0/7.10	0/5.84	Indoor
14	PMSE	LTE Pico BS	-6	0.15/1.47	-	-	-	-	-	-	
13	PMSE	GSM Pico BS	-6	66.29/33.56	43.38/18.98	33.89/0	26.22/0	24.82/0	25.00/0	25.37/0	

A1.3 PMSE RECEIVER

For the scenarios, in which PMSE is the victim system a specific wanted signal was used. The wanted signal of the PMSE equipment is considered as a Gaussian distributed signal, with a wanted signal power of -90 dBm with a location probability of 95%. The standard deviation is assumed with σ = 12 dB, this provides a sufficient margin for large signal notches on some places on the stage.

The MFCN LTE macro BS (wide area) uses a duplex filter, the influence is considered as an additional attenuation to the transmitted signal. Due to the lack of other measurements or standard values, a conservative assumption is made, based on the available measurement from one manufacturer. It can be assumed that the duplex filters used in the MFCN BS, are better than the values presented in this annex.

A1.3.1 Modelling the wanted signal for PMSE

The median power of the wanted signal (dRSS) has to be calculated taking account of the used standard deviation and required location probability of 95%. The following equation is based on table 3 of ITU-R Rec. P.1546-4.

$$C_{\text{median}_{\text{new}}} = C_{\text{median}} - \sigma \cdot -1.645$$

$$C_{\text{median}_{\text{new}}} = -90dBm - 12dB \cdot -1.645 \approx -70dBm$$

$$dRSS = \ -70dBm \ with \ \sigma = 12dB$$

The Figure 5 and Figure 6 show the C.D.F. of the wanted signal.

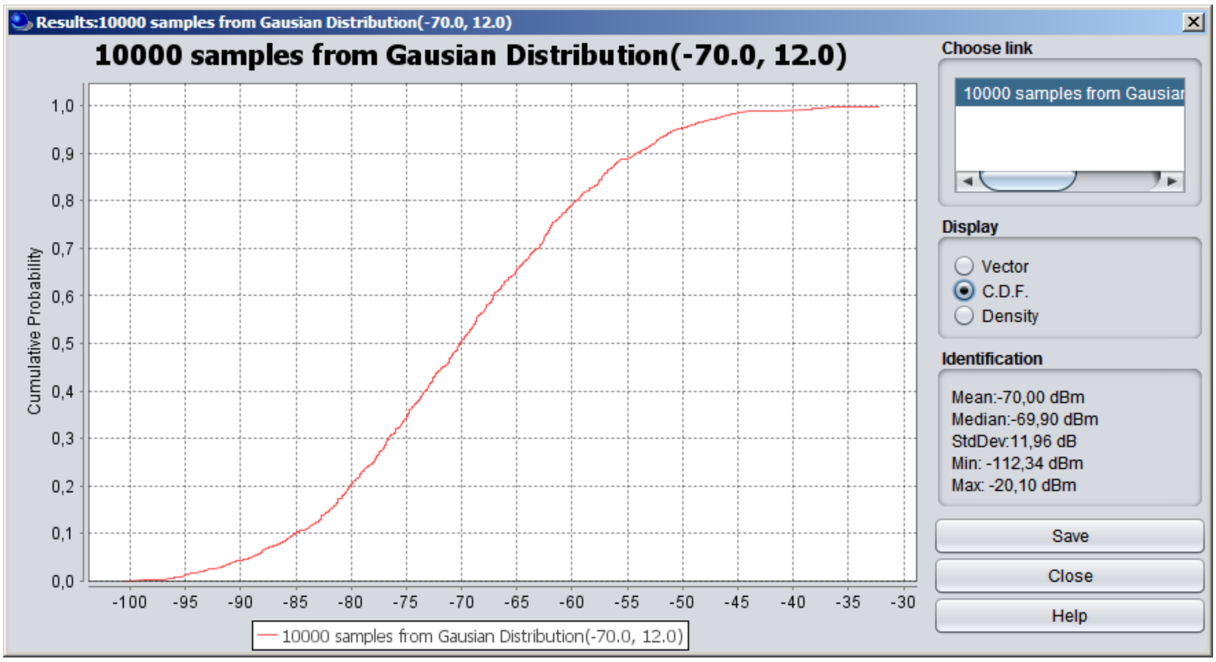


Figure 5: C.D.F. of the used dRSS

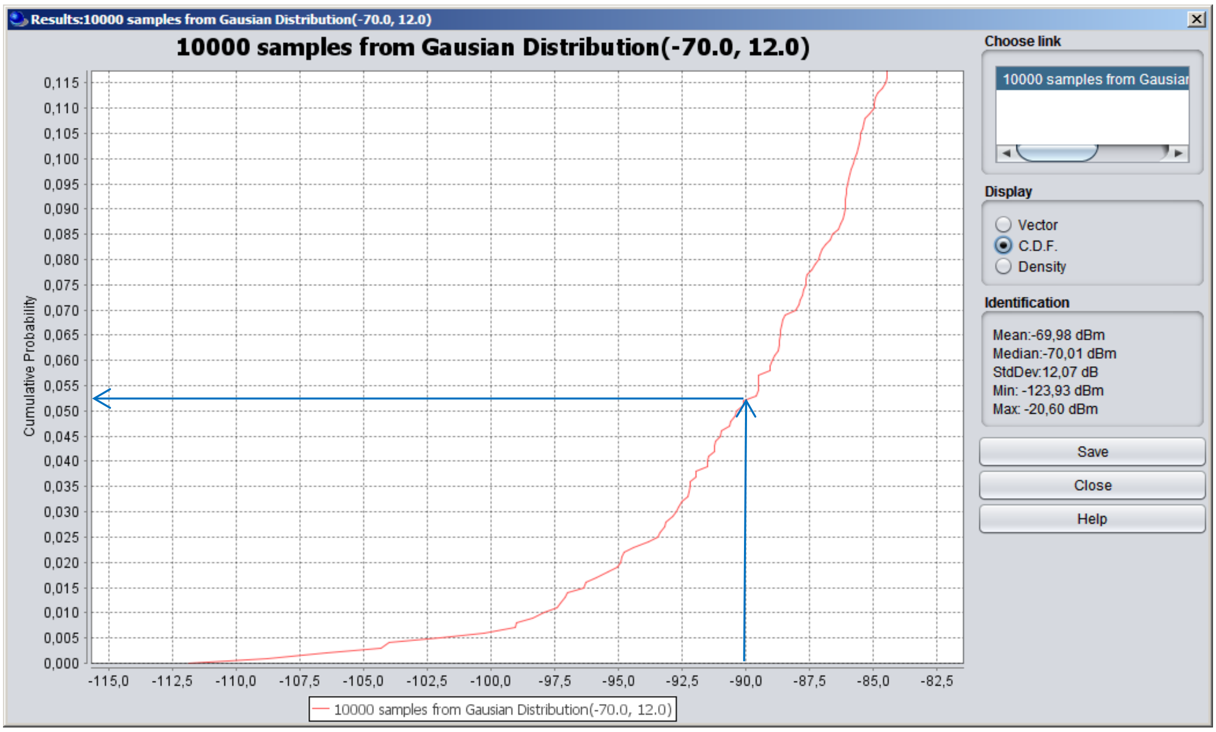


Figure 6: C.D.F. of the used dRSS, detail view for C = -90 dBm and the corresponding probability

To take into account the wanted signal, the criteria to assess the probability of exceedance of a limit is therefore C/(N+I) = 25 dB.

A1.3.2 Used duplex filter for MFCN LTE macro BS (wide area)

For the scenarios 8 and 8a the MFCN LTE macro BS is transmitting at the centre frequency of 1810 MHz. Therefore the duplex filter of the BS has an influence to the transmitted spectrum, in terms of additional attenuation. Due to the lack of enough measurements or standard values, a conservative assumption is made, based on the available measurement from one manufacturer. The principle additional attenuation is presented in the figure below.

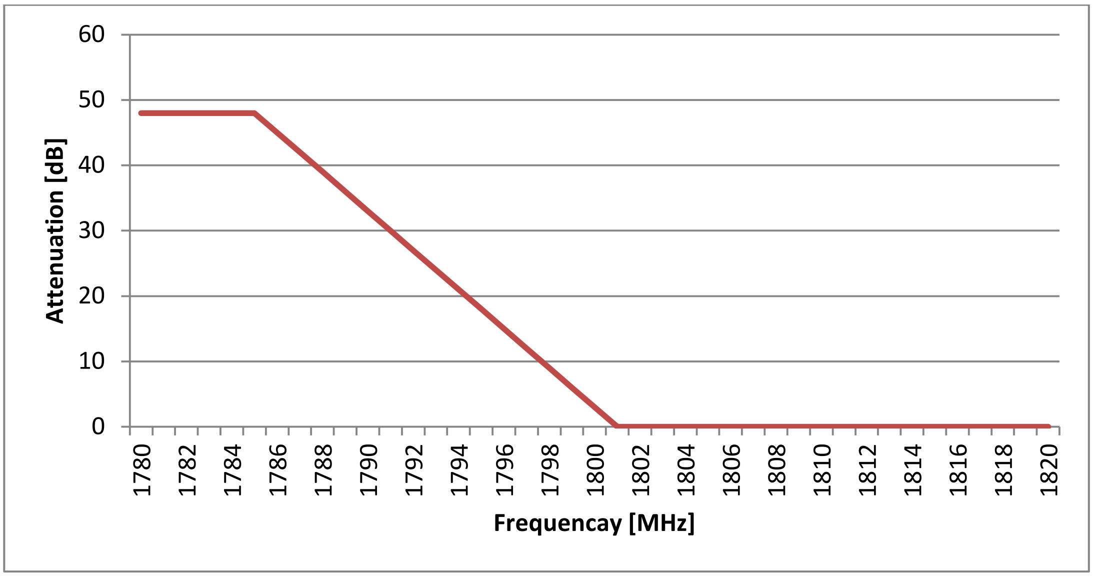


Figure 7: Principle trend of the duplex filter

A1.3.3 IMPACT OF LTE UE EMISSIONS ON PMSE IN THE DUPLEX GAP 1785-1805 MHz

A1.3.3.1 LTE UE architecture and Duplex filter

In order to properly model the emissions of a LTE UE terminal in the band 1785-1805 MHz, it is necessary to take into account the structure of the LTE UE architecture.

In particular it is necessary to take into account the effect of the duplex filter used to isolate the RX from the TX.

The characteristics of a typical duplex filter are given in figure 9. As it can be seen, the attenuation provided by the filter (TX to antenna) is in the range of 45-55 dB.

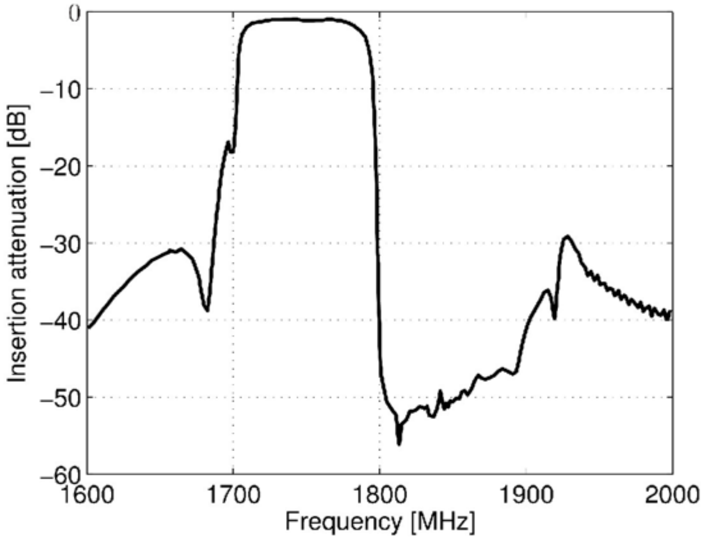


Figure 8: Frequency Response of a typical saw duplexer

A1.3.3.2 Emission from an LTE UE with duplex filter

The standard (3GPP 36.101), specifies the following values:

- For out of band emissions, the emission mask of the transmitter is specified in table 6.6.2.1.1-1 (page 76). The standard defines the OOB domain, for a channel bandwidth of 10 MHz, as the frequency range up to 15 MHz from the channel edge.
- For the spurious domain, the limit is set in table 6.6.3.2-1 of the standard, as -30 dBm/MHz.
- Also it should be noted that the standard specifies a limit for spurious emission for LTE UE coexistence, in table 6.6.3.2-1, as -50 dBm/MHz.

If it is assumed that spurious of TX in the band 1805-1880 MHz (the RX band of the UE terminal) is equal to the value set by the standard, and a typical duplex filter attenuation, i.e. 45 dB, at the antenna the power level is -50 dBm - 45 dB= -95 dBm/MHz. Considering that in that band a typical duplex filter has 2 dB attenuation from the antenna to the receiver, a value of around -97 dBm is at the receiver input. This value has to be compared with the noise level of the receiver. Assuming a noise figure of 7 dB, over a 1 MHz bandwidth, KTBF= -106.9 dBm/MHz, which is significantly lower than -97 dBm. In other words, the duplex filter alone is not sufficient to make the spurious emission of the TX low enough to avoid impairing the receiver performance. In fact, the actual design of UE terminals relies on two factors at the same time to reduce the transmitter interference in the RX band to an acceptable level:

- Use of the duplex filter (as explained above, this is not sufficient), which provides a 45 dB attenuation;

- Additional reduction of the spurious emissions of the transmitter, beyond what is prescribed by the standard.

Before proceeding with other considerations, it is derived, how many dBs the additional reduction of the spurious emissions should attain. Considering a noise level of -106.9 dBm/MHz, the sensitivity of the receiver is reduced by 0.5 dB (acceptable level) if the interference from the transmitter is 9 dB below this level. This gives a level of -106.9 dBm - 9 dB = -115.9 dBm. If, as derived above, a typical duplex filter can lower the TX noise level down to -97 dBm, the emission from the TX should be around -97 + 115.9 = 20 dB lower than the standard (in the receiver bandwidth). So, a typical UE architecture will rely on:

- A duplex filter with a 45 dB attenuation
- An emission level, in the RX band of the UE, that is 20 dB less than the value prescribed by the standard.

A1.3.3.3 Simulation of emission of the LTE terminal

As said before, the proper simulation would require taking into account the following two factors:

- The real emission mask of the TX. This emission mask is not provided in datasheets. From the considerations provided above, it is possible to deduce that in the proximity of the LTE DL band it will be around 20 dB lower that the mask provided in the standard;
- The attenuation of the duplex filter.

In the following simulation:

- the duplex filter attenuation is considered (see figure 10);
- the fact that the emission mask of the transmitter will in reality be better than the 3GPP mask has not been taken into account;
- the mask defined in the standard, presented above, is considered.

Hence, not considering the reduction of the TX emission mask with respect to the standard, but only the duplex filter, the simulation is conservative.

In other words, the filter attenuation to the 3GPP mask is applied, as indicated in figure 10:

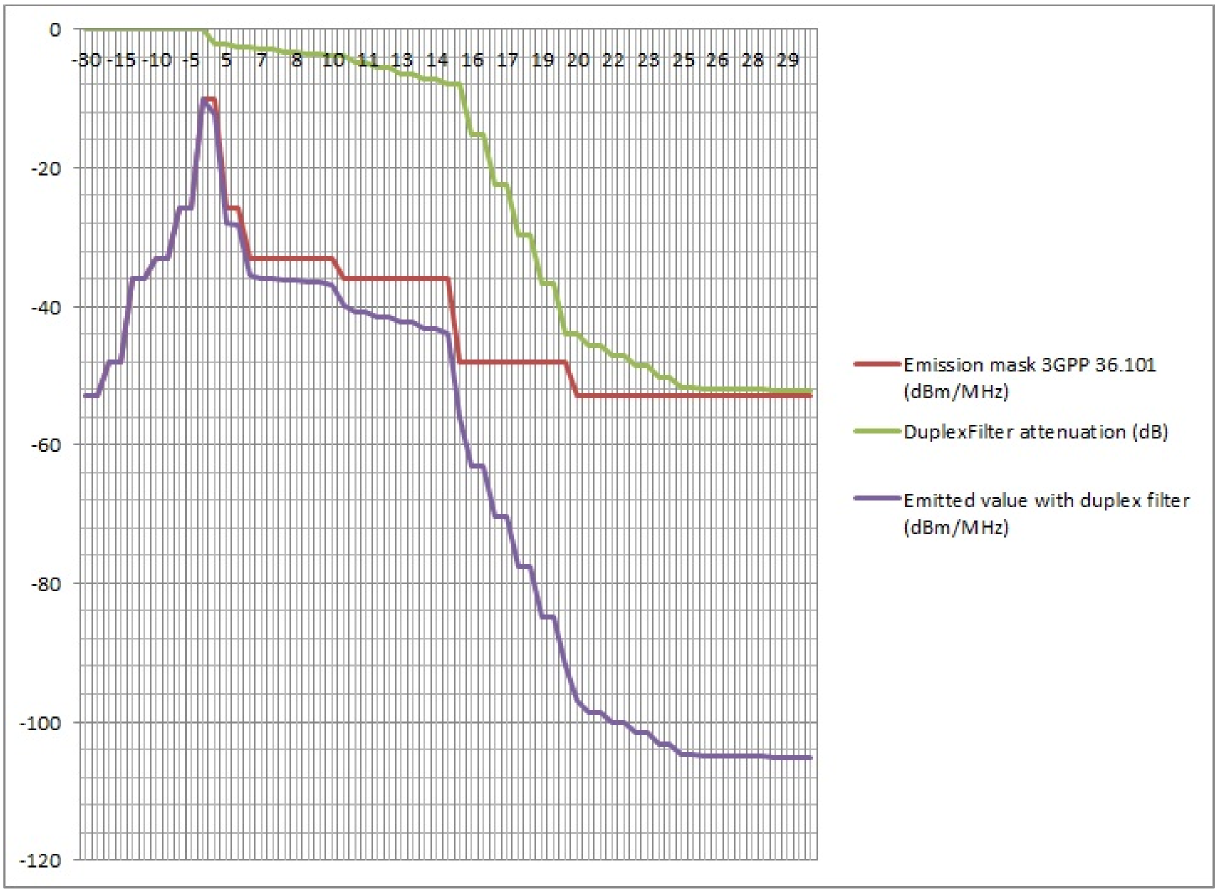


Figure 9: Emission masks (Note that X axis is NOT proportional)

Entering new emission mask in SEAMCAT, results will be shown in the following tables.

Table 21: SEAMCAT results for scenario 12

Scenario 12: Interference probability: Unwanted/Blocking [%]										
PMSE Frequency [MHz]	1786.8	1788.8	1790.8	1792.8	1794.8	1796.8	1798.8	1800.8	1802.8	1804.8
Frequency separation from edge (1785) [MHz]	1.8	3.8	5.8	7.8	9.8	11.8	13.8	15.8	17.8	19.8
% interference unwanted/blocking	29.31/ 0.00	27.38/ 0.00	19.57/ 0.00	17.2/ 0.00	14.25/ 0.00	0.35/ 0.00	0.02/ 0.00	0.00/ 0.00	0.00/ 0.00	0.00/ 0.00

Table 22: SEAMCAT results for scenario 4

Scenario 12: Interference probability: Unwanted/Blocking [%]										
PMSE Frequency [MHz]	1786.8	1788.8	1790.8	1792.8	1794.8	1796.8	1798.8	1800.8	1802.8	1804.8
Frequency separation from edge (1785) [MHz]	1.8	3.8	5.8	7.8	9.8	11.8	13.8	15.8	17.8	19.8
% interference unwanted/blocking	8.73/ 0.00	7.75/ 0.00	4.58/ 0.00	3.59/ 0.00	2.92/ 0.00	0.03/ 0.00	0.00/ 0.00	0.00/ 0.00	0.00/ 0.00	0.00/ 0.00

Table 23: SEAMCAT results for scenario 8a

Scenario 8a: Interference probability: Unwanted/Blocking [%]										
PMSE Frequency [MHz]	1786.8	1788.8	1790.8	1792.8	1794.8	1796.8	1798.8	1800.8	1802.8	1804.8
Frequency separation from edge (1805) [MHz]	18.2	16.2	14.2	12.2	10.2	8.2	6.2	4.2	2.2	0.2
% interference unwanted/blocking	0.00/ 0.01	0.00/ 0.01	0.00/ 0.01	0.01/ 0.01	0.02/ 0.01	0.1/ 0.01	0.42/ 0.01	1.09/ 0.01	1.22/ 0.01	6.92/ 0.01

The results in Table 25 show the exceedance probabilities for the considered scenarios an overview is given in Table 24.

Table 24: Overview of scenarios and used distances

Scenario	Outdoor/ Indoor	Interferer	Victim	Distance range (Monte-Carlo Simulations)	Propagation model
4	Outdoor	LTE UE	PMSE	15..100 m	IEEE 802.11 Model C, break-point at 5m
8		LTE macro BS	PMSE	100..350 m	Extended Hata, Urban
8a	Mixed	LTE macro BS (outdoor)	PMSE (indoor)	100..350 m	Extended Hata, Urban Wall attenuation 10 dB
12	Indoor	LTE UE	PMSE	5..50 m	IEEE 802.11 Model C, break-point at 5m
16		LTE pico BS	PMSE		

Table 25: PMSE Receiver

Unwanted/Blocking (exceedance probability) [%]. Victim PMSE, C/I = 25 dB						
Scenario		4	8	8a	12	16
		Outdoor		Mixed BS (outdoor) PMSE (indoor)	Mixed BS (outdoor) PMSE (indoor)	Indoor
Interferer		LTE UE	LTE BS	LTE BS	LTE UE	LTE Pico BS
Frequency distance between the PMSE channel edge and the band edge of the MFCN [MHz]	0.2	25.07/0.0	14.73/0.04	6.92/0.01	54/0.0	27.17/0.07 (Note)
	0.4		11.06/0.07	4.05/0.01		
	0.6		8.71/0.05	2.83/0.01		
	0.8		6.11/0.04	2.04/0.01		
	1.0		3.86/0.05	1.19/0.01		
	1.2		3.79/0.03	1.20/0.00		
	1.4		4.36/0.04	1.23/0.01		
	1.8	8.73/0.00	NA	NA	29.31/0.00	NA
	2.2	NA		1.22/0.01	NA	
	3.8	7.75/0.00		NA	27.38/0.00	
	4.2	NA		1.09/0.01	NA	
	5.8	4.58/0.00		NA	19.57/0.00	
	6.2	NA		0.42/0.01	NA	
	7.8	3.59/0.00		NA	17.2/0.00	
	8.2	NA		0.1/0.01	NA	
	9.8	2.92/0.00		NA	14.25/0.00	
	10.2	NA		0.02/0.01	NA	
	11.8	0.03/0.00		NA	0.35/0.00	
	12.2	NA		0.01/0.01	NA	
	13.8	0.00/0.00		NA	0.02/0.00	
	14.2	NA		0.00/0.01	NA	
	15.8	0.00/0.00		NA	0.00/0.00	
	16.2	NA		0.00/0.01	NA	
	17.8	0.00/0.00		NA	0.00/0.00	
	18.2	NA		0.00/0.01	NA	
	19.8	0.00/0.00		NA	0.00/0.00	

Note: A higher frequency offset in the scenario has no influence on the exceedance probability, because the LTE emission mask is constant over the considered frequency range.

A1.4 RESULTS

The results show that a PMSE setup is required to ensure the needed QoS for PMSE, in the presence of a MFCN (PMSE is able to operate only within environments where the operational channels provide sufficient high QoS, see ANNEX 5:). It can be assumed that PMSE is able to operate within the frequency range provided that influence of the MCFN UE could be reduced accordingly. If this is guaranteed, PMSE can operate without causing any harmful impact to MFCN.

The studies regarding the impact on PMSE show that PMSE is able to find an operational channel with a sufficient QoS. To show the impact of the out-of-band emissions of the LTE equipment, the probability of interference was determined.

The most critical case is if the PMSE receiver is close to a transmitting MFCN pico BS. If this separation distance is increased, the probability of interference decreases accordingly. Concerning the impact from MFCN UE into PMSE, real UE will have better out-of-band emission performance than in the published ETSI standards (e.g. through the implementation of duplex filtering) and this will significantly reduce the probability of interference into PMSE receivers.

For the case that the MFCN LTE macro BS and PMSE are located both outdoor a separation distance of 100m is sufficed to ensure that PMSE has the possibility to find an operational channel. The operation of a MCFN LTE pico station in the same room/hall where PMSE is used should be avoided if additional mitigation techniques are not applied. For frequency offsets larger than 1 MHz and 100 m separation, the impact of the MFCN LTE base station can be neglected.

The probability of interference is considerably relaxed, if PMSE is operated indoor and the MFCN LTE base station is located outdoor due to the wall attenuation. In that case PMSE could find an operational channel with a sufficient QoS.

According to ECC Report 131 [5] a probability of ≤ 5%, of exceeding the limits is considered, if the desensitization for the MFCN BS or UE is 1 dB or 3 dB.

A1.5 MONTE-CARLO SIMULATIONS WITH MODIFIED ASSUMPTIONS

In this section simulation results for interference from PMSE to MFCN are presented. These can be found in the tables below.

The main assumptions used in this section are:

- Only hand-held PMSE is considered since it is the limiting case;
- PMSE bandwidth is 200 kHz;
- For outdoor cases where the base station is the victim, the minimum and maximum distances are 60 and 300 m, respectively;
- For the outdoor PMSE to MFCN terminal station case, the IEEE802.11 propagation model with a 20 m break point has been used;
- For the indoor cases, the IEEE802.11 propagation model with a 5 m break point has been used;
- Antenna patterns:
  - -1, -7, -20 dB, with maximum gain in a 5 degree sector (See Table 10);
  - Constant -1 dB which corresponds to a PMSE device on a stand, i.e., without any human interaction;
- The probability for unwanted *plus* blocking interfering power exceeding the I/N criteria has been considered;
- Required guard band for 5% exceedance of I/N has been calculated with the assumption of 0.8 dB improvement of blocking response for every 200 kHz.

Detailed assumptions can be found in the Section 3.1.

Table 26: Parameters used in simulations

Scenario	Interferer	Victim	r_{min} (m)	r_{max} (m)	Propag. Model	Environment
2	PMSE	LTE UE	10	100	IEEE 802.11C[1]	Outdoor
4	LTE UE	PMSE	10	100	IEEE 802.11C[1]	
6	PMSE	LTE BS	60	300	Extended Hata	
8	LTE BS	PMSE	60	300	Extended Hata	
5	PMSE	GSM BS	60	300	Extended Hata	
10	PMSE	LTE UE	5	50	IEEE 802.11C[1]	Indoor
14	PMSE	LTE Pico BS	5	50	IEEE 802.11C[1]	
16	LTE Pico BS	PMSE	5	50	IEEE 802.11C[1]	
12	LTE UE	PMSE	5	50	IEEE 802.11C[1]	

Note: For MCL calculation the minimum distance between victim receiver and interferer is $r_{min.}$

[1] The break point for outdoor environment is 20m and for the indoor 5m.

Table 27: PMSE Hand Held (Antenna pattern: constant -1 dB)

				Unwanted + Blocking (exceedance probability) [%]							Guard band req'rd for 5% exceed. [MHz]	
				Frequency distance between the PMSE channel edge and the band edge of the MFCN [kHz]								
Scenario	Interferer	Victim	I/N [dB]	200	400	600	800	1000	1200	1400		
2	PMSE	LTE UE (5 MHz)	0	33.8		29.7		25,9		21.7	3.6	Outdoor
2	PMSE	LTE UE (10 MHz)	0	25,7		22.5		19.2		16.3	2.8	
6	PMSE	LTE BS	-6	0.9	-	-	-	-	-	-	-	
5	PMSE	GSM BS	-6	1.9	0.3	0.1	-	-	-	-	-	
10	PMSE	LTE UE (5 MHz)	0	38.9		33.8		29,7		24.9	4.5	Indoor
10	PMSE	LTE UE (10 MHz)	0	29.3		26.3		22.4		18.5	3.7	
14	PMSE	LTE Pico BS	-6	18.2	-	-	-	-	-	-	-	
13	PMSE	GSM Pico BS	-6	98		66.7		54.8		54.3	-	

Table 28: PMSE Hand Held (Antenna pattern: -1, -7, -20 dB)

				Unwanted + Blocking (exceedance probability) [%]							Guard band req'rd for 5% exceed. [MHz]	
				Frequency distance between the PMSE channel edge and the band edge of the MFCN [kHz]								
Scenario	Interferer	Victim	I/N [dB]	200	400	600	800	1000	1200	1400		
2	PMSE	LTE UE (5 MHz)	0							5.8	1.6	Outdoor
2	PMSE	LTE UE (10 MHz)	0			6.4	5.2	4.8		3.2	1.0	
6	PMSE	LTE BS	-6	0.12	-	-	-	-	-	-	-	
5	PMSE	GSM BS	-6	0.2	0.0	0.0	-	-	-	-	-	
10	PMSE	LTE UE (5 MHz)	0							7.1	1.8	Indoor
10	PMSE	LTE UE (10 MHz)		9.2		7.1		6.0	5.2	4.7	1.4	
14	PMSE	LTE Pico BS	-6	4.6	-	-	-	-	-	-	-	
13	PMSE	GSM Pico BS	-6	53.4	34.8	27.1	21.8	20.9	20.7	21.0		

A1.5.1 Conclusion to section A1.5

It is concluded that a significant guard band is needed between PMSE devices and the MFCN downlink.

ANNEX 2: DERIVATION OF A BEM BASED ON MINIMUM COUPLING LOSS ANALYSIS

One simple BEM derivation method is to conduct a Minimum Coupling Loss analysis based on the interfered receiver sensitivity/blocking parameters, the loss of the propagation channel over the assumed protection distance and other relevant attenuation factors.

When considering a GSM UE or BS, the blocking level indicated for the 3rd adjacent channel is actually wrong. The correct value is the one provided for the 4th adjacent channel. As a result, for the 4th adjacent channel and the following ones, the blocking level for adjacent channel N is given in adjacent channel N+1. But this has no impact on the BEM proposed in this report.

A2.1 RESULTS ANALYSIS AND BEM

Details on calculation method and assumptions are provided in Section A2.2.

A2.1.1 Results from blocking calculations

Blocking calculations result in in-block e.i.r.p. limits. When the maximum e.i.r.p. acceptable from a microphone is lower than the e.i.r.p. allowed by ERC/REC 70-03 [1], then a restricted frequency range (RFR) is required.

The table below summarizes the results.

Table 29: Results of blocking MCL analysis

Scenario	Victim	**Handheld PMSE:** restricted frequency range (RFR)	**Body worn PMSE:** restricted frequency range (RFR)
1	GSM UE, outdoor	200 kHz (1804.8-1805 MHz)	200 kHz (1804.8-1805 MHz)
2	LTE UE, outdoor	1.4 MHz (1803.6-1805 MHz)	No requirement
5	GSM macro BS, outdoor	200 kHz (1785-1785.2 MHz)	No requirement (A)
6	LTE macro BS, outdoor	No requirement	No requirement
9	GSM UE, indoor	600 kHz (1804.4-1805 MHz)	400 kHz (1804.6-1805 MHz)
10	LTE UE, indoor	5 MHz (1800-1805 MHz)	2.6 MHz (1802.4-1805 MHz)
13	GSM pico BS, indoor	1.6 MHz (1785-1786.6 MHz)	400 kHz (1785-1785.4 MHz)
14	LTE pico BS, indoor	Not allowed (C)	No RFR requirement but ei.r.p. limited to 15 dBm (B)

(A) A restricted frequency range of 200 kHz would be required for separation distance lower than 95m.
(B) With a separation distance of 6m, body worn microphones can transmit at full e.i.r.p. (17 dBm).
(C) Improvements brought by BS filter are not taken into account.

A2.1.2 Results from out-of-block calculations

Out-of-block calculations result in out-of-block e.i.r.p. limits.

The table below summarizes the results.

Table 30: Results of out-of-block MCL analysis

Scenario	Victim	Handheld PMSE: OOB emission level	Body worn PMSE: OOB emission level
1	GSM UE, outdoor	-37 dBm/200kHz	-23 dBm/200kHz
2	LTE UE, outdoor	-36 dBm/200kHz	-22 dBm/200kHz
5	GSM macro BS, outdoor	-20 dBm/200kHz	-6 dBm/200kHz
6	LTE macro BS, outdoor	-17 dBm/200kHz	-3 dBm/200kHz
9	GSM UE, indoor	-53.5 dBm/200kHz	-39.5 dBm/200kHz
10	LTE UE, indoor	-52.5 dBm/200kHz	-38.5 dBm/200kHz
13	GSM pico BS, indoor	-60 dBm/200kHz	-46 dBm/200kHz
14	LTE pico BS, indoor	-55 dBm/200kHz	-41 dBm/200kHz

A2.1.3 BEM

Based on these calculations, the following Block Edge Mask for PMSE audio terminals operating outdoor in 1785-1805 MHz band can be justified:

Table 31: Block Edge Mask for PMSE audio terminals operating in 1785-1805 MHz

Frequency range	Emission limit (handheld)	Frequency range	Emission limit (body worn)
1710-1785 MHz	-20 dBm/200kHz	1710-1785 MHz	-10 dBm/200kHz
1785.2-1803.6 MHz	13 dBm/channel (A)	1785.2-1804.8 MHz	17 dBm/channel (A)
1805-1880 MHz	-37 dBm/200kHz	1805-1880 MHz	-23 dBm/200kHz

(A) In-band emission limits are those defined in ERC/REC 70-03 Annex 10.

For an indoor use, a BEM approach cannot ensure a systematic coexistence between PMSE and MFCN. On a case by case basis, coexistence can be enabled thanks to appropriate separation distance from possible pico BS and UE, wall absorption and other appropriate regulatory measures adopted at national level.

A2.2 MCL CALCULATIONS

A2.2.1 Calculation tables for in-block e.i.r.p. (blocking case)

Outdoor, UE, Scenarios 1 and 2:

For an outdoor UE (scenarios 1 and 2), the maximum e.i.r.p acceptable from a microphone is given by the following formula:

Mic_ e.i.r.p.$_{max,in\text{-}block}$ = Blocking_Level + Path_Loss - UE_Antenna_Gain + UE_Body_Loss + Mic_Body_Loss

where path loss is calculated according to IEEE 802.11 Model C propagation model and for a separation distance of 15m.

Table 32: Calculation of maximum allowed microphone e.i.r.p. for a GSM UE (Scenario 1)

Frequency range	MHz	1805-1804.8	1804.8-1804.6
Offset from the edge	MHz	0-0.2	0.2-0.4
Victim UE characteristics			
Narrow-band blocking level	dBm	-90	-58
Attenuation calculation			
Path loss	dB	68.2	68.2
Antenna gain	dBi	-4	-4
UE body loss	dB	3	3
Handheld Microphone			
Microphone body loss	dB	1	1
Max e.i.r.p. acceptable	dBm	-13.8	18.2
Microphone e.i.r.p. allowed	dBm	13	13
Conclusion		Restricted	Ok
Body worn Microphone			
Microphone body loss	dB	15	15
Max e.i.r.p. acceptable	dBm	0.2	32.2
Microphone e.i.r.p. allowed	dBm	17	17
Conclusion		Restricted	Ok

Table 33: Calculation of maximum allowed microphone e.i.r.p. for an LTE UE (Scenario 2)

Frequency range	MHz	1804.8-1804.6	1803.8-1803.6	1803.6-1803.4
Offset from the edge	MHz	0.2-0.4	1.2-1.4	1.4-1.6
Victim UE characteristics				
Narrow-band blocking level	dBm	-67.4 (Note 1)	-63.4	-62.6
Attenuation calculation				
Path loss	dB	68.2	68.2	68.2
Antenna gain	dBi	-4	-4	-4
UE body loss	dB	3	3	3
Handheld Microphone				
Microphone body loss	dB	1	1	1
Max e.i.r.p. acceptable	dBm	8.8	12.8	13.6
Microphone e.i.r.p. allowed	dBm	13	13	13
Conclusion		Restricted	Restricted	Ok
Body worn Microphone				
Microphone body loss	dB	15	15	15
Max e.i.r.p. acceptable	dBm	22.8	26.8	27.6
Microphone e.i.r.p. allowed	dBm	17	17	17
Conclusion		Ok	Ok	Ok

Note 1: At 212.5 kHz offset, the blocking level is -67.8 dBm. Since a linear slope of 8 dB / 2 MHz is assumed, at 300 kHz offset the blocking level is -67.8 + 8.[(0.3-0.2125)/2] = -67.8 + 0.35 = -67.45 dBm.

Outdoor, macro BS, Scenarios 5 and 6:

For an outdoor macro BS (Scenarios 5 and 6), the maximum e.i.r.p. acceptable from a microphone is given by the following formula:

$$Mic\_e.i.r.p._{max,in\text{-}block} = Blocking\_Level + Path\_Loss - BS\_Antenna\_Gain + BS\_Antenna\_Discrimination + Mic\_Body\_Loss$$

where path loss is calculated according to Extended Hata propagation model and for a separation distance of 100m.

Table 34: Calculation of maximum allowed microphone e.i.r.p. for a GSM macro BS (Scenario 5)

Frequency range	MHz	1785-1785.2	1785.2-1785.4
Offset from the edge	MHz	0-0.2	0.2-0.4
Victim BS characteristics			
Narrow-band blocking level	dBm	-98	-66
Attenuation calculation			
Path loss	dB	100.9	100.9
Antenna gain (w/ cable loss)	dBi	15	15
Antenna discrimination	dB	15	15
Handheld Microphone			
Microphone body loss	dB	1	1
Max e.i.r.p. acceptable	dBm	3.9	35.9
Microphone e.i.r.p. allowed	dBm	13	13
Conclusion		Restricted	Ok
Body worn Microphone			
Microphone body loss	dB	15	15
Max e.i.r.p. acceptable	dBm	17.9	49.9
Microphone e.i.r.p. allowed	dBm	17	17
Conclusion		Ok (Note 1)	Ok

Note 1: A restricted frequency range of 200 kHz would be required for separation distance lower than 95m.

Table 35: Calculation of maximum allowed microphone e.i.r.p. for an LTE macro BS (Scenario 6)

Frequency range	MHz	1785.4-1789.8
Offset from the edge	MHz	0.4-4.8
Victim BS characteristics		
Narrow-band blocking level	dBm	-59.7
Attenuation calculation		
Path loss	dB	100.9
Antenna gain (w/ cable loss)	dBi	15
Antenna discrimination	dB	15
Handheld Microphone		
Microphone body loss	dB	1
Max e.i.r.p. acceptable	dBm	42.1
Microphone e.i.r.p. allowed	dBm	13
Conclusion		Ok
Body worn Microphone		
Microphone body loss	dB	15
Max e.i.r.p. acceptable	dBm	56.1
Microphone e.i.r.p. allowed	dBm	17
Conclusion		Ok

Indoor, UE, Scenarios 9 and 10:

For an indoor UE (Scenarios 9 and 10), the maximum e.i.r.p. acceptable from a microphone is given by the following formula:

$Mic\_ e.i.r.p._{max,in\text{-}block}$ = Blocking_Level + Path_Loss - UE_Antenna_Gain + UE_Body_Loss + Mic_Body_Loss

where path loss is calculated according to IEEE 802.11 Model C propagation model and for a separation distance of 5m.

Table 36: Calculation of maximum allowed microphone e.i.r.p. for a GSM UE (Scenario 9)

Frequency range	MHz	1805-1804.8	1804.8-1804.6	1804.6-1804.4	1804.4-1803.4
Offset from the edge	MHz	0-0.2	0.2-0.4	0.4-0.6	0.6-1.6
Victim UE characteristics					
Narrow-band blocking level	dBm	-90	-58	-50	-43
Attenuation calculation					
Path loss	dB	51.5	51.5	51.5	51.5
Antenna gain	dBi	-4	-4	-4	-4
UE body loss	dB	3	3	3	3
Handheld Microphone					
Microphone body loss	dB	1	1	1	1
Max e.i.r.p. acceptable	dBm	-30.5	1.5	9.5	16.5
Microphone e.i.r.p. allowed	dBm	13	13	13	13
Conclusion		Restricted	Restricted	Restricted	Ok
Body worn Microphone					
Microphone body loss	dB	15	15	15	15
Max e.i.r.p. acceptable	dBm	-16.5	15.5	23.5	30.5
Microphone e.i.r.p. allowed	dBm	17	17	17	17
Conclusion		Restricted	Restricted	Ok	Ok

Table 37: Calculation of maximum allowed microphone e.i.r.p. for an LTE UE (Scenario 10)

Frequency range	MHz	1804.8-1804.6	1802.6-1802.4	1800.2-1800	1800-1789.8
Offset from the edge	MHz	0.2-0.4	2.4-2.6	4.8-5	5-5.2
Victim UE characteristics					
Narrow-band blocking level	dBm	-67.4 (Note 1)	-56.6	-47.0	-46.2
Attenuation calculation					
Path loss	dB	51.5	51.5	51.5	51.5
Antenna gain	dBi	-4	-4	-4	-4
UE body loss	dB	3	3	3	3
Handheld Microphone					
Microphone body loss	dB	1	1	1	1
Max e.i.r.p. acceptable	dBm	-7.9	2.9	12.5	13.3
Microphone e.i.r.p. allowed	dBm	13	13	13	13
Conclusion		Restricted	Restricted	Restricted	Ok
Body worn Microphone					
Microphone body loss	dB	15	15	15	15
Max e.i.r.p. acceptable	dBm	6.1	16.9	26.5	27.3
Microphone e.i.r.p. allowed	dBm	17	17	17	17
Conclusion		Restricted	Restricted	Ok	Ok

Note 1: At 212.5 kHz offset, the blocking level is -67.8 dBm. Since a linear slope of 8 dB / 2 MHz is assumed, at 300 kHz offset the blocking level is -67.8 + 8.[(0.3-0.2125)/2] = -67.8 + 0.35 = -67.45 dBm.

Results for scenario 10 take into account the additional duplex filter rejection of 2 dB at 2 MHz offset, as assumed in CEPT Report 30 [3], Section A5.2.2.

Indoor, pico BS, Scenarios 13 and 14:

For an indoor pico BS (Scenarios 13 and 14), the maximum e.i.r.p. acceptable from a microphone is given by the following formula:

$$Mic\_ e.i.r.p._{max,in\text{-}block} = Blocking\_Level + Path\_Loss - BS\_Antenna\_Gain + BS\_Antenna\_Discrimination + Mic\_Body\_Loss$$

where path loss is calculated according to IEEE 802.11 Model C propagation model and for a separation distance of 5m.

Table 38: Calculation of maximum allowed microphone e.i.r.p. for a GSM pico BS (Scenario 13)

Frequency range	MHz	1785-1785.2	1785.2-1785.4	1785.4-1785.6	1785.6-1786.6	1786.6-1788
Offset from the edge	MHz	0-0.2	0.2-0.4	0.4-0.6	0.6-1.6	1.6-3
Victim BS characteristics						
Narrow-band blocking level	dBm	-89	-57	-49	-47	-37
Attenuation calculation						
Path loss	dB	52.1	52.1	52.1	52.1	52.1
Antenna gain (w/ cable loss)	dBi	0	0	0	0	0
Antenna discrimination	dB	0	0	0	0	0
Handheld Microphone						
Microphone body loss	dB	1	1	1	1	1
Max e.i.r.p. acceptable	dBm	-35.9	-3.9	4.1	6.1	16.1
Microphone e.i.r.p. allowed	dBm	13	13	13	13	13
Conclusion		Restricted	Restricted	Restricted	Restricted	Ok
Body worn Microphone						
Microphone body loss	dB	15	15	15	15	15
Max e.i.r.p. acceptable	dBm	-21.9	10.1	18.1	20.1	30.1
Microphone e.i.r.p. allowed	dBm	17	17	17	17	17
Conclusion		Restricted	Restricted	Ok	Ok	Ok

Table 39: Calculation of maximum allowed microphone e.i.r.p. for an LTE pico BS (Scenario 14)

Frequency range	MHz	1785.4-1789.8
Offset from the edge	MHz	0.4-4.8
Victim BS characteristics		
Narrow-band blocking level	dBm	-51.7
Attenuation calculation		
Path loss	dB	52.1
Antenna gain (w/ cable loss)	dBi	0
Antenna discrimination	dB	0
Handheld Microphone		
Microphone body loss	dB	1
Max e.i.r.p. acceptable	dBm	1.3 (Note 1)
Microphone e.i.r.p. allowed	dBm	13
Conclusion		Restricted
Body worn Microphone		
Microphone body loss	dB	15
Max e.i.r.p. acceptable	dBm	15.3 (Note 2)
Microphone e.i.r.p. allowed	dBm	17
Conclusion		Limited e.i.r.p.

Note 1: With a separation distance of 11.50m, handheld microphones can transmit at full e.i.r.p. (13 dBm).
Note 2: With a separation distance of 6m, body worn microphones can transmit at full e.i.r.p. (17 dBm).

A2.2.2 Calculation tables for out-of-band e.i.r.p. (out-of-band emissions case)

The in-band interference level is given in the formula below:

In-band_Interference_Level = Thermal_Noise + Noise_Figure + INR

Thermal_Noise = 10 log (k_B.T.BW.1000),
where k_B is the Boltzmann constant, T = 290 K, and BW is the bandwidth considered in Hz

INR = 10 log ($10^{D/10}$ - 1)
where D is the desensitization of the victim receiver (BS or UE)

Outdoor, UE, Scenarios 1 and 2:

For an outdoor UE (scenarios 1 and 2), the maximum out-of-band emissions e.i.r.p. acceptable from a microphone is given by the following formula:

$\text{Mic\_ e.i.r.p.}_{max,oob}$ = In-band_Interference_Level + Path_Loss - UE_Antenna_Gain + UE_Body_Loss + Mic_Body_Loss

where path loss is calculated according to IEEE 802.11 Model C propagation model and a separation distance of 15m.

Table 40: Calculation of maximum allowed out-of-band microphone e.i.r.p. for a GSM UE (Scenario 1)

Victim UE characteristics		
Interferer power allowed	dBm/200kHz	-113.0
Attenuation calculation		
Path loss	dB	68.2
Antenna gain	dBi	-4
UE body loss	dB	3
Handheld Microphone		
Microphone body loss	dB	1
Max out-of-band e.i.r.p.	dBm/200kHz	-36.8
Body worn Microphone		
Microphone body loss	dB	15
Max out-of-band e.i.r.p.	dBm/200kHz	-22.8

Table 41: Calculation of maximum allowed out-of-band microphonee.i.r.p. for an LTE UE (Scenario 2)

Victim UE characteristics		
Interferer power allowed	dBm/200kHz	-112.0
Attenuation calculation		
Path loss	dB	68.2
Antenna gain	dBi	-4
UE body loss	dB	3
Handheld Microphone		
Microphone body loss	dB	1
Max out-of-band e.i.r.p.	dBm/200kHz	-35.8
Body worn Microphone		
Microphone body loss	dB	15
Max out-of-band e.i.r.p.	dBm/200kHz	-21.8

Outdoor, macro BS, Scenarios 5 and 6:

For an outdoor macro BS (scenarios 5 and 6), the maximum out-of-band emissions e.i.r.p. acceptable from a microphone is given by the following formula:

$$\text{Mic\_e.i.r.p.}_{max,oob} = \text{In-band\_Interference\_Level} + \text{Path\_Loss} - \text{BS\_Antenna\_Gain} + \text{BS\_Antenna\_Discrimination} + \text{Mic\_Body\_Loss}$$

where path loss is calculated according to Extended Hata propagation model and a separation distance of 100m.

Table 42: Calculation of maximum allowed out-of-band microphone e.i.r.p. for a GSM macro BS (Scenario 5)

Victim BS characteristics		
Interferer power allowed	dBm/200kHz	-119
Attenuation calculation		
Path loss	dB	100.9
Antenna gain (w/ cable loss)	dBi	15
Antenna discrimination	dB	15
Handheld Microphone		
Microphone body loss	dB	1
Max out-of-band e.i.r.p.	dBm/200kHz	-17.1
Body worn Microphone		
Microphone body loss	dB	15
Max out-of-band e.i.r.p.	dBm/200kHz	-3.1

Table 43: Calculation of maximum allowed out-of-band microphone e.i.r.p. for an LTE macro BS (Scenario 6)

Victim BS characteristics		
Interferer power allowed	dBm/200kHz	-122
Attenuation calculation		
Path loss	dB	100.9
Antenna gain (w/ cable loss)	dBi	15
Antenna discrimination	dB	15
Handheld Microphone		
Microphone body loss	dB	1
Max out-of-band e.i.r.p.	dBm/200kHz	-20.1
Body worn Microphone		
Microphone body loss	dB	15
Max out-of-band e.i.r.p.	dBm/200kHz	-6.1

Indoor, UE, Scenarios 9 and 10:

For an indoor UE (scenarios 9 and 10), the maximum out-of-band emissions e.i.r.p. acceptable from a microphone is given by the following formula:

$$\text{Mic\_e.i.r.p.}_{max,oob} = \text{In-band\_Interference\_Level} + \text{Path\_Loss} - \text{UE\_Antenna\_Gain} + \text{UE\_Body\_Loss} + \text{Mic\_Body\_Loss}$$

where path loss is calculated according to IEEE 802.11 Model C propagation model and a separation distance of 5m.

Table 44: Calculation of maximum allowed out-of-band microphone e.i.r.p. for a GSM UE (Scenario 9)

Victim UE characteristics		
Interferer power allowed	dBm/200kHz	-113.0
Attenuation calculation		
Path loss	dB	51.5
Antenna gain	dBi	-4
UE body loss	dB	3
Handheld Microphone		
Microphone body loss	dB	1
Max out-of-band e.i.r.p.	dBm/200kHz	-53.5
Body worn Microphone		
Microphone body loss	dB	15
Max out-of-band e.i.r.p.	dBm/200kHz	-39.5

Table 45: Calculation of maximum allowed out-of-band microphone e.i.r.p. for an LTE UE (Scenario 10)

Victim UE characteristics		
Interferer power allowed	dBm/200kHz	-112.0
Attenuation calculation		
Path loss	dB	51.5
Antenna gain	dBi	-4
UE body loss	dB	3
Handheld Microphone		
Microphone body loss	dB	1
Max out-of-band e.i.r.p.	dBm/200kHz	-52.5
Body worn Microphone		
Microphone body loss	dB	15
Max out-of-band e.i.r.p.	dBm/200kHz	-38.5

Indoor, pico BS, Scenarios 13 and 14:

For an indoor pico BS (scenarios 13 and 14), the maximum out-of-band emissions e.i.r.p. acceptable from a microphone is given by the following formula:

$$Mic\_e.i.r.p._{max,oob} = In\text{-}band\_Interference\_Level + Path\_Loss - BS\_Antenna\_Gain + BS\_Antenna\_Discrimination + Mic\_Body\_Loss$$

where path loss is calculated according to IEEE 802.11 Model C propagation model and for a separation distance of 5m.

Table 46: Calculation of maximum allowed out-of-band microphone e.i.r.p. for a GSM pico BS (Scenario 13)

Victim BS characteristics		
Interferer power allowed	dBm/200kHz	-113
Attenuation calculation		
Path loss	dB	52.1
Antenna gain (w/ cable loss)	dBi	0
Antenna discrimination	dB	0
Handheld Microphone		
Microphone body loss	dB	1
Max out-of-band e.i.r.p.	dBm/200kHz	-59.9
Body worn Microphone		
Microphone body loss	dB	15
Max out-of-band e.i.r.p.	dBm/200kHz	-45.9

Table 47: Calculation of maximum allowed out-of-band microphone e.i.r.p. for an LTE pico BS (Scenario 14)

Victim BS characteristics		
Interferer power allowed	dBm/200kHz	-108
Attenuation calculation		
Path loss	dB	52.1
Antenna gain (w/ cable loss)	dBi	0
Antenna discrimination	dB	0
Handheld Microphone		
Microphone body loss	dB	1
Max out-of-band e.i.r.p.	dBm/200kHz	-54.9
Body worn Microphone		
Microphone body loss	dB	15
Max out-of-band e.i.r.p.	dBm/200kHz	-40.9

A2.3 MCL CALCULATIONS FOR PMSE TOWARDS LTE

A2.3.1 Results

This subsection contains MCL calculation results for PMSE towards LTE based on the parameters defined in the next subsection, for two different propagation models.

Table 48: Minimum distance calculation in kilometers

Propagation Model	PMSE Body Loss	PMSE -> LTE UE with frequency separation of:		PMSE -> LTE pico BS with frequency separation of:		PMSE -> LTE Macro BS with frequency separation of:	
		0 KHz	200 KHz	0 KHz	200 KHz	0 KHz	200 KHz
FSPL	1 dB	0.213	0.031	0.855	0,035	8.550	0.345
	7 dB	0.107	0.016	0.429	0,017	4.285	0.218
IEEE 802.11C	1 dB	0.043	0.014	0.095	0,015	N/A	
	7 dB	0.029	0.010	0.064	0,010		
Extend Hata for Metropolitan areas	1 dB	N/A		N/A		0.332	0.054
	7 dB					0.224	0.041

A2.3.2 Parameters

This subsection contains the parameters used in the MCL calculations.

Table 49: Parameters for the LTE system

Parameter	Unit	UE	Pico BS	Macro BS
ACS	dB	33	46	46
Frequency	MHz	1810	1780	1780
Noise figure	dB	9	13	5
Noise level	dBm	-95,4	-94,4	-102,4
I/N	dB	0	-6	-6
Body loss	dB	3	0	0
Tx Bandwidth	MHz	9	4,5	4,5
Antenna Gain	dBi	-4	0	15

Table 50: Parameters for PMSE

Parameter	Unit	UE	Pico BS
Frequency offset	KHz	0	200
Bandwidth	KHz	200	200
Frequency	MHz	1785.1	1785.3
		1804.9	1804.7
ACLR[4]	dB	16.3	48.8
Antenna Gain	dBi	0	
Body Loss	dB	1	
		7	
Transmit Power	dBm	13	

[4] These ACLR values are obtained from the PMSE spectrum mask in SEAMCAT

ANNEX 3: ADAPTATION OF CEPT REPORT 30 DERIVATION

The method described in section A5.2 of CEPT Report 30 [3] has been adjusted to the band 1800 MHz it considers interference from low power applications to MFCN.

The impact of the unwanted emissions and the blocking from PMSE to MFCN has been considered.

For this method, it is assumed that, in practice, a device's rejection of an adjacent-channel interferer is 3 dB better than that implied by the 3GPP blocking specifications.

Table 51: Calculation of maximum interfering power

Specification	Narrow band blocking on MFCN TS	Narrow band blocking on MFCN BS
Source	ETSI TS 136.101 section 7.6.3	ETSI TS 136.104 section 7.5
Blocking requirement	-55 dBm	-49 dBm
Associated desensitization	13 dB	6 dB
Target desensitization	3 dB	1 dB

- Improved ACS for narrow-band interfering signal according to frequency offset.
  - For an offset of 2 MHz from the victim's channel-edge, the narrowband selectivity is naturally greater than for a 0 MHz offset. Starting from a narrowband selectivity at zero offset, a linear slope of 17/5 dB/MHz would result in a higher narrowband ACS value at higher offset.
- Duplex filter rejection according to frequency offset.
  - It is assumed that an MFCN TS receiver duplex filter provides an additional rejection of 2 dB at 2 MHz offset from the channel-edge for narrow band signals (<1 MHz).
  - A linear slope of 2/2 dB/MHz for the duplex filter rejection was considered.

The table below shows that a 1 MHz guard band would be needed to protect LTE TS from hand-held radio microphone emissions. Indeed, for such a guard band, the in-band e.i.r.p. would be 13 dBm (which is the in-band hand-held radiomicrophone e.i.r.p.) and in this case, the out-of-block e.i.r.p. above 1805 MHz should be -31 dBm/10 MHz.

Nevertheless a 1.2 MHz guard band would be preferable to protect TS LTE from hand-held radiomicrophone emissions. Indeed, for this guard band, the out-of-block e.i.r.p. above 1805 MHz should be -27 dBm/10 MHz (higher than -31 dBm/10 MHz) which is equivalent to -44 dBm/200 kHz to be compared to the -38.9 dBm/200 kHz of method 4 (see table below).

At the end, the better compromise would indeed probably to consider a 1.2 MHz guard band as it enables higher radiomicrophone out-of-block emissions than for a 1 MHz guard band.

Table 52: Interfering link budget calculations

		BEM hand held PMSE					
		Interferer: PMSE					
Parameter	**Units**	Victim: LTE TS					**Comment**
Interferer frequency	MHz	1805-1804.8	1804.8-1804.6	1804-1803.8	1803.8-1803.6	1803.6-1803.4	
3GPP specs for victim		**Narrow band blocking on LTE TS**	**Narrow band blocking on LTE TS**	**Narrow band blocking on LTE TS**	**Narrow band blocking on LTE TS**	**Narrow band blocking on LTE TS**	
Interferer power	dBm	-55.00	-55.00	-55.00	-55.00	-55.00	Puw (Specified)
Implied desensitisation	dBm	13.00	13.00	13.00	13.00	13.00	D (Specified)
Imax 13 dB	**dBm**	**-82.66**	**-82.66**	**-82.66**	**-82.66**	**-82.66**	
Target desensitisation	dB	3.00	3.00	3.00	3.00	3.00	Performance criterion
Receiver NF	dB	9.00	9.00	9.00	9.00	9.00	NF
Thermal noise floor (9 MHz)	dBm	-95.43	-95.43	-95.43	-95.43	-95.43	Pn = 10log(k.T.BW) + NF + 30
Receiver selectivity	dB	27.66	28.3	31	31.7	32.4	receiver selectivity=ACS(fg=0)+(17/5)*fg with ACS(fg=0)=Iinterf power-Imax 13 dB
Victim's performance							
Performance beyond specs	dB	3.00	3.00	3.00	3.00	3.00	Gdevice
Guard-band	MHz	0	0.2	1	1.2	1.4	fg (Guard-band at victim's boundary)
Duplexer attenuation	dB	0.00	0.6	3.2	3.8	4.5	Gduplex (given the guard-band fg)=(16/5)*fg
Receiver selectivity	**dB**	**31**	**32**	**37**	**39**	**40**	**ACS = ACS + Gdevice + Gduplex**
Geometry							
Horizontal distance	M	15.00	15.00	15.00	15.00	15.00	

Interferer height	M	1.5	1.5	1.5	1.5	1.5	
Victim height	M	1.5	1.5	1.5	1.5	1.5	
Link budget							
Interferer body-loss	dB	-1.00	-1.00	-1.00	-1.00	-1.00	Gb.i
Hata path loss	dB	-68.2	-68.2	-68.2	-68.2	-68.2	Gpl
Victim body loss	dB	-3.00	-3.00	-3.00	-3.00	-3.00	Gb.v
Victim ant. elevation pattern	dB	0.00	0.00	0.00	0.00	0.00	dGa,v
Victim antenna gain	dBi	0.00	0.00	0.00	0.00	0.00	Ga,v
Coupling loss	**dB**	**-72**	**-72**	**-72**	**-72**	**-72**	**G = Gb,i + Gpl + Gwl + Gb,v + Ga,v+dGa,v**
Interferer in-block e.i.r.p.	**dBm**	**7.00**	**8.00**	**13.00**	**13.00**	**13.00**	**Pib**
Interferer out-of-block e.i.r.p.	**dBm/ (10 MHz)**	**-35**	**-32**	**-31**	**-27**	**-26**	**Linear: Poob = PI/G - Pib/ACS**

Table 53: Interfering link budget calculations

		BEM body worn PMSE				
		Interferer: PMSE				
Parameter	**Units**	**Victim: LTE TS**				**Comment**
Interferer Frequency	MHz	1804.9-1804.7	1804.7-1804.5	1804.1-1803.9	1803.9-1803.7	
3GPP specs for victim		**Narrow band blocking on LTE TS**	**Narrow band blocking on LTE TS**	**Narrow band blocking on LTE TS**	**Narrow band blocking on LTE TS**	
Interferer power	dBm	-55.00	-55.00	-55.00	-55.00	Puw (Specified)
Implied desensitisation	dBm	13.00	13.00	13.00	13.00	D (Specified)
Imax 13 dB	**dBm**	**-82.66**	**-82.66**	**-82.66**	**-82.66**	
Target desensitisation	dB	3.00	3.00	3.00	3.00	Performance criterion
Receiver NF	dB	9.00	9.00	9.00	9.00	NF
Thermal noise floor (9 MHz)	dBm	-95.43	-95.43	-95.43	-95.43	Pn = 10log(k.T.BW) + NF + 30
Receiver selectivity	dB	27.66	28.4	31.7	32.4	receiver selectivity=ACS(fg=0)+4*(fg-0.1) with ACS(fg=0)=Iinterf power-Imax 13 dB
Victim's performance						
Performance beyond spec		3	3	3	3	Gdevice
Guard-band	MHz	0.1	0.3	1.1	1.3	fg (Guard-band at victim's boundary)
Duplexer attenuation	dB	0.00	0.2	0.8	1	Gduplex (given the guard-band fg)=(2/2)*(fg-0.1)
Receiver selectivity	**dB**	**31**	**32**	**34.2**	**35**	**ACS = ACS + Gdevice + Gduplex**
Geometry						
Horizontal distance	m	15.00	15.00	15.00	15.00	

Interferer height	m	1.5	1.5	1.5	1.5	
Victim height	m	1.5	1.5	1.5	1.5	
Link budget						
Interferer body-loss (body worn)	dB	-15.00	-15.00	-15.00	-15.00	Gb,i
Hata path loss	dB	-61.03	-61.03	-61.03	-61.03	Gpl
Victim body loss	dB	-3.00	-3.00	-3.00	-3.00	Gb,v
Victim ant. elevation pattern	dB	0.00	0.00	0.00	0.00	dGa,v
Victim antenna gain	dBi	-4.00	-4.00	-4.00	-4.00	Ga,v
Coupling loss	**dB**	**-83.03**	**-83.03**	**-83.03**	**-83.03**	**G = Gb,i + Gpl + Gwl + Gb,v + Ga,v+dGa,v**
Interferer in block e.i.r.p.	**dBm**	**17.00**	**17.00**	**17.00**	**17.00**	**Pib**
Interferer out-of-block e.i.r.p.	**dBm/ (10 MHz)**	**-18.5**	**-16.5**	**-15.4**	**-13.8**	**Linear: Poob = PI/G - Pib/ACS**

Table 54: Interfering link budget calculations

		BEM hand held	BEM body worn	
		Interferer: PMSE		
Parameter	**Units**	**Victim: LTE BS**		**Comment**
Interferer Frequency	MHz	1785.1-1785.3	1785.1-1785.3	
3GPP specs for victim		**Narrow band blocking on LTE TS**	**Narrow band blocking on LTE TS**	
Interferer power	dBm	**-49**	**-49**	Puw (Specified)
Implied desensitisation	dBm	6	6	D (Specified)
Imax 6 dB	**dBm**	**-94.7**	**-94.7**	
Target desensitisation	dB	1	1	Performance criterion
Receiver NF	dB	5,00	5,00	NF
Thermal noise floor (9 MHz)	dBm	-99.4	-99.4	Pn = 10log(k.T.BW) + NF + 30
Receiver selectivity	dB	45.7	45.7	receiver selectivity=ACS(fg=0)+4*(fg-0.1) with ACS(fg=0)=Iinterf power-Imax 13 dB
Victim's performance				
Performance beyond spec		3	3	
Guard-band	MHz	0.1	0.1	fg (Guard-band at victim's boundary)
Receiver selectivity	**dB**	**48.7**	**48.7**	**ACS = ACS + Gdevice**

Geometry				
Horizontal distance	m	60	60	
Interferer height	m	1,5	1,5	
Victim height	m	30	30	
Link budget				
Interferer body-loss	dB	-7	-15	Gb,i
Hata path loss	dB	-85.6	-85.6	Gpl
Victim ant. elevation pattern	dB	-15.00	-15.00	dGa,v
Victim antenna gain	dBi	15	15	Ga,v
Coupling loss	**dB**	**-92.6**	**-100.6**	G = Gb,i + Gpl + Gwl + Gb,v + Ga,v+dGa,v
Interferer in-block e.i.r.p.	**dBm**	**13**	**17**	**Pib**
Interferer out-of-block e.i.r.p.	**dBm/(10 MHz)**	**-12.7**	**-4.7**	**Linear: Poob = PI/G - Pib/ACS**

ANNEX 4: DERIVATION OF A BEM BASED ON MOBILE UE EMISSION LIMIT REQUIREMENTS

The deployment scenario for the BEM corresponds to low power devices with deployment topology similar to UE. It should be noted that UE specifications already include specific requirements to avoid UE to UE or UE to BS interference for equipment operating in the 1710-1785/1805-1880 MHz mobile band. Protection of mobile service can simply be insured through extension of such requirements to other equipment operating in the centre gap.

The introduction of UMTS, LTE and WiMAX terminals in the band 1710-1785/1805-1880 MHz has been studied in ECC Report 82 [22] and CEPT Report 40 [13] and has been found satisfactory. Any system creating no more interference than GSM/UMTS/LTE/WiMAX terminals in the band 1710-1785/1805-1880 MHz should therefore clearly be compatible with services in this band.

A4.1 EMISSIONS IN THE 1710-1785 MHZ BAND

Maximum e.i.r.p. for a GSM UE is 30 dBm; and the one for an LTE UE is 23 dBm. These values are above the 17 dBm that is the maximum e.i.r.p. for a body worn wireless microphone.

The GSM specification ETSI TS 145.005 (see Table 4.2.1.3-b1) Table 55, provides the following spectrum emission mask:

Table 55: GSM UE spectrum emission mask

Offset from centre frequency (in kHz)	dBc	
0	0.5	30.5 dBm / 200 kHz
100	0.5	30.5 dBm / 200 kHz
200	-30	0 dBm / 200 kHz
250	-33	-3 dBm / 200 kHz
400	-60	-30 dBm / 200 kHz
600..1800	-60	-30 dBm / 200 kHz
1800..6000	-65	-35 dBm / 200 kHz

The LTE specification ETSI TS 136 101 (see Table 6.6.2.1.1-1) Table 56 provides the following spectrum emission mask:

Table 56: LTE UE spectrum emission mask

Offset from the edge (in MHz)	dBm	
0..1	-18 dBm / 30 kHz	-9.8 dBm / 200 kHz
1..5	-10 dBm / MHz	-17 dBm / 200 kHz

As mobile deployments can occur in adjacent channels, and compared to the wireless microphone spectrum emission mask (see Section 3.1), it is clear that an emission level of -10 dBm / MHz in 1710-1785 MHz does not create undue interference to existing networks in that band.

A4.2 EMISSIONS IN THE 1805-1880 MHz BAND

The ERC/REC 74-01, Annex 2 Table 2.1, [2] (as ITU-R SM.329-11) indicates that unwanted emissions in the spurious domain from land mobile terminals and radio microphones should be limited to -30 dBm / MHz above 1 GHz. This limit is quoted in the LTE specification ETSI TS 136 101 [7] (see Table 6.6.3.1-2).

In ETSI TS136.101 there also exist an additional requirement (6.6.3.2, the requirement is -50 dBm/MHz) to protect other DL bands. PMSE should not be allowed to interfere more than a LTE UE.

Therefore, PMSE audio equipment can be allowed to transmit in 1805-1880 MHz at a power of -30 dBm / MHz. As a result, an emission limit of -37 dBm / 200 kHz can be justified.

According to the wireless microphone spectrum emission mask (see section 3.1), this requirement is met:

- at 135 kHz from the edge for a 200 kHz channel microphone;
- at 252 kHz from the edge for a 400 kHz channel microphone;
- at 333 kHz from the edge for a 600 kHz channel microphone.

Table 57: Limits for terminal stations (In-block power limits for terminal stations)

	Maximum mean power (including Automatic Transmitter Power Control range)
Total radiated power (TRP)	31 dBm/5 MHz
e.i.r.p.	35 dBm/5 MHz
NB: e.i.r.p. should be used for fixed or install terminal stations and the TRP should be used for the mobile or nomadic terminal stations. TRP is a measure of how much power the antenna actually radiates. The TRP is defined as the integral of the power transmitted in different directions over the entire radiation sphere.	

A4.3 CONCLUSION

Based on previous CEPT studies and the spurious emission requirement, the following Block Edge Mask for PMSE audio terminals operating in 1785-1805 MHz can be justified:

Table 58: Block Edge Mask for PMSE audio terminals operating in 1785-1805 MHz

Frequency range	Emission limit (e.i.r.p.)
1710-1785 MHz	-17 dBm / 200 kHz
1785-(Note 1) MHz	17 dBm / channel
(Note 1)-1805 MHz	-10 dBm / 200 kHz
1805-1880 MHz	-37 dBm / 200 kHz
Note 1: ▪ 1804.8 MHz for a 200 kHz channel ▪ 1804.7 MHz for a 400 kHz channel ▪ 1804.6 MHz for a 600 kHz channel	

Note: In order to prevent interferences, a guard-band of 200 kHz is usually implemented between two mobile networks when at least one of them uses GSM technology. This is similar to the results obtained here.

ANNEX 5: SETUP PROCEDURE FOR AN INTERFERENCE FREE OPERATION OF WIRELESS MICROPHONE AND IN-EAR MONITOR LINKS

In this annex the setup procedure for an interference free operation is described. This procedure is performed before the PMSE user can go online and during the use of the equipment. The procedure is used for analogue systems and in principle also for digital systems [23].

A5.1 SECURE INTERFERENCE FREE OPERATION OF WIRELESS MICROPHONE AND IN-EAR MONITOR LINKS

Microphone user sets up his equipment.

First thing to do: switch on the receiver and listen to its output. This is either done through the connected PA system via the mixing console or through a headphone directly connected to the receiver headphone socket.

If there is no signal audible the receiver’s frequency can be used for operation.

There may or may not be an audible signal at the receiver output. If there is an audible signal, the frequency is already occupied and cannot be used. However, it is possible that the frequency is occupied but there is no audio signal coming from the receiver. Most analogue PMSE systems use a "tone key" system which helps prevent unwanted signals and noise from being output by the receiver. Unless the unwanted PMSE transmission is using the same tone key frequency, the user will not be able to hear it. However, the unwanted signal may still cause interference if it is strong enough. Likewise, digital PMSE systems use various modulation and coding schemes which are typically incompatible. It is quite possible that a channel could be occupied by a different type of digital system and no audio would be heard from the receiver. The same thing would happen if an analogue PMSE system picked up a digital PMSE transmission, and vice versa.

The user also monitors the RF and Audio Level indicators to prove the audible output of the link. If there is no indication at these two level meters the frequency is not in use and can be used for interference free operation: the transmitter can be switched on at the receiver’s frequency.

The most basic method for determining whether a given frequency is in use is by monitoring the receiver's RF indicator. However, the lack of an indication does not necessarily mean that interference-free operation is assured because these RF indicators are not precision devices and there could still be a residual signal present on the frequency.

If there is a signal audible or the two level meter show signals a different frequency will be adjusted at the receiver and the same test has to be done again.

Some receivers do this check already alone in “sound-check-mode” or similar. In this mode the spectrum is scanned and frequencies for operation are indicated. The user can choose out of the offered frequencies one for his operation.

Many recent PMSE models incorporate some type of built-in scanning capability that will help the user determine which channels are usable. The operation of this function may range from basic to highly sophisticated, rivalling the performance of a dedicated spectrum analyser. In general, these scanners are useful for finding "open" frequencies.

Certain manufacturers offer for their receiver systems an Ethernet link so that the receiver can be connected to a notebook. These manufacturers also offer on their homepage free of charge software that makes the receiver to operate as a spectrum scanner – similar to the above mentioned “sound-check-mode”. This time all the results can be seen on the notebooks screen and a frequency gap for the operation can be chosen.

Several manufacturers have enabled their PMSE systems to be connected to a computer to provide enhanced scanning and frequency management capabilities. A variety of interfaces are used, including Ethernet and USB. For multichannel operation of wireless links the manufacturers offer sets of frequencies which are calculated to be free of interference. These frequencies have to be chosen for the operation for maximum security of the wireless link. In the vast majority these frequencies are stored as presets in both: receiver and transmitter.

A5.2 THE PRESELECTED COMPATIBLE CHANNEL GROUPS PROVIDED BY PMSE

Manufacturers are selected to be free from Inter-modulation Distortion interference. This does not mean that they are free from all sources of interference; only interference caused by interaction between multiple systems. The use of these frequencies should help ensure that a multi-channel PMSE system can be operated reliably. They do not affect whether the link is "secure" in the sense that the transmissions are protected from outside interference or interception.

PMSE user coordination on site:

PMSE users coordinate themselves on site for interference free operation. The current analogue systems allow listening to the links of other users and making it easy to get into personal contact with these operators. In this personal contact the operation time or the coordinating of the frequency use will be coordinated personally.

For the reasons given above, either analogue or digital systems necessarily allow users to monitor the links of other users. Therefore, this technique is not commonly used or relied upon as a means of frequency coordination at multi-user events.

It has to be noticed that the coordination has to be modified with digital systems as the finding of the “interfering” operator will be more complicated. Solutions for this, like monitoring of signal strength indicator, have to be discussed.

For large events, there will typically be an assigned frequency coordinator who also monitors frequency use. PMSE system operators are normally required to register their systems with the coordinator to prevent interference. Coordinators typically use spectrum analysers to monitor and control spectrum usage.

ANNEX 6: IMPACT OF MFCN BANDWIDTH ON PMSE TX - MFCN LTE RX STUDIES

A6.1 INTRODUCTION

The LTE standard specifies several operating bandwidths (ETSI TS 136.101 [7] - Table 5.6-1 and ETSI TS 136.104 [8] - Table 5.6-1). The standard also differentiates between the Channel Bandwidth and the Transmission Bandwidth (e.g. for a specific test channel). The relationship between the Channel Bandwidth and the Transmission Bandwidth is provided in the Table 59 for both uplink and downlink.

Table 59: Channel Bandwidth and Transmission Bandwidth in ETSI TS 136.101 and ETSI TS 136.104

Link	Channel BW	Transmission BW (Sensitivity)
Uplink	10	4.5 MHz (25RB, ETSI TS 136.104, Table 7.2.1-x) (Sensitivity Wide Area BS = -101.5 dBm, ETSI TS 136.104 Table 7.2.1-1 Sensitivity Local Area BS = -93.5 dBm, ETSI TS 136.104 Table 7.2.1-2)
Downlink	10	9 MHz (50RB, ETSI TS 136.101, Table A.2.2.1.1-1) (Sensitivity = -94 dBm, ETSI TS 136.101 Table 7.3.1-1)

The selection of an assumed bandwidth has an impact on the noise level assumed in the study, since the noise level N is directly related to the bandwidth by the formula:

$$N = 10.\log10(k.T) + 10.\log10(BW) + NF$$

where k = Boltzmann constant; T = 290 K; BW = Bandwidth and NF = Noise Figure.

The table below indicates the different values of N, for NF(LTE UE) = 9 dB, NF(LTE macro BS) = 5 dB and NF(LTE pico BS) = 13 dB.

Table 60: Noise levels for Channel and Transmission Bandwidths

Link	Channel BW / Noise	Transmission BW (MHz) / Noise (dBm)
Uplink	10 MHz -99 dBm (Macro) -91 dBm (Pico)	4.5 MHz -102.5 dBm (Macro) -94.5 dBm (Pico)
Downlink	10 MHz / -95 dBm	9 MHz / -95.5 dBm

The present Annex demonstrates that the studies on the interference from PMSE to MFCN (LTE) are not impacted by the choice of either the Channel Bandwidth or the Transmission Bandwidth.

A6.2 PMSE OUT-OF-BAND EMISSION LIMITS

In OOB studies, we compare the level of OOB emission (OOB) in the receiver's bandwidth with the noise level on the same bandwidth, ensuring that a target ratio of interference on noise is respected, i.e. (OOBE – N) is constant and independent of the receiver bandwidth.

Assuming 2 different receiver bandwidths BW_1 and BW_2, we would have:

$$N_1 = 10.\log10(k.T) + NF + 10.\log10(BW_1)$$

and

$$N_2 = 10.\log10(k.T) + NF + 10.\log10(BW_2)$$

Given that OOBE - N is constant:

$$OOBE_1 - N_1 = OOBE_2 - N_2$$

which implies that

$$OOBE_1 - 10.\log10(BW_1) = OOBE_2 - 10.\log10(BW_2)$$

Demonstrating that the normalised values of $OOBE_1$ and $OOBE_2$ (in dBm/MHz) are strictly identical.

Therefore, the choice of a specific receiver bandwidth has no impact on the acceptable level of OOB emission derived.

A6.3 BLOCKING

Assuming 2 different receiver bandwidths BW_1 and BW_2, we would have:

$$N_1 = 10.\log10(k.T) + NF + 10.\log10(BW_1)$$

and

$$N_2 = 10.\log10(k.T) + NF + 10.\log10(BW_2)$$

From the derivation of the blocking response derivation in ANNEX 3:

$$\text{Blocking Response} = N + 10.\log10[10\text{^}(D_{STANDARD}/10) - 1] - I_{OOB\text{-}STANDARD}$$

In ETSI TS 136.104 and ETSI TS 136.101, $I_{OOB\text{-}STANDARD}$ and $D_{STANDARD}$ are independent from the consideration of Channel Bandwidth of Transmission Bandwidth. Therefore:

$$\text{Blocking Response }(N_2) = \text{Blocking Response }(N_1) + (N_2\text{-}N_1)$$

In turn, in order to find the absolute level for blocking, it is necessary to calculate the $I_{IB\text{-}TARGET}$ based on the noise floors (N_1 and N_2) and a Margin which is a function of D_{TARGET}:

$$I_{IB\text{-}TARGET}(N_1) = N_1 + \text{Margin}(D_{TARGET}),$$

and

$$I_{IB\text{-}TARGET}(N_2) = N_2 + \text{Margin}(D_{TARGET}).$$

Therefore:

$$\begin{aligned} I_{OOB\text{-}TARGET}(N_2) &= I_{IB\text{-}TARGET}(N_2) - \text{Blocking Response }(N_2) \\ &= N_2 + \text{Margin}(D_{TARGET}) – [\text{Blocking Response}(N_1) + (N_2\text{-}N_1)] \\ &= N_1 + \text{Margin}(D_{TARGET}) – \text{Blocking Response (N1)} \\ &= I_{OOB\text{-}TARGET}(N_1) \end{aligned}$$

Which demonstrates that the Blocking Level derived is independent from the consideration of either the Channel Bandwidth or the Transmission Bandwidth.

ANNEX 7: CONSIDERATIONS ON RECEIVER BLOCKING RESPONSE AND RECEIVER BLOCKING LEVEL

A7.1 PRELIMINARY

The blocking parameters of a standard are specified for specific values testing parameters which do not always correspond to typical operational values. In particular, blocking values in LTE standards are specified for desensitization values (e.g. 6 dB for BS, 13 dB for MS) which may not correspond to the desired operational value for specific studies (e.g. 1 dB for BS and 3 dB for MS). It is therefore sometimes necessary to translate the Blocking Level defined by the standard for a desensitization $D_{STANDARD}$ into the corresponding Blocking Level for another desensitization D_{TARGET}.

The analysis in Section A7.3 is conducted for a standard that provides a maximum power (Blocking Level) of an interfering signal received outside of the in-band, for a given frequency offset between the wanted signal and the interfering signal. This absolute blocking level is specified in the standard for a specific desensitization $D_{STANDARD}$. This is the case for the narrowband blocking specifications in LTE standards (ETSI TS 136.101 and ETSI TS 136.104). It is also the case for the blocking specifications for the 3rd adjacent channel and the following ones in GSM (ETSI TS 145.005).

The analysis in Section A7.4 is conducted for a standard that provides a protection ratio. This is the case for the blocking specifications for the first 2 adjacent channels in GSM (ETSI TS 145.005).

A7.2 DEFINITIONS

Abbreviation	Explanation
Blocking Level	Maximum power (Maximum I_{OOB}) of an interfering signal outside of the in-band, for a given frequency offset between the wanted signal and the interfering signal, given in dBm
Blocking Response	Receiver filter attenuation of signals outside of receiver's channel/band, given in dB. It is derived by the following equation: Blocking Response = I_{IB} - I_{OOB}
$C_{STANDARD}$	Wanted signal level defined by the standard for the blocking specification
D	Desensitization of the receiver in the presence of an interfering signal, given in dB. It corresponds to the 'noise rise' due to the interfering signal and is derived by the following equation in dB: D = 10.log10[(10^(N/10) + 10^(I_{IB}/10))] - N
$D_{STANDARD}$	Desensitization defined by the standard for the blocking specification
D_{TARGET}	Target desensitization for a specific interference study
I_{IB}	I_{OOB} in-band equivalent interfering signal
$I_{IB-STANDARD}$	$I_{OOB-STANDARD}$ equivalent in-band interfering signal
$I_{IB-TARGET}$	$I_{OOB-TARGET}$ equivalent in-band interfering signal
I_{OOB}	Interfering signal at the RF input of a receiver, outside of the receiver's bandwidth.
$I_{OOB-STANDARD}$	Allowed power of an interfering blocking signal as specified by the standard (for $D_{STANDARD}$).
$I_{OOB-TARGET}$	Allowed power of an interfering blocking signal for D_{TARGET}.
N	Noise floor, given in dBm. N is derived from the following equation in dB: 10.log10(k.T.BW) + NF, where k = Boltzmann constant, T = 290 K, BW = Bandwidth, NF = Noise figure
SENSITIVITY	Minimum power of the wanted signal defined by the standard for appropriate reception in the absence of interference

$C_{STANDARD}$ is referred to in different standards and documents as:

- *Useful signal* (ETSI TS 145.005 - Chapters 5.1.2 and 5.1.3)
- *Wanted signal mean power* (ETSI TS 136.104 - Table 7.5.1-1)
- *Pw* (ETSI TS 136.101 - Table 7.6.3.1-1)
- *Prefsens + desensitization* (ETSI TS 136.104 - Table 7.5.1-1, ETSI TS 136.101 - Table 7.6.3.1-1)
- "*C*"

$C_{STANDARD}$ is specified for a given sensitivity and a given desensitization.

$I_{OOB\text{-}STANDARD}$ is referred to in different standards as:

- *Blocking signal level* (ETSI TS 145.005 - Table 5.1-2a)
- *Puw* (ETSI TS 136.101 - Table 7.6.3.1-1)
- *Interfering signal mean power* (ETSI TS 136.104 - Table 7.5.1-1)

$I_{OOB\text{-}STANDARD}$ is specified for a given frequency offset, a given sensitivity and a given desensitization $D_{STANDARD}$.

$I_{OOB\text{-}TARGET}$ is derived for a given frequency offset, a given SENSITIVITY and a given desensitization D_{TARGET}.

SENSITIVITY is referred to in different standards as:

- *Reference sensitivity level* (ETSI TS 145.005 - Tables 6.2-1x),
- *Reference sensitivity* (ETSI TS 136.101 - Table 7.3.1-1),
- *Reference sensitivity power level* (ETSI TS 136.104 - Tables 7.2.1-1 and 7.2.1-2),
- *Prefsens* (ETSI TS 136.101 - Table 7.3.1-1, ETSI TS 136.104 - Tables 7.2.1-1 and 7.2.1-2).

A7.3 WHEN THE BLOCKING LEVEL (MAXIMUM I_{OOB}) IS GIVEN BY THE STANDARDS

A7.3.1 Derivation of the Receiver Blocking Response

A7.3.1.1 Goal

When an interfering signal I_{OOB} is applied to the RF input of a receiver outside of the receiver's bandwidth, the receiver will be interfered due to the non-perfect selectivity of the receiver's filter. However, the receiver's filter attenuate the interfering signal I_{OOB} into an 'equivalent in-band interfering signal' I_{IB}. In other words, the performance of the receiver are left unchanged in presence of the interfering signal I_{OOB} at the given frequency offset, or in presence of the interfering signal I_{IB} in the receiver's bandwidth.

The receiver Blocking Response is defined as the receiver filter attenuation of signals outside of receiver's channel/band (in dB):

$$\text{Blocking Response} = I_{IB} - I_{OOB}$$

The present section derives the receiver Blocking Response from the Blocking Level specified in the standard.

A7.3.1.2 Derivation

Starting from:

$$D_{STANDARD} = 10.\log10[10\text{^}(N/10) + 10\text{^}(I_{IB\text{-}STANDARD}/10)] - N$$

$I_{IB\text{-}STANDARD}$ can be then derived from the following equation in dB:

$$I_{IB\text{-}STANDARD} = N + 10.\log10[10\text{^}(D_{STANDARD}/10) - 1]$$

$$I_{IB\text{-}STANDARD} - N = 10.\log10[10\text{^}(D_{STANDARD}/10) - 1]$$

For example,

- For $D_{STANDARD}$ = 16 dB, ($I_{IB\text{-}STANDARD}$ – N) = 15.9 dB (ETSI TS 136.101 - Table 7.6.3.1-1, Channel Bandwidth = 5 MHz).
- For $D_{STANDARD}$ = 13 dB, ($I_{IB\text{-}STANDARD}$ – N) = 12.7 dB (ETSI TS 136.101 - Table 7.6.3.1-1, Channel Bandwidth = 10MHz).
- For $D_{STANDARD}$ = 6 dB, ($I_{IB\text{-}STANDARD}$ – N) = 4.7 dB (ETSI TS 136.104 - Table 7.5.1-1, Wide Area BS and Local Area BS).
- For $D_{STANDARD}$ = 3 dB, ($I_{IB\text{-}STANDARD}$ – N) = 0 dB (ETSI TS 145.005 - Chapters 5.1.2 and 5.1.3).

Blocking Response is then derived by the following equation:

$$\begin{aligned}\text{Blocking Response} &= I_{IB\text{-}STANDARD} - I_{OOB\text{-}STANDARD} \\ &= N + (I_{IB\text{-}STANDARD} - N) - I_{OOB\text{-}STANDARD} \\ &= N + 10.\log10[10\text{^}(D_{STANDARD}/10) - 1] - I_{OOB\text{-}STANDARD}\end{aligned}$$

A7.3.1.3 Graphical representation

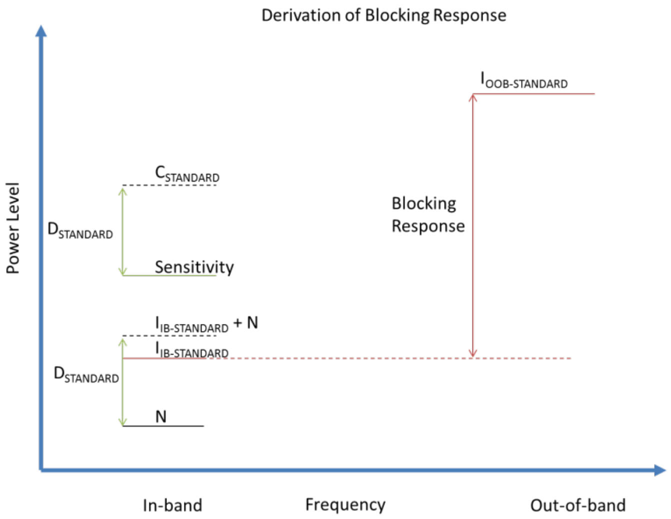


Figure 10: Derivation of the Blocking Response from the Blocking Level specified by the standard

A7.3.2 Derivation of the receiver Blocking Level

A7.3.2.1 Goal

From the Blocking Response, it is possible to derive the receiver Blocking Level for another value of desensitization.

In order to derive this new receiver Blocking Level, we assume that the Blocking Response is constant and fully linear over the complete range of desensitization from 0 to $D_{STANDARD}$.

A7.3.2.2 Derivation

$I_{IB\text{-}TARGET}$ can be derived from the following equation:

$$I_{IB\text{-}TARGET} = N + 10.\log10[10\text{^}(D_{TARGET}/10) - 1]$$

$I_{OOB\text{-}TARGET}$ can be derived from the following equation:

$$I_{OOB\text{-}TARGET} = I_{IB\text{-}TARGET} - \text{Blocking Response}$$

A7.3.2.3 Graphical representation

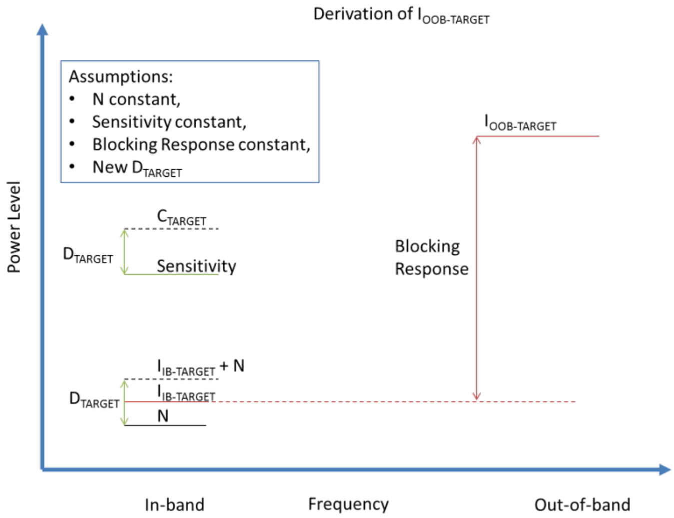


Figure 11: Derivation of the Blocking Level for a desired D_{TARGET}

A7.4 WHEN A PROTECTION RATIO IS GIVEN BY THE STANDARDS

This is the case for GSM, with regards to the 3 first adjacent channels.

In ETSI TS 145.005, Table 6.3-1, the $C_{STANDARD}$ - $I_{OOB\text{-}STANDARD}$ is specified in dB for a desensitization $D_{STANDARD}$ of 3 dB (see chapter 5.1.2 in ETSI TS 145 005).

- First adjacent channel, $[C/Ia1]_{Linear}$[5] = C – Ia1= -9 dB
- Second adjacent channel, $[C/Ia2]_{Linear}$5 = C –Ia2 = -41 dB

These are the “blocking protection ratios”.

A7.4.1 Derivation

Let’s consider for instance a BS and the first adjacent channel.

$$C_{STANDARD} = \text{SENSITIVITY} + D_{STANDARD}$$
$$= -104 \text{ dBm} + 3 \text{ dB}$$
$$= -101 \text{ dBm}$$

[5] It should be noted that the standard refers to C/Ia which is an equation in the linear domain, but specifies the value in dB, i.e. in the logarithmic domain.

$I_{OOB\text{-}STANDARD}$ = $C_{STANDARD}$ - Blocking Protection Ratio

= -101 dBm - (-9 dB)

= -92 dBm

Blocking Response = N + 10.log10[10^($D_{STANDARD}$/10) -1] - $I_{OOB\text{-}STANDARD}$

= -113 + 0 - (-92)

= -21 dB

The Receiver Blocking Level $I_{OOB\text{-}TARGET}$ for a desensitization D_{TARGET} of 1 dB can be derived from the following equation:

$I_{OOB\text{-}TARGET}$ = N + 10.log10[10^(D_{TARGET}/10) -1] - Blocking Response

= -113 - 6 + 21

= -98 dBm

ANNEX 8: A MIXED SCENARIO

A8.1 SIMULATIONS OF AN OUTDOOR EVENT

There are a multitude of scenarios possible for PMSE equipment. It could for example be an outdoor event, or an indoor event in an urban or rural environment. The simulation scenario considered has focussed on the analysis of a real PMSE venue within a densely populated urban environment with both indoor and outdoor users of the mobile network.

One suitable site has been identified in the city centre of Stockholm, Sweden. It is an example of a highly populated urban environment in close proximity to terrestrial MFCN. It is a square (Sergels Torg), which is commonly used for outdoor events. Next to the square is the house of culture (Kulturhuset). A view of the square and the house of culture is shown in Figure 13: Sergels Torg and the house of culture in Stockholm, Sweden. One particular (of several) existing base station will be used in the SEAMCAT simulations. The base station covers the square, and the house of culture, and has approximately the same view as the photo in Figure 14, only directed more to the right.

Figure 12: Sergels Torg and the house of culture in Stockholm, Sweden

Three UL scenarios were simulated, two for GSM and one for LTE. The two GSM UL scenarios simulated were based on an SINR approach. These scenarios were as follows:

- Scenario 1: Outdoor BTS, outdoor radio microphone (on the square), outdoor MS (on the square)
- Scenario 2: Outdoor BTS, outdoor radio microphone (on the square), indoor MS (inside the house of culture)

The LTE UL scenario simulated was as follows and was done on the basis of BS desensitization:

- Scenario 3: Outdoor BS and an outdoor radio microphone (on the square)

A8.1.1 Simulation set-up

The geometry of the Sergels Torg simulation is shown in Figure 14.

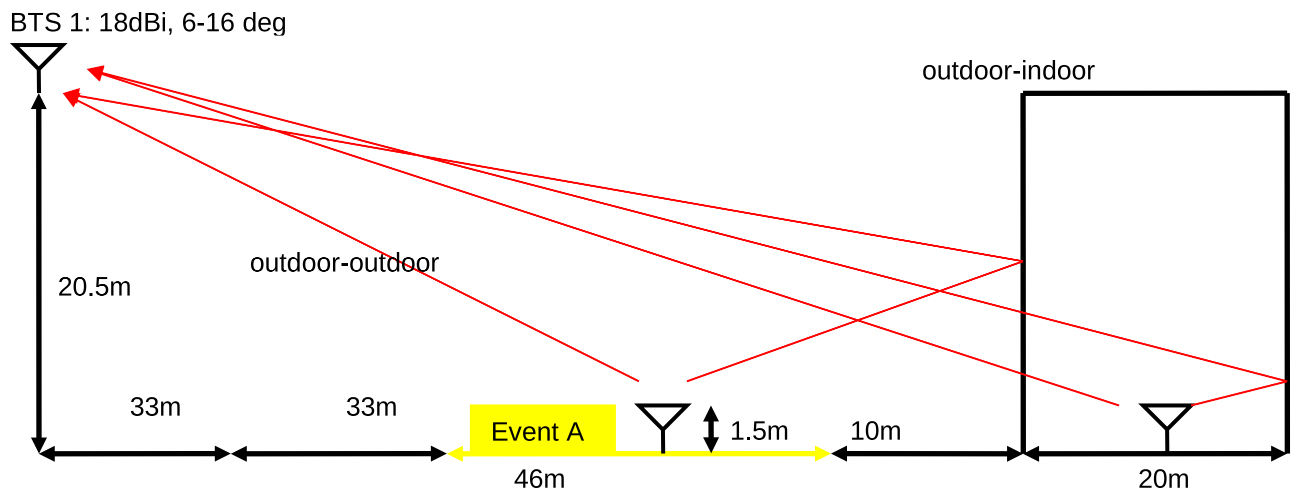


Figure 13: The Sergels Torg simulations

In the three scenarios, the simulations were first performed using an extended Hata propagation model for the interfering radio microphone to base station link, in order to account for a multi-path environment, and then repeated using a free space path loss model to account for the case in which there is a direct line of sight path between the radio microphone and the base station. In all wanted uplink cases (i.e. MS to BS) only the extended Hata model was considered. In the LTE simulation, simulations results were generated for EUTRA signals bandwidths of 1.4 MHz and 5 MHz.

A8.2 RESULTS

A8.2.1 GSM

The criterion of C/(I+N) was used to measure the probability of interference. The results represent the probability of a C/(N+I) value less than 8 dB being encountered by the BTS under the various simulation conditions.

Table 62 and Table 63 contain the simulation results for the two GSM scenarios:

- Radio microphone outside (on the square), MS outside (Scenario 1)
- Radio microphone outside, MS inside (the building) (Scenario 2)

Table 61 tabulates the results for the scenario in which the propagation path between the BTS and radio microphone is a multipath characterised by the Extended Hata model and Table 63 tabulates the results for the scenario in which there exists a line of sight path (Free Space Path Loss Model) between the BTS and radio microphone.

Table 62: GSM Simulation results for multipath propagation between BTS and the Radio Microphone

Probability of less than 8 dB SINR occurring under conditions 1 dB desensitization (GSM) (Extended Hata Model for BTS – Radio Mic Propagation Path)					
GSM	MS Location				
	Outdoor	Indoor			
Body Loss (dB)	Guard Band 0 kHz	Guard Band 0 kHz	Guard Band 200 kHz	Guard Band 400 kHz	Guard Band 600 kHz
0	1.2 %	16.73 %	3.37 %	0.33 %	0.08 %
8	0.29 %	7.51 %	1.08 %	0.09 %	0 %
16	0.04 %	2.61 %	0.22 %	0.01 %	0 %

Table 63: GSM Simulation results for line of sight propagation between BTS and the Radio Microphone

Probability of less than 8 dB SINR occurring under conditions 1 dB desensitization (GSM) (Free Space Path Loss Model for BTS – Radio Mic Propagation Path)					
GSM	MS Location				
	Outdoor	Indoor			
Body Loss (dB)	Guard Band	Guard Band	Guard Band	Guard Band	Guard Band
	0 kHz	0 kHz	200 kHz	400 kHz	600 kHz
0	11.95%	68.04%	28.64%	5.10%	0.84%
8	3.77%	45.57%	12.05%	1.19%	0.07%
16	0.92%	24.57%	4.09%	0.14%	0%

The relationship between radio microphone carrier frequency and guard band for a 600 kHz bandwidth signal is described by Table 64.

Table 64: Relationship between Radio Microphone Carrier Frequency, Frequency Offset and Guard Band for a 600 kHz signal bandwidth

Radio Microphone Signal Carrier Frequency (MHz)	Carrier Frequency Offset from Upper Band Edge of Band 3 Uplink (kHz)	Guard Band between upper band edge of Band 3 uplink and lower radio microphone signal frequency (kHz)
1785.3	300	0
1785.5	500	200
1785.7	700	400
1785.9	900	600

The results of Table 62 and Table 63 are depicted graphically in Figure 15.

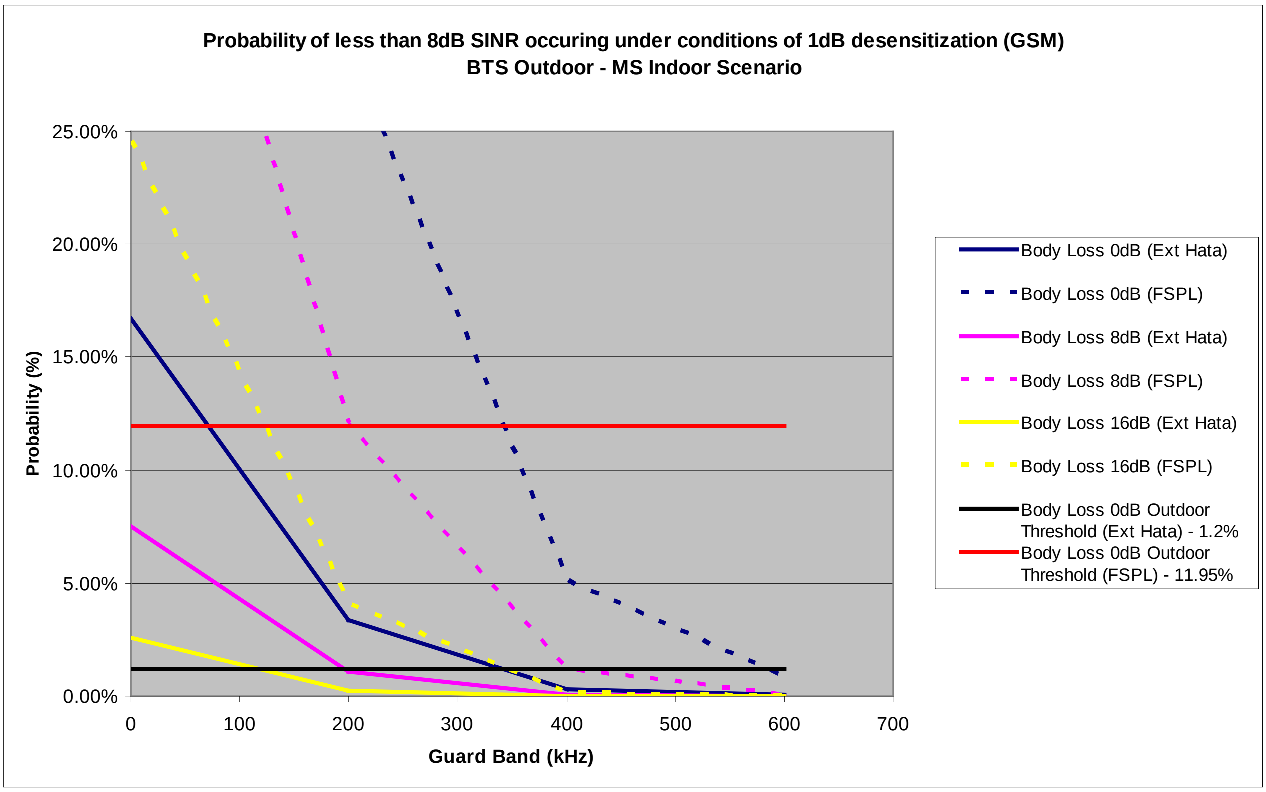


Figure 14: Probability of less than 8 dB SINR occurring under conditions of 1dB desensitization (GSM)

The probability of blocking in the case of 0 dB body loss, 0 kHz guard band, BTS and MS outdoor and multipath propagation between the BTS and radio microphone is 1.2 %. When the MS is indoor it can be seen that a probability of blocking equal to 1.2 % can be arranged by ensuring a guard band of at least 350 kHz. The probability of blocking in the case of 0 dB body loss, 0 kHz guard band, BTS and MS outdoor and line of sight propagation between the BTS and radio microphone is 11.95 %. Again when the MS is indoor it can be seen that a probability of blocking equal to 11.95 % can be arranged by ensuring a guard band of at least 375 kHz. Furthermore, in this case, the probability can be reduced to 1.2 % by ensuring a guard band of 600 kHz.

A8.2.2 LTE

The criterion of (N+I)/N (i.e. the desensitization of the BS) was used to measure the probability of interference. The results represent the probability of a desensitization of greater than 1 dB being encountered by the BS under the various simulation conditions. A desensitization of 1 dB corresponds to an I/N ratio of -6 dB.

Table 53 and Table 54 contain the simulation results for the LTE scenario with an EUTRA signal bandwidth of 1.4 MHz.

Table 65: LTE Simulation results for multipath propagation between BS and the Radio Microphone and EUTRA signal Bandwidth of 1.4 MHz

Probability of the occurrence of > 1 dB desensitization for LTE 1.4 MHz (Extended Hata Model for BTS – Radio Mic Propagation Path)				
EUTRA (1.4 MHz)				
Body Loss (dB)	Guard Band 0 kHz	Guard Band 200 kHz	Guard Band 400 kHz	Guard Band 600 kHz
0	88.13	46.32	10.46	4.96
8	68.11	19.21	2.07	0.82
16	39.35	4.58	0.32	0.14

Table 66: LTE Simulation results for line of sight propagation between BS and the Radio Microphone and EUTRA signal Bandwidth of 1.4 MHz

Probability of the occurrence of > 1 dB desensitization for LTE 1.4 MHz (Free Space Path Loss Model for BTS – Radio Mic Propagation Path)				
EUTRA (1.4 MHz)				
Body Loss (dB)	Guard Band 0 kHz	Guard Band 200 kHz	Guard Band 400 kHz	Guard Band 600 kHz
0	100%	100%	98.97%	80.03%
8	100%	100%	54.03%	31.46%
16	100%	83.21%	4.4%	0%

Table 66 tabulates the results for the scenario in which the propagation path between the BS and radio microphone is a multi-path characterised by the Extended Hata model and Table 67 tabulates the results for the scenario in which there exists a line of sight path (Free Space Path Loss Model) between the BS and radio microphone.

The results of Table 65 and Table 66 are depicted graphically in Figure 16.

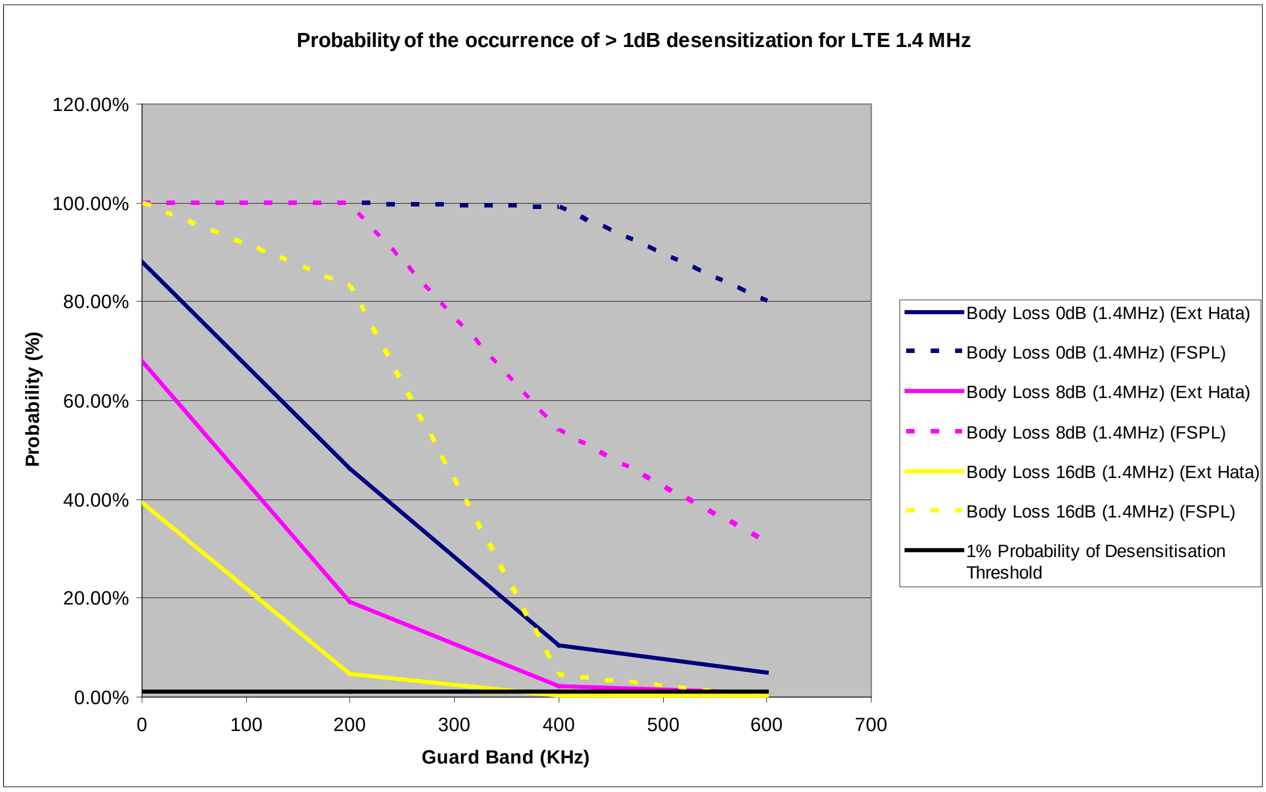


Figure 15: Probability of the occurrence of > 1 dB desensitization for LTE 1.4 MHz

Figure 16 shows that the probability of greater than 1 dB desensitization occurring for a 1.4 MHz bandwidth EUTRA signal can be reduced to the 1 % probability threshold by ensuring a guard band of 550 kHz. The exceptions to this can be seen to be the case of 0 dB body loss and multipath propagation between the BS and the radio microphone and the cases of 0 dB and 8 dB body loss for line of sight propagation between the BS and the radio microphone. As can be seen from the figure, these cases would require a larger guard band.

Table 68 and Table 69 contain the simulation results for the LTE scenario with an EUTRA signal bandwidth of 5 MHz.

Table 67: LTE Simulation results for multipath propagation between BS and the Radio Microphone and EUTRA signal Bandwidth of 5 MHz

Probability of the occurrence of > 1 dB desensitization for LTE 5 MHz (Extended Hata Model for BTS – Radio Mic Propagation Path)				
EUTRA (5 MHz)				
Body Loss (dB)	Guard Band 0 kHz	Guard Band 200 kHz	Guard Band 400 kHz	Guard Band 600 kHz
0	73.93	25.27	4.48	3.06
8	46.29	7.74	0.96	0.53
16	19.81	1.82	0.15	0.09

Table 68: LTE Simulation results for line of sight propagation between BS and the Radio Microphone and EUTRA signal Bandwidth of 5 MHz

Probability of the occurrence of > 1 dB desensitization for LTE 5 MHz (Free Space Path Loss Model for BTS – Radio Mic Propagation Path)				
EUTRA (5 MHz)				
Body Loss (dB)	Guard Band 0 kHz	Guard Band 200 kHz	Guard Band 400 kHz	Guard Band 600 kHz
0	100%	100%	77.23%	62.58%
8	100%	94.5%	29.43%	15.35%
16	100%	44.86%	0%	0%

Table 67 tabulates the results for the scenario in which the propagation path between the BS and radio microphone is a multi-path characterised by the Extended Hata model and Table 68 tabulates the results for the scenario in which there exists a line of sight path (Free Space Path Loss Model) between the BS and radio microphone.

The results of Table 67 and Table 68 are depicted graphically in Figure 17

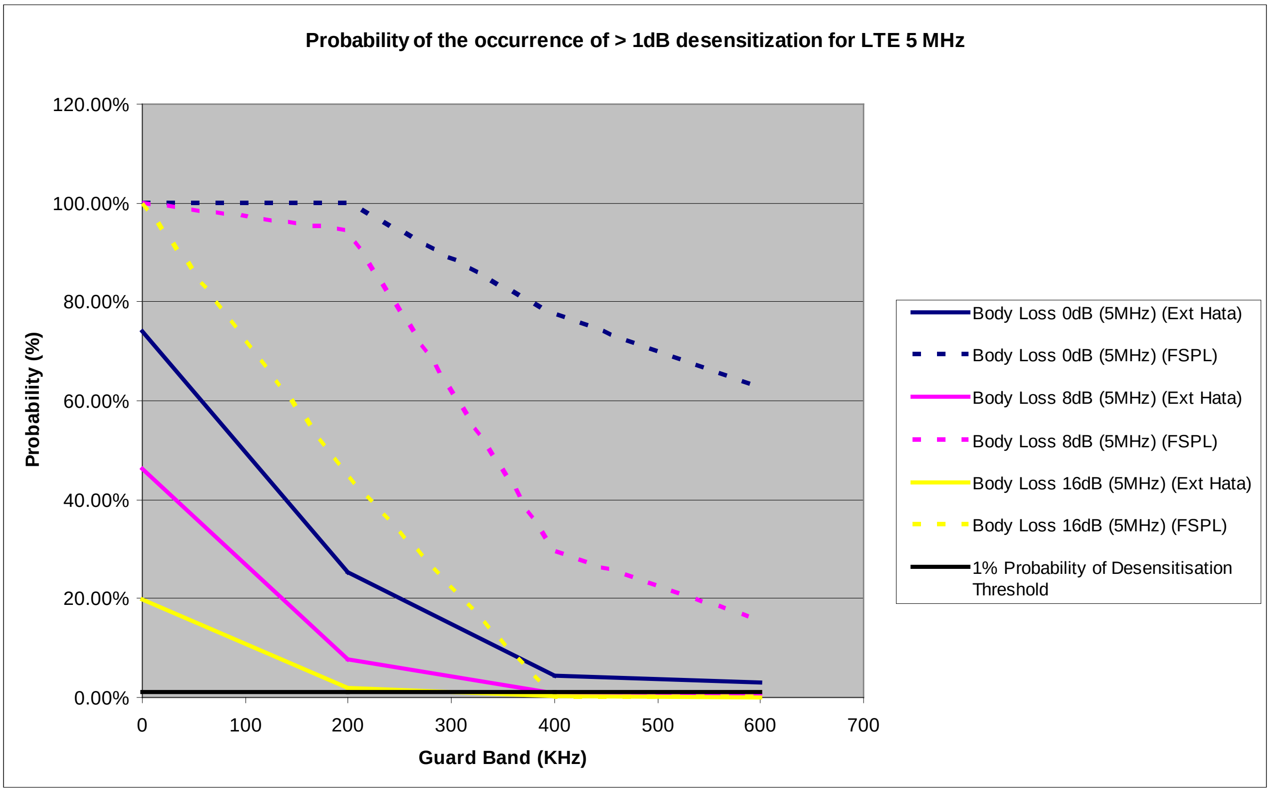


Figure 16: Probability of the occurrence of > 1 dB desensitization for LTE 5 MHz

Figure 17 also shows that the probability of greater than 1 dB desensitization occurring for a 5 MHz bandwidth EUTRA signal can be reduced to the 1% probability threshold by ensuring a guard band of 400 kHz. Again the exceptions to this can be seen to be the case of 0 dB body loss and multipath propagation between the BS and the radio microphone and the cases of 0 dB and 8 dB body loss for line of sight propagation between the BS and the radio microphone. As can be seen from the figure, these cases would require a larger guard band.

A8.2.3 Conclusion

The results for GSM indicate that a 600 kHz guard band is sufficient to ensure that, irrespective of the propagation mechanism between the Radio Microphone and the BTS and body loss, the situation in which the BTS is outdoor and the MS is indoor is equivalent to the case in which both BTS and MS are outdoor. In the scenario considered this equates to a probability of blocking of below 1.2 % when considering a required SINR of 8 dB and assuming a desensitization of 1 dB.

For the cases simulated, the results for LTE also indicate that a 600 kHz guard band is required to reduce the probability of the BS experiencing a desensitization of > 1 dB to below 1 %. This assumes that an I/N ratio of -6 dB is an adequate value for an LTE system operating in a dense urban environment. The exceptions to this are for the case of 0 dB body loss and multipath propagation between the BS and the radio microphone and the cases of 0 dB and 8 dB body loss for line of sight propagation between the BS and the radio microphone. These cases would require a larger guard band.

The simulation scenario considered has focused on the analysis of a real PMSE venue within a densely populated urban environment. As such it is considered that this system will be subject to noise from UEs and BS associated with the same system as the BS under analysis. Under these circumstances a higher I/N can be tolerated than that which can be tolerated in a rural implementation. In a rural implementation, due to the lack of other neighbouring interferers, the effect of an interferer will be more predominant as the system will be required to operate with more stringent requirements on I/N. For example, an I/N of -10 dB may be a more appropriate threshold. In this case, in order to avoid exceeding a lower desensitization threshold, either a larger guard band or greater separation distance would be required between the BS and the radio microphone.

A8.3 SIMULATION DETAILS

A8.3.1 simulation parameters

The frequency allocation for the BTS, the radio microphone and the MS are shown in Figure 18.

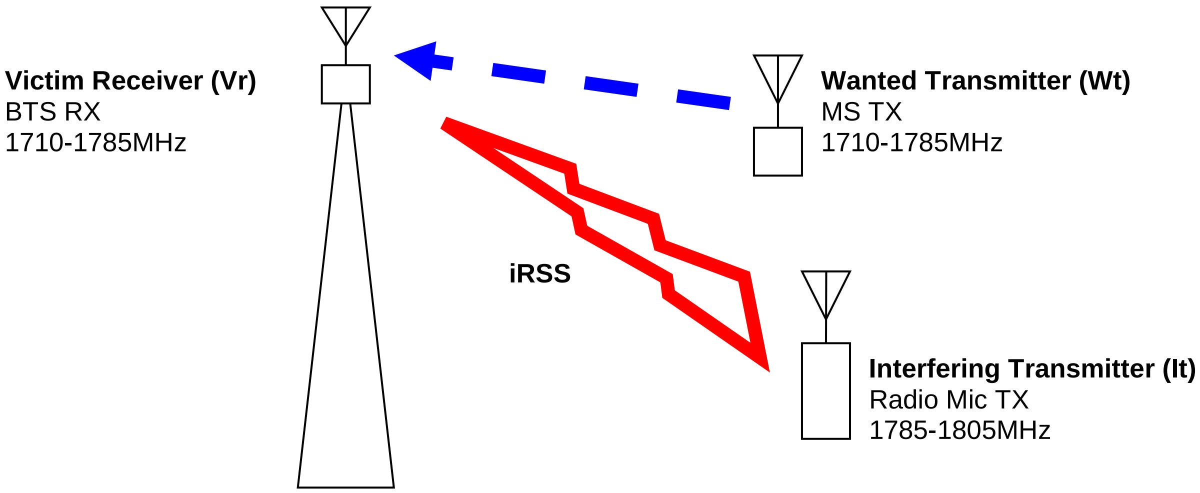


Figure 17: Frequency allocations in the simulations

The following parameter set-ups were used in the simulations:

Table 69: GSM1800 BTS (Vr) Parameters for SEAMCAT

Parameter	Units	BTS (Vr)
Frequency (ARFCN 885)	MHz	1784.8
Receiver bandwidth	kHz	200
Reference System noise figure (taken from [4])	dB	4
Reference Noise level (taken from [4])	dBm/channel	-117
Reference Receiver Sensitivity (taken [4])	dBm/channel	-108
Antenna Height	m	20.5
Maximum Antenna Gain	dBi	18

Table 70: GSM1800 MS (Wt) Parameters for SEAMCAT

Parameter	Units	MS (Wt)
Frequency (ARFCN 885)	kHz	1784.8
Tx Power	dBm/channel	30
Antenna Height	m	1.5
Maximum Antenna Gain	dBi	0 (omni assumed)

Table 71: LTE1800 BS (Vr) Parameters for SEAMCAT

Parameter	Units	BTS (Vr)	
Frequency	MHz	1784.2	1782.4
Receiver bandwidth	MHz	1.4	5
Noise Bandwidth	MHz	1.08	4.5
Reference System noise figure (taken from [4])	dB	5	5
Reference Noise level	dBm	-108.55	-102.35
Antenna Height	m	20.5	20.5
Maximum Antenna Gain	dBi	18	18

Table 72: Radio Microphone (It) Parameters for SEAMCAT

Parameter	Value
Maximum power	20 mW (13 dBm) Hand Held
Frequency	1785 – 1805 MHz
It Simulation Frequency	1785.3 MHz
Antenna Height	1.5 m
Bandwidth	600 kHz
Body Loss	0 dB, (radio microphone on stand) 8 dB 16 dB
Maximum Antenna Gain	-6 dBi (omni assumed)

A8.3.2 Simulation assumptions

The BTS (Vr) antenna pattern was assumed to be as defined in [20].

Scenario 1 propagation models (Multipath propagation path between BTS and Radio Microphone)

BTS and Radio Microphone outdoor

- Model: Extended Hata
- General Environment: Urban
- Local Environment (receiver): Outdoor
- Local Environment (transmitter): Outdoor
- Propagation Environment: Above Roof (due to the height of the BTS transmitter)

BTS and MS outdoor

- Model: Extended Hata
- General Environment: Urban
- Local Environment (receiver): Outdoor
- Local Environment (transmitter): Outdoor
- Propagation Environment: Above Roof (due to the height of the BTS transmitter)

Scenario 1 propagation models (Line of sight propagation path between BTS and Radio Microphone)

BTS and Radio Microphone outdoor

- Model: Free Space Path Loss
- Variation Std. Dev.: 1 dB

BTS and MS outdoor

- Model: Extended Hata
- General Environment: Urban
- Local Environment (receiver): Outdoor
- Local Environment (transmitter): Outdoor
- Propagation Environment: Above Roof (due to the height of the BTS transmitter)

Scenario 2 propagation models (Multipath propagation path between BTS and Radio Microphone)

BTS and Radio Microphone outdoor

- Model: Extended Hata
- General Environment: Urban
- Local Environment (receiver): Outdoor
- Local Environment (transmitter): Outdoor
- Propagation Environment: Above Roof (due to the height of the BTS transmitter)

BTS and MS indoor

- Model: Extended Hata
- General Environment: Urban
- Local Environment (receiver): Outdoor
- Local Environment (transmitter): Indoor
- Propagation Environment: Above Roof (due to the height of the BTS transmitter)

Scenario 2 propagation models (Line of sight propagation path between BTS and Radio Microphone)

BTS and Radio Microphone outdoor

- Model: Free Space Path Loss
- Variation Std. Dev.: 1 dB

BTS and MS indoor

- Model: Extended Hata
- General Environment: Urban
- Local Environment (receiver): Outdoor
- Local Environment (transmitter): Indoor
- Propagation Environment: Above Roof (due to the height of the BTS transmitter)

All parameters relating to indoor propagation were allowed to default to their default settings in SEAMCAT

Scenario 3 propagation models (Multipath propagation path between BS and Radio Microphone)

BS and Radio Microphone outdoor

- Model: Extended Hata
- General Environment: Urban
- Local Environment (receiver): Outdoor
- Local Environment (transmitter): Outdoor
- Propagation Environment: Above Roof (due to the height of the BS transmitter)

Scenario 3 propagation models (Line of sight propagation path between BS and Radio Microphone)

BS and Radio Microphone outdoor

- Model: Free Space Path Loss
- Variation Std. Dev.: 1 dB

A8.3.3 Radio microphone emission mask

The ETSI standard EN 300 422 [6] describes the PMSE operation above 1 GHz for three different channel bandwidths (200, 400 and 600 kHz). The relevant spectrum masks are still in discussion, but the 600 kHz channel bandwidth emission mask was used in these simulations, see Figure 19. The center frequency for the radio microphone channel was chosen to be 1785.3 MHz.

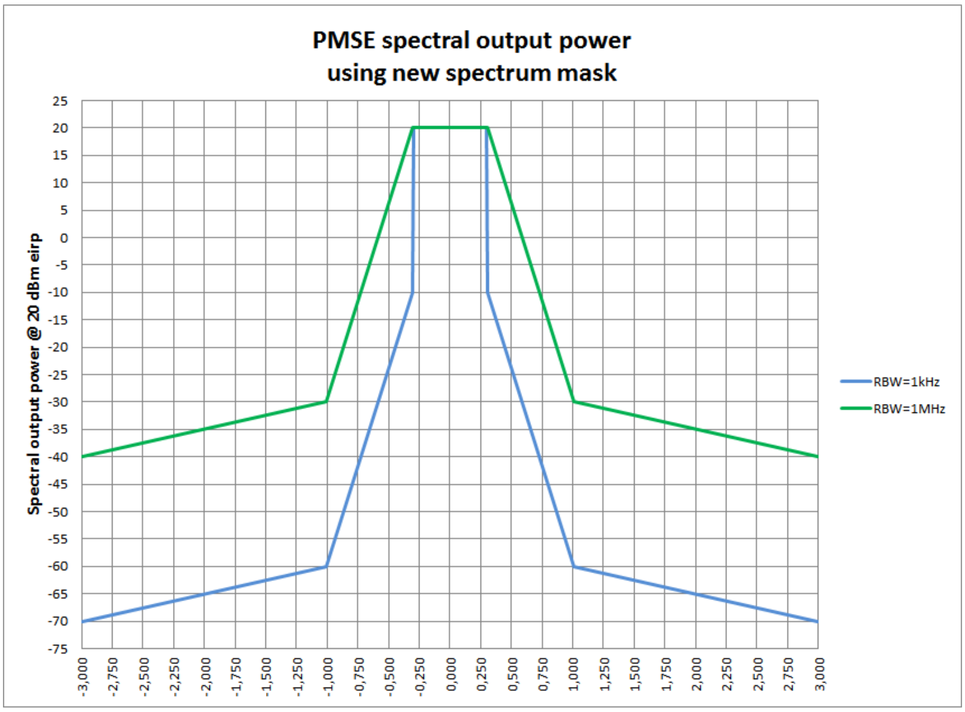


Figure 18: Emission mask with 600 kHz channel bandwidth

ANNEX 9: LIST OF REFERENCES

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[10] ETSI EN 301 357: “Electromagnetic compatibility and Radio spectrum Matters (ERM); Technical characteristics and test methods for analogue cordless wideband audio devices using integral antennas operating in the CEPT recommended 863 MHz to 865 MHz frequency range”
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[18] ITU-R P.1411-5: "Propagation data and prediction methods for the planning of short-range outdoor radiocommunication systems and radio local area networks in the frequency range 300 MHz to 100 GHz"
[19] Extended Hata, http://tractool.seamcat.org/raw-attachment/wiki/Manual/PropagationModels/ExtendedHata/Hata-and-Hata-SRD-implementation_v2.pdf
[20] ITU-R F.1336-2 “Reference radiation patterns of omnidirectional, sectoral and other antennas in point-to-multipoint systems for use in sharing studies in the frequency range from 1 GHz to about 70 GHz”
[21] ERC Report 25: "The European table of frequency allocations and utilisations in the frequency range 9 kHz to 3000 GHz", amended Lille 2011.
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[23] Information provided by Association of Professional Wireless Production Technologies (APWPT)