CEPT ECC
Electronic Communications Committee

ECC Report 221

Adjacent band compatibility between MFCN and PMSE audio applications in the 700 MHz frequency band

Approved September 2014

0 EXECUTIVE SUMMARY

0.1 STUDIES INCLUDED IN THE REPORT

The European Commission has mandated the CEPT to develop technical conditions for the introduction of wireless broadband in the 700 MHz band and also to study the possibility of shared spectrum use with certain incumbent uses such as PMSE.

The preferred frequency band plan has been preliminarily agreed within CEPT based on 2-times 30 MHz FDD and up to 20 MHz SDL with the possibility to use the guard band and duplex gap according to national requirements for other services for example PMSE and SDL. The purpose of this report is to find conditions for operation of PMSE audio equipment (wireless microphones) in the 700 MHz frequency range.

This report considers interference in both directions between PMSE equipment operating in the band 733-758 MHz and MFCN equipment operating in the bands 703-733 MHz (uplink) and 758-788 MHz (downlink). In this study the band 733-758 MHz is exclusively used by PMSE. The introduction of further application for example SDL will affect the calculated scenarios. The compatibility situation at the boundary between PMSE and MFCN around 733 MHz, is the same at 703 MHz due to the fact that the equipment is the same.

The report considers a total of 9 scenarios corresponding to a specific combination of the following options:

- Indoor/outdoor;
- PMSE interferes with MFCN or MFCN interferes with PMSE;
- MFCN BS or MFCN UE.

The LTE pico BS was sufficiently covered in ECC Report 191 [6], and therefore scenarios 8 and 9 were not investigated further.

In order to address a compatibility study for PMSE in the duplex gap in the 700 MHz frequency band two methods have been used:

- Method 1 - Monte-Carlo simulations carried out with the SEAMCAT tool.
- Method 2 - Minimum Coupling Loss (MCL) analysis.

0.2 RESULTS OF THE STUDIES

The proposed power restriction for audio PMSE is based on the assumption that LTE mobile system equipment with a 10 MHz channel bandwidth is used. However, the influence of a 3 MHz bandwidth is also studied when the MFCN is the victim system. Both 3GPP band 20 and band 28 (APT band plan) are considered. The PMSE system is based on 200 kHz channel bandwidth. Within the calculations two different sets of body loss values for PMSE were used, the first set is based on ECC Report 191 [6] the second set is based on CEPT Report 30 [7].

For the scenarios corresponding to audio PMSE equipment interfering with the MFCN UE, a better blocking rejection of 0.8 dB every 200 kHz of additional offset from the channel edge is assumed. In addition, it is assumed that the duplex filter in the MFCN UE provides an additional rejection of 2 dB at 2 MHz offset from the channel edge for narrowband signals. The critical case is when the PMSE equipment is close to the MFCN UE. The simulations show that for Scenario1 (Outdoor) with a separation distance between 15-100 meters, there is no compatibility issue for the handheld PMSE device. For the body worn PMSE device, there is no compatibility issue for the 10 MHz bandwidth, but a potential narrowband blocking issue for the 3 MHz LTE UE may occur. The simulations show that for Scenario 6 (Indoor) with a separation distance between 5-50 meters, both hand held and body worn PMSE devices have a potential compatibility issues. In this case, both unwanted emissions and blocking cause degradation of the MFCN performance. If this separation distance is increased, the probability of interference decreases accordingly.

With the proposed power restrictions for PMSE, the compatibility between PMSE equipment and MFCN BS can be achieved. The simulations show that for Scenario 3 (Outdoor) with a separation distance between 100-350 meters, there is no compatibility issue.

For the scenarios corresponding to MFCN (both UE and BS) interfering with audio PMSE equipment, duplex filters in the LTE macro base station and in the user equipment are assumed.

The results of this report do not guarantee that audio PMSE equipment will be able to operate in all the compatibility scenarios, but identify the scenarios and technical conditions under which PMSE could be operated with sufficient quality of service (QoS). PMSE should be operated only if a check of quality of service in the radio environment is performed before use and shows a sufficient quality. The PMSE setup indicates whether enough PMSE channels with no interference are available to guarantee the needed QoS. This procedure is described in Annex 5 of ECC Report 191 [6]. However, it is noted that the spectrum environment is subject to change between setup and performance if the audience brings in active mobile devices.

The power restrictions highlighted in the Table 1 to Table 4 differ as they are derived from the different body loss assumptions used in ECC Report 191 [6] / CEPT Report 50[1] [16] (Table 1 and Table 2) or CEPT Report 30[2] [7] (Table 3 and Table 4).

Note: The compatibility situation at the boundary between PMSE and MFCN around 733 MHz is the same at 703 MHz due to the fact that the equipment is the same.

Table 1: power restrictions for handheld microphone[3]

	Frequency Range	Handheld e.i.r.p.	Reasoning
OOB	MFCN Downlink	-45 dBm/200kHz	ETSI EN 300 422 [11]
	2.8 MHz offset from MFCN Downlink block edge	Guard band	
	From 2.8 to 4.2 MHz offset from MFCN Downlink block edge	13 dBm/200kHz	
	From 4.2 MHz offset from MFCN Downlink block	19 dBm/200kHz	
OOB	MFCN Uplink	-45 dBm/200kHz	ETSI EN 300 422 [11]

Table 2: power restrictions for body worn microphone[4]

	Frequency Range	Body worn e.i.r.p.	Reasoning
OOB	MFCN Downlink	-45 dBm/200kHz	ETSI EN 300 422 [11]
	1.2 MHz offset from MFCN Downlink block edge	Guard band	
	From 1.2 MHz offset from MFCN Downlink block edge	19 dBm/200kHz	
OOB	MFCN Uplink	-45 dBm/200kHz	ETSI EN 300 422 [11]

[1] ECC Report 191 [6] / CEPT Report 50 [16]: Body loss for handheld: 1 dB, body loss for body worn: 15 dB, frequency range: 1785-1805 MHz.
[2] CEPT Report 30 [7] (Fig A5.5): Body loss for handheld: 8 dB, body loss for body worn: 18 dB, frequency range: 821-832 MHz.
[3] These power restrictions for handheld microphone are also contained in CEPT Report 53.
[4] These power restrictions for body worn microphone are also contained in CEPT Report 53.

Table 3: power restrictions for handheld microphone

	Frequency Range	Handheld e.i.r.p.	Reasoning
OOB	MFCN Downlink	-45 dBm/200kHz	ETSI EN 300 422 [11]
	1.4 MHz offset from MFCN Downlink block edge	Guard band	
	From 1.4 to 2.4 MHz offset from MFCN Downlink block edge	13 dBm/200kHz	
	From 2.4 MHz offset from MFCN Downlink block	19 dBm/200kHz	
OOB	MFCN Uplink	-45 dBm/200kHz	ETSI EN 300 422 [11]

Table 4: power restrictions for body worn microphone

	Frequency Range	Body worn e.i.r.p.	Reasoning
OOB	MFCN Downlink	-45 dBm/200kHz	ETSI EN 300 422 [11]
	0.4 MHz offset from MFCN Downlink block edge	Guard band	
	From 0.4 MHz offset from MFCN Downlink block edge	19 dBm/200kHz	
OOB	MFCN Uplink	-45 dBm/200kHz	ETSI EN 300 422 [11]

TABLE OF CONTENTS

LIST OF ABBREVIATIONS

Abbreviation	Explanation
3GPP	3rd Generation Partner Project
BEM	Block Edge Mask
BL	Blocking
BS	Base 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
ERP	Effective Radiated Power
ETSI	European Telecommunications Standards Institute
E-UTRA	Evolved Universal Terrestrial Radio Access
FDD	Frequency Division Duplex
FFT	Fast Fourier Transform
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
Mic	Wireless microphone
NF	Noise Figure
OOB	Out-Of-Band
PMSE	Programme Making and Special Events
PWMS	Professional Wireless Microphone Systems
RB	Resource Block
REC	Recommendation
RF	Radiofrequency
RFR	Restricted Frequency Range
RR	Radio Regulations
SEAMCAT	Spectrum Engineering Advanced Monte Carlo Analysis Tool
SM	Spectrum Management
TR	Technical Report
TS	Technical Specification
UE	User Equipment

UL	Uplink
UW	Unwanted emissions

1 INTRODUCTION

The World Radiocommunication Conference 2012 (WRC-12) agreed on an allocation of the 694-790 MHz ('700 MHz') band to the Mobile Service in ITU Region 1 after WRC-15. The European Commission has mandated the CEPT to develop technical conditions for the introduction of wireless broadband in the 700 MHz band and also to study the possibility of shared spectrum use with certain incumbent uses such as PMSE.

This report considers 7 scenarios corresponding to different interference cases: indoor/outdoor, PMSE interfering with MFCN BS (LTE) and MFCN UE (LTE) interfering with PMSE.

The study assumes that the frequency band plan is based on 2-times 30 MHz FDD and up to 20 MHz SDL with the possibility to use the guard band and duplex gap according to national requirements.

Studies have been performed with 2 different methods, Monte-Carlo simulations (using SEAMCAT 4.1.0) and Minimum Coupling Loss (MCL) analyses.

The Report is structured as follows:

- In Chapter 2, the frequency usages are described (with different options for the allocation for MFCN);
- 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.

2 FREQUENCY ENVIRONMENT

This report considers interference in both directions between PMSE equipment operating in the band 733 758 MHz and MFCN equipment operating in the bands 703-733 MHz (uplink) and 758 788 MHz (downlink). In this study the band 733-758 MHz is exclusively used by PMSE. The introduction of further application for example SDL will affect the calculated scenarios. The compatibility situation at the boundary between PMSE and MFCN around 733 MHz, is the same at 703 MHz due to the fact that the equipment is the same.

3 PARAMETERS AND SCENARIOS FOR STUDIES

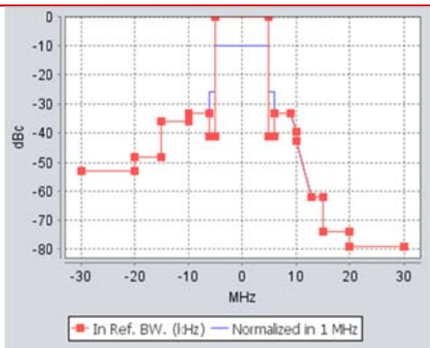
3.1 MFCN AND PMSE PARAMETERS

In the following tables the relevant parameters are defined.

Table 5: Parameters for an LTE UE

Parameter	Unit	Value	Comment
Channel Bandwidth	MHz	3/10	
Transmission Bandwidth (BW)	MHz	2.7/9	ETSI TS 136 101 [8], Table 7.3.1-2 → Sensitivity for a 10 MHz channel is defined for 50 Resource Blocks (RB). ETSI TS 136 211 [10], section 6.2.3 → 1 Resource Block corresponds to 180 kHz
Reference Sensitivity (Band 20)	dBm	-100.2/-94	ETSI TS 136 101 [8], Table 7.3.1-1, Band 20
Reference Sensitivity (Band 28)	dBm	-95.5	ETSI TS 136 101 [8], Table 7.3.1-1 Band 28, 10 MHz System
Noise Figure (NF)	dB	9	3GPP TR 36.824
Noise Floor (N, after FFT processing)	dBm	-100.7/-95.4	10·log(k·T·BW·1000) + NF[5] This is the noise floor at the output of the FFT, i.e. affecting the transmission bandwidth.
Standard Desensitization $D_{STANDARD}$	dB	13	ETSI TS 136 101 [8], Table 7.6.3.1-1
Standard Narrowband Blocking Level $I_{OOB-STANDARD}$	dBm	-55	ETSI TS 136 101 [8], 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 → the receiver duplex filter provides an additional rejection of 2 dB at 2 MHz offset from the channel-edge for narrow band signals
Target Desensitization D_{TARGET}	dB	1/3	I/N= -6/0 SE7(12)061 ITU-R Report M.2039
Target Narrowband 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 → the receiver duplex filter provides an additional rejection of 2 dB at 2 MHz offset from the channel-edge for narrow band signals
Antenna Height	m	1.5	
Body Loss	dB	4	
Antenna Gain	dBi	-3	Average value Omni directional
Maximum Transmit	dBm	23	ETSI TS 136 101 [8], Table 6.2.2-1

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

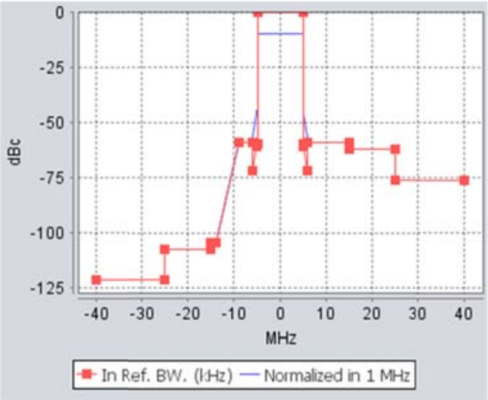
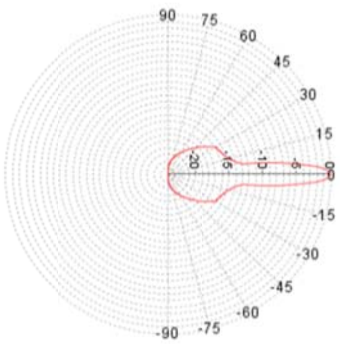
Parameter	Unit	Value	Comment
Power			
Out-of-band emissions (Monte-Carlo Simulations)	dB		ETSI TS 136 101 [8], Table 6.6.2.1.1-1 → values relative to 23 dBm Duplex filter attenuation: CEPT Report 30 See Notes 1 and 2
Duplexer impact		<4 MHz -> 0 dB 4 – 8 MHz-> 6.5 dB per MHz >8 MHz -> no change	Frequency offset seen from the upper boundary of the considered Uplink. Assumption from CEPT Report 30 [7]

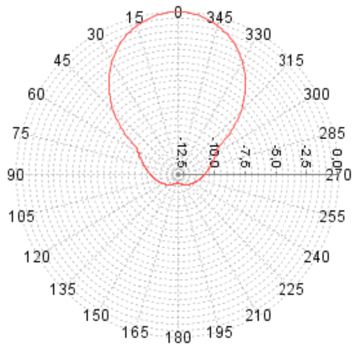
Note 1: The combination of the spectrum emission mask and the additional duplex filter leads to a spectrum emission mask with reduced OOB emissions. The adopted mask was used to simulate the impact of LTE on PMSE.

Note 2: It has to be noted for LTE at 700 MHz a maximum OOBE level of -42 dBm/8 MHz will be adopted for UEs below 694 MHz with a 9 MHz guard band between TV channel 48 and LTE uplink; in consequence it is expected that the OOBE level of these equipment be different than that considered in the CEPT Report 30 [7]I n the centre gap. As a result, the estimates of interference probability from LTE into PMSE operating in the LTE 700 MHz duplex gap may change.

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

Parameter	Unit	Value	Comment
Channel Bandwidth	MHz	3/10	
Transmission Bandwidth (BW)	MHz	2.7/4.5	ETSI TS 136 104 [9], Table 7.2.1-1 → Sensitivity for a 10 MHz channel is defined for 25 Resource Blocks (RB) ETSI TS 136 211 [10], section 6.2.3 The 3 MHz system assumes one active UE which gives 2.7 MHz transmission bandwidth. The 10 MHz system assumes 2 active UEs which gives 2x4.5 MHz transmission bandwidth → 1 Resource Block corresponds to 180 kHz The SEAMCAT simulations are based on 1 UE.
Reference Sensitivity	dBm	-103/-101.5	ETSI TS 136 104 [9], Table 7.2.1-1(given per UE transmission bandwidth)
Noise Figure (NF)	dB	5	3GPP TR 36.824
Noise Floor (N, after FFT processing)	dBm	-104.7/-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.

Parameter	Unit	Value	Comment
			affecting the transmission bandwidth.
Standard Desensitization $D_{STANDARD}$	dB	6	ETSI TS 136 104 [9], Table 7.5.1-1
Standard Narrowband Blocking Level $I_{OOB-STANDARD}$	dBm	-49	ETSI TS 136 104 [9], Table 7.5.1-1
Blocking Response	dB	-48.7	
Target Desensitization D_{TARGET}	dB	1	I/N=-6 SE7(12)061
Target Narrowband 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 [9], Table 6.6.3.2.2-1 → values relative to 46 dBm Duplex filter attenuation: CEPT Report 30
BS duplex filter impact		<4 MHz -> 0 dB 4 – 9 MHz -> 9 dB/MHz >9 MHz -> no change	Frequency offset seen from the lower boundary of the considered Downlink. Assumption from CEPT Report 30
Vertical antenna pattern (Monte-Carlo Simulations)	dB	 A down-tilt of 3° is assumed	Recommendation ITU-R F.1336
Horizontal antenna pattern	dB		Recommendation ITU-R F.1336

Parameter	Unit	Value	Comment
			

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 handheld audio PMSE

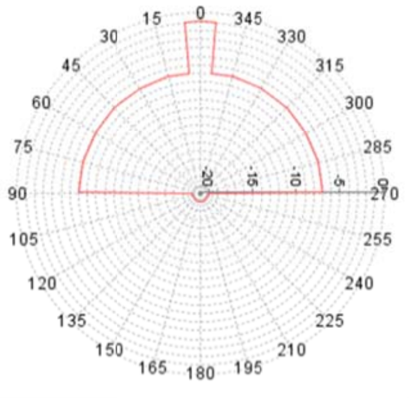
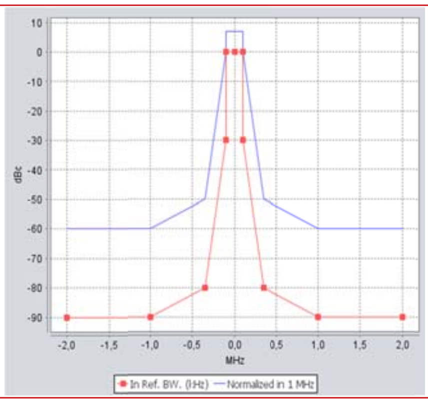
Parameter	Unit	Value	Comment
Bandwidth (BW)	MHz	0.2	
Antenna height	m	1.5	
Body loss	dB	1 around 0° 7 elsewhere 	Calculations are also provided with body loss of 8 dB in front (-90…+90 deg) and 20 dB behind the user. Additional results are included in Annex 5.
Maximum e.i.r.p.	dBm	19.15	ERC/REC 70-03, Annex 10 This value is equivalent to 17 dBm e.r.p.
Transmitter mask (Monte-Carlo Simulations)	dBm		ETSI EN 300 422 (revised) [11]

Table 8: Parameters for body worn audio PMSE

Parameter	Unit	Value	Comment
Bandwidth (BW)	MHz	0.2	
Antenna height	m	1.5	

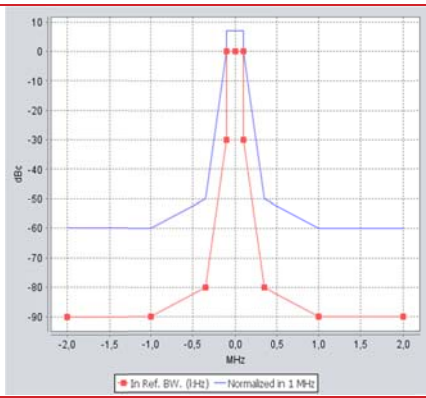
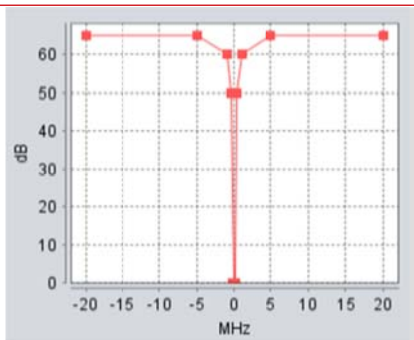
Parameter	Unit	Value	Comment
Body loss	dB	15	Calculations are also provided with body loss of 18 dB. Additional results are included in Annex 5.
Maximum e.i.r.p.	dBm	19.15	ERC/REC 70-03, Annex 10 This value is equivalent to 17 dBm e.r.p.
Transmitter mask (Monte-Carlo Simulations)	dBm		ETSI EN 300 422 (revised)

Table 9: Parameters for PMSE receivers

Parameter	Unit	Value	Comment
Bandwidth (BW)	MHz	0.2	
Reference Sensitivity	dBm	-90	ETSI TR 102 546 [12], section B.4.1.3
Noise Figure (NF)	dB	6	ETSI TR 102 546 [12], section B.3.1
Noise Floor (N)	dBm	-115	$10 \cdot \log(k \cdot T \cdot BW \cdot 1000) + NF$
Standard Desensitization $D_{STANDARD}$	dB	3	$D_{TARGET} = D_{STANDARD}$
Blocking Response	dB		ETSI TR 102 546 [12] Attachment 2, Applicable Receiver Parameter for PWMS below 1 GHz
Antenna Height	m	3	
Antenna Gain	dBi	0	Omni directional

Note 1: 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.

3.1.1 PMSE receiver

For the scenarios, in which PMSE is the victim system a specific wanted signal is 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. It has to be noted that according to ECC Report 185, the standard deviation is much higher in practise, 30 dB or even higher.

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 CEPT Report 30 [7]. It can be assumed that the duplex filters used in the MFCN BS, are better than the values presented in this report.

3.1.1.1 Modelling the wanted signal for PMSE

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 Recommendation ITU-R P.1546-5.

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

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

$$dRSS = -70\text{ dBm with } \sigma = 12\text{ dB}$$

The Figure 1 and Figure 2 show the C.D.F. of the wanted signal.

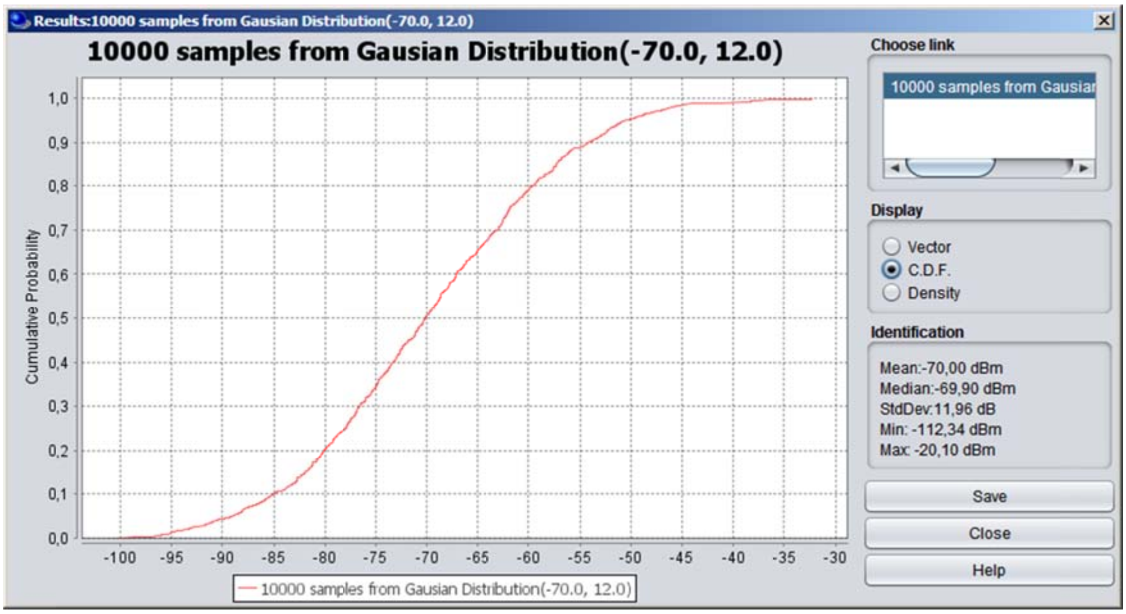


Figure 1: C.D.F. of the used dRSS

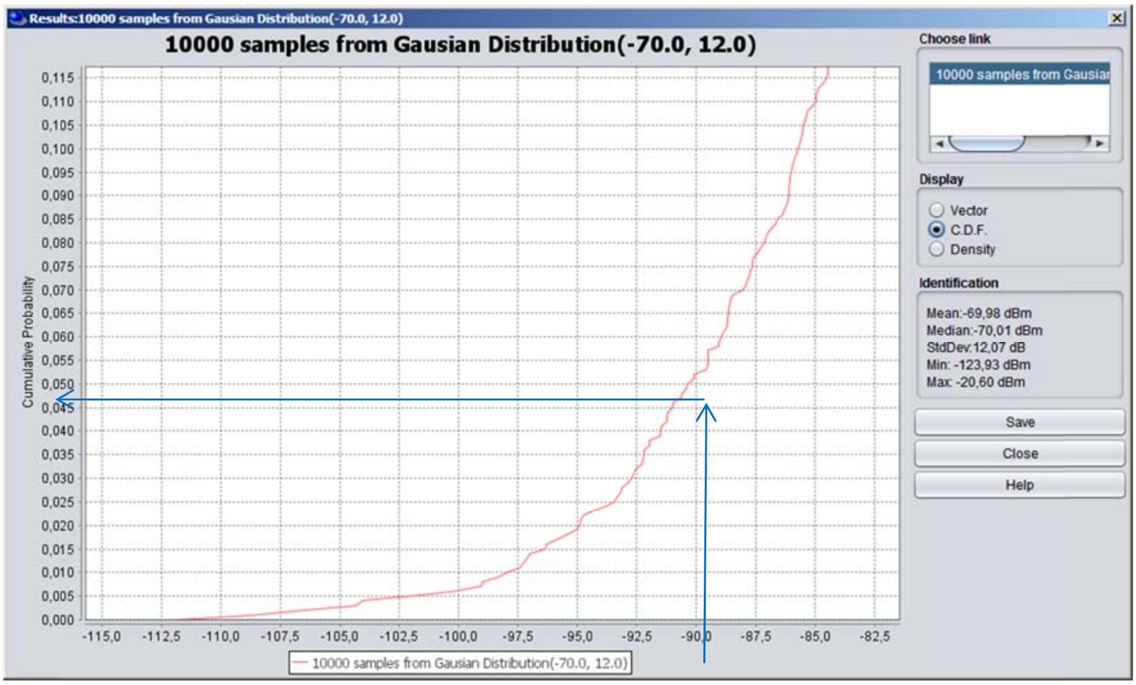


Figure 2: C.D.F. of the used dRSS, detail view for C = -90 dBm and the corresponding probability

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.

3.2 SCENARIOS

In the following table the relevant scenarios are listed.

Table 10: Overview of scenarios

Scenario	Outdoor/ Indoor	Interferer	Victim	Distance (MCL)	Distance range (Monte-Carlo Simulations)	Propagation model
1	Outdoor	PMSE	LTE UE	15 m	15..100 m	IEEE 802.11 Model C [14], break-point at 5 m
2		LTE UE	PMSE			
3		PMSE	LTE BS			Extended Hata [13], Urban (Wall attenuation 10 dB)
4		LTE BS	PMSE			
5	Mixed	LTE BS (outdoor)	PMSE (indoor)	100 m	100..350 m	
6	Indoor	PMSE	LTE UE	5 m	5..50 m	IEEE 802.11 Model C [14], break-point at 5 m
7		LTE UE	PMSE			
8		PMSE	LTE pico BS	Note 3		
9		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[6]. 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.
Note 3: The LTE pico BS was sufficiently covered in ECC Report 191 [6], and is not investigated further.

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

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

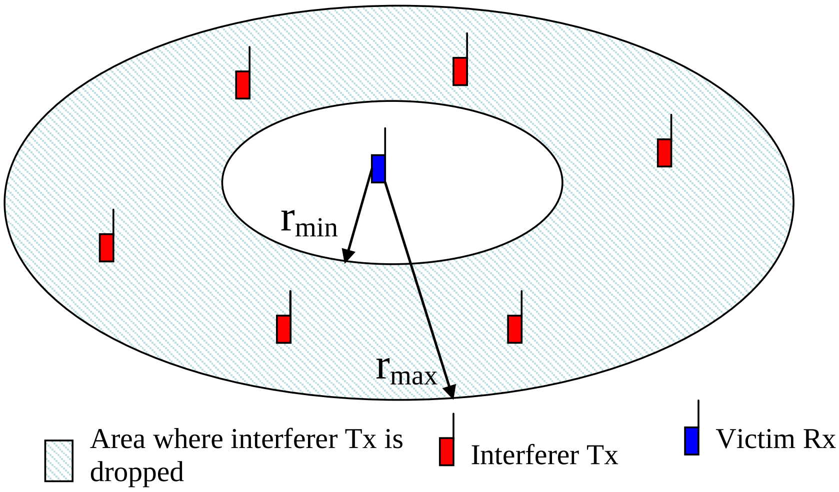


Figure 3: Illustration of the distance range

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 of ECC Report 191 [6].

The two following figures below illustrate the outdoor and indoor scenarios:

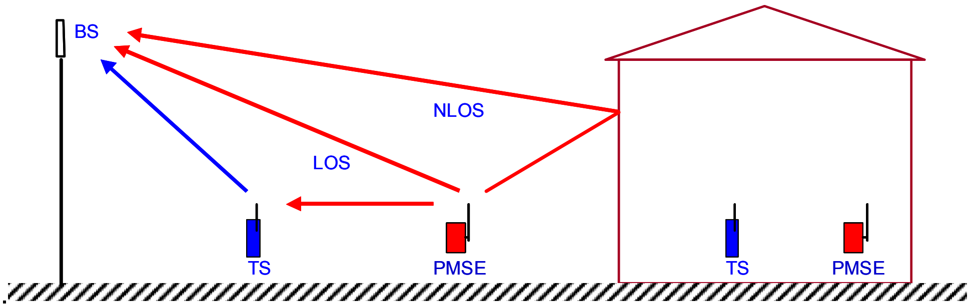


Figure 4: Outdoor interference scenario

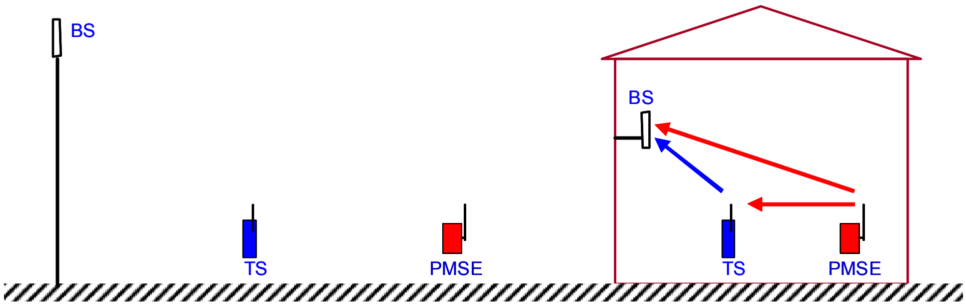


Figure 5: Indoor interference scenario

4 RESULTS OF COMPATIBILITY STUDIES

4.1 METHODOLOGY

In order to address a compatibility study for PMSE in the duplex gap in the 700 MHz frequency band two methods have been used:

- Method 1 - Simulations: In order to investigate the compatibility between PMSE and MFCN, SEAMCAT is used. SEAMCAT is a software tool based on the Monte-Carlo simulation method. The tool permits statistical modelling of different radio interference scenarios for performing sharing and compatibility studies between radiocommunication systems in the same or adjacent frequency bands.
- 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 a maximum acceptable e.i.r.p. calculated from an assumed typical separation distance between PMSE and MFCN systems.

The full descriptions of methods 1 and 2 can be found in Annexes 1 and 2. In addition, ANNEX 3: identifies the current emission limits in the band considered for terminals with similar characteristics as audio PMSE devices. These methods are fully in line with ECC Report 191 [6]. The probability of exceedance is given in percent for the chosen interference criteria, for the mechanisms of unwanted (UW) and blocking (BL). The calculation is performed with SEAMCAT 4.1.0. All values and the depending frequency separations could be found in ANNEX 1:

It should be highlighted that for the MCL analyses the minimum body loss for PMSE handheld equipment is assumed as 1 dB; this represents the body loss in front of a user when the microphone is hand held.

The proposed power restrictions for PMSE are calculated with the MCL analysis of Method 2 (see ANNEX 2:). The probabilities of exceedance of MFCN thresholds are calculated, with the assumption that the proposed power restrictions apply and the spectrum emission mask from ETSI EN 300 422 [11] is used by PMSE (see ANNEX 1:).

4.2 COMPATIBILITY RESULTS USING PMSE EMISSION MASK ACCORDING TO ETSI EN 300 422

4.2.1 Method 1 - SEAMCAT

The results provided by Method 1 for handheld and body worn PMSE are summarised in the following tables. In the simulations both LTE UE and LTE BS are assumed to have 10 MHz bandwidth.

Table 11: Summary of results, Handheld PMSE interference into MFCN

Scenario	Interferer	Victim	Method 1 UW / BL in [%]	Frequency offset from LTE block edge[MHz]
1 (Band 20)	PMSE	LTE UE	0 / 3.03	2.7
1 (Band 28)*	PMSE	LTE UE	0 / 3.17	2.7
3	PMSE	LTE BS	0.57 / 0.24	0
6	PMSE	LTE UE	0.11/6.31	2.7

* See Table 16.

In the simulations both LTE UE and LTE BS are assumed to have 10 MHz bandwidth.

Table 12: Summary of results, Body Worn PMSE interference into MFCN

Scenario	Interferer	Victim	Method 1 UW / BL in [%]	Frequency offset from LTE block edge [MHz]
1 (Band 20)	PMSE	LTE UE	0 / 3.14	1
1 (Band 28) *	PMSE	LTE UE	0 / 3.02	1
3	PMSE	LTE BS	0.12 / 0.01	0
6	PMSE	LTE UE	0/ 25.63	1

* See Table 16

In these simulations no frequency offset is assumed between MFCN and PMSE and both LTE UE and LTE BS have 10 MHz bandwidth.

Table 13: Summary of results, MFCN interference into PMSE

Scenario	Interferer	Victim	Method 1 UW / BL in [%]
2	LTE UE	PMSE	6.87 / 0
4	LTE BS	PMSE	18.35 / 0.13
5	LTE BS	PMSE	8.11 / 0.04
7	LTE UE	PMSE	64.25 / 0

4.2.2 Method 2 – MCL

The proposed power restrictions provided by Method 2 for handheld and body worn PMSE are summarised in the following tables.

Table 14: power restrictions for handheld microphone

	Frequency Range	Handheld e.i.r.p.	Reasoning
OOB	MFCN Downlink	-45 dBm/200kHz	ETSI EN 300 422 [11]
	2.8 MHz offset from MFCN Downlink block edge edge	Guard band	
	From 2.8 to 4.2 MHz offset from MFCN Downlink block edge	13 dBm/200kHz	
	From 4.2 MHz offset from MFCN Downlink block	19 dBm/200kHz	
OOB	MFCN Uplink	-45 dBm/200kHz	ETSI EN 300 422 [11]

Table 15: power restrictions for body worn microphone

	Frequency Range	Body worn e.i.r.p.	Reasoning
OOB	MFCN Downlink	-45 dBm/200kHz	ETSI EN 300 422 [11]
	1.2 MHz offset from MFCN Downlink block edge	Guard band	
	From 1.2 MHz offset from MFCN Downlink block edge	19 dBm/200kHz	
OOB	MFCN Uplink	-45 dBm/200kHz	ETSI EN 300 422 [11]

Notes to Method 2 – MCL

The proposed power restrictions provided by Method 2 for handheld and body worn PMSE are summarised the following tables and Table 15.

Note 1: The compat*ibility* situation at the boundary between PMSE and MFCN around 733 MHz, is the same at 703 MHz due to the fact that the equipment is the same.

4.3 COMPATIBILITY RESULTS WITH PROPOSED POWER RESTRICTIONS FOR PMSE

The proposed power restrictions for PMSE were subject to SEAMCAT simulations in order to analyse the compatibility with MFCN systems The LTE parameters are according to 3GPP band 28 requirements. The simulations are done for two LTE system bandwidths, 3 and 10 MHz.

4.3.1 Hand held PMSE

The simulations were done for band 28.

Table 16: Compatibility results with proposed power restriction for Hand held PMSE

Scenario	Interferer	Victim	UW / BL [%]		PMSE e.i.r.p.
			3 MHz	10 MHz	
1	PMSE	LTE UE	0.68/2.51	0.79/0.79	13 dBm
			0.68/0.23	0.8/1.59	19 dBm
6	PMSE	LTE UE	11.60/17.17	11.26/11.30	13 dBm
			11.13/7.24	11.19/13.65	19 dBm
3	PMSE	LTE BS	1.02/1.99	1.09/1.71	19 dBm

4.3.2 Body worn PMSE

The simulations were done for band 28.

Table 17: Compatibility results with proposed power restriction for Body worn PMSE

Scenario	Interferer	Victim	UW / BL [%]		PMSE e.i.r.p.
			3 MHz	10 MHz	
1	PMSE	LTE UE	0.0/21.76	0.0/3.47	19 dBm
6	PMSE	LTE UE	6.65/62.86	6.65/26.37	19 dBm
3	PMSE	LTE BS	0.30/0.74	0.30/0.60	19 dBm

In ANNEX 7:, compatibility results for other potential BEMs are available.

4.3.3 Conclusion

The simulations show that, for Scenario1 (Outdoor) with a separation distance between 15-100 meters, there is no compatibility issue for the handheld PMSE device. For the body worn PMSE device, there is no compatibility issue for the 10 MHz bandwidth, but a potential narrowband blocking issue for the 3 MHz LTE UE may occur.

The simulations show that for Scenario3 (Outdoor) with a separation distance between 100-350 meters, there is no compatibility issue.

The simulations show that for Scenario 6 (Indoor) with a separation distance between 5-50 meters, both hand held and body worn PMSE devices have a potential compatibility issues. In this case, both unwanted emissions and blocking cause degradation of the MFCN performance.

5 CONCLUSION

5.1 STUDIES INCLUDED IN THE REPORT

The purpose of this report is to find conditions for operation of PMSE audio equipment (wireless microphones) in the 700 MHz frequency range.

This report considers interference in both directions between PMSE equipment operating in the band 733-758 MHz[7] and public mobile network equipment operating in the bands 703-733 MHz (uplink) and 758-788 MHz (downlink). The operation of PMSE below 703 MHz is not studied because the compatibility at this boundary between PMSE and MFCN is the same as the one around 733 MHz since the equipment is the same.

The report considers a total of 9 scenarios corresponding to a specific combination of the following options:

- Indoor/outdoor;
- PMSE interferes with MFCN or MFCN interferes with PMSE;
- MFCN BS or MFCN UE.

The LTE pico BS was sufficiently covered in ECC Report 191, and is not investigated further.

In order to address a compatibility study for PMSE in the duplex gap in the 700 MHz frequency band two methods have been used:

- Method 1 - Monte-Carlo simulations carried out with the SEAMCAT tool;
- Method 2 - Minimum Coupling Loss (MCL) analysis.

The proposed power restriction for audio PMSE is based on the assumption that LTE mobile system equipment with a 10 MHz channel bandwidth is used. However, the influence of a 3 MHz bandwidth is also studied when the MFCN is the victim system. Both 3GPP band 20 and band 28 (APT band plan) are considered. The PMSE system is based on 200 kHz channel bandwidth.

For the scenarios corresponding to audio PMSE equipment interfering with the MFCN UE, a better blocking rejection of 0.8 dB every 200 kHz of additional offset from the channel edge is assumed. In addition, it is assumed that the duplex filter in the MFCN UE provides an additional rejection of 2 dB at 2 MHz offset from the channel edge for narrowband signals. With the proposed power restrictions for PMSE, the compatibility between PMSE equipment and MFCN BS is feasible.

The critical case is when the PMSE equipment is close to the MFCN UE. The simulations show that for Scenario1 (Outdoor) with a separation distance between 15-100 meters, there is no compatibility issue for the handheld PMSE device. For the body worn PMSE device, there is no compatibility issue for the 10 MHz bandwidth, but a potential narrowband blocking issue for the 3 MHz LTE UE may occur. The simulations show that for Scenario 3 (Outdoor) with a separation distance between 100-350 meters, there is no compatibility issue. The simulations show that for Scenario 6 (Indoor) with a separation distance between 5-50 meters, both handheld and body worn PMSE devices have a potential compatibility issue. In this case, both unwanted emissions and blocking cause degradation of the MFCN performance. If this separation distance is increased, the probability of interference decreases accordingly.

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

The results of this report do not guarantee that audio PMSE equipment will be able to operate in all the compatibility scenarios, but identify the scenarios and technical conditions under which PMSE could be operated with sufficient QoS. PMSE should be operated only if a check of quality of service in the radio

[7] In this study the band 733-758 MHz is exclusively used by PMSE. The introduction of further application will affect the calculated scenario.

environment is performed before use and shows a 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 of ECC Report 191 [6]. It was shown that PMSE is able to find an operational channel with sufficient QoS with the assumption of certain spatial distances between the PMSE equipment and the MFCN equipment. However, it is noted that the spectrum environment is subject to change between setup and performance if the audience brings in active mobile devices. The most critical case is when the PMSE is close to a MFCN UE. If this separation distance is increased, the probability of interference decreases accordingly.

Table 18: power restrictions for handheld microphone[8]

	Frequency Range	Handheld e.i.r.p.	Reasoning
OOB	< 733 MHz	-45 dBm/200kHz	ETSI EN 300 422 [11]
	733 – 753.8 MHz	19 dBm/200kHz	--
	753.8 – 755.2 MHz	13 dBm/200kHz	--
	755.2 – 758 MHz	Guard band	--
OOB	> 758 MHz	-45 dBm/200kHz	ETSI EN 300 422 [11]

Note: The compatibility situation at the boundary between PMSE and MFCN around 733 MHz, is the same at 703 MHz due to the fact that the equipment is the same.

Table 19: power restrictions for body worn microphone[9]

	Frequency Range	Body worn e.i.r.p.	Reasoning
OOB	< 733 MHz	-45 dBm/200kHz	ETSI EN 300 422 [11]
	733 – 756.8 MHz	19 dBm/200kHz	--
	756.8 – 758 MHz	Guard band	--
OOB	> 758 MHz	-45 dBm/200kHz	ETSI EN 300 422 [11]

Note: The compatibility situation at the boundary between PMSE and MFCN around 733 MHz, is the same at 703 MHz due to the fact that the equipment is the same.

[8] These power restrictions, for handheld microphone, correspond to Table 1 which is also contained in CEPT Report 53.
[9] These power restrictions, for body worn microphone, correspond to Table 2 which is also contained in CEPT Report 53.

ANNEX 1: SEAMCAT SIMULATION

In this annex the results of the SEAMCAT simulations are given. The relevant scenarios used for PMSE can be classified into two basic types: outdoor and indoor. The analyses are based on Monte Carlo simulation (with SEAMCAT version 4.1.0) 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 give the possibility to derive power restrictions for PMSE, therefore the same assumptions are made for this annex and ANNEX 2:

For scenarios with LTE UE as the interfering system, power control functionalities are assumed. The results are presented with and without such a power control. For the victim PMSE system a C/(I+N) protection criterion is considered, therefore a wanted signal with 95% location probability is used for PMSE in the simulations (see section 3.1.1).

For scenarios with PMSE as the interfering system, it is assumed that they always transmit with the maximum allowed power; a protection criterion I/N is used for the victim MFCN system in that case.

For the 700 MHz band, it could be assumed that the MFCN UE can use the requirements of its receiver for Band 20 or Band 28 (APT band plan), both systems are studied and the results are presented in the following Table 20:

Table 20: E-UTRA operating bands

Band	Uplink (UL) operating band BS receive UE transmit	Downlink (DL) operating band BS transmit UE receive
20	832 – 862 MHz	791 – 821 MHz
28	703 – 748 MHz	758 – 803 MHz

A1.1 RESULTS

The results which take into account the MFCN UE power control are presented in A1.2. The results presented in A1.1.1 and A1.1.2 doesn’t take into account the proposed PMSE power restrictions. The results presented in A1.1.3 and 0 use for the simulation the power restrictions as proposed in ANNEX 2: for PMSE. In fact the PMSE equipment transmits always the spectrum mask as described in Table 7 and Table 8 of section 3.1; therefore this spectrum mask is used in the simulations. This mask is defined as relative values in dBc; this reduces also the out-of-band emissions if the maximum allowed transmit power is reduced.

A1.1.1 Results for Band 20

Table 21: SEAMCAT results (PMSE body worn; PMSE receiver)

<table>
<tr><th>Scenario</th><th>Victim</th><th>Interferer</th><th colspan="8">PMSE Frequency [MHz]
Unwanted / Blocking propability [%]</th></tr>
<tr><td colspan="3"></td><td>733.1</td><td>734.1</td><td>742.9</td><td>743.9</td><td>754.9</td><td>755.9</td><td>756.9</td><td>757.9</td></tr>
<tr><td>1</td><td>LTE UE</td><td>PMSE</td><td colspan="4">NN</td><td>0 / 0</td><td>0 / 0.73</td><td>0 / 3.14</td><td>0 / 84.86</td></tr>
<tr><td>2</td><td>PMSE</td><td>LTE UE</td><td>44.38 / 0</td><td>25.85 / 0</td><td>0.42 / 0</td><td>0 / 0</td><td colspan="4">0 / 0</td></tr>
<tr><td>3</td><td>LTE BS</td><td>PMSE</td><td colspan="8">0.12 / 0.01</td></tr>
<tr><td>4</td><td>PMSE</td><td>LTE BS</td><td>0 / 0.12</td><td>0 / 0.12</td><td>0 / 0.12</td><td>0 / 0.10</td><td colspan="3">4.80 / 0.13</td><td>18.35 / 0.13</td></tr>
</table>

Scenario	Victim	Interferer	733.1	734.1	742.9	743.9	754.9	755.9	756.9	757.9
5	PMSE	LTE BS	0 / 0.03	0 / 0.03	0 / 0.03	0 / 0.03	1.73 / 0.03			8.11/ 0.04
6	LTE UE	PMSE	NN				0 / 7.78	0 / 17.20	0 / 25.91	0 / 99.91
7	PMSE	LTE UE	73.84 / 0	55.34 / 0	04.19 / 0	0.57 / 0	0.19 / 0			

Note: “NN” indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.

Table 22: SEAMCAT results (PMSE hand held; PMSE receiver)

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking propability [%]							
			733.1	734.1	742.9	743.9	754.9	755.9	756.9	757.9
1	LTE UE	PMSE	NN				0.51 / 9.48	0.54 / 17.47	0.60 / 23.97	0.74 / 60.80
2	PMSE	LTE UE	44.38 / 0	25.85 / 0	0.42 / 0	0 / 0	0 / 0			
3	LTE BS	PMSE	0.57 / 0.24							
4	PMSE	LTE BS	0 / 0.12	0 / 0.12	0 / 0.12	0 / 0.10	4.80 / 0.13			18.35 / 0.13
5	PMSE	LTE BS	0 / 0.03	0 / 0.03	0 / 0.03	0 / 0.03	1.73 / 0.03			8.11/ 0.04
6	LTE UE	PMSE	NN				3.15 / 11.87	3.10 / 23.31	3.29 / 34.26	3.16 / 99.03
7	PMSE	LTE UE	73.84 / 0	55.34 / 0	04.19 / 0	0.57 / 0	0.19 / 0			

Note: “NN” indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.

A1.1.2 Results for Band 28

Only the scenarios in which the MFCN UE is the victim are simulated, as only the MFCN UE receiver is affected by a change in in-band requirements.

Table 23: SEAMCAT results (PMSE body worn; PMSE receiver)

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking probability [%]							
			733.1	734.1	742.9	743.9	754.9	755.9	756.9	757.9
1	LTE UE	PMSE	NN				0 / 0	0 / 0.6	0 / 3.02	0 / 99.33
6	LTE UE	PMSE	NN				0 / 7.41	0 / 16.72	0 / 25.63	0 / 100.0

Note: “NN” indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.

Table 24: SEAMCAT results (PMSE hand held; PMSE receiver)

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking probability [%]							
			733.1	734.1	742.9	743.9	754.9	755.9	756.9	757.9
1	LTE UE	PMSE	NN				0.53 / 9.73	0.58 / 17.51	0.64 / 23.92	0.61 / 70.78
6	LTE UE	PMSE	NN				3.23 / 12.03	3.19 / 24.09	3.22 / 34.36	3.24 / 100.0

Note: "NN" indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.

A1.1.3 Results for Band 20, with PMSE power restrictions

In this section the power restrictions for PMSE of ANNEX 2: are taken into account. This means that the PMSE Spectrum Emission Mask is still used, but the output power and usable frequencies are restricted. The first theoretically usable frequency for PMSE to meet the OOB-Limit of -45 dBm is approx. 816 kHz adjacent to the boundaries of the MFCN (see Figure 6, frequency offset of 0 MHz is the boundary).

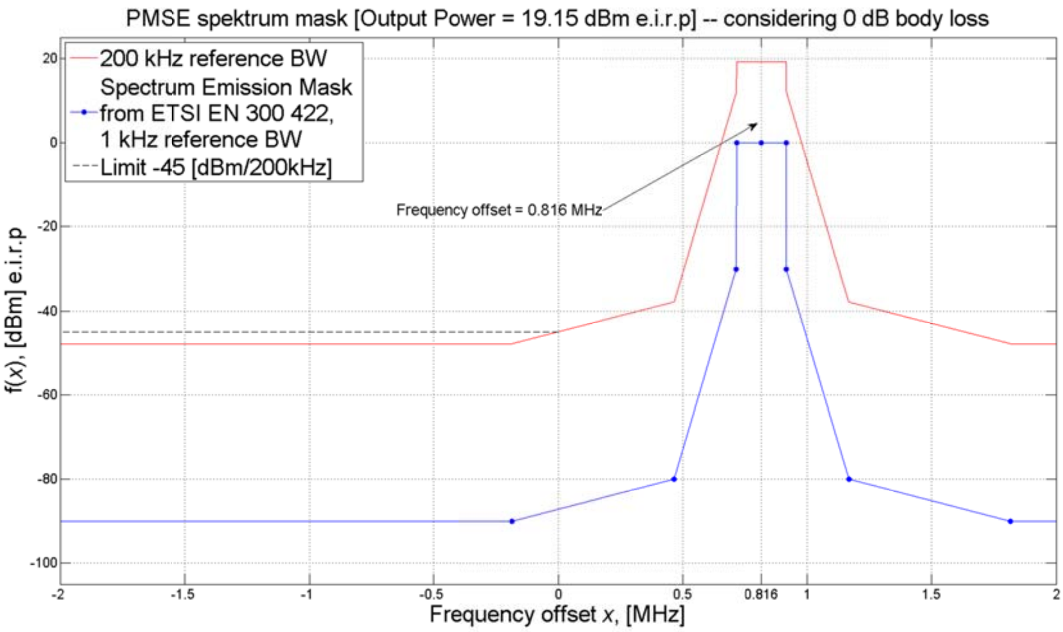


Figure 6: PMSE Spectrum Emission Mask ETSI EN 300 422 (blue curve output power 0dBm) and first theoretically usable frequency for PMSE from the band edge of MFCN

Table 25: SEAMCAT results (PMSE body worn; PMSE receiver)

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking propability [%]							
			733.1	734.1	742.9	743.9	754.9	755.9	756.9	757.9
1	LTE UE	PMSE	NN				0 / 0	0 / 0.73	0 / 3.14	XX
2	PMSE	LTE UE	44.38 / 0	25.85 / 0	0.42 / 0	0 / 0	0 / 0			
3	LTE BS	PMSE	0.12 / 0.01							
4	PMSE	LTE BS	0 / 0.12	0 / 0.12	0 / 0.12	0 / 0.10	4.80 / 0.13			XX
5	PMSE	LTE BS	0 / 0.03	0 / 0.03	0 / 0.03	0 / 0.03	1.73 / 0.03			XX
6	LTE UE	PMSE	NN				0 / 7.78	0 / 17.20	0 / 25.91	XX
7	PMSE	LTE UE	73.84 / 0	55.34 / 0	04.19 / 0	0.57 / 0	0.19 / 0			

Note 1: "NN" indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.
Note 2: "XX" indicates that these specific frequencies are not useable for PMSE duo to the proposed PMSE power restrictions.

Table 26: SEAMCAT results (PMSE hand held; PMSE receiver)

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking propability [%]							
			733.1	734.1	742.9	743.9	754.9	755.2	756.9	757.9
1	LTE UE	PMSE	NN				0.00 / 2.23	0.00 / 3.03	XX	
2	PMSE	LTE UE	44.38 / 0	25.85 / 0	0.42 / 0	0 / 0	0 / 0			
3	LTE BS	PMSE	0.57 / 0.24						XX	
4	PMSE	LTE BS	0 / 0.12	0 / 0.12	0 / 0.12	0 / 0.10	4.80 / 0.13			18.35 / 0.13
5	PMSE	LTE BS	0 / 0.03	0 / 0.03	0 / 0.03	0 / 0.03	1.73 / 0.03			8.11 / 0.04
6	LTE UE	PMSE	NN				0.16 / 5.22	0.11 / 6.31	XX	
7	PMSE	LTE UE	73.84 / 0	55.34 / 0	04.19 / 0	0.57 / 0	0.19 / 0			

Note 1: "NN" indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.
Note 2: "XX" indicates that these specific frequencies are not useable for PMSE duo to the proposed PMSE power restrictions.

A1.1.4 Results for Band 28, with PMSE power restrictions

Only the scenarios in which the MFCN UE is the victim are simulated, as only the MFCN UE receiver is affected by a change in in-band requirements.

Table 27: SEAMCAT results (PMSE body worn; PMSE receiver)

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking probability [%]							
			733.1	734.1	742.9	743.9	754.9	755.9	756.9	757.9
1	LTE UE	PMSE	NN				0 / 0	0 / 0.6	0 / 3.02	XX
6	LTE UE	PMSE	NN				0 / 7.41	0 / 16.72	0 / 25.63	XX

Note 1: “NN” indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.
Note 2: “XX” indicates that these specific frequencies are not useable for PMSE duo to the proposed PMSE power restrictions.

Table 28: SEAMCAT results (PMSE hand held; PMSE receiver)

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking probability [%]							
			733.1	734.1	742.9	743.9	754.9	755.2	756.9	757.9
1	LTE UE	PMSE	NN				0.02 / 2.20	0.01 / 3.17	XX	
6	LTE UE	PMSE	NN				0.21/ 5.60	0.12 / 6.53	XX	

Note 1: “NN” indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.
Note 2: “XX” indicates that these specific frequencies are not useable for PMSE duo to the proposed PMSE power restrictions.

A1.2 RESULTS WITH MFCN UE POWER CONTROL

For the power control of an MFCN UE the values in the table below are used.

Table 29: MFCN UE power control values

Parameter	Unit	Value	Comment
power control step size	dB	1	
minimum threshold	dBm	-101.5	Sensitivity of the MCFN BS
dynamic range	dB	63	

This means if the received power at the base station is higher than the minimum. threshold the UE will reduce the transmitted power in 1 dBm steps, until a minimum transmit power of -40 dBm is reached. In this context the minimum transmit power is:

Minimum transmit power (UE) = Maximum Transmit Power (UE) - dynamic range

For the interfering path the same scenario requirements and parameters for the components are used as described in section 3. For scenario 7 it is assumed that the MFCN BS is outdoor and the MFCN UE is indoor therefore an additional wall loss is taken into consideration. The default values within SEAMCAT 4.1.0 for the Extended Hata propagation model [13] are used.

A1.2.1 Results with MFCN UE power control

Table 30: SEAMCAT results (PMSE receiver) with MFCN UE power control

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking probability [%]							
			733.1	734.1	742.9	743.9	754.9	755.2	756.9	757.9
2	PMSE	LTE UE	6.87 / 0	3.06 / 0	0 / 0	0 / 0	0 / 0			
7	PMSE	LTE UE	64.25 / 0	47.11 / 0	3.16 / 0	0.35 / 0	0.13 / 0			

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

One simple power restriction 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.

A2.1 RESULTS ANALYSIS AND POWER RESTRICTION

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 [2], then a restricted frequency range (RFR) is required. The table below summarises the results.

Table 31: Results of blocking MCL analysis

Scenario	Victim	Handheld PMSE	Body worn PMSE
1	LTE UE	RFR in 753.8-758 MHz 13 dBm/200kHz between 753.8 MHz and 755.2 MHz	RFR in 756.8-758 MHz
3	LTE macro BS	No requirement	No requirement

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 summarises the results.

Table 32: Results of out-of-block MCL analysis

Scenario	Victim	Handheld PMSE: OOB emission level	Body worn PMSE: OOB emission level
1	LTE UE	-43.3 dBm/200 kHz	-29.3 dBm/200 kHz
3	LTE macro BS	-31.9 dBm/200 kHz	-17.9 dBm/200 kHz

A2.2 MCL CALCULATIONS

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

Outdoor, LTE UE, scenario 1:

For an outdoor UE, 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 [14] propagation model and for a separation distance of 15 m.

Table 33: Parameters for MCL calculation

Parameter		Value
Path loss	dB	60.7
UE antenna gain	dBi	-4
UE body loss	dB	3
Handheld mic body loss	dB	1
Body worn mic body loss	dB	15

Table 34: Calculation of maximum allowed handheld microphone e.i.r.p. to protect LTE UE

Frequency range (MHz)	758-757.8	756-755.8	755.2-755	754.2-754	753.8-753.6
Offset from the edge (MHz)	0-0.2	2-2.2	2.8-3	3.8-4	4.2-4.4
Narrowband blocking level (dBm)	-67.8	-58.6	-55.4	-51.4	-49.8
Max e.i.r.p. (dBm)	0.9	10.1	13.3	17.3	18.9

Table 35: Calculation of maximum allowed body worn microphone e.i.r.p. to protect LTE UE

Frequency range (MHz)	758-757.8	757.2-757	756.8-756.6
Offset from the edge (MHz)	0-0.2	0.8-1	1.2-1.4
Narrowband blocking level (dBm)	-67.8	-65.4	-63.8
Max e.i.r.p. (dBm)	14.9	17.3	18.9

Outdoor, macro BS, scenario 3:

For an outdoor macro BS, the maximum e.i.r.p. acceptable from a microphone is given by the following formula:

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

where path loss is calculated according to Extended Hata propagation model [13] and for a separation distance of 100 m.

Table 36: Parameters for MCL calculation

Parameter		Value
Path loss	dB	89.0
BS antenna gain	dBi	15
Antenna discrimination	dB	15
Handheld mic body loss	dB	1
Body worn mic body loss	dB	15

Table 37: Calculation of maximum allowed handheld microphone e.i.r.p. to protect LTE BS

Frequency range (MHz)	733.2-733.4
Offset from the edge (MHz)	0.2-0.4
Narrowband blocking level (dBm)	-59.7
Max e.i.r.p. (dBm)	30.3

Table 38: Calculation of maximum allowed body worn microphone e.i.r.p. to protect LTE BS

Frequency range (MHz)	733.2-733.4
Offset from the edge (MHz)	0.2-0.4
Narrowband blocking level (dBm)	-59.7
Max e.i.r.p. (dBm)	44.3

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, scenario 1:

For an outdoor UE, 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-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 [14] propagation model and a separation distance of 15 m.

Table 39: Calculation of maximum allowed out-of-band microphone e.i.r.p. to protect LTE UE

Victim UE characteristics		
Interferer power allowed	dBm/200kHz	-112
Attenuation calculation		
Path loss	dB	60.7
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	-43.3
Body worn Microphone		
Microphone body loss	dB	15
Max out-of-band e.i.r.p.	dBm/200kHz	-29.3

Outdoor, macro BS, scenario 3:

For an outdoor macro BS, 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-band_Interference_Level + Path_Loss - BS_Antenna_Gain + BS_Antenna_Discrimination + Mic_Body_Loss

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

Table 40: Calculation of maximum allowed out-of-band microphone e.i.r.p. to protect LTE macro BS

Victim BS characteristics		
Interferer power allowed	dBm/200kHz	-122
Attenuation calculation		
Path loss	dB	89.0
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	-31.9
Body worn Microphone		
Microphone body loss	dB	15
Max out-of-band e.i.r.p.	dBm/200kHz	-17.9

ANNEX 3: DERIVATION OF A POWER RESTRICTION BASED ON MOBILE UE EMISSION LIMIT REQUIREMENTS

The deployment scenario for the power restriction 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. Protection of mobile service can simply be insured through extension of such requirements to other equipment operating in the centre gap.

Any system creating no more interference than LTE terminals in the 700 MHz band should therefore clearly be compatible with services in this band.

Maximum e.i.r.p. for an LTE UE is 23 dBm. These values are above the 19 dBm that is the maximum e.i.r.p. for a wireless microphone.

A3.1 EMISSIONS IN THE 703-733 MHZ BAND (UL)

The LTE specification ETSI TS 136 101 [8] (see Table 6.6.2.1.1-1) provides the following spectrum emission mask:

Table 41: 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, it is clear that an emission level of -17 dBm/200 kHz in 703-733 MHz does not create undue interference to networks in that band.

A3.2 EMISSIONS IN THE 758-788 MHz BAND (DL)

The ERC/REC 74-01 [3], Annex 2 Table 2.1, (as ITU-R SM.329-12 [1]) indicates that unwanted emissions in the spurious domain from land mobile terminals and radio microphones should be limited to -36 dBm/100 kHz between 30 MHz and 1 GHz. This limit is quoted in the LTE specification ETSI TS 136 101 [8] (see Table 6.6.3.1-2).

Therefore an emission level of -33 dBm/200 kHz in 758-788 MHz does not create undue interference to networks in that band.

ANNEX 4: PMSE BODY LOSS IN THE 700 MHz BAND

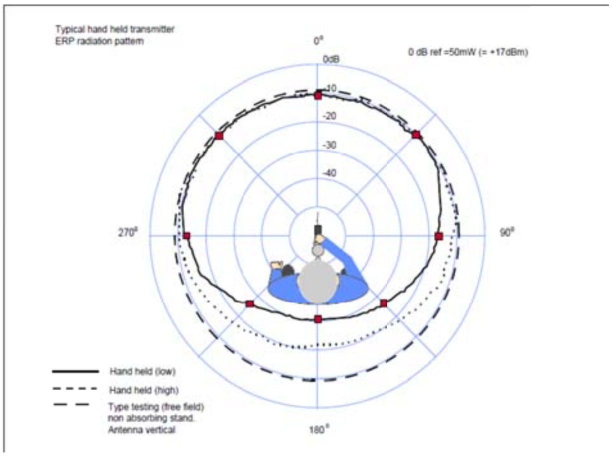
A4.1 DEFINITION OF BODY LOSS

As a brief definition, the term “PMSE body loss effect” can be described as the additional path loss caused by human body absorption and shielding.

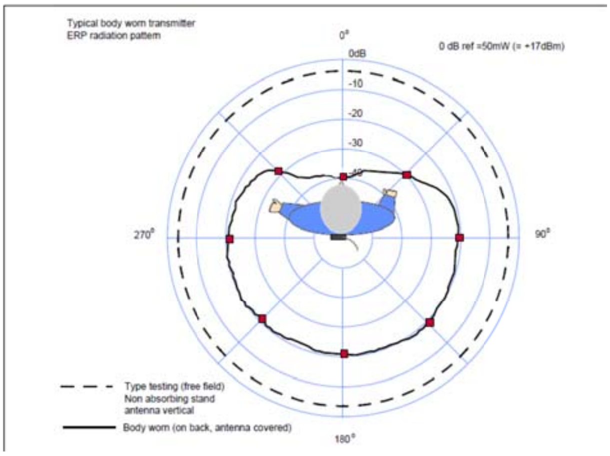
A4.2 SUMMARY OF EXISTING INFORMATION ON PMSE BODY LOSS

ERC Report 42 [4] and CEPT Report 30 [7] show body loss plots:

Table 42: Body loss pattern



Body loss for hand held devices: 8 dB



Body loss for body worn devices: 18 dB

Note: ERC Report 42 refers to 650 MHz and Report 30 to 800 MHz

In addition Figure 7 and Figure 8 incorporate real-live situation pictures:

Figure 7: hand held device

Figure 8: body worn device

Unmounted hand held transmitter 822 MHz (P = 30 mW = 14.7 dBm)

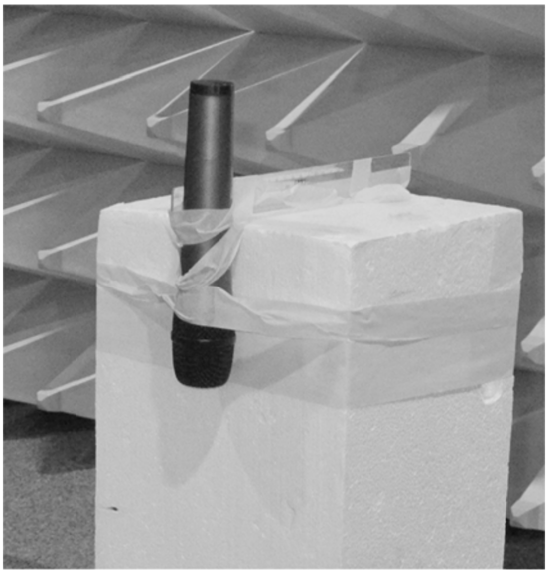


Figure 9: device under test at Styrofoam block

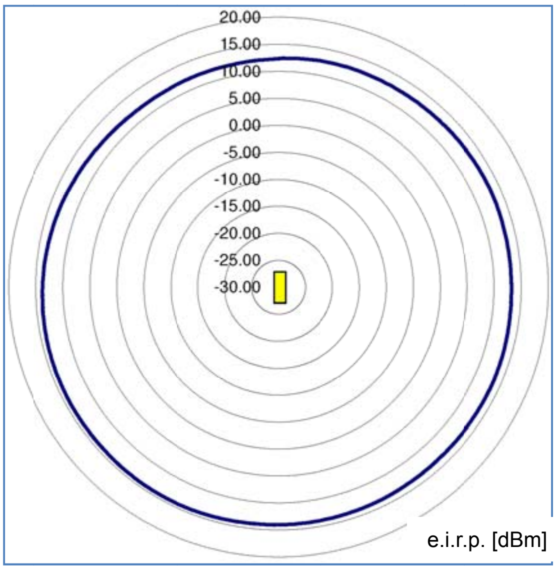


Figure 10: polar pattern of radiated power of device of Figure 9

Note: Each object in the immediate neighbourhood influences the radiation, also the foam block.

Hand held transmitter 822 MHz (P = 30 mW)

Figure 11: hand held device under test

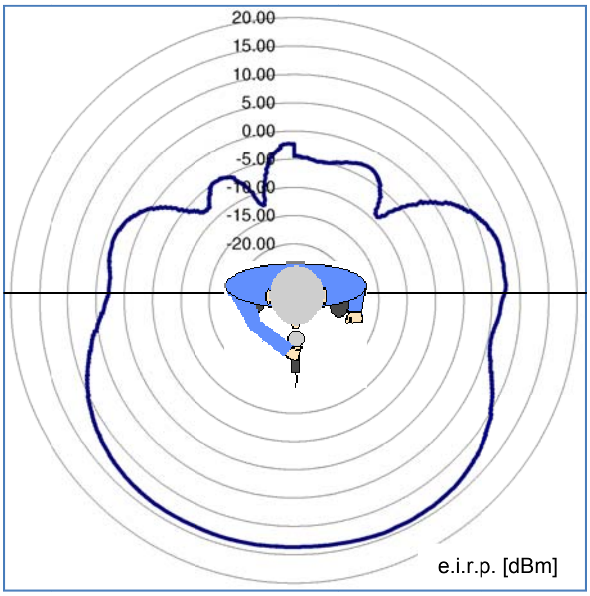


Figure 12: polar pattern of radiated power of device in Figure 11

OFCOM engaged the Cobham Technical Services in 2009 for additional measurements in the Theatre environment. The conclusions on the body loss of this study show similar results and more pictures can be found in the study [15].

A4.3 SUGGESTION

A comparison on the available information presented in this document and its references prove that the information of CEPT Report 30 [7] and ERC Report 42 [4] should be applied.

It is therefore proposed an **average body loss effect** in the 700 MHz band:

- for hand held devices = 8 dB
- body worn devices = 18 dB

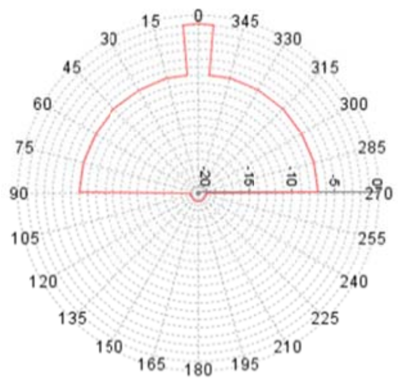
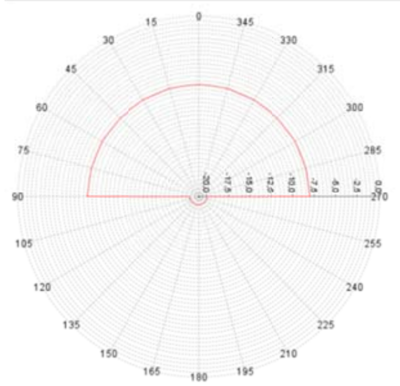
A4.4 FURTHER INFORMATION

The Institute for Applied Physics (Italian National Research Council) provides an Internet resource for the calculation of the "Dielectric Properties of Body Tissues" in the frequency range 10 Hz to 100 GHz: http://niremf.ifac.cnr.it/tissprop/

ANNEX 5: DERIVATION OF POWER RESTRICTION BASED ON MCL AND SEAMCAT WITH OTHER BODY LOSS VALUES FOR PMSE

Based on the body loss values, presented in ANNEX 4: the SEAMCAT simulations (ANNEX 1:) and the MCL analyses (ANNEX 2:) are reused with the necessary changes, to take the different assumptions into account. The changes in the input parameters are given in Table 43.

Table 43: Parameters for audio PMSE

Parameter	Unit	Used in ANNEX 1: and ANNEX 2:	Used in this Annex
handheld body loss	dB	 1 around 0° 20 from 90° to 270° 7 elsewhere	 20 from 90° to 270° 8 elsewhere
Body worn body loss	dB	15	18

A5.1 SEAMCAT ANALYSES

The SEAMCAT results are given for the same scenarios as in ANNEX 1:.

A5.1.1 Results Band 20

Table 44: Results body worn

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking propability [%]							
			733.1	734.1	742.9	743.9	754.9	755.9	756.9	757.9
1	LTE UE	PMSE	NN				0 / 0	0 / 0.08	0 / 0.9	0 / 71.57
3	LTE BS	PMSE	0.09 / 0.04							
6	LTE UE	PMSE	NN				0 / 4.20	0 / 11.99	0 / 19.26	0 / 99.26

Note: "NN" indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.

Table 45: Results hand held

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking propability [%]							
			733.1	734.1	742.9	743.9	754.9	755.9	756.9	757.9
1	LTE UE	PMSE	NN				0.23 / 7.86	0.19 / 16.10	0.19 / 21.96	0,28 / 59.53
3	LTE BS	PMSE	0.52 / 0.24							
6	LTE UE	PMSE	NN				2.36 / 10.69	2.20 / 21.11	2.32 / 31.21	2.46 / 98.96

Note: “NN” indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.

A5.1.2 Results Band 28

Only the scenarios in which the MFCN UE is the victim are simulated, as only the MFCN UE receiver is affected by a change in in-band requirements.

Table 46: Results body worn

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking propability [%]							
			733.1	734.1	742.9	743.9	754.9	755.9	756.9	757.9
1	LTE UE	PMSE	NN				0.23 / 7.86	0.19 / 16.10	0.19 / 21.96	0,28 / 59.53
6	LTE UE	PMSE	NN				2.36 / 10.69	2.20 / 21.11	2.32 / 31.21	2.46 / 98.96

Note: “NN” indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.

Table 47: Results hand held

Scenario	Victim	Interferer	PMSE Frequency [MHz] Unwanted / Blocking propability [%]							
			733.1	734.1	742.9	743.9	754.9	755.9	756.9	757.9
1	LTE UE	PMSE	NN				0.23 / 7.86	0.19 / 16.10	0.19 / 21.96	0,28 / 59.53
6	LTE UE	PMSE	NN				2.36 / 10.69	2.20 / 21.11	2.32 / 31.21	2.46 / 98.96

Note: “NN” indicates that these specific frequencies are not simulated due to a lack of a needed technical parameter.

A5.2 MCL ANALYSES

To take into account the body loss values given in ANNEX 4:, in the MCL calculations presented in ANNEX 2:, the initial assumption from Table 7 and Table 8 should be subtracted from the new values given in Table 43.

This gives an additional loss, in dB, which could be added to the resulting link budgets given in ANNEX 2:. The new results are presented in Table 54 to Table 55.

A5.2.1 Calculation for in-block e.i.r.p. (blocking case)

A5.2.1.1 Outdoor, LTE UE, scenario 1

Table 48: Calculation of maximum allowed handheld microphone e.i.r.p. to protect LTE UE

Frequency range (MHz)	758-757.8	756.6-756.8	756-755.8	755.6-755.4	755.2-755	754.2-754
Offset from the edge (MHz)	0-0.2	1.4-1.6	2-2.2	2.4-2.6	2.8-3	3.8-4
Max e.i.r.p. (dBm) ANNEX 2:	0.9	Not Calculated	10.1	Not Calculated	13.3	17.3
Max e.i.r.p. (dBm) new	7.9	13.5	17.9	19.5	20.3	24.3

Table 49: of maximum allowed body worn microphone e.i.r.p. to protect LTE UE

Frequency range (MHz)	758-757.8	757.6-757.4	757.2-757	756.8-756.6
Offset from the edge (MHz)	0-0.2	0.4-0.6	0.8-1	1.2-1.4
Max e.i.r.p. (dBm) ANNEX 2:	14.9	Not Calculated	17.3	18.9
Max e.i.r.p. (dBm) new	17.9	19.5	20.3	21.9

A5.2.1.2 Outdoor, macro BS, scenario 3

Table 50: Calculation of maximum allowed handheld microphone e.i.r.p. to protect LTE BS

Frequency range (MHz)	733.2-733.4
Offset from the edge (MHz)	0.2-0.4
Max e.i.r.p. (dBm) ANNEX 2:	30.3
Max e.i.r.p. (dBm) new	37.3

Table 51: Calculation of maximum allowed body worn microphone e.i.r.p. to protect LTE BS

Frequency range (MHz)	733.2-733.4
Offset from the edge (MHz)	0.2-0.4
Max e.i.r.p. (dBm) ANNEX 2:	44.3
Max e.i.r.p. (dBm) new	47.3

A5.2.2 Calculation for out-of-band e.i.r.p. (out-of-band emissions case)

A5.2.2.1 Outdoor, LTE UE, scenario 1

Table 52: Calculation of maximum allowed out-of-band microphone e.i.r.p. to protect LTE UE

Handheld Microphone		
Max out-of-band e.i.r.p. (dBm) ANNEX 2:	dBm/200kHz	-43.3
Max out-of-band e.i.r.p. (dBm) new	dBm/200kHz	-36.3
Body worn Microphone		
Max out-of-band e.i.r.p. (dBm) ANNEX 2:	dBm/200kHz	-29.3
Max out-of-band e.i.r.p. (dBm) new	dBm/200kHz	-26.3

A5.2.2.2 Outdoor, macro BS, scenario 3

Table 53: Calculation of maximum allowed out-of-band microphone e.i.r.p. to protect LTE macro BS

Handheld Microphone		
Max out-of-band e.i.r.p. (dBm) ANNEX 2:	dBm/200kHz	-31.9
Max out-of-band e.i.r.p. (dBm) new	dBm/200kHz	-24.9
Body worn Microphone		
Max out-of-band e.i.r.p. (dBm) ANNEX 2:	dBm/200kHz	-17.9
Max out-of-band e.i.r.p. (dBm) new	dBm/200kHz	-14.9

A5.3 POWER RESTRICTIONS FOR PMSE AUDIO DEVICES

Based on the calculations presented above another set of power restriction values may be applicable.

Table 54: power restrictions for handheld microphone

	Frequency Range	Handheld e.i.r.p.	Reasoning
OOB	MFCN Downlink	-45 dBm/200kHz	ETSI EN 300 422 [11]
	1.4 MHz offset from MFCN Downlink block edge	Guard band	
	From 1.4 to 2.4 MHz offset from MFCN Downlink block edge	13 dBm/200kHz	
	From 2.4 MHz offset from MFCN Downlink block	19 dBm/200kHz	
OOB	MFCN Uplink	-45 dBm/200kHz	ETSI EN 300 422 [11]

Note: The compatibility situation at the boundary between PMSE and MFCN around 733 MHz is the same at 703 MHz due to the fact that the equipment is the same.

Table 55: power restrictions for body worn microphone

	Frequency Range	Body worn e.i.r.p.	Reasoning
OOB	MFCN Downlink	-45 dBm/200kHz	ETSI EN 300 422 [11]
	0.4 MHz offset from MFCN Downlink block edge	Guard band	
	From 0.4 MHz offset from MFCN Downlink block edge	19 dBm/200kHz	
OOB	MFCN Uplink	-45 dBm/200kHz	ETSI EN 300 422 [11]

Note: The compatibility situation at the boundary between PMSE and MFCN around 733 MHz is the same at 703 MHz due to the fact that the equipment is the same.

ANNEX 6: PMSE SPECTRUM MASK FROM ETSI EN 300 422

The PMSE spectrum emission mask is given in ETSI EN 300 422 [11] with values in dBc. The values can be easily transferred in dBm. In the figures below the ETSI EN 300 422 mask (reverence bandwidth 1 kHz1kHz) is shown and recalculated for a reverence bandwidth of 200 kHz200kHz and 1 MHz1MHz. The reverence bandwidth for in-band is not changed.

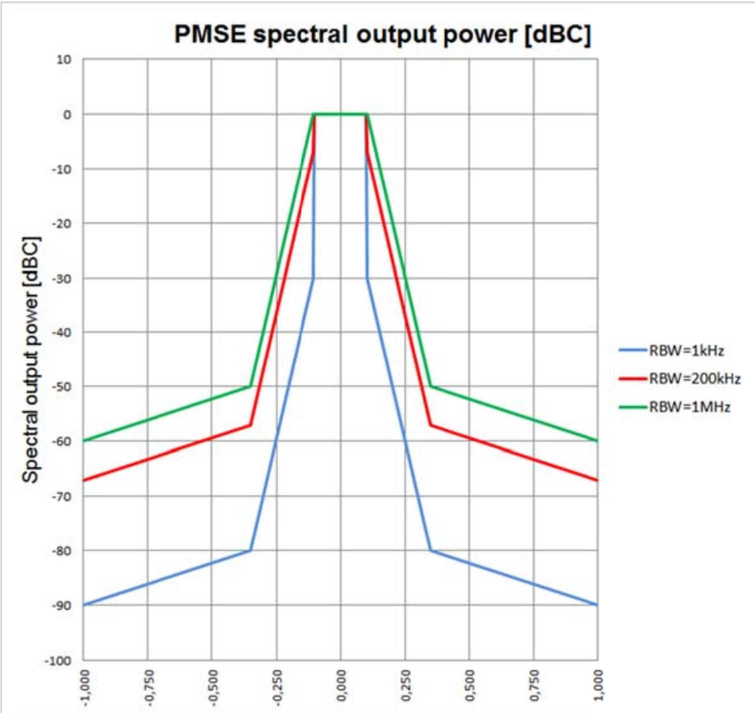


Figure 13: ETSI spectrum mask transferred to differed bandwidth

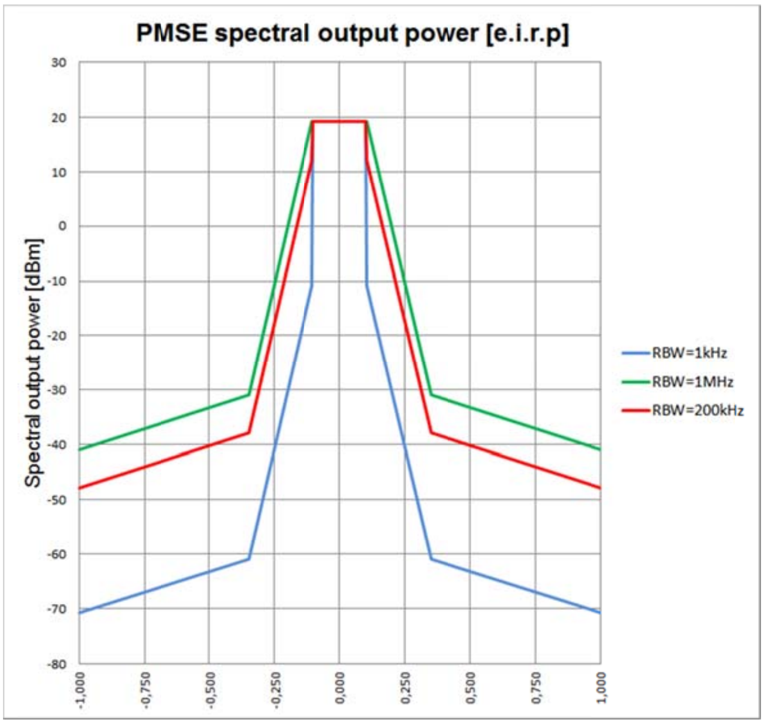


Figure 14: Transfer to maximum isotropic radiated output power (19.15 dBm)

ANNEX 7: EVALUATING PMSE BEMS

Interfering probabilities are calculated using three different proposed BEMs for PMSE.

A7.1 EVALUATING THE BEMS

In order to propose a BEM for PMSE, several BEMs were used in the SEAMCAT simulations. The proposed BEM for PMSE would be based on these simulation results.

The following BEMs were used

- BEM 1800 refers to the BEM suggested in ECC Report 191 [6]
- BEM 800 refers to the BEM in CEPT Report 30
- BEM equal to SEM refers to the PMSE spectrum emission mask (SEM) ETSI EN 300 422 (revised) [11] plus the antenna gain

A7.2 RESULTS

The cases involving the LTE pico BS were sufficiently covered in ECC Report 191, and were not considered in the study. See extract from ECC Report 191 [6] below

- 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.

A7.2.1 Compatibility between body worn PMSE and MFCN

The results provided by methods 1 and 2 for body worn PMSE are summarised in the following table.

It is clear from the simulation results that the 1800 MHz BEM impacts the MFCN devices with unwanted emissions to a much larger extent than the two other BEMS, the 800 MHz BEM and SEM.

Table 56: Simulation results, MFCN 3 MHz band width

Scenario	Victim	Interferer		PMSE Frequancy [MHz] Unwanted / Blocking probability [%]					
				733.1	734.1	749.9	754.9	755.9	757.9
1	LTE UE	PMSE	BEM 1800	4.54/0			4.25/15.97	4.3/22.65	4.46/31.62
			BEM 800	0.0/0.0			0/5	0/16.31	0/30.84
			BEM = SEM	0.0/0.0			0/4.80	0/5.88	6.85/31.46
6	LTE UE	PMSE	BEM 1800	19.28/7.97		29.23/7.82	28.46/30.03	28.79/52	28.44/77.1
			BEM 800	0/7.89		0/7.49	0/29.98	0/52	0/77.12
			BEM = SEM	3.80/7.83		3.5/7.54	3.64/30.2	3.5/52	17.82/77.6
3	LTE BS	PMSE	BEM 1800	26.56/0.97	24.19/0.66	25.50/0.22			
			BEM 800	1.27/ 0.9	1.14/ 0.81	1.15/0.21			

Note: in difference to ANNEX 1: in the frequency range from 733 – 749 MHz, the blocking mask of the MFCN UE has no additional rejection.

ANNEX 8: LIST OF REFERENCES

[1] Radiocommunication ITU-R SM.329-12: Unwanted emissions in the spurious domain, version of September 2012

[2] ERC Recommendation 70-03: Relating to the Use of Short Range Devices (SRD), version of February 2014

[3] ERC Recommendation 74-01: Unwanted emissions in the spurious domain, version of 2011

[4] ERC Report 42: Handbook on radio equipment and systems radio microphones and simple wide band audio links, version of October 1996

[5] ECC Report 131: Derivation of a Block Edge Mask (BEM) for Terminal Stations in the 2.6 GHz frequency band (2500-2690 MHz, version of January 2009

[6] ECC Report 191: Adjacent band compatibility between MFCN and PMSE audio applications in the 1785-1805 MHz frequency range, version of September 2013

[7] CEPT Report 30: The identification of common and minimal (least restrictive) technical conditions for 790-832 MHz for the digital dividend in the European Union, version of October 2009

[8] ETSI TS 136 101: E-UTRA; User Equipment (UE) radio transmission and reception

[9] ETSI TS 136 104: E-UTRA; Base Station (BS) radio transmission and reception

[10] ETSI TS 136 211: E-UTRA; Physical channels and modulation

[11] ETSI EN 300 422: Wireless microphones in the 25 MHz to 3 GHz frequency range

[12] ETSI TR 102 546: Technical characteristics for Professional Wireless Microphone Systems (PWMS); System Reference Document

[13] Extended Hata, http://tractool.seamcat.org/raw-attachment/wiki/Manual/PropagationModels/ExtendedHata/Hata-and-Hata-SRD-implementation_v2.pdf

[14] IEEE 802.11 Model C http://tractool.seamcat.org/wiki/Manual/PropagationModels/IEEE_802.11_Model_C_modified

[15] Cobham Technical Services, Report 2009-0333 “Analysis of PMSE Wireless Microphone Body Loss Effects”, June 2009

[16] CEPT Report 50: Technical conditions for the use of the bands 821-832 MHz and 1785-1805 MHz for wireless radio microphones in the EU

[17] Recommendation ITU-R P.1546-5 (09/2013) Method for point-to-area predictions for terrestrial services in the frequency range 30 MHz to 3 000 MHz