European Radiocommunications Committee (ERC) within the
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INTRODUCTION OF RADIO MICROPHONE APPLICATIONS IN THE FREQUENCY RANGE 1785 - 1800 MHz

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SUMMARY

This study considerd the compatibility between radio microphones and tactical radio relay systems in the frequency range 1785 - 1800 MHz taking account of the use of the adjacent bands by GSM 1800 (1710 - 1785 MHz) and TFTS (1800 - 1805 MHz).

The main results of this work are that the operation of radio microphones within the frequency range 1785 - 1800 MHz is feasible provided that:

- a guard band of 700 kHz is implemented to avoid compatibility problems between radio microphones and GSM 1800 (i.e. 1785 - 1785.7 MHz);
- a guard band of 600 kHz is implemented to provide protection against interference from TFTS emissions from airborne stations (i.e. 1799.4 - 1800 MHz);
- coordination is needed to ensure a 200m separation distance between radiomicrophones and TFTS ground stations in the band 1797 - 1799.4 MHz, and use at airports (with TFTS in operation) should be prohibited;
- co-channel sharing with tactical radio relay is feasible provided a separation distance of 1.4 - 2.8 km is observed, this can be achieved through a national licensing/coordination mechanism.
- the radiated power of the radio microphones is restricted to 10 dBm (17 dBm for body - worn equipment) to minimize interference to tactical radio relay systems.

These conditions are achievable through a national licensing procedure; this would be necessary in any case for professional radio microphone usage to avoid intra-service interference.

For analogue radio microphones the standard ETS 300 422 is applicable; however, if digital equipment were to be developed then a new standard would be required.

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1 INTRODUCTION

The aim of this study is to investigate the possibility of using the frequency range 1785 - 1800 MHz for radio microphones. For this purpose some compatibility considerations have been done.

The radio microphones considered in this study are professional applications. Therefore the stringent requirements for broadcast quality are taken into account. Radio microphones are assumed to be operated mainly indoors, although outdoor use is not prohibited.

This document describes the prerequisites for the introduction of radio microphones in the aforementioned frequency range.

2 BASIC PARAMETERS

2.1 System parameters

2.1.1 GSM 1800

Source: Draft prETS 300 577 (GSM 05.05), May 1995

General parameters:

Frequency band:	1710 - 1785 MHz
Modulation:	GMSK
Transmission method:	TDMA
Carrier spacing:	200 kHz
Channels:	Fu = [1710 + 0.2x (n-512)] where $512 \leq n \leq 885$

Mobile transmitters:

Output power:	max. 1 W (30 dBm) ± 2.5 dB min. 0.25 W (24 dBm) ± 2.5 dB micro station 1 mW (0 dBm) ± 6 dB

Level of spurious emissions
given an output power of 1 W: Draft prETS 300 577, page 13, Table b)

Spurious emissions due to modulation and wideband noise

Δ f (kHz)	200	250	400	600 -1200	1200 -1800	1800 -6000	≥ 6000
Power level (dBc)	- 30	- 33	- 60	- 60	- 60	- 71	- 79

Δf: Frequency offset from the centre frequency of the wanted signal
dBc: Level relative to the wanted signal

Spurious emissions due to switching transients

Δ f (kHz)	400	600	1200	1800
Power level (dBm)	-23	-26	-32	-36

Δf: Frequency offset from the centre frequency of the wanted signal

Intermodulation attenuation:	50 dB at 800 kHz (f1-f2) from the carrier
Antenna gain:	-2 dB
Feeder loss (cable loss):	2 dB

Fixed receivers:

Receiver sensitivity:

Type designation	Normal BTS	BTS M1	BTS M2	BTS M3
Level (dBm)	-104 (equivalent to 33 dB(µV/m))	-102	-97	-92

Co-channel rejection: 9 dB

Maximum permissible interference levels/interfering field strength levels:

Normal BTS: -113 dBm = 24 dB(µV/m)
BTS M1: -111 dBm = 26 dB(µV/m)
BTS M2: -106 dBm = 31 dB(µV/m)
BTS M3: -101 dBm = 36 dB(µV/m)

Adjacent channel rejection:

Δ f (kHz)	±200	±400	±600
Power level (dBc)	-9	-41	-49

Δf: Frequency offset from the centre frequency of the wanted signal
dBc: Level relative to the wanted signal

In-band blocking performance:

Blocking level (dBm)	Δf (kHz)	
	600 ≤ 800	800 ≤ 3000
Normal BTS	-35	-25
M1	-40	-30
M2	-35	-25
M3	-30	-20

Out-of-band blocking performance: 0 dBm

Spurious emissions: Measurement bandwidth:
see draft prETS 300 577, page 17
2 nW (-57 dBm) in the band 9 kHz - 1 GHz
20 nW (-47 dBm) in the band 1 - 12.75 GHz

Antenna gain: 18 dBi
Feeder loss (cable loss): 2 dB
Average antenna height: 25 m
Side lobe attenuation: 14 dB

2.1.2 Tactical radio relay

Source: National Radio Frequency Agency (NARFA), Germany

General parameters:

Frequency band:	1785 - 1800 MHz
System designation:	FM 1000
Modulation mode:	FM
Operation mode:	FDM or TDM
Frequency spacing:	FDM: 125 kHz
	TDM: see occupied bandwidths
Transmission range:	50-60 km
Fade margin:	Approx. 20 dB

Transmitters:

Output power: FDM and TDM 1.25 W (1 dBW)

Occupied bandwidths for TDM operation:

Transmission capacity	Bandwidth
256/288 kbit/s	600 kHz
512/576 kbit/s	980 kHz
1024/1152 kbit/s	1030 kHz

Maximum system values:

FDM operation:

Channel mode	System value
12-channel operation	≥ 159 dB
24-channel operation	≥ 154 dB

TDM operation (BER = 10^{-4}):

Transmission capacity	System gain
256/288 kbit/s	≥ 128 dB
512/576 kbit/s	≥ 127 dB
1024/1152 kbit/s	≥ 119 dB

Wanted and out-of-band emissions:

Δ f (kHz)	515	1030	2060	2500 - 5000
Level (dBc)	0	- 50	- 60	- 60

Δf: Frequency offset from the centre frequency of the wanted signal
dBc: Level relative to the wanted signal

General value of spurious emissions: - 30 dBm

Antenna type 1

Location of use:	Primarily on manoeuvres
Gain:	19.5 - 22 dBi
Side lobe attenuation:	≥ 9 dB
Front-to-back ratio:	≥ 18 dB
Voltage standing wave ratio (VSWR):	≤ 2.0 dB

Antenna type 2

Location of use:	Applications other than manoeuvres
Gain:	≥ 22 dBi
Side lobe attenuation:	≥ 25 dB
Polarisation:	Horizontal and vertical
Polarisation attenuation:	≥ 30 dB
Front-to-back ratio:	≥ 30 dB
Voltage standing wave ratio (VSWR):	≤ 2.0 dB

Both types of antenna

Antenna heights:	17-30 m
Feeder loss (cable loss):	2 dB

Receivers:

Noise figure:	F ≤ 8 dB

Receiver sensitivity:

Bandwidth	Pn = {10 log ($k*^{to}*B$) + F}
approx. 125 kHz (FDM)	-145 dBW
600 kHz (TDM)	-138 dBW
980 kHz (TDM)	-136 dBW
1030 kHz (TDM)	-136 dBW

C/N ratios for TDM:

Bit error ratio (BER)	C/N
$1*10^{-4}$	Binary transmission: 12 dB
	Biternary transmission: 15 dB
$1*10^{-7}$	Binary transmission: 15 dB
	Biternary transmission: 18 dB

Receiver sensitivity:	-88 dBm (average level)
Antennas:	Identical to transmitting antenna characteristics

Adjacent channel rejection:

Δ f (kHz)	515	1034	2060	3000	4000	4500
Power level (dBc)	0	3	3	40	60	80

Δf: Frequency offset from the centre frequency of the wanted signal
dBc: Level relative to the wanted signal

2.1.3 TFTS

Sources: ETS 300 326 1-3

General parameters:

Frequency band:	
Upper band:	1800 - 1805 MHz (TX: airborne station; RX: ground station)
RF channel arrangement:	1/33 MHz = 30.30 kHz
RF channel number:	n = 1-164
General RF channels:	Fa(n) = Fg(n) + 130 MHz Fa = airborne transmit channel where Fg(n) = 1670 MHz + n/33 MHz
No. of speech channels per RF channel:	4

Modulation:

Speech channel:	TDMA
RF channel:	π/4 DQPSK
Gross data rate:	44.2 kbit/s

Airborne transmitter:

Type	Location of use	Transmit power/tolerance	Antenna gain
Aircraft station	On board aircraft	40 dBm/+2 dB -1 dB	1 dBi

(Transmit power corresponds to mean power (PY).)

RF output spectrum mask: (measurement bandwidth: 300 Hz)

Frequency offset from the carrier (kHz)	**Relative level (dBc)**
± 11.3	+1
± 14.5	-20
± 15.6	-35
± 30	-37
± 60	-49
± 120	-65
± 2500	-70
± 5000	-75

Spurious emissions and out-of-band emissions
(see relevant type approval specifications for details of measurement bandwidths)

Frequency band	Maximum power (peak power (PX) at the antenna port
9 kHz - 1 GHz	-36 dBm
1 GHz - 12.75 GHz	-30 dBm

Intermodulation attenuation:	See relevant type approval specification
Feeder loss (cable loss):	2 dB

Ground station receivers:

a) Without interferer

Receiver input sensitivity	BER	Antenna gain	Cable loss
-112 dB	$< 1 \times 10^{-3}$	1 dBi	2 dB (assumed value)
-105 dBm	$< 1 \times 10^{-6}$	1 dBi	2 dB (assumed value)

b) With adjacent interferer

Frequency offset from the wanted signal in (kHz)	**C/I (dB)**	**Bit error ratio (BER)**
0	20	5.0×10^{-3}
30.30	-20	5.0×10^{-3}
60.60	-34	5.0×10^{-3}
90.90	-38	5.0×10^{-3}
120.120	-40	5.0×10^{-3}

Intermodulation attenuation: See relevant type approval specification
Antenna gain: 8 dBi
Feeder loss (cable loss): 2 dB

2.1.4 Radio microphones

Transmitter output power hand held: 10 dBm
Transmitter output power body worn: 17 dBm
Transmitter spectrum mask: as set out in ETS 300 422
Bandwidth (-60 dB): analogue as set out in ETS 300 422 (max. 200 kHz)
digital approx. 300 kHz
(which is not in compliance with ETS 300 422)

Body effect loss hand held: 6 dB
Body effect loss body worn: 14 dB

Receiver input power: analogue - 68 dBm/74 dB(µV/m); (acc. to Chester meeting)
digital - 85 dBm/57 dB(µV/m); (see section 2.2)
C/I ratio: analogue: 25 dB (acc. to manufacturer specification)
digital: 18 dB (acc. to manufacturer specification)
Max. interfering field strength: analogue: 49 dB(µV/m)
digital: 39 dB(µV/m)

Receiver spectrum mask: see **Annex 1**

Operating modes: indoor and outdoor

Channel selection: no dynamic channel selection, frequency tuning possible throughout the frequency range.

Propagation models: free space (worst case analysis) and for distances < 100 m

ITU-R P.529-2,
Hata model 1980;
(suburban)

Application:
Analysis of compatibility between radio relay systems and radio microphones where separation distances > 1 km are necessary.

ITU-R P.529-2,
Hata model 1980;
interpolated (suburban)

Application:
Analysis of compatibility between radio relay systems and radio microphones where separation distances < 1 km are necessary. Interpolation between free space propa-gation for 100 m and Hata value (suburban) for 1 km. See **Annex 1** for a graphical representation. This "model" has not been verified. It was chosen because no other suitable model is currently available for distances of less than 1 km.

2.2 Wanted field strength for radio microphones using digital modulation

Some additional details are required in connection with the wanted field strength values of digital microphones. The minimum wanted field strength for a digital receiver with a sensitivity of - 103 dBm (39 dB(µV/m)) and a required C/I of 18 dB was assumed to be 57 dB(µV/m). In view of the transmitter powers now specified for hand-held and body worn devices a coverage radius of approximately 500 m would be possible. In this case the maximum permissible interfering field strength would be 39 dB(µV/m).

If the same receiver is assumed but the coverage radius is reduced to 150 m, the wanted field strength is 68 dB(µV/m) and the permissible interfering field strength increases to 50 dB(µV/m). The latter value corresponds virtually to that of an analogue radio microphone. However, it should be borne in mind that analogue radio microphones have a coverage radius of only about 70 m.

This means that whilst maintaining an identical maximum permissible interfering field strength the coverage radius of 70 m of an analogue radio microphone can be more than doubled to 150 m by using a digital radio microphone. The results of compatibility analyses of analogue and digital radio microphones with a coverage radius of 150 m are therefore identical. The results obtained for digital radio microphones with a minimum wanted field strength are given in Section 2.3.

However, operation based on a minimum field strength in the frequency ranges shared with radio relay applications leads to considerable separation distances and should therefore be avoided where possible.

2.3 Results of compatibility analyses

Microphone interferes with GSM 1800 (BTS): for a separation distance of 10 m, a frequency separation of **700 kHz** is required; this applies to hand held and body worn devices, analogue and digital

GSM 1800 (MS) interferes with microphone: for a separation distance of 25 m, a frequency separation of **300 kHz** is required; this applies to hand held and body worn devices, analogue and digital

Microphone interferes with tactical radio relay: (side lobe suppression radio relay antenna type 1 = **9 dB**)

hand held	separation distance (free space propagation)	14.9 km
	separation distance (Hata model)	≤ **1 km**
body worn	separation distance (free space propagation)	13.3 km
	separation distance (Hata model)	≤ **1 km**

Microphone interferes with tactical radio relay: (side lobe suppression radio relay antenna type 2 = **25 dB**)

hand held	separation distance (free space propagation)	2.4 km
	separation distance (Hata model interpolated)	**420 m**
body worn	separation distance (free space propagation)	2.1 km
	separation distance (Hata model interpolated)	**380 m**

Radio relay interferes with microphone: (side lobe suppression radio relay antenna type 1 = **9 dB)**

analogue m./digital m. 150 m	separation distance (free space propagation)	33.28 km
	separation distance (Hata model)	**1.4 km**
digital microphone 500 m	separation distance (free space propagation)	105 km
	separation distance (Hata model)	**2.8 km**

(The values of 33.28 km and 105 km for free space propagation are unrealistic because with an antenna height of 30 m the radio horizon is already reached at 19.6 km.)

Radio relay interferes with microphone: (side lobe suppression radio relay antenna type 2 = **25 dB**)

analogue m./digital m. 150 m	separation distance (free space propagation)	5.92 km
	separation distance (Hata model interpolated)	**610 m**
digital microphone 500 m	separation distance (free space propagation)	14.86 km
	separation distance (Hata model interpolated)	**950 m**

Microphone interferes with TFTS (En route/Intermediate/Airport): for a separation distance of 50 m, a frequency separation of **3 MHz** is required; this applies to hand held and body worn devices, analogue and digital

TFTS interferes with microphone: for a separation distance of 80 m, a frequency separation of **600 kHz** is required; this applies to hand held and body worn devices, analogue and digital.

2.4 Overview of results

2.4.1 Results from the viewpoint of the other services affected (i.e. microphones as the interferer)

Service	GSM 1800	Tactical radio relay	**Microphones Tactical radio relay**	Tactical radio relay	TFTS
Frequency range	1710 - 1785 MHz	1785.0- 1785.7 MHz	**1785.7 - 1797.0 MHz**	1797.0 - 1800 MHz	1800 - 1805 MHz
Separation distance	**10 m**		**ca. 1 km**		**50 m**

2.4.2 Results from the viewpoint of radio microphones (i.e. other services as the interferer)

service	GSM 1800	Tactical radio relay	**Microphones Tactical radio relay**	Tactical radio relay	TFTS
frequency range	1710 - 1785 MHz	1785.0 - 1785.3 MHz	**1785.3 - 1799.4 MHz**	1799.4 - 1800 MHz	1800 - 1805 MHz
separation distance	**10 - 25 m**		**1.4 - 2.8 km**		**50 - 80 m**

2.4.3 Combined results

Service	GSM 1800	Tactical radio relay	**Microphones Tactical radio relay**	Tactical radio relay	TFTS
Frequency range	1710 - 1785 MHz	1785.0 - 1785.7 MHz	**1785.7 - 1797.0 MHz**	1797.0 - 1800 MHz	1800 – 1805 MHz
Separation distance	**10 - 25 m**		**1.4 - 2.8 km**		**50 m**

3 RESULTS OF THE COMPATIBILITY ANALYSES

The adjacent channel analyses regarding GSM 1800 and TFTS yielded the result that guard bands will need to be established to protect these services. For GSM 1800 a guard band of 700 kHz is required. As far as TFTS ground station receivers are concerned, a guard band of 3 MHz has to be implemented if no coordination takes place. However, this guard band can be decreased considerably by means of a licensing procedure involving the coordination of ground station receivers. This would enable individual Administrations to protect both the TFTS receivers at airports and any en-route stations whose coordinates are known. This leaves the need for a guard band of 600 kHz to protect microphones against interference caused by airborne TFTS transmitters. In the remaining frequency range 1797 - 1799.4 MHz, coordination is needed with a separation distance of 200 m to protect the TFTS ground stations.

An examination of the sharing range 1785 - 1800 MHz reveals that fairly wide separation distances have to be observed both for tactical radio relay and microphones. This applies especially to radio relay applications vis-à-vis microphone receivers. Here again, a licensing procedure involving coordination is essential.

NB
The results for the operation of radio microphones on adjacent frequencies are based on the receiver spectrum mask in Annex 1. However, this mask was originally developed for initial assessments of the interference situation and may change considerably owing to future developments in radio microphone technology.

4 CONCLUSIONS

- A guard band of 700 kHz will have to be implemented (1785 - 1785.7 MHz) to avoid compatibility problems between radio microphones and GSM 1800.

- A guard band of 600 kHz will have to be implemented (1799.4 - 1800 MHz) to provide protection against interference from TFTS emissions from airborne stations.

- The use of radio microphones subject to licensing is possible in the frequency range 1785.7 - 1799.4 MHz:

  – In the frequency range 1785.7 - 1799.4 MHz a licensing procedure could ensure protection against radio relay transmissions. To this end the use of this frequency range on military sites must be prohibited. In all other cases a distance of 1.4 km to 2.8 km must be observed.

  – In the frequency range 1797 - 1799.4 MHz a licensing procedure could ensure protection of the TFTS ground stations. To this end the use of this frequency range on airports must be prohibited. Furthermore, distances of 200 m to ground stations must be observed.

<table>
<tr><td>GSM 1800</td><td>Tactical
radio relay</td><td colspan="2">Microphones
Tactical radio relay</td><td>Tactical
radio relay</td><td>TFTS</td></tr>
<tr><td>1710 MHz -
1785 MHz</td><td>1785.0 MHz -
1785.7 MHz</td><td>1785.7 MHz -
1797.0 MHz</td><td>1797.0 MHz -
1799.4 MHz</td><td>1799.4 MHz -
1800 MHz</td><td>1800 MHz -
1805 MHz</td></tr>
<tr><td></td><td></td><td colspan="2">1.4 - 2.8 km separation distance to protect
the tactical radio relay systems</td><td></td><td></td></tr>
<tr><td></td><td>700 kHz
guard band</td><td>licensing by national regulator

10 - 25 m separation distance to protect
GSM 1800</td><td>licensing and coordination by national regulator

200 m separation distance to protect
TFTS</td><td>600 kHz
guard band</td><td></td></tr>
</table>

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ANNEX 1
MICROPHONE RECEIVER MASK