European Radiocommunications Committee (ERC)
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COMPATIBILITY AND SHARING ANALYSIS BETWEEN DVB–T AND RADIO MICROPHONES IN BANDS IV AND V

Naples, February 2000

EXECUTIVE SUMMARY

This study assesses the compatibility between radio microphones and DVB–T in bands IV and V and determines the necessary separation distances between radio microphones and DVB–T as a function of frequency. The study takes account of three spectrum masks: the spectrum mask for sensitive cases according to the Chester Agreement, 1997[1] and the spectrum masks recommended by SE PT 21[2]. The results are only valid for the DVB–T and radio microphone system parameters given in this study.

The main results of the study are as follows:

- In most cases, Co-channel operation (frequency offset from 0 to 4 MHz between the centre frequencies) of DVB–T and radio microphones within a DVB–T coverage area will cause unacceptable interference to radio microphones and vice-versa. However, indoor operation of radio microphones e. g. in theatres may be feasible even in the co-channel case depending on building shielding loss and the location of the nearest DVB-T receiver. These cases may be evaluated on a site by site basis.

- Operation of radio microphones in the 1st adjacent channel of DVB–T (frequency offset from 4 to 12 MHz between the centre frequencies), except for the first 500 kHz of this channel, may be possible, depending on local conditions.

- In practice, use of the 2nd adjacent channel (frequency offset from 12 to 20 MHz between the centre frequencies) by radio microphones will be feasible in most cases. This applies to both indoor and outdoor operation of radio microphones.

These conclusions are based on the use of the critical spectrum mask specified in the Chester Agreement. The use of less stringent masks such as the SE PT 21 masks will significantly increase the required separation distances in the adjacent channels.

All protection ratio measurements were limited to professional DVB–T receivers. The immunity of domestic receivers, particularly for adjacent channel rejection, is not yet known. Therefore the frequency separation needed between the future wanted DVB–T channel and radio microphone operation may change slightly for domestic receivers.

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[1] The Chester 1997 Multilateral Coordination Agreement relating to Technical Criteria, Coordination Principles and Procedures for the introduction of Terrestrial Digital Video Broadcasting (DVB-T), Chester, 25 July 1997

[2] Limits for out-of-band emissions adopted by CEPT SE PT 21.

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COMPATIBILITY AND SHARING ANALYSIS BETWEEN DVB–T AND RADIO MICROPHONES IN BANDS IV AND V

1 INTRODUCTION

The aim of this compatibility analysis is to determine the interference potential of DVB–T transmissions with regard to radio microphone reception (see Section 2) and radio microphone transmissions with regard to DVB-T reception (see Section 3). For this purpose, the necessary separation distances between radio microphones and DVB–T as a function of the frequency separation between the two applications are determined. Section 4 of this document uses the results from Sections 2 and 3 to produce overall conclusions with regard to compatibility between DVB-T and radio microphones.

2 INTERFERENCE SCENARIO: DVB–T INTERFERES WITH RADIO MICROPHONES

All compatibility results and conclusions are valid only for the system parameters given below. In case of changes, new calculations are necessary.

2.1 Calculations with the system parameters according to the Chester Agreement

2.1.1 DVB–T system parameters

DVB–T e.r.p.:	100 W, 200 W, 1 kW, 2 kW, 10 kW, 20 kW, 100 kW;	
DVB–T effective antenna heights:	150 m, 300 m.	
Modulation:	16 QAM, 64 QAM and QPSK	(no influence on results)
Number of carriers:	2k, 8k	(no influence on results)
Bandwidth:	8 MHz	
Shoulder attenuation:	50 dB	

Spectrum mask:

Breakpoints	
Relative frequency (MHz)	**Relative level dB**
- 12	-87.2
-6	-62.2
-4.2	-50.2
-3.8	0
+3.8	0
+4.2	-50.2
+6	-62.2
+12	-87.2

Table 1: Spectrum mask

Note: The out of channel values in this spectrum mask correspond to the breakpoints in Figure A1.2 in the Chester Agreement (8 MHz channel in the sensitive case). The value of 3.8 MHz was used because it is more accurate than the value given in the Chester Agreement (In Chester, the true value of 3.81 MHz was rounded up to 3.9 MHz).

2.1.2 Radio microphone system parameters

The parameters in the table below are given in Annex 5 of the Chester Agreement.

Wanted:	Radio microphone (companded)		Default field strength to be protected (dBµV/m)			68	Default receiving antenna height (m)			1.5
Service Identifier		NR8	at frequency (MHz)			650				
Unwanted	DVB–T/8 MHz									
Δf (MHz)	-12.0	-10.0	-8.0	-6.0	-4.2	-3.8	-3.6	0.0	3.6	3.8
PR (dB)	-50.0	-50.0	-45.0	-40.0	-35.0	7.0	12.0	12.0	12.0	7.0
Δf (MHz)	4.2	6.0	8.0	10.0	12.0					
PR (dB)	-35.0	-40.0	-45.0	-50.0	-50.0					

Table 2: Protection ratios for radio microphones

Protection ratios were obtained from a series of measurements made in the UK and in Germany. For the measurements, DVB-T transmissions complying closely with the above spectrum mask were simulated.

The protection ratios in respect of radio microphones are based on the measurement results for the second most sensitive receivers. The performance of the receivers varied widely with some receivers approximately 15 dB less sensitive to DVB–T interference than assumed in this analysis.

2.1.3 Considered interference scenarios

In order to make as realistic an analysis as possible, the two interference scenarios (outdoor operation and indoor operation) are considered separately.

Scenario 1: Outdoor operation

No building attenuation was taken into account and a radio microphone receiving antenna height of 1.5 m was assumed.

The analysis was based on the propagation curve in Rec. ITU-R P.370, Figure 11 (1% of time, 50% of location). A correction factor of 12 dB was applied for a receiving antenna height of 1.5 m, according to Annex 1 of the Chester Agreement.

The Rec. ITU-R P.370 curve does not apply to distances of less than 10 km. The curves for the effective antenna heights of 150 m and 300 m were therefore extrapolated to the free-space propagation curve for distances of less than 10 km (to explain the interpolation procedure, the curves for a DVB-T transmitter of ERP of 1kW are displayed in Annex 1).

Scenario 2: Indoor operation

A correction factor of 7 dB for building penetration loss, the median value given in Annex 1 of the Chester Agreement, was applied in addition to the factor of 12 dB as agreed for a receiving antenna height of 1.5 m. The value of 7 dB is appropriate for the case of 50% of locations inside a building.

2.1.4 Results for an 8 MHz DVB–T signal

Scenario 1: Outdoor operation

Diagrams 1 and 2 and Tables 3a/3b show the required separation distance as a function of the frequency separation, the DVB-T e.r.p. and the DVB-T effective transmitting antenna height.

The results show that the required separation distances from a DVB-T transmitter in the range 0 to 3.8 MHz from the centre of a DVB-T channel are large and that there is a rapid transition to much shorter separation distances in the range of frequency separations from 3.8 to about 4.2 MHz i.e., from co - channel to adjacent channel operation. The separation distances given in Section 3, however, must also be respected.

Scenario 2: Indoor operation

Diagrams 3 and 4 and Tables 4a/4b show the required separation distance as a function of the frequency separation, the DVB-T e. r. p. and the DVB-T effective transmitting antenna height.

The results show, as is to be expected that the required separation distances from a DVB-T transmitter are less if a radio microphone is operated indoors. Indeed, there may be certain situations with high building penetration losses (e.g. theatre) where operation with a frequency separation of less than
3.8 MHz from the centre frequency of a DVB-T transmission may be possible even though inside a DVB-T coverage area, provided that the protection requirements for the closest DVB-T receiver are also respected.

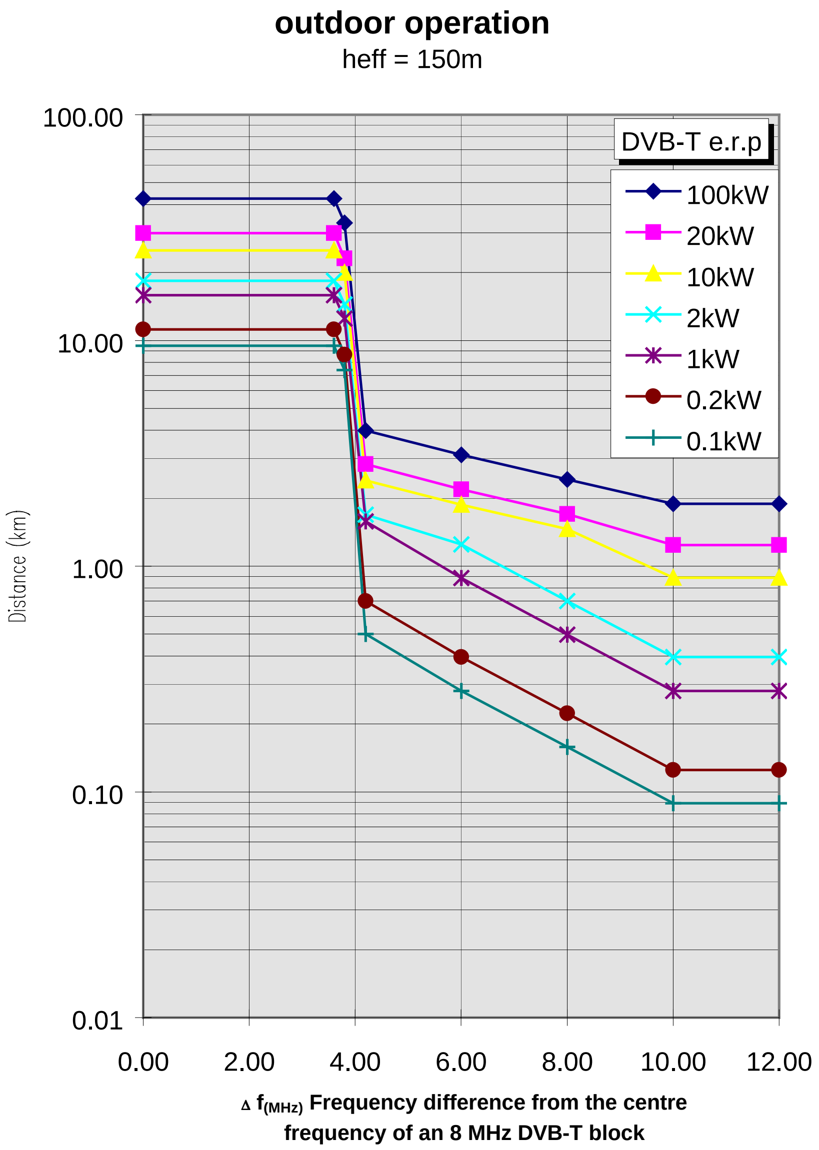


Diagram 1

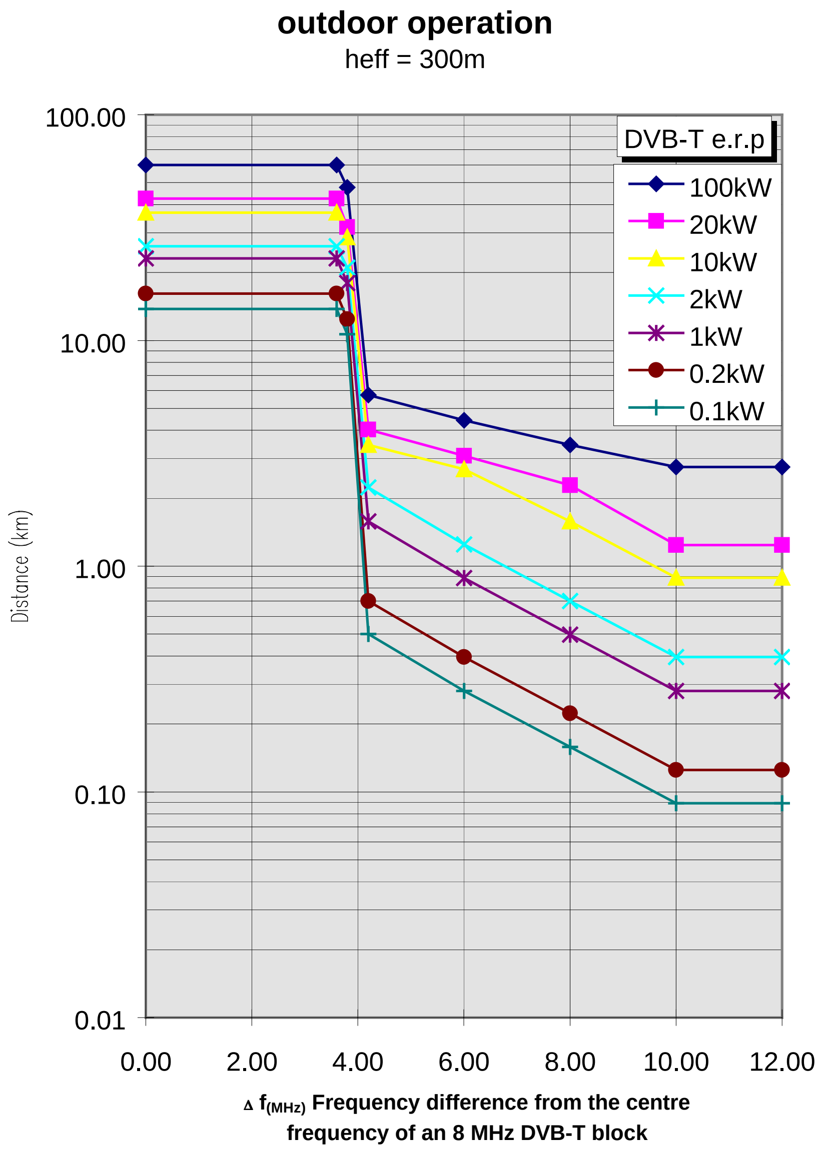


Diagram 2

Necessary separation distances between DVB–T and radio microphones in bands IV and V
Outdoor operation

	DVB–T e.r.p.						
Frequency (MHz)	**100 kW**	**20 kW**	**10 kW**	**2 kW**	**1 kW**	**0.2 kW**	**0.1 kW**
3.6	42.57	29.91	25.07	18.36	15.87	11.21	9.47
3.8	33.18	23.07	19.95	14.46	12.50	8.65	7.40
4.2	3.99	2.83	2.40	1.69	1.58	0.70	0.50
6.0	3.11	2.19	1.87	1.25	0.89	0.40	0.28
8.0	2.42	1.70	1.46	0.70	0.50	0.22	0.16
10.0	1.89	1.24	0.89	0.40	0.28	0.13	0.09
12.0	1.89	1.24	0.89	0.40	0.28	0.13	0.09

Table 3a heff = 150m, distances in km

	DVB–T e.r.p.						
Frequency (MHz)	**100 kW**	**20 kW**	**10 kW**	**2 kW**	**1 kW**	**0.2 kW**	**0.1 kW**
3.6	59.97	42.57	36.80	26.13	23.07	16.12	13.80
3.8	47.72	31.83	28.69	21.01	17.98	12.44	10.64
4.2	5.74	4.03	3.45	2.23	1.58	0.70	0.50
6.0	4.43	3.08	2.69	1.25	0.89	0.40	0.28
8.0	3.45	2.28	1.58	0.70	0.50	0.22	0.16
10.0	2.75	1.24	0.89	0.40	0.28	0.13	0.09
12.0	2.75	1.24	0.89	0.40	0.28	0.13	0.09

Table 3b heff = 300m, distances in km

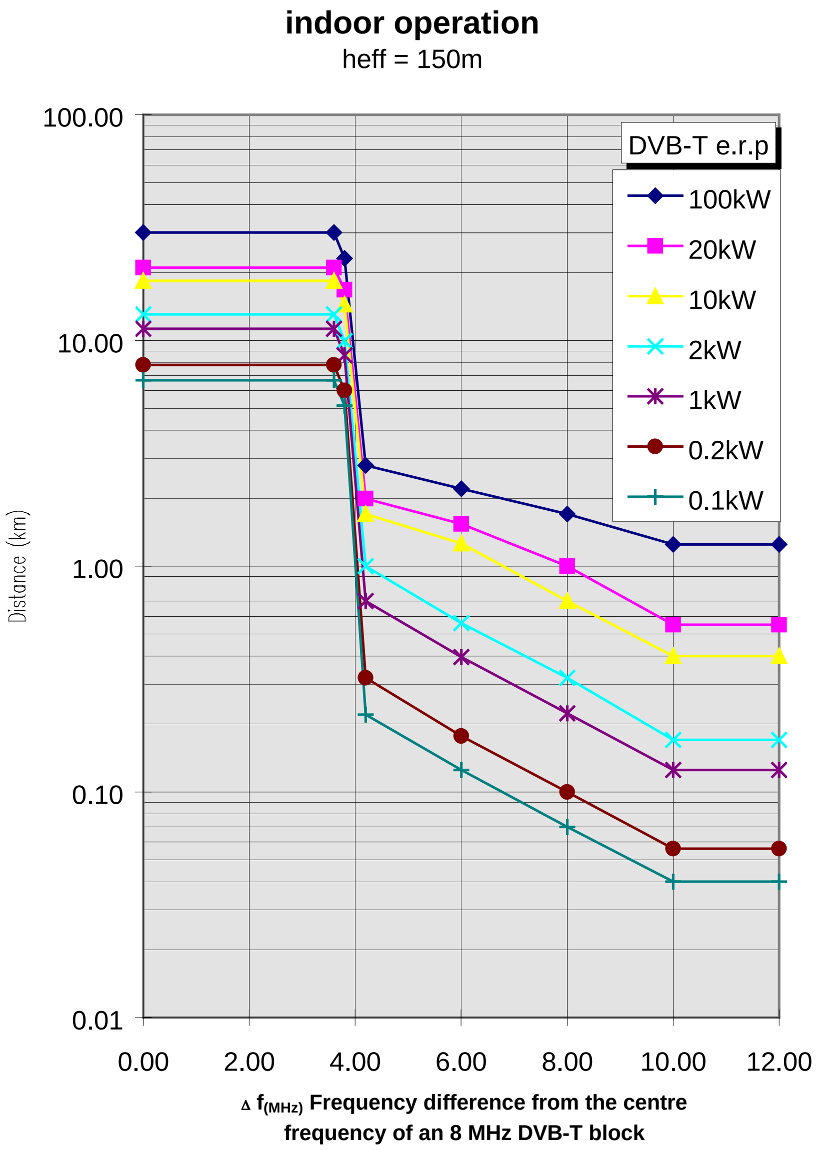


Diagram 3

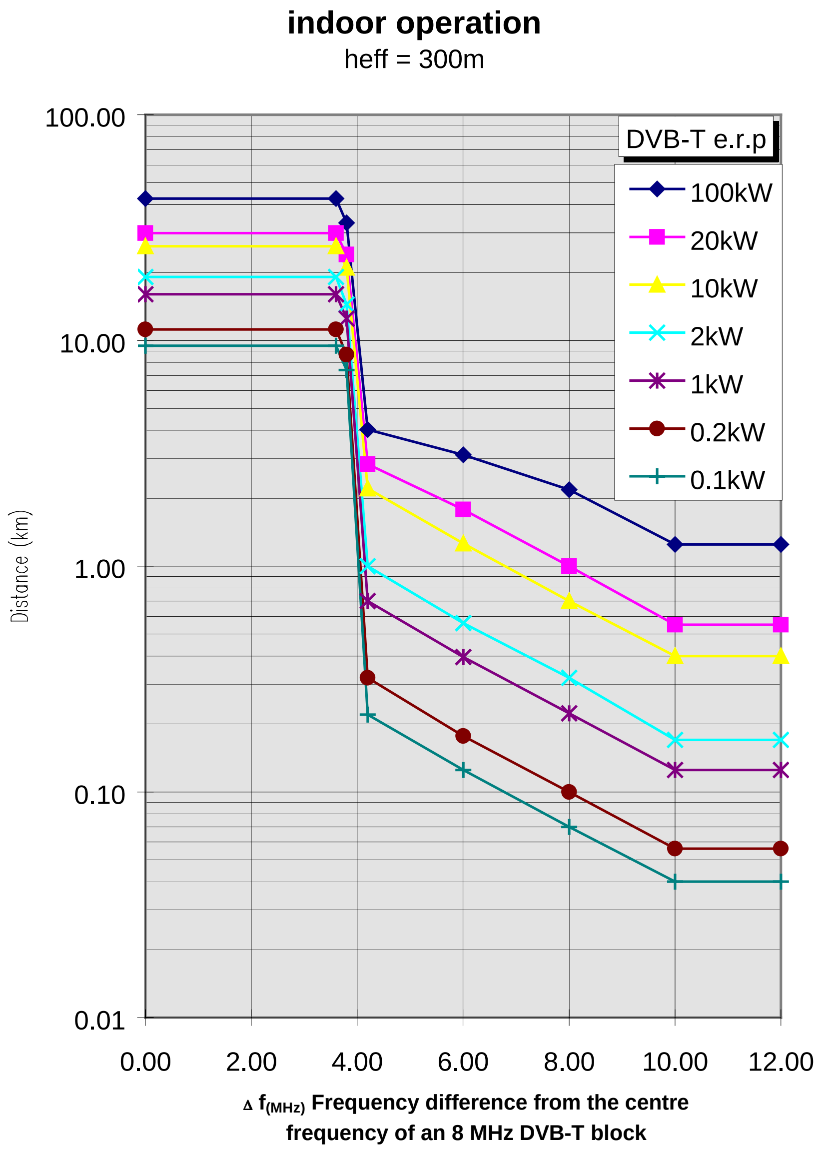


Diagram 4

Necessary separation distances between DVB–T and radio microphones in bands IV and V
Indoor operation

	DVB–T e.r.p.						
Frequency (MHz)	**100 kW**	**20 kW**	**10 kW**	**2 kW**	**1 kW**	**0.2 kW**	**0.1 kW**
3.6	30.10	20.98	18.36	13.03	11.27	7.79	6.67
3.8	23.10	16.75	14.46	9.95	8.60	6.00	5.15
4.2	2.80	1.99	1.70	1.00	0.70	0.32	0.22
6.0	2.20	1.54	1.26	0.56	0.40	0.18	0.13
8.0	1.70	1.00	0.70	0.32	0.22	0.10	0.07
10.0	1.25	0.55	0.40	0.17	0.13	0.06	0.04
12.0	1.25	0.55	0.40	0.17	0.13	0.06	0.04

Table 4a heff = 150m, distances in km

	DVB–T e.r.p.						
Frequency (MHz)	**100 kW**	**20 kW**	**10 kW**	**2 kW**	**1 kW**	**0.2 kW**	**0.1 kW**
3.6	42.57	29.91	26.13	19.14	16.04	11.21	9.47
3.8	33.18	24.05	21.01	14.46	12.50	8.65	7.40
4.2	4.03	2.83	2.21	1.00	0.70	0.32	0.22
6.0	3.11	1.78	1.26	0.56	0.40	0.18	0.13
8.0	2.18	0.70	0.70	0.32	0.22	0.10	0.07
10.0	1.25	0.55	0.40	0.17	0.13	0.06	0.04
12.0	1.25	0.55	0.40	0.17	0.13	0.06	0.04

Table 4b heff = 300m, distances in km

2.2 Calculations with the DVB-T spectrum masks adopted by CEPT SE PT 21 for out-of-band emissions

2.2.1 DVB–T system parameters

DVB–T e.r.p.:	100 W, 200 W, 1 kW, 2 kW, 8 kW, 10 kW, 20 kW, 100 kW	
DVB–T effective antenna heights:	150 m, 300 m	
Assumed antenna gain:	0-10 dBd	
Modulation:	16 QAM, 64 QAM and QPSK	(no influence on results)
Number of carriers:	2k, 8k	(no influence on results)
Bandwidth:	8 MHz	
Shoulder attenuation:	35 dB	

Spectrum mask:

Breakpoints	**Pout = 9-29 dBW**	**Pout = 39-50 dBW**
Relative frequency (MHz)	**Relative level dB**	
- 20	-56.2	-66.2
-12	-48.2	-58.2
-4.2	-35	-35
-3.9	0	0
+3.9	0	0
+4.2	-35	-35
+12	-48.2	-58.2
+20	-56.2	-66.2

Table 5: Spectrum masks

Notes: - The relative levels relate to the output power and not the E.R.P. of the DVB transmitter.

- The values of the DVB-T transmitter output power (Pout) in this spectrum masks correspond to the breakpoints adopted by SE PT 21 for out-of-band emissions.

It was necessary to assume a DVB-T antenna gain in order to calculate the DVB-T e.r.p for the analysis of compatibility. The antenna gain relative to a half-wave dipole was assumed to be 0-10 dB. Some of the DVB-T e.r.p. values are therefore higher than Pout.

2.2.2 Radio microphone system parameters

The following parameters were calculated using the protection ratio values in Section 2.1.2. In this connection it is important to note that it was assumed for the calculations that the DVB-T out-of-band emissions were the dominant interference mechanism. In the case of lower radio microphone wanted signal levels the dominant interference mechanism was indeed the DVB-T out-of-band emissions. In the case of higher radio microphone wanted signal levels the dominant interference mechanism was overloading ("blocking").

Default field strength to be protected:	68 dB(µV/m)
Default receiving antenna height:	1.5 m
Transmitter frequency:	650 MHz

Frequency difference (MHz)	Protection ratio (dB)	
	Pout = 9-29 dBW	Pout = 39-50 dBW
0	12	12
3.6	12	12
3.8	9	9
4.3	-23	-23
12	-36.2	-46.2

Table 6: Protection ratios

2.2.3 Considered interference scenarios

The same indoor and outdoor operation scenarios as described in Section 2.1.3 were considered. However, there are two SE PT 21 spectrum masks for out-of-band emissions: the first mask applies to a DVB-T transmission output power of 9-29 dBW and the second to a DVB-T transmission output power of 39-50 dBW. For power levels between 29 and 39 dBW, a variable mask is used to provide a smooth transition. Statements about compatibility therefore need to distinguish between these two cases.

2.2.4 Results for an 8 MHz DVB–T signal

Scenario 1: Outdoor operation

Diagrams 5a/5b and 6a/6b and Table 7a/7b show the required separation distance as a function of the frequency separation, the DVB-T e.r.p. and the DVB-T effective transmitting antenna height.

The results show that the required separation distances from a DVB-T transmitter in the range 0 to 3.8 MHz from the centre of a DVB-T channel are similar to those in Section 2.1.4. showing a transition to shorter separation distances in the range of frequency separations from 3.8 to about 4.2 MHz i.e., from co - channel to adjacent channel operation. However in this case the separation distances are rather larger than in the previous section. The separation distances given in Section 3, however, must also be respected.

Scenario 2: Indoor operation

Diagrams 7a/7b and 8a/8b and Table 8a/8b show the required separation distance as a function of the frequency separation, the DVB-T e.r.p. and the DVB-T effective transmitting antenna height.

The results show, as is to be expected that the required separation distances from a DVB-T transmitter are less if a radio microphone is operated indoors. Indeed, there may be certain situations with high building penetration losses where operation with a frequency separation of less than 3.8 MHz from the centre frequency of a DVB-T transmission may be possible even though inside a DVB-T coverage area, provided that the protection requirements for the closest DVB-T receiver are also respected.

Outdoor operation

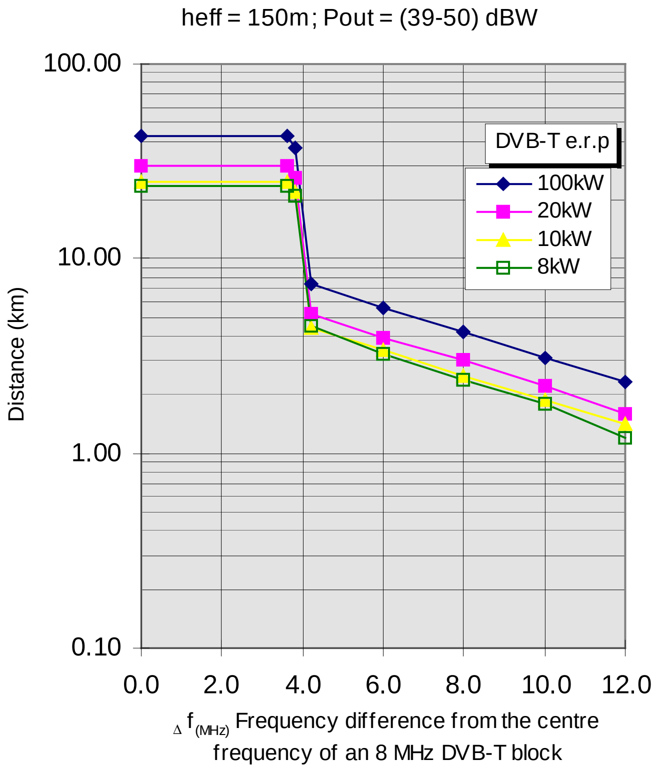


Diagram 5a

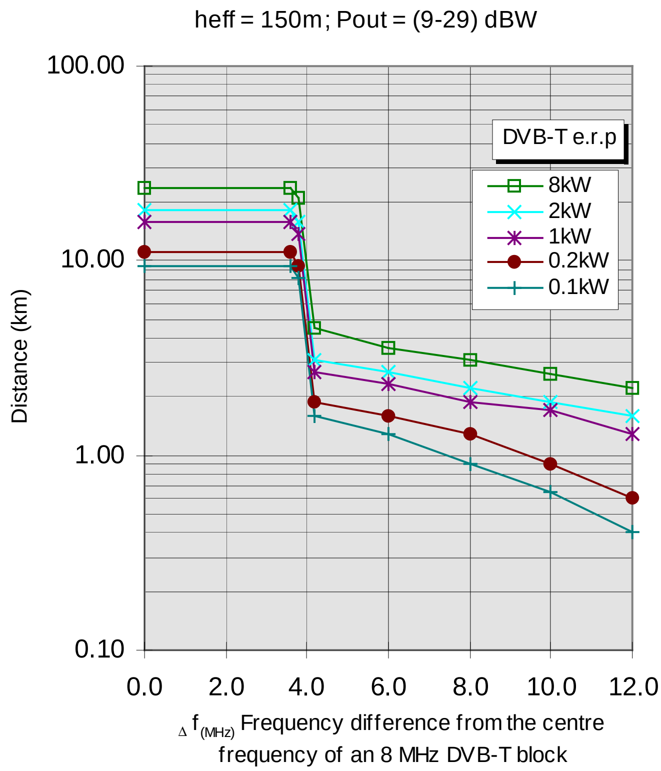


Diagram 5b

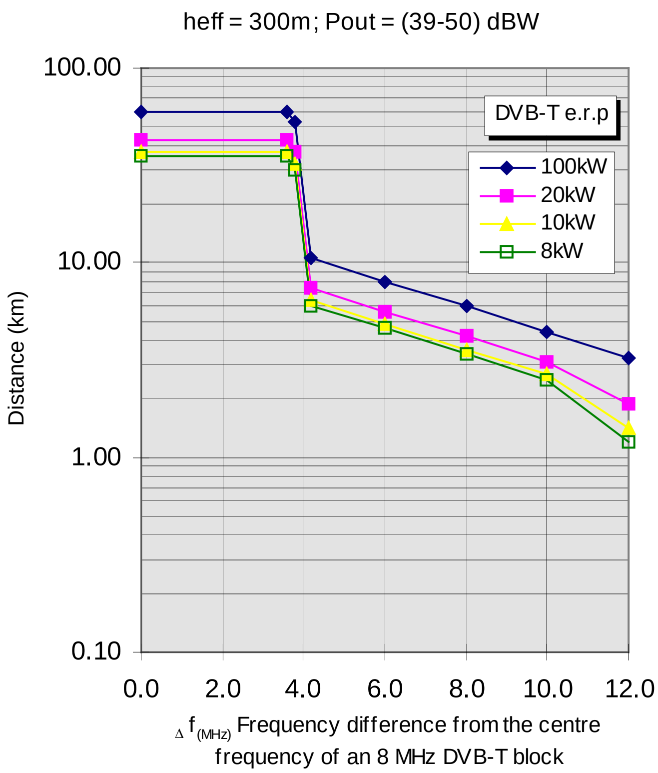


Diagram 6a

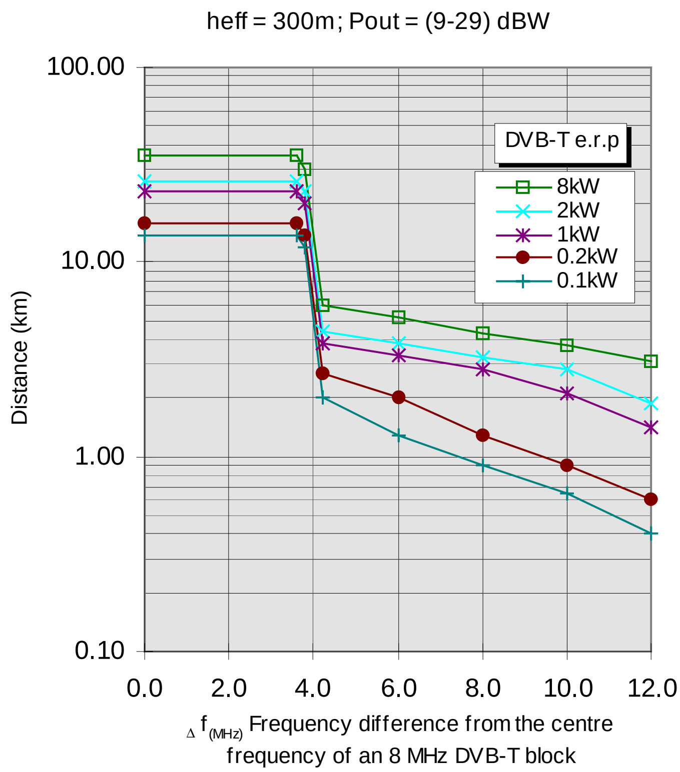


Diagram 6b

Necessary separation distances between DVB–T and radio microphones in bands IV and V
Outdoor operation

	DVB-T e.r.p								
Frequency (MHz)	100kW	20kW	10kW	8kW	8kW	2kW	1kW	0.2kW	0.1kW
0.00	42.60	30.00	25.00	23.80	23.80	18.40	15.90	11.20	9.50
3.60	42.60	30.00	25.00	23.80	23.80	18.40	15.90	11.20	9.50
3.80	36.80	25.70	21.90	20.90	20.90	15.90	13.70	9.50	8.20
4.20	7.40	5.20	4.40	4.50	4.50	3.10	2.70	1.90	1.60
6.00	5.60	3.90	3.40	3.20	3.60	2.70	2.30	1.60	1.30
8.00	4.20	3.00	2.50	2.40	3.10	2.20	1.90	1.30	0.90
10.00	3.10	2.20	1.90	1.80	2.60	1.90	1.70	0.90	0.65
12.00	2.30	1.60	1.40	1.20	2.20	1.60	1.30	0.60	0.40
SE PT 21 mask	(Pout_max = 39-50 dBW)				(Pout_max = 9-29 dBW)				

Table 7a heff = 150m, distances in km

	DVB-T e.r.p								
Frequency (MHz)	100kW	20kW	10kW	8kW	8kW	2kW	1kW	0.2kW	0.1kW
0.00	60.00	43.00	36.80	35.10	35.10	26.10	22.80	15.90	13.80
3.60	60.00	43.00	36.80	35.10	35.10	26.10	22.80	15.90	13.80
3.80	52.39	36.80	31.80	30.10	30.10	23.10	20.00	13.80	11.80
4.20	10.60	7.40	6.40	6.00	6.00	4.40	3.80	2.70	2.00
6.00	7.90	5.60	4.80	4.60	5.20	3.80	3.30	2.00	1.30
8.00	6.00	4.20	3.60	3.40	4.30	3.20	2.80	1.30	0.90
10.00	4.40	3.10	2.70	2.50	3.70	2.80	2.10	0.90	0.65
12.00	3.20	1.90	1.40	1.20	3.10	1.90	1.40	0.60	0.40
SE PT 21 mask	(Pout_max = 39-50 dBW)				(Pout_max = 9-29 dBW)				

Table 7b heff = 300m, distances in km

Indoor operation

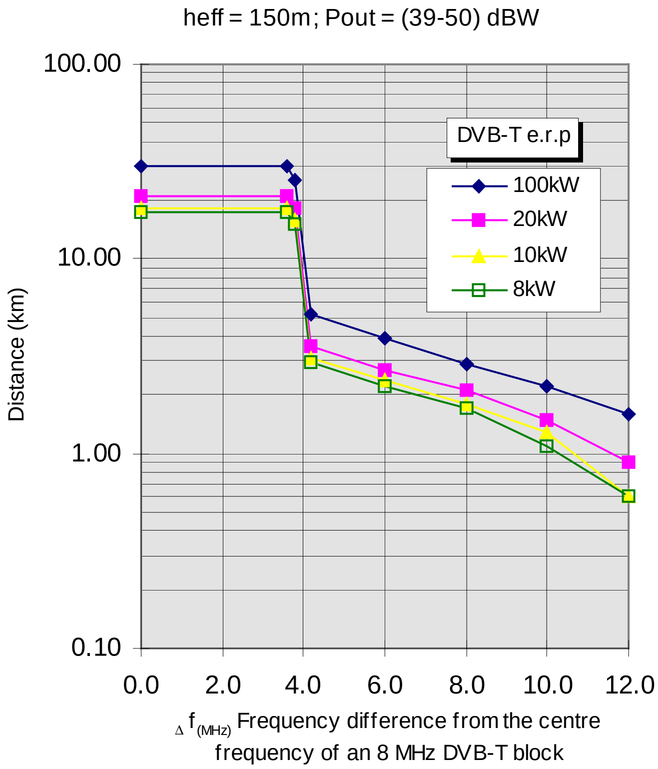


Diagram 7a

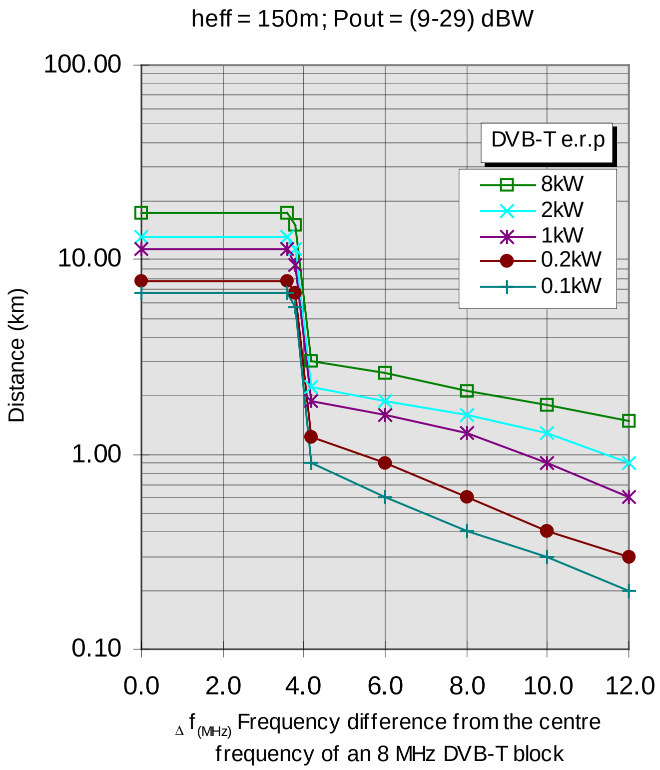


Diagram 7b

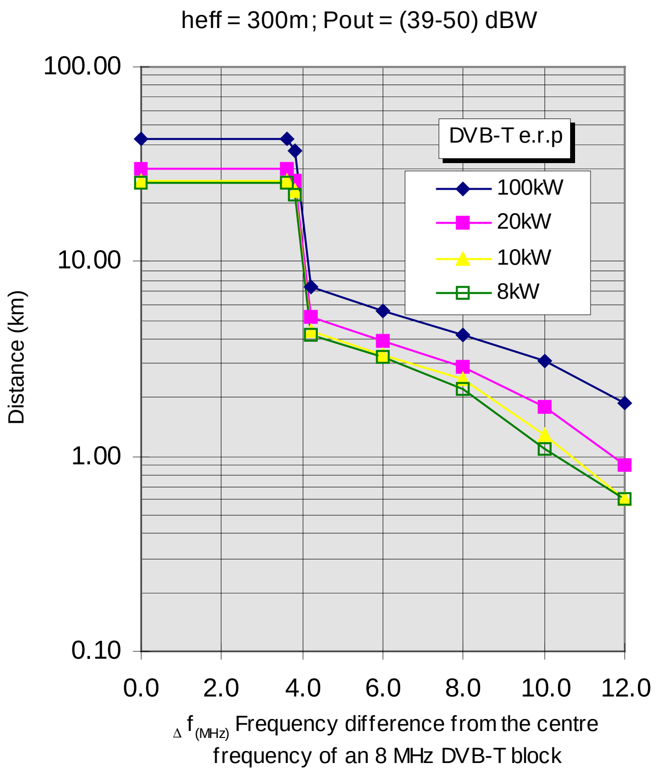


Diagram 8a

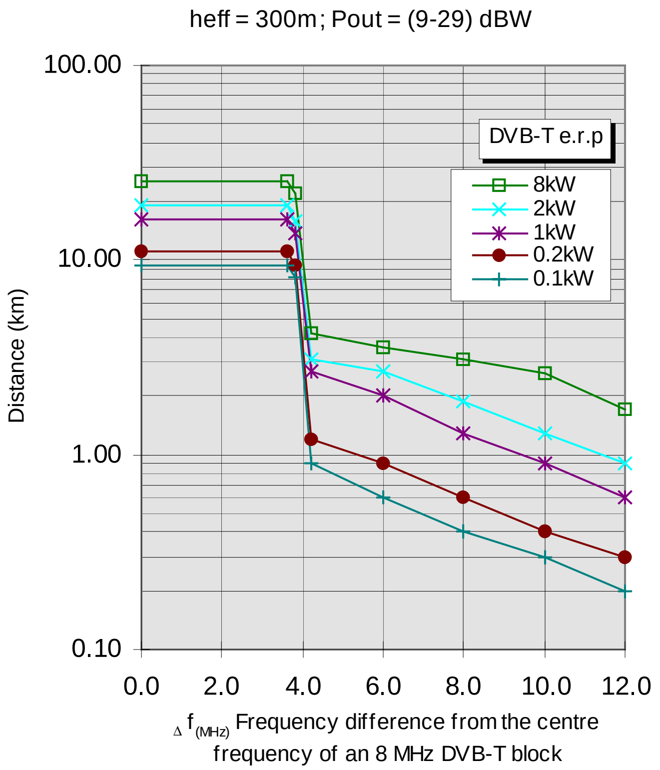


Diagram 8b

Necessary separation distances between DVB–T and radio microphones in bands IV and V
Indoor operation

	DVB-T e.r.p								
Frequency (MHz)	100kW	20kW	10kW	8kW	8kW	2kW	1kW	0.2kW	0.1kW
0.00	29.90	21.00	18.40	17.40	17.40	13.20	11.30	7.80	6.70
3.60	29.90	21.00	18.40	17.40	17.40	13.20	11.30	7.80	6.70
3.80	25.10	18.40	15.90	14.90	14.90	11.30	9.50	6.70	5.70
4.20	5.20	3.60	3.10	2.95	3.00	2.20	1.90	1.24	0.90
6.00	3.90	2.70	2.40	2.20	2.60	1.90	1.60	0.90	0.60
8.00	2.90	2.10	1.80	1.70	2.10	1.60	1.30	0.60	0.40
10.00	2.20	1.50	1.30	1.10	1.80	1.30	0.90	0.40	0.30
12.00	1.60	0.90	0.60	0.60	1.50	0.90	0.60	0.30	0.20
SE PT 21 mask	(Pout_max = 39-50 dBW)				(Pout_max = 9-29 dBW)				

Table 8a heff = 150m, distances in km

	DVB-T e.r.p								
Frequency (MHz)	100kW	20kW	10kW	8kW	8kW	2kW	1kW	0.2kW	0.1kW
0.00	42.60	29.90	26.10	25.10	25.10	18.90	16.00	11.20	9.50
3.60	42.60	29.90	26.10	25.10	25.10	18.90	16.00	11.20	9.50
3.80	36.80	26.10	23.10	22.00	22.00	15.90	13.70	9.50	8.10
4.20	7.40	5.20	4.40	4.20	4.20	3.10	2.70	1.20	0.90
6.00	5.60	3.90	3.30	3.20	3.60	2.70	2.00	0.90	0.60
8.00	4.20	2.90	2.50	2.20	3.10	1.90	1.30	0.60	0.40
10.00	3.10	1.80	1.30	1.10	2.60	1.30	0.90	0.40	0.30
12.00	1.90	0.90	0.60	0.60	1.70	0.90	0.60	0.30	0.20
SE PT 21 mask	(Pout_max = 39-50 dBW)				(Pout_max = 9-29 dBW)				

Table 8b heff = 300m, distances in km

3 INTERFERENCE SCENARIO: RADIO MICROPHONES INTERFERE WITH DVB–T

3.1 Radio microphone system parameters

A signal generator having the same modulation characteristics as a radio microphone was used as the interferer.

Baseband input:	1 kHz sinusoidal
Modulation:	FM, deviation 40.0 kHz; UK measurements
	FM, deviation 75.0 kHz; German measurements

3.2 DVB–T system parameters

DVB–T receiver:	Professional type (NDS system 3000)
UK measurements:	
RF wanted DVB–T levels:	DVB–T Modes
-46.0 dBm:	2k, 16 QAM, FEC 3/4, guard interval 1/32 (measurement 1)
-52.0 dBm:	2k, 16 QAM, FEC 3/4, guard interval 1/32 (measurement 2)
GER measurements:	
RF wanted DVB–T levels:	DVB–T Modes
-66.0 dBm:	2k, QPSK, FEC 2/3
	2k, 16 QAM, FEC 1/2
	2k, 16 QAM, FEC 2/3
	2k, 64 QAM, FEC 1/2
	2k, 64 QAM, FEC 2/3
Baseband I/P:	MPEG-2 transport stream
Interference criterion:	BER 2E-4 after Viterbi decoder

Note that these are a small sub-set of all the variants shown in the DVB specification. They were chosen purely for convenience of measuring and may not represent currently preferred systems.

3.3 Calculations and considered interference scenario

3.3.1 Measurement results for the protection ratio values

The necessary protection ratio values for DVB–T professional receivers were measured by the United Kingdom and Germany. The results are shown in the table below.

Frequency offset	Protection ratios		
	UK measurement results		German measurement results
	wanted DVB–T RF level **-46 dBm** <u>Modulation</u> 2k, 16 QAM, FEC 3/4 (measurement 1)	wanted DVB–T RF level **-52 dBm** <u>Modulation</u> 2k, 16 QAM, FEC 3/4 (measurement 2)	wanted DVB–T RF level **-66 dBm** <u>Modulation</u> 2k, QPSK, FEC 2/3 2k, 16 QAM, FEC 1/2 or 2/3 2k, 64 QAM, FEC 1/2 or 2/3
0 MHz	-3 dB	-3 dB	-4 dB to -10 dB (*)
2 MHz	-4 dB	-4 dB	--
3.8 MHz	-9 dB	-10 dB	--
4.5 MHz	-37 dB	-36 dB	--
6.0 MHz	-51 dB	-45 dB	--
7.0 MHz	-52 dB	-48 dB	--
8.0 MHz	-53 dB	-52 dB	--

Table 9: protection ratio measurement results for DVB–T receivers

(*): This depends on the DVB mode (FEC 2/3 for 2k QPSK, FEC 1/2 and 2/3 for 2k16 QAM and 2k 64QAM).
--: Only the co-channel protection ratios were measured.

The differences in measured protection ratios for 6 and 7 MHz offset are unexpected and must be due to receiver effects that can not be theoretically explained.
In this context it is important to mention that the wanted DVB–T level in the measurements differed from those given in the Chester Agreement. In what way this fact affects the protection ratio values, especially for the adjacent channel, is not yet known.
Furthermore it must be mentioned that the values were measured for professional and not for domestic DVB–T receivers. As the immunity of future domestic receivers is not yet known, the results for such receivers may change.

All further calculations were based on the protection ratio values in column 3 of table 9 for 16 QAM modulation with a code rate of ¾ for a 2k-system. This column contains the worst protection ratio values for the different interference situations and unlike column 4 gives a complete set of values for the adjacent channel.

While other system variants like 64QAM have higher protection ratios, they also need a higher wanted signal level resulting in similar permissible interference levels due to a certain cancellation of the two effects. Conclusions from this study are therefore also valid for other DVB-T systems.

3.3.2 Description of the interference scenario

In practice there are many different interference scenarios. In this report only the critical case was considered, namely the fixed DVB-T reception condition.

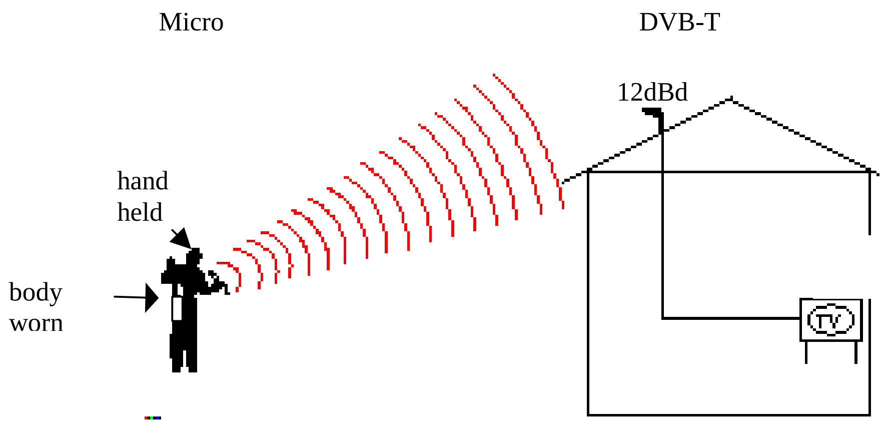


Figure 1

Some other possible scenarios are:

- portable DVB-T reception and outdoor radio microphone operation: Preliminary studies showed that this condition gives shorter separation distances than the fixed case, i. e. if the fixed reception conditions are satisfied then portable is also possible.
- portable indoor DVB-T reception and indoor radio microphone operation (in the same room): In the case of interference it should be possible to switch off one of the devices.
- portable indoor DVB-T reception and indoor radio microphone operation (in different rooms): This situation is equivalent to indoor operation of the DVB-T receiver with outdoor operation of the radio microphone.
- Fixed DVB-T reception and indoor operation of radio microphone: This situation is less critical that the one in Fig. 1 because of building attenuation.

3.3.3 Maximum permissible interfering field strength at the DVB-T receiving location for fixed reception

The minimum equivalent field strength at the receiving place depends on the modulation and code rate of the DVB–T signal. As mentioned above in the paragraph 3.3.1 on further calculations 2k, 16 QAM and the code rate ¾ were chosen. This system variant corresponds to "B3" in table A1.1 of the Chester Agreement. The required C/N for a BER = $2*10^{-4}$ after the Viterbi decoder is 13 dB for fixed reception (Ricean channels). With this C/N value plus the implementation margin of 3 dB (16 dB) the corresponding minimum median equivalent field strength for bands IV and V can be determined. The tables A1.6 and A1.7 in the Chester Agreement are important in this context:

Minimum median equivalent field strength (E_{med}) for DVB-T at 10 m a.g.l. 50% of time and 50% of locations	Band IV (f = 500 MHz)	Band V (f = 800 MHz)
fixed reception	49 dB(µV/m)	53 dB(µV/m)

Table 10: Minimum median equivalent field strength for DVB-T (location probability of 95 %)

The maximum permissible interfering field strength at the DVB-T receiving location, E_{max_int} ,can be calculated as;

$E_{max\_int} = E_{med}$ - C/I - Lc

where

Emed is the minimum median equivalent field strength in table 10
C/I is the measured protection ratio value in table 9
Lc is the location correction factor in table 11

– Location correction factor (the corresponding values are given in table 11 below). Different location correction factors for short and long distances between DVB–T and the radio microphones have to be taken. This is necessary because the standard deviation "τ" especially of the interfering signal depends on the separation distance between the two services. The calculation of the location correction factor is described below:

  Long distance (> 100m):

$$Lc = \mu * \sqrt{(\tau_{DVB-T})^2 + (\tau_{micro})^2} = 1.64 * \sqrt{(5.5)^2 + (5.5)^2} \approx 13dB$$

  Short distance (≤ 100m):

$$Lc = \mu * \sqrt{(\tau_{DVB-T})^2 + (\tau_{micro})^2} = 1.64 * \sqrt{(5.5)^2 + (0)^2} \approx 9dB$$

  µ: distribution factor
  τ_{DVB-T} and τ_{micro}: standard deviations of the distribution

– For longer distances, a standard deviation of the distribution applies to both the wanted and unwanted signal, whereas for short distances the standard deviation of the distribution for the microphone signal is 0 dB.

Location correction factors to be applied are:

Victim DVB-T Reception Condition from Radio Microphone	**Location correction factor in dB**	
	Short Separation Distance	Long Separation Distance
Fixed Reception	9	13

Table 11: Location correction factors

DVB-T Reception Condition: Fixed, E_{med} = 49 dB(µV/m)

Frequency offset	**Maximum permissible interfering field strength at the receiving location, dB(µV/m)**	
	Short Separation Distance (≤ 100 m)	Long Separation Distance (> 100 m)
0 MHz	43	39
2.0 MHz	44	40
3.8 MHz	50	46
4.5 MHz	76	72
6.0 MHz	85	81
7.0 MHz	88	84
8.0 MHz	92	88

Table 12 a: Band IV (A1.6 from Chester)

DVB-T Reception Condition: Fixed, E_{med} = 53 dB(µV/m)

Frequency offset	**Maximum permissible interfering field strength at the receiving location, dB(µV/m)**	
	Short Separation Distance (≤ 100 m)	Long Separation Distance (> 100 m)
0 MHz	47	43
2.0 MHz	48	44
3.8 MHz	54	50
4.5 MHz	80	76
6.0 MHz	89	85
7.0 MHz	92	88
8.0 MHz	96	92

Table 12b: Band V (A1.7 from Chester)

Note:
The values are valid for 500 MHz (Band IV) and 800 MHz (Band V). Values at other frequencies may be obtained from a conversion factor of,

20 log Fr/Fx dB,

where Fr is the required frequency, Fx is the reference frequency for the considered band.

3.3.4 Calculation of the equivalent radiated power of the radio microphones

The reference conditions for the e.r.p. of the radio microphones were used to calculate the compatibility between radio microphones and DVB–T receivers.

Radio microphones can be used as either hand held or as body worn transmitters:

In both cases the radiated power of the transmitters were influenced by body loss. The calculation of the corresponding values are given below.

	Hand held transmitter	Body worn transmitter
Effective radiated power of the radio microphone (corresponds to ETS 300 422)	17 dBm	17 dBm
Attenuation by body (corresponds to ERC Report 42 on SAB/SAP applications)	6 dB	14 dB
Radiated power for compatibility consideration	11 dBm	3 dBm

Table 13: Radiated power for compatibility consideration

3.3.5 Determination of the propagation model

The propagation model for the calculation of the interference from radio microphones to DVB–T receivers was based on free-space propagation for distances < 100 m between the two services.
For distances between 100 m and 1 km, the propagation loss is generally higher than for free space attenuation. The higher propagation loss is due to clutter and topography. Therefore in this calculation a propagation loss of 30 dB per decade was assumed. In the case of separation distances greater than 1 km a propagation loss of 40 dB per decade was chosen from the two-ray model.

The diagram below illustrates the propagation model.

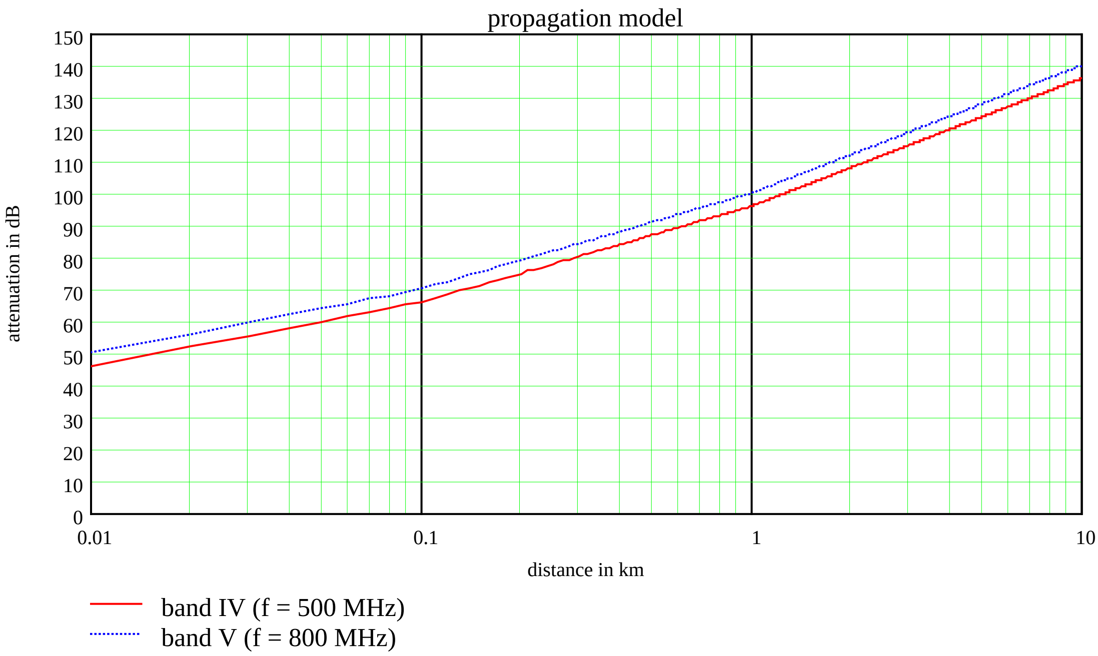


Diagram 9

3.3.6 Description and results of the calculations

The necessary separation distances between a radio microphone and a DVB–T receiver are presented in diagram 10. The diagram shows the results for band IV and V. The values for Diagram 10 were derived from the parameters given in tables 12a and 12b.
For convenience, a single curve in the diagram incorporates both the long and short separation distance case. The curve switches between cases when the interference distance is 100 m. Practically this occurs when the frequency separation is on the transition between co and adjacent channel.

<u>Diagram 10 should be interpreted as follows:</u>
The x-axis shows two parameters, namely the necessary frequency separation in MHz and the separation distances between the two services in km.
The y-axis shows the values both for the maximum permissible interfering field strength for a DVB–T receiver as a function of the frequency separation and for the interfering field strength of the radio microphone as a function of the corresponding separation distance.

An example based on 6 MHz is given to facilitate understanding of the diagram.

In a first step the x-axis is used to determine the maximum permissible interfering field strength for a frequency difference of 6 MHz between the two services. The corresponding value for band V is 89 dB(µV/m).

In a second step the x-axis shows the necessary separation distance in km. An interfering field strength of 89 dB(µV/m) is produced by a radio microphone (hand held) at approximately 30 m. So the necessary separation distance between the two services is approximately 30 m. For a radio microphone (body worn) the corresponding separation distance is < 10 m.
It is also possible to determine the necessary frequency difference for a specific separation distance.

The maximum permissible interfering field strength of 89 dB (µV/m) shown in the curve is calculated as follows:

53 dB(µV/m)	minimum median equivalent DVB–T field strength at 10 m a.g.l. table 12b for fixed reception (Band V)
- (9 dB)	location correction factor (short distance)
- (-45 dB)	C/I value, table 9, column 3, for a frequency offset of 6.0 MHz
89 dB(µV/m)	maximum permissible interfering field strength for DVB–T receiver

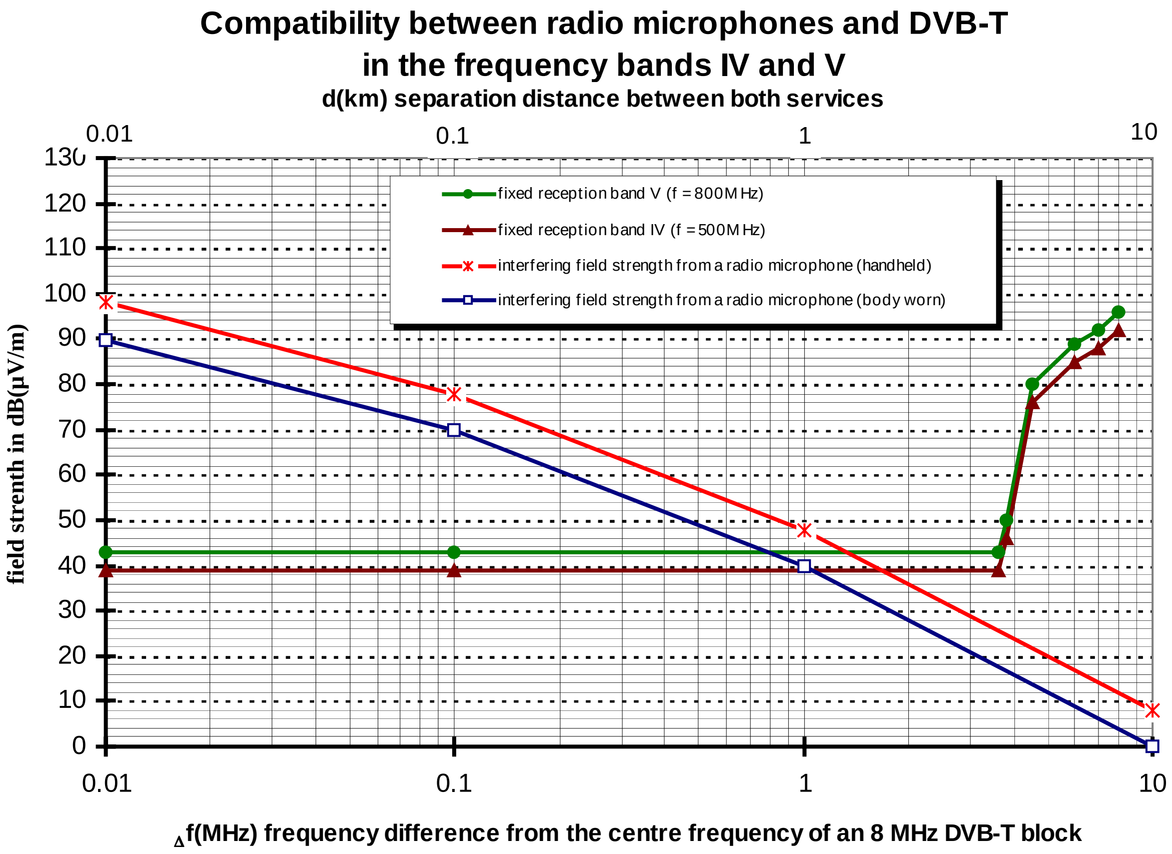


Diagram 10

The necessary separation distances for the fixed reception scenario are shown below in tabular form.

Frequency offset in MHz	Necessary separation distance in the case of hand held mics in km		Necessary separation distance in the case of body worn mics in km	
	Band IV	Band V	Band IV	Band V
0	approx. 1.5	approx. 1.3	approx. 1.0	approx.0.8
2	approx. 1.5	approx. 1.3	approx. 1.0	approx. 0.8
3.8	approx. 1.1	approx. 0.9	approx. 0.7	approx. 0.5
4.5	0.12	0.08	0.05	0.03
6.0	0.05	0.03	0.02	0.01
7.0	0.03	0.02	0.01	< 0.01
8.0	0.02	0.01	< 0.01	< 0.01

Table 14: Separation distances in km for DVB –T fixed reception and outdoor operation of 50 mW radio microphones

Note: The ERC Recommendation 70-03 gives a maximum e.r.p. of 10 mW for handheld and 50 mW in the case of body worn radio microphones only. For those administrations, which apply these arrangements, the separation distances in table 14 for body, worn radio microphones will be applicable to both body worn and handheld devices.

3.4 Interpretation of the results

The fixed reception scenario with outdoor operation of the radio microphone constitutes the worst case. For co-channel operation separation distances in the region of 1 km are necessary. The distance depends on the frequency band and type of radio microphone operation. In practice, distances above 1 km will not be acceptable in most cases. Therefore, in many cases co-channel operation in the same area is not possible. In many cases 1st adjacent channel operation, apart from the first 500 kHz of this channel, is possible for this scenario because the separation distances range from approximately 10 m to 120 m.

In the case of indoor operation of radio microphones the feasibility of sharing with DVB-T will be dependant on the building shielding loss and location of the closest DVB-T receiver. This is particularly relevant to the case of theatres and similar locations with heavy radio microphone usage where co-ordination with the broadcaster should be practical.

4 CONCLUSION

In order to establish if in a given set of circumstances:
- the DVB-T service and
- radio microphone usage at a given location

are compatible, the relevant separation distances derived in Sections 2 and 3, must be examined. If both separation distances are respected, then usage is compatible.

- In most cases, Co-channel operation of DVB–T and radio microphones within a DVB–T coverage area will cause unacceptable interference to radio microphones and vice-versa. However, indoor operation of radio microphones e. g. in theatres may be feasible even in the co-channel case depending on building shielding loss and the location of the nearest DVB-T receiver. These cases may be evaluated on a site by site basis.

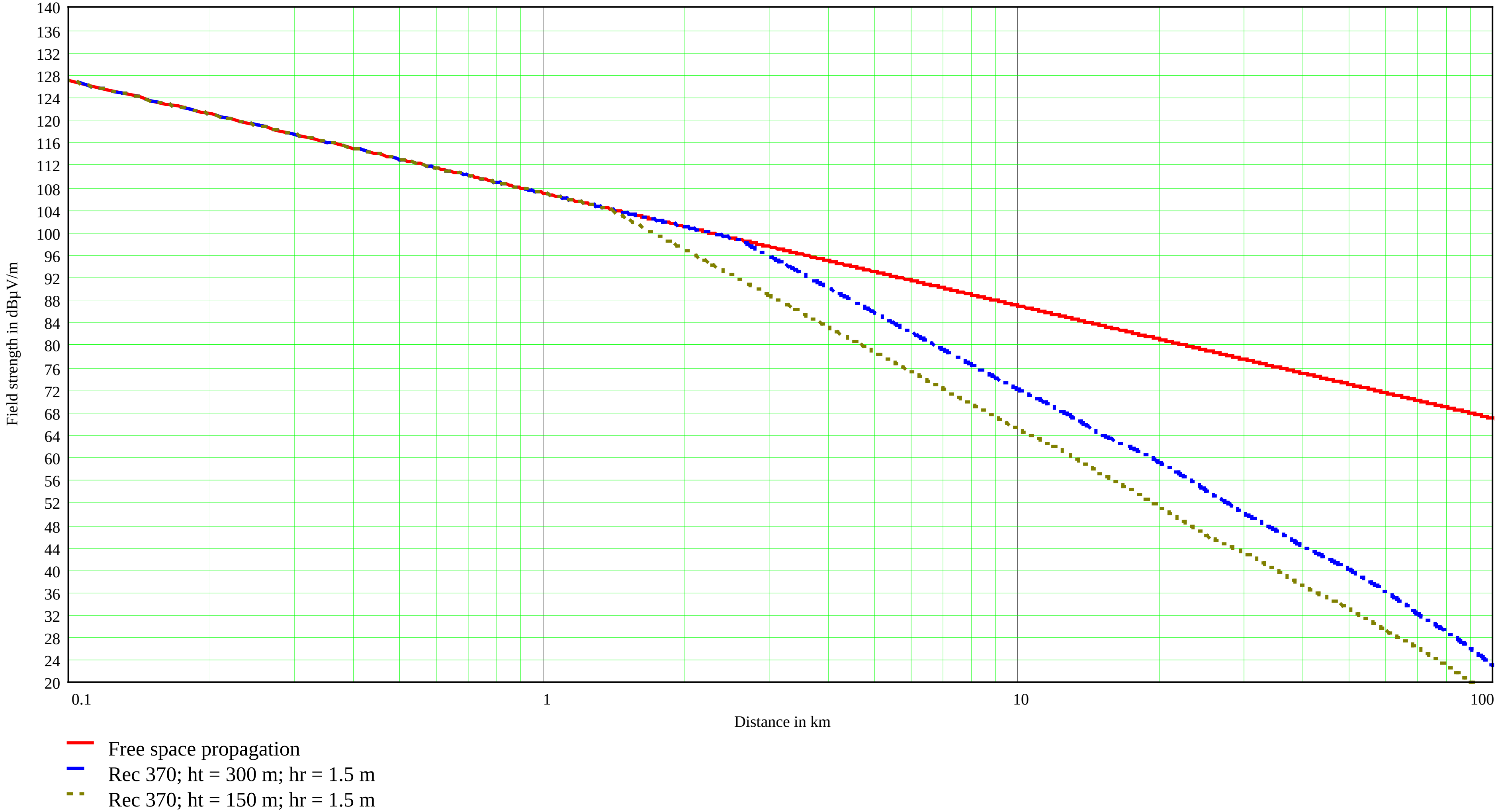
- Operation of radio microphones in the 1st adjacent channel of DVB–T, apart from the first 500 kHz of this channel, will be possible in a lot of cases. The necessary separation distances for SE PT 21 spectrum masks are longer than for the Chester spectrum mask, in particular if the DVB-T e.r.p. is produced using a low transmitter output power and a high antenna gain (the value of the SE21 spectrum mask relates to the output power and not the E.R.P. of the DVB Transmitter).

- In practice, use of the 2nd adjacent channel by radio microphones will be feasible in most cases. This applies to both indoor and outdoor operation of radio microphones. The necessary separation distances for SE PT 21 spectrum masks are again longer than for the Chester mask.

All protection ratio measurements were limited to professional DVB–T receivers. The immunity of domestic receivers, particularly for adjacent channel rejection, is not yet known. Therefore the frequency separation needed between the future wanted DVB–T channel and radio microphone operation may change slightly for domestic receivers.

ANNEX 1: Rec ITU-R P.370-7 propagation model Figur 11 (1% of the time, 50% of location)

NB: The curves were extrapolated down to free space propagation curve for distances < 10 km DVB-T transmitter power **ERP = 1kW**;
Antenna height correction factor = **12 dB**



NB: **ht** = DVB-T effective transmitter antenna height; **hr** = radio microphone receiving antenna height