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Recommendation ITU-R M.1767
(03/2006)

Protection of land mobile systems from terrestrial digital video and audio broadcasting systems in the VHF and UHF shared bands allocated on a primary basis

M Series

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R M.1767*,**

Protection of land mobile systems from terrestrial digital video and audio broadcasting systems in the VHF and UHF shared bands allocated on a primary basis

(Question ITU-R 1-3/8)

(2006)

Scope

The purpose of this Recommendation is to establish a protection criterion of land mobile systems from terrestrial digital video and audio broadcasting systems in the VHF (174-230 MHz) and UHF (470-862 MHz) shared bands allocated on a primary basis, where appropriate.

It provides the methodology and formulas to assess the maximum allowable field strength of digital terrestrial broadcasting signals into the land mobile system bandwidth, also taking into account the case of potential partial overlap in frequencies between both systems. Some examples are provided to illustrate the use of this methodology. In addition, for some specific types of land mobile systems and specific types of interfering digital television signals, measured values of protection ratios are included.

The ITU Radiocommunication Assembly,

considering

a) that it is important to establish a compatibility and sharing criteria between the land mobile service (LMS) and the broadcasting service in the VHF (174-230 MHz) and UHF (470-862 MHz) shared bands allocated to both services on a primary basis, where appropriate;

b) that the bandwidths of typical LMS in this spectrum are generally narrow in comparison with terrestrial digital video broadcasting (DVB) and terrestrial digital audio broadcasting (DAB) signals;

c) that the emission characteristics of terrestrial DVB and DAB in these bands may be approximated by white Gaussian noise;

d) that the noise level, N, of the LMS receiver depends on its IF bandwidth;

e) that an interference criterion $I/N = -6$ dB is a suitable value for the protection of LMS systems from broadcasting systems in the VHF and UHF shared bands;

f) that this $I/N = -6$ dB is equivalent to a 1 dB increase of the LMS receiver system noise;

g) that the direction of arrival of the terrestrial DVB and DAB signals, relative to the base station main beam, influences the maximum allowable field strength at the base station receiver, in cases of directional antennas;

h) that the antenna of the mobile terminal is typically omnidirectional,

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* This Recommendation should be brought to the attention of Radiocommunication Study Group 6.

** The results of the Regional Radiocommunication Conference (Geneva, 2006 (RRC-06)) may affect the content of this Recommendation for those countries party to the RRC Agreement.

recognizing

a) that the bands 174-216 MHz and 470-862 MHz are allocated to the broadcasting service on a primary basis;

b) that the band 216-230 MHz is allocated to the broadcasting service on a primary basis in Regions 1 and 3;

c) that, in Region 3 the bands 174-230 MHz and 470-862 MHz are allocated to the mobile service on a primary basis;

d) that, in some countries of Region 1, the band 174-223 MHz is allocated to the mobile service on a primary basis as per the provisions of Radio Regulations (RR) No. 5.235;

e) that, in some countries of Region 1, the band 223-230 MHz is allocated to the mobile service on a primary basis as per the provisions of RR No. 5.246;

f) that, in some countries in Region 1, the band 790-862 MHz is allocated to the mobile service on a primary basis for those countries only as per the provisions of RR No. 5.316 and conditions specified therein;

g) that, in some countries in Region 2, the bands 470-512 MHz, 512-614 MHz and 614-806 MHz are allocated to the mobile service on a primary basis as per the provisions of RR Nos. 5.292, 5.293 and 5.297, respectively;

h) that, in one country in Region 2, the band 174-216 MHz is allocated to the mobile service on a primary basis as per the provisions of RR No. 5.234,

recommends

1 that the interference power threshold level at the LMS station receiver input, P_r, for sharing between terrestrial DVB and DAB transmitting stations and LMS receiving stations should be determined from the following equation:

$$P_r\,(\text{dBm}) = -114 + F + I/N + 10 \log B_v + P_o \qquad (1)$$

where:

F: noise figure of the LMS base station or mobile station receivers (dB)

I/N: criterion of interference to LMS receiver system noise ratio (dB)

B_v: equivalent noise bandwidth of the LMS base station or mobile station receiver (MHz)

P_o: noise increase due to man-made noise and other interference power level (not from DAB and DVB systems) (dB);

2 that the maximum allowable interfering field strength of the DVB or DAB signal (dB(μV/m)) is derived from *recommends* 1, in the transmitter bandwidth B_i, should be calculated for terrestrial DVB and DAB centre frequencies, f, as follows:

$$\text{Field strength (dB(μV/m))} = -37 + F + I/N - G + L + 10 \times \log (B_i) + P_o + 20 \times \log f - K \qquad (2)$$

where:

F: noise figure of the LMS base station or mobile station receivers (dB)

I/N: criterion of interference to LMS receiver system noise ratio (dB)

G: LMS antenna gain (dBi) for the base station and the mobile station

L: cable feeder loss of the LMS receiver (dB)

B_i: digital broadcast bandwidth (MHz)

P_o: noise increase due to man-made noise and other interference power level (not from DAB and DVB systems) (dB)

f: centre frequency of the interfering broadcasting signal (MHz)

K: overlap correction factor from the Tables in Annex 4, if applicable;

3 that the measured protection ratio values as a function of separation between centre frequencies may be taken into account as shown in Annex 3;

4 that the following Notes should be considered part of the Recommendation.

NOTE 1 – Annex 1 addresses the factors considered in the derivation of the maximum allowable power and field strength in *recommends* 1 and 2.

NOTE 2 – Annex 2 provides an example of calculation for the maximum allowable field strength based on certain values for *I*/*N* criteria, and other parameters of LMS such as receiver noise figure, antenna gain and other noise sources.

Annex 1

Derivation of power and field-strength calculation methodology[1]

1 Signals from terrestrial DVB and DAB systems operating in the VHF and UHF bands can be regarded as broadband white noise in terms of interference to the LMS receivers.

Recommendation ITU-R SM.1541 provides spectrum masks for the terrestrial DVB and Recommendation ITU-R BS.1114 for the terrestrial DAB (see § 3 of Annex 3).

2 The calculation of potential interference requires the receiver characteristics of the LMS base station as well as the mobile station. Two different threshold levels should be calculated. One for the base station and the other for the mobile station. For paired band FDD LMS systems, this implies two frequency bands.

3 The broadcasting service typically uses field strength in μV/m and dB(μV/m) units; while some M-series ITU-R Recommendations refer to power values (dBm).

4 The interfering field strengths differ significantly for the different receiver bandwidths. LMS systems under 1 GHz usually do not have 6-8 MHz bandwidths as used for terrestrial DVB, or about 1.5 MHz as used for DAB. LMS in the VHF bands may have much narrower bandwidths.

5 The allowed interference criterion is used for determining the maximum allowable field strength, which equals the minimum usable field strength (see Recommendation ITU-R V.573), minus the protection ratio (see RR No. 1.170).

6 The sensitivity of the LMS system equals the $k\ T\ B\ F$ (where T is the reference noise temperature) plus a minimum required carrier-to-noise ratio. Interference increases the noise and degrades the sensitivity, in the sense that higher signal levels are required, e.g. an interference level which is equal to $k\ T\ B\ F$ results in a 3 dB sensitivity degradation, an interference level equal to $k\ T\ B\ F$ −6 dB results in a 1 dB sensitivity degradation, and an interference level equal to $k\ T\ B\ F$ −10 dB results in a 0.5 dB sensitivity degradation.

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[1] A similar methodology is used in Recommendation ITU-R F.1670 – Protection of fixed wireless systems from terrestrial digital video broadcasting systems in the VHF and UHF shared bands.

7 Other factors may degrade the sensitivity of the LMS system, i.e. man-made noise or other interference can occur and which will result in a higher sensitivity than that defined by receiver noise floor ($k\ T\ B\ F$) alone. In this case, the sensitivity and interfering field-strength threshold are higher (see Recommendation ITU-R P.372 – Radio noise).

8 The relationship (numbers, not in dB) between field strength, E, and power, P_r, in free space is given by:

$$P_r = \frac{E^2 G\lambda^2}{Z_0 4\pi} = \frac{E^2 Gc^2}{480\pi^2 f^2} \tag{3}$$

9 In the typical case of full inclusion of the LMS receiver bandwidth B_v in the interferer bandwidth B_i, the field strength of the interferer is independent of an LMS receiver bandwidth. This is a significant fact, as LMS bandwidths vary.

The derivation of the equation in *recommends* 2 reflects this fact.

The field strength of the interferer calculated at the antenna input of the LMS receiver referred to the interferer bandwidth B_i is derived with equation (2) and the result is:

$$\text{Field strength (dB}(\mu\text{V/m))} = 77.2 + P_r - G + L + 10 \times \log (B_i/B_v) + 20 \times \log f - K \tag{4}$$

where:

the G, L, B_i, B_v, f and K parameters are given in *recommend*s 1 and 2, and

P_r is calculated as in *recommends* 1 and $10 \times \log (B_i/B_v)$ is the interferer bandwidth to receiver bandwidth ratio factor.

If we introduce equation (1) of *recommends* 1 in equation (4), the field strength of the allowable interfering signal calculated at the LMS receiver antenna input is:

$$\begin{aligned} \text{Field strength (dB}(\mu\text{V/m))} &= -37 + F + I/N + 10 \times \log (B_v) \\ &\quad - G + 10 \times \log (B_i/B_v) + 20 \times \log f + P_o - K \\ &= -37 + F + I/N - G + L + 10 \times \log (B_i) + 20 \times \log f + P_o - K \end{aligned} \tag{5}$$

10 If the LMS receiver (Rx) filter is not entirely included in the terrestrial DVB or DAB power spectrum-density envelope additional overlap correction factor, K, is required, see Annex 4.

11 Actual antenna radiation patterns should be used.

12 For interfering terrestrial DVB or DAB signal arriving to the side lobe of a directional LMS antenna, the side-lobe gain should be used.

13 In some circumstances, there may be some antenna polarization discrimination at the LMS receiver. When this occurs, this should be taken into account.

Annex 2

Example of field-strength calculations applying *recommends* 1 and 2[2]

When assuming a noise figure of 3 dB for the base station and 7 dB for the mobile station, interference criterion I/N of −6 dB, total antenna gain (antenna gain – cable feeder loss) of 13 dB for the base station and 0 dB for the mobile station, the P_o (man-made noise and other interference not DVB or DAB) 0 dB[3], overlapping factor $K = 0$ (the LMS bandwidth within the DAB or DVB interferer) the field strength should be calculated with the *recommend*s 2 equation (in the LMS receiver bandwidth B_v):

$$\text{Field strength (dB(}\mu\text{V/m))} = -37 + F + I/N - G + L + 10 \times \log (B_i) + P_o + 20 \times \log f - K$$

Replacing the assumed I/N result:

$$\text{Field strength (dB(}\mu\text{V/m))} = -43 + F - G + L + 20 \times \log (f) + 10 \times \log (B_i)$$

For the base station:

Frequency (MHz)	470	790	862
Field strength at B_i = 7 MHz (dB(μV/m))	9	13	14
Field strength at B_i = 8 MHz (dB(μV/m))	10	14	15

For the mobile station:

Frequency (MHz)	470	790	862
Field strength at B_i = 7 MHz (dB(μV/m))	26	30	31
Field strength at B_i = 8 MHz (dB(μV/m))	27	31	32

Annex 3

Measured protection ratios for some specific systems

Measured protection ratios for some analogue systems of the land mobile service which use FM modulation are provided below.

A DVB-T signal which is in between both symmetrical masks given in § 3.1 of this Annex has been used for the measurements.

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[2] The values were checked specifically for LMS operating in the band 806-862 MHz: TDMA IS-136 (TIA/EIA-136-280B), GSM 850 (ETSI TS 100 910) and “The digital integrated mobile radio system” (DIMRS); the numbers correspond well.

[3] In LMS without fast power control, P_o is not equal to zero due to the intrasystem interference from LMS transmissions, or other man-made noise.

1 Protection ratios for analogue narrow-band land mobile systems (20 and 25 kHz)

Protection ratios have been measured for two systems of analogue narrow-band FM UHF handheld equipment operating in the frequency range 470-500 MHz and having channel bandwidths of 20 kHz or 25 kHz.

In this Annex the protection ratio is the difference (dB) between the field strength to be protected and the field strength of the interfering DVB-T signal.

E_P: field strength to be protected

PR: protection ratio

E_{DVT}: field strength of DVT-B signal

Example: $E_{DVT} = E_P - PR$

Assuming: $E_P = 31$ dB(μV/m)

$PR = 10$ dB

$E_{DVT} = 31 - (-10) = 41$ dB(μV/m)

The failure criteria was degradation of SINAD from 20 dB to 19 dB.

The resulting protection ratios are as follows:

1.1 The following protection ratios (PR) have been measured for the most critical receivers

Δf (MHz)	**Protection ratio (PR) (dB)**
0	−10
3	−17
4	−55
4.2	−69
6	−78
8	−82
12	−94

1.2 The following protection ratios (PR) have been measured for less critical receivers

Δf (MHz)	**Protection ratio (PR) (dB)**
0	−17
3	−22
4	−61
4.2	−71
6	−82
8	−88
12	−99

The value for field strength to be protected is 31 dB(μV/m) for handheld equipment in the above-mentioned frequency range in line with European Standard ETS 300 296.

2 Protection criteria for service ancillary to broadcasting/service ancillary to programme-making (SAB/SAP) (analogue wideband land mobile systems)

Default values for field strength to be protected as well as protection ratios as a function of frequency separation for radio microphones and audio OB links (wideband FM) are given in the following Tables.

All these values have been derived from measurements by testing a large number of equipment.

2.1 Protection ratios for radio microphones

The protection ratios for radio microphones are based on the measurement results for the second most susceptible receiver. The performance of the receivers varied widely with some receivers approximately 15 dB less susceptible to DVB-T interference than given in the Table below.

The failure criteria was a degradation of the *S*/*N* by 3 dB.

Wanted:	Radio microphone (companded)		Default field strength to be protected (dB(μV/m))			**68**	Default receiving antenna height (m)			**1.5**
			at frequency (MHz)			**650**				
Unwanted	**DVB-T/7 MHz**									
Δ*f* (MHz)	−10.5	−8.75	−7.0	−5.25	−3.68	−3.32	−3.15	0.0	3.15	3.32
PR (dB)	−49.0	−49.0	−44.0	−39.0	−34.0	8.0	13.0	13.0	13.0	8.0
Δ*f* (MHz)	3.68	5.25	7.0	8.75	10.5					
PR (dB)	−34.0	−39.0	−44.0	−49.0	−49.0					

Wanted:	Radio microphone (companded)		Default field strength to be protected (dB(μV/m))			**68**	Default receiving antenna height (m)			**1.5**
			at frequency (MHz)			**650**				
Unwanted	**DVB-T/8 MHz**									
Δ*f* (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
Δ*f* (MHz)	4.2	6.0	8.0	10.0	12.0					
PR (dB)	−35.0	−40.0	−45.0	−50.0	−50.0					

Remark: Radio microphone systems usually incorporate an audio compression/expansion unit (compander) to enhance *S*/*N* by reducing noise.

2.2 Protection ratios for audio OB links

The protection ratios for audio OB links are based on the measurement results for the second most susceptible receiver.

The failure criteria was a degradation of the *S*/*N* by 3 dB.

Wanted:	OB link, (stereo, non-companded)		Default field strength to be protected (dB(μV/m))			**86**	Default receiving antenna height (m)			**10**
			at frequency (MHz)			**650**				
Unwanted	**DVB-T/7 MHz**									
Δ*f* (MHz)	−10.5	−8.75	−7.0	−5.25	−3.68	−3.32	−3.15	0.0	3.15	3.32
PR (dB)	−17.0	−16.0	−11.0	−8.0	−4.0	37.0	44.0	44.0	44.0	37.0
Δ*f* (MHz)	3.68	5.25	7.0	8.75	10.5					
PR (dB)	−4.0	−8.0	−11.0	−16.0	−17.0					

Wanted:	OB link, (stereo, non-companded)		Default field strength to be protected (dB(μV/m))			**86**	Default receiving antenna height (m)			**10**
			at frequency (MHz)			**650**				
Unwanted	**DVB-T/8 MHz**									
Δ*f* (MHz)	−12.0	−10.0	−8.0	−6.0	−4.2	−3.8	−3.6	0.0	3.6	3.8
PR (dB)	−18.0	−17.0	−12.0	−9.0	−5.0	36.0	43.0	43.0	43.0	36.0
Δ*f* (MHz)	4.2	6.0	8.0	10.0	12.0					
PR (dB)	−5.0	−9.0	−12.0	−17.0	−18.0					

3 DVB-T and T-DAB spectrum masks

3.1 DVB-T spectrum masks for out-of-band emissions

Two symmetrical spectrum masks (both for 7 MHz and 8 MHz DVB-T channels) are shown in the Table below. The masks with a shoulder attenuation of 50 dB have been taken from the European Standard ETS 300 744 and are intended for sensitive cases where a large amount of attenuation is needed to adequately protect other services. The masks having a shoulder attenuation of 40 dB are widely used in Europe to protect other services for non-critical cases.

Symmetrical spectrum masks for non-critical and sensitive cases

Breakpoints					
8 MHz channels			7 MHz channels		
	Non-critical cases	Sensitive cases		Non-critical cases	Sensitive cases
Relative frequency (MHz)	Relative level (dB)	Relative level (dB)	Relative frequency (MHz)	Relative level (dB)	Relative level (dB)
−12	−110	−120	−10.5	−110	−120
−6	−85	−95	−5.25	−85	−95
−4.2	−73	−83	−3.7	−73	−83
−3.81	−32.8	−32.8	−3.4	−32.2	−32.2
+3.81	−32.8	−32.8	+3.4	−32.2	−32.2
+4.2	−73	−83	+3.7	−73	−83
+6	−85	−95	+5.25	−85	−95
+12	−110	−120	+10.5	−110	−120

Measurement bandwidth for all cases: 4 kHz.

3.2 T-DAB spectrum mask

The T-DAB spectrum to be used in the calculations is defined in Recommendation ITU-R BS.1114 – System for terrestrial digital sound broadcasting to vehicular, portable and fixed receivers in the frequency range 30-3 000 MHz.

Annex 4

Calculation of the overlap correction factor *K* for DVB-T

The overlap correction factor is K (dB). When calculating interference with the victim receiver the factor must be added to the bandwidth scaling factor by (B_v/B_i), which is already included in the equation of *recommends* 2.

In order to calculate the overlap correction factor K:

– Calculate the overlapped bandwidth $B_{OVERLAP}$

$$B_{OVERLAP} = \text{Min}\,(B_v, (B_v + B_i)/2 - \Delta f)$$

where Δf is the difference between the centre frequency of the LMS and the centre frequency of the interfering (DVB-T 8 and 7 MHz) signal.

TABLE 1

For the DVB-T mask non-critical cases

$B_o = B_{OVERLAP}$ for 8 MHz DVB-T	$B_o = B_{OVERLAP}$ for 7 MHz DVB-T	Overlapping factor K (dB)
$B_o = B_v$	$B_o = B_v$	0
$B_v > B_o > 10^{-4}\ B_v$	$B_v > B_o > 10^{-4}\ B_v$	$10 \log_{10} (B_o/B_v)$
$10^{-4}\ B_v > B_o > -0.5$	$10^{-4}\ B_v > B_o > -0.5$	−40
$B_o = -1$	$B_o = -0.8$	−45
$B_o = -2$	$B_o = -1.75$	−52
$B_o = -4$	$B_o = -3.4$	−60
$B_o = -8$	$B_o = -7$	−77

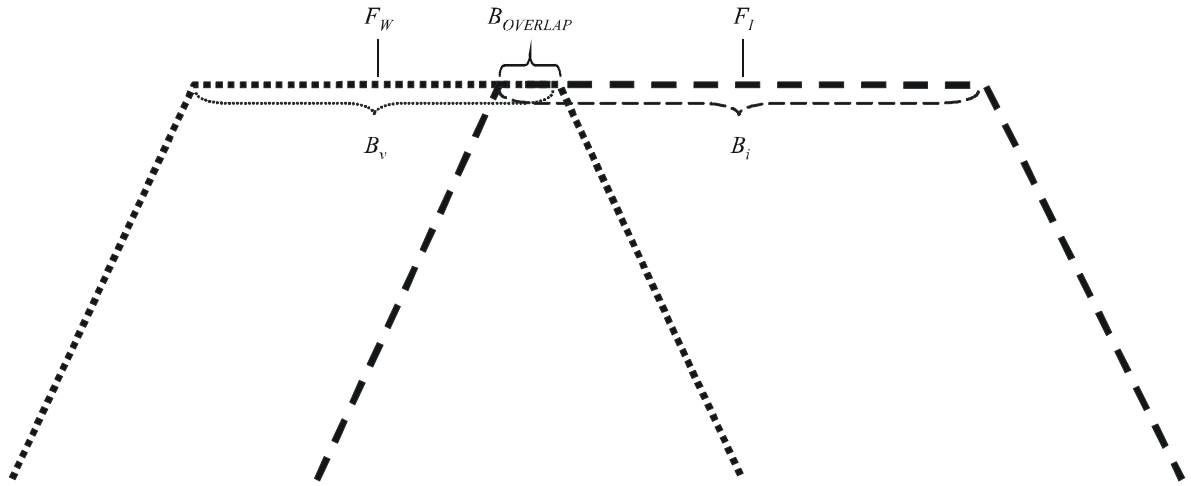
TABLE 2

For the DVB-T mask sensitive cases

$B_o = B_{OVERLAP}$ for 8 MHz DVB-T	$B_o = B_{OVERLAP}$ for 7 MHz DVB-T	Overlapping factor K (dB)
$B_o = B_v$	$B_o = B_v$	0
$B_v > B_o > 10^{-5}\ B_v$	$B_v > B_o > 10^{-5}\ B_v$	$10 \log_{10} (B_o/B_v)$
$10^{-5}\ B_v > B_o > -0.5$	$10^{-5}\ B_v > B_o > -0.5$	−50
$B_o = -1$	$B_o = -0.8$	−55
$B_o = -2$	$B_o = -1.75$	−62
$B_o = -4$	$B_o = -3.4$	−70
$B_o = -8$	$B_o = -7$	−87

where: $B_{OVERLAP}$, B_i and B_v are as shown in Figure 1.

FIGURE 1



F_W centre frequency of the wanted signal
F_I centre frequency of the interfering signal

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Examples

It is assumed that:

B_v = 0.2 MHz

B_i = 8 MHz

DVB-T case is non-critical

Δf (MHz)	3.8	4.0	4.1	4.8
$B_{OVERLAP}$ (MHz)	0.3	0.1	0	−0.7
K (dB)	0	10 log(0.1/0.2) = 3 dB	−40	See below K = −42

Interpolation example

F = 4.8 MHz from example above

Offset = $-B_{OVERLAP}$ = 0.7 MHz

From non-critical Table 1:

0.5 MHz −40 dB

1 MHz −45 dB

K = ((0.7 − 0.5)/(1.0 − 0.5))*(−45 − (−40)) − 40

K = −42 dB