RECOMMENDATION ITU-R F.1670-1*

Protection of fixed wireless systems from terrestrial digital video and sound broadcasting systems in shared VHF and UHF bands

(Question ITU-R 216/9)

(2004-2006)

Scope

This Recommendation deals with protection of fixed wireless systems from terrestrial digital video and sound broadcasting systems in shared VHF and UHF bands.

The ITU Radiocommunication Assembly,

considering

a) that it is important to establish compatibility and sharing criteria between the fixed service (FS) and the broadcasting service in the VHF and UHF bands where appropriate;

b) that the emission characteristics of terrestrial digital video broadcasting (DVB) and digital audio broadcasting (DAB) in these bands may be approximated by white Gaussian noise, in respect to reception by the fixed wireless system (FWS);

c) that the direction of arrival of the terrestrial DVB or DAB signal, relative to the FWS main beam, influences the maximum allowable field strength at the receiving antenna,

recommends

1 that the interference power threshold level, P_r at the FWS station receiver input, for sharing between terrestrial DVB or DAB stations and FWS receiving stations may be determined from the following formula:

$$P_r = -114 + 10 \log B_v + F + I/N + P_o \quad \text{dBm} \tag{1}$$

F: noise figure of the FWS receiver (dB)

I/N: protection criterion for the FWS receiver (dB)

B_v: equivalent noise bandwidth of the FWS receiver (MHz)

P_o: noise increase (dB) due to man-made noise typical value is 1 dB for VHF band and 0 dB for UHF band;

2 that the maximum allowable interfering field strength at the FWS antenna from the terrestrial DVB or DAB signal (dB(μV/m)) derived from *recommends* 1, in the transmitter bandwidth B_i, may be calculated as follows (for the relationship between field strength and power, see Annex 1):

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

* This Recommendation should be brought to the attention of Radiocommunication Study Groups 1 and 6.

G: FWS antenna gain (dBi)

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

B_i: digital broadcast bandwidth (MHz)

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

K: overlap correction factor (dB), from Tables 1 and 2 in Annex 2, if applicable;

3 that, for this case, an interference criterion $I/N = -6$ dB may be applied in these bands (see Note 1).

4 that in the absence of an actual radiation pattern, Recommendation ITU-R F.699 may be used.

NOTE 1 – This is equivalent to a 1 dB increase of the FWS receiver noise floor.

Annex 1

Technical considerations including the relationship between field strength and power

a) Signals from terrestrial DVB and DAB systems operating in the VHF and UHF bands are similar to white noise (see Fig. 1), and can be considered homogenous along the 7 or 8 MHz TV channel (which is not the case for analogue TV (AnTV)) see Fig. 1, and 1.3 MHz DAB (which is not the case for analogue sound).

b) The exact calculations of potential interference require the receiver characteristics of all FWS. It may not be practical to check specific interference and protection ratios, to assess the interference from terrestrial DVB and DAB to FWS.

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

d) The resulting field strengths differ significantly for the different receiver bandwidths. Recommendation ITU-R SM.1541 provides spectrum masks for the terrestrial DVB, and Recommendation ITU-R BS.1114 for the terrestrial DAB.

e) The allowed interference criterion is used for determining the maximum allowable field strength (similar to nuisance interfering field strength), which should be equivalent to the minimum usable field strength (see Recommendation ITU-R V.573), minus the protection ratio (see No. 1.170 of the Radio Regulations).

f) The sensitivity of FWS point-to-point (P-P) or point-to-multipoint (P-MP) systems equals the $(k\,T\,B\,F)_{dB} + (C/N)_{dB}$. The maximum allowed interfering signal (and the maximum interfering field strength) equals: Sensitivity $- C/I$. If $C/N = C/I$, the interfering terrestrial DVB and DAB signals equal the equivalent $k\,T\,B\,F$. For equivalent added protection of 6 dB, the interference, I, equals $k\,T\,B$. The $k\,T\,B\,F$ is the value to be protected for a 3 dB sensitivity degradation, and ($k\,T\,B\,F$) –6 dB for 1 dB degradation. For an equivalent noise figure of 6 dB, the criterion of interference, I, from terrestrial DVB and DAB into the input of the FWS receiver equals –144 dB(W/MHz) or –114 dB(m/MHz), independent of frequency. For this case, the interference

noise threshold depends only on the IF bandwidth of the FWS receiver, disregarding the modulations of the interfering terrestrial DVB or DAB and the interfered-with FWS.

g) In the VHF band, the sensitivity of FWS may be defined not by the $(k\,T\,B\,F)_{dB} + (C/I)_{dB}$, but by man-made noise, that can be higher than the sensitivity defined by the noise floor. In this case, the sensitivity and field strength threshold are higher (see Recommendation ITU-R P.372 – Radio noise), see P_o value.

h) The relationship (in physical units) between field strength at the antenna input, E (μV/m), and power, P_r (W), at the receiver antenna output, in free space is given by:

$$P_r = \frac{E^2\, g\lambda^2}{Z_0 4\pi} = \frac{E^2 g c^2}{480\,\pi^2 f^2} \tag{3}$$

g: antenna gain

c: velocity of light (m/s)

f: carrier frequency (Hz)

λ: wavelength (m)

Z_0: free space resistance (Ω) (120π Ω).

When deriving the input receiver power, the feeder loss, L, needs to be introduced in equation (3). Equation (3) can be represented in logarithmic form:

$$P_r(\text{dBm}) = E(\text{dB}(\mu\text{V/m})) - 20\log(f)\,(\text{MHz}) + G - L - 77 \tag{4}$$

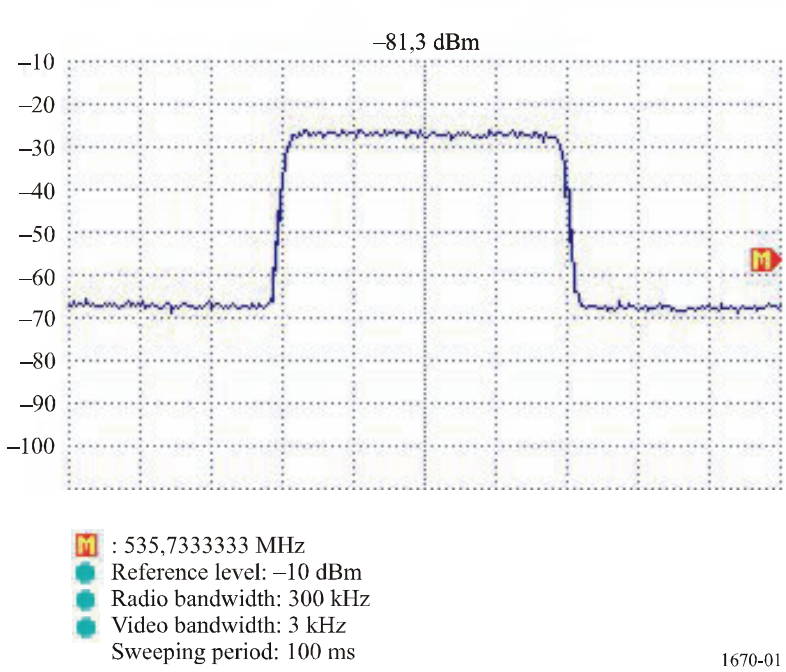
i) FWS antennas can be found deployed in V or H polarizations. Any cross-polarization between the horizontal (mainly used) terrestrial DVB or DAB and the FWS antenna (both polarizations are used) will enable higher terrestrial DVB or DAB interfering power.

j) It could be appropriate to assume a cross-polarization advantage of 10 to 18 dB, at least for the vertically polarized FWS station. For FWS, the antenna polarization discrimination for horizontally polarized broadcasting emissions may reach 18 dB (see Recommendation ITU-R SM.851). Where mixed polarized broadcasting emissions are used, no antenna polarization discrimination should be taken into account. There might also be attenuation in the elevation antenna pattern, due FWS antenna tilt or terrestrial DVB or DAB sites in mountainous areas.

k) Clarifying example: For 8 MHz (9 dB relative to 1 MHz) FWS bandwidth, the sensitivity is −105 dBm FWS antenna gain = 15 dBi and feeder losses up to $L = 8$ dB, and −112 dBm input receiver including the antenna gain. This is the value of power signal to be protected. The corresponding field strength thresholds per 8 MHz, including 7 dB receiver antenna gain and protection ratios, which may interfere into the FWS, are: 10 dB(μV/m) for 174 MHz; 13 dB(μV/m) for 230 MHz; 19 dB(μV/m) for 470 MHz; 23 dB(μV/m) for 790 MHz and 24 dB(μV/m) for 862 MHz.

l) Figure 1 depicts a transmitted (wireless) signal, in Channel 29, with centre frequency 538 MHz; 8 MHz separation bandwidth, quaternary phase shift keying (QPSK), 4-QAM, forward error correction (FEC)-1/2 fast Fourier transform (FFT) 8K, guard interval-1/8.

FIGURE 1



Annex 2

Example of overlap correction factor *K* for DVB-T

When calculating interference to the victim receiver, the K factor must be added to take into account the possible overlapping parts of the spectrum emission masks (see Table 4).

In order to calculate the overlap correction factor K:

Calculate the overlapped bandwidth B_o:

$$B_o = \min\left(B_v, (B_v + B_i)/2 - \Delta f\right)$$

where Δf is the absolute value of the difference between the centre frequency of the FWS, f_w, and the centre frequency, f_I, of the interfering (DVB-T 8 and 7 MHz) signal.

NOTE 1 – When B_o is negative, it implies that there is no overlap between the victim bandwidth and the DVB-T bandwidth defined by the actual DVB-T channel spacing.

TABLE 1

For the DVB-T mask – non-sensitive cases

B_o (MHz) for 8 MHz DVB-T	B_o (MHz) 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

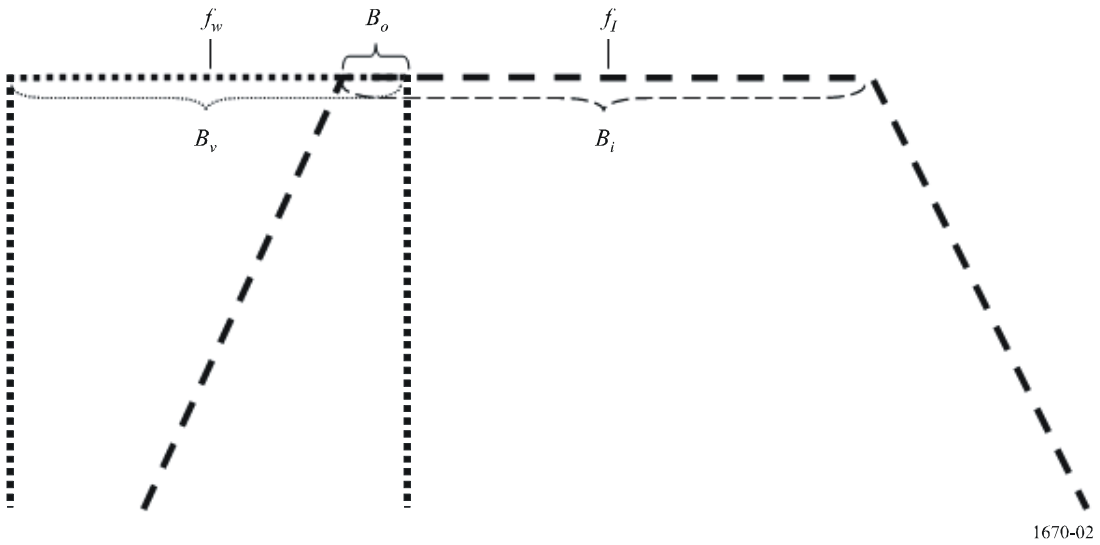
For the DVB-T mask – sensitive cases

B_o (MHz) for 8 MHz DVB-T	B_o (MHz) 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_o, B_i and B_v are as shown in Fig. 2:

FIGURE 2

Partial overlapping case



Examples

It is assumed that: B_v = 0.2 MHz; B_i = 8 MHz

TABLE 3

DVB-T example case – non-sensitive cases

Δf (MHz)	3.8	4.0	4.1	4.8
B (MHz)	0.2	0.1	0	−0.7
K (dB)	0	10 log (0.1/0.2) = –3	−40	See below K = −42

Interpolation example Δf = 4.8 MHz from example above offset = $-B_o$ = 0.7 MHz

From non-sensitive case Table 1: 0.5 MHz −40 dB 1 MHz −45 dB

$$K = ((0.7 - 0.5)/(1.0 - 0.5))*(-45 - (-40)) - 40 \text{ ,Therefore } K = -42 \text{ dB}$$

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 Table 4.

TABLE 4

Symmetrical spectrum masks for non-sensitive and sensitive cases

Breakpoints					
8 MHz channels			**7 MHz channels**		
Δf (MHz)	**Non-sensitive cases**	**Sensitive cases**		**Non-sensitive cases**	**Sensitive cases**
	Relative level (dB)	**Relative level (dB)**	**Relative frequency (MHz)**	**Relative level (dB)**	**Relative level (dB)**
0	–32.8	–32.8	0	–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.

NOTE 1 – The sensitive case mask is used in cases where sharing issues have been identified