International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R SM.851-1

(04/1993)

Sharing between the broadcasting service and the fixed and/or mobile services in the VHF and UHF bands

SM Series

Spectrum management

International Telecommunication Union

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

Electronic Publication
Geneva, 2011

RECOMMENDATION ITU-R SM.851-1*

Sharing between the broadcasting service and the fixed and/or mobile services in the VHF and UHF bands

(1992-1993)

Scope

This Recommendation provides criteria for the protection to determine the protection margin for the analogue broadcasting service (sound and television) when it is operated simultaneously with either the fixed or land mobile service in shared or in adjacent VHF or UHF bands.

This Recommendation also provides criteria for the to determine the protection margin for the land mobile and fixed services when they are operated simultaneously with the analogue broadcasting service in shared or in adjacent VHF or UHF bands;

Keywords

Analogue television broadcasting, PAL, SECAM, NTSC, Analogue sound FM Broadcasting, land mobile service, fixed service, protection margin, sharing, simplified multiplication method, SMM

Abbreviations

AF	Adjustment factors
AM	Amplitude modulation
CW	Continuous wave
FI	Interfering field strength
FM	Frequency Modulation
FS	Field strength
GMSK	Gaussian Minimum Shift Keying
IF	Intermediate Frequency
LNA	Low Noise Amplifier
NTSC	National Television System Committee
PAL	Phased Alternate Line
PM	Protection Margin
PR	protection ratio (dB)
QPSK	Quadrature Phase shift keying
RARC AFBC	Regional Administrative Conference for the Planning of VHF/UHF Television Broadcasting in the African Broadcasting Area and Neighbouring Countries (Geneva 1989) (RARC AFBC(2))
RPR	Relative protection ratio
SECAM	(in French) “Séquential Couleur à Memoire” for Sequential colour with memory
UHF	Ultra High Frequency
VHF	Very High Frequency

The ITU Radiocommunication Assembly,

considering

a) that the World Administrative Radio Conference, (Geneva, 1979) (WARC-79), increased the number of frequency bands that might be shared between the broadcasting service and the fixed and mobile services;

b) that in many parts of the world, some bands are allocated, as specified in Article 5 of the Radio Regulations, to the fixed, mobile and broadcasting services on a co-primary basis;

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* Radiocommunication Study Group 1 made editorial amendments to this Recommendation in the year 2017 in accordance with Resolution ITU-R 1.

c) that some administrations have partitioned the VHF and UHF bands between the three services and this situation has created some difficulty in coordination between two or more administrations which share borders in the coverage areas and which use these bands for different services;

d) that there is a requirement for standardized compatibility analysis procedures to facilitate the development of frequency assignment plans and equipment specifications applicable to national and multilateral arrangements;

e) that careful planning of frequency assignments to broadcasting, fixed and land mobile stations will lead to improvement in spectrum utilization by minimizing harmful interference to operations in the adjacent or shared frequency bands;

f) that fixed service applications in many parts of the world presently use the upper part of UHF television bands for radiotelephone links and are expected to remain for some time to come. However, new applications for those links in the fixed service are not expected to expand in these bands;

g) that fixed and mobile applications for services ancillary to broadcasting are likely to be expanded in the VHF and UHF bands;

h) that a variety of system characteristics exists for broadcasting, fixed and mobile service applications;

j) that studies are progressing in the Radiocommunication Sector (ITU-R) concerning the compatibility between the broadcasting service and the fixed and mobile services, in particular concerning systems involving new technology,

recommends

1. that frequency separation, geographical separation and time sharing, or a combination thereof, be used to ensure compatibility where sharing is required between different services. In this context, frequency sharing refers to the subdivision of the allocated bands between different services, geographical separation refers to the simultaneous use of a frequency by different services in separate geographical areas, and time sharing refers to the use of separate hours of operation for each of the services;

2. that the procedure in Annex 1 be used to determine the protection margin for the broadcasting service (sound and television) when it is operated simultaneously with either the fixed or land mobile service in shared or in adjacent VHF or UHF bands;

3. that the procedure in Annex 2 be used to determine the protection margin for the land mobile service when it is operated simultaneously with the broadcasting service in shared or in adjacent VHF or UHF bands;

4. that the procedure in Annex 3 be used to determine the protection margin for the fixed service when it is operated simultaneously with the broadcasting service in shared or in adjacent VHF or UHF bands;

5. that the system parameters related to determination of these protection margins include: minimum field strengths to be protected, protection ratios, antenna characteristics, propagation conditions and other related factors as described in Annexes 1, 2 and 3;

6. that the parameters contained in this Recommendation be used only for systems referred to in Annexes 1, 2 and 3;

7. that with the introduction of new technology (e.g. digital television, digital audio broadcasting, digital mobile and digital fixed) these parameters should be extended to accommodate future developments and to take account of ongoing Radiocommunication Sector (ITU-R) studies.

ANNEX 1

Protection of the broadcasting service from the fixed and land mobile services

PART I

TO ANNEX 1

Television services

1. Minimum field strength to be protected

Table 1 gives the minimum field strength values to be protected at 10 m above ground level for the broadcasting service (television) and the wanted field strength values from which they are derived.

TABLE 1

	Band I (41-68 MHz)	Band II (76-100 MHz)	Band III (162-230 MHz)	Band IV (470-582 MHz)	Band V (582-960 MHz)
Field strength to be protected (dB(μV/m)) at edge of coverage area (50% of time, 90% of locations)	46	48	49	53	58
Wanted field strength (dB(μV/m)) at edge of coverage area (50% of time, 50% of locations) from Recommendation ITU-R BT.417	48	52	55	65	70

The field strength to be protected is derived from the wanted field strength by taking account of the need to protect 90% of locations and the relatively high man-made noise levels in the VHF bands.

However, the values given in Table 2 are used in North America for the wanted field strength at the edge of coverage area and for the field strength to be protected at 10 m above ground level (50% of time and 50% of locations in both cases).

TABLE 2

	54-88 MHz	174-216 MHz	470-806 MHz
Wanted field strength and field strength to be protected (dB(μV/m)) at edge of coverage area (50% of time and 50% of locations)	47	56	64

2. Protection ratios

2.1 General

Protection ratios for the various television systems are given in Recommendation ITU-R BT.655. The values shown in this Annex are based on these texts as well as on the new studies carried out by some administrations.

Protection ratios covering tropospheric (T) and continuous (C) interference are included, the values being applicable to interference produced by one single source. The ratios applied to tropospheric (T) interference correspond closely to a slightly annoying impairment condition (Grade 3). They are considered to be acceptable only if the interference occurs for a small percentage of the time, not precisely defined but generally considered to be between 1% and 10%. For substantially non-fading unwanted signals, it is necessary to provide a higher degree of protection. In this case, the protection ratios appropriate to continuous (C) interference, which corresponds closely to perceptible but not annoying (Grade 4), should be used. If the latter ratios are not known, then the tropospheric (T) values increased by 10 dB can be applied.

Within a television channel, the required protection ratios for the vision and the sound signals should be considered separately.

Protection ratio requirements, particularly in the out-of-channel range, can be significantly increased due to non-linear effects in the receiver brought about by high level single or multiple unwanted input signals. Studies have shown that values can increase by up to 25 dB.

2.2 Protection ratios for the vision channel

The unwanted signal can fall into any part of the vision channel, therefore the protection ratios for overlapping channels given in Figs. 1 to 3, and Tables 4 to 6 (taken from Recommendation ITU-R BT.655) should be applied.

All the protection ratio values in the figures and tables are relevant for the case of an unwanted CW signal or FM signal, falling into the vision channel, the wanted vision signal being negatively modulated.

The corrections which should be made for positively modulated wanted vision signals and for other types of potentially interfering signals are given in Table 3.

2.2.1 525-line systems

The protection ratio values to be applied for 525-line systems are given in Fig. 1 and Table 4 for tropospheric interference.

For continuous interference the values should be increased by 10 dB.

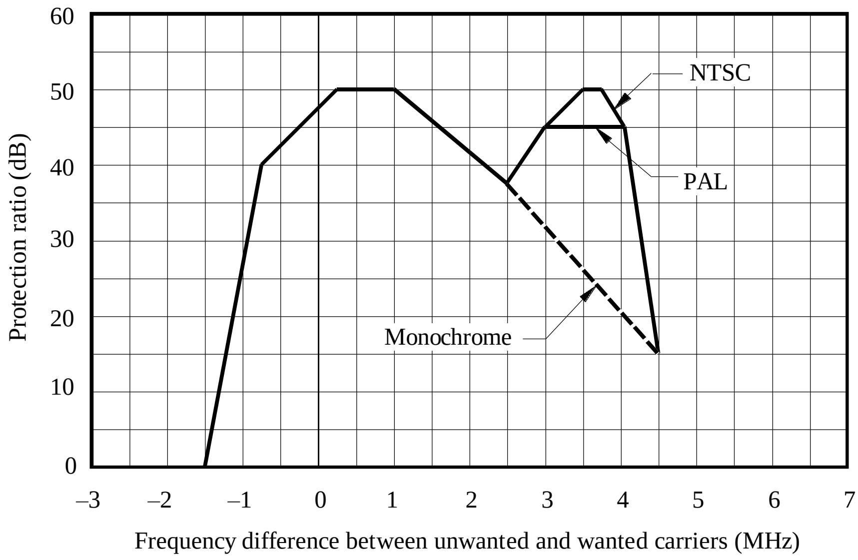
TABLE 3

Correction values for different wanted and unwanted signals

Unwanted signal / Wanted signal	Correction factors (dB)		
	CW	FM	AM
Vision signal negative modulated	0	0	0
Vision signal positive modulated	– 2	– 2	– 2

FIGURE 1 and TABLE 4

525-line systems (M/NTSC and M/PAL) Tropospheric interference
Unwanted signal: CW carrier



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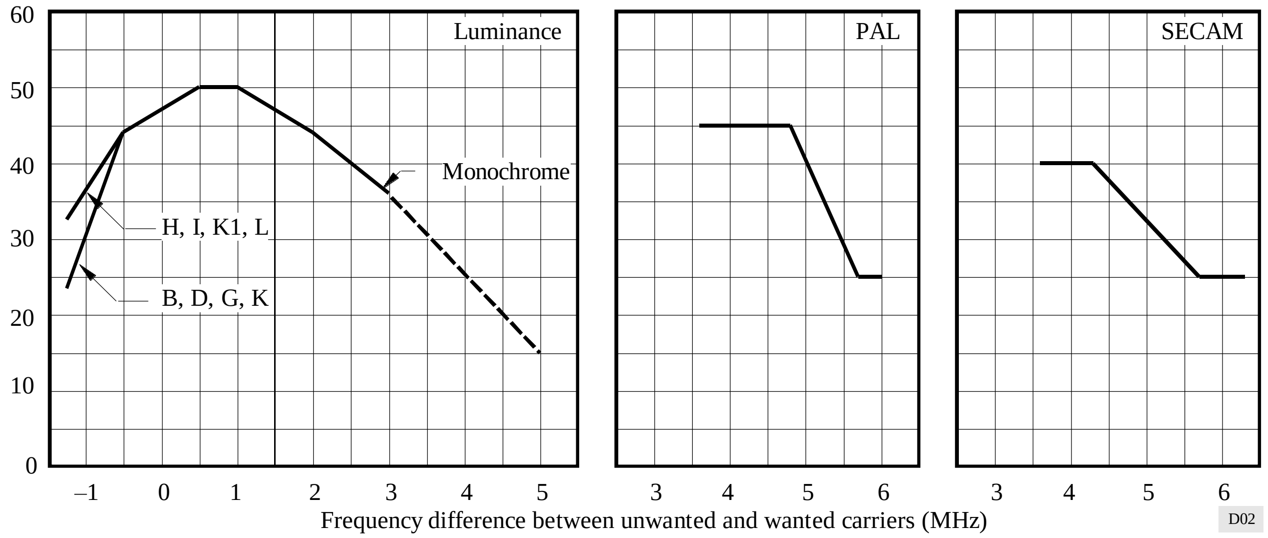
<table>
<tr><td>Frequency difference (MHz)</td><td>–1.5</td><td>–1.0</td><td>–0.75</td><td>0.3</td><td>1.0</td><td>2.5</td><td>3.0</td><td>3.5</td><td>3.7</td><td>4.1</td><td>4.5</td></tr>
<tr><td>NTSC (dB)</td><td rowspan="3">0</td><td rowspan="3">30</td><td rowspan="3">40</td><td rowspan="3">50</td><td rowspan="3">50</td><td rowspan="3">37</td><td rowspan="3">45</td><td>50</td><td>50</td><td rowspan="2">45</td><td rowspan="3">15</td></tr>
<tr><td>PAL (dB)</td><td>45</td><td>45</td></tr>
<tr><td>Monochrome (dB)</td><td>26</td><td>25</td><td>20</td></tr>
</table>

2.2.2 625-line systems

The protection ratio values to be applied for 625-line systems are given in Figs. 2 and 3, and Tables 5 and 6.

FIGURE 2 and TABLE 5

625-line systems
Tropospheric interference



	Frequency difference between unwanted and wanted carriers (MHz)											
	Luminance range								PAL		SECAM	
MHz	–1.25 (1)	–1.25 (2)	–0.5	0.0	0.5	1.0	2.0	3.0	3.6-4.8	5.7-6.0 (3) (4)	3.6-4.3 (5)	5.7-6.3 (3) (4)
dB	32	23	44	47	50	50	44	36	45	25	40	25

(1) H, I, K1, L television systems.

(2) B, D, G, K television systems.

(3) B, G television systems: range is 5.3-6.0 MHz.

(4) This value is valid until the end of the channel.

(5) D/SECAM and K/SECAM: add 5 dB.

2.3 Protection ratios for the sound channel

2.3.1 Analogue sound systems (one or two-sound carrier systems)

Protection ratio values for analogue sound signals are given in Table 7.

In the case of a two-sound carrier system each sound carrier must be considered separately.

The maximum deviation of the wanted FM sound carrier is assumed to be 50 kHz. Corrections should be made for other deviations.

2.3.2 Digital sound systems

Some values for the protection of digital sound signals are given in Table 8.

2.4 Protection ratios for out-of-channel interference

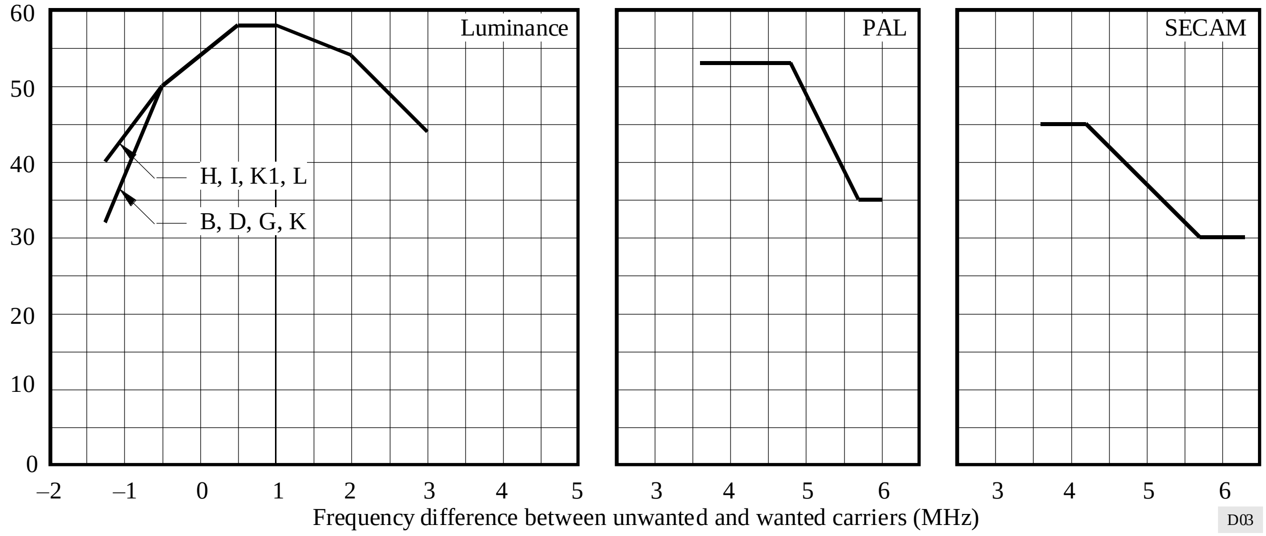
2.4.1 Adjacent channels

2.4.1.1 525-line systems

The protection ratio values to be applied for 525-line systems are given in Figs. 4a and 4b and Table 9 for continuous and tropospheric interference.

FIGURE 3 and TABLE 6

625-line systems
Continuous interference



	Frequency difference between unwanted and wanted carriers (MHz)											
	Luminance range								PAL		SECAM	
MHz	–1.25 (1)	–1.25 (2)	–0.5	0.0	0.5	1.0	2.0	3.0	3.6-4.8	5.7-6.0 (3) (4)	3.6-4.3 (5)	5.7-6.3 (3) (4)
dB	40	32	50	54	58	58	54	44	53	35	45	30

(1) H, I, K1, L television systems.

(2) B, D, G, K television systems.

(3) B, G television systems: range is 5.3-6.0 MHz.

(4) This value is valid until the end of the channel.

(5) D/SECAM and K/SECAM: add 8 dB.

TABLE 7

Protection ratios for wanted analogue sound carriers of a television signal (dB)
Unwanted signal: CW or FM sound carrier

Difference between wanted sound carrier and unwanted carrier (kHz)	Wanted sound signal			
	Tropospheric interference		Continuous interference	
	FM	AM	FM	AM
0	32	49	39	56
15	30	40	35	50
50	22	10	24	15
250	– 6	7	– 6	12

TABLE 8

Protection ratios for wanted digital sound carriers of a television signal (dB)

(No frequency separation)

Wanted \ Unwanted		FM/CW ([1])	AM ([1])	Digital ([2])
Digital	T	12	11	12
	C	12	11	12

([1]) The values given incorporate an additional 6 dB safety margin to allow for the sudden onset of severe degradation of the digital sound system in the presence of interference. For the same reason, there is no difference between the protection ratios for tropospheric and continuous interference.

([2]) Protection ratios for unwanted digital broadcasting signals (refer to Recommendation ITU-R BT.655).

FIGURE 4a

Protection ratios for the lower adjacent channel, NTSC/system M

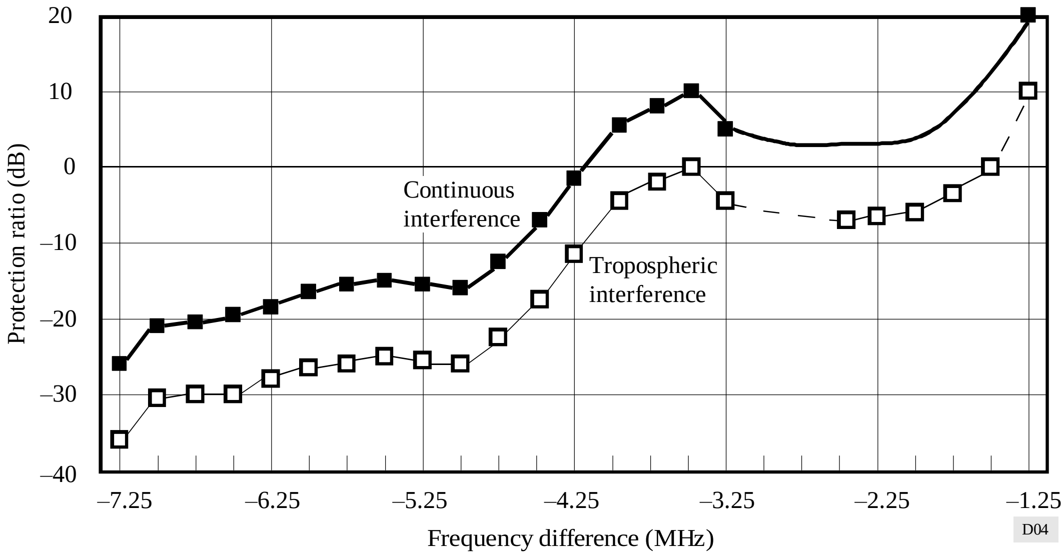


FIGURE 4b

Protection ratios for the upper adjacent channel, NTSC/system M

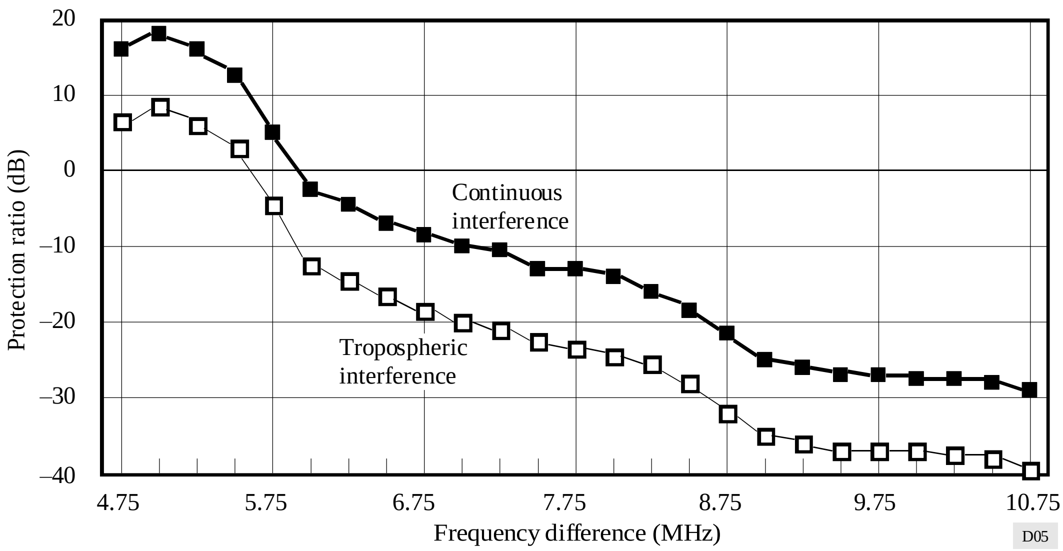


TABLE 9

Protection ratios for the adjacent channels, 525-line NTSC systems

Frequency difference (MHz)	Protection ratio (dB)	
	Continuous	Tropospheric
–7.25	–26	–36
–5.25	–15	–25
–3.5	10	0
–2.25	3	–7
–1.25	20	10
4.75	16	6
5.75	5	–5
6.75	–9	–19
8.75	–22	–32
10.75	–30	–40

2.4.1.2 625-line systems

The protection ratio values to be applied for 625-line systems are given in Table 10 and in Figs. 5 and 6 for tropospheric and continuous interference. For system I/PAL the values for the lower adjacent channel are given in Fig. 7 and Table 11.

TABLE 10

Protection ratios for the adjacent channels, 625-line systems

Frequency difference (MHz)	Protection ratio (dB)		
	Continuous	Tropospheric	TV systems
–14.0	–10	–15	B, D, G, H, K, K1, L
–6.0	–10	–15	B, D, G, H, K, K1, L
–2.5	11	1	B, D, G, H, K, K1, L
–1.5	11	1	B, D, G, H, K, K1, L
–1.25	40	32	H, K1, L
–1.25	32	23	B, D, G, K
5.75	30	25	B, G, H/SECAM
5.75	35	25	B, G, H/PAL
6.2	–2	–12	B, G, H
6.75	30	25	L, D, K, K1/SECAM
8.5	–2	–12	L, D, K, K1/SECAM
15.0	–2	–12	B, D, G, H, K1, L

FIGURE 5

Protection ratios for the adjacent channels, 625-line systems tropospheric interference

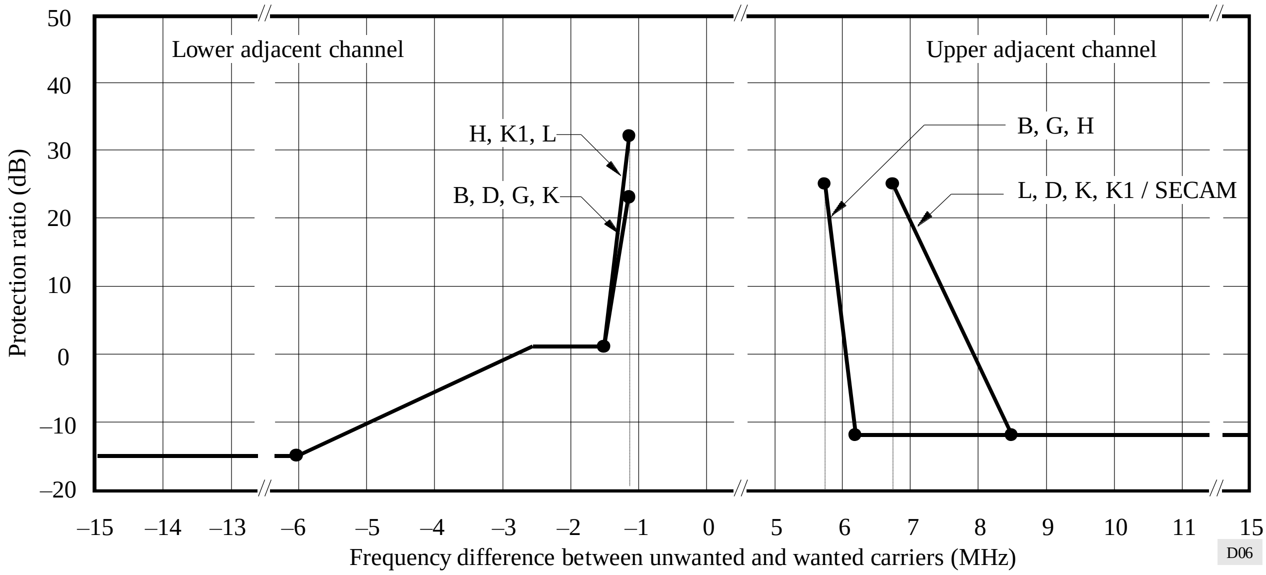


FIGURE 6

Protection ratios for the adjacent channels, 625-line systems continuous interference

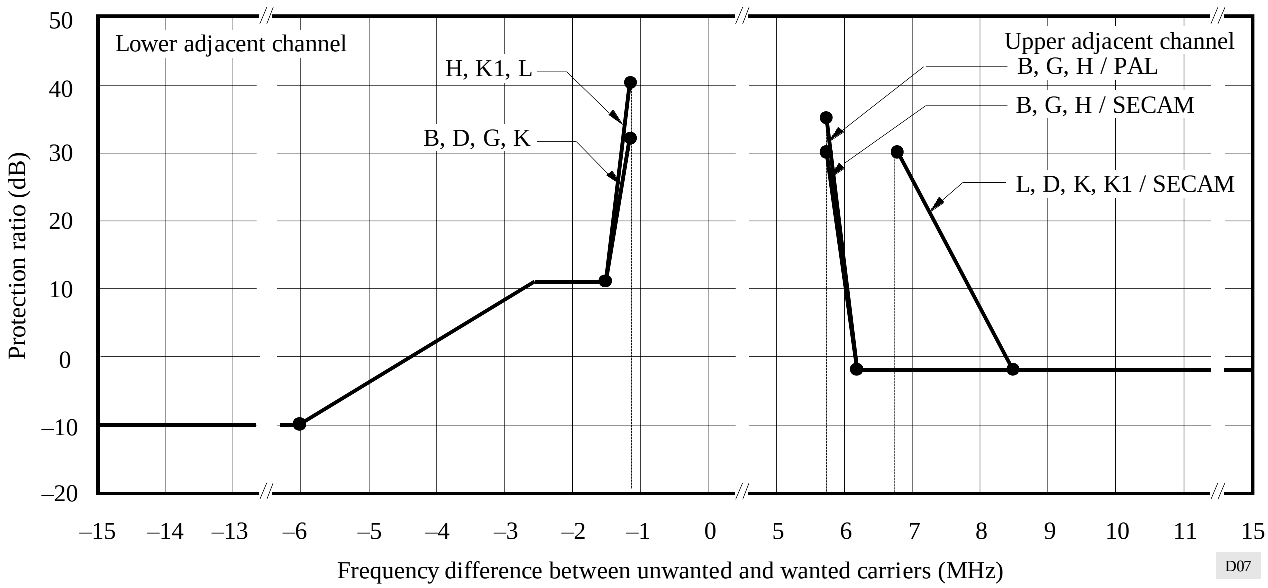


FIGURE 7a

Protection ratios for the lower adjacent channel, 625 lines I/PAL system

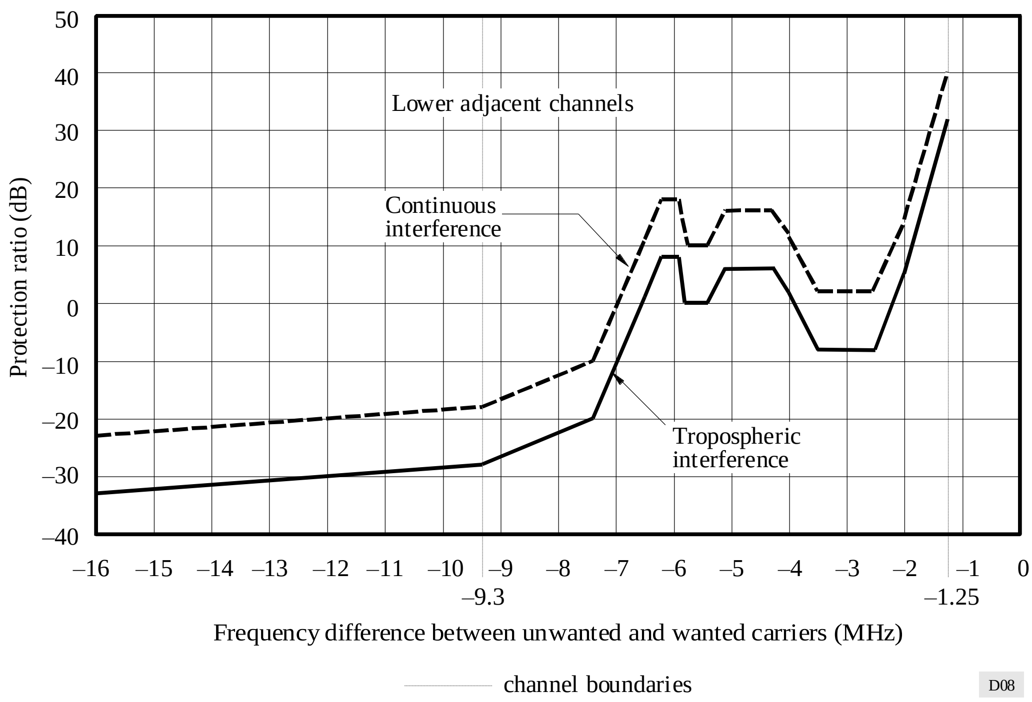


FIGURE 7b

Protection ratios for the upper adjacent channel, 625 lines I/PAL system

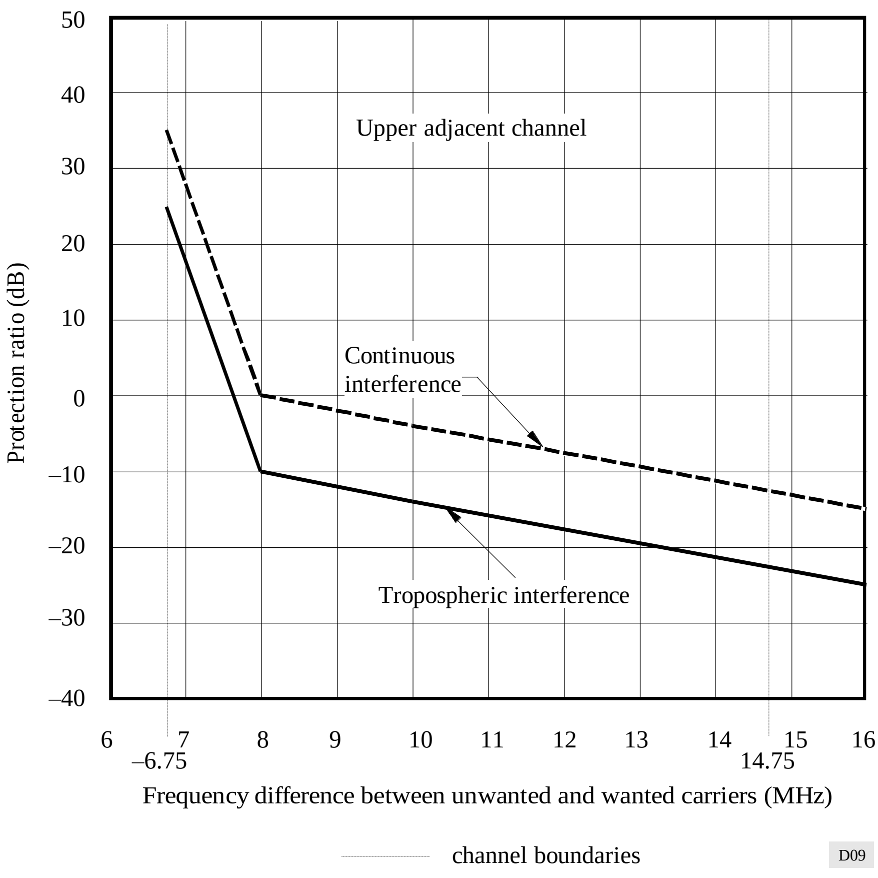


TABLE 11

Protection ratio for the adjacent channels, 625 lines I/PAL system

Frequency difference (MHz)	Protection ratio (dB)	
	Continuous	Tropospheric
–16.0	–23	–33
–9.3	–18	–28
–7.4	–10	–20
–6.5	11	1
–6.2	18	8
–5.9	18	8
–5.8	10	0
–5.4	10	0
–5.1	16	6
–5.0	16	6
–4.3	16	6
–4.0	12	2
–3.5	2	–8
–3.0	2	–8
–2.5	2	–8
–2.0	14	4
–1.25	40	32
+6.75	35	25
+8.0	0	–10
+10	–4	–14
+14.75	–13	–23
+16.0	–15	–25

2.4.2 Image channels

The protection ratio required will depend on the intermediate frequency and image-channel rejection of the receiver, and on the type of unwanted signal falling in the image channel. It can be determined by subtracting the image rejection figure from the required protection ratio given in § 2.2 and 2.3 above.

Image-channel rejection:

systems D and K/SECAM : 45 dB (VHF) and 30 dB (UHF)

system D/PAL: 45 dB (VHF) and 40 dB (UHF)

system I: 50 dB (UHF)

system M (Japan): 60 dB (VHF) and 45 dB (UHF)

all other systems: 40 dB (UHF).

2.4.3 Other types of interference

In the out-of-channel range some specific frequencies, depending upon the technology used in the TV receiver, such as local oscillator frequency, IF spacing, half IF spacing, etc., may require higher values of protection ratio.

3. Protection margin for television services

The protection margin (PM) is given (dB) by:

$$PM = FS - \text{combined value of } (NF + AF) \text{ for all interfering sources}$$

where:

FS : relevant field-strength value (dB(μV/m)) given in § 1 above

AF : adjustment factor (dB), intended to deal with antenna discrimination and clutter loss (see § 4.1)

NF : nuisance field and the larger of E_C and E_T given below (dB(μV/m)).

For continuous interference:

$$E_C = E_{(50,50)} + P + A_C$$

For tropospheric interference:

$$E_T = E_{(50,t)} + P + A_T$$

where:

$E_{(50,t)}$: field strength (dB(μV/m)) of the interfering transmitter, normalized to 1 kW, and exceeded during *t*% of the time, determined using Recommendation ITU-R P.1546.

For tropospheric interference the value of *t* is between 1 and 10 (the precise value should be specified by each administration)

P : e.r.p. (dB(kW)) of the interfering transmitter

A : protection ratio (dB)

and where the indices *C* and *T* indicate continuous and tropospheric interference respectively.

The protection ratio for continuous interference is applicable when the resulting nuisance field is stronger than that resulting from tropospheric interference, that is, when:

$$E_C > E_T$$

This means that E_C should be used in all cases when:

$$E_{(50,50)} + A_C > E_{(50,t)} + A_T$$

The calculated protection margin should be positive at all locations where a television service is required.

The combination of multiple interference from co-sited and non co-sited sources is discussed in § 4.2 and 4.3 below.

Information regarding fixed services or base stations of the land mobile service with effective antenna heights of less than 37.5 m is given in § 4.4 below.

4. Additional factors to be considered

4.1 Adjustment factors (AF)

Four distinct cases of interference to a station of the television service from stations of the fixed or land mobile services can be identified; these are dealt with separately below.

4.1.1 Interference from stations of the fixed service or base stations of the land mobile service which are orthogonally polarized with respect to a station of the television service

In this case, the adjustment factor is equal to the antenna discrimination which has a value of −16 dB for 50% of locations and −10 dB for 90% of locations.

4.1.2 Interference from stations of the fixed service or base stations of the land mobile service which have the same polarization as a station of the television service

In this case, the adjustment factor is equal to the relevant receiving antenna directivity discrimination value given in Recommendation ITU-R BT.419. For television Band II, the values as given for Band I should be used.

4.1.3 Interference from a land mobile station operating at more than 40 km outside the coverage area of a station of the television service

No polarization discrimination can be taken into account because:

– the mobile transmitter system, consisting of an antenna and the body of a vehicle, cannot be assumed to radiate with only horizontal or vertical polarization;

– the effect of environmental clutter near the mobile transmitter can be expected to introduce a degree of depolarization.

It would be impracticable to carry out calculations for all possible geographical locations for any mobile station, taking account of propagation losses and receiving antenna directivity discrimination. A reasonable simplification of the problem is to carry out interference calculations for the e.r.p. of the mobile station assuming this to be situated at the base station site with an effective antenna height of 75 m. It is then appropriate to use an adjustment factor of −15 dB (see Note 1) to allow for the effect of clutter loss and ground reflection effects near the mobile station.

In some cases, it may be possible to include an additional adjustment to allow for the directivity of the television receiving antenna, as given in Recommendation ITU-R BT.419. For television in Band II, the values given for Band I should be used.

Note 1 – See Final Acts of the Second Session of the Regional Administrative Conference for the planning of VHF/UHF Television Broadcasting in the African Broadcasting Area and Neighbouring Countries (RARC AFBC(2)).

4.1.4 Interference from a land mobile station operating less than 40 km from a receiving site of a station of the television service

In this case, it is necessary to carry out detailed calculations for individual, worst-case paths. No polarization discrimination can be taken into account, for the same reasons as are explained in § 4.1.3.

4.2 Multiple interference from co-sited sources

The interference arising from multiple co-sited sources should be combined by means of the power-sum method:

$$E = 10 \log_{10} \sum_{i=1}^{n} 10^{\frac{E_i}{10}}$$

where:

E_i : value (dB(μV/m)), of ($NF + AF$) for each individual co-sited source. As indicated in § 3 NF is expressed in dB(μV/m) and AF in dB

n : number of co-sited sources

E : effective interference (dB(μV/m)).

Note 1 – The value of E represents one of the terms to be included in the procedure given in § 4.3 below.

4.3 Multiple interference from non co-sited sources

The interference arising from multiple non co-sited sources should be combined by using the simplified multiplication method given in Annex II of the Final Acts of the RARC AFBC(2), 1989, reproduced herein as Attachment 1 to Annex 1.

4.4 Effective transmitting antenna heights

The effective transmitting antenna height is determined according to Recommendation ITU-R P.1546.

When the effective transmitting antenna height is less than 37.5 m or more than 1 200 m, the field-strength values are calculated using the method described in the Final Acts of the RARC AFBC(2), reproduced herein as Attachment 2 to Annex 1.

5. Interference assessments

Interference assessments should normally be made for several reception points within the service area of the television transmitter. These points should be those which are considered to be most likely to suffer from interference.

Moreover, for rebroadcasting stations, it is necessary to ensure that the received television signal is also protected against interference. In this case, the protection ratios given in Recommendation ITU-R BT.655 for the limit of perceptibility are normally used.

PART II

TO ANNEX 1

Sound broadcasting services

1. Minimum field strengths to be protected

The minimum values of field strength which require protection from the fixed and mobile service as given in Recommendation ITU-R BS.412, are:

37 dB(μV/m) at an antenna height of 10 m above ground for monophonic reception

48 dB(μV/m) at an antenna height of 10 m above ground for stereophonic reception.

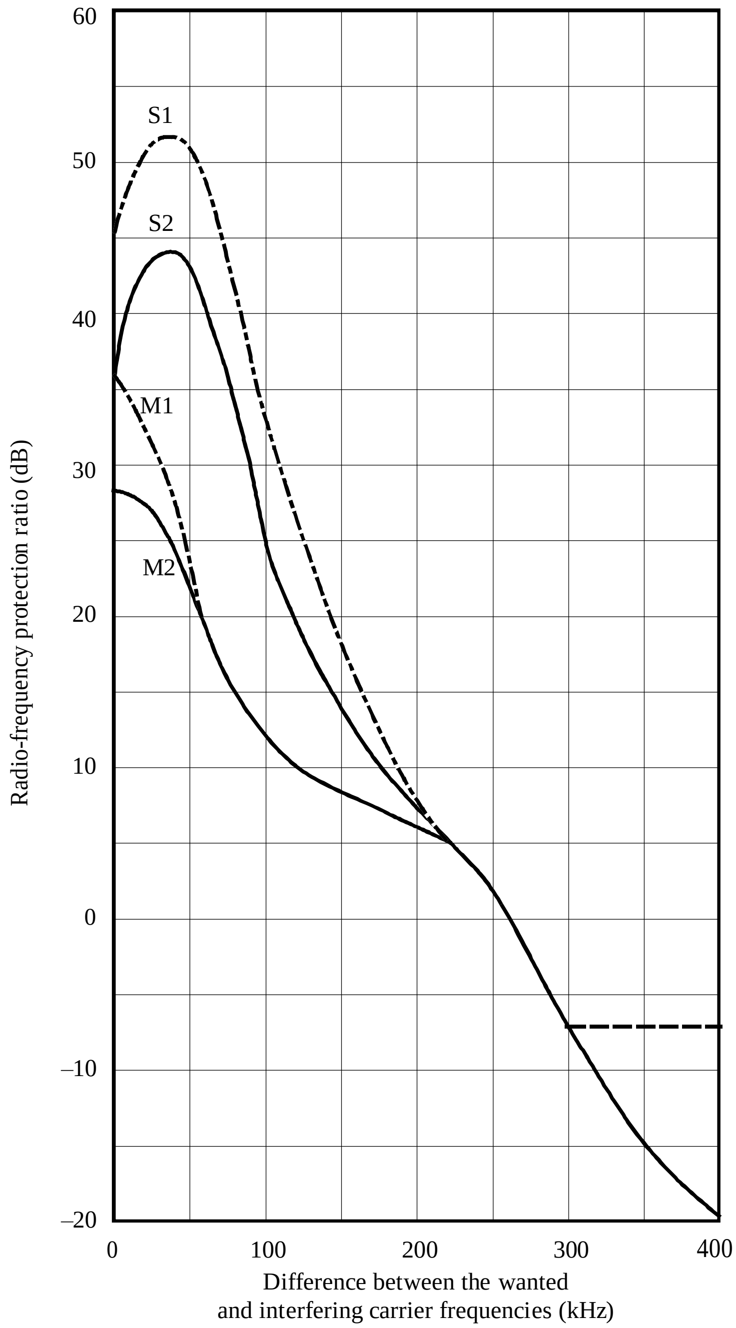
2. Protection ratios

The protection ratios for a wanted FM sound broadcasting station and an unwanted AM or FM fixed or mobile station are given in Figs. 8 and 9, and Tables 12 and 13 (for a maximum frequency deviation of ± 75 and ± 50 kHz respectively).

In the case of a very narrow-band FM interfering system, some relaxation may be possible (see also Report ITU-R SM.659).

FIGURE 8

Radio-frequency protection ratios required by broadcasting services in band 8 (VHF) at frequencies between 87.5 MHz and 108 MHz using a maximum frequency deviation of ± 75 kHz



Curves M1: monophonic broadcasting; steady interference

M2: monophonic broadcasting; tropospheric interference (protection for 99% of the time)

S1: stereophonic broadcasting; steady interference

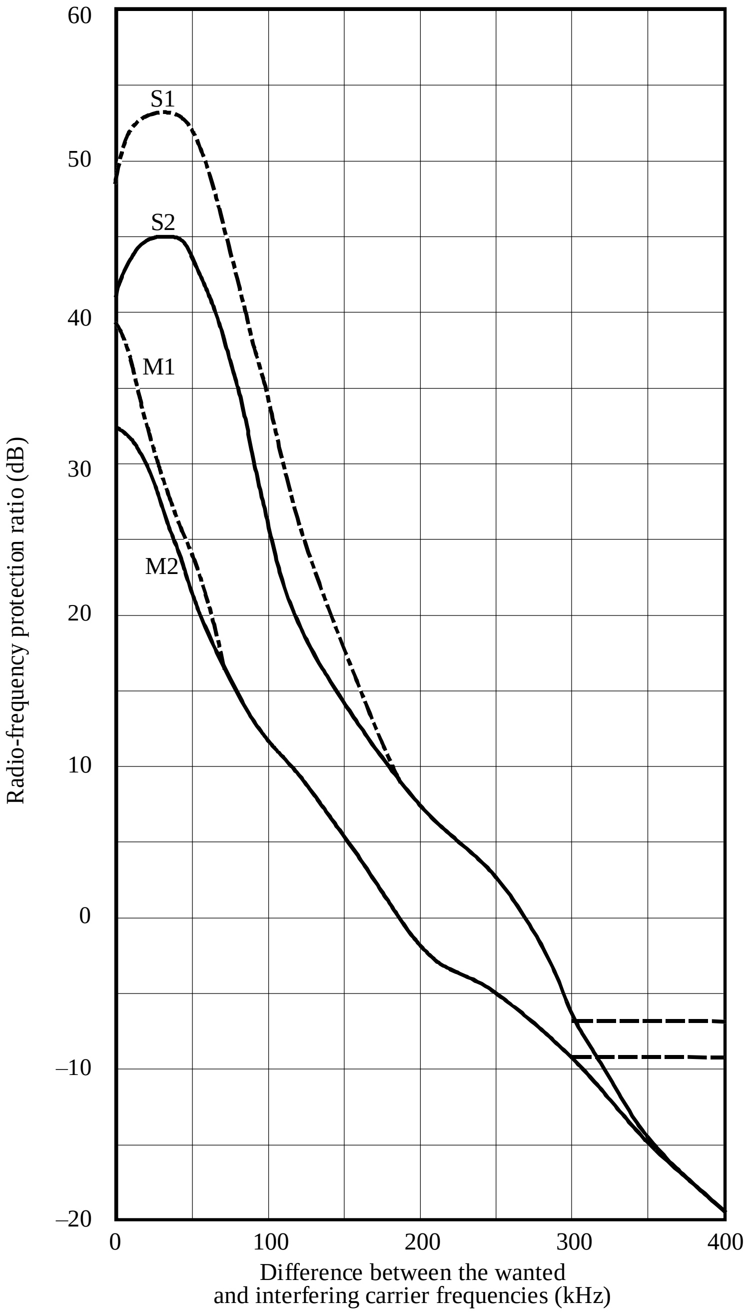
S2: stereophonic broadcasting; tropospheric interference (protection for 99% of the time)

– – – – – – Estimated values for AM interfering stations

D10

FIGURE 9

Radio-frequency protection ratios required by broadcasting services in band 8 (VHF) using a maximum frequency deviation of ± 50 kHz



Curves M1: monophonic broadcasting; steady interference

M2: monophonic broadcasting; tropospheric interference (protection for 99% of the time)

S1: stereophonic broadcasting; steady interference

S2: stereophonic broadcasting; tropospheric interference (protection for 99% of the time)

The values of curves S1 and S2 apply equally to the pilot-tone system and the polar-modulation system

– – – – – – Estimated values for AM interfering stations

D11

TABLE 12

Protection ratios required by broadcasting services in band 8 (VHF) using a maximum frequency deviation of ±75 kHz

Frequency spacing (kHz)	Protection ratio (dB)							
	Monophonic				Stereophonic			
	Steady interference		Tropospheric interference		Steady interference		Tropospheric interference	
	FM	AM	FM	AM	FM	AM	FM	AM
0	36.0	36.0	28.0	28.0	45.0	45.0	37.0	37.0
25	31.0	31.0	27.0	27.0	51.0	51.0	43.0	43.0
50	24.0	24.0	22.0	22.0	51.0	51.0	43.0	43.0
75	16.0	16.0	16.0	16.0	45.0	45.0	37.0	37.0
100	12.0	12.0	12.0	12.0	33.0	33.0	25.0	25.0
125	9.5	9.5	9.5	9.5	24.5	24.5	18.0	18.0
150	8.0	8.0	8.0	8.0	18.0	18.0	14.0	14.0
175	7.0	7.0	7.0	7.0	11.0	11.0	10.0	10.0
200	6.0	6.0	6.0	6.0	7.0	7.0	7.0	7.0
225	4.5	4.5	4.5	4.5	4.5	4.5	4.5	4.5
250	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
275	–2.0	–2.0	–2.0	–2.0	–2.0	–2.0	–2.0	–2.0
300	–7.0	–7.0	–7.0	–7.0	–7.0	–7.0	–7.0	–7.0
325	–11.5	–7.0	–11.5	–7.0	–11.5	–7.0	–11.5	–7.0
350	–15.0	–7.0	–15.0	–7.0	–15.0	–7.0	–15.0	–7.0
375	–17.5	–7.0	–17.5	–7.0	–17.5	–7.0	–17.5	–7.0
400	–20.0	–7.0	–20.0	–7.0	–20.0	–7.0	–20.0	–7.0

TABLE 13

Protection ratios required by broadcasting services in band 8 (VHF) using a maximum frequency deviation of ±50 kHz

Frequency spacing (kHz)	Protection ratio (dB)							
	Monophonic				Stereophonic			
	Steady interference		Tropospheric interference		Steady interference		Tropospheric interference	
	FM	AM	FM	AM	FM	AM	FM	AM
0	39.0	39.0	32.0	32.0	49.0	49.0	41.0	41.0
25	32.0	32.0	28.0	28.0	53.0	53.0	45.0	45.0
50	24.0	24.0	22.0	22.0	51.0	51.0	43.0	43.0
75	15.0	15.0	15.0	15.0	45.0	45.0	37.0	37.0
100	12.0	12.0	12.0	12.0	33.0	33.0	25.0	25.0
125	7.5	7.5	7.5	7.5	25.0	25.0	18.0	18.0
150	6.0	6.0	6.0	6.0	18.0	18.0	14.0	14.0
175	2.0	2.0	2.0	2.0	12.0	12.0	11.0	11.0
200	–2.5	–2.5	–2.5	–2.5	7.0	7.0	7.0	7.0
225	–3.5	–3.5	–3.5	–3.5	5.0	5.0	5.0	5.0
250	–6.0	–6.0	–6.0	–6.0	2.0	2.0	2.0	2.0
275	–7.5	–7.5	–7.5	–7.5	0.0	0.0	0.0	0.0
300	–10.0	–10.0	–10.0	–10.0	–7.0	–7.0	–7.0	–7.0
325	–12.0	–10.0	–12.0	–10.0	–10.0	–7.0	–10.0	–7.0
350	–15.0	–10.0	–15.0	–10.0	–15.0	–7.0	–15.0	–7.0
375	–17.5	–10.0	–17.5	–10.0	–17.5	–7.0	–17.5	–7.0
400	–20.0	–10.0	–20.0	–10.0	–20.0	–7.0	–20.0	–7.0

3. Protection margin for sound broadcasting services

The protection margin (PM) is given (dB) by:

$$PM = FS - \text{combined value of } (NF + AF) \text{ for all interfering sources}$$

where:

FS : relevant field-strength value (dB(μV/m)) given in § 1 above

AF : adjustment factor (dB), intended to deal with antenna discrimination and clutter loss (see § 4.1)

NF : nuisance field and the larger of E_C and E_T given below (dB(μV/m).

For continuous interference:

$$E_C = E_{(50,50)} + P + A_C$$

For tropospheric interference:

$$E_T = E_{(50,t)} + P + A_T$$

where:

$E_{(50,t)}$: field strength (dB(μV/m)) of the interfering transmitter, normalized to 1 kW, and exceeded during *t*% of the time, determined using Recommendation ITU-R P.1546.

For tropospheric interference the value of *t* is between 1 and 10 (the precise value should be specified by each administration)

P : e.r.p. (dB(kW)) of the interfering transmitter

A : protection ratio (dB)

and where the indices *C* and *T* indicate continuous and tropospheric interference respectively.

The protection ratio for continuous interference is applicable when the resulting nuisance field is stronger than that resulting from tropospheric interference, that is, when:

$$E_C > E_T$$

This means that E_C should be used in all cases when:

$$E_{(50,50)} + A_C > E_{(50,t)} + A_T$$

The calculated protection margin should be positive at all locations where a sound broadcasting service is required.

The combination of multiple interference from co-sited and non co-sited sources is discussed in §§ 4.2 and 4.3.

Information regarding fixed services or base stations of the mobile service with effective antenna heights of less than 37.5 m is given in § 4.4.

4. Additional factors to be considered

4.1 Adjustment factors (AF)

Because of the variety of receiving sound broadcasting installations (fixed, portable, car reception, etc.), no antenna discrimination can be taken into account.

4.1.1 Interference from a land mobile station operating at more than 40 km outside the coverage contour of a station of the sound broadcasting service

It would be impracticable to carry out calculations for all possible geographical locations for any mobile station, taking account of propagation losses. A reasonable simplification of the problem is to carry out interference calculations for the e.r.p. of the mobile station assuming this to be situated at the base station site with an effective antenna height of 75 m. It is then appropriate to use an adjustment factor of –15 dB (see Note 1) to allow for the effect of clutter loss and ground reflection effects near the mobile station.

Note 1 – See Final Acts of the RARC AFBC(2).

4.1.2 Interference from a land mobile station operating less than 40 km from a receiving site of a station of the sound broadcasting service

In this case, it is necessary to carry out detailed calculations for individual, worst-case paths.

4.2 Multiple interference from co-sited sources

The interference arising from multiple co-sited sources should be combined by means of the power-sum method:

$$E = 10 \log_{10} \sum_{i=1}^{n} 10^{\frac{E_i}{10}}$$

where:

E_i : value (dB(μV/m)), of (*NF* + *AF*) for each individual co-sited source. As indicated in § 3 above, *NF* is expressed in dB(μV/m) and *AF* in dB

n : number of co-sited sources

E : effective interference (dB(μV/m)).

Note 1 – The value of *E* represents one of the terms to be included in the procedure given in § 4.3.

4.3 Multiple interference from non co-sited sources

The interference arising from multiple non co-sited sources should be combined by using the simplified multiplication method given in Annex II of the Final Acts of the RARC AFBC(2), 1989, reproduced herein as Attachment 1 to Annex 1.

4.4 Effective transmitting antenna heights

The effective transmitting antenna height is determined according to Recommendation ITU-R P.1546.

When the effective transmitting antenna height is less than 37.5 m or more than 1 200 m, the field-strength values are calculated using the method described in the Final Acts of the RARC AFBC(2), reproduced herein as Attachment 2 to Annex 1.

5. Interference assessments

Interference assessments should normally be made for several reception points within the service area of the sound broadcasting transmitter. These points should be those which are considered to be most likely to suffer from interference. At these points, interference calculations should be made for monophonic and stereophonic reception. The most critical values shall be used in assessing compatibility.

Moreover, for rebroadcasting stations, it is necessary to ensure that the received sound broadcasting signal is also protected against interference.

ATTACHMENT 1

TO ANNEX 1

Reproduced from the Final Acts of the Regional Administrative Conference for the Planning of VHF/UHF Television Broadcasting in the African Broadcasting Area and Neighbouring Countries (Geneva 1989) (RARC AFBC(2)), Annex 2, Chapter 4 (edited to include technical corrections).

"Determination of the usable field strength by the simplified multiplication method

4.1 The concept of usable field strength

The usable field strength, E_u, a quantity characterizing the coverage situation. To calculate the usable field strength, it is necessary to identify all the transmitters:

– which lie within a definite range of the wanted transmitter (according to experience: up to 800 km);

– which might cause interference in relation to the required protection ratio (A_i).

For the n interfering transmitters identified, the resulting nuisance field, E_{si}, is:

$$E_{si} = P_i + E_{ni\,(50,\,T)} + A_i + B_i \tag{1}$$

where:

$E_{ni(50,\,T)}$: field strength in dB(μV/m) of the unwanted signal normalized to 1 kW effective radiated power (e.r.p) at 50% locations for T% time (value derived from field strength curves of Recommendation ITU-R P.1546);

P_i : e.r.p. in dB(kW) of the interfering transmitter in the direction of the wanted transmitter;

A_i : protection ratio (dB);

B_i : receiving antenna discrimination (dB).

The usable field strength, E_u, is a function of the n nuisance fields, E_{si}, and is calculated by way of the formula:

$$p_c = \prod_{i=1}^{n} L(x_i) \text{ with } x_i = \frac{E_u - E_{si}}{\sigma_n \sqrt{2}} \tag{2}$$

in which:

p_c : the coverage probability. To initiate the iterative calculation of E_u a predetermined value, P_{cp}, of the coverage probability is taken, e.g. $p_{cp} = 0.5$. With the value of E_u obtained at the end of the iterative process, the coverage probability is $p_c = p_{cp} = 0.5$, i.e. 50% of locations[1];

L : the probability integral for a normal distribution:

$$L(x) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{x} [\exp(-t^2/2)]\, dt \tag{3}$$

In this function x is the difference between the levels of the usable field-strength, E_u, and the nuisance field E_{si}, referred to σ, the standard deviation (with location) of the resulting difference in level.

Identical values are assumed for the standard deviations (with location) of the wanted and interfering field-strength levels: $\sigma_n = \sigma_s$. Thus, the standard deviation of the resulting level difference is:

$$\sigma = \sqrt{\sigma_n^2 + \sigma_s^2} = \sigma_n \sqrt{2}$$

---

1 p_c can be set to any other value of coverage probability (e.g. 45% → $p_c = 0.45$).

The value σ_n = 8.3 dB is assumed for the frequency Bands I to III. For Band IV/V this value is dependent on the terrain attenuation, *g*. σ is then calculated using the formula $\sigma_n = 9.5 + 0.405\, g$. The attenuation correction factor *g* (in dB) can be derived from Δ*h* (see Recommendation ITU-R P.1546).

4.2 Calculation of the probability integral

4.2.1 Tabular evaluation

The probability integral is as follows:

$$\varphi(x) = \frac{2}{\sqrt{2\pi}} \int_0^x [\exp(-t^2/2)]\, \mathrm{d}t \qquad (4)$$

Its numerical values are given in Table 4.I.

Since

$$\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\infty} [\exp(-t^2/2)]\, \mathrm{d}t = 1$$

and

$$\frac{1}{\sqrt{2\pi}} \int_{-\infty}^{0} [\exp(-t^2/2)]\, \mathrm{d}t = 1/2$$

it follows that:

$$L(x) = \frac{\varphi(x)}{2} + 1/2$$

4.2.2 Evaluation using the Hastings approximation

If the calculations are to be done by computer (or programmable pocket or table calculator), the following rational approximation is very useful:

$$x \geq 0: L(x) = 1 - \frac{1}{(2\pi)^{½}}\, e^{-x^2/2} H(y) \qquad (5)$$

$$x < 0: \mathrm{L}(x) = 1 - L(-x)$$

with:

$H(y) = C_5 y^5 + C_4 y^4 + C_3 y^3 + C_2 y^2 + C_1 y^1$

and:

y = $[1 + 0.2\,316\,419\, |x|]^{-1}$

C_5 = 1.330 274 429

C_4 = –1.821 255 978

C_3 = 1.781 477 937

C_2 = –0.356 563 782

C_1 = 0.319 381 530

By means of approximation (5), one can avoid the integration in formula (3) and avoid using tables to evaluate the probability integral. The error involved by using this approximation is less than 10^{-7}.

4.3 Practical calculation procedures to determine the usable field strength

Since it is impossible to calculate formula (2) explicitly for E_u for a predetermined value p_{cp} (e.g. p_{cp} = 0.5), it must be calculated iteratively. Begin with an initial value for E_u, which, according to experience, should be some 6 dB greater than the largest of the E_{si}, and determine, successively, for each value of E_{si} :

$$z_i = E_u - E_{si} = \Delta_i$$

$$x_i = \frac{\Delta_i}{\sigma_n \sqrt{2}} \text{ (in bands I to III: } x_i = \Delta_i/11.738)$$

$\varphi(x_i)$ from Table 4.I.

$$L(x_i) = \frac{\varphi(x_i)}{2} + \frac{1}{2}$$

Since for the standard deviation a value σ_n = 8.3 dB is assumed to apply for Bands I to III, it is appropriate to use Table 4.II where $L(x_i)$ is presented as a function of Δ_i for σ_n = 8.3 dB. In Bands IV and V, where $\sigma_n = 9.5 + 0.405\ g$, Table 4.II may also be used once the Δ_i values have been corrected using:

$$\Delta'_i = \Delta_i \cdot \frac{8,3}{9.5 + 0.405\ g}$$

p_c is then determined by means of formula (2). If p_c is different from p_{cp} (e.g. p_{cp} = 0.5), the value obtained is used as a basis to correct, as a part of the iterative process, the initial E_u value. From experience, the correction may be assumed to correspond approximately to:

$$\Delta E_u \approx \frac{p_{cp} - p_c}{0.05} \text{ dB}$$

TABLE 4.I $\varphi(x) = \frac{2}{\sqrt{2\pi}} \int_0^x [\exp(-t^2/2)]\,dt$

x	$\varphi(x)$	x	$\varphi(x)$	x	$\varphi(x)$	x	$\varphi(x)$
0.00	0.0000	0.60	0.4515	1.20	0.7699	1.80	0.9281
01	0.0080	61	0.4581	21	0.7737	81	0.9297
02	0.0160	62	0.4647	22	0.7775	82	0.9312
03	0.0239	63	0.4713	23	0.7813	83	0.9328
04	0.0319	64	0.4778	24	0.7850	84	0.9342
0.05	0.0399	0.65	0.4843	1.25	0.7887	1.85	0.9357
06	0.0478	66	0.4907	26	0.7923	86	0.9371
07	0.0558	67	0.4971	27	0.7959	87	0.9385
08	0.0638	68	0.5035	28	0.7995	88	0.9399
09	0.0717	69	0.5098	29	0.8029	89	0.9412
0.10	0.0797	0.70	0.5161	1.30	0.8064	1.90	0.9426
11	0.0876	71	0.5223	31	0.8098	91	0.9439
12	0.0955	72	0.5285	32	0.8132	92	0.9451
13	0.1034	73	0.5346	33	0.8165	93	0.9464
14	0.1113	74	0.5407	34	0.8198	94	0.9476
0.15	0.1192	0.75	0.5467	1.35	0.8230	1.95	0.9488
16	0.1271	76	0.5527	36	0.8262	96	0.9500
17	0.1350	77	0.5587	37	0.8293	97	0.9512
18	0.1428	78	0.5646	38	0.8324	98	0.9523
19	0.1507	79	0.5705	39	0.8355	99	0.9534
0.20	0.1585	0.80	0.5763	1.40	0.8385	2.00	0.9545
21	0.1663	81	0.5821	41	0.8415	05	0.9596
22	0.1741	82	0.5878	42	0.8444	10	0.9643
23	0.1819	83	0.5935	43	0.8473	15	0.9684
24	0.1897	84	0.5991	44	0.8501	20	0.9722
0.25	0.1974	0.85	0.6047	1.45	0.8529	2.25	0.9756
26	0.2041	86	0.6102	46	0.8557	30	0.9786
27	0.2128	87	0.6157	47	0.8584	35	0.9812
28	0.2205	88	0.6211	48	0.8611	40	0.9836
29	0.2282	89	0.6265	49	0.8638	45	0.9857
0.30	0.2358	0.90	0.6319	1.50	0.8664	2.50	0.9876
31	0.2434	91	0.6372	51	0.8690	55	0.9892
32	0.2510	92	0.6424	52	0.8715	60	0.9907
33	0.2586	93	0.6476	53	0.8740	65	0.9920
34	0.2661	94	0.6528	54	0.8764	70	0.9931
0.35	0.2737	0.95	0.6579	1.55	0.8789	2.75	0.9940
36	0.2812	96	0.6629	56	0.8812	80	0.9949
37	0.2886	97	0.6680	57	0.8836	85	0.9956
38	0.2961	98	0.6729	58	0.8859	90	0.9963
39	0.3035	99	0.6778	59	0.8882	95	0.9968
0.40	0.3108	1.00	0.6827	1.60	0.8904	3.00	0.99730
41	0.3182	01	0.6875	61	0.8926	10	0.99806
42	0.3255	02	0.6923	62	0.8948	20	0.99863
43	0.3328	03	0.6970	63	0.8969	30	0.99903
44	0.3401	04	0.7017	64	0.8990	40	0.99933
0.45	0.3473	1.05	0.7063	1.65	0.9011	3.50	0.99953
46	0.3545	06	0.7109	66	0.9031	60	0.99968
47	0.3616	07	0.7154	67	0.9051	70	0.99978
48	0.3688	08	0.7199	68	0.9070	80	0.99986
49	0.3759	09	0.7243	69	0.9090	90	0.99990
0.50	0.3829	1.10	0.7287	1.70	0.9109	4.00	0.99994
51	0.3899	11	0.7330	71	0.9127		
52	0.3969	12	0.7373	72	0.9146	4.417	$1 - 10^{-5}$
53	0.4039	13	0.7415	73	0.9164		
54	0.4108	14	0.7457	74	0.9181	4.892	$1 - 10^{-6}$
0.55	0.4177	1.15	0.7499	1.75	0.9199	5.327	$1 - 10^{-7}$
56	0.4245	16	0.7540	76	0.9216		
57	0.4313	17	0.7580	77	0.9233		
58	0.4381	18	0.7620	78	0.9249		
59	0.4448	19	0.7660	79	0.9265		
0.60	0.4515	1.20	0.7699	1.80	0.9281		

TABLE 4.II

Δ	$L(x)$	–log $L(x)$	Δ	$L(x)$	–log $L(x)$	Δ	$L(x)$	–log $L(x)$	Δ	$L(x)$	–log $L(x)$	Δ	$L(x)$	–log $L(x)$
0.0	0.50000	7.000	5.0	0.66493	4.121	10.0	0.80288	2.217	15.0	0.89936	1.071	20.0	0.95580	0.457
0.1	0.50340	6.932	5.1	0.66803	4.074	10.1	0.80523	2.188	15.1	0.90085	1.054	20.1	0.95659	0.448
0.2	0.50680	6.864	5.2	0.67112	4.028	10.2	0.80757	2.158	15.2	0.90233	1.038	20.2	0.95737	0.440
0.3	0.51020	6.796	5.3	0.67419	3.981	10.3	0.80989	2.129	15.3	0.90379	1.022	20.3	0.95813	0.432
0.4	0.51359	6.729	5.4	0.67726	3.936	10.4	0.81219	2.101	15.4	0.90524	1.005	20.4	0.95889	0.424
0.5	0.51699	6.663	5.5	0.68031	3.890	10.5	0.81448	2.072	15.5	0.90667	0.989	20.5	0.95964	0.416
0.6	0.52038	6.596	5.6	0.68335	3.845	10.6	0.81675	2.044	15.6	0.90808	0.974	20.6	0.96037	0.408
0.7	0.52378	6.531	5.7	0.68638	3.801	10.7	0.81900	2.016	15.7	0.90948	0.958	20.7	0.96109	0.401
0.8	0.52717	6.466	5.8	0.68939	3.756	10.8	0.82124	1.989	15.8	0.91086	0.943	20.8	0.96180	0.393
0.9	0.53056	6.401	5.9	0.69239	3.712	10.9	0.82345	1.962	15.9	0.91222	0.928	20.9	0.96251	0.386
1.0	0.53395	6.337	6.0	0.69538	3.669	11.0	0.82565	1.935	16.0	0.91357	0.913	21.0	0.96320	0.379
1.1	0.53733	6.273	6.1	0.69836	3.626	11.1	0.82784	1.908	16.1	0.91491	0.898	21.1	0.96388	0.372
1.2	0.54071	6.209	6.2	0.70132	3.583	11.2	0.83000	1.882	16.2	0.91623	0.884	21.2	0.96455	0.365
1.3	0.54409	6.147	6.3	0.70427	3.541	11.3	0.83215	1.856	16.3	0.91753	0.869	21.3	0.96521	0.358
1.4	0.54747	6.084	6.4	0.70721	3.499	11.4	0.83428	1.830	16.4	0.91882	0.855	21.4	0.96586	0.351
1.5	0.55084	6.022	6.5	0.71013	3.457	11.5	0.83639	1.804	16.5	0.92009	0.841	21.5	0.96650	0.344
1.6	0.55421	5.960	6.6	0.71304	3.416	11.6	0.83848	1.779	16.6	0.92135	0.827	21.6	0.96713	0.338
1.7	0.55758	5.889	6.7	0.71593	3.375	11.7	0.84056	1.754	16.7	0.92259	0.814	21.7	0.96775	0.331
1.8	0.56094	5.839	6.8	0.71881	3.334	11.8	0.84262	1.729	16.8	0.92382	0.800	21.8	0.96836	0.325
1.9	0.56430	5.778	6.9	0.72168	3.294	11.9	0.84466	1.705	16.9	0.92503	0.787	21.9	0.96896	0.318
2.0	0.56765	5.719	7.0	0.72453	3.254	12.0	0.84669	1.681	17.0	0.92623	0.774	22.0	0.96955	0.312
2.1	0.57099	5.659	7.1	0.72737	3.215	12.1	0.84869	1.657	17.1	0.92741	0.761	22.1	0.97013	0.306
2.2	0.57434	5.600	7.2	0.73019	3.176	12.2	0.85068	1.633	17.2	0.92858	0.748	22.2	0.97071	0.300
2.3	0.57767	5.542	7.3	0.73300	3.137	12.3	0.85265	1.610	17.3	0.92974	0.736	22.3	0.97127	0.294
2.4	0.58100	5.484	7.4	0.73579	3.098	12.4	0.85461	1.587	17.4	0.93088	0.723	22.4	0.97183	0.289
2.5	0.58433	5.426	7.5	0.73857	3.060	12.5	0.85634	1.564	17.5	0.93200	0.711	22.5	0.97237	0.283
2.6	0.58765	5.369	7.6	0.74134	3.023	12.6	0.85846	1.541	17.6	0.93312	0.699	22.6	0.97291	0.277
2.7	0.59096	5.312	7.7	0.74408	2.985	12.7	0.86036	1.519	17.7	0.93421	0.687	22.7	0.97344	0.272
2.8	0.59427	5.256	7.8	0.74682	2.948	12.8	0.86225	1.497	17.8	0.93530	0.676	22.8	0.97396	0.266
2.9	0.59757	5.200	7.9	0.74954	2.912	12.9	0.86412	1.475	17.9	0.93637	0.664	22.9	0.97447	0.261
3.0	0.60086	5.144	8.0	0.75224	2.875	13.0	0.86596	1.453	18.0	0.93742	0.653	23.0	0.97497	0.256
3.1	0.60415	5.089	8.1	0.75492	2.839	13.1	0.86780	1.432	18.1	0.93846	0.641	23.1	0.97546	0.251
3.2	0.60743	5.035	8.2	0.75760	2.804	13.2	0.86961	1.411	18.2	0.93949	0.630	23.2	0.97595	0.246
3.3	0.61070	4.980	8.3	0.76025	2.768	13.3	0.87141	1.390	18.3	0.94051	0.619	23.3	0.97643	0.241
3.4	0.61396	4.926	8.4	0.76289	2.733	13.4	0.87319	1.369	18.4	0.94151	0.609	23.4	0.97690	0.236
3.5	0.61722	4.873	8.5	0.76551	2.699	13.5	0.87495	1.349	18.5	0.94250	0.598	23.5	0.97736	0.231
3.6	0.62046	4.820	8.6	0.76812	2.664	13.6	0.87670	1.329	18.6	0.94347	0.588	23.6	0.97781	0.227
3.7	0.62370	4.768	8.7	0.77071	2.630	13.7	0.87843	1.309	18.7	0.94443	0.577	23.7	0.97826	0.222
3.8	0.62693	4.715	8.8	0.77328	2.597	13.8	0.88014	1.289	18.8	0.94538	0.567	23.8	0.97870	0.217
3.9	0.63015	4.664	8.9	0.77584	2.563	13.9	0.88183	1.270	18.9	0.94632	0.557	23.9	0.97913	0.213
4.0	0.63336	4.612	9.0	0.77838	2.530	14.0	0.88351	1.251	19.0	0.94724	0.547	24.0	0.97956	0.209
4.1	0.63657	4.561	9.1	0.78091	2.497	14.1	0.88517	1.232	19.1	0.94815	0.538	24.1	0.97997	0.204
4.2	0.63976	4.511	9.2	0.78342	2.465	14.2	0.88681	1.213	19.2	0.94905	0.528	24.2	0.98038	0.200
4.3	0.64294	4.461	9.3	0.78591	2.433	14.3	0.88844	1.195	19.3	0.94994	0.519	24.3	0.98078	0.196
4.4	0.64611	4.411	9.4	0.78838	2.401	14.4	0.89005	1.176	19.4	0.95081	0.509	24.4	0.98118	0.192
4.5	0.64928	4.362	9.5	0.79084	2.370	14.5	0.89164	1.158	19.5	0.95167	0.500	24.5	0.98157	0.188
4.6	0.65243	4.313	9.6	0.79328	2.339	14.6	0.89322	1.140	19.6	0.95252	0.491	24.6	0.98195	0.184
4.7	0.65557	4.264	9.7	0.79571	2.308	14.7	0.89478	1.123	19.7	0.95336	0.482	24.7	0.98232	0.180
4.8	0.65870	4.216	9.8	0.79811	2.277	14.8	0.89632	1.105	19.8	0.95418	0.474	24.8	0.98269	0.176
4.9	0.66182	4.168	9.9	0.80050	2.247	14.9	0.89785	1.088	19.9	0.95500	0.465	24.9	0.98305	0.173

TABLE 4.II (*Cont.*)

Δ	$L(x)$	–log $L(x)$	Δ	$L(x)$	–log $L(x)$	Δ	$L(x)$	–log $L(x)$	Δ	$L(x)$	–log $L(x)$	Δ	$L(x)$	–log $L(x)$
25.0	0.98341	0.169	30.0	0.99470	0.054	35.0	0.99857	0.014	40.0	0.99967	0.003	45.0	0.99994	0.001
25.1	0.98376	0.165	30.1	0.99483	0.052	35.1	0.99861	0.014	40.1	0.99968	0.003	45.1	0.99994	0.001
25.2	0.98410	0.162	30.2	0.99496	0.051	35.2	0.99864	0.014	40.2	0.99969	0.003	45.2	0.99994	0.001
25.3	0.98443	0.158	30.3	0.99508	0.050	35.3	0.99868	0.013	40.3	0.99970	0.003	45.3	0.99994	0.001
25.4	0.98476	0.155	30.4	0.99520	0.049	35.4	0.99872	0.013	40.4	0.99971	0.003	45.4	0.99995	0.001
25.5	0.98509	0.152	30.5	0.99532	0.047	35.5	0.99875	0.013	40.5	0.99972	0.003	45.5	0.99995	0.001
25.6	0.98541	0.148	30.6	0.99543	0.046	35.6	0.99879	0.012	40.6	0.99973	0.003	45.6	0.99995	0.001
25.7	0.98572	0.145	30.7	0.99554	0.045	35.7	0.99882	0.012	40.7	0.99974	0.003	45.7	0.99995	0.000
25.8	0.98603	0.142	30.8	0.99565	0.044	35.8	0.99886	0.012	40.8	0.99975	0.003	45.8	0.99995	0.000
25.9	0.98633	0.139	30.9	0.99576	0.043	35.9	0.99889	0.011	40.9	0.99975	0.002	45.9	0.99995	0.000
26.0	0.98662	0.136	31.0	0.99587	0.042	36.0	0.99892	0.011	41.0	0.99976	0.002	46.0	0.99996	0.000
26.1	0.98691	0.133	31.1	0.99597	0.041	36.1	0.99895	0.011	41.1	0.99977	0.002	46.1	0.99996	0.000
26.2	0.98719	0.130	31.2	0.99607	0.040	36.2	0.99898	0.010	41.2	0.99978	0.002	46.2	0.99996	0.000
26.3	0.98747	0.127	31.3	0.99617	0.039	36.3	0.99901	0.010	41.3	0.99978	0.002	46.3	0.99996	0.000
26.4	0.98775	0.125	31.4	0.99626	0.038	36.4	0.99904	0.010	41.4	0.99979	0.002	46.4	0.99996	0.000
26.5	0.98802	0.122	31.5	0.99636	0.037	36.5	0.99906	0.009	41.5	0.99980	0.002	46.5	0.99996	0.000
26.6	0.98828	0.119	31.6	0.99645	0.036	36.6	0.99909	0.009	41.6	0.99980	0.002	46.6	0.99996	0.000
26.7	0.98854	0.116	31.7	0.99654	0.035	36.7	0.99912	0.009	41.7	0.99981	0.002	46.7	0.99997	0.000
26.8	0.98879	0.114	31.8	0.99663	0.034	36.8	0.99914	0.009	41.8	0.99982	0.002	46.8	0.99997	0.000
26.9	0.98904	0.111	31.9	0.99671	0.033	36.9	0.99917	0.008	41.9	0.99982	0.002	46.9	0.99997	0.000
27.0	0.98928	0.109	32.0	0.99680	0.032	37.0	0.99919	0.008	42.0	0.99983	0.002	47.0	0.99997	0.000
27.1	0.98952	0.106	32.1	0.99688	0.032	37.1	0.99921	0.008	42.1	0.99983	0.002	47.1	0.99997	0.000
27.2	0.98976	0.104	32.2	0.99696	0.031	37.2	0.99924	0.008	42.2	0.99984	0.002	47.2	0.99997	0.000
27.3	0.98999	0.102	32.3	0.99704	0.030	37.3	0.99926	0.007	42.3	0.99984	0.002	47.3	0.99997	0.000
27.4	0.99021	0.099	32.4	0.99711	0.029	37.4	0.99928	0.007	42.4	0.99985	0.002	47.4	0.99997	0.000
27.5	0.99043	0.097	32.5	0.99719	0.028	37.5	0.99930	0.007	42.5	0.99985	0.001	47.5	0.99997	0.000
27.6	0.99065	0.095	32.6	0.99726	0.028	37.6	0.99932	0.007	42.6	0.99986	0.001	47.6	0.99997	0.000
27.7	0.99086	0.093	32.7	0.99733	0.027	37.7	0.99934	0.007	42.7	0.99986	0.001	47.7	0.99998	0.000
27.8	0.99107	0.091	32.8	0.99740	0.026	37.8	0.99936	0.006	42.8	0.99987	0.001	47.8	0.99998	0.000
27.9	0.99127	0.089	32.9	0.99747	0.026	37.9	0.99938	0.006	42.9	0.99987	0.001	47.9	0.99998	0.000
28.0	0.99147	0.087	33.0	0.99753	0.025	38.0	0.99940	0.006	43.0	0.99988	0.001	48.0	0.99998	0.000
28.1	0.99167	0.085	33.1	0.99760	0.024	38.1	0.99941	0.006	43.1	0.99988	0.001	48.1	0.99998	0.000
28.2	0.99186	0.083	33.2	0.99766	0.024	38.2	0.99943	0.006	43.2	0.99988	0.001	48.2	0.99998	0.000
28.3	0.99205	0.081	33.3	0.99772	0.023	38.3	0.99945	0.006	43.3	0.99989	0.001	48.3	0.99998	0.000
28.4	0.99223	0.079	33.4	0.99778	0.022	38.4	0.99946	0.005	43.4	0.99989	0.001	48.4	0.99998	0.000
28.5	0.99241	0.077	33.5	0.99784	0.022	38.5	0.99948	0.005	43.5	0.99989	0.001	48.5	0.99998	0.000
28.6	0.99259	0.075	33.6	0.99790	0.021	38.6	0.99950	0.005	43.6	0.99990	0.001	48.6	0.99998	0.000
28.7	0.99276	0.073	33.7	0.99795	0.021	38.7	0.99951	0.005	43.7	0.99990	0.001	48.7	0.99998	0.000
28.8	0.99293	0.072	33.8	0.99801	0.020	38.8	0.99953	0.005	43.8	0.99990	0.001	48.8	0.99998	0.000
28.9	0.99309	0.070	33.9	0.99806	0.020	38.9	0.99954	0.005	43.9	0.99991	0.001	48.9	0.99998	0.000
29.0	0.99326	0.068	34.0	0.99811	0.019	39.0	0.99955	0.005	44.0	0.99991	0.001	49.0	0.99999	0.000
29.1	0.99341	0.067	34.1	0.99816	0.019	39.1	0.99957	0.004	44.1	0.99991	0.001	49.1	0.99999	0.000
29.2	0.99357	0.065	34.2	0.99821	0.018	39.2	0.99958	0.004	44.2	0.99992	0.001	49.2	0.99999	0.000
29.3	0.99372	0.064	34.3	0.99826	0.018	39.3	0.99959	0.004	44.3	0.99992	0.001	49.3	0.99999	0.000
29.4	0.99387	0.062	34.4	0.99831	0.017	39.4	0.99961	0.004	44.4	0.99992	0.001	49.4	0.99999	0.000
29.5	0.99402	0.061	34.5	0.99835	0.017	39.5	0.99962	0.004	44.5	0.99992	0.001	49.5	0.99999	0.000
29.6	0.99416	0.059	34.6	0.99840	0.016	39.6	0.99963	0.004	44.6	0.99993	0.001	49.6	0.99999	0.000
29.7	0.99430	0.058	34.7	0.99844	0.016	39.7	0.99964	0.004	44.7	0.99993	0.001	49.7	0.99999	0.000
29.8	0.99444	0.056	34.8	0.99849	0.015	39.8	0.99965	0.004	44.8	0.99993	0.001	49.8	0.99999	0.000
29.9	0.99457	0.055	34.9	0.99853	0.015	39.9	0.99966	0.003	44.9	0.99993	0.001	49.9	0.99999	0.000

Then the determination of E_u has to be continued by repeating, with the corrected E_u, the calculation of new Δ_i and $L(x_i)$ for each E_{si} and of a new p_c. This procedure has to be carried out until the correction ΔE_u falls below the accuracy limit. Table 4.III gives an example for the iterative determination of E_u in the presence of five nuisance fields (σ_n = 8.3 dB). The values of $L(x_i)$ are taken from Table 4.II.

TABLE 4.III

Approximation		1		2		3	
i	E_{si} (dB)	E_u = 78 dB		E_u = 76.6 dB		E_u = 76.44 dB	
		z_i (dB)	$L(x_i)$	z_i (dB)	$L(x_i)$	z_i (dB)	$L(x_i)$
1	64	14	0.8835	12.6	0.8585	12.44	0.8554
2	72	6	0.6954	4.6	0.6524	4.44	0.6474
3	60	18	0.9374	16.6	0.9214	16.44	0.9193
4	50	28	0.9915	26.6	0.9883	26.44	0.9878
5	45	33	0.9975	31.6	0.9964	31.44	0.9963
p_c			0.5696		0.5082		0.5010
ΔE_u (dB)			≈ – 1.4		≈ – 0.16		≈ – 0.02

The result of the iterative computation is E_u = 76.42 dB.

In view of the need to carry out numerous multiplications using at least four-digit numbers, the method may be simplified further by substituting the $L(x_i)$ values by the logarithms of their reciprocal value. This reduces the computation work to a summation of the –log $L(x_i)$ values. To facilitate the computation of ΔE_u further it is appropriate to select a base for these logarithms such that ΔE_u is immediately apparent from a comparison of the sum with –log p_{cp} (logarithm to the same base), e.g. –log 0.5 (50%).

For convenience, the –log $L(x_i)$ values are included in Table 4.II. As an example these logarithms are used in Table 4.IV. The underlying interference problem is identical in Tables 4.III and 4.IV and so are the results.

TABLE 4.IV

Approximation		1		2		3	
i	E_{si} (dB)	E_u = 78 dB		E_u = 76.7 dB		E_u = 76.45 dB	
		z_i (dB)	–log $L(x_i)$	z_i (dB)	–log $L(x_i)$	z_i (dB)	–log $L(x_i)$
1	64	14	1.251	12.7	1.519	12.45	1.575
2	72	6	3.669	4.7	4.264	4.45	4.386
3	60	18	0.653	16.7	0.814	16.45	0.848
4	50	28	0.087	26.7	0.116	26.45	0.123
5	45	33	0.025	31.7	0.035	31.45	0.037
–	– log p_c – log 0.5*		5.685 – 7.000		6.748 – 7.000		6.969 – 7.000
ΔE_u (dB)			≈ – 1.3		≈ – 0.25		≈ – 0.03

* For p_{cp} = 0.5;
for other values of p_{cp}: –log p_{cp} = (–7 log p_{cp}) / log 2
e.g. for p_{cp} = 0.45: –log p_{cp} = 8.064.

The result of the iterative computation is E_u = 76.42 dB."

ATTACHMENT 2

TO ANNEX 1

Reproduced from the Final Acts of the Regional Administrative Conference for the Planning of VHF/UHF Television Broadcasting in the African Broadcasting Area and Neighbouring Countries (Geneva, 1989) (RARC AFBC(2)), Annex 2, Chapter 2, § 2.1.3.

“*2.1.3* Effective transmitting antenna height

The effective transmitting antenna height, h_1, is defined as the antenna height above the average ground level between 3 km and 15 km from the transmitter in the direction of the receiver. The height of the receiving antenna, h_2, is assumed to be 10 m above the ground.

The curves in Figures 2.2 to 2.25 are given for effective transmitting antenna heights between 37.5 m and 1 200 m, each value given of the "effective height" being twice that of the previous one. For different values of effective height a linear interpolation between the two curves corresponding to effective heights immediately above and below the true value shall be used.

For an effective transmitting antenna height, h_1, in the range 0 to 37.5 m, the field strength at a distance x from the transmitter is taken as the same as that given on the curve for 37.5 m at a distance of $(x + 25 - 4.1\sqrt{h_1})$ km. An effective antenna height of less than 0 m is replaced by 0 m. This procedure is valid for distances beyond the radio horizon given by $(4.1\sqrt{h_1})$ km. Field strength values for shorter distances are obtained by:

– calculating the difference between the field strength value at the radio horizon for height h_1 (using the procedure given above) and the value on the 37.5 m curve for the same distance;

– subtracting the absolute value of the difference thus obtained from the field strength value on the 37.5 m curve for the actual distance involved.

This may be expressed as follows:

$$\text{For } x \geq 4.1\sqrt{h_1} \quad F(x, h_1)^{1)} = F((x + 25 - 4.1\sqrt{h_1}), 37.5)$$

$$\text{For } x < 4.1\sqrt{h_1} \quad F(x, h_1) = F(x, 37.5) - F(4.1\sqrt{h_1}, 37.5) + F(25, 37.5)$$

For an effective transmitting antenna height, h_1, greater than 1 200 m, the field strength at a distance x from the transmitter is taken as the same as that given on the curve for 1 200 m at a distance of $(x + 140 - 4.1\sqrt{h_1})$ km. This procedure is valid for distances beyond the radio horizon, given by $(4.1\sqrt{h_1})$ km. Field strength values for shorter distances are obtained by:

– calculating the difference between the field strength value at the radio horizon for height h_1 (using the procedure given above) and the value on the 1 200 m curve for the same distance;

– adding the absolute value of the difference thus obtained to the field strength value on the 1 200 m curve for the actual distance involved.

This may be expressed as follows:

$$\text{For } x \geq 4.1\sqrt{h_1} \quad F(x, h_1) = F((x + 140 - 4.1\sqrt{h_1}), 1\,200)$$

$$\text{For } x < 4.1\sqrt{h_1} \quad F(x, h_1) = F(x, 1\,200) - F(4.1\sqrt{h_1}, 1\,200) + F(140, 1\,200)$$

This procedure is subject to the limitation that the value obtained does not exceed the free-space value.”

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1) Where $F(x, h_1)$ is the field strength (dB(μV/m)) for a distance x (km) and an effective transmitting antenna height h_1 (m).

ANNEX 2

Protection of the land mobile service from the broadcasting service

The criteria specified in this Annex apply only to:

– analogue speech systems and some digital speech systems for the wanted land mobile signal;

– analogue AM vestigial sideband television systems (including the sound carrier) for the interfering broadcasting service (television);

– analogue FM systems for the interfering broadcasting service (sound).

It is noted that some administrations may use different values for any of the following parameters.

1. Minimum field strength values to be protected

1.1 Protection of analogue speech systems

The minimum median field strength to be protected for analogue land mobile systems, using 25 or 30 kHz channel spacings, is given in Table 14.

TABLE 14

Minimum median field strength to be protected for analogue land mobile systems using 25 or 30 kHz channel spacing

Frequency range (MHz)	Minimum median field strength to be protected (dB(μV/m))	
	Signal quality grade 4	Sound articulation (1) 80%
44-68	19	–
87.5-108	20	–
174-254	21	–
470-582	24	–
582-960	38	36

(1) Sound articulation 80% refers to the results of subjective testing where 80% of the received words are intelligible.

For land mobile systems using 12.5 or 15 kHz channel spacing the values should be 3 dB higher.

For channels using diversity reception, the values should be 8 dB lower.

(Signal quality grade 4 refers to a noticeable interfering effect. The best signal quality is grade 5.)

1.2 Protection of digital speech systems

The minimum median field strength to be protected for digital land mobile systems is given in Table 15.

TABLE 15

Minimum median field strength to be protected for digital land mobile systems

Frequency range (MHz)	Minimum median field strength to be protected (dB(μV/m))	
	π/4 QPSK, 50 kHz channel spacing 3×10^{-2} BER	GMSK, BT = 0.3 200 kHz channel spacing
582-960	30 (1)	32

(1) For channels using diversity reception, the values should be 4 dB lower.

2. Protection ratios

2.1 Sharing with the broadcasting service (television) when the mobile channel falls within the television channel

In the case of sharing between the broadcasting service (television) and the land-mobile service, the protection ratio, when the carrier frequency falls within ±0.5 MHz of the vision carrier, is as given in Table 16.

TABLE 16

Protection ratios for the land mobile service when sharing with the broadcasting service (television)

	Analogue speech systems	Digital systems		
		π/4 QPSK, 50 kHz channel spacing 3×10^{-2} BER		GMSK, BT = 0.3 200 kHz channel spacing
		Static	Fading (1)	
Protection ratio (dB) (wanted/unwanted)	10	11 (2)	17 (2)	9 (2)

(1) Fading refers to the wanted signal.

(2) These values are derived from the protection ratios against interfering signals using the same type of modulation as the wanted signal. Correction factors may be required before applying to sharing with the broadcasting service (television).

The curve giving the relative protection ratio values, as a function of the carrier frequency separation from the vision carrier, is given in Fig. 10.

The frequency separation between each of the carriers shown in Fig. 10, depends on the television system in use. The shaded portion of the figure should only be used when the interfering signal contains a NICAM sound carrier.

2.2 Sharing with the broadcasting service (sound) when the mobile channel falls within 600 kHz of the broadcasting channel

In the case of sharing with the broadcasting service (sound) the protection ratio should be as given in Table 17.

FIGURE 10

Relative values of the radio-frequency protection ratio as a function of the carrier frequency spectrum

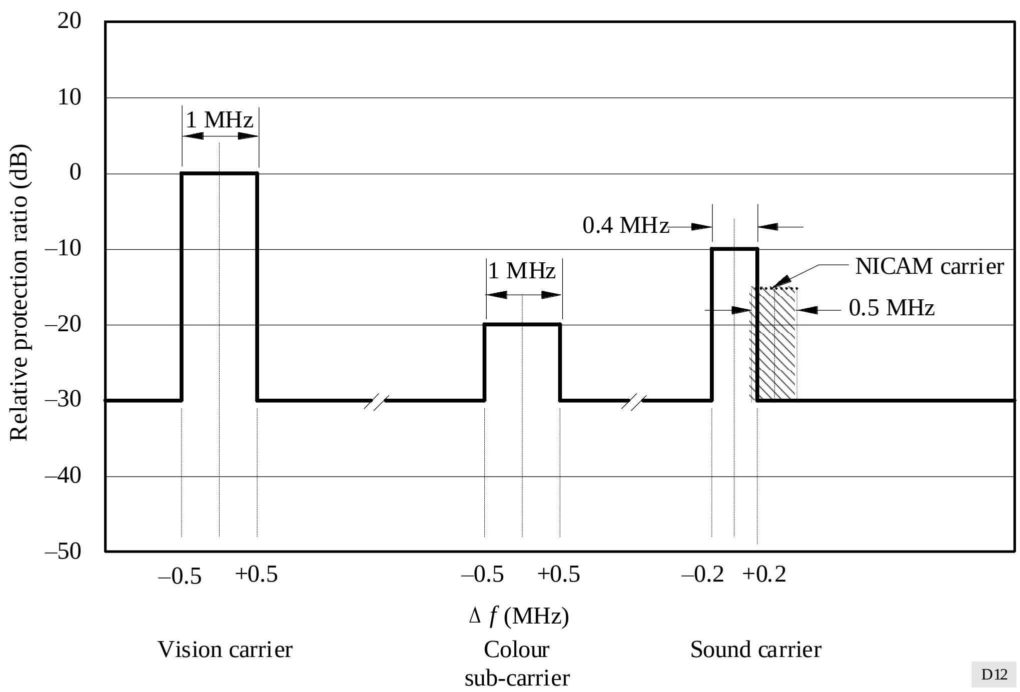


TABLE 17

Protection ratios for the land mobile service when sharing with the broadcasting service (sound)

Frequency separation between carriers of the two services (kHz)	Protection ratio (dB)			
		Digital systems		
	Analogue speech systems (12.5-25 kHz channel spacing)	π/4 QPSK, 50 kHz channel spacing 3 × 10^{-2} BER		GMSK, BT = 0.3 200 kHz channel spacing
		Static	Fading	
0	10	11 (1)	17 (1)	–9 (1)
15	6	–	–1 (1)	–
50	–5.5	–	–42 (1)	–
75	–17.5	–	–	–
100	–27.5	–	–57 (1)	–
200	–	–	–	–9 (1)
400	–	–	–	–41 (1)
600	–	–	–	–49 (1)

(1) These values are derived from the protection ratios against interfering signals using the same type of modulation as the wanted signal. Correction factors may be required before applying to sharing with the broadcasting service (sound).

2.3 Other interference mechanisms

When the land mobile service attempts to operate near a high power transmitter of the broadcasting service operating at different frequencies in the same band, the effects of desensitization, spurious responses or intermodulation product generation can inhibit reception of the wanted land mobile signal.

The figures detailed in the following sections should be used in the calculations described in § 3 of this Annex.

2.3.1 Desensitization

Receivers in the land mobile services can suffer from desensitization in the presence of high power signals occurring outside the mobile channel. The threshold (T) at which desensitization will occur is dependent on the sensitivity of the receiver and the use of out-of-band RF filters. The range for T is typically between 80 and 100 dBμV e.m.f.

In this case, the protection margin (PM) (see § 3) is determined by the following equation:

$$PM = T - R$$

where R is the input voltage to the receiver due to the interfering signal (dBμV).

2.3.2 Intermodulation products

The basic intermodulation phenomena involve the mixing of two or more signals at different frequencies, in a non-linear circuit, which results in the generation of a signal at a different frequency.

In general:

$$f_0 = \pm\, mf_1 \pm nf_2 \pm pf_3 \pm \ldots$$

where:

f_0 : frequency of the intermodulation product

f_1, f_2, f_3 : frequencies of interfering signals

m, n, p : positive integers.

In this Recommendation, only one form of intermodulation is considered, that due to the dominant effect, i.e. the 2-signal, 3rd order mix, given by:

$$f_0 = 2f_1 - f_2$$

When f_0 falls within the bandwidth of the wanted channel(s), the nuisance field (NF) should be determined using the following parameters.

When applying the procedure of § 3, FI is replaced by:

$$\frac{2E_1 + E_2}{3}$$

where E_1 and E_2 are the field strengths (dB(μV/m)) of the interfering signals at frequencies f_1 and f_2.

However, there may be an improvement in the calculated nuisance field which results from the response of the receiver front end at frequencies f_1 and/or f_2.

The protection ratio (PR) required for analogue speech systems (12.5-25 kHz channel bandwidth) associated with intermodulation products is:

–70 dB for base stations

–65 dB for mobile stations.

Similar considerations may apply for digital systems.

2.3.3 Spurious responses

Spurious responses to unwanted signals can be expected to occur in receivers at frequencies related to the receiver local oscillator and intermediate frequencies.

The frequencies at which spurious responses can occur should be calculated using the following expressions:

$$f_{sp} = f_{lo} \pm (if_1 \pm if_2 \pm \ldots \pm if_n \pm sr/2)$$

and

$$f_{sp} = nf_{lo} \pm if_1$$

where:

f_{sp} : frequency at which a spurious response may occur

f_{lo} : frequency of the local oscillator applied to the first mixer of the receiver

s_r : switching range of the receiver (i.e. the maximum frequency range over which the receiver can operate without being reprogrammed or realigned)

n : integer greater than or equal to 2

$if_1, if_2 \ldots if_n$: intermediate frequencies of the receiver.

The protection ratio which applies when the vision or sound carrier of a TV signal or the carrier of a sound broadcasting signal occurs at these frequencies is –67 dB. Under these circumstances, the power of the relevant carrier should be used when calculating the field strength of the unwanted signal.

Similar considerations may apply to digital systems.

3. Protection margin

3.1 Assessment of the protection margin

The protection margin (PM) is given (dB), by:

$$PM = FS - NF - AF$$

where:

FS : minimum field-strength value (dB(μV/m)) given in § 1 of this Annex

NF : nuisance field determined by:

$NF = FI + PR$

FI : interfering field strength of the broadcasting signal for the carrier frequency of the broadcasting signal for 10% of the time and 50% of locations

PR : protection ratio (dB) given in § 2 of this Annex

AF : adjustment factor (dB) to deal with antenna discrimination (see § 4.1 below).

The calculated protection margin should be positive at all locations where the land mobile service is required.

4. Additional factors to consider

4.1 Receiving antenna discrimination

For base stations, the adjustment factor, AF, resulting from the antenna polarization discrimination for horizontally polarized broadcasting emissions is −18 dB.

Where vertically or mixed polarized broadcasting emissions are used, no antenna polarization discrimination should be taken into account and AF is 0 dB.

For mobile stations, no polarization discrimination is taken into account and AF is 0 dB because:

– the mobile receiving system, consisting of an antenna and the body of a vehicle, cannot be assumed to have any orthogonal polarization discrimination;

– the effect of environmental clutter near the mobile station can be expected to introduce a degree of depolarization.

4.2 Antenna heights

For the purpose of interference assessments, the following typical characteristics for the land mobile service may be assumed:

– base station antenna height = 75 m

– mobile station antenna height = 2 m.

5. Interference assessments

Interference assessments should be made for several points within the service area (i.e. where the minimum field strength can be obtained in 50% of locations for 50% of the time) where interference is most likely and at the location of the base station.

The appropriate propagation curves for 50% of locations and 10% of the time of Recommendation ITU-R P.1546 should be used to determine FI, E_1 and E_2.

Appropriate correction factors for frequency, distance, antenna height and terrain should be applied.

To correct values obtained from Recommendation ITU-R P.1564, for receiver antenna heights other than 10 m, but within the range 2 m to 80 m, the following formula or Table 18 should be used:

$$C = 20 \log_{10} \left(\frac{h}{10} \right)$$

where *C* is the correction factor.

In practice, this factor is also dependent on frequency and local clutter but for purposes of calculating interference levels, the formula is adequate.

TABLE 18

Correction factors applicable to Recommendation ITU-R P.1546

Receiving antenna height *h* (m)	Correction factor, *C* (dB)
2	–14
10	0
75	+17.5

ANNEX 3

Protection of the fixed service from the broadcasting service

Introduction

The protection of the fixed service from the broadcasting service in shared or in adjacent VHF and UHF bands should be considered using the methods given below and Recommendation ITU-R F.758.

1. Minimum field strength to be protected

The minimum receiver input level is given by:

$$C_{min} = C/N + N$$

where:

C/N: required carrier-to-noise ratio at the receiver input for a specified performance criteria (dB), see Recommendation ITU-R F.758

N: receiver thermal noise (dBW)

and:

$N = 10 \log_{10} k\, T\, B + F$

k: Boltzmann's constant (1.38×10^{-23})

T: receiver noise temperature (290 K)

B: receiver IF bandwidth (Hz) (system dependent)

F: receiver noise figure (dB) (nominally 5 dB).

If relevant values for receiver IF bandwidth, *B*, and receiver noise figure, *F*, are not available, the receiver thermal noise may be obtained directly from Recommendation ITU-R F.758.

If the receiver IF bandwidth, *B*, is not available, the following approximation can be used.

– For single channel FM systems, the receiver IF bandwidth can be approximated by:

$$B = 2(\beta + BW)$$

where:

β: peak deviation

BW: baseband bandwidth.

– For frequency division multiplex, frequency modulated (FDM-FM) systems, the receiver IF bandwidth can be approximated by:

$$B = 2(\beta + BW)$$

where:

β: multi-channel peak deviation

BW: multi-channel baseband bandwidth.

– For digital systems, the receiver IF bandwidth can be approximated by:

$$B = 1.2R / \log_2 M$$

where:

R: bit rate (bit/s)

M: number of states (e.g., $M = 2$ for PSK, $M = 4$ for QPSK, $M = 16$ for 16 QAM, etc.).

The nominal receiver input level (dBW) is given by:

$$C_{nrx} = C_{min} + FM$$

where:

FM: fade margin

The minimum field strength (FS) (dB(μV/m)) to be protected is given by:

$$FS = C_{nrx}\,(\text{dBW}) - G_r\,(\text{dBi}) + 20 \log_{10} F_o\,(\text{MHz}) + 107.2$$

where:

G_r: receiver antenna gain (dBi)

F_o: receiver-operating frequency (MHz).

2. Protection ratios

In principle, the interference at the receiver input should be more than 6 dB below the receiver thermal noise, *N*. This is equivalent to a fixed system protection ratio (PR) defined in terms of the carrier-to-interference ratio, C_{nrx} / I, given by:

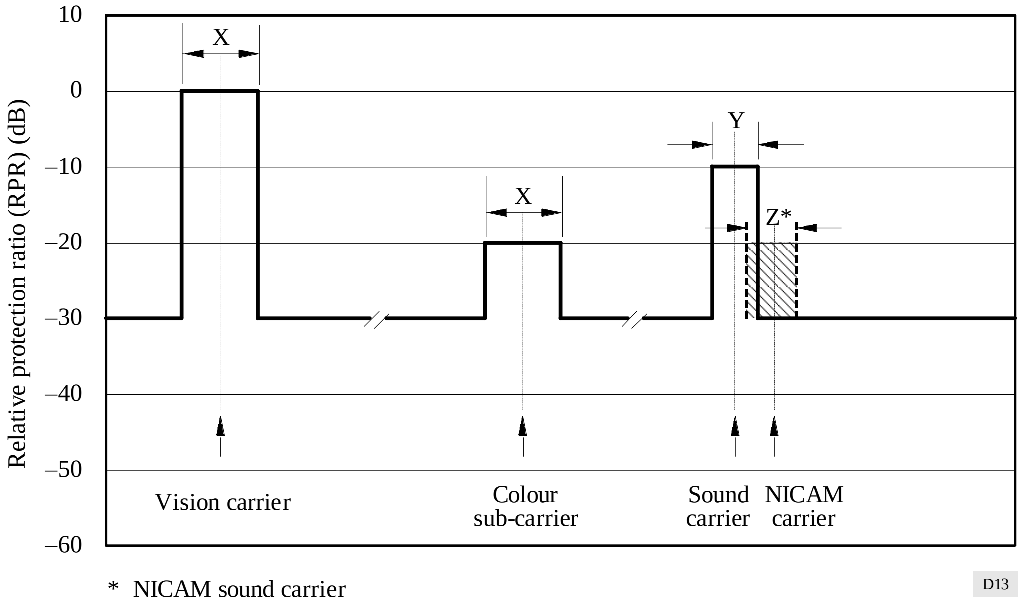
$$PR(\text{dB}) = C_{nrx} / I = C_{nrx} / N + 6 + RPR$$

where I is the interfering signal level (dBW) and RPR is the relative protection ratio normalized to the protection ratio at the vision carrier of the broadcasting signal.

2.1 Sharing in the broadcasting channel (television)

The protection ratio for sharing in the broadcasting channel is a function of the frequency difference between the carrier of the fixed service receiver and the television broadcasting transmitter carrier, the fixed service receiver IF bandwidth (*B*) and the television broadcasting service emission spectrum characteristics. Figure II should be used to determine the relative protection ratio (RPR) when the desired and undesired signals are within the bandwidth of the same broadcasting channel.

FIGURE 11



Relative values of protection ratio as a function of the frequency difference between the fixed service receiver and the TV broadcasting transmitter carrier, the fixed service receiver IF bandwidth (*B*) and the TV broadcasting service emission spectrum characteristics.

Note 1 – $X = 1$ MHz if $B < 1$ MHz

$X = B$ if $B > 1$ MHz

$Y = 0.4$ MHz if $B < 0.4$ MHz

$Y = B$ if $B > 0.4$ MHz

$Z = 0.5$ MHz if $B < 0.5$ MHz

$Z = B$ if $B > 0.5$ MHz

2.2 Sharing outside the broadcasting channel (television)

When the fixed service operates outside the broadcasting service television channel and the fixed service receiver operating frequency (F_o) is separated from the television vision or sound carriers by greater than one-half the receiver IF bandwidth (B), the relative protection ratio (RPR), based on available measurements, can be approximated:

$$RPR = 10 \log_{10} (B / 30) - 70$$

where B is the receiver IF bandwidth (kHz).

2.3 Other interference mechanisms

When the fixed service attempts to operate near a high power transmitter of the broadcasting service operating at different frequencies in the same band, the effects of desensitization, intermodulation and spurious responses can degrade reception of the wanted fixed signal. These effects may be reduced by the use of RF filters.

The figures detailed in the following sections should be used in the calculations described in § 3 of this Annex.

2.3.1 Desensitization

Receivers in the fixed service can suffer from desensitization (front-end-overload) in the presence of high power broadcasting signals occurring outside the fixed receiver channel. Receiver desensitization when the energy from the fundamental frequency (necessary emissions) of an undesired signal saturates the receiver front-end, e.g., low noise amplifier (LNA) resulting in gain compression (reduction in signal level) of the desired signal sufficient to degrade performance. Receiver front-end overload can be mitigated by having adequate RF selectivity prior to the LNA by using a diplexer filter.

The threshold (T) at which desensitization occurs is a function of the gain and the gain compression level (saturation level) of the LNA.

$$T \text{ (dBW)} = 1 \text{ dB compression gain} - \text{LNA gain}$$

A typical 1 dB gain compression level is -20 dBW.

In this case, the protection margin (PM) (see § 3) is determined by the following equation:

$$PM = T - 1$$

2.3.2 Intermodulation products

The basic intermodulation phenomena involve the mixing of two or more signals at different frequencies, in a non-linear circuit, which results in the generation of a signal at a different frequency.

In general:

$$f_0 = \pm\, mf_1 \pm\, nf_2 \pm pf_3 \pm \ldots$$

where:

f_0 : frequency of the intermodulation product

f_1, f_2, f_3 : frequencies of interfering signals

m, n, p : positive integers

In this Recommendation, only one form of intermodulation is considered, that due to the dominant effect, i.e. the 2-signal, 3rd order intermodulation product, given by:

$$f_0 = 2 f_1 - f_2$$

When f_0 falls within the bandwidth of the wanted channel(s), the nuisance field (NF) should be determined using the following parameters.

When applying the procedure of § 3, FI is replaced by:

$$\frac{2 E_1 + E_2}{3}$$

where E_1 and E_2 are the field strengths (dB(μV/m)) of the interfering signals at frequencies f_1 and f_2.

However, there may be an improvement in the calculated nuisance field which results from the response of the receiver front end at frequencies f_1 and/or f_2.

The protection ratio (PR) required for the fixed service associated with intermodulation products is typically 70 dB.

2.3.3 Spurious responses

Spurious responses to unwanted signals can be expected to occur in receivers at frequencies related to the receiver local oscillator frequency (f_{lo})and the receiver intermediate frequencies (f_{IF}).

The frequencies at which spurious responses can occur should be calculated using the following expressions.

$$q f_{sp} = n f_{lo} \pm f_{IF}$$

where:

q: harmonic order of the mixer input signal

f_{sp} : frequency at which a spurious response may occur

n: harmonic order of the local oscillator

f_{lo} : frequency of the local oscillator applied to the mixer stage

The above equation provides the receiver spurious response frequency which produces a signal at the centre of the receiver IF band. Therefore, receiver spurious responses may occur over a frequency range of plus or minus one-half the receiver IF bandwidth.

The protection ratio which applies when the vision or sound carrier of a TV signal occurs at these spurious response frequencies is typically 70 dB. Under these circumstances, the power of the relevant carrier (vision or sound) should be used when calculating the level of the unwanted signal.

3. Protection margin

3.1 Assessment of the protection margin

The protection margin (PM) is given by:

$$PM \text{ (dB)} = FS - NF - AF$$

where:

FS: minimum field-strength value (dB(μV/m)) given in § 1

NF: nuisance field and is determined by:

$NF = FI + PR$

FI: interfering field strength of the broadcasting signal. The appropriate propagation curves for 10% of time and 50% of locations of Recommendation ITU-R P.1546 should be used

PR: protection ratio (dB) given in § 2 of this Annex

AF: adjustment factor (dB) to deal with receiver antenna gain discrimination and polarization discrimination (see § 4).

The calculated protection margin should be positive at all locations where the fixed service is required.

4. Additional factors to consider

4.1 Receiving antenna discrimination

The receiving antenna discrimination is determined by taking into account the receiver antenna gain in the direction of the TV broadcasting station. See Recommendation ITU-R F.699 for determination of the receiving antenna discrimination.

4.2 Receiving antenna cross-polarization discrimination

For fixed stations, the value of the antenna discrimination against orthogonal polarization could be up to 15 dB in the mainbeam. Where non-orthogonal or mixed polarization are used, no antenna polarization discrimination should be taken into account.