

RECOMMENDATION ITU-R BS.412-9*

Planning standards for terrestrial FM sound broadcasting at VHF

(1956-1959-1963-1974-1978-1982-1986-1990-1994-1995-1998)

The ITU Radiocommunication Assembly,

recommends

that the following planning standards should be used for frequency modulation sound broadcasting in band 8 (VHF):

1 Minimum usable field strength

1.1 In the presence of interference from industrial and domestic equipment (for limits of radiation from such equipments refer to Recommendation ITU-R SM.433, which gives the relevant CISPR recommendations) a satisfactory service requires a median field strength (measured at 10 m above ground level) not lower than those given in Table 1:

TABLE 1

Areas	Services	
	Monophonic dB(μ V/m)	Stereophonic dB(μ V/m)
Rural	48	54
Urban	60	66
Large cities	70	74

1.2 In the absence of interference from industrial and domestic equipment, the field strength values (measured at 10 m above ground level) given in Table 2 can be considered to give an acceptable monophonic or stereophonic service, respectively. These field strength values apply when an outdoor antenna is used for monophonic reception, or a directional antenna with appreciable gain for stereophonic reception (pilot-tone system, as defined in Recommendation ITU-R BS.450).

TABLE 2

Services	
Monophonic dB(μ V/m)	Stereophonic dB(μ V/m)
34	48

NOTE 1 – The figures of Table 2 are not median values and, consequently, they are not directly comparable with those given in Table 1.

* Radiocommunication Study Group 6 made editorial amendments to this Recommendation in 2002 in accordance with Resolution ITU-R 44.

1.3 In a practical plan, because of interferences from other sound broadcasting transmissions, the field strength values that can be protected will generally be higher than those of Table 1. Moreover, in the case of the boundary area between any two countries, the exact values to be used should be agreed between the administrations concerned.

2 Radio-frequency protection ratios

2.1 General

2.1.1 The Radio-Frequency (RF) protection ratio is the minimum value of wanted-to-unwanted signal ratio, usually expressed in decibels at the receiver input, determined under specified conditions such that a specific reception quality is achieved at the receiver output.

The protection ratio curves were originally determined by subjective evaluation of interference effects. As subjective tests are rather time-consuming an objective measuring method was developed (see Annex 1 to Recommendation ITU-R BS.641) and found to yield results which are in fair agreement with those of the subjective tests.

2.1.2 Except where otherwise stated, the values of protection ratio quoted apply to interference produced by a single source. In the case of multiple interferences, appropriate assessment methods are indicated in Report ITU-R BS.945.

2.1.3 It is assumed that wanted and unwanted signals contain different programmes without any correlation. In the case of an identical programme (same modulation), an improvement of the protection ratio is expected at least for monophonic signals.

2.1.4 In the case of same frequency and same modulation, with synchronized signals, the protection ratios for monophonic signals are much lower than those in Fig.1. In the case of stereophonic signals the protection ratios depend on the propagation delay and on the stereophonic content (see Annex 3).

2.1.5 The protection ratio values are given for steady and tropospheric interference respectively. The protection ratios for steady interference provide approximately 50 dB signal-to-noise ratio (weighted quasi-peak measurement according to Recommendation ITU-R BS.468, with a reference signal at maximum frequency deviation. See also Annex 1 to Recommendation ITU-R BS.641). The protection ratios for tropospheric interference correspond closely to a slightly annoying impairment condition and it is considered 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 %.

In determining whether the interference is to be regarded as steady or tropospheric, see Annex 1.

Significantly strong wanted signals can require higher protection ratio values than those given in Fig. 1 and Fig. 2, because of non-linear effects in the receiver (see Annex 2).

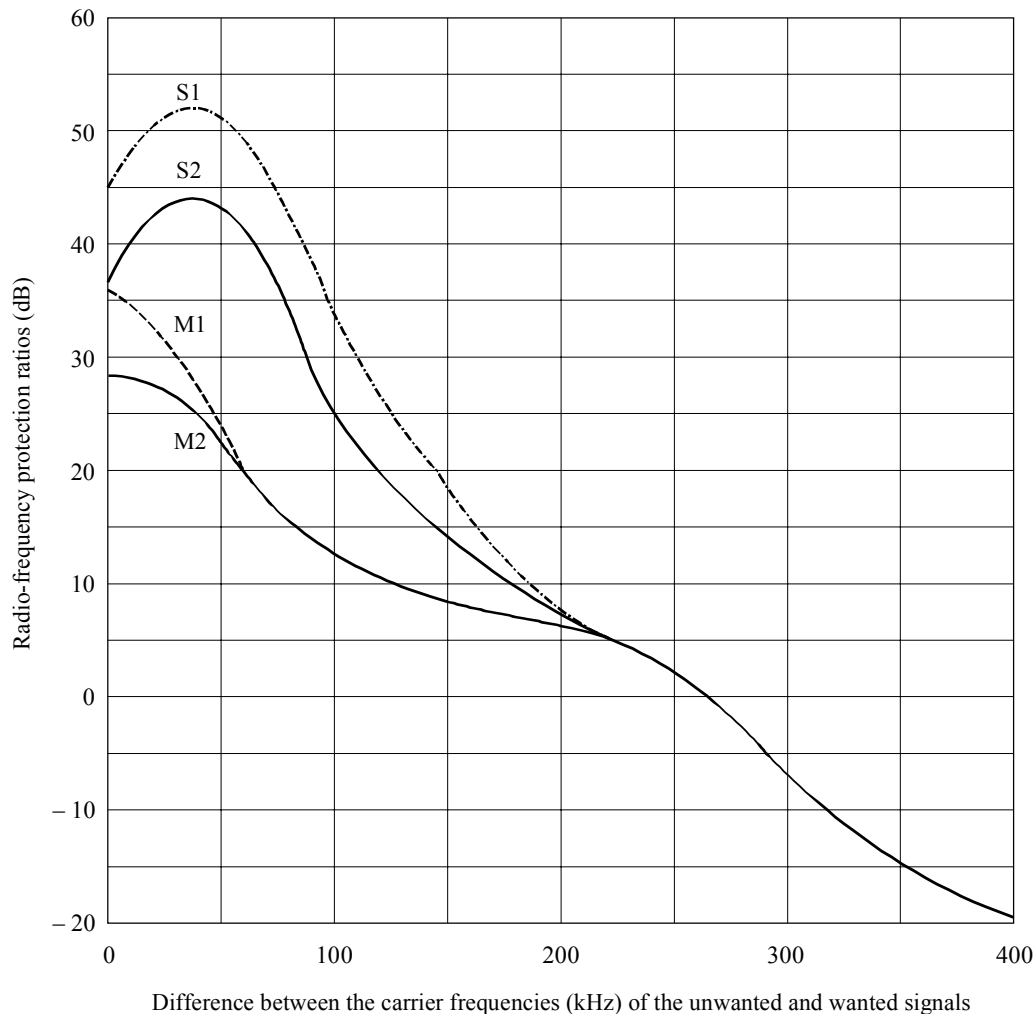
2.2 Monophonic service

2.2.1 The radio-frequency protection ratios required to give satisfactory monophonic reception, in systems using a maximum frequency deviation of ± 75 kHz, for tropospheric interference, are those given by curve M2 in Fig. 1. For steady interference, it is desirable to provide a higher degree

of protection, shown by the curve M1 in Fig. 1. The protection ratios at important values of the carrier frequency spacing are also given in Table 3.

FIGURE 1

**Radio-frequency protection ratio 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
 S1: stereophonic broadcasting; steady interference
 S2: stereophonic broadcasting; tropospheric interference

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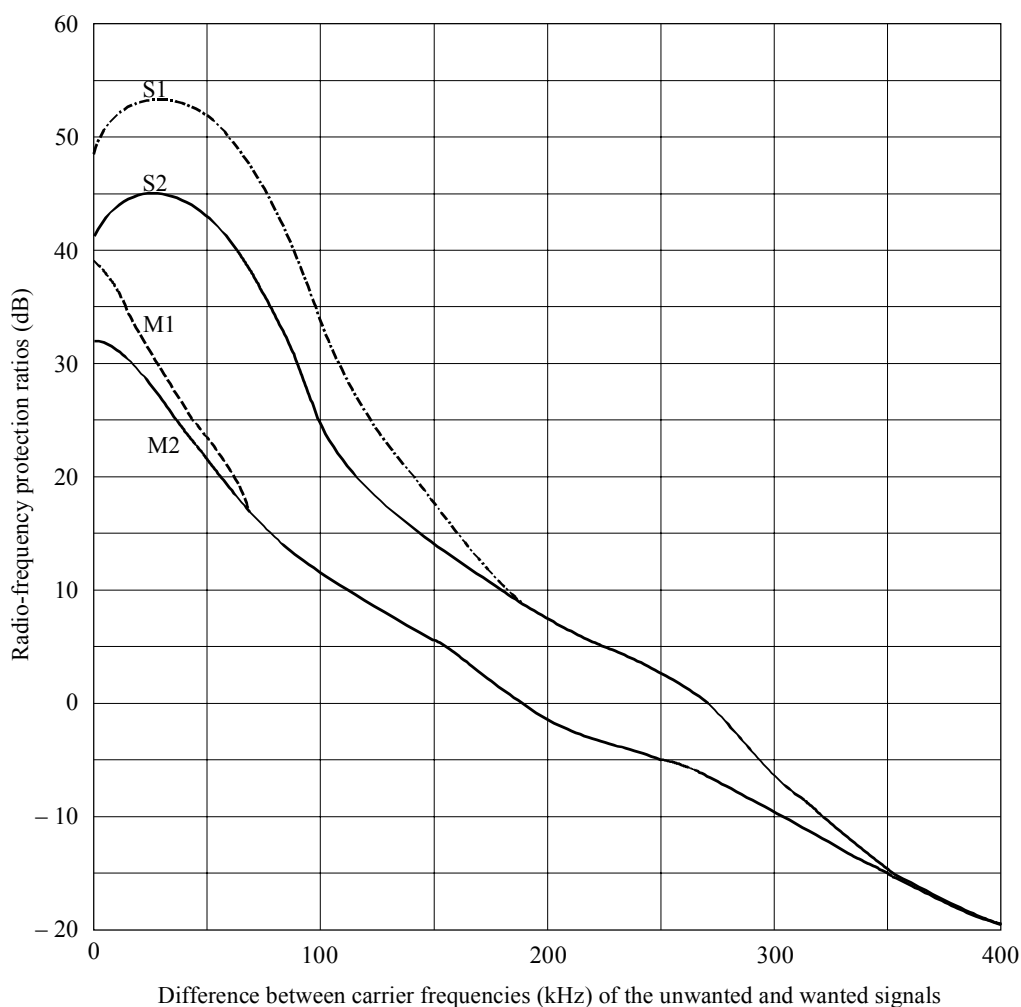
2.2.2 The corresponding values for monophonic systems using a maximum frequency deviation of ± 50 kHz are those given by the curves M2 and M1 in Fig. 2. The protection ratios at important values of the carrier frequency spacing are also given in Table 4.

2.3 Stereophonic service

2.3.1 The radio-frequency protection ratios required to give satisfactory stereophonic reception, for transmissions using the pilot-tone system and a maximum frequency deviation of ± 75 kHz, for tropospheric interference, are those given by curve S2 in Fig. 1. For steady interference it is desirable to provide a higher degree of protection, shown by the curve S1 in Fig. 1.

FIGURE 2

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
 S1: stereophonic broadcasting; steady interference
 S2: stereophonic broadcasting; tropospheric interference

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The protection ratios at important values of the carrier frequency spacing, are also given in Table 3.

2.3.2 The corresponding values for stereophonic systems using a maximum frequency deviation of ± 50 kHz are those given by the curves S2 and S1 in Fig. 2. The protection ratios at important values of the carrier frequency spacing are also given in Table 4.

TABLE 3

Carrier frequency spacing (kHz)	Radio-frequency protection ratio (dB) using a maximum frequency deviation of ± 75 kHz			
	Monophonic		Stereophonic	
	Steady interference	Tropospheric interference	Steady interference	Tropospheric interference
0	36.0	28.0	45.0	37.0
25	31.0	27.0	51.0	43.0
50	24.0	22.0	51.0	43.0
75	16.0	16.0	45.0	37.0
100	12.0	12.0	33.0	25.0
125	9.5	9.5	24.5	18.0
150	8.0	8.0	18.0	14.0
175	7.0	7.0	11.0	10.0
200	6.0	6.0	7.0	7.0
225	4.5	4.5	4.5	4.5
250	2.0	2.0	2.0	2.0
275	-2.0	-2.0	-2.0	-2.0
300	-7.0	-7.0	-7.0	-7.0
325	-11.5	-11.5	-11.5	-11.5
350	-15.0	-15.0	-15.0	-15.0
375	-17.5	-17.5	-17.5	-17.5
400	-20.0	-20.0	-20.0	-20.0

TABLE 4

Carrier frequency spacing (kHz)	Radio-frequency protection ratio (dB) using a maximum frequency deviation of ± 50 kHz			
	Monophonic		Stereophonic	
	Steady interference	Tropospheric interference	Steady interference	Tropospheric interference
0	39.0	32.0	49.0	41.0
25	32.0	28.0	53.0	45.0
50	24.0	22.0	51.0	43.0
75	15.0	15.0	45.0	37.0
100	12.0	12.0	33.0	25.0
125	7.5	7.5	25.0	18.0
150	6.0	6.0	18.0	14.0
175	2.0	2.0	12.0	11.0
200	-2.5	-2.5	7.0	7.0
225	-3.5	-3.5	5.0	5.0
250	-6.0	-6.0	2.0	2.0
275	-7.5	-7.5	0	0
300	-10.0	-10.0	-7.0	-7.0
325	-12.0	-12.0	-10.0	-10.0
350	-15.0	-15.0	-15.0	-15.0
375	-17.5	-17.5	-17.5	-17.5
400	-20.0	-20.0	-20.0	-20.0

2.4 Carrier frequency differences greater than 400 kHz

The curves of Fig. 1 and Fig. 2 give protection ratio values for carrier frequency differences between unwanted and wanted signals of up to 400 kHz.

For carrier frequency differences greater than 400 kHz, the protection ratio values should be substantially lower than -20 dB. Detailed information on this subject is given in Annex 2.

The radio-frequency protection ratio value for the particular carrier frequency difference of 10.7 MHz (intermediate frequency) should be below -20 dB.

2.5 Technical conditions

2.5.1 For the radio-frequency protection ratios given in Fig. 1 and Table 3, it is assumed that the maximum peak deviation of ± 75 kHz is not exceeded. Moreover, it is assumed that the power of the complete multiplex signal (including pilot-tone and additional signals) integrated over any interval of 60 s is not higher than the power of a multiplex signal containing a single sinusoidal tone which causes a peak deviation of ± 19 kHz.

It is important that the limits for modulation levels given above should not be exceeded, otherwise the radiated power of the transmitter has to be reduced in accordance with the increased figures for protection ratios given in Annex 2.

Examples of measurement results, showing the maximum peak deviation and the power of the complete multiplex signal as a function of time are given in Annex 4.

NOTE – The power of a sinusoidal tone causing a peak deviation of ± 19 kHz is equal to the power of the coloured noise modulation signal according to Recommendation ITU-R BS.641, i.e. a coloured noise signal causing a quasi-peak deviation of ± 32 kHz.

2.5.2 The protection ratios for stereophonic broadcasting assume the use of a lowpass filter following the frequency modulation demodulator in the receiver designed to reduce interference and noise at frequencies greater than 53 kHz in the pilot-tone system and greater than 46.25 kHz in the polar-modulation system. Without such a filter or an equivalent arrangement in the receiver, the protection ratio curves for stereophonic broadcasting cannot be met, and significant interference from transmissions in adjacent or nearby channels is possible.

In determining the characteristics of the filters whose phase response is important in the preservation of channel separation at high audio frequencies, reference should be made to Annex III of Recommendation ITU-R BS.644.

2.5.3 In the case of AM-FM receivers, it is necessary to take measures so that the circuits at the AM intermediate frequency (generally 450-470 kHz) do not worsen the protection ratios when the receiver is operating in FM, particularly for differences between the frequencies of the wanted and interfering carrier greater than 300 kHz.

2.5.4 Data systems or other systems providing supplementary information, if introduced, should not cause more interference to monophonic and stereophonic services than is indicated by the protection ratio curves in Fig. 1. It is not considered practicable in the planning to provide additional protection to data services or other services providing supplementary information signals.

3 Channel spacing

In frequency planning, channels are to be assigned in such a way that:

3.1 the carrier frequencies which define the nominal placement of the RF channels within the band are integral multiples of 100 kHz;

3.2 a uniform channel spacing of 100 kHz applies for both monophonic and stereophonic transmissions.

In those cases where a 100 kHz channel spacing would be difficult to implement, the use of a spacing which is an integral multiple of 100 kHz would also be acceptable, provided that the carrier frequencies are chosen in accordance with § 3.1 above.

ANNEX 1

Determination of whether the interference is to be regarded as steady or tropospheric

To apply the protection ratio curves of Figs. 1 and 2 it is necessary to determine whether, in the particular circumstances, the interference is to be regarded as steady or tropospheric. A suitable criterion for this is provided by the concept of “nuisance field” which is the field strength of the interfering transmitter (at its pertinent e.r.p.) enlarged by the relevant protection ratio.

Thus, the nuisance field for steady interference:

$$E_s = P + E(50, 50) + A_s$$

and the nuisance field for tropospheric interference:

$$E_t = P + E(50, T) + A_t$$

where:

P : e.r.p. (dB(1 kW)) of the interfering transmitter

A : radio-frequency protection ratio (dB)

$E(50, T)$: field strength (dB(μV/m)) of the interfering transmitter, normalized to 1 kW, and exceeded during $T\%$ of the time

and where indices s and t indicate steady or tropospheric interference respectively.

At the VHF/FM Conference, Geneva 1984, the percentage of time was chosen to be $T = 1\%$.

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

i.e. $E_s \geq E_t$

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

$$E(50, 50) + A_s \geq E(50, T) + A_t$$

ANNEX 2

Particular interference cases in FM broadcasting**1 Interference caused by an overmodulated transmitter**

Laboratory measurements were made in France to evaluate the sensitivity of several receivers to interference in the case where the interfering transmitter is overmodulated.

Interference was measured as described in Annex 1 to Recommendation ITU-R BS.641, for a stereophonic signal and a wanted RF receiver input level of -50 dB(mW) (0.7 mV/ $50\ \Omega$).

The -3 dB and -40 dB bandwidths of the RF filter added at the output of the interfering transmitter were 500 kHz and $2\ 600$ kHz respectively.

Two overmodulation values were used: $+3$ dB and $+6$ dB. It was found that, for interfering signals within the receiver passband, the increase of protection ratios was not related to the type of receiver; thus, for a 100 kHz carrier frequency spacing, the increases in protection ratio were 11 dB and 15 dB for increases in modulation depth of 3 dB and 6 dB respectively.

On the other hand, it was found that in the case of interference with a (non-standard) 150 kHz carrier frequency spacing, the change in protection ratios could be as high as 6 dB for a 1 dB change in modulation depth of the interfering transmitter.

2 Interference for large carrier frequency differences

Tests to evaluate the effect of interference from transmissions having large frequency differences, which were carried out under similar conditions to those given in § 1 above, were also made in France.

In this case, measurements were made with normal modulation of the interfering transmitter and for carrier frequency spacing up to 1 MHz. The measurements showed that, beyond 400 kHz, there was no relationship whatsoever between protection ratios, whether or not the unwanted transmitter was modulated.

With a professional receiver, the protection ratios decrease when a narrow-band RF filter (-40 dB bandwidth equal to $1\ 200$ kHz) is inserted at the output of the interfering transmitter. This shows that reception is disturbed only by the residual noise sidebands of the unwanted carrier.

On the other hand for the domestic receivers used, the protection ratios are almost constant from 400 kHz onwards, and have a value of around -40 dB which is practically independent of the type of filtering used on the interfering carrier. In this case, it is only the presence of the interfering carrier which impairs reception, with many possible causes of disturbance, such as desensitization of the input stage, local oscillator drive, etc.

3 Interference when the protection ratio is not respected

Tests were carried out in France on three receivers (professional, semi-professional and commercial) when the protection ratio is not respected.