

RECOMMENDATION ITU-R BS.560-4*

**Radio-frequency protection ratios in
LF, MF and HF broadcasting**

(1978-1982-1986-1990-1997)

The ITU Radiocommunication Assembly,

recommends

that the radio-frequency (RF) protection ratios for sound broadcasting in bands 5 (LF), 6 (MF), and 7 (HF) as given in § 1 and 2 should be applied.

1 RF protection ratio in bands 5 (LF) and 6 (MF)

The RF protection ratio (as defined in Recommendation ITU-R BS.638) for co-channel transmissions (± 50 Hz) should be 40 dB when both the wanted and the unwanted signals are stable (ground wave).

When the wanted signal is stable and the unwanted signal fluctuates (including short-term fluctuations), the RF protection ratio should be 40 dB at the reference time (see Annex 1 to Recommendation ITU-R P.1147) for at least 50% of the nights of the year. This protection ratio corresponds to the ratio of the wanted field strength and the annual median value of the hourly medians of the interfering field strength at the reference time.

The protection so defined is provided:

- for 50% of the nights at the reference time;
- for more than 50% of the nights at times other than the reference time;
- for 100% of the days during daylight hours.

The RF protection ratio values specified above will permit a service of excellent reception quality. For planning purposes, however, lower values may be required. In this respect, proposals have been made by some countries and organizations (see Annex 3).

NOTE 1 – The minimum usable field strength to which this protection ratio of 40 dB applies varies in the different regions and also with frequency. Within the European zone, this minimum is of the order of 1 mV/m.

NOTE 2 – A co-channel protection ratio of 26 dB was used by the Regional Administrative MF Broadcasting Conference (Region 2) (Rio de Janeiro, 1981) for both ground-wave and sky-wave services. Region 2 has two noise zones, 1 and 2, the former for most of the Region, the latter for a defined tropical area. In noise zone 1, the nominal usable field strength is 100 μ V/m daytime and 500 μ V/m night-time for Class A stations which have secondary service areas. It is 500 μ V/m daytime for Classes B and C, and 2 500 and 4 000 μ V/m respectively, night-time.

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

In noise zone 2, these values are generally 2.5 times more than the above figures.

Night-time protection, computed for two hours after sunset, is afforded for 50% of the nights of the year, except that the countries of North America agreed to protection from each other for 90% of the nights.

NOTE 3 – Co-channel protection ratios of 30 and 27 dB were used by the Regional Administrative LF/MF Broadcasting Conference (Regions 1 and 3) (Geneva, 1975), for ground-wave and sky-wave services, respectively.

2 Relative RF protection ratio curves in bands 5 (LF), 6 (MF) and 7 (HF)

The relative RF protection ratio is the difference (dB) between the protection ratio when the carriers of the wanted and unwanted transmitters have a frequency difference of Δf (Hz or kHz) and the protection ratio when the carriers of these transmitters have the same frequency.

Once a value for the co-channel RF protection ratio (which is equal to the audio-frequency protection ratio) has been determined, then the RF protection ratio, expressed as a function of the carrier frequency spacing, is given by the curves of Fig. 1 (see also Annex 1):

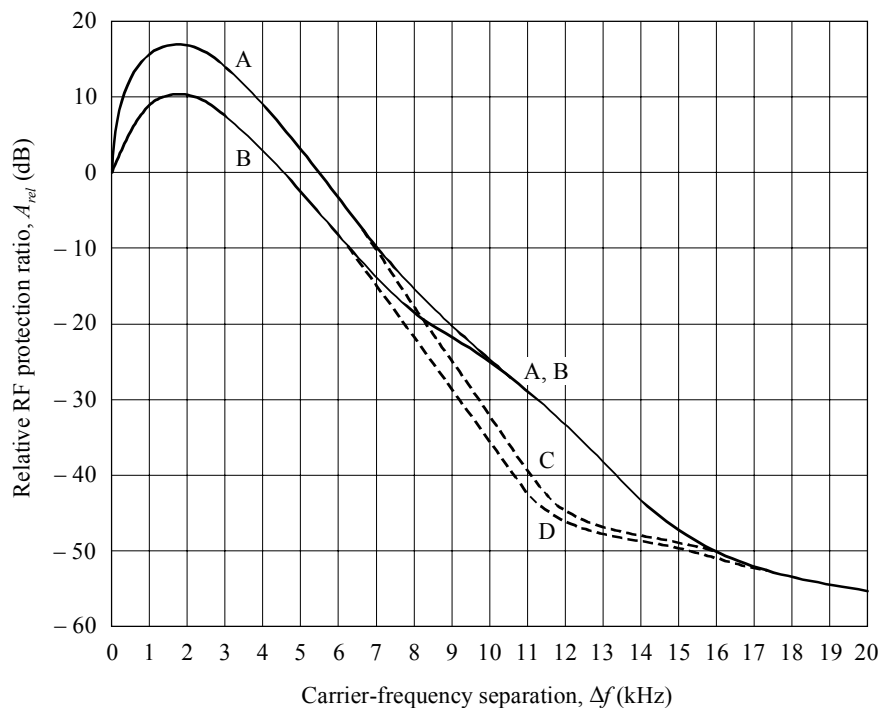
- curve A is applicable when a limited degree of modulation compression is applied at the transmitter input, such as in good quality transmissions, and when the bandwidth of the audio-frequency modulating signal is of the order of 10 kHz;
- curve B is applicable when a high degree of modulation compression (at least 10 dB greater than in the preceding case) is applied by means of an automatic device and when the bandwidth of the audio-frequency modulating signal is in the order of 10 kHz;
- curve C is applicable when a limited degree of modulation compression (as in the case of curve A) is applied and when the bandwidth of the audio-frequency modulating signal is in the order of 4.5 kHz;
- curve D is applicable when a high degree of modulation compression (as in the case of curve B) is applied by means of an automatic device and when the bandwidth of the audio-frequency modulating signal (see Note 1) is in the order of 4.5 kHz.

NOTE 1 – The second session of the World Administrative Radio Conference for the Planning of HF Bands Allocated to the Broadcasting Service (Geneva, 1987) (WARC HFBC-87) decided that the upper limit of the audio-frequency band (at –3 dB) of the transmitter shall not exceed 4.5 kHz and the lower limit shall be 150 Hz, with lower frequencies attenuated at a rate of 6 dB/octave.

If audio-frequency signal processing is used, the dynamic range of the modulating signal shall be not less than 20 dB.

The curves A, B, C and D (see also Annex 1) are valid only when the wanted and unwanted transmissions are compressed to the same extent. They have been obtained mainly from measurements and calculations using a reference receiver representative of good quality receivers used for reception in bands 5 (LF) and 6 (MF). The overall frequency response curve of the European Broadcasting Union (EBU) reference receiver used passes through –3 dB, –24 dB and –59 dB at 2 kHz, 5 kHz and 10 kHz respectively.

FIGURE 1
Relative value of the RF protection ratio as a function
of the carrier-frequency separation



0560-01

ANNEX 1

The shape of the relative RF protection ratio curves depends upon the receiver selectivity, the bandwidth of the audio-frequency modulating signal and the ratio of the energy of the carrier to that of the sidebands. This latter phenomenon is most important between 250 Hz and 5 kHz approximately, where the disturbance is essentially due to the whistle produced by the carrier frequency beat. The shape of the curves in Fig. 1 therefore depends upon the average modulation depth and upon the dynamic compression of the modulation signals.

Curve A represents average values derived from calculations and from tests made with various receivers mainly designed for reception in band 5 (LF) and band 6 (MF), with modulation compression typical of that currently applied in the studio, i.e. with compression permitting a maximum dynamic range of at least 30 dB.

Curve B applies to the use of compression, as could be applied by an automatic device, of at least 10 dB higher than in the preceding case.

Both curves A and B, as distinct from curves C and D, apply to a bandwidth of the audio-frequency modulating signal having a bandwidth in the order of 10 kHz.

Curves C and D apply to the use of compression of the same order of magnitude as in the cases of curves A and B, respectively. The bandwidth of the audio-frequency modulating signal, is, however, restricted to about 4.5 kHz. This degree of bandwidth limitation reduces interference from adjacent channels without leading to any significant degradation of the reception quality in practice.

It should be noted that, in some circumstances, listeners are able to reduce the interfering effect of an unwanted transmission, spaced by more than approximately 3 kHz, by adjusting their receivers (slight detuning, selectivity control, tone control, etc.). Under these conditions, the curves of Fig. 1 are no longer applicable. However, the practice of detuning leads to distortion and cannot be used when two interfering emissions of approximately equal strength are present, on both sides of the wanted carrier frequency. Moreover, many receivers are not equipped with a selectivity control or tone control.

NOTE 1 – In addition to the relative RF protection ratios given in this Recommendation there are other factors of importance in determining optimum frequency spacings.

NOTE 2 – Caution should be exercised when relative values of RF protection ratios beyond –50 dB are obtained from the curves because, in practice, non-linear distortion originating in the transmitter may lead to less protection than indicated.

ANNEX 2

Presentation of experimental results

Whenever possible, the results of measurements of the radio-frequency protection ratio between two broadcast signals should be presented in terms of the following characteristics and parameters:

- type of modulation;
- separation between the carrier frequencies (kHz) (this should lie between 0 and at least 10 kHz);
- modulation depth of both signals;
- occupied bandwidth;
- modulation processing (compression and pre-emphasis);
- type of programmes carried by the wanted and unwanted signals;
- characteristics of fading, if present;
- radio-frequency input voltage of the wanted signal (the RF input voltage should be chosen in such a way so as to ensure that the protection ratios are not significantly affected by non-linearities within the RF and intermediate frequency stages of the receiver);
- passband of the receiver before demodulation;
- overall audio frequency response curve of the receiver, including the loudspeaker;
- the grade of listener satisfaction aimed at, and the statistical distribution of such grades;
- the measuring method (subjective or objective).

ANNEX 3

Protection ratios used in the LF, MF and HF broadcasting**1 Introduction**

This Annex is a summary of the information available concerning protection ratios for amplitude modulation sound-broadcasting services. It is confined, however, to results obtained since 1948.

Agreed values of protection ratios are essential for the solution of frequency assignment problems in the amplitude modulation sound broadcasting service. Moreover, they may serve as basic reference data for the evaluation of the relative merits and the effectiveness to be expected with various amplitude modulation transmission systems.

The protection ratios quoted refer, in all cases, to the ratios at the input to the receiver, no account having been taken of the effect of using directional receiving antennas.

Protection ratios depend on a multiplicity of parameters, among which transmission standards and receiver characteristics play an important role. Apart from technical factors there are others of a physiological and psychological nature which have to be respected. It is, therefore, extraordinarily difficult to determine generally agreed values of protection ratios, even if both the transmission standards and the receiver characteristics are given (see Recommendation ITU-R BS.559).

It is well known that the RF protection ratios for transmitters working in the same channel and transmitting the same programme can be improved considerably by synchronizing techniques, thereby increasing the coverage areas of these transmitters (see also ex-CCIR Report 616 (Dubrovnik, 1986)). Actual values for these protection ratios depend upon various factors, including the synchronization method (see § 10). A value of 8 dB was laid down at the Regional Administrative LF/MF Broadcasting Conference (Regions 1 and 3) (Geneva, 1975).

2 Audio-frequency protection ratio

The audio-frequency protection ratio is the agreed minimum value of the audio signal-to-interference ratio considered necessary to achieve a subjectively defined reception quality (see Recommendation ITU-R BS.638).

This ratio may have different values according to the type of service desired. It depends greatly upon the type of wanted and unwanted programmes. It is therefore essential to carry out a considerable number of subjective listening tests, before a minimum value of the audio frequency signal-to-interference ratio can be agreed upon.

It must clearly be stated that, due to physiological and psychological effects, it is impossible to specify sensible values for the audio-frequency protection ratio by methods other than subjective testing.

3 RF protection ratio

The RF protection ratio is the value of the RF wanted-to-interfering signal ratio that, under specified conditions, enables the audio-frequency protection ratio to be obtained at the output of a receiver.

The RF protection ratio may, thus, be determined by means of subjective tests, as in the case of the audio-frequency protection ratio. When proceeding in this way the number of parameters to be taken into account and, hence, the amount of work to be done, will prove to be far greater than in the preceding case. Comparable results can only be obtained if the test conditions are similar.

However, the assessment of RF protection ratios can be considerably facilitated, once the audio-frequency protection ratio has been determined. Due to the fact that the majority of physiological and psychological effects only influence the audio-frequency protection ratio, it is possible to derive, under specified technical conditions and for a given value of the audio-frequency protection ratio, values of RF protection ratios, either by objective measuring methods or by graphical or numerical methods (see Recommendation ITU-R BS.559).

It must be emphasised that the last three methods mentioned for the establishment of RF protection ratios are based on the same basic ideas. They should lead, therefore, in principle, to the same results and will, provided the three methods are used with sufficiently high precision.

The lack of suitably reliable values for RF protection ratios in the past was mainly a consequence of the very complicated relationship between the RF protection ratio and the overall amplitude/frequency response of the receivers. The latter depends on the selectivity of the RF and the intermediate-frequency stages, the selectivity of the demodulator and the amplitude/frequency response of the audio-frequency stages. This difficulty has been overcome partly by the establishment of the objective two-signal measuring method.

Numerical methods previously mentioned may be used to relate data on receiver selectivity characteristics, as provided by the receiver manufacturers, to values of RF protection ratios. Although the calculations are complicated and need electronic aids, they make possible (in contrast to the objective measuring method), the determination of the overall frequency response of the receiver for a given RF protection ratio curve.

4 General principle of non-subjective methods

All non-subjective methods assume the use of standardized conditions at both the transmitting and the receiving end of the transmission system, as described in Recommendation ITU-R BS.559.

In all interference problems, there are two different types of annoyance:

- that due to the cross-talk from the interfering channel into the wanted channel, caused by modulation; and
- that due to the beat-note produced by both carriers.

For the majority of receivers in use the beat-note predominates in annoyance when the carrier-frequency separation is between about 0.25 and 5 kHz.

5 RF protection ratios for ground-wave services

5.1 Stable wanted and interfering signals (ground-wave signal interfered with by another ground-wave signal)

In § 1 of this Recommendation, a value of 40 dB is given for use in bands 5 (LF) and 6 (MF) for co-channel transmissions.

With this value of RF protection ratio, high quality reception is possible. For planning purposes however, it may be necessary to adopt lower values. This problem has been studied by the EBU and in Japan. The values that have been proposed are 30 and 26 dB, respectively, and in fact, a value of 30 dB was agreed by the Regional Administrative LF/MF Broadcasting Conference (Regions 1 and 3) (Geneva, 1975), whereas 26 dB was used by the Regional Administrative MF Broadcasting Conference (Region 2) (Rio de Janeiro, 1981).

Relative values of RF protection ratios as a function of the separation between the carrier frequencies of the wanted and interfering signal are given in the form of curves (see § 2). These curves are based partly on measurements made in accordance with the objective two-signal method of measurement and partly on computations (see Recommendation ITU-R BS.559).

The influence of dynamic compression and audio-frequency bandwidth limitation can also be seen from these curves. It should be noted, however, that the full improvement in protection resulting from bandwidth limitation, can only be obtained when the non-linearity of the transmitter is small.

5.2 Stable wanted and fluctuating interfering signal

5.2.1 Short-term fading

Short-term fading of the interfering signal modifies the character of the disturbance experienced by the listener: if, for a given audio-frequency signal-to-interference ratio, the interfering signal is made to fluctuate, the disturbance is subjectively felt to be more severe. Some publications indicate that, to obtain the same degree of listener satisfaction, the protection must be increased by about 5 dB.

In § 1 of this Recommendation, the value for short-term fading has been incorporated in the RF protection ratio.

5.3 Long-term field-strength variations

Detailed information is contained in Recommendations ITU-R P.842 and ITU-R P.1147.

6 RF protection ratios for sky-wave services

A characteristic of the sky-wave service, especially when reception is being made with envelope detectors, is that propagation effects usually bring about a degradation of the received signal quality, for example, distortion in the case of selective fading. Because of this fact, it is considered that lower values of protection ratios should be applied to a sky-wave service as compared with a