REPORT 302-1

# INTERFERENCE TO SOUND BROADCASTING IN THE SHARED BANDS IN THE TROPICAL ZONE

(Question 45/10 and Study Programme 45E/10)

(1956–1959–1963–1978)

## 1. Introduction

This Report is a summary of the information available on the question of interference in the bands shared with sound broadcasting in the Tropical Zone for the determination of the radio-frequency protection required for a broadcast signal in the presence of interference. The radio-frequency (RF) protection ratio is the value of the radio-frequency wanted to-interfering signal ratio that enables, under specified conditions, the necessary audio-frequency protection ratio to be obtained at the output of a receiver (Recommendation 638). These specified conditions include such diverse parameters as spacing $\Delta f$ of the wanted and interfering carrier, emission characteristics (type of modulation, modulation depth, frequency deviation, etc.), receiver input and output levels as well as the receiver characteristics (selectivity and susceptibility to cross-modulation, etc.). The audio-frequency (AF) protection ratio is the agreed minimum value of the audio-frequency signal-to-interference ratio considered necessary to achieve a subjectively defined reception quality. This ratio may have different values according to the type of service desired (Recommendation 638). The wanted signal is from a broadcasting station operating in the shared bands in the Tropical Zone and the interfering signal may be either:

- from A1A/A1B and A2A/A2B telegraphy,
- A3E telephony and broadcasting or combinations of more than one type of emission.

Agreed values of protection ratios are necessary for the solution of frequency assignment problems in amplitude modulation sound-broadcasting systems and may also serve as basic reference data for the evaluation of the relative effectiveness to be expected of various amplitude modulation transmission systems.

The minimum wanted field to which this protection ratio is to be maintained is also to be determined taking into account the noise levels prevalent in different parts of the Tropical Zone.

In this Report, Part I deals with the considerations for the determination of protection ratios and Part II is concerned with the determination of the minimum value of the wanted field to which the recommended protection ratio is to be maintained.

PART I (PROTECTION RATIO)

## 2. Studies and measurements

Various administrations have carried out studies to determine, by subjective tests, the protection ratios for different percentages of listener satisfaction. In general, the measurements have been carried out at the output of the receiver, fitted with simple filters having an audio-frequency cut-off of 5 kHz. Some measurements have been made for cut-off frequencies of 6, 7, 8 and 9 kHz also. These measurements have been carried out for various carrier frequency separations up to 10 kHz. The permissible frequency tolerances of both wanted and unwanted signals, as specified in Appendix 7 of the Radio Regulations, have been taken into account while determining the protection ratios.

## 3. Results

3.1 [CCIR, 1956a], gives the results of an extensive series of subjective tests carried out by generally simulating domestic broadcast listening conditions in the absence of fading. A broadcast receiver, with a substantially flat response up to about 4 kHz, but with a filter giving an attenuation of about 8 dB at 5 kHz and a sharp cut-off above this frequency, was used.

For unwanted signals of classes of emission A2A/A2B and A3E and for various frequency separations between the carriers of the wanted and unwanted signals, listeners were presented with various ratios of wanted-to-unwanted signal in random order and asked to state whether they considered the reception satisfactory or unsatisfactory. Table I gives information for the wanted-to-unwanted signal ratios required to provide 90%, 70% and 50% listener satisfaction for unwanted signals of classes of emission A2A/A2B telegraphy, A3E telephony and broadcasting and for:

- frequency separation of 0 kHz and 5 kHz exactly; and
- nominal frequency separations of 0 kHz and 5 kHz under the most unfavourable conditions that could arise within the maximum permissible frequency tolerances of both wanted and unwanted signals, as were specified in the Radio Regulations, Atlantic City, 1947.

Utilizing the information given in the above document, curves giving relative protection ratios for frequency separation between 0 and 5 kHz have been derived and are shown in Fig. 1. The actual values for any frequency separation up to 5 kHz can, however, be obtained from these curves and from the value of co-channel protection ratio given in Table I for different percentages of listener satisfaction.

3.2 [CCIR, 1956b], gives details of the results of subjective tests made to determine the ratio of wanted-to-unwanted signal as a function of the frequency separation of the carriers of the two signals. Two typical broadcast receivers were used, having a fairly uniform response up to about 4 kHz falling to about −8 dB to −10 dB at 5 kHz. The unwanted signal was modulated by speech with a frequency range limited to 3 kHz. The ratio necessary to satisfy nearly all listeners varied from about 54 dB at 1 kHz separation, to a maximum of 56 dB between 2 and 3 kHz separation, falling to 52 dB at 5 kHz separation. The corresponding ratios when nearly all the listeners found the conditions unsatisfactory, were about 15 dB lower. Subsequent tests to determine the ratio at which interference was "perceptible" gave intermediate values.

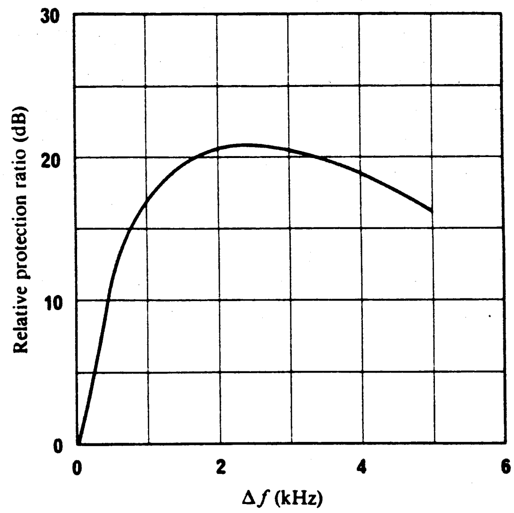
3.3 [CCIR, 1956c], gives the results of similar tests made with two types of receiver, one a narrow-band receiver with considerable attenuation above 3 kHz, and the other a wider-band receiver with an attenuation of about 8 dB at 5 kHz. For the wide-band receiver, as commonly used for broadcast listening, the wanted-to-unwanted signal ratio for various frequency separations follows the same general curve as before and, at a frequency separation of 5 kHz, is 43 dB for 90% listener satisfaction.

3.4 Comparison of the results arrived at in the three documents shows that there is a considerable degree of agreement. The values are within ± 5 dB and those in the United Kingdom and Federal German Republic documents are almost of the same order as those given by India. There is, therefore, sufficient justification to assume that the values of the wanted-to-unwanted signal ratio which provide the various degrees of listener satisfaction given in Table I are reliable.

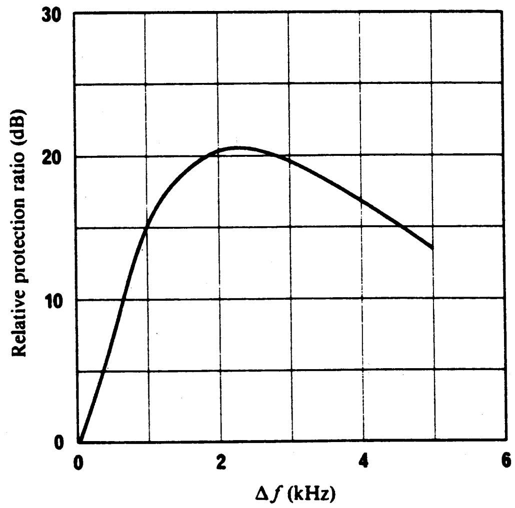
From an examination of Table I, it will be seen that, when the unwanted signal is a mobile A3E emission, there is a considerable increase in the required wanted-to-unwanted signal ratio when allowance is made for maximum frequency tolerances. The possibility of interference to broadcasting services from mobile services would be appreciably reduced, particularly where the two services have the same nominal frequency, if the mobile services operated within closer frequency tolerances, if possible with the same tolerance as the fixed and broadcasting services.

TABLE I

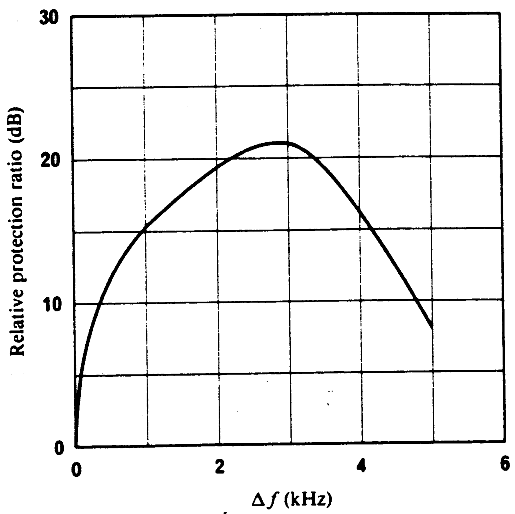
| Interfering emission | Maximum frequency tolerance (App. 7 to Radio Regulations) (Hz) | Frequency separation (kHz) | Signal-to-interference ratios for 90%, 70% and 50% listener satisfaction (dB) | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Ignoring frequency tolerances | | | Allowing for maximum frequency tolerances | | |
| | | | 90% | 70% | 50% | 90% | 70% | 50% |
| A2B – fixed (525 Hz tone) | 150 | 0 | 35 | 31 | 28 | 42 | 38 | 34 |
| A2B – mobile (525 Hz tone) | 1000 | 0 | 35 | 31 | 28 | 49 | 45 | 42 |
| A3E – fixed (3 kHz maximum modulation) | 150 | 0 | 33 | 30 | 28 | 40 | 36 | 33 |
| A3E – mobile (3 kHz maximum modulation) | 1000 | 0 | 33 | 30 | 28 | 50 | 47 | 44 |
| A3E – broadcasting | 150 | 0 | 33 | 30 | 28 | 44 | 40 | 36 |
| A2B – fixed (525 Hz tone) | 150 | 5 | 39 | 37 | 36 | 43 | 40 | 38 |
| A2B – mobile (525 Hz tone) | 1000 | 5 | 39 | 37 | 36 | 49 | 46 | 43 |
| A3E – fixed (3 kHz maximum modulation) | 150 | 5 | 48 | 44 | 40 | 50 | 46 | 42 |
| A3E – mobile (3 kHz maximum modulation) | 1000 | 5 | 48 | 44 | 40 | 52 | 48 | 45 |
| A3E – broadcasting | 150 | 5 | 48 | 46 | 44 | 49 | 46 | 44 |




*a)* Wanted: broadcasting
Unwanted: broadcasting




*b)* Wanted: broadcasting
Unwanted: telephony (A3E)




*c)* Wanted: broadcasting
Unwanted: telegraphy
(A3B with 525 Hz tone modulation)

FIGURE 1 – *Relative protection ratio as a function of frequency separation, Δf*

Although the sidebands of the unwanted signal contributed to some extent to the interference, the heterodyne beat note between the carriers of the wanted and unwanted signals was always predominant. This was the case for a frequency separation of 5 kHz between the two signals and, although the receivers used provided an attenuation of some 8 to 10 dB to the beat note, the use of a filter to provide further attenuation would have reduced the required wanted-to-unwanted signal ratio. Further studies are needed to ascertain what additional attenuation at 5 kHz could usefully be provided and what would then be the required wanted-to-unwanted signal ratio. For this purpose, consideration should also be given to the possibility of providing suitable filters in new and existing receivers.

It is agreed that since the figures shown in Table I are derived from measurements made under steady-state conditions, appropriate allowance should be made for fading, when using these figures to derive the protection ratios to be used in practice. The value of fading allowance to be used for broadcasting in the Tropical Zone requires further study.

India has given the opinion that protection ratios should be based on those figures in Table I that provide 90% listener satisfaction and that the figures for 70% and 50% are for information only and should not be regarded as the lower limit of acceptability. Australia, the Republic of South Africa and France are of the opinion that a listener satisfaction higher than 50% should be provided. The Republic of South Africa and Australia consider that it would be impracticable to achieve 90% listener satisfaction from the point-of-view of signal-to-noise ratio, particularly under heavy static conditions, and therefore, to aim at achieving about 80% listener satisfaction for signal-to-interference would be more realistic. The United Kingdom is of the opinion that the wanted-to-unwanted signal ratios given in Table I are based on too critical an assessment and that lower figures would be generally acceptable. The United Kingdom is also of the opinion that, because of practical considerations, protection ratios will have to be based on figures providing about 50 to 70% listener satisfaction.

3.5 [CCIR, 1959a], summarizes the data presented at various times regarding the protection ratio of the wanted-to-unwanted signal that is required for just tolerable interference at various values of separation of carrier frequencies. The curves obtained in the document are given in Fig. 2. A summary of the conditions of the Post Office tests is also given in the document and is reproduced in § 3 of Annex I.

3.6 [CCIR, 1959b], describes work carried out in connection with Question 1/XII. Protection ratios required against A1A and A1B emissions, both for speech and music programmes, A2A/A2B and A3E emissions for music programmes have been assessed. The results are in § 4 of Annex I.

[CCIR, 1959b] takes into consideration the standards for frequency tolerances laid down in the Radio Regulations, Atlantic City, 1947. The summary is confined to two limiting cases, namely frequency separations of 0 and 5 kHz respectively and indicates the protection ratios required for various types of emission. The document also states that the results refer to steady-state conditions and that an appropriate allowance should be made for fading.

An analysis of selectivity characteristics of receivers in use in India is also given in the document. Extensive tests were carried out to investigate, from the point of view of listener satisfaction, the effect of reducing the bandwidth of broadcast transmissions on overall quality.

The conclusions in the Indian document is that it is necessary to maintain the normal bandwidth of modulating frequencies to well beyond 5 kHz. Any modifications to the design of broadcast receivers tending to attenuate frequencies at 5 kHz and lower will, therefore, result in serious deterioration in the quality of reception.

3.7 [CCIR, 1962 and 1963a], give results of further listening tests for frequency separation of 5 to 10 kHz. The experimental set-up was the same as before, except that, as recommended in Study Programme 1C/XII (1966), filters with cut-off frequencies at 5, 6, 7, 8 and 9 kHz were incorporated at the output of the receiver (ordinary domestic type with average selectivity and fidelity characteristics). The attenuation at 1 kHz below the nominal cut-off frequency of the filter is 6 dB; it is more than 30 dB at the cut-off frequency and very steep thereafter. The wanted signal was modulated with a speech programme, the interfering signals were modulated with music, speech, A1A/A1B and A2A/A2B telegraphy (Morse – 525 Hz tone modulation). The documents show that, on the basis of these experiments, which relate to values required for 90% listener satisfaction, the protection ratio required in each case gradually decreases as the carrier separation increases beyond 5 kHz and also as the cut-off frequency of the filter decreases. Table II gives the values of the protection ratios required for various types of interference when no filter is used in the output circuit of the receiver.

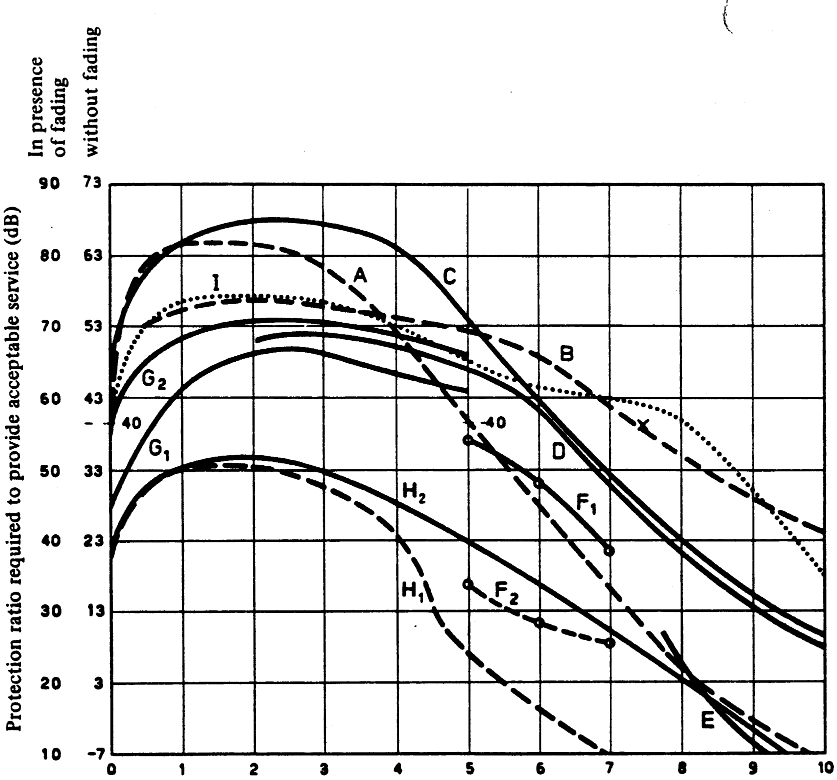



FIGURE 2 – *Protection ratios required to provide acceptable service*

DESIGNATION OF CURVES

| | |
|---|---|
| A* | VAN DER POL (1933) |
| B* | BRAILLARD (CCIR, Bucharest, 1937) |
| C* | B.P.O. tests, 1948 |
| D** | B.P.O. tests, 1950 |
| E** | B.P.O. tests, 1951 |
| $F_1$** | B.P.O. tests, 1956 (no filter) |
| $F_2$** | B.P.O. tests, 1956 (whistle filter) |
| $G_1$** | Indian tests (50% satisfaction) |
| $G_2$** | Indian tests (90% satisfaction) |
| $H_1$** | Curve used by the IFRB, 1956, for HF broadcast plans |
| I*** | French tests, 1962 |
| $H_2$** | Curve drawn from values of "Receiver Discrimination" given in IFRB Technical Standards Series "A" 1968. |

* Criterion of test: Just perceptible interference

** Criterion of test: Just tolerable interference

*** Corresponding to a "tolerable" interference for five different types of receivers.

TABLE II

| Wanted signal | Interfering signal | Frequency separation (kHz) | Desired protection ratio (dB) |
|---|---|---|---|
| Speech | Music | 5 | 46 |
| Speech | Music | 10 | 22 |
| Speech | Speech | 5 | 44 |
| Speech | Speech | 10 | 16 |
| Speech | A3B telegraphy | 5 | 38 |
| Speech | A3B telegraphy | 10 | 8 |
| Speech | A1B emission | 5 | 38 |
| Speech | A1B emission | 10 | 8 |
| Music | Music | 5 | 38 |
| Music | Music | 10 | 12 |
| Music | Speech | 5 | 38 |
| Music | Speech | 10 | 6 |

*Note.* – 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 antenna or of the advantage that can be obtained by using different polarization for transmission of the wanted and unwanted signals.

With the incorporation of filters at the output of the receiver, the required protection ratios become less; the degree of reduction depends upon the frequency separation, the cut-off frequency of the filter and to some extent on the nature of the interference. The details are shown in [CCIR, 1962], (Table II and Figs. 1 to 5) and [CCIR, 1963a] (Table III and Figs. 1 to 3).

The documents conclude that, in assessing the required protection, the allowable frequency tolerance limits of various emissions must be taken into account. Considering the frequency tolerance standards, as laid down in the Radio Regulations, the increase in the required protection has been estimated. For a frequency of operation of 5 MHz, in the limiting case of interference from a broadcast station, the increase in required protection would be of the order of 2 dB for 5 kHz frequency separation and 1 dB for 10 kHz frequency separation. For frequencies of operation higher than 5 MHz, such protection ratios would be still higher. In the other limiting cases of interference from mobile stations, the increase in protection ratio at 5 MHz would be of the order of 4 dB for 5 kHz frequency separation and 3 dB for 10 kHz frequency separation. The incorporation of filters with lower cut-off frequencies would result in the reduction of the required protection ratios, only at the cost of the quality of received music programmes.

Since the results presented have been derived under steady-state conditions, appropriate allowance should be made for fading under actual operating conditions.

3.8 [CCIR, 1963b], describes the results of measurements of protection ratio made in the medium-frequency band under steady-state conditions on various types of receivers of recent manufacture.

The measurements were made by the usual method with a wanted signal and an unwanted signal, the level of the latter being set to give a level of interference considered tolerable by the listeners. Various types of programme were used for the tests but programme material particularly susceptible to interference (e.g. music of high quality with a wide dynamic range) and programmes only slightly susceptible to interference (e.g. modern dance music with a restricted dynamic range) were excluded.

The results of the measurements are shown by curve I of Fig. 2.

There are two main conclusions to be drawn from [CCIR, 1963b], namely that, for medium frequency reception at least, and with the great majority of receivers in use, the protection ratio necessary with no frequency separation (± 20 Hz) is 40 dB, and with 5 kHz spacing, 46 to 50 dB.

The incorporation of special cut-off filters would reduce the required protection ratios, but only at the expense of the quality of received music programmes.

## 4. PART II (MINIMUM FIELD TO BE PROTECTED)

4.1 [CCIR, 1956d] indicates that listening tests have shown that for most of the time a satisfactory signal-to-noise ratio (estimated at 40 dB) can be obtained with a broadcasting system using arrays having vertical incidence radiation and a transmitter power of 5 kW, within a local service area.

For a given power and frequency the day-time field within a given service area is less than the night-time value. On the other hand the day-time noise levels are considerably less than the night-time values.

With the limited amount of information available on atmospheric noise levels in the tropical areas, the day-time and night-time median signal strengths of 100 μV/m and 1000 μV/m respectively would be necessary. These would provide a satisfactory broadcasting service in the Tropical Zone using bands shared with broadcasting having a median signal to upper decile noise ratio of 30 dB (median signal to median noise ratio of 36 dB).

In the light of the above and the fact that the fixed and mobile services must set up a satisfactory signal-to-noise ratio in their own service areas besides giving the necessary protection to the broadcast services, it has been suggested by the United Kingdom that the minimum value of the field intensity of a broadcast signal to be protected in the bands 2300 kHz to 5060 kHz within the local service area, should be 150 μV/m by day and 250 μV/m by night.

4.2 [CCIR, 1959c], gives the results of studies carried out for determination of noise level in tropical regions and the minimum signal required for satisfactory listening. Based on these studies, the minimum signal required for various frequency bands for different times of the day and seasons is given in Fig. 3. These figures indicate that for satisfactory reception higher values of signal are required during night-time as compared with day-time.

4.3 The conclusions of the two documents referred to in §§ 4.1 and 4.2, that noise level is considerably higher at night-time as compared with day-time, are also indicated in Report 322.

### 5. Conclusions

The protection ratio values given in Tables I, II and IV and those in Fig. 2 indicate that there is some divergence in the results that have been obtained. This may be due to the variety of experimental set-ups, types of receiver and different percentage of listener satisfaction employed by various administrations for the determination of protection ratios. Nevertheless, the values given in Tables I, II and IV and those in Fig. 2 for different frequency spacings and percentages of listener satisfaction give a consistent trend and the results could be applied to the solution of frequency assignment problems. However, the curves 'H1' and 'H2' give protection ratios much lower than any of the measured data (Fig. 2).

With the present state of unsatisfactory interference position in high frequency bands, it would be difficult to realise in practice the values of protection ratios given by the curves A to G and I of Fig. 2. Comprehensive data on radio-frequency protection ratios may perhaps be collected now by other than the subjective methods hitherto used, employing objective methods as described in CCIR Recommendation 559. Based on the data so collected, further studies may be necessary to determine the lower limit of protection ratios which would be acceptable in practical considerations.

Regarding the minimum field to be protected, it may be mentioned that due to the prevalence of much higher noise levels during night-time as compared with day-time in the Tropical Zone the night-time field should be higher than the day-time field. This aspect has to be taken into consideration while stipulating the minimum signal to be protected for satisfactory listening.

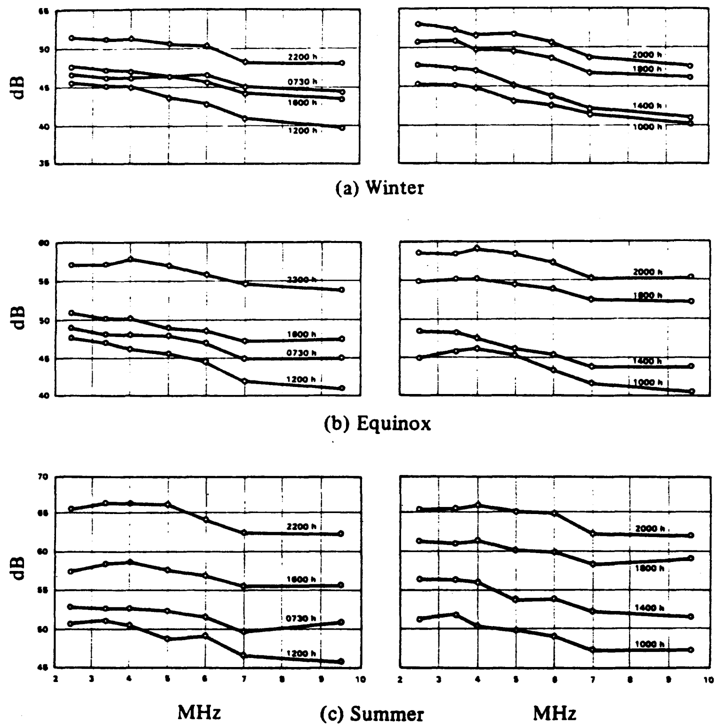



FIGURE 3 – *Minimum signal required for satisfactory listening (dB (μV/m))*

## ANNEX I

### 1. Conditions of test for curve A

The tolerable signal-to-interference ratio (with the receiver tuned to the wanted signal), was chosen as the criterion of receiver sensitivity.

The receiver sensitivity was adjusted to apply 150 mW low-frequency power to the loudspeaker, the wanted signal being modulated by a 400 Hz tone to a depth of 30%. The quasi-maximum of the modulation of the interfering signal corresponded to a modulation index of 90%.

The amplitude of the interfering signal was then increased, up to the point when its interfering effect on an unmodulated wanted signal was just perceptible to the ear at a distance of about 50 cm from the loudspeaker.

Furthermore, if the wanted signal was also modulated, the above ratio may be multiplied by a factor of between 3 and 5.* (Documents of the European Radiocommunication Conference, Lucerne, 1933, 280-282, and Documents of the Fourth Reunion of the CCIR, Bucharest, 1937, Vol. I, 109-112.)

### 2. Conditions of test for curve B

Similar conditions to those of curve A, but relating to very high-quality reception (Documents of the CCIR, Bucharest, 1937, Vol. I, 241).

* *Note by the Director, CCIR.* – The original van der Pol curve was plotted as the ratio of the "tolerable interfering signal to the wanted signal". Accordingly, with the curve A of Fig. 2, which is plotted as the ratio of the wanted signal to the interfering signal, this factor should be 1/3 to 1/5 (−9.5 to −14 dB).

## 3. Conditions of tests for curves C, D, E and F (British Post Office tests)

The conditions under which tests F were conducted require some detailed comment.

A "standard" condition of co-channel interference was set up, this in the first place providing an interfering broadcast signal 23 dB below the wanted carrier level. As finally set up, however, short-term Rayleigh-type fading was introduced and, on the basis of some practical evidence, this was taken to require the co-channel protection ratio to be increased to 33 dB. An allowance of 7 dB for long-term fading would thus give the figure of 40 dB for planning purposes, as used at the Mexico City Broadcasting Conference, 1948. The tests F, however, were carried out only with artificially produced short-term fading and all adjacent channel figures, therefore, relate to a co-channel protection ratio of 33 dB. In the final presentation, these figures have therefore been reduced by 10 dB to equate the results to the non-fading conditions used for all other tests. The ordinate has been so labelled that protection ratios can be read off either for non-fading conditions, or for full fading conditions incorporating a total allowance of 10 + 7 = 17 dB for short-term and long-term fading. For some of these measurements under test F, a simple whistle filter was placed in the loudspeaker input leads, so that the improvement in protection ratio, that might readily be gained by reducing the audible heterodyne whistle at 5, 6 and 7 kHz, could be assessed.

TABLE III

| Test | Date of test | Wanted signal | | Unwanted signal | |
|---|---|---|---|---|---|
| | | Type | Modulation index | Type | Modulation index |
| C | 1948 | Music (0 – 8 kHz) | 30% average, peaking to 100% occasionally | Speech (0 – 8 kHz) | 30% average, peaking to 100% occasionally |
| D | 1950 | Broadcast speech | idem | Telephony (0 – 3 kHz) | 70% |
| E | 1951 | Broadcast speech | idem | Speech (0 – 6 kHz) | 30% average, peaking to 100% occasionally |
| F | 1956 | Broadcast speech | idem | Music (6 dB down at 4.6 kHz) | idem |

## 4. Conditions of test for curves G1 and G2 (Indian tests with 50% and 90% listener satisfaction respectively for broadcasting)

See Tables I and IV.

## 5. Conditions of test curves H1 and H2

5.1 Curve H1 was the protection ratio used by the IFRB in the preparation of the tentative 1956 HF broadcasting plans only.

5.2 Curve H2 is the modified H1 curve based on the data of "receiver discrimination" given in IFRB Technical Standards, Series A, 1968 (Ref. CCIR Recommendation 449-2 (Geneva, 1974)), where both wanted and the interfering emissions are broadcasting emissions.

## 6. Conditions of test for curve I

See § 3.8 of the Report.

TABLE IV

| Wanted signal | Interfering emission | Frequency separation (kHz) | Protection ignoring frequency tolerance (dB) | Maximum frequency tolerance in the shared bands (Atlantic City) (Hz) | Protection taking into account the tolerance in column 5 (dB) |
|---|---|---|---|---|---|
| Speech | A1B-fixed (40 w.p.m.) | 0 | 26.5 | 150 | 33.5 |
| | A1B-mobile (40 w.p.m.) | 0 | 26.5 | 1000 | 44.5 |
| | A3B-fixed (mod. at 525 Hz) | 0 | 35 | 150 | 42 |
| | A3B-mobile (mod. at 525 Hz) | 0 | 35 | 1000 | 49 |
| | A3E-fixed (mod. at 3 kHz max.) | 0 | 33 | 150 | 40 |
| | A3E-mobile (mod. at 3 kHz max.) | 0 | 33 | 1000 | 50 |
| | A3E-broadcasting | 0 | 33 | 150 | 44 |
| | A1B-fixed (40 w.p.m.) | 5 | 41.5 | 150 | 43 |
| | A1B-mobile (40 w.p.m.) | 5 | 41.5 | 1000 | 47 |
| | A3B-fixed (mod. at 525 Hz) | 5 | 39 | 150 | 43 |
| | A3B-mobile (mod. at 525 Hz) | 5 | 39 | 1000 | 49 |
| | A3E-fixed (mod. at 3 kHz max.) | 5 | 48 | 150 | 50 |
| | A3E-mobile (mod. at 3 kHz max.) | 5 | 48 | 1000 | 52 |
| | A3E-broadcasting | 5 | 48 | 150 | 49 |
| | A3E-broadcasting | 0 | 33 | 645 | 51.5 |
| | A3E-broadcasting | 5 | 48 | 645 | 50.5 |
| Music (vocal) | A1B-fixed (40 w.p.m.) | 0 | 27.5 | 150 | 36 |
| | A1B-mobile (40 w.p.m.) | 0 | 27.5 | 1000 | 42.5 |
| Music (instrumental) | A3B-fixed (mod. at 525 Hz) | 0 | 24 | 150 | 28.5 |
| | A3B-mobile (mod. at 525 Hz) | 0 | 24 | 1000 | 36 |
| Music (vocal) | A3E-fixed (mod. at 3 kHz max.) | 0 | 26 | 150 | 34 |
| | A3E-mobile (mod. at 3 kHz max.) | 0 | 26 | 1000 | 41.5 |
| | A1B-fixed (40 w.p.m.) | 5 | 37 | 150 | 39 |
| | A1B-mobile (40 w.p.m.) | 5 | 37 | 1000 | 43 |
| Music (instrumental) | A3B-fixed (mod. at 525 Hz) | 5 | 39 | 150 | 40 |
| | A3B-mobile (mod. at 525 Hz) | 5 | 39 | 1000 | 43 |
| Music (vocal) | A3E-fixed (mod. at 3 kHz max.) | 5 | 42.5 | 150 | 44 |
| | A3E-mobile (mod. at 3 kHz max.) | 5 | 42.5 | 1000 | 46.5 |

## REFERENCES

*CCIR Documents*

[1956] (Warsaw): **a.** 356 (India); **b.** 231 (United Kingdom); **c.** 553 (Federal Republic of Germany); **d.** 428 (United Kingdom).

[1959] (Los Angeles): **a.** XII/1 (United Kingdom); **b.** XII/6 (India); **c.** 92 (India).

[1962] (Bad Kreuznach): XII/7 (India).

[1963] (Geneva): **a.** 94 (India); **b.** 218 (France).