

RECOMMENDATION 639*

NECESSARY BANDWIDTH OF EMISSION IN LF, MF AND HF BROADCASTING**

(Question 44/10, Study Programme 44A/10)

(1986)

The CCIR,

CONSIDERING

- (a) that in amplitude modulated double-sideband (AM-DSB) sound broadcasting, the bandwidth of emission is twice the audio-frequency (AF) bandwidth;
- (b) that for quality reasons, the AF bandwidth should be as high as possible;
- (c) that adjacent-channel interference is determined by, among other factors, the bandwidth of the modulating signal, and that some sound processing of the audio programme may significantly increase the higher frequency audio components;
- (d) that the bandwidth of the complete AM-DSB transmission system (system bandwidth) is determined by the combined effect of the bandwidth of emission and the receiver bandwidth;
- (e) that in most practical cases the bandwidth of emission considerably exceeds the receiver bandwidth, although receivers with wider or double bandwidths are becoming more prevalent in some parts of the world;
- (f) that, among other factors, efficiency of spectrum utilization is affected by the carrier spacing and also by the necessary bandwidth of emission;
- (g) that adjacent-channel interference decreases in areas relatively close to the wanted transmitter, where, for a transmitter of medium to low power, a larger concentration of audience can usually be presumed;
- (h) that where adjacent-channel interference is minimized by appropriate geographical spacing of stations, some advantage can be taken of bandwidths of emission significantly greater than the channel spacing, thus increasing system bandwidth, particularly where receivers of wider bandwidth are employed,

UNANIMOUSLY RECOMMENDS

that where required, either for optimizing spectrum utilization or for providing an improved overall system AF response, the overall system can be optimized and planning problems can be reduced by taking advantage of the existing knowledge of the interrelation between system bandwidth, channel spacing and adjacent-channel protection ratio, as given in Annex I.

ANNEX I

NECESSARY BANDWIDTH OF EMISSION IN
LF, MF, AND HF SOUND BROADCASTING

1. Introduction

In an amplitude-modulation double-sideband sound broadcasting system the bandwidth of emission is approximately twice the audio-frequency bandwidth of the programme and, therefore, greatly influences the quality of reception. On the other hand, for a given frequency separation between adjacent channels, a limitation of the bandwidth of emission is desirable to avoid mutual interference.

The difference between the transmitted bandwidth for amplitude-modulation sound broadcasting and the receiver bandwidth has led to research [CCIR, 1966-69a and b; Netzband and Süverkrübbe, 1968; Süverkrübbe, 1969; Petke, 1973] aimed at improving the whole transmission system. It appears that it would be useful to fix values for the audio-frequency bandwidth of the programme to be radiated as well as for the overall response of the receivers and to obtain these values by the use of band-limiting filters. If both these bandwidths are nearly equal and are suitably related to the channel spacing the transmission system provides for the full utilization of the transmitted bandwidth as well as for the most favourable protection against adjacent channel interference [Eden, 1967].

* This Recommendation should be brought to the attention of Study Group 1.

** The essential contents of Report 457 having been transferred into Annex I of this Recommendation, Report 457 is hereby cancelled.

2. Necessary bandwidth of emission

2.1 Bands 5 (LF) and 6 (MF)

Obviously, the bandwidth of emission, as well as the passband of the receivers, should be chosen in such a way that there is no unnecessary impairment of reception quality or any increase in adjacent-channel interference [Netzband and Süverkrübbe, 1968]. In areas where adjacent-channel interference is expected not to be negligible, the use of equal values for channel spacing, bandwidth of emission and receiver passband would be a good solution. In areas where less adjacent-channel interference is to be expected, different values may be suitable, e.g., the bandwidth of emission and the receiver passband may be equal and considerably exceed the channel spacing. This is especially true if the same transmitter network is operated during day and night. In such circumstances receivers, equipped with filters of switchable bandwidths, may be used successfully to improve the reception quality under different propagation conditions.

2.2 Band 7 (HF)

In short-wave broadcasting, the necessary bandwidth of emission for AM-DSB should in no case exceed the value of 9 kHz. Recommendation 640 specifies a maximum of 4.5 kHz necessary bandwidth for AM-SSB broadcasting.

3. General considerations

3.1 There exists a well-known interrelation between system bandwidth, carrier spacing and adjacent-channel radio-frequency protection ratio [Süverkrübbe, 1969; Petke, 1973].

3.2 The theoretically obtainable optimum value of protection against adjacent channel interference can be assessed by using an ideal receiver with rectangular passband characteristics. In this case the radio-frequency protection ratio is mainly determined by non-linear distortion in the transmitter.

3.3 A theoretical study of the energy spectrum including out-of-band radiation caused by transmitter non-linearities is contained in [Kettel, 1968]. Experimental investigations of the energy spectrum of a high-power transmitter operating in band 6 (MF) [CCIR, 1966-69c] show that the term occupied bandwidth as defined in Article 1, No. 147 of the Radio Regulations does not give an adequate indication of the effects of bandwidth limitation on adjacent channel interference.

4. Relationship between AF bandwidth, RF protection ratio and channel spacing

4.1 Measurement results

Measurements of the radio-frequency protection ratios for the case of various values of audio-frequency bandwidths, which are equal at both transmitter and receiver, and at different channel spacings have been carried out in the Federal Republic of Germany [Süverkrübbe, 1969] using the objective two-signal measuring method given in Recommendations 559 and 560. For the measurements a high quality commercial receiver with an almost ideal passband characteristic was used. The interrelation between the parameters involved is shown in Fig. 1. For a given channel spacing there are many pairs of values of audio-frequency bandwidths and adjacent channel protection ratios. If, however, two of the parameters have been chosen, the third is definitely fixed.

4.2 Computation results

The relationship between system bandwidth, adjacent channel protection ratio and channel spacing can be determined by means of the numerical method (Recommendation 559).

Studies carried out were based on the assumption that both the carrier spacing and the adjacent channel protection ratio are predetermined values. Using Recommendation 560, a relative value of the radio-frequency protection ratio of -26 dB corresponding to a channel spacing of 9 kHz has been assumed. Thereby due account has been taken of the characteristics of current types of receivers.

Any amplitude-modulation sound-broadcasting system has, in principle, the same effect on the reception quality as a low-pass filter. Amplitude-modulation systems designed in conformity with the channel spacing and protection ratio requirements mentioned above may, therefore, differ to some extent in bandwidth and rate of cut-off of the overall amplitude/frequency response. The investigations carried out were, therefore, intended to cover this aspect of the problem of the quality of reception.

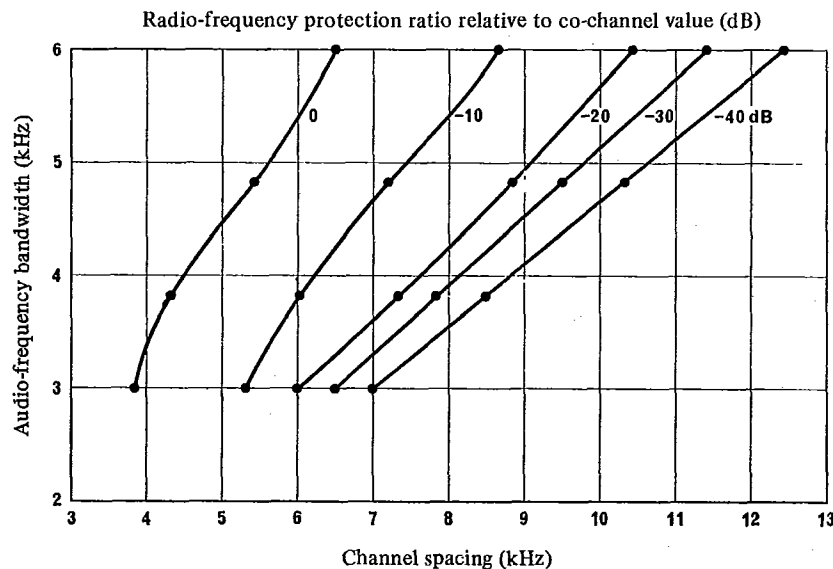


FIGURE 1 – Use of the frequency spectrum

It was assumed that the influence on the overall amplitude/frequency response of the entire system was equally distributed between the transmitting and receiving ends. This approach should, however, be considered as a first attempt only and additional studies will have to be carried out for different conditions. As a result of the calculations made it was found that any one of the three overall amplitude/frequency response curves shown in Fig. 3 would provide satisfactory adjacent-channel protection in an 9 kHz channelling system. The curves of Fig. 2 present pairs of values for the bandwidth, b , and rate of cut-off, a_0 , required at either end of the AM sound-broadcasting system. The solid curve is only valid if use is being made of a notch filter in the receiver to eliminate the beat-note between adjacent channel carriers, whereas the broken line applies to the case where there is no notch filter. The particular points in Fig. 2 numbered ①, ② or ③ correspond to terminal equipment characteristics that would provide the overall amplitude/frequency response curves, A, B or C, respectively, in Fig. 3.

The results obtained are in close agreement with Fig. 1 which should be considered to provide limiting values, since it applies to the ideal case of rectangular passband characteristics. The system bandwidth thus decreases rapidly with decreasing rate of cut-off.

4.3 Listening tests

The influence of reproduction quality of an amplitude-modulation sound-broadcasting system with 9 kHz channel spacing and a relative protection-ratio value of -26 dB for adjacent channel interference can be simulated by using three specified low-pass filters. The passband characteristics of these filters are those of curves A, B and C in Fig. 3.

Subjective listening tests then show quite clearly that a better subjective quality impression can be obtained with frequency response curves A and B than with curve C. However, the difference in quality obtained with curves A and B is very small, a fact which may be of considerable economic interest, since the rate of cut-off of the receiver is 40 dB/octave less with curve B than with curve A.