

REPORT 458-5

CHARACTERISTICS OF SYSTEMS IN LF, MF AND HF BROADCASTING

(Question 44/10)

(1970-1974-1978-1982-1986-1990)

1. Introduction

Question 44/10 relates to the possibility of standardizing one or more sound broadcasting systems on a world-wide basis. It is clear that the study of this complex question is not sufficiently advanced to achieve this aim. The present Report, therefore, is only a summary of the information available, intended to encourage administrations, broadcasting organizations and industry, to take an interest in these questions and to undertake the studies necessary to solve them.

At present, broadcasts in bands 5, 6 and 7, unlike sound and television broadcasting in band 8 (VHF), are operated throughout the world with an almost complete absence of internationally standardized transmission characteristics; with the exception of channel spacings and carrier frequencies for bands 5 and 6, but even these differ from Region to Region. The other transmission characteristics vary from country to country and in many cases even from transmitter to transmitter [EBU, 1971].

2. Systems available for standardization

The following list of possible systems cannot, at the present time, be considered complete. Several of these systems are compared in [Haviland, 1969]. This study also shows that interference between transmitters must be considered when defining a system and the importance of well defined channel spacings becomes apparent.

Each of the above systems may incorporate modulation processing devices (see Note 1). If such a device is necessary in the receiver to obtain full advantage of a similar device in the transmitter, the code should be completed by a suitable abbreviation. Thus, an amplitude-modulation double-sideband (DSB) system with envelope demodulation comprising a compressor in the transmitter and an expander in the receiver, is coded AM-DSB-ENV-COMPANDOR. An example is given in Annex I.

Descriptions of amplitude-modulation double-sideband systems with synchronous detection appear in [Netzband, 1969] and [CCIR, 1966-69] and it should be noted that only these systems can serve as transition systems from amplitude-modulation double-sideband systems with envelope detection to single-sideband (SSB) systems with synchronous detection. Receivers based on synchronous detection would produce undistorted audio-frequency signals for both the above systems ("receiver compatibility").

The transmission of compatible single-sideband signals (see Note 2) in sound broadcasting should be considered to be inappropriate for regular programme services, and consequently be restricted to exceptional cases for the following reasons:

- it is difficult to reduce out-of-band emissions in the suppressed sideband of a compatible SSB system;
- strong out-of-band emissions will result from maladjustments of compatible SSB transmitters;
- imperfections of conventional DSB receivers which have no bearing on the reproduction quality of DSB transmissions may give rise to dynamic distortion, when the automatic gain control follows a portion of the spectrum with high energy density rather than the carrier, or to non-linear distortion due to the amplitude and phase response within the radio-frequency and intermediate frequency stages;

- additional non-linear distortions, similar to those which affect double-sideband signals, which are to be expected when receiving sky-wave signals, cannot be reduced by using a different demodulation technique than envelope detection.

Note 1. – By “modulation processing” is understood any process consisting of altering certain characteristics of the modulation, such as the dynamic range, audio-frequency bandwidth, etc.

Note 2. – A transmission is said to be “compatible” if it can be received on an existing conventional receiver, without any modification whatsoever to the receiver, and then gives a quality of reception at least as satisfactory as that obtained at present in a double-sideband system.

TABLE I

Modulation	Detection	Code
Amplitude-modulation, double sideband	Envelope detection	AM-DSB-ENV
Amplitude-modulation, double sideband	Synchronous detection	AM-DSB-SYNC
Single-sideband, amplitude-modulation	Synchronous detection	SSB-SYNC
Frequency modulation (narrow band)		FM

3. Characteristics to be specified

For the systems mentioned in § 2, the characteristics whose standardization will be required are given below. This list is not necessarily complete.

3.1 All systems

- channel spacing,
- carrier frequencies,
- intermediate frequency or frequencies,
- receiver oscillator frequency stability.

Note 1. – The relationship between these characteristics is shown in Annex II.

- audio-frequency bandwidth of the programme,
- necessary bandwidth of emission,
- overall bandwidth of the receiver.

Note 2. – For the relationship between these characteristics and the channel spacing, see Annex I to Recommendation 639. Deviations from standardized values may be tolerated, if they do not result in unacceptable interference.

- characteristics of modulation processing devices.

In addition, the following characteristics should be standardized:

3.2 Amplitude-modulation double-sideband systems

- maximum depth of modulation.

When laying down the characteristics of the transmission system and the reference receiver, in order to obtain the best adaptation of a frequency-assignment plan to receivers of reasonable performance, the following rules should be taken into account:

3.2.1 The transmission system and receiver characteristic should be suitably related, particularly in the amplitude/frequency response. Harmonic distortion should be reduced to acceptable values. In this respect, criteria for the determination of tolerances for the overall amplitude and phase characteristics and ways for the assessment of practical values are set out and discussed in [Makiedonski, 1974].

3.2.2 The audio-frequency bandwidth transmitted should be related to the carrier spacing (see Annex I to Recommendation 639). (The precise bandwidth cannot be given; some administrations are of the opinion that it should be one half of the spacing between carriers, and some of them believe that this value may even achieve the value of unity; but this depends on the absolute channel spacing.)

3.2.3 Uniform carrier spacings, with nominal carrier frequencies being an integral multiple of the carrier spacing, should be adopted, at least within the broadcasting bands 5 and 6. (There are technical advantages also in the adoption of uniform carrier spacing on a world-wide basis, including band 7.)

3.2.4 The intermediate frequency (or frequencies) of the receiver should be chosen so that interference created internally within the receiver is at a minimum. With stable local oscillators (see Annex II) this condition is best met when the intermediate frequency (or frequencies) of the receiver is an integral multiple of the carrier spacing.

3.3 *Single-sideband systems with synchronous detection*

- degree of reduction of the carrier wave (see Recommendation 326, § 1.5),
- degree of suppression of the unwanted sideband,
- maximum permissible values of intermodulation products,
- auxiliary signals to obtain receiver synchronization.

The considerations under § 3.2 would apply, and where possible the same characteristics should be adopted.

Note 3. — More information about SSB systems is contained in Report 1059.

3.4 *Frequency modulation*

- modulation index,
- maximum modulation frequency.

4. **Stereophonic systems in AM broadcasting**

[CCIR, 1974-78] describes four methods of stereophonic broadcasting for use in bands 5 and 6. All systems described in this Document use conventional amplitude modulation for the stereophonic sum signal and angle modulation of the same carrier frequency for the stereophonic difference signal. They differ in the way the modulations are generated and in the resulting distribution of the audio information in the various radio frequency sidebands.

4.1 *Amplitude modulated stereo system used in Australia and Brazil*

The Australian Administration has, from February 1985, allowed its MF stations to broadcast in stereophony. Compatible quadrature amplitude modulation (CQUAM) has been adopted as the stereophonic modulation standard. Field tests [CCIR, 1982-86] confirmed that the occupied bandwidth of stereophonic transmission is not significantly greater than monophonic transmission. The Brazilian Administration adopted the same system on an exclusive basis since January 1986.

5. **Preemphasis, deemphasis and 10 kHz audio bandwidth limitation for administrations employing 10 kHz channel spacing in band 6 (MF)**

With 10 kHz channel spacing broadcasting in band 6 (MF), a standard preemphasis, deemphasis and 10 kHz audio bandwidth limitation has been implemented [CCIR, 1986-90]. This produces a transmission/reception system with an overall audio frequency response that is essentially flat from 50 Hz to nearly 10 kHz (limited only by the receiver's choice of bandwidth), and reduces interference caused to stations operating +/- 20 kHz removed in frequency. Further, this entirely eliminates undesired high-order dynamic intermodulation products that contribute noise and interference in the MF band. This system is described in detail in Annex I.

REFERENCES

- EBU [August, 1971] Modulation processing techniques in AM sound broadcasting. Doc. Tech. No. 3088.
- HAVILAND, R. P. [June, 1969] A comparative study of communications systems using different modulation-demodulation techniques. *EBU Rev Tech.*, **115-A**, 102-108.
- MAKIEDONSKI, A. [1974] Analiza zniekształcen obwiedni sygnału zmodulowanego przy jednoczesnym występowaniu zniekształcen tłumieniowych i fazowych jego grupy falowej (Analysis of the envelope distortions of a signal modulated in the simultaneous presence of attenuation and phase distortion of its spectrum). *Prace Instytutu Łączności*, Vol. XXI, **375**.
- NETZBAND, R. [April, 1969] A novel arrangement for the reception of single-sideband transmissions as a result of frequency error and harmonic distortion. *EBU Rev. Tech.*, **114-A**, 60-63.

CCIR Documents

- [1966-69]: X/135 (USA).
- [1974-78]: 10/279 (USA).
- [1982-86]: 10/246 (Australia).
- [1986-90]: 10/103 (United States of America).

BIBLIOGRAPHY

- DOC [July, 1984] Report on AM stereo system tests. Lab. Rep. 110. Dept. of Communications (DOC), Belconnen ACT 2616, Australia.
- LACHARNAY, S., FONTEYNE, J. and MASSUCCI, M. [1978] Radiodiffusion en ondes kilométriques et hectométriques (LF and MF broadcasting). *Radiodif.-Télév.*, **1**.

CCIR Documents

- [1978-82]: 10/15 (EBU).
- [1986-90]: 10/81 (Brazil).

ANNEX I

THE USE OF VARIOUS MODULATION PROCESSING DEVICES

In the OIRT, studies have been made of the possibilities of increasing the modulation factor, i.e., the sideband power, by either trapezoidal modulation or dynamic-compression operation, with transmitters operating in bands 6 (MF) and 7 (HF) [CCIR, 1970-74a]. The results were that dynamic compression without clipping should be preferred, if the objective is to increase the sideband power with a minimum loss of quality (e.g. for music programmes). On the other hand, if a loss of quality is deemed unimportant (e.g. for speech programmes), trapezoidal modulation leads to a higher degree of sideband power.

Experiments carried out in the RFZ, Berlin, have confirmed the assumed increase of the sideband power as follows:

- *Compression of the dynamic range by 12 dB:*
average gain with a rise-time of 0.5 ms and a decay-time of 35 ms: ≈ 6 dB.
- *Compression of the dynamic range by 6 dB:*
average gain with a long decline period (1.5 s) for programmes with a wide dynamic range: ≈ 3 dB.
- *Trapezoidal modulation*
average gain with 5 dB increase in the level of the audio-frequency signal and clipping: ≈ 3 dB.

Studies have been carried out in Sweden concerning the improvement in radio-frequency wanted-to-interfering signal ratio obtained by using audio-frequency compression and expansion in connection with a double-sideband amplitude-modulation system and a frequency-modulation system with a maximum deviation of ± 5 kHz [CCIR, 1966-69].

The audio-frequency range was from 40 to 5000 Hz.

The compressor reduced the dynamic range of the audio-frequency signal, expressed in decibels, to half its value, the time-constants were 2 ms for the rise-time and 20 ms for the decay-time. The expander had characteristics reciprocal to those of the compressor.