REPORT 472-2

SINGLE-SIDEBAND RECEPTION FOR RE-BROADCASTING APPLICATIONS WITHIN THE TROPICAL ZONE

Reduction of fading effects

(Question 45/10, Study Programme 45C/10)

(1970-1978-1990)

1. Introduction

One of the most economical methods of re-broadcasting is the use of sky-wave signal from one broadcasting transmitter by another. In view of the simplicity and economy, it is of special importance to developing countries. The efficacy of this method, however, depends to a large extent on the quality of reception of the sky-wave signal at the re-transmission site. The quality is often impaired due to selective fading and "surge" and "flutter" fading peculiar to the Tropical Zone. In order to improve the quality of sky-wave reception by minimizing the adverse effects of the above types of fading, use of single-sideband reception may be considered as one of the effective means for re-broadcasting application.

2. Extent to which the use of single-sideband reception can improve the quality of HF broadcasting

2.1 Single-sideband (SSB) reception of a conventional double-sideband (DSB) amplitude-modulation emission has certain advantages, the principal ones being:

2.1.1 it is possible to select either of the sidebands of the received broadcasting signal, thereby rejecting the sideband most affected by adjacent channel interference;

2.1.2 the demodulation process is more linear at high levels of modulation and does not produce the objectionable audio distortion of an envelope detector, associated with selective fading of the carrier;

2.1.3 this system of reception has been reported to minimize other propagation impairments (e.g. flutter and surge fading) as discussed below. Preliminary studies reported in the CCIR texts have indicated the possibility of reducing the effects of selective, surge and flutter fading by the use of single-sideband reception technique.

2.2 The deterioration of the quality of sky-wave reception due to selective fading results from the non-linear harmonic distortion when envelope detector is adopted in DSB (AM) reception. However, in SSB system of reception, selective fading leads to only linear distortion which is less severe than non-linear distortion as in the DSB (AM) reception.

Studies in the Federal Republic of Germany [CCIR, 1966-69a] have led to the following broad conclusions:

For double-sideband AM emissions, selective fading near the carrier frequency causes an apparent increase in the depth of modulation. This gives rise to distortion as soon as the carrier voltage falls below the sum of sideband voltages. Besides, the amplitudes of the low frequency components of the modulating signal are attenuated – thereby affecting the dynamic range and the tonal quality of the programme. If selective fading occurs in one of the sidebands, an apparent phase modulation of the carrier occurs. This causes a frequency shift of the modulation. However, the change in the depth of modulation is not as pronounced as with selective fading of the carrier because of the retention of the second sideband.

For single-sideband emissions, the interfering effect of selective fading of the carrier is completely eliminated. Compared with the amplitude of the sideband, the amplitude of the carrier re-inserted in the receiver is very high and causes a reduction in the phase modulation of the vector sum of the carrier and sideband to a very low level. Consequently, the signal is not distorted by carrier fading.

Selective fading in the sideband changes the tonal quality of the signal. The effect is particularly noticeable when the low frequencies of a musical programme are affected by fading. This could be remedied by frequency diversity reception of the two sidebands. But this method fails if one sideband suffers interference from another transmitter. In this case, diversity reception is only possible when space or polarization diversity is applied to the undisturbed sideband but it requires more complex equipment. It may, however, be mentioned that the assessment of comparative merits of DSB (AM) and SSB reception by the Federal Republic of Germany was subjective. An experimental method for subjective comparisons developed in the Federal Republic of Germany is described in [CCIR, 1966-69a].

An HF-double-sideband emission (6 MHz band) was received on a receiver with 3 outputs:

- double-sideband;
- single-sideband;
- carrier signal strength measurement.

The signals from the first two outputs were recorded simultaneously on the two tracks of a tape-recorder while the signal from the third output was recorded on a paper chart-recorder. The counter on the tape-recorder was used to mark the paper-recording simultaneously. Switching from track 1 to track 2 and vice-versa of the tape-recorder allowed immediate comparison between the effects of fading on double-sideband and single-sideband reception. Different types of fading were recorded and could be compared with one another. Such comparative reproduction of characteristic passages indicated the improvement that could be obtained with SSB reception.

At the interim meeting of Study Group XII, Palma de Mallorca, 1968, the Federal Republic of Germany gave a demonstration using this experimental method. On the basis of this demonstration Study Group XII agreed unanimously that SSB reception led to a significant improvement in the quality of reception when selective fading occurred.

2.3 Some preliminary listening tests carried out in India [CCIR, 1966-69b] on spoken-word programmes have indicated that in the presence of surge and flutter fading, reception is worst while using DSB reception with automatic gain control (a.g.c.), but perceptible improvement is observed without a.g.c. When surge and flutter fading are severe, a noticeable improvement is obtained by the use of SSB reception even with a.g.c. The study concludes that reception on a single-sideband receiver with a.g.c. can apparently give acceptable quality of the spoken-word programmes when surge and flutter fading are present. In the experiment a commercially-built single-sideband adaptor was used, together with a standard HF communication receiver.

The single-sideband adaptor had the following main characteristics:

- sharply tuned bandpass filters to select either the upper or lower sideband of the emissions;
- carrier rejection filter (30 dB);
- stable, tunable local oscillator for carrier re-insertion;
- automatic frequency control of the local carrier re-insertion oscillator;
- oscilloscope indicator for correct tuning.

3. Preferred Characteristics of SSB receiving system.

The characteristics of the single side-band receiver would be important in determining the degree of improvement in quality of reception. An SSB receiver should have the following characteristics:

- The selectivity characteristics of the receiver must be sharp with an overall bandwidth (-3 dB) of 4 kHz , and a slope of attenuation of 35 dB/kHz,

- The receiver must be equipped with a synchronous demodulator and for carrier acquisition must use a method whereby a carrier is regenerated by means of a suitable control loop which phase locks the regenerated frequency to the incoming carrier.

- A built-in synthesizer for automatic tuning is essential in this type of receiver.

- The receiver must work equally well with both conventional DSB as well as SSB transmissions regardless of whether the carrier reduction is 6 dB or 12 dB relative to peak-envelope power.

4. Conclusion

Studies on single-sideband reception have indicated that there is a considerable improvement in the quality of reception in the presence of selective fading.

Preliminary studies [CCIR, 1966-69b] have also shown the possibility of reducing the effect of surge and flutter by single-sideband reception. But there is a need for further detailed and extensive tests, both subjective and objective, to assess the extent of improvement that could be achieved and the determination of the preferred characteristics of such a system. It may be worthwhile to find out, whether the improvement in reception is due to the reduction of the effects of selective fading which may be associated with "surge" and "flutter".

The introduction of a suitable assessment scale is necessary when observed effects are subjective and are not open to exact measurement.

REFERENCES

CCIR Documents

[1966-69]: **a.** XII/7 (Federal Republic of Germany); **b.** XII/5 (India).