

RECOMMENDATION 612*

MEASUREMENT OF RECIPROCAL MIXING IN HF COMMUNICATION
RECEIVERS IN THE FIXED SERVICE

(Question 1/3, Study Programme 1A/3)

(1986)

The CCIR,

CONSIDERING

- (a) that frequency synthesizers are widely used in HF communication receivers;
- (b) that reciprocal mixing is an important characteristic of such receivers;
- (c) that it is desirable to be able to compare the reciprocal mixing performance of different models of receivers;
- (d) that to facilitate (c) it is necessary to standardize methods of measurement of reciprocal mixing;
- (e) that the methods of measurement should be independent of receiver noise factor,

UNANIMOUSLY RECOMMENDS

that the reciprocal mixing performance of HF communication receivers should be established, using the methods of measurement specified in § 4 of Annex I.

ANNEX I**

1. Introduction

Frequency synthesizers are widely used in modern high quality HF communications receivers. Besides having high frequency stability and accuracy, a frequency synthesizer is easy to operate and control. At present, however, the frequencies provided by the synthesizer are not always sufficiently pure, so that a considerable number of spurious components may accompany the wanted signals in its frequency spectrum. At the same time, on both sides of the wanted output there are noise skirts which degrade the interference rejection and noise characteristics of the receiver. In recent years, a new requirement has therefore appeared in the specifications of HF receivers, i.e. reciprocal mixing, defined as the degradation of the receiver output signal-to-noise ratio due to the mixing of strong interfering signals with the noise skirts of the synthesizer. Relevant reciprocal mixing effects are described in Report 704. This Annex provides a quantitative relationship between the synthesizer out-of-band noise characteristics and receiver reciprocal mixing so that the requirements for synthesizer out-of-band noise characteristics can easily be specified and performance comparison between various receivers facilitated.

* This Recommendation should be brought to the attention of Study Groups 1 and 8.

** This Annex contains text from Report 856 which is hereby deleted.

2. Effects of reciprocal mixing

Reciprocal mixing in a receiver occurs when, during the reception of a wanted signal, a strong out-of-band interfering signal mixes with out-of-band skirt noise from the synthesizer, producing mixing products which fall into the receiver IF band, causing the receiver output signal-to-noise ratio to be degraded (see Fig. 1).

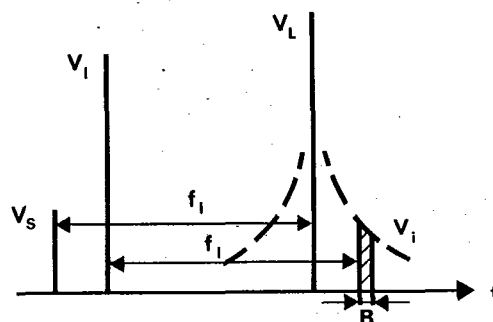


FIGURE 1 - Reciprocal mixing

B : bandwidth of the receiver (Hz)
 f_i : first intermediate frequency
 V_L : wanted output of the synthesizer
 V_i : out-of-band noise density
 V_L : a strong interfering signal at the receiver input
 V_s : wanted signal

From Fig. 1, an equation showing the relationship between V_L and the following items, i.e. receiver output signal-to-noise ratio S_o/N_r , synthesizer output signal purity V_L/V_i as well as the wanted signal V_s , can be derived [Gao, 1977]:

$$V_{L(\text{dB}(\mu\text{V}))} = \left(\frac{V_L}{V_i} \right)_{\text{dB}} - 10 \log B + V_{s(\text{dB}(\mu\text{V}))} - \left(\frac{S_o}{N_r} \right)_{\text{dB}} \quad (1)$$

Where S_o is the signal at the receiver output and N_r represents the reciprocal mixing products only when V_s is sufficiently large so that the front-end noise of the receiver can be neglected.

Assuming the noise density at 20 kHz away from the wanted output of the synthesizer of a given receiver is -120 dB/Hz relative to the wanted output of the synthesizer, $B = 2800$ Hz, $V_s = 40$ dB(μ V), $S_o/N_r = 20$ dB, the $V_L = 105.5$ dB(μ V).

It can be seen from the above, given the wanted signal V_s , the signal-to-noise ratio S_o/N_r at the receiver output, and the bandwidth B , the allowable level of interference V_L rises as the out-of-band noise density of the synthesizer V_i is reduced. It should be noted that, in the above calculation, the effects of second and subsequent down conversions are not taken into account. This is justified because the oscillators used are usually fixed and would have significantly less problems in maintaining spectral purity.

3. Measurement of reciprocal mixing

Up to now, there is no internationally adopted method for measuring reciprocal mixing. The differences in the measuring methods lie in the specified level of receiver input signals and in the method of measuring reciprocal mixing products at the output.