

RECOMMENDATION ITU-R SM.1134-1*

Intermodulation interference calculations in the land-mobile service

(Question ITU-R 44/1)

(1995-2007)

Scope

This Recommendation serves as a basis for the calculation of a maximum of three intermodulation interference that are created at the output of a receiver under influence of intensive unwanted signals at the receiver input due to non-linearity of an amplitude response of the receiver.

The ITU Radiocommunication Assembly,

considering

- a) that, in the most typical cases, the major factors which determine interference in the land-mobile service include:
 - in-band intermodulation products which are generated by two (or more) high-level interfering signals;
 - unwanted emission that can occur in a transmitter when any other signal from another transmitter is also presented at the input of RF stages of the influenced transmitter;
 - the wanted and interfering signal levels are random variables;
- b) that two (or more) unwanted signals must have specific frequencies so that the intermodulation products fall into the frequency band of a receiver;
- c) that the probability of occurrence of intermodulation interference due to more than two high-level unwanted signals is very small;
- d) that the intermodulation interference calculation procedure will offer a useful means of promoting efficient spectrum utilization by the land-mobile service,

recommends

- 1 that the receiver intermodulation model presented in Annex 1 should be used for intermodulation interference calculations in the land-mobile service;
- 2 that intermodulation interference calculations should follow the following procedure, details of which are presented in Annex 1;
 - 2.1 to determine mean value and dispersion of a random wanted signal power at the receiver input;
 - 2.2 to determine mean value and dispersion of a random intermodulation interference signal power at the receiver input;
 - 2.3 to determine the probability that the intermodulation products generated both in the receiver itself and as a result of the intermodulation in the transmitter will occur during the reception;

* This Recommendation should be brought to the attention of Radiocommunication Study Group 8.

3 that the zones affected by intermodulation interference and relevant necessary geographical separation of interfering transmitters and receivers should be determined on the basis of a given value of the interference probability, as it is described in Annex 1.

Annex 1

Intermodulation models

This Annex describes two intermodulation models; the receiver intermodulation (RXIM) model and the transmitter intermodulation (TXIM) model. It is divided into five sections.

Section 1 outlines the general formula for calculating receiver intermodulation interference. Section 2 describes the RXIM measurement procedure. Section 3 outlines a procedure for evaluating receiving intermodulation interference using the general formula. Section 4 outlines the formula for transmitter intermodulation interference. Section 5 describes how the probabilities of RXIM and TXIM interference are calculated.

1 Receiver intermodulation analysis model

The two-signal, third-order intermodulation interference power is given by the following formula (ex-CCIR Report 522-2, Düsseldorf, 1990):

$$P_{ino} = 2(P_1 - \beta_1) + (P_2 - \beta_2) - K_{2,1} \quad (1)$$

where:

- P_1 and P_2 : powers of the interfering signals at frequencies f_1 and f_2 , respectively
- P_{ino} : power of the third-order intermodulation product at frequency f_0 ($f_0 = 2f_1 - f_2$)
- $K_{2,1}$: third-order intermodulation coefficient, may be computed from third-order intermodulation measurements or obtained from equipment specifications
- β_1 and β_2 : RF frequency selectivity parameters at frequency deviations Δf_1 and Δf_2 from the operating frequency f_0 , respectively.

The values of β_1 and β_2 for example can be obtained from the equation to calculate the attenuation of a signal at an off-tune frequency.

$$\beta(\Delta f) = 60 \log \left[1 + \left(\frac{2 \Delta f}{B_{RF}} \right)^2 \right] \quad (2)$$

where B_{RF} is the RF bandwidth of the receiver.

It is worth noting that for a particular set of third-order intermodulation measurements for land mobile analogue radio receivers operating in the VHF and lower UHF bands, equation (1) may be manipulated to derive the following formula [McMahon, 1974]:

$$P_{ino} = 2P_1 + P_2 + 10 - 60 \log(\alpha f) \quad (3)$$

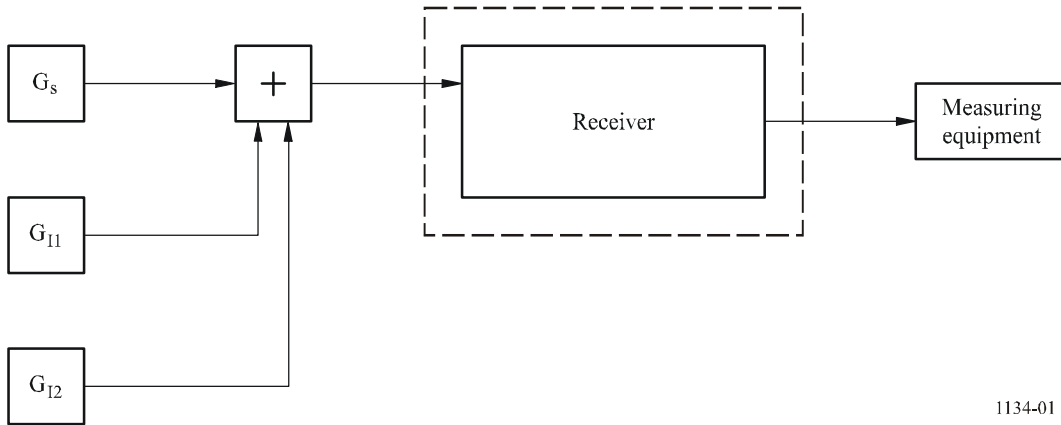
where σf is the mean frequency deviation (MHz) and is equal to:

$$\frac{\Delta f_1 + \Delta f_2}{2}$$

2 Receiver intermodulation interference characteristics

In Fig. 1, G_s is the signal generator of the wanted signal (WS). G_{I1} and G_{I2} are the signal generators of the interfering signals (IS) which constitute the RXIM product. These signals are applied to the input of the receiver (RX).

FIGURE 1
Block diagram for receiver intermodulation measurements



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When measuring the RX intermodulation characteristic, there are two IS with equal levels from the generators G_{I1} and G_{I2} and the WS with level P_{sr} , from the generator G_s that are carried to the RX input. The frequency detuning of the first IS is chosen equal Δf_0 , as for the second IS – it is approximately equal $2\Delta f_0$. The level of both IS at the RX input is increased until $P_I(IM)$ is reached when the reception quality of the WS should not reduce below a specified value. The reception quality is definitely connected with protection ratio A.

Note that:

P_{sr} : sensitivity of radio receiver (dBW)

$P_I(IM)$: the sensitivity to intermodulation, that was measured for the receiver (dBW).

Therefore, according to equation (1):

$$P_{ino} = 3P_I(IM) - 2\beta(\Delta f_0) - \beta(2\Delta f_0) - K_{2,1} \quad (4)$$

This level is related to P_{sr} as follows:

$$P_{sr} - A = P_{ino} \quad (5)$$

$K_{2,1}$ is therefore:

$$K_{2,1} = 3P_I(IM) - 2\beta(\Delta f_0) - \beta(2\Delta f_0) - P_{sr} + A \quad (6)$$