RECOMMENDATION ITU-R BO.790*, **

Characteristics of receiving equipment and calculation of receiver figure-of-merit (*G*/*T*) for the broadcasting-satellite service

(1992)

The ITU Radiocommunication Assembly,

considering

a) that typical receiving equipment for individual reception is comprised of an antenna, a low-noise receiver front end, an indoor unit containing intermediate frequency stages, programme selector, demodulation or adaptor stages and a television monitor or television receiver;

b) that the figure of merit, *G*/*T*, is a primary parameter in the system design and the evaluation of receiver performance;

c) that the in-service performance of the receiving equipment in which operational factors are included should be used for a link budget calculation and that for this parameter, a term "usable *G*/*T*" is given;

d) that the parameter characterizing the intrinsic quality of a receiver is in wide use for evaluation of receiver performance and that for this parameter, a term "nominal *G*/*T*" is given;

e) that the standardization of factors to be taken into account for these two types of *G*/*T* is desirable;

f) that receiving systems using a relatively small diameter antenna are now capable of offering the figure of merit and directivity established in the 12 GHz Plans because:

– the noise figure of the low-noise front end has been improved far below the level previously expected at the WARC-BS-77;

– the antenna efficiency has been enhanced from 55% to 70%; and

– the side-lobe level has been markedly reduced through the use of the offset-feed type antenna;

g) that for reception at 12 GHz the design will probably entail two frequency changes to ease problems of selectivity, image rejection and local oscillator radiation, but that installations with only one frequency change cannot be ruled out;

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* *Note:* Report ITU-R BO.473-5 was used in preparing this Recommendation.

** Radiocommunication Study Group 6 made editorial amendments to this Recommendation in 2001 in accordance with Resolution ITU-R 44.

h) that in satellite broadcasting, the concept of signal reception, not only for individual reception but also for community receiving installations, has been established and that to this end it is necessary to use suitable reception and distribution techniques satisfying, as much as possible, the requirements of maximum commonality between individual and community receivers;

j) that a potential source of unwanted radiation from BSS receiver terminals is the first local oscillator (LO),

recommends

1 that a distinction should be made between installations intended for community reception and for individual reception;

2 that the overall characteristics of receiving equipment should be specified by the figure of merit G/T which is the ratio expressed in dB(K^{-1}), between the gain of the receiving antenna (including losses) and the total noise temperature expressed in Kelvin, referred to the point of measurement of the antenna gain; the set of equations given in Annex 1 should be used to calculate the usable G/T and the nominal G/T;

3 that when there is more than one frequency change, the first down-converter, equipped with a fixed frequency oscillator, should be placed close to, or on, the antenna. For 12 GHz reception, the first intermediate frequency should be chosen so as to avoid interference by terrestrial broadcasting transmitters or by other services using radio transmissions of significant power; the second intermediate frequency should be chosen so as to avoid interference by terrestrial broadcasting and other transmitters (see Annex 2);

4 that for individual reception at 12 GHz of sound-only broadcasts or of supplementary sound channels associated with television broadcasts, at least the same input stages as for the reception of television signals should be used;

5 that in order to avoid picture impairments due to interference problems, receiving equipment with a suitable well-screened construction and suitably designed components should be used; in particular the SHF converter (which should have a high gain but low intermodulation levels) and the down-lead conveying the signals at intermediate frequency;

6 that linearity requirements in the converter and IF amplifiers should take into account the number of television signals of significant amplitude that may be present within the first IF bandwidth.

ANNEX 1

1 Usable G/T

The usable G/T is defined by the following formula, which allows for pointing error, polarization effects and ageing:

$$G/T = \frac{\alpha\,\beta\,G_{\tau}}{\alpha\,T_a + (1-\alpha)\,T_0 + (n-1)\,T_0}$$

where:

α: total coupling losses, expressed as a power ratio

β: total losses due to the pointing error, polarization effects and ageing, expressed as a power ratio

G_τ: effective gain of the receiving antenna, expressed as a power ratio and taking account of the method of feeding and the efficiency

T_a: effective temperature of the antenna (under rain-faded conditions)

T_0: reference temperature = 290 K

n: overall noise factor of the receiver, expressed as a power ratio.

The following expression may be used to calculate the pointing loss P (dB):

$$P = 12 \frac{\left(\theta_1^2 + \theta_2^2 + \theta_3^2\right)}{\theta_0^2}$$

where:

θ_1: initial pointing accuracy of the fixed-mount receiving equipment in the direction of the satellite (degrees)

θ_2: pointing stability of the receiving equipment under the influence of the climatic environment (degrees)

θ_3: orbital drift of the satellite (degrees)

θ_0: half-power beamwidth of the receiving antenna (degrees).

The effective antenna noise temperature, T_a, is expressed by the relationship*:

$$T_a = T_c/L + T_0\,(1 - 1/L)$$

where:

T_c: antenna noise temperature in clear-sky condition. The value of T_c depends on the size of antenna, elevation angle and frequency. For a small size antenna of around 1 m diameter at high elevation angles, the value of 50 K is used for T_c at 12 GHz

$L = 10^{0.1A}$

A : atmospheric attenuation (dB).

2 Nominal G/T

The nominal G/T is the G/T value under clear-sky conditions and without taking into account the pointing error as well as the polarization and ageing effects; i.e., with $L = 1$ and $\beta = 1$.

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* This formula expresses the effective antenna noise temperature as a function of T_0. It is equivalent to the conventionally used formula $T_a = T_c + T_m(1 - 1/L)$ where T_m is about 230 K (mean physical temperature of the medium).

ANNEX 2

Selection of intermediate frequencies

The home receiver designed mainly for individual reception may possibly be applied to group reception; in this case a common front end is connected to more than one indoor unit. When the selected value of the second intermediate frequency is smaller than the value of the total frequency bandwidth at 12 GHz allocated for satellite broadcasting in a service area, local oscillator frequencies coincide with part of the first intermediate frequency band. Depending on the level of the received signal and leakage power, attention has to be given to mutual interference between indoor units caused by the local oscillator leakage. To make this interference as low as possible by arranging the second local oscillator frequencies between any two adjacent channels allocated to that area, the following relationship is desirable for the second intermediate frequency:

$$f = 38.36\ (n + 1/2)\ \text{MHz (in Regions 1 and 3)}$$

$$f = 29.16\ (n + 1/2)\ \text{MHz (in Region 2)}$$

where n is an integer.

This relationship is valid when the selected frequency f is smaller than the value of the total frequency bandwidth to that area. However, if $2f$ is smaller than the total bandwidth there is the possibility of image frequency interference, and a small adjustment of the value of f may be beneficial.

The second intermediate frequency, having a bandwidth of 27 MHz, might be chosen in the vicinity of 70 to 400 MHz, which would again make it possible to avoid the broadcasting bands. For a receiver used in Regions 1 or 3, this could be achieved through use of a 27 MHz four-pole filter. The attenuation at the second image frequency should be at least 30 dB.

In Europe, the frequency 10.750 GHz is normally used as first local oscillator; this corresponds to a first IF of between 950 and 1 750 MHz. In Japan, the first local oscillator frequency is 10.678 GHz which corresponds to a first IF between 1 036 and 1 332 MHz.