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Interference criteria to protect fixed wireless systems from time varying aggregate interference produced by non-geostationary satellites operating in other services sharing the 37-40 GHz and 40.5-42.5 GHz bands on a co-primary basis

F Series
Fixed service

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

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RECOMMENDATION ITU-R F.1606*

Interference criteria to protect fixed wireless systems from time varying aggregate interference produced by non-geostationary satellites operating in other services sharing the 37-40 GHz and 40.5-42.5 GHz bands on a co-primary basis

(2003)

Scope

This Recommendation specifies the interference criteria to protect fixed wireless systems from time varying aggregate interference produced by non-geostationary satellites operating in other services sharing the 37-40 GHz and 40.5-42.5 GHz bands on a co-primary basis. The criteria are defined in terms of the *I*/*N* at the input of the FS receiver for both long-term and short-term interferences. Annex 1 provides guidance material for the use of this Recommendation.

The ITU Radiocommunication Assembly,

considering

a) that it is desirable to determine the protection criteria of fixed wireless systems (FWS) operating in the 38 GHz (37-40 GHz) and 40 GHz (40.5-42.5 GHz) bands with respect to aggregate interference from systems of other services operating co-primary, especially short-term interference;

b) that in interference situations involving non-geostationary (non-GSO) space stations, FWS are potentially exposed to high levels of interference for short periods of time which could affect the performance or availability of these systems;

c) that the FS link design in the 38 and 40 GHz bands is controlled by rain attenuation, which can be modelled using Recommendation ITU-R P.530;

d) that in the 38 and 40 GHz bands, some administrations employ automatic transmitter power control (ATPC) on some FS links and that such use will increase the susceptibility of these links especially with regard to short-term interference;

e) that some FS links employing small net fade margins may not be fully protected from interference from non-GSO satellite systems without unduly constraining those services;

f) that typical FS links using ATPC will require tighter protection criteria than those needed for FS links with large fade margin that do not use ATPC;

g) that it is desirable to derive the aggregate FS protection criteria based on the calculation of the allowable degradation of error performance objective (EPO) due to interference, considering typical FS links using ATPC features,

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* Radiocommunication Study Group 5 made editorial amendments to this Recommendation in December 2009 in accordance with Resolution ITU-R 1.

recognizing

a) that the bands 37.5-40 GHz and 40.5-42.5 GHz are shared on a co-primary basis with the FSS,

noting

a) that the determination of the maximum degradation of EPO allowable to interference from other services sharing the same frequency band on a co-primary basis is given in Recommendation ITU-R F.1094;

b) that the allowable degradation in performance of FWS due to interference from other services sharing the same frequency bands on a primary basis, expressed as a permissible fraction of the total EPO is defined in Recommendation ITU-R F.1565,

recommends

1 that the following interference criteria should be used to protect the FS systems from varying aggregate interference from systems of other services operating in the 37-40 GHz and the 40.5-42.5 GHz bands on a co-primary basis;

1.1 for the long term, the *I*/*N* at the input of the FS receiver should not exceed –10 dB for more than 20% of the time (see Note 1);

1.2 for the short term, the *I*/*N* at the input of the FS receiver should not exceed +10 dB for more than 0.013% of the time, for systems designed in compliance with ITU-T Recommendation G.828, and 0.05% of the time for other systems (see Note 1);

1.3 for the short term, for some links in certain broadband wireless access (BWA) applications, the *I*/*N* at the input of the FS receiver should not exceed +5 dB for more than 0.013% of the time, for systems designed in compliance with ITU-T Recommendation G.828 and 0.05% of the time for other systems (see Note 1);

2 that the information contained in Annex 1 should be used as guidance for the use of this Recommendation.

NOTE 1 – These *I*/*N* levels are referenced to the total noise at the receiver input including system noise level (*k T BF*) and 1 dB for intra-service interference (see § 5 in Annex 1).

Annex 1

Derivation of FS aggregate protection criteria in the 37-40 GHz and 40.5-42.5 GHz bands

1 Introduction

The methodology presented in this Annex is based on the assumption that fading in the 38 GHz and 40 GHz bands is dominated by rain and that, therefore, even if long-term interference has an effect on the performance of the link, the main way to have an outage of the FS link is to have an interference level higher than the fade margin of the link, whatever the propagation conditions may be.

On this basis, the following apportionment of the effect of interference on the degradation of the link (and on the EPOs) has been assumed:

– 20% of FS link degradation due to long-term interference;

– 80% of FS link degradation due to short-term interference.

2 EPOs

The allowable degradation in performance of real FWS due to interference from other services sharing the same frequency bands on a primary basis are expressed as a permissible fraction (10%) of the total EPOs and are defined in Recommendation ITU-R F.1565.

FS systems are currently used in the 38 GHz band for the access networks or mobile telephone infrastructure networks for both point-to-point (P-P) and point-to-multipoint (P-MP) applications. Since the same applications are already foreseen in the 40 GHz band the same reference EPOs have been used for the present studies in both bands based on either the access network section or short-haul inter-exchange network section, which are given as similar in Recommendation ITU-R F.1565.

The corresponding EPO values are given in Table 1, and correspond to the following assumptions:

– Short-haul inter-exchange or access network section (Tables 4a and 4b, or 5a and 5b of Recommendation ITU-R F.1565);

– Rate VC-3 in Tables 4a and 5a, and rate from 15 to 55 Mbit/s in Tables 4b and 5b;

– $B = C = 8\%$.

TABLE 1

	EPO (fraction of any month) based on the application of Recommendation ITU-R F.1565		
	Total allowable to interference	**Long-term interference (20%)**	**Short-term interference (80%)**
Errored second ratio (ITU-T Rec. G.826)	6×10^{-4}	1.2×10^{-4}	4.8×10^{-4}
Errored second ratio (ITU-T Rec. G.828)	1.6×10^{-4}	3.2×10^{-5}	1.3×10^{-4}
Severely errored second ratio	1.6×10^{-5}	3.2×10^{-6}	1.3×10^{-5}

3 Short-term criteria

3.1 Methodology

As explained in § 1, the main way to have an outage of the FS link, considering short-term interference, is to have an interference level higher than the fade margin of the link, whatever the propagation conditions may be.

The definition of short-term criteria is then linked to both values of fade margin (or net fade margin considering ATPC[1]) and EPO allocated to short-term interference as defined in Table 1, considering that the fade margin is allocated to the short-term criteria.

3.2 FS fade margins

In the 38 GHz and 40 GHz bands, and since link lengths are likely to be short, an FS fade margin of 14 dB was considered representative of conventional links since it was assumed that a majority of such links have a fade margin (or net fade margin[1]) higher than this value. It has to be noted that this 14 dB fade margin, when considering systems using ATPC, corresponds to a link with higher margin (e.g. = 14 dB net fade margin +10 dB ATPC range).

On the other hand, it was also noted that in certain BWA applications, a fade margin of 10 dB is used for some short links and that these links would consequently require a lower I/N value.

In support of the consideration of these margins, the Table in Appendix 1 to Annex 1, which is based on Recommendation ITU-R P.530, gives the required rain margin for 99.999% availability for link lengths up to 1.6 km at five different rain rates for both vertical and horizontal polarization.

However, it has to be noted that the 14 dB or the 10 dB rain fade margin in these 37 GHz and 40 GHz bands are justified on calculations using Recommendation ITU-R P.530 which does not provide values of fade margin referenced to an error performance measure, but gives absolute attenuation values (rain fading) for a given percentage of time.

In addition, according to Recommendation ITU-R F.1498, for a link designed for a 99.999% availability and in particular BWA systems which are assumed to compete with fibre, the fade margin may refer to the BER 10^{-6} or severely errored second (SES) level. It was agreed to retain the SES level as the reference level for the fade margin. It was also agreed that the design of the FS link should take into account a 1 dB allowance for interference from the FS, which hence increases the reference noise power to 1 dB above the system noise power.

In addition, it was also considered that, due to technical reasons (minimum practicable power, available antenna sizes, fixed transmit power for hub stations, …), the FS links in the 38 GHz and 40 GHz bands, and in particular P-MP systems, may present an extra design margin compared to the rain margin. At the minimum, for P-P links, the value of this extra design margin depends on the level of granularity of the power setting, the possible attenuators as well as the antenna gain that

[1] For an FS link using ATPC, the net fade margin = total fade margin – ATPC range.

would allow the FS designer to adjust the receiver level as close as possible to the theoretical level. Even though it has not been taken into account in the definition of the reference total margin of the FS link, it was agreed to consider it as an additional confidence factor in the derivation of the protection criteria.

As the EPO are referenced to ITU-T Recommendations G.826 and G.828 definitions, it is necessary to extrapolate the fade margin corresponding to errored seconds (ES) and SES levels. On the basis of agreed assumptions, the fade margins (FMs) for ES and SES are respectively 3 dB lower and 1 dB higher than the FM referenced to the BER 10^{-6} level, which is 2 dB lower than the FM referenced to the BER 10^{-3} level. Table 2 summarizes these different values of FMs and, associated with the correspondent EPO ratios, allows two short-term criteria for the FS in the bands to be defined.

TABLE 2

	14 dB rain margin (dB)	**10 dB rain margin (dB)**	**Associated EPO ratio**
ES (ITU-T Rec. G.826)	10	6	4.8×10^{-4}
ES (ITU-T Rec. G.828)	10	6	1.3×10^{-4}
BER 10^{-6}	13	9	
SES	14	10	1.3×10^{-5}
BER 10^{-3}	15	11	

Due to the shape of the calculated interference distributions which in general shows that when the criterion for ES is met, the one for SES is also met, it was decided for simplification to only retain the ES based criteria.

Assume that M_{SES} is the fade margin that brings the $C/N + I$ to the performance threshold T_{SES} for SES. In the design of a link for a performance threshold to be met for a specified percentage of time, Recommendation ITU-R P.530 is used to determine the required fade margin as was done in developing the margins in Table 2. To accommodate for the allocation of interference the link is designed for an unfaded signal power, C_0, so that

$$T_{SES} = C_0 - M_{SES} - N \tag{1}$$

where N is the sum at the receiver of the FS system noise and the allocated increment for interference from within the fixed service. Denoting N_0 as the total system noise ($k\,T\,BF$), $N = N_0 + 1$ dB.

More generally, the total noise including the interference from other co-primary services may be expressed as:

$$N_{tot} = N + 10 \log (1 + 10^{(I/N)/10}) \quad \text{dB} \tag{2}$$

The permissible short-term I/N is the largest value that will not cause ES in the absence of fading. In accordance with Table 1, the $C/N + I$ for ES, T_{ES}, is 4 dB higher than that for SES. Hence, $T_{ES} = T_{SES} + 4 = C_0 - N$. Using equations (1) and (2) in this expression and recognizing $M_{SES} - 4$ as the fade margin for ES gives the following expression for the I/N (dB):

$$I/N = 10 \log (10^{M_{ES}/10} - 1) \tag{3}$$

Using the considered fade margins from Table 2 for ES, 10 dB and 6 dB, in equation (3), leads to values of I/N of 9.54 dB and 4.74 dB, respectively. These values are presented in Table 3 with the associated EPO from Table 2. The I/N values have been rounded to the next higher whole number of decibels.

On this basis, the short-term criteria proposed to be used in the 38 GHz and 40 GHz bands are given in Table 3 and have been defined associating the ES EPO (see Table 1) and the corresponding FM value as defined in Table 2.

TABLE 3

	I/N **(dB)**	**Percentage of time not to be exceeded**
Criterion 1	10	0.05%
Criterion 2[(1)]	10	0.013%
Criterion 1 for low net fade margin systems	5	0.05%
Criterion 2[(1)] for low net fade margin systems	5	0.013%

(1) Criterion 2 applies to links designed in compliance with ITU-T Recommendation G.828.

4 Long-term criteria

The long-term criterion specified in Recommendation ITU-R F.758 to be used for the 38 GHz band is $I/N = -10$ dB, not to be exceeded for more than 20% of the time.

Since similar FS applications are assumed to be used in the 40 GHz band, the same long-term criteria would apply in this band.

5 Noise level reference

For both short-term and long-term criteria as given in § 3 and 4, the I/N levels refer to the total FS noise level, which includes the FS system noise and an agreed 1 dB allowance for intra-service interference. This means that $N = 10 \log (k\,T\,BF) + 1$ dB.

Appendix 1
to Annex 1

Rain fade margins for 99.999% availability

Link distance (km)	Fade margin at 39.3 GHz, horizontal polarization (dB)					Fade margin at 39.3 GHz, vertical polarization (dB)				
	Rain rate (mm/h) (zone)					Rain rate (mm/h) (zone)				
	12 (B)	22 (E)	42 (K)	63 (M)	95 (N)	12 (B)	22 (E)	42 (K)	63 (M)	95[(1)] (N)
0.1	0.8	1.3	2.5	3.6	5.2	0.6	1.1	2.1	3	3.0
0.2	1.5	2.7	4.9	7.1	16.4	1.3	2.3	4.2	6	5.9
0.3	2.2	4	7.3	10.6	15.4	1.9	3.4	6.2	9	8.8
0.4	3	5.3	9.6	14	20.3	2.6	4.5	8.2	11.9	11.6
0.5	3.7	6.5	12	17.4	25.1	3.2	5.6	10.2	14.7	14.3
0.6	4.4	7.8	14.3	20.7	29.8	3.8	6.7	12.2	17.6	17.0
0.7	5.2	9.1	16.6	24	34.3	4.5	7.8	14.2	20.3	19.6
0.8	5.9	10.4	18.9	27.2	38.8	5.1	8.9	16.1	23	22.2
0.9	6.6	11.6	21	30.4	43.2	5.7	10.0	18.0	25.8	24.7
1.0	7.3	12.8	23.3	33.6	47.5	6.3	11.0	19.9	28.5	27.1
1.1	8	14.1	25.5	36.7	51.7	6.9	12.1	21.8	31	29.5
1.2	8.7	15.3	27.7	39.8	55.8	7.5	13.1	23.7	33.7	31.9
1.3	9.4	16.5	29.9	42.8	59.8	8.1	14.2	25.5	36.2	34.1
1.4	10.1	17.7	32	45.8	63.8	8.7	15.2	27.3	38.8	36.4
1.5	10.8	18.9	34.1	48.7	67.6	9.3	16.2	29.1	41.3	38.6
1.6	11.4	20.1	36.2	51.6	71.4	9.9	17.3	30.9	43.7	40.8

(1) Fade margins for the case of 95 mm/h rain rate for vertical polarization were calculated under the assumption that the latitude is less than 30° (which impacts the calculation in accordance with Recommendation ITU-R P.530).