RECOMMENDATION ITU-R M.1231

INTERFERENCE CRITERIA FOR SPACE-TO-EARTH LINKS OPERATING IN THE MOBILE-SATELLITE SERVICE WITH NON-GEOSTATIONARY SATELLITES IN THE 137-138 MHz BAND

(Question ITU-R 83/8)

(1997)

Summary

In this Recommendation, the interference criteria for downlinks of FDMA non-GSO MSS networks and SSMA non-GSO MSS networks are recommended in terms of the maximum aggregate interference levels.

The ITU Radiocommunication Assembly,

considering

a) that interference criteria are needed to ensure that systems can be designed to achieve adequate performance in the presence of interference;

b) that interference criteria may be determined using the methodology described in Recommendation ITU-R SA.1022 and the performance objectives specified in Recommendation ITU-R M.1230;

c) that interference criteria assist in the development of criteria for sharing bands among systems, including those operating in other services;

d) that systems in the mobile-satellite service (MSS) in the 137-138 MHz band must accept interference at least equal to the permissible levels;

e) that two general types of modulation are to be considered for non-geostationary (non-GSO) MSS operating in the 137-138 MHz band, which are: narrow-band modulation with frequency division multiple access (FDMA), and wideband modulation with direct sequence spread spectrum multiple access (DS-SSMA);

f) that Annex 1 presents the parameters of two representative systems that provide the basis for permissible levels of interference in the mobile-satellite service in the 137-138 MHz band,

recommends

1 that the interference levels specified in Table 1 be used as the total level of interfering signal power at the antenna input of receiving stations operating in the MSS in the 137-138 MHz band;

2 that the interference levels defined herein are used as a basis for deriving sharing criteria.

NOTE 1 – The total interfering signal power level that may be exceeded for *p*% of the time, where *p* is less than 20% but greater than the specified short-term time percentage, may be determined by interpolation between the specified values using a logarithmic scale (base 10) for percentage of time and a linear scale for interfering signal power or signal power density (dB) (see Fig. 1) .

NOTE 2 – Using the guidelines in Recommendation ITU-R SA.1022, the permissible levels of interference may be scaled for application to stations with antenna gain or bandwidth values that differ from the specified values.

NOTE 3 – The interference criteria are based on the systems described in Annex 1. The interference criteria for systems using narrow-band modulation with FDMA techniques are given in terms of power levels in the reference bandwidth of the ground station receiver. The interference criteria associated with wideband modulations with DS-SSMA are given in terms of total power contribution of potential interferers in the 137-138 MHz band regardless of the bandwidth of the interferer.

NOTE 4 – The interference criteria are specified with respect to the percentage of time of reception.

NOTE 5 – The interference criteria for the wideband system is predicated on the link budget provided in Table 3. One of the main constraints in developing this link budget is a reduced power flux-density (pfd) required to protect the existing operations of the meteorological-satellite (MetSat) service. This reduction in pfd necessitates a decreased link margin for the wideband non-GSO MSS system, resulting in more restrictive interference criteria than would result in the absence of the MetSat operations. When the MetSat operations move to the 137.025-137.175 MHz and the 137.825 -138.0 MHz bands, the pfd from the future wideband non-GSO MSS may be increased with a corresponding increase in the interference criteria.

TABLE 1

Interference criteria for stations in the mobile-satellite service in the 137-138 MHz band

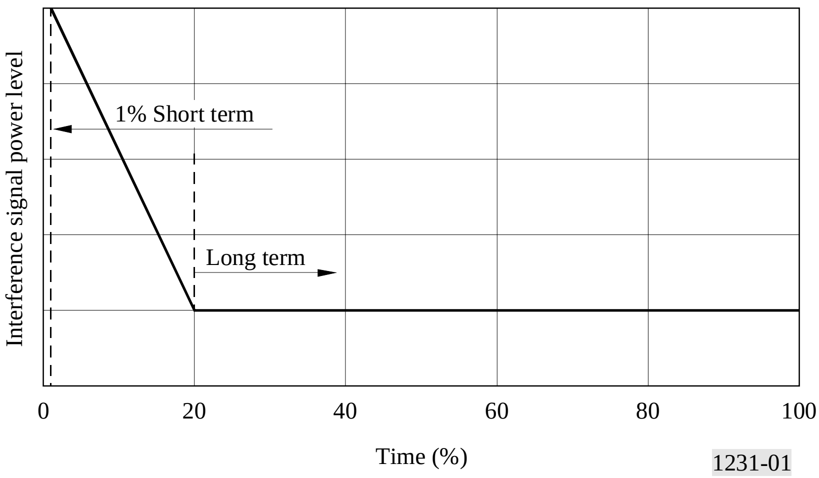
Modulation type	Function, and earth station platform and antenna	Interfering signal power (dBW) in the reference bandwidth to be exceeded for no more than 20% of the time(1)	Interfering signal power (dBW) in the reference bandwidth to be exceeded for no more than p_2% of the time(2)
Narrow-band modulation and FDMA	Data downlink to gateway (15 dBi horn antenna) Reference bandwidth is 44 kHz	–142.1	–133.4
Narrow-band modulation and FDMA	Data downlink to subscriber terminal (0 dBi monopole antenna with a $\cos^2$ pattern) Reference bandwidth is 19.2 kHz	–155.3	–144.5
Wideband modulation and SSMA (see Note 5)	Data downlink to gateway (16 dBi antenna) Reference bandwidth is 885 kHz	–134.5	–128.5

(1) The interfering signal power level is determined during reception at elevation angles equal to or greater than 20°.

(2) The interfering signal power level is determined during reception at elevation angles equal to or greater than 5° and for $p_2 = 0.25$.

FIGURE 1

Interference criteria model



ANNEX 1

Basis for interference criteria

1 Introduction

This Annex presents the parameters used as inputs to the methodology described in Recommendation ITU-R SA.1022 to determine the interference criteria. Tables 2 and 3 summarize these parameters. Additionally, § 5 presents the results of a dynamic analysis which involved computer modelling and simulations which were used to verify the calculated interference levels for the narrow-band system.

2 Non-GSO MSS in the 137-138 MHz band using narrow-band modulation with FDMA

The MSS operating below 1 GHz in non-GSO orbits operates downlinks in the 137-138 MHz band. Typical mobile terminals use an omnidirectional antenna with a 0 dBi gain at low elevation angles, and typical gateway earth stations use a conical horn antenna with a 15 dBi gain.

3 Non-GSO MSS in the 137-138 MHz band using wideband modulation with DS-SSMA

For spread-spectrum transmissions, reception by mobile terminals is not contemplated at the moment. Only gateway earth stations are considered here. They use a directive antenna with a 16 dBi antenna gain.

4 Interference criteria

The interference criteria establishes the total power from all potential interference sources that a system can tolerate and still provide an acceptable grade of service. Using the system's link budget and the performance objectives specified, the total interference power level is calculated. This level is determined by taking the margin available in the link, making some simplifying assumptions as explained in Recommendation ITU-R SA.1022 and separating it into a long-term and a short-term interference criteria (see equations (1) and (2), respectively).

$$i_{20} = n_{p1} + M_{p1} - 4.8 \tag{1}$$

where:

i_{20}: long-term interference criteria (dBW)

n_{p1}: noise power for the time the link is unavailable (dBW)

M_{p1}: short-term margin for the time the link is unavailable (dB).

$$i_{p2} = n_{20} + 10 \log (10^{0.1 M_{20}} - 1) \tag{2}$$

where:

i_{p2}: short-term interference criteria (dBW)

n_{20}: noise power to be exceeded for no more than 20% of the time (dBW)

M_{20}: long-term link margin (dB).

It is assumed that the long-term interference criteria is to be limited to less than 20% of the time and that the link is faded. In addition, in order to arrive at the long-term criteria, it is assumed that 33% of the short-term intra-system noise power be allowed as inter-system interference (i.e. an $I/N = -4.8$ dB). The short-term interference criteria is specified as the interfering signal power level that is to be exceeded for no more than some small percentage of time; it is assumed that the link is not faded. Of the 1% unavailability, 25% of this time is the unavailability allowed due to inter-system interference sources. Also, it is important to note that as explained in the methodology, the long-term interference criteria is calculated using the short-term margin and the short-term interference criteria is calculated using the long-term margin.

TABLE 2

Performance analysis used as a basis for interference criteria for narrow-band modulation with FDMA mobile-satellite receivers operating in the 137-138 MHz band

Performance factor	Parameter value		Parameter value	
Link function	Data downlink, subscriber receiver		Data downlink, gateway receiver	
Modulation type	DPSK		OQPSK	
Frequency range (MHz)	137-138			
Per cent time	1.0	20	1.0	20
1. Transmitter output power (dBW)	13.1		7.1	
2. Filter/cable line losses (dB)	1		1.4	
5. Antenna pointing error (dB)	0.2		0	
6. Antenna gain (dBi)	3.5	3.1	0.8	
7. E.i.r.p. (dBW)	15.4	15.0	6.5	
8. Antenna elevation angle	5°	20°	5°	20°
9. Satellite altitude (km)	775			
10. Free-space loss (dB)	143.9	139.9	143.9	139.9
11. Excess path loss including fading, etc. (dB)	5	1	1	
12. Receiver antenna gain (dBi)	0	–0.5	15	
13. Antenna pointing error (dB)	0		0.2	
14. Polarization mismatch loss (dB)	4.1		0.1	
15. Demodulator implementation loss (dB)	3			
16. Received signal power (dBW)	–140.6	–133.5	–126.7	–122.72
17. Reference bandwidth (kHz)	19.2		44.0	
18. Reference bandwidth (dB)	42.8		46.4	
19. Received energy C_0 (or E_b)(dB(W/Hz))	–183.5	–176.4	–173.15	–169.16
20. Receiver system noise temperature (K)	724		955	
21. Receiver noise spectral density (dB(W/Hz))	–200		–198.8	
22. Adjacent channel interference power (dB(W/Hz))	–210.6	–207.1	–400	
23. Total system $I + N$ power density (dB(W/Hz))	–199.6	–199.2	–198.8	
24. C_0/N_0 (or E_b/N_0) (dB)	16.2	22.9	25.65	29.64
25. Link bit error ratio	1×10^{-5}		1×10^{-6}	
27. Data storage/handling error ratio	------			
28. Total bit error ratio	1×10^{-5}		1×10^{-6}	
29. Required C_0/N_0	10.3		10.6	
30. Margin	5.9	12.6	15.05	19.04
Long-term or short-term margin (dB)	12.6 (20%)	5.9 (0.25%)	19.04 (20%)	15.05 (0.25%)
Interference power (dBW in reference bandwidth)	–144.5	–155.3	–133.4	–142.1
Interference power (dB(W/4 kHz))	–151.3	–162.1	–143.4	–152.1

TABLE 3

**Performance analysis used as a basis for interference criteria –
wideband modulation with DS-SSMA**

Link function: Data downlink to gateway receiver
Modulation type: MSK/DS-SSMA
Frequency range: 137-138 MHz

Per cent time	0.1%	20%
Elevation	5°	20°
Transmitter output power (dBW)	–15.5	
Uplink noise contribution (dB(W/Hz))	–63.1	
Internal interference contribution (dB(W/Hz))	–59.8	
Filter/cable line losses (dB)	–1	
Antenna gain (dBi)	4	
E.i.r.p. (dBW)	–12.5	
Satellite altitude (km)	1 300	
Free-space loss (dB)	–146.7	–143.6
Multipath loss (dB)	–2	–1
Polarization mismatch loss (dB)	–0.3	
Receiver antenna gain (dBi)	16	
Received signal power (dBW)	–145.5	–141.4
T_{eq} (dBK)	35.2	
C/N_0 up (dB(Hz))	47.6	
C/I_0 internal (dB(Hz))	44.3	
C/N_0 down (dB(Hz))	48	52
$(C/(N_0 + I_0))_T$	41.5	42.2
$(N_0 + I_0)$ (dB(W/Hz))	–187.1	–183.7
Implementation loss	–1.5	
R_b (bit/s)	600	
R_b (dB)	27.8	
Frequency domain adaptive filter (FDAF) loss (dB)	–6	
$E_b/(N_0 + I_0)$ (dB)	6.2	6.9
Required $E_b/(N_0 + I_0)$ (dB)	3.7	
Margin (dB)	2.5	3.2
Long-term or short-term margin (dB)	3.2 (20%)	2.5 (0.25%)
i_{20} (dB(W/Hz))		–189.4
i_{p2} (dB(W/Hz))	–183.3	
R_c (chip/s)	614 400	
R_c (dB)	57.9	
Maximum interference power	–128.5	–134.5

NOTE 1 – Maximum interference case corresponds to narrow-band signals at 137.5 MHz:

$$P = \frac{1}{2}\, i \; R_c \qquad \text{with } R_c \; = \; 614\,400 \text{ chip/s.}$$

For different values of narrow-band carrier frequency the interference powers can be increased as follows:

Centre frequency (MHz)	ΔP (dB)
137.4 or 137.6	+0.9
137.3 or 137.7	+3.6
137.2 or 137.8	+9
137.1 or 137.9	+20
137.05 or 137.95	+36.7
137 or 138	+27.8

5 Results of dynamic analysis – narrow-band modulation with FDMA

To assist in validating the results obtained by using the ITU-R methodology, two 90-day computer simulations were conducted. The orbital parameters of two example mobile-satellite constellations were used as inputs to the model. The RF characteristics were chosen to represent spread spectrum systems that are likely to operate co-channel with the narrow-band system. All interferers were assumed to be transmitting all the time. These simulations calculate the $C/(N + I)$ ratio (dB) and the cumulative statistics for a given interference scenario. The results of these simulations are shown below in Tables 4 and 5 as cumulative distributions for the subscriber and gateway receiver, respectively.

TABLE 4

Cumulative distribution of $C/(N + I)$ ratio in subscriber receiver with two interfering constellations

Per cent of time	Amount of time (min)	$C/(N + I)$ (dB)
0.009259	0	7
0.099537	117	8
0.300154	260	9
0.612654	405	10
1.165895	717	11
2.9375	2 296	12
7.560957	5 992	13
15.401235	10 161	14
27.331018	15 461	15
44.216049	21 883	16
63.891975	25 500	17
78.902008	19 453	18
86.296295	9 583	19
88.846451	3 305	20
89.138115	378	21
89.148918	14	22

TABLE 5

Cumulative distribution of $C/(N+I)$ ratio in gateway receiver with two interfering constellations

Per cent of time	Amount of time (min)	$C/(N+I)$ (dB)
0.003858	0	9
0.074074	91	10
0.346451	353	11
1.68287	1 732	12
3.625	2 517	13
5.95216	3 016	14
8.574074	3 398	15
11.253858	3 473	16
14.185185	3 799	17
17.199846	3 907	18
20.317902	4 041	19
23.36574	3 950	20
26.381172	3 908	21
29.35108	3 849	22
32.403549	3 956	23
35.611111	4 157	24
38.906635	4 271	25
42.690586	4 904	26
47.397377	6 100	27
52.334877	6 399	28
57.679783	6 927	29
62.788582	6 621	30
67.652779	6 304	31
72.138115	5 813	32
76.198303	5 262	33
79.726082	4 572	34
82.802467	3 987	35
85.560188	3 574	36
88.125771	3 325	37
90.622688	3 236	38
93.172066	3 304	39

As can be seen for both the subscriber and the gateway, even under worst-case conditions when all interferers are continuously transmitting, the desired $C/(N+I)$ of 10.3 dB for the subscriber (10.6 dB for the gateway) is not maintained for only small percentages of time (less than 1%).