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Recommendation ITU-R SA.1160-3
(07/2017)

Aggregate interference criteria for data transmission systems in the Earth exploration-satellite and meteorological-satellite services using satellites in the geostationary orbit

SA Series
Space applications and meteorology

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RECOMMENDATION ITU-R SA.1160-3

Aggregate interference criteria for data transmission systems in the Earth exploration-satellite and meteorological-satellite services using satellites in the geostationary orbit

(Question ITU-R 141/7)

(1995-1997-1999-2017)

Scope

The purpose of this Recommendation is to provide aggregate interference criteria for data transmission links for GSO satellites in the Earth exploration-satellite and meteorological-satellite services.

Keywords

EESS, METSAT, GSO satellites, data transmission, interference criteria

Related Recommendations and Reports

Recommendations ITU-R SA.1022, ITU-R SA.1159 and ITU-R SA.1161

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 listed in Recommendation ITU-R SA.1159;

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 Earth exploration-satellite service (EESS) and meteorological-satellite (MetSat) service must specify interference thresholds at levels greater than or equal to the permissible levels;

e) that the Annex presents the parameters of representative systems that provide the basis for determination of interference criteria for pertinent transmissions in the EESS and MetSat service,

recommends

that the interference criteria levels specified in Table 1 should be used as the permissible aggregate levels of interfering signal power at the antenna output of stations operating in the EESS and MetSat service.

TABLE 1

Interference criteria for stations in the EESS and MetSat service using spacecraft in the geostationary orbit

Frequency band (MHz)	Interfering signal power (dBW) in the reference bandwidth to be exceeded for no more than 20% of the time	Interfering signal power (dBW) in the reference bandwidth to be exceeded for no more than *p*% of the time
1 670-1 710 space-to-Earth	−158.0 dBW per 1 MHz	−152.8 dBW per 1 MHz $p = 0.025$
2 025-2 110 Earth-to-space	−139.9 dBW per 1 MHz	−136.6 dBW per 1 MHz $p = 0.025$
25 500-27 000 space-to-Earth	−144.6 dBW per 10 MHz	−133.0 dBW per 10 MHz $p = 0.25$

NOTE 1 – The interfering signal powers (dBW) in the reference bandwidths are specified for reception at elevation angles ≥ 3°.

NOTE 2 – The total interfering signal power level that may be exceeded for no more than *x*% of the time, where *x* is less than 20% but greater than the specified short-term time percentage (*p*% of the time), 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 density (dB).

NOTE 3 – The interference criteria can be expressed as permissible power flux-densities into the main beam of the receive antenna by subtracting $10 \log(G \lambda^2/4\pi)$ from the value given in Table 1, where G is the receive antenna gain and λ is the wavelength.

NOTE 4 – Although the interference criteria are based on the systems described in the Annex, the interference criteria apply to all systems that operate in the subject frequency bands and which provide the specified service functions.

Annex

Basis for determination of interference criteria

This Annex presents the parameters used as inputs to the methodology of Recommendation ITU-R SA.1022 to determine the interference criteria for raw instrument data downlink transmissions to main reception earth stations belonging to satellite operator and data dissemination to user stations.

1 Raw instrument data downlink transmissions to main reception earth stations

Table 2 develops these criteria for raw instrument data downlink transmissions to main reception earth stations, in which all of the interference enters the receiving earth station directly, and none is received at these stations via the satellite that originates the data.

The interference criteria can be expressed as permissible power flux-densities into the main beam of the receive antenna by subtracting $10 \log(G \lambda^2/4\pi)$ from the values given in Table 2, where G is the receive antenna gain and λ is the wavelength.

TABLE 2

Performance of raw instrument data downlink transmissions to main reception earth stations used as a basis for interference criteria of stations operating with satellites in geostationary orbit

a) Frequency band 1 670-1 710 MHz

Link parameter		Value	Notes
Down-link e.i.r.p.		16.1 dBW	
Down-link loss		190.1 dB	Free-space, polarization, and antenna pointing
Down-lnk G/T		24.4 dB(K^{-1})	
Down-link C/N_0		79.0 dB.Hz	
Data rate		2.6 Mbit/s	
Required C/N_0		78.1 dB.Hz	BER = 1×10^{-6} 2.2 dB implementation loss 1 dB modulation loss
Margin		0.9 dB	Long-term and short-term
Receive antenna gain		45.1 dBi	
Receiver noise density		–207.9 dB(W/Hz)	
Interference criteria	Long-term	–153.9 dB(W/2.6 MHz)	q = 1/3 and M_{min} = 1.2 dB
	Short-term	–148.7 dB(W/2.6 MHz)	q = 1 and M_{min} = 1.2 dB

b) Frequency band 25.5-27.0 GHz

Link parameter		Value	Notes
Down-link e.i.r.p.		55.5 dBW	
Down-link loss	Long-term	227.9 dB	Free-space, rain and atmospheric, polarization, and antenna pointing
	Short-term	231.3 dB	7.1 dB excess loss
Down-link G/T		37.6 dB(K^{-1})	
Down-link C/N_0	Long-term	93.8 dB.Hz	
	Short-term	90.4 dB.Hz	
Data rate		164 Mbit/s	
Required C/N_0		88.7 dB.Hz	BER = 1×10^{-9} 1.5 dB implementation loss 1.75 dB modulation loss
Margin	Long-term	5.1 dB	
	Short-term	1.7 dB	
Receive antenna gain		60.6 dBi	Including pointing losses
Receiver noise density		–205.6 dB(W/Hz)	
Interference criteria	Long-term	–144.6 dB(W/10 MHz)	q = 0.1 and M_{min} = 4.5 dB
	Short-term	–133.0 dB(W/10 MHz)	q = 1 and M_{min} = 4.5 dB

2 Data dissemination to user stations

Dissemination of high-resolution processed data is affected by interference received at the station via the satellite as well as by interference transmitted directly into the station in the 1 670-1 710 MHz band. The high-resolution processed data are up-linked to the satellite in the 2 025-2 110 MHz band, and relayed, along with interfering signals entering the satellite in the same band, to the Earth station receivers via fixed-gain satellite transponders.

The up-link and down-link carrier-to-noise plus interference density ratios are respectively:

$$\left(\frac{C}{N_0 + I_0}\right)_{up} = \frac{(C/N_0)_{up}}{1 + \frac{I_{01}}{k T_1}}$$

and

$$\left(\frac{C}{N_0 + I_0}\right)_{down} = \frac{(C/N_0)_{down}}{1 + \frac{I_{02}}{k T_2}}$$

where:

I_{01} and I_{02}: interference densities transmitted into the satellite and station receivers

T_1 and T_2: system noise temperatures of the satellite and station receivers

k: Boltzmann's constant.

The composite carrier-to-noise plus interference density ratio is:

$$\frac{C}{N_0 + I_0} = \left[\left(\frac{C}{N_0 + I_0}\right)_{up}^{-1} + \left(\frac{C}{N_0 + I_0}\right)_{down}^{-1}\right]^{-1}$$

From Recommendation ITU-R SA.1022 this can also be written:

$$\frac{C}{N_0 + I_0} = M^{-q}\,\frac{C}{N_0}$$

where:

M: interference-free margin

q: action of the interference-free margin that the interference is allowed to consume

C/N_0: composite carrier-to-noise density ratio given by:

$$C/N_0 = \left[(C/N_0)_{up}^{-1} + (C/N_0)_{down}^{-1}\right]^{-1}$$

From the foregoing equations:

$$M^q = 1 + \frac{\frac{I_{01}}{k T_1}(C/N_0)_{up} + \frac{I_{02}}{k T_2}(C/N_0)_{down}}{(C/N_0)_{up} + (C/N_0)_{down}}$$

Assume that the up-link and down-link interference are allocated so that a fraction p of the interference received at the earth station is received via the satellite, and that a fraction $1 - p$ is transmitted directly into the station. It is desirable for p to be near 1/2 in order to provide a reasonable balance in the interference allocated to the up-link and to the down-link. For a fixed-gain transponder it can be shown that:

$$\frac{I_{02}}{k\,T_2} = \frac{1 - p}{p}\,\frac{I_{01}}{k\,T_1}\,\frac{(C/N_0)_{down}}{(C/N_0)_{up}}$$

so that:

$$M^q = 1 + \frac{1}{p}\,\frac{I_{01}}{k\,T_1}\left[1 + \frac{(C/N_0)_{up}}{(C/N_0)_{down}}\right]^{-1}$$

Accordingly, the permissible up-link interference density becomes:

$$I_{01} = 1 + p\,k\,T_1\left[1 + \frac{(C/N_0)_{up}}{(C/N_0)_{down}}\right]\left(M^q - 1\right) \qquad \text{for } M > M_{mín}$$

where, according to Recommendation ITU-R SA.1022, M_{min} is the smallest interference-free margin for which only a fraction q of the margin is consumed by the interference. Correspondingly, the permissible down-link interference density is:

$$I_{02} = (1 - p)\,k\,T_2\left[1 + \frac{(C/N_0)_{down}}{(C/N_0)_{up}}\right]\left(M^q - 1\right) \qquad \text{for } M > M_{min}$$

Table 3 summarizes the calculation of I_{01} and I_{02} for high-resolution, assuming that $p = 1/2$, $q = 1/3$, and $M_{min} = 1.2$ dB for long-term interference, and that $p = 1/2$, $q = 1$, and $M_{min} = 1.2$ dB for short-term interference.

The interference criteria can be expressed as permissible power flux-densities into the main beam of the receive antenna by subtracting $10 \log(G\,\lambda^2/4\pi)$ from the values given in Table 3, where G is the receive antenna gain and λ is the wavelength.

TABLE 3

Performance analysis used as a basis for interference criteria of high-resolution data dissemination to user stations using geostationary satellites

Link parameter	Value	Notes
Up-link e.i.r.p.	72.1 dBW	
Up-link loss	191.7 dB	Free-space, polarization, and antenna pointing
Up-link G/T	−17.5 dB(K^{-1})	Post-launch measurement
Up-link C/N_0	91.5 dB/Hz	
Down-link e.i.r.p.	23.8 dBW	
Down-link loss	190.1 dB	Free-space, polarization, and antenna pointing
Down-link G/T	15.2 dB(K^{-1})	
Down-link C/N_0	77.5 dB.Hz	
Composite C/N_0	77.3 dB.Hz	
Data rate	2.11 Mbit/s	
Required C/N_0	75.9 dB.Hz	BER = 1×10^{-6} 1.9 dB implementation loss
Margin	1.4 dB	

TABLE 3 (*end*)

Link parameter		Value	Notes
Up-link receive antenna gain		9.5 dBi	
Up-link noise density		−201.6 dB(W/Hz)	T = 500 K
Up-link interference criterion (2 025-2 110 MHz)	Long-term	−136.7 dB(W/2.11 MHz)	q = 1/3
	Short-term	−133.4 dB(W/2.11 MHz)	q = 1
Down-link receive antenna gain		39.5 dBi	
Down-link noise density		−204.3 dB(W/Hz)	T = 269 K
Down-link interference criterion (1 670-1 710 MHz)	Long-term	−153.4 dB(W/2.11 MHz)	q = 1/3
	Short-term	−148.1 dB(W/2.11 MHz)	q = 1

3 Conclusions

3.1 Frequency band 1 670-1 710 MHz

The above analyses provide two different sets of interference criteria, for raw instrument data downlink transmissions to main reception Earth stations and data dissemination to user stations respectively.

It is assumed that raw instrument data downlink transmissions to main reception Earth stations are the most representative systems in the band. For simplification, it is further proposed to normalise the criteria in a 1 MHz bandwidth, leading to the following values:

– long-term: −158.0 dBW/MHz

– short-term: −152.8 dBW/MHz.

3.2 Frequency band 2 025-2 110 MHz

The above analysis provides a single sets of interference criteria for data dissemination systems. For simplification, it is further proposed to normalise the criteria in a 1 MHz bandwidth, leading to the following values:

– long-term: −139.9 dBW/MHz

– short-term: −136.6 dBW/MHz

3.3 Frequency band 25.5-27 GHz

The above analysis provides a single sets of interference criteria for raw instrument data downlink transmissions to main reception, representing the new generation of systems using the band 25.5-27 GHz and leading to the following values:

– long-term: −144.6 dBW/10 MHz

– short-term: −133.0 dBW/10 MHz