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Recommendation ITU-R SA.1163-3

(12/2018)

Aggregate interference criteria for service links in data collection systems for GSO satellites in the Earth exploration-satellite and meteorological-satellite services

SA Series

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International Telecommunication Union

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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 SA.1163-3

Aggregate interference criteria for service links in data collection systems for GSO satellites in the Earth exploration-satellite and meteorological-satellite services

(Question ITU-R 142/7)

(1995-1997-1999-2018)

Scope

This Recommendation provides the interference criteria for permissible aggregate levels of interfering signal power at the antenna output of stations operating for service links in the Earth exploration-satellite and meteorological-satellite services.

Keywords

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

Related ITU-R Recommendations and Reports

Recommendations ITU-R SA.1020, ITU-R SA.1022, ITU-R SA.1159.

The ITU Radiocommunication Assembly,

considering

a) that the hypothetical reference system specified in Recommendation ITU-R SA.1020 defines links for data collection and data collection platform interrogation;

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

c) that the 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;

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

e) that systems in the Earth exploration-satellite (including meteorological-satellite) service must accept an interference threshold at least as high as the threshold of permissible interference;

f) that the Annex presents the parameters of representative systems that provide the basis for permissible levels of interference for pertinent transmissions in the Earth exploration-satellite and meteorological-satellite services,

recommends

that the interference levels specified in Table 1 should be used as the permissible aggregate levels of interfering signal power at the antenna output of stations operating for service links in the Earth exploration-satellite and meteorological-satellite services.

TABLE 1

Aggregate interference criteria for service links of stations for GSO satellites in the Earth exploration-satellite and meteorological-satellite services

Frequency band (MHz)	**Interfering signal power (dBW) in the reference bandwidth to be exceeded no more than 20% of the time**	**Interfering signal power (dBW) in the reference bandwidth to be exceeded no more than *p*% of the time**
401-403 Earth-to-space	–191.5 dBW per 100 Hz (1)	–186.3 dBW per 100 Hz (2) p = 0.1
1 670-1 690 space-to-Earth	–198.8 dBW per 100 Hz (1)	–193.6 dBW per 100 Hz (2) p = 0.025
2 025-2 110 Earth-to-space	–191.2 dBW per 100 Hz (1)	–186.0 dBW per 100 Hz(2) p = 0.025
460-470 space-to Earth	–187.5 dBW per 100 Hz (1)	–182.3 dBW per 100 Hz (2) p = 0.1

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

(2) The interfering signal powers (dBW) in the reference bandwidths are specified for reception at elevation angles > 0°.

NOTE 1 – 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 2 – 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.

NOTE 3 – The interference criteria are specified with respect to the percentage of time of reception by the earth station. Thus, receiver performance statistics associated with reception from or by one particular satellite (i.e. cumulative distribution of bit error rate (BER)) are the same as the statistics for reception from several similar satellites. The total time of reception includes time periods associated with signal acquisition (i.e. before and during local ascension of the satellite), receiver synchronization to the data, and synchronized reception of data. The analyses of short-term performance that are presented in the Annex (i.e. performance exceeded for all but a small percentage of time p, $p \leq 1\%$) assume that the satellite is located at the minimum elevation angle associated with the applicable performance objective. This yields the BER performance exceeded for all but *p*% of the time because E_b/N_0 and BER are monotonically related to elevation angle.

NOTE 4 – The elevation angle exceeded for all but 20% of the time during reception is well approximated by the angle exceeded for all but 20% of the time that the satellite is visible above the minimum elevation angle specified in the performance objective. This approximation is made in the performance analyses presented in the Annex because the underlying cumulative time error cannot exceed 1% (i.e. *p*% of the time) and the associated total error in satellite antenna gain, free space loss, excess path loss, and earth station parameter values are negligible. The resulting elevation angle that is exceeded for all but 20% of the time of reception yields the BER performance exceeded for all but 20% of the time because E_b/N_0 and BER are monotonically related to elevation angle.

Annex

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.

2 General description of service link in data collection systems

Data Collection Platforms (DCPs) in Data Collection Systems (DCS) transmit DCP reports (DCPR) in the 401-403 MHz band that are relayed through a satellite to a Command and Data Acquisition (CDA) station, mainly in the 1 670-1 690 MHz band. The satellite transponder accommodates several hundred simultaneous DCPR transmissions. Two different types of DCS systems are operated:

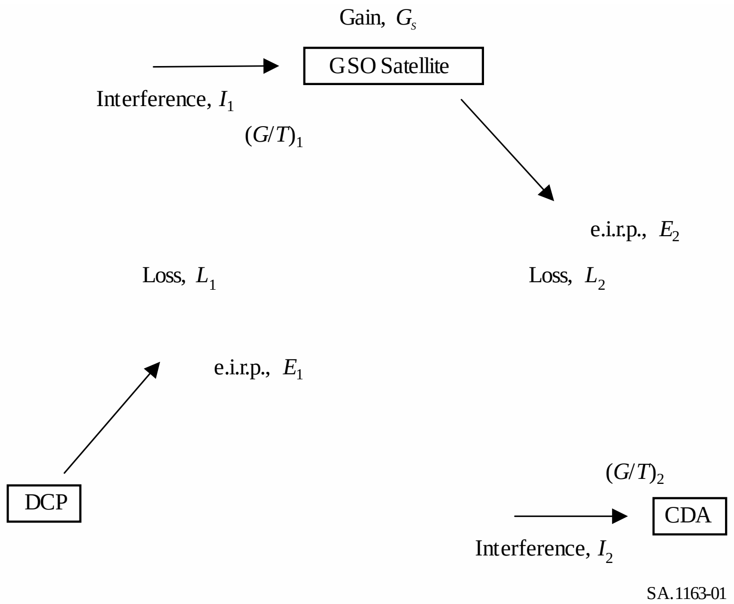
1) DCSs with constant gain transponders

2) DCSs using automatic gain control (AGC) that maintains the downlink DCPR e.i.r.p. constant regardless of the transponder input power.

Figure 1 below describes general scheme of a DCS, valid for both types of systems.

FIGURE 1

GSO DCPR link parameters



where:

E_1: DCP e.i.r.p.

E_2: satellite e.i.r.p.

G_1: satellite receive antenna gain

G_2: CDA station receive antenna gain

L_1 and L_2: uplink and downlink losses

G_S : satellite gain (excluding the satellite receive antenna)

T_1 and T_2: satellite and station system noise temperatures

I_1 and I_2: interference into the satellite and into the CDA station

G/T: ratio of the antenna gain-to-system noise temperature.

Because the DCPR data are not regenerated in the satellite, the wanted and interfering signals at the satellite receiver are amplified by the transponder and retransmitted to the downlink. The interfering signal at the satellite receiver has therefore an impact on the $C/(N+I)$ at the CDA station. Moreover, interfering signals received directly into the CDA station will further impact the $C/(N+I)$ at the CDA station. Overall, both uplink and downlink interfering signals (long-term and/or short-term) affect the DCS performance.

As such, the impact of these various interference scenarios is complex to model and is further complicated by the following considerations:

– The characteristics of Data Collection Systems vary greatly;

– The satellite transponder can accommodate several hundred simultaneous DCPR transmissions that in addition, are not transmitted at the same level of e.i.r.p.;

– There is a large variation of DCP e.i.r.p., typically in the range 5 to 19 dBW;

– For DCS satellites using automatic gain control (AGC), the satellite gain is not constant and is impacted by the level of interfering signal at the satellite receiver.

In view of the above, the description of a DCS link budget does not allow a description of a typical margin M since this margin presents a high range of variation from few dBs to even negative figures. It is therefore very difficult to undertake an analysis consistent with the model described in Recommendation ITU-R SA.1022 on the basis of a single margin *M*.

It is therefore proposed to develop the interference related to DCS based on the minimum margin (M_{min}) concept described in Recommendation ITU-R SA.1022 considering the following elements:

– M_{min} = 1.2 dB;

– q = 1/3 for long-term interference, i.e. that the long-term noise increase allowance, *A*, is 0.4 dB;

– q = 1 for short-term interference, i.e. that the short-term noise increase allowance, *A*, is 1.2 dB.

These elements are applied to both uplink and downlink using the noise increase formula:

$$I = 10\log(kT) + 10\log(10^{(A/10)} - 1)$$

where:

A: noise increase allowance

k: Boltzmann's constant (1.38×10^{-23} J/K)

T: system noise temperature.

The following Table A-1 provides characteristics of some DCS and related maximum interference levels calculations.

TABLE A-1

DCP link parameters and maximum interference levels

Parameter	Unit/comment	GOES DCPR	FYGEOSAT DCPR	MSG DCP	MTG DCP (low data rate)	MTG DCP (high data rate)
E_1 (short-term) for 0.1%	dBW	5	5	5	N/A	N/A
E_1 (long-term) for 20%	dBW	11	11	11	3.2	8
L_1	dB (Free-space and polarization loss)	177.1	179.05	177	179	179
G_1	dBi	13.8	8.5	3.9	11.9	11.9
T_1	K	534	464	296	545	545
$(G/T)_1$	dB-K^{-1}	−13.5	−18.2	−20.8	−15.5	−15.5
Bandwidth	kHz	400	400	400	400	400
G_s	dB	N/A	142.5	N/A	N/A	N/A
E_2	dBW	3.7	N/A	−22.7	N/A	N/A
L_2 (dB)	dB (Free-space and polarization loss)	190.1	190.01	190.3	N/A	N/A
G_2	dBi	47.5	44	45.5	N/A	N/A
T_2	K	100	186	141	N/A	N/A
$(G/T)_2$	dB-K^{-1}	27.5	21.3	24	N/A	N/A
$(C/N_0)_{required}$	dB.Hz	31.6	39.1	33.4	32.15	37.8
$I_{1long\text{-}term}$ (401-403 MHz)	dBW/Hz	−211.5	−212.1	−214.0	−211.4	−211.4
$I_{1short\text{-}term}$ (401-403 MHz)	dBW/Hz	−206.3	−206.9	−208.9	−206.2	−206.2
$I_{2long\text{-}term}$ (1 670-1 690 MHz)	dBW/Hz	−218.8	−216.1	−217.3	N/A	N/A
$I_{2short\text{-}term}$ (1 670-1 690 MHz)	dBW/Hz	−213.6	−210.9	−212.1	N/A	N/A

Based on the calculations in Table A-1 above, it is proposed to retain the interference criteria for DCSs the figures related to the GOES DCPR system. These limits are expressed below with respect to a 100 Hz bandwidth:

Uplink (401-403 MHz band):

$$I_{1long\text{-}term} = -191.5 \text{ dB(W/100 Hz)}$$

$I_{1short\text{-}term}$ = −186.3 dB(W/100 Hz)

Downlink (1 670-1 690 MHz band):

$I_{2long\text{-}term}$ = −198.8 dB(W/100 Hz)

$I_{2short\text{-}term}$ = −193.6 dB(W/100 Hz)

3 Meteorological-satellite service in the 460-470 MHz band downlink

Geostationary satellites relay BPSK-modulated DCP Command (DCPC) from the CDA station in the 2 025-2 110 MHz band to the DCPs in the 460-470 MHz band. The satellite transponder is a hard-limiter that maintains the downlink DCPC e.i.r.p. constant.

A similar approach to the DCPR case as described in § 2 is applied and it is therefore proposed to develop the interference related to DCS based on the minimum margin (M_{min}) concept described in Recommendation ITU-R SA.1022 considering the following elements:

M_{min} = 1.2 dB

q = 1/3 for long-term interference, i.e. that the long-term noise increase allowance, A, is 0.4 dB

q = 1 for short-term interference, i.e. that the short-term noise increase allowance, A, is 1.2 dB

These elements are applied to both uplink and downlink using the noise increase formula:

$$I = 10\log(kT) + 10\log(10^{(A/10)} - 1)$$

where:

A: noise increase allowance

k: Boltzmann's constant (1.38 × 10^{-23} J/K)

T: system noise temperature.

The following Table A-2 provides characteristics of some DCS and related maximum interference levels calculations:

TABLE A-2

DCPC link parameters and maximum interference levels

Parameter	Value	Notes
E_1	55.7 dBW	
P	55.7 dBW	One DCPC signal
L_1	191.7 dB	Free-space, polarization and pointing loss
$(G/T)_1$	−18.4 dB(K^{-1})	
B	200 kHz	
E_2	15.0 dBW	
L_2	178.5 dB	Free-space, polarization, and pointing loss
$(G/T)_2$	−29.3 dB(K^{-1})	
T_1	570 K	
T_2	1 338 K	

TABLE A-2 (*end*)

Parameter	Value	Notes
$(C/N_0)_{required}$	33.0 dB/Hz	BER 10^{-5} 2 dB implementation loss 1.2 dB modulation loss
$I_{1.long\text{-}term}$ (2 015-2 110 MHz)	−211.2 dBW/Hz	
$I_{1.short\text{-}term}$ (2 015-2 110 MHz)	−206 dBW/Hz	
$I_{2.long\text{-}term}$ (460-470 MHz)	−207.5 dBW/Hz	
$I_{2.short\text{-}term}$ (460-470 MHz)	−202.3 dBW/Hz	

Further normalized to a 100 Hz bandwidth, the interference criteria for the DCPC service become:

Uplink (2 025-2 110 MHz band):

$I_{1long\text{-}term}$ = −191.2 dB(W/100 Hz)

$I_{1short\text{-}term}$ = −186 dB(W/100 Hz)

Downlink (460-470 MHz band):

$I_{2long\text{-}term}$ = −187.5 dB(W/100 Hz)

$I_{2short\text{-}term}$ = −182.3 dB(W/100 Hz)

List of abbreviations and acronyms

AGC Automatic gain control

BPSK Binary phase shift keying

CDA Command and data acquisition

DCP Data collection platform

DCPC Data collection platform command

DCPR Data collection platform report

DCS Data collection system

EESS Earth exploration-satellite service

e.i.r.p. Effective isotropic radiated power

FY Feng-Yun (China)

GOES Geostationary Operational Environmental Satellite (USA)

GSO Geosynchronous Orbit

G/T Ratio of the antenna gain-to-system noise temperature

MetSat Meteorological Satellite

MSG Meteosat Second Generation (EUMETSAT)

MTG Meteosat Third Generation (EUMETSAT)