International Telecommunication Union

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Recommendation ITU-R SA.2044-0

(12/2013)

Protection criteria for non-GSO data collection platforms in the band 401-403 MHz

SA Series

Space applications and meteorology

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.2044-0

Protection criteria for non-GSO data collection platforms in the band 401-403 MHz

(Questions ITU-R 139/7 and ITU-R 141/7)

(2013)

Scope

This Recommendation provides information on the performance and interference criteria for non-GSO Data Collection Systems (DCS) in the 401-403 MHz.

The ITU Radiocommunication Assembly,

considering

a) that system designers require performance objectives in the presence of interference for their systems;

b) that performance objectives for representative systems operating in the EESS and MetSat services are intended to provide guidelines for the development of actual systems;

c) that performance objectives for EESS and MetSat services are a prerequisite for conducting interference assessments;

d) that protection criteria are required to meet the desirable performance objectives in the presence of interference,

recommends

1 that the analysis to determine the effect on non-GSO DCS systems in the 401-403 MHz should be based on the following protection criteria:

– –197.9 dB(W/(m^2 · Hz)) maximum aggregate acceptable spectral power flux-density (spfd) at the antenna of a non-GSO DCS instrument for broadband noise interference (see Annex 1);

– –165.4 dB(W/m^2) maximum power flux-density (pfd) within a resolution bandwidth of 19 Hz at the antenna of a non-GSO DCS instrument for each narrow-band spectral line interference (see Annex 2);

2 that protection criteria defined in *recommends* **1** should not be exceeded for more than a percentage of 1% of time in the field of view of the satellite.

Annex 1

Protection criteria for non-GSO DCS instruments in the band 401-401.69 MHz against broadband noise interference emissions

1 Introduction

This Annex provides information relating to an existing typical non-GSO DCS system in operation so called ARGOS and therefore to its protection requirements from broadband noise interference emissions.

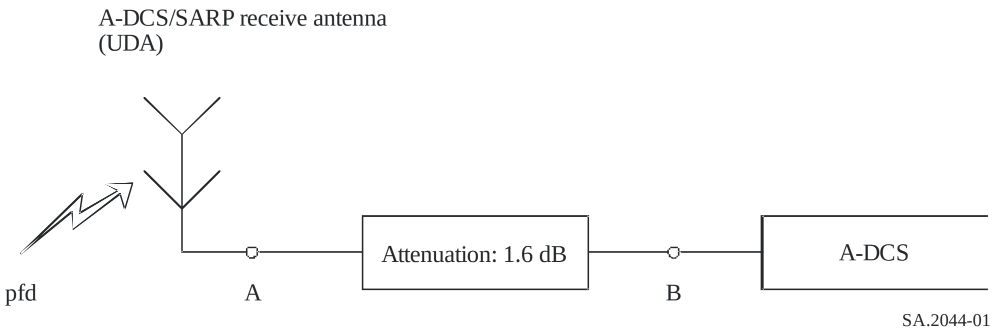
2 Spectral power flux-density threshold level of interference

The addition of broadband noise to the ARGOS instrument will have the effect of increasing the system bit-error ratio (BER), and therefore adversely affect its performance requirement. This analysis identifies the maximum acceptable pfd associated with broadband noise in the ARGOS uplink channel.

Figure 1 shows the main hardware elements on board the NOAA satellites. This general principle is applicable to METOP and NOAA satellites.

FIGURE 1

On-board hardware equipment



The UDA antenna gain pattern specification is expressed according to the nadir angle in Table 1:

TABLE 1

SARP/ARGOS receive antenna (UDA) gain pattern

Nadir satellite angle	**62**	**59**	**54**	**47**	**39**	**31**	**22**	**13**	**5**	**0**
Gain in RHCP	3.85	3.54	2.62	1.24	–0.17	–1.33	–2.24	–3.08	–3.80	–3.96
Gain in LHCP	–5.69	–6.23	–7.52	–9.39	–11.39	–13.12	–14.52	–15.77	–17.17	–18.00
Axial ratio	6.02	5.85	5.59	5.26	4.90	4.57	4.31	4.11	3.78	3.49

The specified figures in Table 1 are of the receive antenna pattern shared between the SARP and ARGOS instruments, as they should be for the NOAA and METOP satellites.

The ARGOS typical figures are: noise figure = 3 dB (ARGOS input parameter), worst-case background noise temperature = 1 200 K (measured value taking into account the industrial noise in Europe), attenuation between the antenna and the ARGOS receiver = 1.6 dB. Thus, the system noise temperature at the input of the ARGOS receiver (point B on Fig. 1) equals 1 214 K and therefore, the noise spectral density equals N_0 = –197.8 dB(W/Hz).

The worst-case specification states that the ARGOS is designed to operate correctly when the received signal has a power $C = -160$ dBW (minimum level of the received signal) at the input of the receiver, which provides an effective E_b/N_0 = 8.3 dB in the bit detector of the ARGOS if we take into account the beacon waveform and the various losses.

Therefore, in order to achieve a BER of 2×10^{-4} that corresponds to a minimum E_b/N_0 of 8 dB, the maximum acceptable degradation is 0.3 dB.

Hereunder, the additive noise corresponding to the 0.3 dB degradation for the C/N_0 is calculated.

Let I_0 represent the additive noise power density. Therefore, the initial N_0 noise becomes $N_0 + I_0$.

The signal-to-noise ratio C/N_0 becomes $C/(N_0 + I_0)$.

The degradation is 0.3 dB = 10 log $((C/N_0)/(C/(N_0 + I_0)))$, thus $I_0/N_0 = -11.5$ dB and $I_0 = -209.3$ dB(W/Hz) which corresponds to a temperature of 86 K, and therefore an increase of 7% of the system noise temperature at the input of the receiver.

Therefore, the maximum admissible level of noise density is $I_0 = -209.3$ dB(W/Hz) (calculated for point B in Fig. 1).

As shown in Fig. 1, the noise density, I_0, takes into account the attenuation and the antenna gain. As the spfd is required, it is necessary to transform this figure in dB(W/(m^2 · Hz)). The equivalent surface area of an antenna having a gain G is $S = G\frac{\lambda^2}{4\pi}$. Therefore, the corresponding spfd equals $-209.3 + 1.6$ (losses) – 10 $\log_{10}S = -197.9$ dB(W/(m^2 · Hz)), taking into account the highest satellite nadir angle.

Annex 2

Protection criteria for non-GSO DCS instruments in the band 401-401.69 MHz against narrow-band spectral line interference emissions

1 Introduction

This Annex provides information relating to an existing typical non-GSO DCS system in operation so called ARGOS and therefore to its protection requirements against narrow-band spectral line interference emissions.

2 Background

Annex 1 contains the protection criteria for ARGOS in the band 401-401.69 MHz to be used as a basis for analysis of interference from broadband interference emissions. This Annex provides protection requirements for the ARGOS instrument in respect of interference from narrow-band spectral line interference emissions.

3 Protection requirement from narrow-band spectral line emissions

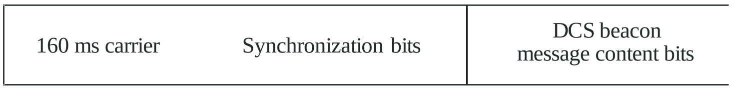
Figure 1 shows the main ARGOS hardware elements.

To better understand the rationale of this specification, it is necessary to briefly recall the behaviour of the instrument.

ARGOS beacon transmissions begin with 160 ms of unmodulated carrier to allow a phase-locked loop to lock more easily on the carrier. Figure 2 represents the ARGOS message format.

FIGURE 2

DCS message format



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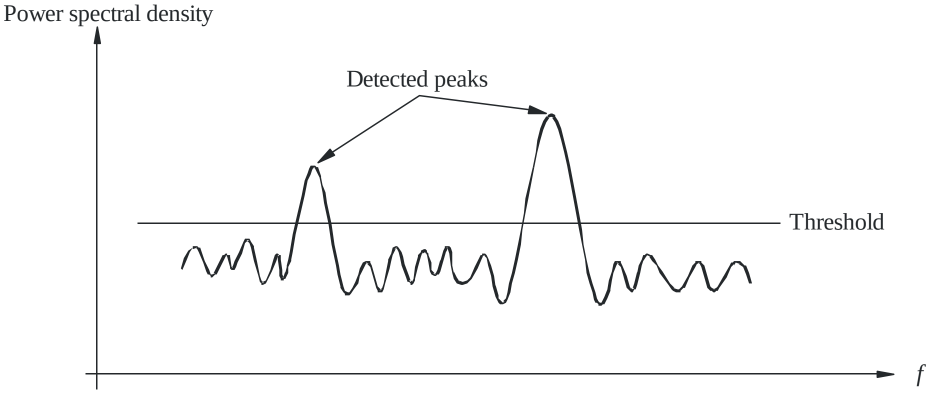
A spectrum analyser in the instrument continuously monitors the full coverage bandwidth in search of the pure carrier portion of the DCS messages. When the spectrum analyser detects such a line, it considers that it is the beginning of a DCS message. The theory is based on the detection of a pure carrier wave (sine wave) in a white, additive and Gaussian noise environment. The power spectral density of the received signal (pure carrier + noise) is computed using fast Fourier transform techniques, and each signal above the system threshold is processed as if it were a DCS beacon (see Fig. 3).

FIGURE 3

Detection of a sine wave in white Gaussian noise



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The ARGOS receiver processors are therefore designed to detect discrete spectral components (unmodulated beacon carrier) and the corresponding resolution bandwidth is 19 Hz. Signals above the threshold level are assigned to an on-board data recovery unit (DRU) for further processing and transmission to the Earth on the mission telemetry channel.

In order to satisfy ARGOS detection probability performances for a wide range of user applications (wild animal tracking, fishery, oceanography, etc.), the ARGOS instrument has been designed to detect and process extremely weak signals. Its performance is such that any signal, C_{min}, which exceeds the local noise density level by 21 dB(Hz) ($C_{min}/N_0 > 21$ dB(Hz)) would be assigned to a DRU for additional processing. Consequently, narrow-band interfering signals meeting this criteria would cause a DRU to be assigned to it. The consequence would be that the performance of the ARGOS instrument, in terms of capacity (e.g. the number of simultaneous DCS messages that are able to be processed), would be seriously degraded.

The ARGOS typical figures are: noise factor = 3 dB (ARGOS typical figure), worst-case background noise temperature = 1 200 K (ARGOS input parameter), attenuation between the antenna and the receiver = 1.6 dB. Thus, the system noise temperature at the input of the receiver (point B on Fig. 1) equals 1 214 K and therefore, the noise spectral density equals $N_0 = -197.8$ dB(W/Hz).

As $C_{min}/N_0 = 21$ dB(Hz), $C_{min} = -176.8$ dBW. Therefore, any narrow-band spurious emission greater than −176.8 dBW at the input of the ARGOS (point B of Fig. 1), would result in a degradation of the system capacity.

It is then necessary to compute this maximum admissible level of spectral line at the input of the ARGOS antenna.

The ARGOS receive antenna gain pattern specification is expressed according to the nadir angle in Table 2.

TABLE 2

Receive antenna (UDA) gain pattern

Nadir satellite angle	**62**	**59**	**54**	**47**	**39**	**31**	**22**	**13**	**5**	**0**
Gain in RHCP	3.85	3.54	2.62	1.24	–0.17	–1.33	–2.24	–3.08	–3.80	–3.96
Gain in LHCP	–5.69	–6.23	–7.52	–9.39	–11.39	–13.12	–14.52	–15.77	–17.17	–18.00
Axial ratio	6.02	5.85	5.59	5.26	4.90	4.57	4.31	4.11	3.78	3.49

Therefore, the maximum admissible power at point A of Fig. 1 equals –176.8 + 1.6 (losses) = −175.2 dBW, taking into account the highest satellite nadir angle. As the pfd is required, it is necessary to transform this figure in dB(W/m^2). The equivalent surface area of an antenna having a gain G is $S = G\frac{\lambda^2}{4\pi}$ corresponding to the highest satellite nadir angle. Therefore, the corresponding pfd equals –175.2 – 10 $\log_{10}S$ = −165.4 dB(W/m^2).

4 Conclusion

Following the above computations, the conclusions and recommendations regarding the impact of the aggregation of spectral narrow-band interference emissions, should not exceed −165.4 dB(W/m^2) at the input of the ARGOS antenna for the frequency band 401-401.69 MHz, within a resolution bandwidth of 19 Hz.