International Telecommunication Union

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R SF.1843
(10/2007)

Methodology for determining the power level for high altitude platform stations ground terminals to facilitate sharing with space station receivers in the bands 47.2-47.5 GHz and 47.9-48.2 GHz

SF Series

Frequency sharing and coordination between fixed-satellite and fixed service systems

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

Electronic Publication
Geneva, 2011

RECOMMENDATION ITU-R SF.1843*

Methodology for determining the power level for high altitude platform stations ground terminals to facilitate sharing with space station receivers in the bands 47.2-47.5 GHz and 47.9-48.2 GHz

(2007)

Scope

This Recommendation presents a methodology and its applications to determine the power level for the ground terminals of HAPS to promote frequency sharing with an FSS space station receiver in the bands 47.2-47.5 GHz and 47.9-48.2 GHz.

The ITU Radiocommunication Assembly,

considering

a) that new technology is being developed utilizing telecommunication relays located on high altitude platform stations;

b) that WRC-97 made provision for the operation of high altitude platform stations (HAPS), also known as stratospheric repeaters, within the fixed service in the bands 47.2-47.5 GHz and 47.9-48.2 GHz;

c) that the bands 47.2-47.5 GHz and 47.9-48.2 GHz are allocated to the fixed-satellite service (FSS) in the Earth-to-space direction;

d) that ITU-R was invited to study, as a matter of urgency, power limitations applicable for HAPS ground stations to facilitate sharing with space stations receivers;

e) that because systems in the FS using HAPS can use the full range of elevation angles, sharing with the FSS may present difficulties;

f) that Recommendation ITU-R F.1500 contains the characteristics of systems in the fixed service using HAPS,

recognizing

a) that according to No. 5.552A of the Radio Regulations (RR), the allocation to the FS in the bands above, is designated for use by HAPS,

recommends

1 that the methodology given in Annex 1 should be used to determine the maximum level of transmit power applicable for HAPS ground terminals to facilitate sharing with space station receivers in the bands 47.2-47.5 GHz and 47.9-48.2 GHz, in the ground-to-HAPS direction.

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* Radiocommunication Study Groups 4 and 5 made editorial amendments to this Recommendation in September 2011 and November 2010, respectively, in accordance with Resolution ITU-R 1.

Annex 1

Methodology

1 System characteristics

1.1 The high altitude platform system

The parameters used in this analysis are given in Recommendation ITU-R F.1500 and are as follows:

TABLE 1

HAPS coverage zones (platform at 21 km)

Coverage area	Elevation angles (degrees)	Ground range (km)
UAC(1)	90-30	0-36
SAC(2)	30-15	36-76.5
RAC(3)	15-5	76.5-203

(1) UAC: Urban area coverage.

(2) SAC: Suburban area coverage.

(3) RAC: Rural area coverage.

TABLE 2

Ground terminal transmitter parameters

Communication to	Transmitter power density (dB(W/2 MHz))	Antenna gain (dBi)
UAC(1)	–8.2	23
SAC(2)	–7	38
RAC(3)	–1.5	38

(1) UAC: Urban area coverage.

(2) SAC: Suburban area coverage.

(3) RAC: Rural area coverage.

1.2 GSO FSS satellite station

The parameters used in this analysis are as follows:

TABLE 3

GSO FSS satellite parameters

Maximum antenna gain (dBi)	51.8
Interference criterion (dB(W/MHz))	–150.5
Antenna pattern	Recommendation ITU-R S.672-4

2 Interference analysis

This section investigates interference from HAPS ground terminals into an FSS space station receiver. For the aggregate interference analysis, the HAPS coverage areas are populated with ground terminals and the interference received at the FSS space station is calculated for a number of trials, where each trial corresponds to a random distribution of HAPS ground terminals in full distribution based on Recommendation ITU-R F.1500. The parameters of HAPS ground terminals used in the analysis are shown in Table 4. It is assumed that a fully loaded platform would be able to support 100 co-channel ground terminals in each of the three coverage areas and that the main lobe of a receiving antenna beam pattern of an FSS space station receiver is always directed to the nadir of HAPS to consider the sharing condition.

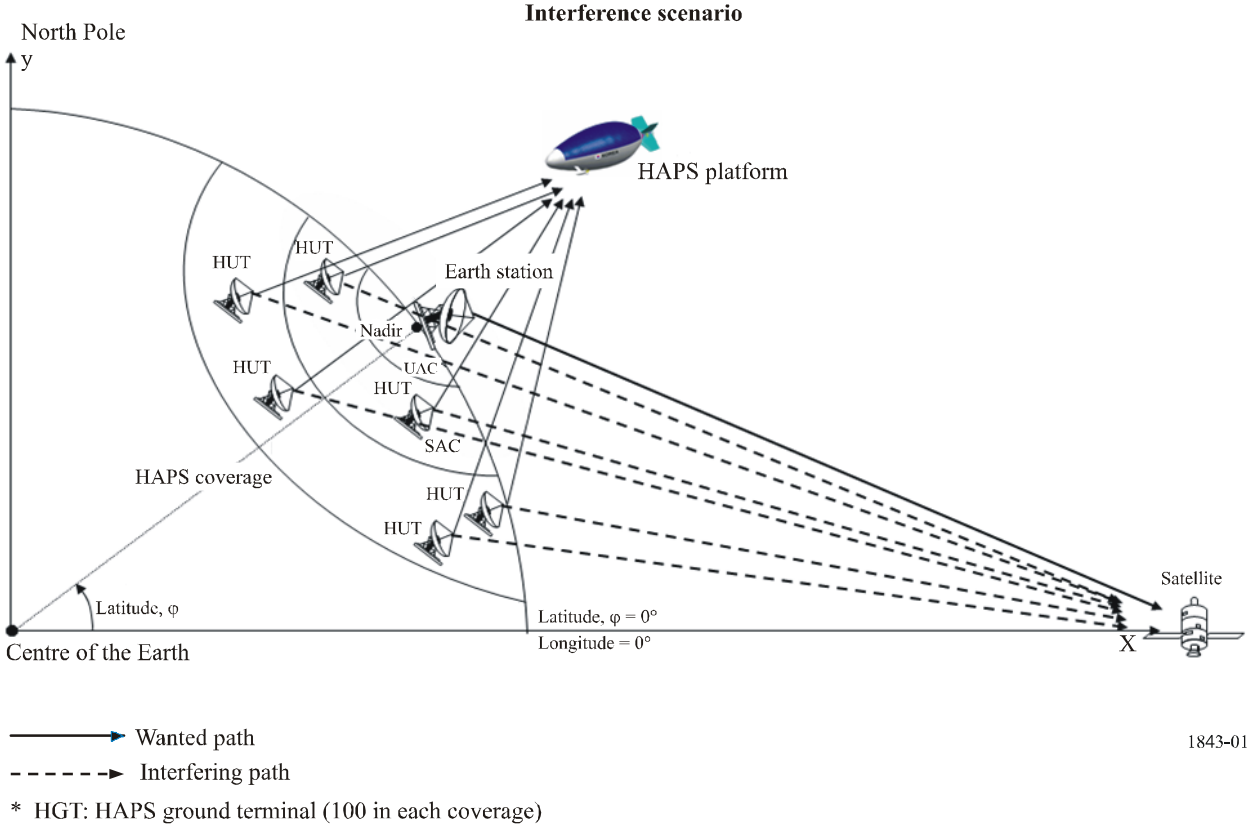
TABLE 4

Transmitting parameters of HAPS ground terminals

Coverage area	RAC	SAC	UAC
Range of elevation angles (degrees)	5-15	15-30	30-90
Number of ground terminals	100	100	100
Antenna gain (dBi)	38	38	23
Power (dBW)	–1.5	–7	–8.2
Channel bandwidth (MHz)	2	2	2

FIGURE 1

Interference scenario



In this analysis, the interference scenario is assumed as shown in Fig. 1. The earth station is located at the nadir (the centre of HAPS coverage) and the satellite is located at latitude = 0° and longitude = 0°, while the position of HAPS coverage is varied with only the latitude (longitude = 0°).

The expected received power density at the space station receiver can be calculated by equation (1):

$$P_r = P + G_t - L_{tf} + G_r - L_{rf} - L_a - L_p - 10 \log B - 20 \log (4\pi d/\lambda) - 60 \quad \text{dB(W/MHz)} \quad (1)$$

where:

Pr: expected received carrier power density (dB(W/MHz))

P: transmitting output power density (dB(W/MHz))

Gt: transmitting antenna gain (dBi)

Ltf: antenna feeder loss (dB)

Gr: gain of the receiving antenna (dBi)

Lrf: receiving antenna feeder loss (dB)

La: atmospheric absorption for a particular elevation angle (dB)

Lp: attenuation due to other propagation effects (dB)

B: bandwidth (MHz)

d: distance of signal path (km)

λ: wavelength (m).

The bandwidth of HAPS ground terminals is assumed to be 2 MHz as described in Recommendation ITU-R F.1500. For the antenna beam patterns of HAPS ground terminals, Recommendations ITU-R F.1245 and ITU-R F.699 are referred to. Taking into account the maximum antenna gains described in Table 4, antenna beam patterns for cases where the ratio between the antenna diameter and the wavelength is less than or equal to 100, in both Recommendations above, are considered.

As an example of the antenna beam patterns, Fig. 2 shows the antenna beam pattern from Recommendation ITU-R F.1245 has a lower side lobe than that from Recommendation ITU-R F.699.

FIGURE 2

Radiation beam patterns

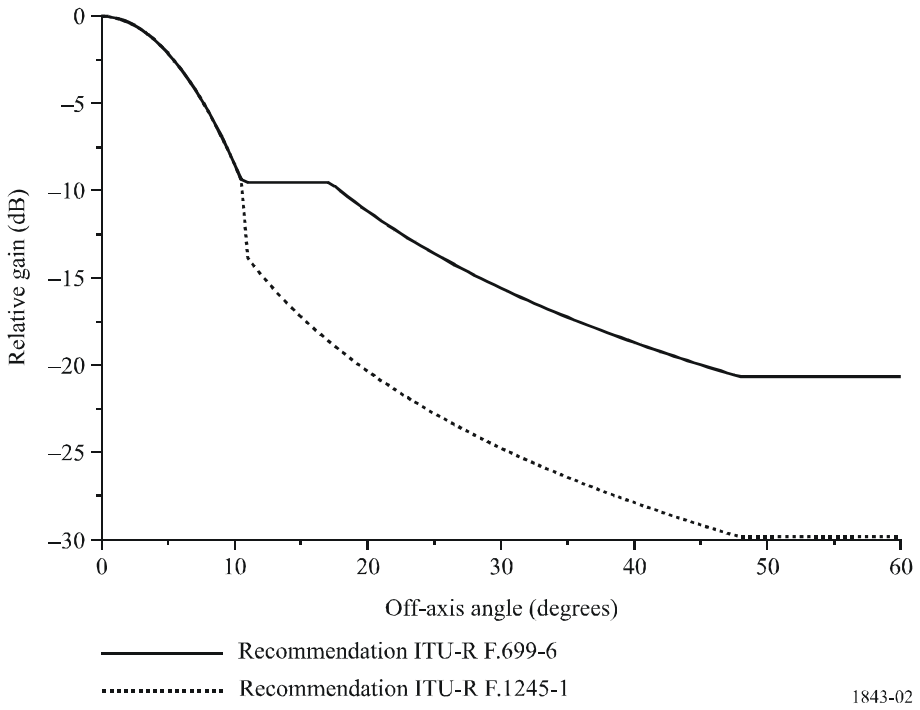


Figure 3 shows an example of the interference cumulative distribution function (CDF) with the latitude of a HAPS platform and earth station of the satellite for 1 000 trials, with the parameters based on Table 4. In this example the antenna beam pattern of Recommendation ITU-R F.699-6 was used for HAPS ground terminals. If the interference criterion for the FSS space station is −150.5 dB(W/MHz) as mentioned in Table 3, all cases with the latitude greater than 70° exceed the interference criterion. For situations below 70° latitude, as the latitude becomes higher, the interference from HAPS ground terminals into the FSS space station is increased. If the latitude is above 70°, the interference is decreased again.

Figure 4 shows the CDF difference using the antenna beam patterns of Recommendations ITU-R F.699 and ITU-R F.1245. The result shows HAPS ground terminals with the antenna beam pattern of Recommendation ITU-R F.1245 give less interference to the space station receiver than those with the antenna beam pattern of Recommendation ITU-R F.699 at the same latitude.

FIGURE 3

An example of CDF with the latitude of HAPS nadir (using the antenna beam pattern from Recommendation ITU-R F.699)

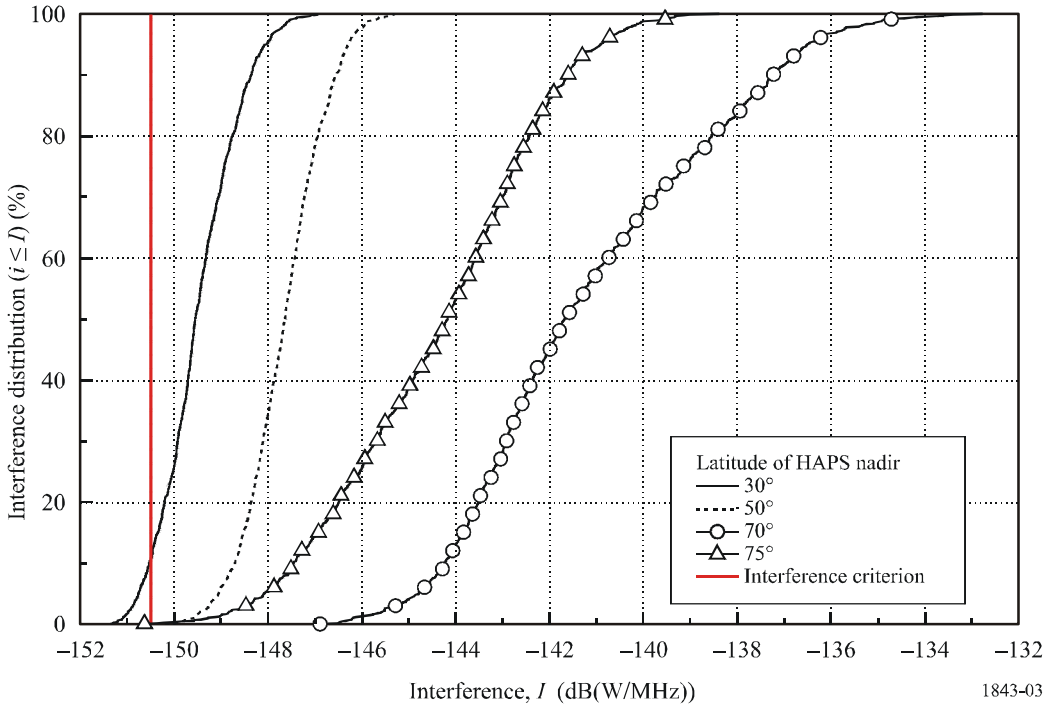
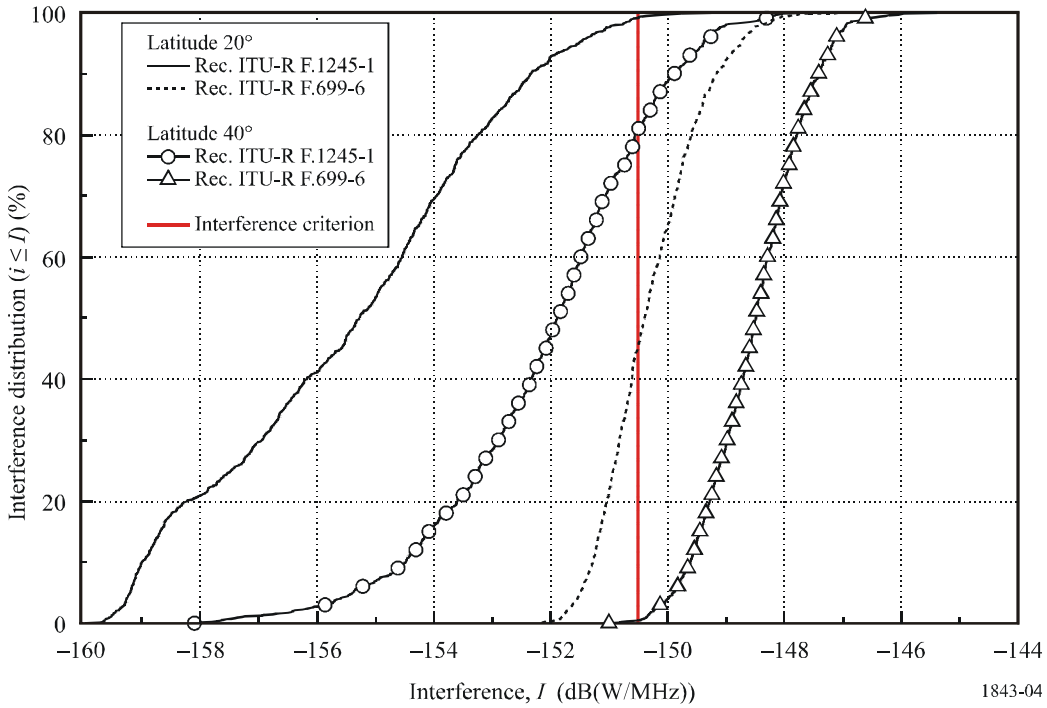


FIGURE 4

CDF with antenna beam patterns (antenna beam pattern of Recommendation ITU-R F.699 vs. Recommendation ITU-R F.1245)



3 Transmitting power level of HAPS ground terminals

To reduce interference power from HAPS ground terminals to the FSS space station, the maximum power level from the ground terminals should be specified. This section shows examples to specify the maximum power level from the ground terminals of HAPS with antenna beam patterns mentioned in Recommendations ITU-R F.699 and F.1245.

The power reduction of the HAPS ground terminals given in Recommendation ITU-R F.1500 is carried out so that interference avoidance of HAPS ground terminals with FSS space stations can be achieved even in co-coverage areas. It is assumed that HAPS ground terminals have a power control scheme.

As shown in Figs. 3 and 4, since the interference is different from the latitude of HAPS nadir and the antenna beam patterns of HAPS ground terminals, it is necessary to specify the appropriate power with the latitude and antenna beam pattern.

Table 5 shows the parameters for the HAPS ground terminals with the power reduction when the antenna beam pattern of Recommendation ITU-R F.699 is applied to the HAPS ground terminals. In the cases of C and D in the Table, HAPS ground terminals in SAC and RAC are excluded since the possibility that main beams of HAPS ground terminals are directed to the FSS space station receiver is increased due to the low elevation angle in higher latitude.

TABLE 5

Sharing parameters with latitude of HAPS nadir (using the antenna beam pattern of Recommendation ITU-R F.699)

Case	Latitude of HAPS and SAT ES	Transmitter parameters	UAC	SAC	RAC
			Elevation angles (90°-30°)	Elevation angles (30°-15°)	Elevation angles (15°-5°)
A	$0° \le \varphi \le 30°$	Number of ground terminals	100	100	100
		Antenna gain	23 dBi	38 dBi	38 dBi
		Power	–13.2 dBW	–7 dBW	–1.5 dBW
B	$30° < \varphi \le 50°$	Number of ground terminals	100	100	100
		Antenna gain	23 dBi	38 dBi	38 dBi
		Power	–13.2 dBW	–12 dBW	–6.5 dBW
C	$50° < \varphi < 58°$	Number of ground terminals	100	–	–
		Antenna gain	23 dBi	–	–
		Power	–13.2 dBW	–	–
D	$\varphi \ge 58°$	Number of ground terminals	100	–	–
		Antenna gain	23 dBi	–	–
		Power	–8.2 dBW	–	–

Remark

Case A: 5 dB power reduction only in UAC.

Case B: 5 dB power reduction in all.

Case C: 5 dB power reduction in UAC with no users in SAC and RAC.

Case D: No power reduction with no users in SAC and RAC.

Table 6 shows the parameters for the HAPS ground terminals with the power reduction when the antenna beam pattern of Recommendation ITU-R F.1245 is applied to the HAPS ground terminals. Due to the same reason as stated above, in the cases of C and D in the Table, HAPS ground terminals in SAC and RAC are also excluded.

TABLE 6

Sharing parameters with latitude of HAPS nadir (using the antenna beam pattern of Recommendation ITU-R F.1245)

Case	Latitude of HAPS and SAT ES	Transmitter parameters	UAC	SAC	RAC
			Elevation angles (90°-30°)	Elevation angles (30°-15°)	Elevation angles (15°-5°)
A	0° ≤ φ ≤ 30°	Number of ground terminals	100	100	100
		Antenna gain	23 dBi	38 dBi	38 dBi
		Power	–10.7 dBW	–7 dBW	–1.5 dBW
B	30° < φ ≤ 50°	Number of ground terminals	100	100	100
		Antenna gain	23 dBi	38 dBi	38 dBi
		Power	–12.2 dBW	–11 dBW	–5.5 dBW
C	50° < φ < 58°	Number of ground terminals	100	–	–
		Antenna gain	23 dBi	–	–
		Power	–10.7 dBW	–	–
D	φ ≥ 58°	Number of ground terminals	100	–	–
		Antenna gain	23 dBi	–	–
		Power	–8.2 dBW	–	–

Remark

Case A: 2.5 dB power reduction only in UAC.

Case B: 4 dB power reduction in all.

Case C: 2.5 dB power reduction in UAC with no users in SAC and RAC.

Case D: No power reduction with no users in SAC and RAC.

Figure 5 shows the possibility of interference avoidance of HAPS ground terminals with an FSS space station by up to 5 dB power reduction of HAPS ground terminals.

Figure 6 shows the possibility of interference avoidance of HAPS ground terminals with an FSS space station by up to 4 dB power reduction of HAPS ground terminals.

For the low latitude (below 30°) the power of HAPS ground terminals in UAC is an important factor, but for high latitude (above 30°) those in SAC and RAC are the dominant factor. Figures 5 and 6 show that all cases do not exceed the interference criterion.

FIGURE 5

CDF with the parameters of Cases A, B, C and D (using the parameters in Table 5)

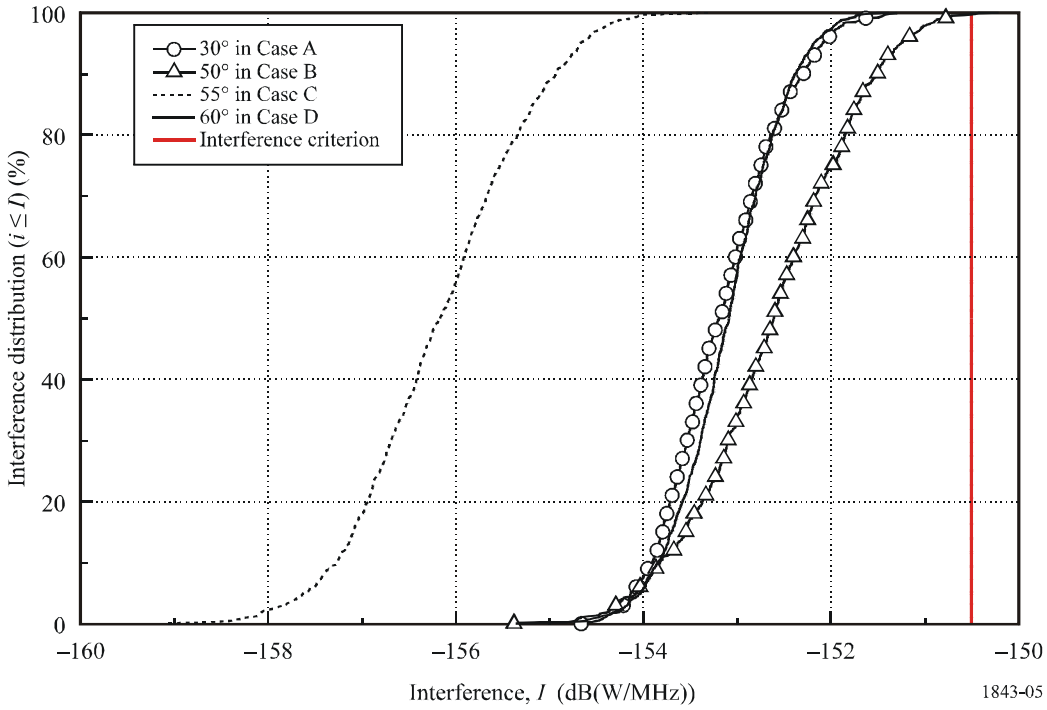
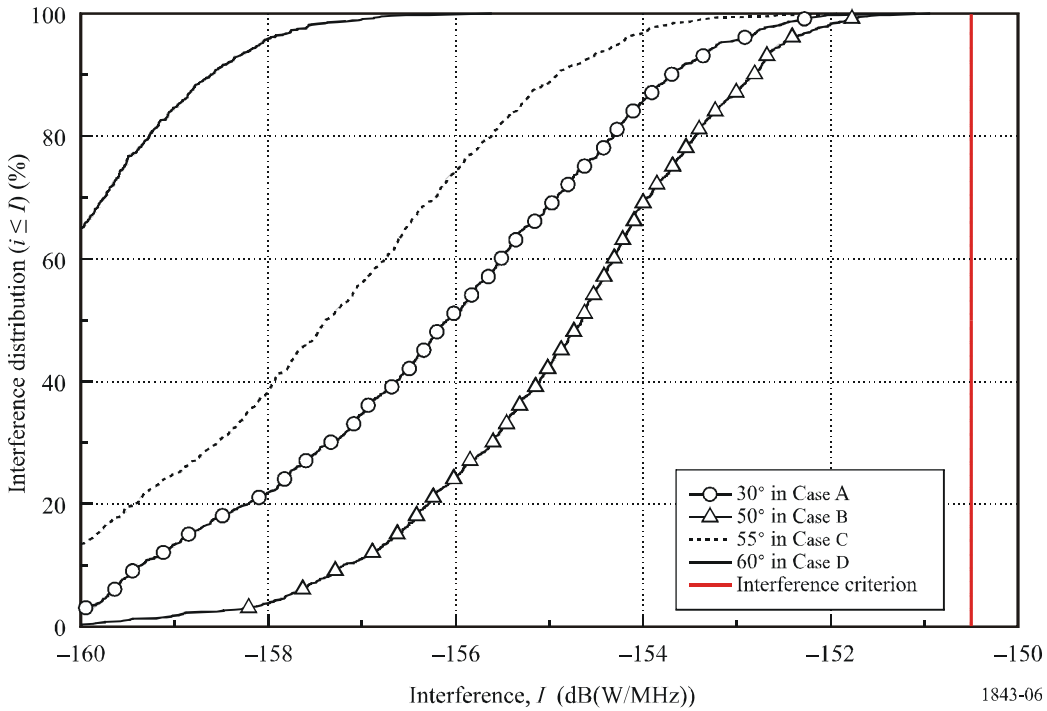


FIGURE 6

CDF with the parameters of Cases A, B, C and D (using the parameters in Table 6)



If HAPS ground terminals are equipped with a power control system, they can reduce the transmit power in clear-sky conditions, not exceeding the interference criterion of the FSS space station receiver in a co-coverage area. In clear-sky conditions, the reduction can be achieved up to the amounts of rain attenuation given in Recommendation ITU-R F.1500, e.g. 11.2 dB, 14.9 dB and 22.4 dB in UAC, SAC and RAC, respectively. In this analysis, the power reduction (for example: maximum 5 dB in the case of the parameters in Table 5, maximum 4 dB in Table 6) is assumed to show the possibility of interference avoidance in a co-coverage area. The reduction would be applicable in co-coverage areas. In rainy conditions, the reduced power would be restored.

4 Summary

This Annex presents a methodology and its applications to determine the power level for the ground terminals of HAPS to promote frequency sharing between HAPS ground terminals and an FSS space station in the bands 47.2-47.5 GHz and 47.9-48.2 GHz. Power reduction can meet the interference criterion, when the parameters shown in Tables 5 and 6 are used (i.e. power control range of 5 dB).

In summary, this Annex shows the possibility of interference avoidance of an FSS space station receiver from HAPS ground terminals equipped with a power control range of 5 dB.