RECOMMENDATION ITU-R S.1418

METHOD FOR CALCULATING SINGLE ENTRY CARRIER-TO-INTERFERENCE RATIOS FOR LINKS IN INTER-SATELLITE SERVICE USING GEOSTATIONARY ORBIT

(Question ITU-R 239/4)

(1999)

The ITU Radiocommunication Assembly,

considering

a) that Question ITU-R 239/4 for the World Radiocommunication Conference (Geneva, 1997) (WRC-97) calls for "very urgent and priority studies" to determine sharing criteria and coordination guidelines for systems utilizing the inter-satellite service (ISS);

b) that there is extensive planned use of the ISS between satellites in the geostationary orbit (GSO);

c) that GSO ISS networks typically require wide bandwidths, and typically form high data rate trunk links for the space segments of networks;

d) that high data rate trunk lines must have high availability;

e) that a method is required to evaluate the level of interference between such systems,

recommends

1 that the method described in Annex 1 be used to calculate *C*/*I* ratios for inter-satellite links in the GSO.

ANNEX 1

Method for calculating single entry *C*/*I* for links of ISS using GSO

1 Inputs

The required inputs for the calculation of single entry *C*/*I* are shown in Table 1.

TABLE 1

Inputs for methodology for calculation of single entry *C*/*I*

Item	Symbol
Centre frequency (MHz)	f_c
Victim system	
Longitude of receiver (degrees)	V_{rx}
Longitude of transmitter (degrees)	V_{tx}
Transmit power (dBW)	P_v
Transmit gain (dBi)	$G_{v,tx}$
Transmit bandwidth (MHz)	B_v
Receive gain (dBi)	$G_{v,rx}$
Receive antenna diameter (m)[(1)]	$d_{v,rx}$
Interfering system	
Longitude of receiver (degrees)	I_{rx}
Longitude of transmitter (degrees)	I_{tx}
Transmit power (dBW)	P_i
Transmit gain (dBi)	$G_{i,tx}$
Transmit bandwidth (MHz)	B_i
Receive gain (dBi)	$G_{i,rx}$
Transmit antenna diameter (m)[(1)]	$d_{i,tx}$

(1) The antenna diameters are sometimes required for calculation of antenna discrimination.

2 Method

2.1 Carrier power

To calculate carrier power, it is necessary to calculate the range loss between the satellites. The range between victim satellites is given by:

$$R = 2 r_{GSO} \sin\left(\left| V_{tx} - V_{rx} \right| / 2 \right) \qquad \text{km}$$

where:

V_{tx}: longitude of the victim transmitter

V_{rx}: longitude of the victim receiver

r_{GSO}: radius of the GSO (42 164 km)

R: range between satellites (km).

The free space loss is given by:

$$L_{fs} = 20 \log f + 20 \log R + 32.45 \qquad \text{dB}$$

where f is the carrier frequency (MHz).

The carrier power is then computed:

$$C = P_v + G_{v,tx} - L_{fs} + G_{v,rx} \qquad \text{dB}$$

2.2 Interference power

To calculate interference power, it is necessary to calculate the range loss between the satellites. The range from the interfering transmitter to the victim receiver is given by:

$$R = 2r_{GSO} \sin\left(\left| I_{tx} - V_{rx} \right| / 2\right) \qquad \text{km}$$

where:

I_{tx}: longitude of the interfering transmitter

V_{rx}: longitude of the victim receiver

r_{GSO}: radius of the GSO (42 164 km)

R: range between satellites (km).

The free space loss is given by:

$$L_{fs} = 20 \log f + 20 \log R + 32.45 \qquad \text{dB}$$

where f is the carrier frequency (MHz).

To facilitate calculation of off-boresight angles, the coordinates of all satellites are transformed from polar coordinates to the rectangular coordinate system within the equatorial plane, with the origin at geocentre.

The x axis component of each satellite is given by:

$$S_x = r_{GSO} \cos(\text{longitude})$$

and the y axis component is given by:

$$S_y = r_{GSO} \sin(\text{longitude})$$

where S is the position of the satellite in question, and r_{GSO} is the GSO radius (42 164 km).

If **A** is the vector from satellite 1 to satellite 2, and **B** is the vector from satellite 1 to satellite 3, the angle (θ) between **A** and **B** (measured at satellite 1) is given by:

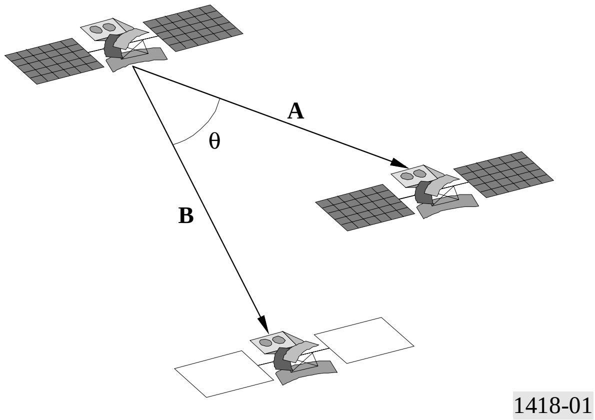
$$\theta = \cos^{-1}\left(\frac{\mathbf{A} \cdot \mathbf{B}}{|\mathbf{A}||\mathbf{B}|}\right)$$

as illustrated in Fig. 1. |**A**| and |**B**| are the magnitudes of A and B, and $\mathbf{A} \cdot \mathbf{B}$ is the inner product of the two vectors. For example, for **A** and **B** expressed in rectangular coordinates then:

$$\mathbf{A} \cdot \mathbf{B} = A_x B_x + A_y B_y + A_z B_z$$

FIGURE 1

Angle between satellites



For example, if the antenna discrimination at the victim receiver is required, let **A** represent the vector from the victim receiver to the victim transmitter, and let **B** represent the vector from the victim receiver to the interfering transmitter. The resulting angle θ is input to an appropriate antenna pattern model to compute the antenna discrimination.

The bandwidth reduction factor is given by:

$$L_{BW} = \begin{cases} 10 \log \dfrac{B_i}{B_v} & \text{if } \dfrac{B_i}{B_v} > 1 \\ 0 & \text{otherwise} \end{cases}$$

The interference power is then computed:

$$I = P_i + G_{i,tx}(\theta_{tx}) - L_{fs} + G_{v,rx}(\theta_{rx}) - L_{BW} \qquad \text{dB}$$

where θ_{tx} and θ_{rx} are the off-boresight angles at the interfering transmitting and victim receiving ends, respectively, and $G_{i,tx}(\theta_{tx})$ and $G_{v,rx}(\theta_{rx})$ are the off-boresight gains of the interfering transmitting and victim receiving antennas.

3 Sample computation of *C*/*I* for the GSO ISS

The antenna pattern model used for this example is Recommendation ITU-R S.672 (Annex 1), with first side lobe of 20 dB below maximum gain.

The inputs for this example are shown in Table 2. It is assumed that $B_i/B_v = 1$.

TABLE 2

Inputs for example

Item		Symbol
Centre frequency (Hz)	60×10^9	f_c
Victim system		
Longitude of receiver (degrees)	12	V_{rx}
Longitude of transmitter (degrees)	0	V_{tx}
Transmit power (dBW)	13	P_v
Transmit gain (dBi)	49	$G_{v,tx}$
Receive gain (dBi)	49	$G_{v,rx}$
Receive antenna diameter (m)	0.75	$d_{v,rx}$
Interfering system		
Longitude of receiver (degrees)	10	I_{rx}
Longitude of transmitter (degrees)	2	I_{tx}
Transmit power (dBW)	13	P_i
Transmit gain (dBi)	55.7	$G_{i,tx}$
Receive gain (dBi)	55.7	$G_{i,rx}$
Transmit antenna diameter (m)	1	$d_{i,tx}$

Table 3 shows the results of the *C*/*I* calculation.

TABLE 3

***C*/*I* calculation**

Item		Symbol
Carrier power		
Transmit power (dBW)	13.0	P_v
Transmit antenna gain (dBi)	49.1	$G_{v,tx}$
Free space loss (dB)	–206.9	L
Receive antenna gain (dBi)	49.1	$G_{v,rx}$
Carrier power (dBW)	–95.7	C
Interference power		
Transmit power (dBW)	13.0	P_i
Transmit off-angle (degrees)	1.0	θ_{tx}
Transmit gain (dB)	35.7	$G_{i,tx}(\theta_{tx})$
Free space loss (dB)	–205.3	L
Receive off-angle (degrees)	1.0	θ_{rx}
Receive gain (dB)	29.1	$G_{v,rx}(\theta_{rx})$
Interference power (dBW)	–127.5	I
C/*I* (dB)	31.8	