

RECOMMENDATION ITU-R S.1528

Satellite antenna radiation patterns for non-geostationary orbit satellite antennas operating in the fixed-satellite service below 30 GHz

(Question ITU-R 231/4)

(2001)

The ITU Radiocommunication Assembly,

considering

- a) that the use of space station antennas with the best available radiation patterns will lead to the most efficient use of the radio-frequency spectrum;
- b) that both elliptical and circular beam antennas are used on operational space stations;
- c) that although improvements are being made in the design of space station antennas, further information is still required before a reference radiation pattern can be adopted for coordination purposes;
- d) that the adoption of a design objective radiation pattern for space station antennas will encourage the fabrication and use of orbit-efficient antennas;
- e) that it is only necessary to specify space-station antenna radiation characteristics in directions of potential interference for coordination purposes;
- f) that for wide applicability the mathematical expressions should be as simple as possible consistent with effective predictions;
- g) that nevertheless, the expressions should account for the characteristics of practical antenna systems and be adaptable to emerging technologies;
- h) that measurement difficulties lead to inaccuracies in the modelling of spacecraft antennas at large off-axis angles;
- j) that the size constraints of launch vehicles lead to limitations in the D/λ values of spacecraft antennas;
- k) that a multiple beam antenna on the non-geostationary-satellite orbit (non-GSO) has to provide an earth coverage field-of-view (FOV) of up to $\pm 30^\circ$ half-cone angle from a medium earth orbit (MEO) satellite, and up to $\pm 60^\circ$ from a low earth orbit (LEO) satellite;
- l) that most non-GSO fixed-satellite service (FSS) satellites are planned to use a large number of beams per satellite with either steerable or fixed beams;
- m) that the peak gain of a multiple beam antenna decreases while the side-lobe level increases as a function of the off-axis beam pointing angle;
- n) that the 1st and 2nd side lobes of a multiple beam antenna may be merged into the main beam when the beam is pointed toward or close to the edge of the Earth;
- o) that for a practical antenna, spill-over from the main reflector, subreflector, or diffraction from the supporting structure may significantly affect the accuracy of our estimates in the near-in and far-out side lobe regions;

p) that actual radiation patterns of some kinds of multiple beam antennas may be significantly different from beam to beam,

recommends

1 that for multiple-beam non-GSO satellite antennas in the FSS having either circular or elliptical beams, the following radiation patterns should be used as a design objective or to perform interference analysis:

1.1 measured antenna patterns

Measured antenna patterns should be used in performing interference analysis whenever they are available.

When a measured pattern is not available, one or other of reference patterns given in the remaining sections may be used:

1.2 the reference pattern given by:

$$G(\psi) = G_m - 3 (\psi/\psi_b)^\alpha \quad \text{dBi} \quad \text{for } 0 < \psi \leq a\psi_b \quad (1)$$

$$G(\psi) = G_m + L_N + 20 \log(z) \quad \text{dBi} \quad \text{for } a\psi_b < \psi \leq 0.5 b\psi_b \quad (2a)$$

$$G(\psi) = G_m + L_N \quad \text{dBi} \quad \text{for } 0.5 b\psi_b < \psi \leq b\psi_b \quad (2b)$$

$$G(\psi) = X - 25 \log(\psi) \quad \text{dBi} \quad \text{for } b\psi_b < \psi \leq Y \quad (3)$$

$$G(\psi) = L_F \quad \text{dBi} \quad \text{for } Y < \psi \leq 90^\circ \quad (4a)$$

$$G(\psi) = L_B \quad \text{dBi} \quad \text{for } 90^\circ < \psi \leq 180^\circ \quad (4b)$$

where:

$$X = G_m + L_N + 25 \log(b\psi_b) \quad \text{and} \quad Y = b\psi_b 10^{0.04(G_m + L_N - L_F)}$$

ψ_b : one-half the 3 dB beamwidth in the plane of interest (3 dB below G_m) (degrees)

ψ_b : $\sqrt{1200}/(D/\lambda)$ for minor axis (use actual values if known) (degrees)

ψ_b : (major axis/minor axis) $\sqrt{1200}/(D/\lambda)$ for major axis (use actual values if known) (degrees)

$G(\psi)$: gain at the angle ψ from the main beam direction (dBi)

G_m : maximum gain in the main lobe (dBi)

L_N : near-in-side-lobe level (dB) relative to the peak gain required by the system design

L_F : 0 dBi far-out side-lobe level (dBi)

L_B : back-lobe level (dBi)

z : (major axis/minor axis) for the radiated beam

$L_B = 15 + L_N + 0.25 G_m + 5 \log z$ dBi or 0 dBi, whichever is higher

D : diameter of the antenna (m)

λ : wavelength of the lowest band edge of interest (m).

The numeric values of a , b , and α for $L_N = -15$ dB, -20 dB, -25 dB, and -30 dB side-lobe levels are given in Table 1. The values of a and α for $L_N = -30$ dB require further study. Administrations are invited to provide data to enable the values of a and α for $L_N = -30$ dB to be refined.

NOTE 1 – Patterns applicable to elliptical beams require experimental verification. The values of a and α in Table 1 are provisional.

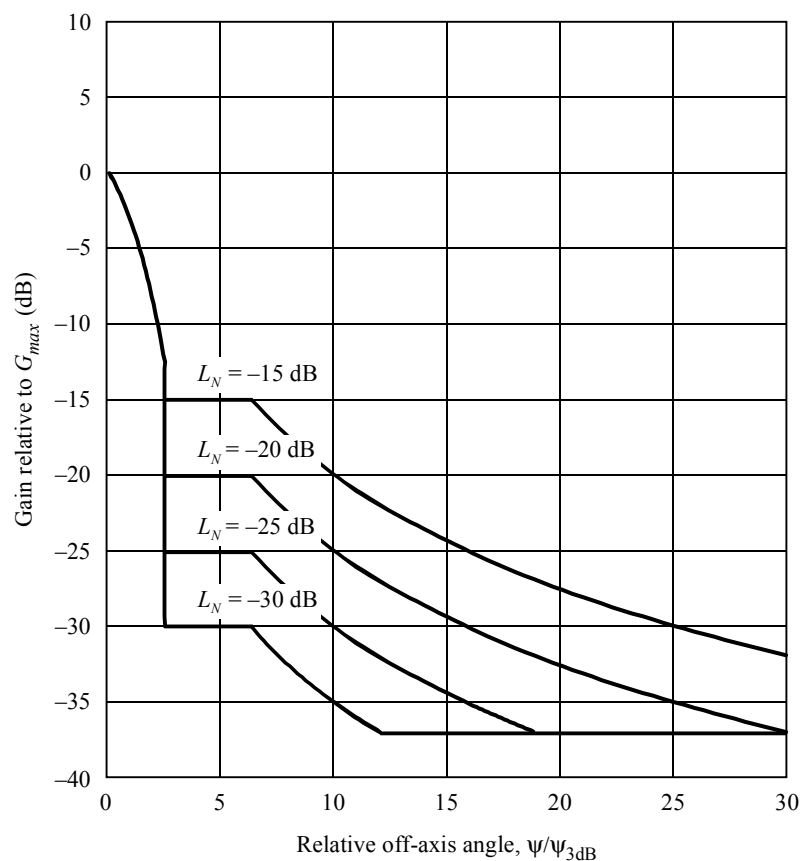
TABLE 1

L_N (dB)	a	b	α
–15	$2.58\sqrt{1 - 1.4 \log(z)}$	6.32	1.5
–20	$2.58\sqrt{1 - 1.0 \log(z)}$	6.32	1.5
–25	$2.58\sqrt{1 - 0.6 \log(z)}$	6.32	1.5
–30	$2.58\sqrt{1 - 0.4 \log(z)}$	6.32	1.5

The radiation pattern in relative gain vs. ψ/ψ_b is shown in Fig. 1.

FIGURE 1

Radiation pattern envelope functions



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1.3 the reference pattern given by:

For $D/\lambda < 35$:

$$\begin{aligned}
 G(\psi) &= G_m - 3 (\psi/\psi_b)^2 & \text{dBi} & & \text{for } \psi_b < \psi < Y \\
 G(\psi) &= G_m + L_s - 25 \log (\psi/Y) & \text{dBi} & & \text{for } Y < \psi < Z \\
 G(\psi) &= L_F & \text{dBi} & & \text{for } Z < \psi < 180^\circ
 \end{aligned}$$