RECOMMENDATION ITU-R M.694-1

Reference radiation pattern for ship earth station antennas

(Question ITU-R 88/8)

(1990-2005)

Scope

This Recommendation provides a reference radiation pattern for ship earth station antennas that should be used for coordination studies and the assessment of interference between ship earth stations in the mobile-satellite service (MSS) and terrestrial and space stations which share the same frequency bands. The technical considerations on the proposed reference radiation pattern are also contained in the Recommendation that include the existing reference radiation patterns used for various services, measured antenna patterns, and the effect of the reflection from the sea and a ship's superstructure.

The ITU Radiocommunication Assembly,

considering

a) that for coordination studies and the assessment of interference between ship earth stations and terrestrial stations, and between ship earth stations and the space stations of different satellite systems sharing the same frequency bands, it may be appropriate to use a single radiation pattern for each type of ship earth station antenna;

b) that the reference radiation pattern for ship earth station antennas must take account of the effect of local reflections from the sea, from a ship's superstructure, etc.;

c) that the use of antennas with the best achievable radiation pattern will lead to the most efficient use of the radio-frequency spectrum and the geostationary-satellite orbit,

recommends

1 that a single reference radiation pattern for each type of ship earth station antenna should be used for:

1.1 coordination studies and the assessment of interference between ship earth stations in the mobile-satellite service (MSS) and terrestrial stations in other services which share the same frequency bands;

1.2 coordination studies and the assessment of interference between ship earth stations in the MSS and the space stations of different satellite systems which share the same frequency bands;

2 that the reference radiation pattern in Annex 1 should be used for ship earth station antennas having circular paraboloidal reflectors with diameters between 0.8 m and 1.3 m and with an operating frequency range of 1518 to 1660.5 MHz;

3 that studies should continue in order to define the requirement for other types of ship earth station antennas.

Annex 1

Reference radiation pattern for ship earth station antennas having circular paraboloidal reflectors with diameters between 0.8 m and 1.3 m and with an operating frequency range of 1518 to 1660.5 MHz

$$G = G_{max} - 2.5 \times 10^{-3} \, (D/\lambda \, \varphi)^2 \quad \text{dB} \quad \text{for} \quad 0 < \varphi < \varphi_m$$

$$G = 2 + 15 \log (D/\lambda) \quad \text{dB} \quad \text{for} \quad \varphi_m \le \varphi < 100 \, (\lambda/D)$$

$$G = 52 - 10 \log (D/\lambda) - 25 \log \varphi \quad \text{dB} \quad \text{for} \quad 100 \, (\lambda/D) \le \varphi < \varphi_1$$

$$G = 0 \text{ dB} \quad \text{for} \quad \varphi_1 \le \varphi$$

where:

φ : angle from beam centre (degrees)

$\varphi_m = 20 \, \lambda/D \sqrt{G_{max} - 2 - 15 \log (D/\lambda)}$ (degrees)

$\varphi_1 = 120 \, (\lambda/D)^{0.4}$ (degrees)

G : gain of the antenna relative to isotropic (dB)

G_{max} : maximum gain of the antenna relative to isotropic (dB)

D : antenna diameter
λ : wavelength
} expressed in the same unit

NOTE 1 – The reference radiation pattern should be assumed to be rotationally symmetrical.

Appendix 1 to this Annex provides the technical considerations on this reference radiation pattern, as demonstrated by some measured antenna patterns.

Appendix 1 to Annex 1

Technical considerations on the reference radiation pattern for ship earth station antennas

1 Introduction

This Appendix provides the technical considerations on the reference radiation pattern for ship earth station antennas in Annex 1.

2 Existing reference radiation patterns

Reference radiation patterns have been studied and developed in various Radiocommunication Study Groups. These study results provided a reference radiation pattern for antennas less than 100 λ, as stated below:

$$G = 52 - 10 \log (D/\lambda) - 25 \log \varphi \quad \text{dB} \quad \text{for} \quad 100 (\lambda/D) \leq \varphi < \varphi_1$$

$$G = G_1 \quad \text{for} \quad \varphi_1 \leq \varphi$$

where:

D : antenna diameter, λ : wavelength — expressed in the same unit

φ : angle from beam centre (degrees).

For values of φ less than 100 (λ/D), WARC-97 has defined the following reference radiation pattern for interference calculations:

$$G = G_{max} - 2.5 \times 10^{-3} (D/\lambda \, \varphi)^2 \quad \text{dB} \quad \text{for} \quad 0 < \varphi < \varphi_m$$

$$G = 2 + 15 \log (D/\lambda) \quad \text{dB} \quad \text{for} \quad \varphi_m \leq \varphi < 100 (\lambda/D)$$

where:

$$\varphi_m = 20 \lambda/D \sqrt{G_{max} - 2 - 15 \log (D/\lambda)} \quad \text{(degrees)}$$

G_{max} : maximum gain of the antenna relative to isotropic.

These equations assume the case of a circular paraboloidal reflector antenna, which might not be relevant for some kinds of antennas which could be used in the future for ship earth stations. Therefore, the use of this kind of pattern should clearly be restricted to the case of circular paraboloidal reflector antennas. Moreover, the above reports have not specifically considered the question of the applicability of these equations to very small values of D/λ; therefore, for antennas of such diameter as small as 4 λ, the value of G_1 must be carefully established taking into account measured radiation patterns.

3 Measured antenna patterns

All production designs of ship earth stations manufactured to date for use in the MARISAT system have employed a parabolic reflector antenna having a diameter of between 1.2 and 1.3 m with a G/T of –4 (dB(K^{-1})). This value is the current requirement for Inmarsat Standard-A ship earth stations.

Figures 1 and 2 present the measured antenna pattern for a 1.3 m antenna for transmit and receive frequencies, respectively. Figures 3 and 4 present measured antenna patterns for a 1.2 m antenna for transmit and receive frequencies, respectively. Figure 5 presents the measured antenna pattern for a 0.8 m antenna for receive frequencies. The reference radiation pattern in Annex 1 is included in all figures.

With respect to the Inmarsat Standard-A ship earth stations, the following expression has been determined as the performance requirement for the side-lobe envelope based on the measured radiation patterns of paraboloidal antenna with diameters between 0.8 m and 1.2 m:

$$G = 8 \quad \text{dB} \quad \text{for} \quad 16 \leq \varphi < 21$$

$$G = 41 - 25 \log \varphi \quad \text{dB} \quad \text{for} \quad 21 \leq \varphi < 57$$

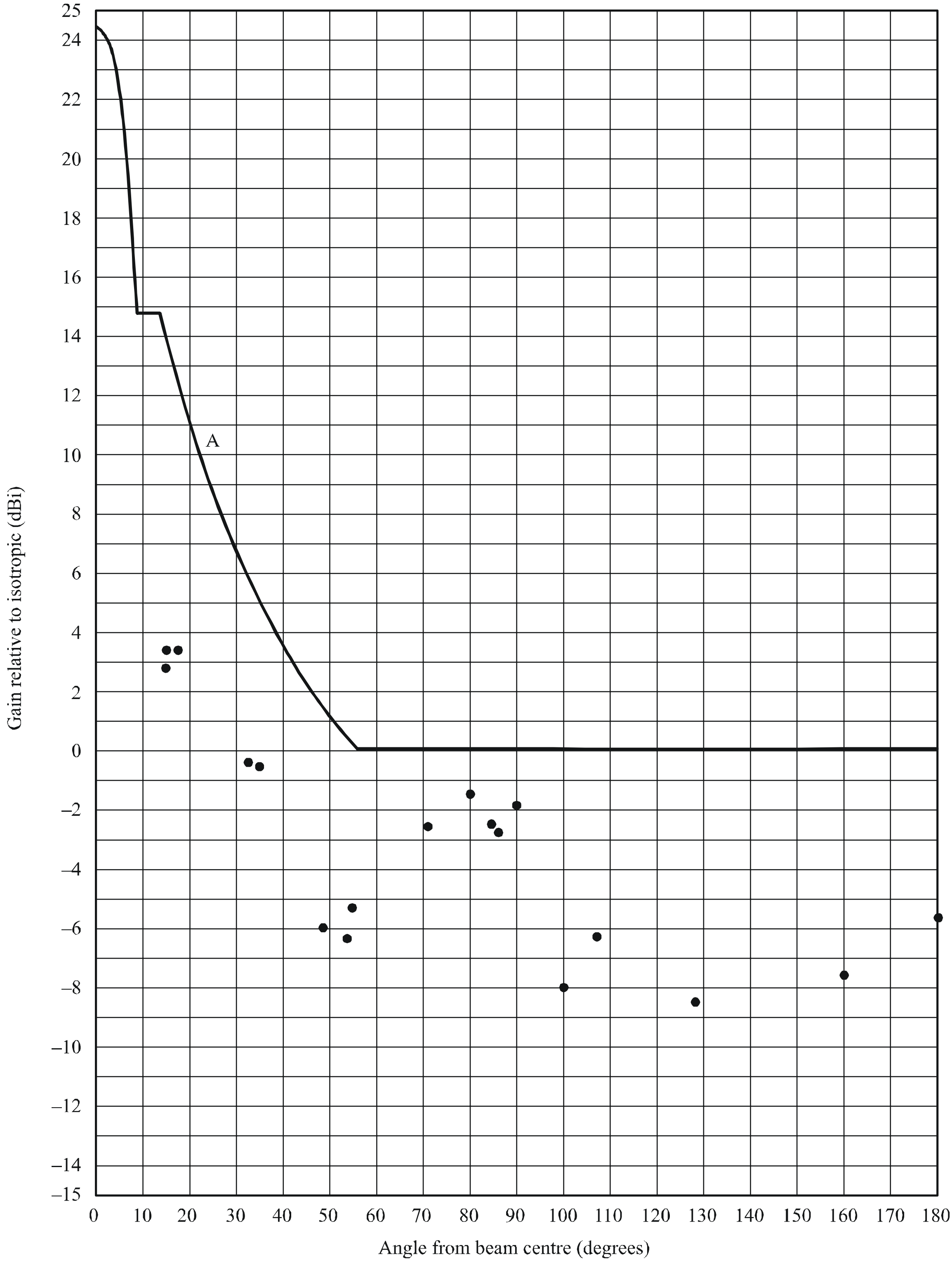
$$G = -3 \quad \text{dB} \quad \text{for} \quad 57 \leq \varphi$$

where G is the antenna gain relative to isotropic at an angle φ from beam centre. Figure 6 illustrates the Inmarsat antenna pattern together with the reference radiation pattern derived from Annex 1 for a 1.2 m antenna diameter (24 dB maximum gain).

FIGURE 1

Measured antenna pattern for a ship earth station antenna

Type of antenna: circular parabolic
Frequency band: 1 636.5-1 645 MHz (transmit)
Diameter: 1.3 m



● : maximum gain: 24.6 dBi
A : reference radiation pattern

Polarization: right-hand (RH) circular
Manufacturer: United Kingdom

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FIGURE 2

Measured antenna pattern for a ship earth station antenna

Type of antenna: circular parabolic
Frequency band: 1 535-1 543.5 MHz (receive)
Diameter: 1.3 m

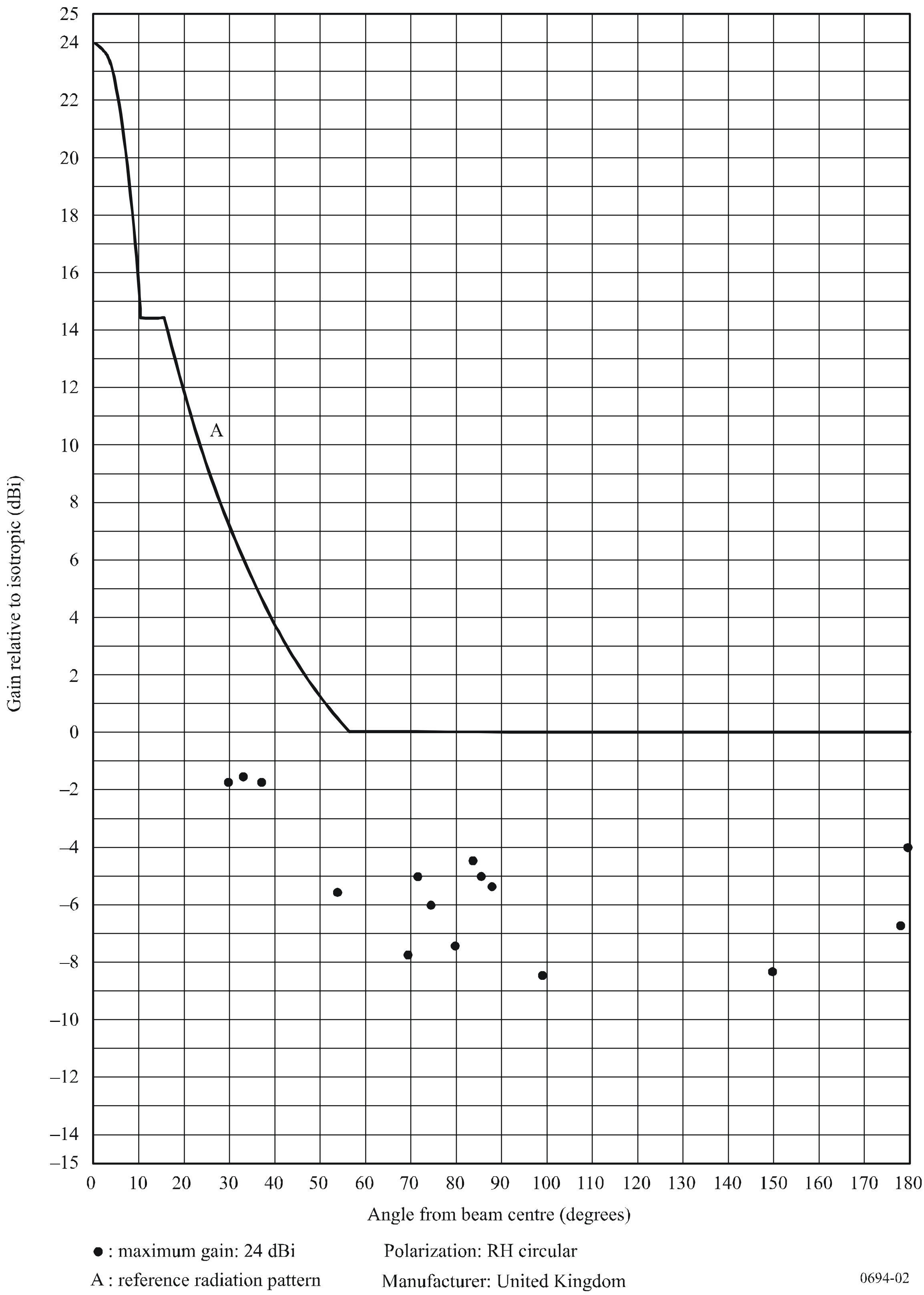


FIGURE 3

Measured antenna pattern for a ship earth station antenna

Type of antenna: circular parabolic
Frequency band: 1 636.5-1 645 MHz (transmit)
Diameter: 1.2 m

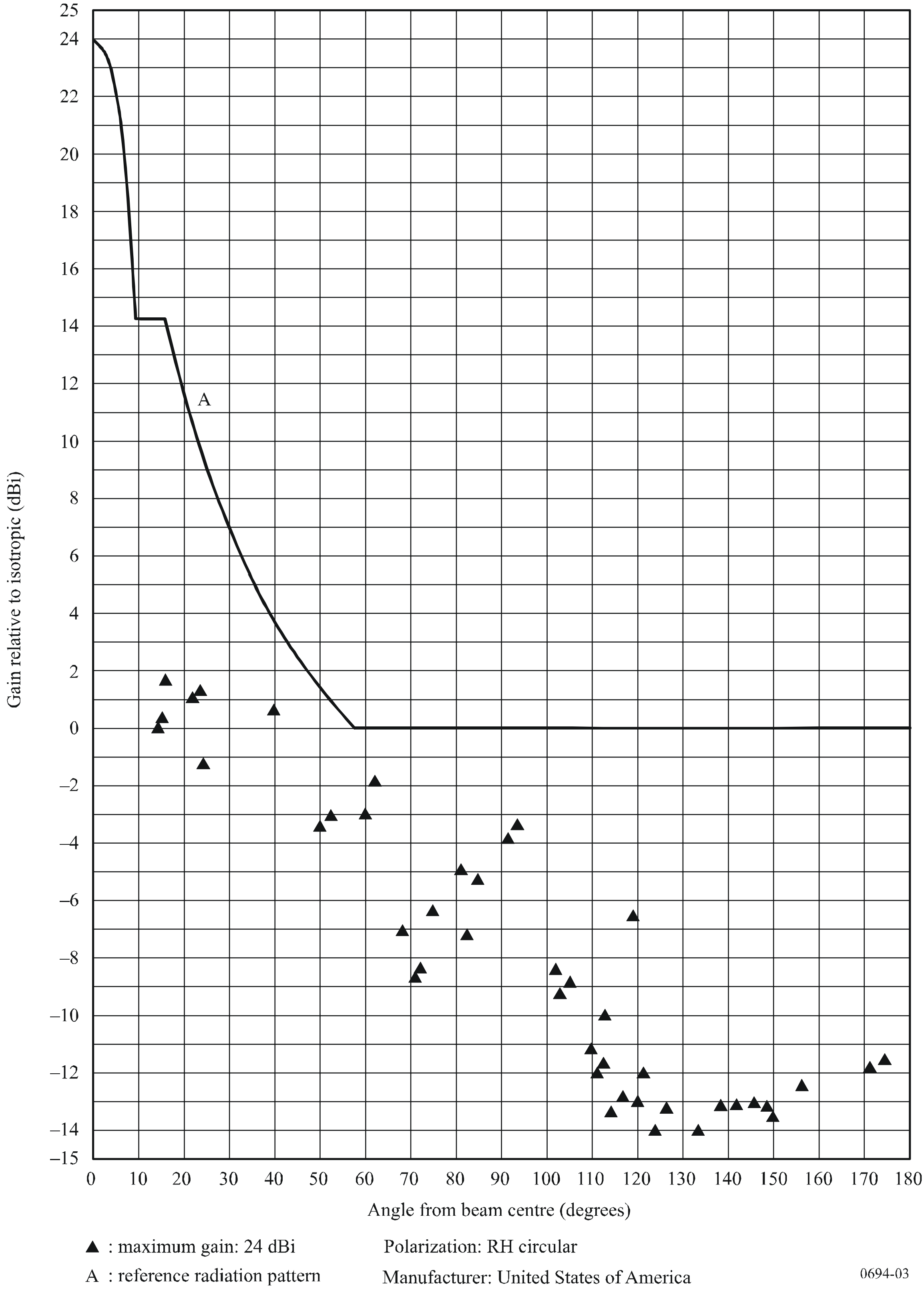


FIGURE 4

Measured antenna pattern for a ship earth station antenna

Type of antenna: circular parabolic
Frequency band: 1 535-1-1 543.5 MHz (receive)
Diameter: 1.2 m

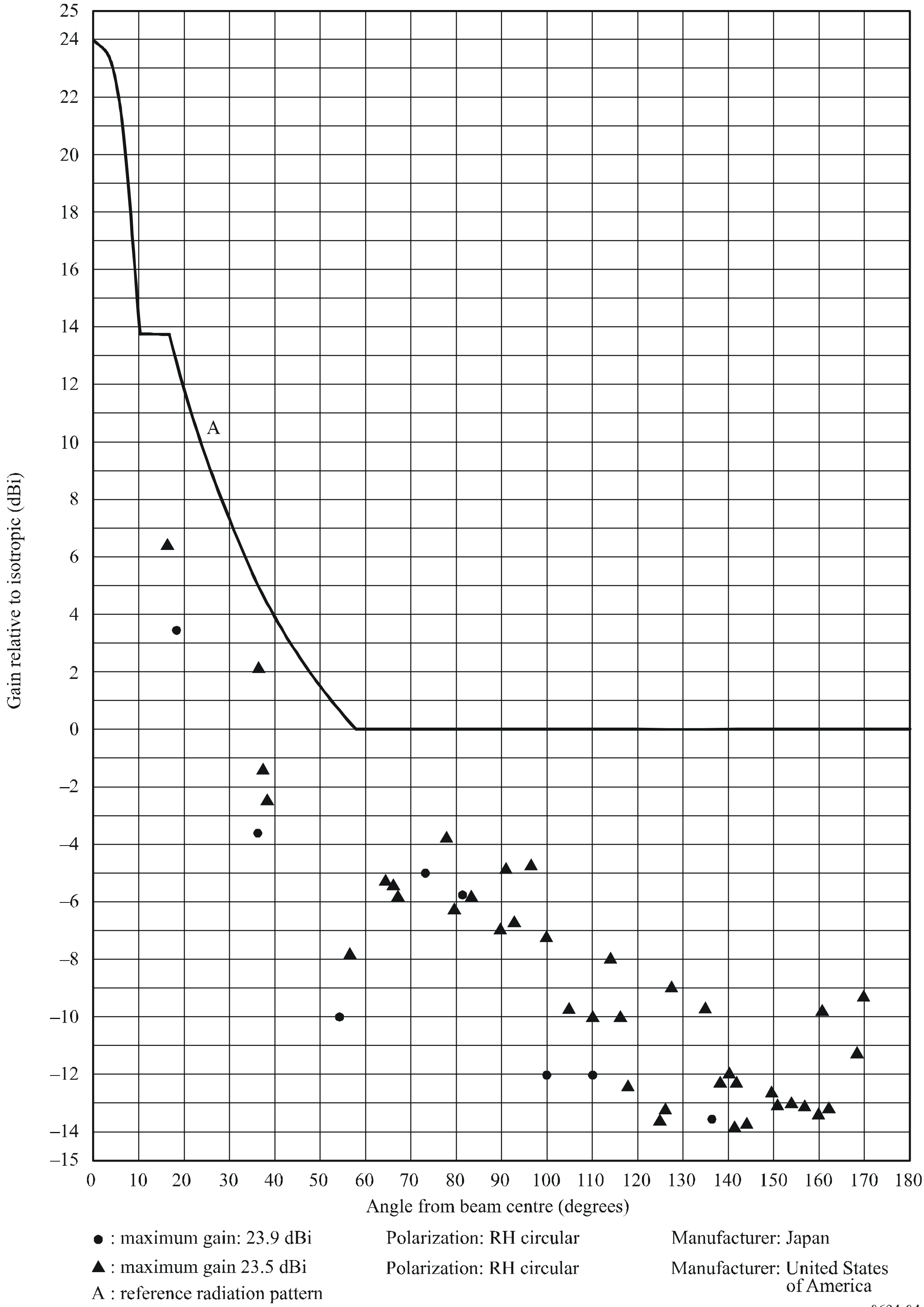
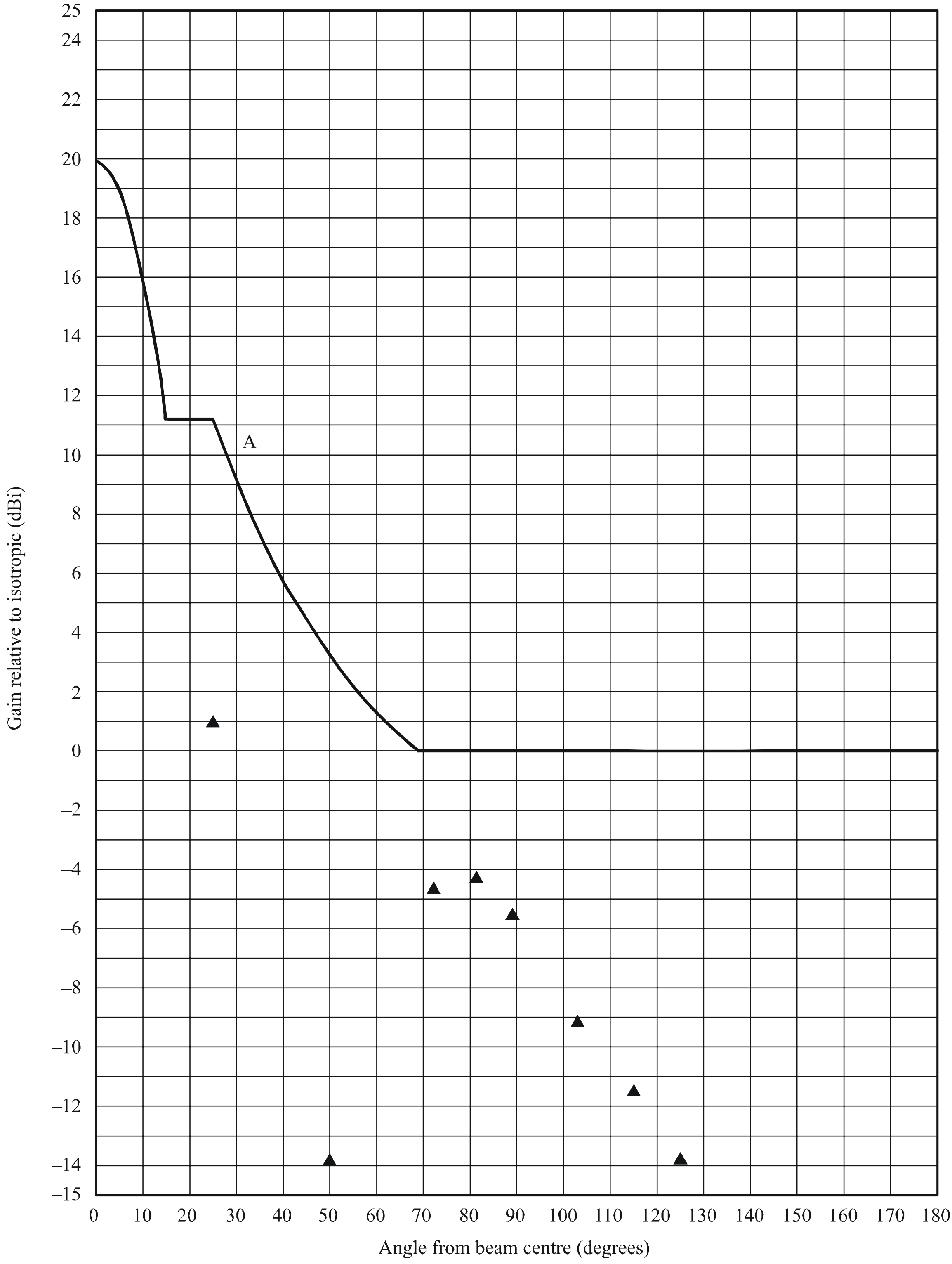


FIGURE 5

Measured antenna pattern of a ship earth station antenna

Type of antenna: circular parabolic
Frequency band: 1 535-1-1 543.5 MHz (receive)
Diameter: 0.8 m



▲: maximum gain: 20 dBi Polarization: RH circular
A : reference radiation pattern Manufacturer: Japan

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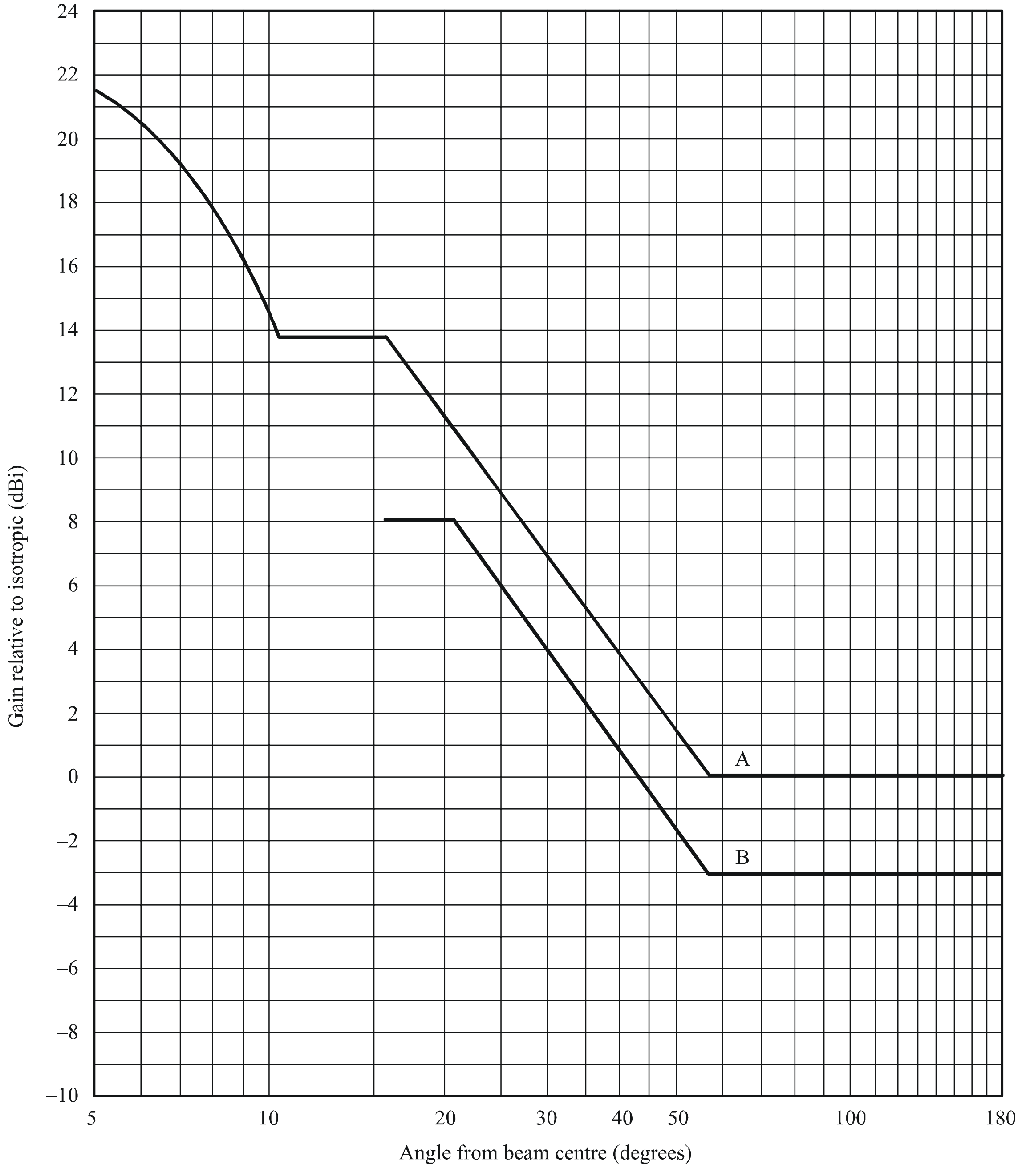
FIGURE 6

Inmarsat antenna side-lobe envelope for standard-A ship earth stations



A: Reference radiation pattern (1.2 m antenna diameter, 24 dBi maximum gain)

B: Inmarsat pattern

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4 The effect of reflection due to the sea and a ship's superstructure

Considerations have been given to the concept that the design objectives and the reference radiation pattern for interference studies may be defined separately, because the reference radiation pattern should include the effect of local reflections from the sea and a ship's superstructure.

However, it is very difficult to estimate quantitatively such effects, which may be of the order of several dB, because the directions of reflected waves vary in accordance with the ship's movement. Moreover, the time probability of the interference caused by such reflected side-lobes is very difficult to assess. Further study is needed to clarify the effect of such reflections.