Importance of reference antenna radiation patterns in sharing studies

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Contents

- Application of suitable reference radiation patterns in the 3 F-series Recommendations
- Use of average side-lobe radiation patterns in Rec. F.1245 and Rec. F.1336
- Points of recently revised Rec. F.1336-2 : Improvement of the azimuth plane patterns
- Possibility of future extension of the sectoral antenna patterns in Rec. F.1336 to the frequency bands below 1 GHz

Application of suitable reference radiation patterns in the 3 Recommendations

The reference radiation patterns specified in the 3 Recs are used for mutual interference assessment:

- between fixed service (FS) system stations;
- between stations of FS systems and stations of systems in other radiocommunication services.

The characteristics of each Recommendation are as follows:

	Fixed service type	Antenna type	Mathematical model	Frequency range
Rec. ITU-R F.699-7	Point to point	Rotationally symmetrical	Peak side-lobe radiation pattern	100 MHz to 70 GHz
Rec. ITU-R F.1245-2	Point to point	Rotationally symmetrical	Average side-lobe radiation pattern	1 GHz to 70 GHz
Rec. ITU-R F.1336-3	Point to multipoint	Omnidirectional and Sectoral	Peak side-lobe radiation pattern and Average side-lobe radiation pattern	1 GHz to 70 GHz

Use of the average side-lobe radiation patterns

The average side-lobe radiation patterns defined in Recommendations ITU-R F. 1245-2 and F.1336-3 should be used for assessing :

- the aggregate interference to a geostationary or non-geostationary satellite from a large number of FS stations;
- the aggregate interference to a FS station from many geostationary satellites;
- the interference to a FS station from one or more non-geostationary satellites under the continuously varying angles.

The level difference between the peak and the average side-lobe patterns is generally 3 dB in angles sufficiently far from the main axis.

Existing reference sectoral antenna radiation pattern in Rec. F.1336-2

An antenna gain parameter x
of the sectoral antenna at an arbitrary inclination angle α is determined

$$\alpha = \arctan\left(\frac{\tan\theta}{\sin\varphi}\right) \quad -90° \le \alpha \le +90°$$

$$\psi_\alpha = \frac{1}{\sqrt{\left(\frac{\cos\alpha}{\varphi_3}\right)^2 + \left(\frac{\sin\alpha}{\theta_3}\right)^2}}$$

$$\psi = \arccos\left(\cos\varphi\cos\theta\right) \quad 0° \le \psi \le 180°$$

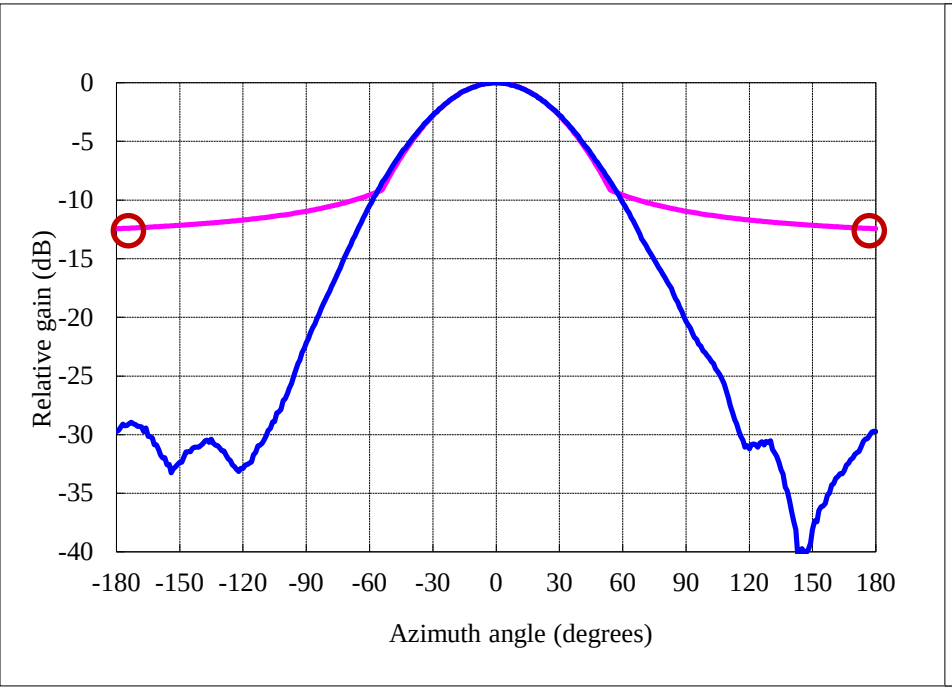
$$x = \psi / \psi_\alpha$$

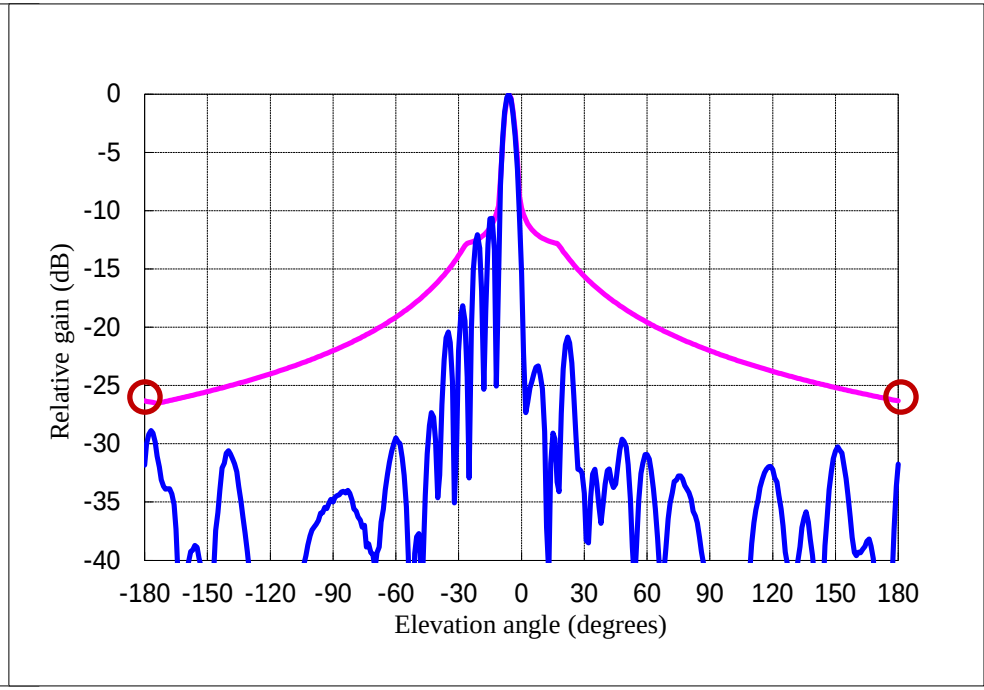
φ: azimuth angle,
θ: elevation angle,
φ_3: 3dB beamwidth in the azimuth plane,
θ_3: 3dB beamwidth in the elevation plane,
ψ_α: 3 dB beamwidth of an elliptical beam form at an arbitrary inclination angle α,
ψ: off-axis angle in the plane of the inclination angle α

Comparison between the measured patterns and the existing calculated peak side-lobe patterns in Rec. F.1336-2

There is the fairly large difference between the measured and the calculated patterns in the azimuth plane in particular in angles 90-180 degrees in the existing model of Rec. F.1336-2.

(Existing calculated pattern, Measured pattern)



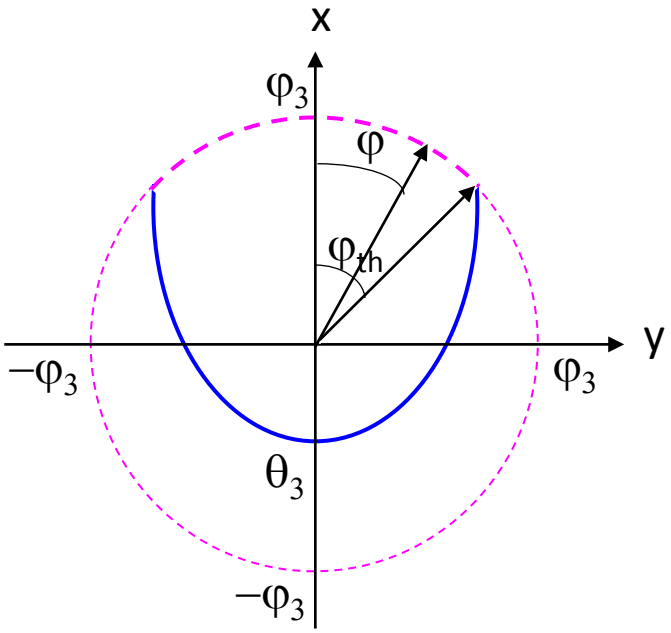


a) Azimuth plane b) Elevation plane

(φ_3 = 62° , θ_3 = 5.5° , β = 6° , f = 2.045 GHz)

Points of recently revised Recommendation F.1336-2 (1)

In order to improve this the inconsistency at the cross point, it is necessary for φ_3 and θ_3 to converge on only one value at the cross point.



$$\varphi_{3m} = \frac{1}{\sqrt{\left(\frac{\cos\left(\frac{|\varphi| - \varphi_{th}}{180 - \varphi_{th}} \cdot 90\right)}{\varphi_3}\right)^2 + \left(\frac{\sin\left(\frac{|\varphi| - \varphi_{th}}{180 - \varphi_{th}} \cdot 90\right)}{\theta_3}\right)^2}}$$

$$\varphi_{th} < |\varphi| \leq 180°$$

Points of recently revised Recommendation F.1336-2 (2)

The antenna gain parameter x is determined by using equations including 3 additional equations

$$\alpha = \arctan\left(\frac{\tan\theta}{\sin\varphi}\right) \qquad -90° \le \alpha \le +90°$$

$$\psi_\alpha = \frac{1}{\sqrt{\left(\frac{\cos\alpha}{\varphi_3}\right)^2 + \left(\frac{\sin\alpha}{\theta_3}\right)^2}} \qquad 0° \le \psi \le 90°$$

$$\psi_\alpha = \frac{1}{\sqrt{\left(\frac{\cos\theta}{\varphi_{3m}}\right)^2 + \left(\frac{\sin\theta}{\theta_3}\right)^2}} \qquad 90° < \psi \le 180°$$

$$\psi = \arccos(\cos\varphi\cos\theta) \qquad 0° \le \psi \le 180°$$

$$x = \psi / \psi_\alpha$$

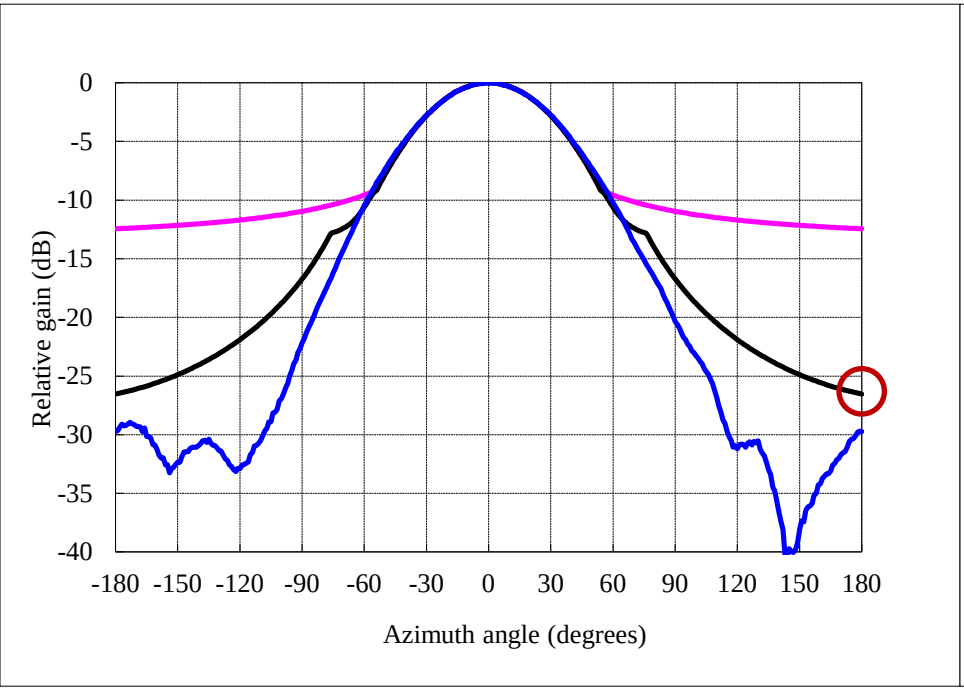
$\varphi_{3m} = \varphi_3$ $\quad 0° \le |\varphi| \le \varphi_{th}$

$$\varphi_{3m} = \frac{1}{\sqrt{\left(\frac{\cos\left(\frac{|\varphi| - \varphi_{th}}{180 - \varphi_{th}} \cdot 90\right)}{\varphi_3}\right)^2 + \left(\frac{\sin\left(\frac{|\varphi| - \varphi_{th}}{180 - \varphi_{th}} \cdot 90\right)}{\theta_3}\right)^2}} \qquad \varphi_{th} < |\varphi| \le 180°$$

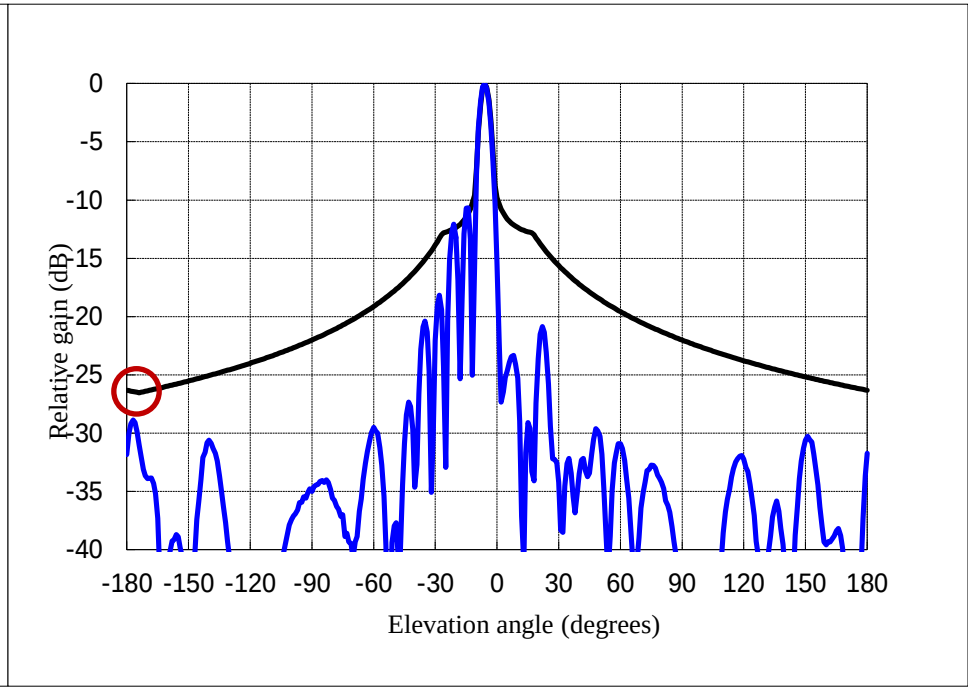
Comparison between the measured patterns and the calculated peak side-lobe patterns

The alternative approximation introduced in Rec. F.1336-3 (Annex 8) results in much improved patterns.

(Existing calculated pattern, Alternative pattern, Measured pattern)



a) Azimuth plane

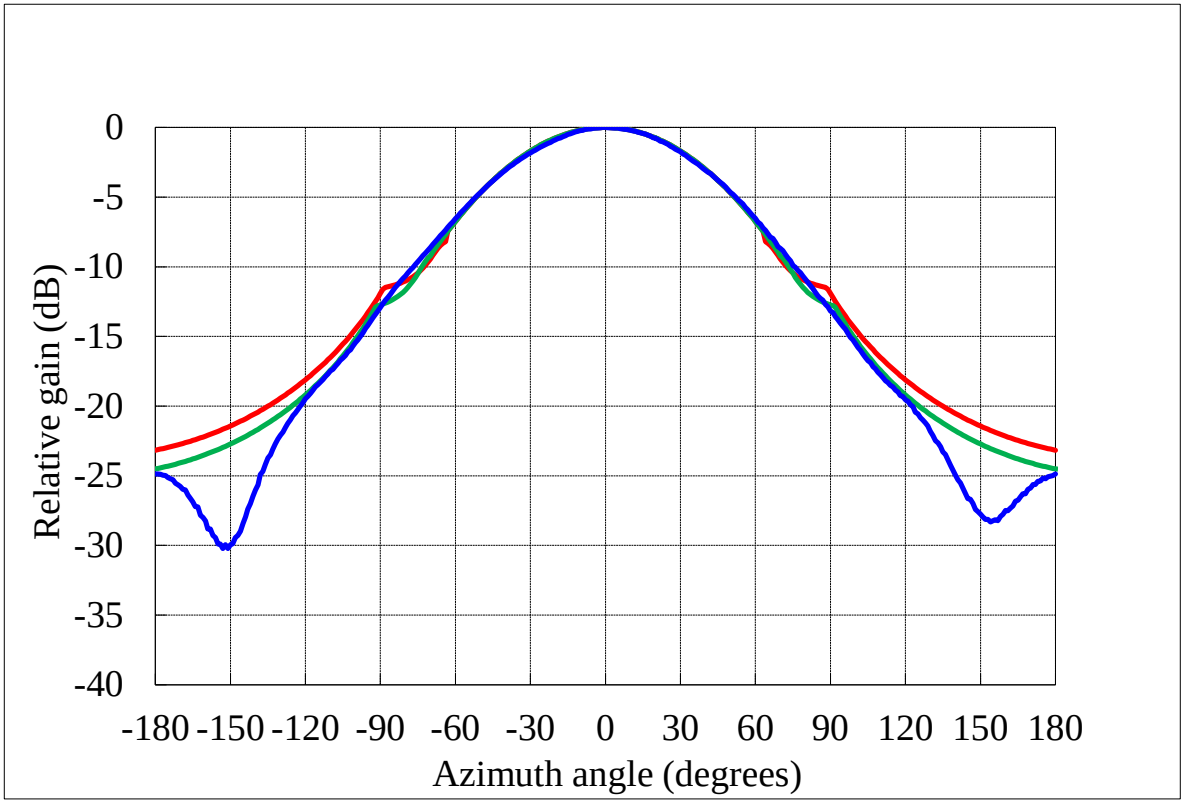


b) Elevation plane

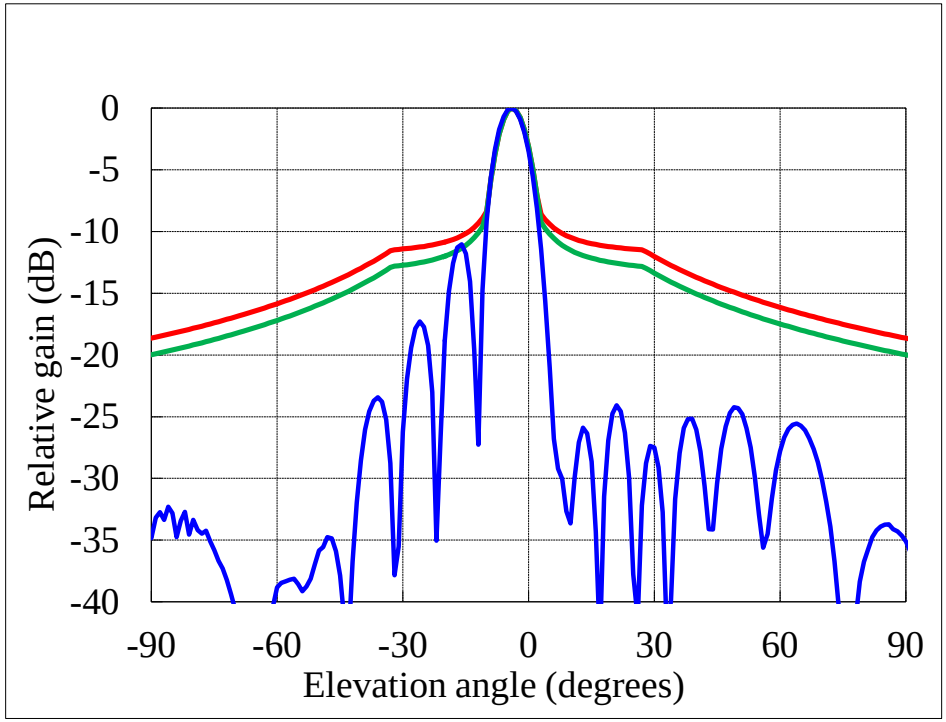
(φ_3 = 62° , θ_3 = 5.5° , β = 6° , f = 2.045 GHz)

Possibility of future extension of the reference sectoral antenna pattern to the frequency bands below 1 GHz in Rec. F.1336

The alternative approximation also demonstrates good approximation by properly selecting k parameter.



a) Azimuth plane (φ_3 = 79°, θ_3 = 7.5°, β = 4°, f = 870 MHz)



b) Elevation plane

Measured data are solicited for consideration of possible extension of the frequency range to address the interference assessment in the lower frequency bands.

Summary

- It is important in the interference assessment to apply a suitable reference radiation pattern in the 3 Recommendations through correct understanding of the characteristics of each pattern,
- For Rec. F.1336, it has been demonstrated that the alternative approximation recently introduced could improve the gain performance in the azimuth plane,
- For possible future extension of the frequency range of Rec. F.1336 to the bands below 1 GHz, it is required to invite more contributions on measured data of sectoral antenna patterns.