Beam Solid Angle Computation Using MATLAB

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1. Introduction

The beam solid angle (ΩA) describes the angular spread of radiation from an antenna. It is measured in steradians and directly relates to antenna directivity. This laboratory work computes ΩA numerically using MATLAB and compares multiple radiation patterns.

2. Theory

Beam Solid Angle formula (assuming ϕ-independence):

```
ΩA = 2π ∫■^π F_n(θ) sinθ dθ
Directivity D = 4π / ΩA
```

3. MATLAB Implementation (Using integral())

```
clc; clear; close all;

Fn1 = @(theta) (cos(theta)).^2;
Fn2 = @(theta) abs(cos(theta));
Fn3 = @(theta) (cos(theta)).^4;

Omega1 = 2*pi*integral(@(theta) Fn1(theta).*sin(theta), 0, pi);
Omega2 = 2*pi*integral(@(theta) Fn2(theta).*sin(theta), 0, pi);
Omega3 = 2*pi*integral(@(theta) Fn3(theta).*sin(theta), 0, pi);

D1 = 4*pi/Omega1;
D2 = 4*pi/Omega2;
D3 = 4*pi/Omega3;

fprintf('cos^2(theta) Directivity = %.4f\n', D1);
fprintf('|cos(theta)| Directivity = %.4f\n', D2);
fprintf('cos^4(theta) Directivity = %.4f\n', D3);

% 3D Radiation Pattern Example
theta = linspace(0, pi, 200);
phi = linspace(0, 2*pi, 200);
[THETA, PHI] = meshgrid(theta, phi);
R = (cos(THETA)).^2;

X = R .* sin(THETA) .* cos(PHI);
Y = R .* sin(THETA) .* sin(PHI);
Z = R .* cos(THETA);
figure;
```

```
surf(X,Y,Z);
shading interp;
title('3D Radiation Pattern: cos^2(theta)');
xlabel('X'); ylabel('Y'); zlabel('Z');
```

4. Results and Comparison

Directivity comparison:

Radiation Pattern	Expected Directivity Trend
cos^2(theta)	Moderate directivity (~6)
|cos(theta)|	Lower directivity
cos^4(theta)	Higher directivity (narrower beam)

5. Discussion

Increasing the power of cosine narrows the radiation beam and reduces the beam solid angle, which increases antenna directivity. The integral() function provides high numerical accuracy compared to basic trapezoidal approximation methods.

6. Conclusion

The MATLAB simulation successfully computed the beam solid angle and directivity for multiple antenna radiation patterns. Results confirm that smaller beam solid angles lead to higher antenna directivity.