EE307 Homework 9

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Use the formulars of the reflector analysis in this lecture to solve the following problems.

Problem： Design an optimum gain *X*-band (8.2–12.4 GHz) pyramidal horn so that its gain (above isotropic) at f = 11 GHz is 22.6 dB. The horn is fed by a WR 90 rectangular waveguide with inner dimensions of *a* = 0.9 in. (2.286 cm) and *b* = 0.4 in. (1.016 cm).

Solution：

- **Firstly, we convert the gain at 11GHz form dB to a scalar,that is :**

$$G(dB) = 22.6\ dB = 10\log_{10} G \Rightarrow G = 10^{2.26} \approx 181.97$$

- **Then, Since the working frequency is 11GHz, we know that the working wavelength is:**

$$\lambda = \frac{c}{f} = \left(\frac{2.998 \times 10^8}{11 \times 10^9}\right) \approx 0.027m = 2.7cm$$

- **Next, we can convert a and b into a scalar related to the wavelength λ, that is:**

$$a = 0.9in. = 2.286cm \approx 0.847\lambda$$
$$b = 0.4in. = 1.016cm \approx 0.376\lambda$$

- **Then, we can get the initial value of χ is:**

$$\chi \approx \frac{G_0}{2\pi\sqrt{2\pi}} = \frac{181.97}{2\pi\sqrt{2\pi}} \approx 11.554$$

- **After a few tries, a more accurate value is:**

$$\chi = 11.1157$$

- **Therefore, we can calculate the ρ_e and ρ_h, that is:**

$$\rho_e = \chi \cdot \lambda = 11.1157\lambda = 30.012cm = 11.816in$$
$$\rho_h = \frac{G_0^2}{8\pi^3}\left(\frac{1}{\chi}\right)\lambda = 12.0094\lambda = 32.425cm = 12.766in$$

- **According to the formula in course ppt, we can also get the length of the horn a_1 and the width of the horn b_1, that is:**

$$a_1 = \sqrt{3\lambda\rho_2} = \sqrt{3\lambda\rho_h} = \frac{G_0}{2\pi}\sqrt{\frac{3}{2\pi\chi}}\lambda = 6.002\lambda = 16.2054cm$$

$$b_1 = \sqrt{2\lambda\rho_1} = \sqrt{2\lambda\rho_e} = \sqrt{2\chi}\lambda = 4.715\lambda = 12.7305cm$$

- **Next, in this problem, we can also calculate the p_e and p_h , that is:**

$$p_e = (b_1 - b) = \left[\left(\frac{\rho_e}{b_1}\right)^2 - \frac{1}{4}\right]^{\frac{1}{2}} = 10.005\lambda = 27.014cm = 10.635in.$$

$$p_h = (a_1 - a) = \left[\left(\frac{\rho_h}{a_1}\right)^2 - \frac{1}{4}\right]^{\frac{1}{2}} = 10.005\lambda = 27.014cm = 10.635in.$$

- **Finally, after calculating all the parameters related to this antenna, we can plot this horn antenna in MATLAB, that is:**
  - **The MATLAB code is shown below:**

```
% Create a horn antenna
% Generated by MATLAB(R) 9.10 and Antenna Toolbox 5.0.
% Generated on: 21-Apr-2022 21:31:41

%% Antenna Properties
antennaObject = design(horn, 11*1e9);
antennaObject.FlareLength = 0.27286;
antennaObject.FlareWidth = 0.16205;
antennaObject.FlareHeight = 0.12731;
antennaObject.Length = 0.039814;
antennaObject.Width = 0.02286;
antennaObject.Height = 0.01016;
% Show
figure;
show(antennaObject)
```

  - **The result figure is shown below:**

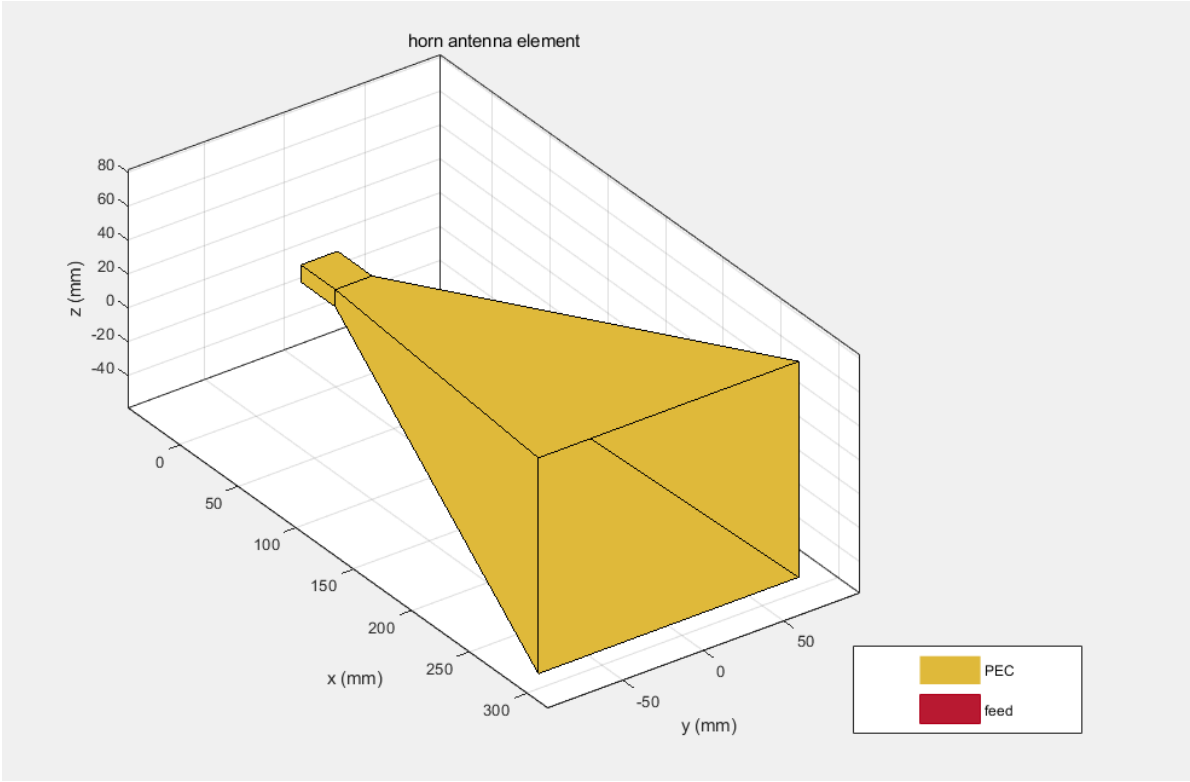

Figure 1 Horn antenna