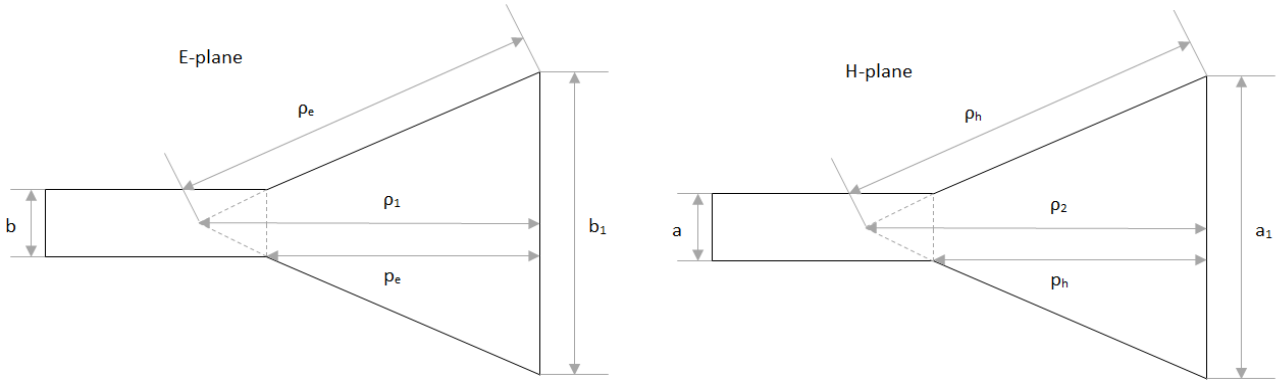
Pyramidal Horn Design

Introduction

This application calculates the optimum design parameters for an X-band pyramidal horn.

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restart :
with( plots) :
with( ColorTools) :
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Parameters

Gain in dB at design frequency:

$G_{odB} := 22.6$:

$G_o := 10^{\frac{G_{odB}}{10}} = 181.97$

Speed of light (cm/s):

$c := 3 \cdot 10^{10}$:

Frequency (s^{-1}):

$f := 11.0 \cdot 10^{9.}$:

Wavelength (in cm):

$\lambda := \frac{c}{f} = 2.73$

Geometrical constraints (cm):

$a := 2.286$:

$b := 1.016$:

Governing Equations

Following are needed for optimum directivity. p_e and p_h are equal.

$cons1 := G_o = \frac{2 \cdot \pi}{\lambda^2} \cdot a_1 \cdot b_1$:

$cons2 := a_1 = \sqrt{3 \cdot \lambda \cdot \rho_h}$:

$cons4 := p_e = (b_1 - b) \cdot \sqrt{\left(\frac{\rho_e}{b_1}\right)^2 - \frac{1}{4}}$:

$cons3 := b_1 = \sqrt{2\cdot\lambda\cdot\rho_e}$:

$cons5 := p_h = (a_1 - a)\cdot\sqrt{\left(\frac{\rho_h}{a_1}\right)^2 - \frac{1}{4}}$:

$cons6 := p_e = p_h$:

Numerical Solution

$res := fsolve(\{cons1, cons2, cons3, cons4, cons5, cons6\})$

$$\{a_1 = 16.56, b_1 = 13.01, p_e = 27.98, p_h = 27.98, \rho_e = 31.04, \rho_h = 33.50\} \quad \textbf{(4.1)}$$

Plot the E-Plane Radiation Pattern

> $assign(res)$

> $\rho_1 := \sqrt{\rho_e^{\,2} - \left(\frac{b_1}{2}\right)^2}$:

> $t_1 := \theta \to \sqrt{\frac{2}{\lambda\cdot\rho_1}}\cdot\left(-\frac{b_1}{2} - \rho_1\cdot\sin(\theta)\right)$:

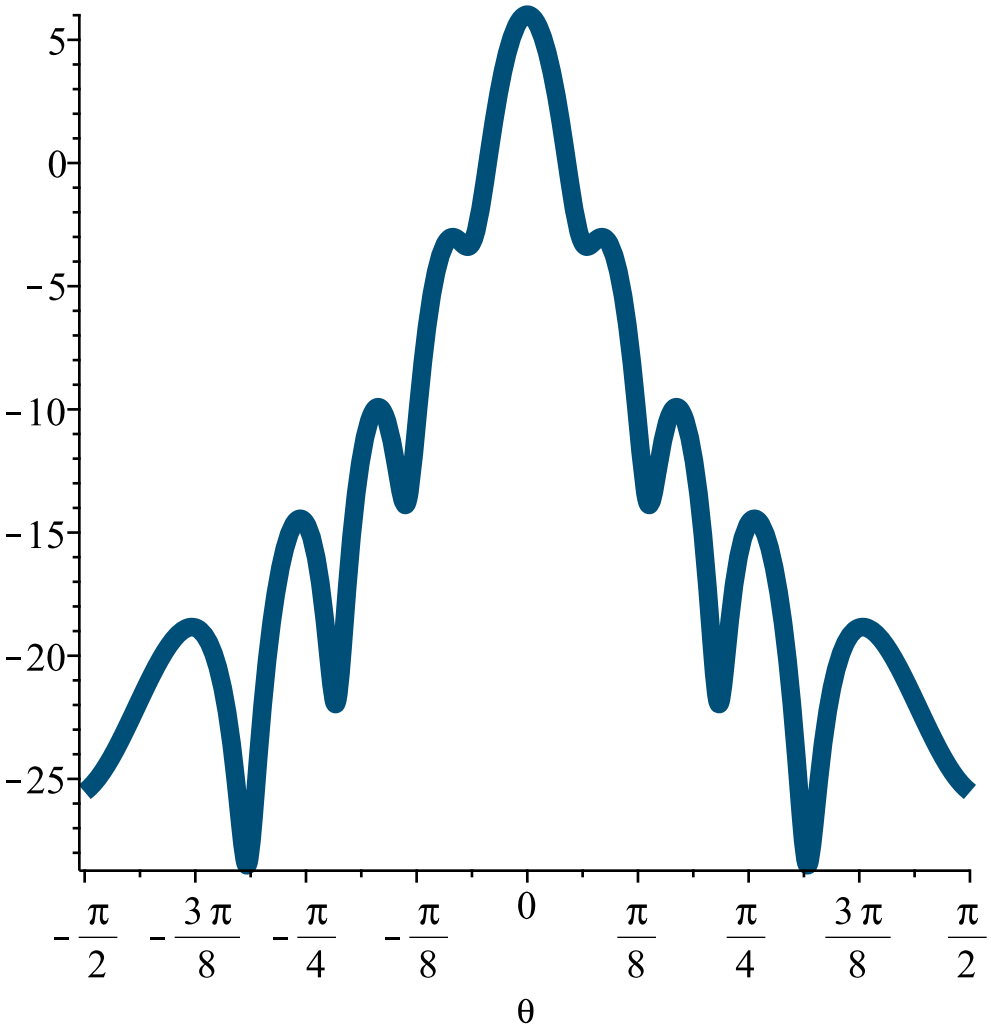
> $t_2 := \theta \to \sqrt{\frac{2}{\lambda\cdot\rho_1}}\cdot\left(\frac{b_1}{2} - \rho_1\cdot\sin(\theta)\right)$:

> $F := \theta \to \mathrm{FresnelC}(t_2(\theta)) - \mathrm{FresnelC}(t_1(\theta)) - I\cdot(\mathrm{FresnelS}(t_2(\theta)) - \mathrm{FresnelS}(t_1(\theta)))$:

Radiation Pattern

> $E_\theta := \theta \to 20\cdot\log10\left(|1 + \cos(\theta)|\cdot\frac{|F(\theta)|}{|F(0)|}\right)$:

> $plot\left(E_\theta(\theta), \theta = -\frac{\pi}{2}..\frac{\pi}{2}, thickness = 7, color = Color("RGB", [0, 79/255, 121/255]), axes = frame\right)$

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> polarplot(E_θ(θ) + 70, θ = 0..2π, thickness = 0, color = Color("RGB", [0, 79/255, 121/255]),
  filled = true, transparency = 0, title = "E-Plane Radiation Pattern", size = [800, 800])
```

E-Plane Radiation Pattern