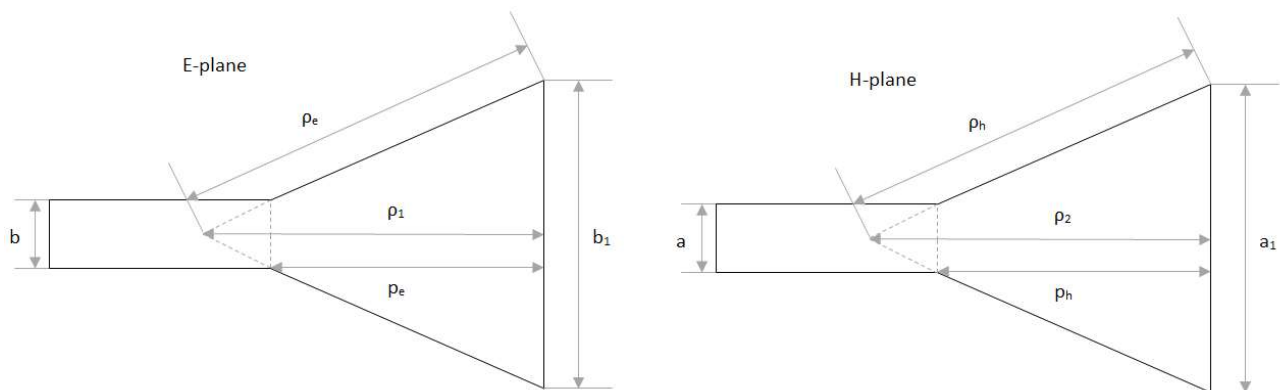


# Pyramidal Horn Design

## ▼ Introduction

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



Reference:

Based on example 13.6, page 782 of *Antenna Theory, Analysis and Design*, Constantine A. Balanis, 3<sup>rd</sup> Edition.

- > restart :
- with(plots) :
- with(ColorTools) :

## ▼ Parameters

The design equations require that the gain be unitless and that the wavelength,  $\lambda$ , be in cm. So our first equations which address design criteria (1) and (2), are

Gain in dB at design frequency:

$$> G_{odB} := 22.6 :$$

Hence

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

$$G_o := 181.9700859$$

(2.1)

Frequency ( $s^{-1}$ ):

$$> f := 11.0 \cdot 10^9 :$$

Geometrical constraints (cm):

$$> a := 2.286 :$$

$$b := 1.016 :$$

Speed of light (cm/s):

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

Wavelength (in cm):

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

$$\lambda := 2.727272727$$

(2.2)

## ▼ Governing Equations

These equations are extracted from the reference, and are derived therein.

We require the following for optimum directivity.

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

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

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

The dimensions  $\rho_e$  and  $\rho_h$  are equal.

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

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

$$> cons6 := \rho_e = \rho_h :$$

## ▼ Numerically Solve the Governing Equations

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

(4 1)

$$res := \left\{ a_1 = 16.55573668, b_1 = 13.01154178, p_e = 27.97911838, p_h = 27.97911838, p_e \right. \\ \left. = 31.03837357, p_h = 33.50018428 \right\} \quad (4.1)$$

## ▼ Plot the E-Plane Radiation Pattern

> *assign(res)*

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

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

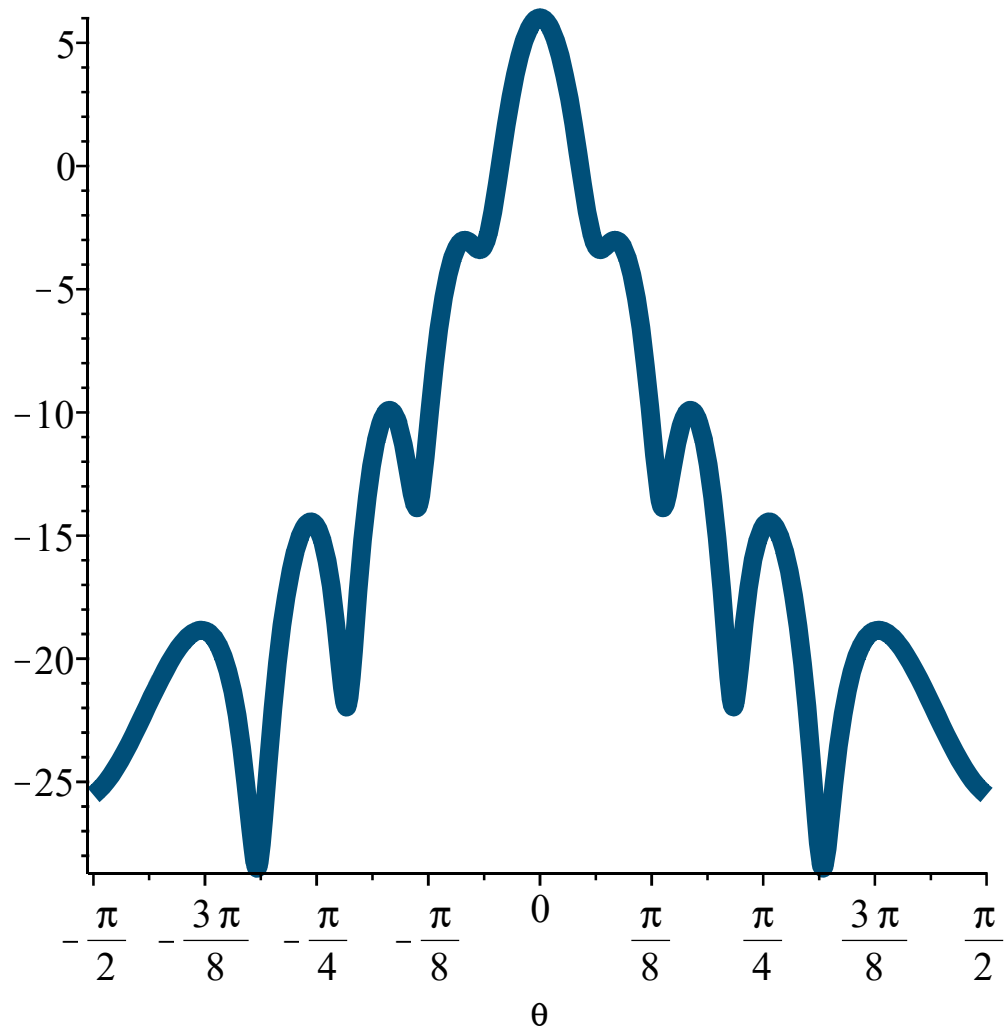
$$> t_2 := \theta \rightarrow \sqrt{\frac{2}{\lambda \cdot \rho_1}} \cdot \left(\frac{b_1}{2} - \rho_1 \cdot \sin(\theta)\right) :$$

$$> F := \theta \rightarrow \text{FresnelC}(t_2(\theta)) - \text{FresnelC}(t_1(\theta)) - i \cdot (\text{FresnelS}(t_2(\theta)) - \text{FresnelS}(t_1(\theta))) :$$

Radiation Pattern

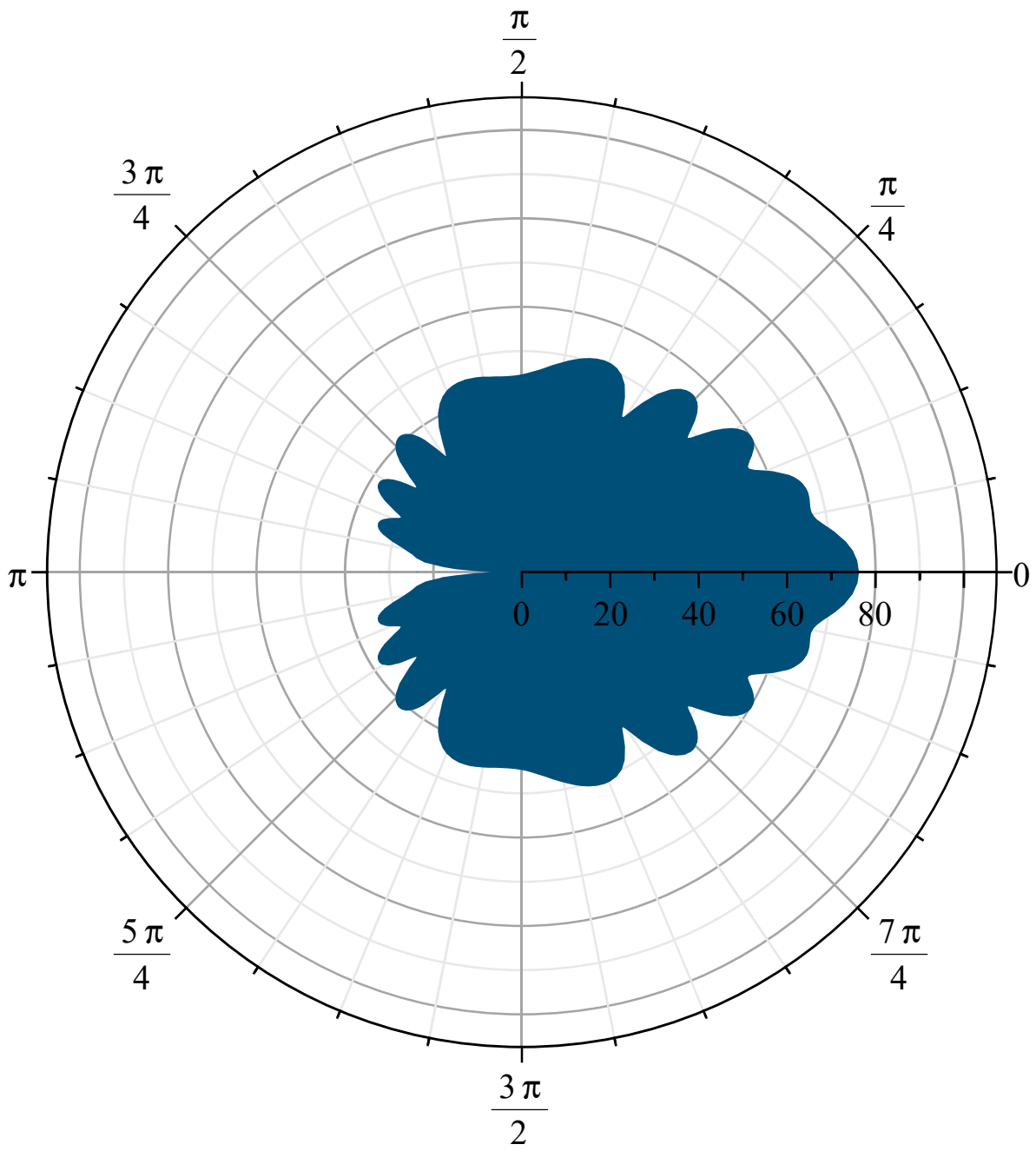
$$> E_\theta := \theta \rightarrow 20 \cdot \log_{10} \left( |1 + \cos(\theta)| \cdot \frac{|F(\theta)|}{|F(0)|} \right) :$$

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



> `polarplot( $E_{\theta}(\theta) + 70, \theta = 0..2\pi, thickness = 0, color = Color("RGB", [0, 79/255, 121/255])$ ),  
 filled = true, transparency = 0, title = "E-Plane Radiation Pattern", size = [800, 800])`

# E-Plane Radiation Pattern





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