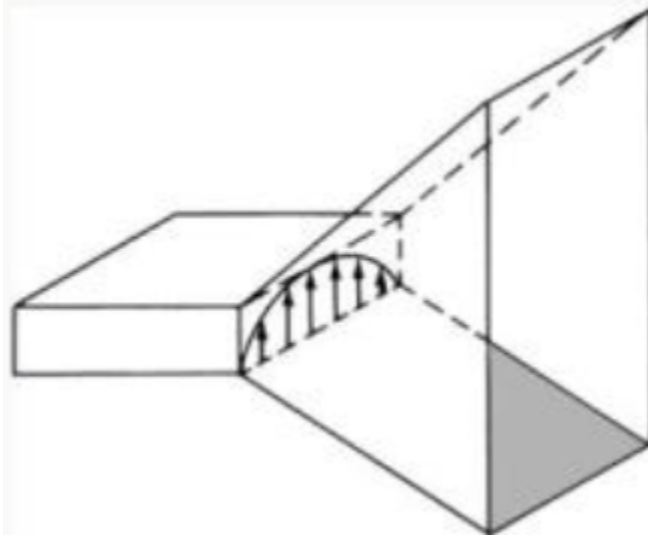


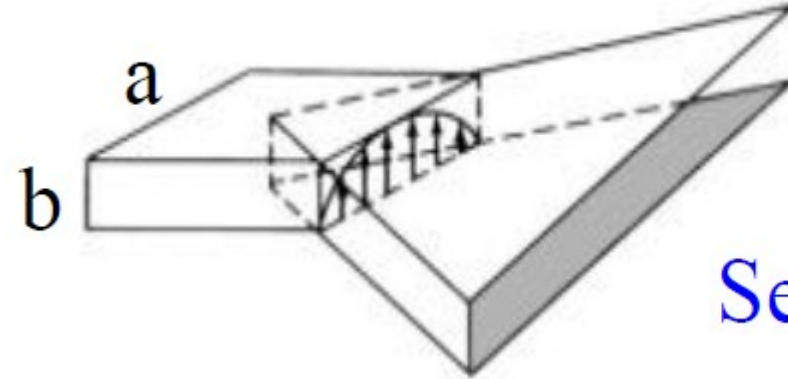
Antene de tip Horn



Tipuri de antene horn dreptunghiulare

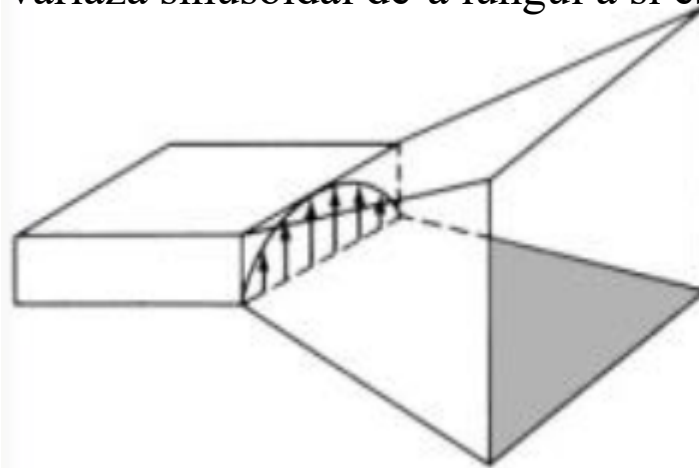


E-Plane
Sectoral
Horn



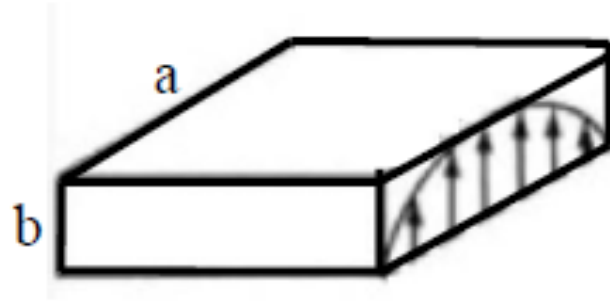
H-Plane
Sectoral Horn

Modul TE_{10} în Ghid de undă dreptunghiular
Câmpul E variază sinusoidal de-a lungul a și este uniform de-a lungul lui b



Pyramidal Horn

Ghid de undă



Modul TE_{10} într-un ghid de undă dreptunghiular

Pentru modul fundamental TE_{10} : câmpul E variază sinusoidal de-a lungul axei a și este uniform de-a lungul axei b

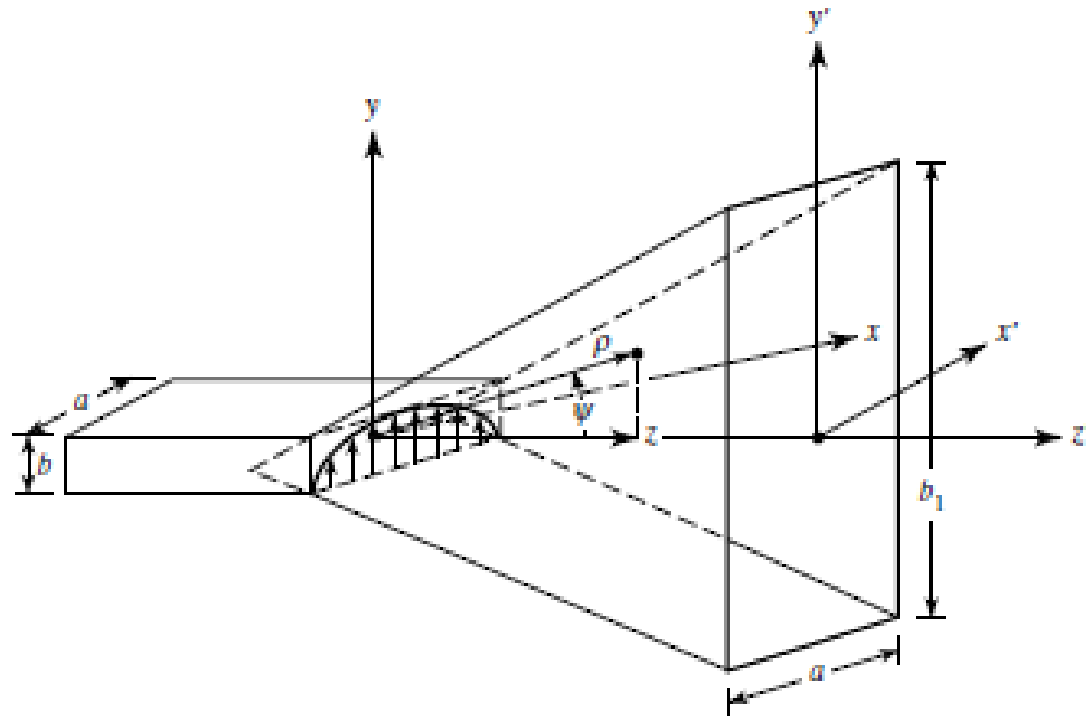
Ghid de undă X Band WR90 (de la 8,4 la 12,4 GHz)

a=0,9 inci, b=0,4 inci

Lungimea de undă de tăiere = $2a = 2 \cdot 0,9 \cdot 2,54 = 4,572$ cm

Frecvența de tăiere = $3 \cdot 10^{10} / 4,572 = 6,56$ GHz

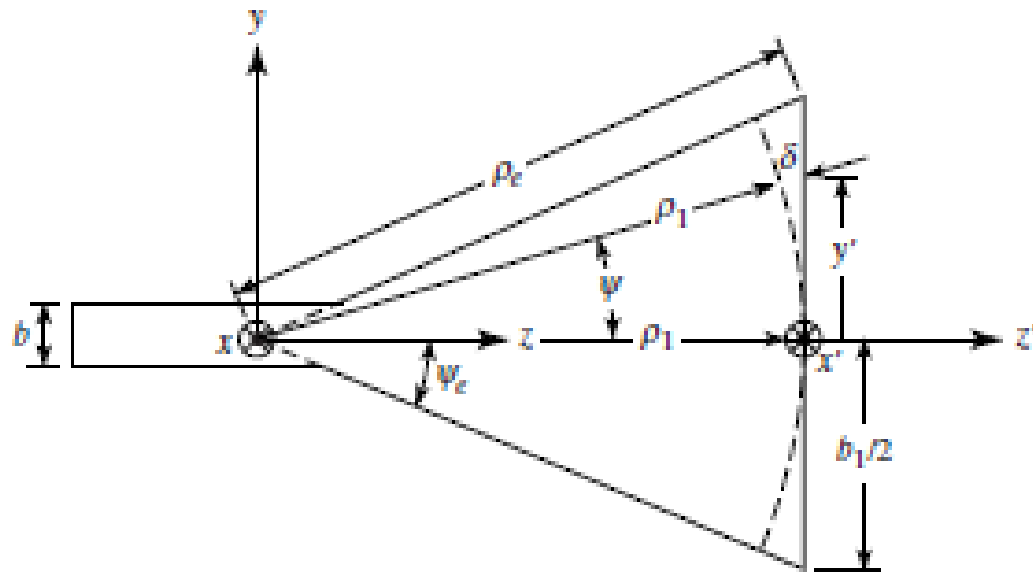
Antene Horn sectoriale de plan E



$$E'_y(x', y') = E_1 \cos\left(\frac{\pi}{a} x'\right) e^{-j\frac{ky'^2}{2\rho_1}}$$

Amplitudine Fază

Antenă Horn sectorială de plan E- vedere laterală

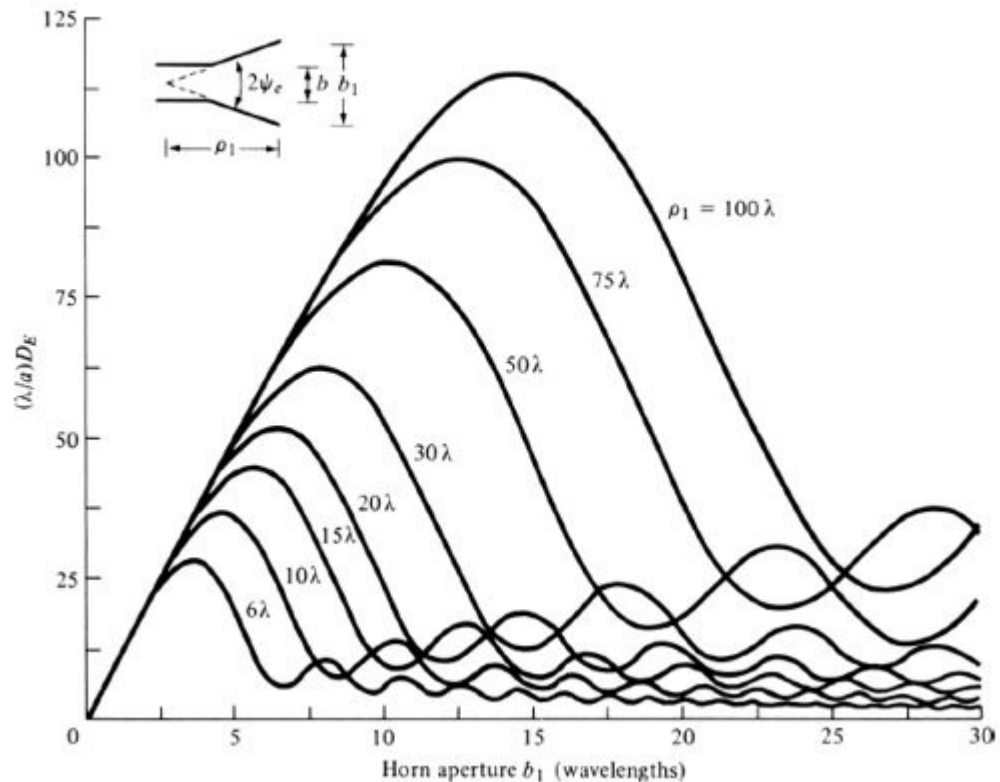


$$\delta(y') = -\rho_1 + \rho_1 \left[1 + \left(\frac{y'}{\rho_1} \right)^2 \right]^{1/2} \longrightarrow \delta(y') = \frac{1}{2} \left(\frac{y'^2}{\rho_1} \right)$$

Antenă Horn sectorială de plan E- curba de directivitate

- Directivitate maxima

$$b_1 = \sqrt{2\lambda\rho_1}$$



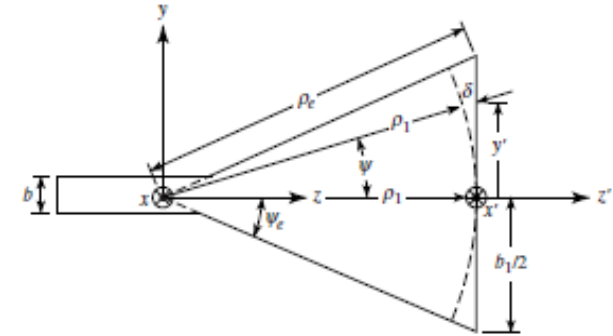
ρ_1	6	10	20	100
b_1	3.46	4.47	6.32	14.14

Antenă Horn sectorială de plan E- eroarea maxima de faza

- Directivitate maxima

$$b_1 = \sqrt{2\lambda\rho_1}$$

- Eroarea maximă de fază apare când $y' = b_1/2$



$$\delta(y') = \frac{1}{2} \left(\frac{y'^2}{\rho_1} \right)$$

$$\delta_{max} = 2\pi s, \text{ unde } s = \frac{b_1^2}{8\lambda\rho_1}$$

De aici S devine aproximativ egal cu:

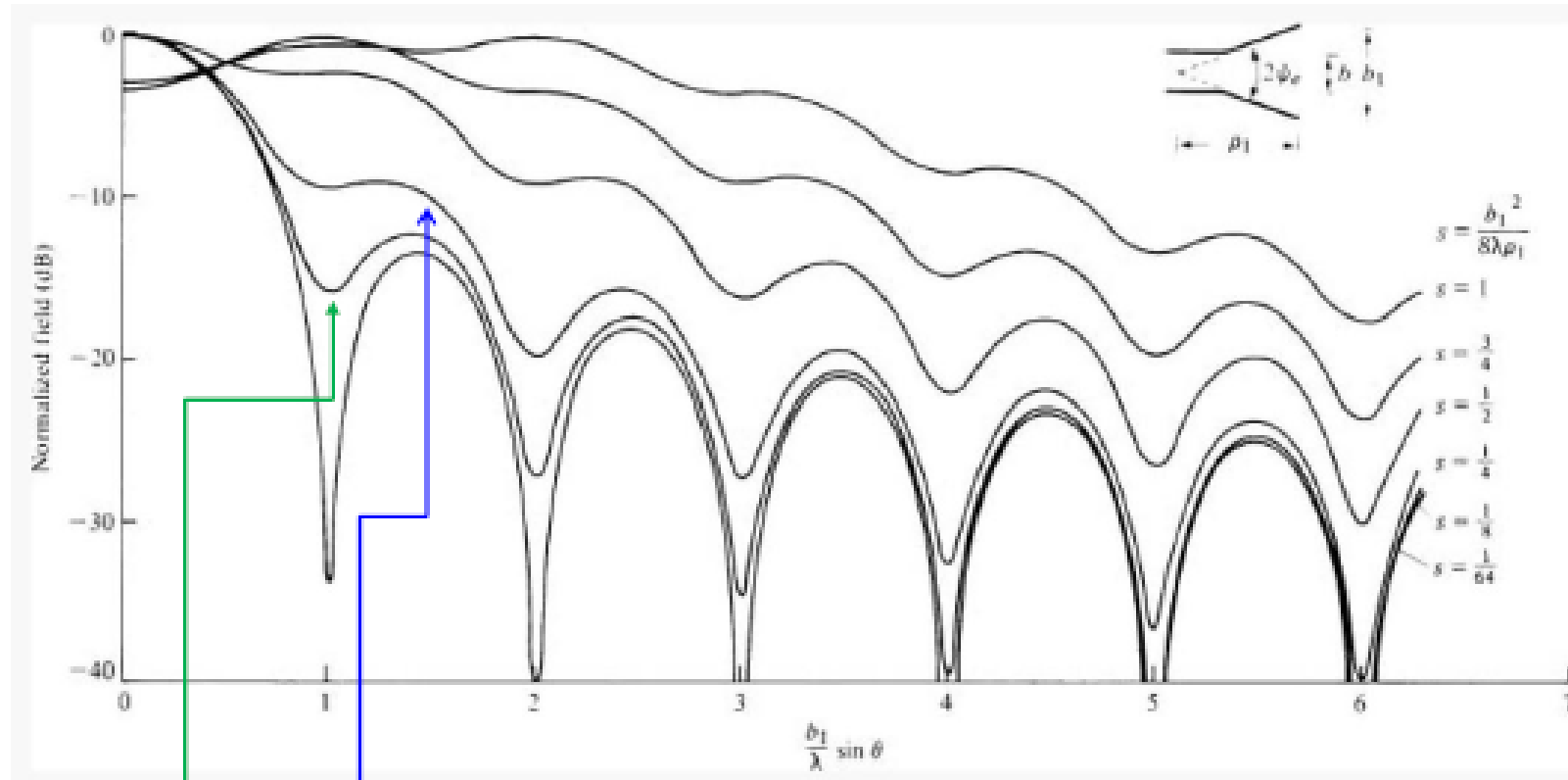
$$S_{ap} = \frac{b_1^2}{8\lambda\rho_1}$$

Pentru directivitatea maxima cu b_1 de mai sus

$$S_{ap} = \frac{1}{4} \Rightarrow \delta_{max} = 90^\circ$$

Eroarea de fază este prea mare, deci nu este recomandată

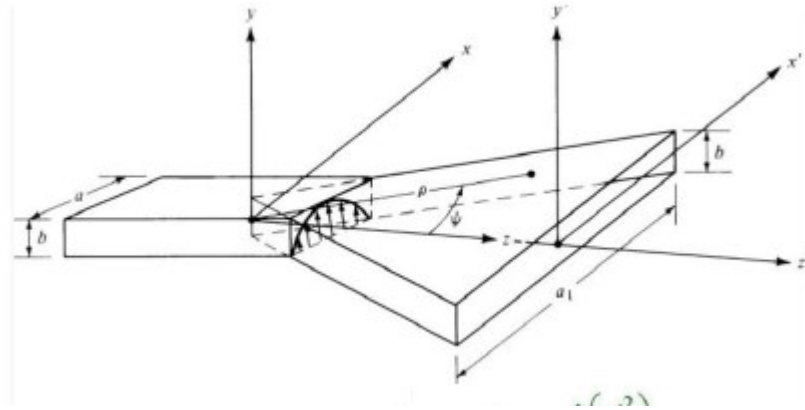
Antenă Horn sectorială de plan E-pattern universal



E-Field for $s = 1/4$ ($\delta_{max} = 90^\circ$)

E-Field for $s = 1/8$ ($\delta_{max} = 45^\circ$) - Recommended

Antenă Horn sectorială de plan H

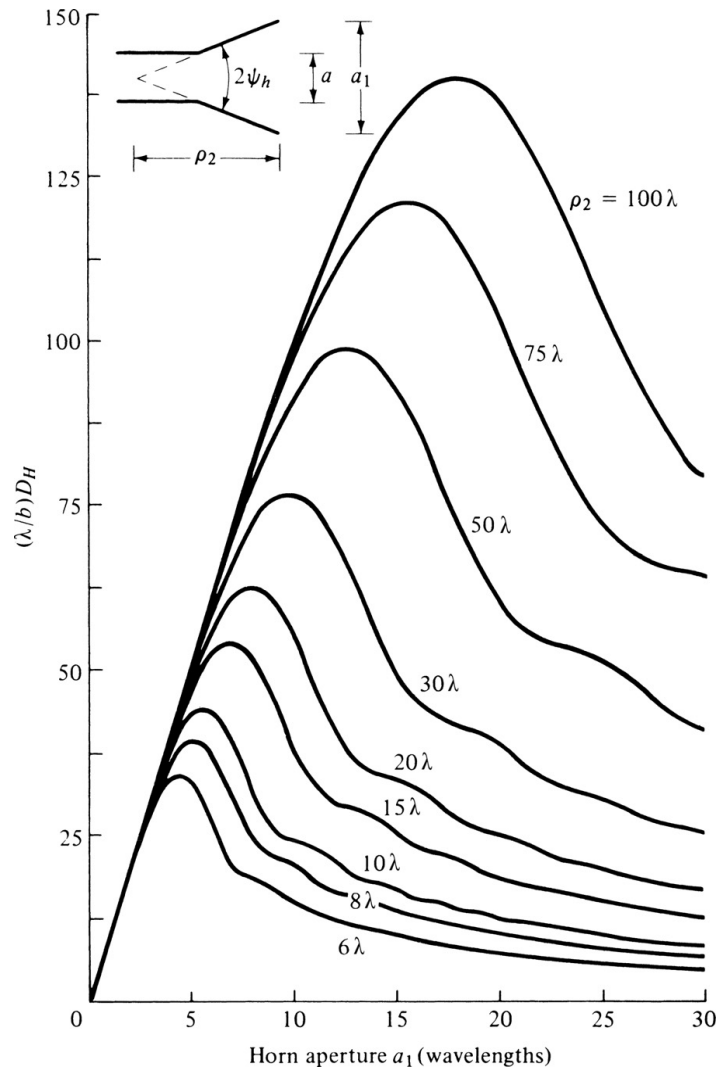


$$E'_y(x', y') = E_2 \cos\left(\frac{\pi}{a_1} x'\right) e^{-j\frac{kx'^2}{2\rho_2}}$$

Eroarea maximă de fază apare când $x' = a_1/2$

$$\delta_{max} = 2\pi t, \text{ unde } t = \frac{a_1^2}{8\lambda\rho_2}$$

Antenă Horn sectorială de plan H- curba de directivitate



- Directivitate maxima

$$a_1 = \sqrt{2\lambda\rho_2}$$

ρ_2	6	10	20	100
a_1	4.24	5.48	7.75	17.32

Antenă Horn sectorială de plan H- eroarea maxima de faza

- Directivitate maxima

$$a_1 = \sqrt{2\lambda\rho_2}$$

- Eroarea maximă de fază apare când $x' = a_1/2$

$$\delta_{max} = 2\pi t, \text{ unde } t = \frac{a_1^2}{8\lambda\rho_2}$$

De aici t devine aproximativ egal cu:

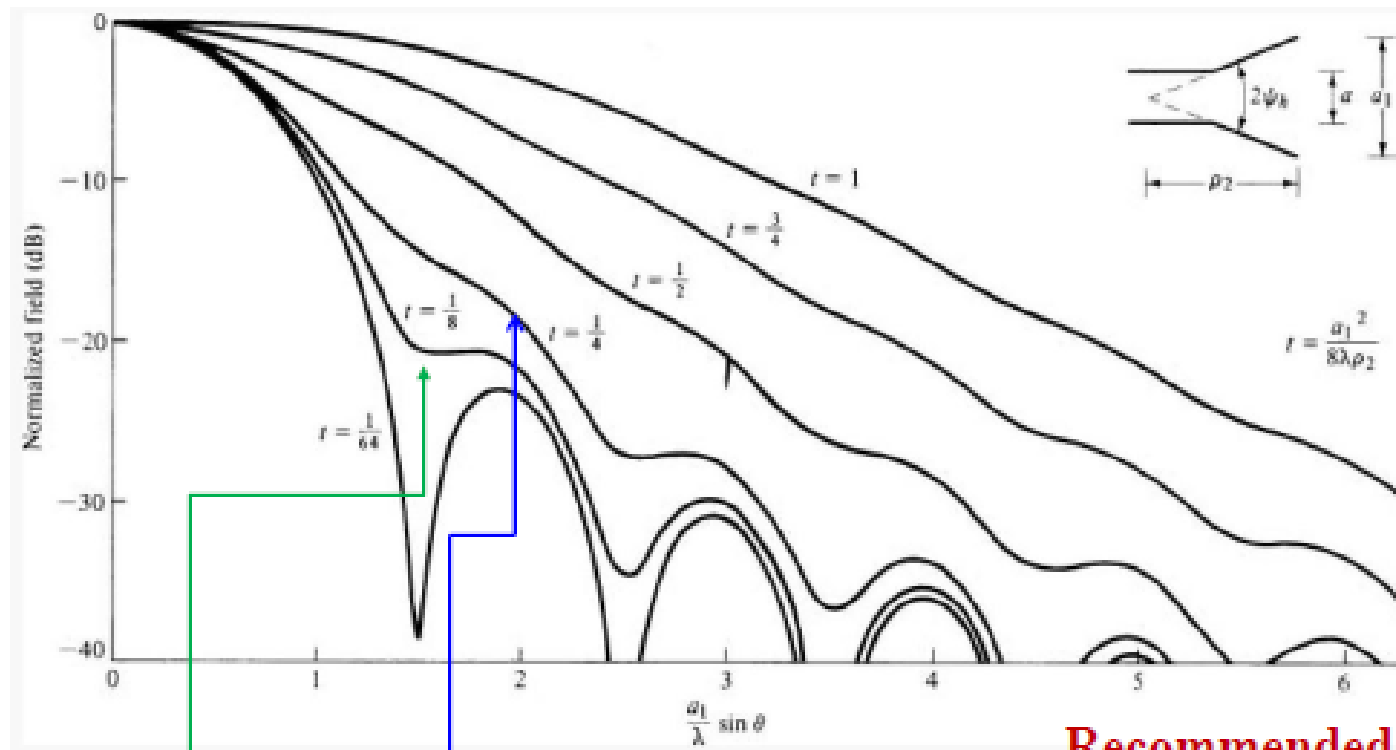
$$t_{ap} = \frac{a_1^2}{8\lambda\rho_2}$$

Pentru directivitatea maxima cu a_1 de mai sus

$$t_{ap} = \frac{3}{8} \Rightarrow \delta_{max} = 135^\circ$$

Eroarea de fază este prea mare, deci nu este recomandată

Antenă Horn sectorială de plan E-pattern universal

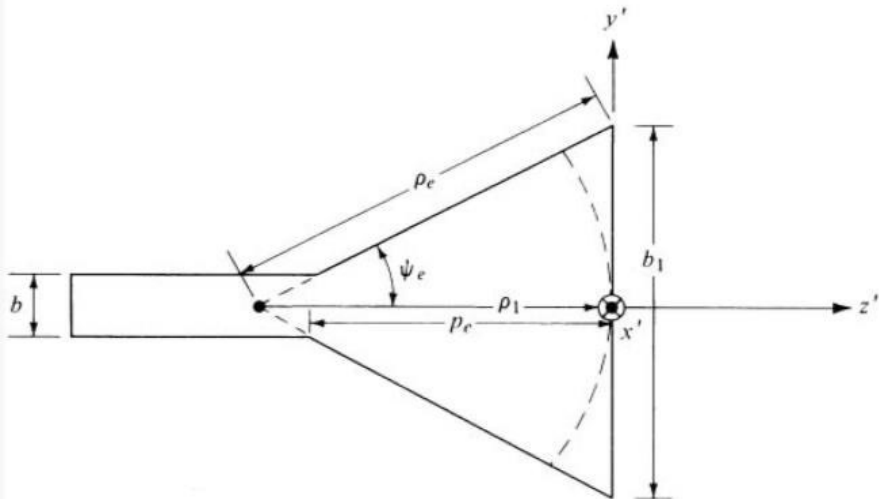
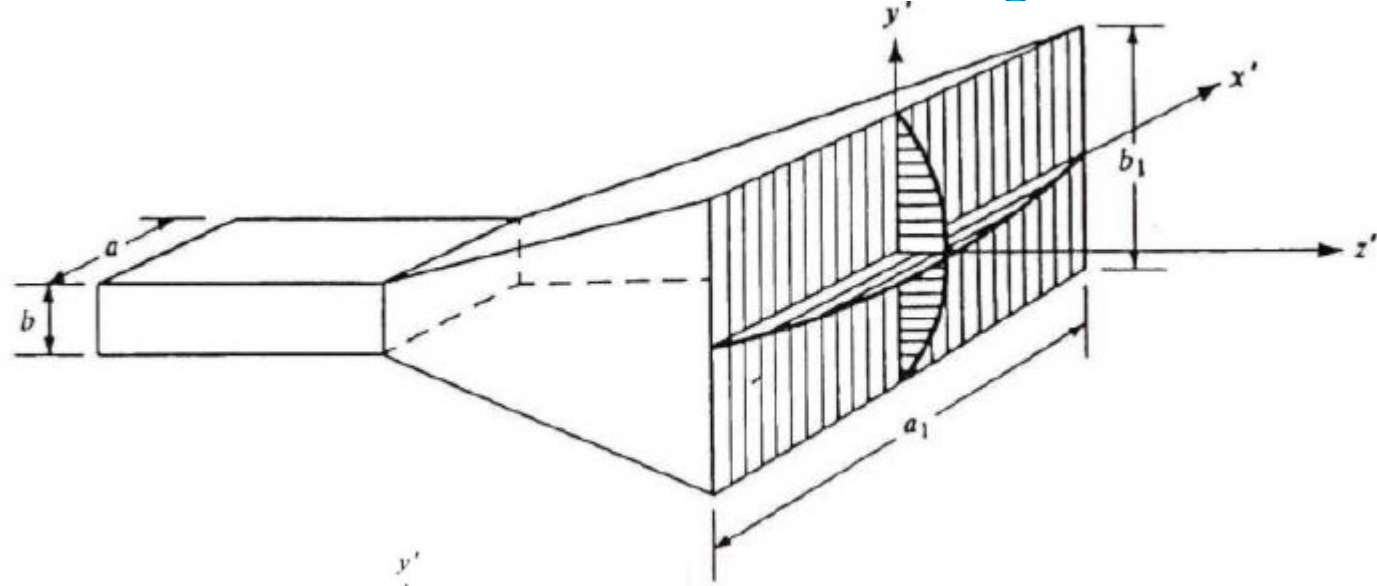


E-Field for $t = 1/4$ ($\delta_{max} = 90^\circ$)

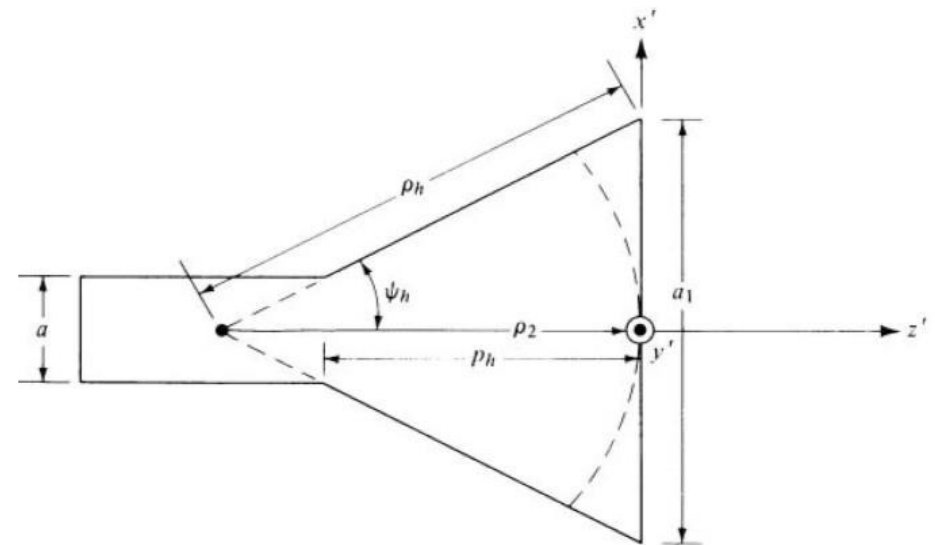
E-Field for $t = 1/8$ ($\delta_{max} = 45^\circ$)

Recommended
max. phase
error between
 45° and 90°

Antena Horn piramidală



Vedere laterală



Vedere de sus

Antena Horn piramidală

$$E'_y(x', y') = E_0 \cos\left(\frac{\pi}{a_1} x'\right) e^{-jk\left(\frac{x'^2}{2\rho_2} + \frac{y'^2}{2\rho_1}\right)}$$

Condiția pentru realizarea fizică:

$$p_c = (b_1 - b) \left[\left(\frac{\rho_c}{b_1}\right)^2 - \frac{1}{4} \right]^{1/2}$$

$$p_h = (a_1 - a) \left[\left(\frac{\rho_h}{a_1}\right)^2 - \frac{1}{4} \right]^{1/2}$$

$$p_c = p_h$$

Antena Horn piramidală-procedura de proiectare

- Directivitatea unei antene de tip horn piramidală poate fi obținută folosind curbele de directivitate pentru antenele Horn sectoriale de plan E și H

$$G_0 \cong \frac{1}{2} \left(\frac{4\pi}{\lambda^2} a_1 b_1 \right)$$

$$a_1 = \sqrt{3\lambda\rho_2} \approx \sqrt{3\lambda\rho_h} \quad \rho_2 \cong \rho_h$$

$$b_1 = \sqrt{2\lambda\rho_1} \approx \sqrt{2\lambda\rho_c} \quad \rho_1 \cong \rho_c$$

$$p_c = (b_1 - b) \left[\left(\frac{\rho_c}{b_1} \right)^2 - \frac{1}{4} \right]^{1/2}$$

$$p_h = (a_1 - a) \left[\left(\frac{\rho_h}{a_1} \right)^2 - \frac{1}{4} \right]^{1/2}$$

Antena Horn piramidală-procedura de proiectare

$$\left(\sqrt{2\mathcal{X}} - \frac{b}{\lambda}\right)^2 (2\mathcal{X} - 1) = \left(\frac{G_0}{2\pi} \sqrt{\frac{3}{2\pi} \frac{1}{\sqrt{\mathcal{X}}} - \frac{a}{\lambda}}\right)^2 \left(\frac{G_0^2}{6\pi^3} \frac{1}{\mathcal{X}} - 1\right)$$

$$\rho_c = \mathcal{X}\lambda \Rightarrow \mathcal{X} = \frac{\rho_c}{\lambda}$$

$$\rho_h = \frac{G_0^2}{8\pi^3} \frac{1}{\mathcal{X}} \lambda$$

$$1. \mathcal{X} = \mathcal{X}_1 = x(\text{trial}) = \frac{G_0}{2\pi\sqrt{2\pi}}$$

$$2. \rho_c = \mathcal{X}\lambda, \rho_h = \frac{G_0^2}{8\pi^3} \frac{1}{\mathcal{X}} \lambda$$

$$3. a_1 = \sqrt{3\lambda\rho_2} = \sqrt{3\lambda\rho_h} = \frac{G_0}{2\pi} \sqrt{\frac{3}{2\pi\mathcal{X}}} \lambda$$

$$b_1 = \sqrt{2\lambda\rho_1} = \sqrt{2\lambda\rho_c} = \sqrt{2\lambda^2\mathcal{X}}$$

$$4. \rho_c, \rho_h$$

Antena Horn piramidală-procedura de proiectare(exemplu)

- Se da: antena horn X-band (8.2-12.4 GHz), $f=11$ GHz, câștig= $22,6$ dB
 $a=0,9$ inci (2,286 cm), $b=0,4$ inci (1,016 cm)
- Se cere să se determine dimensiunile antenei horn piramidale

$$G_0(\text{dB}) = 22,6 = 10 \log_{10} G_0 \Rightarrow G_0 = 10^{2.26} = 181.97$$

$$\text{La } f = 11 \text{ GHz} \Rightarrow \lambda = \frac{30 \times 10^9}{11 \times 10^9} = 2.7273 \text{ cm}$$

$$b = \frac{1.016}{2.7273} \lambda = 0.3725 \lambda$$

$$a = \frac{2.286}{2.7273} \lambda = 0.8382 \lambda$$

Antena Horn piramidală-procedura de proiectare(exemplu)

1. Valoarea initiala a lui \mathcal{X}

$$\mathcal{X}_1 = \frac{G_0}{2\pi\sqrt{2\pi}} = \frac{181.97}{2\pi\sqrt{2\pi}} = 11.5539 \quad \text{Care nu satisface cerintele, sau}$$

$$\left(\sqrt{2\mathcal{X}} - \frac{b}{\lambda}\right)^2 (2\mathcal{X} - 1) = \left(\frac{G_0}{2\pi} \sqrt{\frac{3}{2\pi} \frac{1}{\sqrt{\mathcal{X}}} - \frac{a}{\lambda}}\right)^2 \left(\frac{G_0^2}{6\pi^3} \frac{1}{\mathcal{X}} - 1\right)$$

După câteva încercări se obține o valoare de o acuratețe mai mare :

$$\mathcal{X} = 11,1157$$

$$2. \rho_c = \mathcal{X}\lambda = 11.1157\lambda = 30.316 \text{ cm} = 11.935 \text{ inci}$$

$$\rho_h = \frac{G_0^2}{8\pi^3} \frac{1}{\mathcal{X}} \lambda = 12.0094\lambda = 32.753 \text{ cm} = 12.895 \text{ inci}$$

Antena Horn piramidală-procedura de proiectare(exemplu)

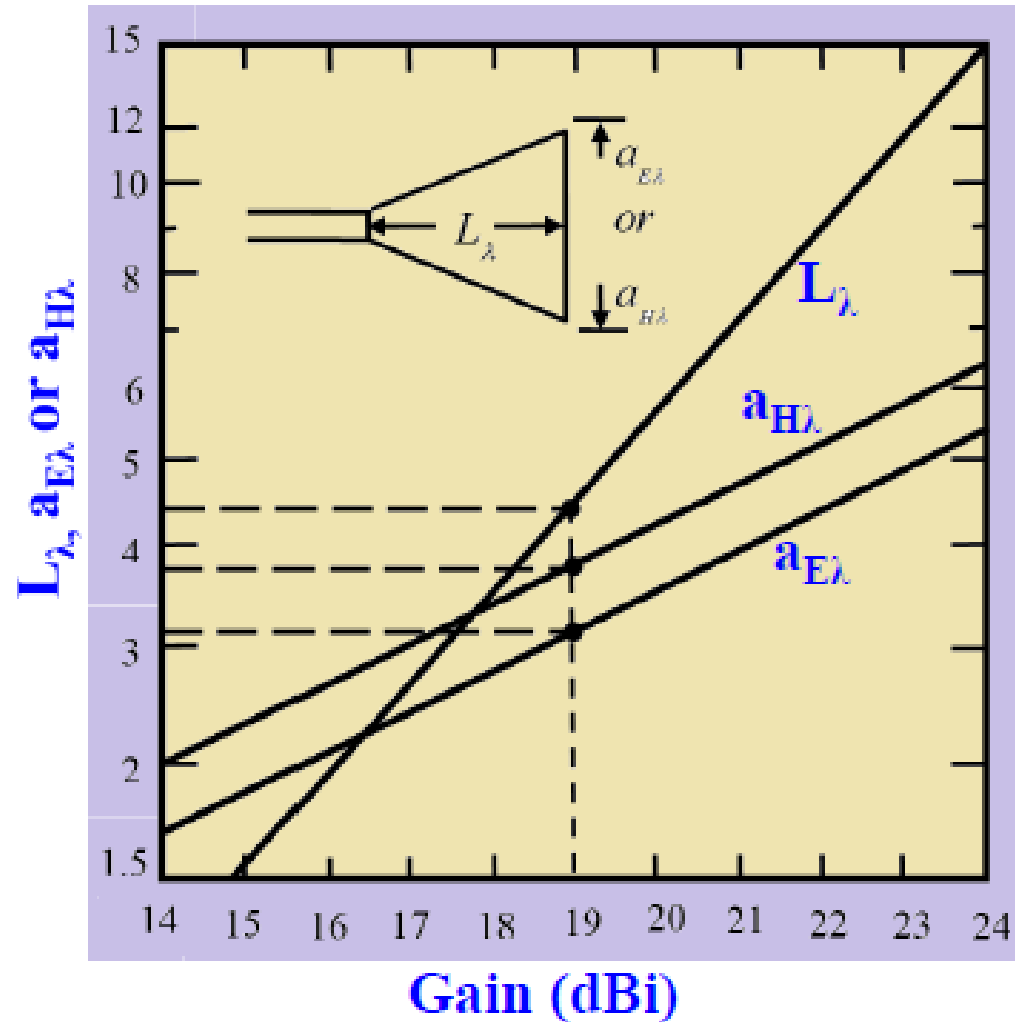
$$3. a_1 = \sqrt{3\lambda\rho_2} = \sqrt{3\lambda\rho_h} = \frac{G_0}{2\pi} \sqrt{\frac{3}{2\pi\mathcal{X}}} \lambda = 6.002\lambda = 16.370 \text{ cm}$$

$$b_1 = \sqrt{2\lambda\rho_1} = \sqrt{2\lambda\rho_c} = \sqrt{2\lambda^2\mathcal{X}} = 4.715\lambda = 12.859 \text{ cm}$$

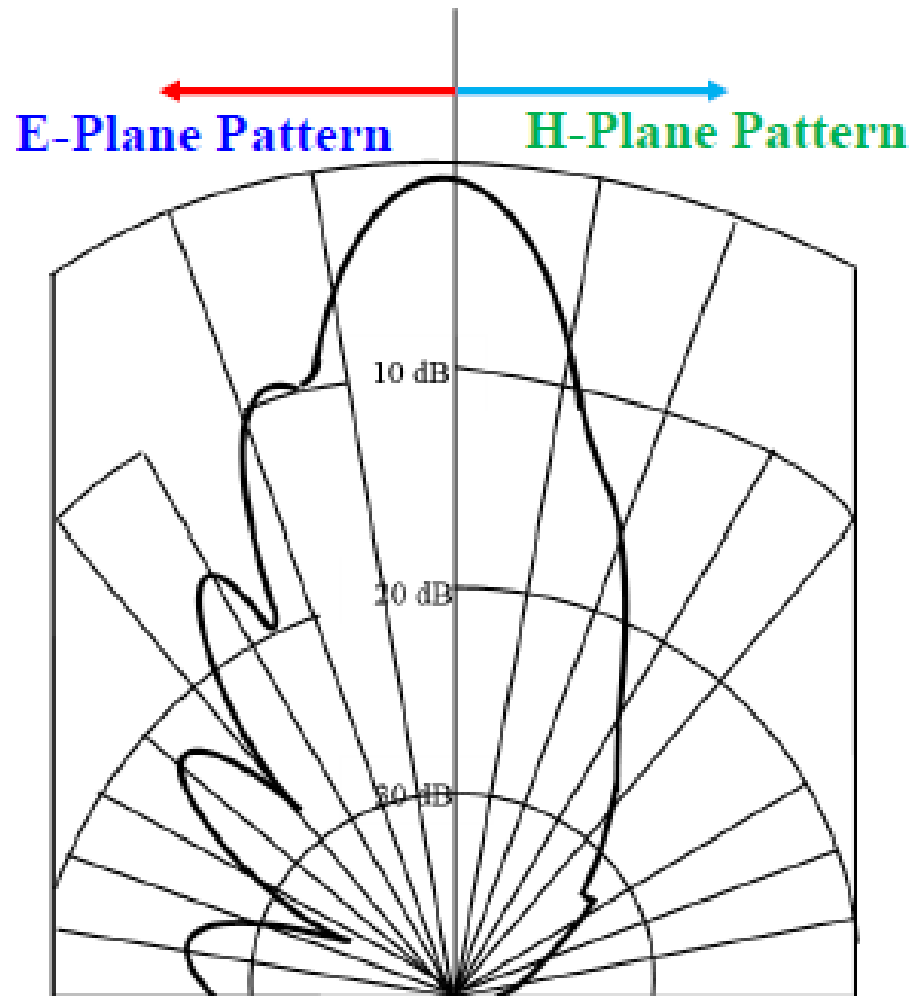
$$4. p_c = (b_1 - b) \left[\left(\frac{\rho_c}{b_1} \right)^2 - \frac{1}{4} \right]^{\frac{1}{2}} = 10.005\lambda = 27.286 \text{ cm}$$

$$p_h = (a_1 - a) \left[\left(\frac{\rho_h}{a_1} \right)^2 - \frac{1}{4} \right]^{\frac{1}{2}} = 10.005\lambda = 27.286 \text{ cm}$$

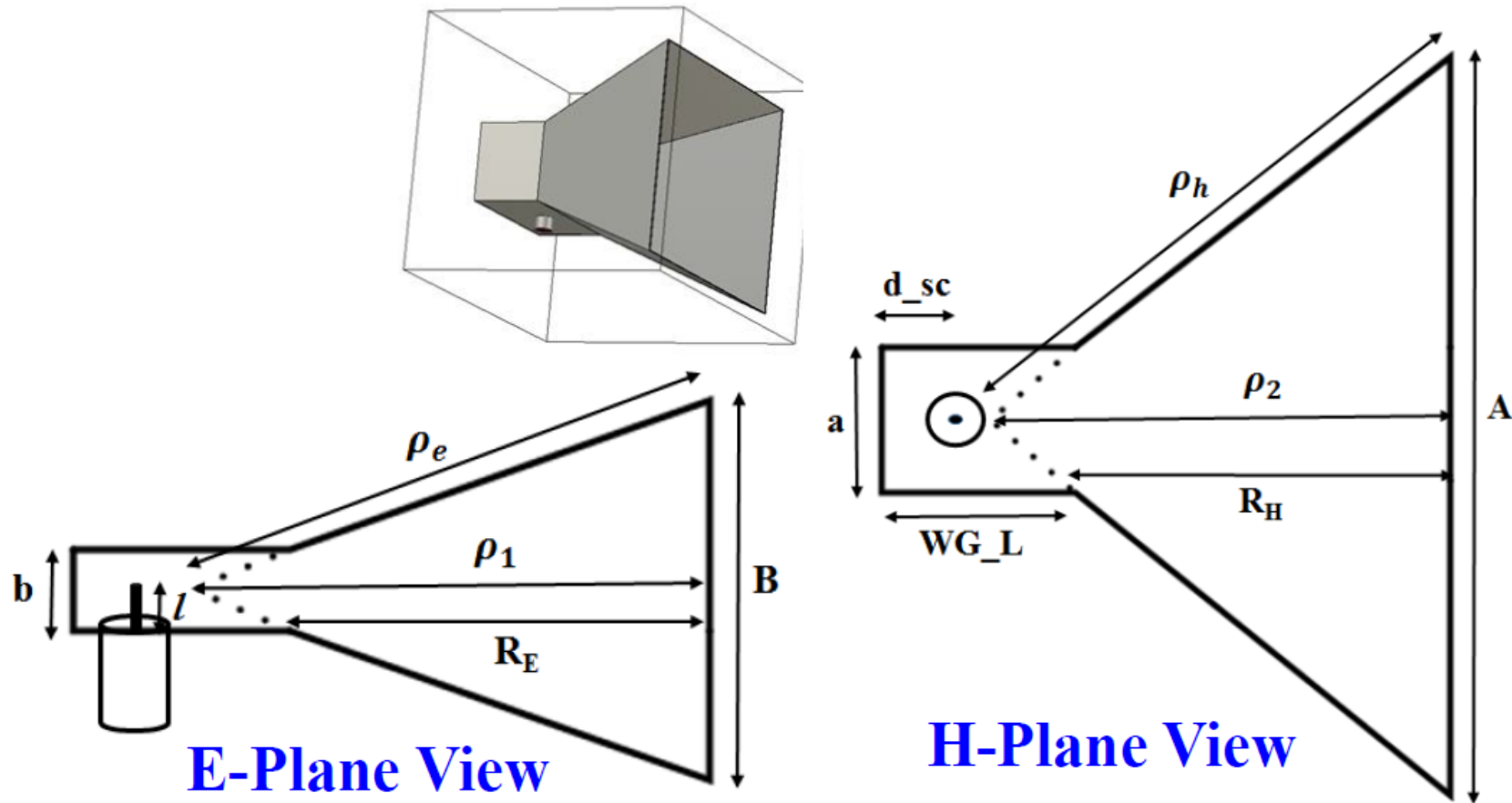
Dimensioni optime versus direttivitate



Patternul de radiație a unei antene horn piramidale



Alimentare coaxială a unei piramide horn piramidale

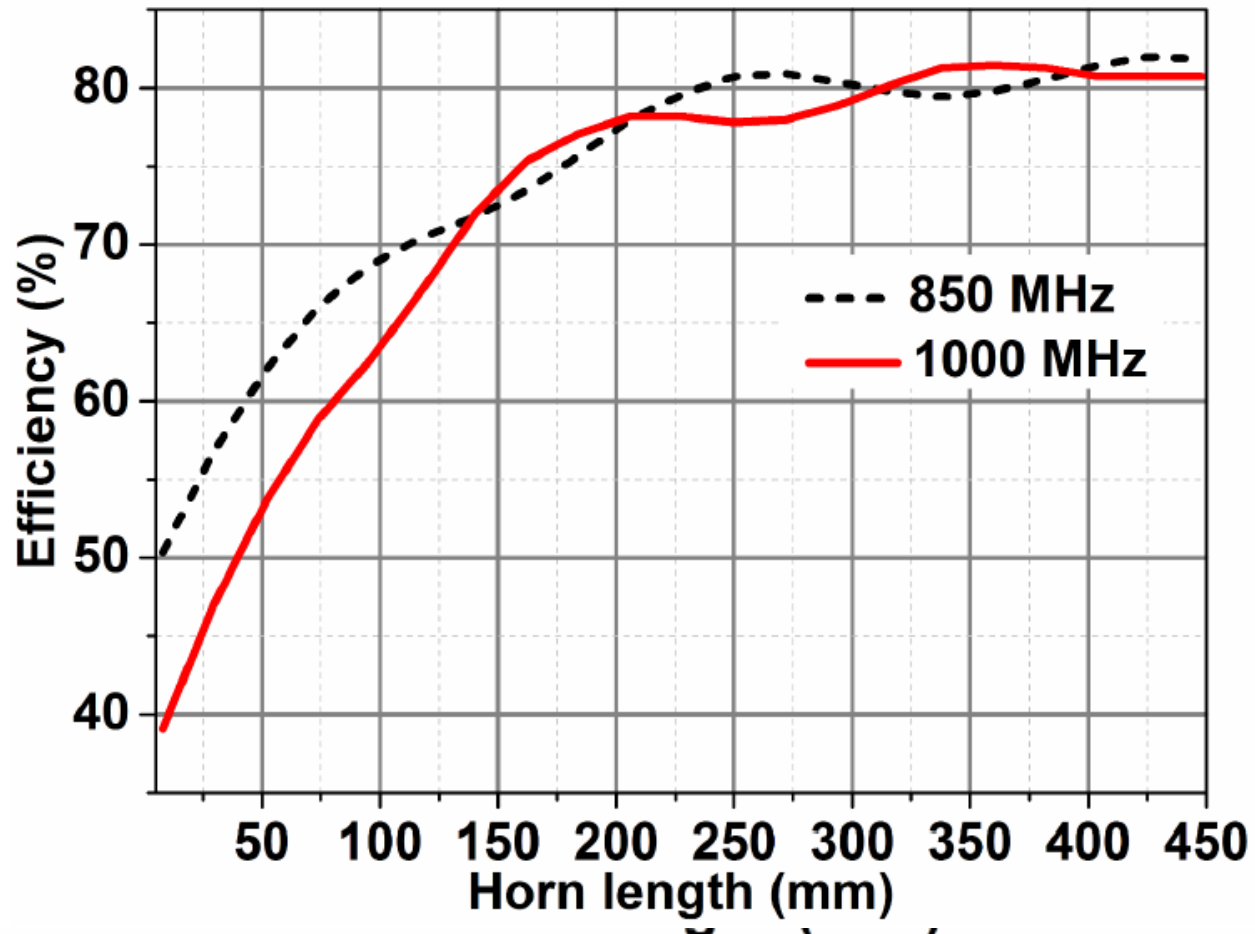


Reference: Hemant Kumar and Girish Kumar, “Design and Parametric Analysis of Pyramidal Horn Antenna with High Efficiency”, Proceedings of International Symposium on Microwave and Optical Technology (ISMOT) 2015, pp. 134-137.

Alimentare coaxială a unei piramide horn piramidale la 900 MHz

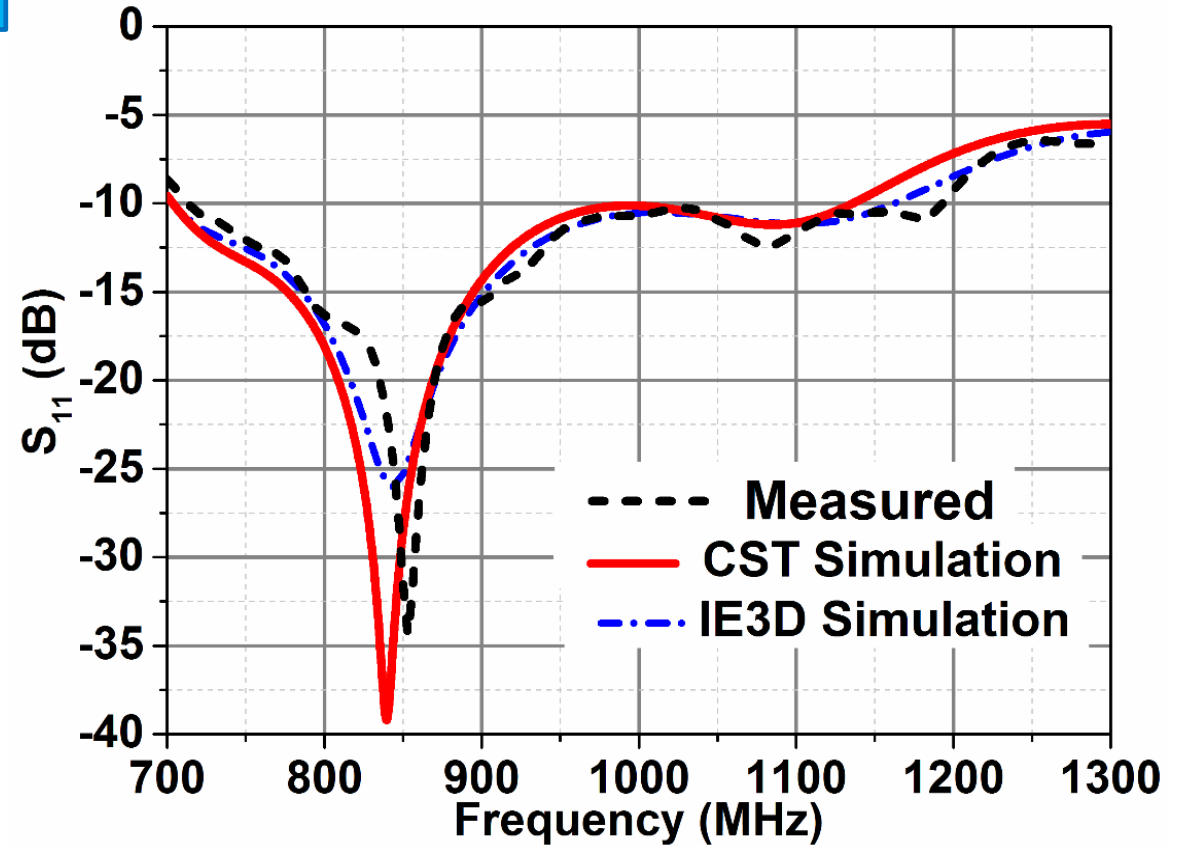
Parameter	Value (mm)	Description
A	450	Aperture Width
B	320	Aperture Height
a	240	Waveguide Width
b	120	Waveguide Height
WG_L	110	Waveguide Length
$R_E = R_H$	250	Horn Length
l	75	Probe Length
r	3.5	Probe Radius
d_sc	67.5	Distance of feed from short

Efectul lungimii antenei horn asupra eficienței



For Horn Length $R_E = R_H > 150$ mm, efficiency $\geq 72\%$
and for $R_E = R_H > 250$ mm, efficiency $\approx 80\%$

$|S_{11}|$ pentru o antenă horn piramidală alimentată coaxial



Lățime de bandă pentru $|S_{11}| < -10\text{dB}$:

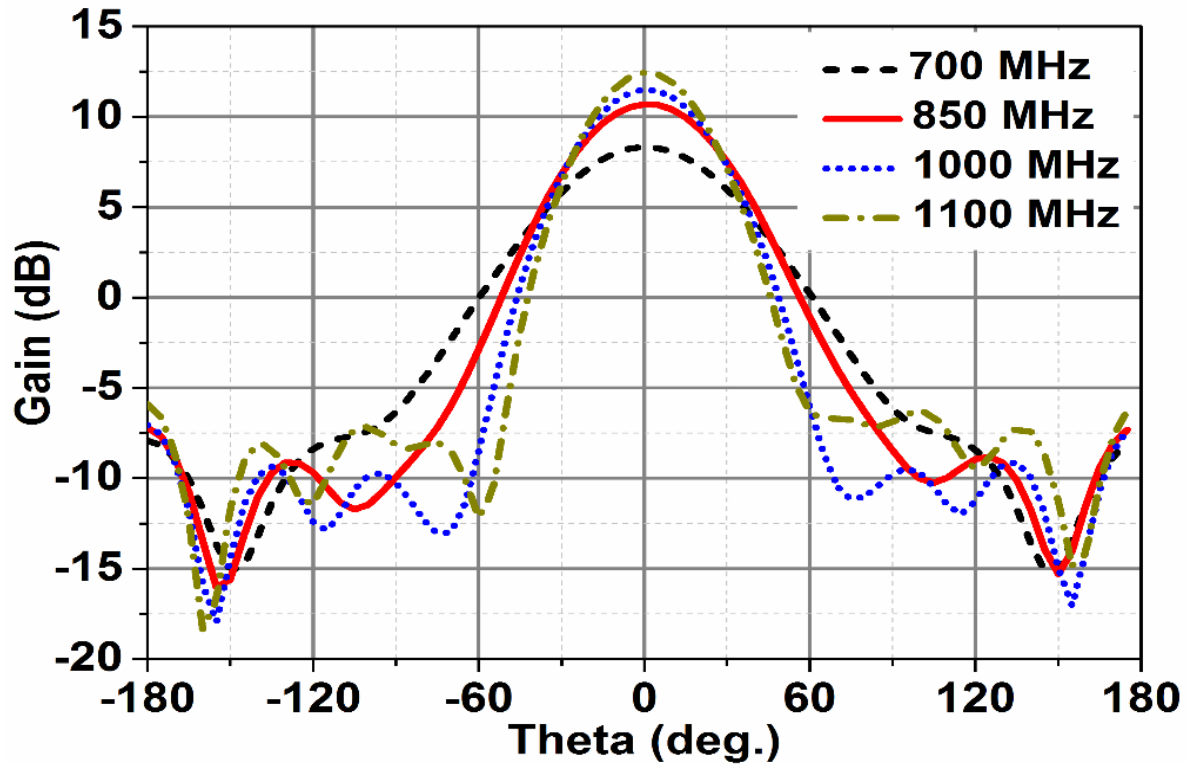
CST: 47%

IE3D : 49.5%

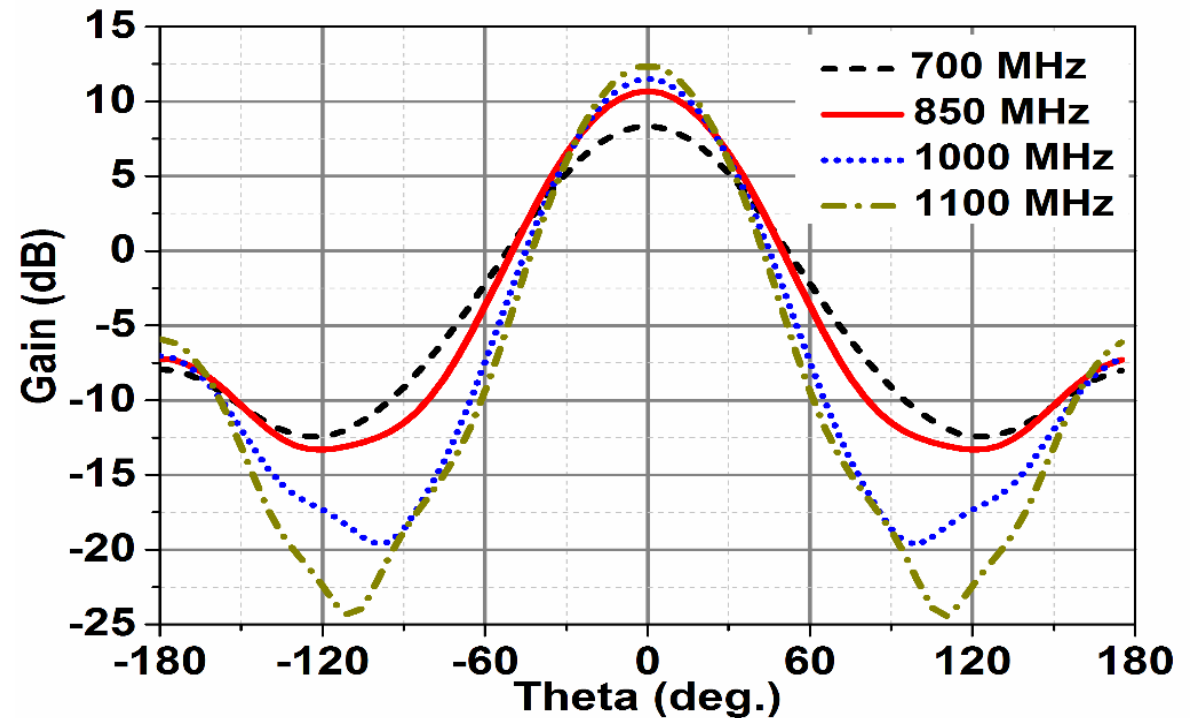
Rezultate măsurate: 52%

Pattern-ul de radiație pentru antena horn piramidală

Pattern de radiație pentru planul E

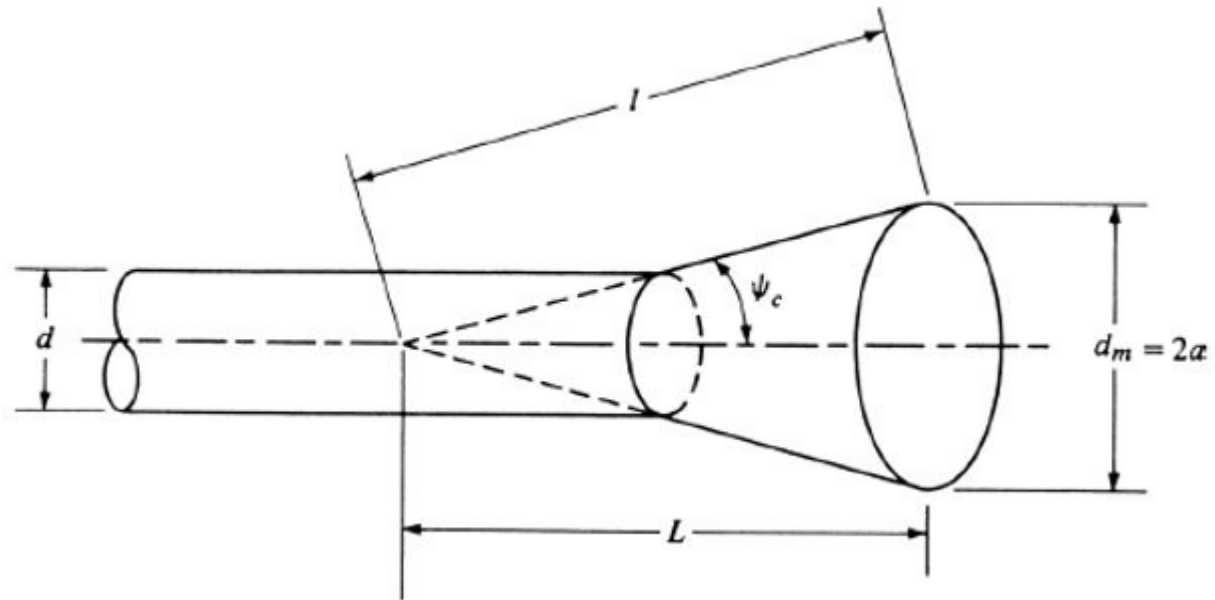


Pattern de radiație pentru planul H

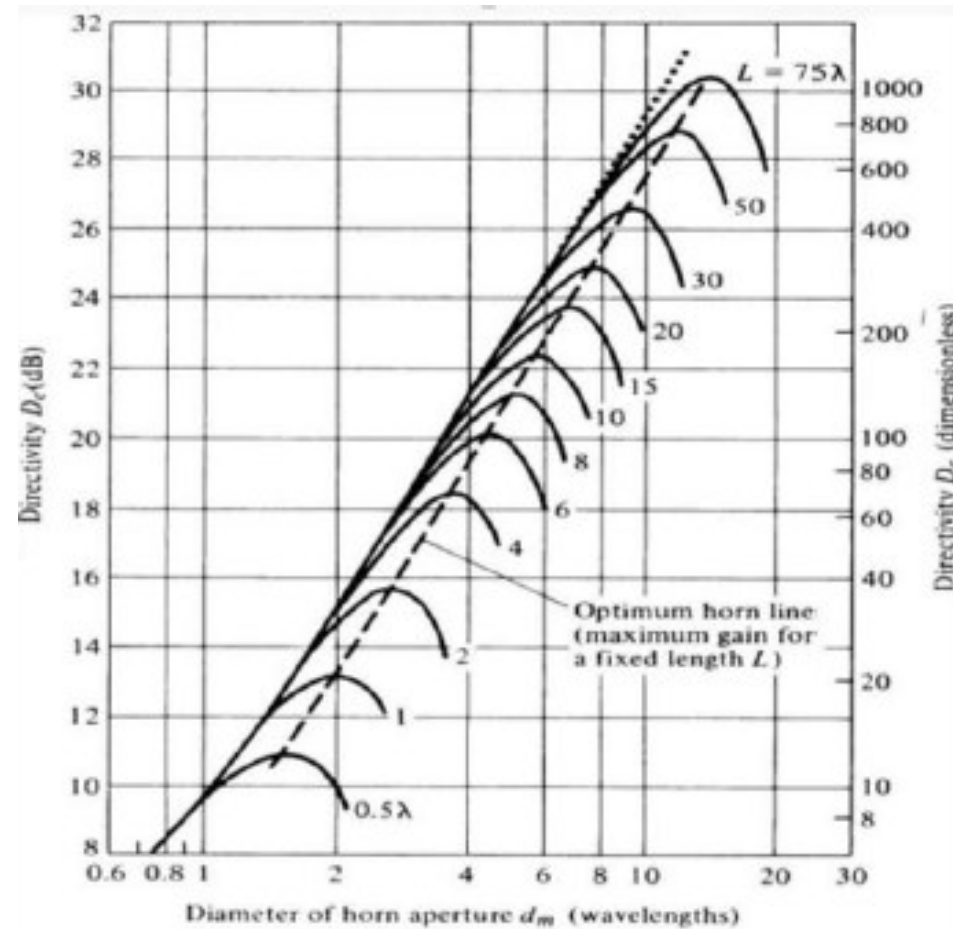


Câștig = $\eta(4 \pi A B / \lambda^2)$ – câștigul variază cu frecvența

Antene horn conice



Antene horn conice-curba de directivitate



Antene horn conice- directivitatea

$$S = \frac{d_m^2}{8\lambda l} = \text{devia\cete maxim\c4 de faz\c4 (in } \lambda \text{)}$$

C\c4știgul unei antene conice horn este optim c\c4nd:

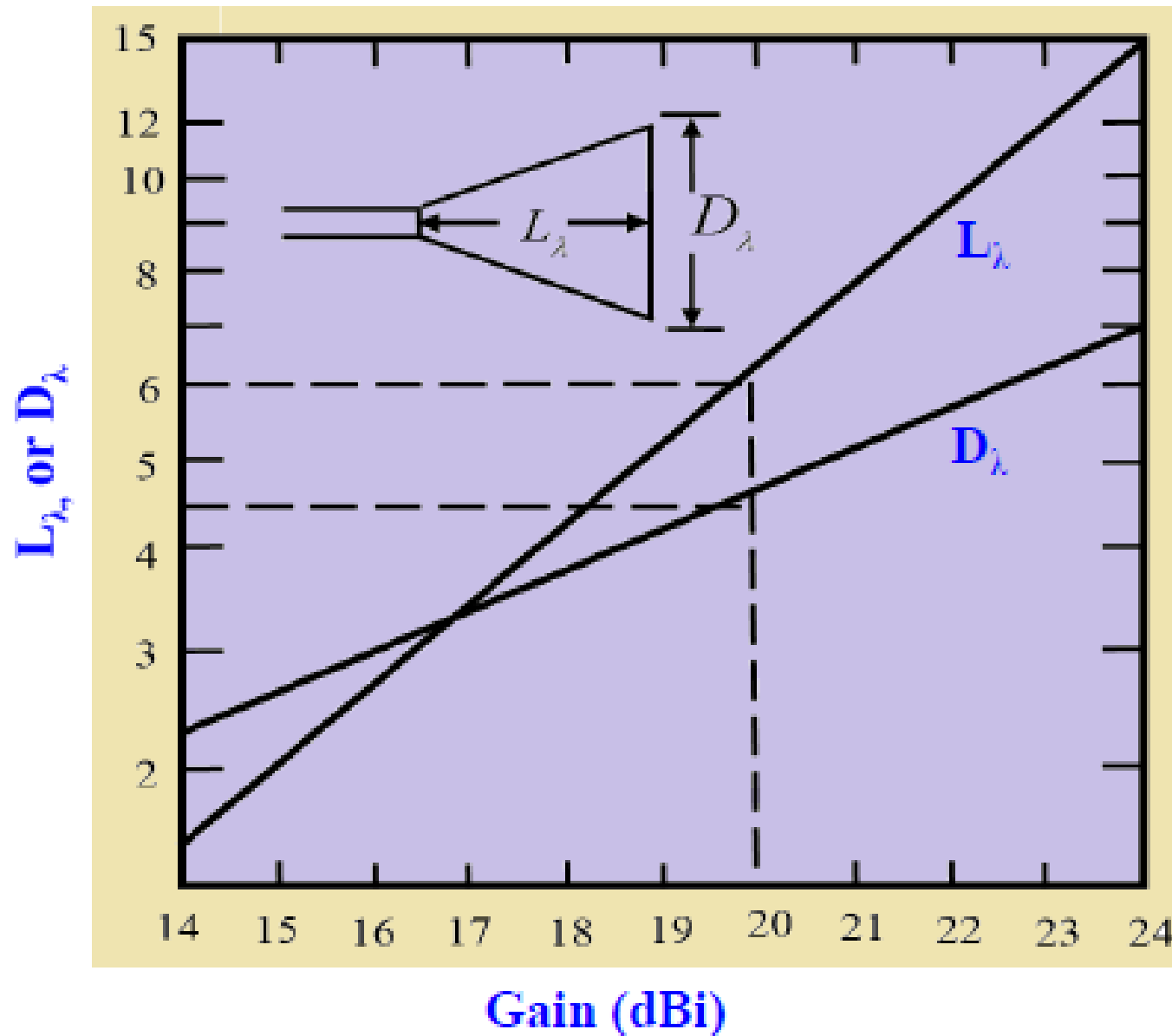
$$d_m = \sqrt{3\lambda l}$$

deci

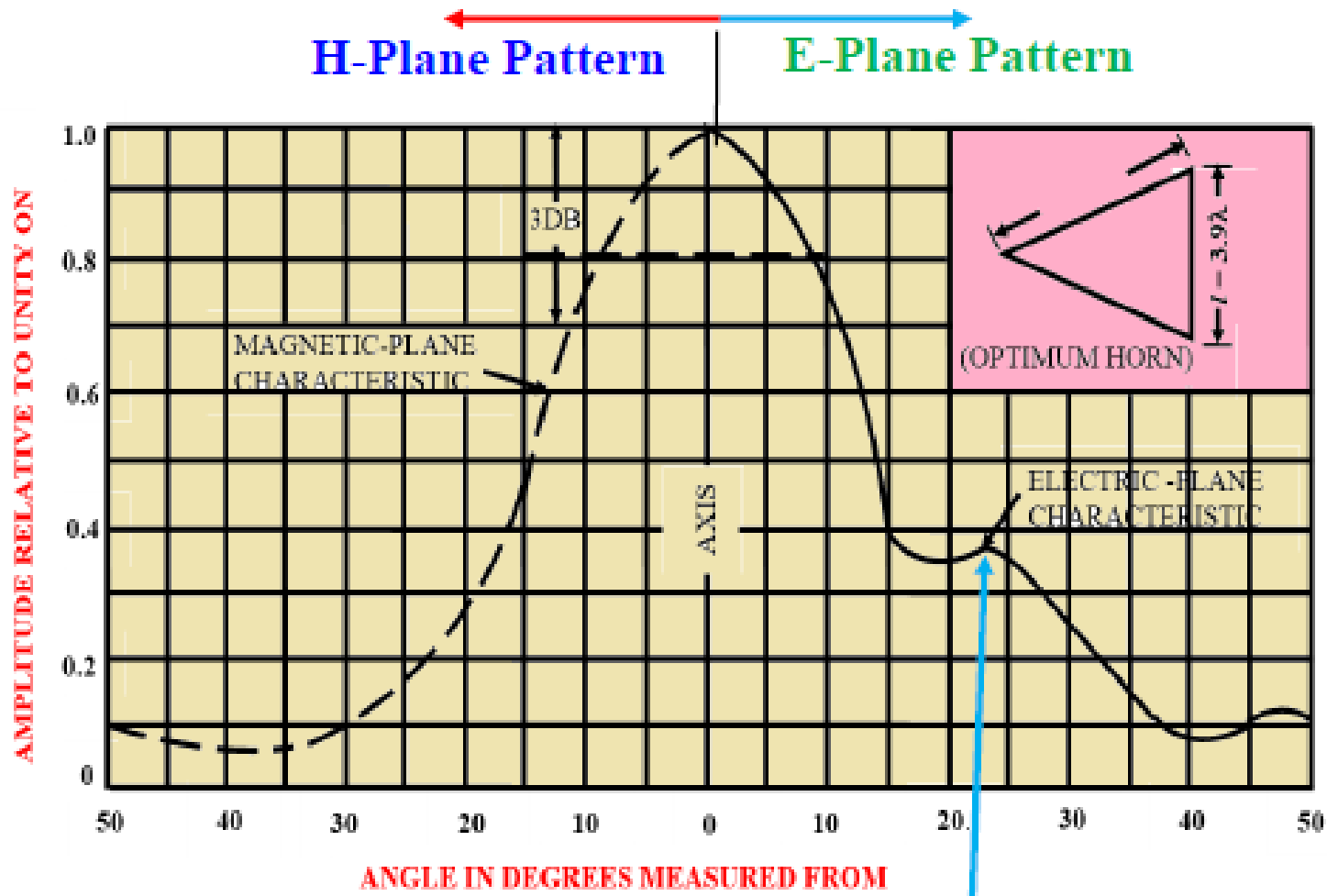
$$S|_{\text{c\c4știg optim}} = \frac{d_m^2}{8\lambda l} \Big|_{d_m = \sqrt{3\lambda l}} = \frac{3\lambda l}{8\lambda l} = \frac{3}{8} \Rightarrow \delta_{max} = 135^\circ$$

Eroarea de faz\c4 este prea mare, deci nu este recomandat

Dimensiuni optime versus directivitate

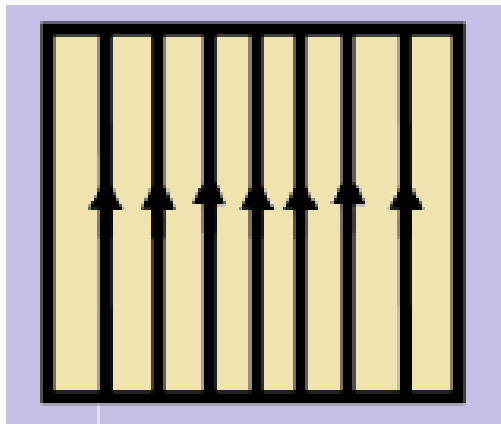
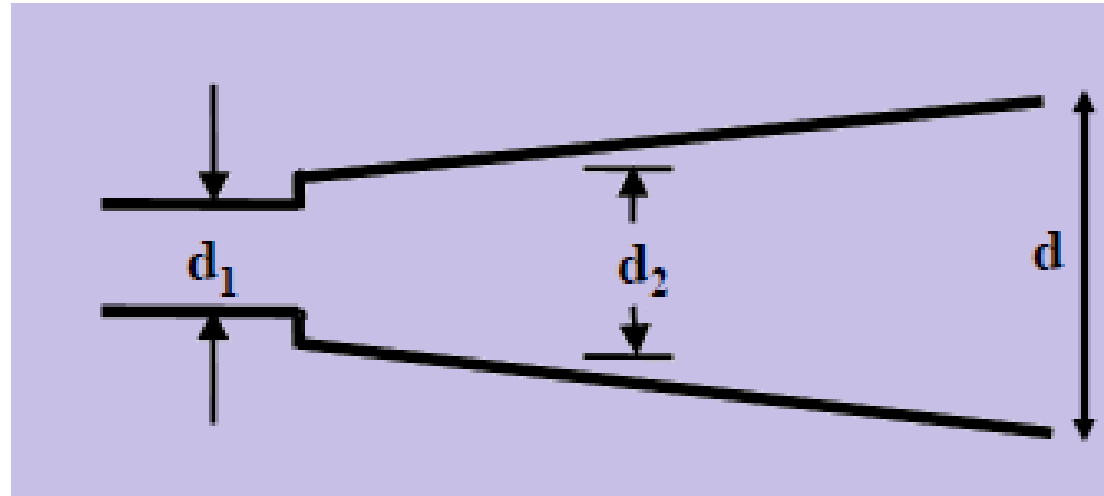


Patternul măsurat pentru o antenă horn conică

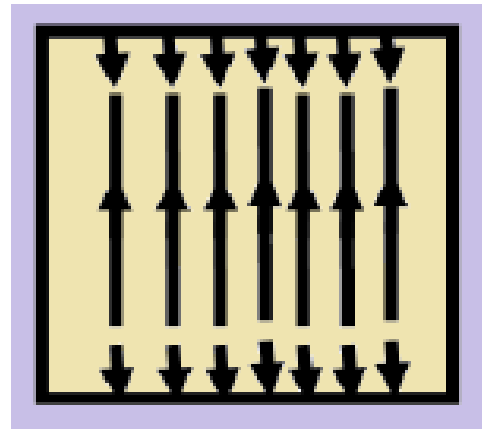


$20 \text{ Log } 0.37 = -8.6 \text{ dB}$. Higher SLL due to large phase error.

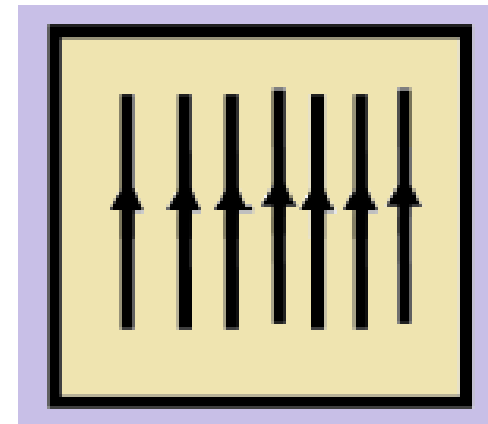
Antenă horn piramidală bimodală



TE_{10}

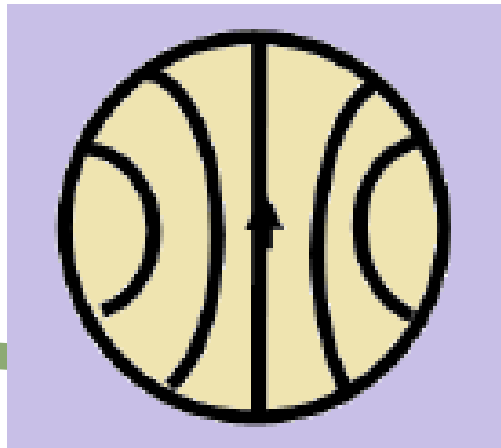
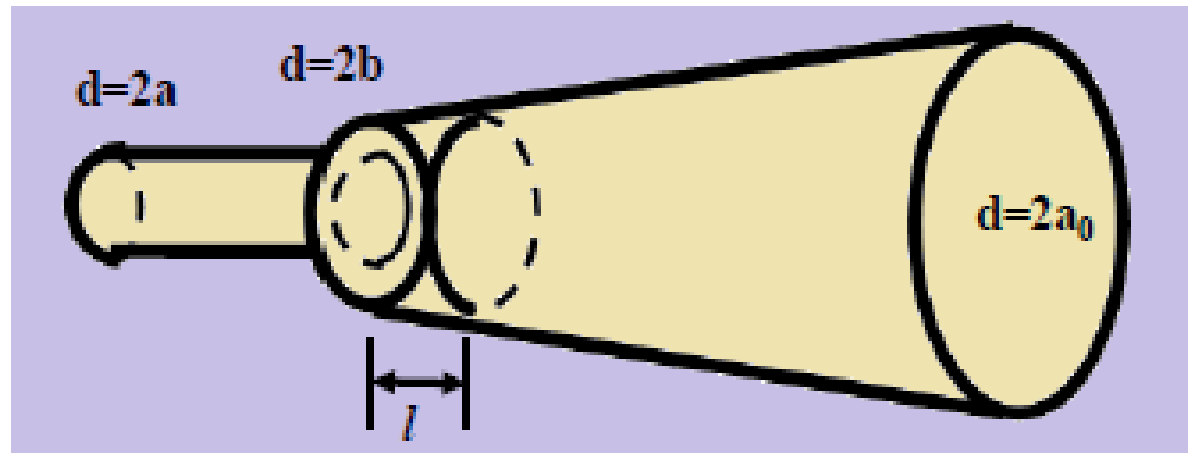


TE_{12}/TM_{12}

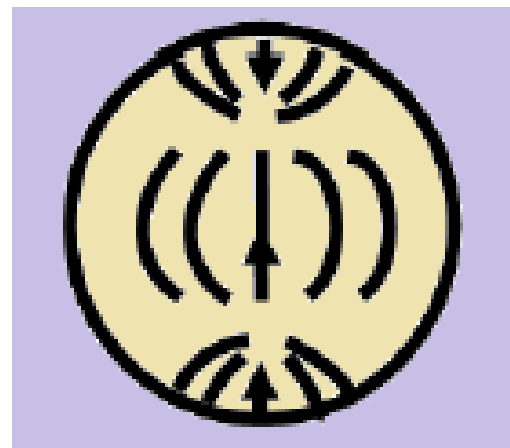


Multimodală

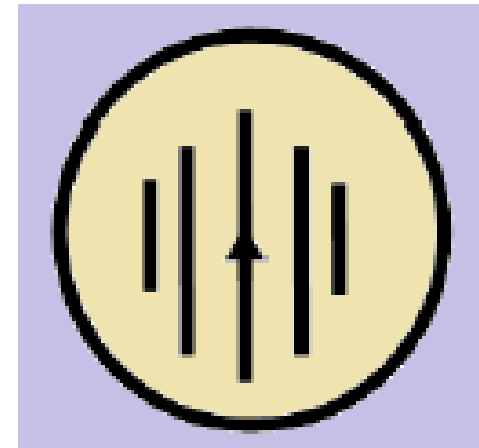
Antenă horn conică bimodală



TE_{11}

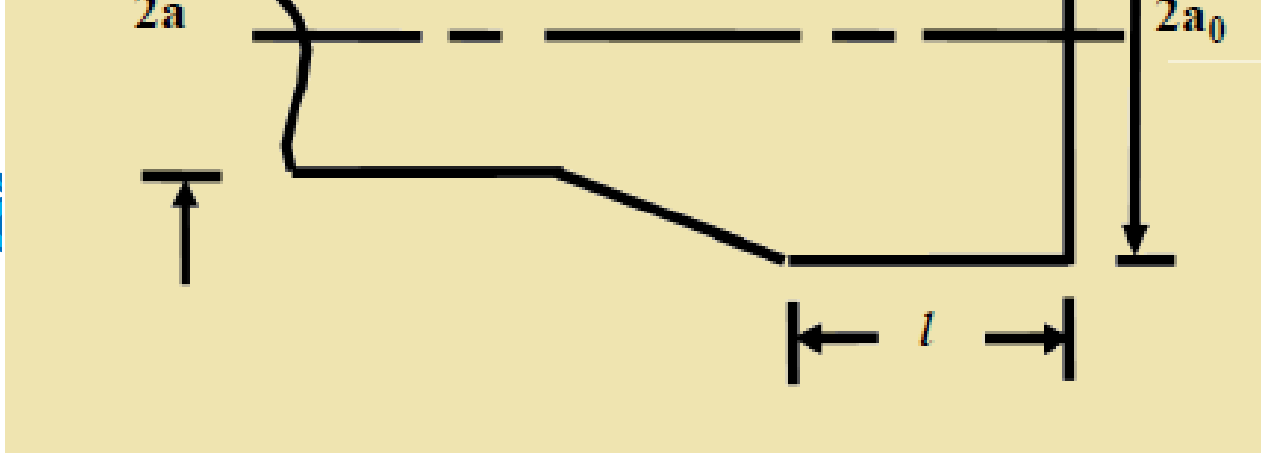


TM_{11}



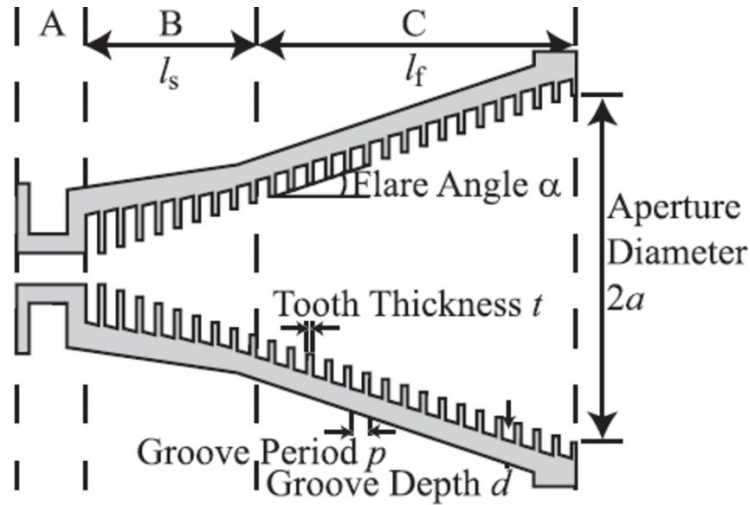
Bimodală

Antenă

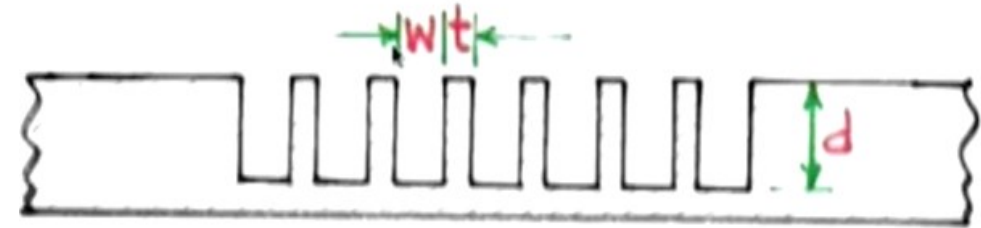
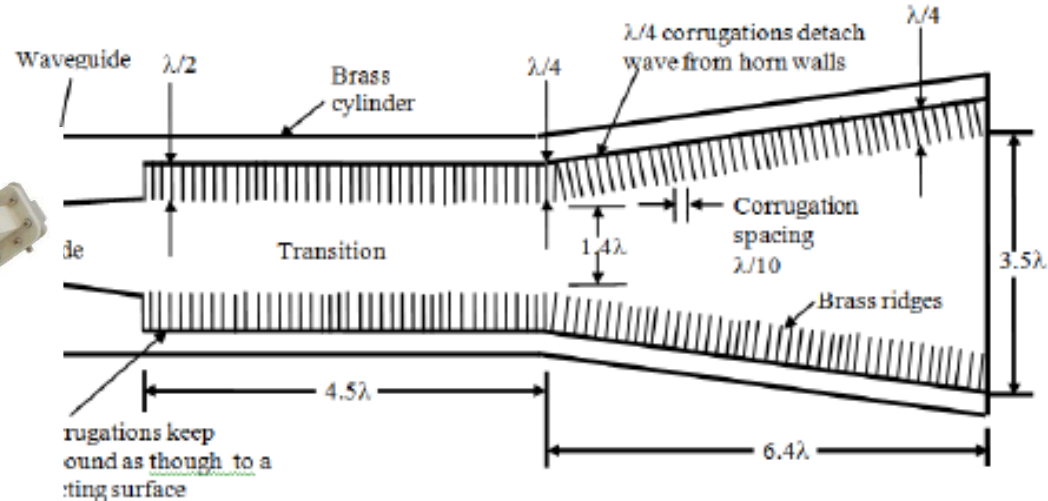


antena trepte

Antena horn ondulată



- A: Circular waveguide
- B: Smooth-walled waveguide
- C: Flare section



Typical Values of d , No. of Teeth, w and t :

Depth of the gap (d) = 0.25λ to 0.5λ

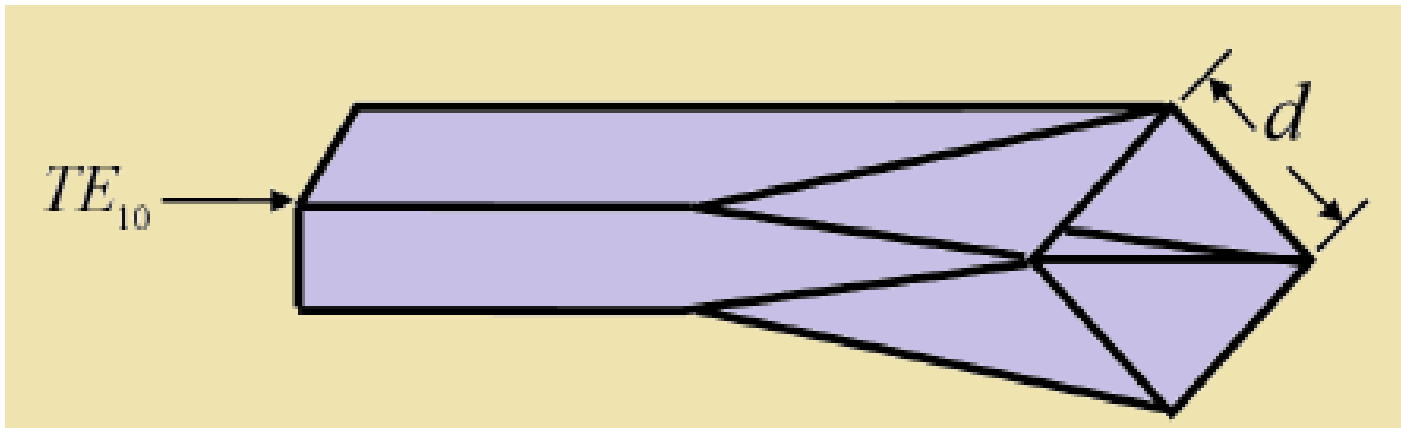
No. of Teeth (n) = 4 to 10 per λ

Width of the gap (w) = 0.05λ to 0.2λ

Teeth thickness (t) = 0.02λ to 0.1λ

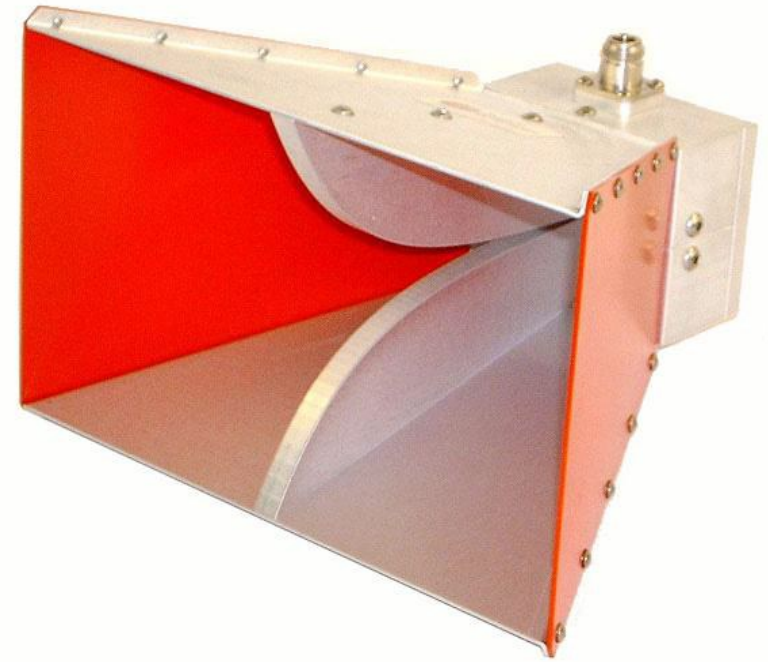
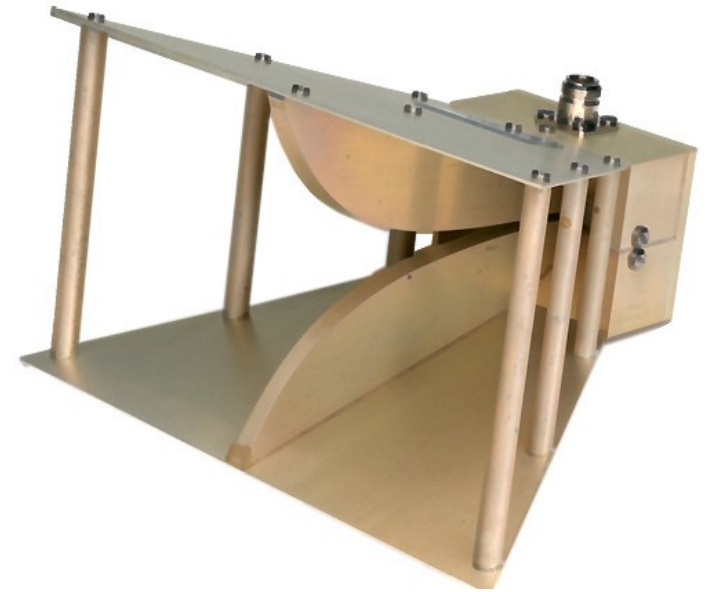
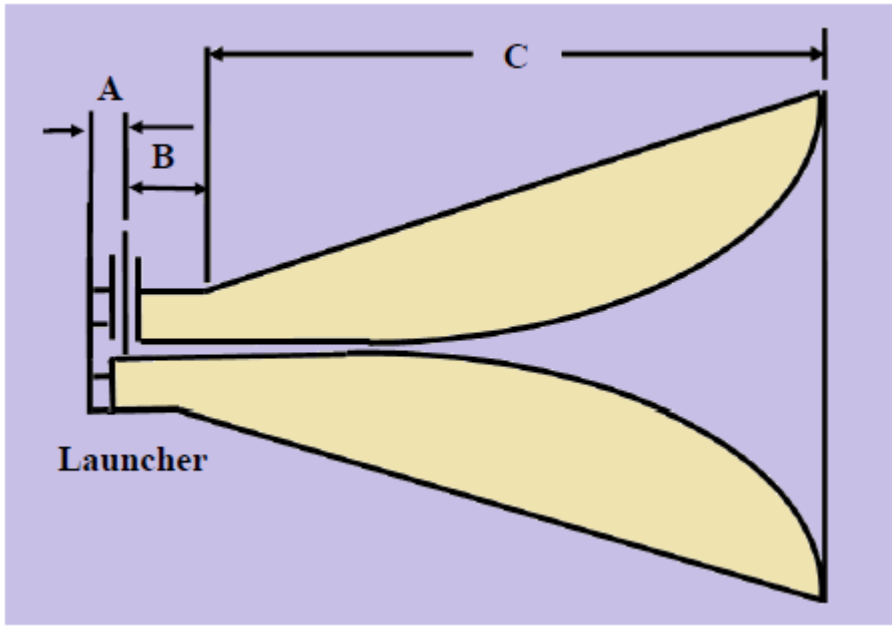


Antena horn multimod

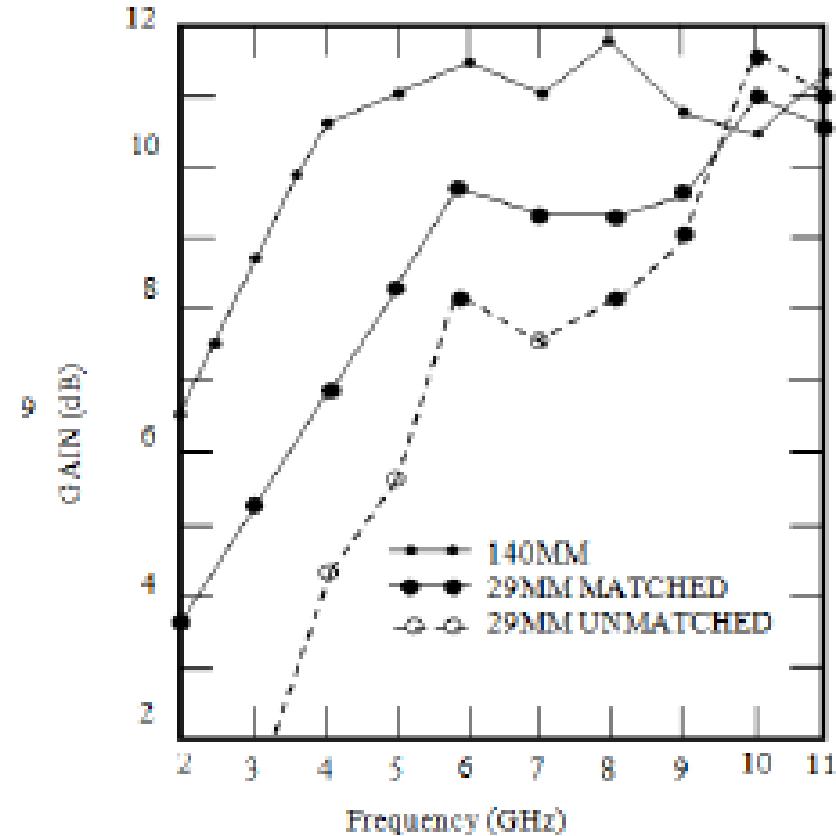
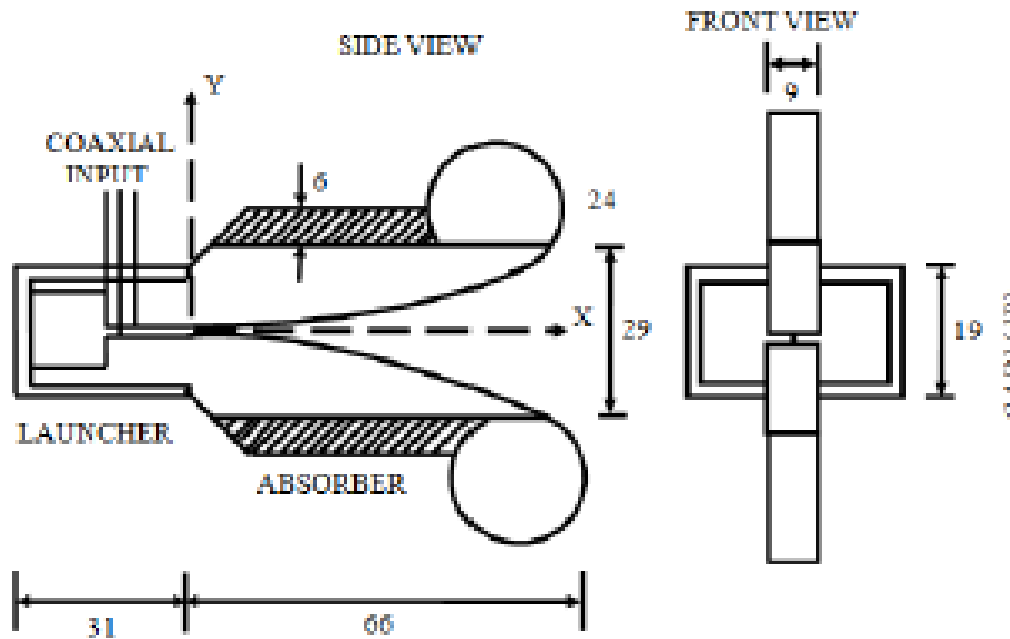


*TE_{10} și TE_{01} alimentate cu semnale de aceeași amplitudine și fază într
– un ghid de undă dreptunghiular*

Horn de banda largă conică



Antene horn compacte de deschidere adaptată



Crestele exponențiale sunt folosite pentru a crește lățimea de bandă. Se ajunge la adaptarea deschiderii pentru a îmbunătăți VSWR, pentru a crește câștigul