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Antenna & Propagation

Horn Antenna

by
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Chapter Synopsis

In this chapter, the student will be exposed to the types of horn antenna that classified as rectangular horn antennas and circular horn antennas. Furthermore, the equations that related to designing the horn antenna also will covered in this chapter.

Teaching Outcome

At the end of this course student should be able to:

- ❑ Categorized the types of horn antennas.
- ❑ Understand the equations in designing horn antenna.
- ❑ The radiation of horn antenna.
- ❑ The features of horn antennas.

Outline

- Types of Horn Antennas
- Design Equation of Horn Antennas
- Radiation from Electromagnetic Horn
- Features of Horn Antennas
- Applications of Horn Antennas

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Introduction

- The horn antenna is most widely used form of the microwave antenna.
- Range of microwave is approximately 1 GHz to 40 GHz
  - Total of all usable frequencies under 1 GHz gives a reference on the capacity of in the microwave range.
- Microwave communication is line of sight (LOS) radio communication.
- Antenna types for directive antennas, or broadcasting are omnidirectional antennas.
- Radio Transmission: the speech signals are converted to EM.
- Power is transmitted in space towards destination.
- EM waves are intercepted by receiving antennas and signal power is collected.

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Antenna Operations

- The horn antenna can be considered as a waveguide with hollow pipe of different cross sections.
- Which is flared into a large opening.
- When one end of the waveguide is excited while other end is kept open, it radiates in open space in all directions.
- In waveguide, the small amount of the power in the incident wave is radiated ,while due to open circuit at other end, large amount of power is reflected back.
- In order to overcome it, the mouth of waveguide is flared like a horn.
- So that, the total power incident will be radiated in forward direction. Thus, the radiation is increased. As the edges is open mouth or flared out, the diffraction at the edges reduces and improve the directivity.
- The main function of horn antenna is to produce an uniform phase front with a aperture larger than waveguide to give higher directivity.

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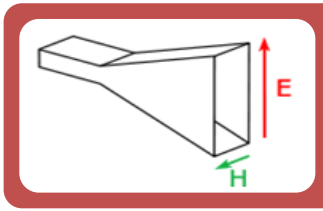
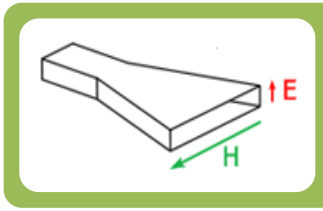
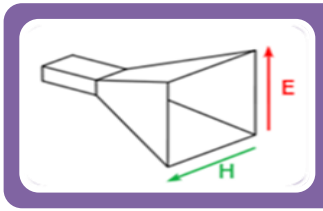
Types of Horn Antennas



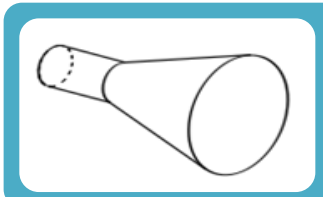
E-Plane Sectoral Horn



H-Plane Sectoral Horn



Pyramidal Horn



Conical Horn

Source: https://et.wikipedia.org/

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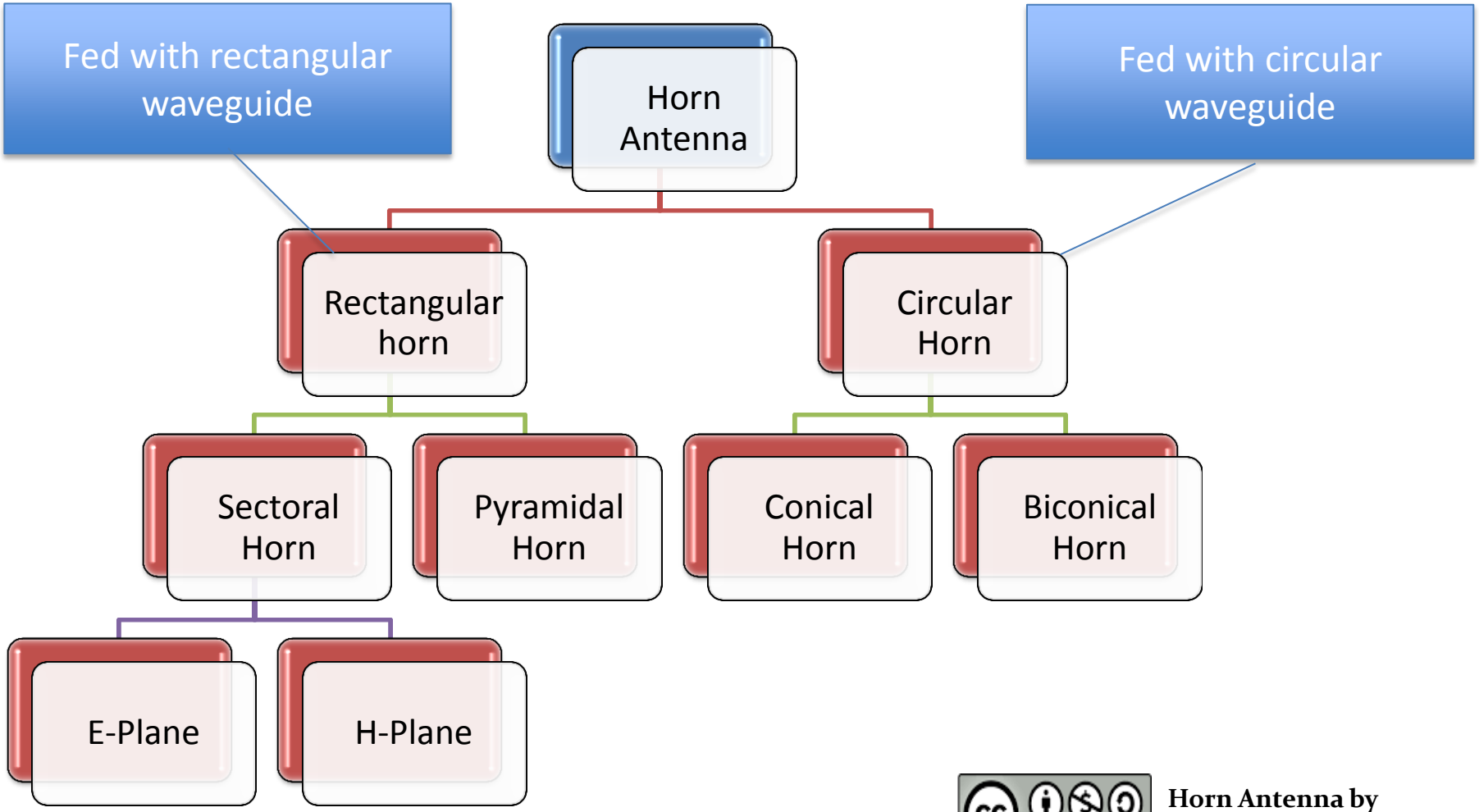
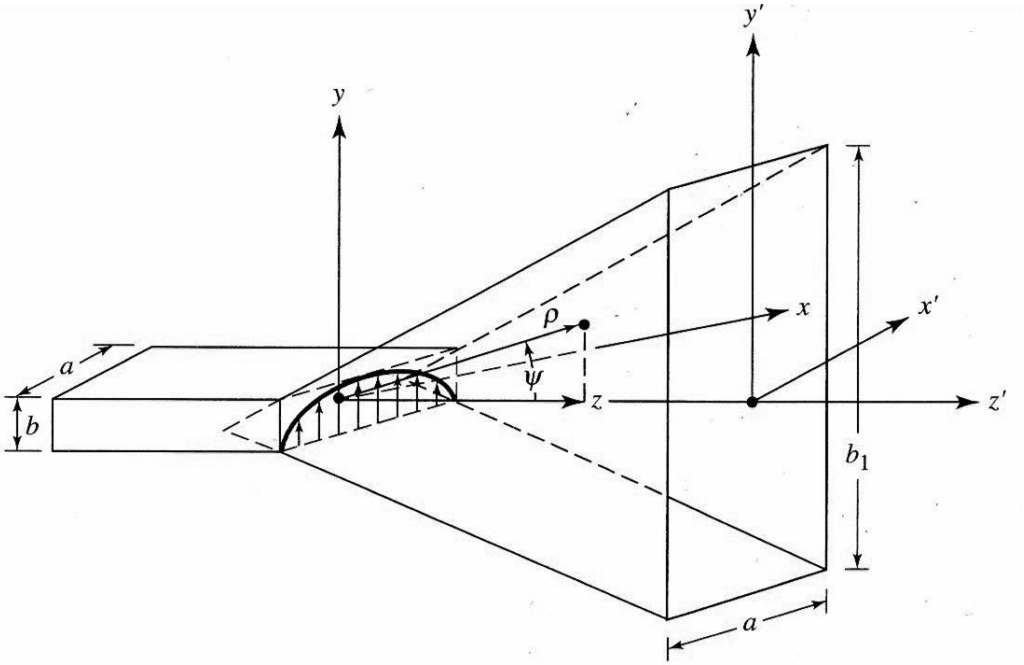
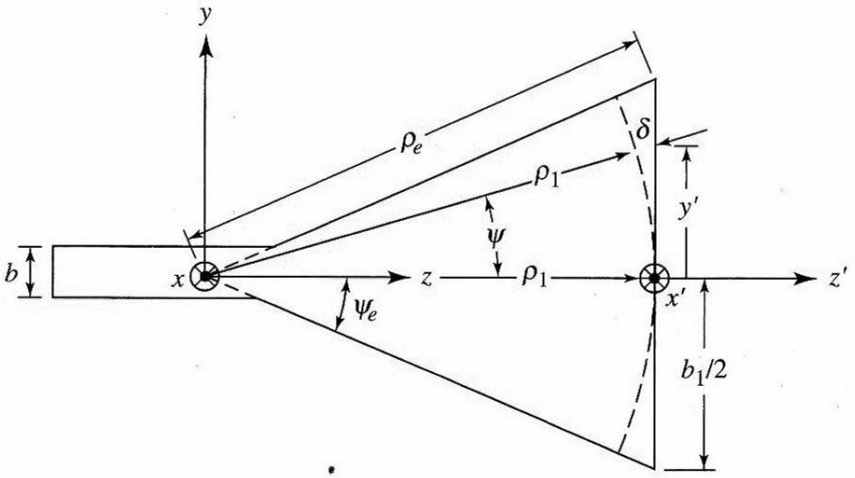
Types of Horn Antenna



E-Plane View



(a) *E*-plane horn



(b) *E*-plane view

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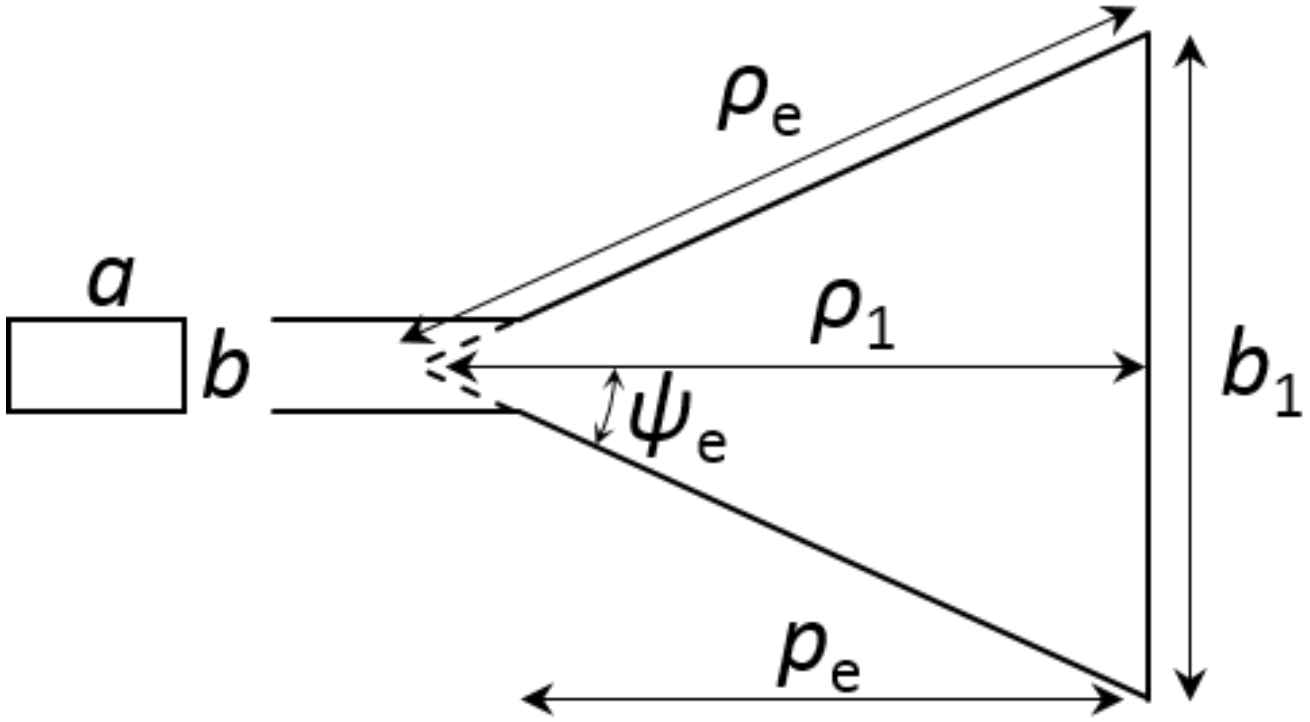
Dimensions of E-Plane

Consider equivalent dimensions of E-plane sectoral horn as shown in figure below:



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Total Field Intensity (E-Plane)

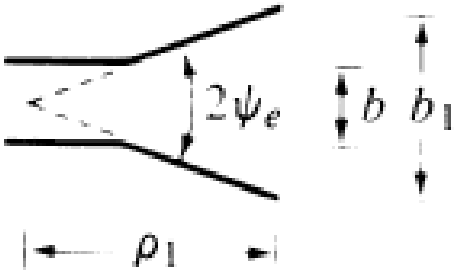
- Find the normalized field intensity E(dB), by using these equations below:

$$s = \frac{b_1^2}{8\lambda\rho_1} \quad \text{and} \quad \frac{b_1}{\lambda}\sin(\theta)$$

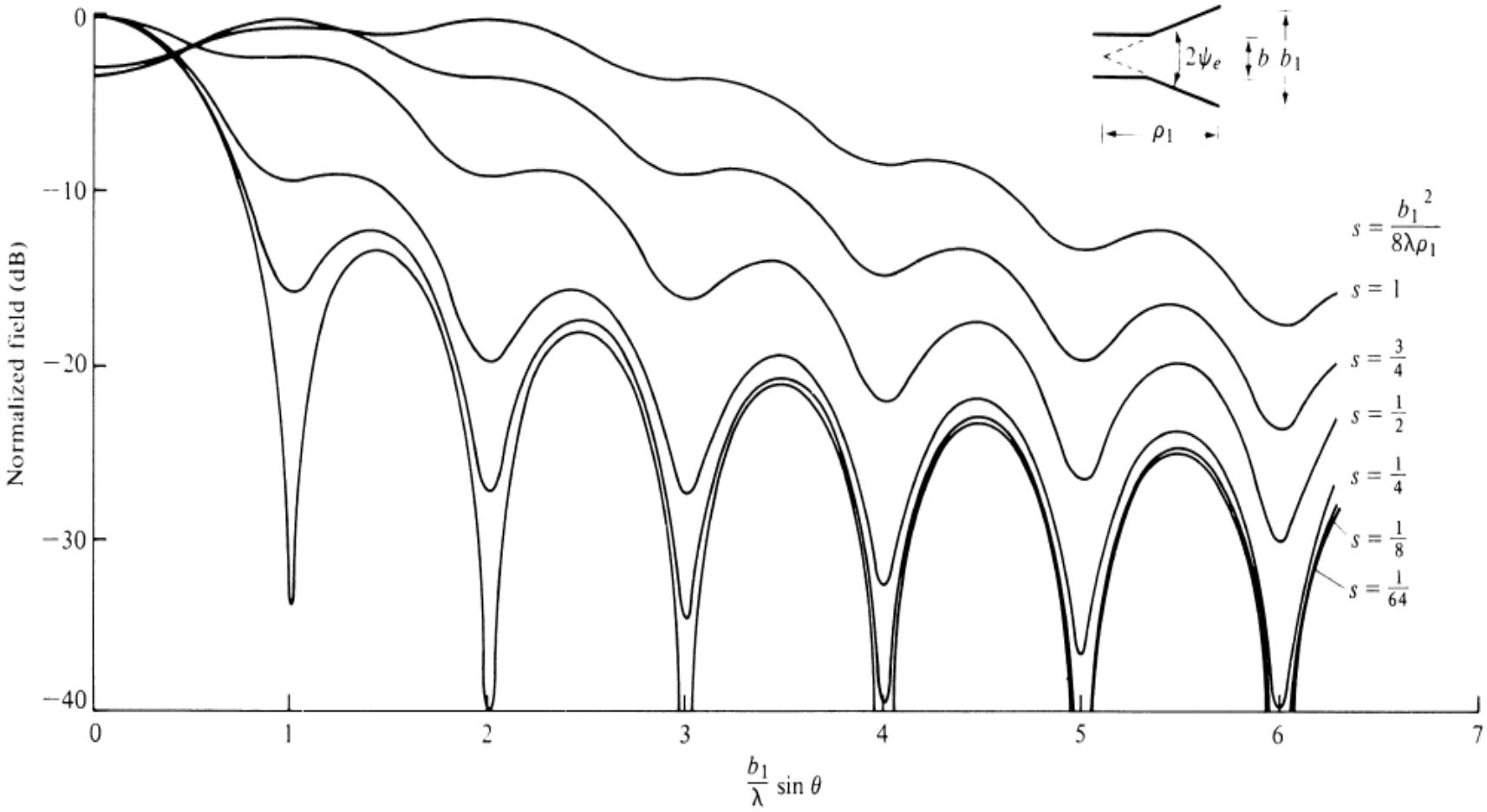
- Refer to the Universal Curve in next page, find the field intensity E(dB).

- Total field intensity:

$$E_\theta(dB) = [E(dB)] + 20\log_{10}\left(\frac{1+\cos\theta}{2}\right)$$



Universal Curve – E plane



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Directivity (E-Plane)

$$D_E = \frac{\alpha}{\lambda} \frac{G_E}{\sqrt{\frac{50}{\rho_e/\lambda}}}$$

Where, $B = \frac{b_1}{\lambda} \sqrt{\frac{50}{\rho_e/\lambda}}$

If B<2: $G_E = \frac{32}{\pi} B$

If B>2:find G_E from figure

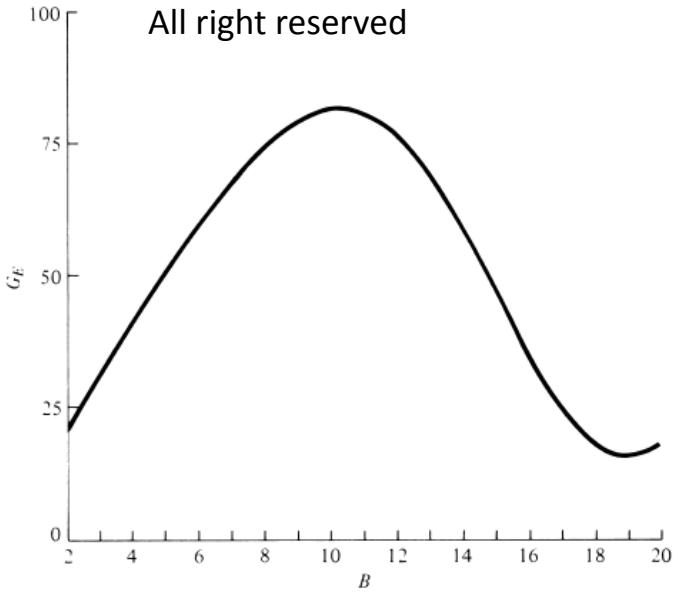
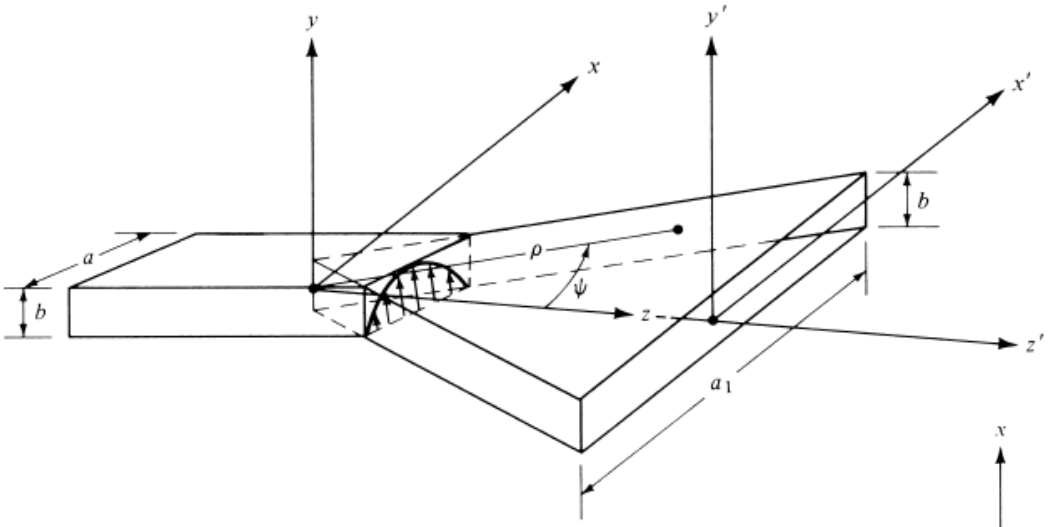
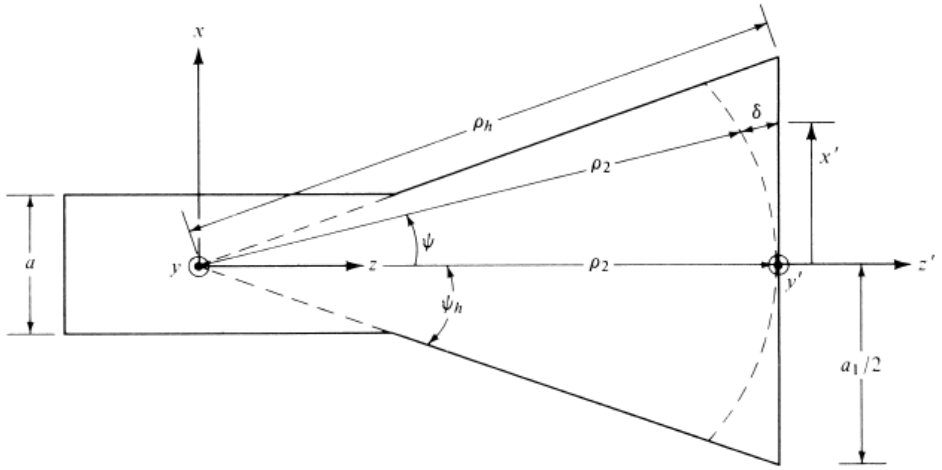


Figure 13.9 G_E as a function of B. (SOURCE: Adopted from data by E. H. Braun, "Some Data for the Design of Electromagnetic Horns," *IRE Trans. Antennas Propagat.*, Vol. AP-4, No. 1, January 1956. © 1956 IEEE)

H-Plane View



(a) *H*–plane sectoral horn



(b) *H*–plane view

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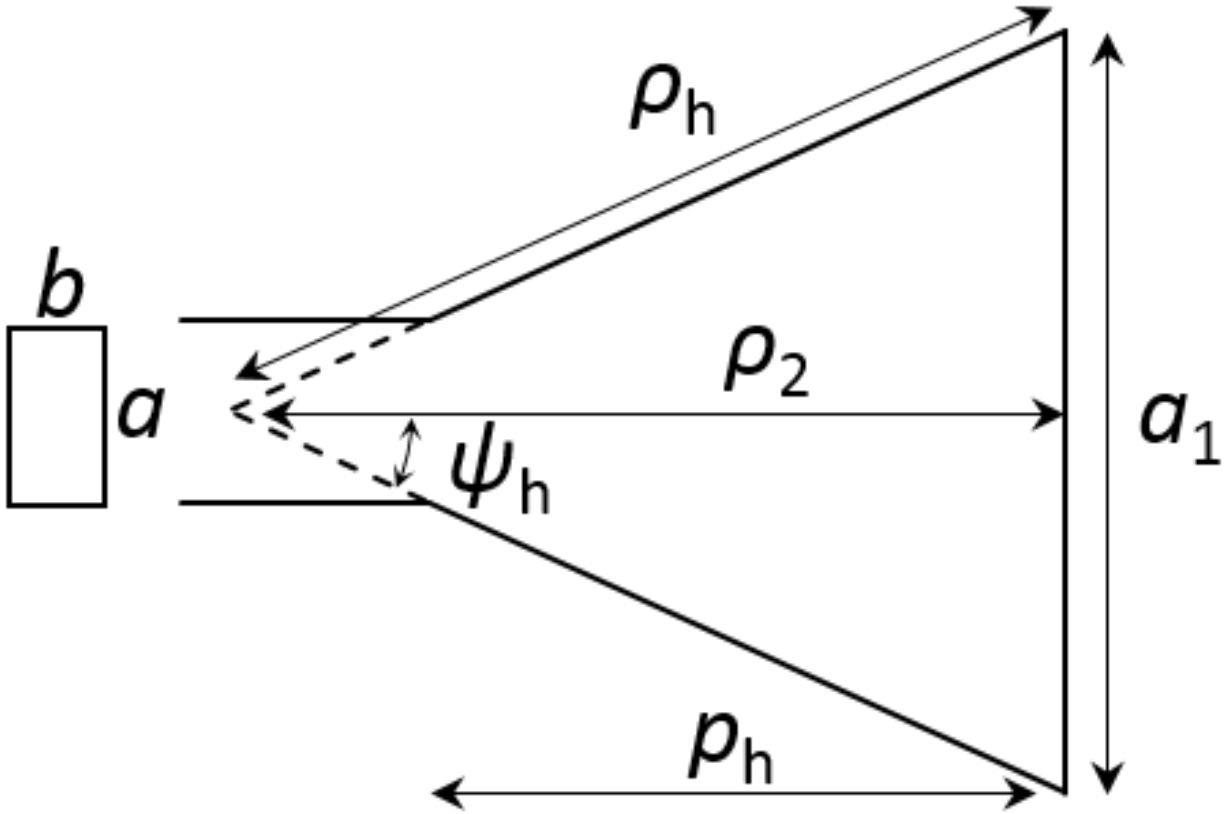
Dimensions of H-Plane



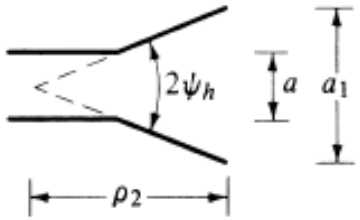
Total Field Intensity (H-Plane)

- Find the normalized field intensity E(dB), by using these equations below:

$$t = \frac{{a_1}^2}{8\lambda\rho_2} \quad \text{and} \quad \frac{a_1}{\lambda}\sin\theta$$

- Refer to the Universal Curve in next page, find the field intensity E(dB).
- Total field intensity:

$$E_\theta(dB) = \left[E\left(dB\right)\right] + 20\log_{10}\left(\frac{1+\cos\theta}{2}\right)$$



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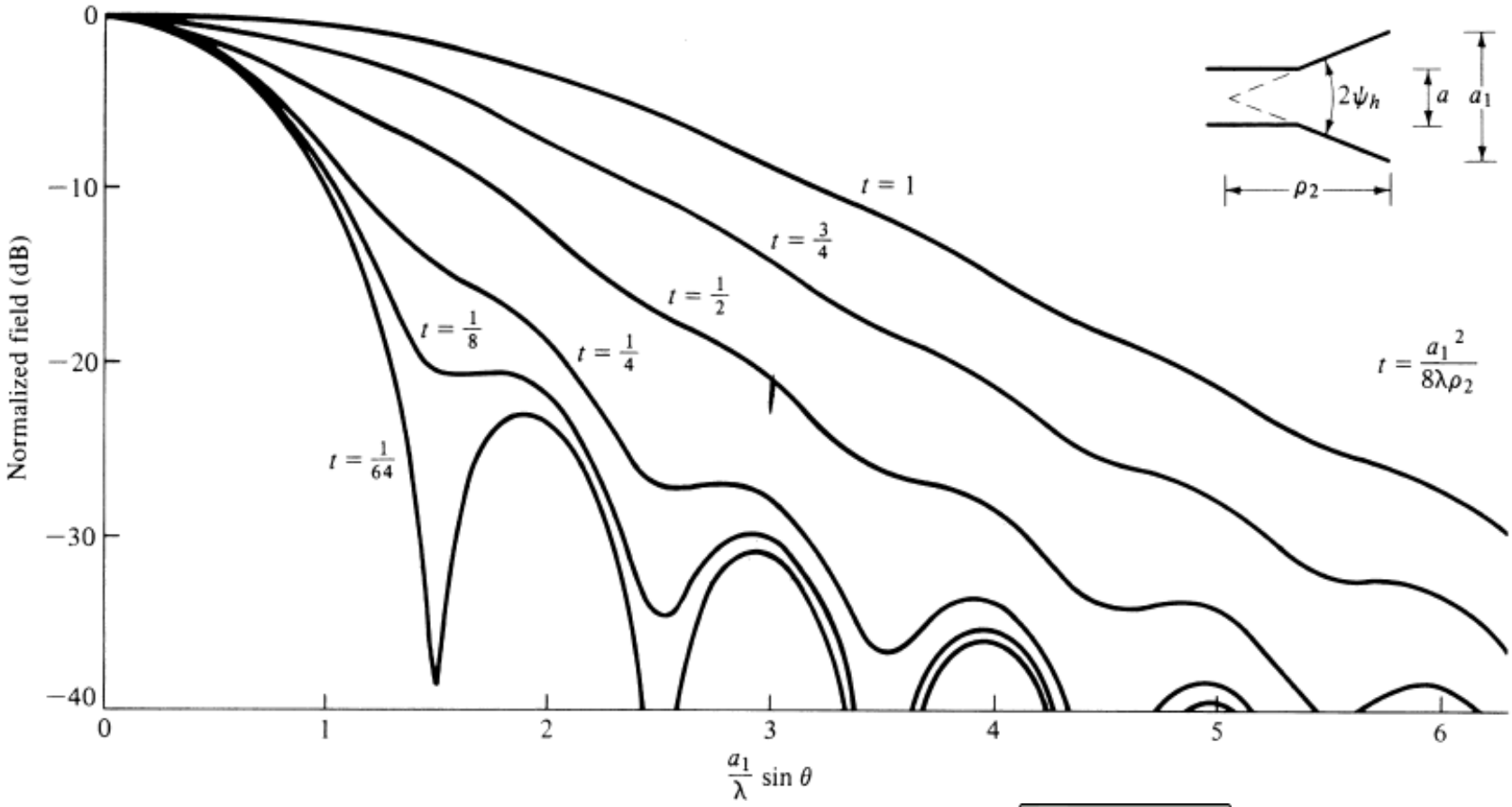
Universal curve – E plane



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Directivity (H-Plane)

$$D_H = \frac{b}{\lambda}\frac{G_H}{\sqrt{\frac{50}{\rho_h \lambda}}}$$

Where, A= $\frac{a_1}{\lambda}\sqrt{\frac{50}{\rho_h/\lambda}}$

If B<2: $G_E = \frac{32}{\pi}A$

If B>2:find G_E from figure

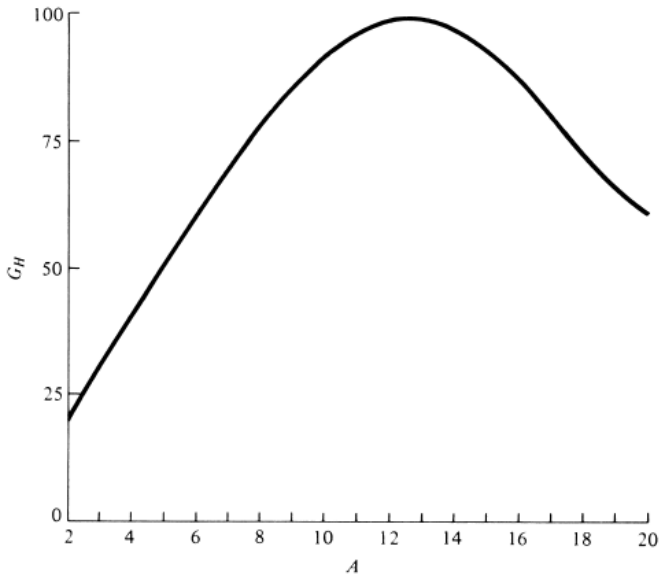

Figure 13.17 G_H as a function of A. (SOURCE: Adopted from data by E. H. Braun, "Some Data for the Design of Electromagnetic Horns," *IRE Trans. Antennas Propagat.*, Vol. AP-4, No. 1, January 1956. © 1956 IEEE)

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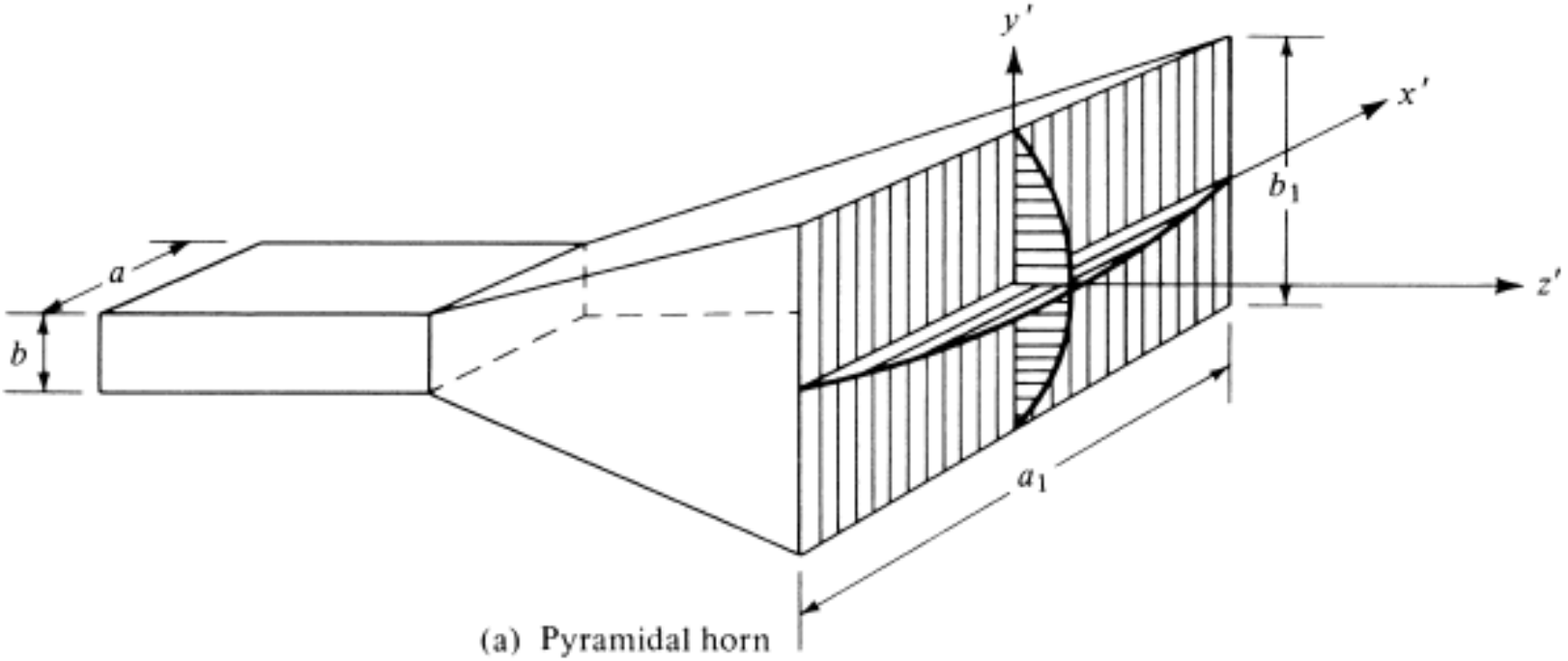
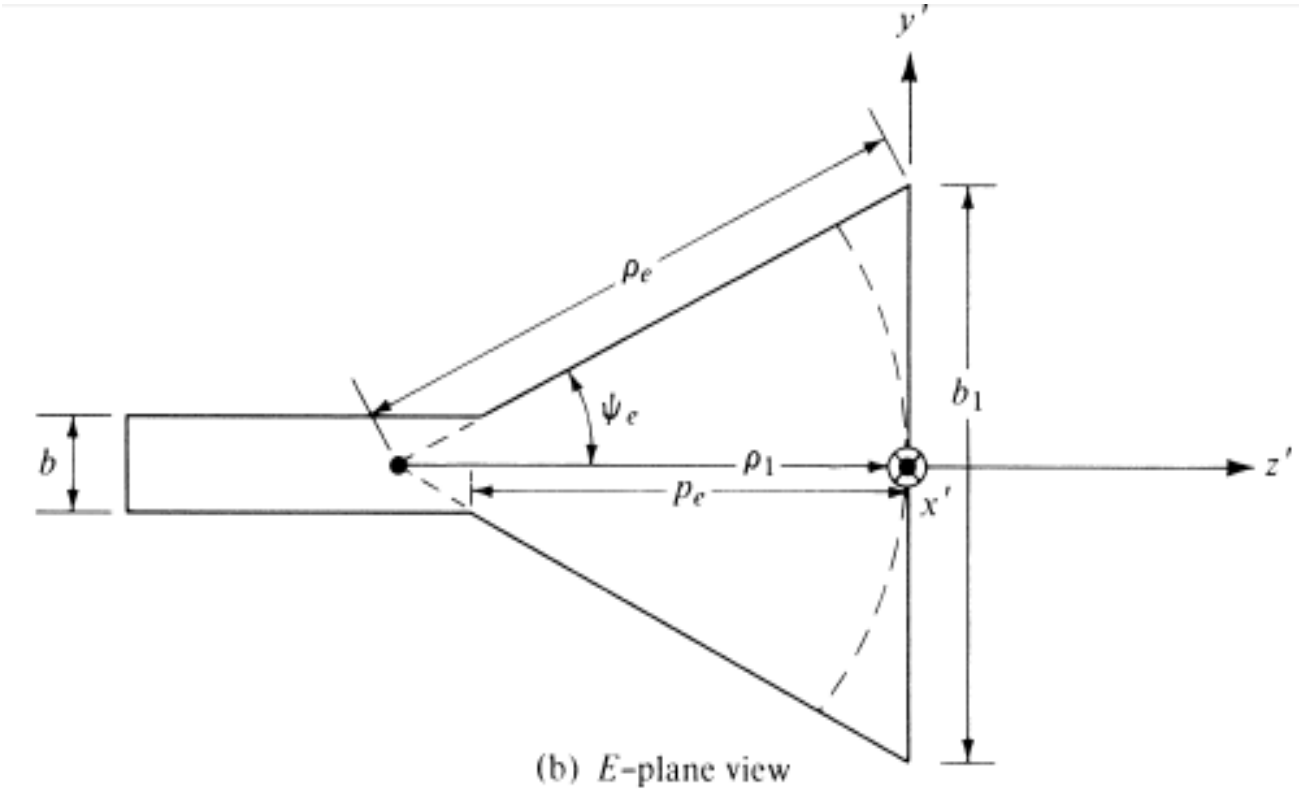
Pyramidal View



(a) Pyramidal horn

E-Plane View (Pyramidal)



(b) *E*-plane view

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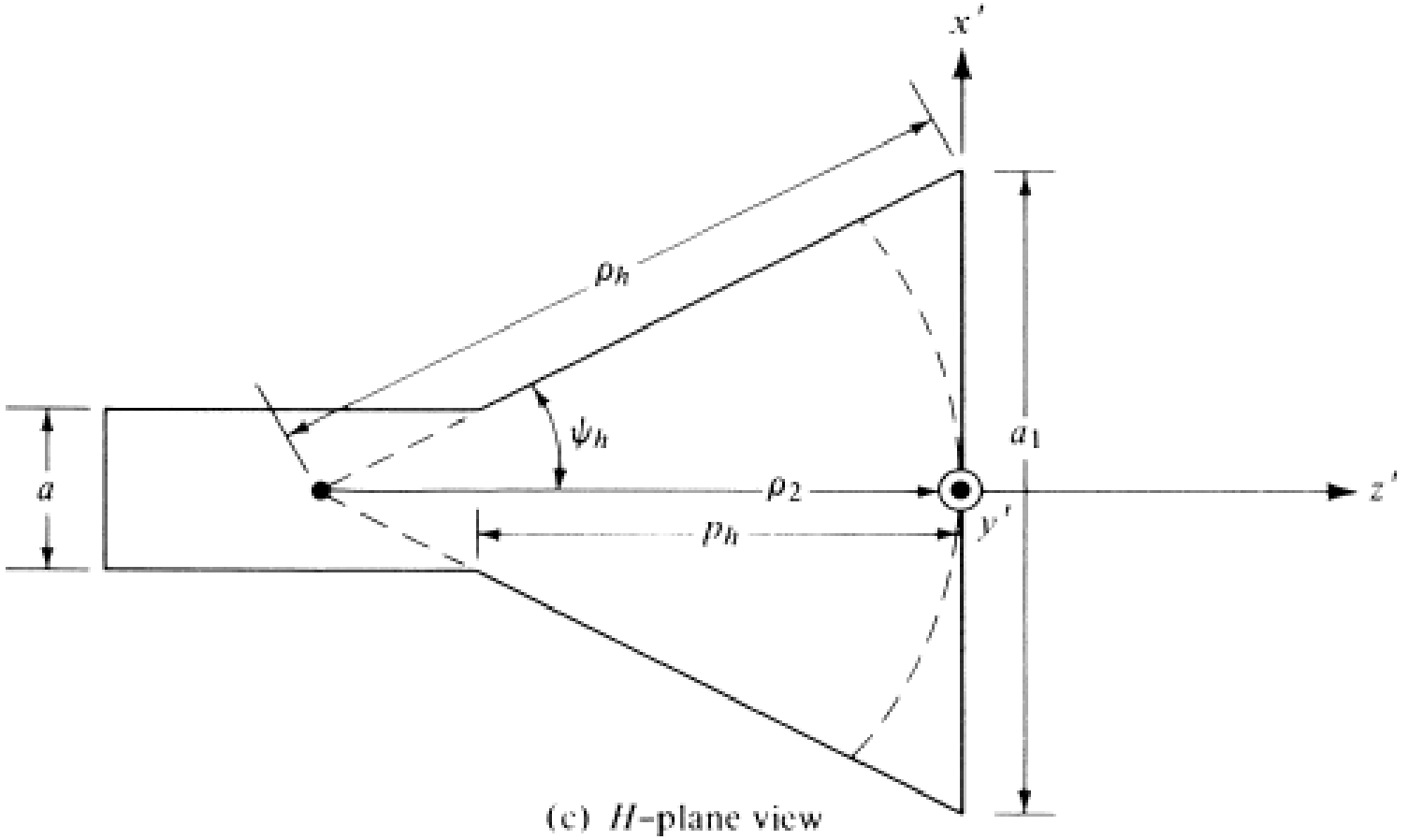
H-Plane View (Pyramidal)



(c) *H*-plane view

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Directivity (Pyramidal)

- To physically construct a pyramidal horn, the dimension P_e is given by:

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

- The dimension P_h is given by:

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

- Directivity :

$$D_p = \frac{\pi\lambda^2}{32ab} D_E D_H$$

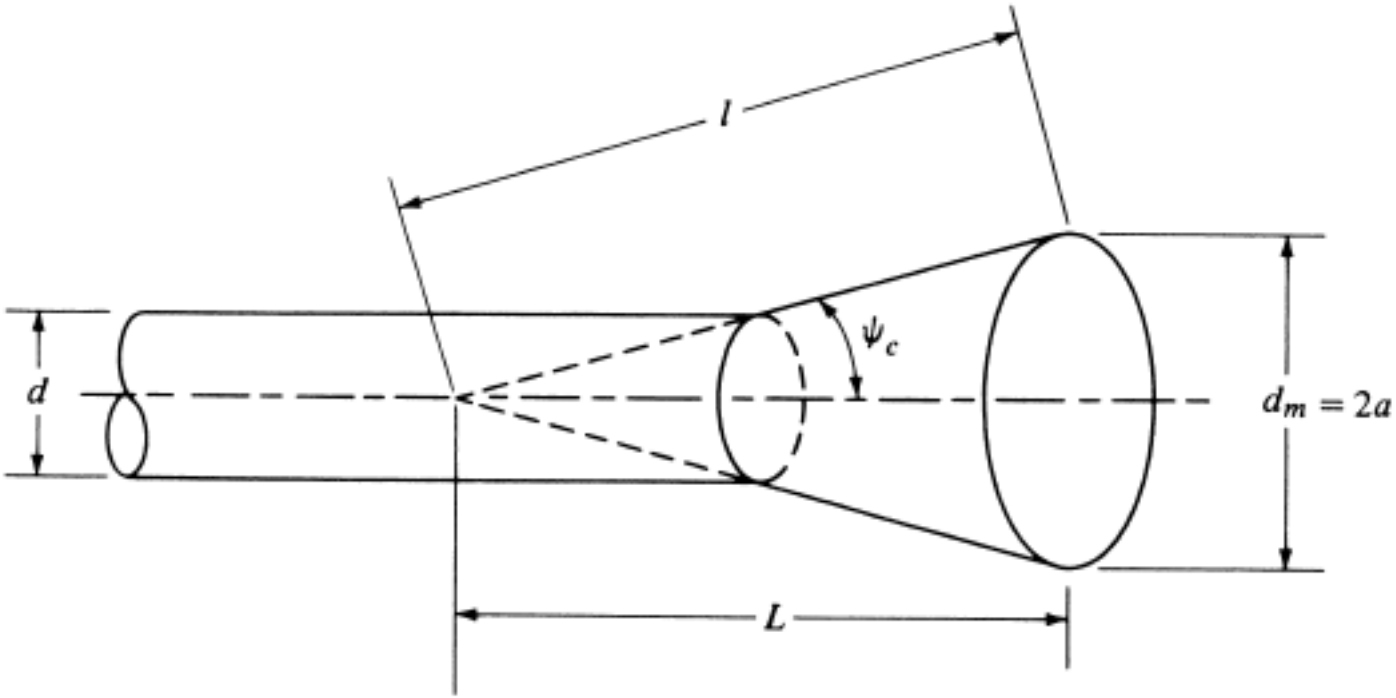
Where;

D_E *and* v D_H, *can be calculated as in* $E-$ *plane and* $H-$ *plane itself*.

Conical Horn

- Another very practical microwave antenna is the conical horn. The feed of a conical horn is often a circular waveguide.

Dimensions of Conical Horn



Horn Antenna Features

1. The horn antenna is used with the waveguide and it is used as radiator

2. It is generally used with parabolic antenna as primary antenna

3.
- The flare angle of horn is related to axial length
- If flare angle is smaller :1) the horn become smaller, 2) the radiation pattern is directive, 3) the wavefront is spherical, 4) the directivity is smaller and it is lower than that of parabolic antenna.

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Applications of Horn Antennas

1. As feed element in parabolic reflector antenna.
2. Most widely used antenna for measurement of various antenna parameters in the laboratories.
3. Most suitable antenna for various application in microwave frequency range where moderate gains are sufficient.

References

[1] C.A. Balanis:"Antenna Theory: Analysis & Design", John Wiley & Sons, 2012.

[2] Stutzman and Thiele, *Antenna Theory and Design*, John Wiley, 2012.

[3] T. A. Milligan, "Modern Antenna Design" John Wiley, 2nd edition, 2005.

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