Horn Antennas – Types, Design considerations of Pyramidal Horns

Horn Antenna

→ flared out (or) opened out waveguide.

Function :

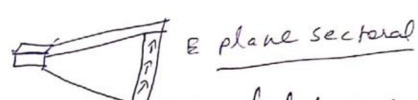
To produce an uniform phase front with a aperture larger than waveguide to give greater directivity.

Basic Types

(i) Sectoral Horn → flaring is done in one direction.

2 types.

(a) E plane Sectoral Horn

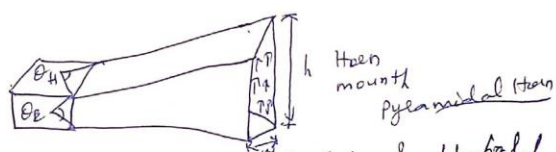


Flaring is done in the direction of E-field vector.

(b) H-plane sectoral Horn

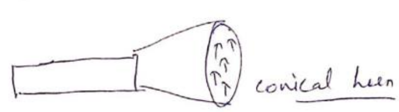
Flaring is done in the direction of H-field vector.

(ii) Pyramidal Horn



Flaring is done in both E field & H-field vector directions.

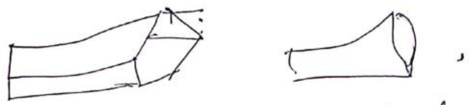
(iii) Conical Horn



obtained from circular waveguide.

(iv) Biconical Horn

Exponentially tapered



gradual exponential taper.

2 Key criteria

(i) Input match

↓

How the transition from input waveguide to aperture is constructed.

(ii) required radiation pattern characteristics

↓

dependent on current distribution on the antenna surface.

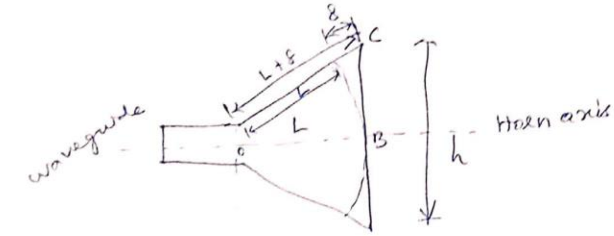
→ For good input match → apex angle must be small.

→ pattern characteristics → determined from aperture size & the field distribution (or) Equivalent current distribution ~~on the antenna surface~~. over the aperture.

Phyramidal Horn Antenna

* Most important Horn antenna.
* Used as primary feed for reflector antennas, standard gain reference antennas in antenna measurements.
* Obtained by flaring all four sides of a rectangular wave guide.

Horn Antenna - Design



θ - flare angle
L - Axial length
A - Aperture

$\angle COB \quad \cos\theta = \frac{L}{L+\delta}$ $\quad\Big|\quad$ $\tan\theta = \frac{h/2}{L} = \frac{h}{2L}$

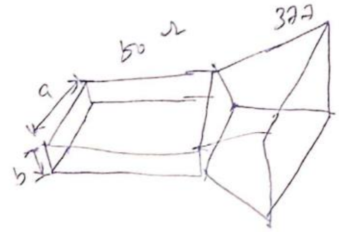
$\theta = \cos^{-1}\left(\frac{L}{L+\delta}\right)$ $\quad\Big|\quad$ $\theta = \tan^{-1}\left(\frac{h}{2L}\right)$

$$\boxed{\theta = \cos^{-1}\left(\frac{L}{L+\delta}\right) = \tan^{-1}\left(\frac{h}{2L}\right)}$$

→ VEO → Television receive only

By Pythagorus theorem, $(L+\delta)^2 = (h/2)^2 + L^2$

$L^2 + \delta^2 + 2L\delta = \frac{h^2}{4} + L^2$



δ is small, can be neglected (δ^2 → neglect)

$2L\delta = \frac{h^2}{4}$

$$\boxed{L = \frac{h^2}{8\delta}}$$

BPP
Microwave
short range RADAR
feed for Parabolic ref.

L, θ → design parameters of Horn antenna

(flare angle) 2θ → Large → wave front at the mouth of the Horn — curved → rather than plane.

→ results in non-uniform phase distribution over the aperture.

→ ↑ BW, ↓ Directivity

2θ → small → small aperture area,

$\theta_E = \frac{56\lambda}{h}$ deg

$\theta_H = \frac{67\lambda}{w}$ deg

$D = \frac{7.5\, hw}{\lambda^2} = \frac{7.5\, A}{\lambda^2}$

A → Area of horn mouth = h × w

Power gain $= \frac{4.5\, hw}{\lambda^2} = \frac{4.5\, A}{\lambda^2}$

phase variation - Assumption

i) wavefront is assumed cylindrical with its phase center at the intersection line of two flared sides.

ii) Propagation constant within the horn section is assumed to be same as free space propagation constant

iii) It is assumed that no higher order modes generated at the discontinuities at the waveguide to horn junction & horn aperture.

The radius of curvature of the phase front in the x-z plane,

$$r_{ox} = a/_2 \tan(\psi_h/2)$$

y-z plane

$$r_{oy} = b/_2 \tan(\psi_e/2)$$

$\psi_h, \psi_e \rightarrow$ flare angles in the H & E planes respectively

phase of the field at $(x', 0)$ w.r.t center of the aperture = path length difference × prop. constant k

$$f(x') = k\left\{\sqrt{r_{ox}^2 + x'^2} - r_{ox}\right\} \rightarrow \text{in the } x\text{-}z \text{ plane.}$$

$$f(y') = k\left\{\sqrt{r_{oy}^2 + y'^2} - r_{oy}\right\} \rightarrow y\text{-}z \text{ plane.}$$

phase variation over the aperture

$$f(x', y') = k\left\{\sqrt{r_{ox}^2 - x'^2} - r_{ox} + \sqrt{r_{oy}^2 + y'^2} - r_{oy}\right\}$$

For small flare angles, aperture tan E & H fields as