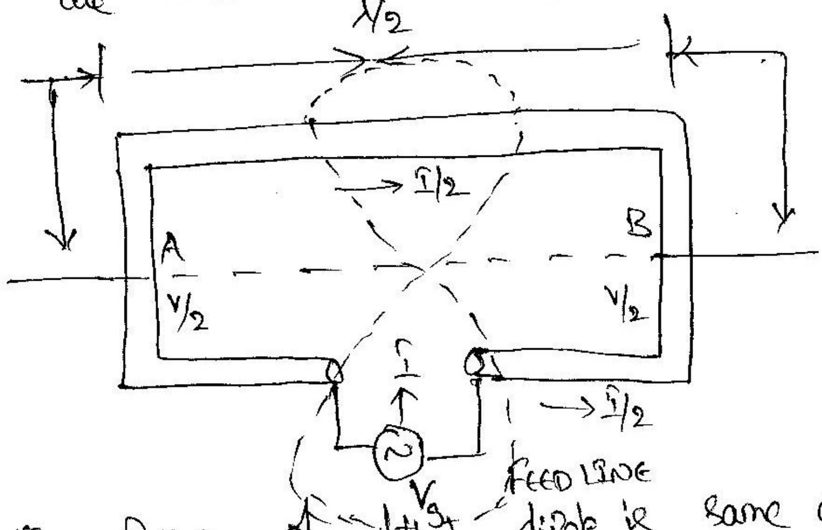
1) Folded Dipole Antenna :- (used at VHF & Yagi-Uda Antenna).

Conventional half wave dipole is the folded dipole in which two half wave dipoles - one Continous and other split at the Centre - have been folded and joined together in Parallel at the ends.

The split dipole is fed at the Centre by a transmission line with a voltage source hence the volts in both the dipoles are same and Currents are also divided equally.



→ The radiation Pattern of folded dipole is same as half wave dipole it differs from directivity & beam width.

→ The i/p impeadence of folded dipole is very high.

→ The radius (or) radii of two dipoles are same so the current flowing through the two half wave dipoles are same.

→ The folded dipole has impeadence transformer Property means that i/p impeadance can be changed by choosing different diameters for the half wave dipoles.

→ The i/p impeadence of folded dipole antenna is square equal to the Product of square of no:- of Conductors and radiation resistance of half wave dipole 73 Ω.

For Equation i/p impedance for 2-wire dipole is

$$Z_{in} = n^2 * R_{rad}(\lambda/2)$$

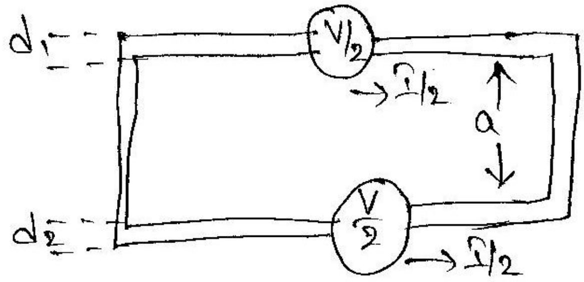
$$= (2)^2 \times 73\Omega$$

$$= 4 \times 73\,\Omega$$

$$Z_{in} = 292\,\Omega$$

(i) Equation for i/p impedance of 2-wire folded dipole:-

Let V be the applied volts to the two wire folded dipole since the diameter of 2-half wave dipoles are same so the currents flowing through 2-dipoles are same and volts is divided Equally i.e V/2



$$I_1 = I_2$$

The diameters of 2-dipoles is same by Z-parameters

$$V_1 = Z_{11} I_1 + Z_{12} I_2$$

∵ The Volt is divided Equally for 2-dipoles

$$\frac{V}{2} = Z_{11} I_1 + Z_{12} I_2$$

$$= I_1 [Z_{11} + Z_{12}] \quad (\because Z_{11} = Z_{12})$$

Spacing b/w the dipoles are same

$$\frac{V}{2} = I_1 [Z_{11} + Z_{11}]$$

$$\frac{V}{2} = 2 I_1 Z_{11}$$

$$V = 4 I_1 Z_{11}$$

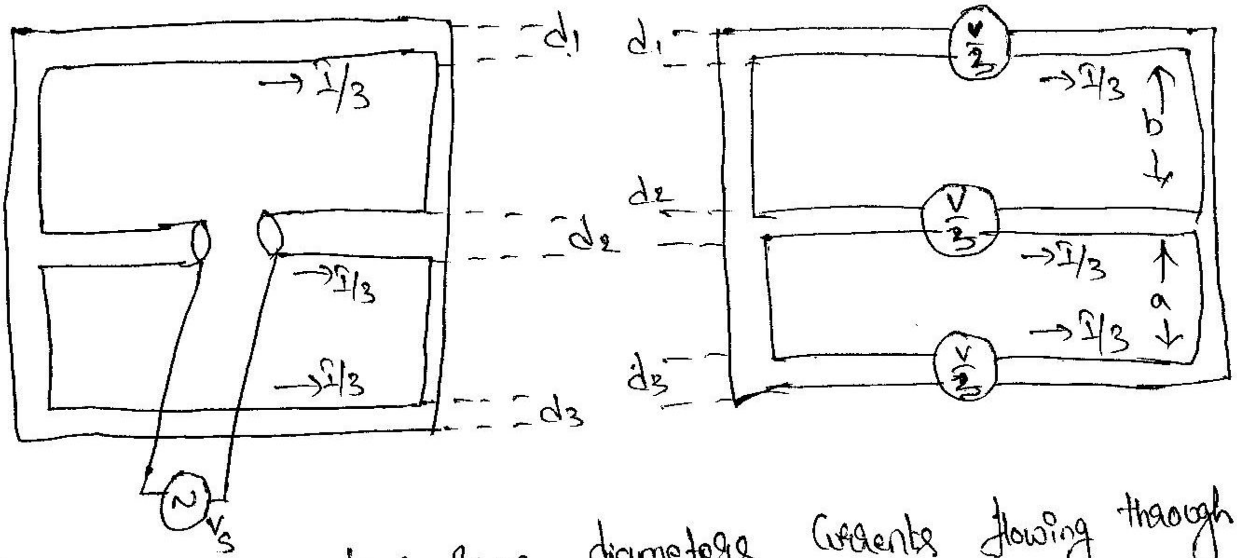
$$4 Z_{11} = \frac{V}{I_1}$$

$$\Rightarrow \frac{V}{I_1} = 4 \times 73 \quad (\because Z_{11} = 73\Omega)$$

$$= 292\,\Omega$$

Z_{11} = radiation resistance of halfwave dipole.

(ii) Equation for tripole (or) 3-wire folded dipole :-



Since 3-dipoles have same diameters currents flowing through them is same and volts are divided equally and assume spacing b/w the dipole is less (a, b).

$$Z_{11} = Z_{12} = Z_{13} \text{ (spacing)}$$
$$I_1 = I_2 = I_3 \text{ (diameter)}$$

from Z-parameters

$$V = Z_{11} I_1 + Z_{12} I_2 + Z_{13} I_3$$
$$\frac{V}{3} = Z_{11} I_1 + Z_{12} I_2 + Z_{13} I_3$$
$$\frac{V}{3} = Z_{11} I_1 + Z_{11} I_1 + Z_{11} I_1$$
$$\frac{V}{3} = 3 Z_{11} I_1$$
$$V = 9 Z_{11} I_1$$
$$\frac{V}{I_1} = 9 Z_{11}$$
$$= 9 \times 73$$
$$\frac{V}{I_1} = 657\,\Omega$$

In general the i/p impedance of folded dipole is given by :-

Two wire $\frac{V}{2} = 2 Z_{11} I_1$

Three wire $\frac{V}{3} = 3 Z_{11} I_1$

n-wire
$$\frac{V}{n} = n Z_{11} I_1$$

$$V = n^2 Z_{11} I_1 \qquad n = \text{no of half wave dipole}$$

$$\boxed{Z_{in} = \frac{V}{I_1} = n^2 Z_{11}} \qquad Z_{11} = \text{radiation resistance of half wave dipole}$$

we know that i/p impeadence depends on spacing b/w the half wave dipoles so it is given by

$$Z_{in} = \left[1 + \frac{\log \frac{a}{r_1}}{\log \frac{a}{r_2}}\right] \cdot Z_{11}$$

$r_1 \to$ radius of first half wave dipole

$r_2 \to$ radius of second half wave "

$a \to$ spacing b/w dipoles depends of diameter it is given by

$$Z_{in} = \left[1 + \frac{r_2}{r_1}\right]^2 Z_{11}$$

Advantages of Folded dipole :-

* It has high impeadence
* Act as a impeadence transformer
* Directivity is very high since 2-dipoles arranged in parallel.

Applications :-

→ Used as a driven Element in Yagi-Uda Antenna

→ Used in wide band applications i.e TV, Applications.

2) Yagi-uda Antenna :-

It is a high gain Antenna used in television applications this antenna is otherwise called as Yagi-uda array it contains 3-Elements

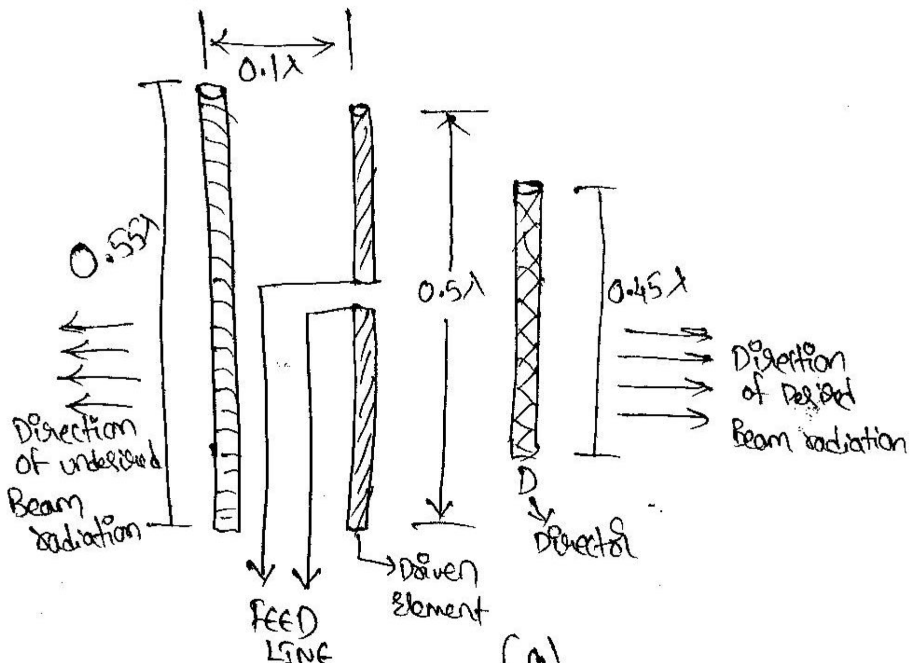
(i) Driven Element
(ii) Reflector
(iii) Director

The Driven Element is connected to the transmission line through which signal source connected and it is a resultant half wave dipole.

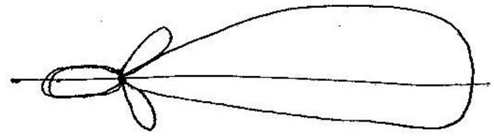
Reflector and director elements are parasitic elements because they are not connected to the source directly but they are connected to the driven element through the magnetic coupling.

The parasitic element infront of the driven element is called as the director. It directs the signal towards the desired directions.

The parasitic element behind & back to the driven element is called as Reflector. It reflects the signal from driven element to towards the desired directions.

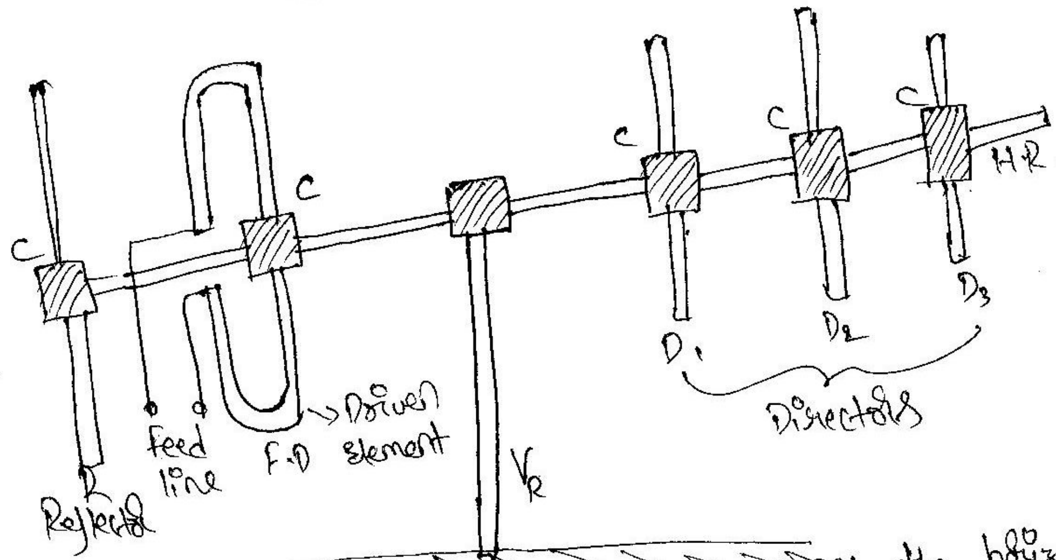


(a)


(b) Radiation Pattern

The length of the driven Element is 0.5λ & director length is 5% < driven Element and also the reflector length is 5% > driven Element.

The spacing b/w Elements is 0.1λ.



Vertical Rod to support the horizontal rod.

The Parasitic Elements reflector and directors are clamped on a metalic rod Parallel to the driven Element Either to reflect or direct the radiated Energy.

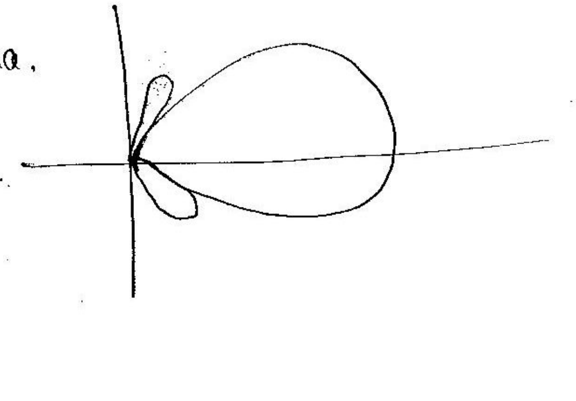
The Parasitic elements of Equal or > λ/2 will be inductive in nature (lagging Phase).

The Parasitic Elements of Equal or < λ/2 will be Capacitive ie leading in Phase.

The additional gain will be achieved by increasing the no. of directors.

(a) Radiation Pattern:-

It is a fixed frequency Antenna.



b) Designed Parameters :-

(i) Reflector length $l_R = \frac{500}{f(MHz)}$

(ii) Driven element length $l_{DR} = \frac{475}{f(MHz)}$

(iii) Director length $l_D = \frac{455}{f(MHz)}$

c) General characteristics of Yagi-uda Antenna :-

→ This Antenna contains three elements i.e, Driven element, director,
and reflector such an Antenna is called as Beam Antenna.

→ This Antenna is otherwise called as uni-directional Antenna,
which moderate directivity, light weight and low cost.

→ The gain & directivity are high so the Antenna is called as
super gain (or) super directive antenna.

→ It is a fixed freq device the band width is above 3%
and is sufficient for the reception of T.V. signals.

→ It provides a gain of 8dB and front to back ratio of 20dB.

d) Voltage and current relations in Parasitic Antenna's :-

one or more passive elements coupled magnetically to driven element is known as parasitic antenna. The presence of parasitic elements effect the directional pattern. The effect on the directional pattern produced depends upon the magnitude and phase of the induced current in parasitic elements. i.e on spacing of antenna and tuning of the parasitic Antenna.

The relations b/w currents and volts of Yagi-udas array is obtained by the Z-parameters.

$$V_1 = Z_{11} I_1 + Z_{12} I_2 \rightarrow (1)$$

$$V_2 = Z_{21} I_1 + Z_{22} I_2 \rightarrow (2)$$

$$\vdots \qquad \vdots \qquad \vdots$$

$$V_n = Z_{n1} I_1 + Z_{n2} I_2 + \ldots Z_{nn} I_n \rightarrow (n)$$

$V_1, V_2, V_n \ldots \rightarrow$ Voltage applied to antenna no: 1, 2, 3 ... n

$I_1, I_2 \ldots I_n \rightarrow$ Current flowing in antenna 1, 2, 3 .... n

$Z_{11}, Z_{22}, Z_{33} \ldots Z_{nn} \rightarrow$ Self impedance of Antenna no: 1, 2, 3 ... n

$Z_{12}, Z_{21}, Z_{13} \ldots Z_{31} \rightarrow$ Mutual impedance b/w Antenna of subscripts

V_1 is driven Volt ; V_2 is induced Volt

$$V_2 = 0$$

now:

$$V_1 = I_1 Z_{11} + I_2 Z_{12}$$

$$\therefore \quad 0 = I_1 Z_{21} + I_2 Z_{22}$$

$$Z_{21} I_1 = -Z_{22} I_2$$

$$I_1 = \left(\frac{-Z_{22}}{Z_{21}}\right) I_2 \rightarrow (3)$$

$$\Rightarrow I_2 = \left(\frac{-Z_{21}}{Z_{22}}\right) \cdot I_1 \rightarrow (4)$$

Substitute eq (3) in eq (1)

$$V_1 = Z_{11}\left(-\frac{Z_{22}}{Z_{21}}\right) \cdot I_2 + Z_{12} I_2$$

$$V_1 = I_2 \left(Z_{12} - \frac{Z_{11} \cdot Z_{22}}{Z_{21}} \right)$$

Impedance of Parasitic Elements

$$\boxed{\frac{V_1}{I_2} = Z_{12} - \frac{Z_{11} Z_{22}}{Z_{21}}}$$

By reciprocity theorem $Z_{12} = Z_{21}$

substituting eq (4) in (1)

$$V_1 = Z_{11} I_1 + Z_{12}\left[\frac{-Z_{21}}{Z_{22}}\right] \cdot I_1$$

$$V_1 = I_1 \left[Z_{11} - \frac{Z_{12} \cdot Z_{21}}{Z_{22}} \right]$$

$$\boxed{\frac{V_1}{I_1} = Z_{11} - \frac{Z_{12} \cdot Z_{21}}{Z_{22}}}$$

③ Horn Antenna :-

→ It is a flared wave guide to transmit the EM waves into free spaces. It is a micro waves antenna.

→ A microwave is capable of radiating radiation in to open space provided the same is excited at one end and opened at other end.

→ In a wave guide a small amount of energy incident at i/p end results a large amount of energy reflected back if it is open circuited to improper impedance matching.

To overcome this drawback waveguide is terminated with a proper of horn (or) o/p end which is wired. So that entire energy is transmitted towards the forward direction.

There are 2-types of horn Antenna's

(i) Rectangular horn Antenna

(ii) Circular horn Antenna.

As compared with radiation through transmission line, the radiation through the waveguide is larger.

Depending upon the direction of flaring (wided), the rectangular horns are further classified as sectoral horn and pyramidal horn.

A sectoral horn is obtained if the flaring (tapering) is done in one direction.

further classified as

(i) E-Plane sectoral horn

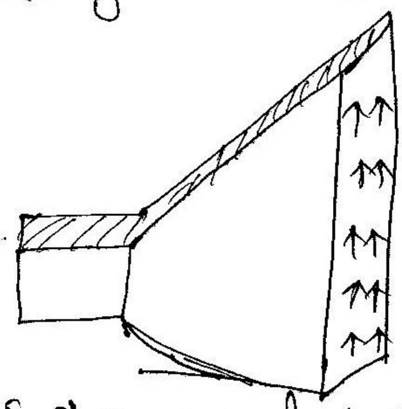
(ii) H-Plane sectoral horn

(iii) Pyramidal horn

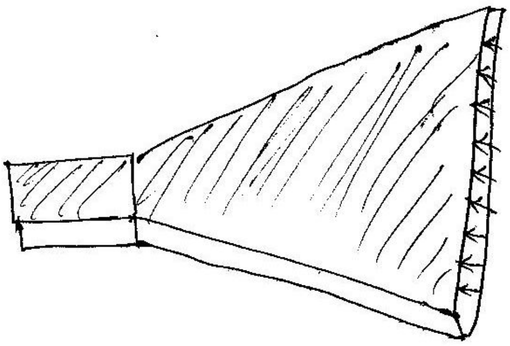
*) The E-plane sectoral horn is obtained when the flaring is done in the direction of electric field vectors.

*) The H-plane sectoral horn is obtained if the flaring is done in the direction of magnetic field vector.

*) In both E & H-Plane sectoral horn the flaring is done along a single wall of the rectangular waveguide in one direction.

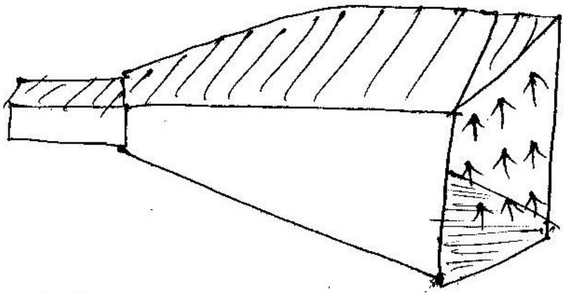


E-Plane sectoral horn



H-Plane sectoral horn

→ Pyramidal horn:- The flaring is done along both the walls of the rectangular waveguide in the direction of both the electric and magnetic field vectors the horn is obtained Pyramidal horn.

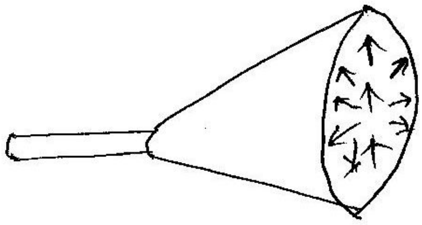


(ii) Circular horn Antenna:-

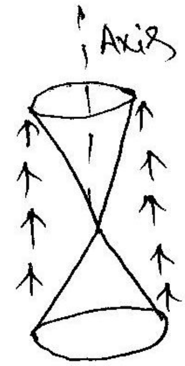
2 - types

(a) Conical horn Antenna

(b) Biconical horn Antenna



(a) Conical horn

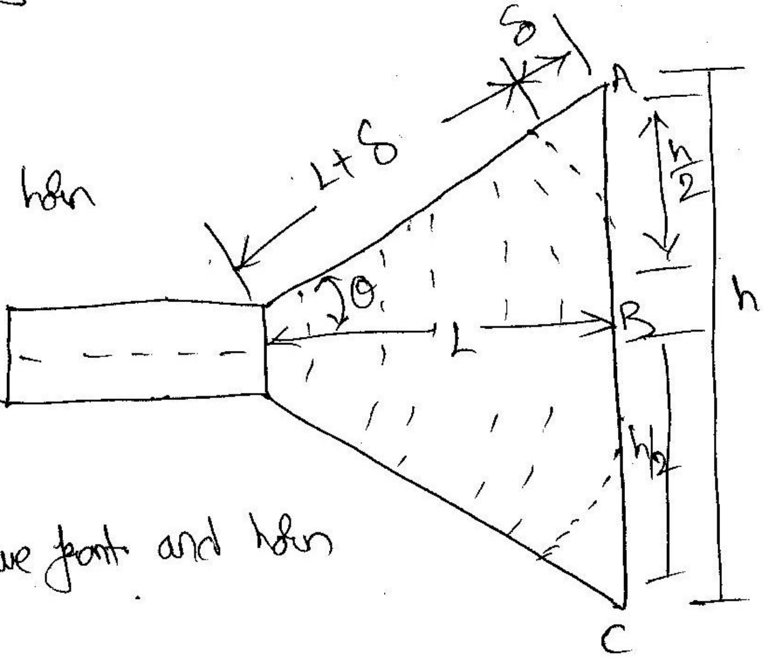


(b) Biconical horn

By providing proper impedance matching we can avoid the standing wave ratio and we get maximum directivity.

Design Equations:-

Consider a E-plane sectoral horn



Where θ is flare angle

L - is axial length.

h - is height of the mouth

δ - is path difference b/w wave front and horn

$$\cos\theta = \frac{L}{L+\delta}$$

$$\tan\theta = \frac{h/2}{L} = \frac{h}{2L}$$

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

From right angled Δle

$$(L+\delta)^2 = L^2 + \left(\frac{h}{2}\right)^2$$

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

Let δ as small so δ^2 is negligible

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

$$2\delta L = \frac{h^2}{4} \Rightarrow \boxed{L = \frac{h^2}{8\delta}} \Rightarrow \boxed{h = \sqrt{8\delta L}}$$

Here S-Varies values for E-plane horn $S_E = 0.2\lambda$

For H-plane horn $S_H = 0.4\lambda$

For Co-axial horn $S_{Conical} = 0.3\lambda$

The approximate formulaes for half power beamwidth of optimum horn antenna is

$$\theta_E = \frac{57\lambda}{h} \text{ deg}$$

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

$$\text{Area} = \text{height} \times \text{width}$$

$$\text{Directivity } (D) = \frac{7.5hw}{\lambda^2} = \frac{7.5A}{\lambda^2}$$

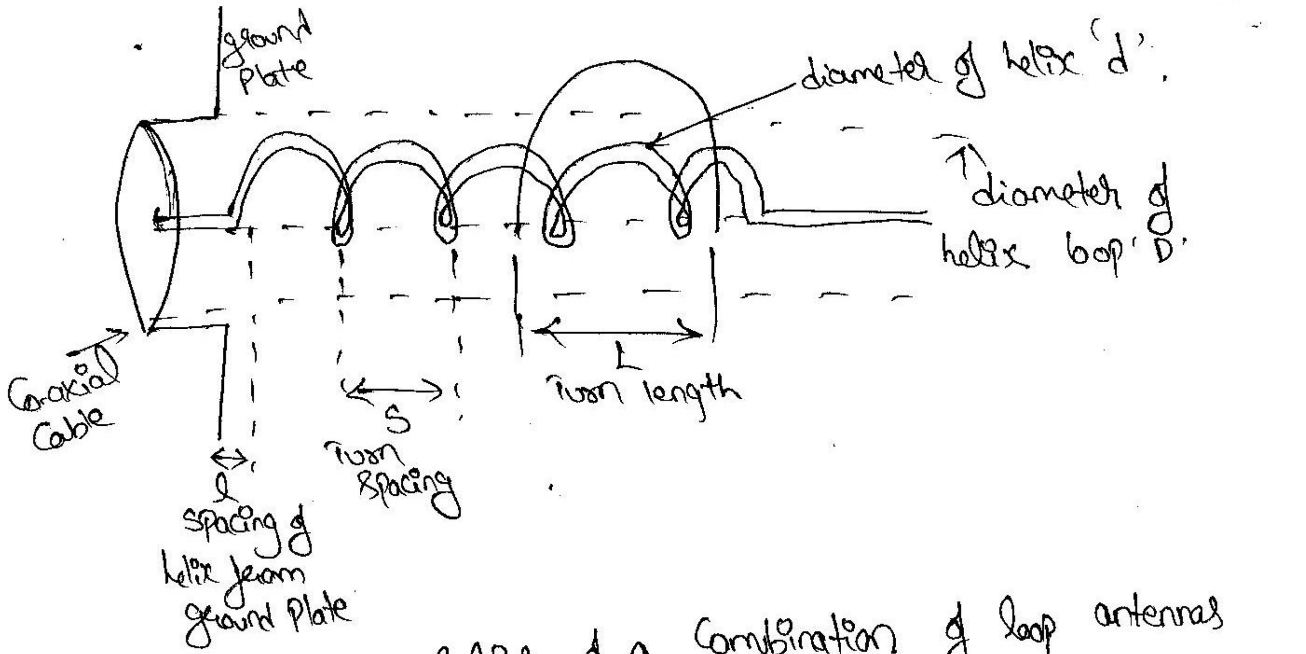
$$\text{Directive gain } G_d = \frac{4.5\,hw}{\lambda^2} = \frac{4.5A}{\lambda^2}$$ hw - half width

small flare angle represents small aperture and also less directivity. For optimum operation flar angle varies from 40°-15° and beam width of 66°.

4) Hellical Antenna:-

Hellical Antenna is a very high frequency antenna used to generate a circularly Polarised waves and is used in Communication system (Satellite Communication). The Antenna is a helics of thick copper wire or tubing wound and shape is like a screw thread used as an antenna it has a flat metal plate called as ground plate.

→ The helics is fed from a co-axial cable with its helics one end is connected to inner conductor of the coaxial cable and outer conductor is connected to ground plate.



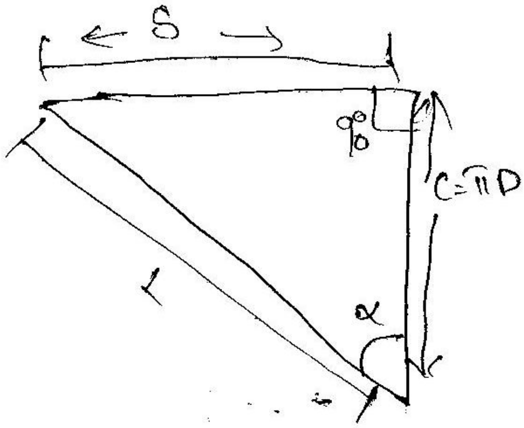
→ This antenna is a series of a combination of loop antennas and dipole antennas.

→ The radiation pattern of helical antenna depends on a diameter of the helics (d), the turn spacing (s) and also axial length ($A = N.S$) and also the circumference of helics.

→ There is a relation b/w circumference $C = (\pi D)$ and turn spacing (s) and pitch angle (α).

ⓐ **Pitch angle :-**

Pitch angle is defined as the angle b/w a line tangent to the helics and a plane normal to the axis and it is calculated from the triangle.



$$\tan \alpha = \frac{S}{C}$$

$$\alpha = \tan^{-1}\left(\frac{S}{C}\right)$$

$$\alpha = \tan^{-1}\left(\frac{S}{\pi D}\right) \quad (\because C = \pi D)$$

→ For one turn helics the relation b/w spacing S, Pitch angle α, Circumference is given by

$$L^2 = S^2 + C^2$$

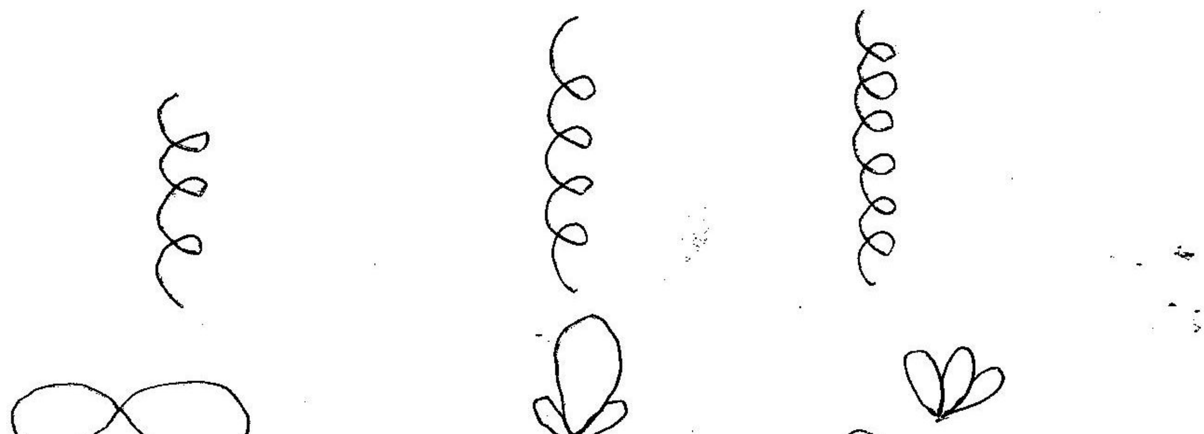
$$L = \sqrt{S^2 + C^2}$$

In helical antenna in two ways radiation takes place based on the parameters like N, C, S, they are

N = no:- of turns
D = Diameter of helix (Centre to Centre).
C = Circumference of helix = πD
S = Spacing b/w two turn measured Centre to Centre
A = Axial length
λ = Length of one turn
α = Pitch angle
d = Diameter of Conductor.

In general, a helical antenna can radiate in many modes. But the most important modes of radiation

(i) Normal (or) Perpendicular mode of radiation
(ii) Axial (or) End fire (or) Beam mode of radiation.



(a) Normal mode (b) Axial mode (c) Conical mode

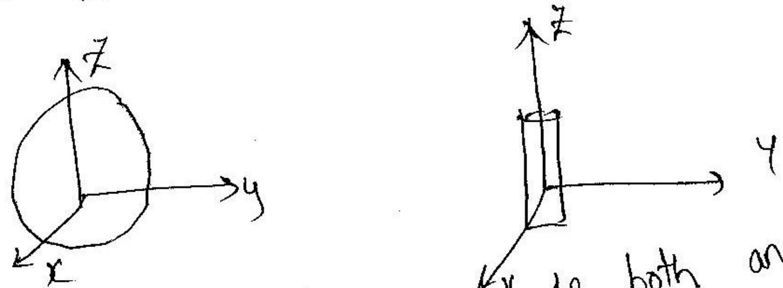
(i) Normal mode (or) Perpendicular mode of radiation:-

→ Normal mode can be set by considering $N.L \ll \lambda$

→ In this mode the maximum radiation is $\perp^{er}$ to the axis.
This mode gives narrow beam width and less efficiency

→ Based on the pitch angle if $\alpha = 0$ then antenna becomes loop

→ if $\alpha = 90^\circ$ then Antenna becomes a wire (or) dipole



→ The radiation pattern is same for both antenna (loop & dipole) and is either circularly polarised & linearly polarised

→ In general α is small then loop polarisation dominates.

(ii) Axial ratio:-

$$(A_r) \text{ Axial ratio} = \frac{E_\theta}{E_\phi}$$

$$\because E_\phi = \frac{120\pi^2 I \sin\theta}{r} A/\lambda^2 \quad ; \quad E_\theta = \frac{j60\pi I \sin\theta}{r} S/\lambda$$

Where I is retarded current ; A is area of helics $= \frac{\pi D^2}{4}$
r is distance ; $S \to$ spacing (or) length of the dipole

$$A_r = \frac{E_\theta}{E_\phi} = \frac{\frac{j60\pi I \sin\theta}{r} \cdot S/\lambda}{\frac{120\pi^2 I \sin\theta}{r} \cdot A/\lambda^2}$$

$$A_r = \frac{j\cancel{60}\cancel{\pi}\cancel{I \sin\theta}}{\cancel{r}} S/\lambda \times \frac{\cancel{r}}{\underset{2}{\cancel{120}}\pi^{\cancel{2}}\cancel{I \sin\theta}} \cdot \lambda^{\cancel{2}}/A$$

$$A_r = \frac{J S \lambda}{2\pi A}$$

$$|A_r| = \frac{S\lambda}{2\pi A} = \frac{S\lambda}{2\pi \times \frac{\pi D^2}{4}}$$

$$|A_r| = \frac{2 S\lambda}{\pi^2 D^2} = \frac{2 S \lambda}{C^2} \quad (\because C = \pi D)$$

from above A_r when $A_r = 0$ then linear horizontal Polarization takes Place.

→ when $A_r = \infty$ linear vertical Polarization takes places

→ when $A_r = 1$ then we get circular Polarization.

$$A_r = \frac{2 S \lambda}{\pi^2 D^2}$$

$$\frac{2 S\lambda}{\pi^2 D^2} = 1 \Rightarrow 2 S \lambda = \pi^2 D^2$$

$$\boxed{S = \frac{\pi^2 D^2}{2\lambda} = \frac{C^2}{2\lambda}}$$

∴ Pitch Angle :-

$$\alpha = \tan^{-1}\left(\frac{S}{C}\right)$$

$$= \tan^{-1}\left(\frac{S}{\pi D}\right) = \tan^{-1}\left(\frac{\pi^{\cancel{2}} D^{\cancel{2}}}{2\lambda . \cancel{\pi} \cancel{D}}\right)$$

$$\Rightarrow \tan^{-1}\left(\frac{\pi D}{2\lambda}\right)$$

$$\boxed{\alpha = \tan^{-1}\left(\frac{C}{2\lambda}\right)}.$$

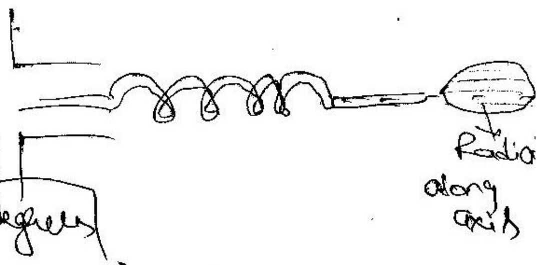
(iii) Axial Mode operation:-

In this mode we get maximum radiation along the axis and is used in practical applications. This mode is also called as End fire mode. Because radiation is along the axis.

This mode is set by considering spacing and circumference are of the order of wavelength. The gain is high in this mode and also we get wide bandwidth. The pitch angle for axial mode of operation is varies from 12° to 18° for optimum operation it should be 14°.

The terminal impedance varies from 100 to 200 Ω

$$\boxed{R_{terminal} = \frac{140\,C}{\lambda}\,\Omega}$$



Half power beam width is $\boxed{\theta_{HPBW} = \frac{52}{C}\sqrt{\frac{\lambda^3}{NS}} \text{ degrees}}$

Beam width b/w the first nulls is given by

$$\theta_{BWFN} = \boxed{\frac{115}{C}\sqrt{\frac{\lambda^3}{NS}}} \text{ deg}$$

Max. directive gain is represented by $\boxed{G_d = \frac{15NSC^2}{\lambda}}$

Axial ratio is $\boxed{AR = 1 + \frac{1}{2N}}$