30-8-19

UNIT-5

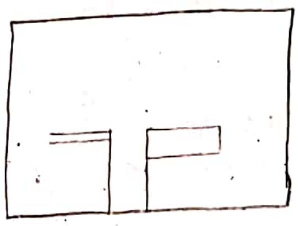
VHF, UHF and Microwave Antennas

VHF: 30-300MHz   UHF: 300M-3G   Microwave: 3G-30GHz

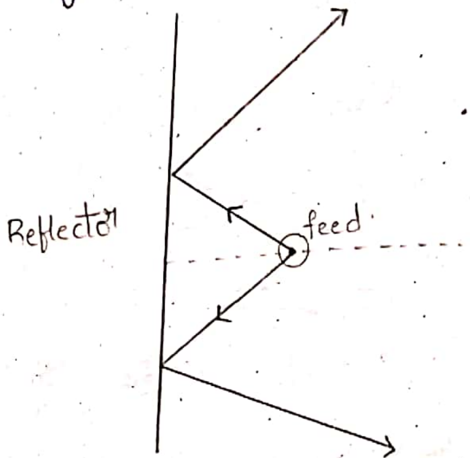
30Hz - 300GHz. Radio frequency.

Reflector antennas :- These antennas are widely used to modify the radiation pattern of a radiating element. For example, the backward radiation from an antenna may be eliminated with the plane sheet reflector of large dimensions.

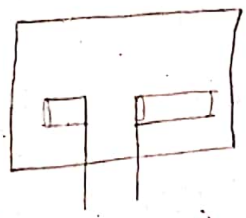
→ plane Reflector / Flat Sheet Reflector :-



(b) large flat sheet



(a) plane reflector

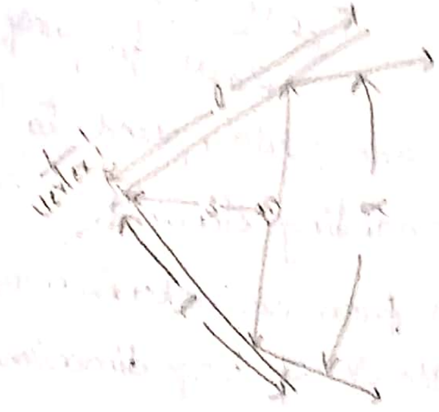


(b) small-flat sheet.

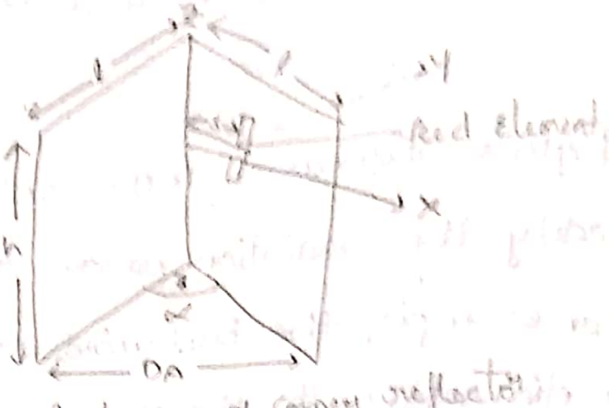
This plane reflector is a simplest type of reflector and introduced to propagate the electromagnetic wave in a desired direction. The polarisation of radiating energy and its position relating to the reflecting source can be used to control the radiating properties of the overall system.

03-09-2019

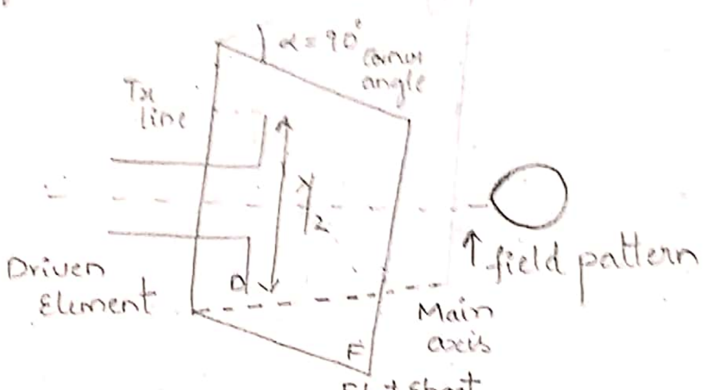
Corner Reflector :-



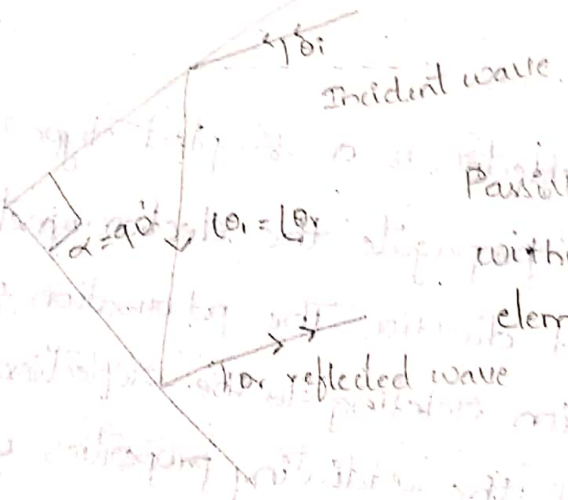
Corner reflector



front view of corner reflector



Vertical corner reflector with field pattern along main axis



Passive corner reflector without any driven element.

The main disadvantage of flat sheet reflector is side radiations will present.

To avoid this limitation the shape of flat sheet reflector is further modified in such a way that the radiation will be forward direction only.

Scanned by CamScanner

The modified reflector contains two sheets which are intersected with an angle α.

Whenever the two sheets are intersected with an angle α ($<180°$) then it is called as corner reflector.

The angle between two sheets in a corner reflector is called as included angle or corner angle.

In Most of the corner reflectors the included angle is $90°$. and in very few other applications the included angle is other than $90°$.

Whenever the two sheets are intersected with an angle we will get an effective directional antenna called as corner reflector.

When the included angle $\alpha = 90°$ then the corner reflector is called as square corner reflector.

If The included angle $\alpha < 90°$ then the corner reflector is not advantageous.

The analysis of corner reflector is done by considering the two sheets as a metallic perfect conducting planes. The system efficiency always depends on spacing between vertex of corner reflector and the field element.

The distance from the reflector and the feed element always depends on the included angle α.

If the included decreases the distance between vertex of the corner reflector and the feed element given will increase. In general, the feed element is half wave dipole, to get the better bandwidth instead of dipole as feed element, a biconical or cylindrical dipoles are preferred.

For analysis, the dimensions of common reflector is given as :- S :- Spacing between vertex of corner reflector and feed point.

D_A :- Aperture distance of the common reflector.

L :- length of the "

h :- Height of the " "

The aperture distance D_A generating generally lies between single wavelength and double wavelength

$(\lambda < D_A < 2\lambda)$.

The spacing between vertex of common reflector and feed point lies between $(\lambda/3 < S < \frac{2\lambda}{3})$

In general the length of the reflector is two times the spacing between vertex of the reflector and the feed point when $\alpha = 90°$ i.e., $L = 2S$.

The height of the reflector is 1.2 to 1.5 times greater than the total length of the feed element.

The polarisation, gain, efficiency depends on the included angle which are equally spaced at equal ~~dis'~~ ~~states~~ distance $\alpha = \pi/N$.

Case i, when $N=1$

then $\alpha = \pi$

when $N=1$, it is called as flat sheet reflector.

Case ii, when $N=2$. then $\alpha = \pi/2 = 90°$

when $\alpha = 90°$, $N=2$ it is called as Square Corner reflector.

Square Corner reflector without driven element is passive corner reflector.

Case iii, when $N=3$ then $\alpha = 60°$.

It is called as $60°$ Corner reflector.

Case iv, when $N=4$ $\alpha = 45°$

It is called as $45°$ Corner reflector.

→ Design Consideration of Corner reflector :-

| D_A, l, h, S description first |

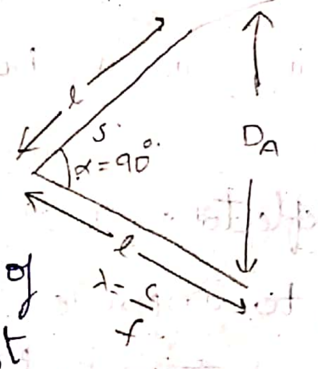
$$\lambda = \frac{c}{f}$$

$$D_A = \sqrt{l^2 + l^2} = \sqrt{2l^2}$$ when $\alpha = 90°$.

$D_A = \sqrt{2}\, l$ $(\because l = 2S)$

$D_A = 2\sqrt{2}\, S$

In general the length of the reflector is 2 times the spacing b/w the vertex and feed point.



The Band width and the gain of the corner reflector depends on the spacing between the vertex of the corner reflector and feed point.

If the spacing is more the bandwidth of the reflector is also more hence undesired side lobes will present. Hence the directivity nature will be lost.

If The spacing between .. is ~~more~~ less then the gain and directivity are more the bandwidth is less.

→Important features of Corner antenna:-

1. It is simple in Construction.

2. In Most of the cases the angle between two sheets $\alpha = 90°$.

3. To increase the effeciency spacing between the vertex of the corner reflector and feed element either increase or decrease with respecto to the included angle.

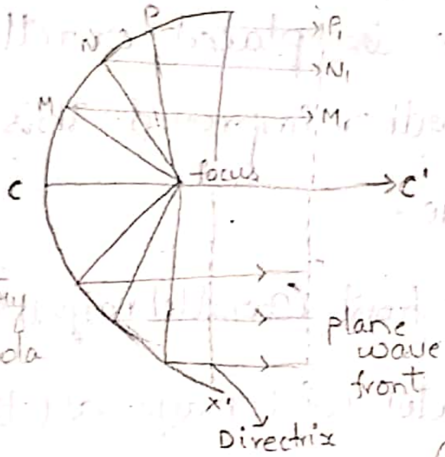
If s increases directivity will be lost.
" " de " " " high and gain also high.

For smaller included angle the side length should be large.

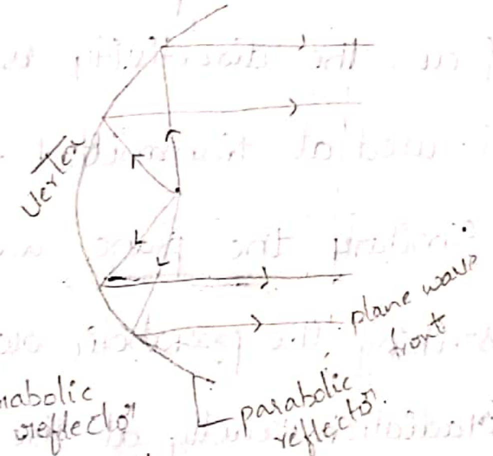
It can be used in RADAR, Sea communication applications
" " " " " home TV applications.

04-09-19.

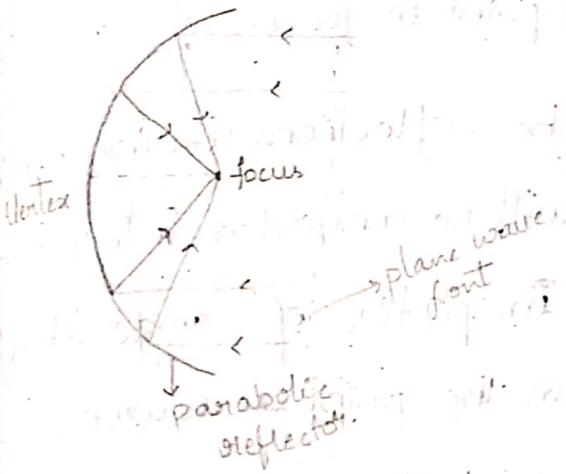
Curved Reflector :- 1. It is also called as parabolic reflector; to improve the overall radiation characteristics and to get higher directivity parabolic reflector parabolic ~~refl~~ is oftenly used



(a) Geometry of parabola



(b) Parabolic reflector transmitter.



(c) Parabolic reflector of receiving end

To increase the directivity nature, it is necessary to use a parabolic reflector which converts incident spherical wavefront into plane wavefront (Parallel beams).

Parabola is formed by joining the locus of all allpoints to a fixed distance point called focal point or focus. The straight line from a point to edges of the parabola is called directrix.

Working principle of parabolic reflector :-

When a point source is placed exactly at the focus or focal point then the reflections coming back from the parabolic reflector will forms a parallel rays.

When the point source is placed exactly at the focus, the directivity is further improved. This principle is used at transmitted side.

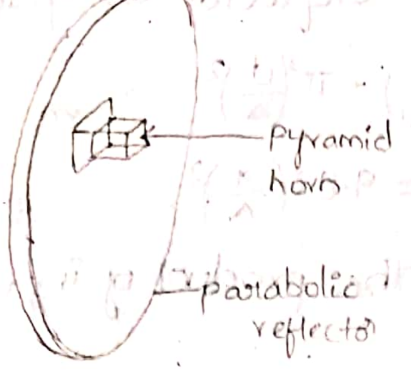
Similarly the plane wave front (Parallel rays) which is striking the parabolic reflector will have all the radiation exactly at the focal point or focus.

From the above diagrams, the reflections coming back from the parabolic reflector will be converted into plane front or parallel wave front. Irrespective of angle which is striking the reflector from the point ~~are~~ source.

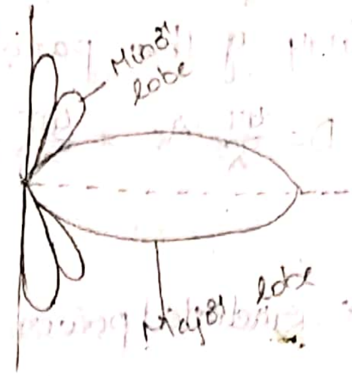
The open end of the parabolic reflector is called aperture

Since the waveform is parallel to the axis of parabola the distance travelled by each ray to reach the the edge of the reflector is same. The time taken by the parallel rays to reach the aperture of parabolic reflector is also same. Hence all the rays are uniformly spaced.

When the effective microwave antenna concentrated beam is obtained. Hence the directivity of parabolic reflector is more sharper, high gain



(a) parabolid



(b) parabolid with pyramid horn as feed

05-09-19

In most of the applications a 3D reflector is used. It is obtained by rotating the parabola around its own axis. Hence it can be called as parabolid reflector.

The open end of the parabolic reflector looks like a cross section of circle. The radiation pattern of parabolic reflector is having more directivity with very few minor lobes and the concentrated major lobe. The power gain of parabolic reflector is given as $G_p = \frac{4\pi}{\lambda^2} A_0$.
where A_0 is captured area which is less than actual area, so $A_0 = KA$
where $K = 0.65$ for dipole antenna.

$$\therefore G_p = \frac{4\pi}{\lambda^2}(0.65 A)$$

where $A = \pi r^2 = \pi\left(\frac{d^2}{4}\right)$

$$G_p = \frac{4\pi}{\lambda^2} \cdot 0.65 \pi r^2$$

$$= \frac{4\pi^2}{\lambda^2} r^2 \, 0.65$$

$$\frac{4\pi^2}{\lambda^2}\left(\frac{d^2}{4}\right) 0.65 \Rightarrow \pi^2 \times 0.65 \left(\frac{d}{\lambda}\right)^2$$

$$G_p = 6\left(\frac{d}{\lambda}\right)^2$$

The directivity of the parabolic reflector is given as

$$D = \frac{4\pi}{\lambda^2} A_e = \frac{4\pi}{\lambda^2}\left(\frac{\pi d^2}{4}\right) = \pi^2\left(\frac{d}{\lambda}\right)^2$$

$$= 9.87\left(\frac{d}{\lambda}\right)^2$$

The Effective radiated power is the product of input power and the power gain

$$ERP = P_{in} \times G_p.$$

The power gain is always the function of ratio of diameter of the circular aperture and its wavelength in the free space.

The ratio of the term $\frac{d}{\lambda}$ is called aperture ratio.

The first null beam width of a parabolic reflector is given as $FNBW = \left(140\frac{\lambda}{d}\right)$ degrees/radians (with circular apertures).

The first null beam width of a parabolic reflector is

$FNBW = 115(\lambda/L)$ (rectangular aperture).

* $\frac{f}{d}$ ratio, spill over, back lobe and aperture blockage:-

i) f/d ratio:- 'f' indicates focal length + d indicates ~~directivity~~ diameter

(f/d) ratio is an important aspect to design a parabolic reflector. To get the better directivity it is necessary to keep the diameter constant and vary the focal length.

There are 3 cases of f/d ratio as follows.

i) The focal point lies inside the aperture of the reflector

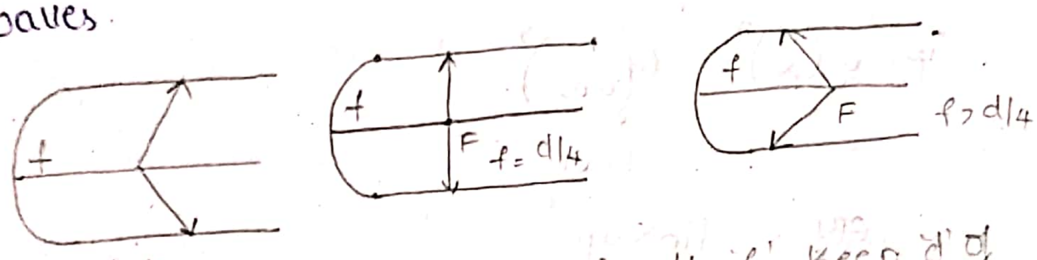
ii) " " " " exactly on the open mouth or end of the reflector.

ii) Focal point lies beyond open end of the reflector.

If the focal length is less than the 1/4 of the diameter ($f < d/4$) then uniform radiation is not possible.

If the focal length is exactly equals to 1/4 of the diameter $f = d/4$ then max radiation will be obtained.

If the focal length is beyond the 1/4 of the diameter then it is highly impossible to direct the reflected waves.



Effect of variation of focal length 'f'. Keep 'd' of aperture 'd' fixed in paraboloid.

06-09-19.

ii, Spill over :- practically it is not observed that some of the rays are not fully captured by reflector such non captured rays form spill over.

iii, Back lobe :- Few radiations originated from the primary radiators are observed in forward direction. Such radiations get added to desired parallel beam. This is called back lobe radiation, as it originates from the backlobe of primary radiator.

iv, Aperture Blockage :- The area which the rays reflected by the parabolid and blocked by the horn itself is called as Aperture Blockage.

→ Calculate the effective radiated power if the input feeding power is 1 watt, the diameter of Parabolic reflector is 1m and $\lambda = 0.02m$.

Sol Given

$\lambda = 0.02m$

$P_{in} = 1 watt$

$d = 1m$.

$$G_p = 6\left(\frac{d}{\lambda}\right)^2 = 6\left(\frac{1}{0.02}\right)^2$$

$$= 15000$$

$$ERP = P_{in} \times G_p$$

$$= 15,000 \times 1 \text{ watt}$$

$$= 15,000 \text{ watt}$$

A Parabolic reflector of 1.8 diameter is used at 6GHz Calculate first Null beam width and gain

Sol Given $d = 1.8$.

$f = 6GHz$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{6 \times 10^9} = 0.05$$

$$FNBW = 140\left(\frac{\lambda}{d}\right)$$

$$= 140\left(\frac{0.05}{1.8}\right)$$

$$= 3.88^\circ/\text{rad}$$

$$Gain = 6\left(\frac{d}{\lambda}\right)^2 = 6\left(\frac{1.8}{0.05}\right)^2$$

$$= 7776$$

$$(Gain) = 20\log 7776$$

$$= 38.9D$$

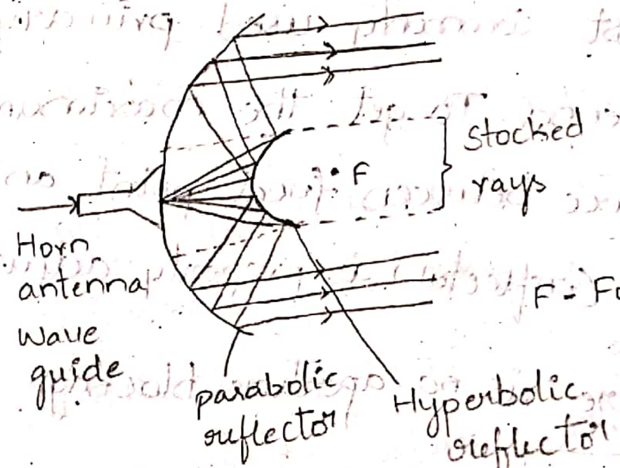
09-09-19

Different feeds of parabolic reflector:-

There are two types of feeds present in parabolic reflector. They are 1. Cassegrain feed system.
2. Offset feed system.

1. Cassegrain feed System:- This feed system is named after a mathematician Called Cassegrain. This feed system is different from all the other feed systems. In this system the primary antenna is not located exactly at the focus point instead it is located at vertex of the parabolic reflector. The reflector in which the Cassegrain feed system is a hyperbolic deflector. The focus point is coincides with parabolic reflector. The primary antenna used in Cassegrain feed system is Horn antenna.

Cassegrain feed System



F- Focus of parabolic reflector and Hyperbolic " "

The Cassegrain reflector is also called as Sub-reflector. To eliminate the unwanted signal and to reduce the noise Cassegrain feed System will be used.

Advantages:-

1. It reduces the spill over and minor lobe radiation.

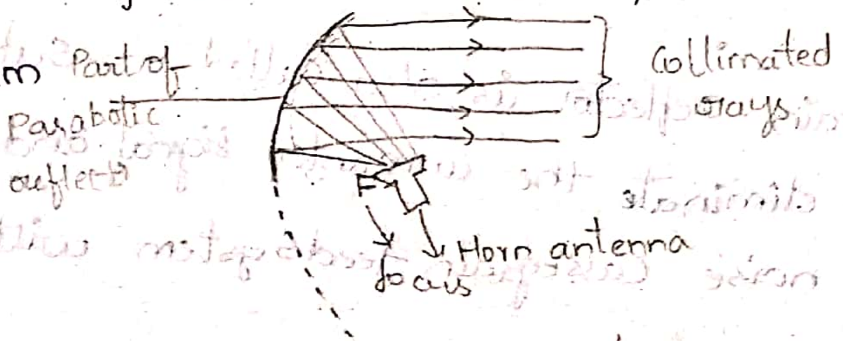
2. Using this system the beam can be broad end by adjusting one of the reflector surfaces.

Disadvantages:-

1. In Cassegrain feedsystem some of the rays will get blocked which may contain wanted information.

2. It is not a major problem, the dimensions of the reflector is large, but if the dimensions are very less it is a major problem.

2. Offset feed System:- The offset feedsystem design will always ensures that the maximum radiation by keeping the primary antenna or feed antenna exactly at the focus point, whether it is $\lambda/2$ dipole or Horn antenna. The most commonly used primary antenna is Horn antenna. To get the maximum radiation the distance between focal point and the secondly radiator (reflector) is properly adjusted. The advantage is there is no aperture blockage problem



offset feed system

Important features of parabolic reflector.

1. It produces the directional beam with sharp main lobe.

2. For non directional antenna First Null Beam Width is given taken as $140(\lambda/d)$ where λ is wave length.
d is diameter.

3. The power gain of the antenna depends on the aperture ratio (d/λ)

4. For higher efficiency the open end of the diameter is must be atleast 10λ

5. For a small input power the effective radiated power is very high.

Disadvantages:-

1. Because of large size practical construction may be difficult and it cannot be used at very high frequencies.

2. The feed antenna cannot be located at the focus exactly.

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→ Horn Antenna :- It is mostly used and simplest micro -wave antenna, it is used as a feedelement in large radio astronomy, communication dishes, and satellite towers through out the world. Since, it is used at microwave frequencies, it is also called as aperture antenna. The Horn antenna is a rectangular wave guide hollow pipe which is having different cross sections. It is obtained by flaring at one end of the wave guide. when one end of the wave guide is excited and the other end is opened, then the radiation is not perfect due to mismatching between freespace impedance and wave guide characteristic impedance. To get the better directivity, the Horn wave guide is properly flared into different shapes.

Types of Horn antenna :-

Horn antenna is simply a flared wave guide or open ended wave guide. The main purpose of the Horn antenna is to produce uniform phase with better directivity by designing different cross sections.

There are two types

1. Rectangular Horn waveguide
2. Circular " "

Rectangular Horn antenna is fed with rectangular wave guide and the circular horn antenna is fed with circular wave guide. To get the better directivity the rectangular horn antenna is divided into two types

1. ~~circular~~ Sectoral Horn antenna
2. pyramidal " "

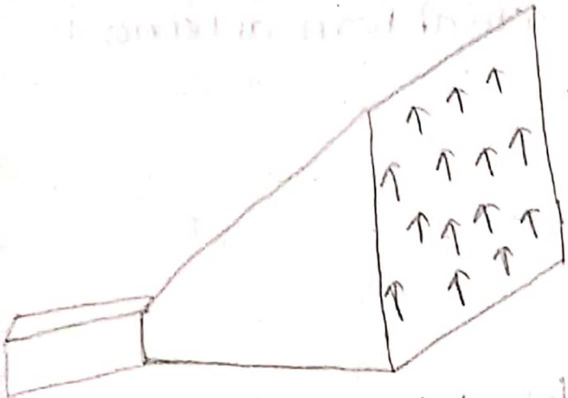
The sectoral horn antennas are again divided into two types

1. E plane Sectoral Horn antenna.
2. H " " "

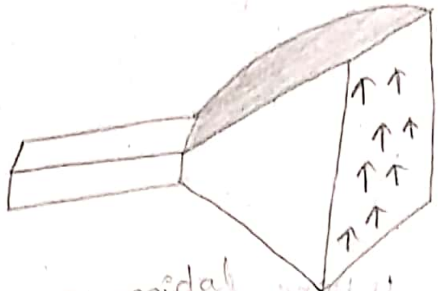
E plane SHA is obtained when flaring is done in one direction i.e., along the electric field vector direction

H plane SHA is obtained when the flaring is done in one direction i.e, along the magnetic field vector direction.

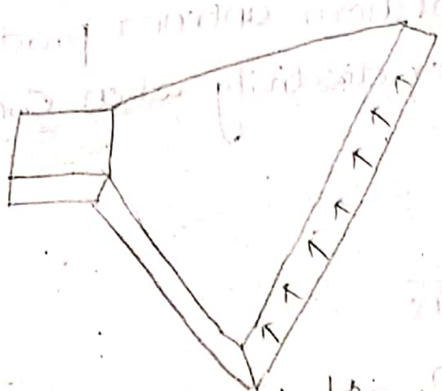
When the flaring is done in both Electric and magnetic field vector directions the pyramidal Horn antenna is obtained.



E plane Sectoral horn



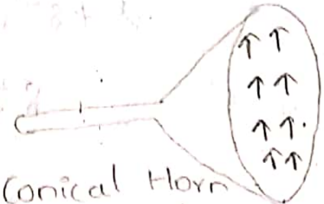
pyramidal horn.



H- Plane Sectoral horn

Circular horn antenna

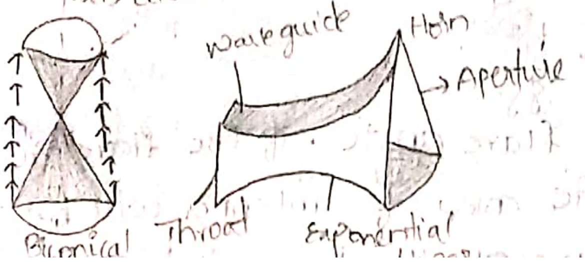
Circular horn antenna can be obtained by flarring the walls of circular wave guide. The circular horn antenna is divided into two types.



Conical Horn antenna

1. Conical horn antenna
2. Biconical horn antenna.

fig: Circular Horn antennas



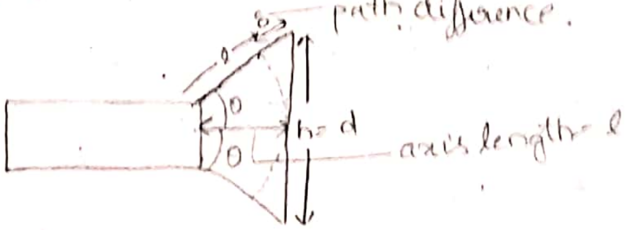
Biconical Exponential

Exponential taperd Conical

Many times the transistion region between throat of Antenna & aperture is flarring with the exponential to reduce the unwanted reflections along the wave guide. This type of antenna is called as exponentially flarred horn antenna.

Design Equations of horn antenna

let us consider E-plane sectoral horn antenna is shown in figure.



where l = axial length ; h indicates the height of the open end of the aperture ; θ indicates optimum flaring angle & δ indicates path difference.

By the E-plane sectoral horn antenna producer uniform phase with greater directivity when compared with normal wave guide.

from the figure,

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

$$\tan\theta = \frac{h}{2l}$$

from right angle triangle

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

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

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

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

$$l = \frac{h^2}{8\delta}$$

The 2θ angle indicates flare angle. If the flare 2θ is very small when aperture area of antenna will be small and the directivity nature of the beam is high and angle θ is called as optimum aperture angle.

For flare angle for which the value of δ doesn't exceed a typical value such as 0.25λ for E-plane sectoral horn antenna. 0.4λ for H-plane sector horn antenna & 0.32λ for conical horn antenna. The directivity of pyramidal horn & conical horn antenna is highest as compared other horn antenna.

The advantage of horn antenna is that it can be operated for a wide range of high frequencies. Assuming no loss, the directivity of horn antenna is given as

$$G = G_p = \eta D$$

where $\eta = 1$

$$G_p = D$$

$$D = \frac{4\pi}{\lambda^2} A_e$$

where A_e is effective apperture area.

WKT the aperture efficiency $E_{ap} = \frac{A_e}{A_p}$

where A_p is physical area

$$D = \frac{4\pi}{\lambda^2} (E_{ap} A_p)$$

$E_{ap} = 0.6$ for horn antenna

$$D = \frac{4\pi}{\lambda^2} (0.6 A_p)$$

$$D = \frac{7.5}{\lambda^2} A_p \qquad (\because A_p = \text{physical area of circle})$$

$$D = \frac{7.5}{\lambda^2} (\pi r^2)$$

$$D = 23.56 \left(\frac{r}{\lambda}\right)^2$$

The Important features of horn Antenna

* The horn antenna is used with wave guide and it is used as a primary radiator in parabolic reflectors.

* If the flare angle is smaller then area of horn antenna becomes smaller & radiation pattern is more directive in nature.

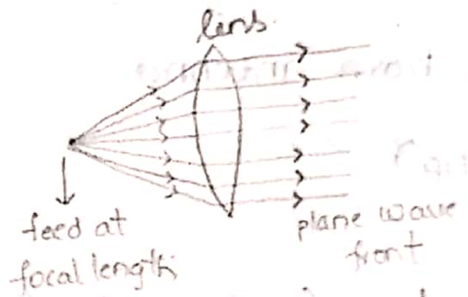
Applications:

The horn antenna is used for measurement of Various Antenna parameters in the laboratory.

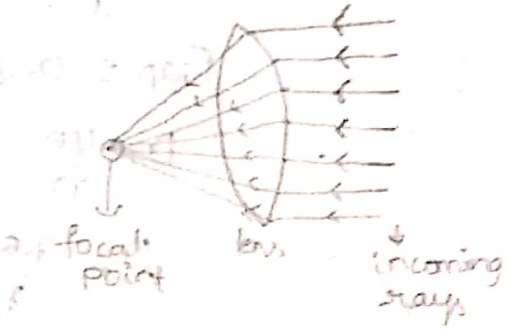
It is the most suitable antenna for various application in microwave frequency range where moderate gains are sufficient.

17-09-19

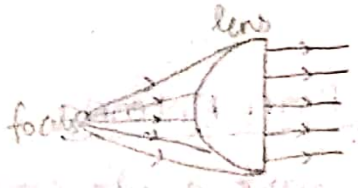
Lens Antenna:- Lens antenna is an antenna consisting of an Electromagnetic lens with a feed. It is a pre dimensional Electromagnetic device having refractive index other than unity. Its operation is similar to a glass lens used in optics. The lens antenna can be used in both transmitting and receiving mode as shown in fig.



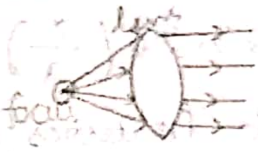
a. Transmitting mode



(b) Receiving mode.

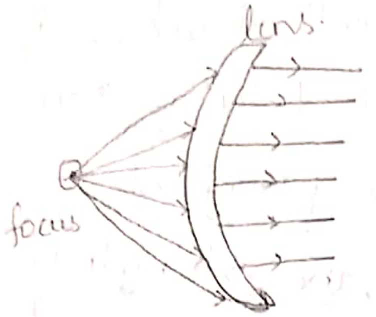


1. Convex plane

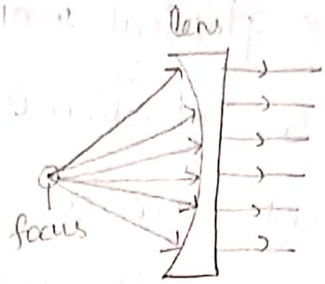


2. Convex Convex

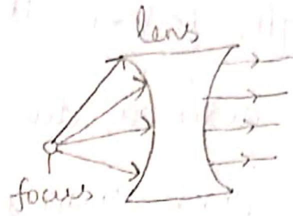
$\eta > 1$.



3. Convex-concave

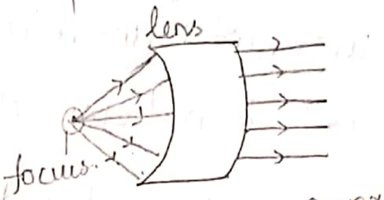


4. Concave plane



5. Concave-Concave plane

fig:- lens antenna with refractive index $\eta > 1$



6. Concave - Convex

fig:- lens antenna with refractive Index $\eta < 1$

In general the functions of lens antennas are as follows 1. It guides the EM waves

2. It produces the directional characteristics

3. In receiving mode it converges the incoming wave front at its focus or focal point.

4. It produces a plane wave front from a spherical wave front.

5. The main application of lens antenna is to guide the divergent energy to preventing from spreading into unwanted or undesired direction.

6. The lens antenna can be used at high frequency

7. The size of lens antenna is extremely large and weight is more at low frequencies.

Principle of operation of lens antenna:-

Let us consider a convex plane lens whose refractive index is other than unity, a feedpoint or a feed source will radiate a divergent spherical wave front. The distance between feed source and EM lens is called as focal

length. When the spherical wave front reaches the lens antenna due to refraction it will be converted into plane wave front. Since the plane wavefront contains many no. of parallel rays, the strength of the major lobe will increase, hence the waveform is wide directional in nature. To get better directivity the feed source must be placed along the axis of lens antenna. This principle is used at transmitting end.
When the incoming parallel rays strikes the lens antenna in the receiving side then the waveform will be converged exactly at the focal point to get the maximum information. This principle is used at receiving side.

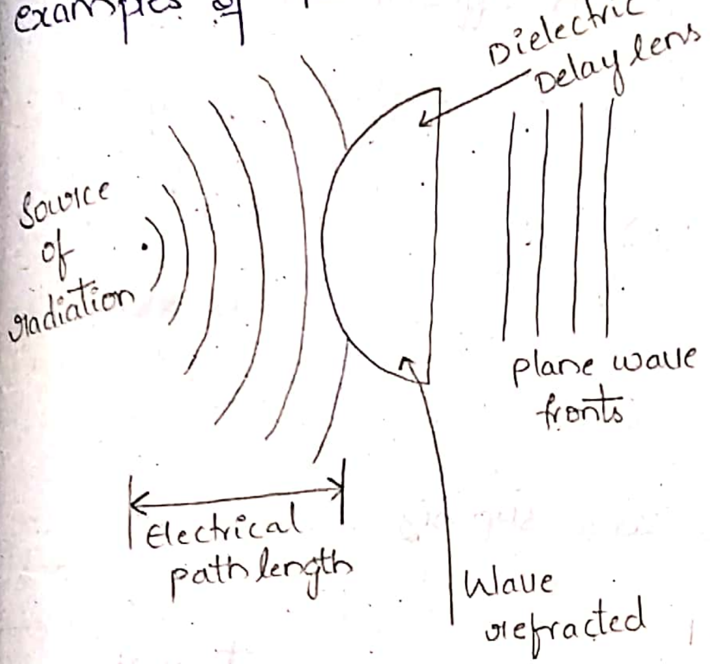
→ Types of lens antenna :- Depending on the geometrical structure and the material used for the lens antenna, it is divided into types

1. Delay lens antenna (or) Dielectric lens antenna (or) H plane metallic lens antenna
2. Fast lens antenna / E plane metallic " "

1. Delay lens antenna :- It is an antenna in which the electric path length is increased by lens medium. Hence the waveforms get retarded.
After passing through the lens medium the electro magnetic wave velocity is decreased.

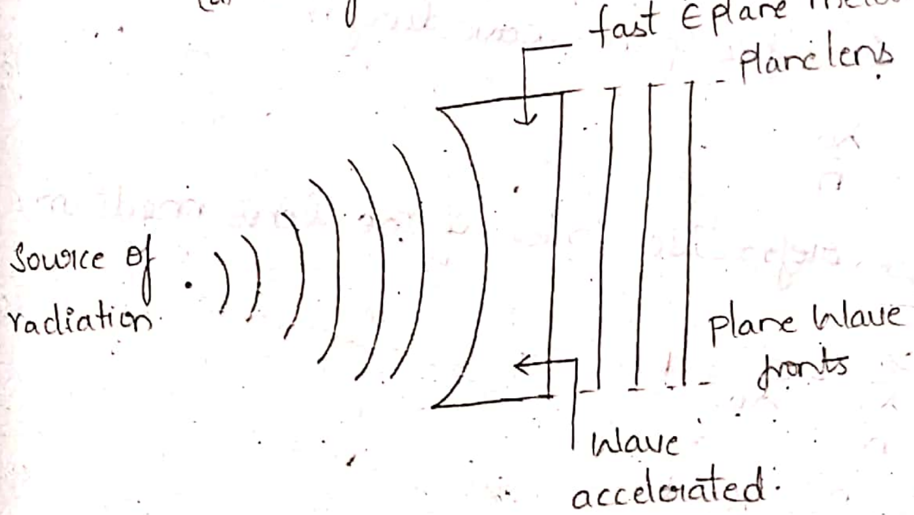
2. Fast lens antenna :- It is an antenna in which the electric path length is decreased by lens medium. Hence the waveforms gets accelerated

H plane metallic lenses are the examples of delay lens antenna; and E plane metallic lenses are the examples of fast lens antenna.



(a) Delay lens antenna

Fig:- Fast and Delay lens antenna



(b) Fast lens antenna.

→ Zoning :- To reduce the weight of lens antenna for some section of lens antenna should be removed known as zoning.

Zoning has to be done to a particular frequency or to a particular design in such a way that the operation of lens antenna should not be affected.

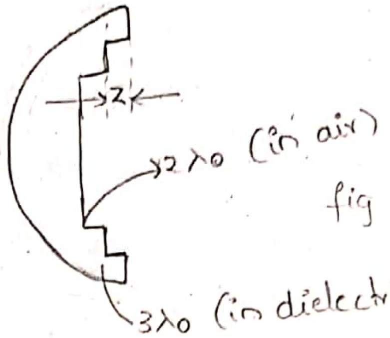


fig - zoning of lens antenna.

From the fig z indicates zone step size

$$\frac{z}{\lambda_d} - \frac{z}{\lambda_0} = 1$$

where λ_d is wave length in dielectric material

λ_0 is free space wave length.

where $\lambda_d = \frac{\lambda_0}{n}$

where n is refractive index of the lens medium

$$\frac{z}{\frac{\lambda_0}{n}} - \frac{z}{\lambda_0} = 1.$$

$$\frac{z}{1} \times \frac{n}{\lambda_0} - \frac{z}{\lambda_0} = 1$$

$$zn - z = \lambda_0$$

$$z(n-1) = \lambda_0$$

$$\boxed{z = \frac{\lambda_0}{n-1}}$$

Zoning can be classified into types 1. Curved surface zoning.
2. Plane " "

Differences

Curved Surface Zoning	Plane-Surface Zoning
1. When the zoning is done on the Curved surface of the lens antenna then it is curved surface zoning.	1. When the zoning is done on the Plane surface of the lens antenna then it is plane Surface zoning.
2. Mechanical strength is high.	2. Mechanical strength is weak.
3. less weight.	3. more weight.
4. power dissipation is less	4. The power dissipation is more when Compared with curved surface zoning.

→ find the Step Size of the lens antenna having frequency 3GHz and refractive index is 3. find z.

Sol Given $f = 3GHz$.

$n = 3$.

$\lambda = \frac{c}{f}$.

$\lambda = \frac{\cancel{3}\times 10^8 m/s}{\cancel{3}\times 10^9}$.

$= \frac{1}{10}$ th

$z = \frac{\frac{1}{10}}{3-1} = \frac{\frac{1}{10}}{2} = \frac{2}{10}$

$= 0.05$.

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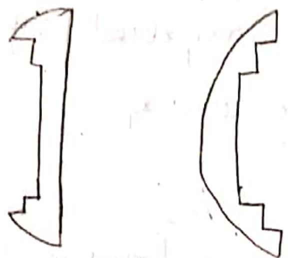
Advantages of zoning:- 1. By zoning the weight of lens antenna will decrease.

2. Zoning will ensure the emerging ray will be inphase

3. The power dissipation of the zoned antennas are less when compared with unzoned antenna.

Disadvantages:- 1. When compared with unzoned antenna the zoned antenna is highly sensitive to the frequency.



1. Curved Surface zoning

2. plane surface zoning

fig:- Types of surface zoning.

Applications of zoning:- 1. It is mostly used at microwave frequency above 3GHz.

2. For narrow B.W applications the dielectric lens antennas are used.

Advantages of lens antenna:- 1. The lens antenna can produce spherical wave front into plane wave front which is highly directional in nature.

2. In lens antenna the rays are transmitted away from the feed system, hence the aperture is not obstructed due to the feed and the feed support.

3. The lens antenna the waves entered from one side and leaves out from the other end. Hence the greater extent of wrapping and twisting is possible without disturbing the electrical path length.

4. lens antenna is used in the applications where the beam is needed to move angularly w.r.t the axis.

Disadvantages :- 1. lens antenna is bulky.

2. The design of lens antenna is complicated compared with reflectors, the lens antennas are expensive for same gain and B.W requirements.

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Antenna Measurements :- To analyze the performance of the antenna, antenna measurements are needed. The important antenna measurements are 1. Radiation pattern
2. Gain
3. Directivity

1. Radiation pattern :- To measure the radiation pattern two antennas must be needed, one antenna is antenna Under test (AUT) and the other antenna is located far away from AUT. These two antennas can be used as transmitting and receiving antennas. In general the transmitting primary antenna is referred as ~~reciever~~ transmitting antenna and secondary antenna is referred as AUT (recieving antenna)

There are two ways to calculate the radiation pattern as follows

Case.i :- Keep the primary antenna stationary, the secondary antenna is rotated circularly with Uniform radius r around the primary antenna. At different points of location calculate the field strength and plot the radiation pattern on polar plot.

Case ii :- In this case, Both primary and Secondary antennas are kept stationary. The secondary antenna is used as receiving antenna and it aims the primary antenna. The secondary antenna is rotated about a vertical axis. So, that the field strength reading and the direction of primary antenna w.r.t secondary antenna is important using pattern recorder. Generally at low frequencies first case is used and at high frequencies second case is used.

→ SetUp for measurement of Radiation pattern of an Antenna :-

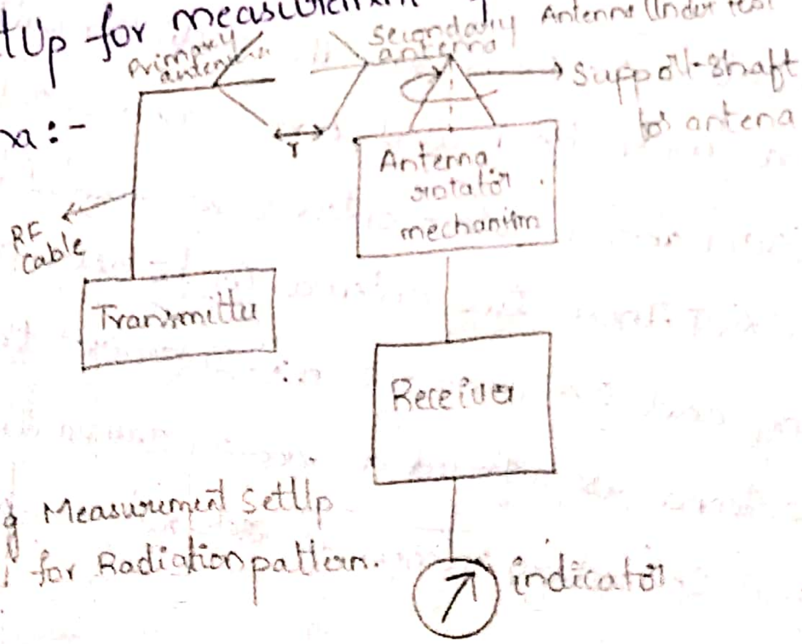


fig Measurement setUp for Radiation pattern.

The simple radiation pattern consisting of primary antenna in transmitting mode, secondary antenna in receiving mode (AUT). The secondary antenna is coupled with rotating shaft and it is rotated using antenna rotator mechanism. The secondary antenna is properly illuminated by the stationary primary antenna. The secondary antenna is rotated about its vertical axis, then we can measure the E plane and H-plane patterns.

→ Uniform Distance Measurement :- To get the accurate field pattern, the distance between the primary antenna and the secondary antenna must be very large. If the distance is smaller near field region will be obtained. According to the standard condition of far field region, the distance b/w must be $r = \frac{2d^2}{\lambda}$ where d is the largest dimension of the antenna, where λ is the wave length.

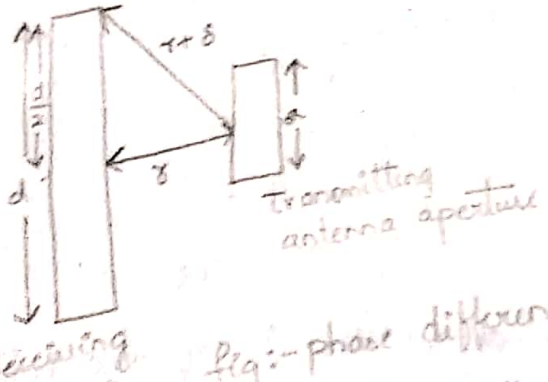


fig:- phase difference between centre and the edge of the receiving antenna for uniform distance requirement.

From the right angle triangle.

$$(r+\delta)^2 = r^2 + \left(\frac{d}{2}\right)^2$$

$$\cancel{r^2} + \delta^2 + 2r\delta = \cancel{r^2} + \frac{d^2}{4}$$

$$\delta^2 + 2r\delta = \frac{d^2}{4}$$

Neglect δ^2.

$$2r\delta = \frac{d^2}{4}$$

$$\boxed{r = \frac{d^2}{8\delta}}$$

where δ is phase difference $\delta < \lambda/16$.

from the above Equation, it is clear that minimum distance depends on the wavelength (λ) and the aperture of the receiving antenna

→ Uniform Amplitude Requirement.

Uniform amplitude requirement is also one of the important requirement for the effectiveness of the antenna.

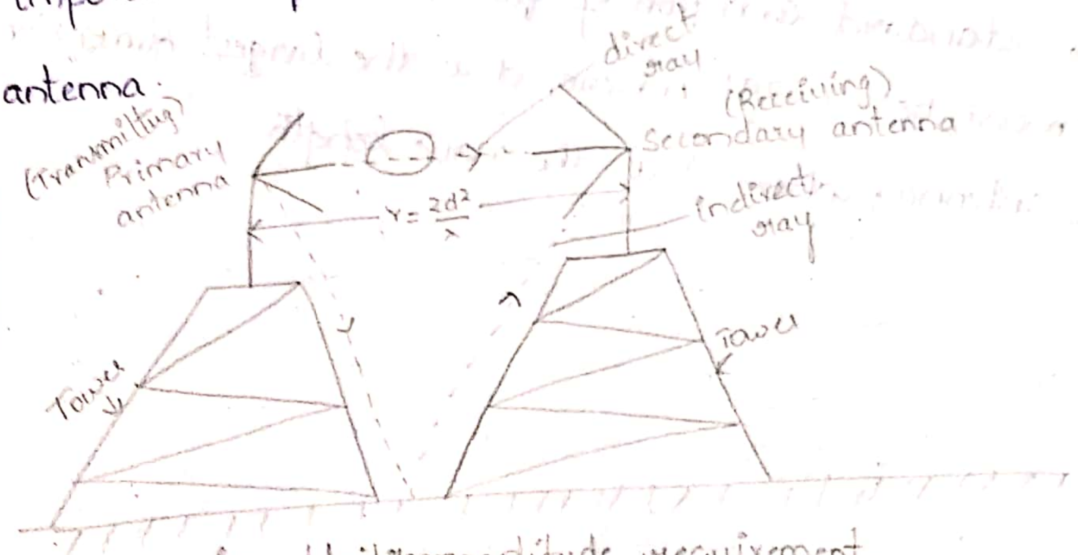
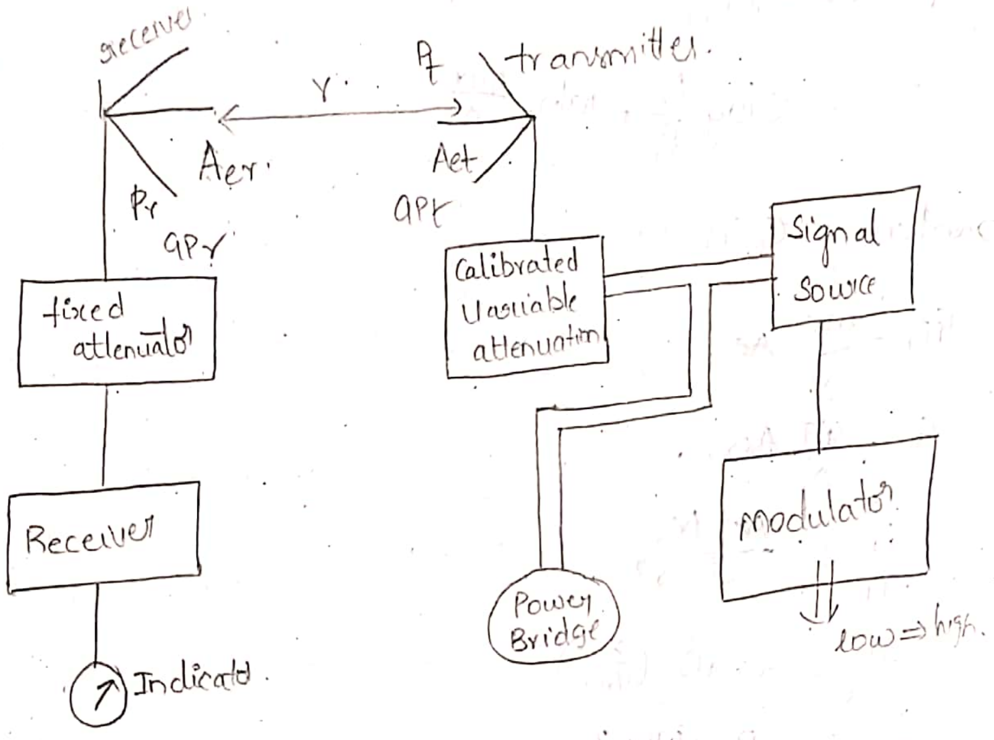


fig:- Uniform amplitude requirement.

It is necessary to avoid the interference between direct rays and indirect rays from both the transmitting and receiving antenna. To avoid the reflections from buildings and trees, it is necessary mount the antennas on the top of the tower and also transmitting and receiving antennas are highly directional

Gain:-



$$G_p = \frac{4\pi}{\lambda^2} A_e$$

$$G_{P_t} = \frac{4\pi}{\lambda^2} A_{et} \Rightarrow A_{et} = G_{P_t}\frac{\lambda^2}{4\pi}$$

$$G_{P_r} = \frac{4\pi}{\lambda^2} A_{er} \Rightarrow A_{er} = G_{P_r}\frac{\lambda^2}{4\pi}$$

Frii's transmission Equation:

$$\frac{P_r}{P_t} = \frac{A_{er} A_{et}}{\lambda^2 r^2}$$

$$\frac{P_r}{P_t} = \frac{G_{P_r}\frac{\cancel{\lambda^2}}{4\pi}\, G_{P_t}\frac{\lambda^2}{4\pi}}{\cancel{\lambda^2} r^2}$$

$$\frac{P_r}{P_t} = G_{P_t} G_{P_r}\left(\frac{\lambda}{4\pi r}\right)^2$$

$$G_{P_t} G_{P_r} = \frac{P_r}{P_t}\left(\frac{4\pi r}{\lambda}\right)^2$$

$$(G_p)^2 = \frac{P_r}{P_t}\left(\frac{4\pi r}{\lambda}\right)^2$$

$$G_p = \sqrt{\frac{P_r}{P_t}}\;\frac{4\pi r}{\lambda}$$

$$(G_p)_{dB} = 10\log\left(\sqrt{\frac{P_r}{P_t}}\;\frac{4\pi r}{\lambda}\right)$$

$$= 10\log\sqrt{\frac{P_r}{P_t}} + 10\log\frac{4\pi r}{\lambda}$$

$$= 10\log\left(\frac{P_r}{P_t}\right)^{1/2} + 10\log\left(\frac{4\pi r}{\lambda}\right)$$

$$= 5\log\frac{P_r}{P_t} + 10\log\frac{4\pi r}{\lambda}$$

3antenna Gain

$$G_{P_1} = \frac{4\pi}{\lambda^2} A_{e_1}$$

$$G_{P_2} = \frac{4\pi}{\lambda^2} A_{e_2}.$$

$$\frac{P_r}{P_t} = \frac{A_{e_1} A_{e_2}}{\lambda^2 \; r^2}.$$

$$\frac{P_r}{P_t} = G_{P_1} G_{P_2} \left(\frac{\lambda}{4\pi r}\right)^2.$$

$$G_{P_1} G_{P_2} = \frac{P_r}{P_t}\left(\frac{4\pi r}{\lambda}\right)^2.$$

Case (i), $(G_{P_1})_{dB} + (G_{P_2})_{dB} = 10\log\frac{P_r}{P_t} + 20\log\left(\frac{4\pi r}{\lambda}\right)$ — (1)

Case (ii), $(G_{P_2})_{dB} + (G_{P_3})_{dB} = 10\log\frac{P_r}{P_t} + 20\log\frac{4\pi r}{\lambda}$ — (2)

Case (iii), $(G_{P_3})_{dB} + (G_{P_1})_{dB} = 10\log\frac{P_r}{P_t} + 20\log\frac{4\pi r}{\lambda}.$ — (3)

$$G_{P_1} = \frac{(1) + (3) - (2)}{2} \qquad G_{P_2} = \frac{(1) + (2) - 3}{2}$$

$$G_{P_3} = \frac{(2) + (3) - (1)}{2}.$$

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