UNIT 5

1. What is parasitic element? Describe the use of different types of parasites in TV receiving antennas?

Ans:

Parasitic Element

A radio antenna element which does not have any wired input is known as parasitic element. It absorbs radio waves radiated from another active antenna element in proximity and reradiates it in phase with the active element, so that it adds to the total transmitted signal. This will change the antenna pattern and beam width.

Usage of Different Types of Parasites in TV Receiving Antennas

Basically, there are two different types of parasites used in TV receiving antennas. They are,

1. Reflector
2. Director.

The above parasitic elements (i.e., passive elements which are not connected directly to the transmission line but electrically coupled) are able to receive their induced voltage by the current flow in the driven element. The phases of the currents are determined by the spacing between elements and the lengths of the parasitic elements. Using the parasitic elements, we can either reflect or direct the radiated energy, so that a compact directional antenna system can be obtained. A parasitic element of length less than $\lambda/2$, will be capacitive while the elements of length equal to or greater than $\lambda/2$, will be inductive. Thus, the phases of currents in the former case will lead the induced voltage and in the later case will lag the induced voltage.

The director which is shorter than driven element used to add the fields of driven element in the direction away from the driven element. In case of more than one directors, each one is used to excite the next director. The reflector which is equal to or greater than driven element, used to add up the fields of driven element in the direction from reflector to driven element. Further, the use of parasitic elements in conjunction with driven element causes the dipole impedance to fall below 73Ω.

Gain up to 12 dB is also achieved by using additional directors at an interval of 0.15 λ in the beam direction. When the distance between driven and director elements is increased, the capacitive reactance needed to provide correct phasing of parasitic current is also more. The variations in the distance between driven element and parasitic element allow us to make the radiation pattern as unidirectional by changing the relative phases. Practically, a parasitic element shortened by 5 % with respect to driven element acts as director and lengthened by 5% acts as reflector. The parasitic antennas which are properly designed with a large front to back ratio are having special use at higher frequencies between 100-1000 MH.

2. Explain the working of Yagi antenna?

Ans:

Yagi-Uda Antenna

It consists of a reflector, a driven element and one or more directors. Consider the arrangement of Yagi-Uda antenna shown in figure 5.2.1 below. Here resonant half-wave dipole acts as a driven element and parasitic elements are arranged parallel to the driven element.

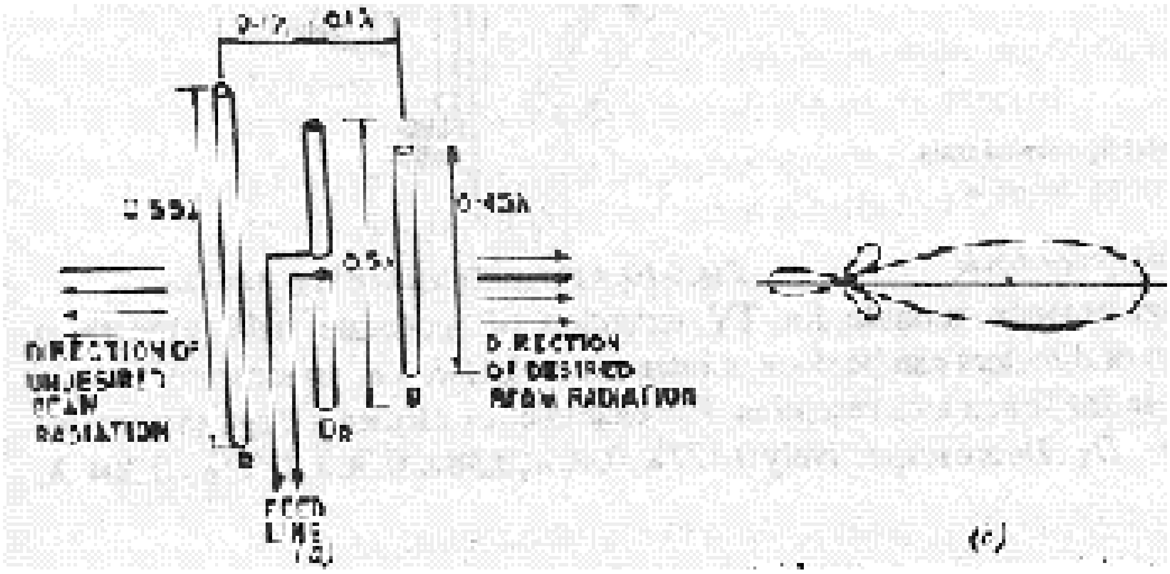


Fig 5.2.1 (a) Yagi Uda Antenna (b) Its Radiation Pattern

Here,

D - Director or Parasitic element

R - Reflector or Parasitic element

D_R- Driven element.

The current flowing through the director depends upon the voltage induced in the parasitic elements. The spacing between the driven element and parasitic element is approximately 0.1 λ (or) 0.15 λ.

The driven element is placed between two parasitic elements. The parasitic element in the back of the driven element is known as reflector and in front of the driven element is known as director. The length of director is approximately 0.45 λ and reflector is 0.55 λ. The length of director, reflector and parasitic element depends upon the frequency. The general expressions for 3-element Yagi-Uda antenna is,

Reflector length = $500/f(\text{MHz})$ feet

Director length = $455/f(\text{MHz})$ feet

Driven element length = $475/f(\text{MHz})$ feet

The length of parasitic element determines its reactance. If the length is equal or greater than $\lambda/2$, it will be inductive and less than $\lambda/2$ it will be capacitive.

(i) If the less than $\lambda/2$, the current lags the induced voltage.
(ii) If the length is greater than $\lambda/2$, the current leads the induced voltage.

Hence there is 180° phase difference between the parasitic elements, and therefore which can be analyzed as an end fire-array. Yagi-Uda antenna is also known as super gain antenna because the gain can be increased by adding a number of directors after the driven element. The distance between any two elements range from 0.1 λ to 0.3 λ. As the distance between the driven element and parasitic element reduces, the input impedance of driven element reduces.

3. List out the differences between the active and passive corner reflectors. What are retro reflectors?

Ans:

Backward radiations from an antenna can be eliminated by using plane conducting sheets as reflectors. When two flat sheets intersecting at an angle α are used as reflectors, then such an arrangement is called corner reflector. Corner reflectors are of two types. They are,

(i) Active corner reflector
(ii) Passive corner reflector.

(i) Active Corner Reflector

When two flat sheets intersecting at an angle $\alpha < 180°$ with a driven element producing a sharp radiation pattern, then such an arrangement is called active corner reflector. The opening of the corner or aperture should be in the range of 1λ to 2λ.

(ii)Passive corner reflector

When two metal sheets intersecting at an angle α = 90° without any driven element used, it reflects back the entire incident wave towards its source. Such an arrangement is called passive corner reflector. The main characteristic differences between an active and passive corner reflector are,

(a) Absence of driven element
(b) Angle of corner (α)
(c) Aperture length.

(a)Absence of driven element

There is no driven element present in passive corner reflector, hence spacing of the antenna from corner and relative width of the corner with antenna is not a concern.

(b)Angle of corner (α)

The angle of corner in passive corner reflector should always be equal to 90° (α = 90°) whereas in active corner reflector it can have any value satisfying the condition α < 180°, practically it can be $\alpha = 180^0 / n$ where *n* is any positive integer.

(c)Aperture Length

The passive corner reflector should have the aperture length equal to several wavelengths whereas in active corner reflector the aperture length should be limited up to λ or 2 λ.

Passive reflectors are used in radar applications and active corner reflectors are used in wide band applications.

Retro reflectors

A passive corner reflector is also called as retro corner reflector. It consists of 3-mutually perpendicular reflecting sheets intersecting each other at the centre producing eight 3-dimensional square-corner reflectors. Each square corner occupies one octant (5157 square degree) and 8 square corners occupies a full sphere solid angle of 41, 253 square degree. The cluster of 8 square corners together is called a Retro reflector. The maximum value of reflecting area is $\sqrt{3d}$^2 from any direction out of total area of $4d^2$. The retro reflector is used in radar applications. The metal sheets can be replaced with mesh having lengths equal to several λ and mesh holes λ/2 and surface should be flat in the vicinity of λ/16.

To improve the aperture area to 3/4 d^2 , the reflector is truncated along the diagonal lines, hence a uniform echo area is obtained.

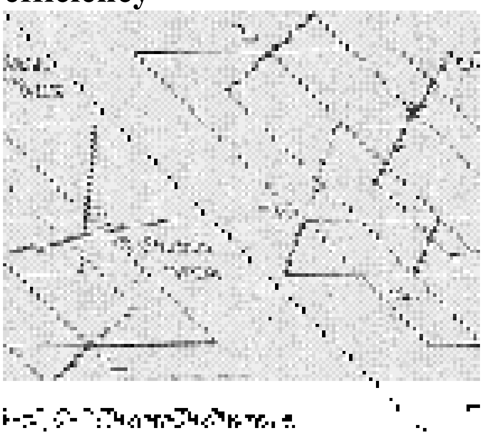
4. With reference to paraboloids, explain the following,

(i) Aperture efficiency

(ii) Front to back ratio

(iii) Types of feeds.

Ans:



(i) Aperture efficiency

"The Aperture efficiency (η) is defined as ratio of effective area of the primary antenna to the physical area of the reflector".

$$\eta = A_e / A_p$$

Where,

A_e = Effective aperture area

A_p = Physical area of reflector

η = Aperture efficiency.

Physical area, $A_p = \Pi D^2/4 = \Pi r^2$
Where, D – Diameter

(ii) Front to Back Ratio

Radiation pattern of paraboloids is a combination of front side radiation and back side radiation. Front to back ratio is defined as the ratio of power radiated in desired direction to the power radiated in opposite direction. Back radiation is a function of spill over and edges of diffraction.

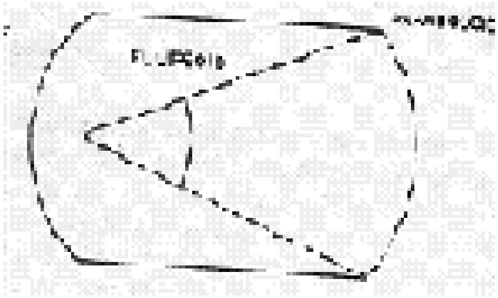


Fig 5 .2 Gregorian Feed

(iii) Types of Feeds

Feed systems are used to improve aperture efficiency and effective area. In paraboloid, feed systems are classified into,

(a) Cassegrain feed
(b) Gregorian feed
(c) Offset feed.

(a) Cassegrain Feed

Cassegrain principle is an optical technique widely used in telescope construction. The same principle is used to build cassegrain antenna used in microwave region. Cassegrain feed is a dual reflector system with the larger primary reflector having a parabolic surface and a secondary sub-reflector with a hyperbolic contour in order to achieve uniform illumination of the primary reflector. This arrangement is shown in the figure 5.4.1.

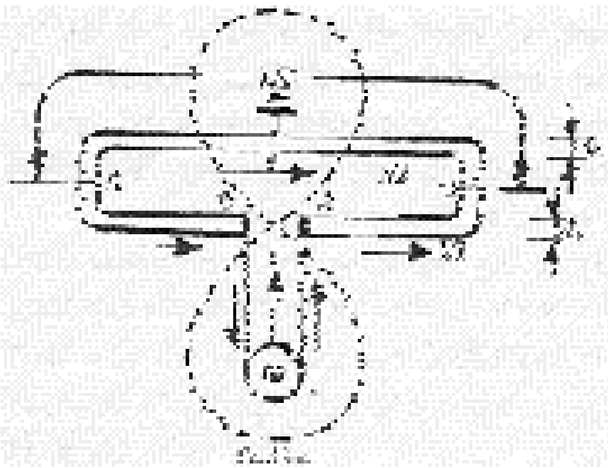
(b) Gregorian Feed

These forms are the variations from Cassegrain form which employ a different form of main reflectors and sub-reflectors. The convex, concave or even flat shapes may be used. A classical Gregorian reflector form is shown in figure 5.4.2.

Here the focal point of the main dish is moved to the region between the two dishes, a concave elliptical sub-reflector is used.

(c) Offset Feed

To overcome the disadvantage of Cassegrain feed we go for offset feed as shown in figure 5.4.3.



5. Write short notes on folded dipole?

Ans:

A very important variation of conventional half-wave dipole is the folded dipole. One of the application of the folded dipole is impedance matching. A folded dipole is made of two half-wave dipoles, one continuous and the other split at the centre. Both have been folded and joined together in parallel at the ends, as shown in Fig. 5.5.1. The split dipole is fed at the centre by a transmission line, which is balanced.

The radiation pattern of a folded dipole is same as the conventional half-wave dipole, but the input impedance of the former is higher. A folded dipole differs from the conventional dipole mainly in two aspects viz, directivity and broadness in bandwidth. The directivity of a folded dipole is bidirectional, but because of the distribution of currents in the parts of the folded dipole, the input impedance becomes higher. As the radii of the 2 conductors are equal, the current flow in the two dipoles are equal in magnitude and phase. As the total power developed in folded dipole is equal to that developed in a conventional dipole, the input terminal impedance of the folded dipole, is therefore greater than that of the conventional dipole. The input impedance at the terminals of the folded dipole antenna is equal to the square of the number of conductors comprising the antenna times the impedance at the terminals of a conventional dipole.

Advantages of Folded Dipole

Other than impedance matching or transformation, folded dipoles can be used in wide band operation such as televisions. The folded dipole has the following advantages,

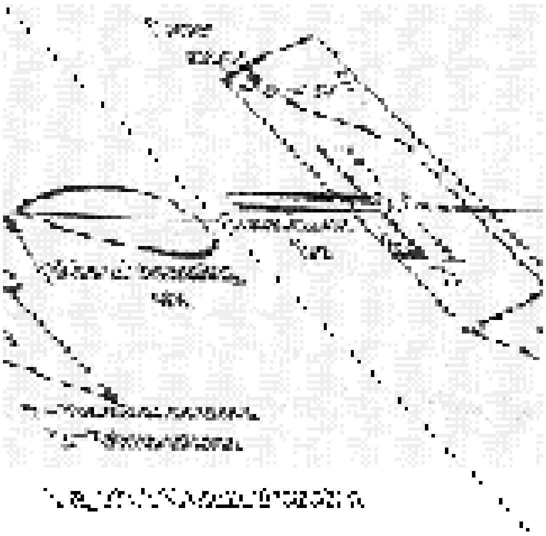
a. High input impedance
b. Wide band in frequency
c. Acts as a built-in reactance compensation network.

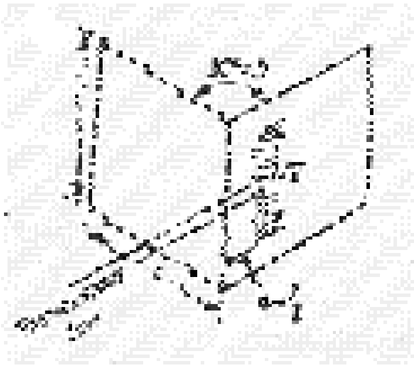
6. Write short notes on Corner Reflector Antenna?

Ans:

Corner reflector antenna

Comer reflector antenna is an arrangement with a corner reflector i.e., flat reflecting sheets meeting at an angle or corner, and a driven antenna, generally a half wave dipole as shown in Fig.5.6.1. If corner angle $\beta = 90°$ then the two flat sheets meeting at right angles form a square corner reflector shown in Fig.5.6.2.





When the driven antenna is used in conjunction with the corner reflector, the arrangement is an effective or active directional antenna for a wider range or corner, i.e. $0 < \beta < \Pi$. The square corner reflector without the driven antenna is an effective passive reflector over a wide range of angles of incidence ($0 < i < \pm\Pi/4$)

Applications

Corner reflectors are extensively used in applications like

(a) Television

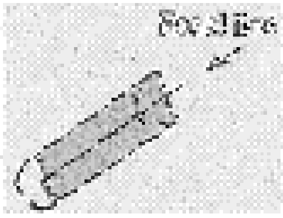
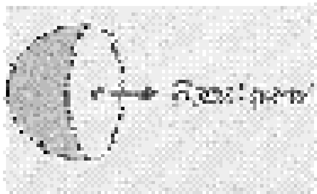
(b) Point to point communication

(c) Radio Astronomy.

The advantage of using corner reflector for these applications lies in the increased power gain of 10 to 13 db (10 to 20 times that of an isolated half wave dipole antenna with reasonable radiation resistance).

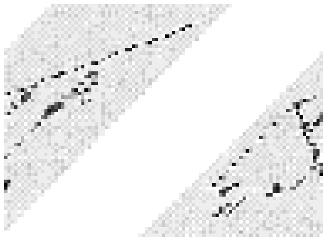
7. Distinguish between spherical and cylindrical paraboloids. Comment on their efficiency and applications.

Ans:

Cylindrical	**Spherical**
1. A cylindrical paraboloid is shown in the following figure. 	1. A spherical paraboloid is shown in the following figure. 
2. The most widely used feed for this paraboloid is a linear dipole, a linear array or a slotted waveguide.	2. The most widely used for this paraboloid is a pyramidal or conical horn.
3. The amplitude taper, is proportional to 1/p.	3. The amplitude taper, is proportional to $1/r^2$.
4. The focal region, where incident plane wave.	4. The focal region where incident plane wave converge is a point source (focal point).
5. No cross-polarized components are produced.	5. Cross-polarized components are produced.
6. Simpler to build.	6. Compared to cylindrical paraboloids, complex to build.
7. Provide larger aperture blockage.	7. Provide lesser aperture blockage.
8. Aperture efficiency, $\eta_a = (D\lambda^2/4\pi A)$	8. Aperture efficiency, $\eta_a = (D\lambda^2/4\pi A)$
9. This is used in, (i) Low – noise application as radio astronomy. (ii) Satellite ground based systems.	9. This is used in, (i) Radio astronomy. (ii) Small- earth station applications.

8. Compare corner reflector and parabolic reflector.

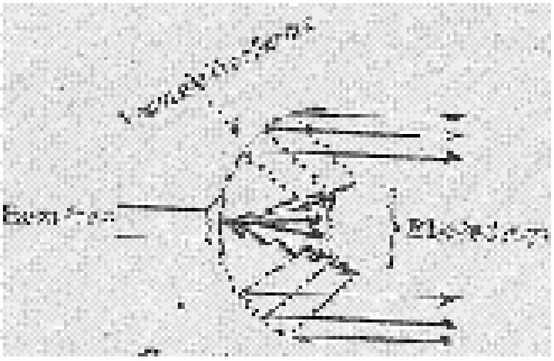
Ans:

Corner Reflector	Parabolic Reflector
1. The corner reflector consists of two flat conducting plates that meet at 'β' angle forming a corner as shown in the following figure. 	1. The parabolic reflector is formed by the revolution of parabola along its axis as shown in the following figure. 
2. The comer reflector does not need a directional feed as the direct and reflected rays are combined as per image theory.	2. This reflector should have a directional feed to avoid spill over, so that feed should be radiated maximum into parabolic surface.
3. There is no need to place feed at focal point perhaps, no focal point exists in this reflector.	3. Feed should be placed at focal point only, so that maximum radiation occurs on to the surface of reflector.
4. Corner reflectors are used for small apertures only.	4. Parabolic reflectors are used for both small and very large apertures.
5. The gain of corner reflectors depends on length of plates and ‘d’ at a particular ‘β’.	5. The gain of parabolic reflector depends on aperture ratio (D/λ) i.e., on focal points position.
6. Comer reflector antennas are simple and easy to build.	6. They are complex and costlier.
7. Corner reflector provides applications in radar field, stealth mode for military, and TV reception in homes.	7. These are widely used in radio astronomy.

9. With reference to paraboloids. Explain,
(i) Aperture blocking (ii) F/D ratio (iii) Spill over.
Ans:

(i) Aperture blocking

Aperture blocking is the undesirable phenomenon associated with a Cassegrain feed reflector where the primary reflector is obstructed by the sub-reflector.



If the dimensions of paraboloid are small, the effect of aperture blocking is significant. To minimize this, the sub-reflector should be small compared to the parabola. Aperture blocking can be eliminated by employing offset feed.

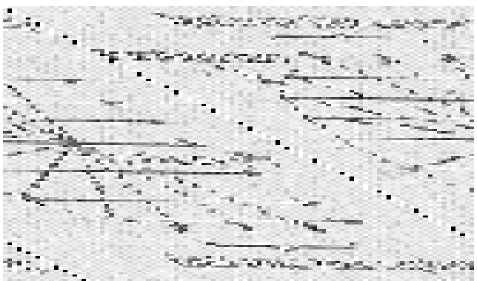
(ii) F/D Ratio

In the case of paraboloids, the ratio of focal length to dish diameter is referred as the F/D ratio. The F/D ratio exhibited by a paraboloid reflector with a diameter of 3 m and a focal length of 1.26 m is 0.42. The F/D ratio considered by the antenna designer also calculates the depth of the dish i.e., the amount of contour of the paraboloid within its fixed diameter. A high F/D (long focus) paraboloid reflector will have a shallow contour and where as a low F/D (short focus) paraboloid reflector represents a deep bowl. The minimum value of F/D ratio is 0.25, which places the focal point directly in the plane of the aperture antenna.

In antenna design, a small value of F/D ratio requires a feed horn that has a wider beam width and a large value of F/D ratio requires a feed horn that has a narrower beam width.

(iii) Spill Over

The waves originating from focus will be reflected parallel to the axis of parabola. Some of the waves originating from focus may not fall on the parabola. This phenomenon is called spill over.

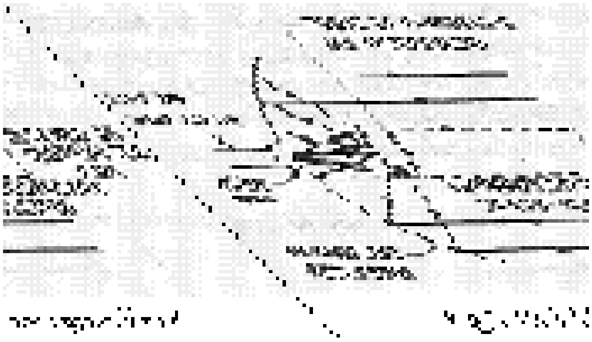


10. Explain the cassegrain mechanism in transmission mode. List out the advantages and disadvantages of cassegrain feed?

Ans:

Cassegrain feed

Cassegrain principle is an optical technique widely used in telescope construction. The same principle is used to build cassegrain antenna used in microwave region.



Cassegrain feed is a dual reflector system with the larger primary reflector having a parabolic surface and a secondary sub-reflector with a hyperbolic contour in order to achieve uniform illumination of the primary reflector. This arrangement is shown in the above figure 5.10.1.

One of the two foci of the hyperbola is the real focal point of the system. The feeder is located at this point which corresponds, to the vertex of the parabola. The other focus of the hyperbola is a virtual focal point and is located at the locus of the parabolic surface. A parallel beam of rays are reflected by the parabola as a convergent beam width which is re-reflected by the hyperbolic sub-reflector to make the beam convergent at the position of the feed.

Advantages of Cassegrain Feed Arrangement

1. The paraboloid surface is more uniformly illuminated.
2. There is less spill over reducing interface.
3. Shorter wave guide feed of the horn results in lower feed losses.
4. There is a greater reduction in side-lobe power.
5. The noise level is lower due to small cross-section.
6. There are lesser polarization errors.

Disadvantages

1. Design of the entire antenna system is with critical mechanical alignment and is complex.

Uses

1. Cassegrain feed arrangement is extensively used in Monopulse Radar.

2. Low noise temperature makes this antenna very important for radio astronomy, microwave communication and satellite tracking.