



# INSTITUTE OF ENGINEERING , CENTRAL CAMPUS,PULCHOWK

## PROPAGATION AND ANTENNA

### ASSIGNMENT #1

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# Propagation and Antenna

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# 1 Question -1

## Part 1. Q.3 Different Array Antennas

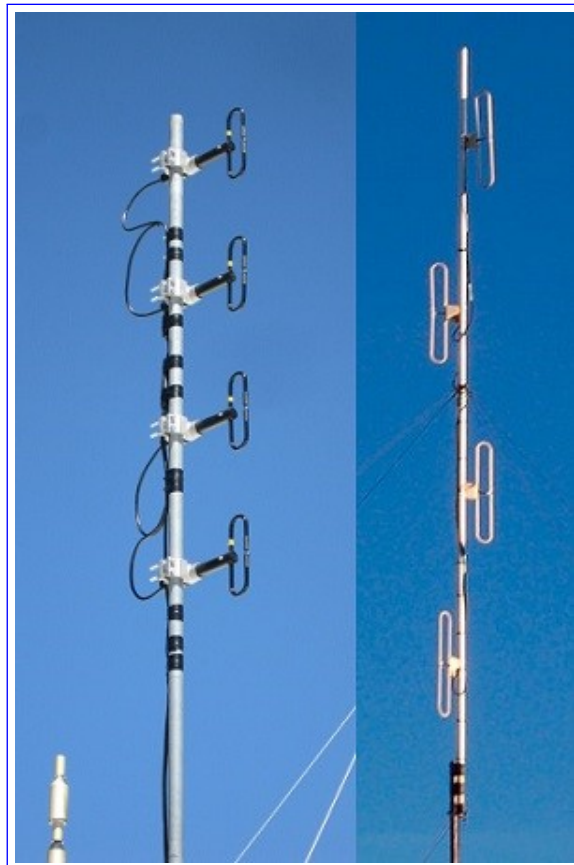
*Answer:*

Array antenna are the set of multiple antennas acting as the single antenna and placed closely to one another such that radiation pattern produced are vector sum of individual ones. These types of Array antenna increases signal strength, has high directivity, gain, signal to noise ratio however it also increases resistive losses and increase external space. Due to these properties Array antennas are widely used in satellite communication, wireless communication, astronomical study and in military radar too.

Different types of array antenna are explained below:-

### 1.1 Collinear array

When two or more dipole antennas are vertically stacked in such a way that their corresponding elements are parallel and collinear with each other, it is called a collinear antenna array.



*Figure 1: Collinear Array Antenna*

A Collinear array consists of two or more half-wave dipoles, which are placed end to end. These antennas are placed on a common line or axis, being parallel or collinear. The frequency range in which the collinear array antennas operate is around 30 MHz to 3GHz which belong to the VHF and UHF bands. These collinear arrays are uni-directional antennas having high gain. The main purpose of this

array is to increase the power radiated and to provide high directional beam, by avoiding power loss in other directions. The antennas are mounted in such a way that every element of each antenna is in an extension of other antenna stacked upon it.

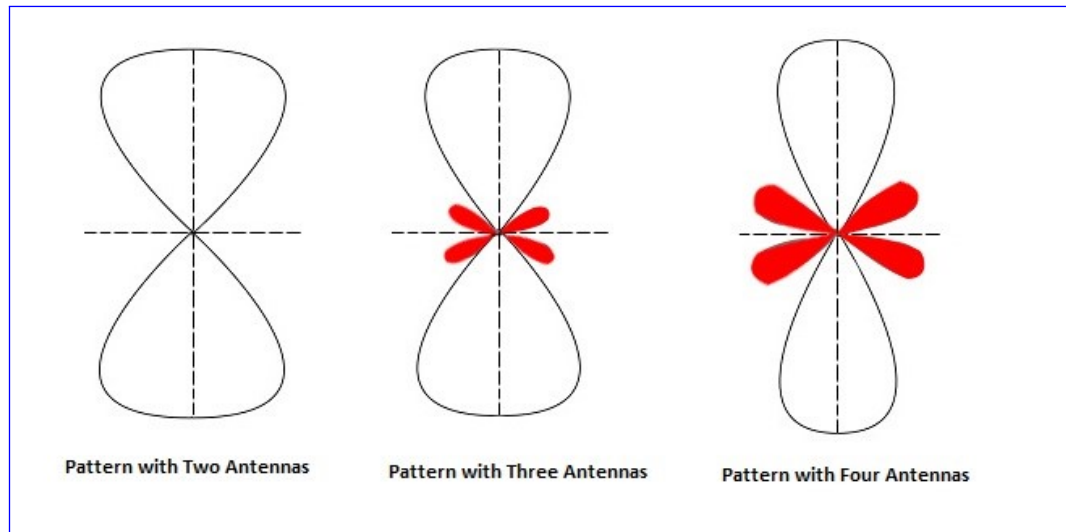


Figure 2: Radiation Pattern of Collinear Array Antenna

Collinear Array antenna increases directivity, power wastage is reduced, however it can be placed outdoor only. Due to these features it is used in UHF and VHF bands and Broadcasting purpose.

## 1.2 Broad side array

A broadside array is a type of antenna array which is used to radiate the energy in specific direction to make better transmission. The broadside array is defined as the radiation pattern's direction is perpendicular or broadside to the array axis. It uses the dipole elements that are fed in phase and separated by the one-half wave length. It is a bidirectional array which can send and receive process at both ends (sending and receiving end).

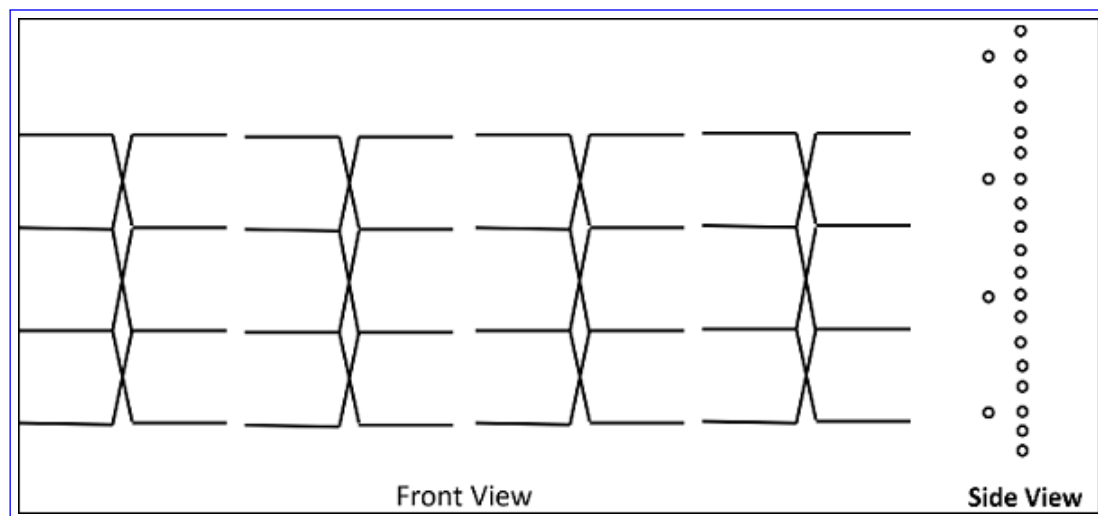


Figure 3: Front and side view Broad Side Array

The antenna array in its simplest form, having a number of elements of equal size, equally spaced along a straight line or axis, forming collinear points, with all dipoles in the same phase, from the same source together form the broad side array. Typical antenna lengths in the broad side array are from 2 to 10 wavelengths. Typical spacings are  $\lambda/2$  or  $\lambda$ . The broad side array is strongly directional at right angles to the plane of the array. However, the radiation in the plane will be very less because of the cancellation in the direction joining the center.

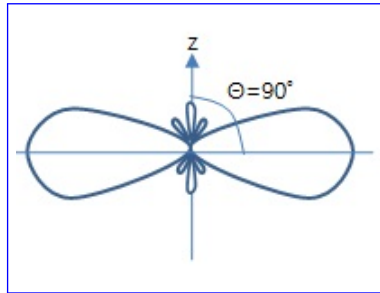


Figure 4: Radiation Pattern of Broad size array

The radiation pattern of this antenna is bi-directional and right angles to the plane. The beam is very narrow with high gain.

### 1.3 End fire array

An end-fire array is an array that gives a radiation pattern whose main beam is along the axis of the array.

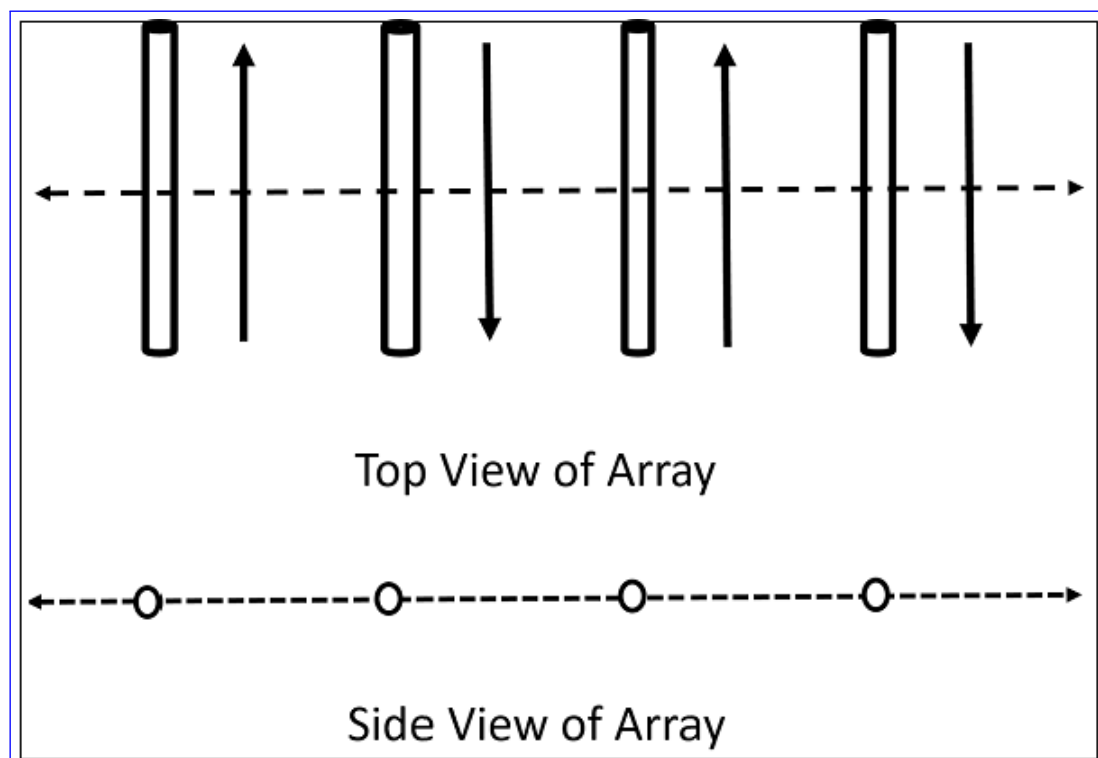


Figure 5: Top and side view from End fire array

In a wider sense, the end-fire array is a linear or planar antenna whose direction of maximum radiation is along the line or in the plane of the array. In End fire array,

all elements are equally spaced along the array axis and fed with current of equal magnitude but their phases are different.

The radiation pattern of the broadside array is Unidirectional. A major lobe occurs at one end, where maximum radiation is present, while the minor lobes represent the losses

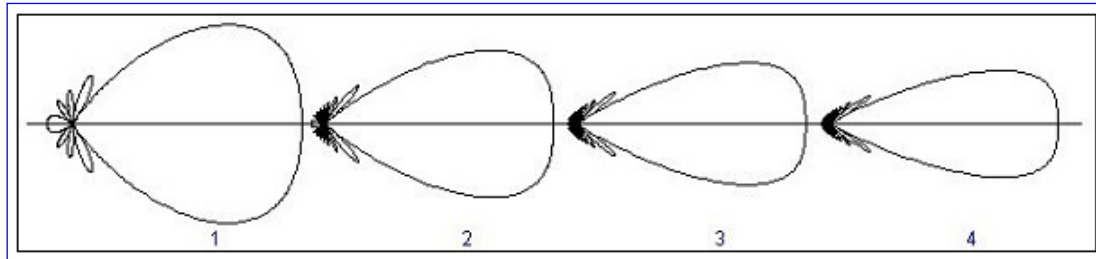


Figure 6: Radiation Pattern of End fire array

Both end fire and broad side array are linear , has narrow beam and used for transmission purposes only.

#### 1.4 Parasitic array

A PARASITIC ARRAY consists of one or more parasitic elements with a driven element. Parasitic are those which do not possess an electrical connection between them to the driven element or the feed and positioned so that they lie in the induction field of the driven element. The dipole that is connected to the feed is known as a driven element.

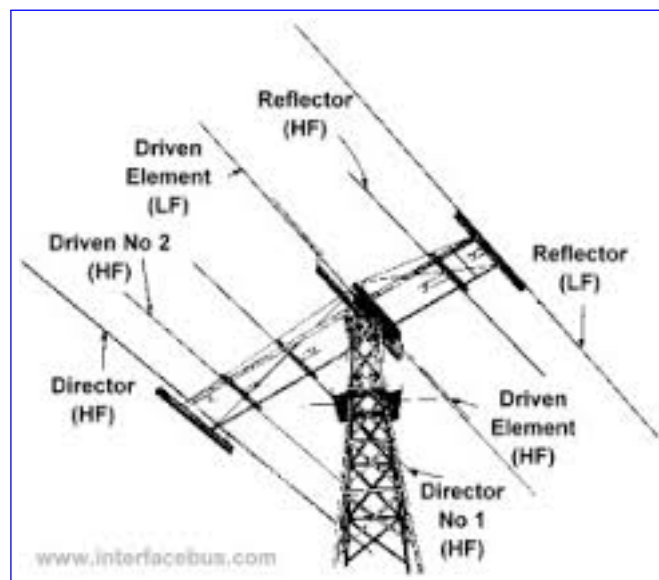


Figure 7: Parasitic Array

The amount of power gain and directivity depends on the lengths of the parasitic elements and the spacing between them. The arrays are used at frequencies ranging from 2MHz to several GHz. These are especially used to get high directivity, and better forward gain with a uni-directional.

## 1.5 Yagi-Uda array

A Yagi antenna or a Yagi-Uda antenna, is a directional antenna that radiates signals in one main direction.

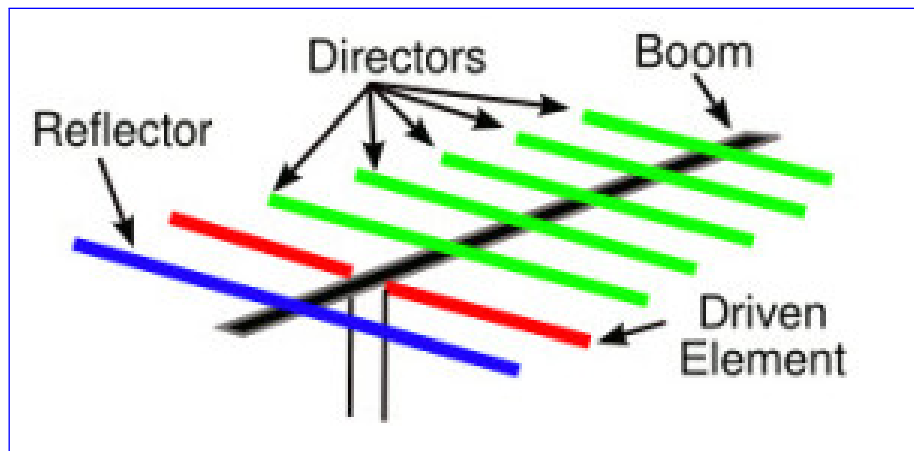


Figure 8: Yagi-Uda array Antenna

It consists of a long transmission line with a single driven element consisting of two rods connected on either side of the transmission line. It also consists of a single reflector on one side of the transmission line and a number of parasitic elements which act as directors. The driven element of a Yagi is equivalent of a center-fed, half-wave dipole antenna. Parallel to the driven element are straight rods or wires called reflectors and directors. A reflector is placed behind the driven element and is slightly longer than driven element; a director is placed in front of the driven element and is slightly shorter than driven element. A typical Yagi antenna has one reflector and one or more directors.

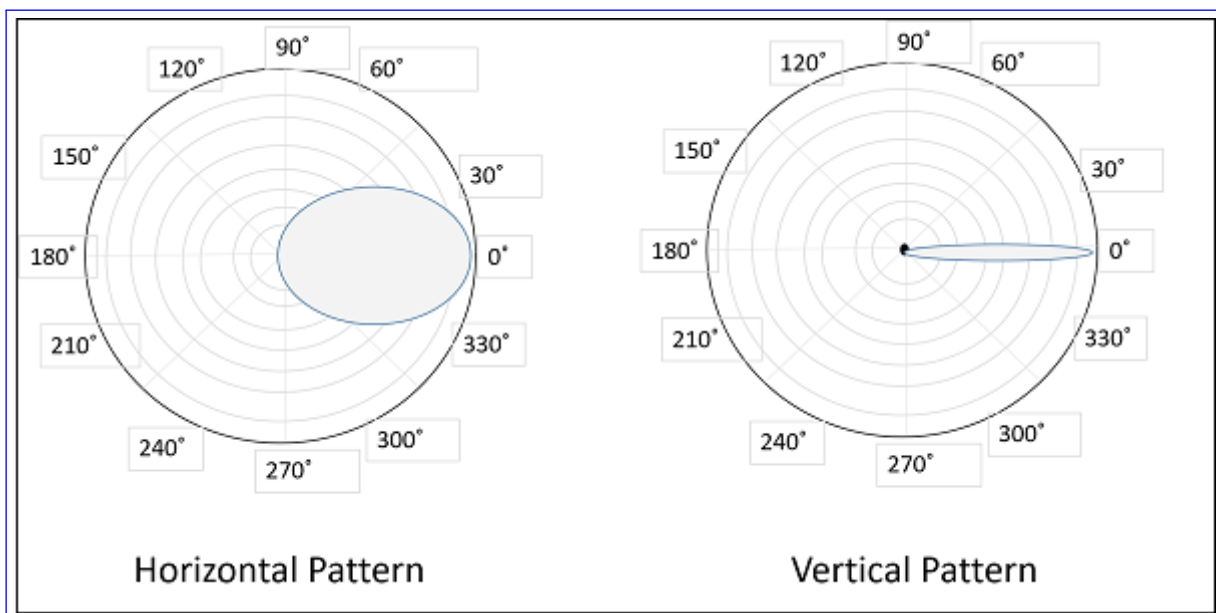


Figure 9: Horizontal and vertical Radiation pattern of Yagi-Uda array

Yagi-Uda antennas have high gain, less power wastage, high directivity and cover a broad range of frequencies. However, they are prone to noise and atmospheric effects. So, they are mostly used in TV reception and single frequency applications.



## 1.6 Log-periodic array

One form of antenna that is able to provide gain and directivity along with a wide bandwidth is known as the log periodic antenna. Although larger than an equivalent Yagi or other directive design for an equivalent level of gain, it provides the capability to operate on many different frequencies.



*Figure 10: Log-periodic Antenna*

A log-periodic antenna is a group of dipole antennas of varying sizes strung together and fed alternately through a common transmission line. The dipole antennas diminish in size from the back to the front. The element at the back of the array which is the largest, acts as a half wave dipole at the lowest frequency and that at the front is a half wavelength at the highest frequency of operation. This unique configuration, enables Log-periodic antennas to have wide bandwidths. The frequency range, in which the log-periodic antennas operate is around 30 MHz to 3GHz which belong to the VHF and UHF bands. There are several type of log-periodic antennas such as the planar, trapezoidal, zig-zag, V-type, slot and the dipole.

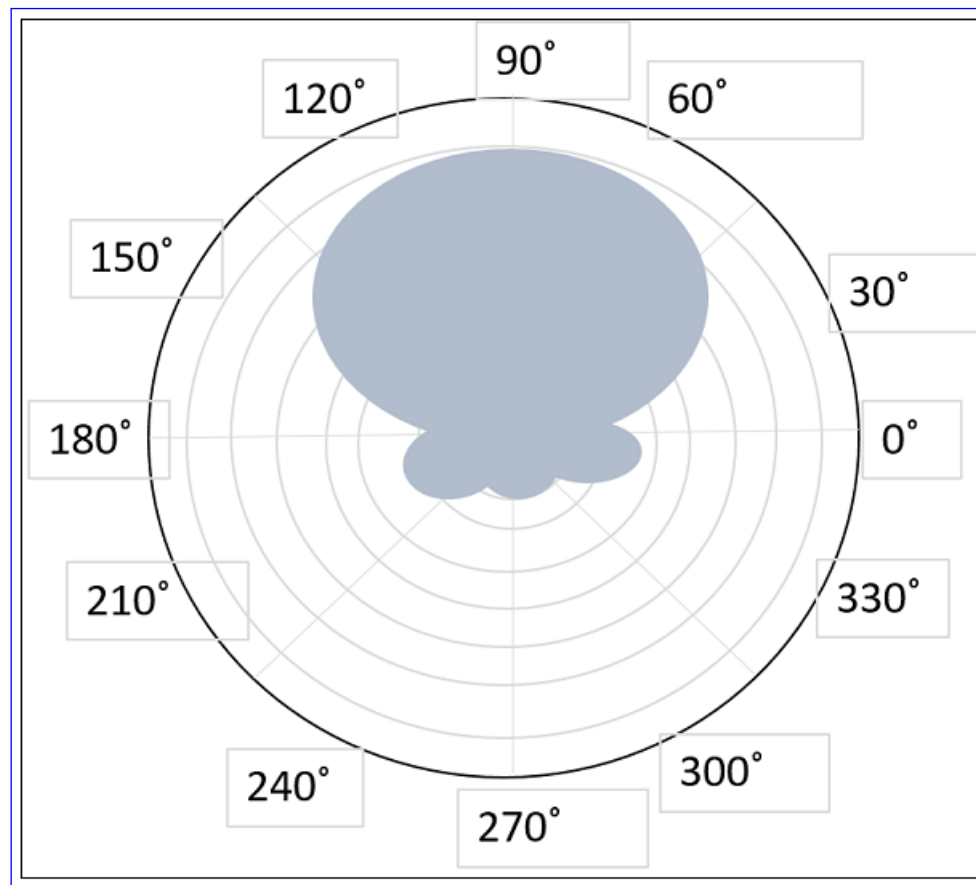


Figure 11: Radiation pattern of Log- periodic antenna

Log-periodic has compact design and the gain and radiation pattern can be tuned as per requirement. The installation cost is high and it has to be external mount. It is used in HF communication and particular TV reception and also used for all round monitoring in higher frequency bands.

## 2 Question -2

**Part 2. Q.3 List out the major parameters of the antenna. Define four of them with mathematical expression if necessary. Sketch symmetrical gregorian type antenna.**

*Answer:*

Some of the major parameters of antenna are defined below:-

### 2.1 Directivity

The ratio of maximum radiation intensity of the subject antenna to the radiation intensity of an isotropic or reference antenna, radiating the same total power is called the directivity. Directivity is a dimensionless ratio and may be expressed numerically or in decibels (dB). Its radiation intensity is focused in a particular direction, while it is transmitting or receiving. Hence, the antenna is said to have its directivity in that particular direction. If that particular direction is not specified, then the direction in which maximum intensity is observed, can be taken as the directivity of that antenna. The directivity of a non-isotropic antenna is equal to the ratio of

the radiation intensity in a given direction to the radiation intensity of the isotropic source.

**Mathematically,**

$$\text{Directivity} = \frac{\text{Maximum radiation intensity of subject antenna}}{\text{Radiation intensity of an isotropic antenna}}$$

$$D = \frac{\phi(\theta, \phi)_{\max}(\text{from subject antenna})}{\phi_0(\text{from an isotropic antenna})}$$

Where,

$\phi(\theta, \phi)_{\max}$  is the maximum radiation intensity of subject antenna.

$\phi_0$  is the radiation intensity of an isotropic antenna (antenna with zero losses).

## 2.2 Aperture efficiency

Aperture efficiency of an antenna, is the ratio of the effective radiating area (or effective area) to the physical area of the aperture. An antenna has an aperture through which the power is radiated. This radiation should be effective with minimum losses. The physical area of the aperture should also be taken into consideration, as the effectiveness of the radiation depends upon the area of the aperture, physically on the antenna.

**Mathematically,**

$$\epsilon_A = \frac{A_{eff}}{A_p}$$

Where,

$\epsilon_A$  is Aperture Efficiency.

$A_{eff}$  is effective area.

$A_p$  is physical area.

## 2.3 Antenna Efficiency

Antenna Efficiency is the ratio of the radiated power of the antenna to the input power accepted by the antenna. Simply, an Antenna is meant to radiate power given at its input, with minimum losses. The efficiency of an antenna explains how much an antenna is able to deliver its output effectively with minimum losses in the transmission line. This is otherwise called as Radiation Efficiency Factor of the antenna.

**Mathematically,**

$$\eta_e = \frac{P_{rad}}{P_{input}}$$

Where,

$\eta_e$  is the antenna efficiency.

$P_{rad}$  is the antenna efficiency.

$P_{input}$  is the input power for the antenna.

## 2.4 Gain

Gain of an antenna is the ratio of the radiation intensity in a given direction to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically. Simply, gain of an antenna takes the directivity of antenna into account along with its effective performance. If the power accepted by the antenna was radiated isotropically (that means in all directions), then the radiation intensity we get can be taken as a referential. It describe how much power is transmitted in the direction of peak radiation to that of an isotropic source. Its unit is **dB**

**Mathematically,**

$$G = \eta_e D$$

Where,

$G$  is the antenna efficiency.

$\eta_e$  is the antenna efficiency.

$D$  is the input power for the antenna.

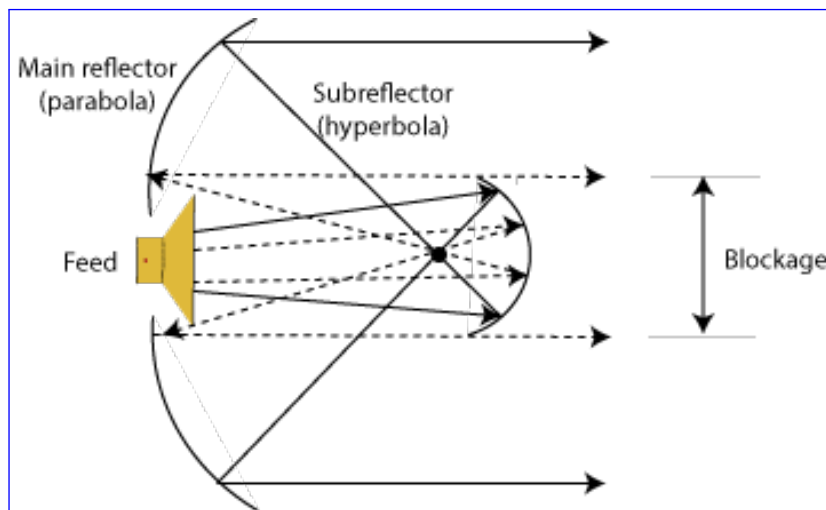


Figure 12: Gregorian Type Antenna with Concave reflector