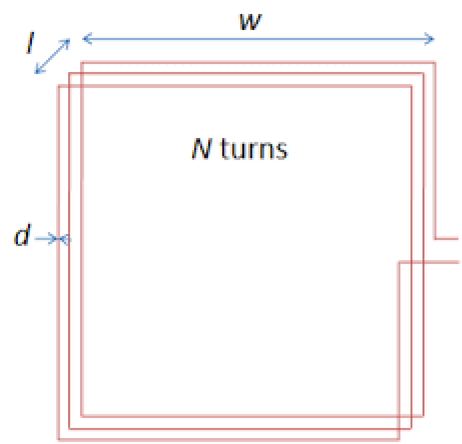
3.1Loop Antennas

All antennas used radiating elements that were linear conductors. It is also possible to make antennas from conductors formed into closed loops. Thereare two broad categories of loop antennas:



1. Small loops which contain no morethan 0.086λ wavelength,s of wire

2. Large loops, which contain approximately 1 wavelength of wire.

Loop antennas have the same desirable characteristics as dipoles and monopoles in that they areinexpensive and simple to construct. Loop antennas come in a variety of shapes (circular,rectangular, elliptical, etc.) but the fundamental characteristics of the loop antenna radiationpattern (far field) are largely independent of the loop shape.Just as the electrical length of the dipoles and monopoles effect the efficiency of these antennas,the electrical size of the loop (circumference) determines the efficiency of the loop antenna.Loop antennas are usually classified as either electrically small or electrically large based on thecircumference of the loop.

electrically small loop = circumference λ/10

electrically large loop - circumference λ

The electrically small loop antenna is the dual antenna to the electrically short dipole antenna. That is, the far-field electric field of a small loop antenna isidentical to the far-field magnetic field of the short dipole antenna and the far-field magneticfield of a small loop antenna is identical to the far-field electric field of the short dipole antenna.

Advantages

1. A small loop is generally used as magnetic dipole.

2. A loop antenna has directional properties whereas a simple vertical antenna not has the same.

3. The induced e.m.f around the loop must be equal to the difference between the two vertical sidesonly.

4. No e.m.f is produced in case of horizontal arms of a loop antenna.

5. The radiation pattern of the loop antenna does not depend upon the shape of the loop (for smallloops).

6. The currents are at same magnitude and phase, throughout the loop.

Disadvantages

1. Transmission efficiency of the loop is very poor.

2. It is suitable for low and medium frequencies and not for high frequencies.

3. In loop antenna, the two nulls of the pattern result in 180° ambiguity.

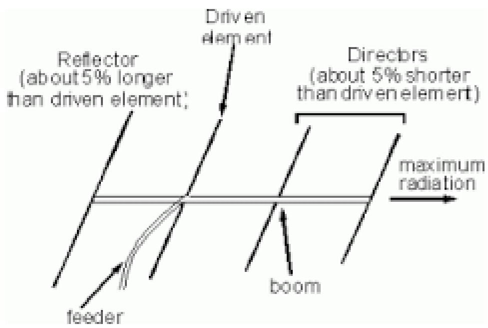
4. Loop antennas used as direction finders are unable to distinguish between bearing of a distanttransmitter and its reciprocal bearing

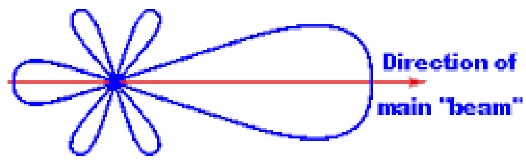
3.2 Yagi-Uda Array

A Yagi-Uda array is an example of a parasitic array. Any element inan array which is not connected to the source (in the case of a transmitting antenna) or thereceiver (in the case of a receiving antenna) is defined as a parasitic element. A parasitic array isany array which employs parasitic elements. The general form of the N-element Yagi-Uda array isshown below.

Driven element - usually a resonant dipole or folded dipole.), folded dipoles are employed as driven elements to increase the array input impedance

Reflector - slightly longer than the driven element so that it isinductive (its current lags that of the driven element).Approximately 5 to 10 % longer than the driven element.
Director - slightly shorter than the driven element so that it iscapacitive (its current leads that of the driven element).Approximately 10 to 20 % shorter than the driven element), not necessarily uniform.





Advantages

1. Lightweight, Low cost

2.Simple construction

3.Unidirectional beam (front-to-back ratio)

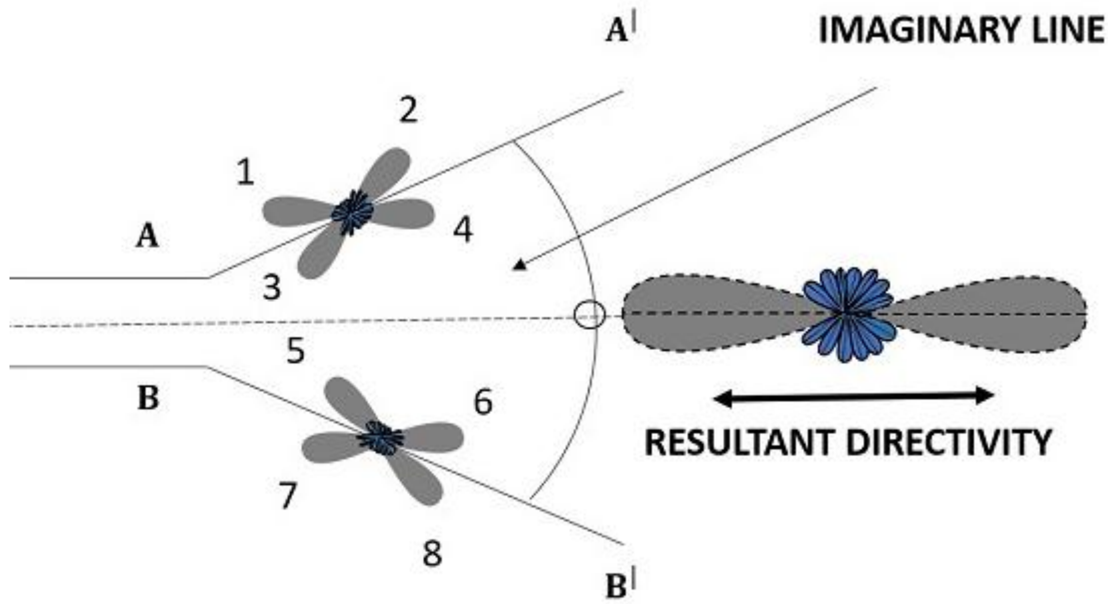
4.Increased directivity over other simple wire antennas

5.Practical for use at HF (3-30 MHz), VHF (30-300 MHz), andUHF (300 MHz - 3 GHz)

Reflector spacing 0.1 to 0.258

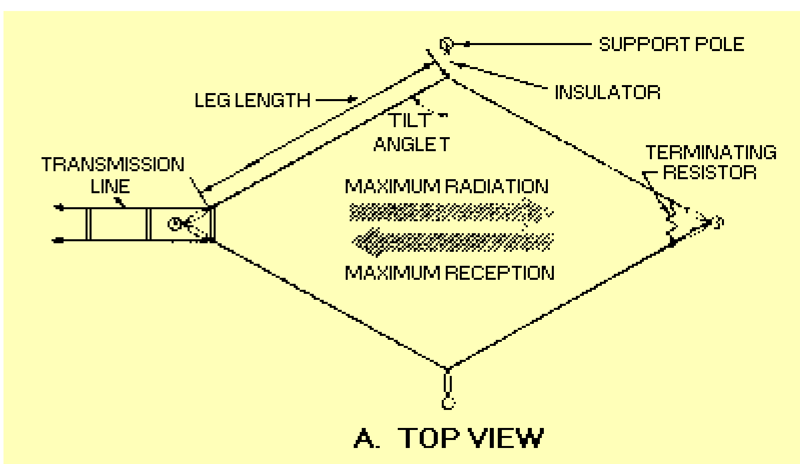
3.3 Vee Traveling Wave Antenna

The main beam of single electrically long wire guiding waves in one direction (traveling wave segment) was found to be inclined at an angle relative to the axis of the wire. Traveling wave antennas are typically formed by multiple traveling wave segments. These traveling wave segments can be oriented such that the main beams of the component wires combine to enhance the directivity of the overall antenna. A vee traveling wave antenna is formed by connecting two matched traveling wave segments to the end of a transmission line feed at an angle of 22degrees relative



3.4 Rhombic Antenna

The highest development of the long-wire antenna is the RHOMBIC ANTENNA . It consists of four conductors joined to form a rhombus, or diamond shape. The antenna is placed end to end and terminated by a noninductive resistor to produce a uni-directional pattern. A rhombic antenna can be made of two obtuse-angle V antennas that are placed side by side, erected in a horizontal plane, and terminated so the antenna is non resonant and unidirectional.



The rhombic antenna is widely used for long-distance, high-frequency transmission and reception. It is one of the most popular fixed-station antennas because it is very useful in point-to-point communication.

Radiation Patterns

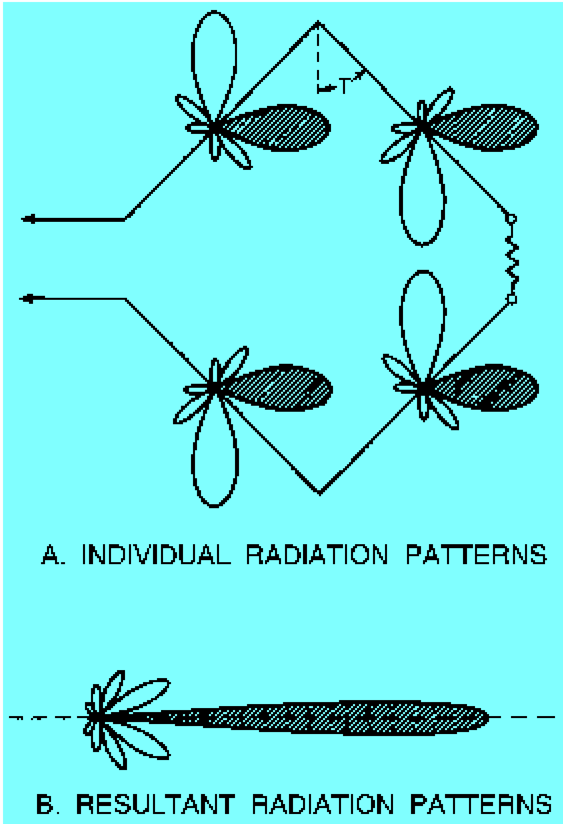


Figure a. shows the individual radiation patterns produced by the four legs of the rhombic antenna and the resultant radiation pattern. The principle of operation is the same as for the V and the half-rhombic antennas. Figure b. Formation of a rhombic antenna beam.

Advantages

- The input impedance and radiation pattern of rhombic antenna do not change rapidly over a considerable frequency range.
- It is highly directional broad band antenna with greatest radiated or received power along the main axis.
- Simple and cheap to erect
- Low weight

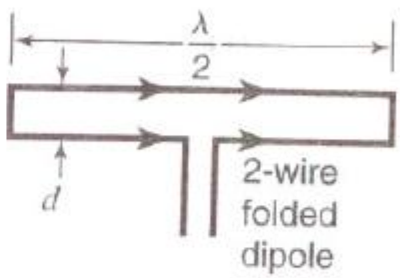
Disadvantages

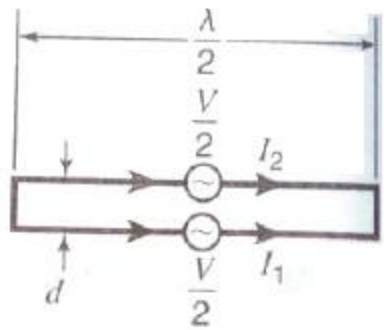
- It needs a larger space for installation

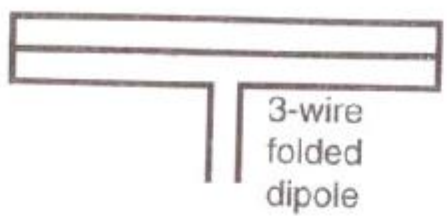
- Due to minor lobes, transmission efficiency is low

3.5 Folded Dipole:

A folded dipole is a dipole antenna with the ends folded back around and connected to each other, forming a loop as shown in Figure. It turns out the impedance of the folded dipole antenna will be a function of the impedance of a transmission line of length L/2. Also, because the folded dipole is "folded" back on itself, the currents can reinforce each other instead of cancelling each other out, so the input impedance will also depend on the impedance of a dipole antenna of length L.







The input impedance for a dipole is 73 Ω. Hence for a folded dipole with 2 arms the radiation resitance is 2* 73Ω= 292Ω. If 3 arms are used the resistance will be 3^2 * 73Ω = 657Ω

Advantages

- High input impedance
- Wide band in frequency
- Acts as built in reactance compensation network

Uses:

Folded dipole is used in conjunction with parasitic elements in wide band operation such as television. In this application, in the yagi antenna, the driven element is folded dipole and remaining are reflector and director

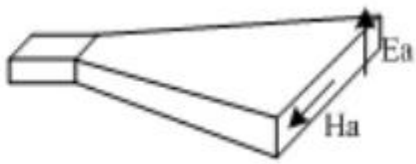
3.6 Horn Antennas

Horn antennas are popular in the microwave band (above 1 GHz). Horns provide high gain, low VSWR (with waveguide feeds), relatively widebandwidth, and they are not difficult to make. The horns can be also flared exponentially. This provides better matching ina broad frequency band, but is technologically more difficult and expensive.The rectangular horns are ideally suited for rectangular waveguide feeders.The horn acts as a gradual transition from a waveguide mode to a free-spacemode of the EM wave. When the feeder is a cylindrical waveguide, the antenna is usually a conical horn.

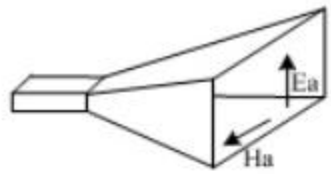
Types of the horn antennas as - Plane Sectoral Horn - Plane Sectoral Horn - Pyramidal and Conical Horn These horns are fed by a rectangular waveguide oriented its broad wall horizontal.

If flaring is done only in one direction, then it is called sectoral horn.Flaring in the direction of E and H, the sectoral E-plane and sectoral H plane are obtained respectively.If flaring is done along both the walls (E&H),then pyramidal horn is obtained.

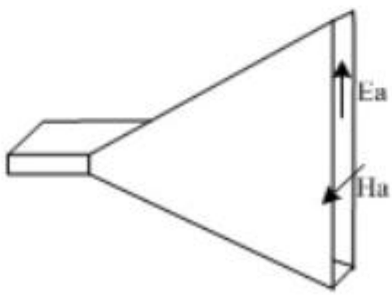
Horn antenna emphasizes traveling waves leads to wide bandwidth and low VSWR. Because of longer path length from connecting waveguide to horn edge, phase delay across aperture causes phase error. Dielectric or metallic plate lens in the aperture are used to correct phase error. Those with metallic ridges increase the bandwidth. Horns are also used for a feed of reflector antennas.



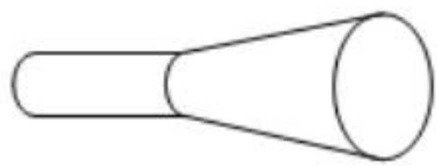
H-plane sectoral horn



Pyramidal horn



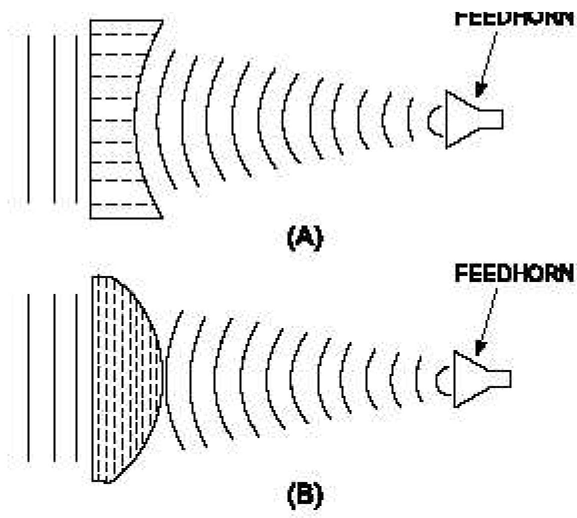
E-plane sectoral horn


Conical Horn Antenna

3.7 LENS ANTENNA:

Another antenna that can change spherical waves into flat plane waves is the lens antenna. This antenna uses a microwave lens, which is similar to an optical lens to straighten the spherical wavefronts. Since this type of antenna uses a lens to straighten the wavefronts, its design is based on the laws of refraction, rather than reflection.

Two types of lenses have been developed to provide a plane-wavefront narrow beam for tracking radars, while avoiding the problems associated with the feedhorn shadow. These are the conducting (acceleration) type and the dielectric (delay) type.



The lens of an antenna is substantially transparent to microwave energy that passes through it. It will, however, cause the waves of energy to be either converged or diverged as they exit the lens. This type of lens consists of flat metal strips placed parallel to the electric field of the wave and spaced slightly in excess of one-half of a wavelength. To the wave these strips look like parallel waveguides. The velocity of phase propagation of a wave is greater in a waveguide than in air. Thus, since the lens is concave, the outer portions of the transmitted spherical waves are accelerated for a longer interval of time than the inner

Advantages :

1. The lens antenna, feed and feed support do not block the aperture as the rays are transmitted away from the feed
2. It has greater design tolerance
3.It can be used to feed the optical axis and hence useful in applications where a beam is required to be moved angularly with respect to the axis.

3.8 Parobolic Reflector Antenna

A parabolic antenna is an antenna that uses a parabolic reflector, a curved surface with the cross-sectional shape of aparabola, to direct the radio waves. The most common form is shaped like a dish and is popularly called a dish antennaor parabolic dish. The main advantage of a parabolic antenna is that it has high directivity. It functions similarly to a search light or flashlight reflector to direct the radio waves in a narrow beam, or receive radio waves from one particular direction only. Parabolic antennas have some of the highest gains, that is, they can produce the narrowest beamwidths, of any antenna type. In order to achieve narrow beam widths, the parabolic reflector must be much larger than thewavelength of the radio waves used,so parabolic antennas are used in the high frequency part of the radio spectrum, at UHF and microwave (SHF) frequencies, at which the wavelengths are small enough that conveniently-sized reflectors can be used.

Parabolic reflector basics

The RF antenna consists of a radiating system that is used to illuminate a reflector that is curved in the form of a paraboloid. A parabolic shape has the property that paths taken from the feed point at the focus to the reflector and then outwards are in parallel, but more importantly the paths taken are all the same length and therefore the outgoing waveform will form a plane wave and the energy taken by all paths will all be in phase.

This shape enables a very accurate beam to be obtained. In this way, the feed system forms the actual radiating section of the antenna, and the reflecting parabolic surface is purely passive.

When looking at parabolic reflector antenna systems there are a number of parameters and terms that are of importance:

•**Focus:** The focus or focal point of the parabolic reflector is the point at which any incoming signals are concentrated. When radiating from this point the signals will be reflected by the reflecting surface and travel in a parallel beam and to provide the required gain and beam width.

•**Vertex:** This is the innermost point at the centre of the parabolic reflector.

•**Focal length**: The focal length of a parabolic antenna is the distance from its focus to its vertex. Read more about the focal length

Design

The operating principle of a parabolic antenna is that a point source of radio waves at the focal point in front of a paraboloidal reflector of conductive material will be reflected into a collimated plane wave beam along the axis of the reflector. Conversely, an incoming plane wave parallel to the axis will be focused to a point at the focal point.

A typical parabolic antenna consists of a metal parabolic reflector with a small feed antenna suspended in front of the reflector at its focus, pointed back toward the reflector. The reflector is a metallic surface formed into a paraboloid of revolution and usually truncated in a circular rim that forms the diameter of the antenna. In a transmitting antenna, radio frequency current from a transmitter is supplied through a transmission line cable to the feed antenna, which converts it into radio waves. The radio waves are emitted back toward the dish by the feed antenna and reflect off the dish into a parallel beam. In a receiving antenna the incoming radio waves bounce off the dish and are focused to a point at the feed antenna, which converts them to electric currents which travel through a transmission line to the radio receiver.

Advantages:

- ***High gain:*** Parabolic reflector antennas are able to provide very high levels of gain. The larger the 'dish' in terms of wavelengths, the higher the gain.
- ***High directivity:*** As with the gain, so too the parabolic reflector or dish antenna is able to provide high levels of directivity. The higher the gain, the narrower the beamwidth. This can be a significant advantage in applications where the power is only required to be directed over a small area. This can prevent it, for example causing interference to other users, and this is important when communicating with satellites because it enables satellites using the same frequency bands to be separated by distance or more particularly by angle at the antenna.

Disadvantages:

Like all forms of antenna, the parabolic reflector has its, limitations and drawbacks:

- ***Requires reflector and drive element:*** the parabolic reflector itself is only part of the antenna. It requires a feed system to be placed at the focus of the parabolic reflector.
- ***Cost :*** The antenna needs to be manufactured with care. A paraboloid is needed to reflect the radio signals which must be made carefully. In addition to this a feed system is also required. This can add cost to the system

- ***Size:*** The antenna is not as small as some types of antenna, although many used for satellite television reception are quite compact.

Parabolic reflector antenna applications

There are many areas in which the parabolic / dish antenna may be used. Its performance enables it to be used almost exclusively in some areas.

- **Direct broadcast television:** Direct broadcast or satellite television has become a major form of distribution for television material. The wide and controllable coverage areas available combined with the much larger bandwidths for more channels available mean that satellite television is very attractive.

Microwave links: T

- **Satellite communications:** Many satellite uplinks, or those for communication satellites require high levels of gain to ensure the optimum signal conditions and that transmitted power from the ground does not affect other satellites in close angular proximity. Again the ideal antenna for most applications is the parabolic reflector antenna.
- **Radio astronomy:** Radio astronomy is an area where very high levels of gain and directivity are required. Accordingly the

- **Aperture** : The aperture of a parabolic reflector is what may be termed its "opening" or the area which it covers. For a circular reflector, this is described by its diameter. It can be likened to the aperture of an optical lens.
- **Gain:** The gain of the parabolic reflector is one of the key parameters and it depends on a number of factors including the diameter of the dish, wavelength and other factors.
- **Feed systems**: The parabolic reflector or dish antenna can be fed in a variety of ways. Axial or front feed, off axis, Cassegrain, and Gregorian are the four main methods.Read more about Parabolic reflector feed types.

Parabolic reflector feed types

There are several different types of parabolic reflector feed systems that can be used. Each has its own characteristics that can be matched to the requirements of the application.

- Focal feed - often also known as axial or front feed system
- Cassegrain feed system
- Gregorian feed system
- Off Axis or offset feed

Focal feed system

The parabolic reflector or dish antenna consists of a radiating element which may be a simple dipole or a waveguide horn antenna. This is placed at the focal point of the parabolic reflecting surface. The energy from the radiating element is arranged so that it illuminates the reflecting surface. Once the energy is reflected it leaves the antenna system in a narrow beam. As a result considerable levels of gain can be achieved.

Achieving this is not always easy because it is dependent upon the radiator that is used. For lower frequencies a dipole element is often employed whereas at higher frequencies a circular waveguide may be used. In fact the circular waveguide provides one of the optimum sources of illumination.

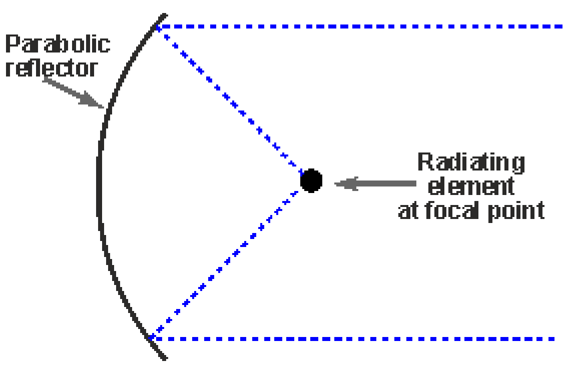


Diagram of a focal feed parabolic reflector antenna

The focal feed system is one of the most widely used feed system for larger parabolic reflector antennas as it is straightforward. The major disadvantage is that the feed and its supports block some of the beam, and this typically limits the aperture efficiency to only about 55 to 60%.

Cassegrain feed system

The Cassegrain feed system, although requiring a second reflecting surface has the advantage that the overall length of the dish antenna between the two reflectors is shorter than the length between the radiating element and the parabolic reflector. This is because there is a reflection in the focusing of the signal which shortens the physical length. This can be an advantage in some systems.

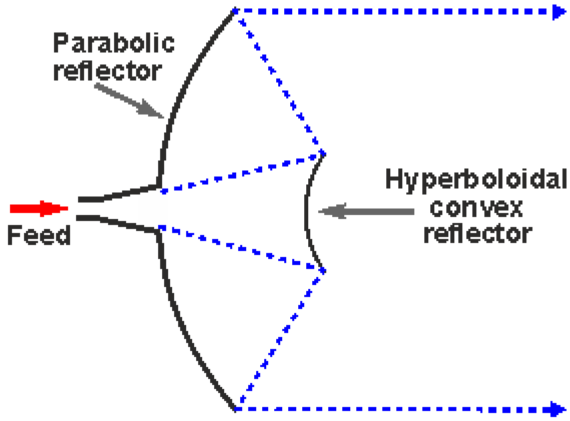


Diagram of a Cassegrain feed parabolic reflector or dish antenna

Typical efficiency levels of 65 to 70% can be achieved using this form of parabolic reflector feed system.The Cassegrain parabolic reflector antenna design and feed system gains its name because the basic concept was adapted from the Cassegrain telescope. This was reflecting telescope which was developed around 1672 and attributed to French priest Laurent Cassegrain.

Gregorian parabolic reflector feed

The Gregorian parabolic reflector feed technique is very similar to the Cassegrain design. The major difference is that except that the secondary reflector is concave or more correctly ellipsoidal in shape.

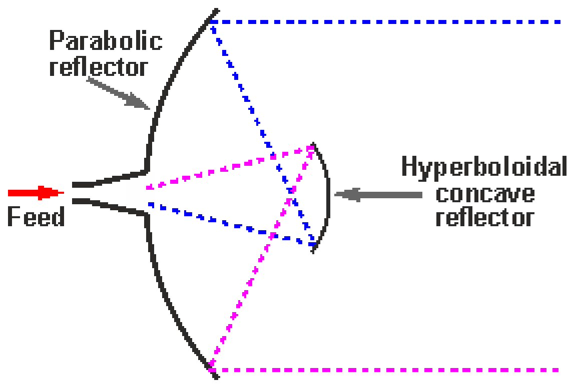


Diagram of a Gregorian feed parabolic reflector or dish antenna

Typical aperture efficiency levels of over 70% can be achieved because the system is able to provide a better illumination of all of the reflector surface.

Off axis or offset parabolic reflector antenna feed

As the name indicates this form of parabolic reflector antenna feed is offset from the centre of the actual antenna dish used.

The reflector used in this type of feed system is an asymmetrical segment of the parabolic shape normally used. In this way the focus and the feed antenna are located to one side of the reflector surface.

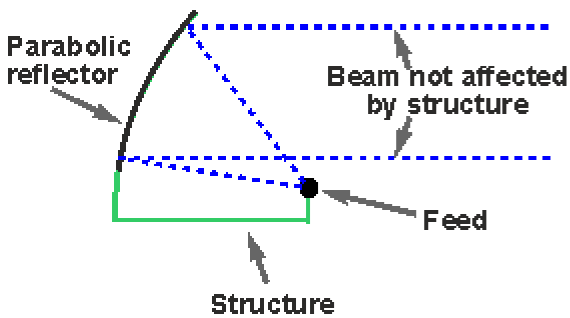


Diagram of an Offset feed parabolic reflector or dish antenna

The advantage of using this approach to the parabolic reflector feed system is to move the feed structure out of the beam path. In this way it does not block the beam.

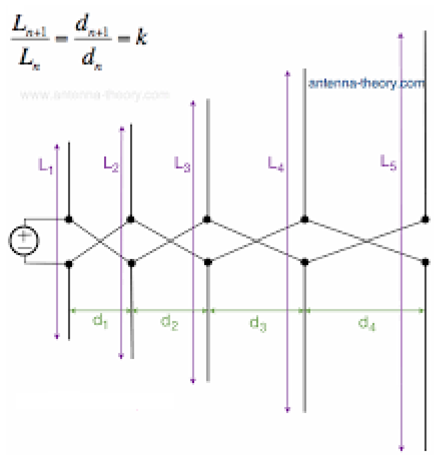
3.9 LOG PERIODIC DIPOLE ARRAY

The log periodic dipole array (LPDA) is one antenna that almost everyone over 40 years old has seen. They were used for years as TV antennas. The chief advantage of an LPDA is that it is frequency-independent. Its input impedance and gain remain more or less constant over its operating bandwidth, which can be very large. Practical designs can have a bandwidth of an octave or more.

Although an LPDA contains a large number of dipole elements, only 2 or 3 are active at any given frequency in the operating range. The electromagnetic fields produced by these active elements add up to produce a unidirectional radiation pattern, in which maximum radiation is off the small end of the array. The radiation in the opposite direction is typically 15 - 20 dB below the maximum. The ratio of maximum forward to minimum rearward radiation is called the Front-to-Back (FB) ratio and is normally measured in dB.

Operation of the Log Periodic Dipole Antenna

The log periodic dipole antenna basically behaves like a Yagi-Uda array over a wide frequency range. As the frequency varies, the active set of elements for the log periodic antenna (those elements which carry the significant current) moves from the long-element end at low frequency to the short-element end at high frequency. The director element current in the Yagi array lags that of the driven element while the reflector element current leads that of the driven element. This current distribution in the Yagi array points the main beam in the direction of the director.



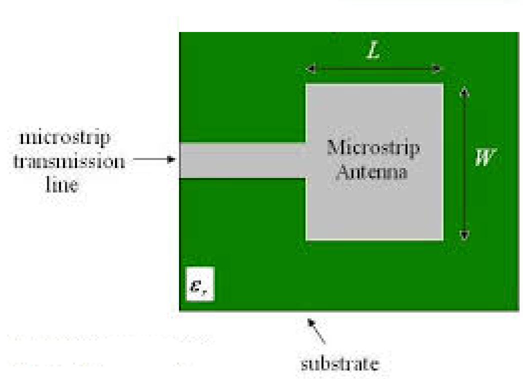
In order to obtain the same phasing in the log periodic antenna with all of the elements in parallel, the source would have to be located on the long-element end of the array.The log periodic dipole array must be driven from the short element end. But this arrangement gives the exact opposite phasing required to point the beam in the direction of the shorter elements. It can be shown that by alternating the connections from element to element, the phasing of the log periodic dipole elements points the beam in the proper direction.

3.10 Microstrip Antennas

- Also called “patch antennas”
- One of the most useful antennas at microwave frequencies (f > 1 GHz).
- It consists of a metal “patch” on top of a grounded dielectric substrate.
- The patch may be in a variety of shapes, but rectangular and circular are the most common

Basic Principles of Operation

The patch acts approximately as a resonant cavity (short circuit walls on top and bottom, open-circuit walls on the sides). In a cavity, only certain modes are allowed to exist, at different resonant frequencies. If the antenna is excited at a resonant frequency, a strong field is set up inside the cavity, and a strong current on the (bottom) surface of the patch. This produces significant radiation (a good antenna).



Advantages :

- Low profile (can even be "conformal").
- Easy to fabricate (use etching and photolithography).
- Easy to feed (coaxial cable, micro strip line, etc.) .
- Easy to use in an array or incorporate with other microstrip circuit elements.
- Patterns are somewhat hemispherical, with a moderate directivity (about 6-8 dB is typical)

Disadvantages :

- Low bandwidth (but can be improved by a variety of techniques).
- Efficiency may be lower than with other antennas. Efficiency is limited by conductor and dielectric losses, and by surface-wave loss.
- Conductor and dielectric losses become more severe for thinner substrates.
- Surface-wave losses become more severe for thicker substrates (unless air or foam is used).