LOOP ANTENNA

An RF current carrying coil is given a single turn into a loop, can be used as an antenna called as **loop antenna**. The currents through this loop antenna will be in phase. The magnetic field will be perpendicular to the whole loop carrying the current.

Frequency Range

The frequency range of operation of loop antenna is around **300MHz to 3GHz**. This antenna works in **UHF** range.

Construction & Working of Loop Antennas

A loop antenna is a coil carrying radio frequency current. It may be in any shape such as circular, rectangular, triangular, square or hexagonal according to the designer's convenience.

Loop antennas are of two types.

- Large loop antennas
- Small loop antennas

Large loop antennas

Large loop antennas are also called as **resonant antennas**. They have high radiation efficiency. These antennas have length nearly equal to the intended wavelength.

$L=\lambda$

Where,

- **L** is the length of the antenna
- **λ** is the wavelength

The main parameter of this antenna is its perimeter length, which is about a wavelength and should be an enclosed loop. It is not a good idea to meander the loop so as to reduce the size, as that increases capacitive effects and results in low efficiency.

Small loop antennas

Small loop antennas are also called as **magnetic loop antennas**. These are less resonant. These are mostly used as receivers.

These antennas are of the size of one-tenth of the wavelength.

$L=\lambda/10$

Where,

- **L** is the length of the antenna
- **λ** is the wavelength

The features of small loop antennas are −

- A small loop antenna has low radiation resistance. If multi-turn ferrite core constructions are used, then high radiation resistance can be achieved.
- It has low radiation efficiency due to high losses.
- Its construction is simple with small size and weight.

Due to its high reactance, its impedance is difficult to match with the transmitter. If loop antenna have to act as transmitting antenna, then this impedance mis-match would definitely be a problem. Hence, these loop antennas are better operated as **receiver antennas**.

Frequently Used Loops

Small loop antennas are mainly of two types −

- Circular loop antennas
- Square loop antennas

These two types of loop antennas are mostly widely used. Other types (rectangular, delta, elliptical etc.) are also made according to the designer specifications.

Fig 1: Circular loop antenna

Fig 2: Square loop antenna

The above images show **circular and square loop antennas**. These types of antennas are mostly used as AM receivers because of high Signal-to-noise ratio. They are also easily tunable at the Q-tank circuit in radio receivers.

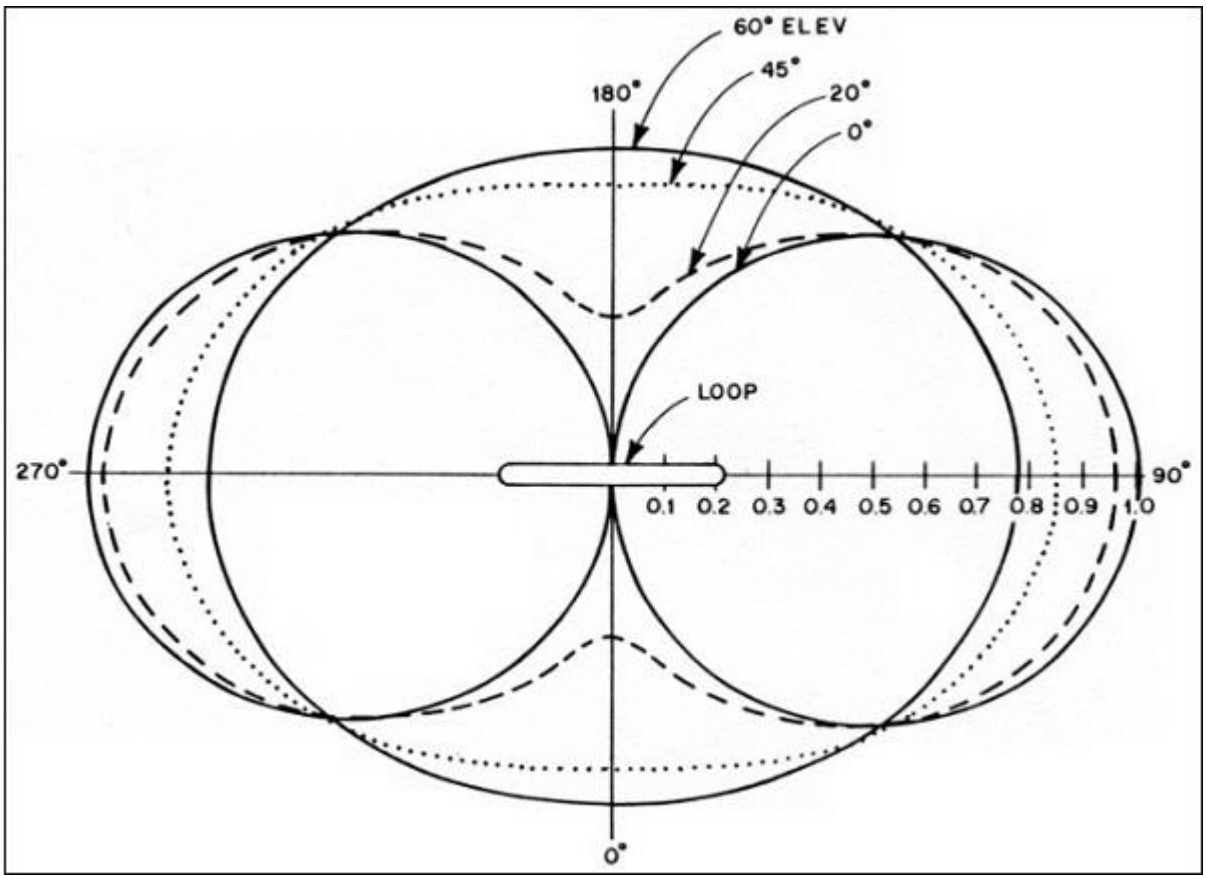
Polarization of Loop

The polarization of the loop antenna will be vertically or horizontally polarized depending upon the feed position. The vertical polarization is given at the center of the vertical side while the horizontal polarization is given at the center of the horizontal side, depending upon the shape of the loop antenna.

The small loop antenna is generally a **linearly polarized** one. When such a small loop antenna is mounted on top of a portable receiver, whose output is connected to a meter, it becomes a great direction finder.

Radiation Pattern

The radiation pattern of these antennas will be same as that of short horizontal dipole antenna.



The **radiation pattern** for small, high-efficiency loop antennas is shown in the figure given above. The radiation patterns for different angles of looping are also illustrated clearly in the figure. The tangent line at 0° indicates vertical polarization, whereas the line with 90° indicates horizontal polarization.

Advantages

The following are the advantages of Loop antenna −

- Compact in size
- High directivity

Disadvantages

The following are the disadvantages of Loop antenna −

- Impedance matching may not be always good

- Has very high resonance quality factor

Applications

The following are the applications of Loop antenna −

- Used in RFID devices
- Used in MF, HF and Short wave receivers
- Used in Aircraft receivers for direction finding
- Used in UHF transmitters

HORN ANTENNA

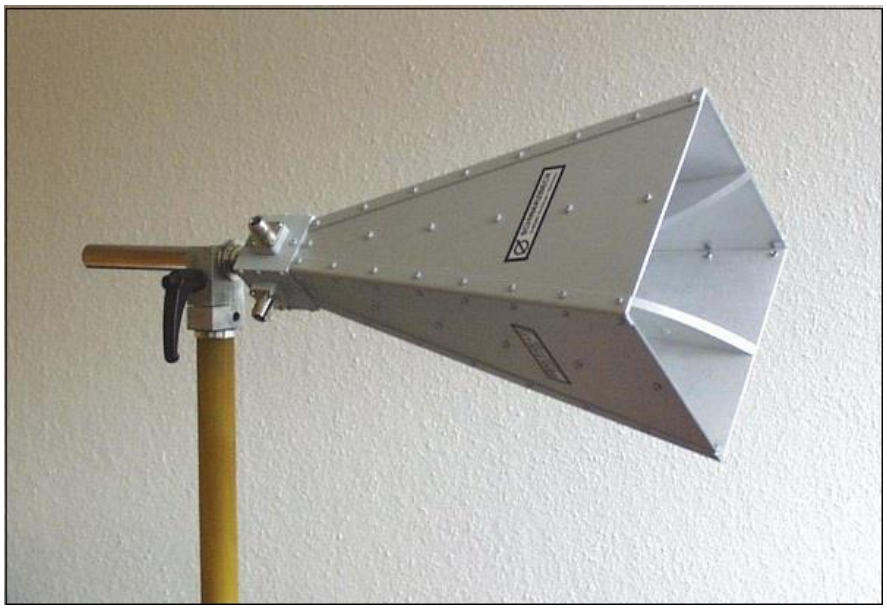
To improve the radiation efficiency and directivity of the beam, the wave guide should be provided with an extended aperture to make the abrupt discontinuity of the wave into a gradual transformation. So that all the energy in the forward direction gets radiated. This can be termed as **Flaring**. Now, this can be done using a horn antenna.

Frequency Range

The operational frequency range of a horn antenna is around **300MHz to 30GHz**. This antenna works in **UHF** and **SHF** frequency ranges.

Construction & Working of Horn Antenna

The energy of the beam when slowly transform into radiation, the losses are reduced and the focussing of the beam improves. A **Horn antenna** may be considered as a **flared out wave guide**, by which the directivity is improved and the diffraction is reduced.



The above image shows the model of a horn antenna. The flaring of the horn is clearly shown. There are several horn configurations out of which, three configurations are most commonly used.

Sectoral horn

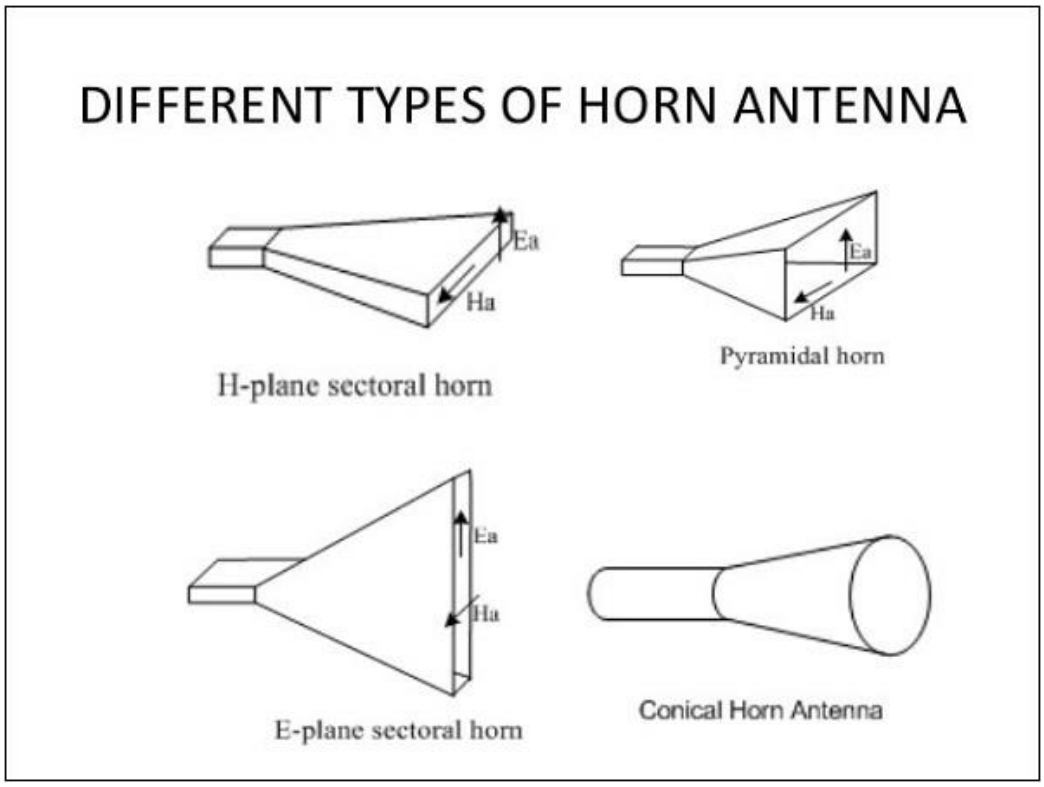
This type of horn antenna, flares out in only one direction. Flaring in the direction of Electric vector produces the **sectorial E-plane horn**. Similarly, flaring in the direction of Magnetic **vector, produces the sectorial H-plane horn.**

Pyramidal horn

This type of horn antenna has flaring on both sides. If flaring is done on both the E & H walls of a rectangular waveguide, then **pyramidal horn antenna** is produced. This antenna has the shape of a truncated pyramid.

Conical horn

When the walls of a circular wave guide are flared, it is known as a **conical horn**. This is a logical termination of a circular wave guide.



The above figures show the types of horn configurations, which were discussed earlier.

Flaring helps to match the antenna impedance with the free space impedance for better radiation. It avoids standing wave ratio and provides greater directivity and narrower beam width. The flared wave guide can be technically termed as **Electromagnetic Horn Radiator**.

Flare angle, **Φ** of the horn antenna is an important factor to be considered. If this is too small, then the resulting wave will be spherical instead of plane and the radiated beam will not be directive. Hence, the flare angle should have an optimum value and is closely related to its length.

Combinations

Horn antennas, may also be combined with parabolic reflector antennas to form special type of horn antennas. These are −

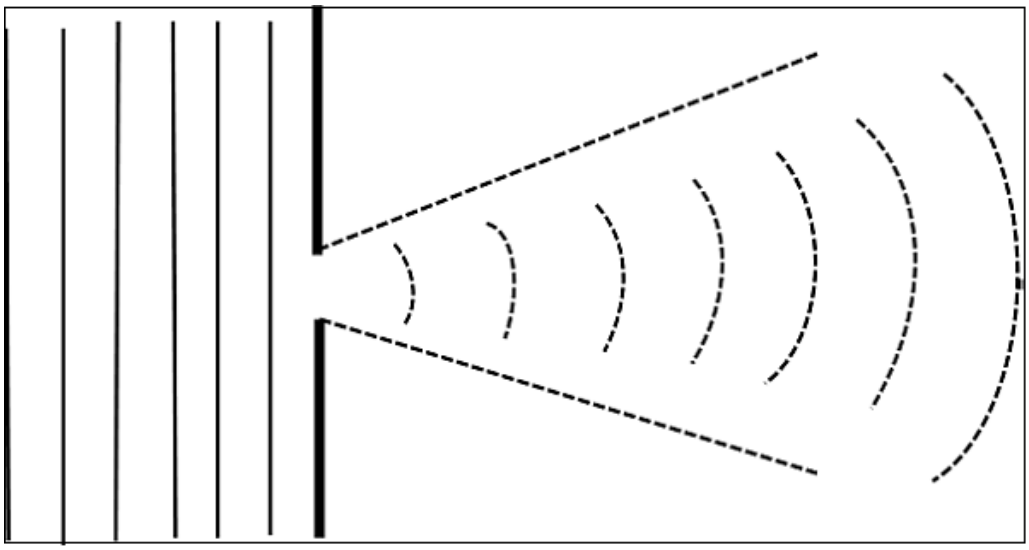
- Cass-horn antenna
- Hog-horn or triply folded horn reflector

In **Cass-horn antenna**, radio waves are collected by the large bottom surface, which is parabolically curved and reflected upward at 45° angle. After hitting top surface, they are reflected to the focal point. The gain and beam width of these are just like parabolic reflectors.

In **hog-horn** antenna, a parabolic cylinder is joined to pyramidal horn, where the beam reaches apex of the horn. It forms a low-noise microwave antenna. The main advantage of hog-horn antenna is that its receiving point does not move, though the antenna is rotated about its axis.

Radiation Pattern

The radiation pattern of a horn antenna is a Spherical Wave front. The following figure shows the **radiation pattern** of horn antenna. The wave radiates from the aperture, minimizing the diffraction of waves. The flaring keeps the beam focussed. The radiated beam has high directivity.



Advantages

The following are the advantages of Horn antenna −

- Small minor lobes are formed
- Impedance matching is good
- Greater directivity
- Narrower beam width
- Standing waves are avoided

Disadvantages

The following are the disadvantages of Horn antenna −

- Designing of flare angle, decides the directivity
- Flare angle and length of the flare should not be very small

Applications

The following are the applications of Horn antenna −

- Used for astronomical studies
- Used in microwave applications

SLOT ANTENNA

Slot Antenna is an example of Aperture antenna. A rectangular slot is made on the conducting sheet. These slot antennas can be formed by simply making a cut on the surface, where they are mounted on.

Frequency Range

The frequency range used for the application of Slot antenna is **300 MHz to 30 GHz**. It works in **UHF** and **SHF** frequency ranges.

Construction & Working of Slot Antennas

The use of slot antennas is well understood through its working principle. Let us have a look at the structure of a slot antenna.

When an infinite conducting sheet is made a rectangular cut and the fields are excited in the aperture (which is called as a slot), it is termed as **Slot antenna**. This can be understood by observing the image of a slot antenna. The following image shows the model of a Slot antenna.

The working of Slot Antenna can be easily understood through Babinet's principle of optics. This concept gives an introduction to the slot antennas.

Babinet's Principle

Babinet's principle states that- "When the field behind a screen with an opening is added to the field of a complementary structure, the sum is equal to the field when there is no screen".

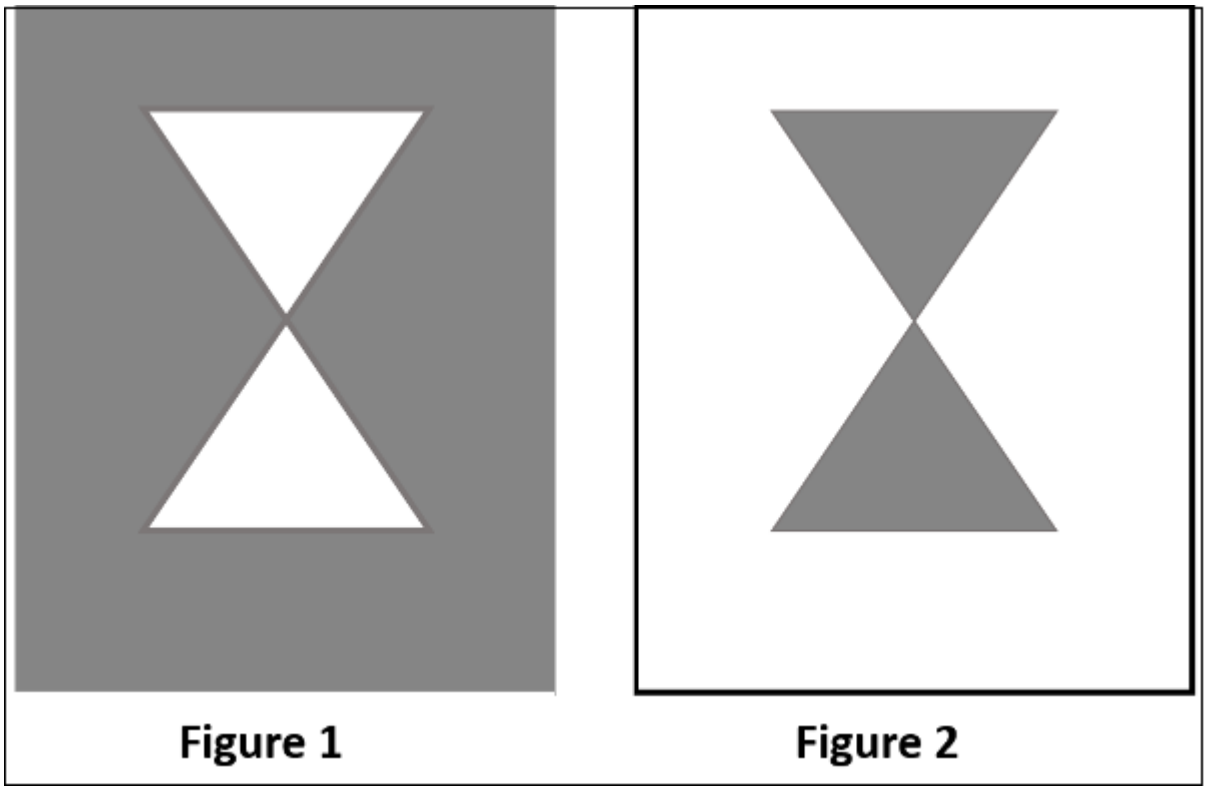


Figure 1 Figure 2

The above images clearly explain the principle. In all the regions, which are non-collinear with the beam, the above two screens, in figures 1 & 2, produce the same diffraction pattern.

Case 1 − Consider a light source and a conducting plane (field) with an aperture before a screen. The light does not pass through the opaque area, but passes through the aperture.

Case 2 − Consider the light source and a conducting plane of the size of the aperture in the previous case, being held against the screen. The light does not pass through the plane but through the remaining portion.

Case 3 − Combine these two conducting planes of both the cases and put before the light source. The screen is not placed to observe the resultant combination. The effect of screen gets nullified.

Working of Slot Antenna

This principle of optics is applied to electromagnetic waves for the wave to get radiated. It is true that when a HF field exists across a narrow slot in a conducting plane, the energy is radiated.

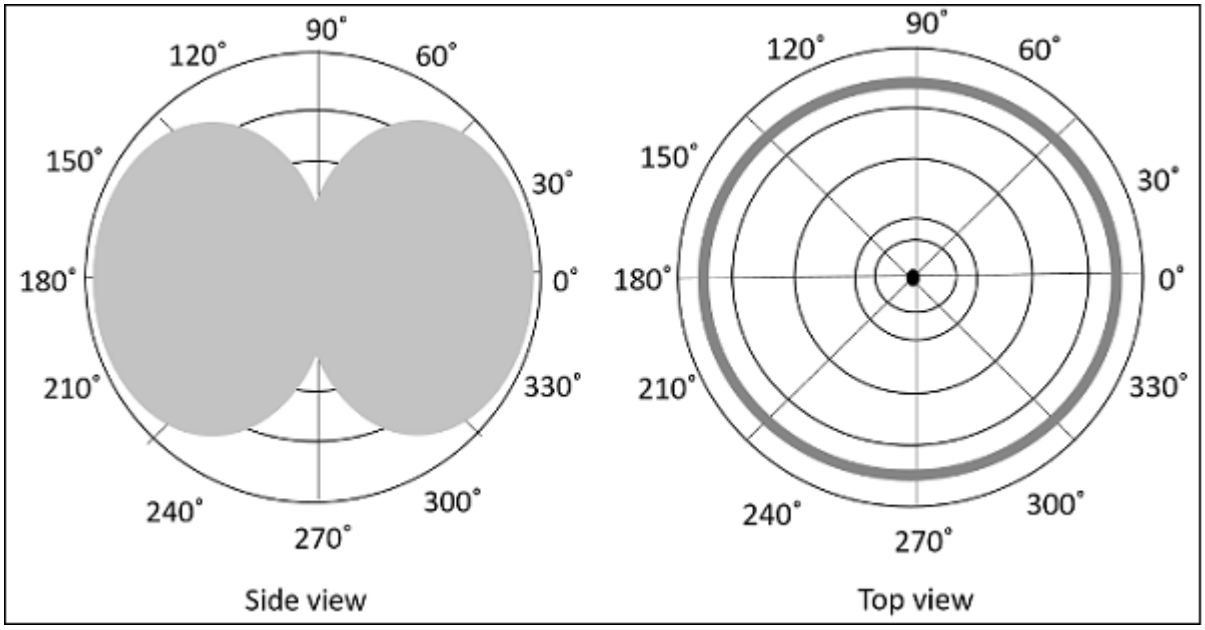
The image shows a slot antenna, which explains well about its working.

Consider an infinite plane conducting screen is taken and pierced with apertures of desired shape and size and this will be the screen of slot antenna. Another screen is considered interchanging the places of aperture and screen area which is the complementary screen.

These two screens are said to be **complementary** as they result in complete infinte metal screen. Now, this becomes the slot antenna. The terminal impedance is quite desirable for the radiation.

Radiation Pattern

The radiation pattern of the Slot antenna is **Omni-directional**, just like a half-wave dipole antenna. Take a look at the following illustration. It shows the radiation pattern of Slot antenna drawn in Horizontal and Vertical planes respectively



Advantages

The following are the advantages of Slot antenna −

- It can be fabricated and concealed within metallic objects
- It can provide covert communications with a small transmitter

Disadvantages

The following are the disadvantages of Slot antenna −

- Higher cross-polarization levels
- Lower radiation efficiency

Applications

The following are the applications of Slot antenna −

- Usually for radar navigational purposes
- Used as an array fed by a wave guide

MICRO STRIP OR **PATCH ANTENNA**

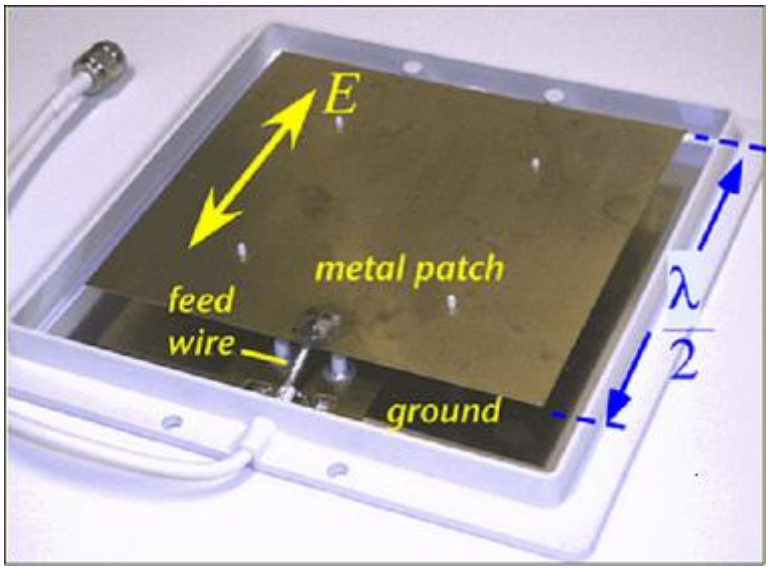
Micro strip antennas are low-profile antennas. A metal patch mounted at a ground level with a di-electric material in-between constitutes a **Micro strip** or **Patch Antenna**. These are very low size antennas having low radiation.

Frequency Range

The patch antennas are popular for low profile applications at frequencies above **100MHz**.

Construction & Working of Micro strip Antennas

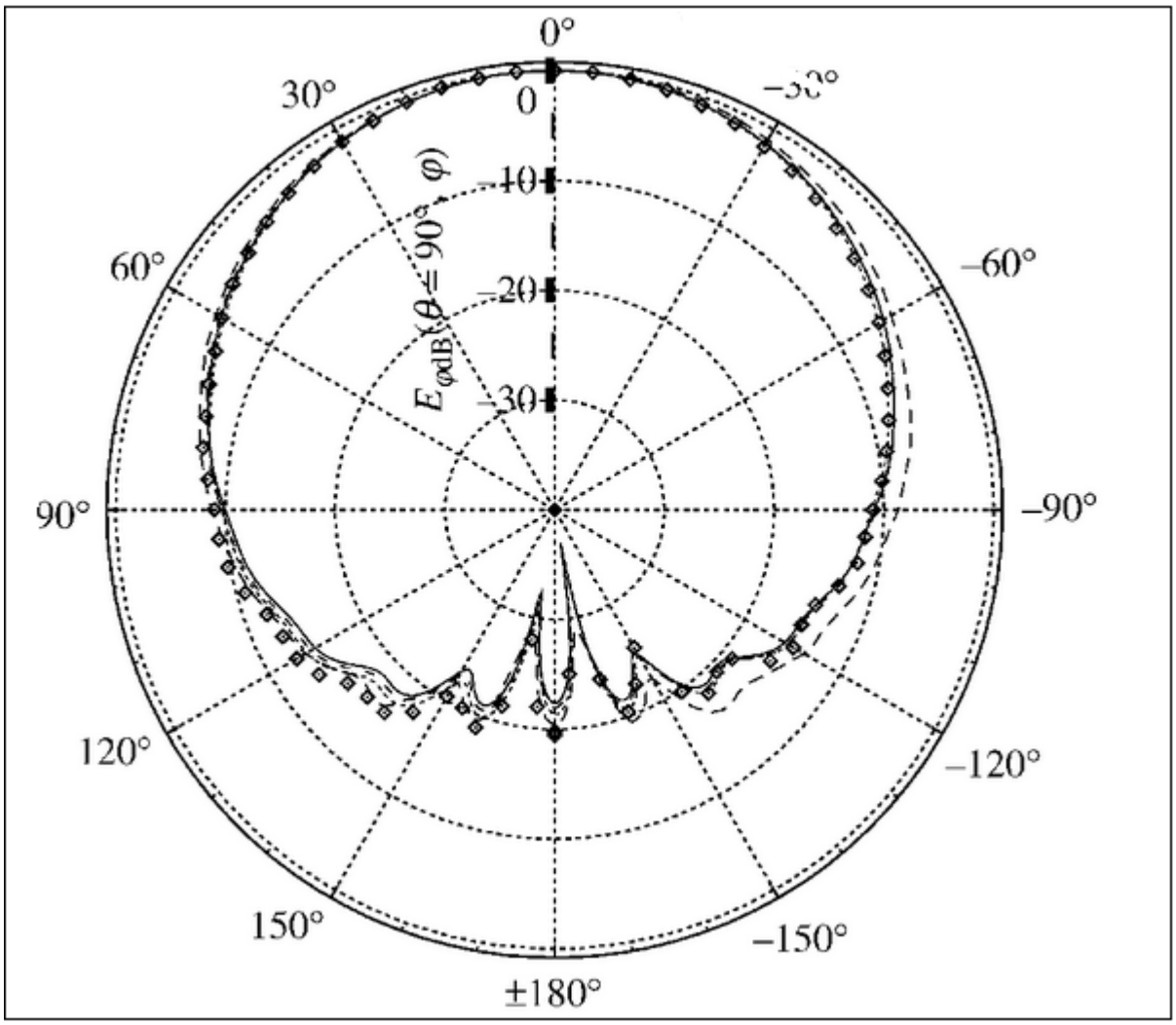
Micro strip antenna consists of a very thin metallic strip placed on a ground plane with a di-electric material in-between. The radiating element and feed lines are placed by the process of photo-etching on the di-electric material. Usually, the patch or micro-strip is choosen to be square, circular or rectangular in shape for the ease of analysis and fabrication. The following image shows a micro-strip or patch antenna.



The length of the metal patch is λ/2. When the antenna is excited, the waves generated within the di-electric undergo reflections and the energyis radiated from the edges of the metal patch,which is very low.

Radiation Pattern

The radiation pattern of microstrip or patch antenna is **broad**. It has low radiation power and narrow frequency bandwidth.



The **radiation pattern** of a microstrip or patch antenna is shown above. It has lesser directivity. To have a greater directivity, an array can be formed by using these patch antennas.

Advantages

The following are the advantages of Micro strip antenna −

- Lighteweight
- Low cost
- Ease of installation

Disadvantages

The following are the disadvantages of Micro strip antenna −

- Inefficient radiation
- Narrow frequency bandwidth

Applications

The following are the applications of Micro strip antenna −

- Used in Space craft applications
- Used in Air craft applications
- Used in Low profile antenna applications