LOOP ANTENNAS

- Another method of using long wire is by bending and making the wire into a loop shaped pattern and observing its radiational parameters.
- 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-
  - around **300MHz to 3GHz**.in **UHF** range.

Construction & Working

- 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.

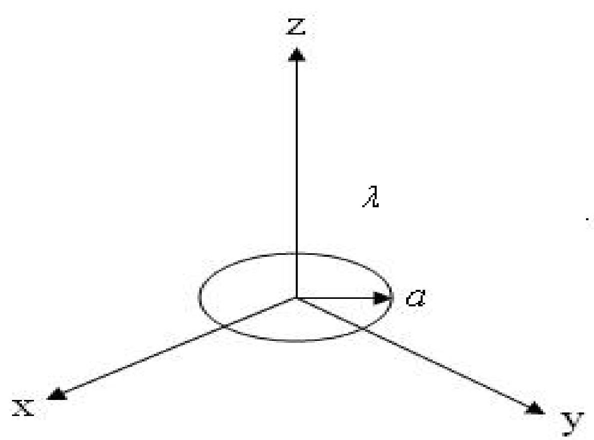
Small Loop Antennas

- The small loop antenna is a closed loop.
- have low radiation resistance and high reactance.
- Their impedance is difficult to match to a transmitter.
- As a result, these antennas are most often used as receive antennas.
- also called as **magnetic loop antennas.**

λ

The radius is a, and is assumed to be much smaller than a wavelength ($a \ll \lambda$). The loop lies in the x-y plane.

Since the loop is electrically small, the current within the loop can be approximated as being constant along the loop, so that $I = I_o$.



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

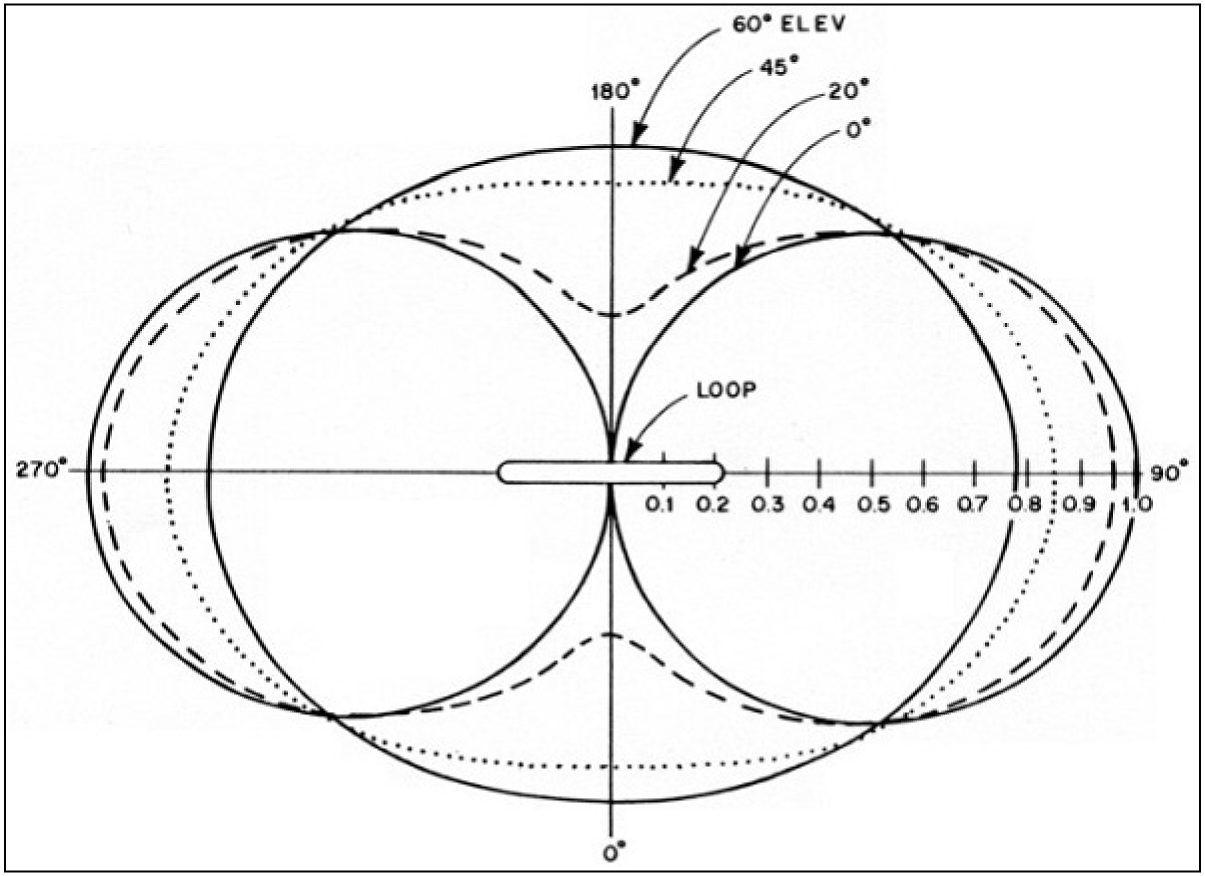
$$L=\lambda/10$$

- **Frequently Used Loops**
  - Circular loop antennas
  - Square loop antennas
-

Fig 1: Circular loop antenna

Fig 2: Square loop antenna

Radiation Pattern

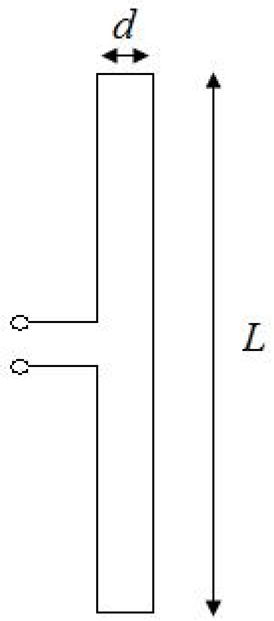


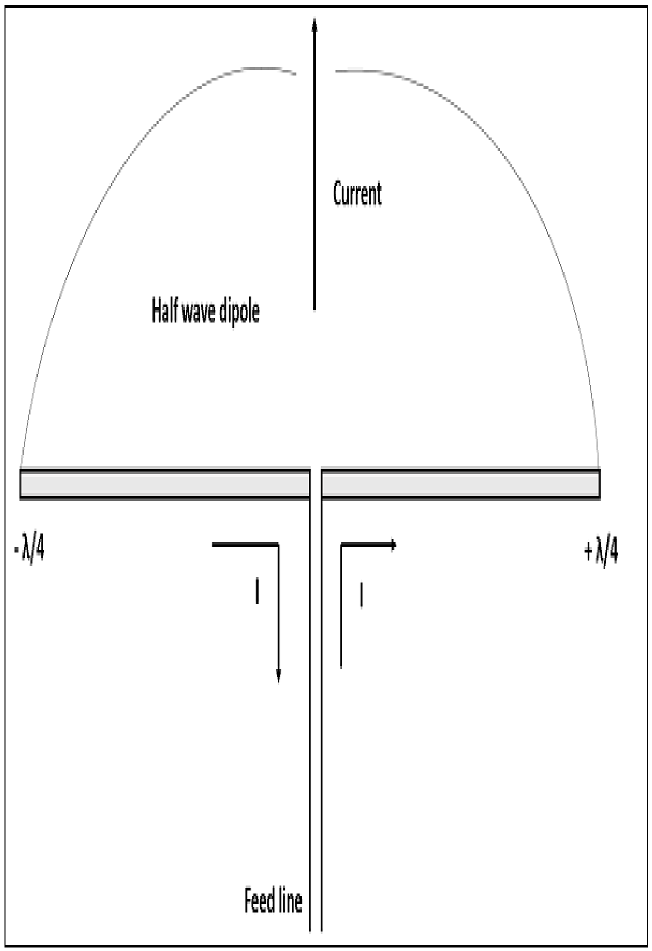
- Advantages
  - Compact in size
  - High directivity
- Disadvantages
  - Impedance matching may not be always good
  - Has very high resonance quality factor
- Applications
  - Used in RFID devices
  - Used in MF, HF and Short wave receivers
  - Used in Aircraft receivers for direction finding
  - Used in UHF transmitters

FOLDED DIPOLE ANTENNA

- Two conductors connected on both sides, and folded to form a cylindrical closed shape, to which feed is given at the center.
- dipole antenna with the ends folded back around and connected to each other, forming a loop.
- The length of the dipole is half of the wavelength. Hence, it is called as **half wave folded dipole antenna**.
- Frequency range-around 3KHz to 300GHz.
- This is mostly used in television receivers.

- Typically, the width *d* of the folded dipole antenna is much smaller than the length *L*.
- Because the folded dipole forms a closed loop, one might expect the input impedance to depend on the input impedance of a short-circuited transmission line of length *L*.
- However, you can imagine the folded dipole antenna as two parallel short-circuited transmission lines of length *L*/2.


d
L


Current
Half wave dipole
-λ/4
+λ/4
I
I
Feed line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www.antenna-theory.com

- The input impedance ZA of the folded dipole is given by:

$$Z_A = \frac{4Z_t Z_d}{Z_t + 2Z_d}$$

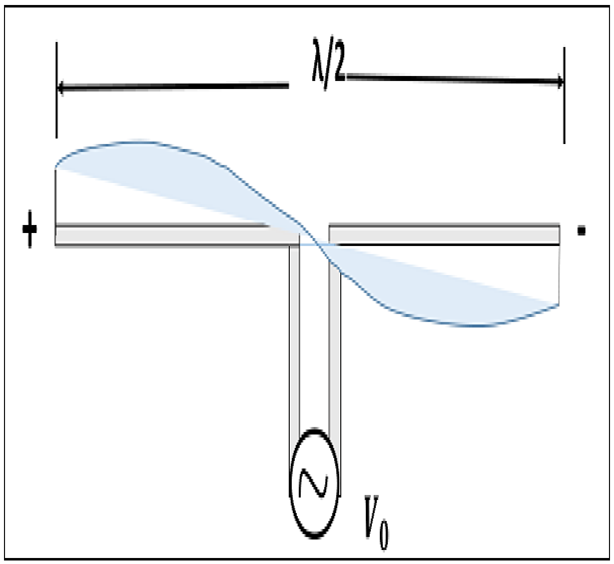
- Zd represent the impedance of a dipole antenna of length *L* and
- Zt represent the impedance of a transmission line impedance of length *L*/2,
- which is given by:

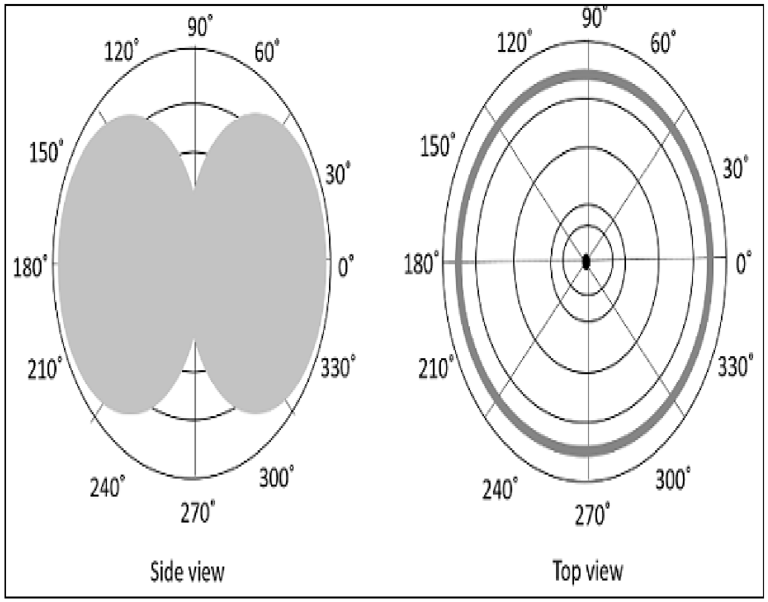
$$Z_t = jZ_0 \tan\frac{\beta L}{2}$$

Half-Wavelength Folded Dipole

- The antenna impedance for a half-wavelength folded dipole antenna ZA=4*Zd.
- At resonance, the impedance of a half-wave dipole antenna is approximately 70 Ohms, so that the input impedance for a half-wave folded dipole antenna is roughly 280 Ohms.
- Because the characteristic impedance of twin-lead transmission lines are roughly 300 Ohms.

- The radiation pattern of half-wavelength folded dipoles have the same form as that of half-wavelength dipoles.





- This folded dipole is the main element in **Yagi-Uda antenna**.
- Advantages
  - Reception of balanced signals.
  - Receives a particular signal from a band of frequencies without losing the quality.
  - A folded dipole maximizes the signal strength.
- Disadvantages
  - Displacement and adjustment of antenna is a hassle.
  - Outdoor management can be difficult when antenna size increases.
- Applications
  - Mainly used as a feeder element in Yagi antenna, Parabolic antenna, turnstile antenna, log periodic antenna, phased and reflector arrays, etc.
  - Generally used in radio receivers.
  - Most commonly used in TV receiver antennas.

Yagi-Uda antenna

- Most commonly used type of antenna for **TV reception** over the last few decades.
- It is the most popular and easy-to-use type of antenna with better performance, which is famous for its high gain and directivity.
- **Frequency range-**around **30 MHz to 3GHz** which belong to he **VHF** and **UHF** bands.

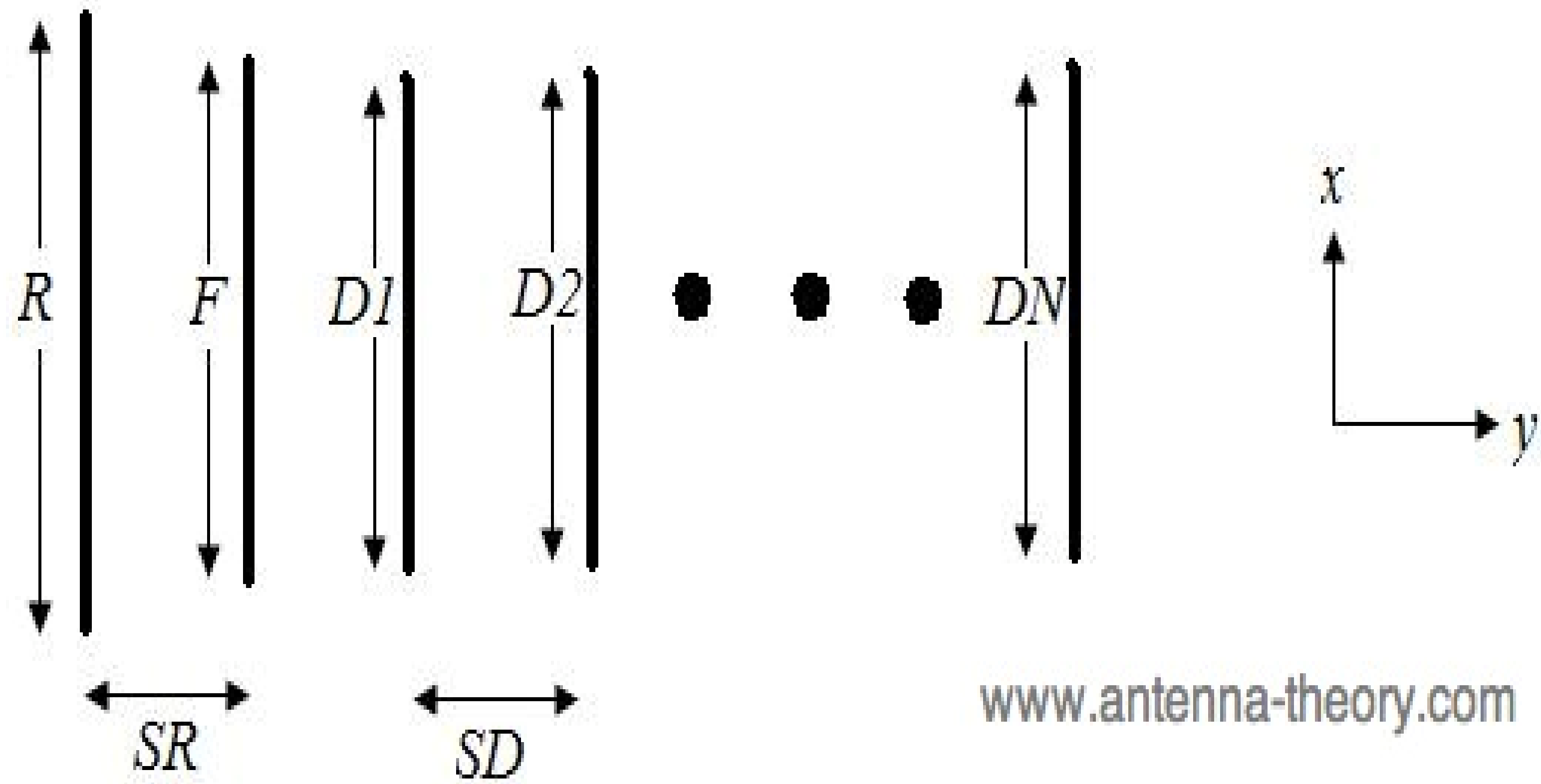
- The Yagi antenna was invented in Japan, with results first published in 1926. The work was originally done by Shintaro Uda, but published in Japanese. The work was presented for the first time in English by Yagi.
- It is seen that there are many directors placed to increase the directivity of the antenna.
- The feeder is the folded dipole.
- The reflector is the lengthy element.

Geometry of Yagi Antennas

- The Yagi antenna consists of a single 'feed' or 'driven' element, typically a dipole or a folded dipole antenna. This is the only member of the above structure that is actually excited.
- The rest of the elements are parasitic – they reflect or help to transmit the energy in a particular direction.
- This feed antenna is often altered in size to make it resonant in the presence of the parasitic elements.

  (typically, 0.45-0.48 wavelengths long for a dipole antenna).

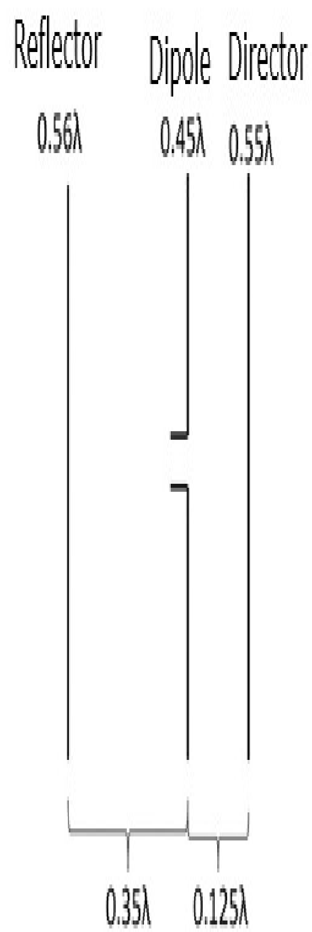
Geometry of Yagi Antennas



- The element to the left of the feed is the reflector.
- The length of this element is given as *R* and the distance between the feed and the reflector is *SR*.
- The reflector element is typically slightly longer than the feed element.
- There is typically only one reflector; adding more reflectors improves performance very slightly.
- This element is important in determining the front-to-back ratio of the antenna.

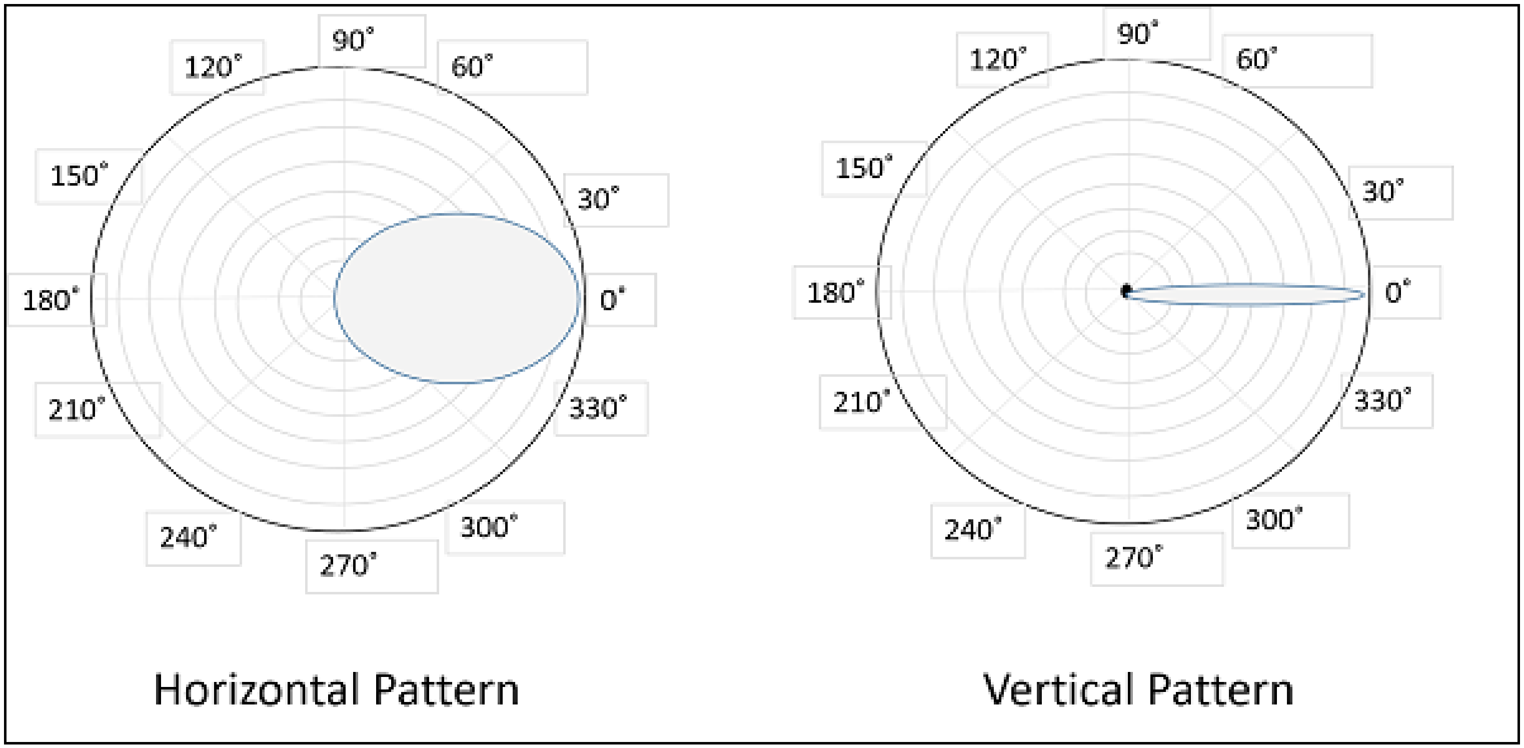
Design of a Yagi-Uda antenna

- quite simple.
- Because Yagi antennas have been extensively analyzed and experimentally tested.



ELEMENT	SPECIFICATION
Length of the Driven Element	0.458λ to 0.5λ
Length of the Reflector	0.55λ to 0.58λ
Length of the Director 1	0.45λ
Length of the Director 2	0.40λ
Length of the Director 3	0.35λ
Spacing between Directors	0.2λ
Reflector to dipole spacing	0.35λ
Dipole to Director spacing	0.125λ

Radiation Pattern



- Advantages
  - High gain is achieved.
  - High directivity is achieved.
  - Ease of handling and maintenance.
  - Less amount of power is wasted.
  - Broader coverage of frequencies.
- Disadvantages
  - Prone to noise.
  - Prone to atmospheric effects.
- Applications
  - Mostly used for TV reception.
  - Used where a single-frequency application is needed.

Log-Periodic Antenna

- The Yagi-Uda antenna is mostly used for domestic purpose.
- However, for commercial purpose and to tune over a range of frequencies - **Log-periodic antenna**.
- A Log-periodic antenna is that whose impedance is a logarithmically periodic function of frequency.
- Frequency range: around **30 MHz to 3GHz** which belong to the **VHF** and **UHF** bands.

- **Definition**: A broad band antenna that is designed **to provide such electrical characteristics that vary repeatedly in a periodic manner with logarithmic of the frequency of operation.**
- The **impedance** and **radiation pattern are the factors that are logarithm function of the frequency.**


BAZ

Introduction

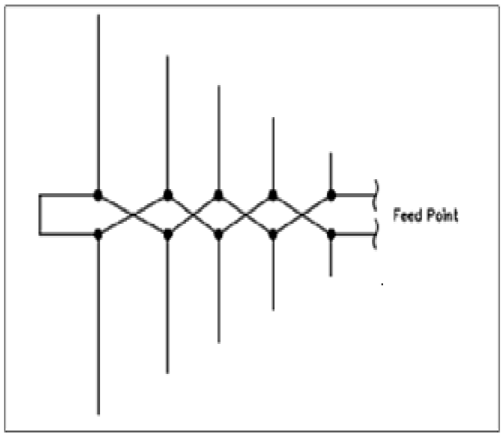
- It is a **multi-element antenna** that offers **good directivity** over a wide range of frequency of operation.
- Defined on the basis of angles only is categorized as a **frequency-independent antenna**.
- In such cases, the impedance, as well as the radiation pattern both, does not show dependency on frequency.
- **Impedance** and **Pattern** should **remain invariable over a range of frequency**.

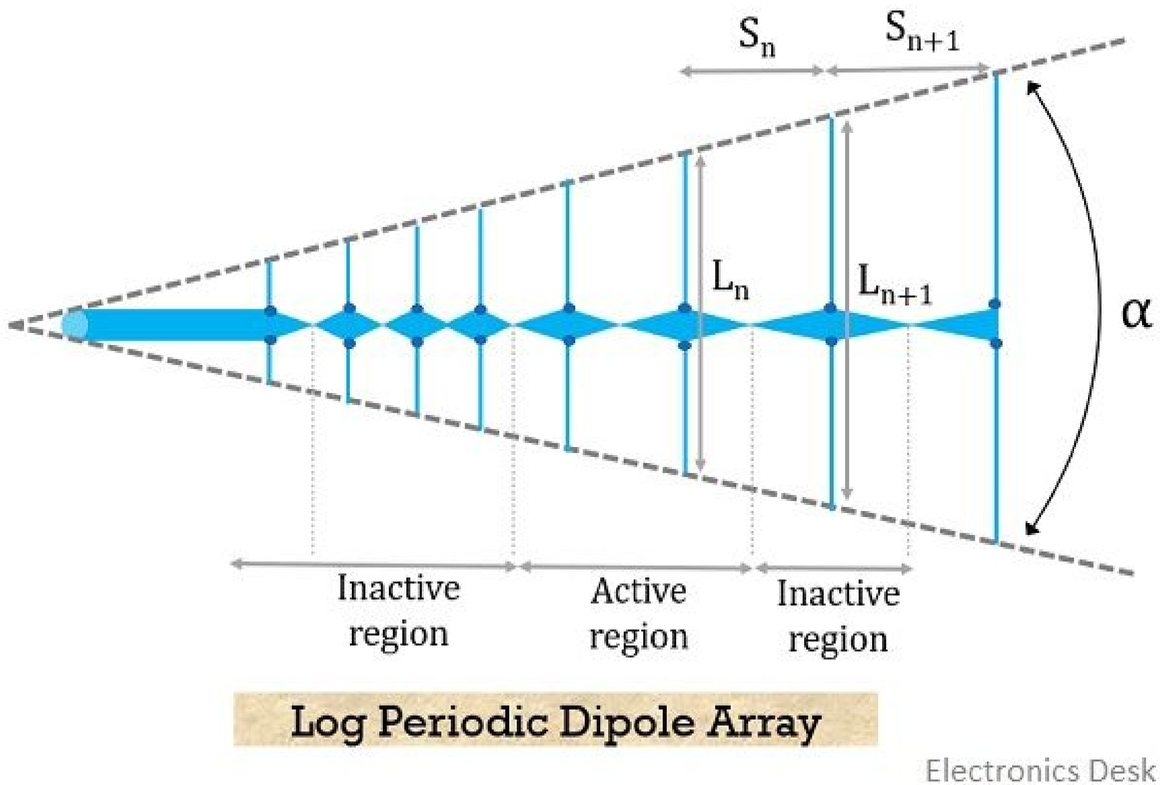
- The antenna elements are **mounted on a single line along with a support boom**.
- Log periodic dipole array, the increase in the number of connected elements improves the frequency response or bandwidth that is offered by the system.

Construction of Log-periodic Antenna

- constructed by the **use of various half-wave dipole elements with a gradual increase in the length.**
- In Log Periodic Dipole Array, there is a gradual increase in the length of the elements from point of feed to the other end, keeping the angle ‘α’ constant.
- The increase in the length of the elements along with the spacing between them in wavelength should be so adjusted that there must be certain ratio in the dimensions of the adjacent dipoles.

- The connection of the **feed lines is made either at the narrow end or apex of the array**.





- The construction and operation of a log-periodic antenna is similar to that of a Yagi-Uda antenna.
- The main advantage of this antenna is that it exhibits constant characteristics over a desired frequency range of operation.
- It has the same radiation resistance and therefore the same SWR.
- The Gain and front-to-back ratio are also the same.

- With the change in operation frequency, the active region shifts among the elements and hence all the elements will not be active only on a single frequency. This is its **special characteristic**.
- There are several type of log-periodic antennas such as the planar, trapezoidal, zig-zag, V-type, slot and the dipole.
- The mostly used one is log-periodic dipole array, in short, **LPDA**.

- The array consists of dipoles of different lengths and spacing, which are fed from a two-wire transmission line.
- This line is transposed between each adjacent pair of dipoles.
- The parameter that defines here the relation between the length of the antenna elements and spacing between adjacent elements is called **Design Ratio** or **Scale Factor**.
- This is denoted by **τ**. It is sometimes referred as **Periodicity Factor**, having a value **less than 1**.

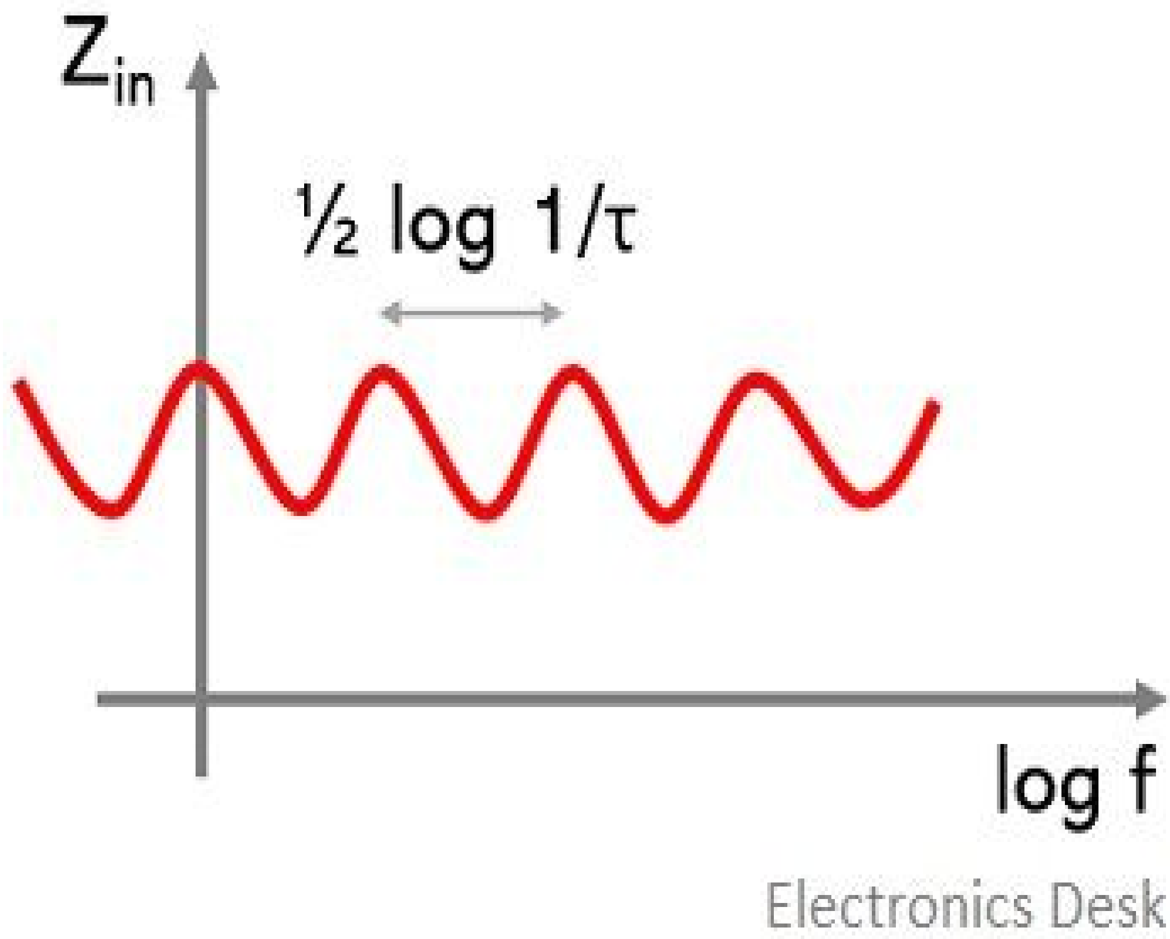
- The length of the dipoles (L) and spacing (R or S) between them are related in the following way:

$$\frac{R_1}{R_2} = \frac{R_2}{R_3} = \frac{R_3}{R_4} = \text{-------} \frac{R_n}{R_{n+1}} = \tau = \frac{L_1}{L_2} = \frac{L_2}{L_3} = \frac{L_3}{L_4} = \text{-----} = \frac{L_n}{L_{n+1}}$$

$$\frac{R_n}{R_{n+1}} = \frac{L_n}{L_{n+1}} = \tau$$

$$\frac{S_n}{S_{n+1}} = \frac{L_n}{L_{n+1}} = \tau \qquad \frac{S_{n+1}}{S_n} = \frac{L_{n+1}}{L_n} = \frac{1}{\tau} = k$$

The value of α is generally **30**° with **τ = 0.7**.



Z in
½ log 1/τ
log f
Electronics Desk

Working of Log-Periodic Antenna

- Has 3 regions:
  - **Transmission line region**
  - **Active region**
  - **Reflective region**
- operates only in the active region rather than the whole structure.

Transmission Line Region

- The length of the elements is shorter than the half-wavelength (i.e., resonant length).
- Provide high capacitive impedance.
- Spacing between the elements is small.
- The current flowing through the elements in this region is of small magnitude and leads the supplied voltage by 90°.
- Thus, the small current through the element results in small radiation in the backward direction.

Active Region

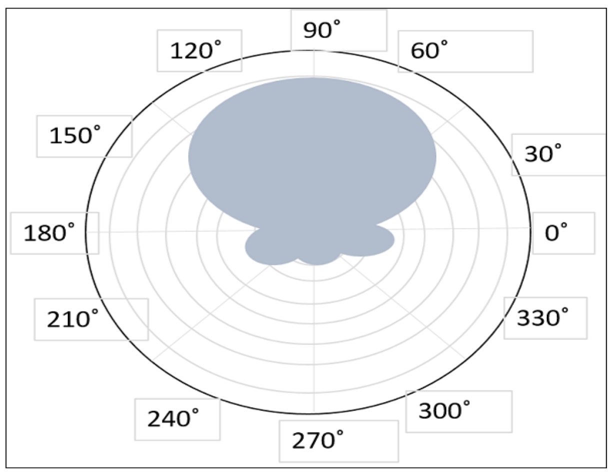
- Has element length equal to half wavelength and offers resistive impedance.
- Here the current through the element is large and **in phase with the supplied voltage**.
- **Large spacing exists between the dipoles**.
- **Provide maximum radiation**
- Frequencies where the **length of the longest and shortest dipole is λ/2** is said to be the **cut-off frequency**.
- For **maximum frequency - the active region will be towards the apex,**
- **For intermediate frequency - the region will shift towards the middle region of the structure**.
- For **minimum frequencies - near the region of longest elements**.

Reflective Region

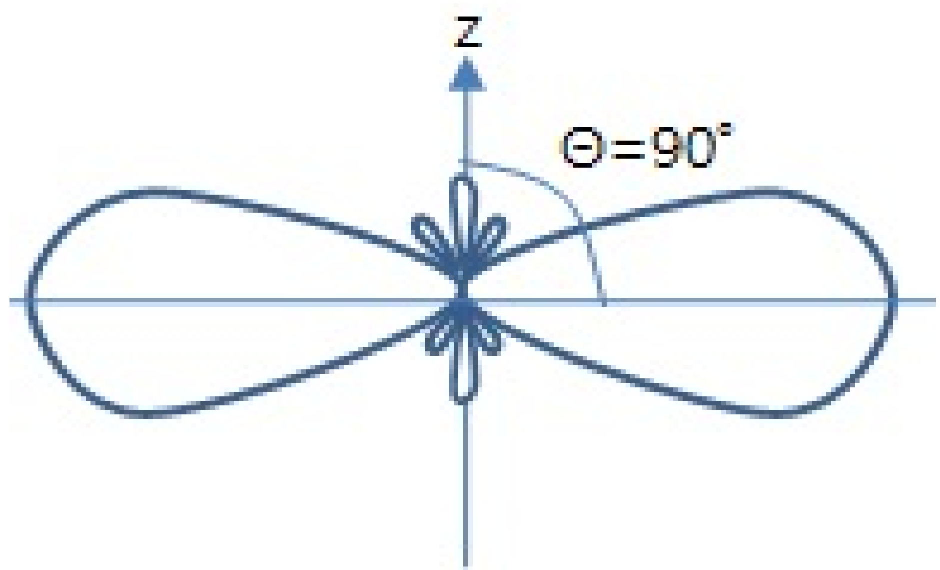
- The region having elements with length greater than resonant length (i.e., $\lambda/2$) becomes the inactive region.
- The **impedance is inductive in nature** that leads to generate a current that lags the supplied voltage.
- It is to be noted here that this region receives very small voltage from the transmission line.
- Because the active region attracts and radiates the maximal radiation.

Radiation Pattern

- Offer **bidirectional as well as unidirectional radiation pattern depending upon the log periodic structures**.
- Basically, a structure with a single active region, there will be a unidirectional radiation pattern.



- But if there exist two active regions, there will be a bidirectional radiation pattern.



Characteristics

- The excitation to the LPDA is provided at the shorter length side in case of the single active region while at the centre in case of two active regions log periodic.
- To have a unidirectional radiation pattern, the structure must radiate towards the shorter element (i., left direction) and negligible towards the right.
- The transmission line inactive region must possess desired characteristic impedance with very small or negligible radiation.
- In the active region, to have strong radiation, the magnitude and phase of the currents must be proper.

Advantages

- The antenna design is compact structure.
- Gain and radiation pattern are varied according to the requirements.
- These offer negligible loss of power when terminated.

- **Disadvantages**
  - External mount. The mounting platform must be of sufficient strength to hold the elements.
  - Installation cost is high.
- **Applications**
  - Used for HF communications.
  - Used for particular sort of TV receptions.
  - Used for all round monitoring in higher frequency bands.

Helical antenna

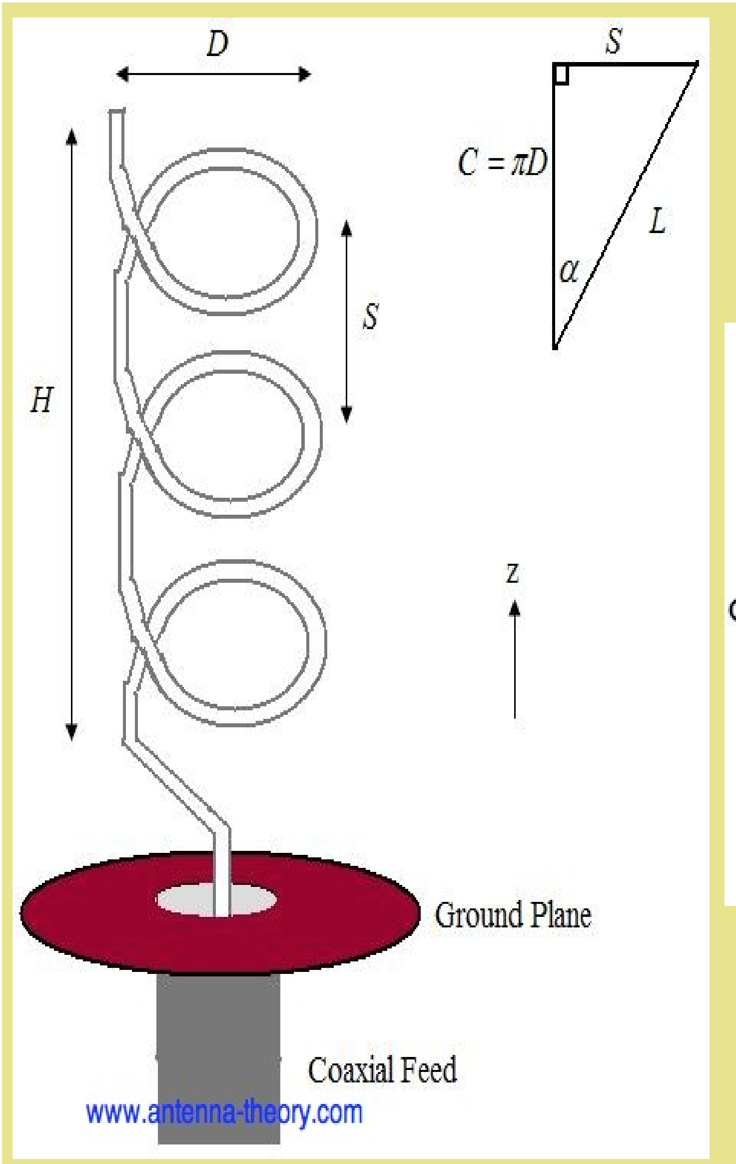
- an example of wire antenna and itself forms the shape of a helix.
- Provides **circularly polarized waves**.
- Frequency Range: is around **30MHz to 3GHz**.
- This antenna works in **VHF** and **UHF** ranges.

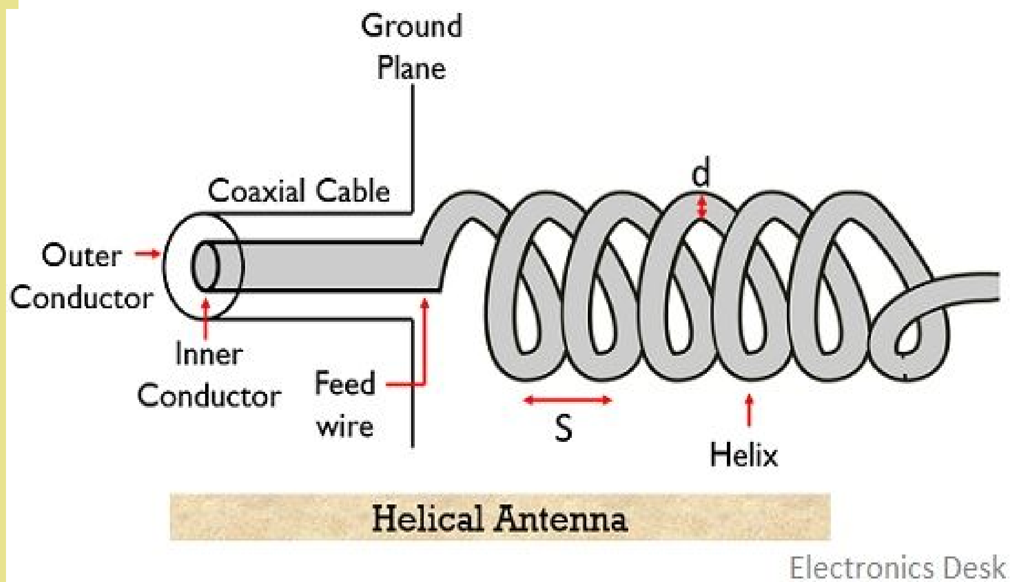
Construction

- **Helical antenna** or helix antenna is the antenna in which the conducting wire is wound in helical shape and connected to the ground plate with a feeder line.
- It is the simplest antenna.
- It is used in extra-terrestrial communications in which satellite relays etc., are involved.

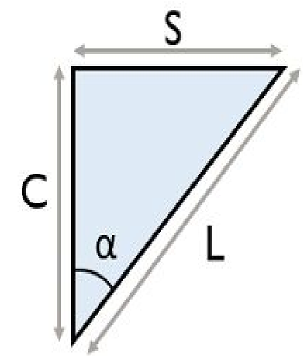
- It consists of a helix of thick copper wire or tubing wound in the shape of a screw thread used as an antenna in conjunction with a flat metal plate called a ground plate.
- One end of the helix is connected to the center conductor of the cable and the outer conductor is connected to the ground plate.
- The radiation of helical antenna depends on the diameter of helix, the turn spacing and the pitch angle.

- The excitation to the helical antenna is provided at an end using a coaxial transmission line. Here the central conductor is attached to the helix and outer conductor forms a connection with the ground plane.


D
S
$C = \pi D$
L
α
S
H
z
Ground Plane
Coaxial Feed
www.antenna-theory.com


Ground
Plane
Coaxial Cable
d
Outer
Conductor
Inner
Conductor
Feed
wire
S
Helix
Helical Antenna
Electronics Desk

- **Pitch angle (α)**is the angle between a line tangent to the helix wire and plane normal to the helix axis.



Relation between turn length, spacing and circumference

$$\alpha = \tan^{-1}(S/C)$$

  – C=πD

- where,
  – **D** is the **diameter** of helix.
  – **S** is the **turn spacing** (centre to centre).
  – **α** is the **pitch angle**.

$$L = \sqrt{S^2 + C^2}$$

$$L = \sqrt{S^2 + (\pi D)^2}$$

The **pitch angle** of the helix is the angle existing between the tangential line to the helical wire and the plane in direction, normal to its axis.

Thus $\tan \alpha = \frac{S}{C} = \frac{S}{\pi D}$

Hence $\alpha = tan^{-1}(\frac{S}{\pi D})$

$$\boxed{\frac{3\lambda}{4} \le C \le \frac{4\lambda}{3}}$$

Working of Helical Antenna

- When a conductive wire is excited by using feed likes like coaxial cable or two-wire transmission line then current flows through the conducting wire.
- These causes the generation of field lines and radiations are emitted.
- **Modes of Operation:**
- The predominant modes of operation of a helical antenna are –
  - **Normal** or perpendicular mode of radiation.
  - **Axial** or end-fire or beam mode of radiation.

Modes Helical Antenna – Normal Mode

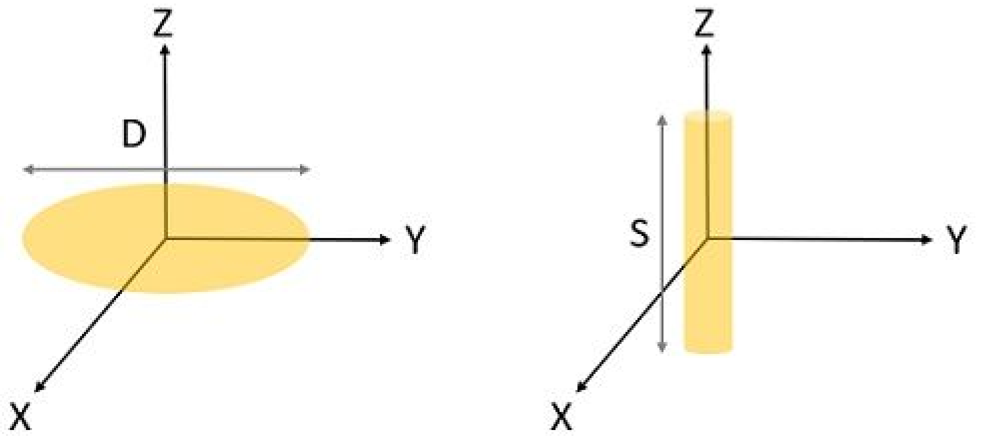
- This mode of operation is also known as **perpendicular mode** of operation; this is so because, in this mode, maximal radiation is emitted in the direction of the plane perpendicular to the axis of the antenna.
- And the waves are **circularly polarized in nature**.
- This means that the field radiated is maximum along the plane perpendicular to axis and minimum along the axis.
- This mode of operation is achieved when the dimensions of the antenna are comparatively smaller than the wavelength. This means

$$\mathbf{NL << \lambda}$$

- However, this small dimensional antenna offers **low radiation efficiency** and **very narrow bandwidth**.

- The radiation field is normal to the helix axis.
- This mode of radiation is obtained if the dimensions of helix are small compared to the wavelength.
- The radiation pattern of this helical antenna is a combination of **short dipole** and **loop antenna**.
- It depends upon the values of diameter of helix-**D** and its turn spacing-**S**.
- **Drawbacks** of this mode of operation is **low radiation efficiency** and **narrow bandwidth**. Hence, it is **hardly used**.

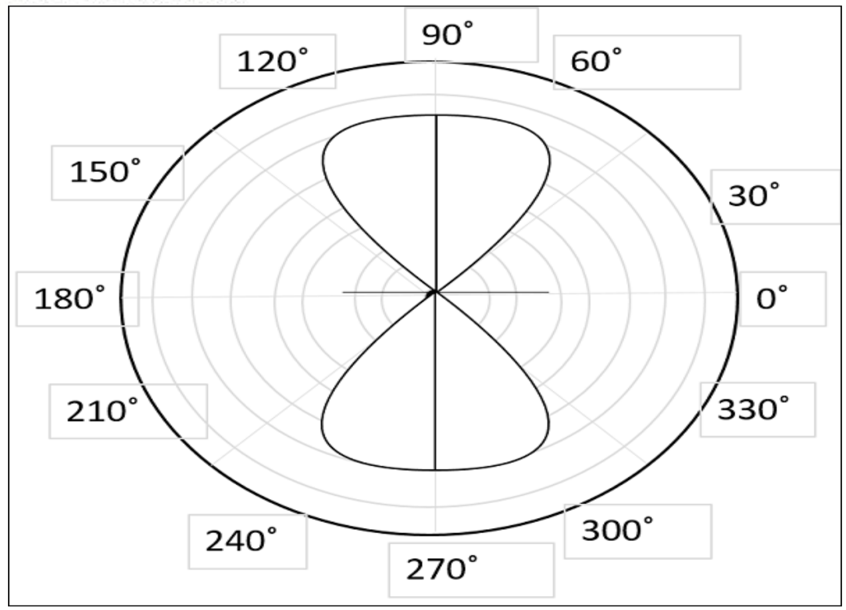
- Offers **low radiation efficiency** and **very narrow bandwidth**.
- The antenna in this configuration is known as broadside helical antenna and acts as an electric short dipole antenna.
- The reason behind this is that at **α = 0°**, the helix corresponds as loop and at **α = 90°**, it acts as a linear dipole.
- Therefore, patch angle at 0° and 90° serves as the limiting conditions of the helical antenna.



Loop, α = 0° Short dipole, α = 90°

Limiting conditions of Helical Antenna

Electronics Desk



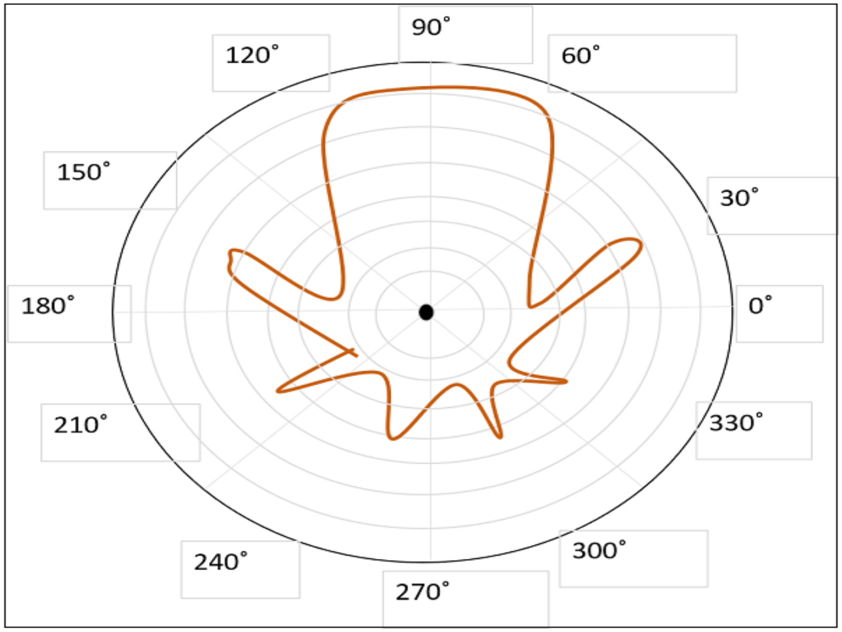
Axial Mode

- In **axial mode** of radiation, the radiation is in the end-fire direction along the helical axis and the waves are circularly or nearly circularly polarized.
- This mode of operation is obtained by raising the circumference to the order of one wavelength **(λ)** and spacing of approximately **λ/4**.
- The radiation pattern is broad and directional along the axial beam producing minor lobes at oblique angles.

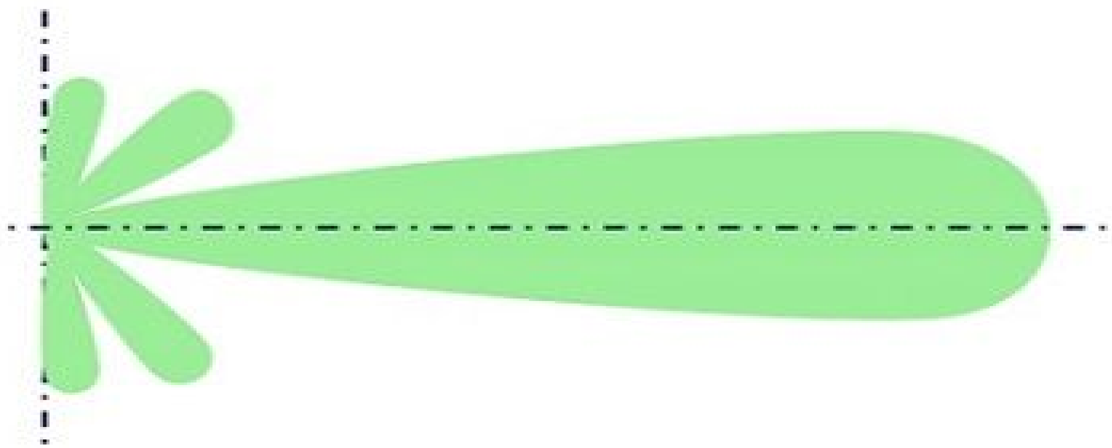
- If this antenna is designed for right-handed circularly polarized waves, then it will not receive left-handed circularly polarized waves and vice versa.
- This mode of operation is generated with great ease and is **more practically used**.
- The **crucial differentiating factor** between normal mode and axial mode is that in normal mode, maximum radiation is along the perpendicular direction of the axis. While in axial mode, maximum radiation is along the axis itself.

$$\mathbf{NL \approx \lambda}$$

- For axial mode, the pitch angle shows variation between 12° to 18°.
- However at **14°** this mode shows best results.



Radiation Pattern



Radiation pattern of helical antenna in axial mode

Electronics Desk

- Advantages
  - Simple design
  - Highest directivity
  - Wider bandwidth
  - Can achieve circular polarization
  - Can be used at HF & VHF bands also
- Disadvantages
  - Antenna is larger and requires more space
  - Efficiency decreases with number of turns
- Applications
  - A single helical antenna or its array is used to transmit and receive VHF signals
  - Frequently used for satellite and space probe communications
  - Used for telemetry links with ballastic missiles and satellites at Earth stations
  - Used to establish communications between the moon and the Earth
  - Applications in radio astronomy

Features

- This is a simple antenna used for circular polarization.
- It is utilized in different bands like VHF &UHF.
- It is most commonly used in axial mode.
- It is not chosen in normal mode where efficiency and beam-width are small in this mode.
- Its design is very simple & has maximum directivity.
- In axial mode, it is a wideband antenna.
- If the axial ratio is zero then, linear horizontal polarization occurs.
- If the axial ratio is infinite then linear vertical polarization occurs.
- If the axial ratio is one, then circular polarization occurs.

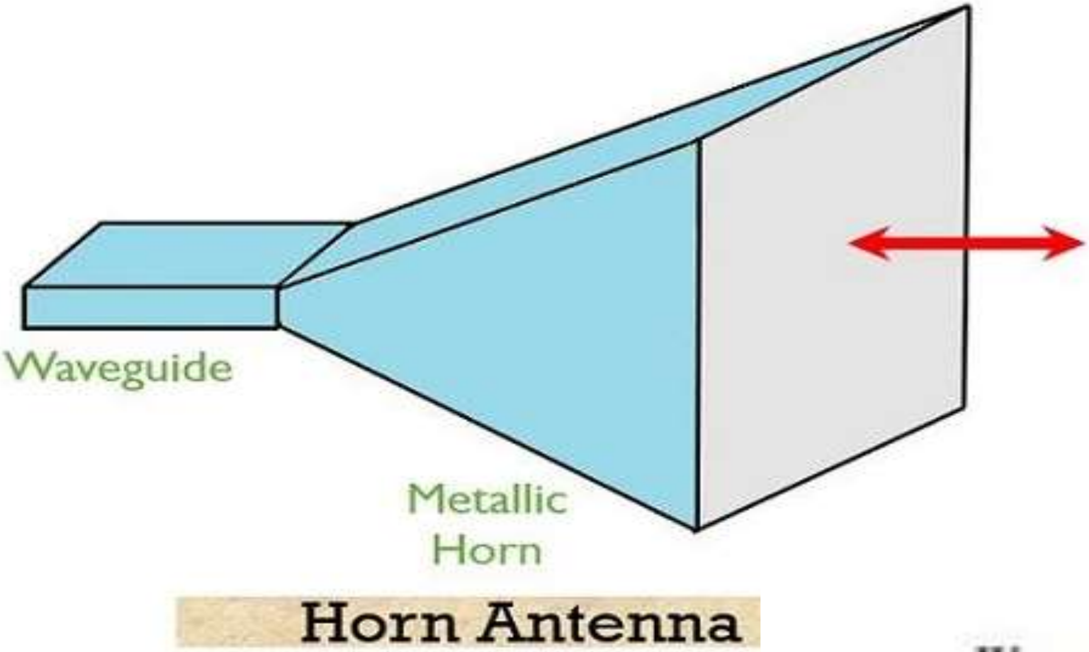
HORN ANTENNAS

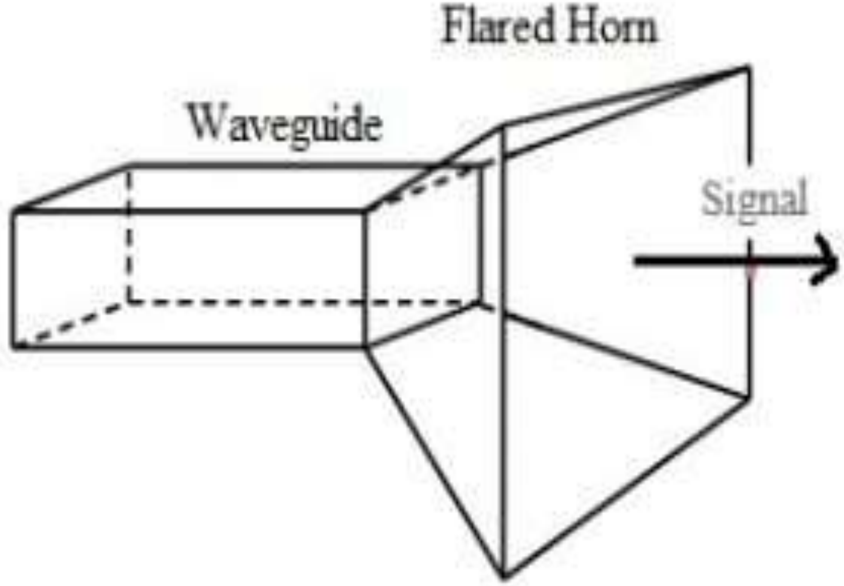
- The first horn antenna was designed with pioneering experiments through microwaves by a radio researcher namely **Jagadish Chandra Bose** in 1897.
- The current horn antenna was invented separately in 1938 by **G. C. Southworth & Wilmer Barrow**.
- **Definition**: Horn antenna is a type of antenna which is **constructed when the end of the antenna is flared out or tapered in the shape of a horn**.
- Horn antenna operates in microwave frequency.

What is Horn Antenna?

- is a type of aperture antenna which is specially designed for microwave frequencies.
- The **end of the antenna is widened** or in **the horn shape**.
- Because of this structure, there is larger directivity so that the emitted **signal can be easily transmitted to long distances**.
- These operate in ultra-high and super-high frequencies ranging between **300 MHz to 30 GHz**.

- These antennas are **used as feed horns for big antennas like parabolic antennas, directive antennas**, etc.
- The **benefits** of using these antennas are **simple design** & **adjustment**, **low SWR** (standing wave ratio), **moderate directivity**, and **broad bandwidth**.
- It is generally considered as a waveguide **whose one of the ends is widened out in the shape of the horn**.
- Due to the flared-out structure of the antenna, there is greater directivity thus the emitted signal can be transmitted to longer distances.


Waveguide
Metallic
Horn
Horn Antenna


Flared Horn
Waveguide
Signal

- Horn antennas often have a **directional radiation pattern with a high antenna gain**, which can range up to **25 dB** in some cases, with **10-20 dB being typical**.
- Horn antennas have **very little loss**, so the **directivity of a horn is roughly equal to its gain**.

Need of Horn Antenna

- We know that the open end of the waveguide radiates energy, **but only a fraction of incident energy is radiated by the waveguide** and **rest is reflected back by that open end**.
- This is so because due to the open end, there exist **poor impedance matching between the waveguide and space**.
- Also, **diffraction at the edges of the waveguide results in the poor radiating ability of the waveguide**.
- And so, the **radiation pattern is non-directive in nature**.

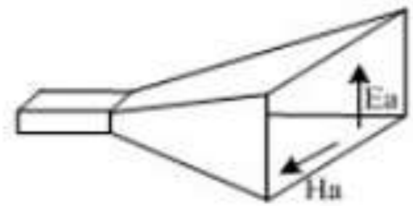
- Thus, to overcome the disadvantages associated with the waveguide, **its end is opened out in the form of an electromagnetic horn**.
- This allows a smooth transition between the waveguide and space thereby offering better directivity to the radio wave.
- By terminating the waveguide with a horn-like structure, the discontinuity existing between the waveguide and space, having impedance **377 ohms** is eliminated.

Types of Horn Antenna

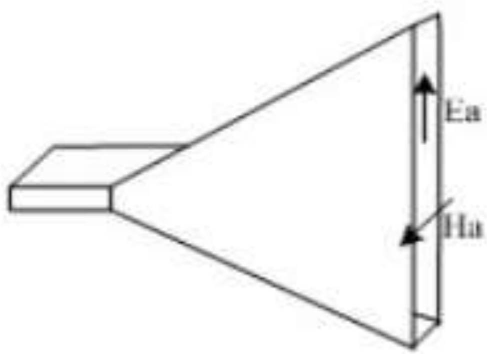
- Pyramidal Horn
- Sectoral Horn
- Conical Horn
- Exponential Horn

DIFFERENT TYPES OF HORN ANTENNA

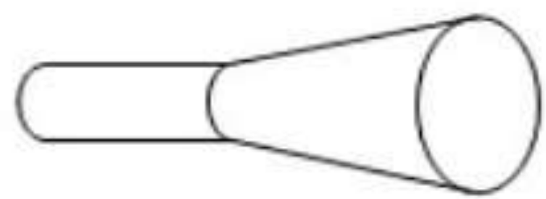
H-plane sectoral horn



Pyramidal horn



E-plane sectoral horn



Conical Horn Antenna

Pyramidal Horn

- A type of horn antenna which is formed by **flaring both the walls of the waveguide** is known as pyramidal horn antenna.
- In pyramidal horn antenna generally, a rectangular waveguide is used and **the flaring is done in the direction of both electric and magnetic field vectors**.
- Here the flared structure of the waveguide resembles like a pyramid thus is named so.

Sectoral Horn

- In this type of horn antenna **flaring is performed only along one of the walls of the waveguide**. However, these are further classified as:
- **E-Plane**: When **one of the walls of the waveguide is flared along the direction of electric field vector** is known as E-plane sectoral horn antenna.
- **H-Plane**: When **the wall of the waveguide is flared along the direction of the magnetic field vector** then we call it H-plane sectoral horn antenna.

Conical Horn

- The formation of a conical horn antenna is a **result of flaring a circular waveguide**.
- A circular horn antenna can be **either conical** or **biconical in nature**.

Exponential Horn

- Exponential horn antenna has a **curved side and sometimes referred as scalar horn antenna**.
- It is called the exponential horn antenna because the separating distance between the **sides rises exponentially as a function of length**.
- These antennas offer constant impedance up to a large frequency thus there are fewer chances of internal reflections.

Horn Antenna Design & Working

- Horn antenna design can **be done with a flared waveguide which is formed as a horn**.
- These are used to transmit and receive RF microwave signals.
- Usually, these are used in combination with waveguide feeds & direct radio waves within a narrow beam.
- Here, the **flared portion can be in any shape like square, conical or rectangular**.

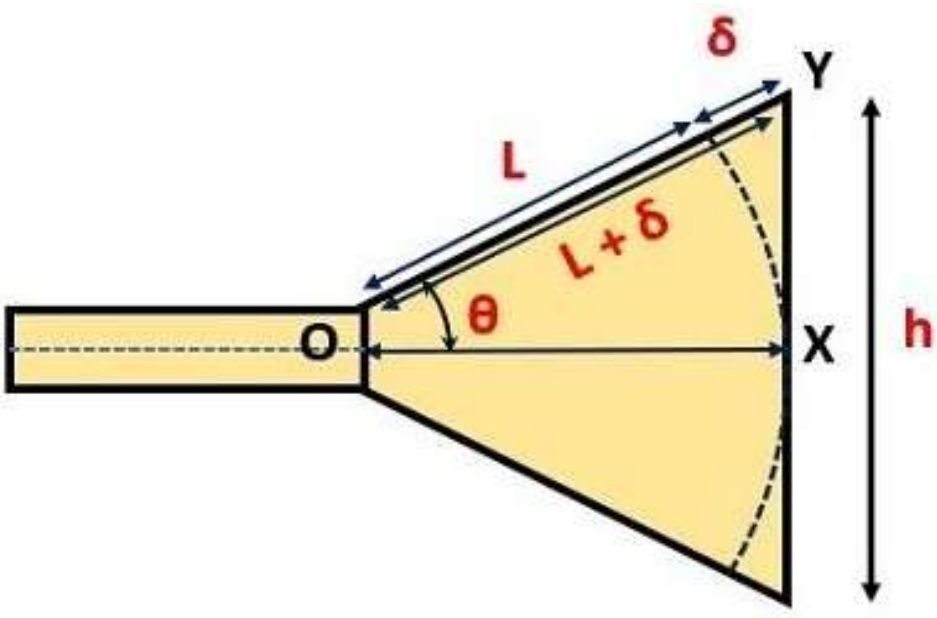
- For proper working, this **antenna should be in minimum size**.
- If the wavelength is very large or the horn size is very small then the antenna will not work properly.
- So that a smooth transition can be allowed in between the space & waveguide thus offering better directivity toward the radio wave.

- The working of the horn antenna is as follows, **once the waveguide's one end is excited then the field can be generated**.
- In general, the fields within the waveguide & free space will transmit in a similar way.
- But, in the case of propagation with the waveguide, the propagating field can be controlled through the waveguide walls so the field will not pass spherically as this is not the case through free-space propagation.

- Once the traversing field arrives at the waveguide end then it transmits in the same way as the free space.
- So, at the waveguide end, **spherical wavefronts** can be attained.
- The flaring not only offers **impedance matching** but also results in **higher directivity** and **narrow beamwidth** thus we get the **desired radiation pattern**.

Design equation of Horn Antenna

- Suppose we have an E-plane sectoral horn with a source that radiates cylindrical radiations as shown below:



- The uniform wavefronts propagates in outward direction are cylindrical.
- Consider the path difference to be δ.

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

and

$$\tan \theta = \frac{h/2}{L}$$

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

Therefore,

$$\theta = \tan^{-1} \left(\frac{h}{2L}\right) = \cos^{-1} \left(\frac{L}{L+\delta}\right) \quad \text{———} \quad 1$$

Considering right angle triangle OYX, and applying Pythagoras theorem,

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

- Therefore equation 1 and 2 are the design equations of the horn antenna.

Since δ is small thus δ^2 can be neglected.

Hence

$$2L\,\delta = \frac{h^2}{4}$$

$$L = \frac{h^2}{8\delta} \quad \text{———} \; 2$$

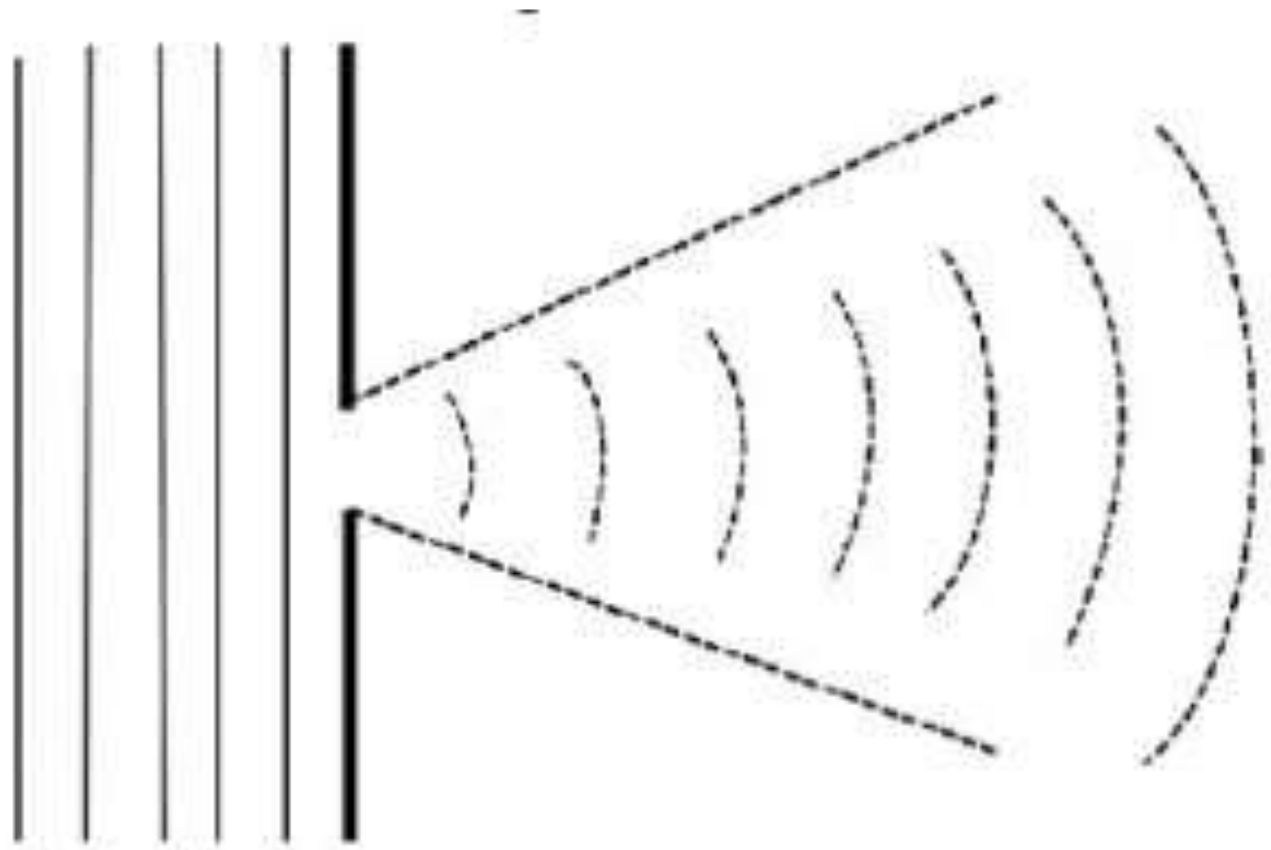
Gain of Horn Antenna

- The gain of horn antenna can be calculated **very easily through design parameters of horn antenna like axial length, path difference, flare angle, and aperture dimension**.
- Generally, **Pyramidal horns are designed to give optimal gain**.
- So the gain of this antenna over an isotropic source that equally emits in all directions can be simply derived.

- Gain = $4\pi eA A/\lambda^2$
- Where
  - 'A' is the physical region of the aperture
  - 'd' is the diameter of an antenna aperture
  - 'λ' is the wavelength
  - 'eA' is the aperture efficiency

Radiation Pattern

- The horn antenna **radiation pattern is a Spherical Wavefront**.
- In this antenna, the waves move as spherical wavefronts to downward of a horn through their source at the top of the horn known as the phase center.



Advantages

- These antennas offer easy construction as can be easily configured with a waveguide.
- The absence of a resonance element in the structure allows it to operate over a **wide bandwidth**.
- It provides **good impedance matching**.
- Horn antenna is highly directional in nature thereby **providing higher directivity**.
- These antennas can operate over a wide bandwidth, wide range of frequencies since they don’t have resonant elements.
- The beamwidth of the horn antenna is 10:1 ratio
  (1 GHz – 10 GHz) which is common and 20:1 is possible.

- Designing is simple.
- They are also simple to connect to the waveguide & a coaxial feeder.
- These antennas have a **low SWR** (standing wave ratio that means they reduce standing waves.
- Its performance is stable for the entire range of frequencies.
- Small minor lobes can be formed.
- These antennas are used as feed horns for large parabolic antennas.
- The nonexistence of a resonance element within the construction allows it to work over a wide bandwidth.
- It is extremely directional within nature thus providing higher directivity.
- It provides fewer reflections.

Disadvantages

- The directivity of the antenna is dependent on the flare angle.
- The dimensions of the flare must be sufficiently large and this sometimes makes the antenna bulky.
- These antennas will radiate energy in spherical wavefront shape, thus this antenna does not provide a directive or sharp beam.

- They have limited gain like 20 dB, so in order to enhance the antenna gain, the opening of the horn should be made larger so that the length of the horn will become excessive.
- The length of the flare & Flare angle should not be extremely small.

Applications

- These are used mainly for astronomical studies.
- These are used in microwave-based applications.
- These can be used as **feed elements**.
- These are used in laboratories to measure different antenna parameters.

- At microwave frequencies, these are used wherever moderate gains are adequate.
- The horn dimensions must be high for high gain to use in moderate gain operations.
- These types of antennas are applicable in speed enforcement cameras to keep away from reflections that interrupt the desired response.
- Parabolic reflectors can be excited by feeding elements like horn antennas. So the higher directivity provided through this antenna permits it to light up the reflector.