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UNIT 4

1. Write short notes on travelling wave antenna?

Ans:

Travelling Wave Antenna

Travelling wave or non-resonant or aperiodic antennas are those antennas in which there is no reflected wave i.e., standing wave does not travel over such antennas. As against this, there are resonant or tuned or standing waves or periodic antennas in which standing waves exist due to improper termination. Such antenna operates properly on limited band for which they are tuned. Since in radio communications which employ ionosphere for reflection, frequently require to operate on a widely spaced frequencies and thus there is a need for an antenna having greater band width. This need of larger bandwidth is met by these travelling wave antennas. In order to avoid reflected waves from the radiator so that only incident travelling wave travel on the antenna, the antennas are terminated at one end other than the feed end. Although this dissipates some powers but because of its simplicity it has its own attraction. Now to have a thorough understanding of travelling wave radiators we have to consider the radiation from a single wire carrying travelling waves.

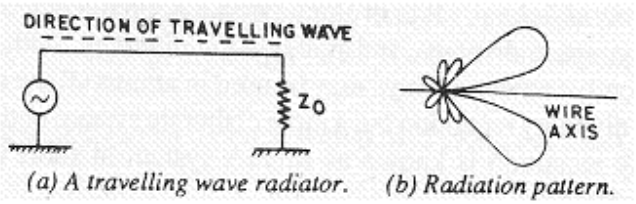


Fig 4.1.1 Travelling Wave Radiator and its Radiation Pattern

Now consider a two wire transmission line terminated at its far end by its characteristics impedance so that there is no reflected wave and travelling waves travel along the line. The spacing between two wires transmission line and the other line (i.e. return conductor of the line) can be disregarded for the moment, as radiation from a current clement can be applied for a single wire. Further uniform current throughout the single wire is assumed. Thus a single long wire may be thought as number of Hertzian dipoles joined end to end (Fig.4.1.1) with current with phase lagging according to distance i.e. it is similar to an end fire array of collinear Hertzian dipoles, if velocity of light is assumed to be same in the wire and the free space. Thus travelling wave antenna is essentially an end fire antenna with a sharp null in the forward direction Fig.4.1.1 (b). The field strength at a distance r from the wire at an angle θ can be shown to be

Where,

$$E = (60\, I_{rms}/\, r).\, (\sin\theta\, /1-\cos\theta\,).\, \sin(\,\pi\, L/\,\lambda\, \{1-\cos\theta\,\})$$

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L = Length of the wire, I_{rms} = rms value of travelling wave current.

If radiation pattern for various lengths are plotted as in Fig.4.1.2, it would be seen that as the length of wire increases, the major lobes get closer and narrower to the wire axis.

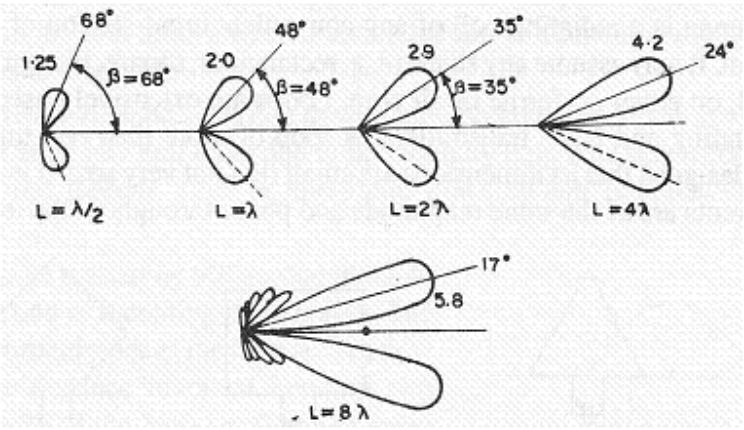


Fig 4.1.2 Radiation patterns for travelling wave antenna of different lengths

It is further seen that for a variation of length of travelling wave radiator from 2 λ to 8 λ, the angle of major lobe varies from 17° to 68°. Besides the amplitude of the lobe also increases. The travelling wave radiators can be excited without the second line or return conductor. Since an end fed antenna possesses standing wave so it can be made a travelling wave radiator if its other end is terminated with a suitable value resistor. Thus a single wire radiator, if terminated with impedance of value equal to characteristic impedance, will work as travelling wave radiator.

2. Write short notes on Long wire or Harmonic antenna?

Ans:

An antenna will be resonant so long as its length is integral multiple of half wave length. When an antenna is more than a half-wave long it is called as a long-wire or a harmonic antenna. Thus the long wire antenna is a single long wire, generally two or more wave length (i.e. 4 λ/2 or more λ/2) long at the operating frequency. The higher the number of λ/2 the better its directivity. Since the wire is made longer in terms of the number of half wave lengths (λ/2), the directional effect changes. The directional characteristics split up into various lobes at different angles from wire axis as against "doughnut shape" of a single λ/2 antenna. It radiates a horizontally polarized wave at low angles from about 17° to 24" relative to the earth surface. In

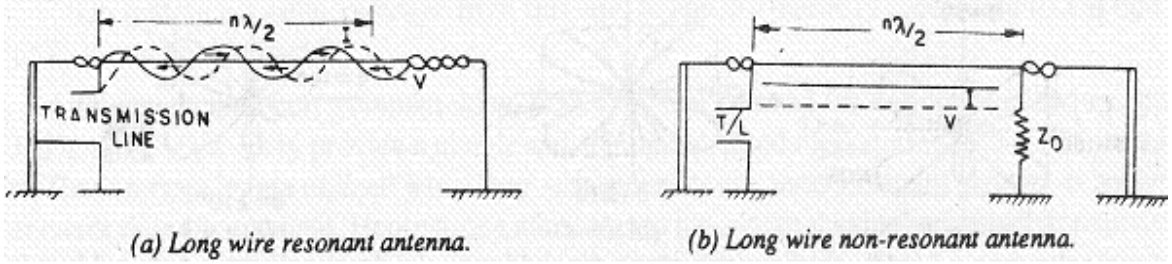


Fig 4.2.1 (a) Long Wire Resonant Antenna (b) Long Wire non-Resonant Antenna

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long wire antenna, the currents in adjacent half wave section must be out of phase and hence any feeder system can be used that does that disturb this condition. This condition can be satisfied if long wire antenna is fed at either end or at any current loop. A long wire antenna is generally made a half wave length at the lowest frequency of operation and fed at the end. Long wire antennas are shown in Fig. 4.2.1 in which n is the number of half wavelength.

The long wire may assume two forms e.g. resonant (unterminated) and non-resonant (terminated at characteristics impedance). In resonant long wire antenna standing wave exists along its length and the pattern is bidirectional corresponding to incident waves and reflected waves. However, in case of non-resonant long wire antenna all the incident waves are absorbed in terminating impedance and there is no reflected wave. This is why the pattern is only due to incident wave's i.e. unidirectional only and uniform current and voltage exist along the axis of the wire.

The directional patterns of resonant and non-resonant types of antennas are shown in Fig. 4.2.2. The angle of radiation with reference to wire axis depends on number of wavelength i.e. even or odd. For n = 3 and n = 4 directional pattern is shown in figure. For example maximum radiation from a long wire antenna of 8 λ long w.r.t. wire axis is at 17.5° with many small minor lobes.

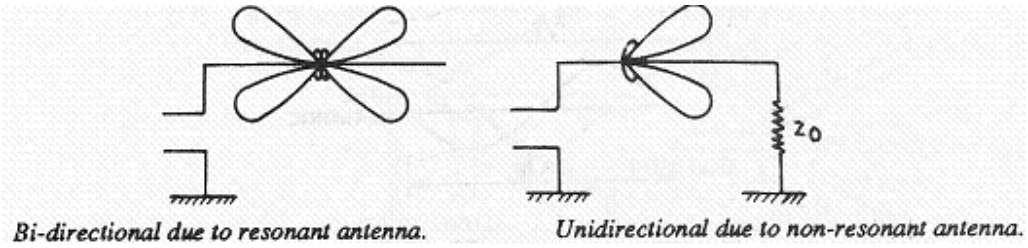


Figure 4.2.2 Radiation Patterns

The physical length of a long wire antenna can be extended from the physical length of λ/2 antenna as follow from equation

$\lambda/2 = (492 \times 0.95)/f$ (MHz) feet if one half wavelength in wavelength

Hence for n half wavelength long wire antenna

$$\text{(length)} = \boldsymbol{492(n - 0.05)/f(MHz)} \text{ feet}$$

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Where *n* is the number half wave length in the wire length.

Resonant and non resonant long wire antennas are used for transmission and reception i.e. from 500 kHz to 30 MHz. They provide a simple and effective method of obtaining directional pattern and power gain. These properties are utilized when long wire antennas are used as circuit element in an array such as V antennas or rhombic antennas. Hence a long wire antenna has practical value because of its structural simplicity and relatively low cost, irrespective of theoretical complications.

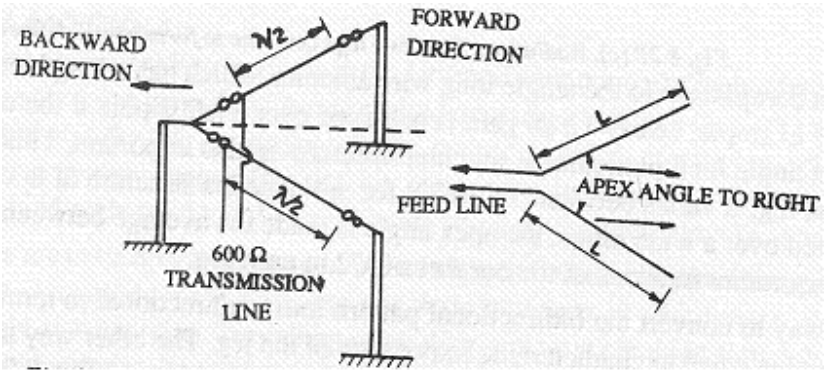


Fig 4.3.1 Resonant V Antenna

3. What is a V- antenna? Explain its characteristics?

Ans:

V–antenna

The V antenna is an extension of long wire antennas. Two long wire antennas (called legs) are arranged in the form of a horizontal V, fed at the apex as shown in Fig. 4.3.1.

If the angle between the two sides of the V, is equal to twice the angle that the cone of maximum radiation of each wire makes with the axis of that wire, then the two cones will add up in the direction of the line bisecting the apex angle of V, and there produce a maximum lobe of radiation. The two wires are fed 1800 out of phase with each other. This provides gain and directivity. The higher the length of legs, the greater the directivity and gain. These are achieved by cancelling oppositely directed corresponding radiation lobes in each leg and by adding the

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similarly directed corresponding lobes in each leg. The resultant is bi-directional patterns which are sharper than the same length single long wire. The gain achieved with the V an antenna is nearly twice in comparison to the single long wire antenna, which has a length equal to that of the legs of the V antenna. For example, nearly 12 db gain is achieved over a λ /2 dipole if the each leg is 16 x λ/2 i.e. 8 λ long. The apex angle for a particular V antenna structure is also important. This apex angle varies according to length of the leg. It varies between 36 0 to 72 0for a V antenna structure of 8 λ to 2 λ long. If the V antenna is to be operated over a wide range, the apex angle is made the average between the optimum for the highest and lowest frequencies in terms of the number of λ/2 in each leg.

V antenna provides multiband operation so it can conveniently be fed by tuned feeders. If non resonant lines are to be used, probably a better matching system is to use a λ/4 matching section or stub. The resonant V antenna is perhaps the one of the cheapest forms of receiving or transmitting antenna for providing a low angle beam for fixed frequency operation in HF band. One of the serious drawback of V antenna is that it provides strong minor lobes too.

4. Write a short note on the inverted V antenna?

Ans:

Inverted V antenna

Antennas are to be operated on a number of allotted frequencies, travelling wave antennas are employed for the purpose. Travelling wave antennas are those antennas in which there are no standing waves and waves travel in only one direction. Travelling wave distribution is obtained simply by terminating one end of antennas by a non-inductive resistance of value equal to its characteristic impedance. Such antennas are also called as aperiodic or non-resonant antennas. By doing so, the band width is increased. Inverted V antenna used in high frequency band, is one of the travelling wave antenna. A travelling wave antenna for low frequency reception is wave or Beverage antenna already discussed.

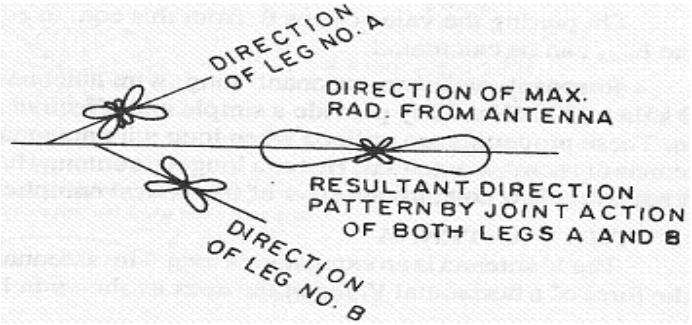


Fig 4.3.2 Radiation Pattern of V antenna

As shown in Fig 4.4.1 the inverted V antenna is easily installed on a non-conducting mast. Unlike flat V, inverted V

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requires only one mast as against 3 in the former. The direction of maximum radiation is towards terminated end as shown. The input from transmitter is fed at point C through a transmission line. The other end is connected to a number of radial earth wires. The next end of the Antenna wire D is terminated with a resistor which itself is connected to the radial earth wide.

The value of resistor is generally of 400Ω and is adjusted to set substantially travelling waves in the antenna wire CBD. The length of legs of V antenna is 8 λ/2 at the highest frequency and 4 λ/2 at the lowest frequency. Although legs of length 2 λ/2 is also employed.

The angle θ is known as tilt angle and for a given number of wave length L/λ in leg CB is a compromise between two factors e.g.

(i) Angle of major lobe corresponding to L/λ

(ii) Angle of tilt for which the fields from BC and BD will combine to give maximum gain.

From the Fig. 4.4.1 the lobes *A* and B' will be cancelled out but B and A' should be made to combine at a distance. But since these lobes are on opposites of the wire, a phase reversal is needed. This can be achieved either by reversal of current fed at a point B or by spacing towards the R_x. Ultimately a optimum value of θ is determined by taking a average value. This angle ranges from 36° to 71°.

The disadvantages in the inverted V antenna are that it has considerable undesired minor lobes due to the other portion of the radiating lobes. These minor lobes emits horizontally polarized wave in some directions and hence this inverted V antenna may also receive some horizontally polarized waves from these waves.

5. Explain the constructional features and characteristics of a rhombic antenna?

Ans:

Rhombic antenna

Consider the rhombic antenna which is placed horizontally as shown in the figure 4.5.1.

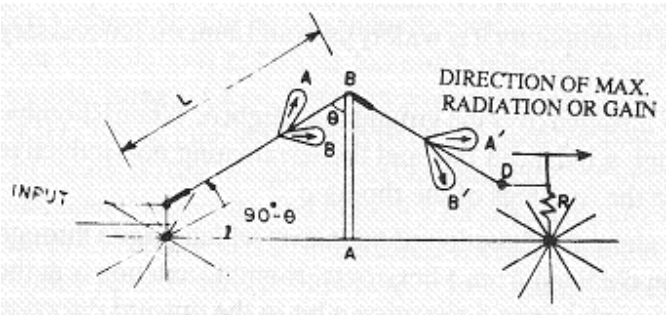


Fig 4.4.1 Inverted V antenna

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It consists of two wires arranged in the form of diamond or rhombus. The basic principle of rhombic antenna depends upon the travelling wave radiator. Rhombic antenna is used for both transmission and reception. In case of transmission, the input is applied through a feed line and receiving end is terminated by characteristic impedance. The rhombic antenna is similar to the two V-antennas connected in series and is suitable for point-to-point communication. The each arm of the rhombic antenna produces a pattern as shown in figure 4.5.2. The lobes BCEG are producing the resultant field pattern at the receiving end which is terminated by characteristic impedance. The remaining lobes such as ADFG are also partici-pating in the radiation pattern process and which are going to increase the directivity of the resulting signal further. Radiation pattern of rhombic antenna as shown in figure 4.5.2. The gain of rhombic antenna is increased by adding four lobes BDEK and tilt angle is equal to the angle of major lobe minus 98.

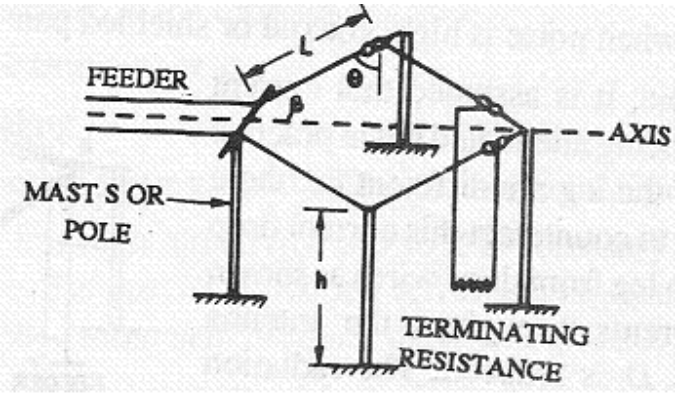


Fig 4.5.1 Rhombic Antenna

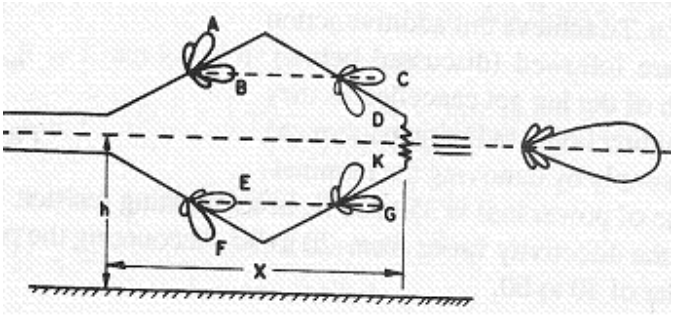


Fig 4.5.2 Radiation Pattern of Rhombic antenna

Construction of Rhombic antenna

Construction of rhombic antenna depends upon three major factors. They are,

1. Tilt angle(θ)
2. Leg length(L)
3. Height above ground (h).

Basically, there are two types of design. They are,

1. Alignment design
2. Maximum output design.

This classification is based upon the elevation angle (β).

1. Alignment design

In alignment design, the height h above ground is selected such that, angle of main beam is equal to the elevation angle (β). General expression for height is,

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$$h = \lambda/u \sin\beta$$

Leg length, $L = 0.37\lambda / \sin^2\beta$ and

Tilt angle, $\theta = 90^0 - \beta$

2. Maximum output design

In maximum output design, the height (h) above ground is selected such that, the maximum field strength is obtained from desired elevation angle (β). The values of tilt angle (θ), leg length **(**L**)** and height above ground **(**h**)** is calculated below. In vertical plane, the relative field intensity of rhombic antenna is,

$$E = \{2\cos\theta[\sin(2\pi h\sin\beta/\lambda)][\sin(\pi L/\lambda)(1-\cos\beta\sin\theta)]^2\}/(1-\cos\beta\sin\theta)$$

Where,

E = Electric field strength (V/m)
β = Elevation angle
L = Leg length
λ = Operating wavelength
h = Height above ground.

From above field strength equation, we calculate the values of leg length (L), height (h) and tilt angle (θ).

Advantages of Rhombic Antenna

1. Rhombic antennas are very much useful for radio communication.
2. It is useful for long distance propagation because of low vertical angle of radiation.
3. The input impedance of single wire antenna is half of the impedance of rhombic antenna.
4. The performance of rhombic antenna is measured in terms of leg length, height and tilt angle.
5. Single wire antennas have less receiving power along main axis whereas, rhombic antennas have more receiving power. So, rhombic antennas are highly directional broadband antennas.
6. The input impedance and radiation pattern does not depend upon frequency so, rhombic antennas are used in broadside arrays.
7. Rhombic antennas are untuned and easily convert from one frequency to another frequency.

Disadvantages of Rhombic Antenna

1. Transmission efficiency of rhombic antenna is very less.
2. It requires more space.

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6. Sketch and explain the constructional features of a helical antenna?

Ans:

Helical Antenna

Helical antenna is useful at very high frequency and ultra high frequencies to provide circular polarization. Consider a helical antenna as shown in figure 4.6.1.

Here helical antenna is connected between the coaxial cable and ground plane. Ground plane is made of radial and concentric conductors. The radiation characteristics of helical antenna depend upon the diameter (D) and spacing S.

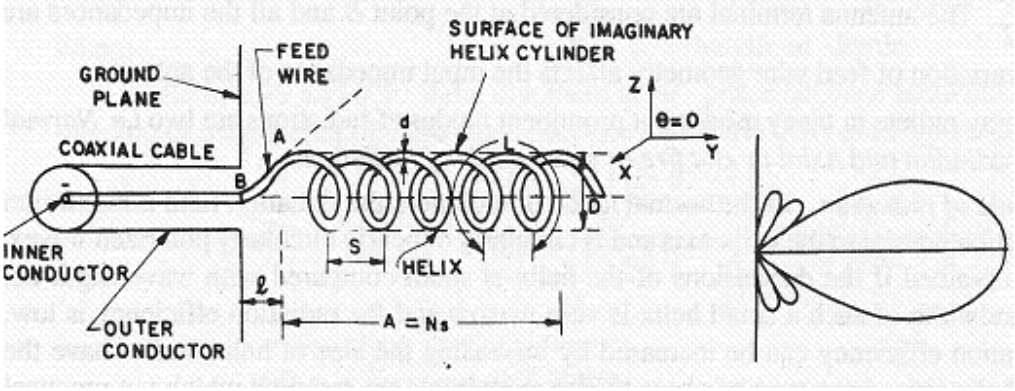


Fig 4.6.1 Helical antenna and its radiation pattern

In the above figure,

L = length of one turn = $\sqrt{S^2 + (\pi D)^2}$

N = Number of turns

D = Diameter of helix = πD

α = Pitch angle = $\tan^{-1}(S/\pi D)$

l = Distance between helix and ground plane.

Helical antenna is operated in two modes. They are,

1. Normal mode of radiation
2. Axial mode of radiation.

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1. **Normal mode of radiation**

Normal mode of radiation characteristics is obtained when dimensions of helical antenna are very small compared to the operating wavelength. Here, the radiation field is maximum in the direction normal to the helical axis. In normal mode, bandwidth and efficiency are very low. The above factors can be increased, by increasing the antenna size. The radiation fields of helical antenna are similar to the loops and short dipoles. So, helical antenna is equivalent to the small loops and short dipoles connected in series.

We know that, general expression for far field in small loop is,

$$E_\Phi = \{120\ \pi^2[I]\ \sin\theta/r\}[A/\lambda^2]$$

Where,

r = Distance

$I = I_0 \sin \omega(t-r/C)$ = Retarded current

A = Area of loop = $\pi D^2/4$

D = Diameter

λ = Operating wavelength.

The performance of helical antenna is measured in terms of Axial Ratio *(AR)*. Axial ratio is defined as the ratio of far fields of short dipole to the small loop.

Axial Ratio, AR = $|E\theta|/|E\Phi|$

2. **Axial mode of radiation**

Helical antenna is operated in axial mode when circumference C and spacing S are in the order of one wavelength. Here, maximum radiation field is along the helical axis and polarization is circular. In axial mode, pitch angle lies between 12° to 18° and beam width and antenna gain depends upon helix length NS.

General expression for terminal impedance is,

$$R = 140C/\lambda \text{ ohms}$$

Where,

R = Terminal impedance

C = Circumference.

In normal mode, beam width and radiation efficiency is very small. The above factors increased by using axial mode of radiation. Half power beam width in axial mode is,

$$HPBW = 52/C\sqrt{\lambda^3/NS} \text{ degrees.}$$

Where,

λ = Wavelength

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C = Circumference

N = Number of turns

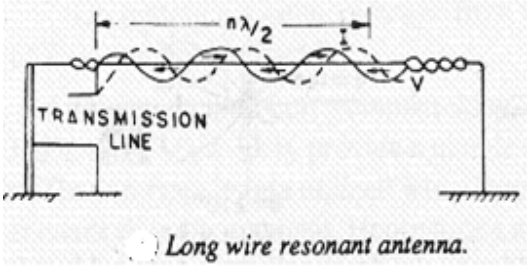
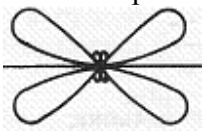
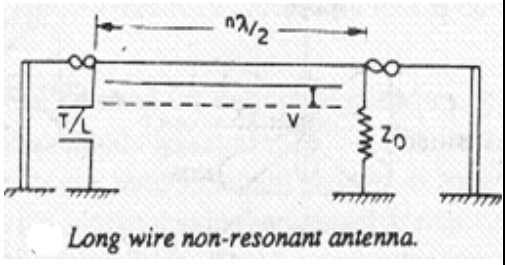
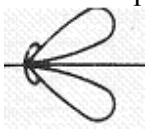
S = Spacing.

Axial Ratio, AR = 1 + 1/2N

7. Distinguish between Resonant and non-resonant antennas.

Ans:

Difference between Resonant and Non-resonant Antennas

Resonant Antenna	Non-resonant Antenna
1. These correspond to a resonant transmission line that is an exact number of half wave length long and is open at both ends. 2. Because of incident and reflected waves, standing waves exist. 3. The radiation pattern of this antenna is bi-directional. 4. These antennas are used for fixed frequency operations. 5. Resonant antenna  Long wire resonant antenna. 6. Radiation pattern  Bi-directional radiation pattern.	1. These correspond to a transmission line that is exited at one end and terminated with characteristic impedance at the other end. 2. Due to the absence of reflected waves, standing waves do not exist. 3. The radiation pattern of this antenna is uni-directional. 4. These antennas are used for variable and wide frequency operations. 5. Non-resonant antenna  Long wire non-resonant antenna. 6. Radiation pattern  Uni-directional radiation pattern.

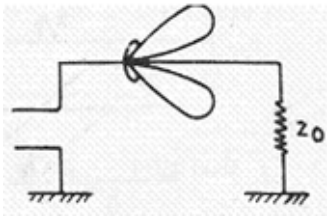
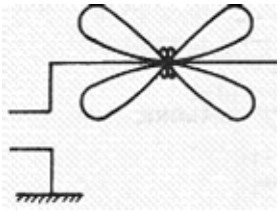
8. Distinguish between travelling wave and standing wave antennas.

Ans:

Travelling Wave Antennas	Standing Wave Antennas

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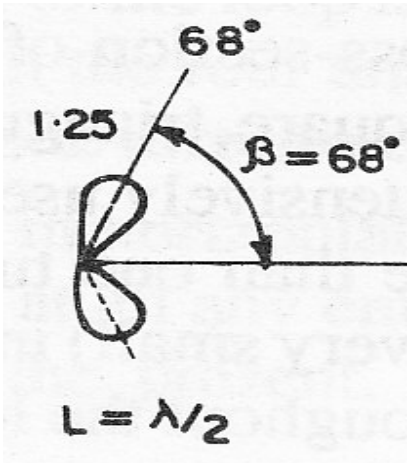
1. Travelling wave antenna is one, in which standing waves does not exist. 2. Travelling wave antennas are also known as aperiodic or non-resonant antenna. 3. Reflected wave does not appear in travelling wave antennas. 4. Radiation pattern of travelling wave antenna is uni-directional. 5. Uni-directional pattern for ***n* = 4** is shown in figure. Here, ***n*** = Number of wave lengths.  6. Directivity is more. 7. The length of wire increases, major lobes get closer and narrower to the wire axis.	1. In standing wave antenna, standing wave exists. 2. Standing wave antennas are also known as periodic or resonant antennas. 3. Reflected wave appears in standing wave antenna. 4. Radiation pattern of standing wave antenna is bi-directional. 5. Bi-directional pattern for ***n*** = 3 is shown in figure.  6. Directivity is less. 7. Length of wire does not depend upon the lobes.

9. Draw the radiation pattern for travelling wave antenna for L = λ/2, λ, 2λ, 4λ, and 8λ.

Ans:

For L = λ/2

Directivity = 1.25

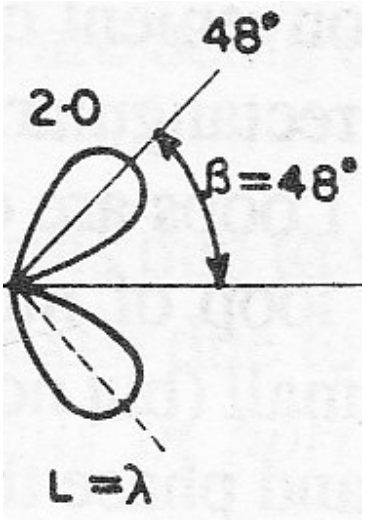


For L = λ

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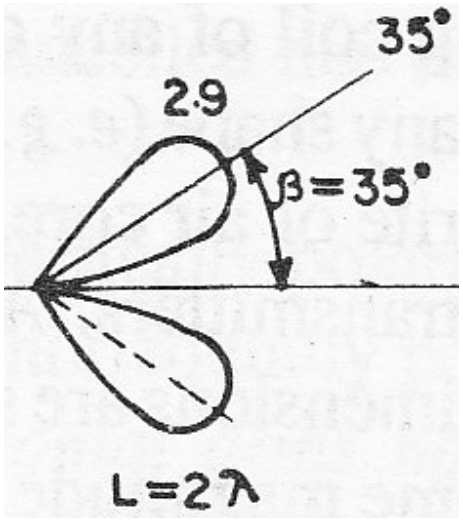
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Directivity = 2



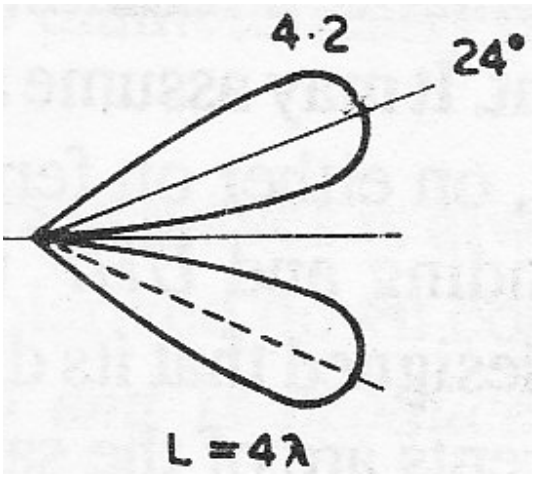
For L = 2λ

Directivity = 2.9



For L = 4λ

Directivity = 4.2

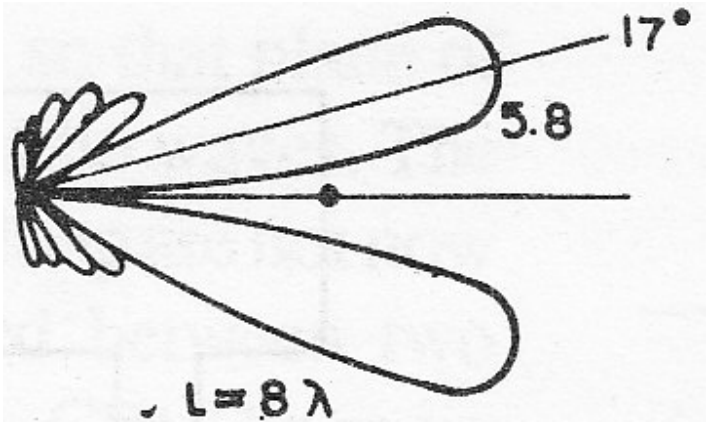


For L = 8λ

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Directivity = 5.8



10. Distinguish between Narrow band and Wide band antennas.
Ans:

Narrow Band Antennas	Wide Band Antennas
1. Since, the bandwidth of receiving antenna is narrow, it is difficult for high-speed data communication.	1. Since, the bandwidth of receiving antenna is very high, it is very easy for high-speed data communication.
2. These are bigger in size.	2. These are small in size.
3. Because of the constitution of narrow band radio module, these are more expensive.	3. These are less expensive than narrow band antennas.
4. These antennas can realize stable long range communication.	4. Because of large bandwidth, these are not suitable for long range communication.
5. These antennas lead to the high efficiency of radio wave use within same frequency band.	5. These antennas lead to the less efficiency of radio wave use within same frequency band.

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