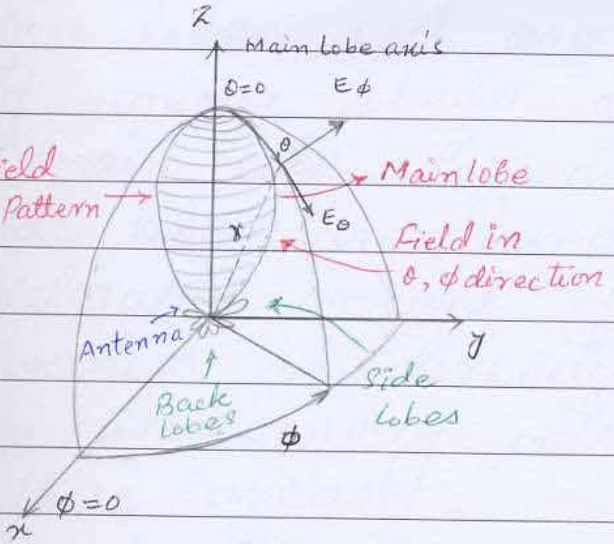
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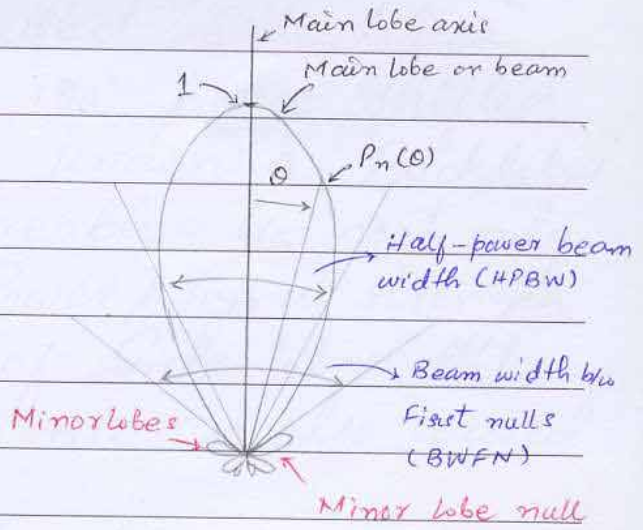
(3)

Radiation Pattern & Other Characteristics

Radiation Pattern:

* It is a polar graph representing field strength ($\bar{E}$) or power densities (Poynting vector) at various angular positions relative to an ata.
* Radiation pattern simply means that signal strength $|\bar{E}|$ radiated in each direction around an ata.





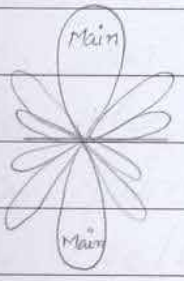
* Ata. radiation pattern are valid for far-field regions.
* They depends on shape of ata & source $\bar{E}$ field.
* In above figure, pattern shows field intensity at a certain distance 'r' from ata in direction θ, ϕ.

Q: Differentiate between Near field & far field regions, why these regions are also known as Induction field & radiation fields respectively.

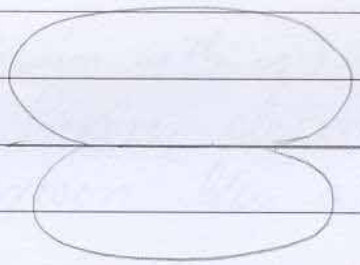
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Main Lobe:

* It is intended part of Radiation pattern where it desired to have most energy / strength / power of radiation to occur.
* Main lobe is along principal axis (z-axis) It is also known as principal or major lobe.
* In addition Main lobe / lobes there are other types such as "secondary & minor lobes."
* These minor lobes are just adjacent to main lobe and are called "Side lobes."
* If minor lobe(s) are 180° phase shifted to main lobe they are known a "Back lobes."
* Side lobes are undesireable b/c not only considerable amount of Power / Signal strength is wasted in direction of Side lobes but even unnecessary interference is also caused in those areas.
* For direction Ata, we should reduce side lobes.

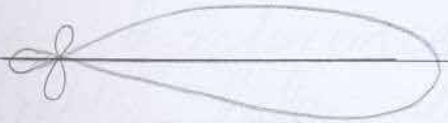


(1)

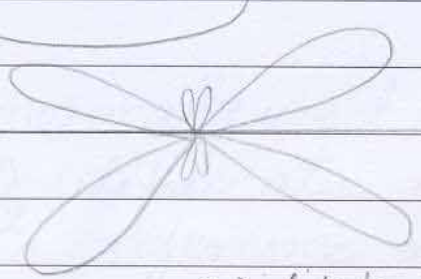


$\lambda/2$ dipole

(2)



Horn Antenna (3)



(4)

2λ dipole

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Front-to-Back Ratio :

* For a directional ata. max radiation should be in wanted or desired direction.
* Hence for directional ata. FBR is an important parameter.
* FBR is defined as ratio of max. power radiated in desired direction to power radiated in opposite direction.

$$FBR = \frac{\text{Power radiated in Desired Direction}}{\text{Power radiated in opposite Direction}}$$

Gain of antenna :

* This parameter is an important figure of merit for ata performance.
* The ability of an ata to concentrate the radiated power in a desired direction / or absorbs incident power from that direction is specified by
  (1) Antenna Gain
  (2) Directivity (Gain with η) } Closely Related.
* Note that Ant. is a Passive element.
* Ata. gain is a comparison b/w a Test ata & a reference ata.
* The reference ata, normally used is an Isotropic ata, although $\frac{\lambda}{2}$ dipole ata is also sometimes used as a reference ata.

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However, Isotropic ($\frac{\lambda}{2}$) reference ata is a natural choice.

Gain (G) = $\frac{\text{Max. Radiation Intensity from Test Antenna}}{\text{Max. Radiation Intensity from Ref Antenna}}$

↳ Note: They both have same o/p Power.

$$G_1 = \frac{\phi_m}{\phi_0}$$

Another definition for ata gain for Receiving ata.

$$G_1 = \frac{\text{Max. Power Rxed from Test ata } (P_1)}{\text{Max. Power Rxed from Ref ata } (P_2)}$$

$$G_1 = \frac{P_1}{P_2} \quad \text{or} \quad P_1 = G_1 P_2$$

we know that

$$P_t = G_1 P_2 \Rightarrow \text{EIRP}$$

* A $\frac{\lambda}{2}$ dipole ata has a gain of 1.64 times over an isotropic ata (or 2.15 dB).
* Gain of ata w.r.t isotropic is denoted as (G_i) or (dB_i)
* $\lambda/2$ ata is sometimes used as a reference. In that case, gain of ata w.r.t dipole is represented as (G_d) or (dB_d).

$$G_1(dB_d) = G_1(dB_i) - 2.14\ dB$$

(Dipole Gain) (Isotropic Gain)

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Directivity of Antenna:

* Ata directivity 'D' is simply antenna gain without taking into account the effidency of a Practical ata.

$$G_1 = D\eta$$

where

G_1: Gain (Ratio, not in dB)
D: Directivity (ratio, not in dB)
η: Efficiency

And

$$\eta = \frac{P_r}{P_t} \quad \begin{matrix} (\text{Radiated Power}) \\ (\text{Power Supplied to Anta}) \end{matrix}$$

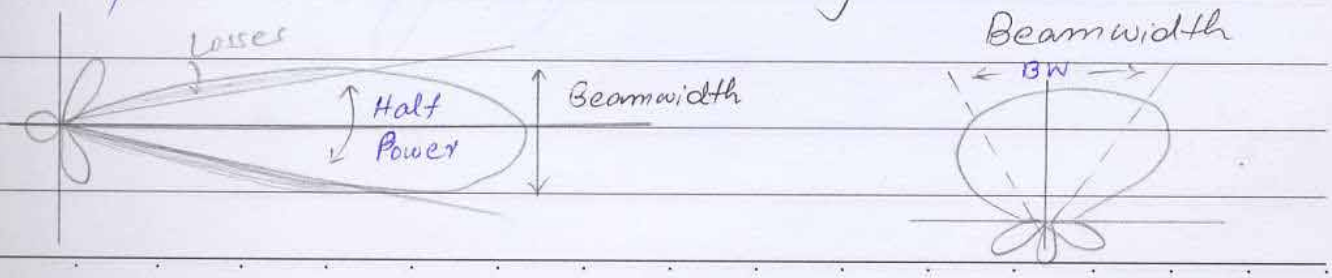
* For an Ideal (omni), lossless ata G_1 & D are same.

$$G_1 = D \qquad [\eta = 1]$$

Beamwidth:

* Measure of directivity of ata.
* Ata BW is defined as angular Seperation btw half power points on radiation pattern of an ata.
* The half power points are also called "3 dB" points.

Directivity $\propto \frac{1}{\text{Beamwidth}}$



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Aperture of ata (Effective area / Capture area)

* A Tx ata transmitts Em-energy in space & Rx. ata recieves a fraction of this Em-energy.
* Effective Area or Capture Area or aperture of a Rxing ata can be described as

$$A_e = \frac{\text{Power Rxed at ata. load.}}{\text{Power Density incident on Ata.}} \quad \frac{P_r}{P_{density}} = m^2$$

↳ $P_{density}$: Is captured power (power available ata o/p

↳ P_r : Is not actual power Rxed, but rather amount of power incident at Rx-ata or passing thru it.

* The captured power can be delivered to a load. It is directly proportional to Rxed power density & effective capture area of Rx-ata.

* The Physical cross-sectional area of Rx ata & its effective capture area are not necessarily equal.

↳ P.T.O.

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Let A_e = Effective capture area or Aperture

$$A_c = \frac{A_r \lambda^2}{4\pi} \quad (1)$$

A_r := Rx-ata Power Gain.

λ := wavelength of Rx-Signal

Solving Eqn (1) in terms of A_r

$$A_r = \frac{A_c 4\pi}{\lambda^2} \quad (2)$$

Power Rxed or Captured by a Rx-ata is

$$P_{cap} = P A_c \quad (3)$$

P := Power Density

$$P = \frac{P_{in} A_t}{4\pi R^2} \quad (4)$$

where P_{in} = Power i/p to Tx-ata.

A_t = Tx-ata Power gain.

R = Distance b/w Tx & Rx Ata.

$$P_{cap} = P\left(\frac{A_r \lambda^2}{4\pi}\right) \quad (5)$$

$$P_{cap} = \left(\frac{P_{in} A_t}{4\pi R^2}\right)\left(\frac{A_r \lambda^2}{4\pi}\right)$$

$$P_{cap} = P_{in} A_t A_r \left(\frac{\lambda}{4\pi R}\right)^2 \quad (6)$$

As

$$P_{in} A_t = EIRP$$

So

$$P_{cap} = (EIRP) A_r \left(\frac{\lambda}{4\pi R}\right)^2 \quad (7)$$

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Also,

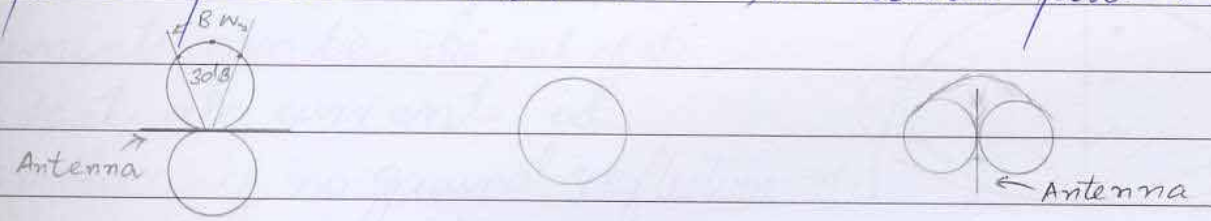
$$\frac{1}{L_p} = \text{Path Loss} = \frac{\lambda^2}{16\pi^2 R^2} \quad \text{---} \quad (8)$$

$$P_{cap} = (EIRP)(A_r)(L_p)$$

$$P_{cap}(dBm) = EIRP(dBm) + A_r(dB) + L_p(dB)$$

Summary of characteristics;

* Radiation Pattern is a graph of radiated field strength vs angle or location from ata.
* The max field strength for a $\lambda/2$ dipole occurs at right angle to ata while virtually zero energy is launched "off the ends", usually known as "Directional".
* An isotropic source of waves have spherical radiation pattern usually known as Omni-directional.
* Beamwidth is angular seperation btw half power points on its radiation pattern.



Hertz $\frac{\lambda}{2}$ dipole Isotropic Point Source (Doughnut-shaped)

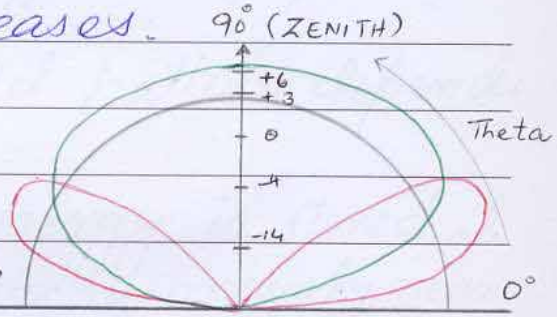
* Anta gain is a different entity from amplifier gain. Feeding more power into an ata doesn't result in greater power than radiated field energy with reference to a reference ata.

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* $\frac{\lambda}{2}$ dipole ata is usually taken as standard reference to all other atas are compared w.r.t to their gain.

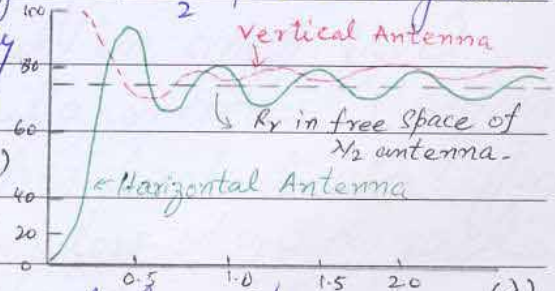
Ground Effects

* When an ata is installed within a few wavelengths of ground, the Earth acts as a reflector and has a considerable influence on the radiation pattern of ata & can cause fading upto HF range. At VHF and above ground has no significance.
* This can be caused by change in radiation resistance that intercept ata & alter the amount of current flow thro it.
* And certain heights of ata from ground this allows reflection of wave to induce ata currents in phase with transmitter current so that total current increases.
* At other ata heights, two currents can be 180° out of Φ So, that ata current is less than if no ground reflection.



(— Dipole with ground ignored, → $\frac{1}{4}\lambda$ dipole above ground, → $\frac{\lambda}{2}$ Dipole above ground)

* R_R of horizontal ata rises steadily to max 90Ω at a height of $\frac{3}{8}\lambda$. Falls around avg 73Ω w/c is value of free space. Variation in R_r of vertical is much less than horizontal antenna.



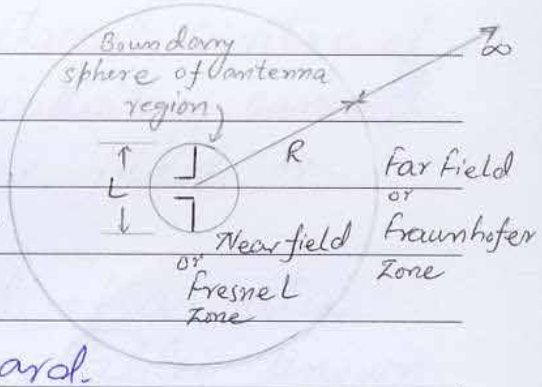
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Field of Antenna

* The field around an ata may be divided into two principal regions, one at away from ~~near~~ anta called "far field" or "Fraunhofer Zone" while one near to ata is "near field" or "Fresnel Zone".

The boundary b/w two may be arbitarily taken to be at a radius.

$$R = \frac{2L^2}{\lambda} \quad (m)$$



* In far region, measurable field components are transversed to radial direction & all power flow from ata to radially outward.
* In far field shape of field pattern is independent of distance.
* In near field longitudinal component of electric field may be significant & power flow is not entirely radial.
* In near field shape of field pattern depends in general on distance.
* For a $\lambda/2$ dipole antenna, energy is stored at one instant of time in E field, mainly near ends of ata or max charge regions while $\frac{1}{2}$ period later energy is stored in mag. field mainly near center of ata or max 'I' region.
* Induction field is 1 w/c collapses back to ata, effects $\lambda/2$ distance basically a trying loss where as radiation field has no effect, useful for Pwr & is a Gain.

Date:

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