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Paper : Antenna and wave propagation

Semester : 8th

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Date : 23-06-2020

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Q1(a) The directivity of an antenna array can be increased by adding more antenna element as a large number of elements?

(A) Approve the radiation efficiency

(B) Increase the effective area of the antenna.

(C) Result in a better impedance matching?

(d) allows more power to be transmitted by an antenna.

Ans) The Answer is (B) Increase the effective area of the antenna.

$$D = \frac{4\pi}{\lambda^2} A_e$$

$$D\uparrow \rightarrow A_e\uparrow$$

An antenna is an electrical device which converts electric power into radio waves and vice versa. It is usually used with a radio transmitter or radio receiver.

Q1 b) Radiation resistance of an antenna is 90Ω & loss resistance is 30Ω, calculate antenna radiation efficiency?

Solution:-

$R_{rad} = 90\Omega$

$R_{loss} = 30\Omega$

$$\eta = \frac{R_{rad}}{R_{rad} + R_{loss}}$$

$$= \frac{90}{90+30}$$

$$= 90/120 = 3/4 \quad \text{Ans}$$

Q2(a) An antenna has a loss resistance of 40Ω power gain of 60 & directivity 13. calculate the radiation resistance?

Solution

$R_L = 40\Omega$

Power gain = 60

D = 13

$\Rightarrow$ K = KD

$= \frac{60}{13}$

$k = \frac{R_r}{R_r + R_L}$

$\frac{60}{13} = \frac{R_r}{R_r + 40}$

$60(R_r + 40) = R_r(13)$

$60R_r + 2400 = 13R_r$

$2400 = 13R_r - 60R_r$

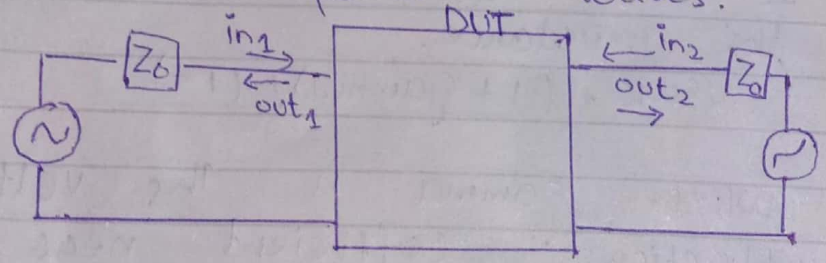
$\frac{2400}{-47} = \frac{-47R_r}{-47}$

$R_r = -51.06$

Q2b):- Explain scattering parameter & VSWR?

Ans:- **Scattering Parameter :-**

Scattering parameter describe the input output relation between parts in an electrical system. Specify at high frequency it becomes essential to describe a given network in terms of waves rather than voltage or current Thus in S-parameter we use power waves.



The S parameter matrix can be used to determine reflection cofficients and transmission gains from bothsides of a two port networks.

VSWR :-

VSWR (voltage standing wave ratio) is a measure of how efficiency radio frequency power is transmitted from a power amplifier through a transmission line, to an antenna).

In an ideal system 100% of the energy is transmitted.

Mathematically:-

VSWR is the voltage ratio of the signal on the transmission line

VSWR = |V(max)| / |V(min)|

Where Vmax is the maximum voltage of the signal along the line & V(min) is the minimum voltage along the line.

It can also be derived from the impedance.

VSWR = (1 + gamma) / (1 −)

where gamma is the voltage reflection cofficient near the load derived from the load impedance (ZL) and the source impedance (Z0)

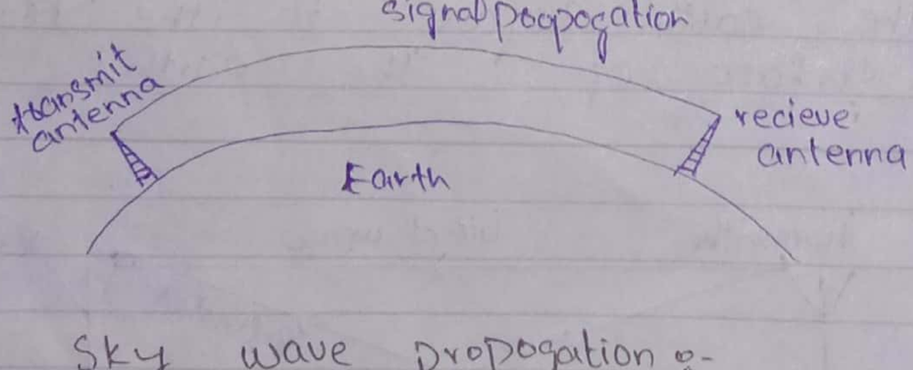
$= (Z_L - Z_0) / (Z_L + Z_0)$

Q3(a) Breifly explain Ground wave propogation & sky progogation & space wave propogation?

Ans:-

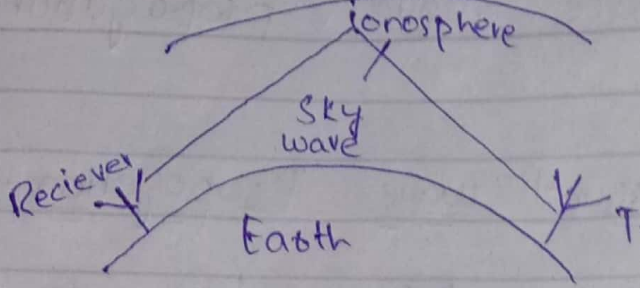
Ground wave Propogation :-

Ground wave propogation is a method of radio wave propogation that uses the area between the surface of the earth and the ionosphere for transmission. The ground wave can propogate a considerable distance over the earth surface particularly in the low frequency & medium frequency portion of the radio spectrum.



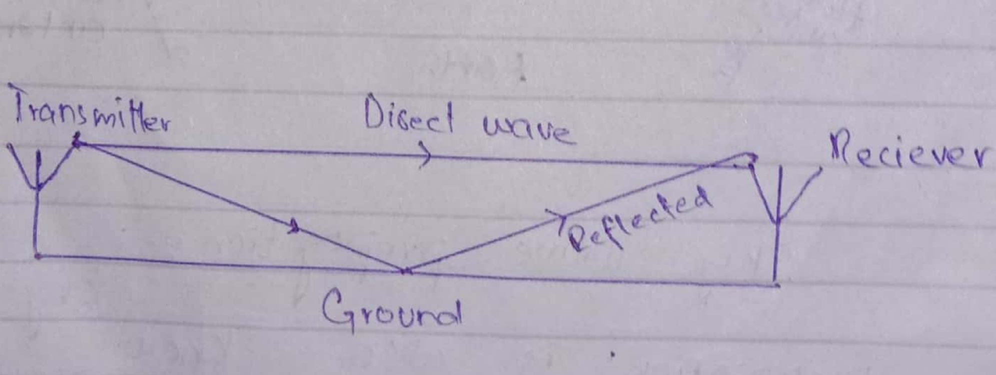
Sky wave propogation :-

Sky wave propogation is also known as skip is a type of radio wave propogation. It is either the reflected or refracted back wave to the earth from the ionsphere which is an electrically chaoged layer of the upper atmosphere.



Space wave propogation :-

Space wave propogation is define for the radio waves that occur within the 20km of the atmosphere i-e troposphere, compoising of a direcled & reflected waves. These waves are also known as tropospheric propogation as they can travel directly from the earth surface to the troposphere surface of the earth.



Q3(b)

what is the effective aperture, Reciprocity & FNBW?

Effective Aperture :-

Ans:- A usefull parameter calculating the receive power of an antenna is the effective area or effective aperture. Assume that a plane wave with the same polarization as the receive antenna is incident upon the antenna.

Then the effective aperture parameter describes how much power is captured from a given plane wave. Let p be the power density of the plane wave (in W/m^2). if P_t represent the power (in watts) at the antennas terminals available to the antenna's receiver, then :-

$$P_t = PA_e$$

Hence the effective area represents how much power is captured from the plane wave and delivered by the antenna. This area factors in the losses intrinsic to the antenna.

A general relation for the effective aperture interm of the peak antenna gain (G) of any antenna is given by :-

$$A_e = \frac{\lambda^2}{4\pi} G$$

Reciprocity:-

Reciprocity states that the reciever & transmit properties of an antenna are identical. Hence antenna do not have distinct transmit & recieve radiation patterns. If you know the radiation pattern in the transmit mode than one you also know the pattern in the reciever mode.

FNBW

First null beam width is the angular seperation quoted ~~ay~~ away from the main beam, which is drawn b/w the null points of radiation pattern, on its major lobe.
The angular span b/w the first pattern null adjacent to the main lobe is called FNBW.

Q4) Explain the design and working principle of MPA (microstrip patch antenna) and discuss four feeding method of MPA.

Answer:

Basics of microstrip patch antenna:

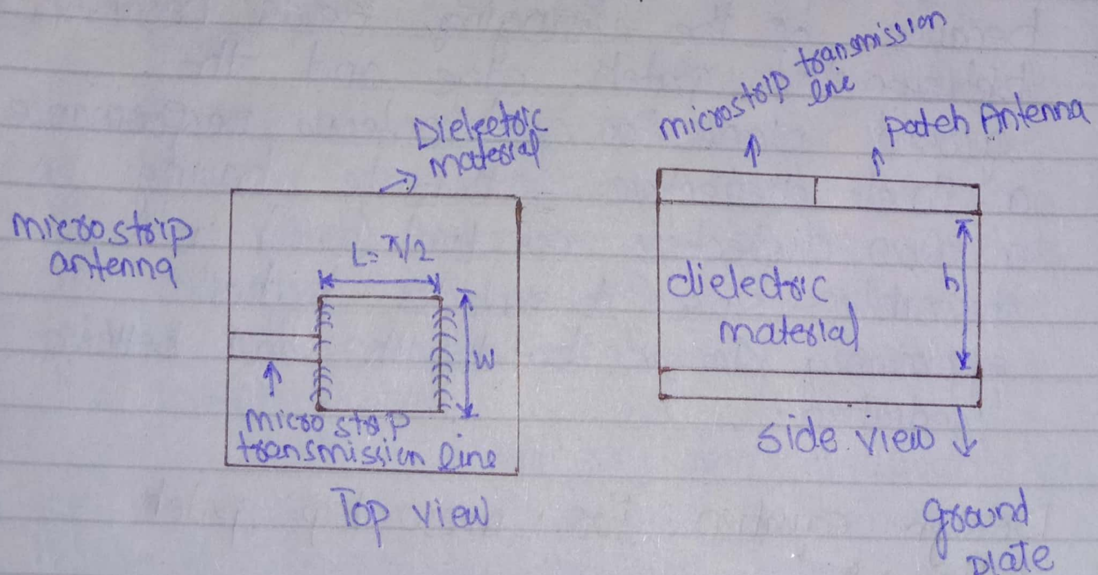
1) It is metallic patch placed on directoric material and supported by ground plane.

2) It could by easily fabricated on printed circuit board.

3) It is most widely used antenna.

4) Installation is very easy due to low size weight and cost.

Structure of microstrip patch antenna:



Operating frequency :

$$f_0 = \frac{c}{2W\sqrt{\varepsilon_r}}$$

Electric field of microstrip :

$$E_\theta = \frac{\sin\left[\frac{kw \sin\theta \sin\phi}{2}\right]}{\frac{kw \sin\theta \sin\phi}{2}} \cos\left(\frac{kL}{2}\sin\theta\cos\phi\right)\cos\theta$$

$$E_\phi = \frac{\sin\left[\frac{kw \sin\theta \cos\phi}{2}\right]}{\frac{kw \sin\theta \sin\phi}{2}} \cos\left(\frac{kL}{2}\sin\theta\cos\phi\right)\cos\theta \sin\phi$$

Working Principle :

Microstrip antenna radiate primarily because of the fringing fields because between the patch edge and the ground plane. For good antenna performance a thick dielectric substrate having a low dielectric constant (<6) is desirable since it provides higher efficiency, larger bandwidth and better radiation.

Design equation for microstrip patch antenna :

f_0, h, ε_r

$\lambda = c/f$

$|\lambda| = \frac{c}{2f}\sqrt{\frac{2}{\varepsilon_r + 1}}$

$L = L_{eff} - 2\Delta L$

L_{eff} is effective length and it is given by

$$L_{eff} = \frac{c}{2f\sqrt{\varepsilon_{r\,eff}}}$$

Feeding Methods:-

A feeding is used to excite to radiate by direct or indirect contact. There are many different methods of feeding and four most popular methods are microstrip line feed, coaxial probe, aperture coupling and proximity coupling.

1) Microstrip Line Feeding:-

Microstrip line feeding is one of the easier methods to fabricate as it is a just conducting strip connecting to the patch and therefore can be consider as extension of patch. It is simple to model and easy to match by controlling the inset position.

However the disadvantage of this method is that as substrate thickness increases, surface wave and ~~sup~~ spurious feed radiation increases which limit the bandwidth.

2) Coaxial feeding:-

Coaxial feeding method in which that the inner conductor of the coaxial is attached to the radiation patch of the antenna while the outer conductor is connected to the ground plane.

Advantages:-

- Easy of fabrication
- Easy to match
- Low spurious radiation.

Disadvantages:-

- Narrow bandwidth.
- Difficult to model specially for thick substrate.

3) Aperture Coupling:-

Aperture coupling consist of two different substrate by a ground plane. On the bottom side of lower substrate there is a microstrip feed line whose energy is coupled to the patch through a slot on the ground plane sperating two substrates. This arrangment allows indepedent optimization of the feed mechanism and the radiating element.

Advantages:

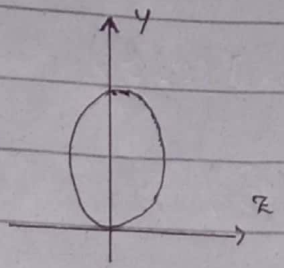
↳ Allows Independent optimization of feed mechanism element.

4) Proximity coupling:

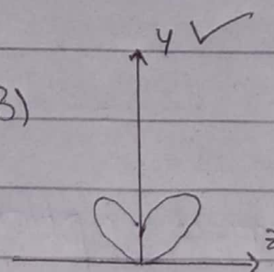
Proximiting coupling has the largest bandwidth, has a low spurious radiation. However fabrication is difficult. Length of feeding stub and width-to-Length ratio of patch is used to control the match

Q5 :- A $\frac{\lambda}{2}$ dipole is kept horizontally at height of $\frac{\lambda_0}{2}$ above a perfectly conducting infinite ground plane. The radiation pattern in the plane of dipole ($\vec{E}$ plane) looks approximately as

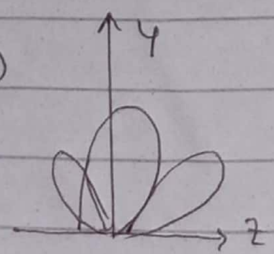
(A)



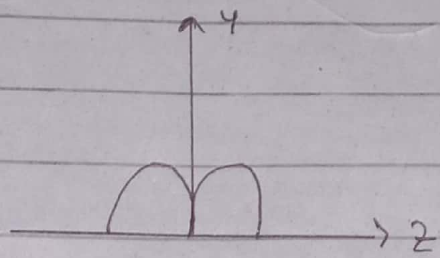
(B) ✓



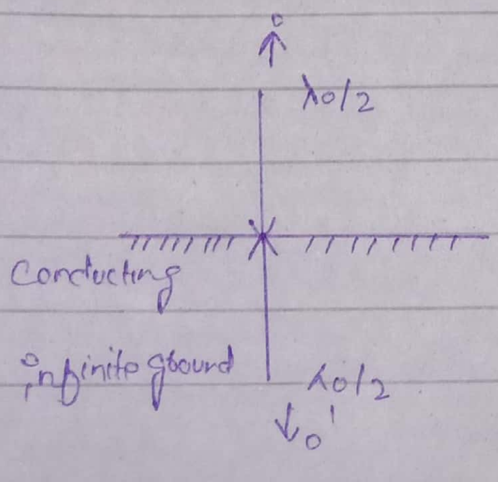
(C)



(D)



Solution :-



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Here $d = \lambda$ $\alpha = \pi$ Thus $\beta d = \frac{2\pi}{\lambda}$

Array factor is $= \cos\left[\frac{\beta\cos\theta + \alpha}{2}\right]$

$= \cos\left[\frac{2\pi\cos\theta + \pi}{2}\right]$

$= \sin(\pi\cos\theta)$

correct option (B)

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