Quiz Solutions

Lecture 10,11,12

Quiz-4 - Integer43

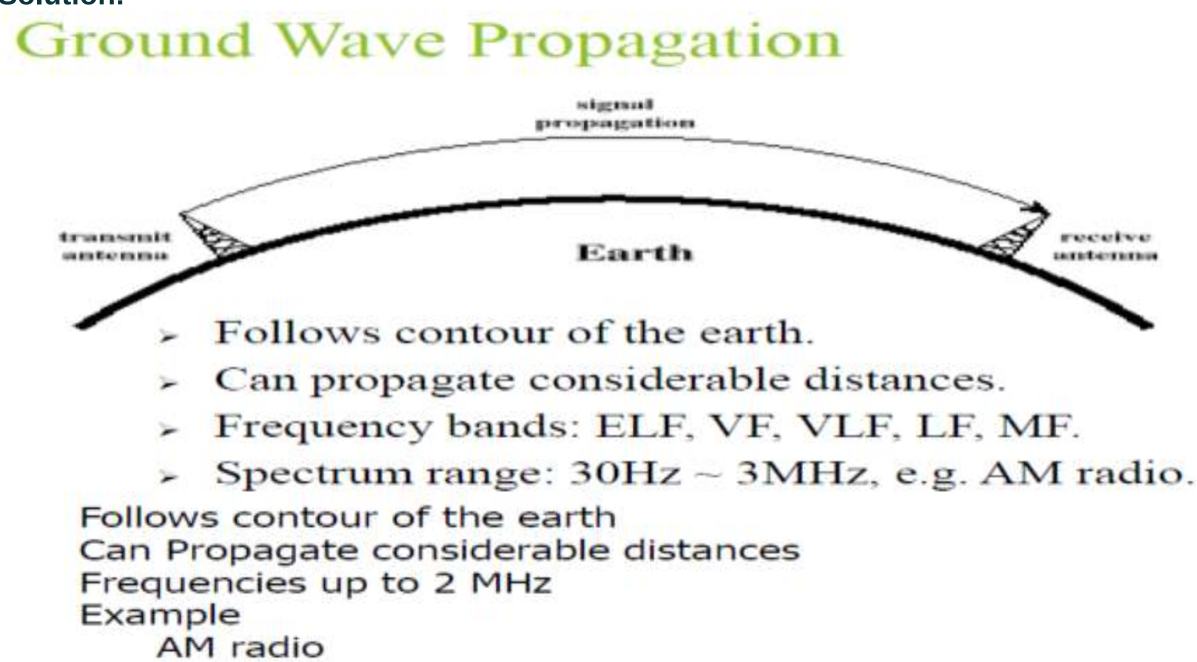
Set-A

1. a) What is Transmission Antenna?

Solution: The antenna which radiates electromagnetic energy into space.

1. b) Describe Ground Wave Propagation.

Solution:



2. Assume a receiver is located 7 km from a 10W transmitter. The carrier frequency is 6 GHz and free space propagation is assumed. Take $G_t = 7$ and $G_r = 2$.

a) Find the power at the receiver. [1.5]

b) What is effective area of an antenna? [1]

c) Find the path loss in dB. [1.5]

2.a. **Solution:** ***by Younus-131***

$$P_r = P_t G_t G_r \frac{\lambda^2}{(4\pi d)^2}$$

$$= 10 \times 7 \times 2 \times \frac{(0.05)^2}{(4 \times 3.1416 \times 7 \times 10^3)^2}$$

$$= 4.523 \times 10^{-11}\ W$$

$$= -103.445\ dB$$

$P_t = 10W$

$G_t = 7$, $G_r = 2$

$d = 7 \times 10^3\ m$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{6 \times 10^9}\ m = 0.05\ m$$

2.b. **Solution:** ***by Younus-131***

Effective area simply represents how much power is captured from the plane wave and delivered by the antenna.

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

$$A_t = \frac{G_t \lambda^2}{4\pi} = \frac{7 \times (0.05)^2}{4 \times 3.1416}\ m^2 = 1.3926 \times 10^{-3}\ m^2$$

$$A_r = \frac{G_r \lambda^2}{4\pi} = \frac{2 \times (0.05)^2}{4 \times 3.1416} = 3.979 \times 10^{-4}\ m^2$$

$G_t = 7$

$G_r = 2$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{6 \times 10^9} = 0.05\ m$$

2.c. **Solution:** ***by Younus-131***

$$\frac{P_t}{P_r} = \frac{10}{4.523 \times 10^{-11}} = 2.21 \times 10^{11}$$

$$L_{dB} = 10 \log\left(\frac{P_t}{P_r}\right) = 113.45\ dB$$

3. a) Find the optimum distance from the quarter-wave dipole antenna to the half-wave dipole antenna of frequency 20 MHz.

b) A half-wave dipole antenna has frequency of 14 GHz. Calculate the 3 dB beamwidth for the antenna.

3.a. **Solution:** ***by Younus-131***

Length of quarter-wave dipole antenna, $h_1 = \frac{\lambda}{4}$

Length of half-wave dipole antenna, $h_2 = \frac{\lambda}{2}$

$$d_{max} = 3.57\left(\sqrt{Kh_1} + \sqrt{Kh_2}\right)$$

$$= 3.57\left(\sqrt{\frac{4}{3} \times \frac{15}{4}} + \sqrt{\frac{4}{3} \times \frac{15}{2}}\right)$$

$$= 19.272 \text{ Km}$$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{20 \times 10^6} \text{ m} = 15 \text{ m}$$

3.b. **Solution:** ***by Younus-131***

for a half-wave dipole antenna, $D = \frac{\lambda}{2}$

$$\therefore \text{Beamwidth} = \frac{70\lambda}{D} = \frac{70\lambda}{\frac{\lambda}{2}}$$

$$= 140^\circ$$

Set-B

1. For an isotropic T-R system working at a carrier frequency of 800MHz, the power transmitted is 100 mW and the receiver gain is -120 dB.

a) Find the distance between Transmitter and Receiver. [1.5]

b) Find the path loss in dB. [1.5]

c) The effective area of the receiver antenna. [1]

1.a. **Solution:** ***by Younus - 131***

$$P_r = P_t G_t G_r \frac{\lambda^2}{(4\pi d)^2}$$

$$\Rightarrow (4\pi d)^2 = \frac{P_t}{P_r} G_t G_r \lambda^2$$

$$\Rightarrow d = \frac{\lambda}{4\pi} \sqrt{\frac{P_t}{P_r} G_t G_r}$$

$$= \frac{0.375}{4 \times 3.1416} \sqrt{\frac{0.1}{1\times 10^{-12}} \times 1}$$

$$= 9436.705 \text{ m}$$

$G_r = 1$, $G_t = 1$

$P_t = 100 \text{ mW} = 0.1 \text{ W}$

$P_r = -120 \text{ dB}$

$= 1 \times 10^{-12} \text{ W}$

$\lambda = \frac{c}{f} = \frac{3\times 10^8}{800 \times 10^6}$

$= 0.375$

1.b. **Solution:** ***by Younus - 131***

$$L_{dB} = 10 \log\left(\frac{P_t}{P_r}\right) = 10 \log\left(\frac{0.1}{1\times 10^{-12}}\right)$$

$$= 110 \text{ dB}$$

1.c. **Solution:** ***by Younus - 131***

Effective Area for receiver antenna $= \frac{\lambda^2}{4\pi}$ [Isotropic]

$$= \frac{(0.375)^2}{4 \times 3.1416} \, m^2$$

$$= 0.01119 \, m^2$$

2. a) Determine the height of an antenna for a radio station that must be able to reach customers (using Hertz antenna of frequency 30 MHz) up to 60 km away.

b) Find the radiative near-field distance for a quarter-wave dipole antenna operating at frequency of 800 MHz.

2.a. **Solution:** ***by Younus - 131***

$$d = 3.57\left(\sqrt{Kh_1} + \sqrt{Kh_2}\right)$$

$$\Rightarrow 60 = 3.57\sqrt{\tfrac{4}{3}\times 5} + 3.57\sqrt{\tfrac{4}{3}\times h_2}$$

$$\Rightarrow \sqrt{\tfrac{4}{3}\times h_2} = \frac{50.78}{3.57}$$

$$\Rightarrow h_2 = \left(\frac{50.78}{3.57}\right)^2 \times \frac{3}{4} = 151.76 \, m$$

$K = \frac{4}{3}$

$h_1 = \frac{\lambda}{2}$ [Hertz Antenna]

$$= \frac{c}{2f} = \frac{3\times 10^8}{2\times 30 \times 10^6}$$

$$= 5 \, m$$

$d = 60 \, km$

2.b. **Solution:** ***by Younus - 131***

$$0.62\sqrt{\frac{D^3}{\lambda}} < R < \frac{2D^2}{\lambda}$$

$$D = \frac{\lambda}{4}$$

$$\lambda = \frac{c}{f}$$

$$= \frac{3\times10^8}{800\times10^6}\,m$$

$$= 0.375\,m$$

$$\Rightarrow 0.62\sqrt{\frac{\lambda^3}{4^3\times\lambda}} < R < \frac{2\lambda^2}{4^2\lambda}$$

$$\Rightarrow 0.62\times\frac{\lambda}{\sqrt{64}} < R < \frac{\lambda}{8}$$

$$\Rightarrow 0.62\times\frac{0.375}{\sqrt{64}} < R < \frac{0.375}{8}$$

$$\Rightarrow 0.0291\,m < R < 0.0469\,m$$

3.a) What is Main Lobe of an antenna?

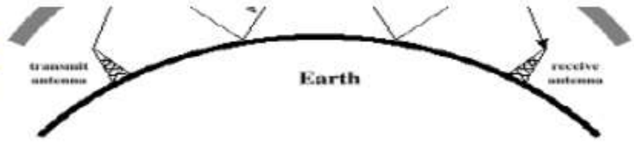
Solution:

Main lobe: This is the radiation lobe containing the direction of maximum radiation.

3.b) Describe Sky Wave Propagation.

Solution:

Sky Wave Propag



- Signal reflected from ionized layer of upper atmosphere back down to earth, which can travel a number of hops, back and forth between ionosphere and earth's surface.
- HF band with intermediate frequency range: 3MHz ~ 30MHz.
- Example International broadcast.

Signal reflected from ionized layer of atmosphere back down to earth
Signal can travel a number of hops, back and forth between ionosphere and earth's surface
Reflection effect caused by refraction
Examples
    Amateur radio
    sw radio

Set-C

1. For an isotropic T-R system working at a carrier frequency of 900MHz, the power transmitted is 120 mW and the receiver gain is -90 dB.

a) Find the distance between Transmitter and Receiver. [1.5]

b) Find the path loss in dB. [1.5]

c) The effective area of the receiver antenna. [1]

1.a. **Solution:** ***by Younus - 131***

$$P_r = P_t G_t G_r \frac{\lambda^2}{(4\pi d)^2}$$

$$\Rightarrow d = \frac{\lambda}{4\pi}\sqrt{\frac{P_t}{P_r}\cdot G_t G_r}$$

$$= \frac{0.33}{4\times3.1416}\sqrt{\frac{0.12}{1\times10^{-9}}}$$

$$= 290.575\,m$$

$G_r = 1$ & $G_t = 1$

$P_t = 120\,mW = 0.12\,W$

$P_r = -90\,dB$

$= 1\times10^{-9}\,W$

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{900\times10^6}$$

$$= \frac{1}{3} = 0.333$$

1.b. **Solution:** ***by Younus - 131***

$$L_{dB} = 10\log\left(\frac{P_t}{P_r}\right) = 10\log\left(\frac{0.12}{1\times10^{-9}}\right)$$

$$= 80.792\,dB$$

1.c. **Solution:** ***by Younus - 131***

$$A_r = \frac{\lambda^2}{4\pi} = \frac{(0.33)^2}{4\times3.1416}\,m^2$$

$$= 8.8242\times10^{-3}\,m^2$$

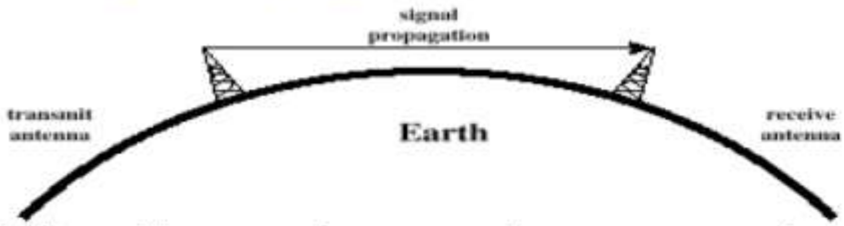
2. a) Calculate the 3 dB beamwidth, of a Marconi antenna that is designed to receive the FM station at 107.1MHz.

b) Find the optimum distance from the Hertz antenna to the quarter-wave dipole antenna of frequency 15 MHz.

2.a. **Solution:** ***by Younus - 131***

$\text{Beamwidth} = \frac{70\lambda}{D} = \frac{70\lambda}{\frac{\lambda}{4}} = 70 \times 4 = 280^\circ$ $D = \frac{\lambda}{4} = \frac{c}{f \times 4} = \frac{3\times10^8}{107.1\times10^6\times4}$
2.b. **Solution:** ***by Younus - 131***   Length of quarter-wave dipole antenna, $h_1 = \frac{\lambda}{4}$ Length of half-wave dipole antenna, $h_2 = \frac{\lambda}{2}$ $d_{max} = 3.57\left(\sqrt{Kh_1} + \sqrt{Kh_2}\right) = 3.57\left(\sqrt{\frac{4}{3}\times\frac{20}{4}} + \sqrt{\frac{4}{3}\times\frac{20}{2}}\right) = 22.2535\text{ Km}$ $\lambda = \frac{c}{f} = \frac{3\times10^8}{15\times10^6}\text{ m} = 20\text{ m}$
3.a) What is the Beamwidth?   **Solution:** Beamwidth is the angular separation between the points in the main lobe that are down from the maximum gain by 3 dB.
3.b) Describe LOS Propagation?   **Solution:**

Line-of-Sight Propagation



- Above 30 MHz, neither ground wave nor sky wave propagation modes operate, and communication must be by line of sight (LOS)
- For satellite communication, signal above 30 MHz not reflected by ionosphere.
- For ground communication, antennas within *effective* LOS due to refraction.
- Frequency bands: VHF, UHF, SHF, EHF, Infrared, optical light
- Spectrum range : 30MHz ~ 900THz.

Transmitting and receiving antennas must be within line of sight

Satellite communication – signal above 30 MHz not reflected by ionosphere

Ground communication – The term effective is used because microwaves are bent or refracted by the atmosphere.

Set-D

1. a) What is Receiving antenna?

Solution: The antenna which collects electromagnetic energy from space

1. b) Describe Free Space Loss.

Solution:

Free Space Loss

- For any type of wireless communication the signal disperses with distance.
- If no other sources of attenuation or impairment are assumed, a transmitted signal attenuates over distance because the signal is being spread over a larger and larger area.This form of attenuation is known as free space loss.
- Can be express in terms of the ratio of the radiated power P_t to the power P_r, received by the antenna.

2. Assume a receiver (isotropic) is located 5 km from a 50W transmitter (isotropic). The carrier frequency is 900 MHz and free space propagation is assumed.

a) Find the power at the receiver. [1.5]

b) Find the path loss in dB. [1.5]

c) The effective area of the receiver antenna. [1]

2.a. **Solution:** ***by Younus - 131***

$$P_r = P_t G_t G_r \frac{\lambda^2}{(4\pi d)^2}$$

$$= 50 \times 1 \times 1 \times \frac{(0.33)^2}{(4 \times 3.1416 \times 5 \times 10^3)^2}$$

$$= 1.379 \times 10^{-9}\, W$$

$$= -88.604\, dBW$$

$P_t = 50W$

$G_t = 1$ & $G_r = 1$

$$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{900 \times 10^6} m$$

$$= 0.33m$$

$d = 5 \times 10^3 m$

2.b. **Solution:** ***by Younus - 131***

$$L_{dB} = 10 \log\left(\frac{P_t}{P_r}\right)$$

$$= 10 \log\left(\frac{50}{1.379 \times 10^{-9}}\right)$$

$$\doteq 105.594\, dB$$

$P_t = 50W$

$P_r = 1.379 \times 10^{-9}\, W$

2.c. **Solution:** ***by Younus - 131***

Effective Area $= \frac{\lambda^2}{4\pi}$ [Isotropic] $= \frac{(0.33)^2}{4 \times 3.1416} m^2$ $= 8.666 \times 10^{-3} m^2$
3. a) Determine the height of an antenna for a radio station that must be able to reach customers (using Hertz antenna of frequency 15 MHz) up to 90 km away. b) The length of a Hertz antenna is 900 mm; what is its operating frequency and far field distance?
3.a. **Solution:** ***by Younus - 131*** $d = 3.57(\sqrt{Kh_1} + \sqrt{Kh_2})$ $\Rightarrow 90 = 3.57\sqrt{\frac{4}{3} \times 10} + 3.57\sqrt{\frac{4}{3} \times h_2}$ $\Rightarrow \sqrt{\frac{4}{3} \times h_2} = \frac{76.9642}{3.57}$ $\Rightarrow h_2 = \left(\frac{76.9642}{3.57}\right)^2 \times \frac{3}{4} = 348.58m$ $K = \frac{4}{3}$ $h_1 = \frac{\lambda}{2}$ [Hertz Antenna] $= \frac{c}{2f} = \frac{3 \times 10^8}{2 \times 15 \times 10^6}$ $= 10m$ $d = 90km$
3.b. **Solution:** ***by Younus - 131*** The length of a Hertz antenna is 900 mm $\therefore \frac{\lambda}{2} = 900 \times 10^{-3} m$ $\Rightarrow \frac{c}{2f} = 900 \times 10^{-3} m$ $\Rightarrow f = \frac{900 \times 10^{-3} \times 2}{3 \times 10^8} = 6 \times 10^{-9} Hz$ Far field distance $R = \frac{2D^2}{\lambda}$ $= \frac{2 \times (900 \times 10^{-3})^2}{2 \times 900 \times 10^{-3}} = 0.9 m$ So, Far-field region > 0.9m $\frac{\lambda}{2} = 900 \times 10^{-3} m$ $\lambda = 2 \times 900 \times 10^{-3} m$

Quiz-4 - Previous Semester

Set-1

1. A half-wave dipole antenna has frequency of 14 GHz. Calculate the 3 dB beamwidth for the antenna. [2]

$\lambda = \frac{c}{f} = \frac{3*10\text{^}8}{14*10\text{^}9} = 0.02$

D= λ / 2 = 0.01 m

Beamwidth = $\frac{70\,\lambda}{D} = \frac{70 * 0.02}{0.01}$ = 140 degree

2. Assume a receiver is located 7 km from a 10W transmitter. The carrier frequency is 6 GHz and free space propagation is assumed. Take $G_t = 7$ and $G_r = 2$. [4]

   a. Find the power at the receiver. [1.5]

$G_t = 7$
$G_r = 2$
d = 7 km = 7000 m
Transmitted power P_t = 10W
f = 6 GHz

$\lambda = \frac{c}{f} = \frac{3*10^8}{6*10^9} = 0.05\,m$

Power at the receiver $P_r = P_t\, G_t\, G_r\, \frac{\lambda^2}{(4\pi d)^2}$

$= 10*7*2*\frac{(0.05)^2}{(4*3.1416*7000)^2}$=4.52*10^-11 W

   b. Find the path loss in dB. [1.5]

Loss path = 10 log $\frac{Pt}{Pr}$ = $10\,log\,\frac{10}{4.52*10^{-11}}$=113.448 dB

   c. The effective area of the receiver antenna. [1]

$G_r = \frac{4\pi Ae}{\lambda^2}$
$G_r = 2$
$\lambda = 0.05$

$A_e = \frac{Gr*\lambda}{4\pi} = \frac{2*(0.05)^2}{4*3.1416}$=3.98*10^-4 m^2

3. Find the optimum distance from the quarter-wave dipole antenna to the half-wave dipole antenna of frequency 20 MHz. [2]

$\lambda = \frac{c}{f} = \frac{3*10^8}{20*10^6} = 15$

$h_1 = \frac{\lambda}{2} = 7.5$

$h_2 = \frac{\lambda}{4} = 3.75$

$k = \frac{4}{3}$

Distance $= 3.57(\sqrt{kh1} + \sqrt{kh2})$

$= 3.57(\sqrt{\frac{4}{3} * 7.5} + \sqrt{\frac{4}{3}3.75})$

$= 19.27$ m

Set-3

1. Calculate the 3 dB beamwidth, of a Marconi antenna that is designed to receive the FM station at 107.1MHz. [2]

$\lambda = \frac{c}{f} = \frac{3*10^8}{107.1*10^6} = 2.8\,m$

Marconi antenna = quarter wave antenna

D=$\frac{\lambda}{4} = \frac{2.8}{4} = 0.7$

Beamwidth = $\frac{70\lambda}{D} = \frac{70 * 2.8}{0.7} = 280\,degree$

2. For an isotropic T-R system working at a carrier frequency of 900MHz, the power transmitted is 120 mW and the receiver sensitivity is -90 dB [4]

   a. Find the distance between Transmitter and Receiver. [1.5]

$\lambda = \frac{c}{f} = \frac{3*10^8}{900*10^6} = 0.33$

P_t = 120mW = 120*10^-3 m =0.12 m

P_r = -90 dB = $10^{(\frac{-90}{10})} = 10^{-9}\,w$

For isotropic antenna, $\frac{Pt}{Pr} = \frac{(4\pi d)^2}{\lambda^2}$

or , d = $\sqrt{\frac{Pt}{Pr}}\,\lambda\frac{1}{4\pi}$ = 287.67 m

   b. Find the path loss in dB. [1.5]

Loss path = 10 log $\frac{Pt}{Pr}$= $10\,log\,\frac{0.12}{10^{-9}}$=80.79 dB

3. Determine the height of an antenna for a radio station that must be able to reach customers (using Hertz antenna of frequency 30 MHz) up to 60 km away. [2]

h_2 = 0

Distance = 3.57($\sqrt{kh1}$ + $\sqrt{kh2}$) = 60

or, 3.57 ($\sqrt{kh1}$) = 60

or , $\sqrt{kh1}$ = 16.81

or , $kh1$ = 282.58

or , $\frac{4}{3}\,h1$ = 282.58

or , h1 = 211.94 m

Random Questions

3. Find the optimum distance from the Hertz antenna to the quarter-wave dipole antenna of frequency 15 MHz. [2]

$\lambda = \frac{c}{f} = \frac{3*10^8}{15*10^6} = 20$

$h_1 = \lambda = 20$

$h_2 = \lambda/4 = 5$

k= 4/3 = 1.33

Distance $= 3.57(\sqrt{kh1} + \sqrt{kh2})$

$= 3.57(\sqrt{1.33 * 20} + \sqrt{1.33 * 5})$

$= 27.65$

4. Given a receiver with thermal noise power -133.9 dB and a 15 MHz bandwidth. What is the effective noise temperature at the receiver? [2]

Thermal noise level , N = -228.6 dBW + 10 log (T) + 10 log (B)

T = effective noise temperature
B= bandwidth of B Hertz

-228.6 dBW + 10 log (T) + 10 log (15*10^6) = -133.9 dB
Or , 10 log (T) = 22.94
Or , T = 10^2.294
So , T = 196.78 K

Source:

or, in decibel-watts,

$$N = 10 \log k + 10 \log T + 10 \log B$$
$$= -228.6 \text{ dBW} + 10 \log T + 10 \log B$$

Example 5.5 Given a receiver with an effective noise temperature of 294 K and a 10-MHz bandwidth, the thermal noise level at the receiver's output is

$$N = -228.6 \text{ dBW} + 10 \log(294) + 10 \log 10^7$$
$$= -228.6 + 24.7 + 70$$
$$= -133.9 \text{ dBW}$$