Swami Keshvanand Institute of Technology, Management & Gramothan

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Affiliated to Rajasthan Technical University, Kota

Sample Tutorial Sheets

Session: 2022-23

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Tutorial Sheets-1 (with EMD Analysis)

Course Name-Antennas & Wave Propagation

Course code- 6EC04-04 Topic –Fundamental Concepts

Q1-Calculate the directivity of isotropic antenna.

Solutions - Directivity D is given by

$$D = \frac{4\pi}{\Omega_A}$$

For isotropic antenna $\Omega_A = 4\,\pi$

$$\text{So} \quad D = \frac{4\pi}{4\pi} = 1$$

The directivity of an isotropic antenna is unity.

Q2- Calculate the effective length of an $\frac{\lambda}{2}$ antenna.

Given - $R_r = 73\Omega \; (A_{e_{max}}) = 0.13\lambda^2$

$$\eta = 120\pi$$

Solutions- $I_e = \frac{2\sqrt{(A_e)max.R_r}}{\sqrt{Z}} = 2\frac{\sqrt{0.13\lambda^2 \times 73}}{\sqrt{120\times 314}}$

$$= 2\,\lambda \; \frac{\sqrt{9.49}}{\sqrt{376.80}}$$

$$I_e = 2\,\lambda \times 0.1567 = 0.13174\,\lambda$$

Q3- Calculate the maximum effective aperture of an antenna which is operating at a wavelength of 2 meter & has a directivity of 100°.

Solutions – The maximum effective aperture

$$(A_{e_{max}}) = \frac{\lambda^2}{4\pi} D = \frac{2^2}{4\pi} \times 100 = 31.84\; m^2$$

Q4- What is bandwidth of resonant circuit whose Q =100 & resonant frequency =5 MHz.

Solutions - $\Delta f = f_2 - f_1 = \frac{f_r}{Q}$

Δf = Bandwidth f_r = resonant bandwidth & Q = Quality factor

$f_r = 5$ MHz & Q = 100

$\Delta f = \frac{5\times10^8}{100} = 50\times 10^3 = 50$ KHz

Q5- Calculate the maximum effective aperture of microwave antenna which has a directivity of 900.

Solutions-

$D = \frac{4\pi}{\lambda^2}(A_e)_{max}$

$(A_e)_{max} = \frac{D.\lambda^2.}{4\pi}$

$= \frac{900}{4\pi}..\lambda^2$

$=0.71619 \times 10^2 \times \lambda^2$

$= 71.619\,\lambda^2$

Q6- An antenna has a loss resistance 100 ohm ,power gain of 20 & directivity 22.Calculate its radiation resistance ?

Solutions- $\eta = \frac{G_P}{G_d} = \frac{R_r}{R_r+R_l}$

$G_P = 20$; $G_d = 22$, $R_l = 10\Omega$, $R_r = ?$

$\frac{20}{22} = \frac{R_r}{R_r+10}$

$20(R_r + 10) = 22R_r$

$R_r = \frac{200}{2} = 100\boldsymbol{\Omega}$

Q7- Calculate the maximum effective aperture of an antenna which is operating at a wavelength of 2 metres. & has a directivity of 100.

Solutions- Maximum effective aperture is given by

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

Given D =100

$\boldsymbol{\lambda}$=2 meter

$\frac{2^2}{4\pi} \times 100 = \frac{400}{4\pi} = \frac{100}{\pi}$ =31.84

Q8- Find the radiation resistance of a $\frac{\lambda}{16}$ wire dipole in free space.

Solutions- $R_r = 80\pi^2 \left(\frac{dl}{\lambda}\right)^2$

$= 80 \times 9.8696 \times \left(\frac{\lambda}{16\lambda}\right)^2$

$= 3.08\boldsymbol{\Omega}$

Tutorial Sheet (EMD Analysis)

Q No.	Cos	Remarks
1	1	E
2	1	E
3	1	D
4	1	D
5	1	D
6	1	E
7	1	M
8	1	D
9	1	M

**E: Easy, M: Moderate, D: Difficult

Faculty Members of Concerned Subject

Dr. Pallav Rawal
Mr. Harshal Nigam

Tutorial Sheets-2 (with EMD Analysis)

Course Name-Antennas & Wave Propagation

Course code- 6EC04-04 UNIT -3

Topic – Radiation of wires & Loops

Q1- The transmitting and receiving antennas are separated by a distance of 200**λ** and have directive gain of 25 and 18dB respectively. If 15 Mw power is to be received. Calculate the minimum transmitted power.

Solutions - G_d(dB) = 25 dB = 10 $log_{10}G_{dt}$

G_{dt}= $10^{2.5}$ = 316.25

G_{dt}(dB) = 18 dB

G_{dt} = $10^{1.8}$ = 63.1

Using the friss equation

$$P_t = G_{dt}Gdt \left[\frac{\lambda}{4\pi r}\right]^2 P_r$$

$$P_t = \quad P_t \left[\frac{4\pi r}{\lambda}\right]^2 \frac{1}{G_{dr}G_{dt}}$$

$$= \quad 5\times 10^3 \left[\frac{4\pi\times 200\lambda}{\lambda}\right]^2 \frac{1}{(63.1)(316.23)}$$

= 1.583W

Q2- If the electric field strength of a plane wave is 2V/m. What is the strength of Magnetic field H in free space.

Solutions- Since we know that η = $\frac{E}{H}$ WHERE η is free space impedance

η = 120 π = 377Ω

H = $\frac{E}{\eta}$

$$\frac{2V/M}{120\,\pi\,Ohm} = \frac{1}{188.4} = 0.0052V\ A/m$$

Q3- An antenna has an effective height of 110 metres and the current at the base is 400 amperes at 40 KHz . What is the power radiated?

Solutions – The power radiated = W = $R_r.I^2 rms$ & $R_r = 160\,\pi^2\left(\frac{l_e}{\lambda}\right)^2$

Given $l_e = 110$ m, $I_{rms} = 400\,A$, F = 40 KHz

$\lambda = \frac{300}{f} = 7500$ m

$R_r = 160\,\pi^2\left(\frac{110}{7500}\right)^2 = 160\,\pi^2\left(\frac{11}{75}\right)$

$= 23.16\Omega$

Power radiated W = $R_r.I^2 rms$

$= 23.16 \times 400^2$

= 3705.6 k watt

Q4- What is bandwidth of resonant circuit whose Q =100 & resonant frequency =5 MHz.

Solutions - $\Delta f = f_2 - f_1 = \frac{f_r}{Q}$

Δf = Bandwidth f_r = resonant bandwidth & Q = Quality factor

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Tutorial Sheets-3 (with EMD Analysis)

Course Name-Antennas & Wave Propagation Course code- 6EC04-04

Course code- 6EC04-04 UNIT -4

Topic – Aperture & Reflector Antennas

Q1. A coaxial feed pyramidal horn antenna is designed at 1 GHz with the following dimensions: a=25 cm, b=10 cm, aperture A=50 cm, B=40 cm and horn length from neck to mouth = 25 cm. Assuming efficiency of 70%. Find the approximate gain of the horn.

Solution: Gain of an antenna is

$$G = \eta D = \eta \frac{4\pi}{\lambda^2} A$$

Where, G: gain, D: directivity, η: efficiency, A: Aperture area and λ: wavelength

$$G = 0.7 \times \frac{4\pi}{30^2} \times 50 \times 40 = 19.55 = 13\, dB$$

Q2 . Design a Rectangular Pyramidal Horn antenna to be operated at 11 GHz frequency with required gain of 22.6dB if dimension of the connecting waveguide are a= 2.286cm and b= 1.016 cm.

Solution: Given f=11 GHz, $\lambda_o = \frac{c}{f} = \frac{3\times10^{8}}{11\times10^{9}} = 2.7273\ cm$

$$G_o\,(dB) = 22.6 = 10\log_{10} G_o$$

$$G_o = 10^{2.26} = 181.97$$

$$b = \frac{1.016}{2.7272}\lambda = 0.3725\lambda$$

$$a = \frac{2.286}{2.7272}\lambda = 0.8382\lambda$$

Initial value of

$$\chi_1 = \frac{G_0}{2\pi\sqrt{2\pi}} = \frac{181.97}{2\pi\sqrt{2\pi}} = 11.553$$

It does not satisfy the condition

$$\left(\sqrt{2\chi} - \frac{b}{\lambda}\right)^2 (2\chi - 1) = \left[\frac{G_o}{2\pi}\sqrt{\frac{3}{2\pi}}\frac{1}{\sqrt{\chi}} - \frac{a}{\lambda}\right]^2 \left[\frac{G_o^2}{6\pi^3}\frac{1}{\chi} - 1\right]$$

After few iteration $\quad \chi = 11.1157$

Now

$$\rho_e = \chi\lambda = 11.1157 \times 2.7273 = 30.316\ cm$$

$$\rho_h = \frac{G_o^2}{8\pi^3}\left(\frac{1}{\chi}\right)\lambda = 32.753\ cm$$

$$a_1 = \sqrt{3\lambda\rho_h} = 16.37\ cm$$

$$b_1 = \sqrt{2\lambda\rho_e} = 12.85\ cm$$

$$p_e = (b_1 - b)\left[\left(\frac{\rho_e}{b_1}\right)^2 - \frac{1}{4}\right]^{\frac{1}{2}}$$

$$p_h = (a_1 - a)\left[\left(\frac{\rho_h}{a_1}\right)^2 - \frac{1}{4}\right]^{\frac{1}{2}}$$

$$p_e = p_h$$

$$P_e = P_h = 27.286\ cm$$

Q3. An end fire array consisting of several half wave lengths long isotropic radiators is to have a directive gain of 20 dB. Find the array length and width of the major lobe. What will be these values for broadside array?

Solution: Given D = 20 dB = $10\log_{10}$D = 20 dB

D=10^2 =100

For end fire array

$$D = \frac{4L}{\lambda} \Rightarrow 100 = \frac{4L}{\lambda}$$

$$\frac{L}{\lambda} = \frac{100}{4} = 25$$

Array length L=**25λ**

Width of major lobe

$$FNBW = 114.6\sqrt{\frac{2}{L/\lambda}} = 114.6\sqrt{\frac{2}{25}} = \mathbf{32.4^o}$$

For Broad side array

$$D = \frac{2L}{\lambda} \Rightarrow 100 = \frac{2L}{\lambda}$$

$$\frac{L}{\lambda} = \frac{100}{2} = 50$$

Array length L=**50λ**

Width of major lobe

$$FNBW = \frac{114.6}{L/\lambda} = \frac{114.6}{50} = \mathbf{2.3^o}$$

Q5. A rectangular aperture is with a constant field distribution with a=5**λ** and b=3**λ** is mounted on an infinite ground plane. Compute

1) FNBW in E-Plane 2) HPBW in E- Plane

Answer: Given, a=5λ and b=3λ

(i) FNBW in E-plane: $FNBW = 114.6\, sin^{-1}\left(\frac{\lambda}{b}\right)$

$$FNBW = 114.6\, sin^{-1}\left(\frac{\lambda}{2\lambda}\right)$$

$$= 114.6\, sin^{-1}\left(\frac{1}{2}\right) = 114.6(0.524) = \mathbf{60^o}$$

(ii) HPBW in E-plane: $HPBW = 114.6\left(\frac{0.443\lambda}{b}\right)$

$$HPBW = 114.6\left(\frac{0.443\lambda}{2\lambda}\right)$$

$$= 114.6\left(\frac{0.443}{2}\right) = 25.4^o$$

Tutorial Sheet (EMD Analysis)

	Cos	Remarks
1	3	E
2	3	D
3	3	E
4	4	E
5	3	M

**E: Easy, M: Moderate, D: Difficult

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Tutorial Sheets-4 (with EMD Analysis)
Course Name-Antennas & Wave Propagation Course code- 6EC04-04

Course code- 6EC04-04 UNIT -5

Topic – Broadband Antennas

Q1- A log periodic dipole array is to be designed to cover frequency range from 84 MHz to 200 MHz and has a gain of 7.5 dB. Find the required element length and spacing for optimum design and also find out the total length of the antenna.

For the given gain of 7.5 dB, corresponding value of $\tau = 0.862$ and $\sigma = 0.159$. We know that

$$\alpha = tan^{-1}\left(\frac{1-\tau}{4\sigma}\right)$$

$$\alpha = tan^{-1}\left(\frac{1-0.862}{4\times 0.159}\right) = 12.24^o$$

$$l_{max} = \frac{\lambda_{max}}{2} = \frac{c}{2f_{min}} = \frac{300}{2\times 84} = 1.785\text{ m}$$

$$l_{min} = \frac{\lambda_{min}}{2} = \frac{c}{2f_{max}} = \frac{300}{2\times 200} = 0.75\text{ m}$$

We also know that,

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

Hence, L_1=1.785 m, L_2= 0.862 X 1.785=1.593 m, L_3=1.326 m, L_4=1.143 m, L_5=0.985 m, L_6=0.849, L_7=0.732 m.

Array is terminated in seven element, since L_7=0.732 m is less than l_{min}=0.75 m.

We also Know, Spacing between element is

$$d_n = 2\sigma L_n$$

d_1=2x0.159x1.785= 0.318 x 1.785= 0.568 m,

d_2=0.506 m, d_3= 0.421 m, d_4=0.363 m, d_5= 0.313 m, d_6=0.269 m.

Total length of antenna is $\sum_1^6 d_n = 2.424\, m$

Q2- Find the directivity of 10 turn helix antenna having a pitch angle 10°,circumference C equal to λ .

Solution-

C = λ , -N=10, S =C tanα

Directivity D= $\frac{15NSC^2}{\lambda^3}$

$= \frac{15\times 10\times C\tan\alpha \times c^2}{\lambda^3}$

= 150 tan α

D(dB) = $10log_{10}$ (26.45) = 14.22

Q3- A 10 Turn Helix is constructed at 8GHZ with a circumference of 3.45cm and a pitch angle of 15°.Find the HPBW & Gain.

Solution-

λ at 8GHz = 30/8 =3.75cm

C= 3.45 =0.92λ

For the pitch angle α =15° , S = c tan α = 0.92$\lambda\times tan15°$= 0.2465λ=0.9244 cm

HPBW= $\frac{65\ DEGREE}{\frac{C}{\lambda}\sqrt{N\frac{S}{\lambda}}}$ $= 45°$

G = 6.2 $\left(\frac{c^2}{\lambda}\right)$ N $\frac{S}{\lambda}$ $= 11dB$

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Tutorial Sheet (EMD Analysis)

	Cos	Remarks
1	4	E
2	4	D

**E: Easy, M: Moderate, D: Difficult

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Tutorial Sheets-5 (with EMD Analysis)

Course Name-Antennas & Wave Propagation

Course code- 6EC04-04 UNIT - 6

Topic – Microstrip Antennas

Q1- Design a rectangular microstrip patch antenna to be used in satellite communication at a frequency of 1.6 GHz. Assume the dielectric constant of substrate is 10.2 and thickness is 0.127 cm.

Solutions-

Answer: Given-

f_r = 1.6 GHz

h= 0.127 cm

ε_r= 10.2

Width of Patch:

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}}$$

$$W = \frac{3 \times 10^8}{2 \times 1.6 \times 10^9}\sqrt{\frac{2}{10.2 + 1}} = 3.96\ cm$$

Effective dielectric constant:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + \frac{12h}{w}\right]^{-\frac{1}{2}}$$

$$\varepsilon_{reff} = \frac{10.2 + 1}{2} + \frac{10.2 - 1}{2}\left[1 + \frac{12 \times 0.127}{3.96}\right]^{-\frac{1}{2}} = 9.51$$

Extension in length:

$$\Delta L = 0.412 \times h \frac{(\varepsilon_{reff} + 0.3)\left(\frac{w}{h} + 0.264\right)}{(\varepsilon_{reff} - 0.258)\left(\frac{w}{h} + 0.8\right)}$$

$$\Delta L = 0.412 \times 0.127 \frac{(9.51 + 0.3)\left(\frac{3.96}{0.127} + 0.264\right)}{(9.51 - 0.258)\left(\frac{3.96}{0.127} + 0.8\right)} = 0.545\ mm$$

Length of patch:

$$L = \frac{c}{2f_r\sqrt{\varepsilon_{reff}}} - 2\Delta L$$

$$L = \frac{300}{2 \times 1.6\sqrt{9.51}} - 2 \times 0.545 = 29.31\ mm = 2.931\ cm$$

L= 29.31mm

W= 39.6mm

Q2- Design a circular microstrip patch antenna at a frequency of 10 GHz. Assume the dielectric constant of substrate is 2.2 and thickness is 0.1588 cm?

Solution: Given f_r=10 GHz, ε_r=2.2, h=0.1588

Using equation

$$F = \frac{8.791 \times 10^9}{f_r\sqrt{\varepsilon_r}}$$

$$F = \frac{8.791 \times 10^9}{10 \times 10^9 \sqrt{2.2}} = 0.593$$

Therefore, using equation

$$a = \frac{F}{\left\{1 + \frac{2h}{\pi \varepsilon_r F}\left[ln\left(\frac{\pi F}{2h}\right) + 1.7726\right]\right\}^{\frac{1}{2}}}$$

$$a = \frac{0.593}{\left\{1 + \frac{2\times0.1588}{0.593\times\pi\times2.2}\left[ln\left(\frac{\pi\times0.593}{2\times0.1588}\right) + 1.7726\right]\right\}^{\frac{1}{2}}} = 0.525 \text{ cm}$$

Hence the radius of circular patch is 0.525 cm.

Tutorial Sheet (EMD Analysis)

	Cos	Remarks
1	4	D
2	3	D

**E: Easy, M: Moderate, D: Difficult

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Tutorial Sheets-6 (with EMD Analysis)

Course Name-Antennas & Wave Propagation

Course code- 6EC04-04 UNIT - 7

Topic – Antenna Arrays

Q1-

Design a linear array of isotropic elements placed along the z-axis such that the zeros of the array factor occur at $\theta = 20^0, 80^0, 110^0$ and 150^0. Assume that the elements are spaced a distance of $\lambda/4$ apart and that $\alpha = 90^0$.

(i). Sketch and label the visible region on the unit circle.

(ii). Find the required number of elements.

(iii). Determine their excitation coefficients.

Solutions-

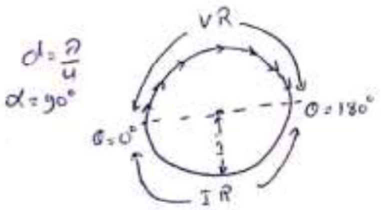
(i). For spacing between elements of $d=\lambda/4$ and phase difference $\alpha = 90^o$.

$$\psi = kd\cos\theta + \alpha$$

$$= \frac{2\pi}{\lambda} \times \frac{\lambda}{4}\cos\theta + \frac{\pi}{2}$$

$$= \frac{\pi}{2}(cos\theta + 1)$$

For θ=0; ψ=π and θ=180; ψ=0



(ii). Using Schelkunoff polynomial method

$$AF = \sum_{n=1}^{N} a_n z^{(n-1)} = a_1 + a_2 z^1 + a_3 z^2 + \cdots + a_N z^{N-1}$$

Where N is number of element

For angle of nulls θ=20°, 80°, 110°, 150°

$$AF = (z - z_1)(z - z_2)(z - z_3)(z - z_4)$$

$$AF = \sum_{n=1}^{N} a_n z^{(n-1)} = a_1 + a_2 z^1 + a_3 z^2 + a_4 z^3 + a_5 z^4$$

Hence, Number of elements N=5

(iii). Excitation coefficient:

$$z = |z|e^{j\psi} = |z|\angle\psi = 1\angle\psi$$

And

$$\psi = \frac{\pi}{2}(cos\theta + 1)$$

Ψ_1=90(1+cos20)=174.57; Z_1=-0.99+j0.094

Ψ_2=90(1+cos80)=105.62; Z_2=-0.269+j0.963

Ψ_3=90(1+cos110)=59.218; Z_3=0.52+j0.859

Ψ_4=90(1+cos150)=12.05; Z_4=0.977+j0.21

$$AF = (z - z_1)(z - z_2)(z - z_3)(z - z_4)$$

$$AF = (z - (-0.99 + j0.094))(z - (-0.269 + j0.963))(z - (0.52 + j0.859))(z - (0.977 + j0.21))$$

$$AF = Z^4 - j0.144Z^3 + 2.402Z^3 - j3.1Z - 1.757$$

a_1=-1.757
a_2=-j3.1

$a_3=2.402$
$a_4=-j0.144$
$a_5=1$

Q2- Draw the radiation pattern of an array of 4-isotropic sources of equal amplitudes and phases with the distance of λ/2 apart.

A) Broadside case B) End-fire case

Answer:

(i). Broadside case: α=0

Principal maxima

$$\psi = \beta d cos\theta + \alpha = 0$$

$$\psi = \beta d cos\theta = 0$$

$$\theta = 90^o, 270^o$$

Maxima for minor lobe:

$$(\theta_{max})_{minor} = cos^{-1}\left\{\pm \frac{(2N+1)\lambda}{2nd}\right\}$$

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Where

n=4 element, d=λ/2

$(\theta_{max})_{minor} = cos^{-1}\{\pm\frac{3}{4}\}$ if N=1

$$(\theta_{max})_{minor} = \pm 41.4^o \; and \; \pm 138.6^o$$

Minima for minor lobe:

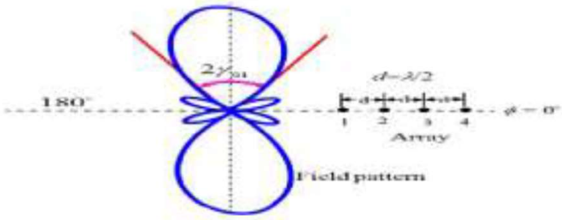
$$(\theta_{min})_{minor} = cos^{-1}\{\pm\frac{N\lambda}{nd}\}$$

Where

n=4 element, d=λ/2

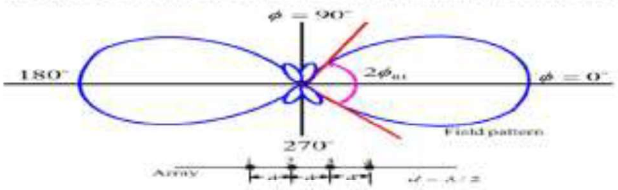
$$(\theta_{min})_{minor} = \pm 60^o, \pm 120^o, 0^o \; and \; 180^o$$

Hence the pattern is



(ii). End fire case: α=π

To find pattern of End fire array, similar formula can be derived with taking α=π. Hence pattern is



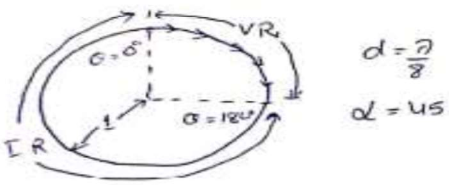
Q3. Sketch and label the visible region on the unit circle of Schelkunoff polynomial method:

(i). d= λ/8, α = 450 (ii). d= λ/4, α = 900

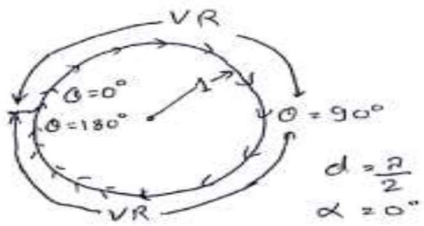
(iii). d= λ/2, α = 00 (iv). d= λ/8, α = -250

Solutions-

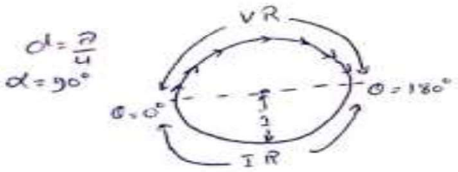
(i)



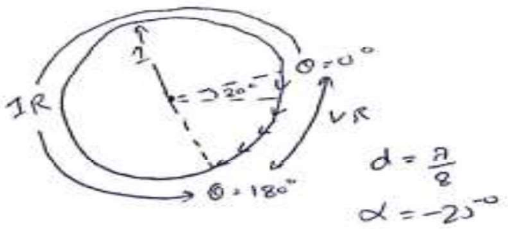
(iii)



(ii)



(iv)



Tutorial Sheet (EMD Analysis)

S.NO	Cos	Remarks
1	4	D
2	3	D
3	4	D

**E: Easy, M: Moderate, D: Difficult

Faculty Members of Concerned Subject

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Tutorial Sheets-7 (with EMD Analysis)

Course Name-Antennas & Wave Propagation

Course code- 6EC04-04 UNIT - 9

Topic – Different modes of Radio Wave Propagation

Q1- A Part of microwave link can be assumed to be a free space conditions.The antenna ,gains are each 40dB. The frequency is 10 GHz and the path length is 80km. Calculate the transmission path loss and the received power for a transmitted power of 10 Watts.

Solutions - Given that

$$G_T = 40\text{dB}$$

$$G_T = 40\text{dB}$$

F = 10 GHz =10,000MHz

D = 80 Km

$$W_T = 10\text{ W}$$

Ls(dB) = 20 log_{10}f + 20 log_{10}d – 147.56

= 20 log_{10} 10×10^9 +20 log_{10}8000 −147.56

= 150.512dB

W_R(dB) = G_TdB +G_rdB - L_sdB + W_TdB

= 40 +40 -150.512 +10

= -70.512 +10 = -60.512

$W_{r=}$ 0.89081W

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Q2- The antenna of gain 2.2dB of a VHF transmitter 5KW at 62.25 MHz is located at a height of 40 metres above the surface of the earth .If the height of the receiving antenna of gain 1.6dB is 10 metres only. What is the ultimate maximum distance up to which a LOS Communication may be possible ?Assume a standard atmosphere .What will be power received at this maximum distance.

Solutions- According to question following parameters are given:

1) Gain of transmitting antenna G_T = 2.2dB
2) Power of transmitting antenna W_T = 5KW
3) Carrier frequency = 62.25 MHz
4) Height of transmitting antenna h_t= 40 metres
5) Height of receiving antenna h_r = 10 metres
6) Gain of receiving antenna G_r = 1.6 Db

Using the concept of effective earth radius and equation below for standard atmosphere

D =4.12[$\sqrt{h_r} + \sqrt{h_t}] \, km$

D = 4.12 [$\sqrt{40} + \sqrt{10}$]

D = 39.085 km

Now using formula for free space loss

L_S dB = 20 log_{10}f + 20 log_{10}d – 147.56

= 155.88+91.84 -147.56 = 100.16 Db

$and \; w_t$ in dB is

W_t dB = 10 $log_{10} W_t$ in watt = 10 $log_{10} 5 \times 10^3$ =36.99Db

W_r dB = W_t dB + G_t dB +G_R dB - L_SDb

= -59.37dB

Q3- Two plane 15Km apart are in radio communication . The transmitting plane delivers 500 Watt. Its antenna gain being 10 in the direction of other plane power absorbed in 2 micro watts by the receiving antenna of the second plane. Find the effective area assuming that the ground and ionospheric reflections are negligible .

Solutions – Given

D = 10 Km

G_t = 10

W_T =500 Watts

W_r = 2×10^{-6} watts

A_e = ?

$P_d = \frac{W_t G_t}{4\pi d^2}$

$W_R = P_D . A_e = \frac{W_t G_t}{4\pi d^2}$

$A_e = \frac{w_r}{w_t} \times \frac{4\pi d^2}{G_T}$ = 0.5024 m^2

Tutorial Sheet (EMD Analysis)

Q No.	Cos	Remarks
1	1	E
2	1	D
3	1	D

**E: Easy, M: Moderate, D: Difficult

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