Total No. of Questions: 6 *Total No. of Printed Pages:3*

Enrollment No.....

Faculty of Engineering

End Sem (Odd) Examination Dec-2022

EC3CO13 Antennas & Propagation

Programme: B.Tech. Branch/Specialisation: EC

Duration: 3 Hrs. **Maximum Marks: 60**

Note: All questions are compulsory. Internal choices, if any, are indicated. Answers of Q.1 (MCQs) should be written in full instead of only a, b, c or d.

Q.1 i. An antenna having input impedance of 200 Ω is connected to an RF source of output impedance of 50 Ω. Reflection coefficient of this antenna is- **1**

(a) 0 (b) 0.6 (c) 1.0 (d) 2.0

ii. For a half wavelength long dipole antenna, approximate directivity in dBi is- **1**

(a) 2 (b) 3 (c) 4 (d) 5

iii. An array fed with equal amplitude and progressive phase shift is designed to scan at 20° from the array axis. To avoid grating lobes, the maximum allowed inter-element separation is- **1**

(a) 0.425λ (b) 0.516λ (c) 0.710 λ (d) 0.915λ

iv. The directivity of a linear broadside array with half wave length spacing is equal to _____. **1**

(a) Zero

(b) Unity

(c) Half of the number of elements present in array

(d) Number of elements present in array

v. Primary objectives of Yagi-Uda and log-periodic antenna configurations are to achieve _____ and _____ respectively. **1**

(a) High bandwidth, high gain

(b) High bandwidth, high bandwidth

(c) High gain, high bandwidth

(d) High gain, high Gain

vi. If the number of turns in a circular loop antenna is doubled, then the input impedance of this antenna will- **1**

(a) Increase by 4 times (b) Increase by 2 times

(c) Decrease by 2 times (d) Decrease by 4 times

P.T.O.

vii. For conventional microstrip antenna design, if height of the substrate increases, its- **1**
(a) Bandwidth increases (b) Losses increases
(c) Efficiency increases (d) Gain decreases

viii. To check the radiation pattern of an antenna in CST microwave studio, the most suitable monitor is- **1**
(a) Voltage monitor (b) Current monitor
(c) Surface current monitor (d) Far-field monitor

ix. High-frequency long-distance propagation mostly depends on- **1**
(a) Ionospheric reflection (b) Tropospheric reflection
(c) Ground reflection (d) Inverted reflection

x. What is the distance from the far end of the ground wave to the nearest point where the sky wave returns to earth called? **1**
(a) Angle of radiation (b) Maximum usable frequency
(c) Skip distance (d) Skip zone

Q.2 i. A dipole antenna is designed using a wire of diameter 0.5 cm. Approximate length of the dipole antenna will be _____ cm for resonance at 2.5 GHz. **2**

ii. Calculate the radiation efficiency of a half wave dipole if the loss resistance is 1 Ω. What is its maximum effective aperture if the frequency of operation is 145 MHz? **3**

iii. Define the followings parameters of antenna: **5**
(a) Gain (b) Polarization (c) Radiation pattern

OR iv. Two half-wave dipoles operating at 2.4 GHz are used to establish a wireless communication link. The antennas are matched to the transmitter and the receiver, respectively. The maximum transmit power is 100 mW and for reliable communication the received power has to be at least −80 dBm. Calculate the maximum possible distance over which reliable communication can be established using this system. **5**

Q.3 i. Find the amplitude of a binomial array with seven elements. **2**

ii. A uniform linear array consists of 16 isotropic point sources with a spacing of $\lambda/4$. If the phase difference is – 90 degree, calculate- **8**
(a) HPBW, (b) Directivity, (c) Beam solid angle, and (d) Effective aperture.

OR iii. Find the excitation coefficients of a four-element broadside Dolph-Tchebyscheff array which produces a radiation pattern with its first side lobe level of 19.08 dB below the main beam. Assume the spacing of the elements to be $\lambda/2$. **8**

Q.4 i. A parabolic reflector is operated at 2 GHz and its mouth diameter of 60 m. If it is fed by non-directional antenna, find out HPBW, BWFN and power gain. **3**

ii. Design a log-periodic dipole array having a directivity of 8.5 dB over a frequency range of 10 MHz to 30 MHz. **7**

OR iii. Design a helical antenna operating in the axial mode that gives a directivity of 14 dB at 2.4 GHz. For this helical antenna, calculate the input impedance, half power beamwidth, beamwidth between the nulls, and the axial ratio. **7**

Q.5 i. Explain in detail all feeding methods of microstrip antenna with neat diagram and equivalent circuit diagram. **4**

ii. Design a rectangular microstrip antenna using a substrate (RT/duroid 5880) with dielectric constant of 2.2, h = 0.1588 cm (0.0625 inches) so as to resonate at 10 GHz. **6**

OR iii. A rectangular microstrip patch antenna has dimensions of L = 0.906 cm, W = 1.186 cm, and h = 0.1575 cm. The dielectric constant of the substrate is ε_r = 2.2. Using the cavity model analysis and assuming no fringing, determine the resonant frequency of the first 4 TM^{Z}_{0np} modes, in order of ascending resonant frequency. **6**

Q.6 Attempt any two:

i. Explain the formation of ionosphere. What are the various layers of the ionosphere? With the help of a neat diagram show their respectively electron densities and heights above the ground. **5**

ii. Prove that the highest frequency which can be reflected by particular layer at vertical incidence is given by $9\sqrt{N_{max}}$; where N_{max}= maximum electron density. **5**

iii. The reflection takes place at a height of 350 km and the maximum density in the ionosphere corresponds to a 0.75 refractive index at 10 MHz. What will be the range (assume earth is flat) for which the maximum usable frequency (MUF) is 12 MHz? **5**

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Scheme of Marking

	Faculty of Engineering End Sem (Odd) Examination Dec-2020 Antennas & Propagation (T) - EC3CO13 (T)
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Note: The Paper Setter should provide the answer wise splitting of the marks in the scheme below.

Q.1	i)	(b) 0.6	1
	ii)	(a) 2	1
	iii)	(b) 0.516λ	1
	iv)	(d) Number of elements present in array	1
	v)	(c) High gain, High bandwidth	1
	vi)	(a) Increase by 4 times	1
	vii)	(a) Bandwidth increases	1
	viii)	(d) Far-field monitor	1
	ix)	(a) Ionospheric reflection	1
	x)	(d) Skip zone	1
Q.2	i.	5.26 cm (As per answer)	2
	ii.	Radiation efficiency : 98.65 % and Maximum effective aperture = 0.552 m^2	3
	iii.	Define the followings parameters of antenna: (a) Gain 2 mark (b) Polarization 2 mark (c) Radiation pattern 1 mark	5
OR	iv.	1.63 km (Stepwise marks)	5
Q.3	i.	The amplitude of a Binomial array with seven elements is as 1 , 6, 15, 20, 15, 6, 1	2
	ii.	(a) HPBW = 41.846 degree 2 mark (b) Directivity (D) = 15 2 mark (c) Beam solid angle = 0.8385 radian 2 mark (d) Effective aperture (Ae) = $1.1942\lambda^2$ 2 mark	8
OR	iii.	(Stepwise marks) The excitation array coefficients are as: 3.375, 5.625, 5.625 ,3.375 The normalized excitation array coefficients are as: 0.6, 1, 1 ,0.6	8
Q.4	i.	HPBW = 0.175 degree 1 mark BWFN = 0.35 degree 1 mark Power gain = 60.103 dB 1 mark	3
	ii.	(Stepwise marks) $\tau = 0.895$ and $\sigma = 0.166$, $\alpha = 8.99°$ The number of elements in the log-periodic array is $N = 11$. The lengths of the other dipoles as $l_{10} = 0.895 \times l_{11} = 13.425$ m, $l_9 = 0.895 \times l_{10} = 12.0154$ m, and so on, $l_8 = 10.7538$ m, $l_7 = 9.6246$ m, $l_6 = 8.614$ m, $l_5 = 7.7096$ m, $l_4 = 6.9$ m, $l_3 = 6.1755$ m, $l_2 = 5.5271$ m, and $l_1 = 4.9468$ m. The location of the dipoles and the distance between them as $R_1 = l_1/(2 \tan \alpha) = 4.9468/(2 \times 0.1582) = 15.6341$ m, $R_2 = 17.4681$ m, $R_3 = 19.5173$ m, $R_4 = 21.8073$ m, $R_5 = 24.3656$ m, $R_6 = 27.2242$ m, $R_7 = 30.4181$ m, $R_8 = 33.9867$ m, $R_9 = 37.9739$ m, $R_{10} = 42.429$ m, and $R_{11} = 47.4067$ m. The wire diameters as: $d_{11} = 10$ mm, $d_{10} = 8.95$ mm, $d_9 = 8.0103$ mm, . . . $d_2 = 3.6847$ mm, and $d_1 = 3.2978$ mm.	7
OR	iii.	For axial mode of operation of the helical antenna, we can choose its circumference equal to one wavelength, i.e., $C = 1\lambda = 0.125$ m and the spacing between the two consecutive turns equal to $\lambda/4$, i.e., $S = \lambda/4 = 0.03125$ m. The number of turns of the helix, $N = 7$. Input impedance = 140 Ω. Half power beamwidth = 39.3 degree Beamwidth between nulls = 86.9 degree Axial ratio = 1.07 Length of one turn of the helix is $L = 0.1288$ m Total length of the wire required to construct the helical antenna is $NL = 7 \times 0.1288 = 0.902$ m.	7
Q.5	i.	There are four feeding techniques: 1. Microstrip line feed. 2. Probe feed, 3. Aperture-coupled feed, and 4. Proximity-coupled feed	4
	ii.	The width of the patch, $W = 1.186$ cm, The actual length of the patch, $L = 0.906$ cm.	

OR	iii.	The excited modes and resonant frequencies of the first four modes are as follows: 1. TM_{001} = 8.52698 GHz 2. TM_{010} = 11.1622 GHz 3. TM_{011} = 14.0465 GHz 4. TM_{002} = 17.0540 GHz.	
Q.6			
	i.	Formation of ionosphere 1 mark Layers of the ionosphere 2 mark Neat diagram with their electron densities and heights above the ground 1 mark	**5**
	ii.	Highest frequency = $9\sqrt{N_{max}}$ (Stepwise marks)	**5**
	iii.	D_{skip} = 631.64 km. (stepwise marks)	**5**

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