Code : 041709

B.Tech 7th Semester Exam., 2020

ADVANCED ELECTROMAGNETIC THEORY

Time : 3 hours *Full Marks* : 70

Instructions :

(i) The marks are indicated in the right-hand margin.

*(ii) There are **EIGHT** questions in this paper.*

*(iii) Attempt **FIVE** questions in all.*

*(iv) Question No. **1** is compulsory.*

1. Answer any *seven* questions from the following : 2×7=14

(a) Comment on a TEM mode cannot exist in a hollow metallic waveguide.

(b) Define the half-power beamwidth of antenna.

(c) What do you understand by antenna reciprocity?

(d) What do you mean by broadside arrays?

(e) Define cut-off frequency of the waveguide.

(f) For a 1 cm × 2 cm rectangular waveguide, calculate the characteristic impedance when operating frequency is 10 GHz.

(g) Comment on a TE_{10} is the dominant mode in rectangular waveguide.

(h) Define the skip distance in radiowave propagation.

(i) Draw the radiation pattern of Yagi-Uda antenna.

2. Answer any *two* parts of the following : 7×2=14

(a) Define the following :

(i) Radiation intensity

(ii) Beam area

(iii) First null beamwidth

(iv) Directivity

(v) Gain

(vi) Antenna temperature

(vii) Effective length of antenna

(b) Explain radiation pattern of an antenna. Calculate the radiation resistance of current element whose overall length is $\lambda/50$.

(c) Derive the radiation resistance of half-wave dipole in free space.

3. Answer any *two* parts of the following : 7×2=14

(a) The field radiation pattern of an antenna is given as $F(\theta) = \sin\theta$ for $0 \le \theta \le \pi/2$, $0 \le \phi \le \pi$ and zero elsewhere. If the antenna efficiency is 86% and it is operating at 0·5 MHz, find the directivity of antenna and the effective aperture of the antenna.

(b) Derive an expression for the time averaged power density vector of the electromagnetic wave radiated by a Hertzian dipole of length *dl*, kept at the origin, oriented along the *x*-axis, and excited by a current of amplitude I_0.

(c) The normalized radiation intensity of a given antenna is given by $U = \sin^3\theta\cos^2\phi$. The intensity exists only in the $0 \le \theta \le \pi$, $0 \le \phi \le \pi$ region, and it is zero elsewhere. Find the azimuthal and elevation plane half-power beamwidths (in degrees).

4. Answer any *two* parts of the following : 7×2=14

(a) Calculate the ratio of circular waveguide cross-sectional area to the rectangular waveguide cross-section. Assume that both these waveguides have similar or equal cut-off frequencies or wavelengths. Assume suitable data.

(b) A 1 cm × 3 cm rectangular waveguide air-filled waveguide operates in the TE_{12} mode at a frequency that is 20% higher than cut-off frequency. Determine *(i)* the operating frequency and *(ii)* the phase and group velocities.

(c) A circular cavity resonator with $d = 1 \cdot 5a$ is to be designed to resonate at 2 GHz in the TE_{101} mode. If the cavity is made from copper ($\sigma_c = 5 \cdot 8 \times 10^7$ s/m) and is air-filled, find its dimensions and quality factor.

5. Answer any *two* parts of the following : 7×2=14

(a) Explain the V-antenna with its applications. Also, explain unidirectional and bidirectional radiation patterns of V-antenna.

(b) Explain the Yagi-Uda antenna with its design considerations. What is the effect of many directors?

(c) Explain the rhombic antenna with its radiation pattern. What are the advantages and disadvantages of rhombic antenna? Obtain alignment design parameters of rhombic antenna to operate at 30 MHz, when the required elevation angle is 30°.

6. Answer any *two* parts of the following : 7×2=14

(a) Describe ground wave propagation. What is the angle of tilt? How does it affect the field strength at a distance from the transmitter?

(b) Bring out the important differences between ground wave propagation and space wave propagation. A television transmitter antenna has a height of 169 m and the receiving antenna has a height of 16 m. What is the maximum distance through which the TV signal could be received by space propagation?

(c) What is the significance of virtual height in sky-wave propagation? Find the skip distance for waves of frequency $4 \cdot 6 \times 10^6$ Hz at a time when the maximum ionization in the E region has a value of $1 \cdot 0 \times 10^{11} e/m^3$ at a height of 110 km.

(Turn Over)

7. Answer any *two* parts of the following : 7×2=14

(a) Determine the critical frequency of EM wave for $D(N = 400$ electrons/cm$^3)$, $E(N = 500000$ electrons/cm$^3)$ and $F(N = 2000000$ electrons/cm$^3)$ layers.

(b) Derive a uniform spaced linear array of N isotropic elements with uniform phase difference consecutive elements. When is the array broadside?

(c) A receiving antenna is located at 80 km from the transmitting antenna. The height of transmitting antenna is 100 m. What is the required height of the receiving antenna?

8. Answer any *two* parts of the following : 7×2=14

(a) Calculate the directivity in dB for the broadside as well as end-fire array consisting eight isotropic elements separated by $\lambda/4$ distance.

(b) What is end-fire array? Ten isotropic elements are placed along the z-axis. Design a Hansen-Woodyard end-fire array with the maximum directed towards $\theta = 180°$. Find the *(i)* desired spacing and *(ii)* progressive phase shift (β).

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(c) Define the effective area of antenna. The transmitting and receiving antennas are separated by a distance of 200 λ and have directive gains of 25 dB and 18 dB respectively. If 5 mW of power is to be received, calculate the minimum transmitted power. Explain sky-wave propagation in detail.

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