National Institute of Technology, Hamirpur (HP)

Name of Examination: B.Tech.(DD) END Semester Examination (Nov.-Dec.-2022)

Branch: ECE-CSN
Subject: Advanced Antenna Design
Time: 3 Hours

Semester: VII
Subject Code: EC-704
Maximum Marks: 50

Note: All Questions are compulsory, use of scientific calculator is permitted. Assume missing data.

Q. 1 The radial component of the radiated power density of an infinitesimal linear dipole of length $l \ll \lambda$ is given by

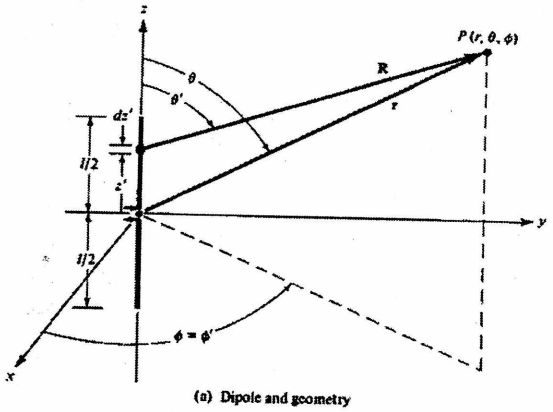
$$\mathbf{W}_{av} = \hat{\mathbf{a}}_r W_r = \hat{\mathbf{a}}_r A_0 \frac{\sin^2\theta}{r^2} \quad (\mathrm{W/m^2})$$

where A_0 is the peak value of the power density, θ is the usual spherical coordinate, and $\hat{a}_r$ is the radial unit vector. Determine the maximum directivity of the antenna and express the directivity as a function of the directional angles θ and ϕ. [5]

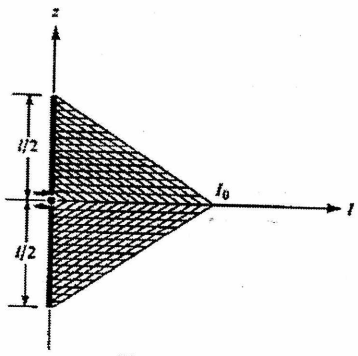
Q. 2 A one-way communication system, operating at 100 MHz, uses two identical $\lambda/2$ vertical, resonant, and lossless dipole antennas as transmitting and receiving elements separated by 10 km. In order for the signal to be detected by the receiver, the power level at the receiver terminals must be at least 1 μW. Each antenna is connected to the transmitter and receiver by a lossless 50-Ω transmission line. Assuming the antennas are polarization-matched and are aligned so that the maximum intensity of one is directed toward the maximum radiation intensity of the other, determine the minimum power that must be generated by the transmitter so that the signal will be detected by the receiver. Account for the proper losses from the transmitter to the receiver. [5]

Q. 3 How is the vector potential **A** useful in solving for the **EM** field generated by a given harmonic electric current **J**? Show with proper mathematical solutions. [5]

Q. 4 For a given dipole and its current distribution, find out the **E**- and **H**-fields radiated by the dipole in far field ($kr \gg 1$).



(a) Dipole and geometry



(b) Current distribution

Q. 5 What is an antenna array? Explain the pattern multiplication for two element arrays of two infinitesimal horizontal dipoles positioned along the z-axis with $d = \lambda/4$ and $\beta = 0$, $\beta = +\pi/2$, and $\beta = -\pi/2$. [5]

Q. 6 What is microstrip antenna? What are the different advantages and disadvantages of microstrip antenna? Explain the different techniques to design a circularly polarized microstrip antenna. [5]

Q. 7 Design a rectangular microstrip antenna using a substrate (RT/duroid 5880) with dielectric constant of 2.2, $h = 0.1588$ cm so as to resonate at 10 GHz. [5]

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Q. 8 Explain the fundamental limits of electrically small antennas. What are the different techniques to miniaturize antenna size? Explain with suitable mathematics and figure. [5]

Q. 9 What is smart antenna technology? Discuss different smart-Antenna Systems in detail with suitable diagrams and mathematics. [5]

Q. 10 What is the bandwidth of an antenna? Discuss the concept of broadband antenna. What are the various categories of antennas come under the preview of broadband antenna. [5]

Note: ***Given Appendices***

$$L = \frac{1}{2f_r\sqrt{\varepsilon_{reff}}\sqrt{\mu_0\varepsilon_0}} - 2\Delta L$$

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

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

$$W = \frac{1}{2f_r\sqrt{\mu_0\varepsilon_0}}\sqrt{\frac{2}{\varepsilon_r + 1}}$$