Antenna Theory

Midterm Exam

November 1 2024

1. Fundamentals

a). Write the relation between the electric field in the far-field region and the far-field function. (1%)

b). Write or explain the relation between the magnetic field in the far-field region and the far-field function. (1%)

c). Explain what the phase reference point of the far-field function is. (1%)

d). Explain what the phase center of the far-field function is. (1%)

e). Explain or write the relation to convey how to transform a far-field function from one phase reference point to another. (2%)

f). Explain or write the relation to convey how to transform a far-field function from one antenna location to another, when the antenna points in the same direction. (2%)

g). Write the E- and H-plane far-field functions of a Huygen's source. (2%)

h). State the condition for the far-field region. (1%)

i). If an antenna has an aperture of area A and works at frequency f (corresponding wavelength λ), what is the maximum available directivity? (1%)

j) Three different types of incremental current sources are used as the fundamental building blocks for the analysis and engineering of antennas. Write out the names of these three types of sources and the expressions for their radiation field functions for linear y-polarization. (3%)

2. Consider an elliptically polarized wave with 3 dB axial ratio.

a) Find the relative cross-polar level and the polarization efficiency when we consider the desired polarization to be the best linear. (5%)

b) Compare the values with those we obtain when the desired polarization is the best circular. (5%)

3. Consider a hypothetical omni-directional antenna with constant phase, i.e.

$$\vec{G}(\theta,\phi)=\kappa\left(\hat{\theta}\sin\phi+\hat{\phi}\cos\phi\right)$$

a) What is the polarization of this antenna along the z-axis? (5%)

b) Find the phase patterns in the E- and H- planes if the phase reference point is moved to z = 0.5λ. Sketch it. (5%)

c) Find the phase patterns in the E- and H- planes if the phase reference point is moved to x = 0.5λ. Sketch it. (5%)

d) Find the directivity of the omni-directional source. Does it depend on the location of the phase reference points? (10%)

e) Find the cross-polarization in the three cases. (5%)

f) Find the directivity when the antenna only radiates into the upper hemisphere, i.e. (10%)

$$\vec{G}(\theta,\phi)=0 \quad \text{for } \pi/2<\theta<\pi\,.$$

4. Antennas for telemetry, tracking and command (TTC) of satellites are often rotationally symmetric biconical antennas with a rotational symmetric radiation field function of the BOR_0 form:

$$\vec{G}(\theta,\phi)=B_0(\theta)\hat{\theta},$$

where $B_0(\theta)$ is a complex function. The z-axis is herein referred as the vertical axis.

a) Which polarization does the radiation field function have in the horizontal plane? (10%)

b) Which value must $B_0(\theta)$ have in the vertical direction and why? (10%)

c) Calculate the directive gain when

$$B_0(\theta)=\begin{cases}A & \text{for } 70^\circ<\theta<110^\circ\\ 0 & \text{elsewhere}\end{cases}$$

where A is a real constant. Give the answer in dBi. (15%)

~ End of Midterm Exam ~