

Receivers, Antennas, and Signals – 6.661

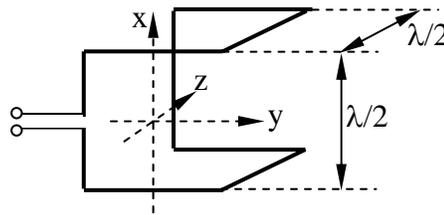
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Problem Set No. 6

Problem 6.1

The illustrated cubic wire antenna measures one-half wavelength on each side.

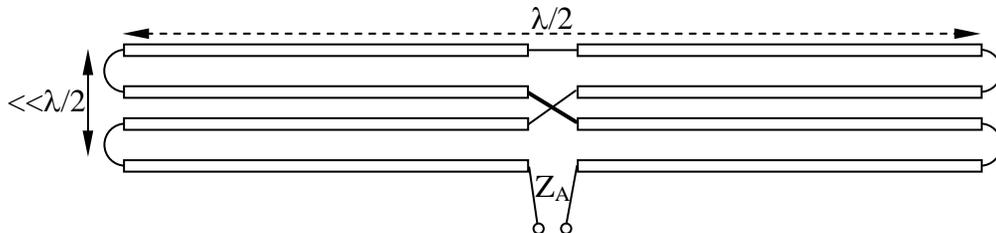


- Sketch a typical instantaneous non-zero current distribution on these wires.
- In what directions (x,y,z) is the gain $G(\theta,\phi)$ (globally, not locally) maximum, and what is the polarization in these directions? We define θ as zero along the $+z$ axis, and $\phi = 0$ in the $x-z$ plane. Consider only the x , y , and z directions in parts (b) and (c).
- In what directions is the gain $G(\theta,\phi)$ zero?

Problem 6.2

Consider the following double-folded dipole one-half wavelength long. It is non-reactive. A normal half-wave dipole has an impedance of ~ 73 ohms.

- Sketch a typical instantaneous non-zero current distribution for this antenna.
- What is the approximate input impedance Z_A for this antenna?



Problem 6.3

One or more approaches are sought to a wire antenna array that will consist of 8 half-wave dipoles placed end-to-end and nearly touching, where all 8 dipoles will be driven in phase so as to produce a lateral disk-shaped antenna pattern.

- a) Roughly what is the antenna beamwidth of this disk pattern if all dipoles are excited equally?
- b) The difficulty with this approach is that the TEM feed wires (say coax) may have currents induced on them that may re-radiate out of phase (like mirrors) if they are positioned incorrectly. Develop at least two design concepts for circumventing the problem of excessive unwanted radiation and gain loss associated with the currents induced on those sections of feedline that are close to the radiating dipoles. Sketch and briefly discuss your ideas.

Problem 6.4

Design the base-station and hand-held antennas and select the transmitter powers for a 1.5-GHz cell-phone system for rural use out to a radius of 20 km from the base station. Assume 1) the receiver system temperature is 600K at both ends, 2) the mobile transmitter power is one watt, 3) the bandwidth per user is 3 kHz (an audio call), 4) the ratio (SNR) of signal power to noise power (kTB) at the receiver is > 20 dB, and 5) we want an additional safety margin of 30 dB to account for fading and shadowing. The uplink (to the base station) and downlink (to the user) frequency bands are different but nearby, and that the total two-way (full-duplex) frequency allocation for the ground station is 3 MHz.

- a) First assume there is no frequency re-use, i.e., each band is used but once. Note that there is no "right" answer to this problem, so simply choose reasonable parameters and then adjust them so they seem sensible.
- b) Now assume that as many as four calls may re-use the same frequency at once, so that multiple antenna arrays with non-overlapping patterns may be invoked.

Problem 6.5

A certain helical antenna operates in front of a ground plane at wavelength λ , as illustrated. What should be the distance d in order to maximize the antenna gain in the forward direction?

