EE 483/583 Antennas for Wireless Communications
Quiz #3 (Spring 2024)

Name Key A

Instructions: Open book & notes. Place answers in indicated spaces and show all work for credit.

At 9 GHz, a vertically polarized WR-90 X-band rectangular horn antenna has a gain of 15.4 dBi. The physical aperture of the horn is 6.15 cm × 6.83 cm. Find the maximum effective aperture (in cm^2) and aperture efficiency (in %) at this frequency. If a vertically polarized electromagnetic (EM) wave with a power density of 400 $\mu W/m^2$ is incident from the direction of maximum gain, how much power is available to a matched load? A clumsy student bumps the horn antenna so that it is tipped 20° off vertical (still pointing in the direction of maximum gain). Now, how much power is available to a matched load?

$G_{max} = G_o = 15.4\ dBi = 10^{15.4/10} = 34.6737$

$\lambda = c/f = \frac{2.9979\times10^8}{9\times10^9} = 0.03331\ m$

(2-111) $A_{em} = e_{cd}\left(\frac{\lambda^2}{4\pi}\right)D_o = e_{cd}G_o\left(\frac{\lambda^2}{4\pi}\right)$

$= 10^{1.54}\left(\frac{0.03331^2}{4\pi}\right) = 0.003061536\ m^2$

$= 30.61536\ cm^2$

(2-100) $\epsilon_{AP} = \frac{A_{em}}{A_{phy}} = \frac{30.61536}{(6.15)(6.83)}\times100\% = 72.8859\%$

(2-94) $A_e = \frac{P_T}{W_i} \Rightarrow P_T = A_e W_i = 0.0030615(400\times10^{-6})$

$= 1.2246144\ \mu W$

Tipped

(2-112) $A_{em} = e_{cd}D_o\left(1-|\Gamma|^2\right)\left(\frac{\lambda^2}{4\pi}\right)PLF$ ($\Gamma = 0$)

$PLF = \cos^2\psi$

$= 10^{1.54}\left(\frac{0.03331^2}{4\pi}\right)\cos^2 20^\circ = 0.0027034\ m^2$

$P_{T,tipped} = 0.0027034(400\ \mu W) = 1.08136\ \mu W$

max. eff. aperture = 30.6154 cm^2 aperture efficiency = 72.886 %

power available$_{pol\text{-}matched}$ = 1.2246 μW power available$_{tipped}$ = 1.0814 μW