EE 483/583 Antennas for Wireless Communications
Quiz #3 (Spring 2025)

Name KEY

Instructions: Open book & notes. Place answers in indicated spaces & show all work for credit. c = 2.9979e8 m/s.

A Wi-Fi link at 2.4 GHz uses vertically polarized monopoles with a gain of 3.2 dBi at broadside. If the transmit power P_t is limited to 20 dBm maximum, find $P_{t,\max}$ (mW). Find the wavelength λ (cm) of operation as well as the maximum effective aperture (cm^2) and gain $G_{\max}$ (unitless) of the antennas. If the antennas ($Z_{in} = 37\,\Omega$) are fed using 50 Ω transmission lines (TL), find the fraction of power transferred between the antennas and TLs. If one antenna is tilted 20° from vertical (other antenna still in broadside direction), find the power loss factor (PLF). If the received power must be ≥ 16 nW, what is the maximum link range $R_{\max}$?

$P_{t_{max}} = 20\,dBm = 10\log_{10}\frac{P_{t,max}}{1mW} \Rightarrow P_{t_{max}} = 10^{20/10} = 100\,mW$

$\lambda = c/f = \frac{2.9979\times10^8}{2.4\times10^9} = 0.124913\,m = 12.491\,cm$

(2-52) $G_{max} = 3.2\,dBi = 10\log_{10} G_{max} \Rightarrow G_{max} = 10^{3.2/10} = 2.0893$

(2-111) $A_{em} = G_{max}\frac{\lambda^2}{4\pi} = 2.0893\,\frac{(12.491\,cm)^2}{4\pi} = 25.942\,cm^2$

$\Gamma = \frac{Z_{in}-Z_0}{Z_{in}+Z_0} = \frac{37-50}{37+50} = -0.14943$ ← reflection coeff.

$1-|\Gamma|^2 = 1-0.14943^2 = 0.97767$ ← fraction past impedance mismatch

$[1-|\Gamma|^2]^2 = 0.955843$

(2-71) $PLF = \cos^2 20° = 0.88302$ ← PLF

(2-118) $P_r/P_t = e_{cdt}\,e_{cdr}\,(1-|\Gamma_t|^2)(1-|\Gamma_r|^2)\left(\frac{\lambda}{4\pi R}\right)^2 D_t D_r |\hat{p}_t\cdot\hat{p}_r|^2$

Friis $\frac{16\times10^{-9}}{0.1} = 2.0893^2\,0.97767^2\left(\frac{0.124913}{4\pi}\right)^2\frac{1}{R_{max}^2}\,0.88302$

$\hookrightarrow R_{max}^2 = 2275.25539 \Rightarrow R_{max} = 47.69964\,m$

$P_{t,\max}$ = 100 mW λ = 12.491 cm max. eff. aperture = 25.942 cm^2 $G_{\max}$ = 2.0893

Frac. power$_{ant.-TL}$ = 0.9777 PLF = 0.88302 $R_{\max}$ = 47.7 m