

## EE 483/583 Antennas for Wireless Communications Quiz #3 (Spring 2022)

Name Key

**Instructions:** Open book & notes. Place answers in indicated spaces and show all work for credit. Per Wikipedia, the  $c = 299,792,458$  m/s,  $\epsilon_0 = 8.8541878 \times 10^{-12}$  F/m,  $\mu_0 = 4\pi \times 10^{-7}$  H/m, &  $1'' = 2.54$  cm.

A Pasternack 1.70 - 2.60 GHz WR430 standard gain rectangular horn antenna with an SMA connector has an input impedance of  $50 \Omega$  and a gain of 10 dBi at 2 GHz. The physical aperture of the horn is 4" tall by 8" wide. The antenna is oriented in the direction of maximum gain and polarization match to the incident wave, but is connected to a  $75 \Omega$  coaxial transmission line with an SMA-BNC adaptor. Find the physical & maximum effective aperture (in  $\text{cm}^2$ ) as well as aperture efficiency (in %) at this frequency. If the incident wave has a power density of  $800 \mu\text{W}/\text{m}^2$ , how much power is available to the transmission line?

$$A_p = (4'')(8'') \left( \frac{2.54 \text{ cm}}{1''} \right)^2 = \underline{206.4512 \text{ cm}^2}$$

$$\text{Per (2-112), } A_{em} = \underset{\rightarrow G_0}{e_{cd} D_0} (1 - |\Gamma|^2) \left( \frac{\lambda^2}{4\pi} \right) \left| \underset{\rightarrow \text{PLF}}{\hat{P}_w \cdot \hat{P}_a} \right|^2$$

where  $e_{cd} D_0 = G_0 = 10^{10/10} = 10$

$$\lambda = c/f = \frac{299792458}{2 \times 10^9} = 0.149896 \text{ m} = 14.99 \text{ cm}$$

PLF = 1 (polarization-matched)

$$\Gamma = \frac{z_a - z_c}{z_a + z_c} = \frac{50 - 75}{50 + 75} = -0.2 \Rightarrow |\Gamma| = 0.2$$

$$A_{em} = 10 (1 - 0.2^2) \frac{14.9896^2}{4\pi} (1) = \underline{171.6496 \text{ cm}^2}$$

$$(2-100) \epsilon_{ap} = \frac{A_{em}}{A_p} = \frac{171.65}{206.45} (100\%) = \underline{83.14294\%}$$

$$(2-94) P_{TL} = W_i A_{em} = 800 \times 10^{-6} \frac{\text{W}}{\text{m}^2} (171.6496) \frac{1 \text{ m}^2}{100^2 \text{ cm}^2} = \\ = \underline{1.373197 \times 10^{-5} \text{ W} = 13.732 \mu\text{W}}$$

physical aperture = 206.4512 cm<sup>2</sup>

max. effective aperture = 171.6496 cm<sup>2</sup>

aperture efficiency = 83.143 %

power available = 13.732 μW