Monday, April 20, 2026

EE 483/583 Antennas for Wireless Communications Quiz #8 (Spring 2026)

Name KEY

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

While visiting Brobdingnag, Gulliver decides to design and build a rectangular microstrip patch antenna to operate at a frequency of 125 MHz using a 4' × 8' (122 cm × 244 cm) sheet of foil-clad polystyrene on where $\varepsilon_r = 1.8$ and $h = 2.54$ cm with 1 oz. aluminum foil ($t = 35$ μm). Find the patch width for optimum radiation efficiency, fringing length, effective length, guided wavelength, and physical length of the patch in **cm** as well as the effective relative permittivity. Assume $c = 2.9979 \times 10^8$ m/s.

Calculate width of patch using (14-6),

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{2.9979\times10^8}{2\,(125\times10^6)}\sqrt{\frac{2}{1.8+1}} \quad \Rightarrow \quad \underline{\boldsymbol{W = 1.013475 \text{ m} = 101.3475 \text{ cm}}}$$

Calculate effective relative permittivity using (14-1)

$$\varepsilon_{r,\text{eff}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-0.5} = \frac{1.8+1}{2} + \frac{1.8-1}{2}\left[1 + 12\frac{2.54}{101.35}\right]^{-0.5} \quad \Rightarrow \quad \underline{\boldsymbol{\varepsilon_{r,\text{eff}} = 1.7507}}$$

Calculate fringing length using (14-2)

$$\Delta L = 0.412h\frac{\left(\varepsilon_{r,\text{eff}} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{r,\text{eff}} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} = 0.412(2.54)\frac{(1.7507 + 0.3)\left(\frac{101.3475}{2.54} + 0.264\right)}{(1.7507 - 0.258)\left(\frac{101.3475}{2.54} + 0.8\right)}$$

$$\Rightarrow \quad \underline{\boldsymbol{\Delta L = 1.4187 \text{ cm}}}$$

Calculate the effective length using (14-5) & guided wavelength

$$L_{\text{eff}} = \frac{c}{2f_r\sqrt{\varepsilon_{r,\text{eff}}}} = \frac{2.9979\times10^8}{2(125\times10^6)\sqrt{1.7507}} \quad \Rightarrow \quad \underline{\boldsymbol{L_{\text{eff}} = 0.906293 \text{ m} = 90.6293 \text{ cm}}}$$

$$\lambda = 2L_{\text{eff}} = 2(90.6293) \quad \Rightarrow \quad \underline{\boldsymbol{\lambda = 181.2585 \text{ cm}}}$$

Calculate the physical patch length L using (14-7)

$$L = L_{\text{eff}} - 2\Delta L = 90.6293 - 2(1.4187) \quad \Rightarrow \quad \underline{\boldsymbol{L = 87.7918 \text{ cm}}}$$

Note: $W / L = 101.3475/87.7918 = 1.154 < 2$, OK w/ center-fed inset microstrip.

patch width = $\underline{\boldsymbol{W = 101.3475 \text{ cm}}}$ effective rel. permittivity = $\underline{\boldsymbol{\varepsilon_{r,\text{eff}} = 1.7507}}$

fringing length = $\underline{\boldsymbol{\Delta L = 1.4187 \text{ cm}}}$ effective length = $\underline{\boldsymbol{L_{\text{eff}} = 90.6293 \text{ cm}}}$

guided wavelength = $\underline{\boldsymbol{\lambda = 181.2585 \text{ cm}}}$ physical patch length = $\underline{\boldsymbol{L = 87.7918 \text{ cm}}}$