EE 483/583 Antennas for Wireless Communications Quiz #8 (Spring 2025)

Name KEY

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

A ham radio operator decides to design and build a rectangular microstrip patch antenna to operate at a frequency of 136 MHz using a 4' × 4' (122 cm × 122 cm) sheet of foil-clad polystyrene on where $\varepsilon_r = 1.06$ and $h = 1.5$" clad with aluminum foil ($t = 0.003$"). 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. Hint: 1" = 2.54 cm.

Substrate height $h = 1.5(2.54) = 3.81$ cm.

Calculate width of patch using (14-6),

$$W = \frac{c}{2f_r}\sqrt{\frac{2}{\varepsilon_r + 1}} = \frac{2.9979\times10^8}{2\,(136\times10^6)}\sqrt{\frac{2}{1.06+1}} \quad \Rightarrow \quad \underline{\boldsymbol{W = 1.086 \text{ m} = 108.6 \text{ cm}}}$$

Calculate effective relative permittivity using (14-1)

$$\varepsilon_{r,\text{eff}} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-0.5} = \frac{1.06+1}{2} + \frac{1.06-1}{2}\left[1 + 12\frac{3.81}{108.6}\right]^{-0.5} \Rightarrow \underline{\boldsymbol{\varepsilon_{r,\text{eff}} = 1.055167}}$$

Calculate fringing length using (14-2)

$$\Delta L = 0.412\,h\frac{\left(\varepsilon_{r,\text{eff}} + 0.3\right)\left(\frac{W}{h} + 0.264\right)}{\left(\varepsilon_{r,\text{eff}} - 0.258\right)\left(\frac{W}{h} + 0.8\right)} = 0.412(3.81)\frac{(1.055167 + 0.3)\left(\frac{108.6}{3.81} + 0.264\right)}{(1.055167 - 0.258)\left(\frac{108.65}{3.81} + 0.8\right)}$$

$$\Rightarrow \underline{\boldsymbol{\Delta L = 2.61968 \text{ cm}}}$$

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

$$L_{\text{eff}} = \frac{c}{2f_r\sqrt{\varepsilon_{\text{r,eff}}}} = \frac{2.9979\times10^8}{2(136\times10^6)\sqrt{1.055167}} \quad \Rightarrow \quad \underline{\boldsymbol{L_{\text{eff}} = 1.07297 \text{ m} = 107.297 \text{ cm}}}$$

$$\lambda = 2L_{\text{eff}} = 2(107.297) \quad \Rightarrow \quad \underline{\boldsymbol{\lambda = 214.5941 \text{ cm}}}$$

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

$$L = L_{\text{eff}} - 2\Delta L = 107.297 - 2(2.6197) \Rightarrow \underline{\boldsymbol{L = 102.0577 \text{ cm}}}$$

patch width = $\underline{\boldsymbol{W = 108.600 \text{ cm}}}$ effective relative permittivity = $\underline{\boldsymbol{\varepsilon_{r,\text{eff}} = 1.0552}}$

fringing length = $\underline{\boldsymbol{\Delta L = 2.620 \text{ cm}}}$ effective length = $\underline{\boldsymbol{L_{\text{eff}} = 107.297 \text{ cm}}}$

guided wavelength = $\underline{\boldsymbol{\lambda = 214.594 \text{ cm}}}$ physical patch length = $\underline{\boldsymbol{L = 102.058 \text{ cm}}}$