

EE 483/583 Antennas for Wireless Communications Quiz #8 (Spring 2022)Name KEYInstructions: Open book & notes. Place answers in indicated spaces and **show all** work for credit.

A rectangular microstrip patch antenna is to operate at a frequency of 3 GHz on a microwave substrate where $\epsilon_r = 3.3$ and $h = 1.252$ mm with 1 oz. copper cladding ($t = 35$ μm). Calculate the patch width for optimum radiation efficiency, effective permittivity, fringing length, effective length, and physical length of the patch. Express all distances/lengths in **millimeters**. Assume $c = 2.9979 \times 10^8$ m/s.

Calculate width of patch using (14-6),

$$W = \frac{c}{2f_r} \sqrt{\frac{2}{\epsilon_r + 1}} = \frac{2.9979 \times 10^8}{2(3 \times 10^9)} \sqrt{\frac{2}{3.3 + 1}} = 0.034075847 \text{ m} \Rightarrow \underline{W = 34.07585 \text{ mm}}$$

Calculate effective relative permittivity using (14-1)

$$\epsilon_{r,\text{eff}} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left[1 + 12 \frac{h}{W} \right]^{-0.5} = \frac{3.3 + 1}{2} + \frac{3.3 - 1}{2} \left[1 + 12 \frac{1.252}{34.07585} \right]^{-0.5} \Rightarrow \underline{\epsilon_{r,\text{eff}} = 3.10803}$$

Calculate fringing length using (14-2)

$$\Delta L = 0.412h \frac{(\epsilon_{r,\text{eff}} + 0.3) \left(\frac{W}{h} + 0.264 \right)}{(\epsilon_{r,\text{eff}} - 0.258) \left(\frac{W}{h} + 0.8 \right)} = 0.412(1.252) \frac{(3.108 + 0.3) \left(\frac{34.076}{1.252} + 0.264 \right)}{(3.108 - 0.258) \left(\frac{34.076}{1.252} + 0.8 \right)} \Rightarrow \underline{\Delta L = 0.60502 \text{ mm}}$$

Calculate the effective length using (14-5)

$$L_{\text{eff}} = \frac{c}{2f_r \sqrt{\epsilon_{r,\text{eff}}}} = \frac{2.9979 \times 10^8}{2(3 \times 10^9) \sqrt{3.10803}} = 0.02834151 \text{ m} \Rightarrow \underline{L_{\text{eff}} = 28.34151 \text{ mm}}$$

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

$$L = L_{\text{eff}} - 2\Delta L = 28.34151 - 2(0.60502) \Rightarrow \underline{L = 27.13148 \text{ mm}}$$

patch width = $W = 34.07585 \text{ mm}$ effective permittivity = $\epsilon_{r,\text{eff}} = 3.10803$ fringing length = $\Delta L = 0.60502 \text{ mm}$ effective length = $L_{\text{eff}} = 28.34151 \text{ mm}$ physical patch length = $L = 27.13148 \text{ mm}$