# EE 481/581 Microwave Engineering Quiz #9 (Fall 2024)

Name __KEY A__

Instructions: Open notes/text. Place answers in indicated spaces. S**how** & **clearly label** *all* work for partial credit.

1) An edge-coupled **stripline** directional coupler is pictured below. Given that it is built using a board with ground plane separation of 1.6 mm and dielectric constant 3.5, determine the even- and odd-mode characteristic impedances, the coupling factor (unitless and in dB), and center frequency.
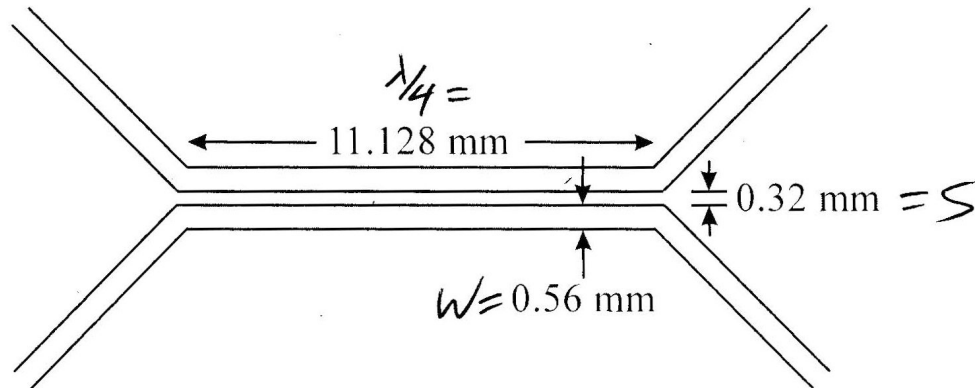
$b = 1.6 \, mm \, , \, \epsilon_r = 3.5$

$\frac{W}{b} = \frac{0.56}{1.6} = 0.35 \quad \& \quad \frac{S}{b} = \frac{0.32}{1.6} = 0.2$

$\hookrightarrow$ Plot on Fig 7.29. Read-off:

$\sqrt{\epsilon_r} \, Z_{0e} = 145.509 \Rightarrow Z_{0e} = \frac{145.509}{\sqrt{3.5}} = \underline{77.78 \, \Omega}$

$\sqrt{\epsilon_r} \, Z_{00} = 93.371 \Rightarrow Z_{00} = \frac{93.371}{\sqrt{3.5}} = \underline{49.909 \, \Omega}$

Per (7.81), $C = \frac{Z_{0e} - Z_{00}}{Z_{0e} + Z_{00}} = \frac{77.78 - 49.9}{77.78 + 49.9} = \underline{0.21826}$

$C(dB) = 20 \log_{10} 0.21826 = +\underline{13.22 \, dB}$

$\frac{\lambda}{4} = 11.128 \, mm \Rightarrow \lambda = 44.512 \, m \Rightarrow$ from $v_p = \frac{c}{\sqrt{\epsilon_r}} = f \lambda$

$\hookrightarrow f = \frac{2.9979 \times 10^8}{\sqrt{3.5} \, (0.044512)} = 3.6 \times 10^9 \, Hz$

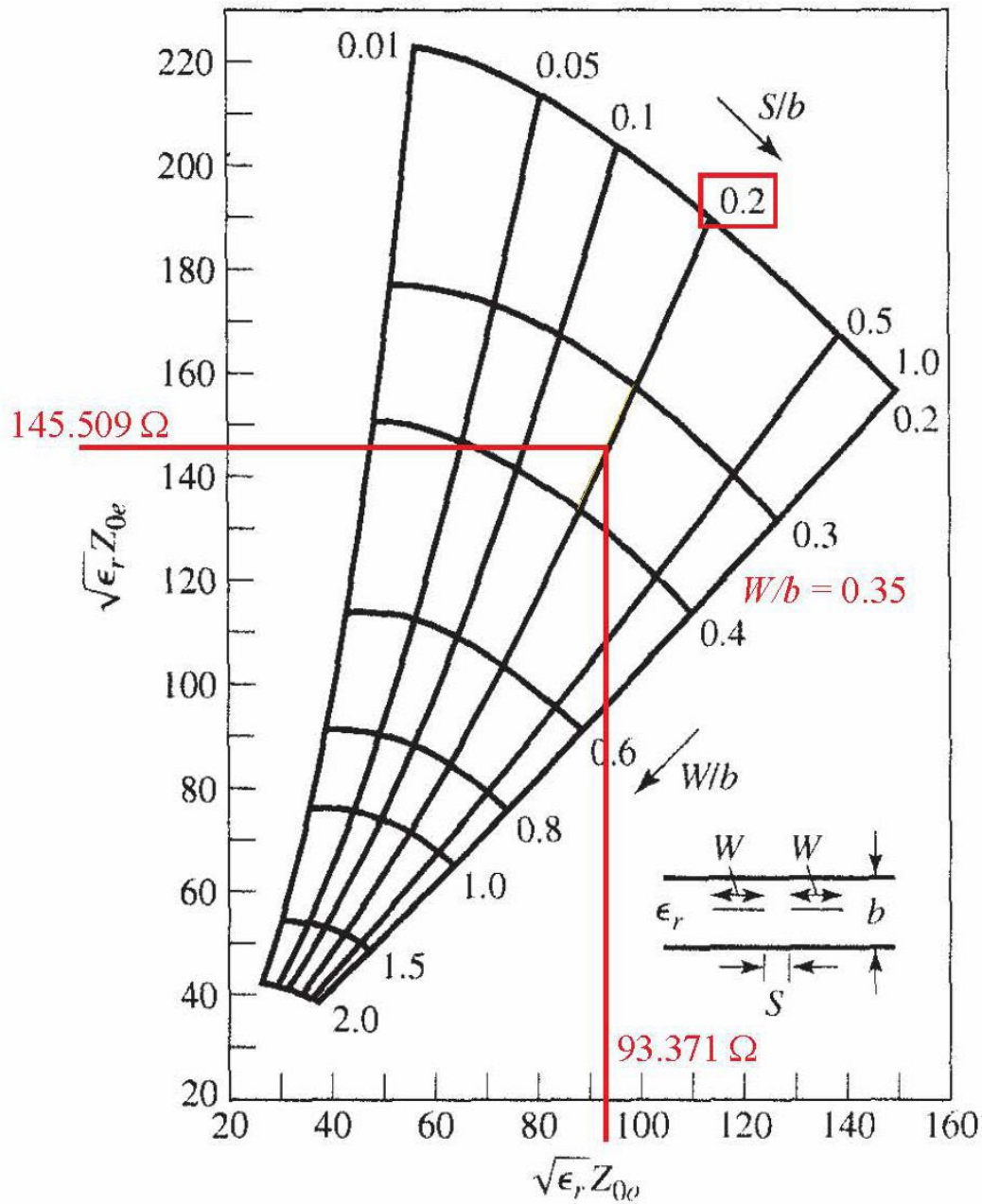even-mode char. impedance = __77.78 Ω__   odd-mode char. impedance = __49.9 Ω__

coupling factor = __0.218__   or __13.22 dB__   center frequency = __3.6 GHz__

Quiz A

FIGURE 7.29   Normalized even- and odd-mode characteristic impedance design data for symmetric edge-coupled striplines.

EE 481/581 Microwave Engineering Quiz #9 (Fall 2024)

Name _____**KEY B**_____

Instructions: Open notes/text. Place answers in indicated spaces. **S**how & **clearly label** *all* work for partial credit.

2) An edge-coupled **stripline** directional coupler is pictured below. Given that it is built using a board with ground plane separation of 2.2 mm and dielectric constant 2.4, determine the even- and odd-mode characteristic impedances, the coupling factor (unitless and in dB), and center frequency.
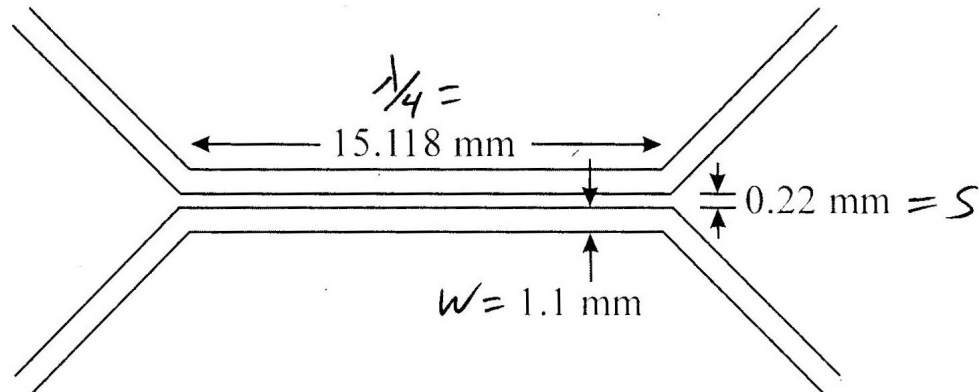
$$b = 2.2\,mm,\ \epsilon_r = 2.4$$

$$\tfrac{w}{b} = \tfrac{1.1}{2.2} = 0.5 \quad + \quad \tfrac{S}{b} = \tfrac{0.22}{2.2} = 0.1 \Rightarrow \text{Plot on Fig 7.29}$$

$$\text{Read-off}\ \sqrt{\epsilon_r}\,Z_{oe} = 125.367 \Rightarrow Z_{oe} = \tfrac{125.367}{\sqrt{2.4}} = \underline{80.924\,\Omega}$$

$$\sqrt{\epsilon_r}\,Z_{oo} = 70 \Rightarrow Z_{oo} = \tfrac{70}{\sqrt{2.4}} = 45.185\,\Omega$$

$$\text{Per (7.81)},\ C = \frac{Z_{oe} - Z_{oo}}{Z_{oe} + Z_{oo}} = \frac{80.9 - 45.2}{80.9 + 45.2} = \underline{0.2834}$$
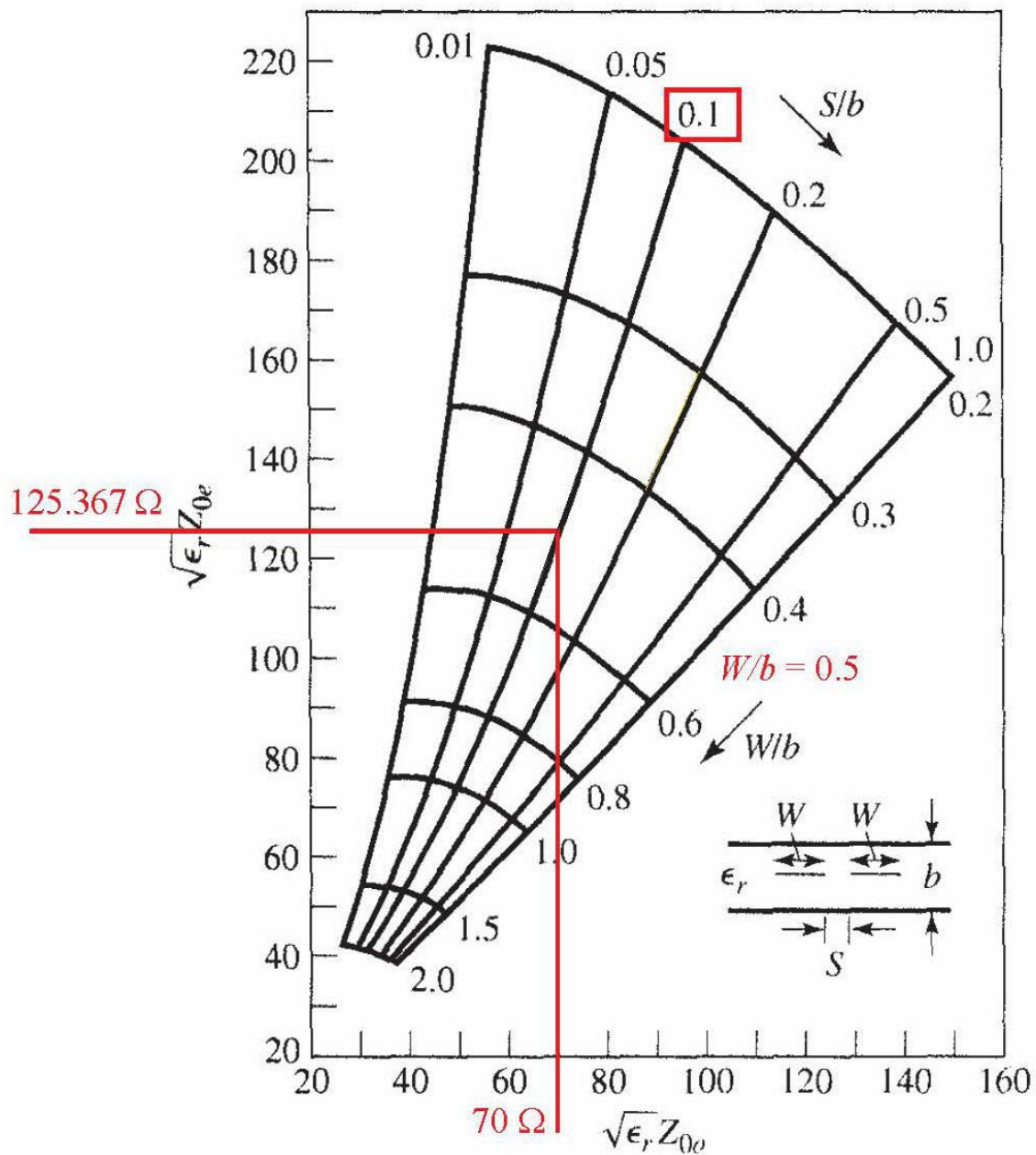
$$C(dB) = -20\log_{10} 0.2834 = \underline{10.952\,dB}$$

$$\tfrac{\lambda}{4} = 15.118\,mm \Rightarrow \lambda = 60.472\,mm$$

$$\text{From}\ v_p = \tfrac{c}{\sqrt{\epsilon_r}} = f\lambda,\ f = \frac{2.9979 \times 10^8}{\sqrt{2.4}\,(0.060472)} = 3.2 \times 10^9\,Hz$$

even-mode char. impedance = ___**80.92 Ω**___   odd-mode char. impedance = ___**45.185 Ω**___

coupling factor = ___**0.283**___ or ___**10.95 dB**___   center frequency = ___**3.2 GHz**___

Quiz B

FIGURE 7.29   Normalized even- and odd-mode characteristic impedance design data for symmetric edge-coupled striplines.