A 20 dB coupler using edge-coupled striplines is desired at 4 GHz in a 50 Ω system with a ground plane separation of 2.54 mm and $\varepsilon_r = 2.2$. a) Find the unitless coupling coefficient C and percentage of power coupled. b) Find the required even-mode Z_{0e} and odd-mode Z_{0o} characteristic impedances. c) Using the graph of Figure 7.29, find the land/trace widths W and separation S. d) Find W_{50}, v_p and $L = \lambda/4$ for $Z_0 = 50\ \Omega$. e) Draw a fully-labeled top view sketch of the striplines for the coupler.

a) Per (7.20a), $C = 10^{-CdB/20} = 10^{-20/20}$ $\Rightarrow$ **$C = 0.1$**

Per notes, % power $= C^2\,(100\%) = 0.1^2\,(100\%)$ $\Rightarrow$ **% power = 1 %**

b) Per (7.87a), $Z_{0e} = Z_0\sqrt{\dfrac{1+C}{1-C}} = 50\sqrt{\dfrac{1+0.1}{1-0.1}}$ $\Rightarrow$ **$Z_{0e} = 55.277\ \Omega$**

Per (7.87a), $Z_{0o} = Z_0\sqrt{\dfrac{1-C}{1+C}} = 50\sqrt{\dfrac{1-0.1}{1+0.1}}$ $\Rightarrow$ **$Z_{0o} = 45.227\ \Omega$**

c) To use graph/Fig. 7.29, we need

$\sqrt{\varepsilon_r}\,Z_{0e} = \sqrt{2.2}\,(55.277) = 81.989\ \Omega$ and $\sqrt{\varepsilon_r}\,Z_{0o} = \sqrt{2.2}\,(45.227) = 67.082\ \Omega$.

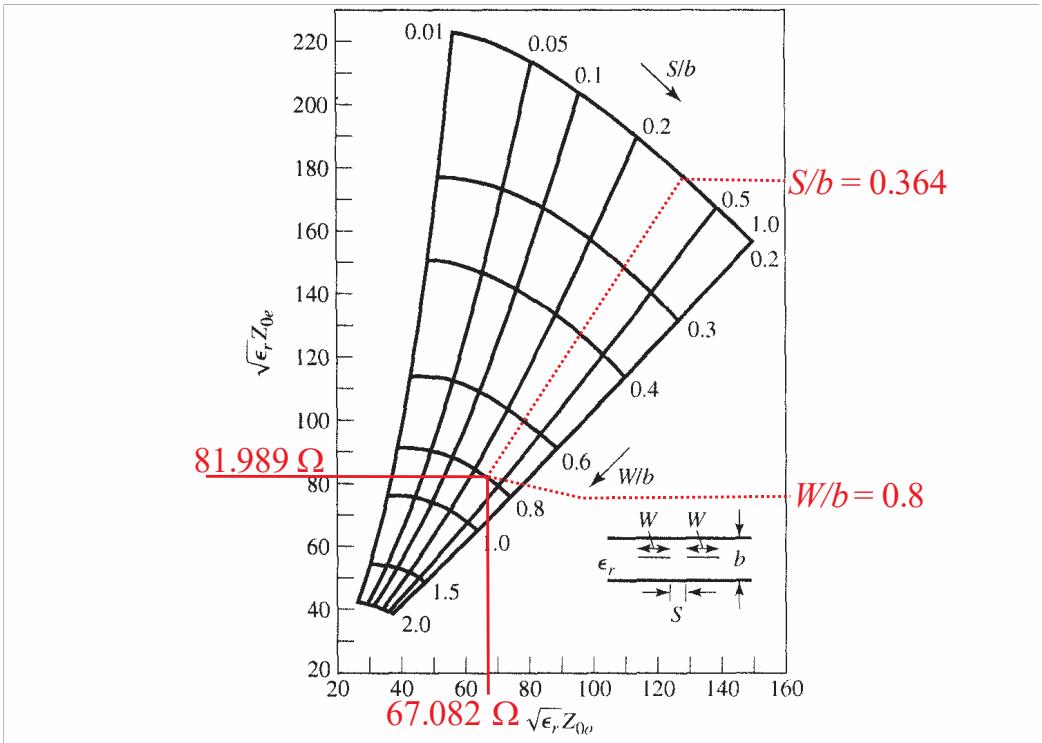

FIGURE 7.29 Normalized even- and odd-mode characteristic impedance design data for symmetric edge-coupled striplines.

$S = S/b\ (b) = 0.364\ (2.54)$ $\Rightarrow$ **$S = 0.925$ mm**

$W = W/b\ (b) = 0.8\ (2.54)$ $\Rightarrow$ **$W = 2.032$ mm**

d) To find W_{50}, we will use (3.180a) & (3.180b). Since $\sqrt{\varepsilon_r}\, Z_0 = \sqrt{2.2}\,(50) = 74.162\ \Omega < 120\ \Omega$, we use the top equation -

$$\frac{W}{b} = x = \frac{30\pi}{\sqrt{\varepsilon_r}\, Z_0} - 0.441 = \frac{30\pi}{\sqrt{2.2}\,(50)} - 0.441 = 0.8298368.$$

The land width is $W_{50} = 0.8298\,(2.54)$ $\Rightarrow$ **$W_{50} = 2.108$ mm**.

(3.176) $v_p = c / \sqrt{\varepsilon_r} = 2.9979 \times 10^8 / \sqrt{2.2}$ $\Rightarrow$ **$v_p = 2.0212 \times 10^8$ m/s**.

$L = \lambda/4 = v_p / f / 4 = 2.0212 \times 10^8 / 4 \times 10^9 / 4$ $\Rightarrow$ **$L = 0.01263$ m = 12.63 mm**.

e)