EE 481/581 Microwave Engineering (Fall 2025)

Homework 9

Monday, November 10, 2025

1) A directional coupler has the scattering matrix given below when ports are terminated with matched loads. Find the return loss, coupling factor, directivity, insertion loss, and isolation of the coupler in decibels.

$$[S]=\begin{bmatrix} 0.11\angle 30° & 0.92\angle 90° & 0.3\angle 165° & 0.008\angle 90° \\ 0.92\angle 90° & 0.11\angle 30° & 0.008\angle 90° & 0.3\angle 165° \\ 0.3\angle 165° & 0.008\angle 90° & 0.11\angle 30° & 0.92\angle 90° \\ 0.008\angle 90° & 0.3\angle 165° & 0.92\angle 90° & 0.11\angle 30° \end{bmatrix}$$

2) At 2 GHz in a 60 Ω system, a nominal 17 dB (16.99 dB) coupler is desired. Use microstrip on Rogers TMM10i board (1 oz. copper, 5.08 mm thick). 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 7.30, find the land/trace widths W and separation S. d) Use Chapter 3 design equations for $Z_0 = 60\ \Omega$ to find W_{60}, ε_{re}, v_p, and $L = \lambda/4$. e) Draw a fully-labeled top view sketch of the design. f) **EE 581 only:** Check answers for C, Z_{0e}, Z_{0o}, W, and S using Rogers MWI. Use Snipping Tool to include relevant screenshots from MWI.

3) 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.

4) Using text design equations and Rogers MWI, design a microstrip quad hybrid for a 50 Ω system with a design frequency of 2 GHz on Rogers RT/duroid 5880 (1 oz. copper, 1.574 mm thick). Draw a fully-labeled top view sketch of design.

5) Design a microstrip ring hybrid for a 50 Ω system with a design frequency of 2 GHz on Rogers RT/duroid 5880 (1 oz. copper, 1.574 mm board thickness). Draw a fully-labeled top view sketch of design.

   Hints for 4) & 5): Consult datasheet for ε_r. In Rogers MWI 'Material Properties' box (in middle), use 'DK values for a specific frequency' option. Use Snipping Tool to include relevant screenshots from datasheet & MWI.

6) 7.28

Due Friday, November 14, 2025.