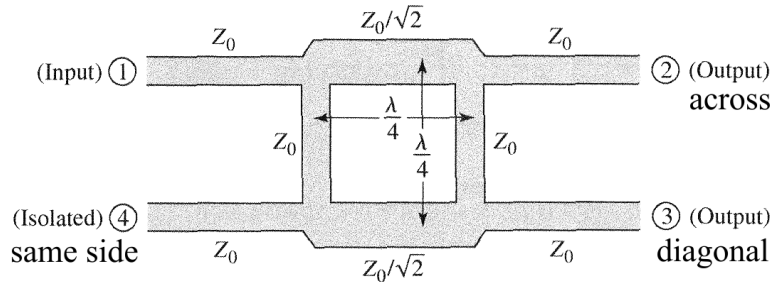


Using text design equations and Rogers MWI, design a microstrip quad hybrid for a 50  $\Omega$  system with a design frequency of 2 GHz on Rogers RT/duroid 5880 (1 oz. copper, 1.574 mm thick). Draw a fully-labeled top view sketch of design.

Per section 7.5 and Figure 7.21, we will need  $Z_0 = 50 \Omega$  and  $50/\sqrt{2} = 35.355 \Omega$  microstrips.



**FIGURE 7.21** Geometry of a branch-line coupler.

The Rogers RT/duroid 5880 datasheet only gives  $\epsilon_r = 2.20$  (no graph versus frequency).

$$Z_0 = 50 \Omega$$

From Rogers MWI at 2 GHz on Rogers RT/duroid 5880 (1 oz. copper, 1.574 mm thick)-  
 $W_{50} = 4.9 \text{ mm}$  and  $\epsilon_{r,e} = 1.8915$ . Started with 'Synthesis Width' option and changed to 'Analytical' option to get closer values for 50  $\Omega$ , only went to one decimal place for width.

Use (3.193) to get  $v_p = c / \sqrt{\epsilon_{r,e}} = 2.9979 \times 10^8 / \sqrt{1.8915} = 2.18 \times 10^8 \text{ m/s}$ .

$$\lambda_{p,50} = v_{p,50} / f = 2.18 \times 10^8 / 2 \times 10^9 = 0.108989 \text{ m} = 108.989 \text{ mm} \Rightarrow \lambda_{p,50} / 4 = 27.25 \text{ mm}.$$

**Microstrip**

Transmission Line Information

Impedance = 50.06 ohms  
Effective dk = 1.8915

Dielectric Loss is = 0.19471 dB/m  
Conductor loss is = 0.33774 dB/m  
Total loss is = 0.53245 dB/m

Dielectric Q Factor is 1285.  
Conductor Q Factor is 856.8  
Total Q Factor for transmission line is 514.1

Wavelength on transmission line:  
1 wavelength = 0.108 meters  
1/2 wavelength = 0.054 meters  
1/4 wavelength = 0.027 meters  
1/8 wavelength = 0.013 meters

Open Single End Fringing = 0.7489 mm  
Skin depth in copper is = 1.476e-6 meters

All material names are licensed, registered trademarks of Rogers Corporation

Material Name	Bulk Dk	Df	TC Dk	Ti
RT/duroid 5870	2.33	0.0012	-115	0.
RT/duroid 5880	2.2	0.0009	-125	0.
RT/duroid 5880LZ	1.96	0.0019	22	0.
RT/duroid 6002	2.94	0.0012	12	0.
RT/duroid 6010LM	10.7	0.0023	-425	0.
RT/duroid 6035HTC	3.6	0.0013	-66	1.
RT/duroid 6202	2.94	0.0015	13	0.
TMM3	3.45	0.002	37	0.
TMM4	4.7	0.002	-15.3	0.
TMM6	6.3	0.0023	-11	0.
TMM10	9.8	0.0022	-38	0.

Material Properties

Material: RT/duroid 5880  
Thickness (H): 1.574 mm

Dk: 2.2  
Df: 0.0009  
Thermal Cond.: 0.2 W/K\*m

Conductor Parameters

Thickness (T): 0.0013 microns  
Surface Area Index: 3.7

1oz ED  
Conductivity:  $5.813 \times 10^{-7} \text{ S/m}$   
Avg Nodule Size (microns): 0.2

Surface Roughness (RMS): 2.1 microns

Roughness loss model: Hall-Huray

Copper roughness values:  
☒ Optimum for accuracy  
☐ Actual measurement

Generate Tables and Files: None

Design Method: ☒ Analytical  
☐ Synthesis Width

Impedance: 50 Ohms  
Frequency: 2 GHz

Calculate

$$Z_0 = 35.355 \Omega$$

From Rogers MWI at 2 GHz on Rogers RT/duroid 5880 (1 oz. copper, 1.574 mm thick)-  
 $W_{35} = 8.0 \text{ mm}$  and  $\epsilon_{r,e} = 1.9507$ . Started with  $W_{50} = 4.9 \text{ mm}$  used 'Analytical' option to get  
 get width value by trial-n-error.

Use (3.193) to get  $v_p = c / \sqrt{\epsilon_{r,e}} = 2.9979 \times 10^8 / \sqrt{1.9507} = 2.146 \times 10^8 \text{ m/s}$ .

$$\lambda_{p,35} = v_{p,35} / f = 2.146 \times 10^8 / 2 \times 10^9 = 0.107323 \text{ m} = 107.323 \text{ mm} \Rightarrow \lambda_{p,35} / 4 = 26.83 \text{ mm}.$$

**Microstrip**

Transmission Line Information

Conventional Microstrip  
 Using 1.574 mm RT/duroid 5880 circuit materials.  
 Conductor width = 8.00 mm

Impedance = 35.36 ohms  
 Effective dk = 1.9507

Dielectric Loss is = 0.20446 dB/m  
 Conductor loss is = 0.31649 dB/m  
 Total loss is = 0.52096 dB/m

Dielectric Q Factor is 1243.  
 Conductor Q Factor is 928.5  
 Total Q Factor for transmission line is 531.5

Wavelength on transmission line:  
 1 wavelength = 0.107 meters  
 1/2 wavelength = 0.053 meters  
 1/4 wavelength = 0.026 meters  
 1/8 wavelength = 0.013 meters

Material Name	Bulk Dk	Df	TC Dk	Ti
RT/duroid 5870	2.33	0.0012	-115	0.
RT/duroid 5880	2.2	0.0009	-125	0.
RT/duroid 5880LZ	1.96	0.0019	22	0.
RT/duroid 6002	2.94	0.0012	12	0.
RT/duroid 6010LM	10.7	0.0023	-425	0.
RT/duroid 6035HTC	3.6	0.0013	-66	1.
RT/duroid 6202	2.94	0.0015	13	0.
TMM3	3.45	0.002	37	0.
TMM4	4.7	0.002	-15.3	0.
TMM6	6.3	0.0023	-11	0.
TMM10	9.8	0.0022	-38	0.

Material Properties

Material: RT/duroid 5880 Thickness (H): 1.574 mm

Dk: 2.2 Df: 0.0009 Thermal Cond.: 0.2 W/K\*m

Conductor Parameters

Thickness (T): 0.0013 microns Surface Area Index: 3.7

1oz ED: 5.813 x 10<sup>-7</sup> S/m Avg Nodule Size (microns): 0.2

Conductivity: 5.813 x 10<sup>-7</sup> S/m Surface Roughness (RMS): 2.1 microns

Roughness loss model: Hall-Huray

Copper roughness values: Optimum for accuracy

Analysis: Analytical Impedance: 50 Ohms Frequency: 2 GHz

