Q1: Design a low pass filter using microstrip technology based on the following specifications.

Order: **3**

Cut-off Frequency: **4.0 GHz**

Source and Load Impedance: **50 Ω**

Port Impedance: **50 Ω**

Filter Type: Chebyshev (**3dB equal-ripple**)

Design this filter using 2 methods:

a) With lumped elements, using two series inductors and one shunt capacitor

b) With shunt stubs (i.e., Richard's Transformation and Kuroda's Identities).

Q: Determine design values for each of the three designs. Show clearly your design steps, and specify all relevant parameters for each design. Perform the simulation using ADS and HFSS/CST.
Q: Do these results indicate that your designs are correct? Explain why you think so.
Q: From these plots, determine the insertion loss of each filter design at 1, 3, 4 and 7 GHz.
Q: Compare these values between the different filter designs. Some of these values are close to the same for each design, while some values are quite different. Explain why this is so.
Q: For each design, plot S_{11} on a Smith Chart over the same frequencies of 0 to 10 GHz.
Q: For what frequencies is the curve on the Smith chart nearest the center? Explain why this is so.

Q3: Design a 1:4 Wilkinson power divider for a 50 Ω system impedance at frequency f_0 = 1 GHz, and plot the return loss (S11), insertion loss S21 & S31, and isolation (S23 = S32) versus frequency from 0.5 f_0 to 1.5 f_0. Assume the device is to be implemented in microstrip, with a 0.787 mm substrate thickness, a dielectric constant of 2.33.

Experiment Tasks:

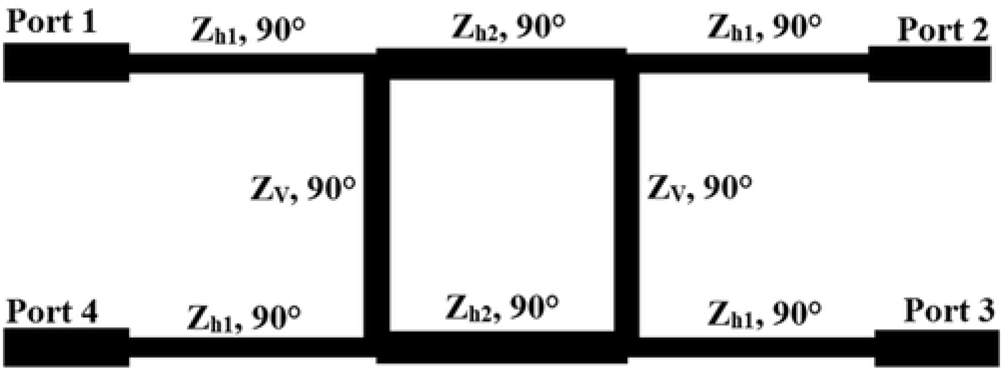
1. Determine design values of Wilkinson power divider for a 50 Ω system. Show clearly your design steps, and specify all relevant parameters for this design.
2. Implement the Wilkinson power divider in ADS and HFSS. Compare the simulation results.
3. Specify your comments on return loss, isolation, power division and bandwidth for both simulation results.

Q4: Design a one-section branch-line directional coupler to provide a coupling of 6 dB. Assume the device is to be implemented in microstrip, with a 0.787 mm substrate thickness, a dielectric constant of 2.33, and that the operating frequency is 1.0 GHz.

Experiment Tasks:

1. Determine design values of the coupler for a 50 Ω system. Show clearly your design steps, and specify all relevant parameters for this design.
2. Implement the Wilkinson power divider in ADS and HFSS. Compare the simulation results.
3. Specify your comments on return loss, isolation, power division and bandwidth for both simulation results.

Q2: Design a wide band branch line coupler operating at 2.4 GHz with a coupling level of 10 dB as shown in figure below. The characteristic impedances of the quarter-wavelength transmission lines are Z_{h1} = 36 Ω, Z_{h2} = 24.59 Ω and Z_v = 72 Ω. Assume the device is to be implemented in microstrip, with a 0.787 mm substrate thickness, a dielectric constant of 2.33.



Q: Do these results indicate that your designs are correct? Explain why you think so.
Q: Compare these values between the ADS simulation results and HFSS simulation results. Some of these values are close, while some values are quite different. Explain why this is so.
Q: How this coupler is different than the conventional branch-line coupler.

Q5: Design a rat-race directional coupler to provide a coupling of 6 dB. Assume the device is to be implemented in microstrip, with a 0.787 mm substrate thickness, a dielectric constant of 2.33, and that the operating frequency is 1.0 GHz.

Experiment Tasks:

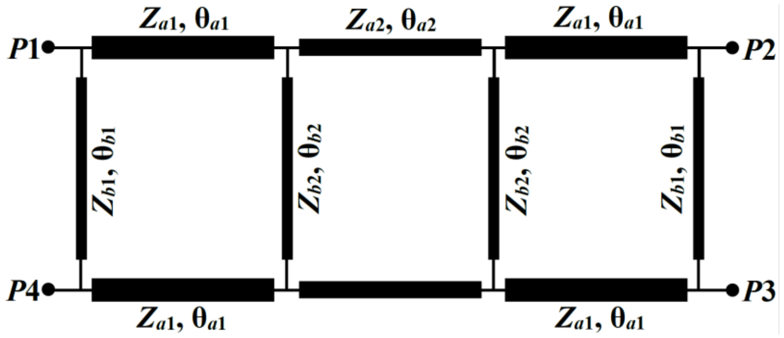
1. Determine design values of the coupler for a 50 Ω system. Show clearly your design steps, and specify all relevant parameters for this design.
2. Implement the Wilkinson power divider in ADS and HFSS. Compare the simulation results.
3. Specify your comments on return loss, isolation, power division and bandwidth for both simulation results.

Q6: Design a single section coupled-line coupler to provide a coupling of 6 dB, 10 dB and 20 dB. Assume the device is to be implemented in microstrip, with a 0.787 mm substrate thickness, a dielectric constant of 2.33, and that the operating frequency is 1.0 GHz.

Experiment Tasks:

1. Determine design values of the coupler for a 50 Ω system. Show clearly your design steps, and specify all relevant parameters for this design.
2. Implement the Wilkinson power divider in ADS and HFSS. Compare the simulation results.
3. Specify your comments on return loss, isolation, power division and bandwidth for both simulation results.

Q7: Design a wide band branch line coupler operating at 2.6 GHz with a coupling level of 10 dB as shown in figure below. The characteristic impedances of the quarter-wavelength ($\theta_{a1} = \theta_{a2} = \theta_{b1} = \theta_{b2} = 90°$) transmission lines are Z_{a1} = 48.6 Ω, Z_{a2} = 48.5 Ω and $Z_{b1} = Z_{b1}$ = 275 Ω. Assume the device is to be implemented in microstrip, with a 0.787 mm substrate thickness, a dielectric constant of 2.33.

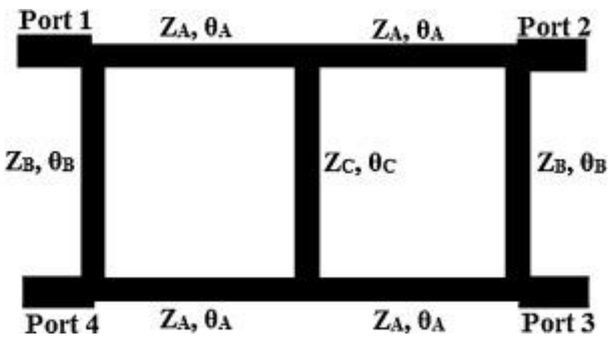


Q: Do these results indicate that your designs are correct? Explain why you think so.

Q: Compare these values between the ADS simulation results and HFSS simulation results. Some of these values are close, while some values are quite different. Explain why this is so.

Q: How this coupler is different than the conventional branch-line coupler.

Q8: Design a wide band branch line coupler operating at 1.5 GHz with a coupling level of 3 dB as shown in figure below. The characteristic impedances of the quarter-wavelength ($\theta_A = \theta_B = \theta_C = 90°$) transmission lines are Z_A = 38 Ω, Z_B = 106 Ω and Z_C = 50 Ω. Assume the device is to be implemented in microstrip, with a 0.787 mm substrate thickness, a dielectric constant of 2.33.



Q: Do these results indicate that your designs are correct? Explain why you think so.

Q: Compare these values between the ADS simulation results and HFSS simulation results. Some of these values are close, while some values are quite different. Explain why this is so.

Q: How this coupler is different than the conventional branch-line coupler.

Q9: Design a stepped-impedance low-pass filter having a maximally flat response and a cut-off frequency of 2.5 GHz. It is desired to have more than 20 dB insertion loss at 4 GHz. The filter impedance is 50 Ω; the highest practical line impedance is 120 Ω, and the lowest is 20 Ω. Consider the effect of losses when this filter is implemented with a microstrip substrate having h = 0.787 mm, εr = 2.33, tan δ = 0.0012, and copper conductors of 0.017 mm thickness.

Q: Determine design values for each of the three designs. Show clearly your design steps, and specify all relevant parameters for each design. Perform the simulation using ADS and HFSS/CST.
Q: Do these results indicate that your designs are correct? Explain why you think so.
Q: From these plots, determine the insertion loss of each filter design at 1, 3, 4 and 7 GHz.
Q: Compare these values between the different filter designs. Some of these values are close to the same for each design, while some values are quite different. Explain why this is so.
Q: For each design, plot S_{11} on a Smith Chart over the same frequencies of 0 to 10 GHz.
Q: For what frequencies is the curve on the Smith chart nearest the center? Explain why this is so.

Q10: Design a low pass filter using microstrip technology based on the following specifications.

Order: **3**

Cut-off Frequency: **8.0 GHz**

Source and Load Impedance: **50 Ω**

Port Impedance: **50 Ω**

Filter Type: Chebyshev (**0.5dB ripple**)

Design this filter using 2 methods:

a) With lumped elements, using two series inductors and one shunt capacitor

b) With shunt stubs (i.e., Richard's Transformation and Kuroda's Identities).

Q: Determine design values for each of the three designs. Show clearly your design steps, and specify all relevant parameters for each design. Perform the simulation using ADS and HFSS/CST.
Q: Do these results indicate that your designs are correct? Explain why you think so.
Q: Compare these values between the different filter designs. Some of these values are close to the same for each design, while some values are quite different. Explain why this is so.
Q: For what frequencies is the curve on the Smith chart nearest the center? Explain why this is so.

Q11: Design a stepped-impedance low-pass filter having a cut-off frequency of 3 GHz and a fifth-order 0.5 dB equal-ripple response. Assume $R_0 = 50\ \Omega$, $Z_l = 15\ \Omega$, and $Z_h = 120\ \Omega$. (a) Find the required electrical lengths of the five sections, and use CAD to plot the insertion loss from 0 to 6 GHz. (b) Lay out the microstrip implementation of the filter on an FR4 substrate having $\varepsilon_r = 4.2$, $h = 1.6$ mm, and $\tan \delta = 0.02$, and with copper conductors 0.035 mm thick. Use ADS and HFSS to plot the insertion loss versus frequency in the passband of the filter.

Q: Determine design values for each of the three designs. Show clearly your design steps, and specify all relevant parameters for each design. Perform the simulation using ADS and HFSS/CST.

Q: Do these results indicate that your designs are correct? Explain why you think so.

Q: Compare these values between the different filter designs. Some of these values are close to the same for each design, while some values are quite different. Explain why this is so.

Q: For what frequencies is the curve on the Smith chart nearest the center? Explain why this is so.