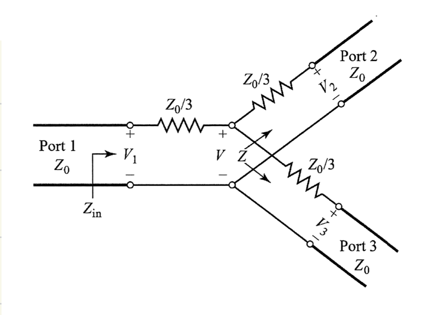
电阻式功率分配器

1. (a) Figure 1 on page 2 shows a resistive power divider circuit with the input at port 1. Determine the voltages and currents at port 1 and port 2 using the figure notations (adding your own labels for the currents and their directions). Then derive S_{21} and all S parameters of the whole 3-port network. Using the S parameters, show that the network is lossy.



Answer: $Z = \frac{Z_0}{3} + Z_0 = \frac{4}{3} Z_0 \qquad \frac{Z}{2} = \frac{2}{3} Z_0$

$$Z_{in} = \frac{Z_0}{3} + \frac{Z}{2} = \frac{Z_0}{3} + \frac{2}{3} Z_0 = Z_0$$

$$V = V_1 \cdot \frac{Z/2}{Z_{in}} = \frac{\frac{2}{3} Z_0}{Z_0} = \frac{2}{3} V_1$$

$$V_2 = V_3 = V \cdot \frac{Z_0}{Z_0 + \frac{1}{3} Z_0} = \frac{3}{4} V = \frac{3}{4} \times \frac{2}{3} V_1 = \frac{1}{2} V_1$$

I_1 is the input current in port 1

$$I_1 = \frac{V_1}{Z_0} \qquad I_2 = I_3 = -\frac{1}{2} I_1 = -\frac{V_1}{2Z_0}$$

$$S_{21} = \frac{b_2}{a_1} = \frac{V_2 - Z_0 I_2}{V_1 + Z_0 I_1} = \frac{\frac{1}{2} V_1 + \frac{1}{2} V_1}{V_1 + V_1} = \frac{1}{2}$$

The three ports are all symmetric, so

$$S_{21} = S_{12} = S_{31} = S_{13} = S_{23} = S_{32} = \frac{1}{2}$$

The input impedance is Z_0, so it is matched. there is no reflect wave.

$$S_{11} = S_{22} = S_{33} = \Gamma_1 = \Gamma_2 = \Gamma_3 = 0$$

$$\therefore S = \begin{pmatrix} 0 & \frac{1}{2} & \frac{1}{2} \\ \frac{1}{2} & 0 & \frac{1}{2} \\ \frac{1}{2} & \frac{1}{2} & 0 \end{pmatrix}$$

(b) Design a capacitively-coupled series resonator filter with third-order maximally flat band-pass response, center frequency of 1.5 GHz, bandwidth 10% and impedance 50 Ω. Using a table, list down the low-pass prototype values, the normalized inverter parameters, the coupling susceptances and capacitances, and the electrical lengths of resonator sections in degrees.

Answer: $N=3$ Butterworth $f_0 = 1.5\text{ GHz}$ bandpass $\Delta = 0.1$ $Z_0 = 50\ \Omega$

3	1.0000	2.0000	1.0000	1.0000

n	g_n	$Z_0 J_n$	J_n	B_n	C_n	θ_n
1	1	0.3963	7.926×10^{-3}	9.4027×10^{-3}	9.9763×10^{-13}	$-24.82°$
2	2	0.1111	2.222×10^{-3}	2.2498×10^{-3}	2.3871×10^{-13}	$-9.54°$
3	1	0.1111	2.222×10^{-3}	2.2498×10^{-3}	2.3871×10^{-13}	$-24.82°$
4	1	0.3963	7.926×10^{-3}	9.4027×10^{-3}	9.9763×10^{-13}	

$$Z_0 J_1 = \sqrt{\frac{\pi\Delta}{2g_0g_1}} \qquad B_n = \frac{J_n}{1-(Z_0J_n)^2}$$

$$Z_0 J_n = \frac{\pi\Delta}{2\sqrt{g_n g_{n-1}}} \qquad C_n = \frac{B_n}{\omega_0}$$

$$Z_0 J_{N+1} = \sqrt{\frac{\pi\Delta}{2g_N g_{N+1}}} \qquad \omega_0 = 2\pi f_0 = 9.425\times10^9$$

$$\theta_n = \pi - \frac{1}{2}[\tan^{-1}(2Z_0B_n) + \tan^{-1}(2Z_0B_{n+1})]$$