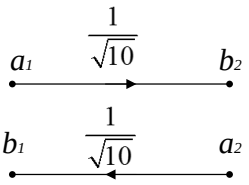
Microwave Review Quiz #3 **solution** 2016.10.25

1. Write down the scattering parameter of a 10dB attenuator circuit and its signal flow graph. The characteristic impedance for port 1 and port 2 is the same given as Z_o. Is it a <u>lossy</u> (lossless or lossy), <u>reciprocal</u> (reciprocal or non-reciprocal), <u>symmetrical</u> (symmetrical or non-symmetrical), and <u>matched</u> (matched or non-matched) circuit?

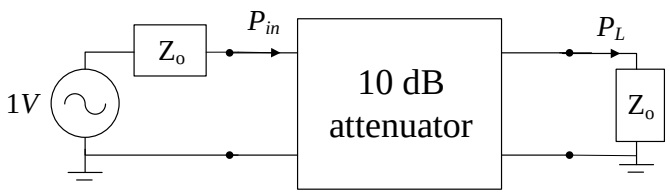
$$S_{11}=0, S_{22}=0 \rightarrow V_1 = V_1^+ + V_1^-(=0), V_2 = V_2^+(=0) + V_2^-$$

$$P_{inc} = \frac{1}{2}\frac{|V_1^+|^2}{Z_o}, P_L = \frac{1}{10}P_{inc} = \frac{1}{10}\frac{1}{2}\frac{|V_1^+|^2}{Z_o} = \frac{1}{2}\frac{|V_2^-|^2}{Z_o} \rightarrow V_2^- = \frac{1}{\sqrt{10}}V_1^+$$



$$\rightarrow S_{21} = \frac{1}{\sqrt{10}} = S_{12} \Rightarrow [S] = \begin{bmatrix} 0 & \frac{1}{\sqrt{10}} \\ \frac{1}{\sqrt{10}} & 0 \end{bmatrix}$$

2. Given this attenuator is connected as shown in the right figure with $Z_o = 50\Omega$. Plot the signal flow diagram, then calculate P_{in} and P_L.

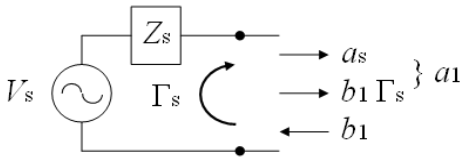


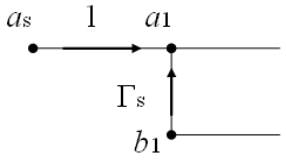
The expression of a_s uses the source representation given in slide (4-36) and the 10dB attenuator uses the result given in question 1.

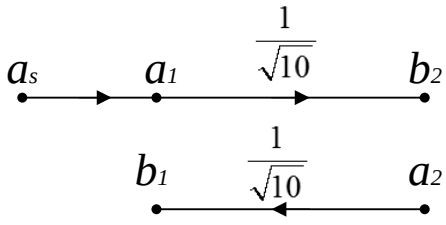
Discussion

1. Source representation

$$e_s = V_s\frac{Z_o}{Z_o+Z_s}, a_s \equiv \frac{e_s}{\sqrt{Z_o}}$$



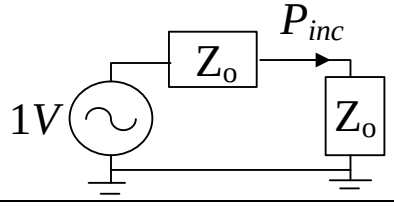




$$a_s = \frac{e_s}{\sqrt{Z_o}} = \frac{1}{\sqrt{Z_o}}V_s\frac{Z_o}{Z_o+Z_s} = \frac{1}{\sqrt{50}}1\frac{1}{2} = \frac{1}{10\sqrt{2}}V$$

$$a_1 = a_s \rightarrow P_{in} = \frac{1}{2}|a_1|^2 = \frac{1}{2}\frac{1}{200} = \frac{1}{400}W = \frac{5}{2}mW = 3.98dBm$$

$$b_2 = \frac{1}{\sqrt{10}}a_1 \rightarrow P_L = \frac{1}{2}|b_2|^2 = \frac{1}{10}\frac{1}{2}|a_1|^2 = \frac{1}{10}P_{in} = \frac{1}{4}mW = -6.02dBm$$



$$P_{inc} = \frac{1}{2}\frac{|V_1^+|^2}{Z_o} = \frac{1}{2}\frac{|V_g/2|^2}{Z_o} = \frac{1}{2}\frac{|1/2|^2}{50} = \frac{1}{400}W = \frac{5}{2}mW = 3.98dBm$$