Menoufia University
Faculty of Electronic Engineering
Electronics and Electrical Communications Eng. Dept.
Third Year – Spring 2018

ECE 323 - Microwave Engineering
Problem Set #6

S-Parameters

[P1] **4.11 -** Find the scattering parameters for the series and shunt loads shown in **Fig. P1**. Show that $S_{12} = 1 - S_{11}$ for the series case, and that $S_{12} = 1 + S_{11}$ for the shunt case. Assume a characteristic impedance Z_0.

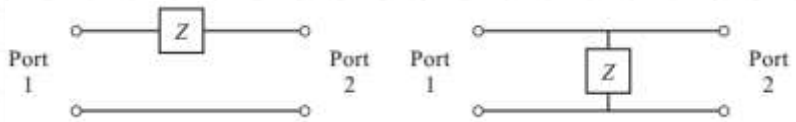

Fig. P1: Circuit for Problem P1.

[P2] **4.12 -** Consider two two-port networks with individual scattering matrices $[S^A]$ and $[S^B]$. Show that the overall S_{21} parameter of the cascade of these networks is given by

$$S_{21} = \frac{S_{21}^A S_{21}^B}{1 - S_{22}^A S_{11}^B}$$

[P3] **4.13 -** Consider a lossless two-port network. (a) If the network is reciprocal, show that $|S_{21}|^2 = 1 - |S_{11}|^2$. (b) If the network is nonreciprocal, show that it is impossible to have unidirectional transmission, where $S_{12} = 0$ and $S_{21} \neq 0$.

[P4] **4.14 -** A four-port network has the scattering matrix shown as follows. (a) Is this network lossless? (b) Is this network reciprocal? (c) What is the return loss at port 1 when all other ports are terminated with matched loads? (d) What is the insertion loss and phase delay between ports 2 and 4 when all other ports are terminated with matched loads? (e) What is the reflection coefficient seen at port 1 if a short circuit is placed at the terminal plane of port 3 and all other ports are terminated with matched loads?

$$[S] = \begin{bmatrix} 0.178\angle 90^\circ & 0.6\angle 45^\circ & 0.4\angle 45^\circ & 0 \\ 0.6\angle 45^\circ & 0 & 0 & 0.3\angle -45^\circ \\ 0.4\angle 45^\circ & 0 & 0 & 0.5\angle -45^\circ \\ 0 & 0.3\angle -45^\circ & 0.5\angle -45^\circ & 0 \end{bmatrix}.$$

[P5] Find the generalized S-parameters of a step in impedance (junction between the two lines) from a line that has a characteristic impedance $Z_1 = 50\ \Omega$ to a line that has a characteristic impedance $Z_2 = 75\ \Omega$ (both lines are semi-infinite). Find the reflected-to-incident power ratio. Find the transmitted-to-incident power ratio.

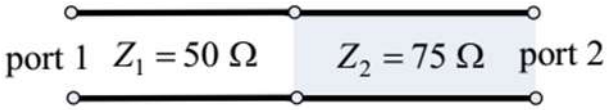

Fig. P5: Circuit for Problem P5.