Signal Integrity and High-Speed Interconnects
Assignment 2

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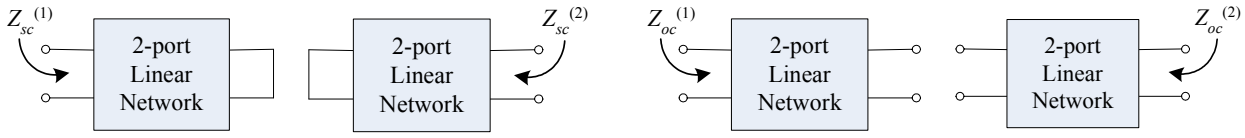
Dr. J. E. Rayas Sánchez

Problem 1

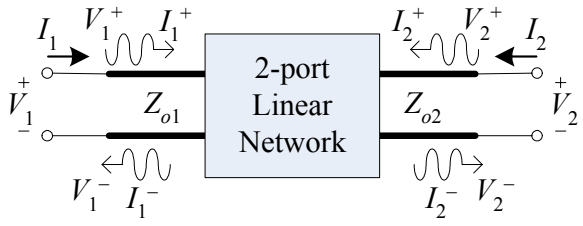
One way of indirectly measuring the Z parameters of a two-port network is by directly measuring the following four input impedances: $Z_{sc}^{(1)}$, $Z_{sc}^{(2)}$, $Z_{oc}^{(1)}$, and $Z_{oc}^{(2)}$, as illustrated below:



Assuming that the network is reciprocal, derive formulas to calculate Z_{11}, Z_{12}, Z_{22}, and Z_{21}, in terms of the four previous input impedances.

Problem 2

The two-port network shown below is driven at both ports such that the port voltages and currents have the following values (measured with respect to a reference impedance of 50Ω):



$V_1 = 1.5^{\angle 0^\circ}$ V

$V_2 = 0.5^{\angle -90^\circ}$ V

$I_1 = 3^{\angle 90^\circ}$ mA

$I_2 = 2^{\angle 0^\circ}$ mA

Calculate the input impedance at each port (Z_{in1} and Z_{in2}), and the incident and reflected voltage waves at each port (V_1^+, V_1^-, V_2^+, and V_2^-).

Problem 3

A four-port network has the S parameters shown below (measured at a given operating frequency).

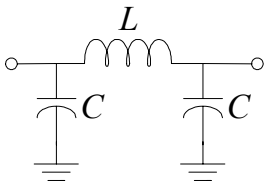
$$\boldsymbol{S} = \begin{bmatrix} 0.15^{\angle 80^\circ} & 0.9^{\angle 45^\circ} & 0.2^{\angle -45^\circ} & 0 \\ 0.9^{\angle 45^\circ} & 0 & 0 & 0.35^{\angle 60^\circ} \\ 0.2^{\angle -45^\circ} & 0 & 0 & 0.75^{\angle -35^\circ} \\ 0 & 0.35^{\angle 60^\circ} & 0.75^{\angle -35^\circ} & 0 \end{bmatrix}$$

a) Is the network reciprocal?; b) Is the network lossless?; 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 (in degrees) between port 2 and 4, when all other ports are terminated with matched loads?; e) What is the return loss at port 1 if port 3 is terminated with a short circuit and all other ports are terminated with matched loads?

Problem 4

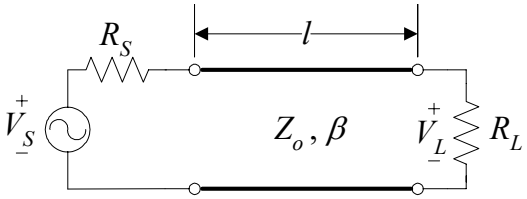
For the following lumped circuit (third order low-pass filter), derive a formula to calculate S_{21} with respect to a reference impedance Z_o =50Ω.



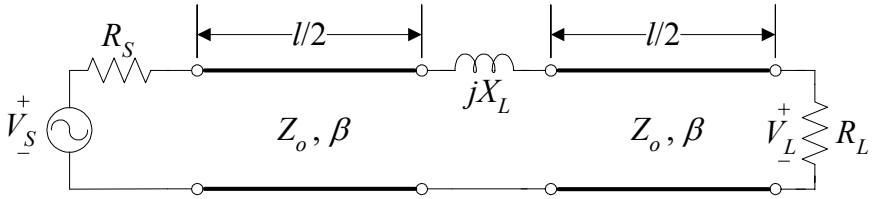
Using L = 1.65nH and C = 1.1791 pF, plot $|S_{21}|$ versus frequency, from 0.1GHz to 15GHz (use Matlab or any other similar program). Compare your plot with that one obtained by simulating the circuit using APLAC.

Problem 5

Using ABCD parameters, calculate the voltage at the load of the following circuit (assume $V_S = 1.5\text{V}\angle 0^o$, $R_S = 30\Omega$, $Z_o = 50\Omega$, $R_L = 70\Omega$, and $l = \lambda/6$).



The previous transmission line is divided in two by an inductive transition (for instance, this inductance could represent a simplified model of a via), with $X_L = 20\Omega$, as follows:



Using again ABCD parameters, re-calculate the voltage at the load.

Submission deadline: Thursday April 27, 2006