ECE 671 – Assignment #1

Q1. Consider the circuit shown in Figure 1. The S-parameters of the two-port network measured in 50Ω system are as follows,

$$[S] = \begin{bmatrix} 0.10\measuredangle -30^\circ & 0.40\measuredangle -75^\circ \\ 0.95\measuredangle -45^\circ & 0.15\measuredangle -10^\circ \end{bmatrix},$$

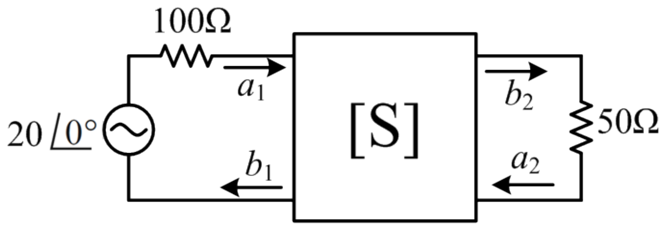

Figure 1

a) Calculate the power available from the source.

b) Calculate normalized waves a_1, b_1, a_2, and b_2.

c) Find the power delivered to the load and the power reflected to the source.

Q2. Consider matching a load $Z_L = 100\Omega$ to a 50Ω line, using single open-circuited shunt-stub, LC network, and double shunt-stub tuners, with open-circuited stubs. Which tuner will give the best bandwidth? Justify your answer using CAD to plot the reflection coefficient versus frequency ($0.5f_o$ to $1.5f_o$).

Q3. In practice, lumped elements have finite Q-factor which induce loss in the circuit. Assume we want to implement a real-to-real L-section matching network shown in Figure 2 using inductor and capacitor with finite Q-factor. Find an approximate equation for the associated loss in the matching network as a function of the transformation ratio (R_L/R_S) and show the loss increases as the transformation ratio increases (assume the components' Q-factor>>1). Calculate the insertion loss of the matching network assuming maximum achievable Q-factor for the inductor and capacitor are 15 and 30 respectively and matching network is designed to match 10Ω to 50Ω at 3GHz. Compare your answer with the exact insertion loss value obtained from a circuit simulator.

Hint: Use eqn's 5.3(a) and (b) in Pozar to find L and C and assume a series R-L and a shunt R-C in Figure 2 to represent non-ideal inductors and capacitors, respectively.

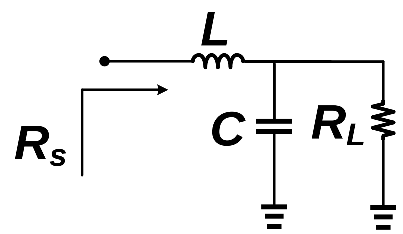

Figure 2 – L-section matching network

Q4. A four-port network has the scattering matrix shown as follows. If ports 3 and 4 are connected with a lossless matched transmission line with an electrical length of 45◦, find the resulting insertion loss and phase delay between ports 1 and 2.

$$[S] = \begin{bmatrix} 0.2\angle 50^\circ & 0 & 0 & 0.4\angle -45^\circ \\ 0 & 0.6\angle 45^\circ & 0.7\angle -45^\circ & 0 \\ 0 & 0.7\angle -45^\circ & 0.6\angle 45^\circ & 0 \\ 0.4\angle -45^\circ & 0 & 0 & 0.5\angle 45^\circ \end{bmatrix}.$$

Q5. In the figure below we have an emitter degenerated common emitter BJT amplifier. Assuming the S-parameters of the BJT transistor (without the inductor in emitter) is known, we aim to find the overall S-parameters of the circuit.

a) Show how the S-parameter of the degenerated common emitter amplifier can be calculated using the inductor value L, and the S-parameters of the transistor.
b) Calculate the S-parameters of the degenerated common emitter at $10GHz$ assuming the common emitter S-parameters of BJT is given as,

$$S = \begin{bmatrix} 0.73\measuredangle -126^\circ & 0 \\ 1.73\measuredangle -73^\circ & 0.75\measuredangle -52^\circ \end{bmatrix},$$
$$L = 0.1nH.$$

The S-parameter values are normalized to 50 Ohms.

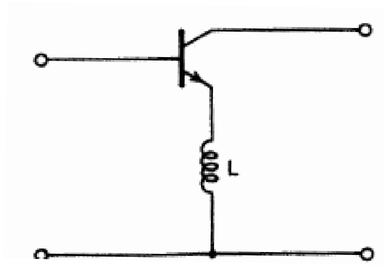

Figure 3 – An emitter degenerated BJT

Q6. Derive the S-parameters of the network shown in Figure 4 (in 50Ω impedance system).

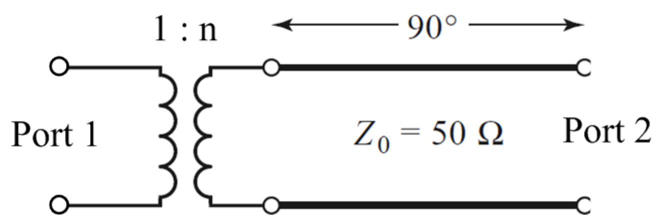

Figure 4