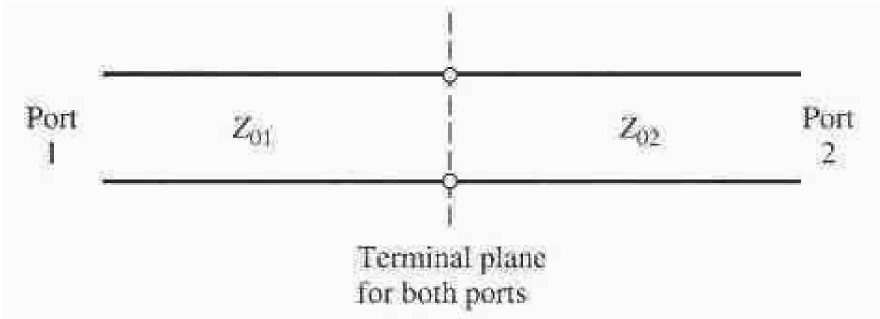
Sheet 4

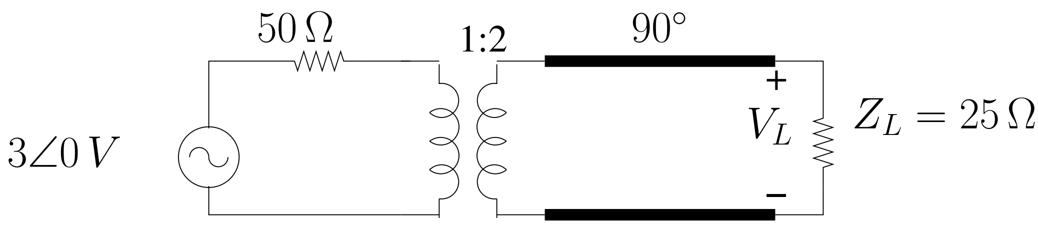
Question (1)

Consider a two-port network consisting of a junction of two transmission lines with characteristics impedances Z_{01} and Z_{02}, as shown in the below. Find the generalized scattering parameters of this network.



Question (2)

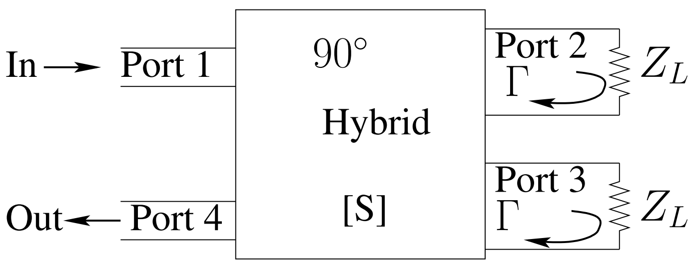
Use the ABCD matrices to find the voltage V_L across the load resistor in the circuit shown below.



Question (3)

The four-port 90° hybrid coupler has the following scattering matrix,

$$[S] = \frac{-1}{\sqrt{2}} \begin{bmatrix} 0 & j & 1 & 0 \\ j & 0 & 0 & 1 \\ 1 & 0 & 0 & j \\ 0 & 1 & j & 0 \end{bmatrix}.$$



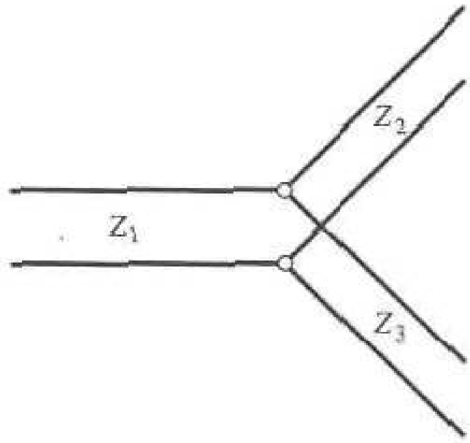
If ports 2 and 3 are terminated with equal adjustable loads Z_L as shown in the figure.

(a) Find the scattering matrix for the resulting two-port network (between port 1 and 4).

(b) Show that the resulting 2-port network represents an attenuator, and plot the attenuation as a function of Z_L/Z_0, for $0 \leq Z_L/Z_0 \leq 10$ (Let Z_L be real).

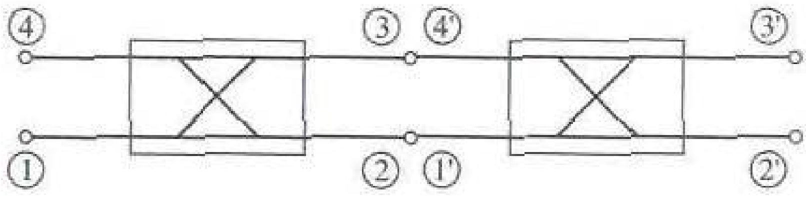
Question (4)

Consider the T-junction of three lines with characteristic impedances Z_1, Z_2, and Z_3, as shown below. Demonstrate the it is impossible for all three lines to be matched, when looking toward the junction.



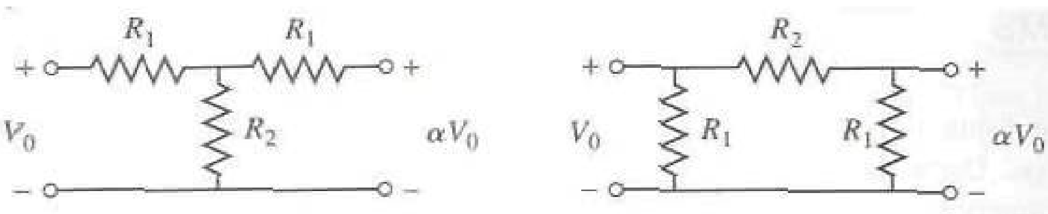
Question (5)

Two identical 90° coupler with C=8.34 dB are connected as shown below. Find the resulting phase and amplitudes at ports 2' and 3', relative to port 1.



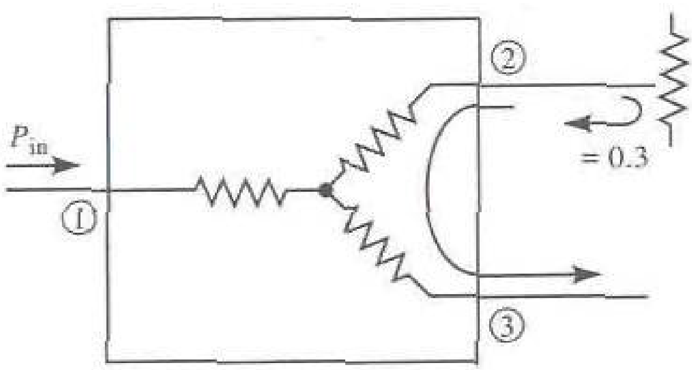
Question (6)

Consider the T and Π resistive attenuator circuits shown below. If the input and the output are matched to Z_0, and the ratio of output voltage to input voltage is α, derive the design equations for R_1 and R_2 for each circuit. If $Z_0 = 50\,\Omega$, compute R_1 and R_2 for 3 dB, 10 dB, and 20 dB attenuators of each type.



Question (7)

Design a three-port resistive divider for an equal power split and a $100\,\Omega$ system impedance. If port 3 is matched, calculate the change in the output power at port 3 (in dB) when port 2 is connected first to a matched load, and then to a load having mismatch of $\Gamma = 0.3$.



Question (8)

Consider the general branch-line coupler shown below, having shunt arm characteristic impedances Z_a, and series arm impedance Z_b. Using an even-odd mode analysis, derive design equations for a quadrature hybrid coupler with arbitrary power division ration $\alpha = P_2/P_3$, and with the input port (port 1) matched. Assume all arms are $\lambda/4$ long. Is port 4 isolated in general.