Set #2

Due Tuesday February 18 25, 1997

Homework format:

- Write only on one side of the paper.
- Please try if possible to start each new problem on a clean sheet of paper.

Problems:

1. A 50 ohm transmission line is matched to a 10 W source, feeds a load \( Z_L = 100 \) ohms. If the line is \( 2.3\lambda \) long and has an attenuation constant of \( \alpha = 0.5 \) dB/\( \lambda \), find the power that is delivered by the source, lost in the line, and delivered to the load.

2. (Collin 4.20) For the circuit shown below find the scattering parameters.

   \[ Z_o = 50 \Omega \]

   \[ jX_1 \quad jX_2 \quad Z_o = 50 \Omega \]

   When \( jX_1 = j25 \), \( jX_2 = j100 \) verify that

   \[ |S_{11}|^2 + |S_{12}|^2 = 1, S_{11}S_{12}^* + S_{12}S_{22}^* = 0 \]

3. Verify the \( S \)- to \( T \)-parameter and \( T \)- to \( S \)-parameter conversions given in the notes on pages 51–52 of the notes, Chapter 2.

4. Consider individual scattering matrices, \([S^A]\) and \([S^B]\). Show that the overall \( S_{21} \) parameter of the cascade of these two networks is given by

   \[ S_{21} = \frac{S_{21}^AS_{21}^B}{1 - S_{22}^AS_{11}^B} \]

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

6. Two types of ell section matching networks are shown below. Select the one that
can match the load \( Y_L = (8 - j12) \times 10^{-3} \) S to a 50 ohm transmission line. Find the element values at \( f = 1 \) GHz.

### 7. Design matching networks, (a) and (b) shown below to match a 50 ohm load to the impedance \( Z_{IN} = 25 - j25 \Omega \).

- **A**
  - \( Z_o = 50 \Omega \)
  - \( Z_o = ? \)
  - \( Z_{IN} = 25 - j25 \Omega \)

- **B**
  - \( Z_o = ? \)
  - \( Z_{IN} = 25 - j25 \Omega \)

### 8. (Collin 5.18) For the matching circuit shown below, show that the required values of \( j\bar{X}_1 \) and \( j\bar{B}_2 \) are given by

\[
j\bar{X}_1 = j(-\bar{X}_L \pm \sqrt{\bar{R}_L(1 - \bar{R}_L)})
\]
\[
j\bar{B}_2 = \pm j \frac{1 - \bar{R}_L}{\sqrt{\bar{R}_L}}
\]

### 9. Consider a series \( RL \) load with \( R = 80 \Omega \) and \( L = 5 \) nH. Design a lumped element \( L \) section matching network to match this load to a 50 ohm line at \( f = 2 \) GHz. Plot \(|\Gamma|\) versus frequency for this network to determine the bandwidth for which \(|\Gamma| \leq \Gamma_m = 0.1\). Compare this with the maximum possible bandwidth for this load, as given by the Bode-Fano criteria. Assume a square reflection coefficient response as shown below. Consider using Puff for the required plot of \(|\Gamma|\).