Problems: Exam is 10% of final grade

50 pts. 1.) Bandstop Filter Design Investigation

Design an \( n = 3 \) bandstop filter with \( \varepsilon_{\text{dB}} = 1 \) dB and 40% fractional bandwidth centered on 1 GHz.

a.) Determine the \( g_i \) values for a Chebyshev normalized lowpass filter.

b.) Transform the lowpass prototype in part (a) into an lumped element bandstop filter with \( Z_o = 50 \) ohms. Note here \( f_o = \sqrt{f_1 f_2} \) and \( 0.4 = (f_2 - f_1)/f_o \). Verify the design by simulating the circuit using Puff or Touchstone.

c.) Find a distributed element realization that uses \( \lambda_o/4 \) open-circuited stubs interconnected with \( \lambda_o/4 \) lines. Note here \( f_o = (f_1 + f_2)/2 \). By using Richard’s transformation and applying Kuroda’s identities the desired filter topology can be synthesized. The design equations for \( n = 3 \), as given in Matthaei\(^1\) are as follows:

\[
\begin{align*}
    z_1 &= z_A \left( 1 + \frac{1}{\Lambda g_0 g_1} \right),
    z_2 &= \frac{z_A g_0}{\Lambda g_2},
    z_3 &= \frac{z_A g_0}{g_4} \left( 1 + \frac{1}{\Lambda g_3 g_4} \right),
    z_{12} &= z_A \left( 1 + \Lambda g_0 g_1 \right),
    z_{23} &= \frac{z_A g_0}{g_4} (1 + \Lambda g_3 g_4),
    z_B &= \frac{z_A g_0}{g_4}
\end{align*}
\]

where for a lumped element prototype with \( \omega_c = 1 \) rad/s

\(^1\) G. Matthaei, L. Young, E.M.T.
2. Narrowband Amplifier Design

Design a narrowband amplifier with center frequency at 1.5 GHz using a Motorola MRF942 bipolar transistor (see the attached data sheets). Assume $V_{ce} = 6$ v and $I_c = 15$ ma.

a.) Determine the device stability at 1.5 GHz and also plot the input ($\Gamma_i$) and output ($\Gamma_L$) stability circles, even if they lie outside the unit radius Smith chart.

b.) Calculate the unilateral figure-of-merit at 1.5 GHz.

c.) For design purposes assume that the device is unilateral. Design the amplifier to have $G_{TU, max}$ using matching network topologies of your choice.

d.) Obtain swept frequency measurements of the amplifier using Puff or Touchstone. The $S$-parameter data is available in Touchstone format (MRF942D.S2P).

e.) In your final design estimate the bandwidth of the amplifier in terms of: (i) 3 dB gain bandwidth, (ii) Input/output 10 dB return loss bandwidth.

f.) Under what passive load and source termination (external to the amplifier, matching circuits included), if any, will the amplifier become unstable at 1.5 GHz?

Tools Supplied on Disk

To make things a bit easier I have included a 3.5” disk which has the MRF942D.S2P file and a parsed version for MATLAB, MRF942D.TXT. The MATLAB m-files described in the handout Narrowband Amplifier Design Essentials are also included.