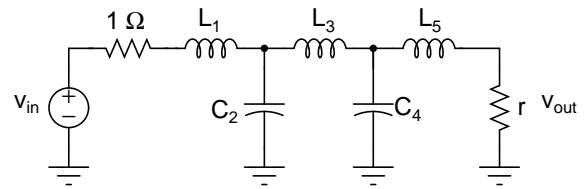# ACTIVE FILTER DESIGN : PROBLEM SET 2

1   Problem 1

Write a MATLAB program to synthesize the equally terminated LC ladder network for the following : any order Butterworth & odd order Chebyshev filters, with a specified (arbitrary) ripple. You can use in-built MATLAB routines to find the transfer functions. Use your code to find the element values for a 9th order Butterworth and 9th order Chebyshev filter with 1 dB passband ripple.

2   Problem 2

A fifth order Inverse Chebyshev lowpass filter is to be realized as a doubly terminated LC ladder. The termination resistance is $1\,\Omega$. The stopband edge is $1\,\mathrm{rad\,s^{-1}}$. The maximum transmission in the stopband must be $50\,\mathrm{dB}$ below the transmission at DC. You may find it less tedious to write a MATLAB script to perform the whole calculation. For parts (a) and (b) use the entire precision offered by your computer. For part (c), first run through the calculations with full precision. Then redo with all coefficients of truncated to 3 decimal places at every stage. Comment on the results.

a. Find the transfer function. Use the inbuilt MATLAB function for this).

b. Find the reflection coefficient $\Gamma(s)$.

c. Calculate the elements values for the ladder network. Assume that transmission zeroes are realized using series resonant networks in the shunt arms of the ladder. The smaller transmission zero must be extracted first. Simulate the frequency response of the resulting LC ladder in SPICE to make sure that your network is indeed what you want. Show all calculations in your solution in a clear and systematic manner.

3   Problem 3

The aim of this excercise is to demonstrate, using Monte-Carlo simulation, that a equally terminated ladder has very low passband magnitude sensitivity. Figure 1 shows a fifth order 1 dB ripple Chebyshev ladder filter. Below are the component values for two different terminations (r=1 & r=3).

r = 1
$L_1 = 2.1349$ $C_2 = 1.0911$ $L_3 = 3.0009$
$L_5 = 2.1349$ $C_4 = 1.0911$

r = 3
$L_1 = 5.3830$ $C_2 = 0.4915$ $L_3 = 6.6673$
$L_5 = 3.9944$ $C_4 = 0.4622$

Figure 1: LC component values for Problem 1.

a. Write a MATLAB script to evaluate the frequency response of the ladder filter. **One way to this easily** is by the following method (at every frequency point). (Feel free to try out an alternate method if you like) -

  • Recall that the ABCD matrices of a series element of impedance Z & a shunt element with admittance Y are as shown in Figure 2.
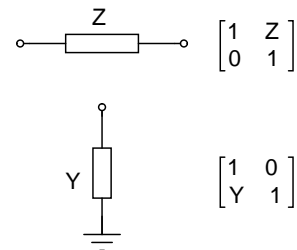

Figure 2: ABCD matrices of elementary sections.

  • Evaluate the ABCD matrix of the entire network between v_{in} & v_{out} as a product of the ABCD matrices of elementary sections.
  • Use the above matrix to find the frequency response.

b. Assume that the L's and the C's have 5% tolerances, that is - they are Gaussian random variables, with mean values shown in Figure 1 and a standard deviation of 5%. Run 100 trails and plot (on the same plot, with x-axis running from 0 to 1 rad/s and the y-axis in dB) the passband frequency responses obtained for the cases r=1 & r=3. To enable comparision, have the same range for the y-axis for both cases. What do you notice ? Why ?