ACTIVE FILTER DESIGN : PROBLEM SET 3

Problem 1

A third order Chebyshev lowpass filter is to be used as the prototype for 6th order bandpass filter. In the passband of the BPF, which is defined by $10\,\text{MHz} < \text{f} < 11\,\text{MHz}$, a ripple of $0.5\,\text{dB}$ is desired. The terminating resistors for the bandpass filter must be $50\,\Omega$.

a. Find the element values for the lowpass prototype, choosing the ladder topology that minimizes the number of inductors used.

b. Find the element values of the bandpass network.

c. Simulate the bandpass filter in SPICE. Plot the magnitude and group delay responses. What do you notice ?

Problem 2

In this excercise, we use Richard's Transformation to design a microwave "lowpass" filter, with a bandedge of $1\,\text{GHz}$. The spectrum must repeat with a period of $5\,\text{GHz}$. Scale the 3^{rd} order Chebyshev LC ladder from Problem 2 to have a bandedge of $1\,\text{GHz}$. Use this as your "lowpass" prototype.

a. Find the characteristic impedances and time delays of the transmission lines required to realize the filter.

b. Simulate the frequency responses of the filters in SPICE. Plot the magnitude response of the lowpass prototype. The x-axis of the graph must range from $0-10\,\text{GHz}$. On the same plot, show the (periodic) response of the microwave filter. Which has a sharper transition ? Why ?

c. Plot the unit step responses of both filters on the same graph. The time axis must range from $0-4\,\text{ns}$. What do you observe ?

Problem 3 : Sensitivity Relations

Consider a filter with a transfer function $H(f)$ built using resistors, capacitors and voltage amplifiers. Further, let $H_{ik}(f)$ be the voltage transfer function from v_i to v_k, the voltage developed across the resistor R_k. Let $H_{ko}(f)$ be the transfer function from the voltage source v_k inserted in series with the resistor to the filter output as shown in Figure 1.

a. Show that $H_{ik}(f)H_{ko}(f) = H(f)\,S_{R_k}^{H(f)}$. This is called Bykhovski's sensitivity relation.

b. Show that $\sum_j S_{C_j}^{H(f)} = \sum_k S_{R_k}^{H(f)} = fH'(f)/H(f)$.

c. Using the results in parts (a) & (b) above, show that $\sum_k H_{ik}(f)H_{ko}(f) = fH'(f)$.

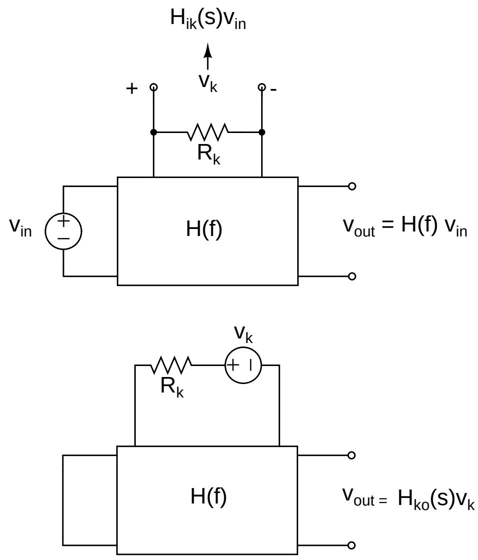

Figure 1: Definitions of $H(f)$, $H_{ik}(f)$ and $H_{ko}(f)$.