Homework Set 8  
EE 5348  
Monday April 5, 2010

1. Design a Chebyshev 50:50 Ω filter with a passband ripple of 0.1 dB from 2.0 GHz to 3.0 GHz. The attenuation should be -15 dB at $f < 1 \text{ GHz}$ and $f > 4.0 \text{ GHz}$. Determine the actual filter attenuation from 1.0 GHz to 4.0 GHz using Spice or ADS to plot the insertion loss. Note the similarity of these specifications with those required in the project.

2. Design a 3 pole Chebyshev bandpass filter with a 0.1 dB passband ripple from 2.0 GHz to 3.0 GHz where now the filter operates between a 50 Ω source impedance and a 75 Ω load impedance. Plot the result of your design using either Spice or ADS.

3. Design a 3 pole low-pass Butterworth filter when $R_G = 50 \Omega$ and $R_L = 85 \Omega$ with a cut off frequency of 2.0 GHz. Use the Darlington synthesis procedure to determine the circuit. Why will not the Butterworth recursion formulas work in this case?

Note that the equation (5.23) should be:

$$n = \frac{\arccosh \left[ \frac{1}{\epsilon} \left( 10^{\alpha_{min}/10} - 1 \right)^{1/2} \right]}{\arccosh(\omega_s/\omega_c)}$$

The following may help explain the use of (5.23). The ratio of the stopband to cutoff frequency is

$$F_c = f_s/f_c$$

The relationship between the normalized low-pass prototype circuit and the band-pass circuit is given by (5.69). This needs to be solved for the equivalent $f_s/f_c$ in the band-pass case.

$$f_n = \frac{1}{w} \left( \frac{f}{f_0} - \frac{f_0}{f} \right)$$

$$w f_0 f_n = f^2 - f_0^2$$

$$0 = f^2 - f(f_0 f_n w) - f_0^2$$

$$f = \frac{f_0 f_n w \pm \sqrt{(f_0 f_n w)^2 + 4 f_0^2}}{2}$$

$$f = \frac{f_0}{2} \left[ f_n w + \sqrt{(f_n w)^2 + 4} \right]$$

The frequency on the left hand side is the frequency variable corresponding to the band-pass circuit while $f_n$ corresponds to the low-pass prototype circuit. The cut off frequency for the low-pass prototype circuit is 1 rad/sec, and this corresponds to the edge of the pass band, $f_2$, for the band-pass circuit. The low-pass prototype stop band frequency is
$f_s = f_c \cdot F_c$. The corresponding stop band to cut off frequency for the band-pass circuit is given below. The low-pass prototype stop band frequency is $f_s = F_c \cdot (1/2\pi)$ since the lowpass prototype cutoff radian frequency is 1 rad/sec. For the bandpass circuit the stop band to upper cutoff frequency is analogous to $F_c$ for the lowpass circuit, but now with the transformed frequency...

$$F_{c, bp} = \frac{f_{s, bp}}{f_2} = \frac{w \frac{F_c}{2\pi} + \sqrt{w^2(\frac{F_c}{2\pi})^2 + 4}}{w \frac{1}{2\pi} + \sqrt{w^2(\frac{1}{2\pi})^2 + 4}}$$