DUE MONDAY APRIL 6

QUOTE: Let each person pass their days in that wherein the skill is greatest. –Sextus Propertius

57-58. Work in MATLAB to the extent possible. A HP filter has specs Amax = 1 dB, Amin = 35 dB, fs = 800 Hz, and fp = 4000 Hz. The minimum Butterworth filter order is 3.

(a) Determine the equivalent NLP specs.

(b) Verify that the minimum order Butterworth fitler is 3.

(c) Compute the 3rd order 3dB NLP Butterworth transfer function and write it as the product of two transfer functions, one of which has a second order denominator and the other a first order denominator, i.e., $H_{3dBNLP}(s) = H_{2ndOrder}(s)H_{1storder}(s)$.

(d) Compute the NLP transfer function by frequency scaling using $K_f = \Omega_c$ as defined in class:

$$H_{NLP}(s) = H_{2NLP}(s)H_{1NLP}(s) = H_{2ndOrder}\left(\frac{s}{\Omega_c}\right)H_{1storder}\left(\frac{s}{\Omega_c}\right)$$

(e) Compute the NHP transfer function

$$H_{NHP}(s) = H_{2NHP}(s)H_{1NHP}(s) = H_{2NLP}\left(\frac{1}{s}\right)H_{1NLP}\left(\frac{1}{s}\right)$$

and provide a frequency response plot of $H_{NHP}(s)$ for $0 \le \omega \le 4$ rad/s. Does it exhibit a NHP characteristic?

(f) Realize $H_{2NHP}(s)$ using the controllable canonical or observable canonical biquad circuit developed in class under two constraints:

(i) all op amps are to have the non-inverting (+) terminal grounded and

(ii) you are to minimize the total number of op amps. (This actually allows the opportunity to think creatively. ☺ Usually a biquad can be done in 4 op amps.)

(g) Next realize $H_{1HP}(s)$ using a leaky integrator circuit in which the capacitor is changed to a resistor R_{leaky} and the two resistors are changed to capacitors of C_{1leaky} and C_{2leaky} respectively. Verify that the new transfer function is $H_{leaky} = \frac{C_{1leaky}s}{???+G_{leaky}}$. Clearly draw the new circuit and label each element.

(h) Set $K_f = \omega_p$. Compute K_m so that the 1 F capacitors in the biquad realizations become 5 nF capacitors in a final circuit after frequency and magnitude scaling. Do the same for the modified leaky integrator circuit. With these values of K_f and K_m, compute final values for each circuit element in your design. Clearly list these values. Clearly draw and clearly label the circuit in your final design. (Suggestion: use an excel spread sheet to compute and specify values.)

(i) If the input source had a source resistance of 100 Ω, how would this affect the input resistor to your design.

(j) Obtain a SPICE simulation frequency response of your op amp circuit. Choose an op amp model from the library. Do not use the ideal op amp default.

59-60. Again work in MATLAB to the extent possible. Your boss, at Working Biquads Inc., has told you to realize a 2nd order BP circuit using one of the company's favorite circuit's, the one taught to you in your ECE 202 Class. Your boss has a customer who wants to capture the secret intelligence associated with an ECE 201 exam that is being broadcast over an unsecure ITAP channel (what's new) in the near future. The channel (center) frequency is exactly 40 kHz and has a 3 dB bandwidth of 10 kHz. The gain at the channel center frequency is precisely 10. Having lost ALL of your 202 BP notes, you ask the TA to determine that the needed BP transfer function is:

$$H_{BP}(s) = \frac{ks}{s^2 + B_\omega s + \omega_m^2}$$

Task 1: Determine k, B_ω, ω_m.

Having remembered something from class about not designing directly but rather first designing a normalized transfer function, you creatively realize that you first compute

$$H_{NBP}(s) = H_{BP}(\omega_m s) = \frac{?\,s}{s^2 + ?\,s + 1}$$

Task 2: Determine the numerical values of the two question marks in the above transfer function.
Task 3: Realize $H_{NBP}(s)$ using the company's favorite biquad circuit under two constraints: (i) all op amps are to have the non-inverting (+) terminal grounded and (ii) you are to minimize the total number of op amps. (This actually allows the opportunity to think creatively. ☺).
Task 4: The 1 F capacitors in your design are to be 1 nF in your final design. Find K_m.
Task 5: Compute new resistor and capacitor values for your final design. Carefully draw and label your final biquad realization of $H_{BP}(s)$.
Task 6. Replace each ideal resistor value in your final design by the closest available manufacturer's value with a tolerance of $\pm 5\%$ to save nickels. No series and/or parallel combinations of resistors allowed. Only single resistors. Such values are available on the internet.
Task 7. Obtain a spice simulation of the frequency response of your realization using these non-ideal available values form Task 6. (Choose an op amp model from the available library.) How good is your design.?