Name_____

Rose-Hulman Institute of Technology
Electrical and Computer Engineering

EC 300 - Exam No. 2 Thursday, January 23, 1996

CLOSED BOOK. Work each problem in the space provided on its sheet. Be sure the work you present is clear so the grader can understand what you have done. One 3" x 5" card and a calculator/computer are allowed. No other aids, animate or inanimate, are permitted. All problems have the same weight. Please do your own work. State answers in engineering form. **Box your answer, please, and don't forget units!**

Problem 1 – You have been asked to design a low-pass filter with a 0 dB gain in the passband, a -3dB passband edge at 1 MHz and no more that -50 dB gain at the stopband of 4 MHz.

A. Sketch the frequency response, *H(f)*, of the desired filter.

B. If you choose Butterworth, what minimum order should the filter be? How did you get your answer?

C. If you choose Chebyshev, what minimum order should the filter be? How did you get your answer?

D. Suppose the spec has changed to require no more the -100 dB in the stopband. What order Butterworth do you need? How did you get your answer?

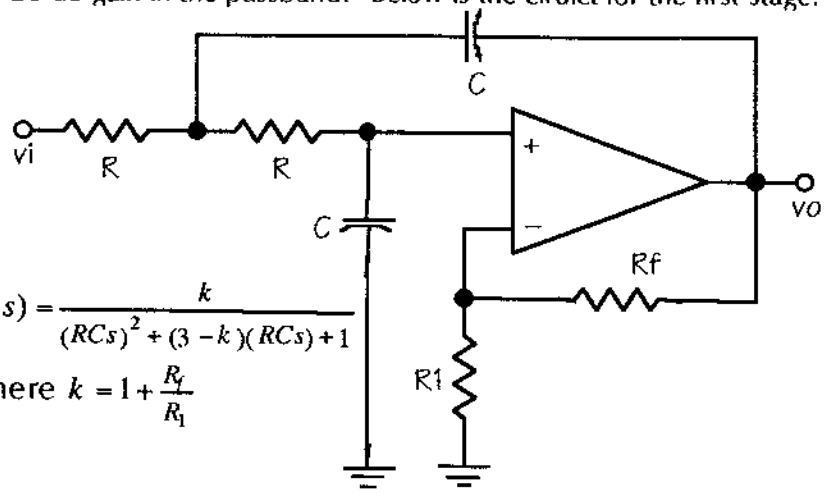
E. Suppose the spec has changed to require -0.3 dB gain at the passband edge and no more the -50 dB in the stopband. What order Butterworth do you need? How did you get your answer?

Problem 2 – After further analysis it has been decided that you are to design a 3rd-order, passive, low-pass, Butterworth filter with a -3dB passband edge frequency of 1 MHz and a passband gain of -50 dB. Your circuit will be driven through 50 Ω and will drive 50 Ω.

Draw the prototype circuit for your filter.

Draw the final circuit for your filter.

Problem 3 – Design a 3rd-order, Chebyshev, active, low-pass filter with a 3dB cutoff frequency of 1 Mhz and a 20 dB gain in the passband. Below is the ciruict for the first stage.



$$H(s) = \frac{k}{(RCs)^2 + (3-k)(RCs) + 1}$$

where $k = 1 + \frac{R_f}{R_1}$

Use R = 1kΩ. Find C, R_f, and R_1 for the **first** stage.

C =
R_1 =
R_f =

Add the **second** stage of the filter to the digram above. Assuming R=1kΩ for the second stage, Find C, R_f, and R_1 for the second stage.

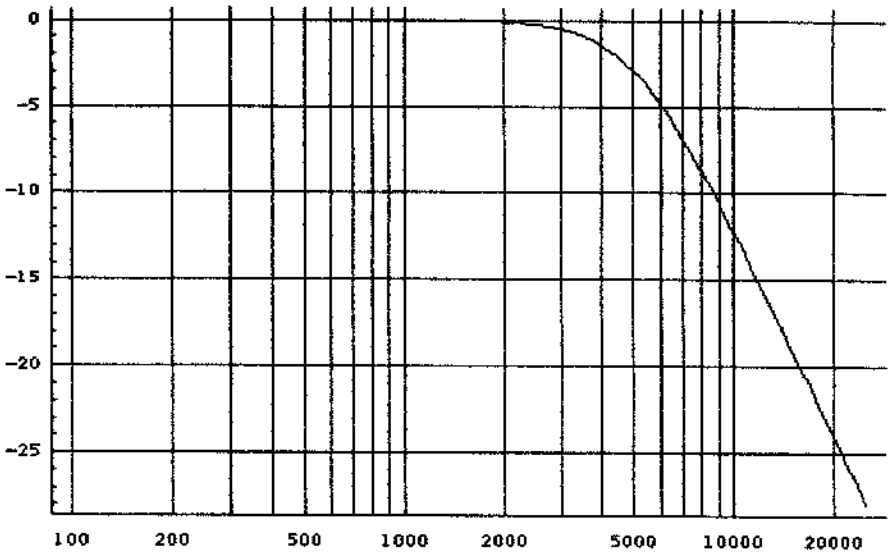
C =
R_1 =
R_f =

Problem 4 - A square wave of amplitude ±1 V and frequency 5 kHz, plotted below, is passed through a 2nd-order Butterworth filter whose H(f) and frequency response in dB are shown. The formula for the Fourier series coefficients is also shown. The 3 dB frequency, f_c, of this filter is 5 kHz.

$$H(f) = \frac{1}{\left(\frac{j2\pi f}{2\pi f_c}\right)^2 + 1.414\left(\frac{j2\pi f}{2\pi f_c}\right) + 1}$$

$$c_k = \frac{2\sin\left(\frac{\pi}{2}k\right)}{\pi k}$$

$$c_0 = 0$$



Sketch the output of the filter on the axis below.

Since time is limited, only consider the harmonics whose amplitudes are at least 20% of the amplitude of the fundamental (5 kHz). Show your work only if you want partial credit. Use the back of the previous page if you need more space.