University of Toronto

Faculty of Applied Science and Engineering

Final Exam

Date - Dec. 21, 1998

Duration: 2.5 Hr.

ECE512F — Analog Filters
Examiner - D.A. Johns

ANSWER QUESTIONS ON THESE SHEETS USING BACKS IF NECESSARY

1. Two aid-sheets allowed.
2. Calculator type unrestricted.
3. Grading indicated by [ ]. Total grade equals 60. Attempt all questions since a blank answer will certainly get a zero.
4. Part marks are given. Clarity and neatness will be appreciated.

Last Name: _____
First Name: _____
Student #: _____

Question	Mark
1	
2	
3	
4	
5	
6	
Total	

Total = 60

[10] Question 1:

Consider the following specifications for a lowpass digital filter:

Passband Ripple: 3 dB
Min Stopband Atten: 40 dB
Passband: 0 to 20kHz
Stopband: 40kHz to 100kHz
Sampling Frequency: 200kHz
Gain at dc: 0 dB

a) Find the order required if a Butterworth transfer-function is used and sketch its resulting transfer-function magnitude up to 400kHz

b) Repeat a) for a Chebyshev transfer-function.

[10] Question 2:

Using only resistors, capacitors and an inductor, find a circuit that realizes a bandpass filter with a center frequency of 100MHz, a Q of 10 and a center frequency gain of 1/3. Let the capacitor have a value of 10 pF.

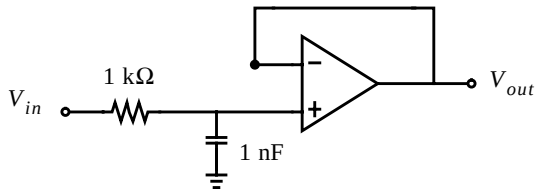
[10] Question 3:

a) Design a Tow-Thomas active-RC bandpass filter with a center frequency gain of -1, a center frequency of 20kHz and a Q of 5. Use integrating capacitors of 1 nF each.

b) Find the dc gain of the **lowpass** output for the filter designed in a). Show how one can modify the resistor values in a) to increase the dc gain by a factor of 2 yet leave the bandpass output unchanged.

[10] Question 4:

Consider the first-order RC filter shown below



op-amp input noise

$V_n(f) = 20nV/\sqrt{Hz}$

$I_n(f) = 20pA/\sqrt{Hz}$

op-amp unity gain freq = 10 MHz

Estimate the expected signal-to-noise ratio (in dB) for a 10mVrms input signal with frequency content all below the 3dB frequency of the filter.

[10] Question 5:

a) A $1kHz$ sinusoidal signal is digitally created using a $20kHz$ sampling-rate producing a sample-and-held signal. Before any smoothing filter is applied and assuming the magnitude of the $1kHz$ signal is $1V_{rms}$, what is the magnitude of the image at $19kHz$?

b) Given that a 6-bit A/D converter has a SNR of 36 dB but is linear to 12 bits, what is the sampling-rate required to achieve 12 bits of accuracy using a second-order delta-sigma modulator on a input signal bandwidth of $1MHz$?

[10] Question 6:

If a circuit is measured to have IIP_3 = 5 dBm and has a gain of 4 dB, what output-signal level should be used such that the third-order intermodulation products are 60 dB below the fundamental?