

**UNIVERSITY OF CALIFORNIA**  
**College of Engineering**  
**Department of Electrical Engineering**  
**and Computer Sciences**

**Homework 1**

**EECS 247**

**Due Tues., September 11, 2007**

**FALL**

**H.**  
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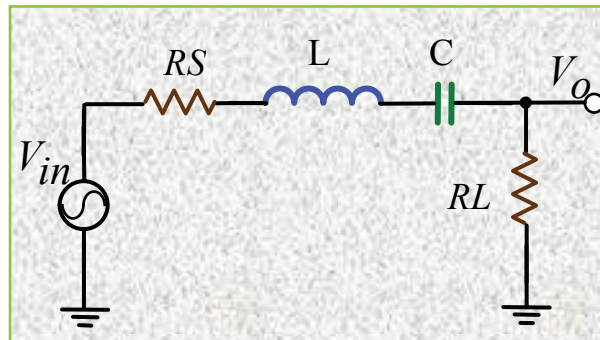
**Please add your email address to your submission**

**2007**

**Problem 1-**

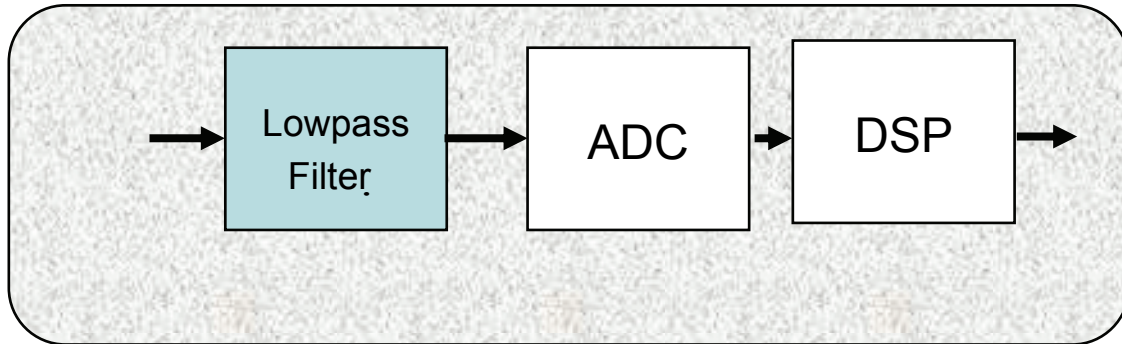
Analyze the RLC filter shown below:

1. Find a transfer function for  $V_o/V_{in}$ .
2. Identify the type of the filter.
3. Find an expression for the critical frequency and filter Q.
4. Assuming the desired critical frequency is 100MHz and  $R_S=R_L=50\Omega$ , find values for C & L for an overall filter Q of 5.
5. Simulate the filter with SPICE (Spectre or Hspice or Pspice ). Submit the magnitude response (in terms of dB), phase response, group delay and measure the filter Q from the graph. Choose the frequency axis to be linear.
6. Next, assume the inductor has a finite quality factor, derive the expression for overall filter quality factor as a function of the ideal filter quality factor and the inductor quality factor.
7. Find the minimum quality factor for the inductance which results in less than 10% change in the overall filter quality factor.
8. Simulate the magnitude response with the inductor quality factor found in part 7. Verify the overall Q and submit the response.
9. In what scenario would the actual filter quality factor be higher compared to the ideal filter quality factor? Is that a realistic case for a filter built with passive components?



## Problem 2-

The block diagram shown below, denotes the baseband portion of the receive path for a communication system.



You are to find a filter type among: Butterworth, Chebychev I, Chebychev II, and Elliptic which satisfies all the following requirements:

- The corner frequency is 140kHz (if you are using Matlab then  $f_{\text{pass}}=140\text{kHz}$ , if not assume  $f_{-3\text{dB}}=150\text{kHz}$ )
- The out-of-band rejection at 220kHz should be -60dB
- Passband ripple, if any <1dB
- Since the output of the filter is converted to the digital form. The system designers believe as long as the (maximum-minimum) group delay within the band of 1kHz to 120kHz is less than  $15\mu\text{s}$  the phase distortion can be corrected for by the DSP.
- Design should be optimized for minimum Silicon area and power dissipation. This to first order corresponds to a filter with minimum number of poles.

You can use any CAD tool you like to find the required filter order and the max-min group delay within the critical band for each filter type. If using *fdatool* in *Matlab*, note that it deals with discrete filters and you need to specify a sampling frequency. For simplicity, choose  $f_{\text{sampling}}=1,000,000$ . In that case, when you graph group-delay the numbers on the y-axis should be divided by the sampling frequency (or multiplied by  $1\text{e-}6$ ).

Please submit:

- Corresponding graphs for all the 4 filter types:
  - Overall magnitude response (frequency range 0 to 350kHz and magnitude range 0dB to -80dB)
  - Magnitude response showing detail of the passband (frequency range 0 to 150kHz and magnitude range 1dB to -4dB)
  - Phase response
  - Group delay, as a function of frequency

2. Fill in the table shown below, indicating the required order for each filter type, group delay for the specified frequency range,
3. Circle the filter you recommend for the above application.

Filter Type	Filter Order <i>n</i>	Group Delay Measured within 1kHz to 120kHz $GD_{\max.} - GD_{\min.}$
Butterworth		
Cheybshev I		
Cheybshev II		
Elliptic		