ECE 307 – MIDTERM

FALL 1998 **A.P. FELZER**

You may consult **your** notes and any books you may have or borrow from the library as well as any computer software or plotting calculators to do the following problems. But you **may not** under any circumstances for any reason talk to any person about the exam except for Felzer. If you **do discuss** this exam or **in any way** make use of the work of others, you will **fail** the course and have a letter put in your file explaining why.

Neatness counts. Completeness counts. Conciseness counts. In addition it should be obvious what each problem is, how you're solving it and what your answer is. You should draw all circuits (including equivalent circuits), draw appropriate graphs, set up appropriate tables and label equations. Note that it is better to do a problem with brute force than not at all. But it's better to do a problem "simply". Include any pertinent computer printouts. Specify your setting when you make plots with your calculator. Be sure you start early enough so that you have time to think about and double check your work

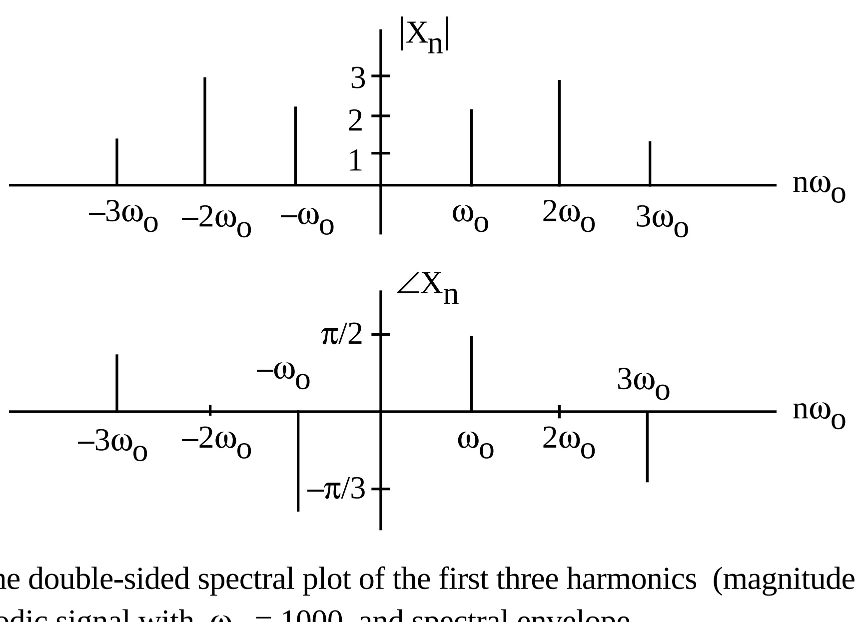
1. Write out a page of notes you would use for this midterm if it was closed book

2. Explain how you would use Fourier Series analysis to find
   a. The steady state response of a linear circuit to a periodic input
   b. The zero state response of a linear circuit to an input like a single pulse

3. Find the steady state response (as a sum of complex exponentials) of a circuit with frequency response

$$G(j\omega) = \frac{j\omega}{j\omega + 2000}$$

to an input with fundamental frequency $\omega_o = 1000$ rad/sec and spectral plot

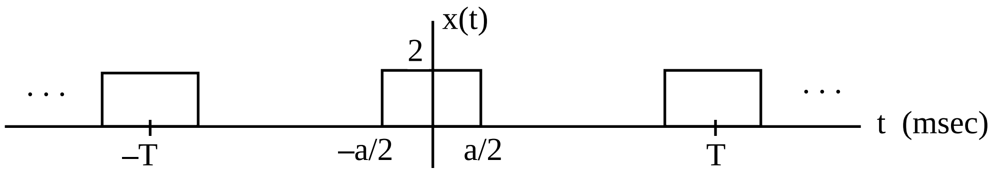


4. Sketch the double-sided spectral plot of the first three harmonics (magnitude and phase) of a periodic signal with $\omega_o = 1000$ and spectral envelope

$$X_{env}(\omega) = 3\ \mathrm{sinc}(\omega/2000)e^{j\omega/1000}$$

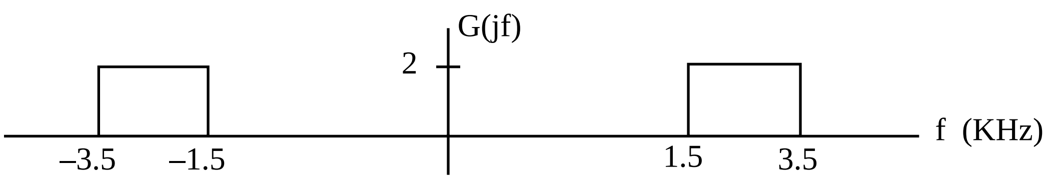
Then express the sum of the first three harmonics as a sum of sinusoids

5. Given the following pulse train with $T = 1$ msec and $a = 0.2$ msec



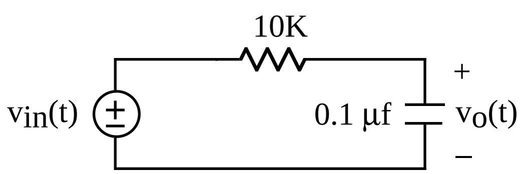
a. Sketch the first three lobes of the envelope $X_{env}(\omega)$. Then draw in the spectral lines
b. What will happen to the magnitude and crossover frequency of the envelope if T is doubled. How will this affect the magnitude and number of harmonics in each lobe
c. What will happen to the magnitude and crossover frequency of the envelope of the original x(t) if the pulse width a is cut in half. How will this affect the magnitude and number of harmonics in each lobe

6. Find and plot the steady state response of the bandpass filter with frequency response



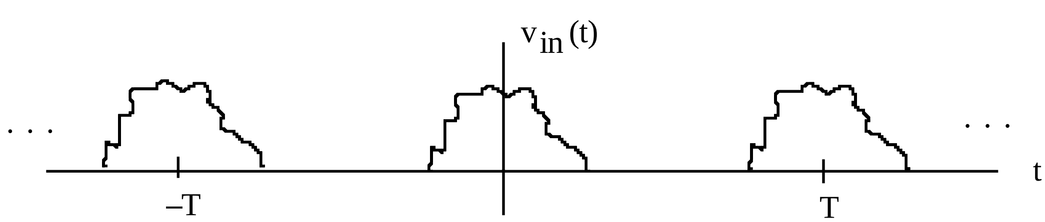
to the original pulse train x(t) in Problem (5)

7. Sketch the steady state response of the following circuit



to a pulse train of magnitude $h = 10$, period $T = 1$ msec and pulse width $a = 0.5$ msec. Explain how you got your result

8. Sketch the response of a lowpass filter to



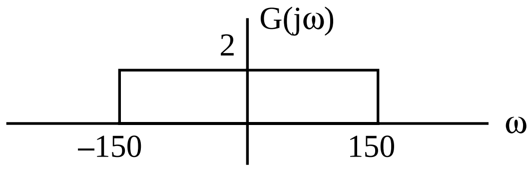
if $T = 1$ msec and the filter has a 3dB frequency of $\omega_{3dB} = 10^6$. Justify your result

9. Given

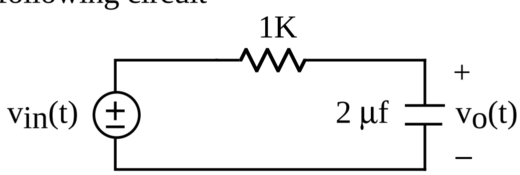
$$x(t) = 2 + 3\cos(100t) + 2\cos(200t + \pi/3)$$

a. Express x(t) as a sum of complex exponentials

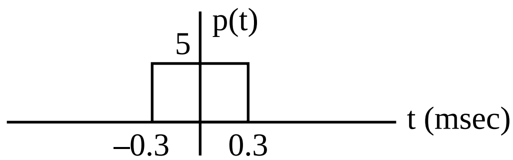
b. Sketch the power spectral plot
c. Find the average normalized power of $x(t)$
d. Find the average normalized power at the output of a circuit N with input $x(t)$ and frequency response as follows



10. Use Fourier Series analysis to find and graph a reasonable approximation of the zero state response of the following circuit

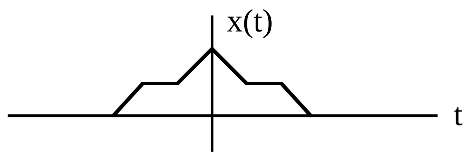


to the nonperiodic input

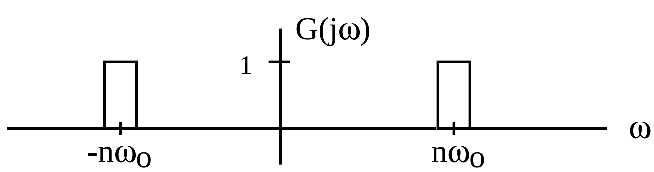


Justify the period T you choose and the number of terms you include in your sum.

11. Suppose we take a signal $x(t)$ like the following



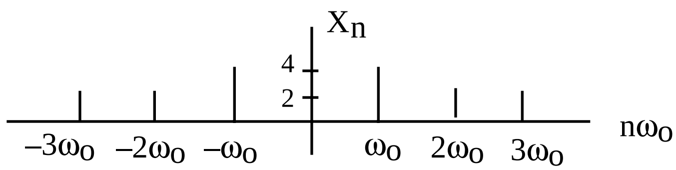
and construct a corresponding periodic signal $x_T(t)$. And then pass $x_T(t)$ through a series of narrow bandwidth bandpass filters centered at the harmonics as follows



Sketch the corresponding spectral density $X_T(\omega)$ if the steady state responses to the filters are as follows

5, 2 cos (100t), 3 cos (200t), cos (300t)

12. Suppose we take a pulse like signal $x(t)$, construct a corresponding periodic signal $x_T(t)$ with T = 5 msec and then make a spectral plot of the first three harmonics as follows



where $X_o = 3$

a. Sketch the corresponding spectral density $X_T(\omega)$.

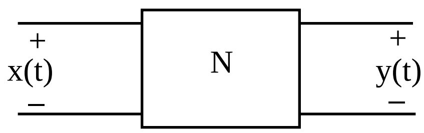
b. Describe what will happen to $X_T(\omega)$ as T is made larger.

c. Sketch a possible spectral density $X(\omega)$ for x(t)

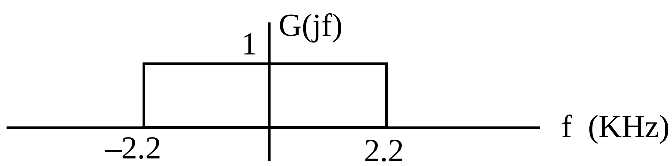
13. Find and sketch the Fourier Transform of

$$x(t) = 2 + 5\cos(100t) + 3\cos(200t)$$

14. Find and sketch the Fourier Transform $Y(\omega)$ of the following circuit

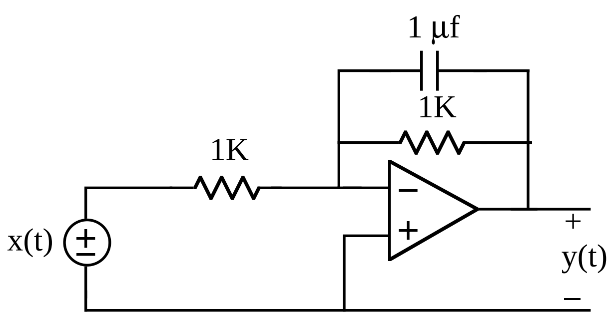


with frequency response

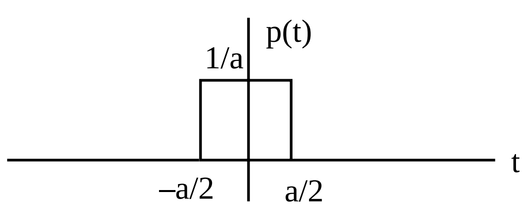


and input x(t) equal to an impulse train with period T = 2 msec

15. Given

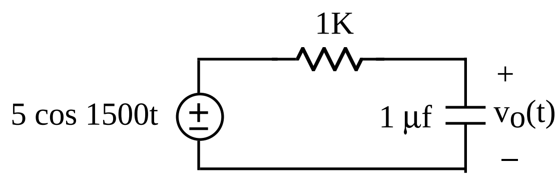


Find and sketch the Fourier Transform $Y(\omega)$ of y(t) if x(t) is the pulse



with $a = 1$ msec. What will $Y(\omega)$ approach as a gets smaller and smaller. Explain. Sketch graphs to illustrate what's happening

16. Find the sinusoidal steady state response of



17. Find the sinusoidal steady state response of a circuit with impulse response $h(t) = 5000\, e^{-1000t}\, u(t)$ to the input $x(t) = \cos(1000t)$

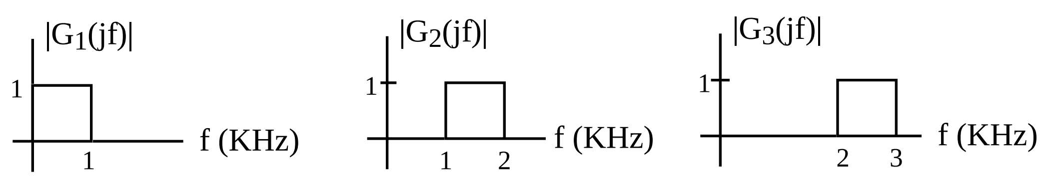
18. Given $x(t) = 2 + 8\cos(1000t)$
    a. Express x(t) as a sum of complex exponentials and then sketch the double sided spectrum
    b. Express $y(t) = x(t)\cos(5000t)$ as a sum of complex exponentials and then sketch the double sided spectrum
    c. Describe the relationship between the spectrums of x(t) and y(t)
    d. Express $w(t) = y(t)\cos(5000t)$ as a sum of complex exponentials and then sketch the corresponding double side spectrum
    e. Now suppose we put w(t) thru an ideal lowpass filter with cutoff frequency $\omega_C = 2000$ and gain $G = 4$. Sketch the double-sided spectrum of z(t) at the output of the filter
    f. How is z(t) related to x(t)

19. Find the Fourier Transform of v(t) satisfying the differential equation

$$v' + 1000v = \cos(1000t)$$

20. Find and sketch the Fourier Transform of the pulse train in Problem (5)

21. Given the energy signal x(t), sketch its energy spectral density in the range $-300\text{ Hz} \le f \le 300\text{ Hz}$ if the responses of the following filters



to x(t) are signals with energies $E_1 = 10$ joules, $E_2 = 15$ joules and $E_3 = 5$ joules.

22. Given x(t) with power spectral density $S_X(f) = 2\delta(f - 1000) + 4\delta(f) + 2\delta(f + 1000)$
    a. Sketch $S_X(f)$
    b. Find the average normalized power of x(t)
    c. Find the average normalized power of x(t) after it passes through an ideal lowpass with cutoff frequency $f_C = 2000$ Hz and gain $G = 2$