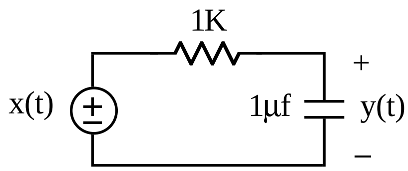
PROBLEMS YOU SHOULD BE ABLE TO DO AFTER YOU TAKE ECE 307

FALL 1995 **A.P. FELZER**

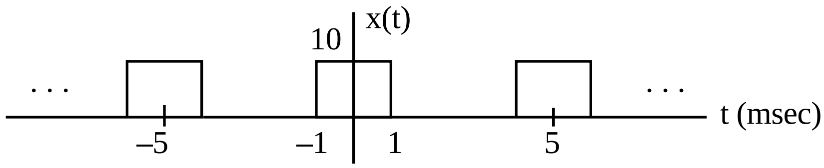
1. Why do we go to all the trouble to express periodic signals as sums of sinusoids, take Fourier Transforms of signals like pulses and take LaPlace Transforms of signals like steps and damped sinusoids

2. Why do we express our Fourier Series expressions in terms of complex exponentials

3. Given the following circuit

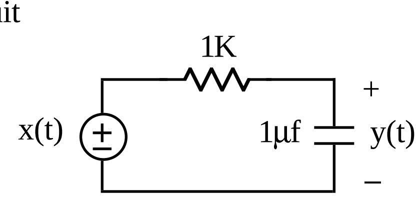


with pulse train input

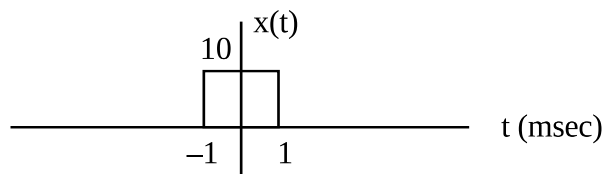


a. Find a general expression for the complex Fourier coefficients X_n of x(t)
b. Find the complex Fourier coefficients X_n from $n = -5$ to $n = 5$. Sketch their double-sided spectral plot. Then find and sketch their envelope
c. Use a plotting calculator or computer to get a lot of the sum of the first five harmonics of x(t)
d. Repeat parts (a), (b) and (c) for y(t)
e. Use SPICE to find the response of the circuit to the pulse train. Verify that once the response reaches steady state it looks pretty much like what you got for y(t) by adding up the harmonics in part (d)
f. Find and sketch the first five harmonics of the power spectral plots of x(t) and y(t) and calculate the corresponding powers
g. How will making the pulses narrower without changing their magnitudes or the period affect the results of this problem. Explain why
h. Now suppose we again make the pulses narrower but this time increase their magnitudes in such a way that the areas of the pulses stay the same. How will this affect the results of this problem. Explain why

3. Given the following circuit

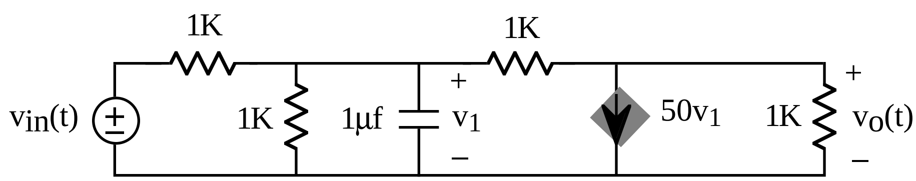


with input



a. Find and sketch the Fourier Transform $X(\omega)$ of x(t)
b. Find and sketch the energy spectral density of x(t)
c. Sketch y(t)
d. Repeat parts (a) and (b) for y(t)
e. How will making the pulses narrower without changing their magnitude or the period affect the results in parts (a)–(d). Explain why
f. Now suppose we again make the pulses narrower but this time increase their magnitudes in such a way that the areas of the pulses the same. How will this affect the results in parts (a)–(d).. Explain why

4. Given the following circuit

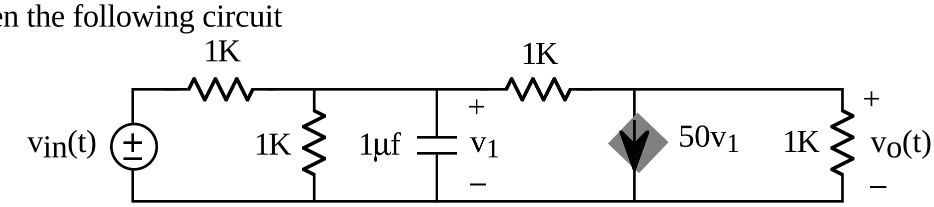


a. Draw the Fourier Transformed circuit
b. Find $V_o(\omega)$ if $v_{in}(t) = \delta(t)$
c. Make use of your result in part (b) to find $v_o(t)$

5. Find and sketch the Fourier Transform of the pulse train in Problem (2)

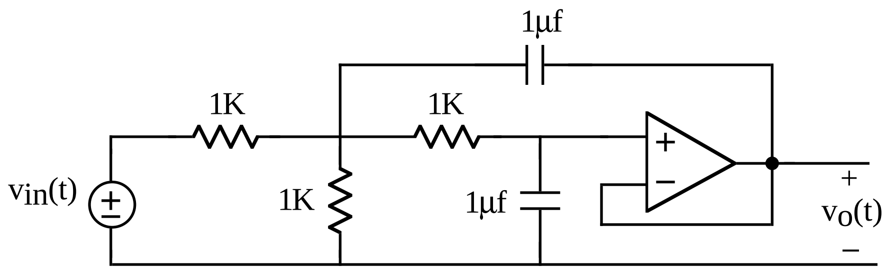
6. Explain in words why the Fourier Transform of a circuit's impulse response h(t) is equal to its frequency response $G(j\omega)$. Make up and do an example

7. Given the following circuit



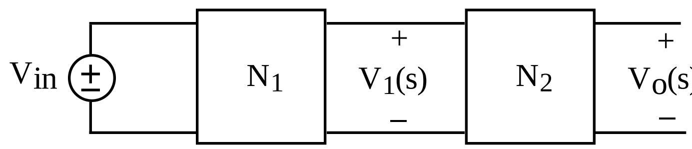
a. Draw the LaPlace Transformed circuit
b. Write and put in matrix form the node equations for the LaPlace Transformed circuit
c. Find $V_o(s)$ and then $v_o(t)$ if $v_{in}(t) = u(t)$
d. Find $G(s) = V_o(s)/V_{in}(s)$
e. Make use of your result for G(s) in part (d) to find $V_o(s)$ when $v_{in}(t) = u(t)$. Make sure you get the same result as in part (c)
f. Find the sinusoidal steady state response when $v_{in}(t) = 5 \cos (1000t + 1.2)$
g. Find the input impedance Z(s) as seen by the source
h. Find the Thevenin equivalent output impedance $Z_o(s) = V_o(s)/I_o(s)$ as seen by the load resistor R_L

8. Write and put in matrix form the node equations for the LaPlace Transformed circuit of



9. How would you find the sinusoidal steady state response of a linear circuit. Explain why

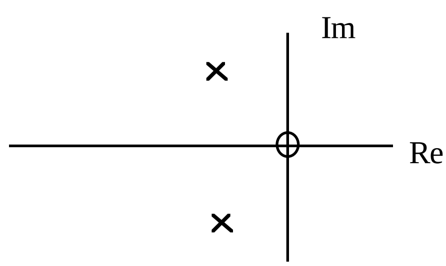
10. Under what circumstance is the overall gain $G(s) = V_o(s)/V_{in}(s)$ of the following cascade of N_1 and N_2



equal to the product of the open circuit voltage transfer functions $G_1(s)$ and $G_2(s)$ of the individual sections

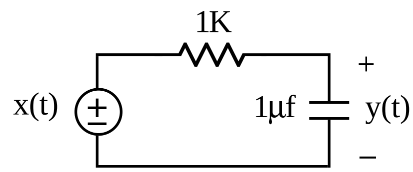
11. What are the poles and zeros of a circuit's transfer function. How are they related to the circuit's natural response. How are they related to the circuit's frequency response

12. Given the following pole-zero diagram

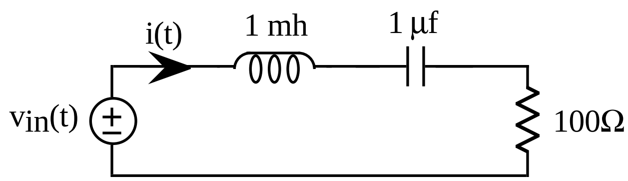


a. Sketch what the natural response looks like
b. Sketch the frequency response
c. Describe and illustrate what happens to the natural and frequency responses as the real part of the poles increase
d. Describe and illustrate what happens to the natural and frequency responses as the real part of the poles decrease
e. What are the consequences of the poles being in the right half plane (RHP)

13. Find and sketch the complete response of the following circuit with nonzero initial conditions $y(0) = 2$ volts

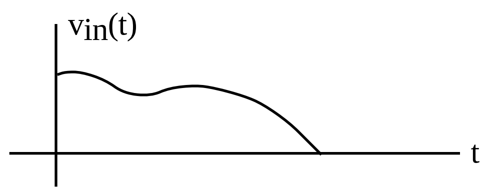


14. Sketch the response of the following circuit



if the initial conditions are such that $i(0) < 0$ and $i'(0) < 0$. Is the circuit underdamped, overdamped or critically damped. Verify with a SPICE plot

15. Explain how the zero state response of a linear circuit to an input like the following



can be approximated by a sum of pulse responses. What's the connection between this scheme for approximating the response of a circuit and the convolution integral

16. Use convolution to find the step response of a circuit with impulse response $h(t) = 5\,e^{-100t}\,u(t)$. Explain and demonstrate the graphical meaning of the convolution integral

17. Find the sinusoidal steady state response of a circuit with impulse response $h(t) = 5\,e^{-100t}\,u(t)$ and input $v_{in}(t) = 5 \cos 200t$