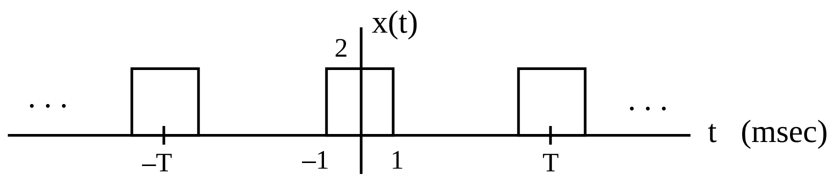
ECE 307 - COMPLEX FOURIER SERIES - INVESTIGATION 7
SPECTRUMS OF PULSE TRAINS

FALL 2000 **A.P. FELZER**

To do "well" on this investigation you must not only get the right answers but must also do neat, complete and concise writeups that make obvious what each problem is, how you're solving the problem and what your answer is. You also need to include drawings of all circuits as well as appropriate graphs and tables.

The objective of this investigation is to see how the spectrum of a pulse train is affected by its period T and pulse width a.

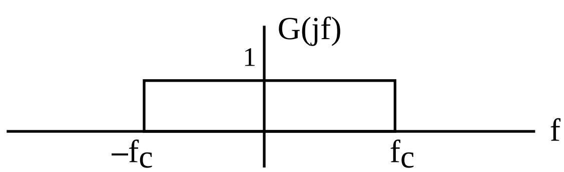
1. The objective of this problem is to see how the spectrum of a pulse train like the following one



with pulse width $a = 2$ msec depends on its period T.

   a. First write out an expression for $X_{env}(f)$ as a function of T
   b. Then find and plot the magnitudes of the spectral envelopes for $T = 4$, 8 and 16 msec. Draw in the spectral lines.
   c. How does doubling the period T of such a pulse train affect
      (i) The shape of the envelope
      (ii) The magnitude of the envelope
      (iii) The distance between the zero-crossover frequencies
      (iv) The number of spectral lines per lobe

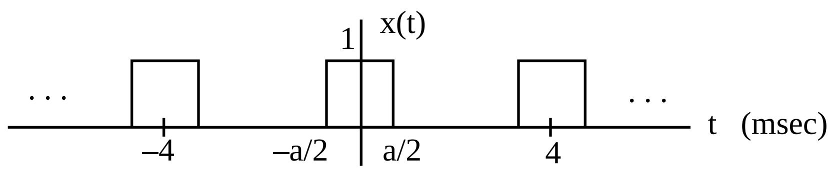
2. The objective of this problem is to see what happens as we vary the period T of a pulse train x(t) passing through an ideal lowpass filter with frequency response as follows



How, in particular, will doubling the period T affect

   a. The number of harmonics of x(t) in the passband of the filter
   b. The magnitudes of the harmonics in the passband of the filter

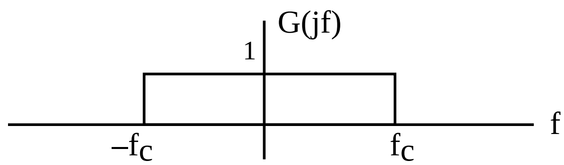
3. The objective of this problem is to see how the spectrum of a pulse train like the following one



with period $T = 4$ msec depends on its pulse width a.

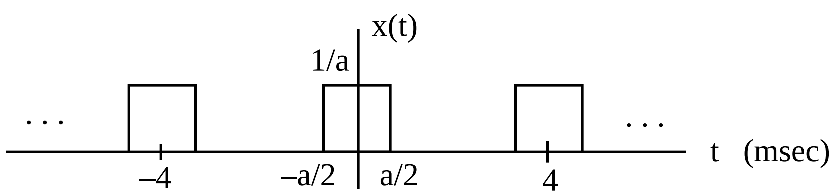
a. First write out an expression for $X_{env}(f)$ as a function of a
b. Then find and plot the magnitudes of the spectral envelopes of this pulse train for a = 2, 1 and 0.5 msec. Draw in the spectral lines.
c. How does decreasing the pulse width a affect
   (i) The shape of the envelope
   (ii) The magnitude of the envelope
   (iii) The distance between the zero-crossover frequencies
   (iv) The number of spectral lines per lobe

4. The objective of this problem is to see what happens as we vary the pulse width a of a pulse train x(t) passing through an ideal lowpass filter with frequency response as follows

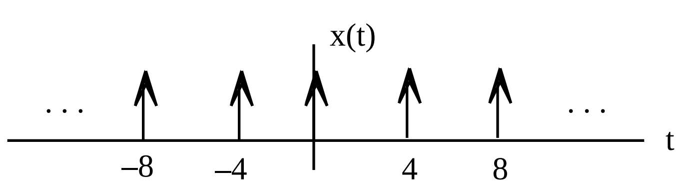


How, in particular, will halving the pulse width a affect
a. The number of harmonics in the passband
b. The magnitudes of the harmonics in the passband

5. Now suppose we have a pulse train with pulses of area one as follows



a. What do you think will happen to the magnitude of the envelope and the corresponding discrete spectrum as the parameter a gets smaller. Why
b. Find and plot the magnitude of the spectral envelope for a = 2, 1, 1/2 and 1/4 msec. Then draw in the discrete spectral lines
c. Describe what's happening to the spectral plots in part (b) as the pulse width a gets smaller. Are your results what you predicted in part (a). If not, explain what in fact is going on
d. What happens to the spectrum of a pulse train in the limit as a goes to zero and the pulse train approaches an impulse train as follows



Sketch the corresponding spectral plot. **Memorize** this result.