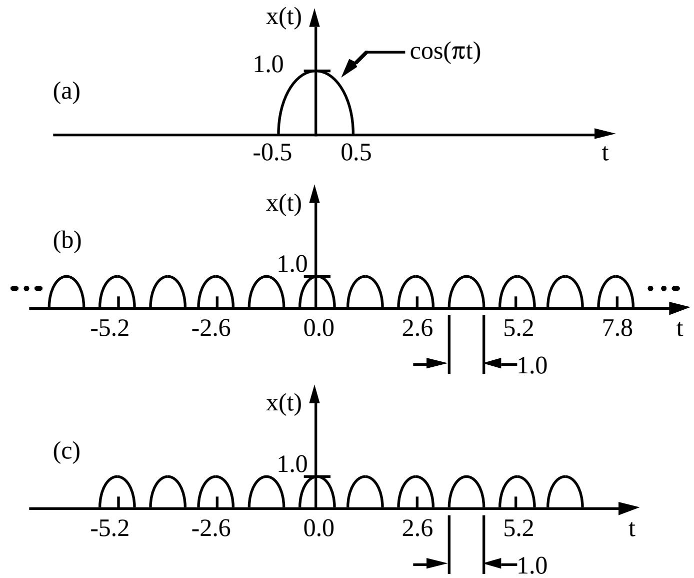
Due 7 February 1997 at 5:00 PM

EE 438 Assignment No. 3 Spring 1997

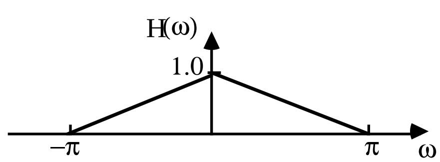
1. For each signal $x(t)$ given in parts a - c below, do the following:

   i. Find an expression for its CTFT $X(f)$. (Use transform relations including comb function and the results of previous parts wherever possible.)

   ii. Carefully sketch $X(f)$.



2. A zero DC square wave with period T sec. and 50% duty cycle is filtered with an ideal low pass analog filter with cutoff at f_c kHz, and then sampled with an ideal sampler at a rate of 8 kHz, filtered with a digital filter having the frequency response $H(\omega)$ shown below, and then reconstructed as an analog signal $y(t)$ with an ideal D/A convertor with a cutoff frequency of 4 kHz.



Find the output $y(t)$ for the following values of T and f_c

a. T = 0.333 msec, f_c = 4 kHz

b. T = 1 msec., f_c = 4 kHz

c. T = 0.4 msec., f_c = 8 kHz

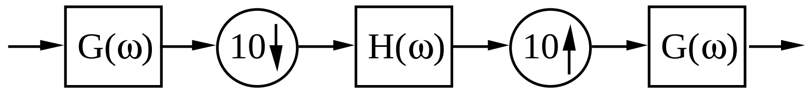
3. Consider the digital filter described by the following difference equation

$$y[n] = \left(x[n] + 2x[n-1] + x[n-2]\right)$$

a. Find a simple expression for the frequency response $H(\omega)$ of this filter.

b. Sketch the magnitude of $H(\omega)$.

Now consider the following digital system,



where $H(\omega)$ is the filter from parts a and b and $G(\omega)$ is an ideal low-pass filter with a cutoff frequency of $\pi / 10$ rad/sample and unity gain in the passband.

c. Find the overall frequency frequency response $F(\omega)$ for this system.

d. Sketch the magnitude of $F(\omega)$.

e. Discuss the possible advantages of a system like that shown above compared to directly implementing a digital filter with frequency response $F(\omega)$ as a single stage.

4. A person sits right in front of a microphone and speaks into it. The microphone also picks up an attentuated and delayed version of this signal which is reflected from a wall located 2.5 m from the microphone. The echo is 6 dB weaker than the direct signal.

a. Derive a CT LTI model for the channel between the speaker's mouth and the microphone that accounts for the reflected signal.

b. Find the frequency response $G(f)$ associated with this system.

c. Assuming ideal A/D and D/A convertors operating at a 50 kHz sampling rate, design a digital filter that will *approximately* cancel the echo. For your echo-cancelling filter, what is:

i. the difference equation that could be used to implement it?

ii. the impulse response $h[n]$?

iii. the frequency response $H(\omega)$?

d. Determine the overall frequency response $D(f)$ of the CT system formed by the cascade of the room channel and your echo canceller.

5. Consider the digital stereo multiplexer discussed in class on 1/30/97.

a. Download the M-file `stereo_mux.m` and the speech files erf1s1t0 and ysf1s1t0 from the web site `http://dynamo.ecn.purdue.edu/~allebach/ee438`.

b. Draw the block diagram of a stereo demultiplexer system that will recover the left and right channel signals $x_l[n]$ and $x_r[n]$ from the multiplexed signal $x_{mux}[n]$. Be sure to identify all parameters of your system, such as modulator frequencies, filter cutoff frequencies, etc.

c. Write an M-file that will implement your block diagram from part a. It should take the signal `xmux` produced by the M-file `stereo_mux.m,` and generate from it the original signals `xl` and `xr` (bandlimited to 3.125 kHz, of course).

d. Turn in plots of the original and demultiplexed bandlimited left channel signals, and the spectra of these signals.

e. Play back your reconstructed signals, and compare to the original signals. Comment on any differences that you observe between the original and demultiplexed signals.