Lab 1+ – LTI systems continued

1. Implement an accumulator and test it with $\delta[n]$ and $u[n]$. Plot the results. Is it stable?
2. Implement $y(n) = a \cdot y(n-1) + x(n)$, accepting a and initial y as parameters. Choose $0 < a < 1$, test impulse response with zero initial condition, initial cond. response, then the combination of both. Plot the results.
3. Experiment with different values of a (1, -1, > 1, < 0 etc.). Plot the results for imp. response and initial cond. response; comment them.
4. Use program `anal` to display real-time signal and its frequency (well, FFT) – measure a sinusoid with different relations of $1/T_s$ and f ($1/T_s < f$, $\approx f$, $> f$). Comment the plots.

Lab 2 – spectral analysis

1. Simulate 2 ms of samples of a square impulse of 1 ms length, sampled with:
   (a) 1 MHz
   (b) 10 kHz
   (c) 10 kHz, but use 4 ms of samples

   Plot amplitude of FFT's of all signals on one graph, keeping the real-world frequency axes the same. Hint: scale the vertical axis so that the DC component bin has the same value. Find out from the FFT definition why is it necessary.

   Think of 1a as "almost CT" signal and comment the spectrum differences.
2. Plot an FFT of 1024 points of following signals:
   (a) a 512 points square impulse
   (b) other (narrower) square impulses
   (c) sine wave (integer and non-integer number of periods in window)
   (d) $e^{jn\theta_0}$ (how many peaks do you see? why?)
   (e) two 32-points square impulses: one beginning at $N_0 = 0$ and other at $N_0 \neq 0$

   (name the effects, note the number of zero places in spectrum etc.)
3. Plot a spectrum of 512 samples of sine wave. Then, zero-pad them to 1024 and 2048 samples. Compare the results. Compute IFFT.
4. Compute spectra of different windows. Note mainlobe width, sidelobe attenuation etc. (If you have enough time, use Matlab: `hamming, bartlett, blackman, hanning, kaiser`, otherwise use Windows program "anator").
5. Do the following experiments to see the effect of windowing:
   (a) Plot a spectrum of 512 samples of sine wave. Choose the frequency to see the rectangular window effect clearly. If necessary, use zero-padding to see the spectrum better.
   (b) Use different windows, trying to obtain good, clear plot of the spectrum.
   (c) Demonstrate the signal separation properties of different windows - try to plot a spectrum of two sinusoids of different frequencies and amplitudes.

File: lab2plus1cd LaTeXed on November 4, 2005