Homework: LabVIEW Programming and Numerical Computations in MATLAB

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1

You know that every periodic function can be represented as a weighted sum of sinusoids of different frequencies. Write the Fourier series of a square wave with amplitude 1 and average value 0 and simulate it in LabVIEW as a sum of its Fourier components. Also simulate a perfect square wave. Compute the FFT for both and explain how the two spectra are similar or different.

2

A realistic spring mass system (or a damped harmonic oscillator) can be represented by the following equation:

$$\frac{d^2x}{dt^2} + 2\zeta\omega_o\frac{dx}{dt} + \omega_o^2 x = \frac{F(t)}{m},$$

where

$$\omega_o = \sqrt{\frac{k}{m}}$$

is the undamped natural frequency of the oscillator, and

$$\zeta = \frac{c}{2\sqrt{mk}}$$

is the damping factor of the system for a certain viscous damping coefficient c. Solve the system equation to determine its response for various values of c, m and k. Try to obtain solutions for over-damped, under-damped and critically damped cases. Verify the relationship between the frequency of oscillations and the damping factor. Graph the responses on the same figure and explain your results.

3

All telecommunication devices and most sophisticated lab instruments employ modulation as a basic operating principle. Simulate a low frequency monotone signal modulated by a high frequency sinusoid of a greater amplitude. Write the data to a file; import it into MATLAB and compute the Fourier transform of the low-frequency signal as well as of the modulated signal. You should be able to explain the mechanism of modulation by looking at the Fourier spectra of both the signals.
(**HINT**: Modulation can be done by a simple arithmetic operation on the two signals.)