EE521
SystemView Example

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The Example

- After Sklar, Digital Communications, Second Edition, problem 2.4 p. 101
- Principles demonstrated
  - Real-world signals and their bandwidths
  - Sampling and aliasing
  - The effect of the sample gate width on the spectrum of the sampled signal
  - Heterodyning or mixing of real signals
  - Parameters of low pass filters

Why This Example is Important

- This is a core set of issues with use of SystemView
- Steps in solving the problem
  - Select a real-world signal and determine its bandwidth, and select a sample rate
  - Implement natural sampling as multiplication by a pulse train or other means
  - Select and design a low-pass filter that provides sufficient bandwidth yet has a stopband that suppresses unwanted aliased signal spectra

The Nyquist Bandwidth

- Bandwidths are to 40 dB down points
  - About 1% is the lower limit of visual significance in plots
  - This is a conservative goal for the purposes of a visual example
- Bottom line
  - Nyquist bandwidth depends on aliasing and other requirements
  - Can be distance between 3 dB points, 10 dB points, 40 dB points, etc.

The Signal

- Frequency sweep from 0 to 20 Hz
- One time only
- Implemented as Aperiodic, Custom
  - Equation for chirp, logical for gate
  - p(0)=sin(0.5*tpi*20*ct^2) * (ct<=1)
  - Multiplication by logic provides aperiodic gating

Getting the Spectra

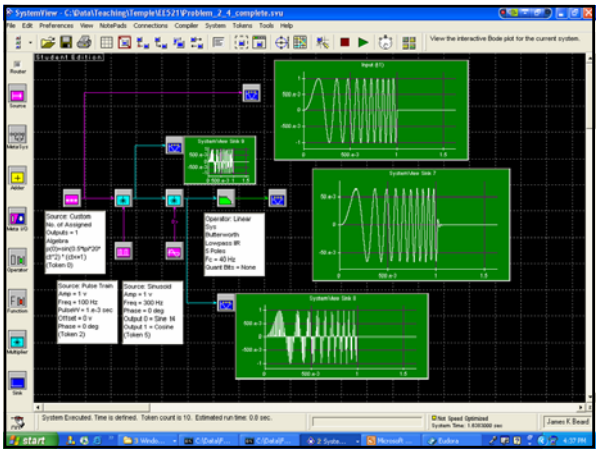
- Select Sink Calculator on waveform plot
- Select Complex FFT, 20*log|FFT|(dB)
- Zoom in on spectrum
- Bandwidth to 40 dB down is about 100 Hz
- Adjust simulation data rate as necessary
  - Sample rate will be 100 Hz
  - Default of 1 kHz is too low
  - 10 kHz works fine

Sampling

- System sample rate of 10 kHz
- Sample rate of 100 Hz
  - Sampling interval of 10 ms
  - Select natural sampling aperture T of 1 ms
  - System clock must be at least 2/T (why?)
- Implement as multiplication of signal by pulse train
- Check spectrum of result

LPF Filter Requirements

- Check the spectrum of the sampled signal
  - Passband should be half the sample rate
  - Stopband should be 40 dB down at fs-W/2
  - Our example:
    - Passband at 50 Hz
    - 40 dB down at 80 Hz
- Low Pass Filter
  - Butterworth (maximally flat) selected
  - Five poles needed to get stopband low enough



Things to vary

- The signal
  - Pick your own
  - Periodic or one-time
  - Band-limit with LPF if necessary
- The sample rate
- The aperture size in the natural sampling
- The selection and design of the LPF
- The frequency of the sine wave

Conclusions

- Sampling generates multiple replicas, or images, of the signal separated in frequency by the sample rate
- Rolloff of the amplitude of the images increases with aperture size
- The SystemView sample rate must be large enough to represent the smallest features in the simulation
- Requirements for the LPF include
  - Low distortion in the passband (why?)
  - Passband to include signal bandwidth
  - Stopband to include unwanted images
- Requirements drive selection and design of the LPF