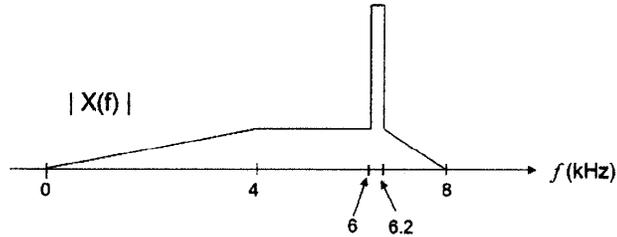


Key

EE432 Fall 08 Homework Problem Set 7 (PS07) Due: 10/21/08

1. Suppose you are given a signal $x(t)$ with frequency spectrum (magnitude of Fourier transform) shown below. Given this plot, answer the following questions.



- a. What is the minimum sample frequency to prevent aliasing?

$$2 \times 8000$$

$$\boxed{16 \text{ kHz}}$$

- b. Sample this signal at 1.25 times the minimum sample frequency. What is the actual sample frequency? Use this sample frequency for the remainder of this problem.

$$16000 (1.25) = \boxed{20 \text{ kHz}}$$

- c. What is the Nyquist frequency?

$$f_N = f_s/2 = \boxed{10 \text{ kHz}}$$

- d. Suppose you collect 20 samples of $x(t)$ that you are going to use for frequency analysis. How long did it take to collect those samples (how many seconds)?

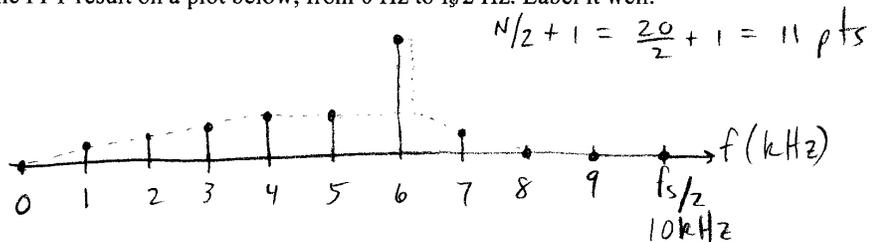
$$\frac{20 \text{ samples}}{20,000 \text{ samples/sec}} = 1 \text{ msec}$$

$$\boxed{1 \text{ msec}}$$

- e. What will be the frequency resolution of your FFT?

$$\Delta f = \frac{f_s}{N} = \frac{20000}{20} = \boxed{1000 \text{ Hz}}$$

- f. Sketch the FFT result on a plot below, from 0 Hz to $f_s/2$ Hz. Label it well.



2. Looking at your plot, are there any significant problems with your frequency analysis? If so, what problem(s) exist? If there are problems, how could you fix them?

- Just narrowly caught the spike
- if you plotted the FFT so the spike is not present, then increasing N by collecting more samples or zero padding should catch the spike

1. If instead of collecting 20 samples, you collected 2000 samples, in what ways would your answer to problem 1.f (your frequency plot) change? Be specific; or give a rough sketch.

$$\Delta f = \frac{f_s}{N} = \frac{20,000}{2000} = 20 \text{ Hz} \quad \left. \vphantom{\Delta f} \right\} \text{ now have 1001 samples in the plotted FFT.}$$

- since the spike width is 200 Hz, there will be 10 samples on the spike.

2. Given a signal consisting of a 25 Hz sinusoid and a 57 Hz sinusoid that is sampled at 125 samples/sec. Suppose you collect 116 samples and compute/plot the FFT. Will there be any leakage on the frequency plot? If so, be specific.

$$\Delta f = \frac{f_s}{N} = \frac{125}{116} \approx 1.0776 \text{ Hz}$$

Neither 25 Hz or 57 Hz is an exact multiple of 1.0776, so there will be leakage.

$$\frac{25}{1.0776} = 23.2, \text{ so the 25 Hz sinusoid will leak onto the sample at } 23(1.0776) = 24.7848 \text{ Hz and the sample at } 24(1.0776) = 25.8624 \text{ Hz}$$

3. An A/D system has a Nyquist frequency of 11025 Hz. What is the maximum frequency content of an input signal such that no aliasing will occur?

$$\boxed{11025 \text{ Hz}}$$

4. What is the minimum sample rate for a system that must decode DTMF tones?

highest freq in any DTMF tone is 1633 Hz,

$$\text{so } f_s > 2(1633) = \boxed{3266 \text{ Hz}}$$

$$\frac{57}{1.0776} = 52.896, \text{ so the 57 Hz tone will leak into the samples at } 52(1.0776) = 56.0352 \text{ Hz and } 53(1.0776) = 57.1128 \text{ Hz}$$