Name: Key

EE432 Fall 2008 Quiz 05

1. Suppose an analog signal has a maximum frequency content of 5.3 kHz. You decide to convert it to a digital signal which is sampled at twice the minimum frequency to prevent aliasing.

   a. What is the sample frequency?

   Nyquist rate = $2 \times 5300 = 10{,}600$ Hz

   $f_s = 2(10{,}600) = \boxed{21{,}200 \text{ Hz}}$

   21,200 Hz

   b. What is the Nyquist frequency?

   $f_N = f_s/2 = \boxed{10.6 \text{ kHz}}$

   10.6 kHz

   c. If you wish to analyze the frequency content using the FFT, what is the minimum number of samples you need to have a frequency resolution that is <u>no greater</u> than 4 Hz?

   $\Delta f = \frac{f_s}{N}$

   $4 \geq \frac{21{,}200}{N}$ so $N \geq \frac{21200}{4} = 5300$

   $\boxed{5300 \text{ samples}}$

   5300 samples

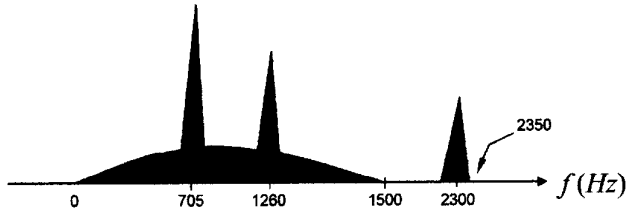
   d. Using your number of samples from part c, if the signal contained a distinct sinusoid that had a frequency of ~~3705~~ 3704 Hz, will there be leakage in the FFT? why or why not?

   $\Delta f = \frac{f_s}{N} = 4$ Hz

   $\frac{3704 \text{ Hz}}{4 \text{ Hz}} = 926$ ← an integer here means that a frequency sample will fall exactly on 3704 Hz so

   $\boxed{\text{No leakage}}$

2. Suppose you've obtained a signal whose frequency spectrum looks like that below. You will convert it to a digital signal.



a. If you sample the signal at 4600 Hz, is there any problem? Why or why not?

Yes - aliasing. Highest freq present is 2350 Hz, so need to sample > 4700 Hz.

b. Suppose you sample it at 10 kHz. How many samples would you need to collect in order to have NO leakage in the FFT?

distinct tonals at 705, 1260, 2300, so a freq resolution of 5 Hz would allow no leakage, since these freqs are all divisible by 5

$\Delta f = 5 = \frac{f_s}{N}$ so $N = \frac{f_s}{5} = \frac{10{,}000}{5} = \boxed{2000 \text{ samples}}$

c. Suppose you collect 10 samples. Sketch the FFT magnitude from 0 to $f_s/2$ Hz.

$\Delta f = \frac{f_s}{10} = \frac{10000}{10} = 1 \text{ kHz}$

$N = 10$, so plot $N/2 + 1 = 6$ points

Bonus: What was the name of the first U.S. aircraft carrier sunk in World War II?

USS Lexington