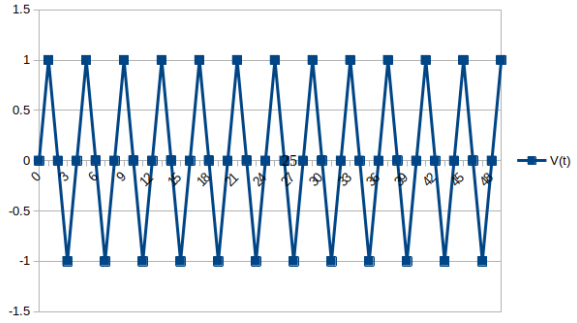
ECE 153A/253, CS 153A - Homework 5

Solutions

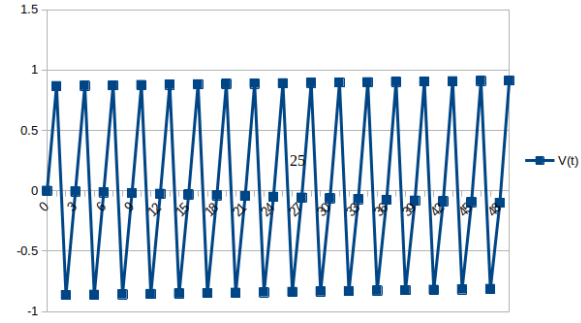
Question 1: Aliasing

- 250Hz



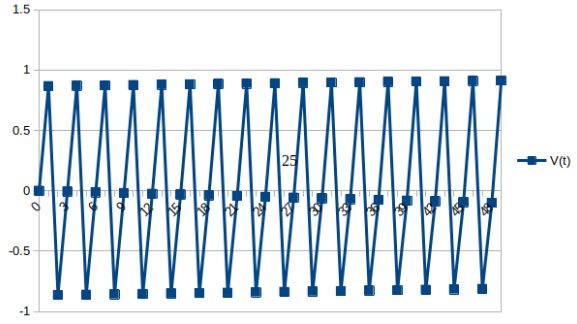
1 cycle every 4 samples - looks like 1kHz/4 = 250Hz

- 333Hz



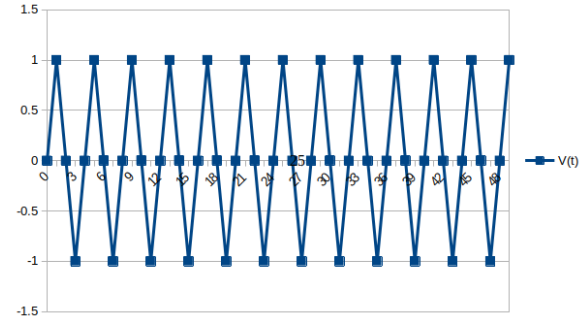
1 cycle every 3 samples - looks like 1kHz/3 = 333Hz

- 667Hz



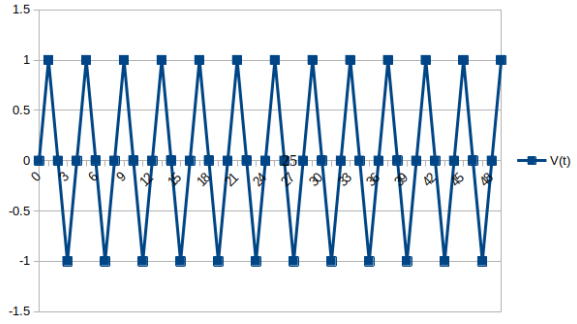
1 cycle every 3 samples - looks like 1kHz/3 = 333Hz

- 750Hz



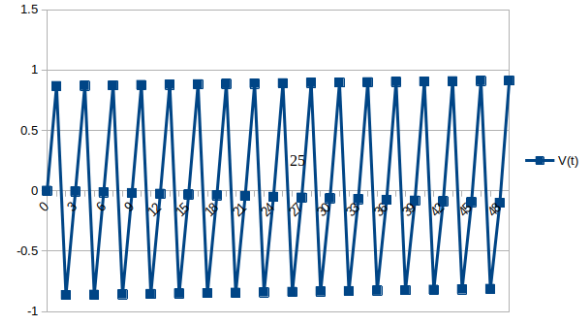
1 cycle every 4 samples - looks like 1kHz/4 = 250Hz

- 1250Hz



1 cycle every 4 samples - looks like 1kHz/4 = 250Hz

- 1333Hz



1 cycle every 4 samples - looks like 1kHz/3 = 333Hz

Question 2: Jitter

(a)

$$T_s = \frac{1}{f_s} = \frac{1}{44.1kHz} = 22.7\mu s$$

(b)

$$V_{rms} = \frac{2}{\sqrt{2}}\pi A f t_{rms} \quad \text{(From notes)}$$

$$A = 15kHz; \quad f = 15kHz; \quad t_{rms} = 1\mu s$$

$$V_{rms} = \sqrt{2}\pi(15kHz)(1\mu s) = 66mV_{rms}$$

(c)

$$t_{rms} \leq \frac{\sqrt{2}}{\pi f(2^D - 1)} \quad \text{(From notes)}$$

$$2^D - 1 < \frac{\sqrt{2}}{\pi f t_{rms}} = \frac{\sqrt{2}}{\pi(15kHz)(1\mu s)} = 30.01$$

$$2^D < 31.01$$

$$D < log_2(31.01) = 4.95bits$$

Question 3: FFT

(a)

$$\frac{50kHz}{128} = 391Hz$$

(b)

Nyquist frequency:$\frac{50kHz}{2} = 25kHz$

(c)

They get further apart. The FFT frequency axis has range $[0, f_s)$ and it gets split into N bins.

(d)

To distinguish need $461Hz - 441Hz = 21Hz$ of distinguishing power.
Need bin spacing less than $5 * (21Hz) = 105Hz$
Need $f_s \leq (128)(105Hz) \leq 13.44kHz$