Student Name: Student Number:

University of Toronto
Faculty of Applied Science and Engineering

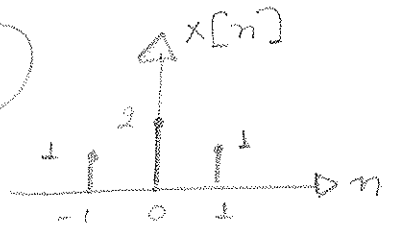
QUIZ 1
ECE431, Digital Signal Processing
September 29, 2011, 10:15-11:00 am, GB412
Examiner: D. Hatzinakos

Exam type A
Calculators are allowed

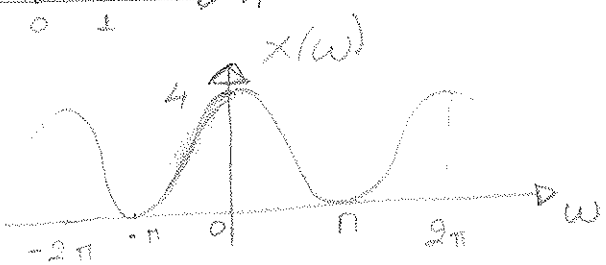
Problem 1. (2.5 points)
Consider the discrete signal $x[n] = \delta[n+1] + 2\delta[n] + \delta[n-1]$, $n = 0, \pm 1, \pm 2, \ldots$

- Calculate and draw the DTFT, $X(\omega)$, for this signal.
- Calculate and draw the 3-DFT, $X[k], k = 0,1,2$
- Do you think that the 3-DFT is a good representation of the DTFT for this signal?

(1)

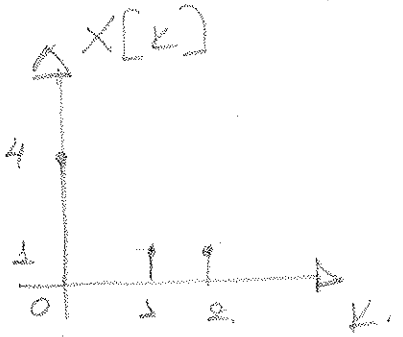


$$X(\omega) = e^{j\omega} + 2 + e^{-j\omega} = 2(1 + \cos\omega)$$



(2) 3-DFT

$$X[k] = X\left(\omega = \frac{2\pi k}{3}\right) = 2\left(1 + \cos\frac{2\pi k}{3}\right), \quad k = 0, 1, 2$$



(3) The 3-DFT is sufficient to recover $x[n]$ since there is no time-aliasing. However, visually it is not a good representation of $X(\omega)$

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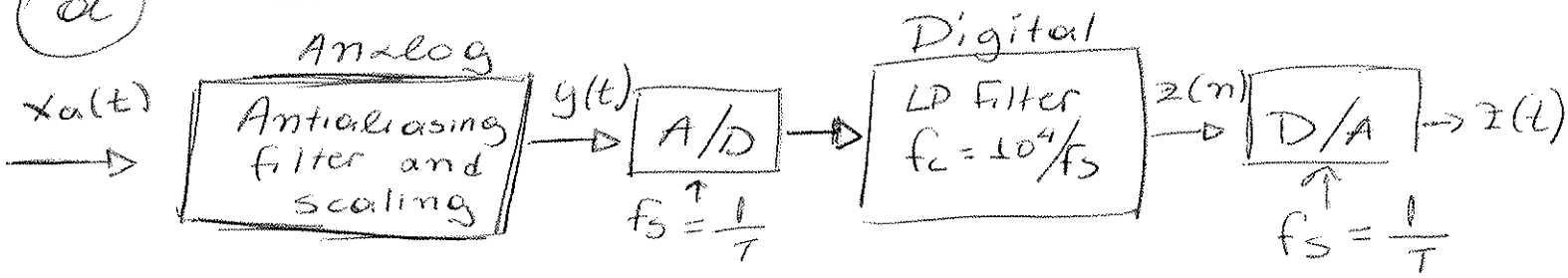
PROBLEM 2. (2.5 points)
UT electronics wants to develop a filter that could be used in analog applications, but is implemented digitally. The filter is to operate on signals that have a 10 kHz bandwidth, and will serve as a lowpass filter.

a) What is the block diagram for this filter? Explicitly denote which components are analog, which are digital, and which interface between analog and digital domains.
b) What sampling rate must be used? How many bits must be used in the A/D converter for the acquired signal's Signal to Noise Ratio (SNR) to be at least 60 dB?

a



b

Assuming that 10 KHz is the two-sided bandwidth of the analog signal, the chosen sampling frequency should be chosen 2-3 times greater i.e, $f_s > 10$ kHz (2-3 times)
[Note: Antialiasing filters are not ideal]

Assuming that the analog signal has been properly scaled to "fit" well the dynamic range of the quantizer in the A/D section, and assuming that b bits are used for binary representation of the signal values, then

$$SNR \simeq 6.02b + 10.8\,dB \geq 60\,dB$$

$$b \geq \frac{49.2}{6.02}$$

$$\Rightarrow b \geq 9$$