Tutorial 2 EE4C5

Q1

How many bits are needed in an A/D converter if we want a signal-to-quantization noise ratio of at least 90 dB? Assume that $x_a(t)$ is gaussian with a variance σ_x^2, and that the range of the quantizer extends from $-3\sigma_x$ to $3\sigma_x$; that is, $X_{\max} = 3\sigma_x$ (with this value for $X_{\max}$, only about one out of every 1000 samples will exceed the quantizer range).

[Hint: we derived eq134 of Chapter 4 in O&S. Look at eq135 for the SNR of a (B+1)-bit uniform quantiser]

[Answer = 16bits]

Q2

An image is to be sampled with a signal-to-quantization noise ratio of at least 80 dB. Unlike many other signals, the image samples are nonnegative. Assume that the sampling device is calibrated so that the sampled image intensities fall within the range from 0 to 1. How many bits are needed to achieve the desired signal-to-quantization noise ratio?

[Hint – need to think about X_{max} here since values are non-negative. You need to make a useful engineering assumption]

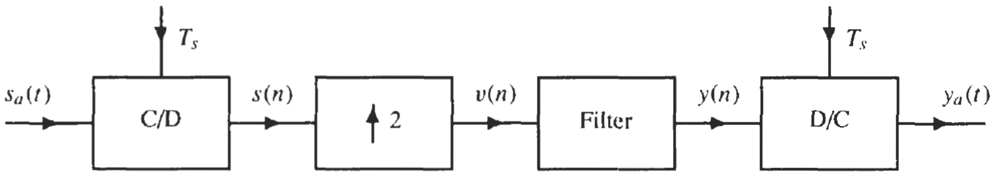
[Answer = 14bits]

Q3. [note for part b, consider what the unit sample response is of this filter. Part c is more challenging]

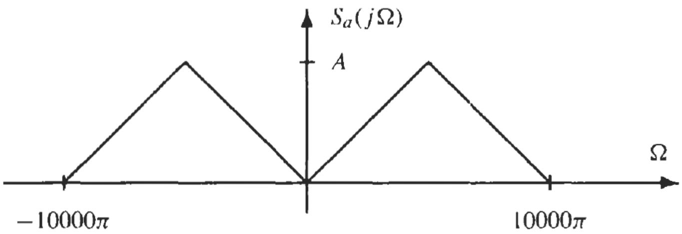
Suppose that we would like to slow a segment of speech to one-half its normal speed. The speech signal $s_a(t)$ is assumed to have no energy outside of 5 kHz, and is sampled at a rate of 10 kHz, yielding the sequence

$$s(n) = s_a(nT_s)$$

The following system is proposed to create the slowed-down speech signal.



Assume that $S_a(j\Omega)$ is as shown in the following figure:



(*a*) Find the spectrum of $v(n)$.

(*b*) Suppose that the discrete-time filter is described by the difference equation

$$y(n) = v(n) + \tfrac{1}{2}[v(n-1) + v(n+1)]$$

Find the frequency response of the filter and describe its effect on $v(n)$.

(*c*) What is $Y_a(j\Omega)$ in terms of $X_a(j\Omega)$? Does $y_a(t)$ correspond to slowed-down speech?