H.W #10

6.2-5 – We have 10 ECG signals, each of bandwidth 100 Hz.

– Sampling Rate = 2 (Nyquist Rate)

$$f_s = 2(2 \times 100) = 400 \text{ Hz}.$$

– Maximum error in sample amplitude is 0.25%

so $\frac{\Delta v}{2} \leq \frac{0.25}{100} m_p$

$$\frac{m_p}{L} \leq \frac{0.25}{100} m_p$$

so $L \geq 400 \Rightarrow L_{min} = 512$

$\Rightarrow n = 9$ bits/sample

– Thus, the data Rate of the ten signals is $R_{TDM} = 10 \times 9 \times 400 = 36$ kbps

– The minimum transmission bandwidth is

$$(B_{TDM})_{min} = \frac{R_{TDM}}{2} = 18 \text{ kHz}.$$

6.2-6 For sinusoidal signal and Assume that the peak amplitude of the quantizer is equal to the peak amplitude of the signal, we have the power of the signal

$\widetilde{m^2(t)} = \frac{1}{2} m_p^2 \rightarrow$ for sinusoidal signal

$$\Rightarrow \frac{\widetilde{m^2(t)}}{m_p^2} = \frac{1}{2}$$

$\therefore SNR = 3L^2 \frac{\widetilde{m^2(t)}}{m_p^2} = \frac{3}{2} L^2 = 47 \text{ dB}$

– Convert the dB scale to Linear scale, we have

$$SNR = \frac{3}{2} L^2 = 10^{47/10} = 50118.7$$

so $L = \sqrt{\frac{2}{3} \times 50118.7} = 182.8$

Since L must be a power of two,

$L_{min} = 256$

and the $SNR = \frac{3}{2} \cdot L^2 = 98304$

$= 49.9\ dB$

$\boxed{6.2\text{-}8}$ For μ-law compander

$$SNR \simeq \frac{3L^2}{[\ln(1+\mu)]^2}$$

So, at $\mu = 100$ and $SNR = 45 dB = 31622.78$

$$\Rightarrow L = \ln(1+\mu)\sqrt{\frac{SNR}{3}}$$

$$= \ln(101)\sqrt{\frac{31622.78}{3}} = 473.83$$

So $L_{min} = 512$

and the corresponding SNR is

$$SNR \simeq \frac{3[512]^2}{[\ln(101)]^2} = 45.67\ dB$$

P3
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3.1.7 SNR = 50 dB is the ratio of 10^5

From Eq. (3.10)

$$\frac{S_o}{N_o} = 10^5 = \frac{3L^2}{[\ln(1+\mu)]^2} \quad \frac{3L^2}{(\ln 256)^2} = \frac{3L^2}{30.75}$$

and $L = \sqrt{\frac{(10^5)\times(30.75)}{3}} = 1012.4$

choose $L = 1024 = 2^{10}$

6.2-9 (a) Nyquist rate : $f_{Nyq} = 2\times10^6$ Hz.

Sampling rate : $f = 1.5 f_{Nyq} = 3\times10^6$ Hz

$L = 256$ and $\mu = 255$

From Eq. (3.10)

$$\frac{S_o}{N_o} = \frac{3L^2}{(\ln 256)^2} = \frac{(3)(256)^2}{30.75} = 6394 = 38.06 \text{ dB}$$

(b) If the sampling rate is reduced, we can increase the value of L correspondingly and yet maintain the same transmission rate. For 3×10^6 samples/sec with 8 bits/sample, we transmit $8\times3\times10^6 = 24\times10^6$ bits/sec .. The new sampling rate is $1.2\times2\times10^6 = 2.4\times10^6$. Hence we can use $(24\times10^6)/(2.4\times10^6) = 10$ bits/sample or $L = 1024$

Hence, the SNR is : $\frac{S_o}{N_o} = \frac{3\times(1024)^2}{[\ln(256)]^2} = 102300 = 50.1$ dB

This is more than 10 dB above the previous SNR. Thus, this value of L meets the specifications.

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