Q1 A continous signal $8\sin(8\pi \times 10^3 t)$ is passed through a Delta modulator whose pulse rate is 4000 pulses/sec. Find the optimal step size (Δ_{opt})?

Sol^n

Given,

$$f_s = 4000 \text{ pulses/sec}$$

$$m(t) = 8\sin(8\pi \times 10^3 t)$$

$$A_m = 8$$

$$f_m = 4\text{kHz}$$

we know the relation :- $\frac{\Delta_{opt}}{T_s} = 2\pi f_m A_m$

For DM, pulse rate = Sampling Rate ($\because n=1$)

$$f_s = \frac{1}{T_s} = 4000 \text{ Samples/sec}$$

$$\therefore \quad \Delta_{opt} \times 4000 = 2\pi \times 4k \times 8$$

$$\Delta_{opt} = 16\pi \text{ Volts}$$

Q2 An analog signal $m(t) = 10t$ is passed through a Delta modulator whose bit rate = 1 kbps. Find optimal step size?

Sol^n

$$m(t) = 10t \quad , \quad R_b = 1 \text{ kbps}$$

Since given $m(t)$ is not sinusoidal so,

$$\frac{d}{dt} m(t) = \frac{\Delta_{opt}}{T_s}.$$

$\Downarrow$

slope of $m(t)$

$$\frac{d}{dt}(10t) = \Delta_{opt} \times 1000 \qquad \left(\because R_b = \frac{1}{T_s} \text{ for DM}, \therefore n = 1\right)$$

$$\Delta_{opt} = 10\,mV.$$

Q3 A sinusoidal msg signal of frequency, f_m and amplitude, A_m is passed through a DM whose step size is $0.628V$. Sampling rate is given by 40000 samples/sec. Find A_m & f_m, given DM will incur slope overload error?

Soln

Given, $\Delta = 0.628V$

$f_s = 40000$ samples/sec

Now, $\frac{\Delta}{T_s} = 0.628 \times 40000 = 25120$

$$\frac{\Delta_{opt}}{T_s} = 2\pi f_m A_m$$

For slope overload error to occur: $\frac{\Delta}{T_s} < \left(\frac{\Delta_{opt}}{T_s} = 2\pi f_m A_m\right)$

So, for $A_m = 2V$, $f_m = 2.5 kHz$

$$2\pi f_m A_m = 31415.925$$

Hence, we can say that for $A_m = 2V$, $f_m = 2.5 kHz$ the condition of SQE is fulfilled.

Q4 A message signal of peak to peak voltage 1.536V is passed through PCM system having 128 quantization levels. Find Quantization noise power.

Soln

$$V_{pp} = 1.536V$$

$$L = 128 = 2^n \Rightarrow n = 7$$

$$\text{Noise power } (N_q) = \frac{\Delta^2}{12} = \frac{1}{2}\left[\frac{1.536}{128}\right]^2$$

$$= 12 \mu W$$

Q5 A message signal Band limited to 4 kHz is transmitted through 256 levels PCM system. Find transmission B.W. of the system??

Soln

$f_m = 4k$

$L = 256, \Rightarrow n = 8$

$f_s = 2f_m = 8k$

$B.W = \frac{n f_s}{2} = \frac{8 \times 8k}{2}$

$B.W = 32k$

Q6 A message signal sampled at 8k is transmitted through a 512 level PCM system. Find $(SQNR)_{dB}$.

Soln

Given,

$f_s = 8k \Rightarrow f_m = 4k \quad (\because f_s = 2f_m)$

$L = 512 \Rightarrow n = 9 \quad (\because L = 2^n)$

$(SQNR)_{dB} = 1.8 + 6n$

$= 1.8 + 54$

$= 55.8 \text{ dB}.$

Q7 For a PCM System having Bit rate of 108 bits/sec, the no. of quantization levels are 256. Find the maximum frequency of the signal allowed by the PCM System?

Sol^n

$$R_b = 10^8 \text{ bits/sec.}$$

$$L = 256 \Rightarrow n = 8$$

$$B.W. = \frac{nf_s}{2} = \frac{R_b}{2}$$

$$\frac{10^8}{2} = \frac{8 \times 2f_m}{2}$$

$$f_m = \frac{10^8}{16}$$

$$f_m = 6.25 \text{ MHz}$$

Q8 A message signal of $m(t) = 6\cos 2000\pi t + 2\cos 4000\pi t$ is passed through DM whose pulse rate is 5000 pulses/sec. Find minimum value of Step size (Δ) required to Overcome Slope overload Error.

Sol^n

$$m(t) = 6\cos 2000\pi t + 2\cos 4000\pi t$$
$$= A_{m_1}\cos 2\pi f_{m_1} t + A_{m_2}\cos 2\pi f_{m_2} t$$

It is a multi-tone signal.

$Am_1 = 6$ $\quad$ $Am_2 = 2$

$fm_1 = 1000Hz$ $\quad$ $fm_2 = 2000Hz$

$$\frac{\Delta_1}{T_s} = 2\pi fm_1 Am_1 \qquad \frac{\Delta_2}{T_s} = 2\pi fm_2 Am_2$$

$$\frac{\Delta_1}{T_s} = 2\pi \times 1000 \times 6 \qquad \frac{\Delta_2}{T_s} = 2\pi \times 2000 \times 2$$

$$\Delta_1 \times 5000 = 2\pi \times 6000 \qquad \Delta_2 \times 5000 = 2\pi \times 2000$$

$$\Delta_1 = \frac{12\pi}{5} = 7.5V \qquad \Delta_2 = \frac{8\pi}{5} = 5.03V$$

Minimum Step Size required to overcome SQE is given by $\max\{\Delta_1, \Delta_2\}$

So $\underline{\Delta = 7.52V}$.

Minimum Step Size required to overcome Granular Error(GE) is given by $\min\{\Delta_1, \Delta_2\} = \underline{5.03\ V}$.