☆ Noise Analysis of Digital Communication:

* Quantization Noise:

⇒ In PCM system input to the LPF is the sampled signals with quantization error. Due to this error in each sample signal distortion occurs and this distortion is called as the quantization noise. So, the quantization error should be as minimum as possible.

⇒ Quantization error depends on the step size.

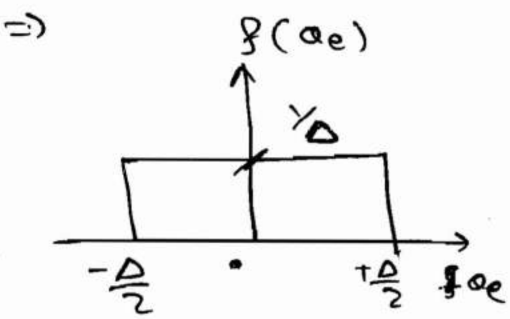
⇒ Assume that the input is a sinusoidal signal

$$m(t) = A_m . \cos 2\pi f_m t.$$

$$\& \quad P = \frac{A_m^2}{2} \ (W).$$

⇒ The noise occur due to the quantization error. so, the mean square value of the quantization error represents the quantization noise power.

⇒



Quantization noise power

$$= \int a_e^2 . f(a_e)\, da_e.$$

∴ Quantization noise power

$$= \int_{-\frac{\Delta}{2}}^{+\frac{\Delta}{2}} a_e^2 . \left(\frac{1}{\Delta}\right)^2 . da_e.$$

$$= \frac{2}{\Delta^2} \times \left[\frac{a_e^3}{3}\right]_0^{\frac{\Delta}{2}}.$$

$$= \frac{2}{\Delta^2} \times \frac{\Delta^3}{48 \times 3}$$

$$= \frac{\Delta^2}{\quad}$$

$$\therefore \boxed{\text{Quantization noise power} = \frac{\Delta^2}{12}}$$

$$\Rightarrow \quad SQNR = \frac{P_{si}}{P_{QN}} = \frac{\frac{A_m^2}{2}}{\frac{\Delta^2}{12}} = \frac{6A_m^2}{\Delta^2 \times \cancel{8}}.$$

But $\Delta = \frac{V_{p-p}}{L} = \frac{2A_m}{L}$.

$$\therefore \quad SQNR = \frac{\cancel{A_m^2}}{4\cancel{A_m^2}} \times \frac{L^2}{\cancel{8}} \times 6$$

IMP

$$\boxed{\begin{array}{l} (SQNR)_{dB} = (\alpha + 6n)\ dB. \\ \alpha = 1.8 \text{ for uncompressed} \\ \alpha = 10\log_{10} C \text{ for Compressed.} \\ \rightarrow C = \frac{3}{[\ln[1+\mu]]^2} \end{array}}$$

$$SQNR = 3/2\ L^2$$

$$L = 2^n.$$

$$\therefore \boxed{SQNR = \frac{3}{2} \times 2^{2n}.}$$

$$\therefore (SQNR)_{dB} = 10\log\left[\frac{3}{2} \times 2^{2n}\right] = 10\log 3/2 + 10\log 2^{2n}$$

$$= 1.76 + 20n\log 2$$

$$= 1.76 + 6n.$$

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

$\Rightarrow$ $n = 2 \Rightarrow 13.8$ dB. } 6 dB / bit.

$n = 3 \rightarrow 19.8$ dB. } 6 dB / bit.

$n = 4 \rightarrow 25.8$ dB.

IMP

$\Rightarrow$ As n increases, the Δ decreases and the quantization noise power also decreases. So, the signal to noise ratio increases and the improvement in the

Q In a PCM system the code length is increased from 6 to 8 bits. The quantization power is decreases by a factor of (A) 2 (B) 2 (C) 8 (D) 16.

Sol^n:

$n = 6 \Rightarrow \Delta \Rightarrow P_{qn} = \frac{\Delta^2}{12}$.

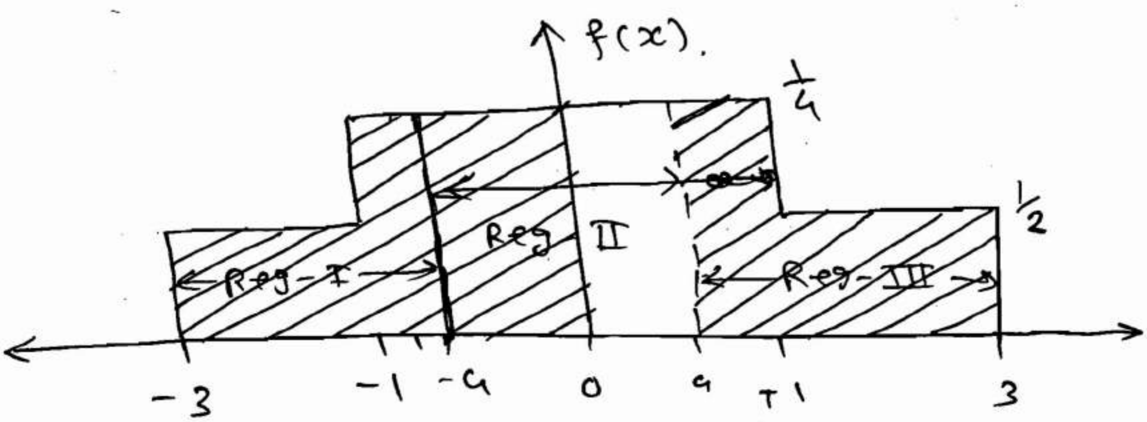
$n = 7 \Rightarrow \frac{\Delta}{2} \Rightarrow P_{qn} = \frac{\Delta^2}{4 \times 12}$.

$n = 8 \Rightarrow \frac{\Delta}{4} \Rightarrow P_{qn} = \frac{\Delta^2}{16 \times 12}$.

So, ans is (D) 16

Q Gate-2005 Linked Type Question

A 3 level quantizer is design assuming the equiprobable occurance of all the 3 quantization levels. The pdf is divided into 3 region as shown in fig.



Q-1 Determine the value of of the a in the above figure.

Q-2 Determine P ... sol^n -a to +a

$\underline{\underline{\text{Sol}^n}}$: ① ~~A~~ Total area = 1.

⇒ All three region i.e Reg- I, Reg- II and Reg - III are eauiprobable.

So, Area of each region is $1/3$.

∴ Area of Reg- II $= 1/3$.

$$\therefore \cancel{2}a \times \frac{1}{\cancel{4}\,2} = \frac{1}{3}$$

$$\therefore \boxed{a = 2/3}$$

②

$$P_{on} = \int_{-a}^{a} x^2 . f(x) . dx$$

$$= \int_{-2/3}^{2/3} \frac{1}{4} . x^2 . dx.$$

$$= \frac{2}{4} \times \left[\frac{x^3}{3}\right]_0^{2/3}.$$

$$= \frac{1}{\cancel{2}} \times \frac{\cancel{8}\,4}{3 \times 9 \times 3}$$

$$\boxed{P_{on} = \frac{4}{81} \text{ W.}}$$