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GATE 2024

प्रचण्ड Batch

COMMUNICATION

QUESTIONS FROM QUANTIZER

TIME- 9:00PM

RENU SIR

Chapter-2

Digital Communications

In today's lecture we will cover the following Topis :

1. *Questions from Quantizer in PCM*

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EXAM TARGET	SUBJECT	TIME	FACULTY
ALL PSUs	ENGINEERING MATHS	11:00 AM	ANANT SIR
GATE 2024-25	NETWORK THEORY	6:00 PM	RAVI SIR
GATE 2024-25	ELECTRICAL MACHINE	7:30 PM	SANTAN SIR
GATE 2024-25	COMMUNICATION	9:00 PM	RENU SIR

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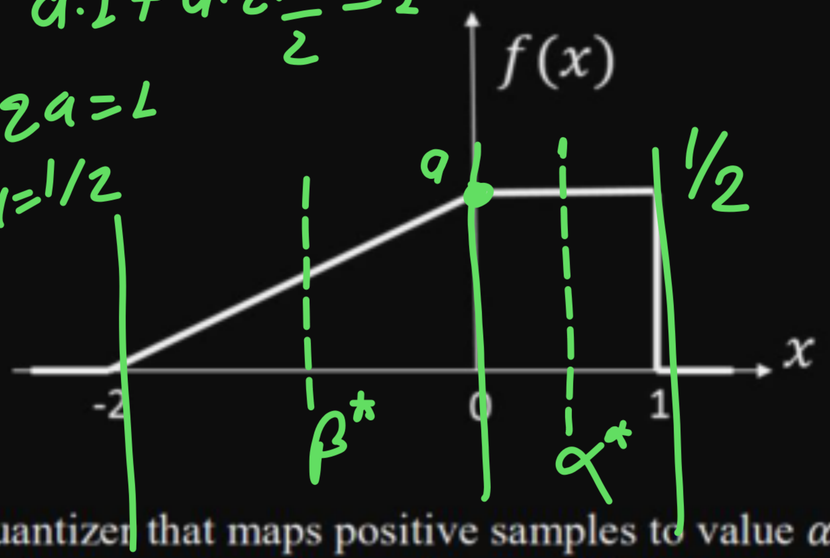
NETWORK THEORY	SATURDAY Live @11AM	RAVI SIR
COMMUNICATION	WEDNESDAY Live @8PM	RENU SIR
ANALOG ELECTRONICS	THURSDAY Live @8PM	LAWRENCE SIR
ENGINEERING MATHEMATICS	FRIDAY Live @11AM	ANANT SIR
ELECTRICAL MACHINE	MONDAY Live @8PM	SANTAN SIR

GATE-22

Consider a real valued source whose samples are independent and identically distributed random variables with the probability density function, $f(x)$, as shown in the figure.

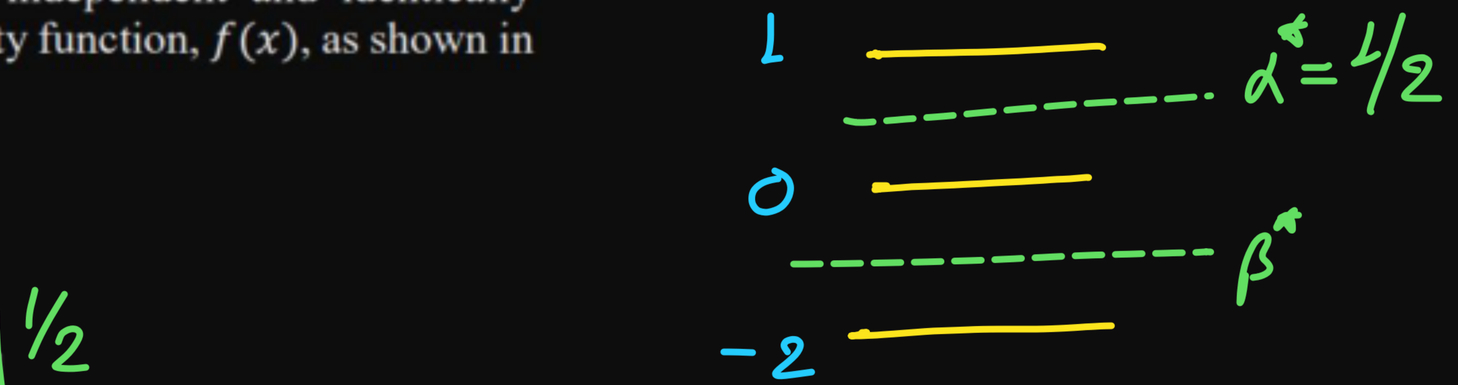


$a \cdot 1 + a \cdot 2 \cdot \frac{1}{2} = 1$

$2a = 1$

$a = 1/2$

Consider a 1 bit quantizer that maps positive samples to value α and others to value β. If α^* and β^* are the respective choices for α and β that minimize the mean square quantization error, then $(\alpha^* - \beta^*) =$ _____ *(rounded off to two decimal places)*.



$\alpha^* = \frac{0+1}{2} = \frac{1}{2}$

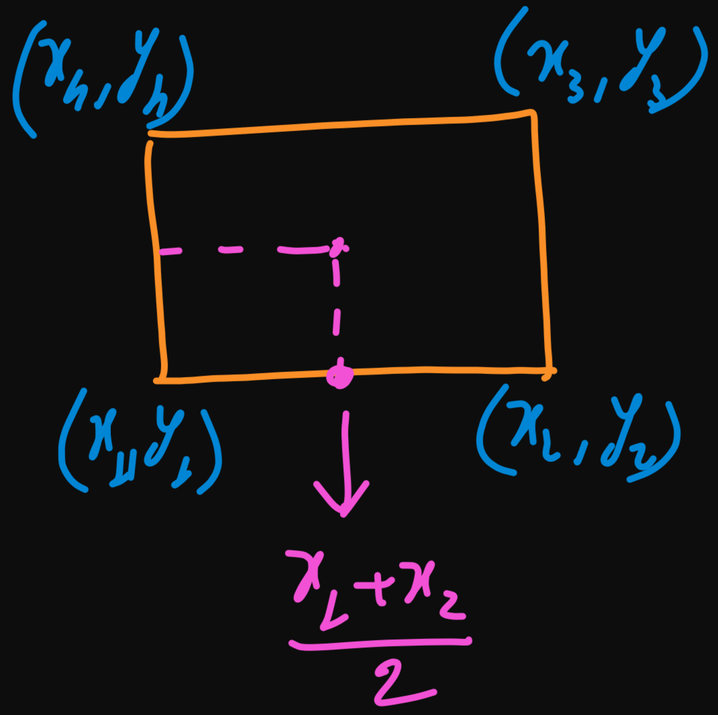
$\beta^* = \frac{\int_{-2}^{0} x f(x)\,dx}{\int_{-2}^{0} f(x)\,dx}$ = (centroid

$\beta^* = \frac{0+0-2}{3} = \frac{-2}{3}$

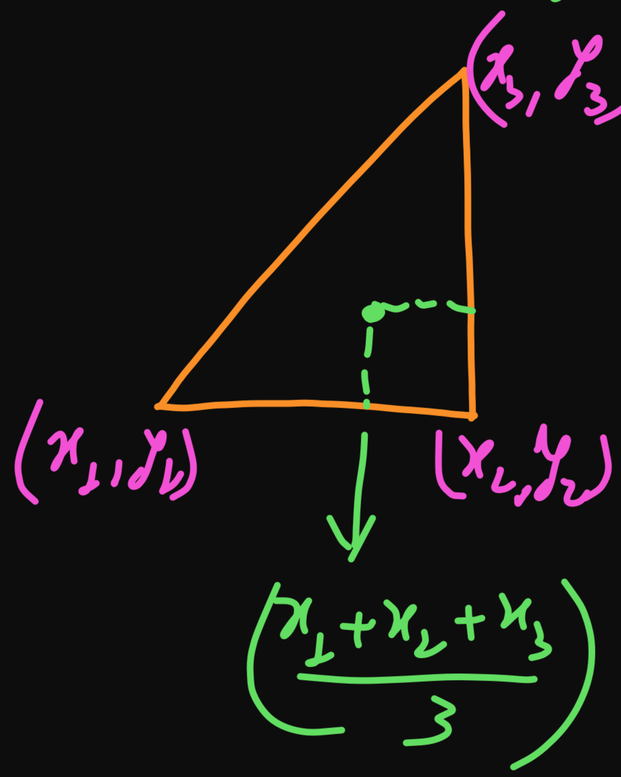
$\alpha^* - \beta^* = \frac{1}{2} - \left(\frac{-2}{3}\right)$

$= \frac{1}{2} + \frac{2}{3} = 7/6$

Centroid of Rectangle:



Centroid of triangle

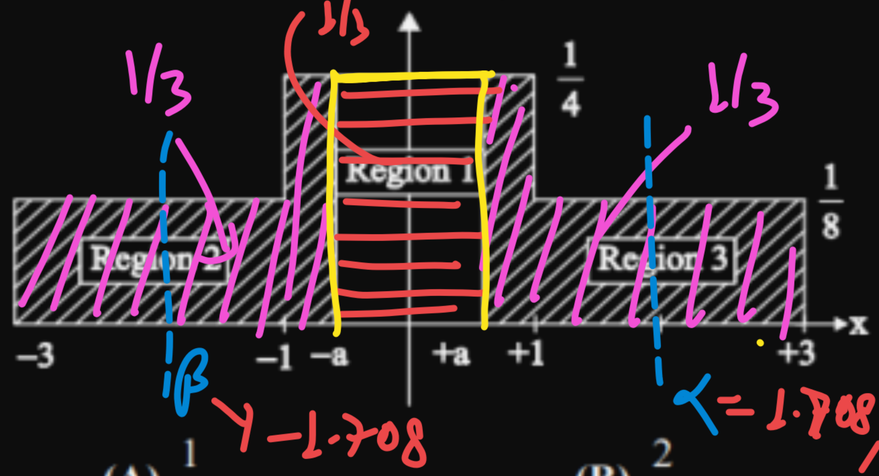


Common Data for the Next Two Questions :

A symmetric three-level midtread quantizer is to be designed assuming equiprobable occurrence of all quantization levels.

[GATE - EC - 2005]

47. If the input probability density function is divided into three regions as shown in figure, the value of 'a' in the figure is :



(A) $\frac{1}{3}$ (B) $\frac{2}{3}$

(C) $\frac{1}{2}$ (D) $\frac{1}{4}$

[GATE - EC - 2005]

48. The quantization noise power for the quantization region between $-a$ and $+a$ in the figure is :

(A) $\frac{4}{81}$ (B) $\frac{1}{9}$

(C) $\frac{5}{81}$ (D) $\frac{2}{81}$

47 $2a \times \frac{1}{4} = \frac{1}{3}$

$q = \frac{2}{3}$

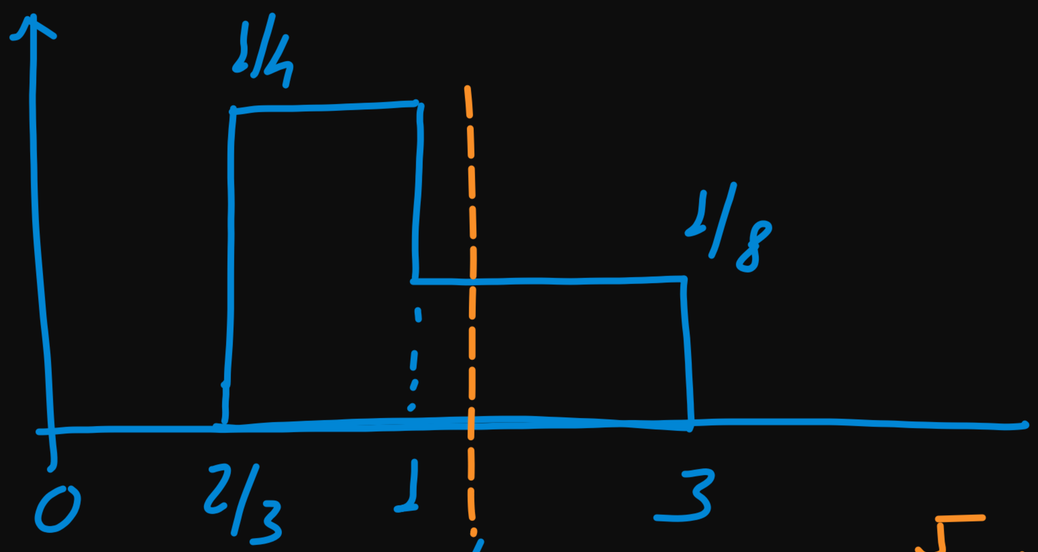
48

Noise Power $(-a \text{ to } +a)$

$= \frac{\Delta^2}{12} \times \text{Avg}$

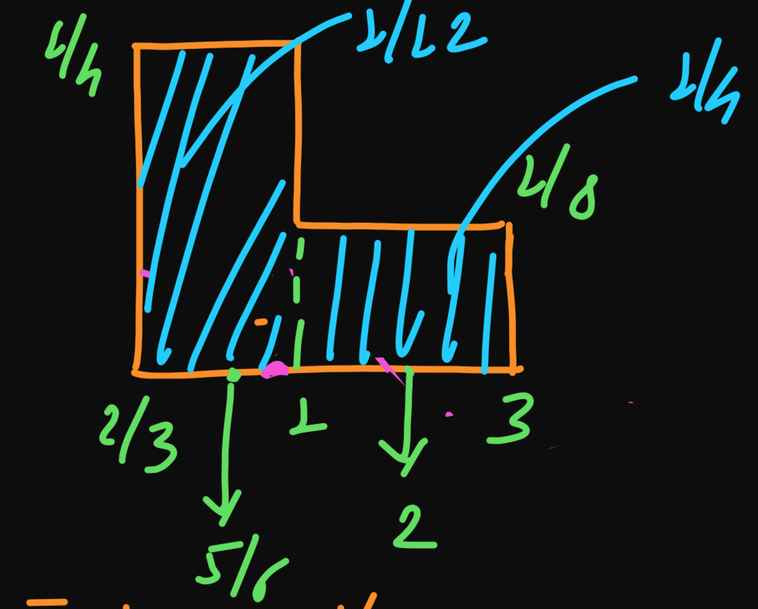
$= \frac{(4/3)^2}{12} \times \frac{1}{3}$

$= \frac{16}{12} \times \frac{1}{27} = \frac{4}{81}$



$\frac{1+\frac{2}{3}}{2} = \frac{5/3}{2} = \frac{5}{6}$

$\frac{1}{3} \times \frac{1}{5}$



$\alpha = 1.708 = \frac{5}{24} + \frac{3 \times 11}{2 \times 12} = \frac{41}{24}$

$\alpha = \frac{\frac{5}{8} \times \frac{1}{12} + 2 \times 1/4}{1/12 + 1/4} = 1.708$

(i) $\int_{2/3}^{3} (x - \alpha) f(x)\, dx = 0$

(ii) $\alpha = \frac{2 \int_{1/3}^{3} x f(x)\, dx}{\int_{1/3}^{3} f(x)\, dx} = \frac{\int_{2/3}^{1} x \cdot \frac{1}{4}\, dx + \int_{1}^{3} x \frac{1}{8}\, dx}{1/3}$

$= \frac{\frac{1}{4} \times \frac{x^2}{2}\Big|_{2/3}^{1} + \frac{1}{8} \frac{x^2}{2}\Big|_{1}^{3}}{} =$

$= \frac{3}{8}\left(1 - \frac{4}{9}\right) + \frac{3}{16}(9 - 1) = \frac{3}{8} \times \frac{5}{9} + \frac{3}{2}$

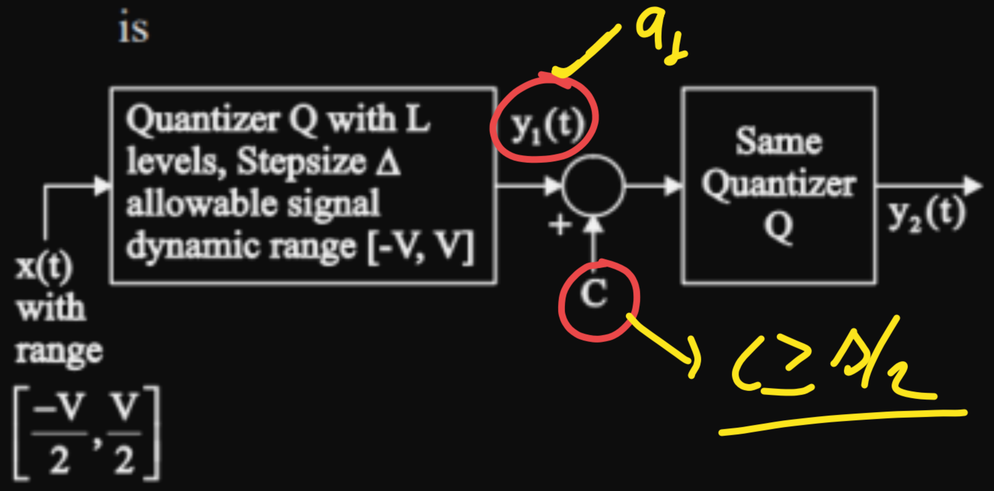
Quantization noise power for $+a$ to 3.

$$\text{M.P.}\Big|_{+a \text{ to } +3} = \int_{+2/3}^{+3} (x-a)^2 f(x)\,dx = \int_{+2/3}^{1} (x-1.708)^2 \cdot \frac{1}{4}\,dx + \int_{+1}^{+3} (x-1.708)^2 \frac{1}{8}\,dx$$

$$=$$

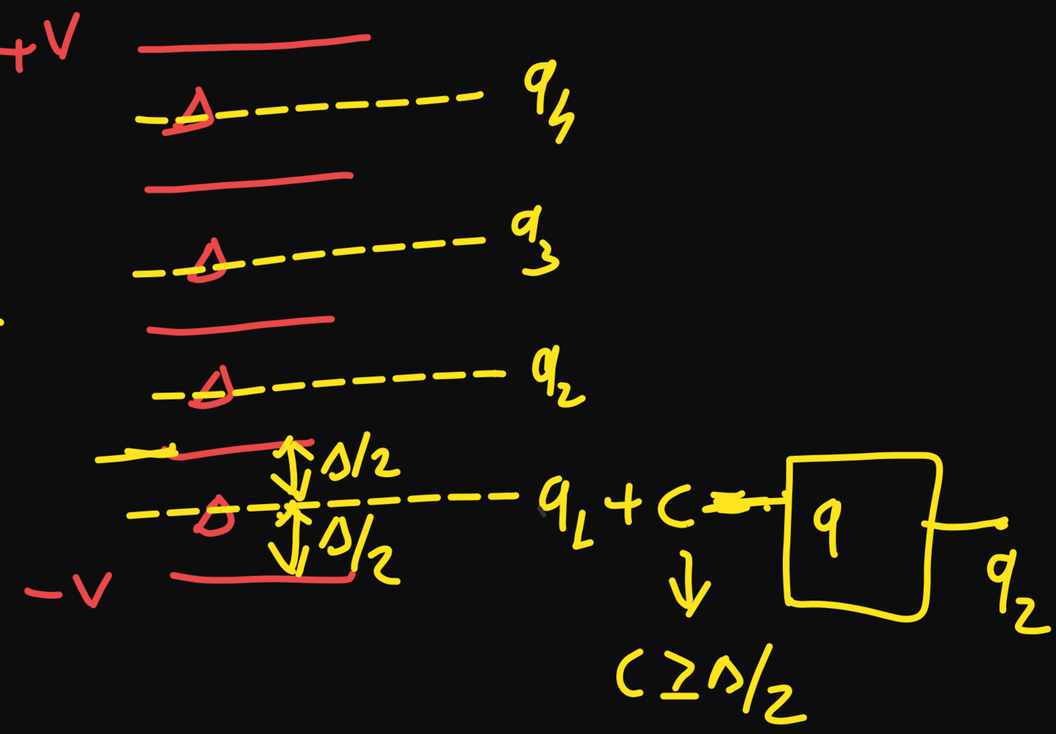
[GATE - EC - 2006]

50. In the following figure the minimum value of the constant "C", which is to be added to $y_1(t)$ such that $y_1(t)$ and $y_2(t)$ are different, is



$V_{max} = +V/2$

$V_{min} = -V/2$



(A) Δ

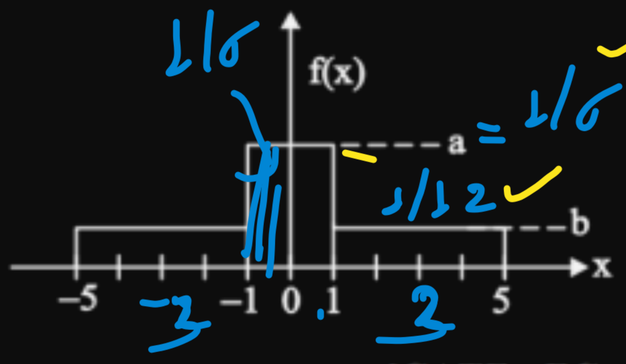
(B) $\frac{\Delta}{2}$

(C) $\frac{\Delta^2}{12}$

(D) $\frac{\Delta}{L}$

Statement for Linked Answer Question for Next Two Questions :

An input to a 6-level quantizer has the probability density function f(x) as shown in the figure. Decision boundaries of the quantizer are chosen so as to maximize the entropy of the quantizer output. It is given that 3 consecutive decision boundaries are '-1', '0' and '1'.



[GATE - EC - 2007]

54. The values of a and b are

(A) a = 1/6 and b = 1/12

(B) a = 1/5 and b = 3/40

(C) a = 1/4 and b = 1/16

(D) a = 1/3 and b = 1/24

[GATE - EC - 2007]

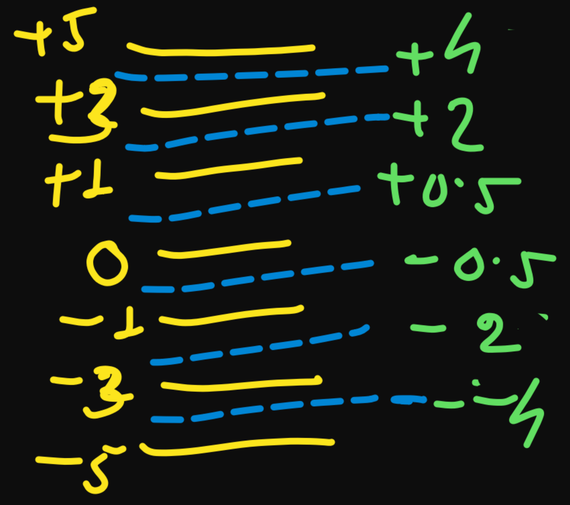
55. Assuming that the reconstruction levels of the quantizer are the mid-points of the decision boundaries, the ratio of signal power to quantization noise power is

(A) $\frac{152}{9}$

(B) $\frac{64}{3}$

(C) $\frac{76}{3}$

(D) 28



$$\text{Signal Power} = S = \int_{-5}^{5} x^2 f(x)\,dx = \int_{-5}^{-1} x^2 \frac{1}{12}\,dx + \int_{-1}^{1} x^2 \frac{1}{6}\,dx + \int_{1}^{5} x^2 \frac{1}{12}\,dx$$

$S = ?$

$$\frac{S}{M} = \checkmark$$

$$\int_{-5}^{-1} x^2 \frac{1}{12}\,dx \neq \int_{-5}^{-3} x^2 \frac{1}{12}\,dx + \int_{-3}^{-1} x^2 \frac{1}{12}\,dx$$

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