K. J. SOMAIYA COLLEGE OF ENGINEERING

(AFFILIATED TO THE UNIVERSITY OF MUMBAI)

Candidate Roll No. ____________ (In figures)

Test Exam.

Name : Basics of Digital Communication

Date : ____________ 200

Junior Supervisor's full Signature with Date

Examination : ____________ Branch/Semester ____________

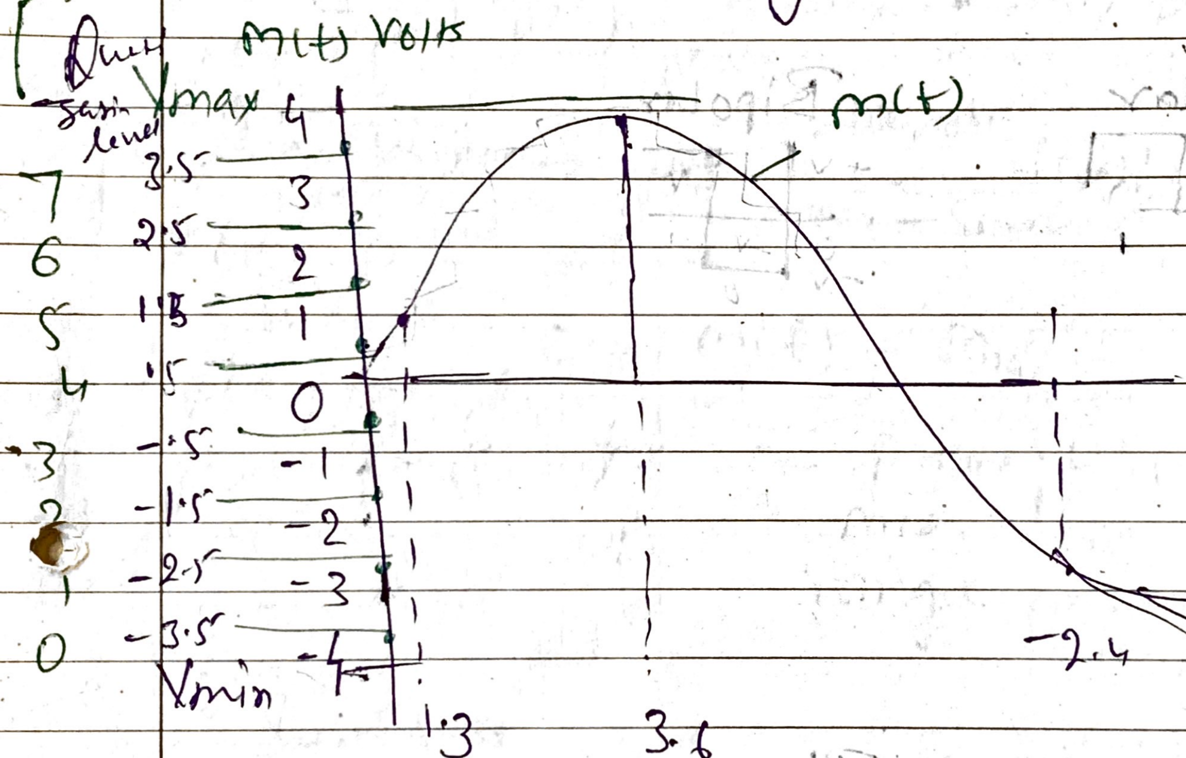
Subject : ____________

Question No.	1	2	3	4	5	6	7	8	9	10	11	12	Total
Marks Obtained													

PCM.

Digital Representation of Analog Signal:

- Sampling
- Quantization
- Encoding



Step size

$S = \frac{V_H - V_L}{2^M}$ (M = No. of levels)

M = No. of levels

a Sample Value - 1.3

b Nearest Quantization level - 1.5

c Code No. - 5

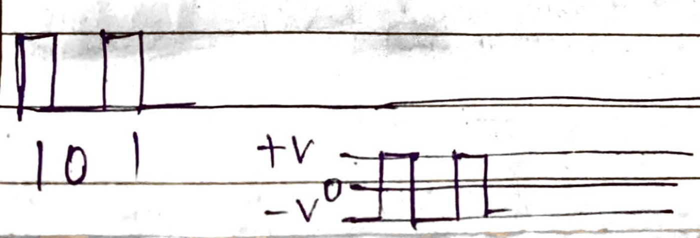
Binary representation - 101

Step size

$S = V_H - V_L$ / Quantization levels

$= \frac{V_H - V_L}{2^8} = 256.$

Electrical Representation of Binary Digits



Pulse representation

Representation for voltage level

Line Coding

Issues in Digital Transmission

(I) Power & B.W. required for transmission
(II) ability to Extract timing information
(III) Error monitoring ability
(IV) Presence of low freq. or dc Component which is unsuitable for ac coupled ckt

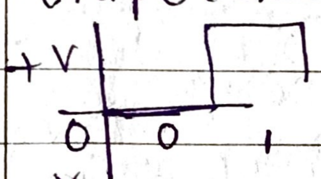
(I) Unipolar (II) Bipolar (III) ~~Biphase~~ Split Phase or Manchester Coding

(I) NRZ < NRZ-L, Mark-M, Space-S

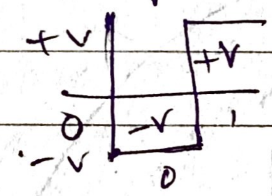
RZ <

NRZ

(I) Unipolar

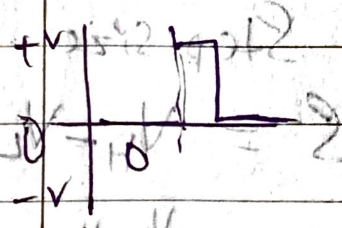


Bipolar

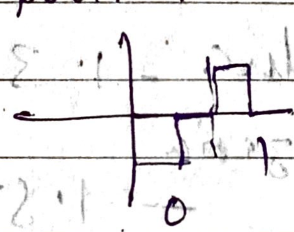


(II) RZ

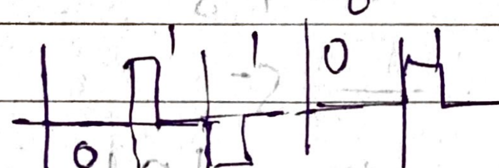
Unipolar



Bipolar RZ



AMI



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(III) Split Phase (Manchester

Quantization error

Quantized Signal and the Original Signal from which it was derived different from one another in a random manner. This difference or error may be viewed as a noise due to the Quantization process and is called quantization error.

$\therefore$ Mean Square quantization error

$e = m - m_k$

$\overline{e^2}$ Where e = diff between the Original & Quantized Signal Voltage

$$\overline{e^2} = \int_{m_1 - S/2}^{m_1 + S/2} f(m)(m - m_1)^2 \, dm$$

(Mean Square Quantization error)

$$+ \int_{m_2 - S/2}^{m_2 + S/2} f(m)(m - m_2)^2 \, dm + \dots$$

Where $e = m(t) - m_k$

error

$+S/2$

m

$-S/2$ S

& $f(m)\,dm$ = probability that $m(t)$ lies in the Voltage range $m - dm/2$ to $m + dm/2$

Substitute $x = (m - m_k)$

$$\overline{e^2} = (f^{(1)} + f^{(2)} + \dots) \int_{-S/2}^{S/2} x^2 \, dx$$

$\left[\frac{x^3}{3}\right]_{-S/2}^{S/2}$

$\frac{S^3}{24} + \frac{S^3}{24}$

$$= (f^{(1)} + f^{(2)} + \dots) \frac{S^3}{12}$$

$$\left(\underbrace{f^{(1)}(S) + f^{(2)}(S) + \dots}\right) \frac{S^2}{12}$$

$$\boxed{\overline{e^2} = \frac{S^2}{12}}$$

$f^{(1)}(S)$ is the Prob. that the Signal voltage $m(t)$ will be in first quantization range, $f^{(2)}\delta$ is the probability that m is in the second quantization range. Hence the sum of terms in the parenthesis has a value of unity.

$\therefore$ $\overline{e^2}$ = mean square quantization error is $\boxed{\overline{e^2} = \frac{\delta^2}{12}}$

No. of Quantization level:

$Q = 2^N$

where N = No. of bits/word

each sample convert to N bit code word

$\therefore$ No. of bits/sec $\boxed{\text{(Signaling rate)}}$ = No. of samples/sec $\times$ No. of bits/sample

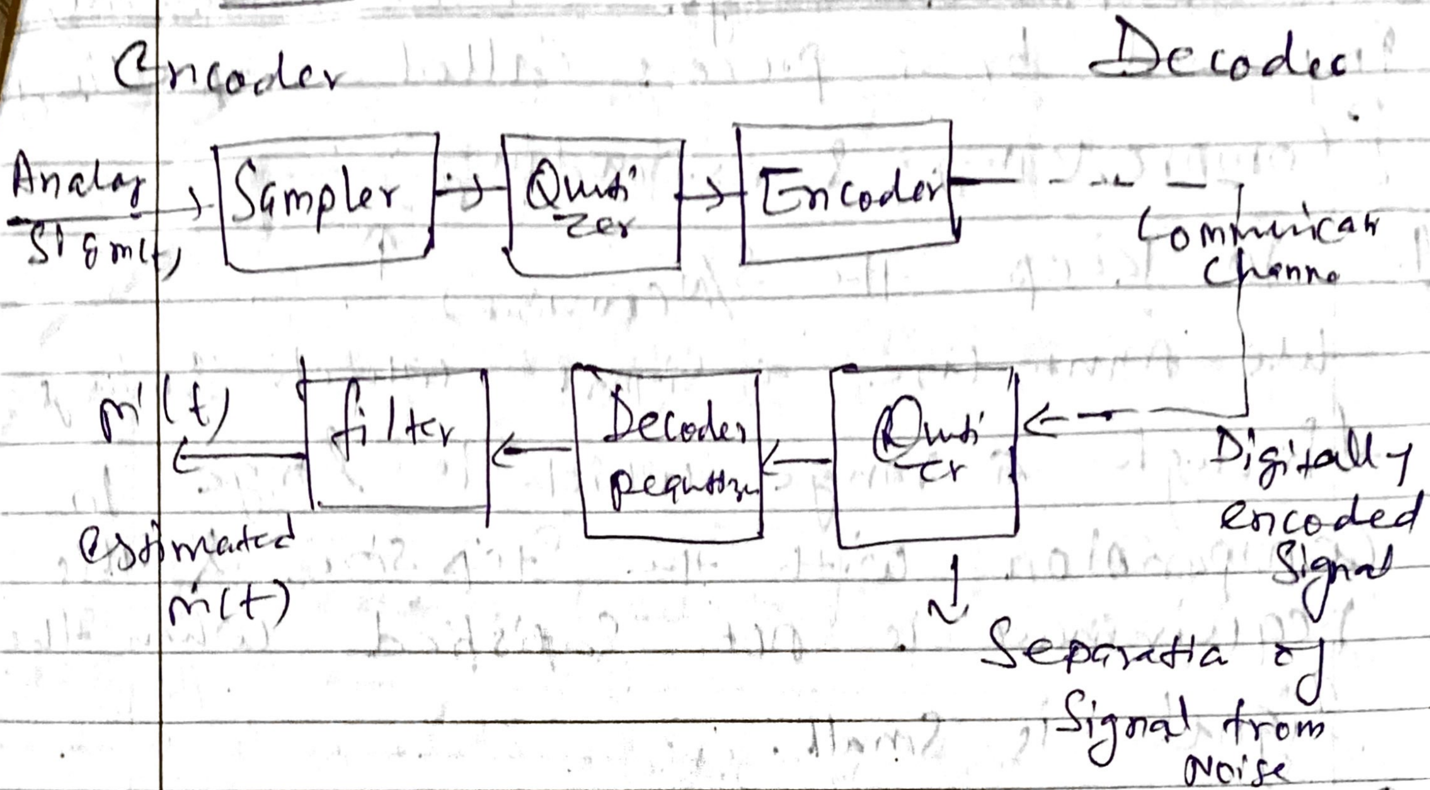
$= f_s$ (Sampling rate) $\times N$

$= \boxed{f_s \times N}$ $2f_s N$

Transmitted B.W. of PCM

$$\boxed{B.W. = \frac{1}{2} N f_s}$$

PCM



Companding

In Quantization Voltage range from V_L to V_H

1. If the Signal m(t) Should make excursion beyond the bounds V_H and V_L, Within these bounds, the instantaneous Quantization error never exceeds $\pm S/2$ while Outside these bounds the error is larger.
2. Similarly Consider a Case in which m(t) has a P to P Voltage which is less than S and never crosses one of the transition level In Such a Case $m_q(t)$ will be a fixed dc voltage & will bear no relationship to m(t) reconstruction is not Possible

$$\text{Noise } \overline{e^2} = \frac{S^2}{12}$$

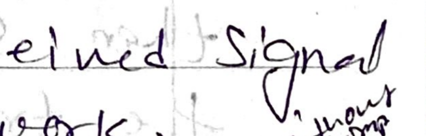
If no. of Quantization level is M then $MS = 2V$ $\quad V = \frac{MS}{2}$ - Step size

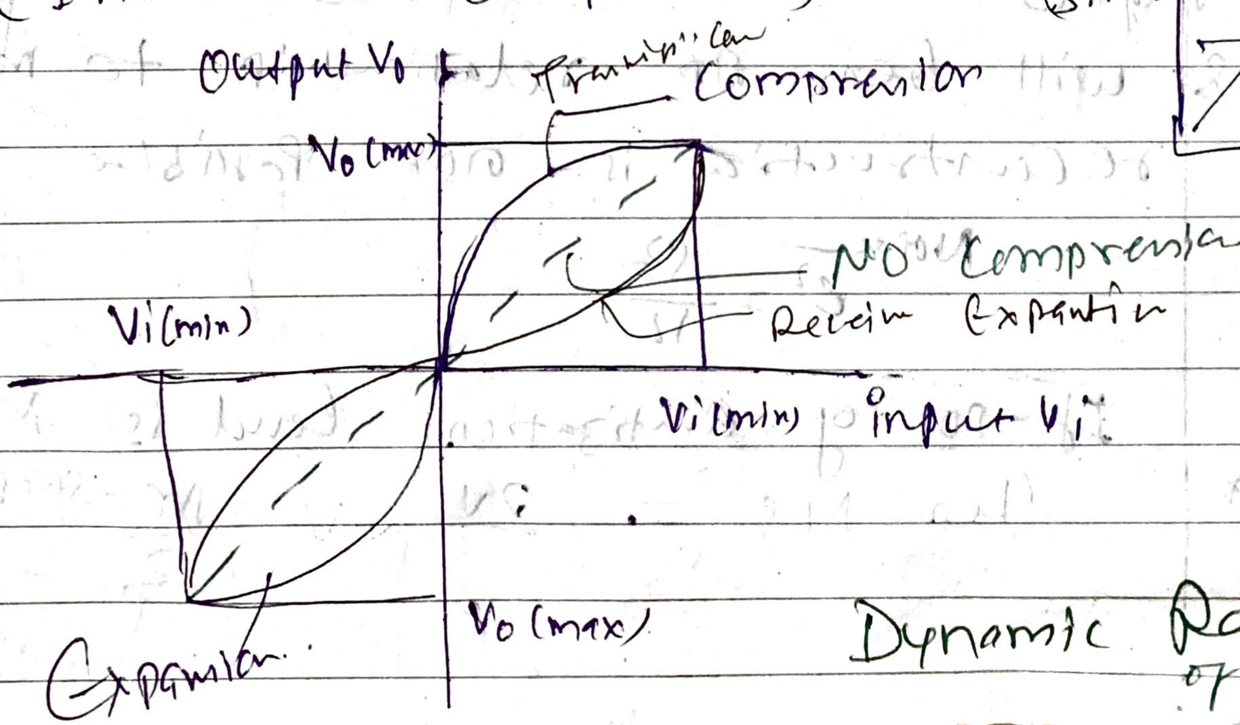
$S = \frac{2V}{M}$

The dynamic range can be materially improved by a process called Companding [Compressing & expanding)

(iii) To keep the S/N (constant)
We must use a signal which swings through a range which is large in comparision with the step size. & this requirement is not satisfied when the signal is small.

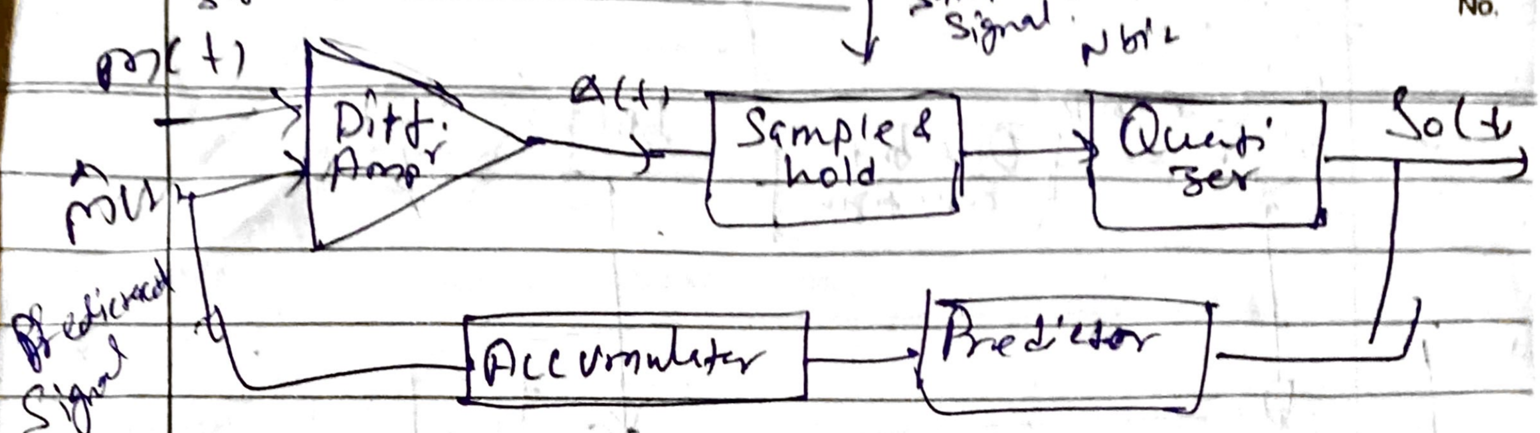
(iv) Before applying the signal to the Quantizer we pass it through a N/w which has an input O/p Characteristic as shown
[at low amplitude the slope is large than at large amplitude
A signal transmitted through such a N/w will have the extremities of its waveform compressed.
the compression produces signal distortion. To undo the distortion, at the receiver we pass the received signal through an expander network. (Inverse to compression)

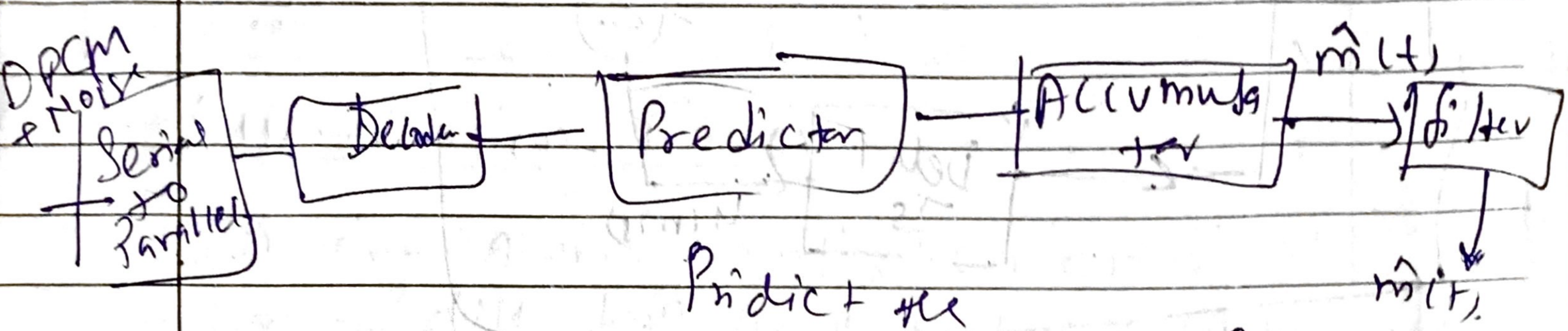




Dynamic Range of the Signal

Differential PCM
~~Delta~~ Modulator





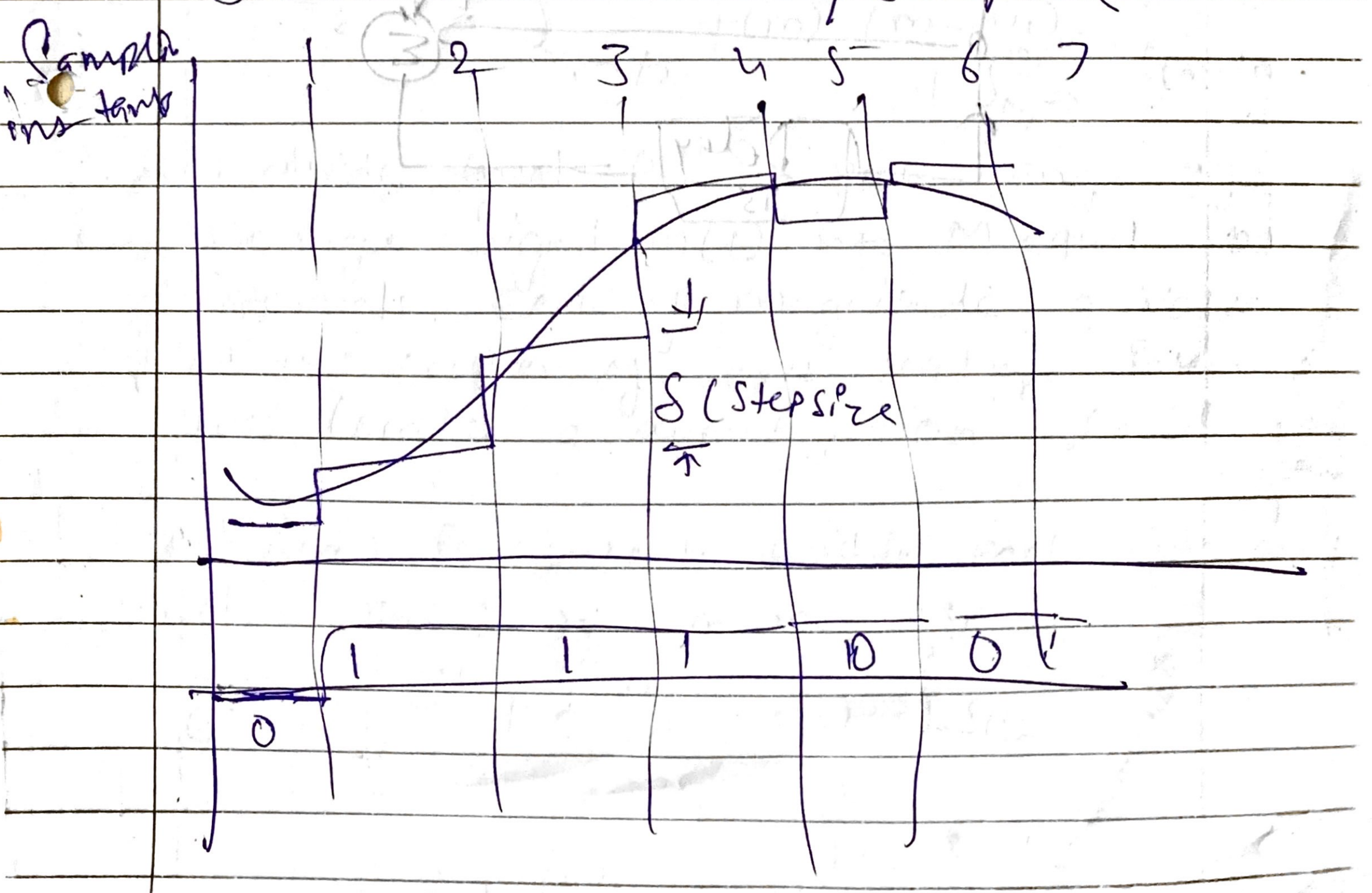
Predict the value of future sample of X(t).

This helps in reducing ~~re~~ redundancy

if $f_s \gg$ Nyquist rate then there is correlation

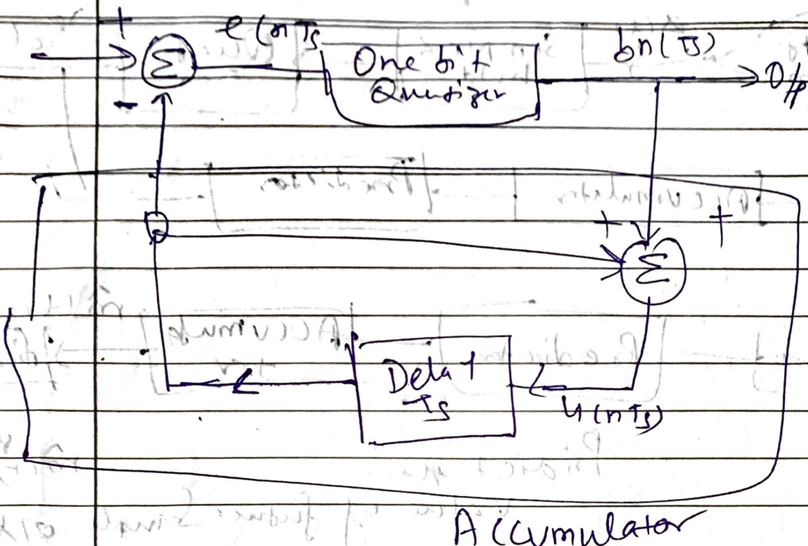
N No. of bits transmitted per sample

Delta Modu One bit / Sample

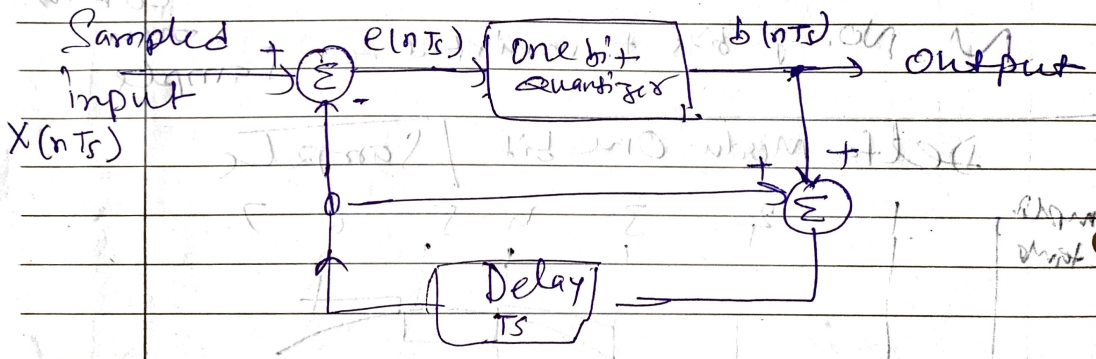


Question No.

D.M.



D.M. Receiver



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Quantization Error.

Mean-Square quantization error $\overline{e^2}$

e = diff. betn the Original and Quantized Signal Voltages.

Quantizer O/P $= m_k$.

$e = m(t) - m_k$ $m(t)$ = Message Signal.

Let $f(m)\,dm$ be the Probability that $m(t)$ lies in the Voltage range $m - dm/2$ to $m + dm/2$

then the mean-square quantization error is

$$\overline{e^2} = \int_{m_1 - S/2}^{m_2 + S/2} f(m)\,(m - m_1)^2\,dm + \int_{m_2 - S/2}^{m_2 + S/2} f(m)\,(m - m_2)^2\,dm + \dots$$

Let's divide total Peak to peak range of the Message Signal m(t) into M equal voltage Intervals each of magnitude S Volts at the center of each voltage interval we locate a quantization level $m_1, m_2, \dots m_M$

Let's f(m) is constant within each quantization level. then & $x = m - m_k$

$$\overline{e^2} = (f^{(1)} + f^{(2)} + \dots) \int_{-S/2}^{S/2} x^2\,dx$$

$$(f^{(1)} S + f^{(2)} S + \dots) \frac{S^3}{12} \quad S^2/12$$

$f^{(1)}(S)$ is the Probability that Signal Voltage will be in 1st quantization level

Question No.

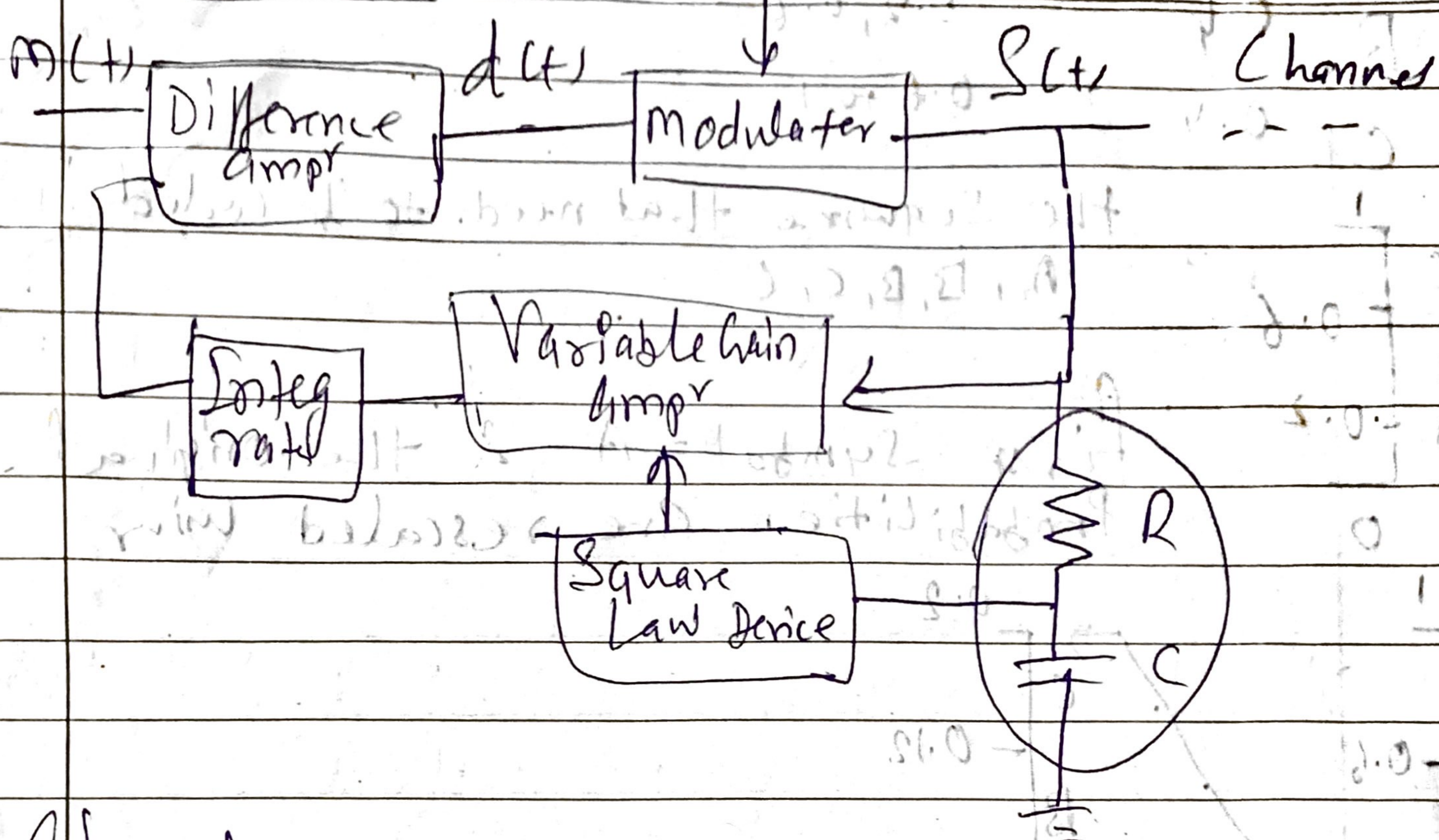
So Sum of total probabilities

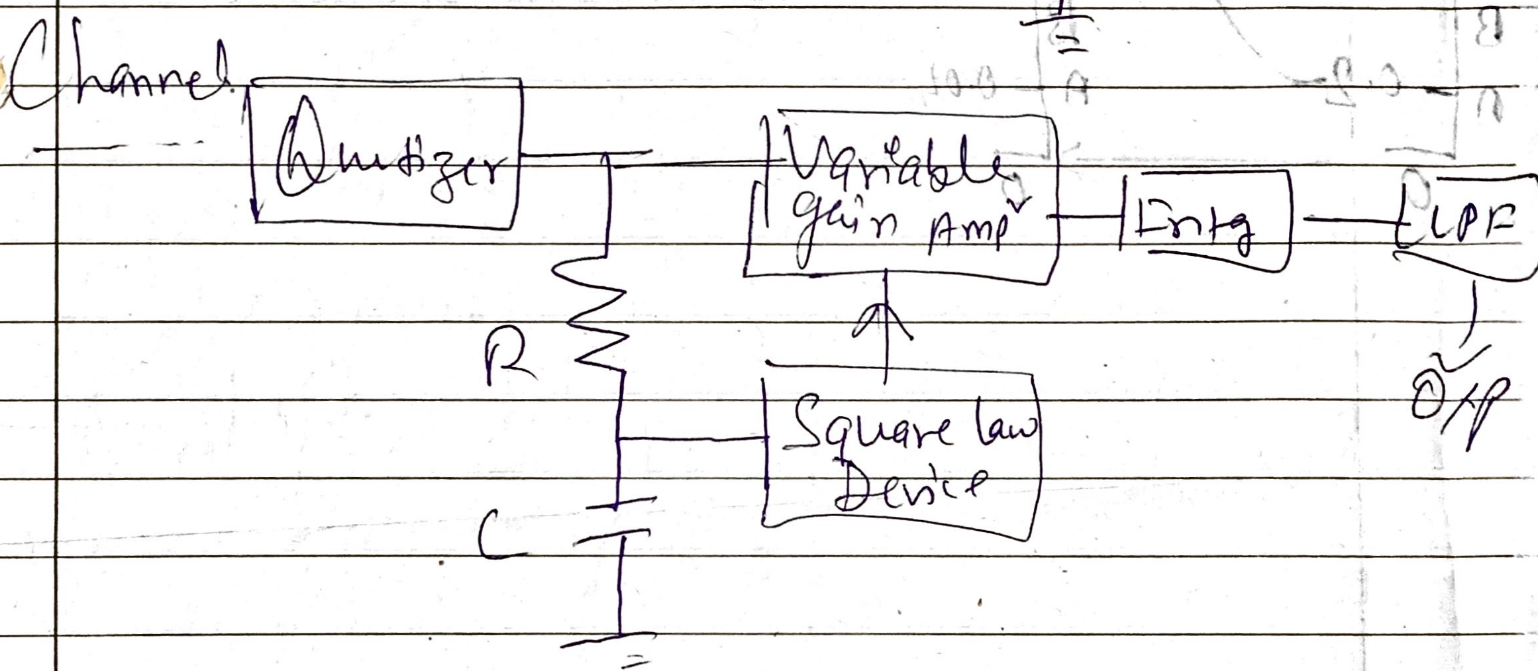
$$\boxed{\overline{e^2} = \frac{S^2}{12}}$$

Companding.

$$\frac{\text{Signal}}{\text{Quantization Noise}}$$

ADPCM





Deltamodulation