Master Tutorial - 2

① Identify the modulation mtd that converts analog to digital. Explain with block diagram.

→ The mtd that converts analog to digital signal is PCM.

Explaination:

(a) Sampling.
(b) Quantization.
(c) Encoding.
(d) Low pass filter.

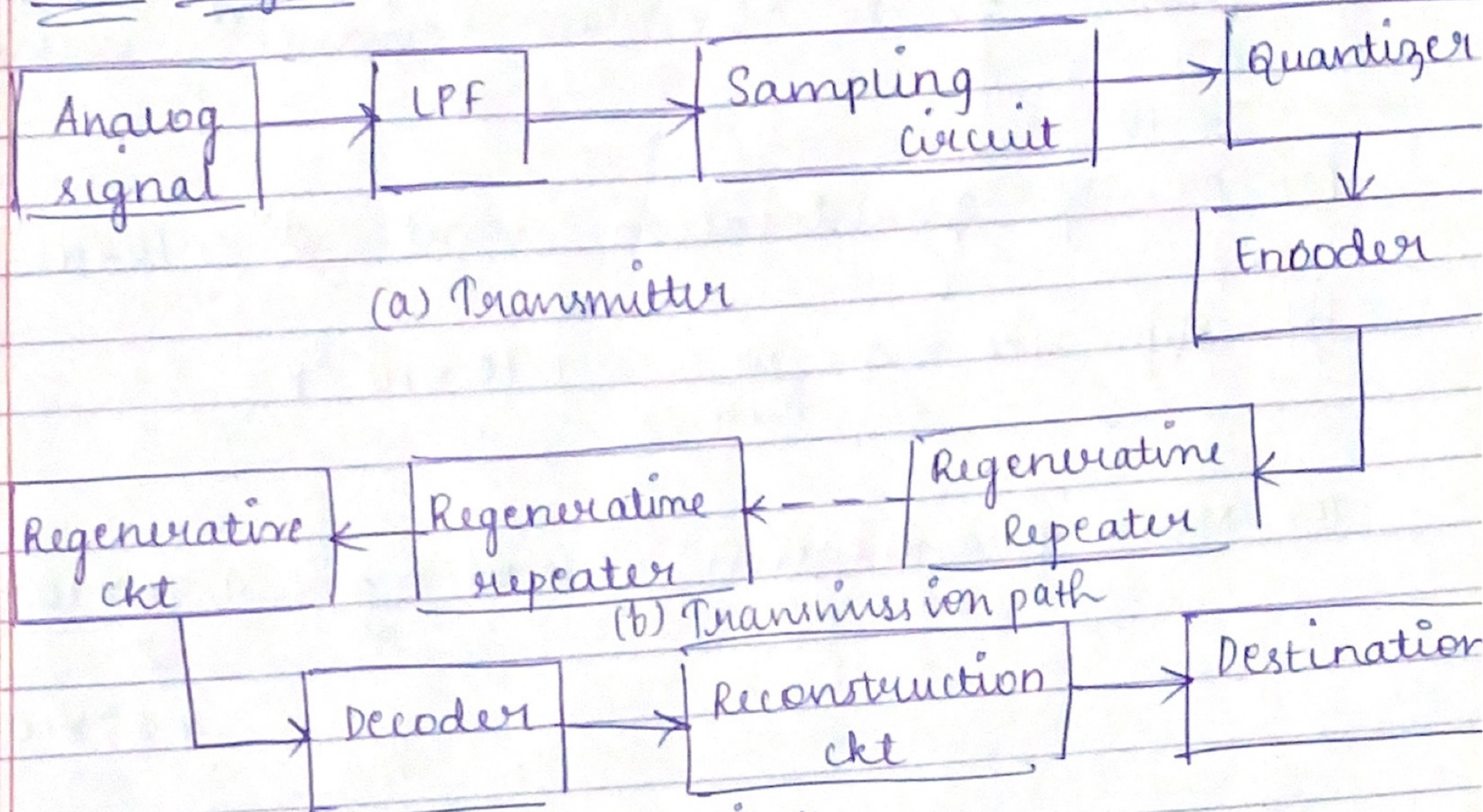
(a) Sampling: The analog signal is sampled at regular intervals, meaning its amplitude is measured at specific points in time.
The sampling rate is crucial, it should be atleast twice the highest frequency component of the analog signal.

(b) Quantization: The sampled amplitudes are assigned discrete values within a specific range.
The process ~~xxxxx~~ rounds off the continuous analog values to nearest allowed digital value.

(c) Encoding: The quantized values are represented as binary codes, typically using binary nos. Encoding establishes a direct correspondance b/w the numerical values represen? the signal & binary sequences.

(d) Low pass filter: Filters out high frequency components above the nyquist frequency to prevent aliasing.

Block diagram:



(a) Transmitter

(b) Transmission path

(c) Receiver

Advantages:
- Robust to noise & interference.
- Enables efficient digital transmission & storage.
- Allows easy signal processing & manipulation
- Widely used in telecommunications.

(7) Consider a PCM system with a signal BW of 4HZ, SR = 10KH & each sample is represented using 16 bits.

→ BW = 4KHZ, f_s = 10KHZ, N=16

(a) Bit rate $= f_s \times N$
$= 10 \times 16$
$= 160$ kbps.//

(b) Nyquist frequency $= 2 \times f_m$
$= 2 \times 4$
$= 8$ kHz.//

(c) Signal to quantiz^{n} noise ratio =
$(SNR)_{PCM} = 1.8 + 6N = 1.8 + (6 \times 16) = 97.18$ dB.//

(8) In a PCM system, the i/p signal ranges from -5V to +5V. The quantiⁿ using 10 bit ADC.

→ $N = 10$

(a) No. of quantization level $= 2^N = 1024$.

(b) Step size $= \Delta = \frac{10}{1024} = 9.76 \times 10^{-3}$ V.

(c) Max. quantization error $= \frac{\Delta}{2} = \frac{9.76 \times 10^{-3}}{2}$

$= 4.88 \times 10^{-3}$

(9) A PCM system is used to encode an analog signal with frequency range of 0 - 4kHz. If the quantiⁿ error should be less than 1% of the maximum i/p signal amplitude, calculate the minimum no. of bits reqⁿ for quantization. determine the bit rate if the sampling rate is 16kHz.

→ $\Delta = 0.01 V_2$

$= 0.02$

- levels $= \frac{\text{range}}{\Delta} = \frac{4k}{0.02}$

levels $= 200k.$ //

- $N = \log_2(\text{level})$

$= \log_2(200 \times 1000)$

$= 17.60 \approx 18$ bit. //

- Bit rate $= f_s \times N$

$= 288$ kbps. //

(10) A speech signal has a total duration of 10s. It is sampled at the rate 8kHz. Signal to noise ratio is 40dB. Calculate minimum storage capacity needed to accomodate this digitized speech signal.

→ $(SNR) = 1.8 + 6N$

$$40 = 1.8 + 6N$$

$$N = 6 \text{ bits}$$

No. of samples $= 8k \times 10$

$= 80k$ samples

No. of bits in 10s samples $= 80k \times 6$

$= 480k$ bits

To convert bits ⇒ byte $= \frac{480}{8} = 60k$ bytes

(13) A Delta modulation system I/p applied 10kHz, 1Vpp. The signal is sampled 10 times more than nyquist rate. What is the min step size requⁿ to prevent slope overload.

→ $x(t) = A_m \sin(2\pi f_m t)$

$$\left|\frac{dx(t)}{dt}\right|_{max} = \Delta \times f_s$$

$$\frac{dx(t)}{dt} = A_m \cos(2\pi f_m t)\, 2\pi f_m$$

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

$$\left|\frac{dx(t)}{dt}\right|_{max} = 2\pi f_m A_m$$ } for reference

$A_m = 0.5$, $f_m = 10k$

$f_s = 10 \times 2 \times f_m$

$= 200k$

(P.T.O)

$$\Delta = \frac{2\pi f_m A_m}{f_s}$$

$$= \frac{2 \times \pi \times 10 \times 0.5}{200}$$

$$\Delta = 0.157.$$

(15) A sinusoidal signal of 2kHz freq is applied to a delta modulator. The sampling rate & step size Δ of the delta-modulator are 20,000 samples per second & 0.1V resp. To prevent slope overload, the maxi. amplitude of the sinusoidal signal is

→ $f_m = 2kHz$

$f_s = 20k$

$\Delta = 0.1$

$$2\pi f_m A_m < \Delta f_s$$

$$A_m = \frac{0.1 \times \cancel{20k}\ 10k}{2\pi \times \cancel{2k}}$$

$$= \frac{1k}{2\pi}$$

$$= 0.159.$$

(2) Adaptive Delta Modulation (ADM) is a digital modulation technique that adjusts its quantization step in response to changes in signal characⁿ. The basic idea behind ADM is to dynamically vary the step size of the quantizer based on the i/p signal characⁿ.

(P.T.O)

Explaination :

(a) Sampler : The i/p signal is sampled at regular intervals.

(b) Quantizer : The sampled signal is then quantized using a quantizer. In ADM, the quantizer adjusts the step size dynamically based on the changing charac^n of the i/p signal.

(c) Predictor : A predictor estimates the next sample based on the quantized value & provides feedback for adapting the quantization step.

(d) Encoder : The quantized signal is encoded into a suitable format for transmission

(e) Channel : The encoded signal is transmitted thro' the communication channel.

(f) Decoder : At the receiver, the transmitted signal is decoded.

(g) Predictor at Receiver : The predictor at the receiver estimates the next sample.

(h) Reconstruction filter : The decoded signal is passed thro' a reconstruction filter to obtain a smooth represen^n.

This adaptive approach allows adaptive delta modulation to be resilient to changes in the i/p signal, making it suitable for dynamic signal environment where conventional fixed-step delta modulation might struggle.

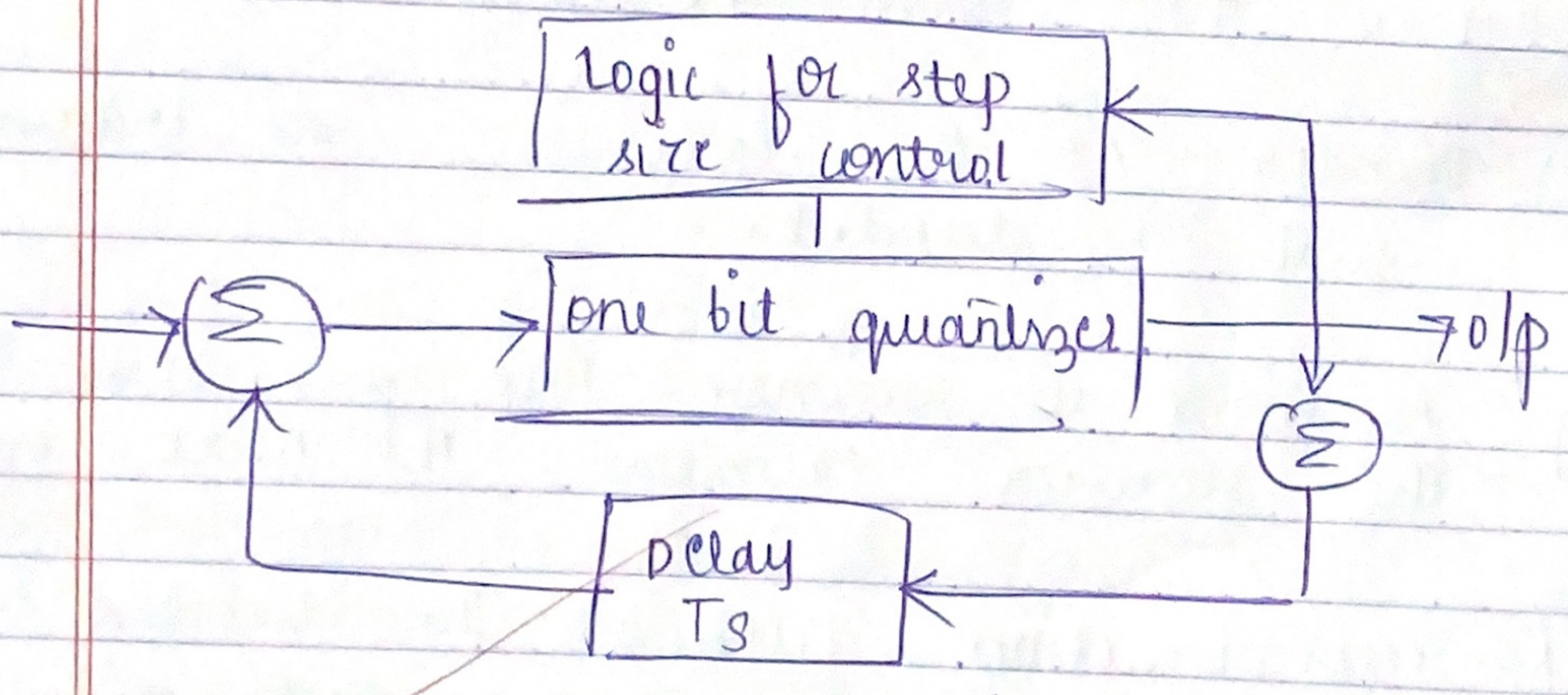
(3) The 2 types of quantization noise are:

(a) Granular Noise:

- Occurs when the range of possible analog value are divided into quadrdization levels.
- The difference b/w the original analog value & its quantized represen^n creates an error signal.
- More noticeable at low signal levels,
- as the quantization steps become relatively larger compared to to the signal amplitude.

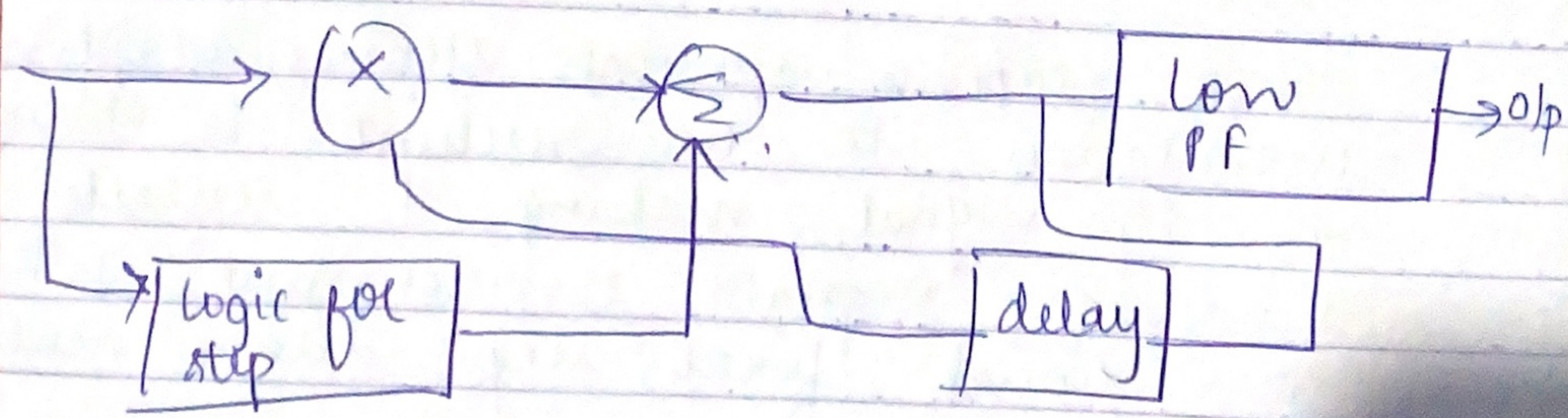
(b) Overload Distortion:

- Occurs when an i/p signal exceeds the maximum representable quantiza^n level.
- The signal is "clipped" or limited to the highest level, causing distortion

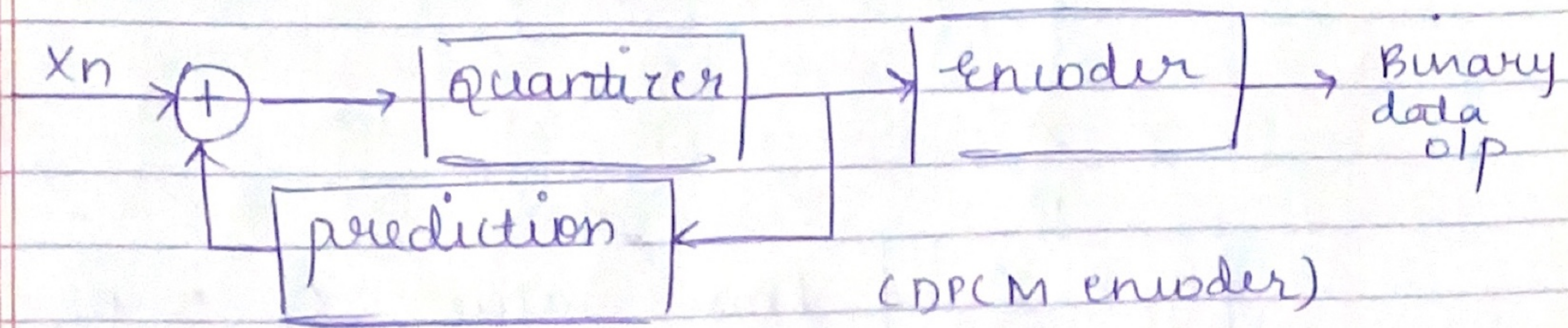


(ADM-transmitter)

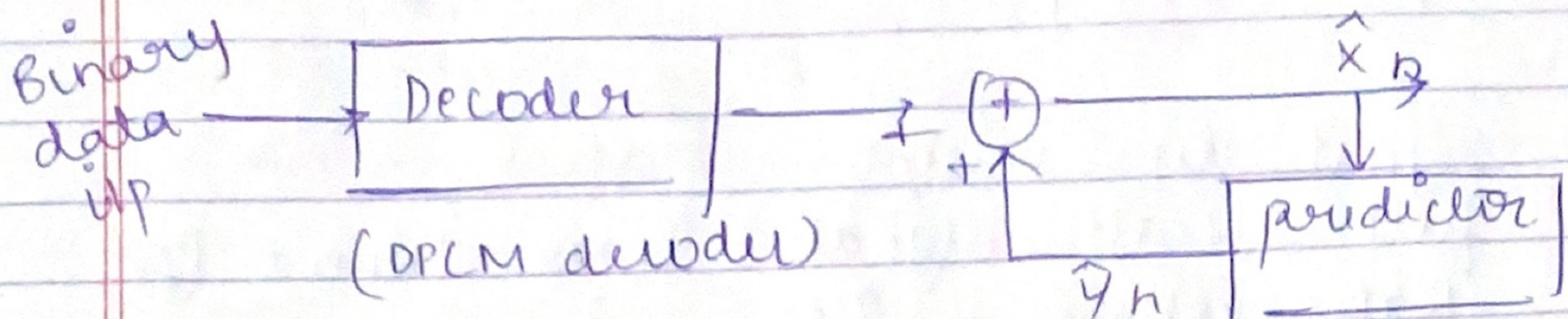
I/p



4. Differential pulse code modulation (DPCM):



(DPCM encoder)



(DPCM decoder)

→ <u>Transmitter</u>:

- Pre-emphasis - filter :- Accentuates high freq.
- Sampler & quantizer :- Digitizes the analog audio signal.
- Predictor :- Estimates the current sample based on past samples.
- Differential Encoder :- Calculates the difference b/w actual & predicted samples.

→ <u>Receiver</u>:

- Decoder :- Recovers the quantized difference signal.
- Difference adder :- Attenuates high freq. to compensate for pre-emphasis.
- Output :- Reconstructed audio signal.

5. SNR to Quantization.

$$SNR = 20 \log \left[\frac{\text{Signal rms voltage}}{\text{Noise rms voltage}} \right]$$

(a) Noise rms voltage :

$$q_e^2 = \frac{1}{\Delta} \int_{-\Delta/2}^{\Delta/2} q^2 \, dq$$

$$= \frac{1}{\Delta} \left[\frac{q^3}{3} \right]_{-\Delta/2}^{\Delta/2}$$

$$= \frac{1}{3\Delta}\left[\frac{\Delta^3}{8} + \frac{\Delta^3}{8}\right]$$

$$= \frac{\Delta^2}{12}.$$

$$\boxed{q_e = \frac{\Delta}{2\sqrt{3}}}$$ Rms value of error.

(b) Signal Rms value:

- full scale signal = $V_{max} - V_{min} = V_{fs}$
- Peak voltage = $\frac{V_{fs}}{2}$
- Rms of peak voltage = $\frac{V_{fs}}{2\sqrt{2}}$ —— (A)

$$\because \Delta = \frac{V_{max} - V_{min}}{2^n} = \frac{V_{fs}}{2^n}$$

$$\because V_{fs} = \Delta 2^n$$

from (A)

signal rms voltage = $\frac{2^n \Delta}{2\sqrt{2}}$

$$SNR = 20 \log\left[\frac{2^n \Delta}{2\sqrt{2}} \times \frac{2\sqrt{3}}{\Delta}\right]$$

$$= 20 \log\left[2^n \times \sqrt{\frac{3}{2}}\right]$$

$$= 20 \log 2^n + 20 \log \sqrt{\frac{3}{2}}$$

$$= 6.02n + 1.76 \text{ dB.}$$

(6) (a) Channel Noise:

Channel noise is any unwanted signal that adds to the transmitted signal during its journey thro' the commun^n channel.

- Thermal noise.
- Interference.
- Channel distortion.

(b) Error probability Analysis:

Error probability analysis aims to calculate the probability of incorrect information being received at the destination due to channel noise.

- Modeling the channel.
- Choosing a signal transmission.
- Calculating the probability of error.

Common metrics used in error probabi^n analysis are:

- Bit error Rate.
- Packet error Rate.
- Symbol Error Rate.

Factors affecting error probabi^n:

- Signal to noise Ratio.
- Channel characteristics.
- Transmission Scheme.

(12) Discrete PAM (Pulse Amplitude Modulation) Signal in Digital communication:

Discrete PAM, also known as M-ary PAM, is a modulation technique where info is encoded in the amplitude of a series of discrete pulses. Unlike analog PAM, which utilizes a continuous range of amplitudes, each pulse in PAM can take on one of M-distinct amplitude levels.

Significance in Digital communication:
- Efficiently transmits digital data.
- Simpler implementation.
- Robustness to noise.

Factors affecting pulse shape choice:
- BW efficiency.
- Intersymbol interference.
- Noise immunity.
- Implementation complexity.

Influence on Power spectra:
The choice of pulse shape significantly impacts the power spectral density.
- Rectangular pulses.
- Sinc pulses.
- Raised cosine pulses.

(14) $A_m = 2V$

$f_s = 32KHz$

$$\Delta = \frac{2\pi \times 4000 \times 2}{32000}$$

$\Delta = 3.141$

Impact of ISI on communication performance:
- Increased bit error rate.
- Reduced data rate.
- Degraded signal quality.

Examples of ISI:
- Transmission of fast data bursts over BW - limited telephone lines.
- Wireless communication.
- Use of rectangular pulses, which have sharp transitions.

Methods to mitigate ISI:
- Pulse shaping.
- Equalization.
- Channel coding.
- Adaptive techniques.

(18) Eye Pattern:

In digital communication, an eye pattern is a visual representation of a received signal obtained by repeatedly sampling & overlapping it on an oscilloscope.

Formation of eye pattern:
- Data Transmission.
- Channel Effects.
- Signal Sampling.
- Horizontal Sweep.
- Overlapping & Averaging.

Factors influencing the Eye Pattern:
- Signal to noise Ratio.
- Inter symbol Inference.
- Timing Jitter.
- Symbol Rate & Pulse Shape.

Significance of Eye Pattern analysis:
- Assess signal quality.
- Optimize system parameters.
- Diagnose Channel issues.

In essence, the eye pattern acts as a window into the inner working of a digital communi^n system, offering valuable insights for ensuring accura[te] & reliable data transmission.

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