LAB 9
PRELAB
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1) Mention the difference between PCM and DPCM?

A:

SL	PCM	DPCM
1.	PCM stands for Pulse Code Modulation.	While DPCM stands for Differential Pulse Code Modulation.
2.	In PCM, feedback is not provided.	While in DPCM, feedback is provided.
3.	It has a good signal to noise ratio.	While it has a moderate signal o noise ratio.
4.	It is less efficient than the DPCM.	While it is more efficient than PCM.
5.	For the transmission channel, PCM needs high bandwidth(B).	Whereas DPCM needs less bandwidth(B) than PCM.

6.	PCM is complex than DPCM in terms of complexity.	While DPCM is simple in terms of complexity.
7.	In PCM, seven bits are transmitted per eight samples.	In DPCM, four bits are transmitted per six samples.
8.	In PCM, for transmitting bits rate varies from fifty-five to sixty-four.	While in DPCM, for transmitting bits rate varies from thirty-two to forty-eight.

2) Give the expressions for μ–law and A-law companding

A: A-law

For a given input *x*, the equation for A-law encoding is as follows,

$$F(x) = \operatorname{sgn}(x) \begin{cases} \frac{A|x|}{1+\ln(A)}, & |x| < \frac{1}{A} \\ \frac{1+\ln(A|x|)}{1+\ln(A)}, & \frac{1}{A} \le |x| \le 1, \end{cases}$$

where *A* is the compression parameter. In Europe, A=87.6

A-law expansion is given by the inverse function,

$$F^{-1}(y) = \operatorname{sgn}(y) \begin{cases} \frac{|y|(1+\ln(A))}{A}, & |y| < \frac{1}{1+\ln(A)} \\ \frac{\exp(|y|(1+\ln(A))-1)}{A}, & \frac{1}{1+\ln(A)} \le |y| < 1. \end{cases}$$

μ–law

For a given input x, the equation for μ-law encoding is,

$$F(x) = \operatorname{sgn}(x) \frac{\ln(1+\mu|x|)}{\ln(1+\mu)} \qquad -1 \le x \le 1$$

where $\mu = 255$ in the North American and Japanese standards and $\operatorname{sgn}(x)$ is the sign function. It is important to note that the range of this function is −1 to 1.

μ-law expansion is then given by the inverse equation

$$F^{-1}(y) = \operatorname{sgn}(y)(1/\mu)((1+\mu)^{|y|} - 1) \quad -1 \leq y \leq 1$$

3) Mention the advantages and disadvantages of DPCM, DM, and ADM.

A:

DPCM

ADVANTAGES OF DPCM SYSTEM

1. As the difference between m[k] and m*[k] is being encoded and transmitted by the PCM technique a small difference voltage is to be quantized and encoded, this will need less number of quantization levels and hence less number of bits to represent them
2. Thus signaling rate and bandwidth of a DPCM will be less than that of a PCM

DISADVANTAGES OF DPCM SYSTEM

1. High bit rate
2. Practical usage is limited
3. Need the predictor circuit to be used which is very complex

DM

ADVANTAGES OF DELTA MODULATION

1. Since the delta modulation transmits only one bit for one sample, therefore the signaling rate and transmission channel bandwidth are quite small for delta modulation compared to PCM.
2. The transmitter and receiver implementation are very much simple for delta modulation. There is no analog to digital converter required in delta modulation.

DISADVANTAGES OF DELTA MODULATION

1. Slope overload distortion
2. Granular or idle noise

ADM

ADVANTAGES OF ADAPTIVE DELTA MODULATION

1. The adaptive delta modulators can take continuous changes in step size or discrete changes in step size.
2. Signal to noise ratio is better.
3. Better utilization of bandwidth.

DISADVANTAGES OF ADAPTIVE DELTA MODULATION

1. Signals vary faster.
2. Granular noise.

4) What are SOLD and granular noise and how to overcome these in DM?

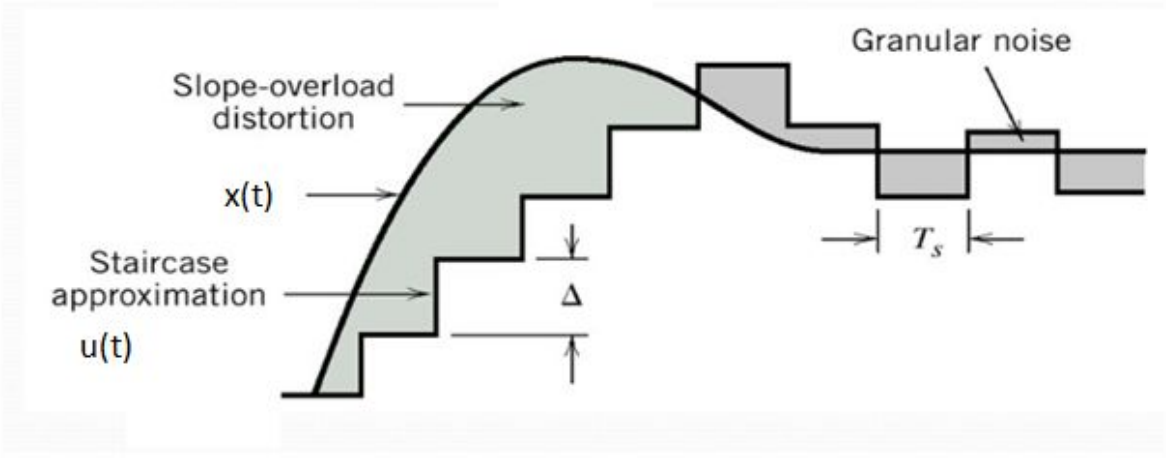
A: The delta modulation has two major drawbacks as under :

1. Slope overload distortion
2. Granular or idle noise

Now, we will discuss these two drawbacks in detail.

<u>Slope Overload Distortion</u>

This distortion arises because of the large dynamic range of the input signal.



We can observe from the figure, the rate of rising of input signal x(t) is so high that the staircase signal can not approximate it, the step size 'Δ' becomes too small for staircase signal u(t) to follow the step segment of x(t).

Hence, there is a large error between the staircase approximated signal and the original input signal x(t).
This error or noise is known as **slope overload distortion**.
To reduce this error, the step size must be increased when the slope of signal x(t) is high.

Granular or Idle Noise

Granular or Idle noise occurs when the step size is too large compared to a small variation in the input signal.

This means that for very small variations in the input signal, the staircase signal is changed by a large amount (Δ) because of the large step size.

Fig.1 shows that when the input signal is almost flat, the staircase signal u(t) keeps on oscillating by ±Δ around the signal.

The error between the input and approximated signal is called **granular noise**.

The solution to this problem is to make the step size small.

The solution to overcome DM

In order to overcome the quantization errors due to slope overload and granular noise, the step size (Δ) is made adaptive to variations in the input signal x(t).

Particularly in the steep segment of the signal x(t), the step size is increased. And the step is decreased when the input is varying slowly.

This method is known as Adaptive Delta Modulation (ADM).

The adaptive delta modulators can take continuous changes in step size or discrete changes in step size.

POST LAB

1. What is the role of a predication filter in DPCM?
A: To reduce the error we would have by encoding the actual sample directly.

2. Give the SNR expressions for DPCM, error in a single sample for DM?
A:

SNR:

$$SNR_{DPCM} = (\sigma_x^2 \sigma^2_d)/(\sigma^2_d \sigma^2_e) = G_p SQNR_{PCM}$$

Where,

σ^2_d = Variance of the prediction error

$SQNR_{PCM}$ = σ_d^2/σ^2_e = SQNR of the quantizer

G_p = σ_x^2/σ^2_d = Prediction Gain

3. Mention the applications of DPCM, DM, and ADM?

A: Applications of DPCM
The DPCM technique mainly used Speech, image, and audio signal compression. The DPCM conducted on signals with the correlation between successive samples leads to a good compression ratio

Applications of DM
Delta Modulation is most useful in systems where timely data delivery at the receiver is more important than the data quality. This modulation is applied to ECG waveform for database reduction and real-time signal processing. For analog-to-PCM encoding, this Modulation method is used.

Applications of ADM
This modulation is used for a system that requires improved wireless voice quality as well as speed transfer of bits. In television signal transmission this modulation process is used. This modulation method is used in voice coding.

4. Compare DPCM with Delta Modulation?

A:

S.NO	Parameter of Comparison	Delta Modulation (DM)	Differential Pulse Code Modulation (DPCM)
1.	Number of bits	It uses only one bit for one sample	Bits can be more than one but are less than PCM.
2.	Levels and step size	Step size is kept fixed and cannot be varied.	Number of levels is fixed.
3.	Quantization error and distortion	Slope overload distortion and granular noise are present.	Slope overload distortion and quantization noise is present.
4.	Transmission bandwidth	Lowest bandwidth is required.	Bandwidth required is less than PCM.
5.	Feedback	Feedback exists in transmitter.	Feedback exists.
6.	Complexity of Implementation	Simple	Simple