University Institute of Engineering & Technology CSJMU

KANPUR

Department of Electronics & Communication Engineering

Course Name- Digital Communication (ECE-S401)

UNIT 2: Waveform Coding Techniques

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Topics Covered:
1) Delta Modulation
2) Slope overload distortion
3**) Granular or Idle Noise distortion**

Delta Modulation:

In PCM the signaling rate and transmission channel bandwidth are quite large since it transmits all the bits which are used to code a sample. To overcome this problem, Delta modulation is used.

Working Principle:

Delta modulation transmits only one bit per sample. Here, the present sample value is compared with the previous sample value and this result whether the amplitude is increased or decreased is transmitted.

Input signal x(t) is approximated to step signal by the delta modulator. This step size is kept fixed.

The difference between the input signal x(t) and staircase approximated signal is confined to two levels, i.e., +Δ and -Δ.

Now, if the difference is positive, then approximated signal is increased by one step, i.e., 'Δ'. If the difference is negative, then approximated signal is reduced by 'Δ' .

When the step is reduced, '0' is transmitted and if the step is increased, '1' is transmitted.

Hence, for each sample, only one binary bit is transmitted.

Fig.1 shows the analog signal x(t) and its staircase approximated signal by the delta modulator.

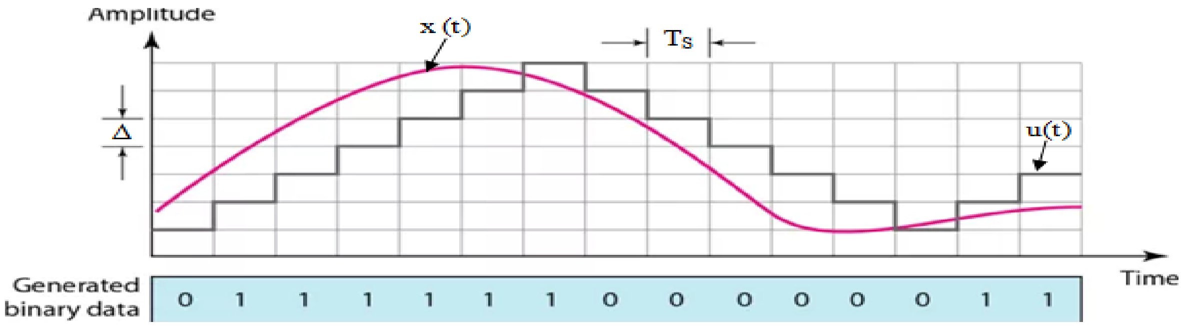

Fig.1

Mathematical Expressions:

The error between the sampled value of x(t) and last approximated sample is given as:

$$e(nT_s) = x(nT_s) - \hat{x}\ (nT_s)$$

Where $e(\ nT_s)$ = error at present sample

$x(nT_s)$ = sampled signal of x(t)

$\hat{x}\ (nT_s)$ = last sample approximation of the staircase waveform

If we assume $u(nT_s)$ as the present sample approximation of staircase output, then

$$u[(n-1)T_s) = \hat{x}\ (nT_s)$$

$$= \text{last sample approximation of staircase waveform}$$

Let us define a quantity $b(\ nT_s)$ in such a way that,

$$b(nT_s) = \Delta\, sgn[e(nT_s)]$$

This means that depending on the sign of error $e(\ nT_s)$, the sign of step size Δ is decided. In other words we can write

$$b(nT_s) = \begin{cases} +\Delta & if\ x(nT_s) \geq \hat{x}(nT_s) \\ -\Delta & if\ x(nT_s)\hat{x} < (nT_s) \end{cases}$$

Also if b (nT_s) =+Δ then a binary ‘1’ is transmitted
and if b (nT_s) =-Δ then a binary ‘0’ is transmitted
Here T_s = sampling interval.

Transmitter Part:

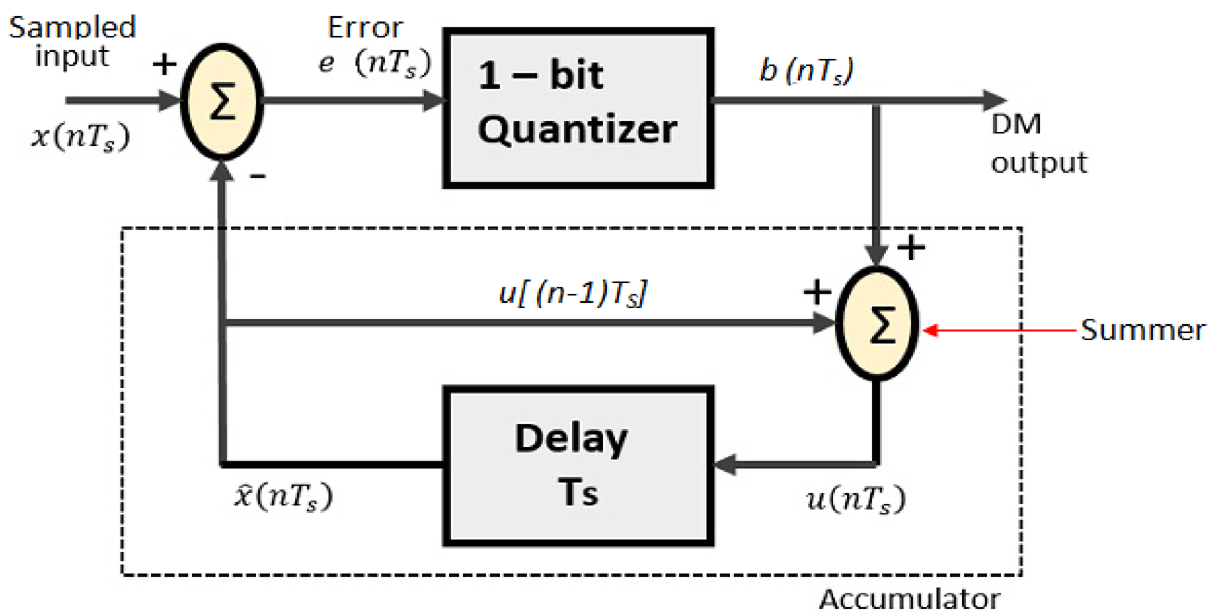

Fig.2 (a) Delta Modulation Transmitter

It consists of a 1-bit quantizer and a delay circuit along with two summer circuits.

The summer in the accumulator adds quantizer output (±Δ) with the previous sample approximation . This gives present sample approximation. i.e.,

$$u(nT_s) = u((nT_s - T_s) + [\pm\Delta]$$

$$or \qquad u(nT_s) = u[(n-1)T_s] + b(nT_s)$$

The previous sample approximation $u[(n-1)T_s]$ is restored by delaying one sample period T_s .
The samples input signal $x(nT_s)$ and staircase approximated signal $\hat{x}(nT_s)$ are subtracted to get error signal $e(nT_s)$.
Thus, depending on the sign of $e(nT_s)$, one bit quantizer generates an output of $+\Delta$ or $-\Delta$.
If the step size is $+\Delta$, then binary ‘1’ is transmitted and if it is $-\Delta$, then binary ‘0’ is transmitted

Receiver Part:

At the receiver end also known as delta demodulator, as shown in fig.2 (b) , it comprises of a low pass filter(LPF), a summer, and a delay circuit. The predictor circuit is eliminated here and hence no assumed input is given to the demodulator.

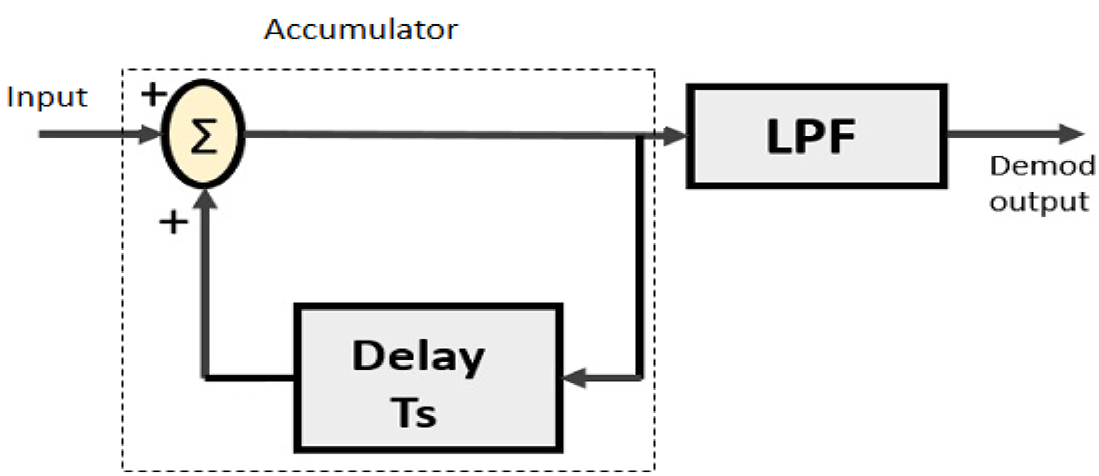

Fig.2 (b) Delta Modulation Receiver

The accumulator generates the staircase approximated signal output and is delayed by one sampling period T_s.

It is then added to the input signal.

If the input is binary ‘1’ then it adds +Δ step to the previous output (which is delayed).

If the input is binary ‘0’ then one step ‘Δ’ is subtracted from the delayed signal.

Also, the low pass filter smoothens the staircase signal to reconstruct the original message signal x(t) .

Advantages of Delta Modulation:

The delta modulation has certain advantages over PCM as under :

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

Disadvantages of Delta Modulation:

The delta modulation has two major drawbacks as under :

1. Slope overload distortion
2. Granular or idle noise

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

Slope overload distortion:

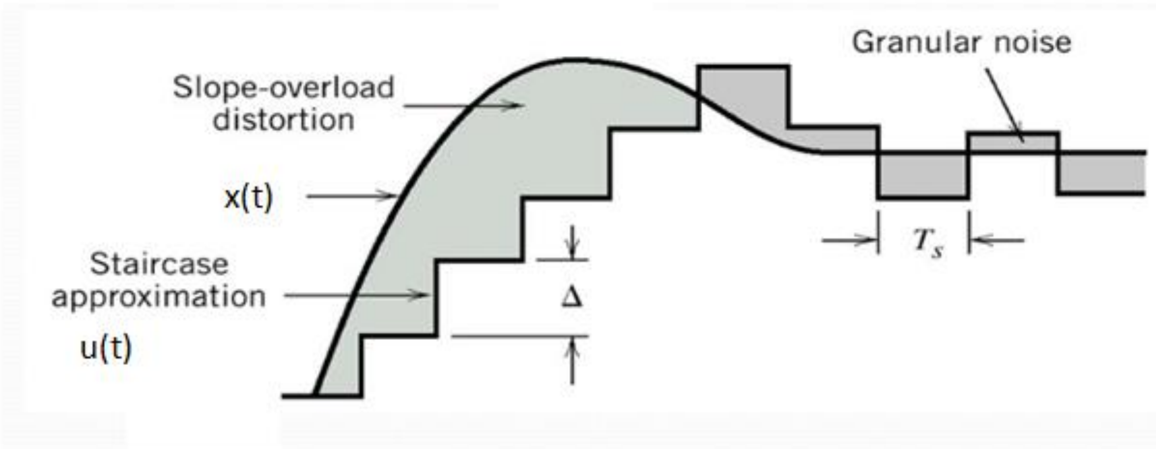

Fig.3 : Quantization errors in Delta modulation

We can observe from Fig.3 , the rate of rise 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 slope of signal x(t) is high.

Since, the step size of delta modulator remain fixed, its maximum or minimum slopes occur along straight lines. Therefore, this modulator is known as **Linear Delta Modulator (LDM)**.

Granular or Idle Noise:

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

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

Fig.3 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.