Lecture Five

Objective of Lecture:

- Delta Modulation (DM)
- Delta-Segma Modulation

2.8 Delta Modulation (DM):

DM transmit only one bit per sample. That is the present sample value is compared with the previous sample of approximated signal which confined to two levels ($-\delta \; and \; +\delta$). If the difference is negative '0' bit is transmitted and '1' bit is transmitted for positive difference, as shown in 2-6.

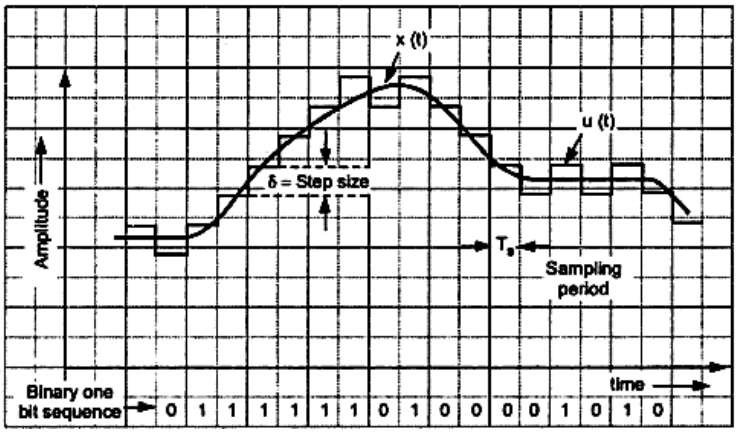

Figure 9 Delta modulation waveform

- **DM transmitter:**

  The block diagram of DM transmitter is shown in figure 2-7

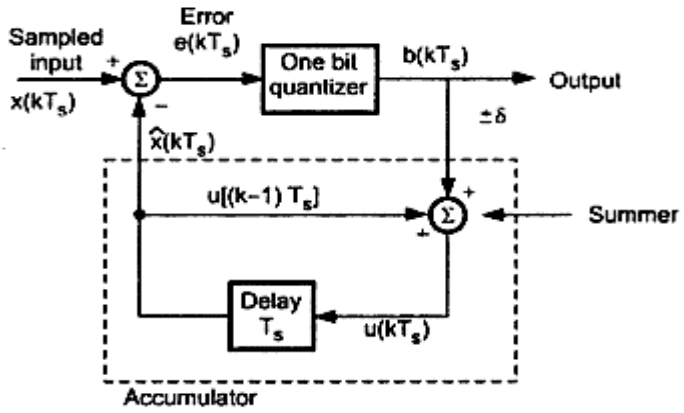

Figure 10 DM transmitter

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

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

From the waveform figure $u(kT_s)$ is the present sample approximation of staircase output and $u[(k-1)T_s] = \hat{x}(kT_s)$ is the last sample approximation of staircase output. Let the quantity of $b(kT_s)$ be define as,

$$b(kT_s) = \delta sign[e(kT_s)]$$

So that

$$b(kT_s) = +\delta \quad if\ x(kT_s) \geq \hat{x}(kT_s), \quad binary\ '1' is\ transmitted$$

$$b(kT_s) = +\delta \quad if\ x(kT_s) < \hat{x}(kT_s), \quad binary\ '0' is\ transmitted$$

Where T_s is sampling interval.

The summer of figure 2-7adds quantizer output $(\overline{+}\delta)$ with previous sample approximation. This gives present sample approximation:

$$u(kT_s) = u(kT_s - T_s) + [\overline{+}\delta] \quad or$$

$$= u[(k-1)T_s] + b(kT_s)$$

The previous sample approximation $u[(k-1)T_s]$ is restored by delayed one sample period T_s. The sampled input signal $x(kT_s)$ and staircase approximated signal $\hat{x}(kT_s)$ are subtracted to get error signal $e(kT_s)$. Then the one bit quantizer produces $+\delta$ or $-\delta$ step size depending on the sign of $e(kT_s)$, '1' bit is transmitted for positive values and '0' bit for negative values.

- **DM receiver:**

At the receiver shown in figure 2-8, the accumulator generates the staircase approximated signal and is delayed by one sample period T_s. It adds $+\delta$ step to the previous sample if the input bit is '1' and subtract $-\delta$ for '0' input bit. The low pass filter with cutoff frequency of highest frequency in $x(t)$.

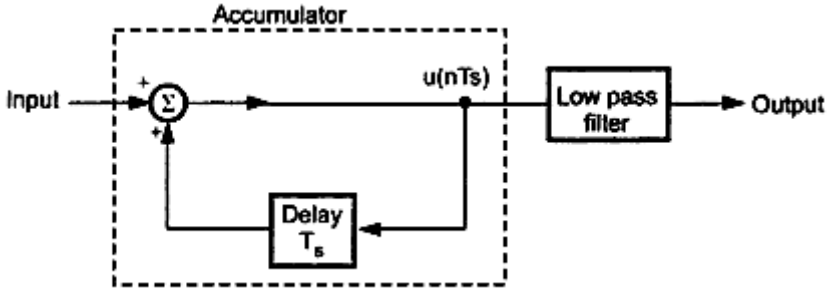

Figure 11 DM receiver

- **Advantageous of DM:**

i- DM transmit only one bit for one sample. Thus the signaling rate and transmission channel bandwidth is quite small for DM.

ii- The DM transceiver system is very much simple.

- **Disadvantageous of DM:**

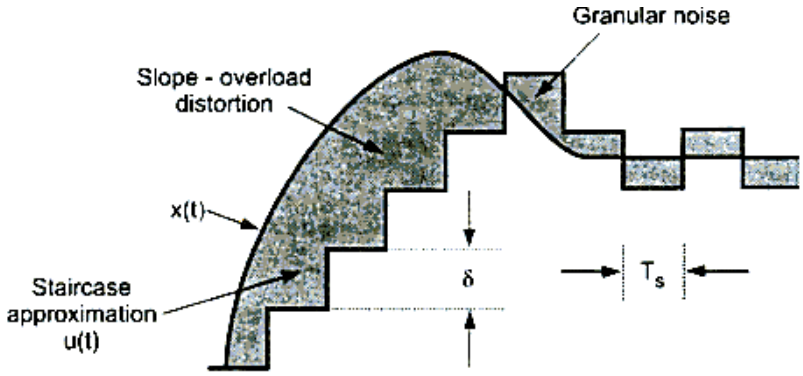

Figure 12 distortion of DM

i- Slop overload distortion: This distortion arises because of large dynamic range of input signal. In this case the step size δ is too small for staircase signal $u(t)$ to follow the steep segment of $x(t)$. Thus there is large error

between those signals. This error called slop overload distortion. To reduce this error the step size should be increased when slop of signal $x(t)$ is high. But since the step size is fixed it is called Linear Delta Modulation (LDM).

ii- Granular Noise (Hunting): It is occur when the step size is too large compared to small variation in the input signal $x(t)$ which can be considered flat, while the staircase signal is oscillated by $\pm\delta$ around it. The error in this case is called granular noise, so that step size should be small to reduce this error.

2.9 Adaptive DM:

The large step size is required to reduce slope overload while small steps are required to reduce granular noise. Adaptive DM shown in figure 2-8 is a modification of LDM to overcome these errors.

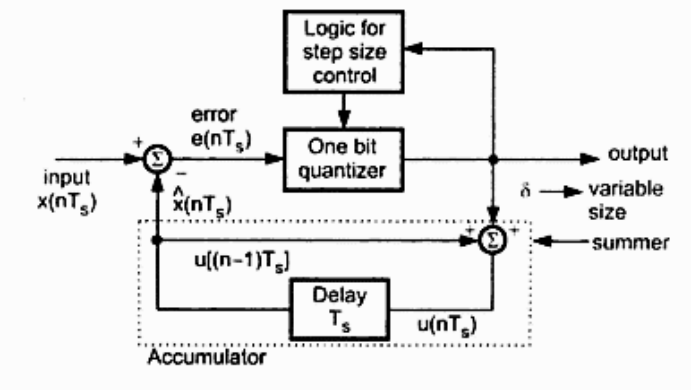

Figure 13 Transmitter of adaptive DM

The step size increases with steep segment of input signal and reduces with small variation. This called Adaptive Delta Modulation (ADM).

At the receiver the logic for step size control is added is added as shown in figure 2-9.

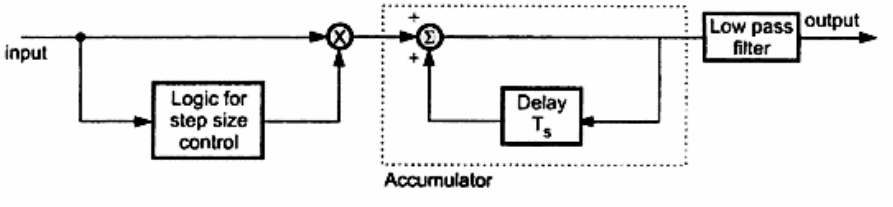

Figure 14 ADM receiver

If one bit quantizer output is high '1' the step size may be doubled for next sample and vice versa as shown in figure 2-10.

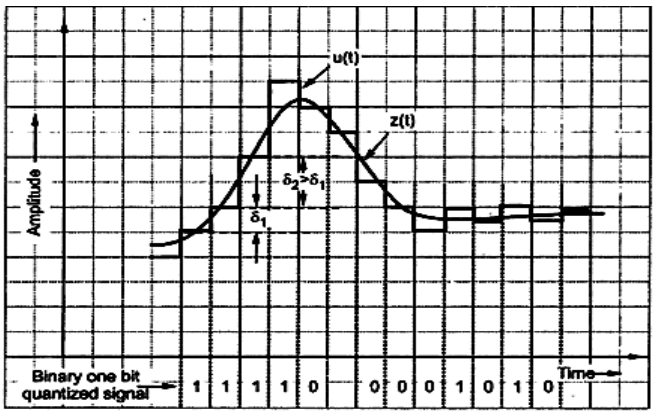

Figure 14 Waveform of ADM

The previous input and the present input decided the step size.