

A thick black L-shaped frame is positioned on the left and bottom edges of the slide, framing the central text.

DELTA MODULATION

Introduction

INTRODUCTION

- We have seen in PCM that, it transmits **all the bits** which are used to code the sample.
- Hence the sampling rate, **r** and transmission channel **Bandwidth** are large
- To overcome this problem DELTA MODULATION (DM) is used.
- Delta Modulation(DM) transmits **only one bit per sample.**
- **Present** sample value is compared with the **previous** sample value, and the **indication**, whether the amplitude is increased or decreased is detected and **sent.**
- Input signal **x(t)** is approximated to step signal **u(t)** by the Delta Modulator.
- **This step size is fixed**

Continue

- The difference between the input signal $x(t)$ and staircase approximated signal $u(t)$ confined to two levels, i.e. $+\delta$ and $-\delta$
- If the difference is **positive**, then the approximated signal is increased by one stape size δ and '1' is transmitted
- If the difference is **negative**, then approximated signal $U(t)$ is reduced by δ and '0' is transmitted.
- Thus for each sample, **only one** binary bit is transmitted.
- The **fig.** in the next slide shows:
 - The analog input signal $x(t)$ to Delta Modulator
 - The staircase approximated signal ($u(t)$)
 - a Delta Modulator **binary** output

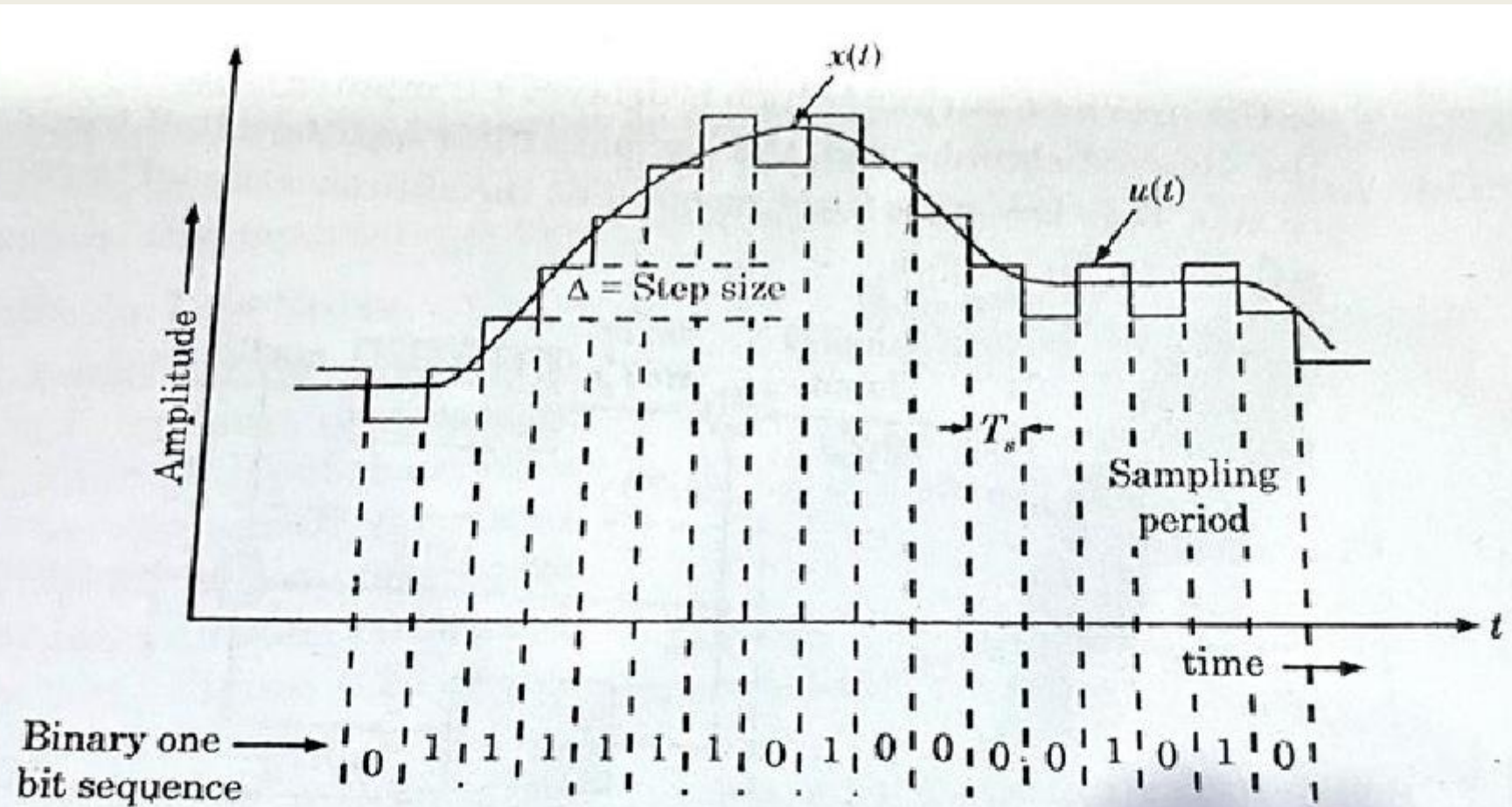
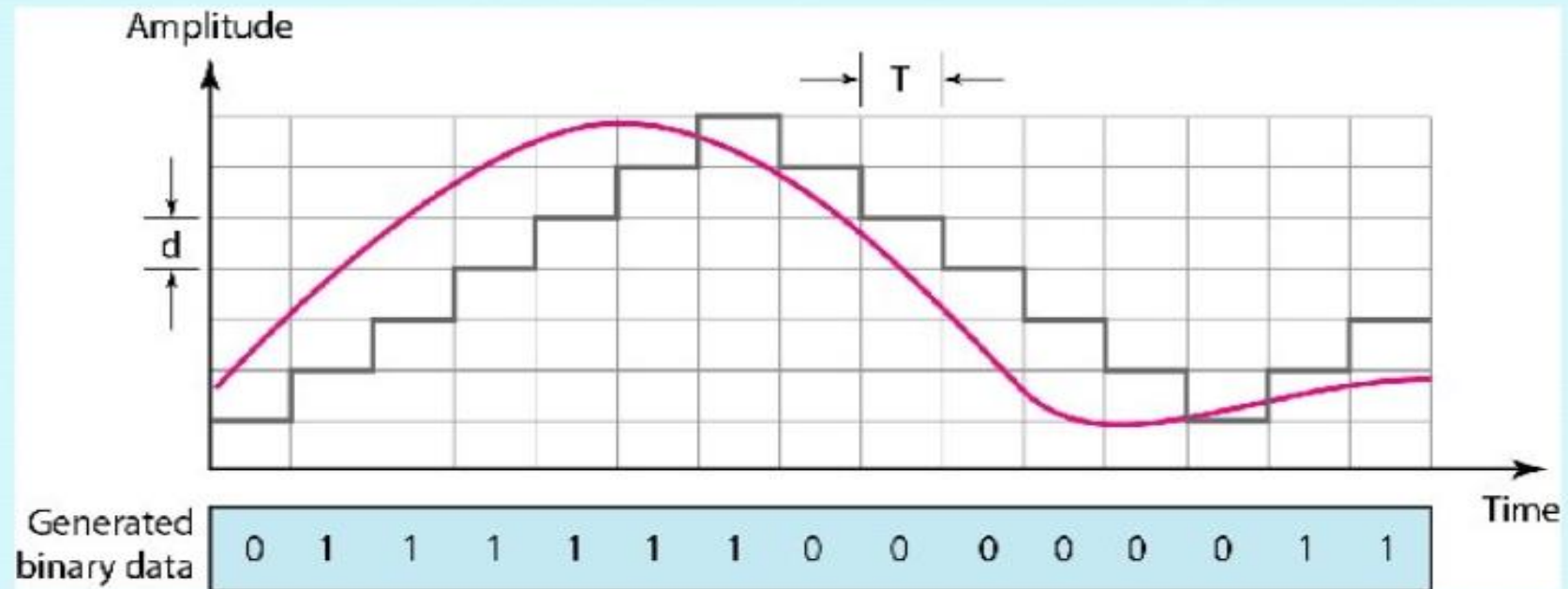


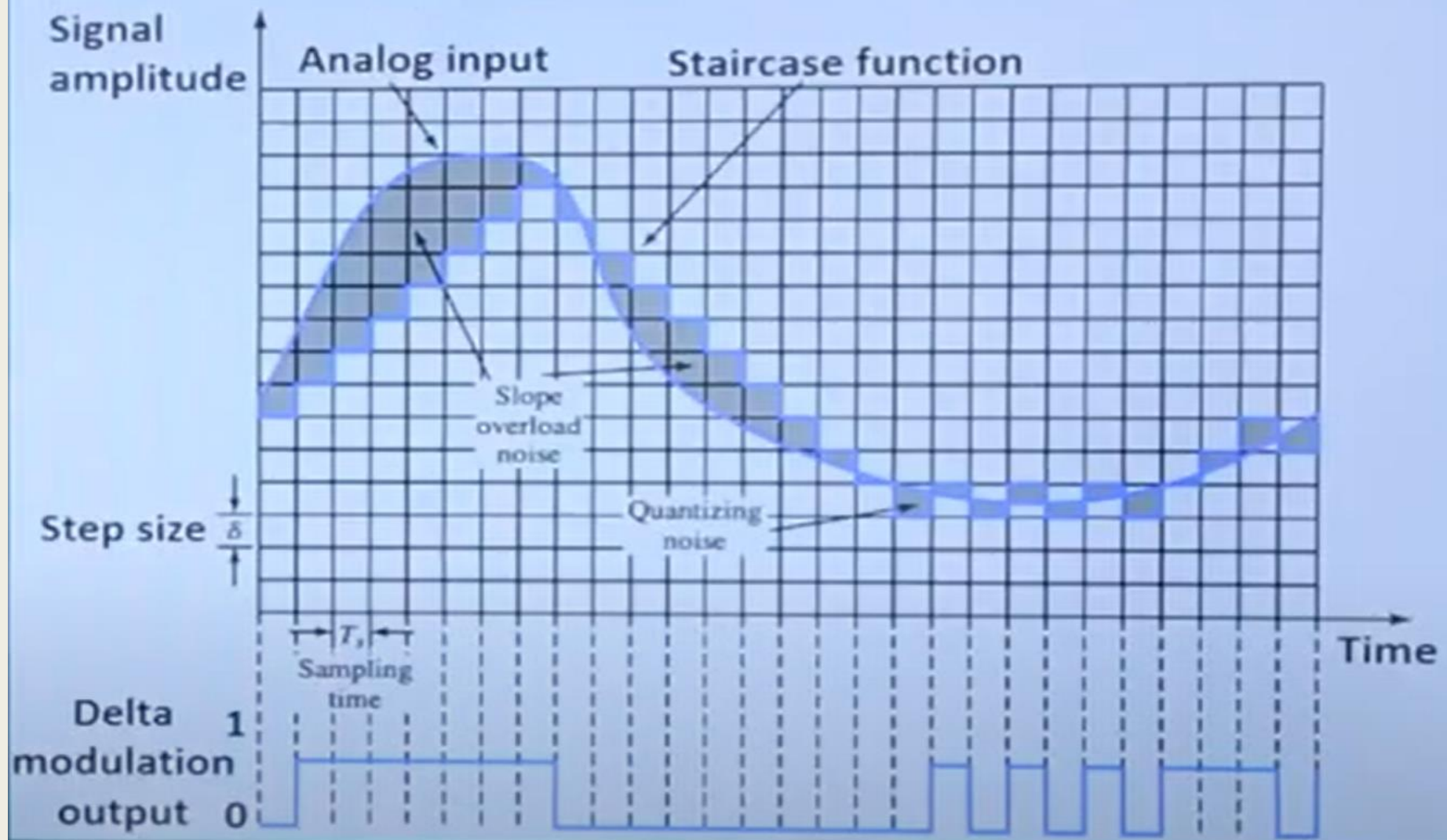
Fig. 6.23 Delta modulation waveform.

Delta Modulation



The process of delta modulation

Example of Delta Modulation –



Continue

- The principle of Delta Modulation can be explained by the following set of equations
- The error between the sampled value of $x(t)$ and last approximated sample is given:

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

continue

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

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

$X(nT_s)$ = sampled signal value

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

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

then $u(n-1)T_s = \hat{x}(nT_s)$
= last sample approximation of staircase
waveform

continue

Let us define a quantity $b(nT_s) = \delta \cdot \text{Sign} [e(nT_s)]$

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:

$$\begin{aligned} b(nT_s) &= +\delta \quad \text{if } x(nT_s) \geq \hat{x}(nT_s) \\ &= -\delta \quad \text{if } x(nT_s) < \hat{x}(nT_s) \end{aligned}$$

Also, If $b(nT_s) = +\delta$ binary “1” is transmitted

And If $b(nT_s) = -\delta$ binary “0” is transmitted

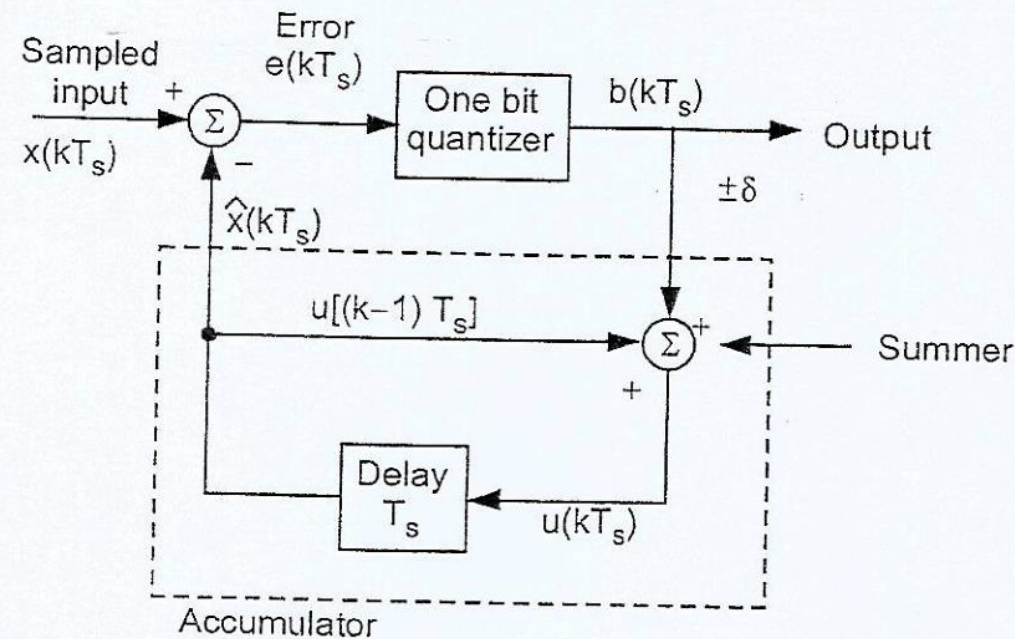
DM – transmitter

fig. below shows the transmitter of DM

The summer in the accumulator adds quantizer output ($\pm\delta$) with the previous sample approximation. This gives present sample approximation. i.e.,

$$\begin{aligned} u(nT_s) &= u(nT_s - T_s) + [\pm\delta] \quad \text{or} \\ &= u[(n-1)T_s] + b(nT_s) \end{aligned}$$

... (6.2.5)



(a)

Continue

The previous sample approximation $u[(n-1)T_s]$ is restored by delaying one

Sample period T_s . The sampled input signal $x(nT_s)$ and staircase approximated signal $x^*(nT_s)$ are subtracted to get error signal $e(nT_s)$. Depending on the sign of $e(nT_s)$ one bit quantizer produces an output step $+\delta$ or $-\delta$. if it is '+', binary '1' is transmitted, and if it is '-' then '0' is transmitted

DM receiver

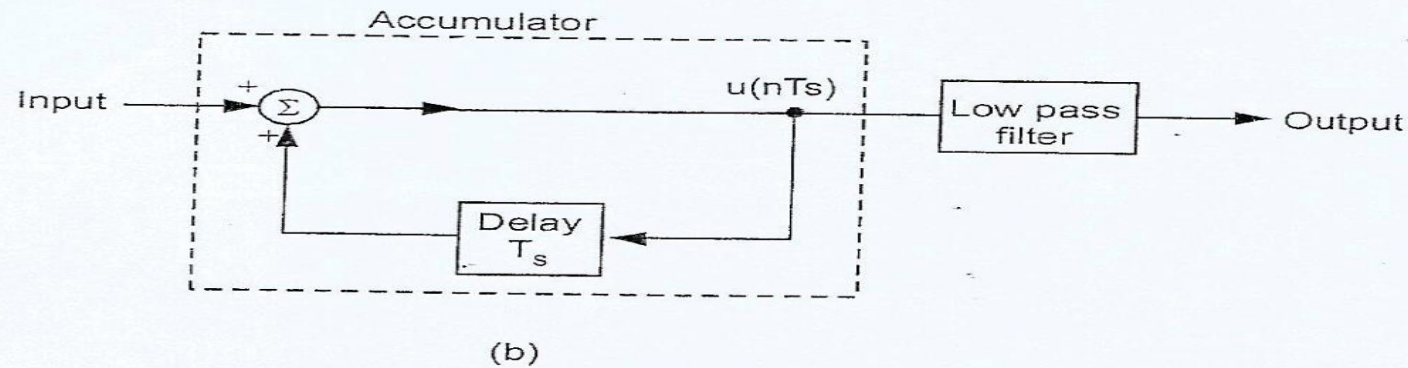


Fig. 6.2.2 (a) Delta modulation transmitter and
(b) Delta modulation receiver

At the receiver shown in Fig. 6.2.2 (b), the accumulator and low-pass filter are used. 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 input is

binary '1' then it adds $+\delta$ step to the previous output (which is delayed). If input is binary '0' then one step ' δ ' is subtracted from the delayed signal. The low-pass filter has the cutoff frequency equal to highest frequency in $x(t)$. This filter smoothen the staircase signal to reconstruct $x(t)$.

Advantages Of Delta Modulation(DM)

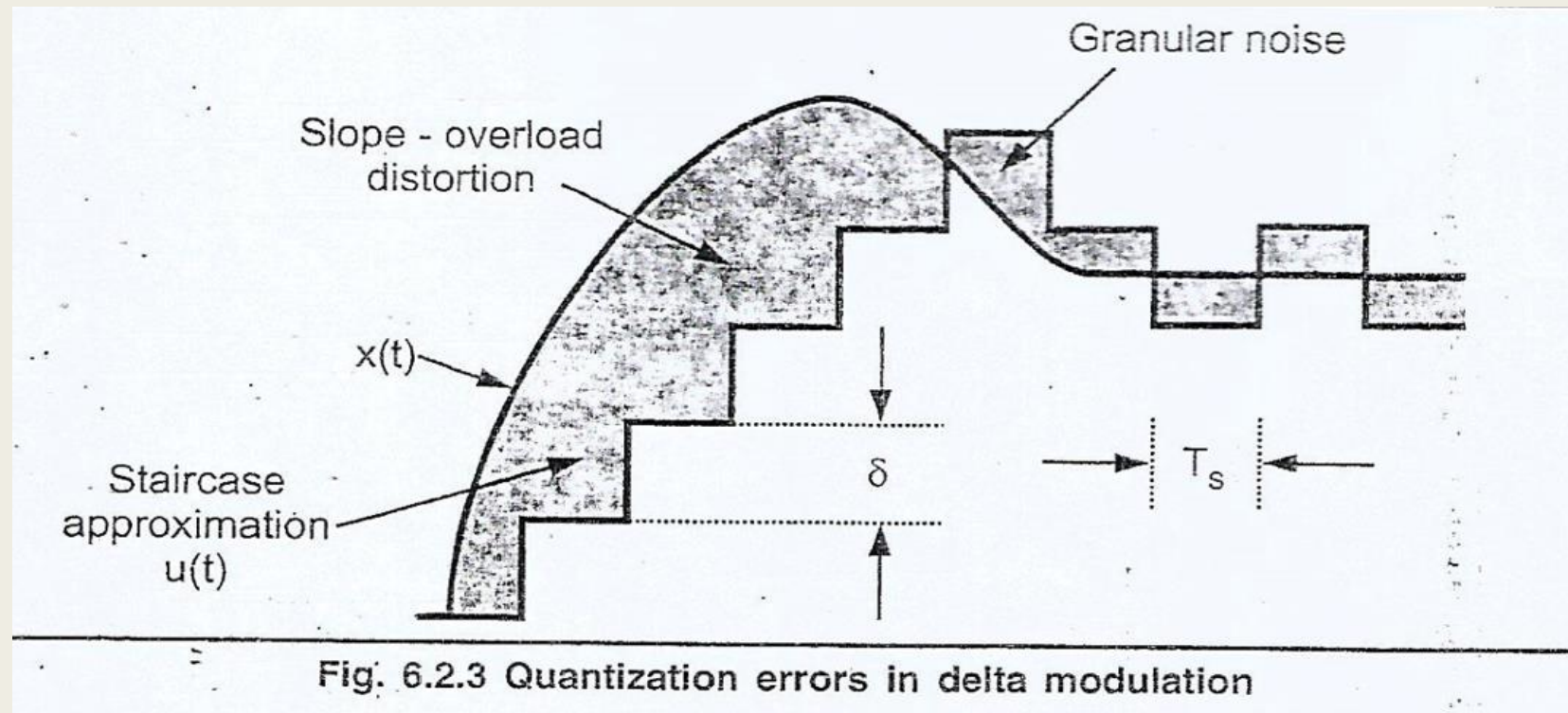
- The Delta Modulation has certain advantages over PCM as under:
 - I. since, the Delta modulation transmits only one bit per sample, therefore the signaling rate and transmission channel bandwidth is quite small for delta Modulation compared to PCM
 - II. The transmitter and receiver implementation is very much simple for delta Modulation.
 - III. There is no analog to digital conversion required in DM

Drawbacks (disadvantages) of Delta - Modulation

■ The delta – modulation has two major drawbacks as under:

I. Slope overload distortion

II. Granular or idle noise



I. Slope overload distortion(Startup error)

- This distortion arises because of **large dynamic range of the input signal**
- As can be observed from Fig. 6.2.3 in slide 14, the rate of rise of input signal $x(t)$ is so high that the staircase signal cannot 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 remains fixed, its maximum or minimum slopes occur along **straight lines**.
- **Therefore, this modulator is also known as Linear delta Modulator(LDM)**

II. Granular or idle noise

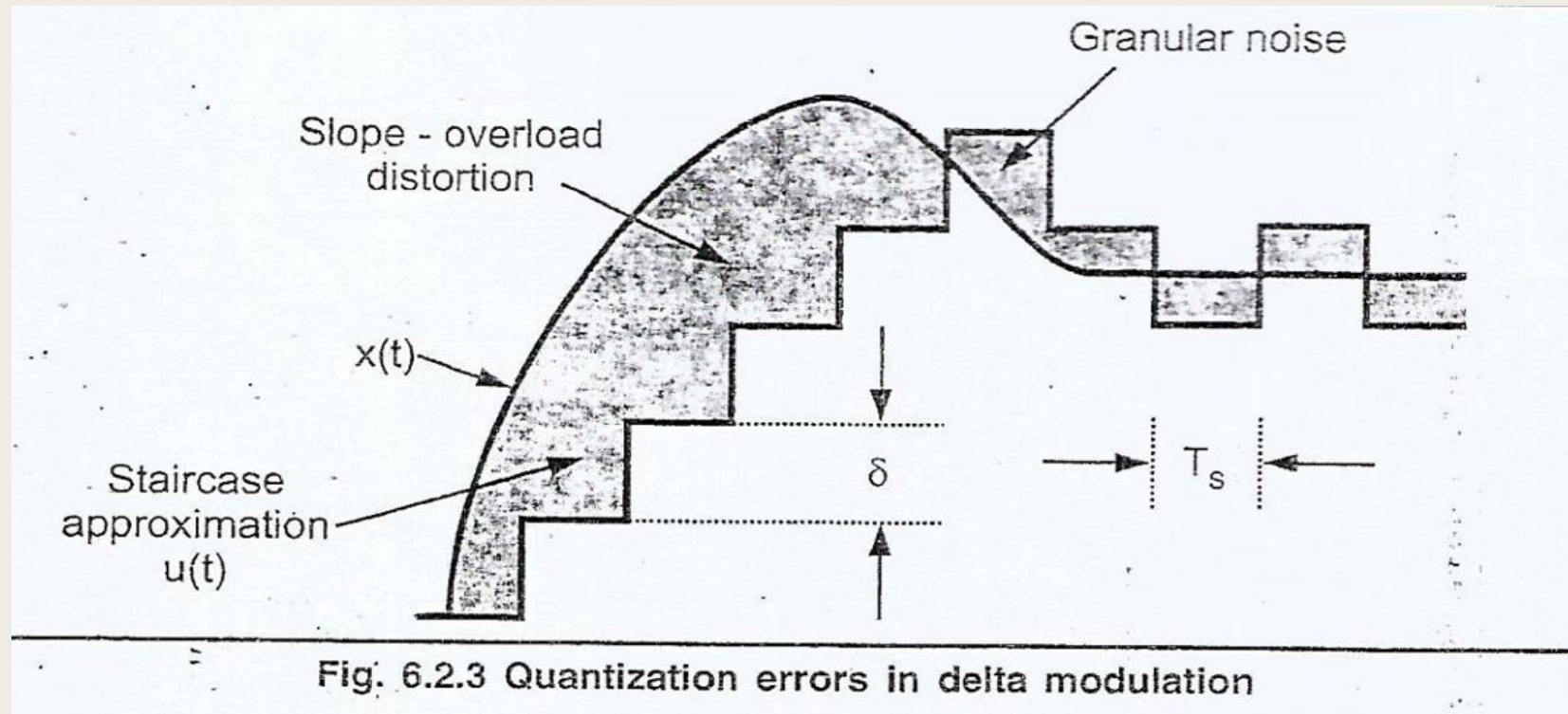
- **Granular or idle noise** occurs when the step size is too large compared to small variations in the input signal.
- This means that for very small variations in the input signal, the staircase signal is changed by large amount δ because of large step size.
- Fig. 6.2.3 shows that when the input signal is almost flat, the staircase $u(t)$ keeps on oscillating by $\pm\delta$ around the signal
- The error between the input and approximated signal is called granular noise
- The solution to this problem is to make step size small

continue

- The large step size is required to accommodate wide dynamic range of the input signal(**to reduce slope overload distortion**)

And **small steps** are required to reduce **granular noise**.

- **Adaptive Delta Modulation (ADM)** is the modification



Example – Delta Modulation (DM)

Ex. 6.3.11 The input to the DM is $m(t) = 0.01 t$. The DM operates at a sampling frequency of 20 Hz and has a step size of 2 mV. Sketch the delta modulator output $\Delta(t)$ and $\hat{m}(t)$.

Sol. : Fig. 6.3.7 shows the DM output. The signal $m(t)$ is sketched for $t = 0$ to 1 sec. The signal $m(t)$ rises linearly with time. The DM changes its output in steps of 2 mV. When reconstructed signal $\hat{m}(t)$ is less than $m(t)$ output is increased by δ . When $\hat{m}(t)$ is greater than $m(t)$, output is reduced by δ . The change in $\hat{m}(t)$ takes place at sampling instants. When $\hat{m}(t)$ is increased by ' δ ', modulator output is $\Delta(t) = 1$. When $\hat{m}(t)$ is reduced by ' δ ', modulator output is $\Delta(t) = 0$. The sampling frequency is $f_s = 20$ Hz. Hence sampling duration will be $T_s = \frac{1}{f_s} = \frac{1}{20} = 0.05$ seconds. Fig. 6.3.7 shows $m(t)$, $\hat{m}(t)$ and $\Delta(t)$ for 0 to 1 sec with sampling durations of 0.05 sec.

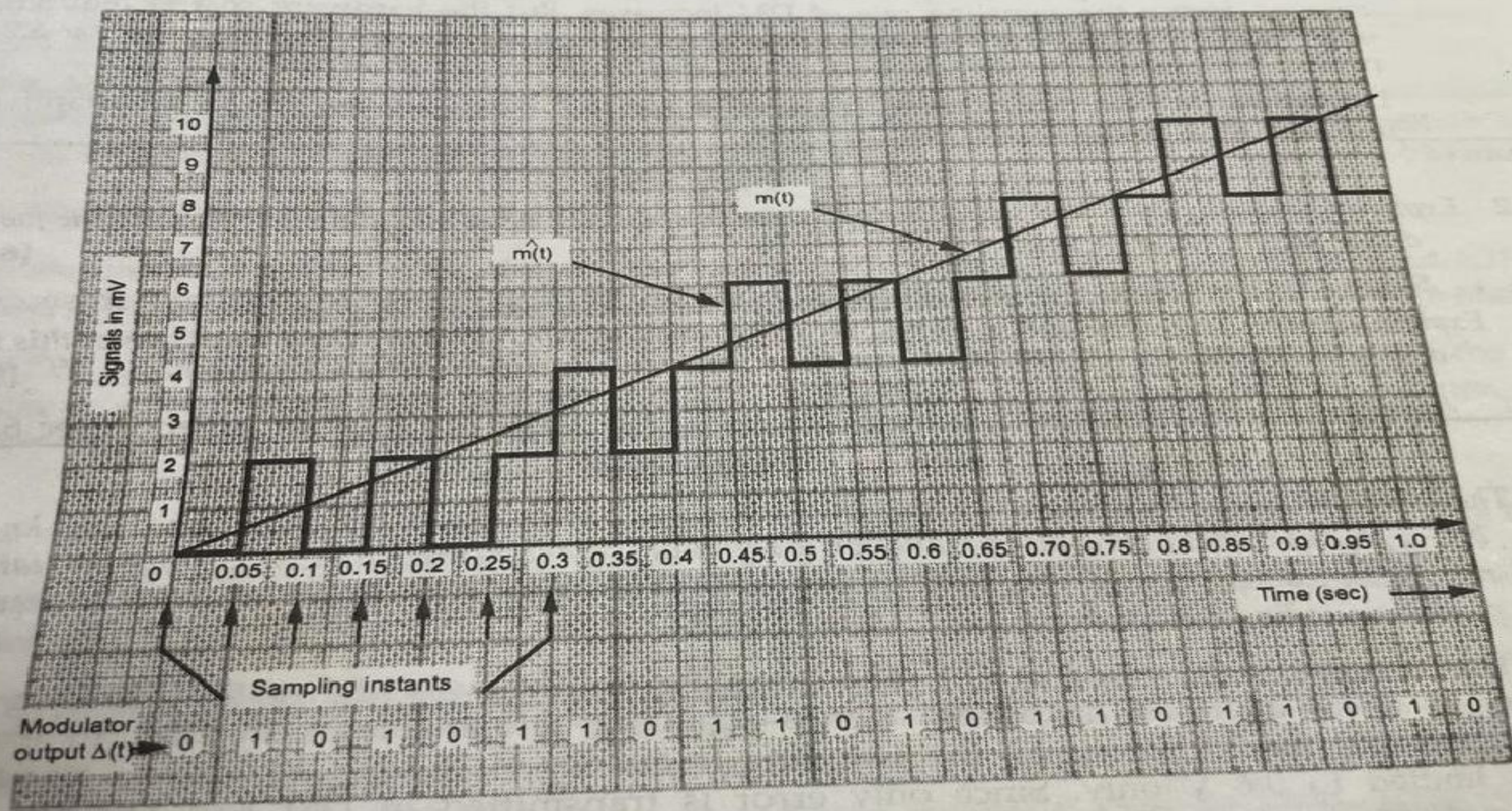


Fig. 6.3.7 Sketch of $m(t)$, $\hat{m}(t)$ and output of modulator