20/03/25

Unit:-10

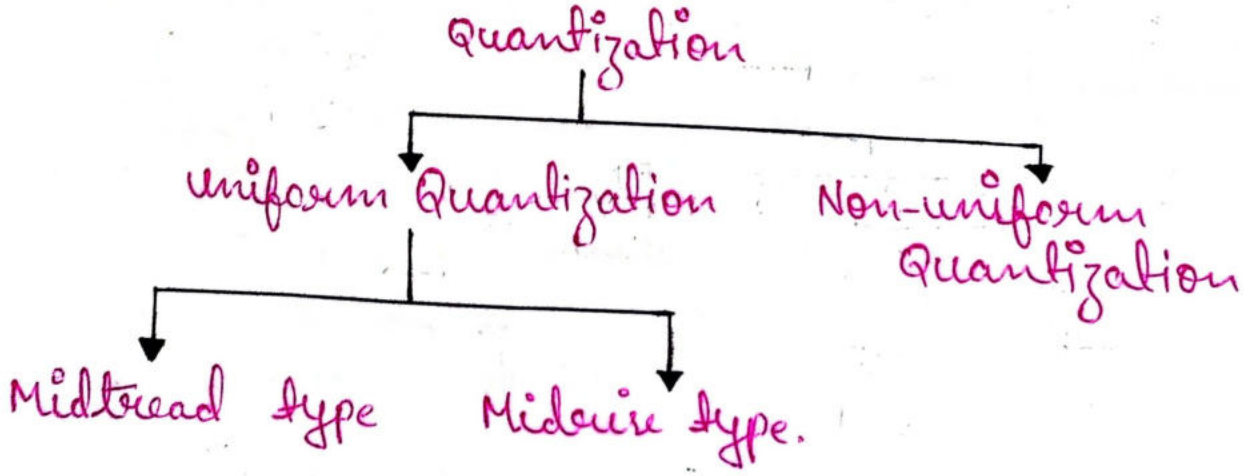
Digital Coding

» Quantization

The digitization of analog signal involves the rounding off the values which are approximately equal to the analog values. The method of sampling chooses a few points on the analog signal and then these points are joined to round off the value to a near stabilized value. Such a process is called as Quantization.

Classification of Quantization Process:-

Basically, quantization process may be classified as follows:-



→ The quantization process can be classified into two types as under:

i) Uniform Quantization
ii) Non-uniform quantization.

This classification is based on the step size as defined.

i) Uniform Quantization :-

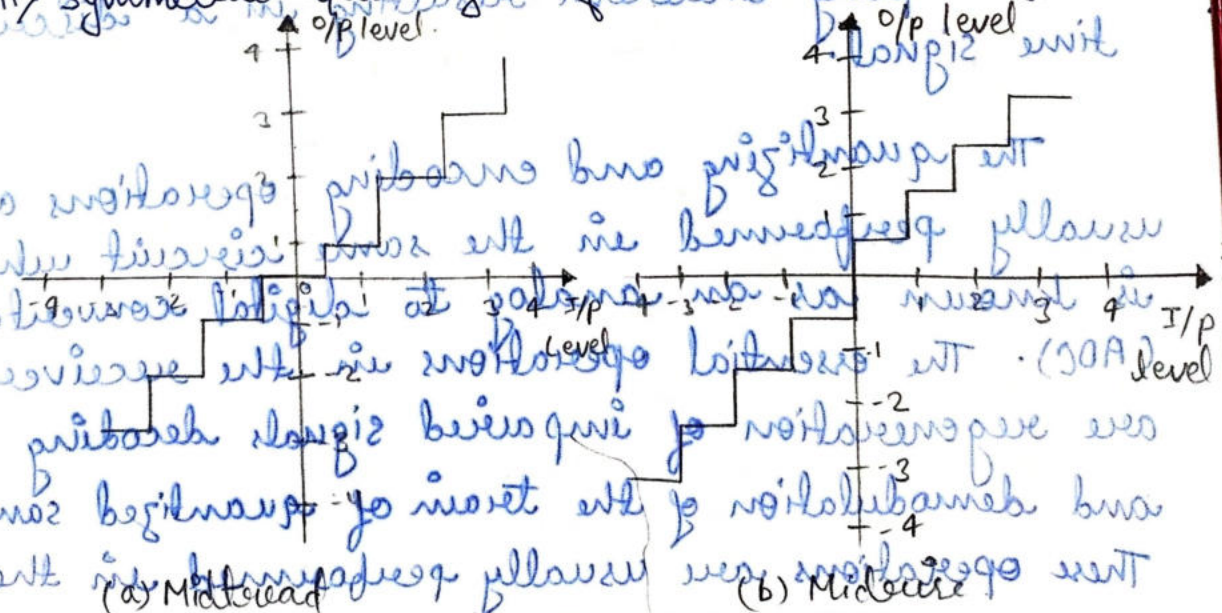
A uniform quantizer is that type of quantizer in which the 'step size' remains and throughout the input range.

ii) Non-Uniform Quantization :-

A non-uniform quantizer is that type of quantizer in which the 'step size' varies according to the input signal values.

* There are two types of Uniform Quantization :-

i) symmetric quantizer of the midtread type
ii) Symmetric quantizer of the midrise type.



(a) Midtread (b) Midrise

≫ Quatrization Noise / Error in PCM

Quantization noise (i.e error) in a PCM system for linear quantization or uniform quantization. Because of quantization, inherent errors are introduced in the signal. This error is called quantization error.

$$\varepsilon = x_q(nT_s) - x(nT_s)$$

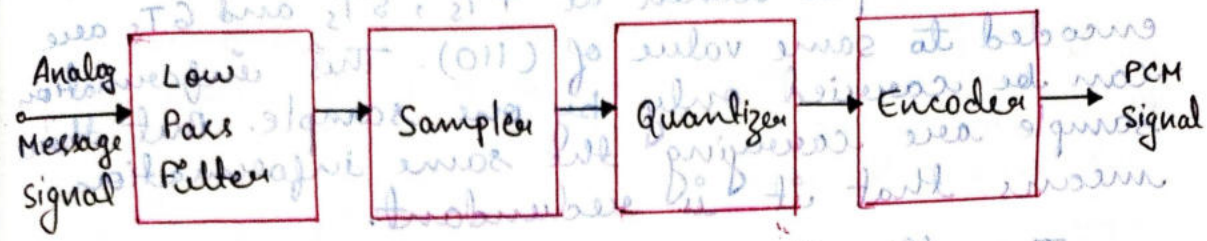
≫ Pulse Code Modulation (PCM)*

Pulse code modulation is known as a digital pulse modulation technique.

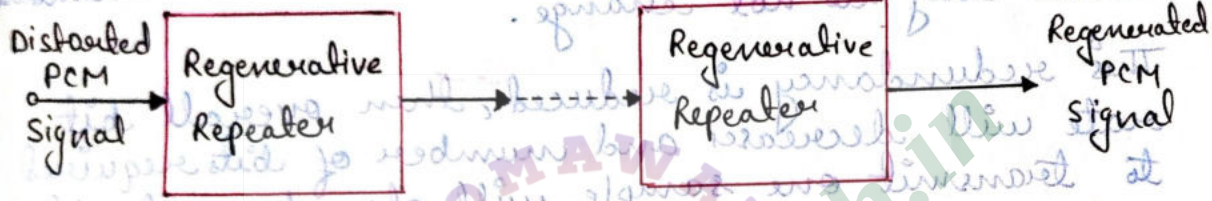
It consist of three main parts i.e., transmitter, transmission path and receiver. The essential operations in the transmitter of a PCM system are sampling, quantizing and encoding. Sampling is the operation in which an analog (i.e continous-time) signal is sampled according to the sampling theorem resulting in a discrete-time signal.

The quantizing and encoding operations are usually performed in the same circuit which is known as an analog to digital converter (ADC). The essential operations in the receiver are regeneration of impaired signals decoding and demodulation of the train of quantized samples. These operations are usually performed in the

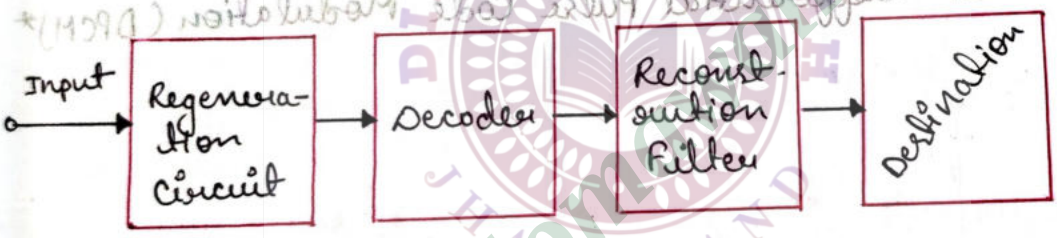
same circuit which is known as digital-to-analog converter (DAC).



(a) Transmitter



(b) Transmission



(c) Receiver

* The basic elements of a PCM System.

* Regenerative repeaters are used to reconstruct (i.e., regenerate) the transmitted sequence of coded pulses in order to combat the accumulated effects of signal distortion and noise.

» Differential Pulse Code Modulation (DPCM)*

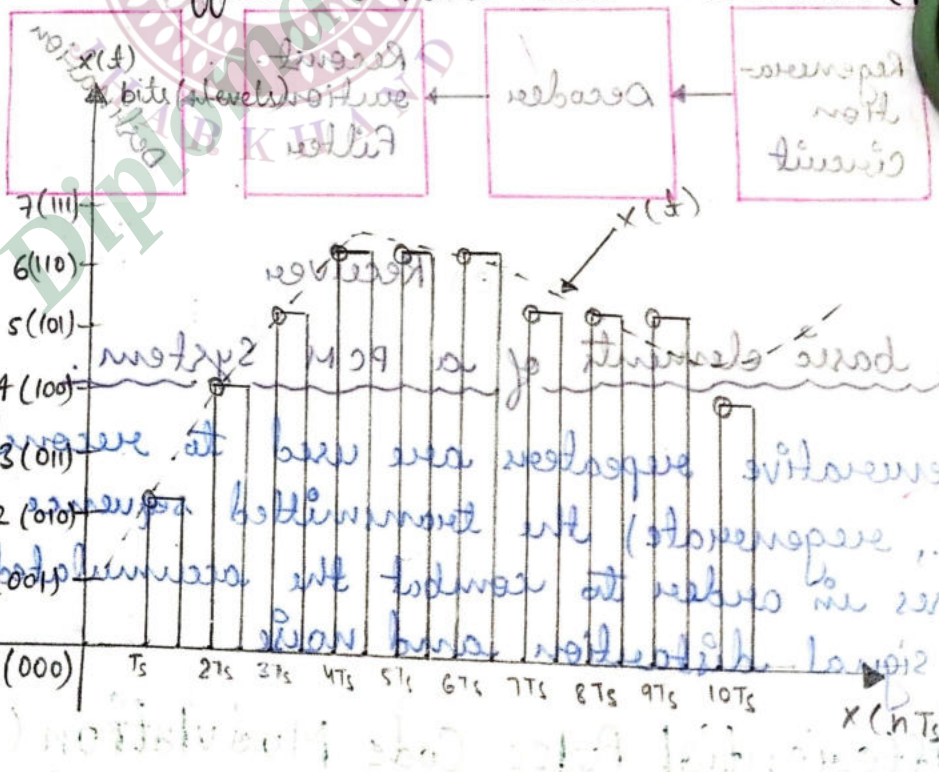
The samples are encoded by using 3 bit (7 level) PCM. The sample is quantized to the nearest digital level as shown by small circles in the figure

The encoded binary value of each sample is written on the top of the samples.

The samples taken at $4T_s$, $5T_s$ and $6T_s$ are encoded to same value of (110). This information can be carried only by one sample. But three sample are carrying the same information means that it is redundant.

The difference between these samples only due to last bit and first two bits are redundant since they do not change.

This redundancy is reduced, then overall bit rate will decrease and number of bits required to transmit one sample will also be reduced. This type of digital pulse modulation scheme is known as Differential Pulse Code Modulation (D



Delta Modulation

i) Reason to use delta Modulation:-

We have observed in PCM that it transmit all the bits which are used to code a sample. Hence, signaling rate and transmission channel bandwidth are quite large in PCM. To overcome this problem, Delta Modulation is used.

ii) Working Principle:-

Delta Modulation transmits only one bit per sample. Here, the present sample value is compared with the previous sample value and the result whether the amplitude is increased or decreased is transmitted. Input signal $x(t)$ and staircase approximated signal is confined to two levels, i.e., $+\Delta$ and $-\Delta$. 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 bits is transmitted.

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

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

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

$x(nT_s)$ = last sample approximation of the staircase waveform.

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

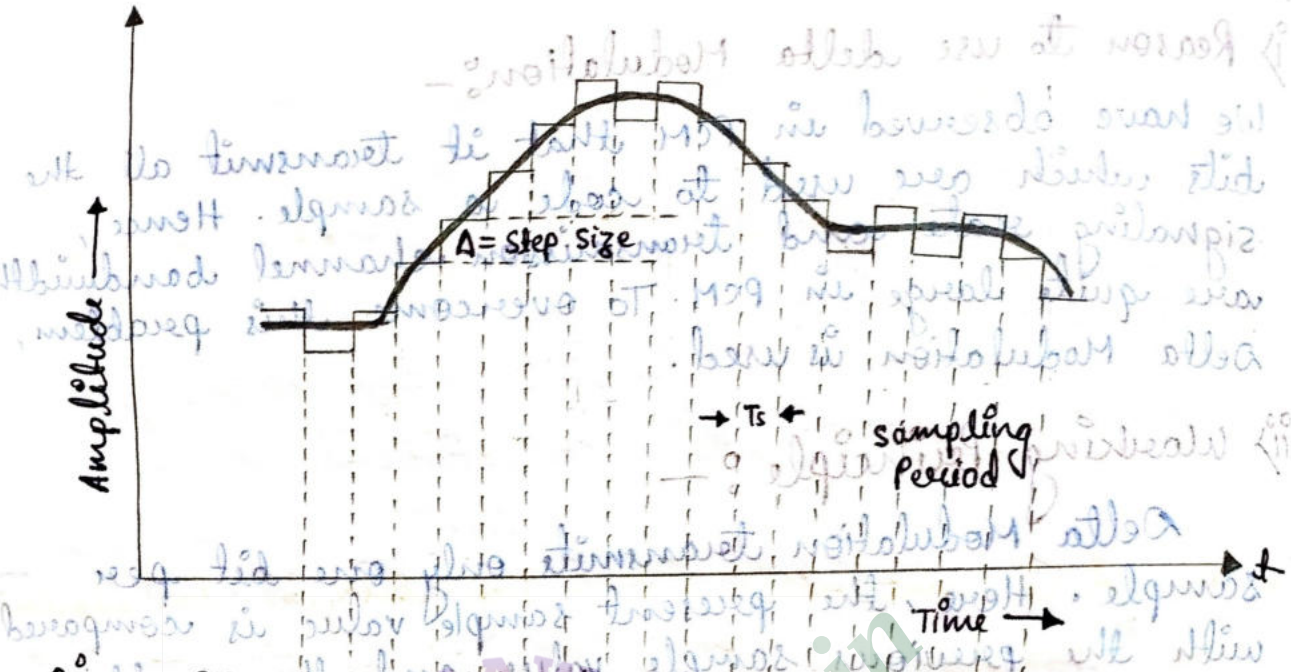


Fig:- Delta Modulation waveform.

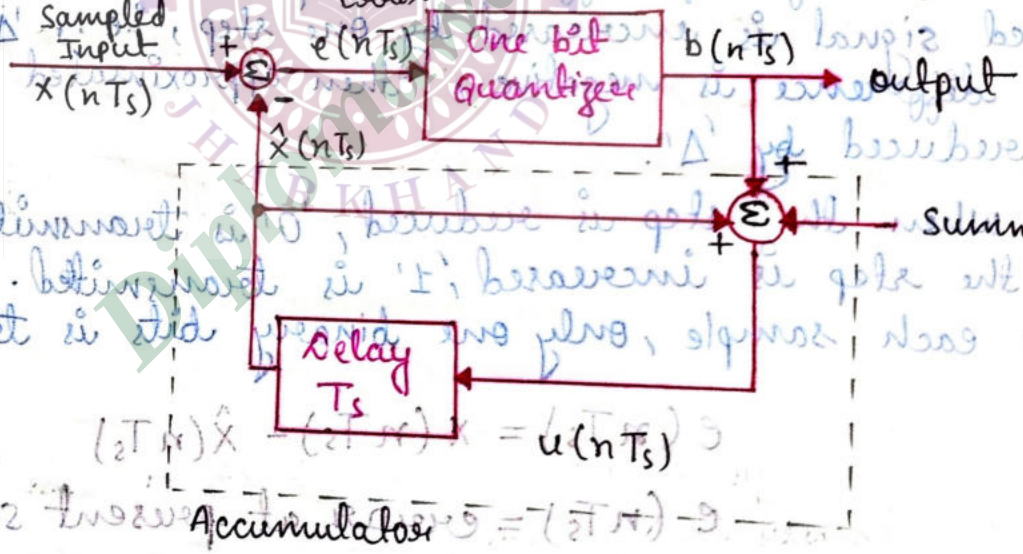


Fig:- Delta modulation transmitter

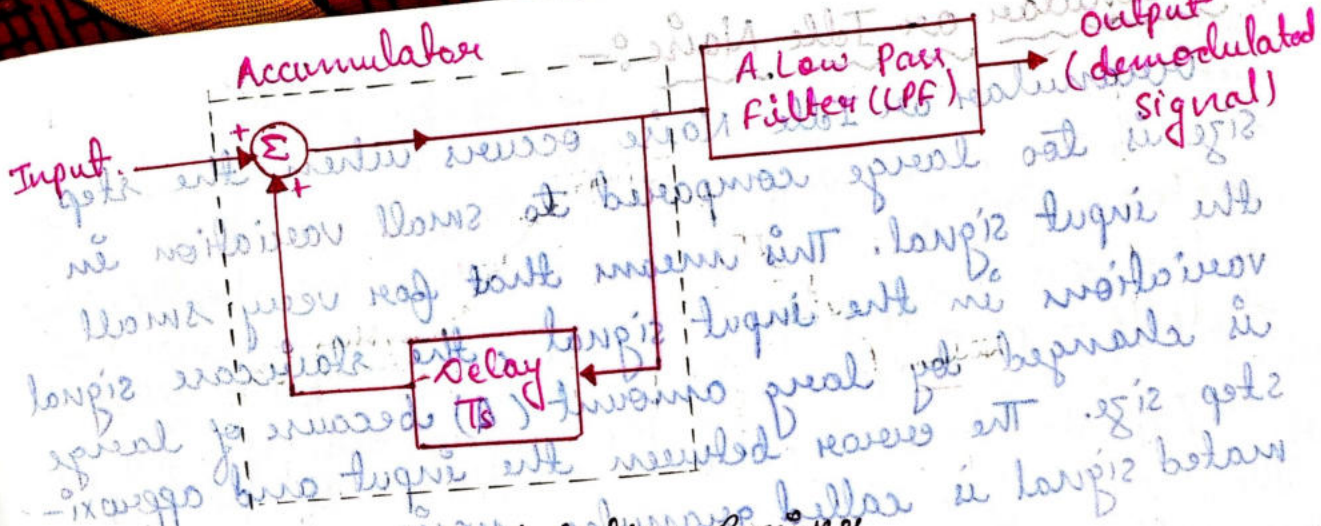


Fig:- Delta Modulation Receiver

* The delta modulation has two major drawbacks as under:-
  i) Slope overload distortion
  ii) Granular or idle noise

i) Slope Overload Distortion:-
This distortion arises because of large dynamic range of the input signal. 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.

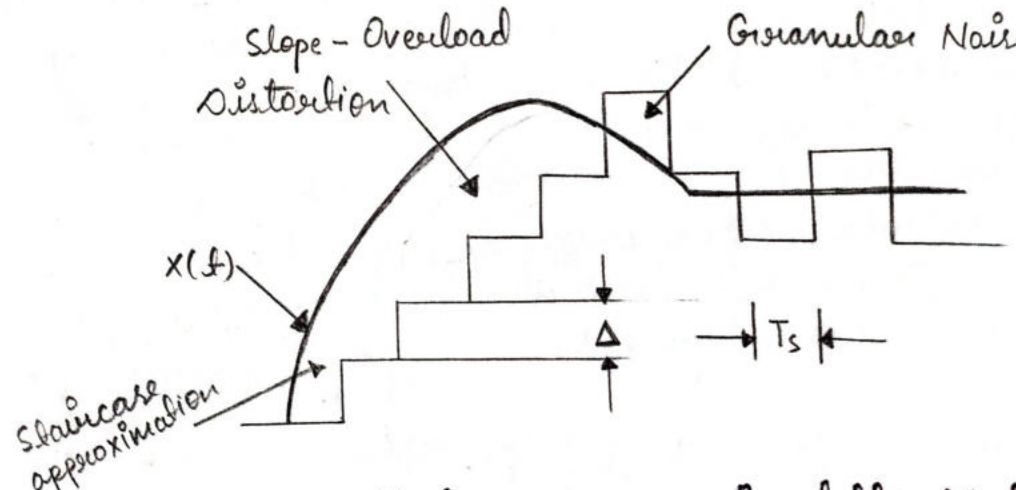


Fig:- Quantization errors in delta Modulation

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

≫ Adaptive Delta Modulation :-

* Reason to use Adaptive delta modulation

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 ($x(t)$). The step segment of the signal $x(t)$, the step size is increased, if the input is varying slowly. Then, this method is known as Adaptive Delta Modulation (ADM).