Delta modulation

Delta modulation is a special type of differential pulse code modulation. In DPCM the dynamic range of the signal is reduced by generating an error function which is obtained by Taking the difference between two consecutive samples. if the signal is not changing very fast the error function will have very small value. Because the samples are corelated to each other.

In delta modulation also the dynamic range is reduced by taking the errorfunction.

But in deltamodulation only 2 level quantization is possible.

$L = 2^n$ (n bit encoder)

when $L = 2$

$2 = 2^1$ which means there is

one bit encoder in delta modulation.

1 bit representation means either 0 or 1.

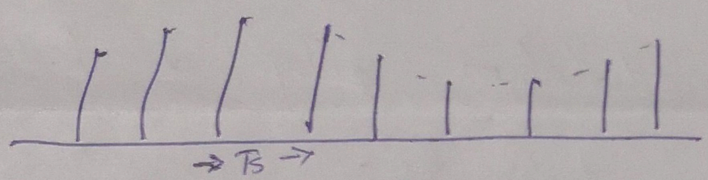
we know that when n is reduced the bandwidth get reduced.

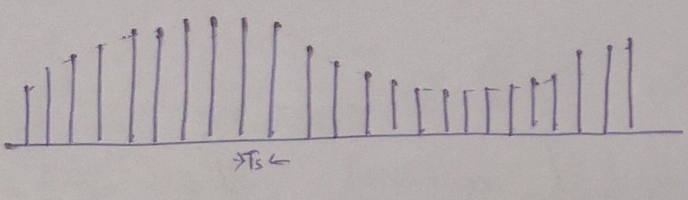
$BW = nf_s$; So in deltamodulation $BW = f_s$ (reduced)

This is Beneficial because we now require less cost to purchase bandwidth spectrum.

As n is decreased (n=1); Bit rate has decreased. Bit rate has a direct relation with speed; when bit rate reduce the speed will reduce. So in order to increase the speed of transmission we can increase the sampling frequency fs. So that we can manage the bitrate problem.

So in Delta modulation the analog signal is highly oversampled (Much higher than Nyquist rate) which in turn increas the adjacent sample correlation. So signal reconstruction is very easy





<u>Working:-</u>

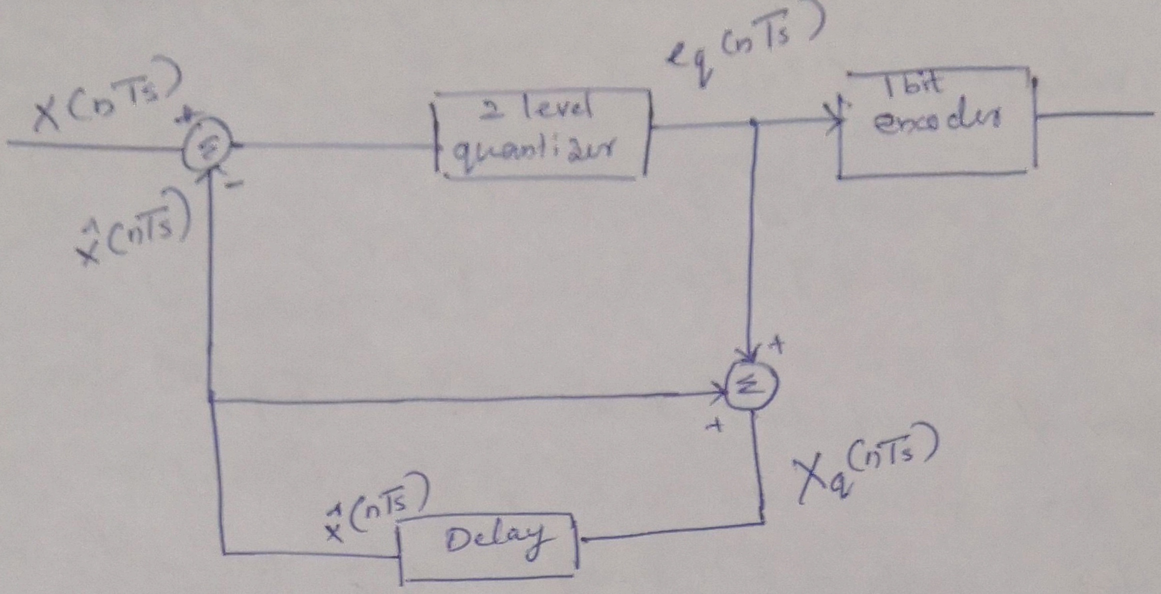
the error function represented by $e(nTs)$

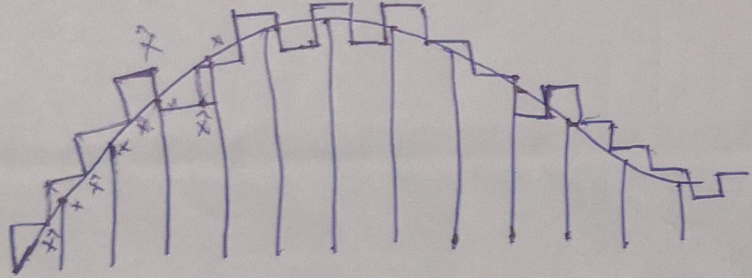
$$e(nTs) = x(nTs) - \hat{x}(nTs)$$

if $e(nTs) > 0$ then $x(nTs) > \hat{x}(nTs)$ and represented by $+\Delta$

$e(nTs) < 0$ then $x(nTs) < \hat{x}(nTs)$ and represented by $-\Delta$

DM Transmitter

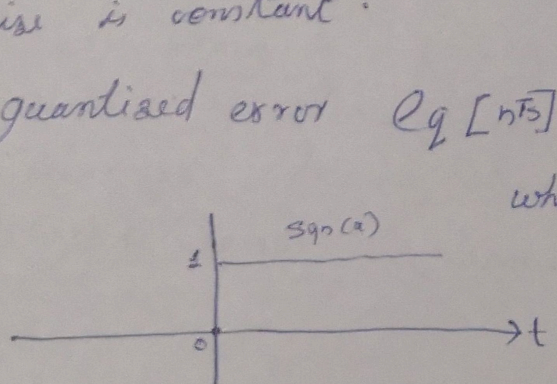




when quantization starts; initially we don't have the predicted value so we starts with $+\Delta$ (It means quantization step going upward) when error function is less that zero it means $x(nT_s)$ is less than $\hat{x}(nT_s)$ and the represented by $-\Delta$ (quantization step going downwards) step size is constant.

the quantized error $e_q[nT_s] = \Delta \, sgn(e[nT_s])$

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



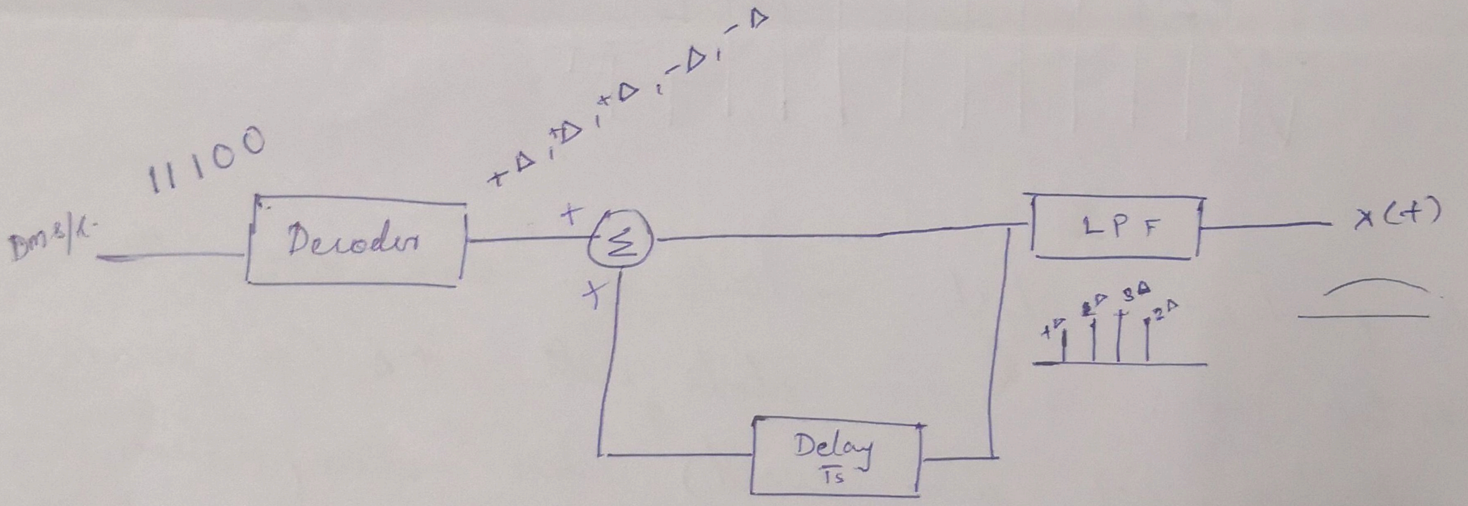
$$sgn(x) = \begin{cases} +1 & \text{if } x > 0 \\ -1 & \text{if } x < 0 \end{cases}$$

This means Δ can take ^direction (upword or downward) only depending upon the value of $e(nT_s)$

$$\boxed{\begin{array}{ll} e[nT_s] > 0 \Rightarrow e_q(nT_s) = +\Delta & — 1 \\ e[nT_s] < 0 \Rightarrow e_q(nT_s) = -\Delta & — 0 \end{array}}$$

So from this we can know that $e_q[n]$ can take only two values $+\Delta$ or $-\Delta$ which implies there is only two levels and therefore only one bit is required for ~~quantization~~ encoding. (0 or 1)

DM Reciever



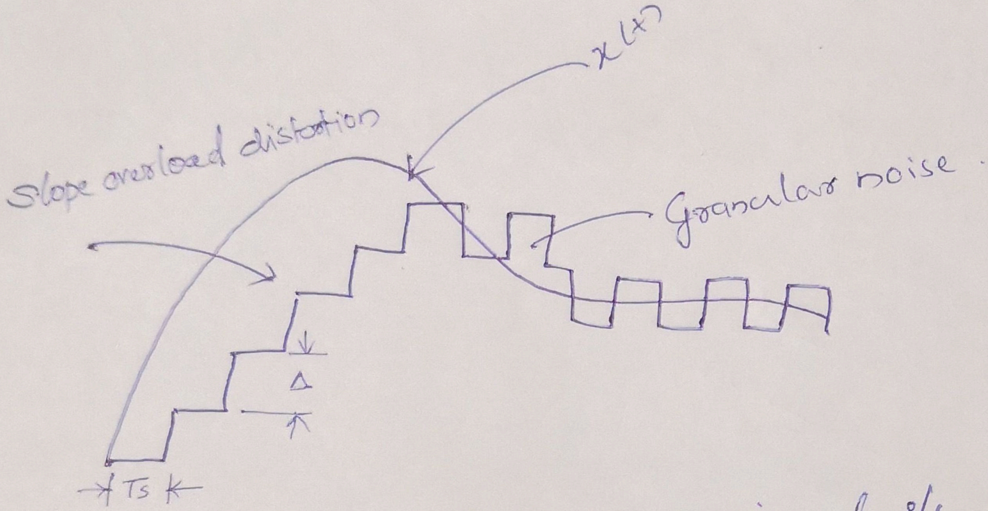
The delta modulated signal is given to a decoder which reproduces the quantised error signal which is added with the previous samples of the error signal which is produced by the delay element. And it is given to a LPF which is a reconstruction filter which produces analog signal $x(t)$.

Errors in Delta Modulation.

(i) Slope over load distortion.

In general the stepsize we choose to quantise is fixed. Hence under maximum slop of the signal stepsize becomes small to follow the sleep of the input waveform. This condition is called slope-overload and the resulting quantizing error is called slop-over load distortion ii Granular noise

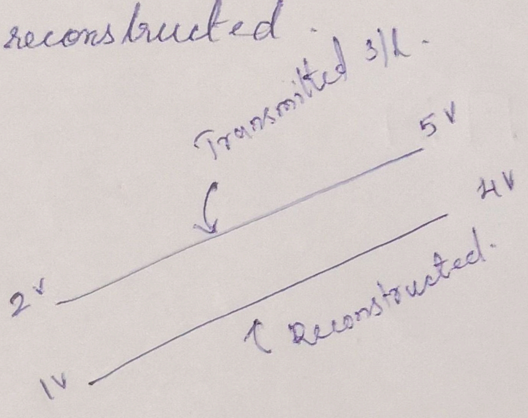
In contrast to the slope overload distortion, the granular noise occurs when the step size Δ is too large relative to the local slope characteristics of the input wave form, thereby causing the staircase approximation to hunt around a relatively flat segment of the input wave form.



slope of the original s/l $x(t) = \dfrac{d\,x(t)}{dt}$

slop of the estimated s/l (stair case) $= \dfrac{\Delta}{T_s}$

* The value of Δ for which $x(t)$ can perfectly reconstructed is called Δ_{opt} or optimum step size.
* If the rate of change (slope) of the reconstructed s/l is same as the transmitted s/l then transmitted can be perfectly reconstructed.



(i) Perfect reconstruction.

slope of $x(t)$ = slope of reconstructed s/l.

$$\frac{d}{dt} x(t) = \frac{\Delta opt}{T_s}$$

(ii) slope overload distortion

$$\frac{\Delta}{T_s} < \frac{d}{dt} x(t)$$

$$\frac{\Delta}{T_s} < \frac{\Delta opt}{T_s}$$

$$\boxed{\Delta < \Delta opt}$$

(iii) Granular Noise

$$\frac{\Delta}{T_s} > \frac{d}{dt} x(t)$$

$$\frac{\Delta}{T_s} > \frac{\Delta opt}{T_s}$$

$$\boxed{\Delta > \Delta opt}$$