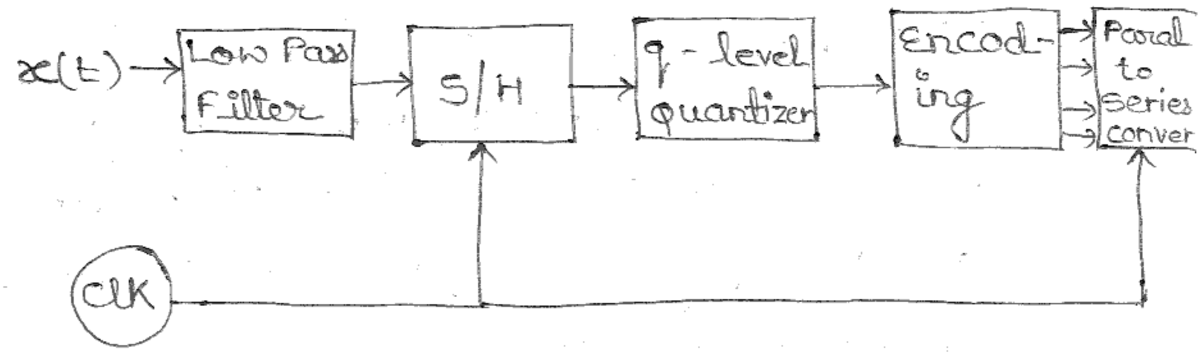
★ A-D Conversion or Basic or Primary Line coding / PCM



A band limiter signal $x(t)$ which has the maximum frequency component w is can be sampled and reconstructed back if the sampling frequency f_s should be greater than or equal to twice of the maximum frequency.

★ Quantization Error :~

The difference between quantised output $x_q(nT_s)$ and sampled output $x(nT_s)$ is called quantization error. It is denoted as ε or $e_q(nT_s)$.

$\varepsilon = x_q(nT_s) - x(nT_s)$ is called quantization error.

★ Entropy :~

The number of primary bits need to represent a single sample is called entropy or average information.

The number of quantisation levels evaluated with the help of entropy is expressed as the 2^n where n is entropy.

i.e. $q = 2^n$

Q- Find the desired or required sampl frequency to transmit in a low band channel if $x(t) = 200 \sin 1500\pi t + 150 \cos 3000\pi t$

Sol- We have

$$f_s = 2W$$

$\therefore$ $x(t) = 200 \sin 1500\pi t + 150 \cos 3000\pi t$

$2f_1 = 1500\,Hz \Rightarrow f_1 = 750\,Hz$

$2f_2 = 3000\,Hz \Rightarrow f_2 = 1500\,Hz$

$\therefore$ $W = 1500$

$2W = 3000$

$\therefore$ $f_s = 3000\,Hz$

<Ans>

★ **Aliasing :~**

If the sampling frequency less than a twice of maximum freq. the over lapping of adjacent symbols may occurs in either transmission channel or receiver. This effect is known as aliasing.

★ **Nyquist rate :~**

The twice of the maximum frequency of incoming analog signal $x(t)$ is called Nyquist rate.

★ **Bit rate (r) :~**

It is defined as the product of sampling frequency and average information (entropy).

$$\text{Bit rate } r = \text{Sampling rate} \times \text{Entropy}$$

$$r = f_s \times V = V f_s$$

$$r = 2VW$$

$$\text{rate } r = \frac{\cancel{\text{samples}}}{\text{sec}} \times \frac{\text{bits}}{\cancel{\text{samples}}}$$

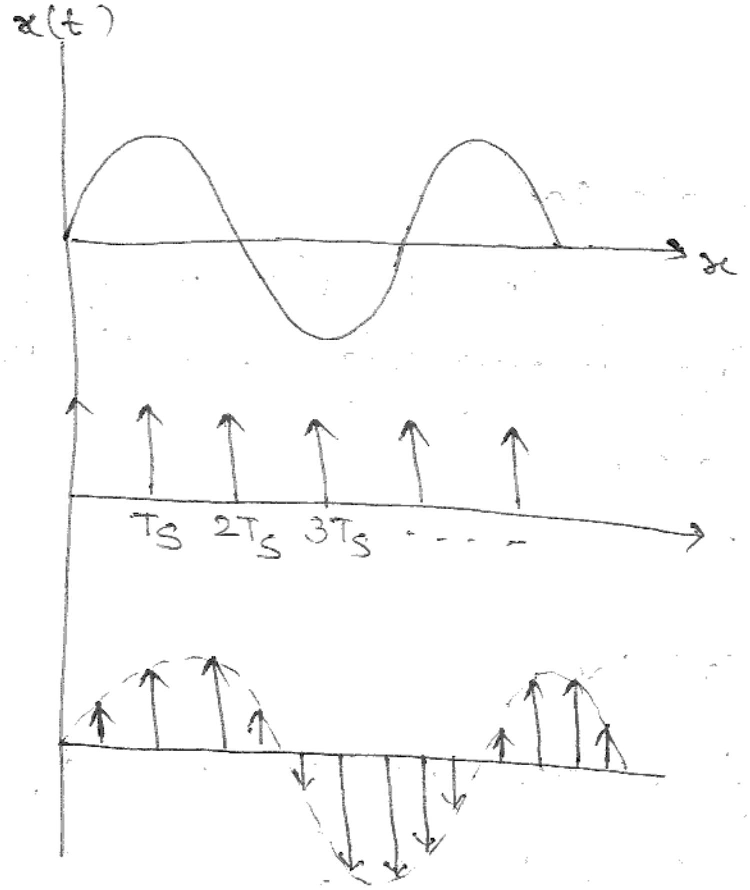
$$r = \text{bits/sec.}$$

★ Sampling

$f_s \geq 2W$

- Clock pulse generate the sequence of

- $$\boxed{X_\delta(f) = f_s \sum_{n=-\infty}^{\infty} X(f - nf_s)}$$



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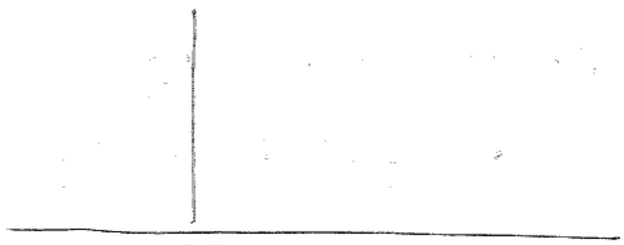


$\delta(t) = A \quad t = 0$

$\delta(t-1) = A \quad \delta(t) = A \quad$ when $t = 0$

$\delta(t) = 0$ when t = any value

$\delta(t+1)$

$$\Rightarrow \delta(t) = \sum_{n=-\infty}^{\infty} \delta(t - nT_s)$$

$$x_\delta(t) = x(nT_s) . \delta(t)$$

$$= x(nT_s) . \sum_{n=-\infty}^{\infty} \delta(t - nT_s)$$

$$= \sum_{n=-\infty}^{\infty} x(nTs)\, \delta(t - nTs)$$

By taking F.T, $x(t) = X(f)$

$$x(nTS)\, \delta(t - nTS) \xrightarrow{FT} fs\, X(f - nfs)$$

$$\boxed{X_\delta(f) = fs \sum_{n=-\infty}^{\infty} X(f - nfs)}$$

The sampled signal can be written in freq. domain as,

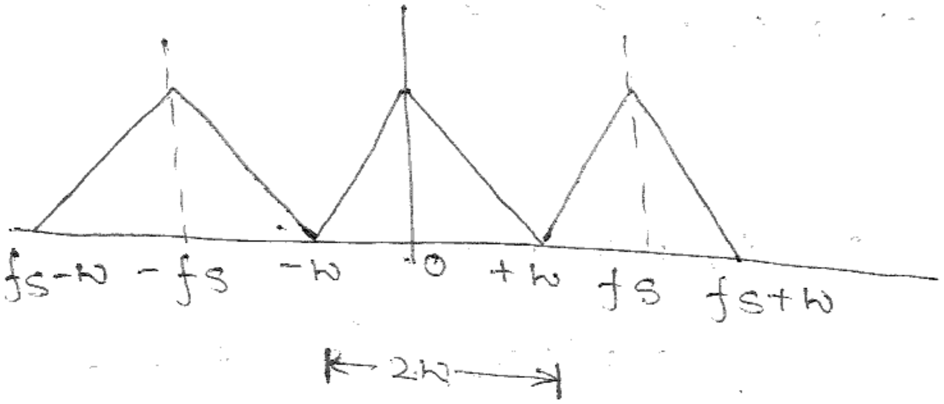
$$X_\delta(f) = fs \sum_{n=-\infty}^{\infty} X(f - nfs)$$

$$= fs\, X(f) + fs\, X(f \pm fs) + fs\, X(f \pm 2fs)$$

$$= fs\, X(f) + fs \sum_{n=-\infty}^{\infty} X(f - nfs)$$

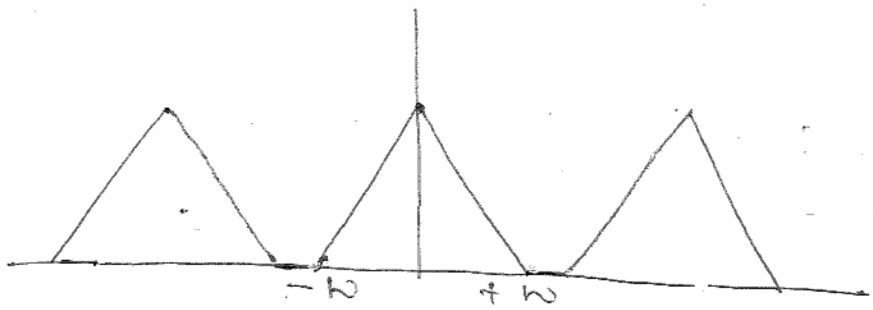
$f_s = 2W$

$\therefore f_s - W = W$



From this freq. spectrum we may conclude that there is no overlapping of samples. But it is in critical position.

If $f_s > 2W$ the freq. spec



→ Sampling Theorem For Bandpass Filter

A band pass signal has the max. bw 2W which can be sampled and reconstructed back if the sampling freq. twice of the band width of incoming signal $x(t)$.

$$f_s \geq 2(2W) \geq 4W$$

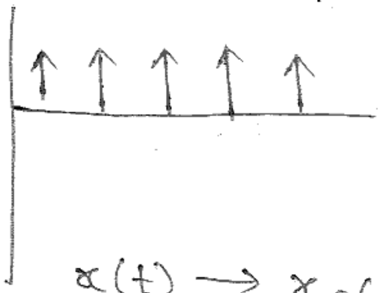
★ Sampling

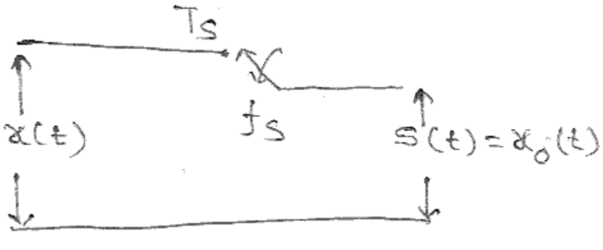
1) Ideal sampling / Instantaneous sampling / Impulse sampling.

II) Natural sampling / chopper sampling.

III) Flat - top sampling.

1) Ideal sampling





$$x(t) \rightarrow x_\delta(t)$$

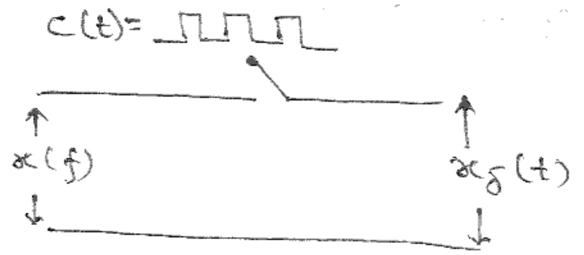
$$\delta(t) = \sum_{n=-\infty}^{\infty} \delta(t - nT_s)$$

$$x_\delta(t) = x(nT_s).\delta(t)$$

$$= \sum_{n=-\infty}^{\infty} x(nT_s).\delta(t - nT_s)$$

$$X(f) = f_s \sum_{n=-\infty}^{\infty} X(f - nf_s)$$

2) Natural sampling



$x(t) \rightarrow$ input signal

$x_\delta(t) \leftrightarrow x(t)$ when $c(t) = A$

$x_\delta(t) = 0$ when $c(t) = 0$

$$c(t) = \frac{TA}{T_0} \sum_{n=-\infty}^{\infty} C_n e^{j2\pi nt/T_0}$$

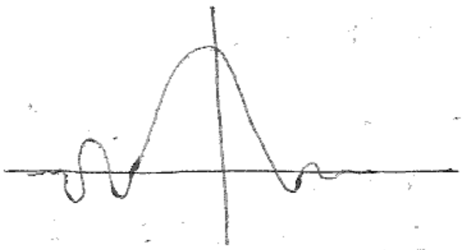
$$C_n = \frac{TA}{T_0} \operatorname{sinc}(f_n T)$$

Put C_n in $c(t)$ we get

$$c(t) = \sum_{n=-\infty}^{\infty} \frac{\tau A}{T_S} \operatorname{sinc}(n f_s \tau)$$

Note :-

$$\operatorname{Sinc}(\theta) = \frac{\sin \pi\theta}{\pi\theta}$$



$$x_\delta(t) = x(nT_s)$$

$$= x(nT_s) \cdot c(t)$$

$$c(t) = \sum_{n=-\infty}^{\infty} c_n e^{j2\pi nft/T_0}$$

$$c_n = \frac{\tau A}{T_s} \operatorname{sinc}(nf_s\tau)$$

$$\therefore c(t) = \sum_{n=-\infty}^{\infty} \frac{\tau A}{T_s} \operatorname{sin}(nf_s\tau) e^{j2\pi nf_s t}$$

$$\therefore x_\delta(t) = x(nT_s) \cdot C(t)$$

$$x_\delta(t) = \frac{\tau A}{T_s} \operatorname{sinc}(nf_s\tau) \sum_{n=-\infty}^{\infty} x(nT_s) e^{j2\pi nf_s\tau}$$

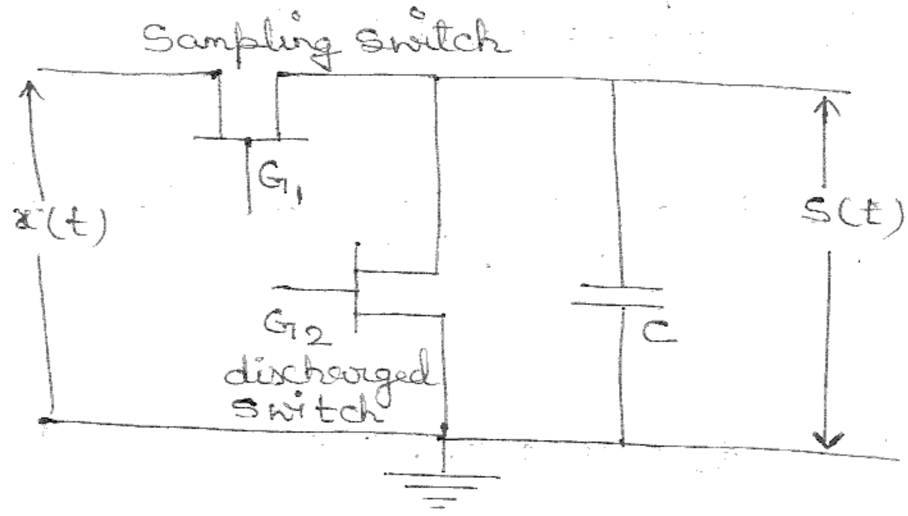
$$X_\delta(f) = \frac{\tau A}{T_s} \operatorname{sinc}(nf_s\tau) F.T\left\{ \sum_{n=-\infty}^{\infty} x(nT_s) e^{j2\pi f s^{-1}} \right\}$$

$$\boxed{X_\delta(f) = \frac{\tau A}{T_s} \operatorname{sinc}(nf_s\tau) \sum_{n=0} X(f - nf_s)}$$

$$\boxed{X_\delta(f) = \frac{\tau A}{T_s} \operatorname{sinc}(nf_s\tau) \sum_{n=-\infty}^{\infty} X(f - nf_s)}$$

Convolution function is used for producing flat-top sampling.

3) Flat - top sampling



$$s(t) = x(t) . h(t)$$

$$s(t) = x_\delta(nT_s) . h(t)$$

$$S(f) = X_\delta(f) . H(f) \quad \text{—} \quad (a)$$

WKT

$$X_\delta(f) = f_s \sum_{n=-\infty}^{\infty} X(f - nf_s) \quad \text{—} \quad (1)$$

Put in the (a) we get

$$S(f) = f_s \sum_{n=-\infty}^{\infty} X(f - nf_s) H(f)$$

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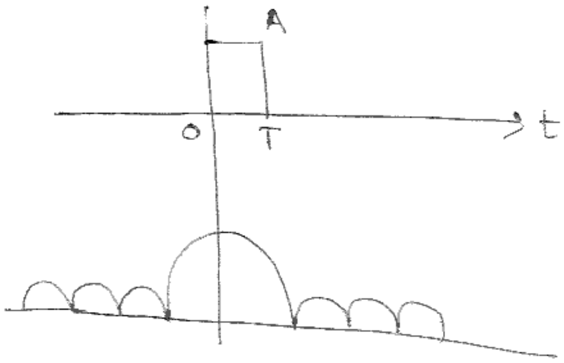

Harmonics = 70% information

30% noise

Imp. marks

- Roll-off factor

  It is the creater of higher harmonics.

- Aperture effect

  Removal of higher harmonics.