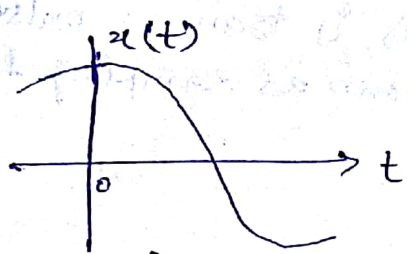
Sampling Technique (3 types)

(1) Instantaneous Sampling (Ideal case)
(2) Natural sampling.] Practical
(3) flat top sampling.] case.

(1) Instantaneous Sampling.

Also called Ideal or Impulse Sampling.

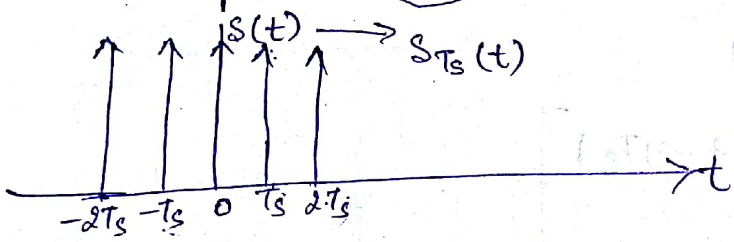
→ In this type of sampling the sampling fx is a train of impulse



Input signal

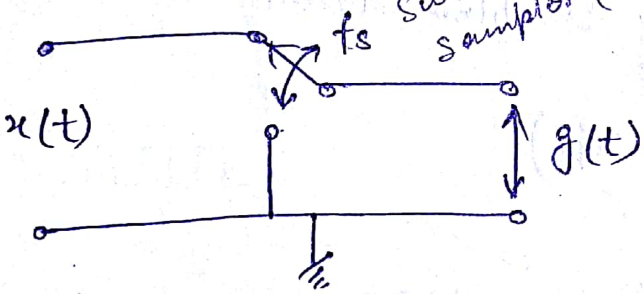
$\delta(t)\big|_{t=0}$

$\delta(t-T_s)\big|_{t=T_s}$



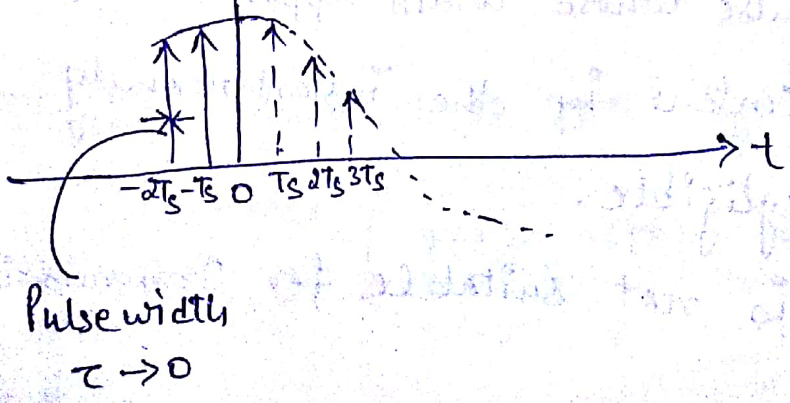
Impulse Train

switching sampler (Sampling fx of (train of impulses)



functional diagram of a switching sampler.

Switch Bydefault at Ground level and change position corresponding to Impulse Train sample like 0 T_s $2T_s$ . . .



Sampled signal

Working - ① ckt consists of a switch. Now if we assume that, the closing time 't' of the switch approaches zero, then the o/p $g(t)$ of this ckt. will contain only instantaneous value of the input signal $x(t)$.

② Since the width of the pulse approaches zero, the instantaneous sampling gives a train of impulses of height equal to the instantaneous value of the input signal $x(t)$ at the sampling instant.

$$\delta_{T_s}(t) = \sum_{n=-\infty}^{\infty} \delta(t-nT_s)$$ → This is train of pulses and known as sampling function.

then sampled signal $g(t)$

$$g(t) = x(t) \cdot \delta_{T_s}(t)$$

$$\left[g(t) = x(t) \cdot \sum_{n=-\infty}^{\infty} \delta(t-nT_s) \right]$$

Fourier transform of ideally sampled signal

$$\left[G(f) = f_s \sum_{n=-\infty}^{\infty} X(f-nf_s) \right]$$

Note - ① Ideal sampling is possible only in theory since it is impossible to have a pulse whose width approaches zero.

② Due to $\tau = 0$ power content in the instantaneously sampled pulse is negligible.

③ Thus this method is not suitable for Transmission purpose.

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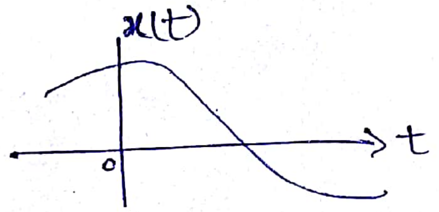
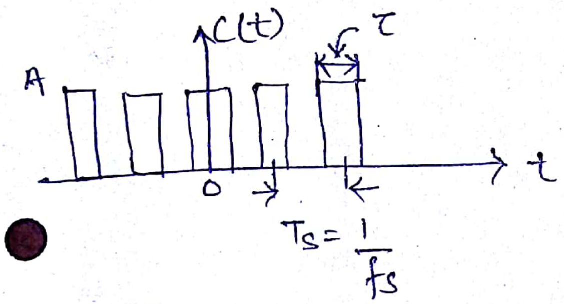
Natural Sampling — In Natural Sampling pulse has a finite width equal to τ.

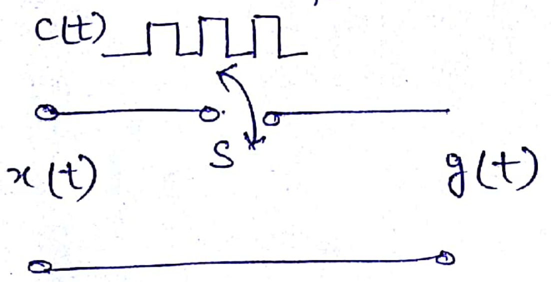
1. Consider analog Continuous time signal $x(t)$.
2. f_s is higher than Nyquist rate (sampling theorem satisfied)
3. Sampling fx $c(t)$ which is a train of periodic pulses of width τ and freq. equal to f_s Hz.
4. with the help of natural sampler a sampled signal $g(t)$ is obtained by multiplication of sampling function $c(t)$ and input signal $x(t)$.



Continuous time signal.



Periodic Pulse train



Natural Sampler.
using chopping ~~ckt~~ Principle.

working: when $c(t)$ goes high switch S is closed.

Therefore
$$g(t) = x(t) \quad \text{when } c(t) = A \rightarrow \text{Amplitude of } c(t)$$
and
$$g(t) = 0 \quad \text{when } c(t) = 0$$

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

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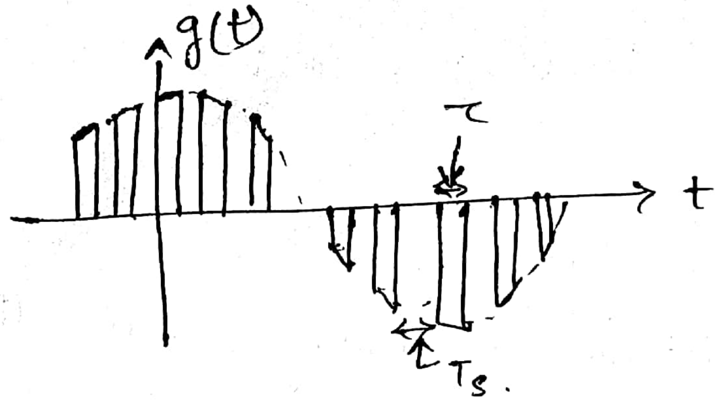

Naturally sampled signal waveform g(t).

* Noise interference is minimum.

Q. ① An Analog signal is expressed by the eq. (3)

$x(t) = 3\cos(50\pi t) + 10\sin(300\pi t) - \cos(100\pi t)$.

Calculate Nyquist rate for this signal.

Soln:

$x(t) = 3\cos \underline{50\pi} t + 10 \sin \underline{300\pi} t - \cos \underline{100\pi} t$

New eqn for signal

$x(t) = 3\cos \omega_1 t + 10\sin \omega_2 t - \cos \omega_3 t$

$\therefore \boxed{\omega = 2\pi f}$ $\omega = 2\pi f$

for ω_1

$2\pi f = 50\pi$

$f = \frac{50\cancel{\pi}}{2\cancel{\pi}}$

$\boxed{f = 25 \text{ Hz}}$

for ω_2

$2\pi f = 300\pi$

$f = \frac{300\pi}{2\pi} = \boxed{150 \text{ Hz}}$

for ω_3

$2\pi f = 100\pi$

$f = \frac{100\pi}{2\pi}$

$\boxed{f = 50 \text{ Hz}}$

so that $f_m = 150$ Hz

Nyquist rate $f_s = 2 \times 150$ Hz

Ans: $\boxed{f_s = 300 \text{ Hz}}$

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Nyquist Rate and Nyquist interval

→ when sampling rate exactly equal to $2f_m$ sample per sec. then it is called Nyquist rate.

→ Nyquist rate is also called the minimum sampling rate.

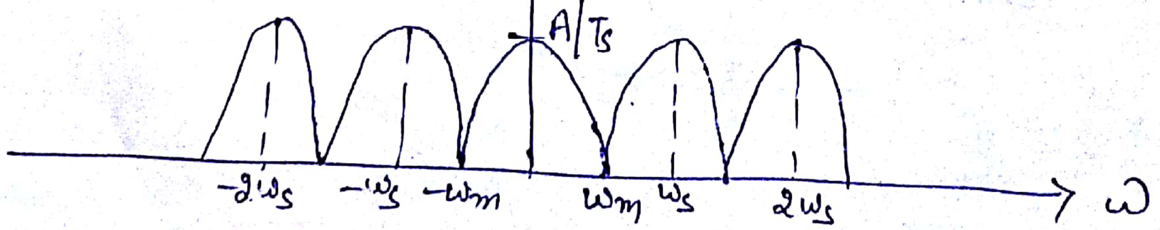
$$\boxed{f_s = 2f_m}$$

→ similarly maximum sampling interval is called Nyquist interval.

$$T_s = \frac{1}{2f_m}$$

→ when $f_s = 2f_m$, sampled spectrum $G(\omega)$ contain non-overlapping $G(\omega)$ repeating periodically. But successive cycle of $G(\omega)$ touch each other.

→ Therefore original spectrum $X(\omega)$ can be recovered from the sampled spectrum by using a low pass filter with a cut off frequency ω_m.



Q: (2) Find the Nyquist rate and Nyquist interval for the signal.

$$x(t) = \frac{2\times 1}{2 \cdot 2\pi} \underbrace{\cos(4000\pi t)}_{A} \underbrace{\cos(1000\pi t)}_{B}$$

Soln :

$$x(t) = \frac{1}{4\pi}\left[2\cos(4000\pi t)\cos(1000\pi t)\right]$$

Since $\left[2\cos A \cos B\right] = \cos(A+B) + \cos(A-B)$

$$x(t) = \frac{1}{4\pi}\left[\cos(4000\pi t + 1000\pi t) + \cos(4000\pi t - 1000\pi t)\right]$$

$$x(t) = \frac{1}{4\pi}\left[\cos \underbrace{5000\pi t}_{\omega_1} + \cos \underbrace{3000\pi t}_{\omega_2}\right]$$

$$x(t) = \frac{1}{4\pi}\left[\cos \omega_1 t + \cos \omega_2 t\right]$$

$\omega_1(t) \rightarrow 2\pi f_1 = 5000\pi$

$$\boxed{f_1 = 2500 \text{ Hz.}}$$

$\omega_2(t) = 3000\pi$

$2\pi f_2 = 3000\pi$

$$\boxed{f_2 = 1500 \text{ Hz.}}$$

So that max. freq. present in the signal is

$$\boxed{f_1 = 2500 \text{ Hz}}.$$

Therefore Nyquist rate $f_s = 2f_m = 2\times 2500 = 5000$ Hz

or $= \boxed{5 \text{ KHz}}$

Nyquist interval

$$T_s = \frac{1}{2f_m} = \frac{1}{2\times 2500} = \frac{1}{5000}$$

$$T_s = 0.2\times 10^{-3} \text{ sec.} = \boxed{0.2 \text{ m sec.}}$$

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Q.3 Determine the Nyquist rate for a continuous time signal

$x(t) = 6 \cos 50\pi t + 20 \sin 300\pi t - 10 \cos 100\pi t$

Soln: General form of any continuous time signal

$x(t) = A_1 \cos w_1 t + A_2 \cos w_2 t + A_3 \cos w_3 t$

Comparing given signal with general form of signal.

$w_1 \Rightarrow 2\pi f_1 = 50\pi$ $\qquad$ $w_2 \Rightarrow 2\pi f_2 = 300\pi$

$\boxed{f_1 = 25 Hz}$ $\qquad$ $\boxed{f_2 = 150 Hz.}$

$w_3 \Rightarrow 2\pi f_3 = 100\pi$

$\boxed{f_3 = 50 Hz}$

highest freq component of given msg signal will be

$f_{max} = 150 Hz$

Therefore
Nyquist rate $= 2 f_{max}$

$= 2 \times 150 Hz$

$\boxed{\text{Nyquist rate} = 300 Hz}$ Ans.

Nyquist Interval. –

$T_s = \frac{1}{2 f_m}$

$= \frac{1}{300}$

$T_s = .003$ sec.