Sampling theorem :-

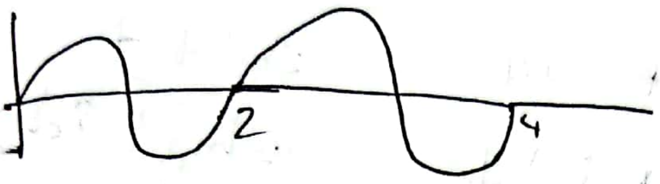
Continuous form of a time varient signal can be represented in the discrete form of a signal with the help of samples and the sampled signal can be recovered to original form when the sampling frequency (f_s) having greater frequency value then or equal to the highest input signal frequency (f_{max}). $F_s \geq 2 F_{max}$.

⇒ Any sampling frequency (F_s) less then twice the input signal frequency will cause a effect. this effect is know as aiasing effect.

When sampling Frequency equals or greater twice the input signal frequency that sample rate is called nyquist rate.

aliasing effects:

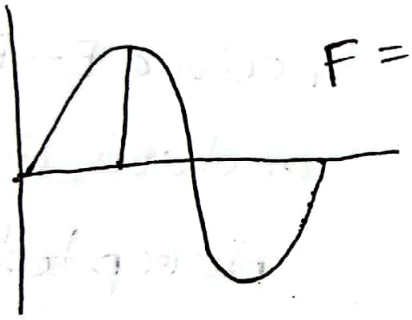
1. Frequencceny: complete wave in 1 second



$F = 0.5 Hz$

$-\alpha < F \alpha \alpha$

Normalized, $f = \frac{F}{F_s}$ F = frequency cont. time signal, F_s = sampling



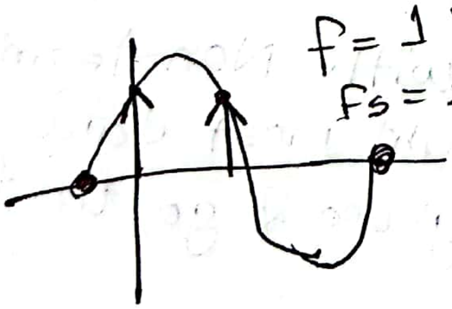
$F = 1 Hz$

$F_s = 2 Hz$

unability to detect which ~~frequency~~ a sample is derived from frequency is aliasing effect.

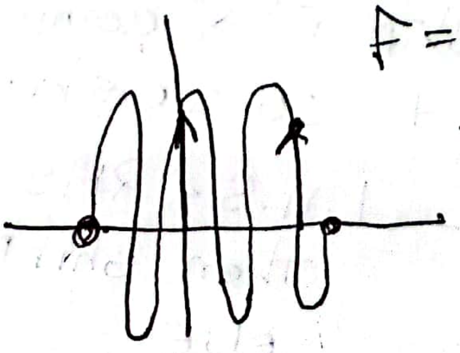
$f = 1 Hz$

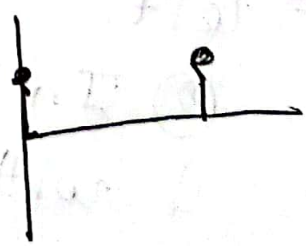
$F_s = 2 Hz$



$F = 3 Hz$

$f_s = 2 Hz$





DSP - 04-09-22

Consider an Analog Signal

$x_a = 2\cos(50\pi t)$

10

13 Q1: Determine the minimum sampling rate

16 required to avoid aliasing?

24

26 $F_s \geq 2F$ (input frequency)

27

32 analog signal $x_a(t) = A\cos(2\pi F t)$ — analog signal input frequency

42 important

19

5 Here,

16 $x_a = 2\cos(2\pi \cdot 25 t)$

$\therefore F_s \geq 2F$

$\geq 2 \times 25$

≥ 50

$\therefore$ the minimum sampling rate required

$\therefore f_s \geq 50$

* Important equations-

$$x_a(t) = A\cos(2\pi F t)$$
$$x(n) = x_a(nt)$$

Q2: Suppose the signal is sampled at the rate $F_s = 200$ Hz. What is the discrete time signal obtained after sampling

$$x(n) = x_a(nT)$$ $T = \frac{1}{F_s}$

$$= A\cos(2\pi F(nT))$$

$$= A\cos(2\pi n FT)$$

$$= A\cos(2\pi n F.\frac{1}{F_s})$$

$$= 2\cos(\cancel{2}.\pi.n.\cancel{25}.\frac{1}{\cancel{200}\ \cancel{100}\ 4})$$

$$= 2\cos(.\pi.n.\frac{1}{4})$$

VVI Model test + Final

$x(n) = 2\cos(\frac{\pi}{4}n)$ i.e discrete time signal with $F_s = 200$ Hz.

Q:- $x_a(t) = 2\cos(50\pi t)$.

$0 < F < \frac{F_s}{2}$ .. f

Q3:- What is the frequency that generate samples a sinusoid identical to obtained in Q_2.

$x(n) = A\cos(2\pi f n) \leftarrow$ discrete time signal.

We know, $x(n) = A\cos(2\pi f n)$ — ① &

$x(n) = 2\cos(\frac{\pi}{4} \cdot n)$ — ⑪ from Q_2

Comparing ① & ⑪ ⇒

$x(n) = 2\cos(2\pi \cdot \frac{1}{8} \cdot n)$

$\therefore f = \frac{1}{8}$

We know, $f = \frac{F}{F_s}$

$F = f \times F_s$

$= \frac{1}{\cancel{8}_{2}} \times \cancel{200}^{\cancel{50}\ 25}$

$= 25\,Hz.$

$\therefore x(t) = 2\cos(2\pi F t)$

$= 2\cos(2\pi\, 25\, t)$

Q4: Consider, analog signal;

$x_a(t) = 3\cos(100\pi t) + 10\sin(400\pi t) - \cos(600\pi t)$

* what is the Nyquist rate of the signal

$x_a(t) = 3\cos(2\pi \underset{f_1}{\underline{50}} t) + 10\sin(2\pi \underset{f_2}{\underline{200}} t) - \cos(2\pi \underset{f_3}{\underline{300}} t)$

Here, $f_1 = 50Hz, f_2 = 200$ Hz., $f_3 = 300Hz$

$\therefore F_{max} = 300Hz$

$\therefore f_N = 2 \times F_{max}$
$= 2 \times 300$
$= 600$ Hz.

input equation এর maximum frequency এর twice or greater frequency rate is nyquist rate

Q4: $x(t) = 3\cos(400\pi t) + 5\sin(800\pi t) + \cancel{10\cos(1400}$
$10\cos(14000\pi t)$

Find → Nyquist rate?

→ If we sample this signal using sampling rate $F_s = 600$ sample/s. What is discrete time signal after sampling.

a) Here,
$x(t) = 3\cos(2\pi 200t) + 5\sin(2\pi 400t) + 10\cos(2\pi 7000t)$

$F_1 = 200$ Hz
$F_2 = 400$ Hz
$f_3 = 7000Hz$.

$\therefore f_{max} = 7000Hz$

$\therefore F_N = 2 \times 7000Hz$
$= 14000Hz$

Nyquist rate
$F_N \geq 14000Hz$.

(b) We know,

$$x_n = x_a(nT)$$

$$= x_a\left(n \cdot \frac{1}{F_s}\right)$$

$$x_n = x_a\left(\frac{n}{6000}\right)$$