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EE 410

For KCST

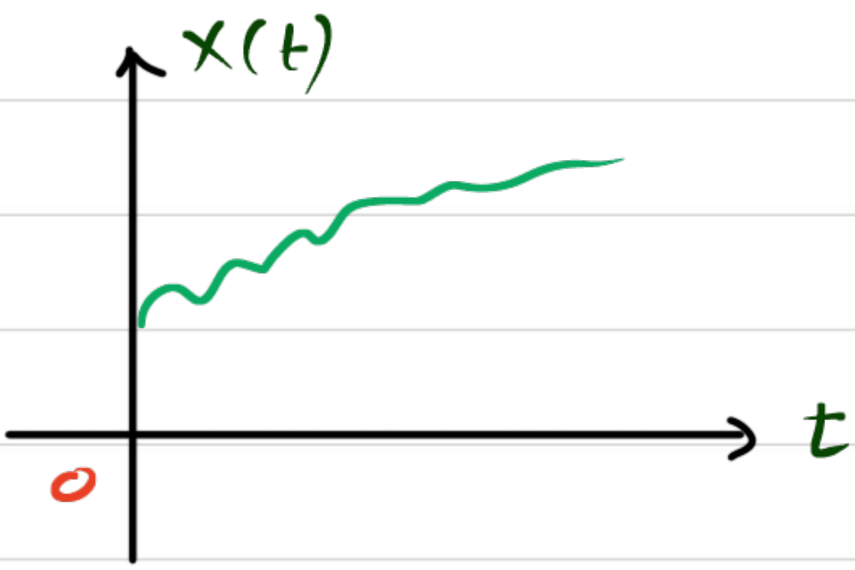
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- EE312 - EE341 - EE342 - EE351 -
EE352 - EE365 - EE410 - EE441 - EE442
- EE443 - EE451

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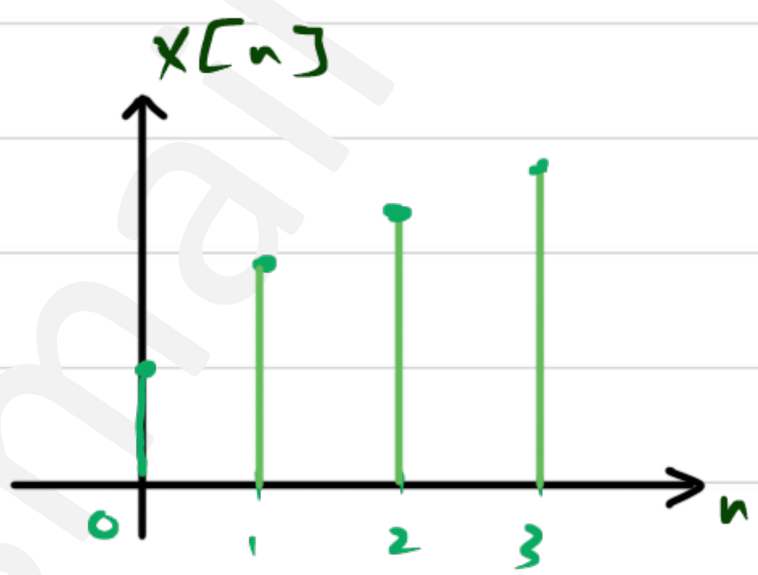
Digital signal processing

Analog

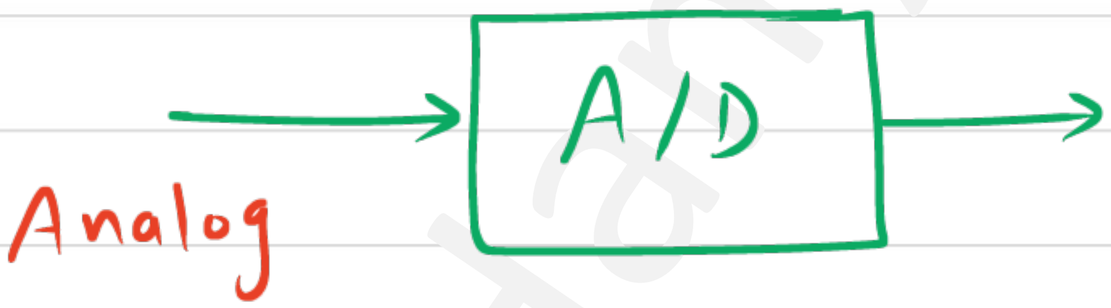


Continous time

Digital



discrete time



* Sampling: Convert from t ⟶ n

f_s ⟶ Sampling frequency

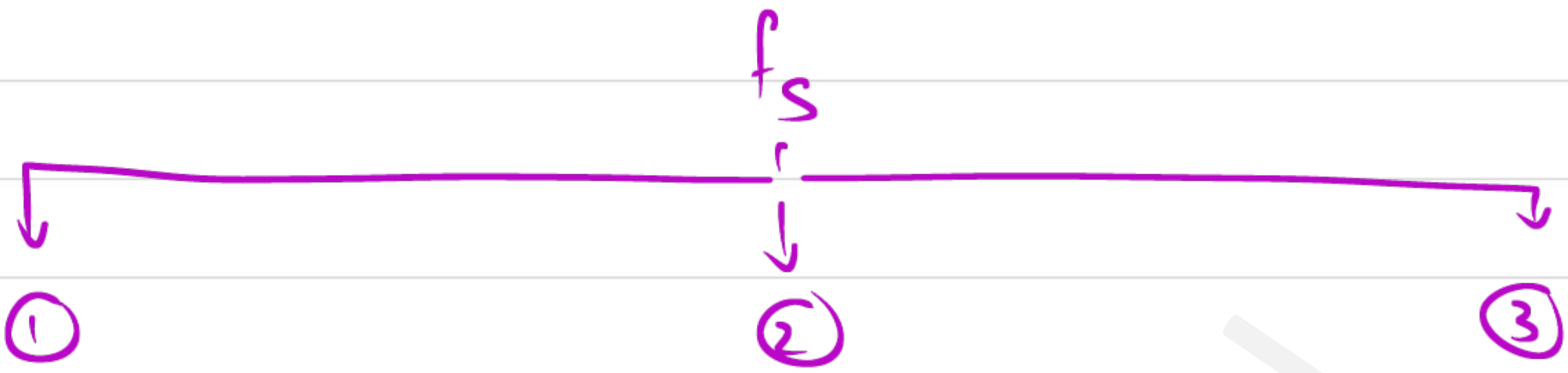
T_s ⟶ Sampling period

$$T_s = \frac{1}{f_s}$$

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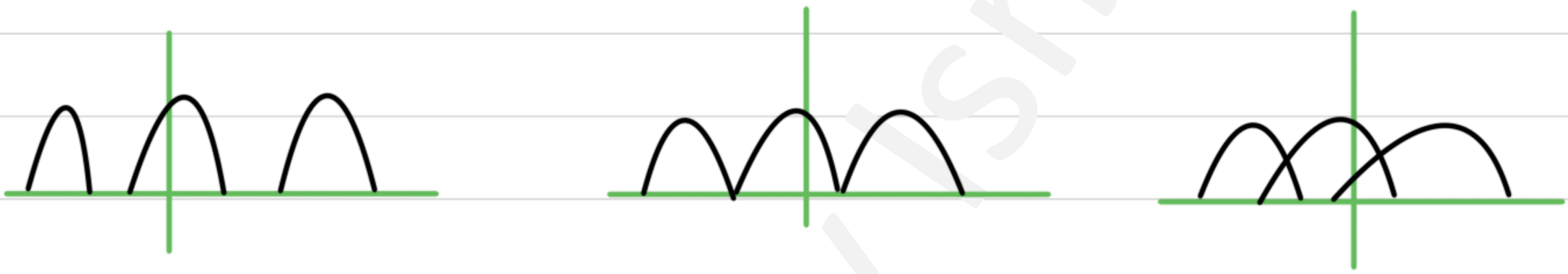
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* Notes :



$f_s > 2f_m$ $\quad$ $f_s = 2f_m$ $\quad$ $f_s < 2f_m$

over sample $\quad$ Nyquist (f_N) $\quad$ under sample



صافي أن تداخل $\quad$ متقاربين بدون تداخل $\quad$ تداخل

$$f_s = \frac{1}{T_s} \longrightarrow \text{Sampling frequency (Hz)}$$

$$T_s = \frac{1}{f_s} \longrightarrow \text{sampling period (s)}$$

$$w = 2\pi f_s = \frac{2\pi}{T_s} \longrightarrow \text{angular frequency}$$

rad/s

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Ex: If $x(t) = 5\cos(100\pi t)$

What should be the sampling frequency?

$$\omega = 100\pi = 2\pi f_m$$

$$f_m = \frac{100}{2} = 50\ Hz$$

$$\therefore f_s \geq 2 f_m \longrightarrow f_s \geq 100\ Hz$$

$x(t) = A\cos(\omega t)$

$\omega = 2\pi f$

Ex: $x(t) = 7 + 5\cos(800\pi t) + 3\sin(1600\pi t)$

What should be the sampling frequency?

$$f_1 = 0$$

$$2\pi f_2 = 800\pi \longrightarrow f_2 = \frac{800}{2} = 400\ Hz$$

$$2\pi f_3 = 1600\pi \longrightarrow f_3 = \frac{1600}{2} = 800\ Hz$$

$\therefore f_m = 800\ Hz$ maximam frequency

$$\therefore f_s \geq 2 f_m \longrightarrow f_s \geq 2 \times 800 \longrightarrow f_s \geq 1600\ Hz$$

$f_N = 1600\ Hz$ (Nyquist frequency)

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Ex: If $x(t) = 5\cos(100\pi t)$

What should be the min sampling frequency needed to avoid the alising?

$$2\pi f_m = 100\pi \longrightarrow f_m = \frac{100}{2} = 50\ Hz$$

$\therefore f_N = 2 f_m$

$f_N = 2 \times 50$

$\therefore f_N = 100\ Hz$

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Analog ⟶ digital

↓ ↓

Continous discrete

x(t) x[n]

Analog ⟶ $x(t) = A\cos(2\pi f + \theta)$

Digital ⟶ $x[n] = A\cos\left(\frac{2\pi f n}{f_s} + \theta\right)$

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Ex: Given that $x(t) = 3\cos(2000\pi t) + 5\sin(6000\pi t) + 10\cos(12000\pi t)$

f_1 f_2 f_3

Find:

1) F_N
2) Discrete time signal if $f_s = 5000HZ$

1) $F_N = ?$

$2\pi f_1 = 2000\pi \longrightarrow f_1 = \frac{2000}{2} = 1000\ Hz$

$2\pi f_2 = 6000\pi \longrightarrow f_2 = \frac{6000}{2} = 3000\ Hz$

$2\pi f_3 = 12000\pi \longrightarrow f_3 = \frac{12000}{2} = 6000\ Hz$

$\therefore f_N = 2f_m$

$\therefore f_N = 2 \times 6000 = 12000\ Hz$

2) $x[n] = ?$

$$x[n] = 3\cos\left(\frac{2\pi \times 1000\, n}{5000}\right) + 5\sin\left(\frac{2\pi \times 3000\, n}{5000}\right) + 10\cos\left(\frac{2\pi \times 6000\, n}{5000}\right)$$