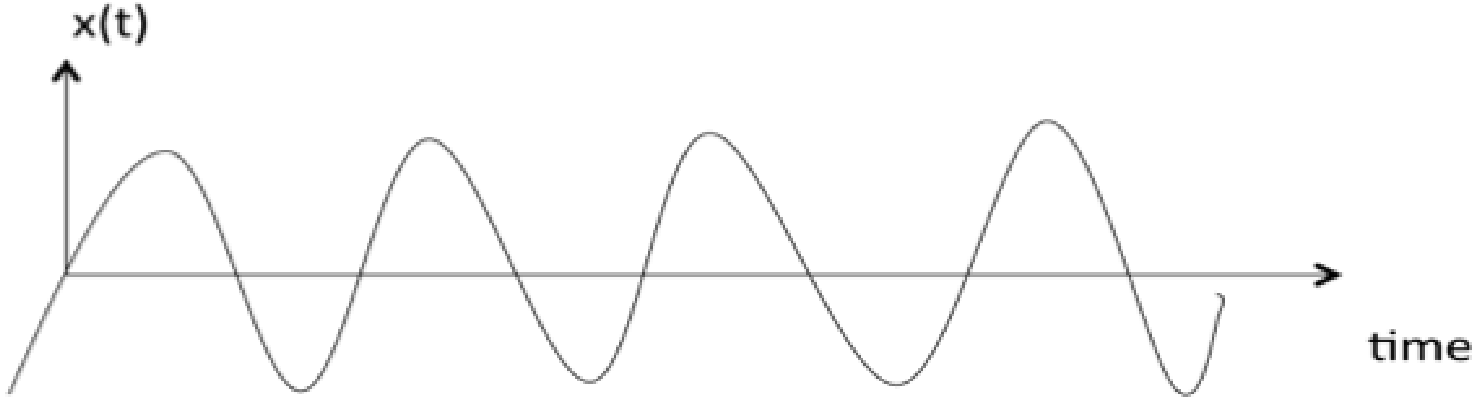
Signals and Systems

Signals and their classifications-II

Deterministic & Random Signals

A signal is said to be deterministic if there is no uncertainty with respect to its value at any instant of time. or, signals which can be defined exactly by a mathematical formula are known as deterministic signals.



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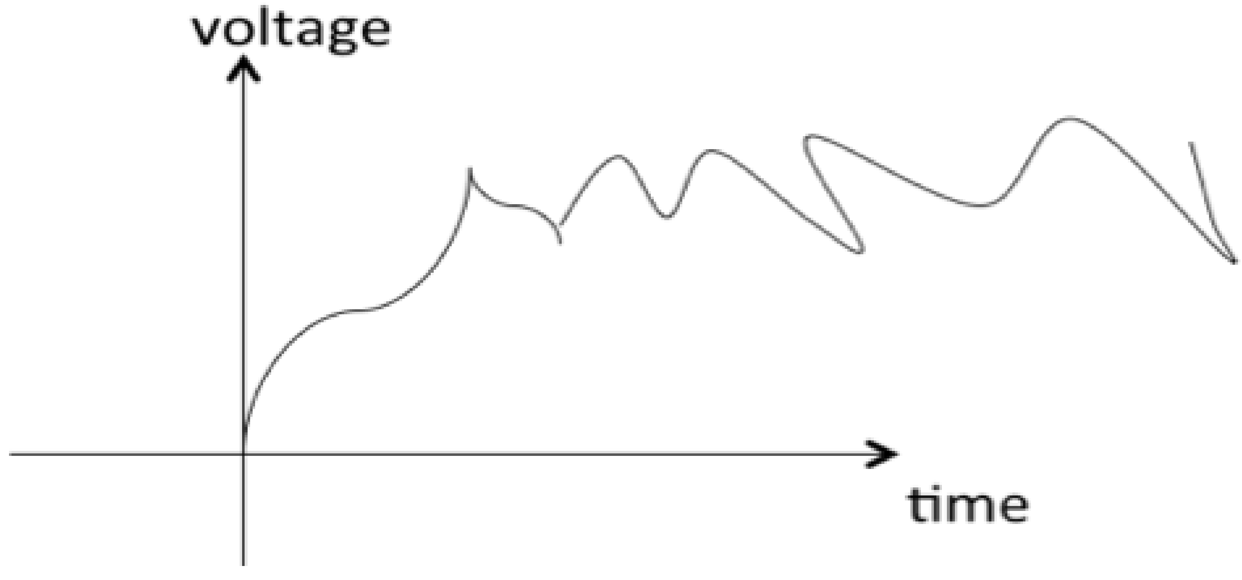
A signal is said to be non-deterministic (random) if there is uncertainty with respect to its value at some instant of time. Non-deterministic signals are random in nature hence they are called random signals. Random signals cannot be described by a mathematical equation. They are modelled in probabilistic terms.



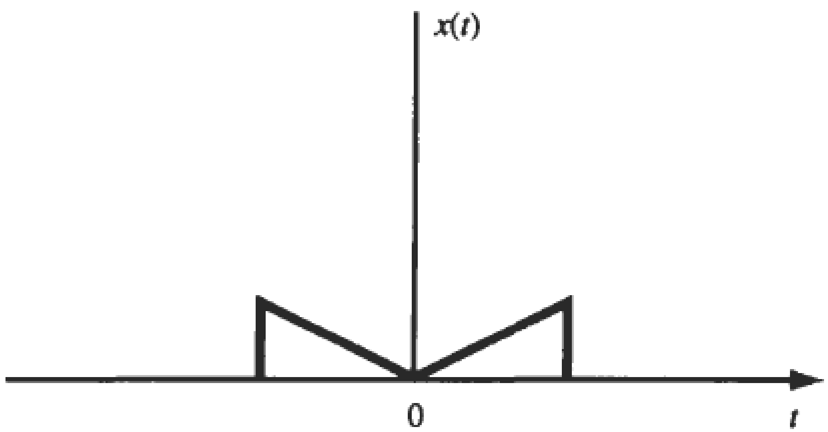
Deterministic signals are those signals whose values are completely specified for any given time. Thus, a deterministic signal can be modeled by a known function of time t. *Random* signals are those signals that take random values at any given time and must be characterized statistically. Random signals will not be discussed in this text.

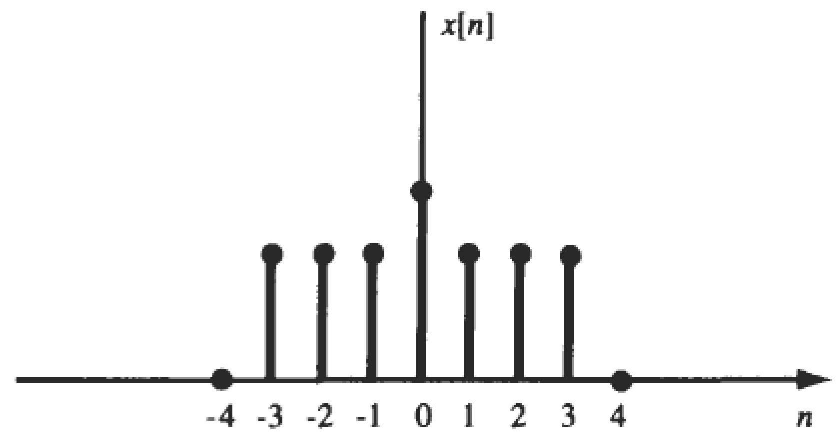
Even and Odd Signals

Even Signals

A signal $x(t)$ or $x[n]$ is referred to as an *even* signal if

$$\begin{aligned} x(-t) &= x(t) \\ x[-n] &= x[n] \end{aligned} \tag{1.2}$$





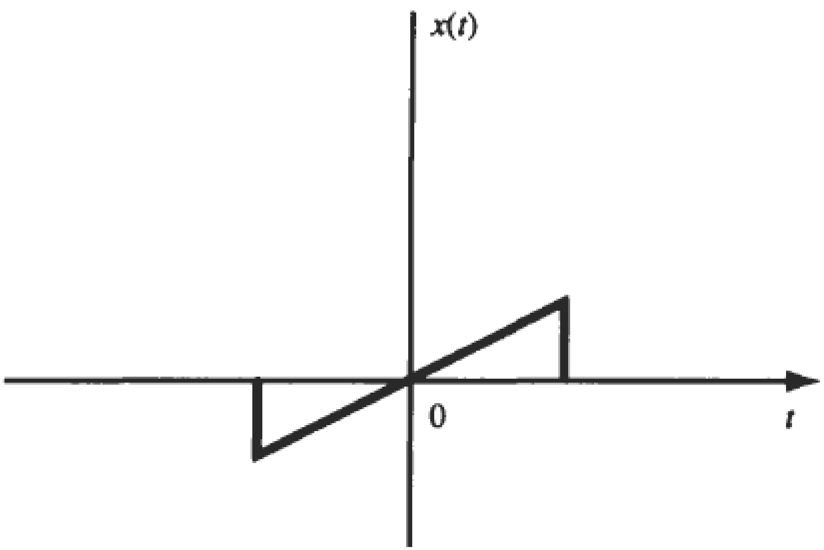
Even and Odd Signals

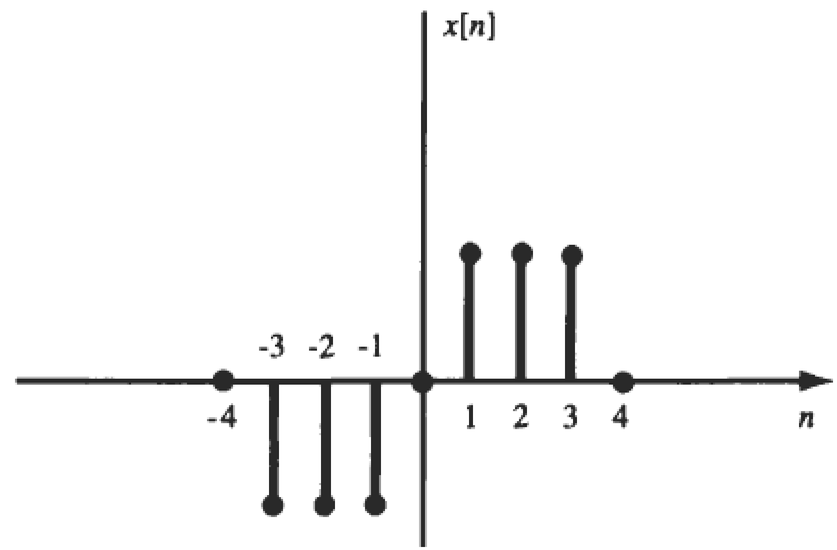
Odd Signals

A signal $x(t)$ or $x[n]$ is referred to as an *odd* signal if

$$\begin{aligned} x(-t) &= -x(t) \\ x[-n] &= -x[n] \end{aligned} \tag{1.3}$$

Examples of even and odd signals are shown in Fig. 1-2.





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Example 1:

Let $x(t) = t^2$

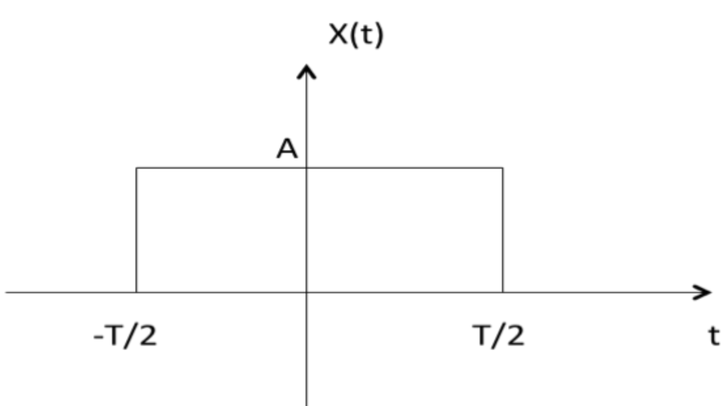
$x(-t) = (-t)^2 = t^2 = x(t)$

$\therefore$, t^2 is even function

Example 2:

$Cos(-\theta) = Cos(\theta)$, even signal

Example 3: As shown in the following diagram, rectangle function x(t) = x(-t) so it is also even function.



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Example 4:

Let x(t) = sin (t)

x(-t) = sin(-t) = -sin t = -x(t)

∴ sin (t) is an odd function.

Note:

Any function $f(t)$ can be expressed as the sum of its even function $f_e(t)$ and odd function $f_o(t)$.

$f(t) = f_e(t) + f_0(t)$

where

$f_e(t) = ½[f(t) + f(-t)]$

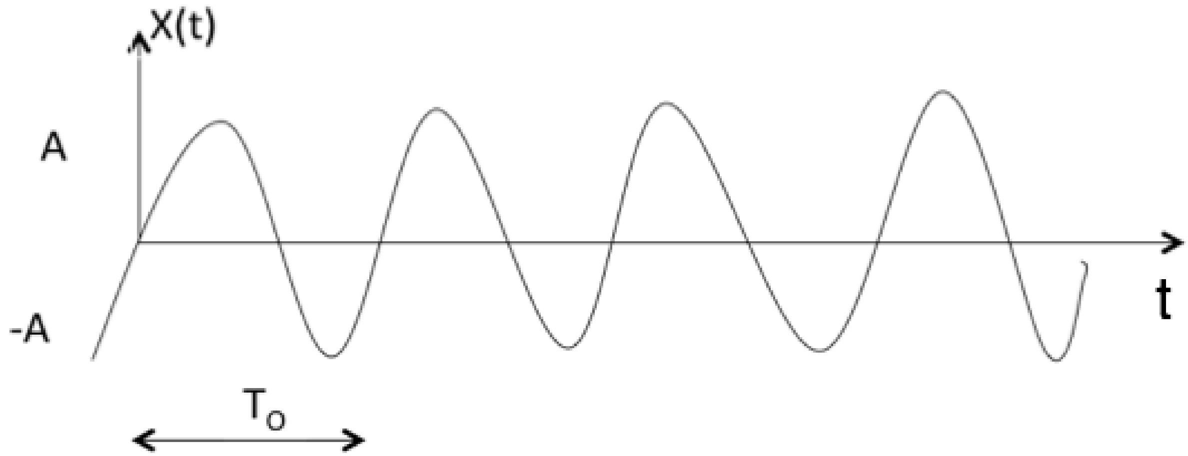
Periodic & Aperiodic Signals

A signal is said to be periodic if it satisfies the condition $x(t) = x(t + T)$ or $x(n) = x(n + N)$.

Where

T = fundamental time period,

$1/T = f$ = fundamental frequency.



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Periodic Signals – An arbitary signal $x(t)$ is said to be periodic if it repeats itself after a period of time 'T'.

where T is the fundamental period of signal.

$$x(t+T) = x(t)$$

Ex – Sin & cosine signals

$\cos \omega_0 t \rightarrow$ Periodic signal

$\therefore$ Fundamental period $T = \frac{2\pi}{\omega_0}$

where ω_0 = fundamental frequency

Cont..

Ex.

$$x_1(t) = \cos 2\pi t$$

$$\omega_0 = 2\pi$$

$$T = \frac{2\pi}{\omega_0} = \frac{2\pi}{2\pi} = 1 \text{ sec.}$$

Ex.

$$x_2(t) = \cos 4t$$

$$\omega_0 = 4$$

$$T = \frac{2\pi}{4} = \frac{\pi}{2}$$

$$T = \frac{\pi}{2} \text{ sec.}$$

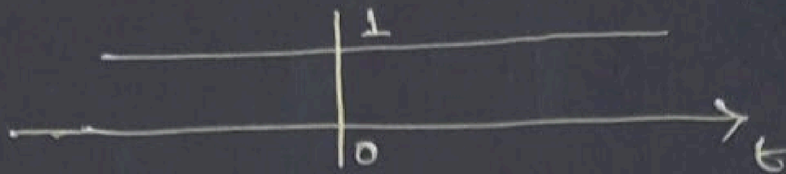
Ex =

$$x_3(t) = 1$$

$$T = ?$$

Cont..

$x_3(t) = 1$



NOTE- The fundamental period of a constant is undefined because the signal is repeating itself for each and every value of T.

Ex- $x_4(t) = \cos \pi t + \cos 2\pi t$

$\omega_{01} = \pi$ $\quad\quad$ $\omega_{02} = 2\pi$

$T_1 = \frac{2\pi}{\pi} = 2$ $\quad\quad$ $T_2 = \frac{2\pi}{2\pi} = 1$

then $\frac{T_1}{T_2}$ or $\frac{T_2}{T_1}$ = rational number

Cont..

NOTE- If a signal is the combination of two or more periodic signals, then it will periodic if and only if the ratio of individual fundamental period ($T_1, T_2, T_3, \ldots$) a rational numer.

The fundamental period $T = \dfrac{\text{LCM (Numerator of } T_1, T_2 \ldots)}{\text{HCF (Denominator of } T_1, T_2, \ldots)}$

$$T = \frac{\text{LCM}(2,1)}{\text{HCF}(1,1)} = \frac{2}{1}$$

$$T = 2$$

Thank You