ECT 204 SIGNALS AND SYSTEMS

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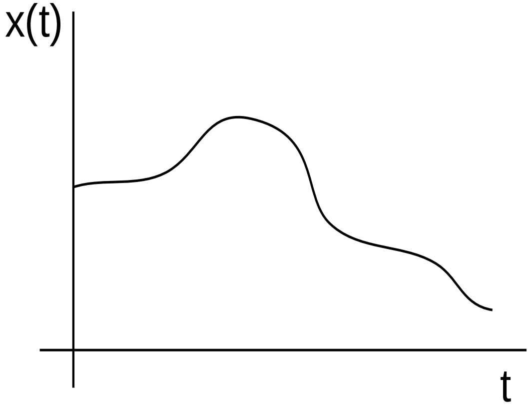
CLASSIFICATION OF SIGNALS

General classification

1. Continuous-Time Signals

- Signal that has a value for all points in time
- Function of time
- Written as x(t) because the signal “x” is a function of time
- Commonly found in the physical world
  ex. Human speech
- Displayed graphically as a line



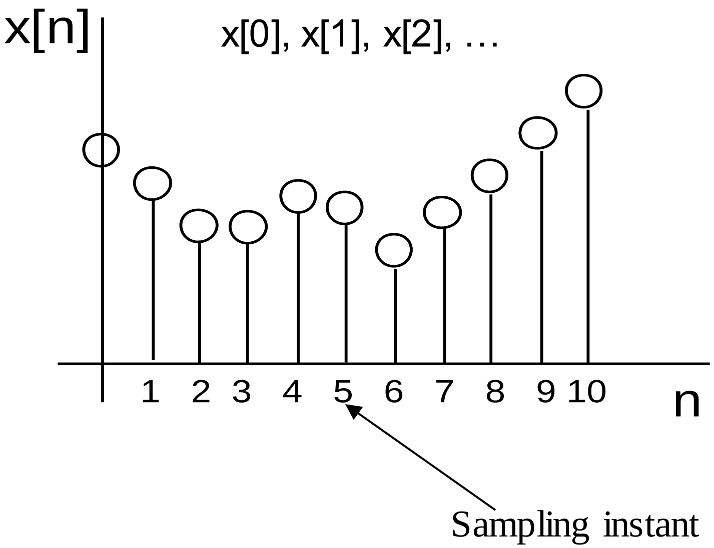
2. Discrete-Time Signals

- Signal that has a value for only specific points in time
- Typically formed by "sampling" a continuous-time signal
- Taking the value of the original waveform at specific intervals in time
- Function of the sample value, **n**
- Written as **x[n]**
- Often called a sequence
- Commonly found in the digital world

Ex: an mp3 file, quarterly GNP, monthly sales of a corporation, stock market daily averages, etc.

•Displayed graphically as individual values

•Called a "stem" plot



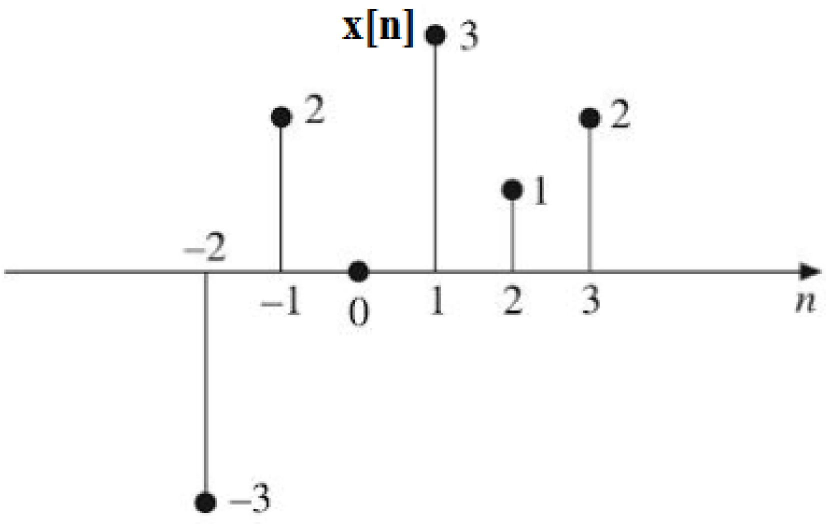
Representation of Discrete-Time Signals

1. Graphical representation
2. Functional representation
3. Tabular representation
4. Sequence representation

Representation of DT Signals contd….

1. Graphical representation

Consider a signal x[n] with values x[-2]= -3, x[-1] = 2, x[0]= 0, x[1] = 3, x[2]=3, and x[3]=2. This discrete signal can be represented as shown below-



Representation of DT Signals contd…

2. Functional representation

In this, the amplitude of the signal is written against the values of n

$$\mathbf{x[n]} = \begin{cases} -3 & \text{for } n = -2 \\ 2 & \text{for } n = -1 \\ 0 & \text{for } n = 0 \\ 3 & \text{for } n = 1 \\ 1 & \text{for } n = 2 \\ 2 & \text{for } n = 3 \end{cases}$$

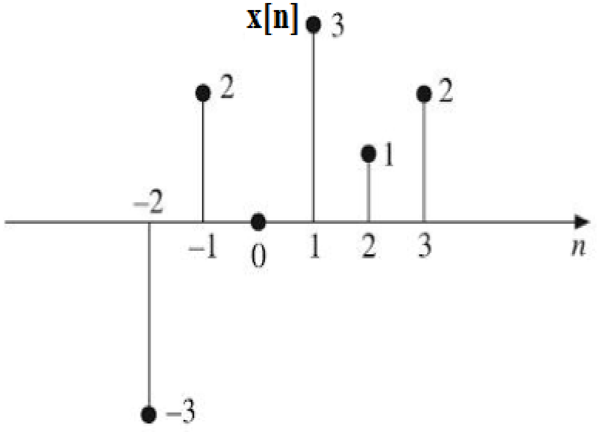
$$\mathbf{x[n]} = \begin{cases} 2^n & \text{for } n \geq 0 \\ 0 & \text{for } n < 0 \end{cases}$$

Representation of DT Signals contd…

3. Tabular representation

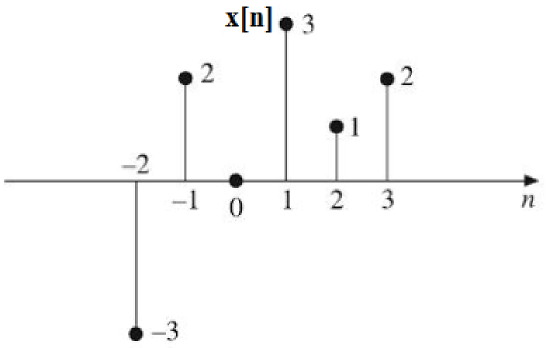
In this, the sampling instant n and the magnitude of the signal at the sampling instant are represented in tabular form.

n	–2	–1	0	1	2	3
x[n]	–3	2	0	3	1	2



Representation of DT Signals contd…

4. Sequence representation



A finite duration sequence can be represented as:

$$\mathbf{x[n]} = \left\{ -3, 2, \underset{\uparrow}{0}, 3, 1, 2 \right\}$$

Another example is

$$\mathbf{x[n]} = \left\{ \ldots 2, 3, \underset{\uparrow}{0}, 1, -2, \ldots \right\}$$

The arrow mark $\uparrow$ denotes the $n = 0$ term. When no arrow is indicated, the first term corresponds to $n = 0$

So a finite duration sequence, that satisfies the condition $\mathbf{x[n]} = 0$ for $n < 0$ can be represented as $\mathbf{x[n]} = \{3, 5, 2, 1, 4, 7\}$.

Classification of Signals

- Based on properties of the signal

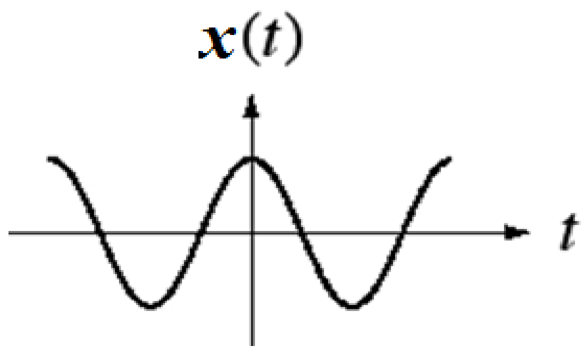
- Even & Odd Signals
- Periodic & non-periodic Signals
- Causal and non-causal Signal
- Deterministic & Non-deterministic (Random) Signals
- Energy & Power Signals

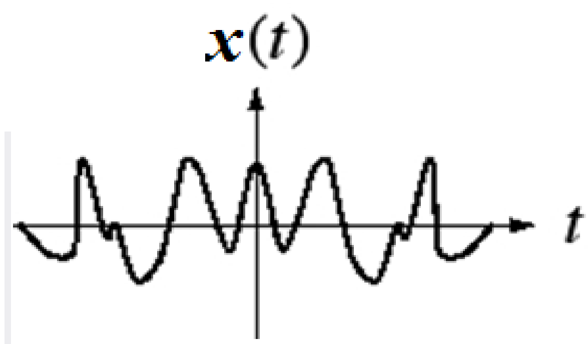
1. Even and odd signals

CT Even and Odd Signals

Even Functions

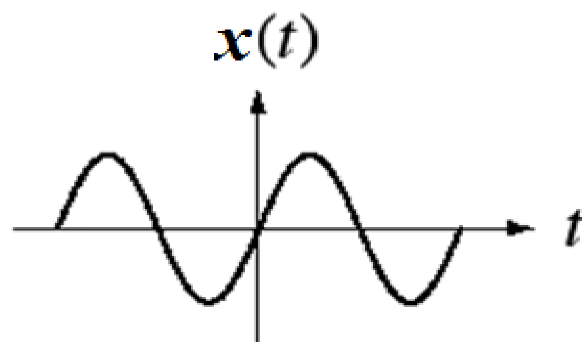
$$x(t) = x(-t)$$

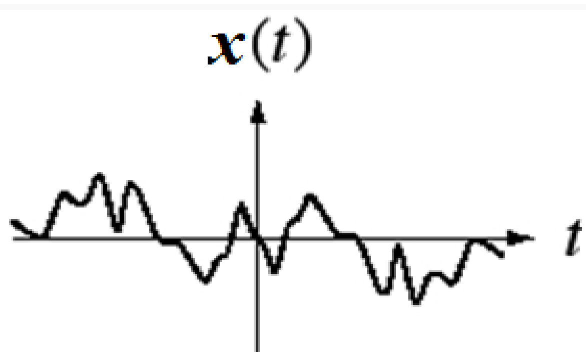




Odd Functions

$$x(t) = -x(-t)$$

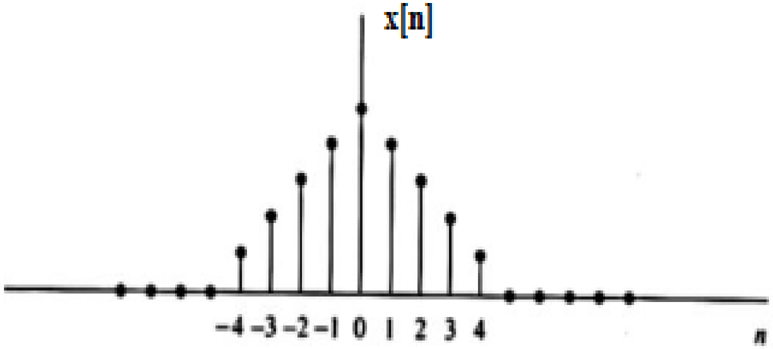




DT Even and Odd Signals

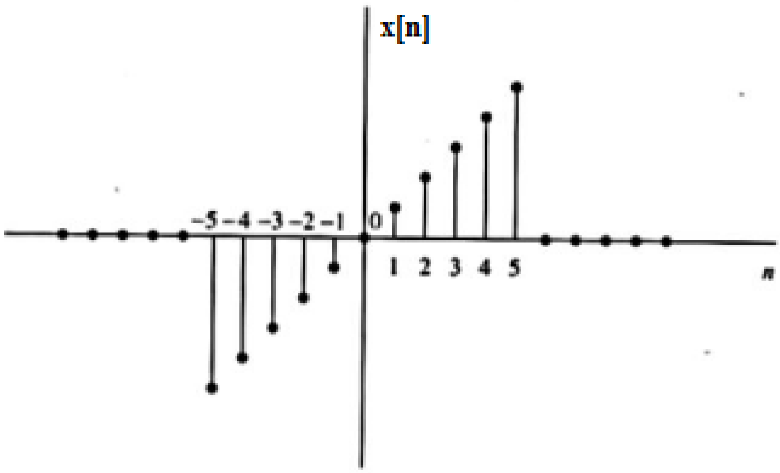
Even Signal

$$x[n] = x[-n]$$



Odd Signal

$$x[n] = -x[-n]$$



Even and Odd Decomposition of a Function

A signal x(t) can be expressed as the sum of an *even and odd* component.

$$\mathbf{x(t) = x_e(t) + x_o(t)}$$

$$x_e(t) = x_e(-t)$$

$$x_o(t) = -x_o(-t)$$

A function whose even part is zero, is odd &
a function whose odd part is zero, is even.

Even and Odd Decomposition contd…

Proof

$$x(t) = x_e(t) + x_o(t) \quad ----(1)$$

Replace t by -t

$$x(-t) = x_e(-t) + x_o(-t)$$

$$= x_e(t) - x_o(t) \quad ----(2)$$

Adding equations (1) and (2)

$$x(t)+x(-t) = 2\, x_e(t)$$

$$ie.\ x_e(t) = \frac{x(t) + x(-t)}{2}$$

Subtracting (2) from (1) we get

$$x_o(t) = \frac{x(t) - x(-t)}{2}$$

Even and Odd Decomposition contd…

The **even part** of a function is $x_e(t) = \dfrac{x(t) + x(-t)}{2}$

The **odd part** of a function is $x_o(t) = \dfrac{x(t) - x(-t)}{2}$

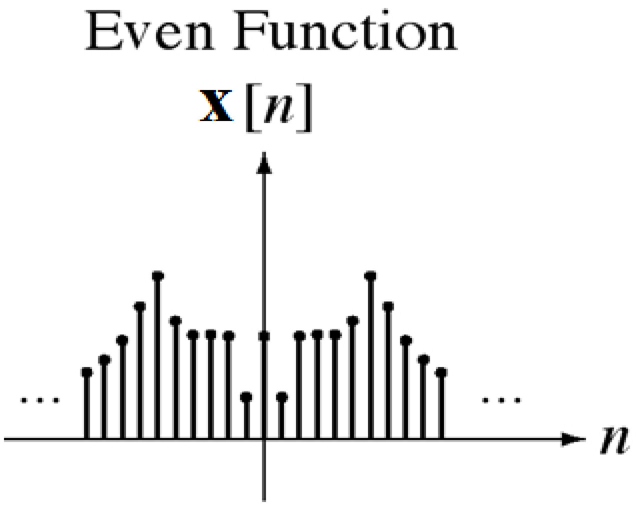
Various Combinations of even and odd functions

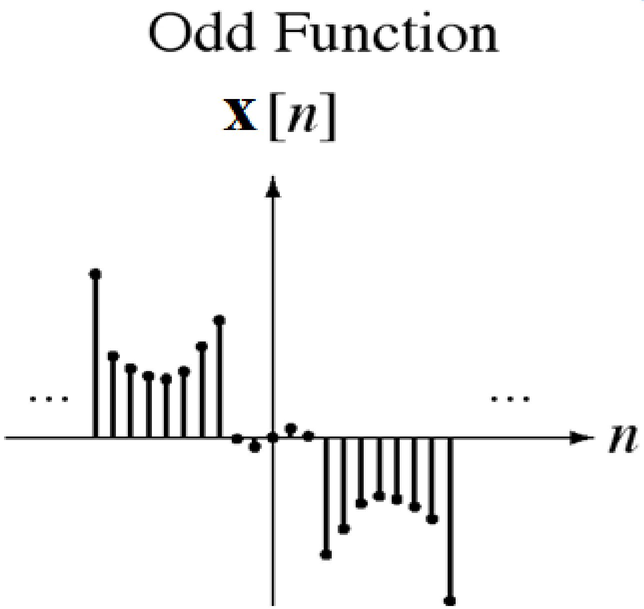
Function type	Sum	Difference	Product	Quotient
Both even	Even	Even	Even	Even
Both odd	Odd	Odd	Even	Even
Even and odd	Neither	Neither	Odd	Odd

Derivatives and Integrals of Functions

Function type	Derivative	Integral
Even	Odd	Odd + constant
Odd	Even	Even + constant

Discrete Time Even and Odd Signals





$$x[n] = x[-n]$$

$$x[n] = -x[-n]$$

Even and odd components of the signal x[n] are

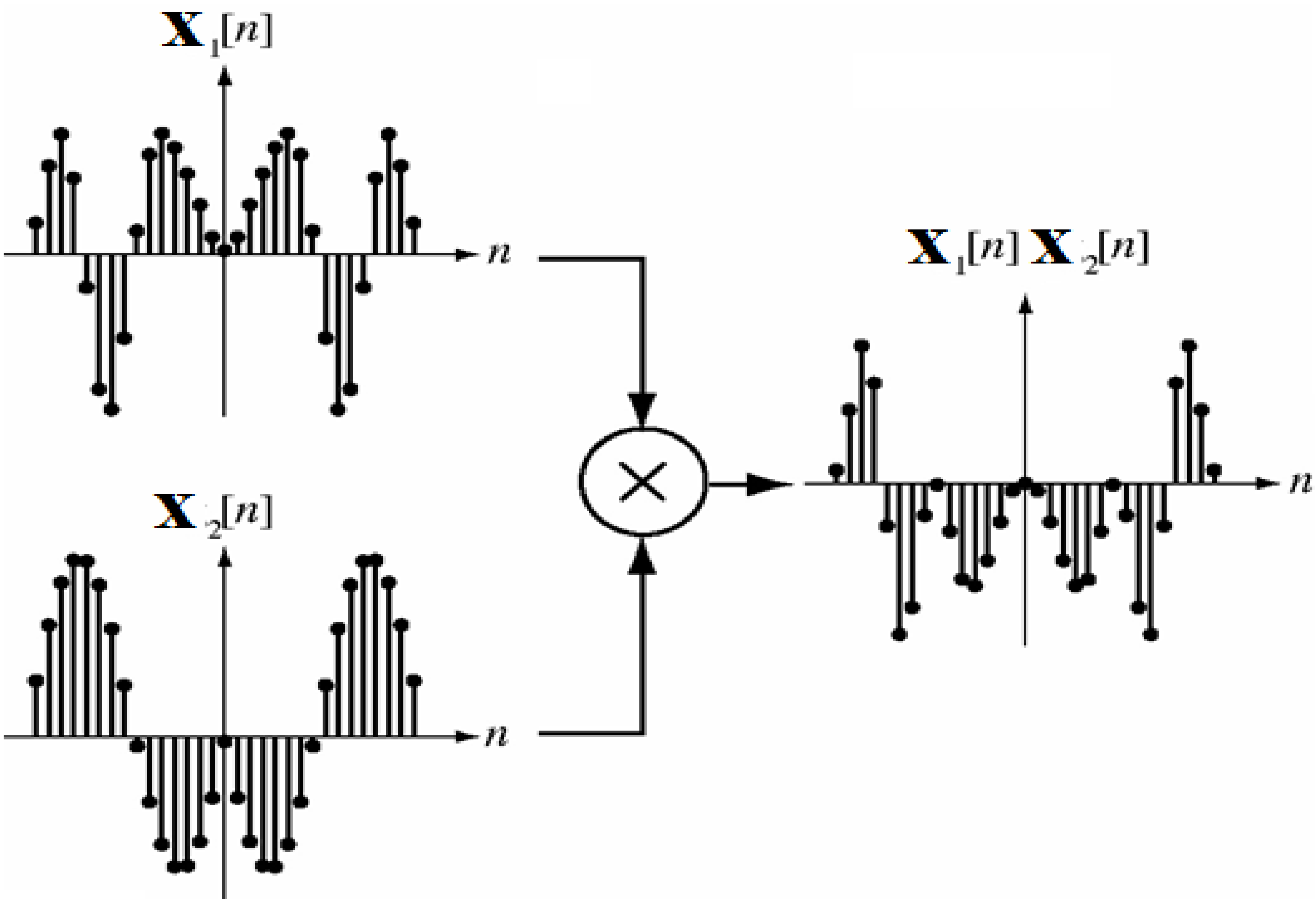
$$x_e[n] = \frac{x[n] + x[-n]}{2}$$

$$x_o[n] = \frac{x[n] - x[-n]}{2}$$

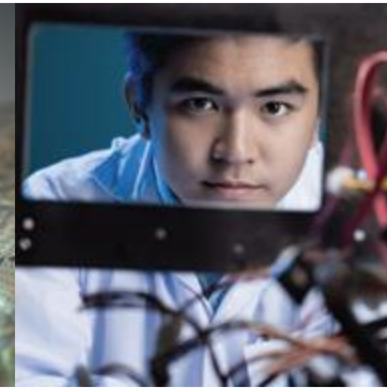
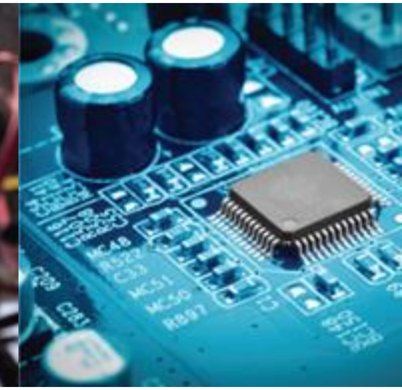
Combination of even and odd function for DT Signals

Function type	Sum	Difference	Product	Quotient
Both even	Even	Even	Even	Even
Both odd	Odd	Odd	Even	Even
Even and odd	Even or Odd	Even or odd	Odd	Odd

Product of Two DT Even Functions





Thank You!