Signal Analysis

Section -A

- Signal Analysis
- Complex Frequency and Network Analysis
- General Characteristics and Descriptions of signal
- Step Function and Associated Wave Forms
- The Unit Impulse
- Introduction to network analysis
- Network elements
- Initial and final conditions
- Step and Impulse response
- Solution of network equation

Signal

- Any physical quantity that varies with respect to time, space or any other independent variables is called a signal
- A function of one or more independent variable that convey information on the nature of physical phenomena
- Sinusoidal signal - $s(t)= A \sin(\omega_0 t+ \Theta)$
  - A= amplitude
  - ω_0 = radian frequency
  - Θ= phase
- Now suppose that the signal is made up of 2n+1 sinusoidal components

$$s(t) = \sum_{i=-n}^{n} A_i \sin(\omega_i t + \theta_i)$$

- In continuous case,

$$s(t) = \int_{-\infty}^{\infty} A(\omega) \sin[\omega t + \theta(\omega)]\, d\omega$$

Complex Frequency

- Complex frequency variable – $S = \sigma + j\omega$
  - Real part= σ= growth of the amplitude of signal
  - Imaginary part = $j\omega$ = angular frequency
- Ideal of complex frequency is $s(t) = A\,e^{j\omega t}$
- Any function which may be written in the form $f(t) = K\,e^{st}$
  - K and s are complex constant

- CASE-I = A constant current, $i(t)= I_0$ may be written as $i(t)= I_0\, e^{(0)t}$
  - The complex frequency of a DC current is zero
- CASE-II= Exponential function, $i(t)= I_0\, e^{\sigma t}$
  - The complex frequency of this current is therefore σ, $s=\sigma+j0$
- CASE-III= A sinusoidal current=
  - $i(t)= I_m \cos(\omega t+\Theta)$

Classification of system

- Linear or Non Linear
- Passive or Active
- Reciprocal
- Causal and Non Causal
- Time – Invariant and Time Varying System
- Derivative and Integral property

Linear or Non Linear

- A system(network) is linear if (a) the principle of SUPERPOSITION and(b) the principle of PROPORTIONALITY hold.
- **<u>SUPERPOSITION PRINCIPLE</u>** :

If for a given network, { e_1 (t), r_1(t) } and {e_2(t),r_2 (t) } are excitation-response pairs, then if the excitation were $e(t) = e_1(t) + e_2(t)$, the response would be $r(t) = r_1(t) + r_2(t)$.

- **<u>PROPORTIONALITY PRINCIPLE :</u>**

If for a given network, e_1 (t), r_1(t) are excitation-response pairs, then if the excitation were $c_1 e_1(t)$, then response would be $c_1 r_1(t)$.The constant of proportionality is c_1 is preserved by the linear network. In a system if $c_1 e_1(t) + c_2 e_2(t)$ gives rise to $c_1 r_1(t) + c_2 r_2(t)$. Then the system is a linear system.

- Note
  - A linear network consist of linear elements, e.g. resistor, inductor and capacitor.
  - A Network is said to be nonlinear if it contains diode, transistor.

Passive and Active network

- A linear network is passive if (a) the energy delivered to the network is non-negative for any arbitrary excitation , and (b) if no voltages or currents appear between any two terminals before an excitation is applied.
- A linear network is active if there is any energy source and a response appear between any two terminal in the absence of an input (excitation) applied.

Reciprocal

- A network is said to be **reciprocal** if when the points of excitation and measurement of response are interchanged , the relationship between excitation and response remains the same. This must be true for any choice of points of excitation & response.

Causal and NonCausal

- A system is causal if the response at any time depends only on values of the excitation at the present and past time. its response is non-anticipatory, i.e. if

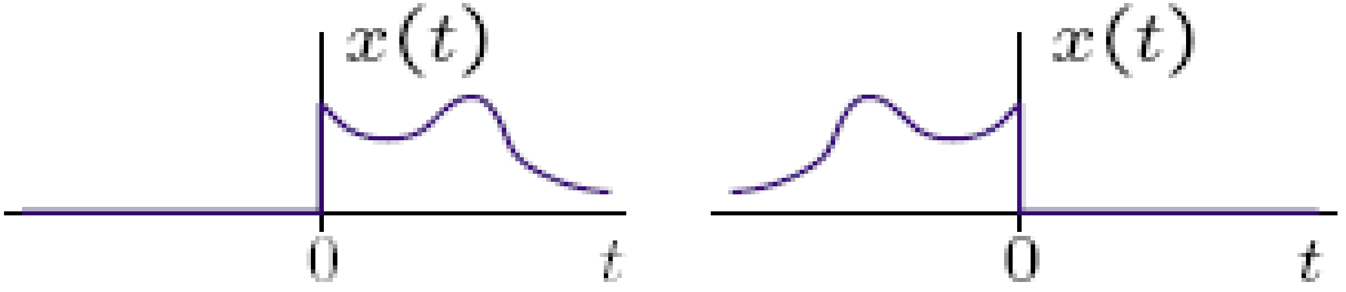
$$e(t) = 0 \qquad t < T$$

then $$r(t) = 0 \qquad t < T$$

in other words , a system is causal if before an excitation is applied at $t = T$, the response is zero for $-\infty < t < T$.

A system is called non-causal system if its output at a given time depends on the input at future time.

A **causal** signal is zero for $t < 0$ and an **non-causal** signal is zero for $t > 0$



Time In variant and time varying system

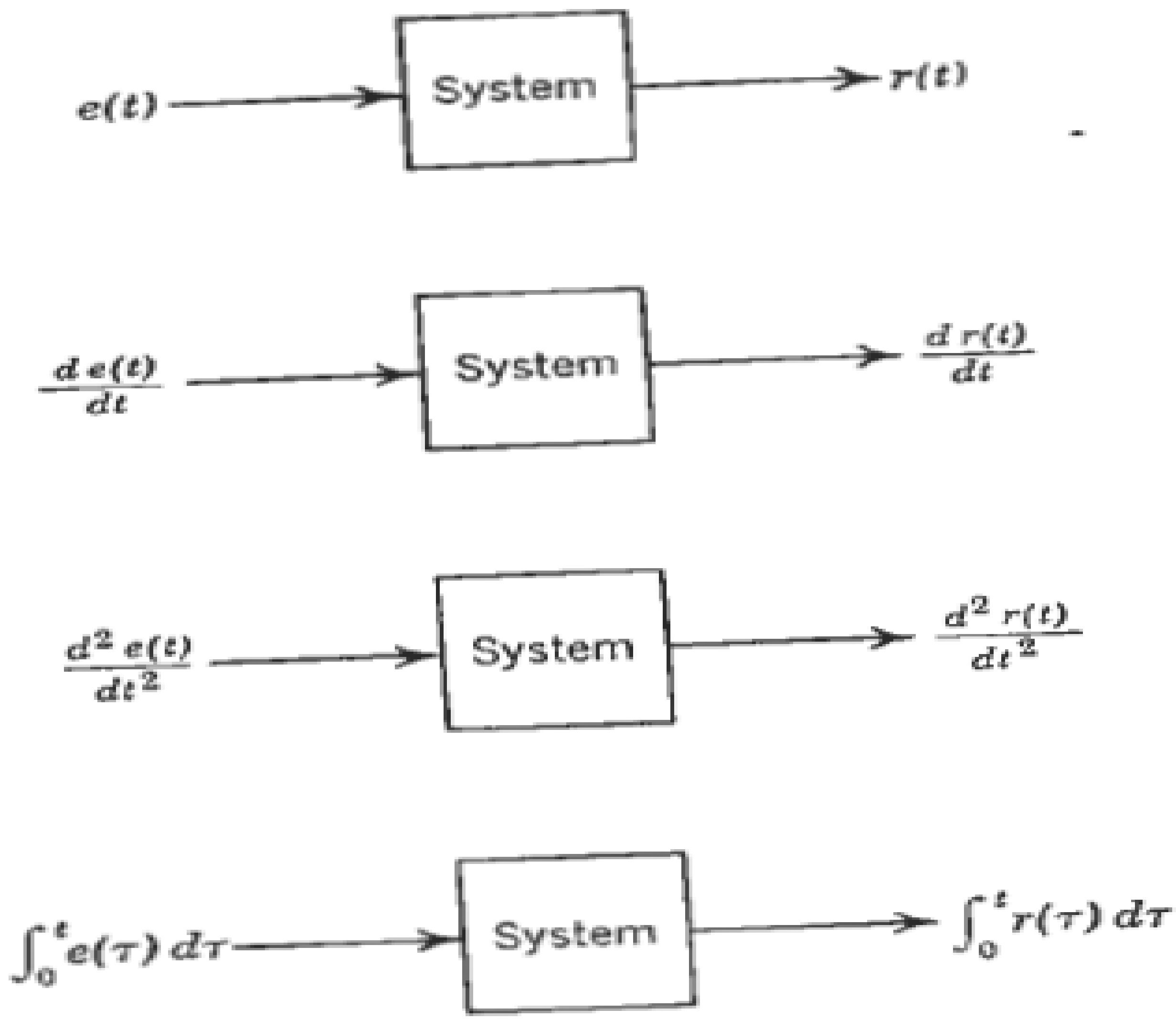
A system is time invariant if a time shift (delay or advance) in the input signal causes the same time shift in output signal, $e(t) \rightarrow r(t)$ implies that $e(t \pm T) \rightarrow r(t \pm T)$. From this property we can show that if e(t) at the input gives rise to r(t) at the output then if the input were e\`(t) i.e. the derivative of e(t) , the response would be r \`(t).

A system which does not satisfy above equation is called a time varying system, i.e. if the input output characteristics of a system change with time

Derivative and Integral Property

- For any time invariant , if r(t) is the response for excitation e(t), then for derivative of e(t) , the response would also be derivative of r(t).

Derivative property of the system



Circuit element

- The voltage source
- The current source
- Dependent source
  - Voltage dependent voltage source
  - Voltage dependent Current source
  - Current dependent Current source
  - Current dependent voltage source
- Resistor
- Capacitor
- Inductor