# UNIT-1

# (Lecture-9)

## Introduction to Network Analysis

# Transient Circuit Analysis

- Natural response and forced response,
- Transient response and steady state response for arbitrary inputs (DC and AC),
- Evaluation of time response both through classical and Laplace methods.

# Solution to First Order Differential Equation

**Consider the general Equation**

$$\tau \frac{dx(t)}{dt} + x(t) = K_S f(t)$$

**Let the initial condition be $x(t = 0) = x(0)$, then we solve the differential equation:**

$$\tau \frac{dx(t)}{dt} + x(t) = K_S f(t)$$

**The complete solution consists of two parts:**

- **the homogeneous solution (natural solution)**
- **the particular solution (forced solution)**

# The Natural Response

**Consider the general Equation**

$$\tau \frac{dx(t)}{dt} + x(t) = K_S f(t)$$

**Setting the excitation $f(t)$ equal to zero,**

$$\tau \frac{dx_N(t)}{dt} + x_N(t) = 0 \ or \quad \frac{dx_N(t)}{dt} = -\frac{x_N(t)}{\tau}, \frac{dx_N(t)}{x_N(t)} = -\frac{dt}{\tau}$$

$$\int \frac{dx_N(t)}{x_N(t)} = \int -\frac{dt}{\tau}, \qquad x_N(t) = \alpha e^{-t/\tau}$$

**It is called the natural response.**

# The Forced Response

**Consider the general Equation**

$$\tau \frac{dx(t)}{dt} + x(t) = K_S f(t)$$

**Setting the excitation $f(t)$ equal to F, a constant for $t \geq 0$**

$$\tau \frac{dx_F(t)}{dt} + x_F(t) = K_S F$$

$$x_F(t) = K_S F \quad for \;\; t \geq 0$$

**It is called the forced response.**

# The Complete Response

**Consider the general Equation**

$$\tau \frac{dx(t)}{dt} + x(t) = K_S f(t)$$

**Solve for α,**

$$for \ \ t = 0$$

$$x(t=0) = x(0) = \alpha + x(\infty)$$

$$\alpha = x(0) - x(\infty)$$

**The complete response is: the natural response + the forced response**

**The Complete solution:** $x(t) = [x(0) - x(\infty)]e^{-t/\tau} + x(\infty)$

$[x(0) - x(\infty)]e^{-t/\tau}$ **called transient response**

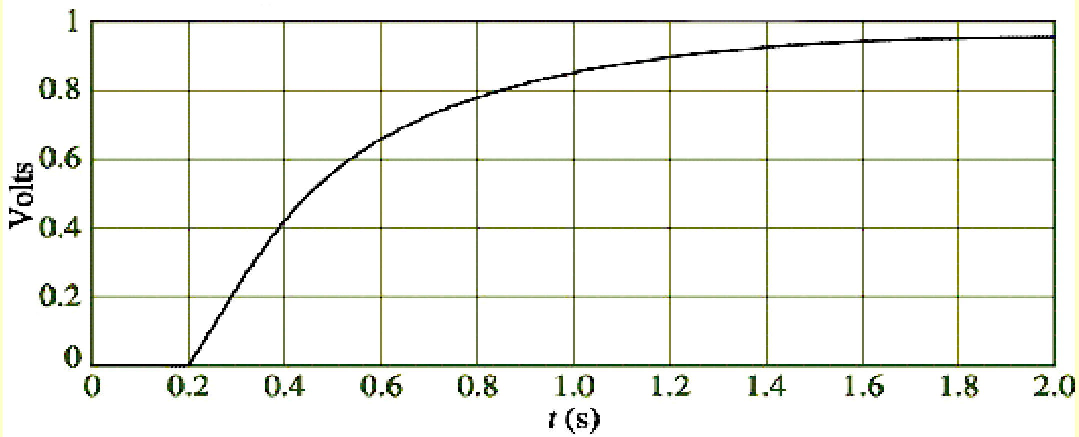
$$x = x_N(t) + x_F(t)$$

$x(\infty)$ **called steady state response**

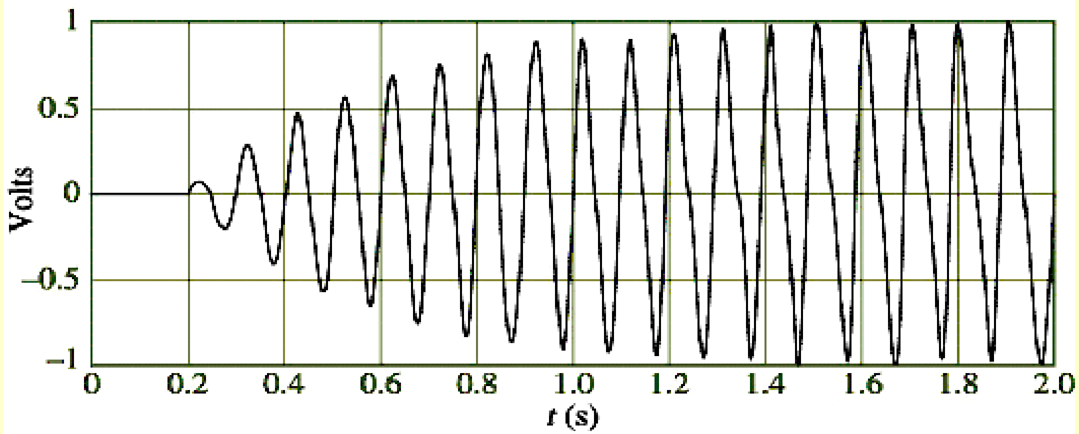
$$= \alpha e^{-t/\tau} + K_S F$$

$$= \alpha e^{-t/\tau} + x(\infty)$$

# WHAT IS TRANSIENT RESPONSE




(a) Transient DC voltage




(b) Transient sinusoidal voltage

# Why there is a transient response?

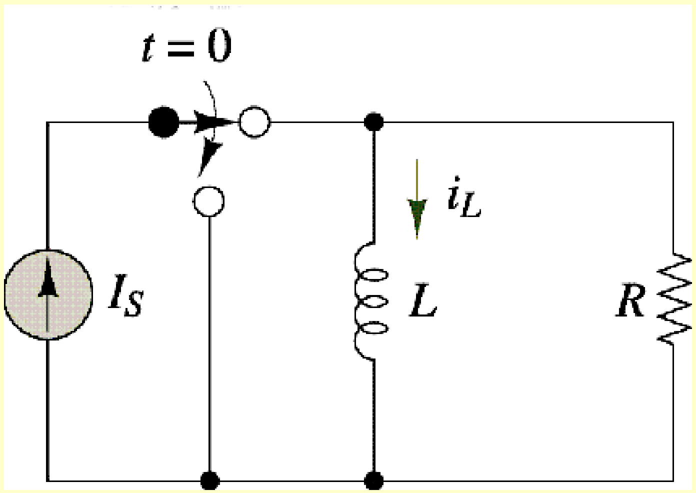
- The voltage across a capacitor cannot be changed instantaneously.

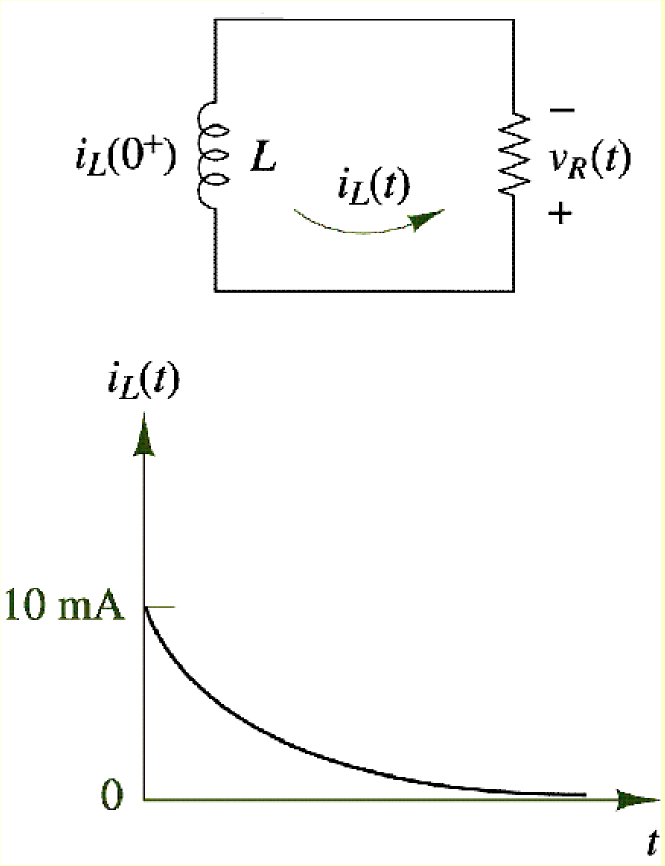
$$V_C(0^-) = V_C(0^+)$$

- The current across an inductor cannot be changed instantaneously.

$$I_L(0^-) = I_L(0^+)$$

# Example



# Transients Analysis

1. **Solve first-order *RC* or *RL* circuits.**

2. **Understand the concepts of transient response and steady-state response.**

3. **Relate the transient response of first-order circuits to the time constant.**