.

EE1101: Circuits and Network Analysis

Lecture 02: Circuit Domain Essentials

Topics :

1. Voltage and Current

2. Kirchhoff's Voltage and Current Laws for DC

Design - Circuit Domain Prospective

for design

a) build the system using Circuit Principles [instead of $\vec{E}$ & $\vec{B}$; use potential (V) & Current (i)]

b) Relevant EM Analysis (EMI|EMC)

Requirements for Design

Knowledge base

a) understand the simplified models & their governing Eqn's.

- 2 terminal elements (R, L, C)
- 3 terminal elements (BJT, MOSFET, OPAmp)

b) methods to analyze Networks built using simplified Components (Ex: Mesh Analysis, Node analysis, Steady State & transient analysis)

focus of this Course.

Actual design

build a rough sketch of the system that meets the requirements

built using simplified models.

Check if the rough sketch meets the requirements

if Yes ⟶ EM Studies

NO ⟶ refine the sketch.

Circuit Domain Essentials - Voltage

def from EM-domain :- external work done in moving a unit positive charge from ∞ to a point p in the field.

$$V_p = -\int_{\infty}^{P} \vec{E} \cdot \vec{dl} \longrightarrow ①$$

a) which path to choose?

b) Would picking a different path result in different V?

for DC scenarios : from Maxwell's Eqn : $\oint_C \vec{E} \cdot \vec{dl} = -\cancel{\frac{d\phi}{dt}}\,0$

(V) → for DC voltage)

$$\Rightarrow \oint_C \vec{E} \cdot \vec{dl} = 0 \Rightarrow \nabla \times \vec{E} = 0$$

$\vec{E}$ - field under DC is a conservative field. $\Rightarrow \vec{E} = -\nabla V$

V_p is uniquely def $\Rightarrow$ Eq ① is path independent.

Potential difference :- b/w two points a & b.

V_{ab} = external work done in moving a charge from b to a $= -\int_b^a \vec{E} \cdot \vec{dl}$

$$V_{ab} = V_a - V_b.$$

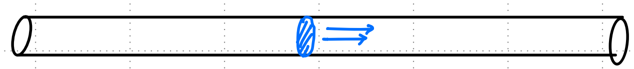
$V_{ab} > 0$: Ext work is needed to move a charge from b to a. (a is at a higher potential)

Circuit Domain Essentials - Current

def from EM-domain: Precise definition requires understanding of Current density

- → line Current density
- → Surface Current density
- → Volume Current density (J)

from Vol Current density $I = \int_S \vec{J} \cdot \vec{ds}$

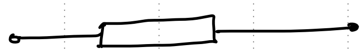


from high school physics: $I = \frac{\Delta Q}{\Delta t}$ Charge flow across the Cross section in a Choosen direction per unit time

Assumption :- Current through an element | Conductor is uniform throughout.

Circuit Domain Essentials - Reference Directions and Polarity

Generic rep of a two terminal element → basic building block of a N/w.

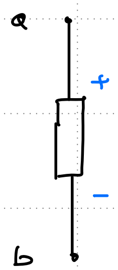


ends of a two terminal elem → Node ← when part of a N/w

" " → branch.

(lower case alphabets / No's are used to denote Nodes)

Polarity :-



V_{ab} : ref to ext work done in moving from b to a.

another way to refer to Vol across an elem.

a) def a polarity (def + / −)

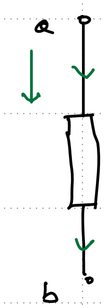
b) define the value of V (work done in moving from terminal marked − to terminal marked +)

for the choosen Polarity

if $V > 0 \Rightarrow V_a > V_b$.

$V < 0 \Rightarrow V_b > V_a$.

Ref for Current :-



I_{ab} : direction choosen to measure charge flow is from 'a' to 'b'

another way

a) indicate ref direction

b) define the value of I.