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EE1101: Circuits and Network Analysis

Lecture 06: DC Circuit Analysis

August 7, 2025

Topics :

1. Node Analysis

Node Analysis - Overview of the approach

Goal for any circuit analysis: To solve for unknown voltages | currents in a N/w

in Node Analysis: Solve for unknown node voltages.

Potential of a particular node w.r.t ref node.

Claim: if all node voltages are known | can be computed, then any other quantity (I, P) can be determined.

① Given a circuit where the reference node is specified, the goal of node analysis is to compute voltages at other nodes.

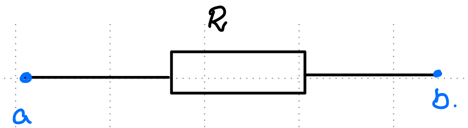
basic idea: Application of KCL at every node (where the potential is not known)

Standard form: in terms of currents but the unknowns are node voltages.

where is branch currents can be written in terms of unknown node voltages. (Not always)

Need to ensure that 'n' linearly independent Equations are generated for finding 'n' unknowns

Node Analysis - Overview of the approach

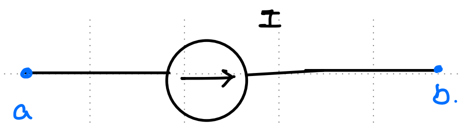


If V_a & V_b are known,

$$I_{ab} = \frac{V_a - V_b}{R} \quad \text{and} \quad I_{ba} = \frac{V_b - V_a}{R}$$

Current through the branch leaving node A. $= I_{ab} = \frac{V_a - V_b}{R}$

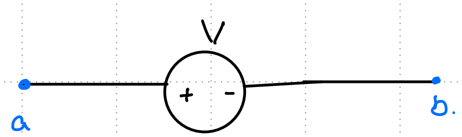
Current through the branch leaving node B. $= I_{ba} = \frac{V_b - V_a}{R}$



either a & b can be a ref node.

Current through the branch leaving node A. = I

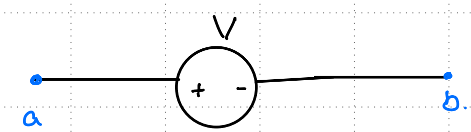
Current through the branch leaving node B. = $-I$



either a or b is ref nodes.

⇓

other node voltage is known



neither a nor b is a ref node.

⇓

writing an expression for I is not straight forward.

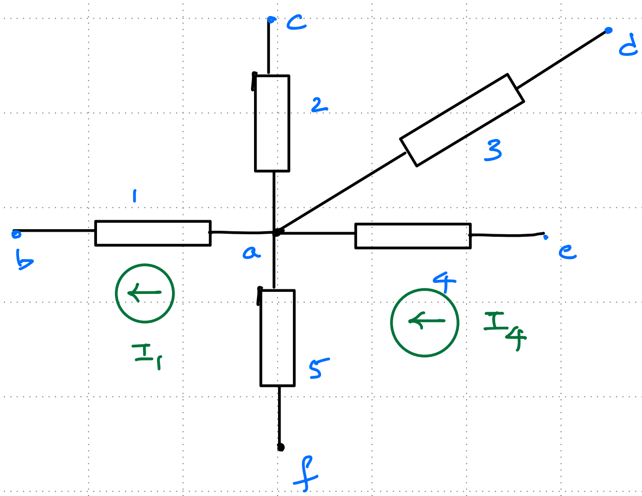
Start : a) ckts that do not contain Voltage Sources.

b) " " contain Voltage Sources b/w node & ref node.

c) " " " " " b/w non-ref nodes.

Node analysis with current sources and resistors

Apply KCL to one node (a) in such a n/w.



Basic idea : KCL

↓

used in this form

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$\sum I_{\text{leaving the node through the connecting branches}} = 0$

Scenario 1 :- branches 1 & 4 (I_1 & I_4) Current Sources

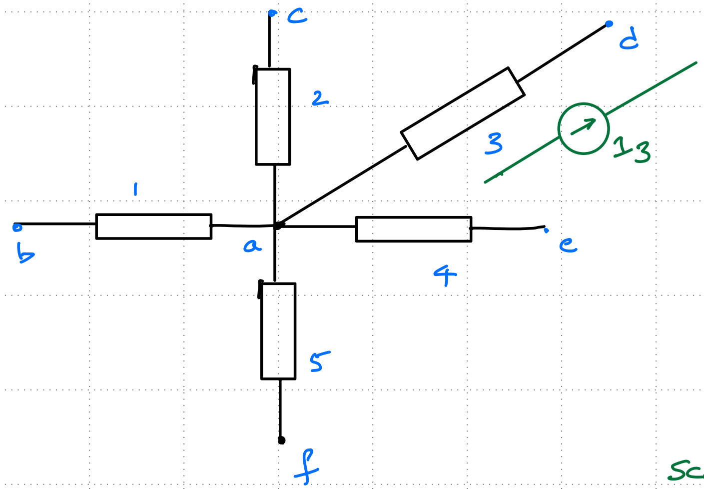
2, 3 & 5 (R_2, R_3, R_5) are Resistors.

$$I_1 + \frac{V_a - V_c}{R_2} + \frac{V_a - V_d}{R_3} - I_4 + \frac{V_a - V_f}{R_5} = 0$$

$$\underbrace{\left(\frac{1}{R_3} + \frac{1}{R_2} + \frac{1}{R_5}\right)}_{G_{aa}} V_a \underbrace{- \frac{1}{R_2}}_{G_{ac} = -1/R_2} V_c \underbrace{- \frac{1}{R_3}}_{G_{ad}} V_d \underbrace{- \frac{1}{R_5}}_{G_{af}} V_f = I_4 - I_1$$

Node analysis with current sources and resistors

Apply KCL to one node in such a n/w.
(a)



Basic idea: KCL

↓

used in this form

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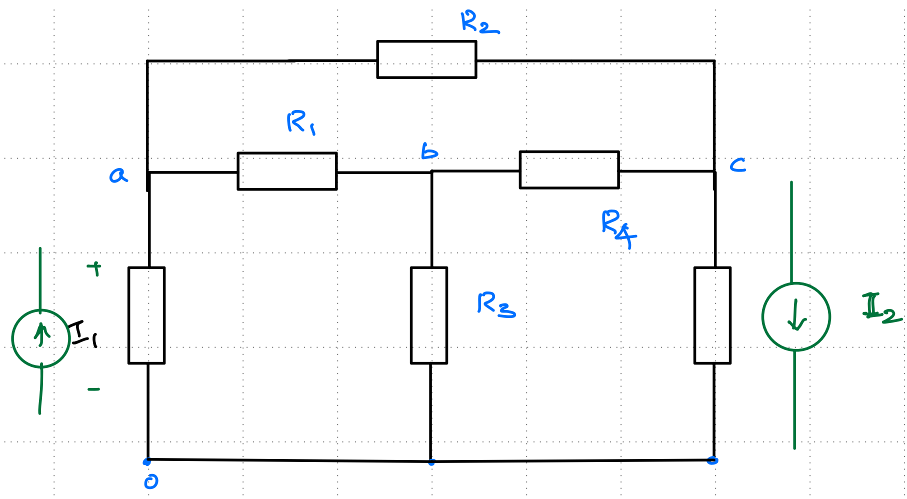
$\sum I$ leaving the node through the connecting branches $= 0$

Scenario 2: branch 3: I_3

branches 1, 2, 4 5: R_1, R_2, R_4 & R_5 resp

$$\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_4}+\frac{1}{R_5}\right)V_a - \frac{1}{R_1}V_b - \frac{1}{R_2}V_c - \frac{1}{R_4}V_e - \frac{1}{R_5}V_f = -I_3$$

Example - Use of Matrices in Node Analysis



3 nodes of unknown potential

at a: $\left(\frac{1}{R_1}+\frac{1}{R_2}\right)V_a - \frac{1}{R_1}V_b - \frac{1}{R_2}V_c = I_1$

at b: $-\frac{1}{R_1}V_a + \left(\frac{1}{R_1}+\frac{1}{R_4}+\frac{1}{R_3}\right)V_b - \frac{1}{R_4}V_c = 0$

at c: $-\frac{1}{R_2}V_a - \frac{1}{R_4}V_b + \left(\frac{1}{R_4}+\frac{1}{R_2}\right)V_c = -I_2.$

Use matrices $\underbrace{[G]}_{\text{Conductance matrix}}\underbrace{[V]}_{\text{Vector of unknown voltages}} = \underbrace{[I]}_{\text{Vector of injected currents}}$

$[V] = [V_a, V_b, V_c]^t$