B.Sc. Part-2 Physics (Hons) Paper-iv, Lecture-17 on the topic

"Nodal Voltage Analysis and Duality in Network."

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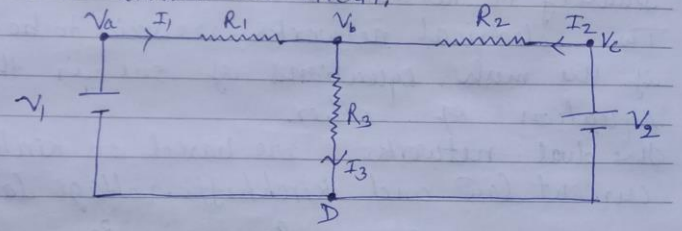
B. Sc. Part-2, physics (Hons), Paper- IV,
Lecture- 17

* Nodal voltage Analysis :-

Nodal voltage analysis is used to find the unknown voltage drops around a circuit between different nodes that provide a common connection for two or more circuit components.

Nodal voltage analysis uses the Nodal equations of Kirchhoff's first law to find the voltage potentials around the circuit.



In the above circuit, node-D is chosen as the reference node and the other three nodes are assumed to have voltage, V_a, V_b and V_c with respect to node D.

Now By the Kirchhoff's current law

$$I_1 + I_2 = I_3$$

$$\frac{V_a - V_b}{R_1} + \frac{V_c - V_b}{R_2} = \frac{V_b}{R_3}$$

$$\frac{V_a}{R_1} - \frac{V_b}{R_1} + \frac{V_c}{R_2} - \frac{V_b}{R_2} = \frac{V_b}{R_3}$$

$$\frac{V_a}{R_1} + \frac{V_c}{R_2} = \frac{V_b}{R_1} + \frac{V_b}{R_2} + \frac{V_b}{R_3}$$

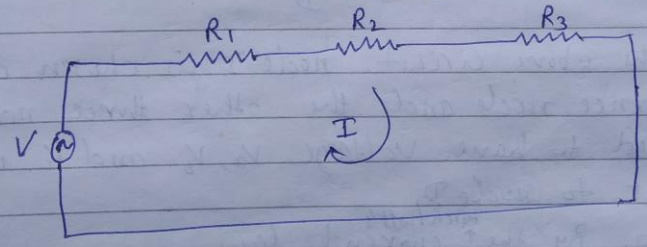
$$\frac{V_a}{R_1} + \frac{V_c}{R_2} = V_b \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)$$

$$V_b\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right)=\left(\frac{V_a}{R_1}+\frac{V_c}{R_2}\right)$$

$$V_b=\frac{\left(\frac{V_a}{R_1}+\frac{V_c}{R_2}\right)}{\left(\frac{1}{R_1}+\frac{1}{R_2}+\frac{1}{R_3}\right)}$$

If we know the value of V_a, V_c, R_1, R_2 and R_3 then we can easily find the value of V_b.

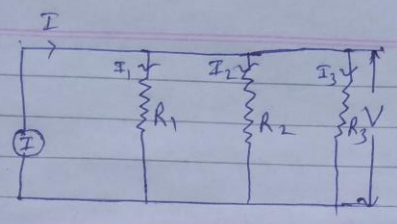
* Duality in networks :-
Two electrical networks are said to be dual if the mesh equations of one is the node equation of other.
The dual network are based on Kirchhoff's current law and Kirchhoff's voltage law.



Applying Kirchhoff's voltage law in above diagram we get

$$V = IR_1 + IR_2 + IR_3$$

$$V = I(R_1+R_2+R_3) \quad \text{——①}$$



Applying Kirchhoff's current law in above diaram we get.

$$I = I_1 + I_2 + I_3$$

$$I = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

$$I = V\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right) \quad \text{——} (2)$$

we have found two equations (1) and (2) Similar in their mathematical form.
Equation (1) is in mesh form and Equation (2) is in nodal form. left side variable in the equation (1) is voltage and left side variable in the equation (2) is current.
Therefore, these two networks are dual networks.
The circuit equations of two dual network are similar in form but the variable are interchanged.