UNIT 1

Graph Theory

Contents

1. Graph of a Network definitions
2. Tree and co tree
3. Link, basic loop
4. Basic cut set
5. Incidence matrix
6. Cut set matrix
7. Tie set matrix
8. Duality
9. Loop and Nodal methods of analysis.

VIII. Cut-set:

Tree branches connect all the nodes in the network graph. Hence, it is possible to trace the path from one node to any other node by traveling along the tree branch only. Therefore, potential difference between any two nodes called node-pair voltage can be expressed in terms of tree branch voltages.

The cut set is a minimal set of branches of the graph, removal of which cuts the graph into two parts. It separates the nodes of the graph into two groups. The cut-set consists of only one tree branch and remainders are links. Each branch of the cut-set has one of its terminal incident at a node in one group and its other end at a node in the other group and its other end at a node in the other group. The orientation of the cut-set is same as orientation of tree branch.

The number of cut-sets is equal to number of tree branches [i.e. (nt-1) = n where n_t is total number of nodes in the network graph].

IX. Cut-set schedule:

For a given network tree, a systematic way of indicating the tree branch voltage through use of a schedule called **cut-set schedule**

To write the cut-set schedule for network graph,

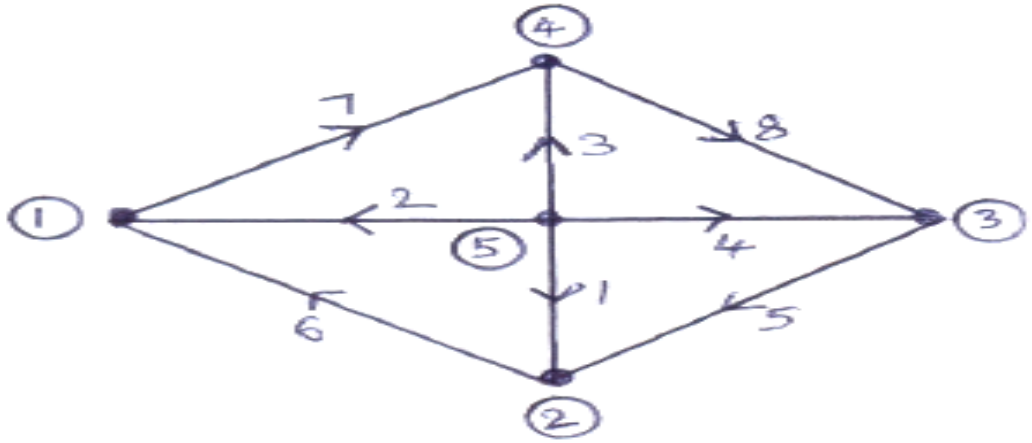
(i) Consider an oriented network graph

(ii) Write any one possible tree of the network graph

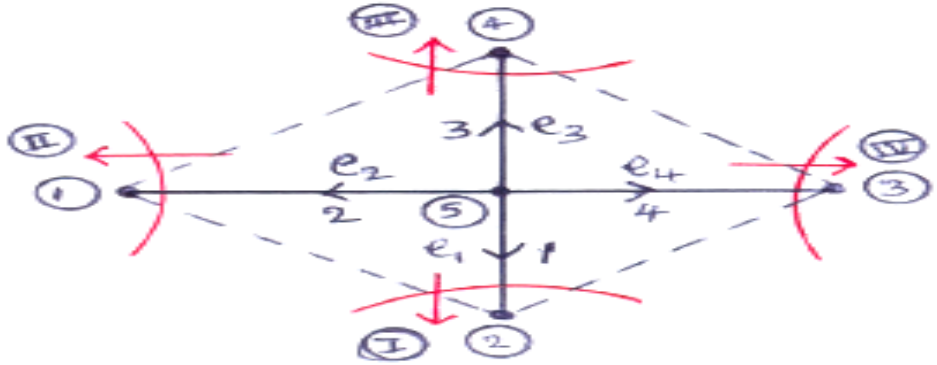
(iii)Assume tree branch voltages as (e1, e2…en) independent variables.

(iv)Assume the independent voltage variable is same direction as that of a tree branch voltage

(v) Mark the cut-sets (recognize) in the network graph.



Oriented Graph



Tree and Cut-sets

The tree branch voltages e_1, e_2, e_3, & e_4 entered in the first column of the schedule correspond to 4 branches 1, 2, 3 & 4. In order to fill the first row corresponding to the tree branch voltages e_1, by looking into the direction of currents in the branches connected to the cut-set under consideration. If the direction of current in the cut-set branch is towards the cut-set node, write **'+1'** in the branch column of concerned cut-set branch. If the direction of current in the cut-set branch is away from the cut-set node, write **'-1'** in that particular cut-set branch column. Write **'0'** in the branch columns, which are not in that particular, cut-set.

Cut-set schedule:

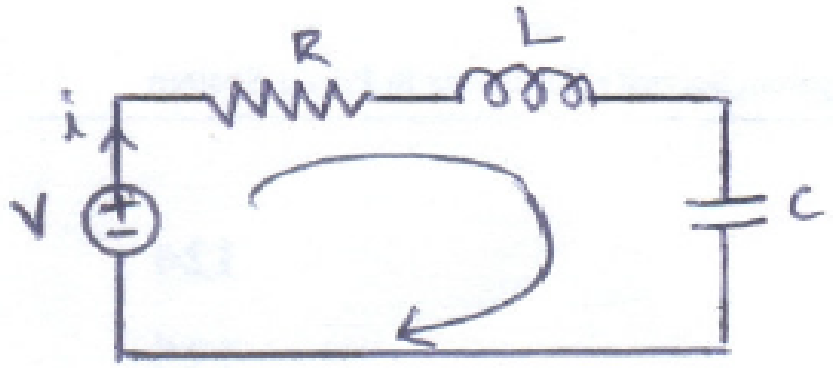
Tree Branch Voltages	Branches							
	1	2	3	4	5	6	7	8
e_1	1	0	0	0	1	-1	0	0
e_2	0	1	0	0	0	1	-1	0
e_3	0	0	1	0	0	0	1	-1
e_4	0	0	0	1	-1	0	0	1

XI. Principle of Duality:

Duality: is the mutual relationship.

We come across a number of similarities in analyzing the network on current (Loop) basis and voltage (Node) basis. The principal quantities (and concepts) involved in the two methods form pairs. Each of the quantity in such a pair thus plays a dual role. These quantities (or concepts) forming pair are called **dual quantities.**

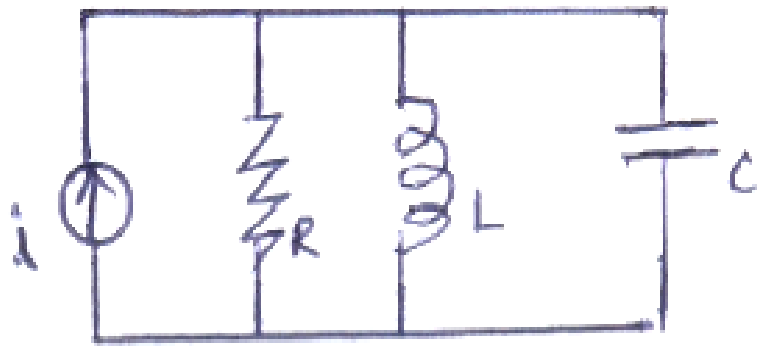
Consider a network containing R, L & C elements connected in series and excited by a voltage source as shown.



The integro- differential equations for the circuit is

$$R\,i + L\,(di/dt) + (1/C)\int i\,dt = v \qquad (1)$$

Consider a network containing R, L & C elements connected in parallel and driven by a current source as shown.



The integro- differential equations for the circuit is

$$(1/R)\, v + C\,(dv/dt) + (1/L) \int v\, dt = i \qquad (2)$$

OR

$$G\, v + C\,(dv/dt) + (1/L) \int v\, dt = i \qquad (2)$$

If we observe both the equations, the solutions of these equations are the same.

Therefore, these two networks are called **duals**

Construction of a Dual of a Network:

Only planar networks without mutual inductances have **duals.**

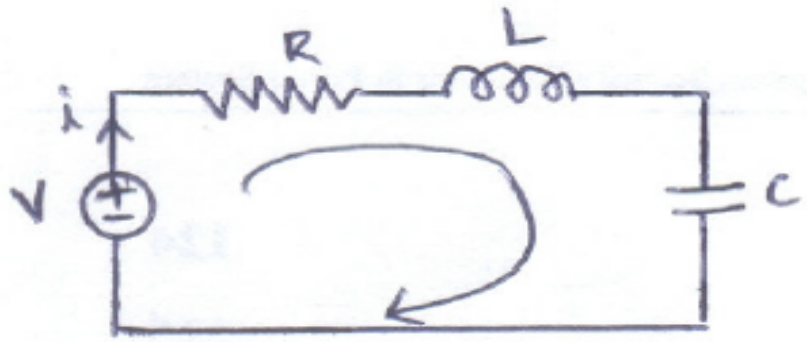
S.N.	Quantity or Concept	Dual Quantity or Concept
1	Current	Voltage
2	Resistance	Conductance
3	Inductance	Capacitance
4	Branch Current	Branch Voltage
5	Mesh	Node
6	Loop	Node-Pair
7	Number of Loops	Number of Node-Pairs
8	Loop Current	Node-Pair Voltage
9	Mesh Current	Node Voltage or Node Potential
10	Link	Tree Branch
11	Tie-set	Cut-set
12	Short Circuit	Open Circuit
13	Parallel Path	Series Path
14	Charge (Q)	Flux Linkages (ψ)

Procedure to draw a Dual Network:

Step 1: In each Loop of a given network place a node and place an extra node called reference node outside the network.

Step 2: Draw the lines connecting adjacent nodes passing through each element and also to the reference node by placing the dual of each element in the line passing through original elements.

Example: 1) Draw the dual of a network for given network shown in figure.



References

1. M. E. Van Valkenburg, “Network Analysis”, Prentice Hall, 2006.

2. D. Roy Choudhury, “Networks and Systems”, New Age International Publications, 1998.

3. W. H. Hayt and J. E. Kemmerly, “Engineering Circuit Analysis”, McGraw Hill Education, 2013.

4. C. K. Alexander and M. N. O. Sadiku, “Electric Circuits”, McGraw Hill Education, 2004.

5. K. V. V. Murthy and M. S. Kamath, “Basic Circuit Analysis”, Jaico Publishers, 1999.Syllabus

6. K.M. Soni, “ Network Theory”, S.K. Kataria Publication