Graph Theory

Presented By:-

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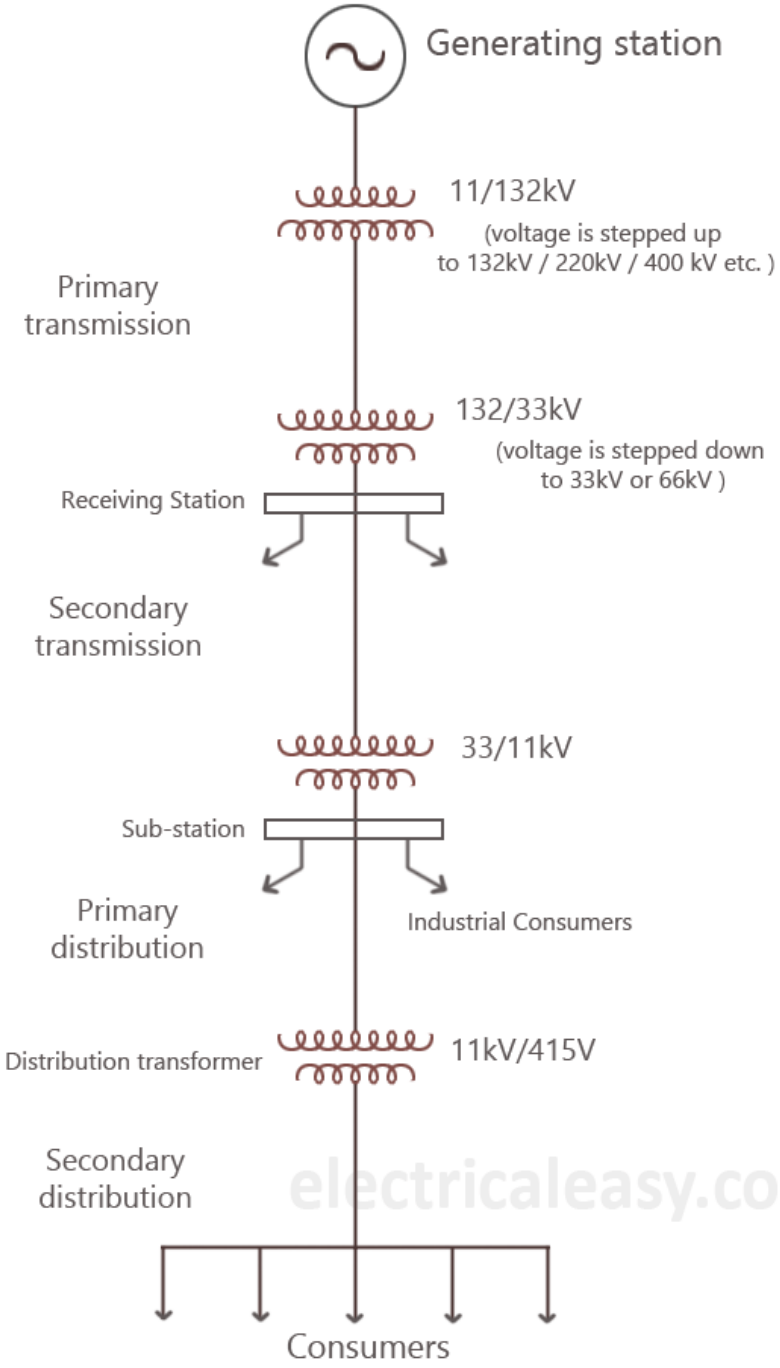
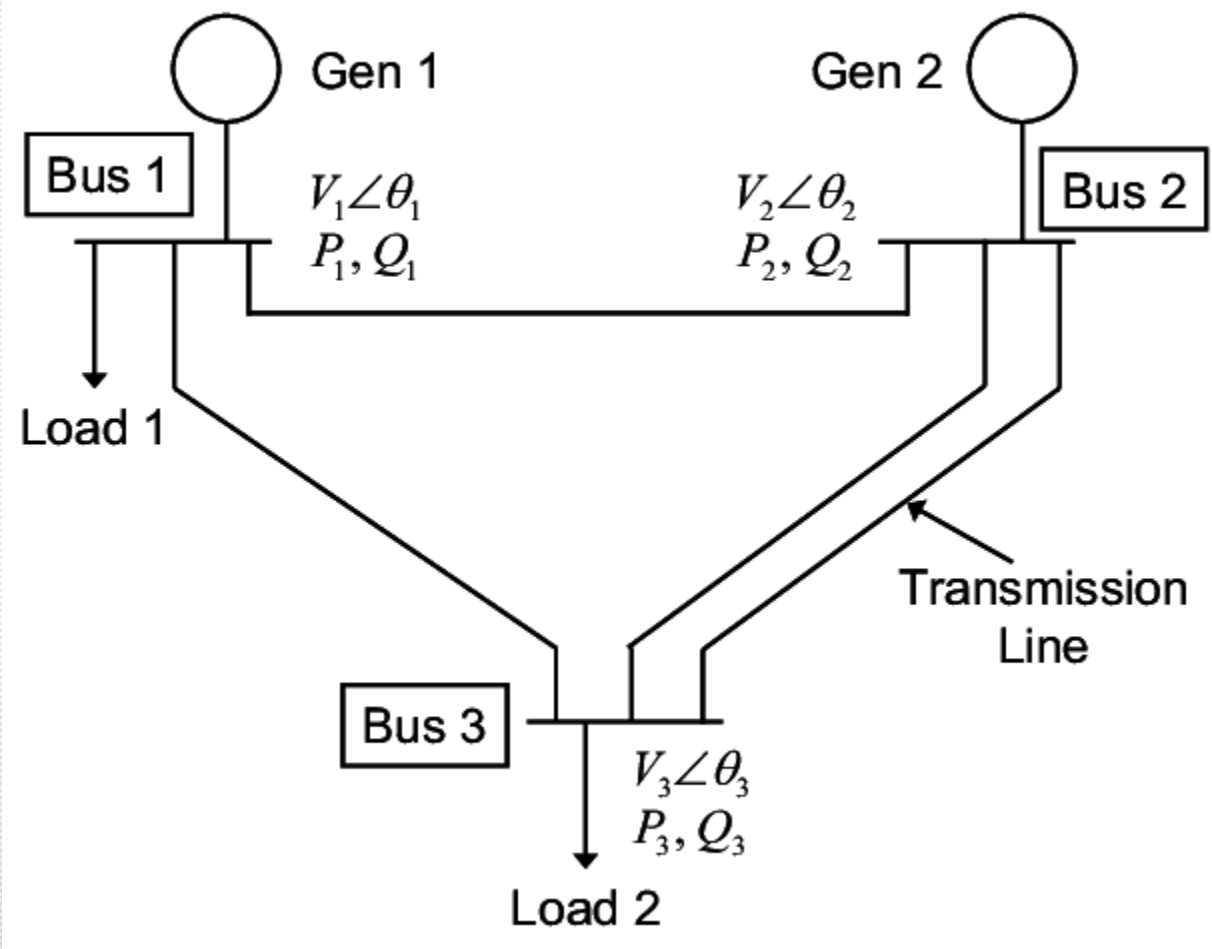
Introduction

- The Electrical Power System is a complex network consisting of a generators, loads, transmission lines, bus bars, circuit breakers, transformers, etc.



Introduction

- The power system network deals with the determination of voltages at various buses and the current that flow in transmission lines operating at different voltage levels.



Introduction

- The power system network deals with the determination of voltages at various buses and the current that flow in transmission lines operating at different voltage levels.
- But a suitable model is needed for analysis of this power system network operation.
- GRAPH THEORY is very useful tool for analysis of any electrical network operation.
- Graph theoretical concepts are widely used to study and model various applications, in different areas.

Introduction

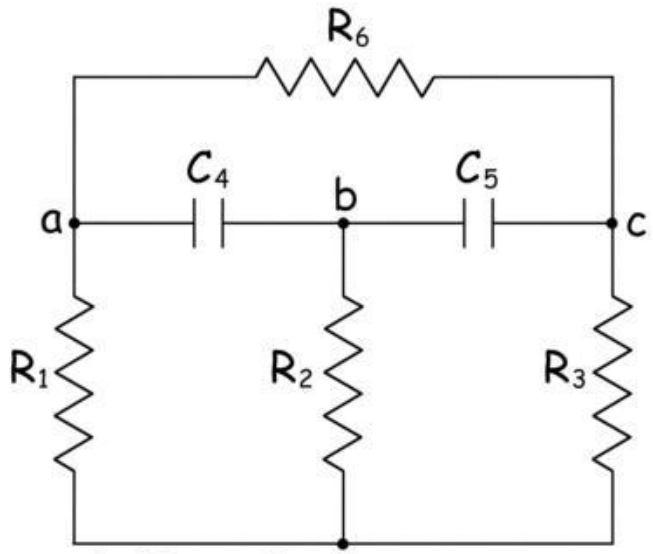
- Many applications of several electrical components such as machines and power system component characteristics are representing in simple way in GRAPH FORM.
- For small circuit analysis based on nodal and meshed equation methods by using Kirchhoff's law and ohm's law are sufficient.
- But for complex networks these methods are difficult and take more time for solving the equations.

Graph Theory

- The circuit elements are resistors, capacitors, inductors, voltage sources, current sources etc. can be connected in different manners, some of them are in series and some of them in parallel.
- Current, voltage, resistance, impedance, reactance, inductance, capacitance, frequency, electric power, electrical energy etc. are the different electrical parameters which is determine by network analysis.
- An electrical network is the combination of different circuit elements and the network analysis is the technique to determine the different electrical parameters of those circuit elements.

Graph Theory

- When this all the circuit elements of an electrical network replace by hand-drawn lines.
- A simple network shown in fig – 1, then the fig. - 2 is known as the graph of the network.



Network (Fig - 1)

Graph of Network

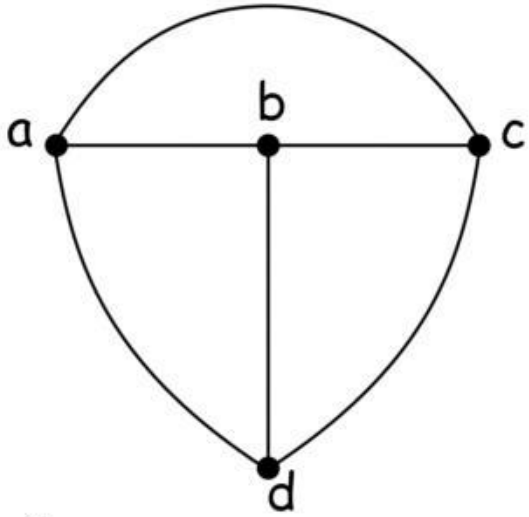


Fig 2

Graph Theory

- Branch:
  - Each hand drawn line in a graph which represents the path for flowing of current is called branch.
- Node:
  - The end point of the branch where other branches meet is called a node.
- Graph:
  - It shows the geometrical interconnection of the elements of a network.
  - A graph is connected if and only if there is a path between every pair of nodes.
- Subgraph:
  - This is a subset of branches of a graph.

Graph Theory

- Oriented Graph:
  - When we draw a graph of a network with the direction of current (the direction may be arbitrary) in each of the branches, the graph is called oriented graph of the network.
  - The figure – 3 below shows the oriented graph of the above network in figure – 1.

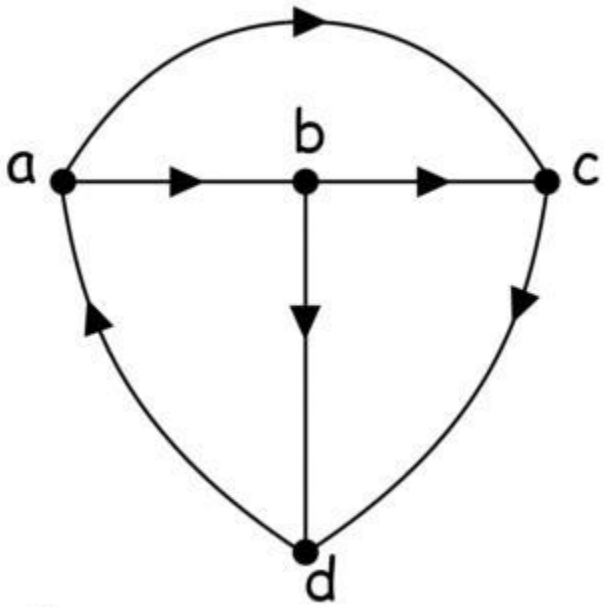


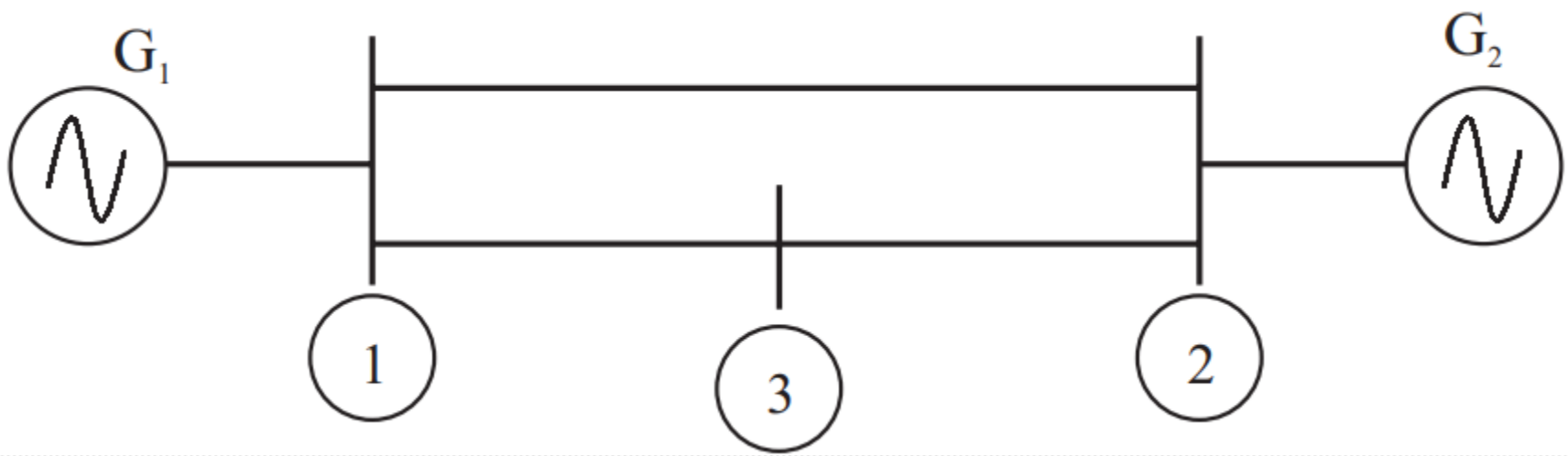
Fig 3

Graph Theory

- Twig:
  - The branches of a tree are referred to as twigs.
- Tree:
  - The tree is a subgraph which contains all nodes of the graph but does not form any closed circuit.
  - If the graph has n number of nodes, the tree will have (n – 1) number of branches.
  - Hence a tree can also be referred to as a set of twigs.
- Cotree:
  - It is a subgraph which contains all those branches which are not included in a tree.
  - It is the complement of a tree.

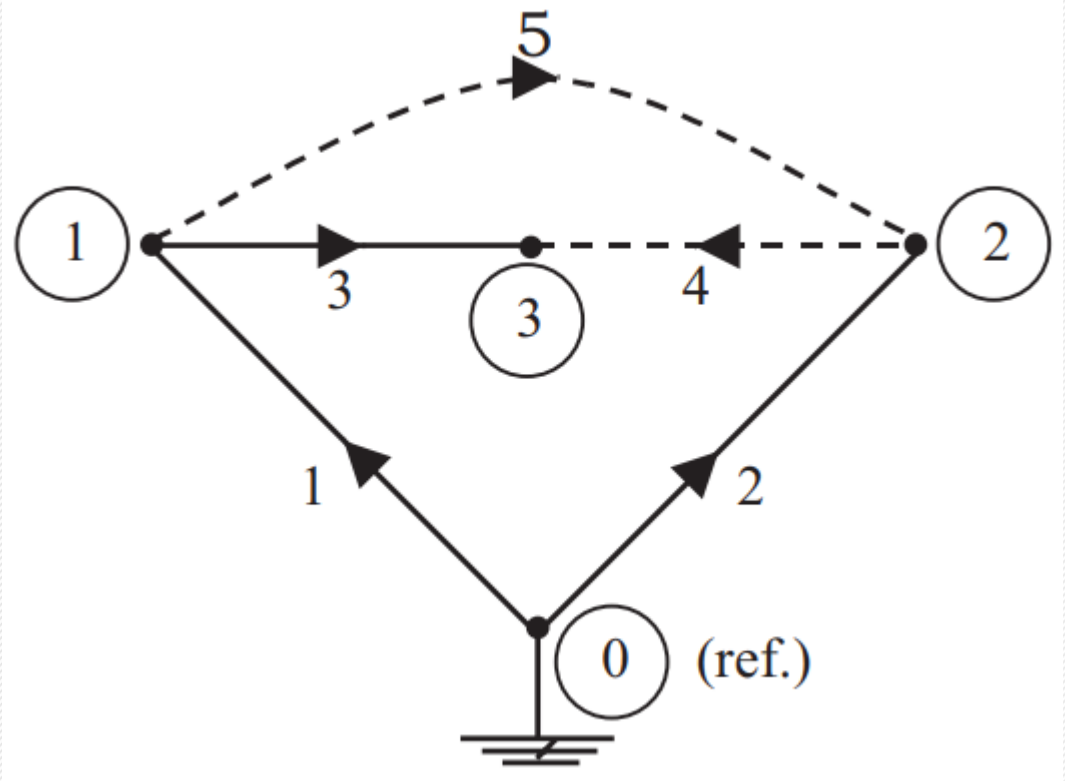
Graph Theory

- Single Line Diagram of Power System Network:



Graph Theory

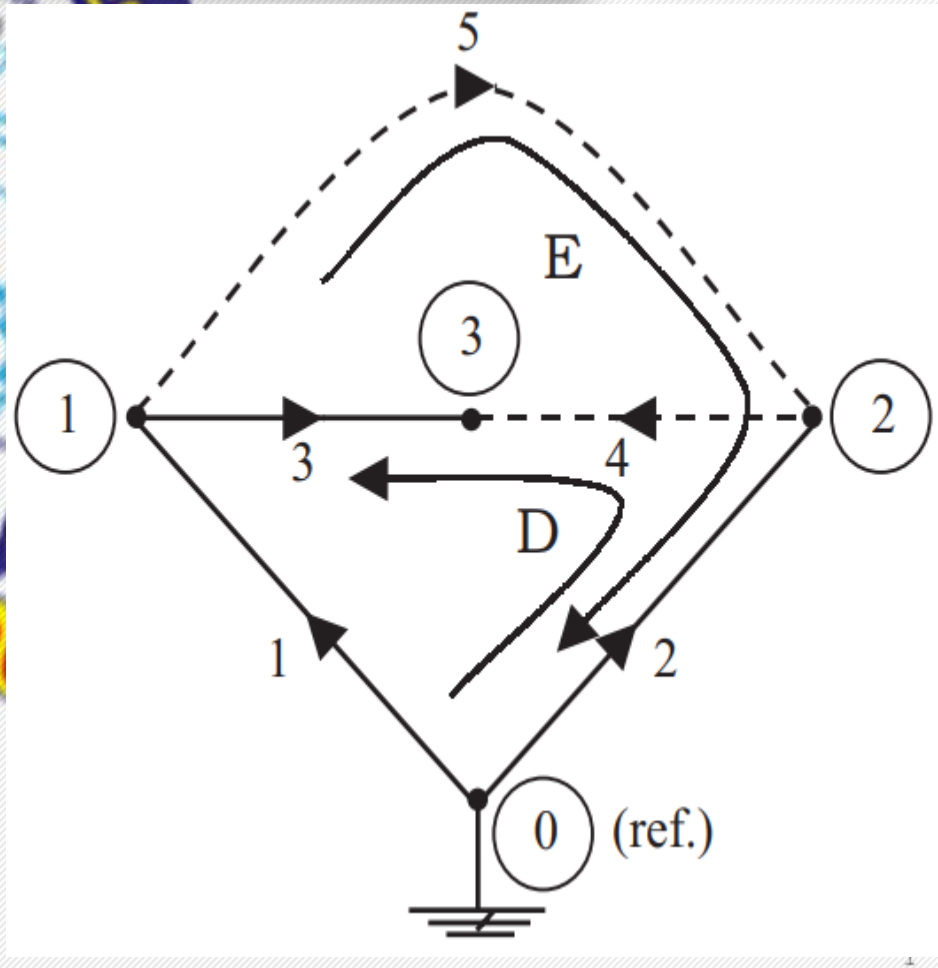
- Tree of Power System Network:



Basic Loops or Fundamental Loops

- Loops which contain only one link are independent and are called basic loops as shown in Fig.
- In other words, whenever a link element is added to the existing tree, basic loops or fundamental loops can be obtained.

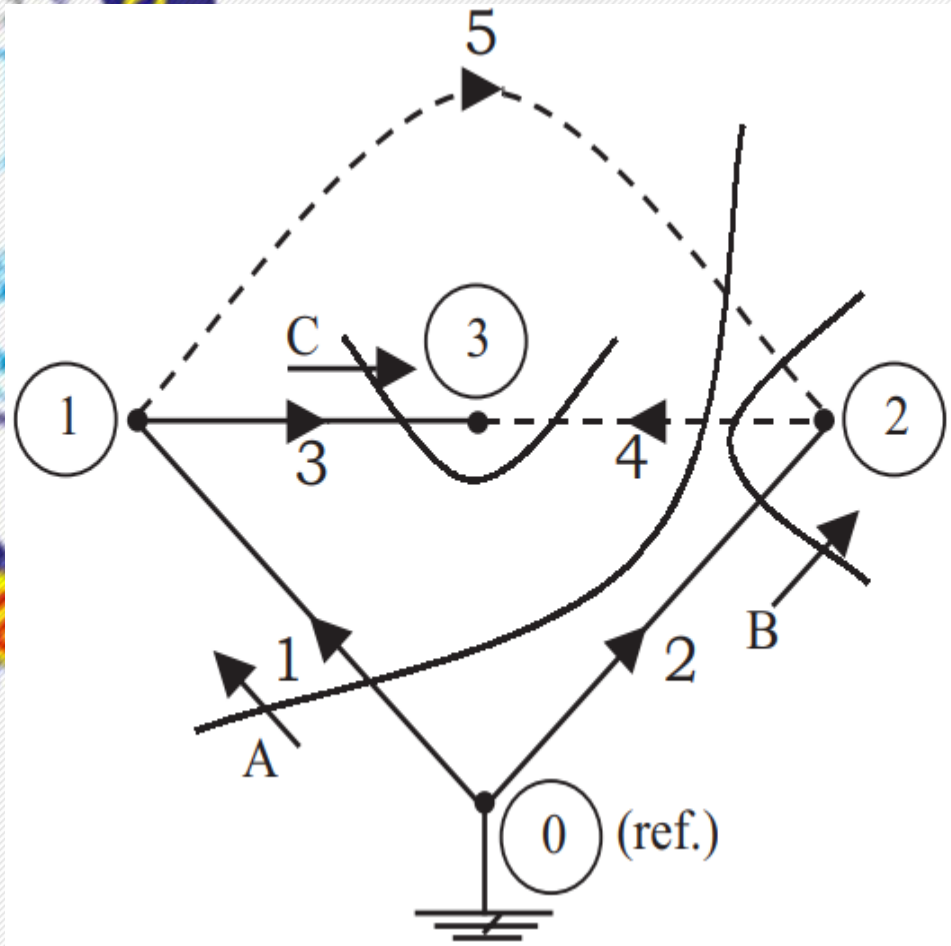
No. of fundamental loops = No. of links



Basic Cut Sets or Fundamental Cut Sets

- A cut set is a set of elements that, if removed, divides a connected subgraphs.
- In other words, a basic or fundamental cut set of the graph is the set of elements consisting of only one branch (or) twig and minimal number of links (or) chords as shown in Fig.

No. of basic cut sets = No. of twigs



Incidence Matrices

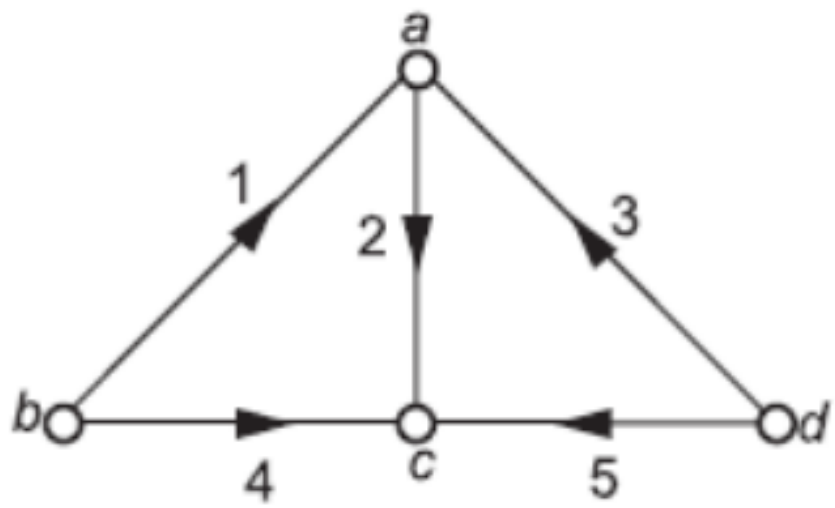
- Every element of a graph is incident between any two nodes.
- Incidence matrices give the information about incidence of elements - may be incident to loops, cut sets etc. and this information is furnished in a matrix, known as incidence matrix.
- Here, oriented graph can be described completely in a compact matrix form and orientation of each branch in the graph and the nodes at which this branch is incident. This branch is called incident matrix.

Incidence Matrices

- The rows of the matrix represent the nodes and the columns represent the branches of the graph.
  1) The elements of the incidence matrix will be +1, -1 or zero.
  2) If a branch is connected to a node and its orientation is away from the node the corresponding element is marked +1.
  3) If a branch is connected to a node and its orientation is towards the node then the corresponding element is marked – 1.
  4) If a branch is not connected to a given node then the corresponding element is marked zero.

Complete Incidence Matrices

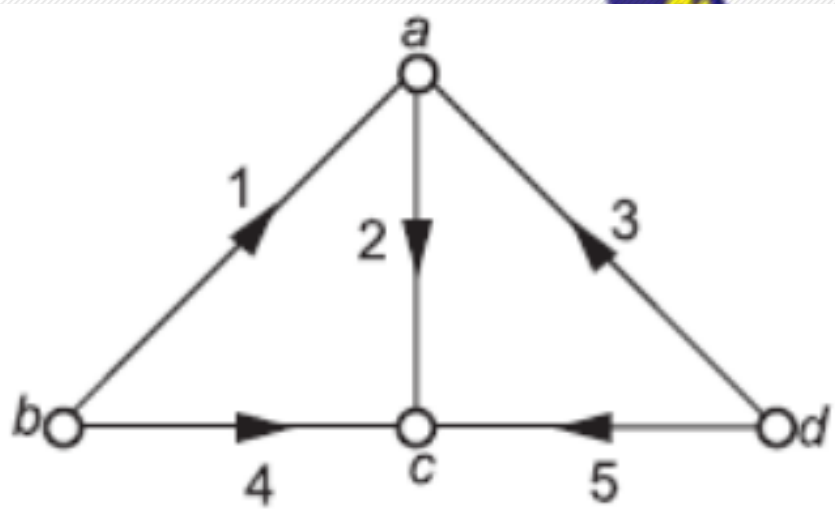
- An incidence matrix in which the summation of elements in any column is zero is called a complete incidence matrix.



$$A_n = \begin{array}{c} \\ \text{Nodes} \\ a \\ b \\ c \\ d \end{array} \begin{array}{c} \text{Branches} \\ \begin{array}{ccccc} 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} -1 & 1 & -1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & -1 & -1 \\ 0 & 0 & 1 & 0 & 1 \end{bmatrix} \end{array}$$

Reduced Incidence Matrices

- The reduced incidence matrix is obtained from a complete incidence matrix by eliminating a row.
- Hence the summation of elements in any column is not zero.



$$A = \begin{array}{c} \\ \text{a} \\ \text{b} \\ \text{c} \end{array} \begin{array}{c} \begin{array}{ccccc} \text{Branches} & & & & \\ 1 & 2 & 3 & 4 & 5 \end{array} \\ \begin{bmatrix} -1 & 1 & -1 & 0 & 0 \\ 1 & 0 & 0 & 1 & 0 \\ 0 & -1 & 0 & -1 & -1 \end{bmatrix} \end{array}$$


Thank You