NETWORK

THEVENIN'S THEOREM, NORTON'S THEOREM, MAXIMUM POWER TRANSFER THEOREM, SUPERPOSITION PRINCIPLE, T AND π NETWORK.

Electronics circuit components or elements

Passive elements- electronic circuit element which cannot amplify or rectify ac power called passive elements. Example resistor, capacitor and inductor

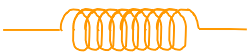
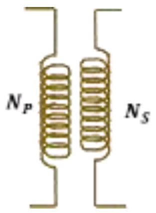
Active elements- electronic circuit element which can amplify or rectify ac power called active elements. Example diode, transistor and tube device.

Linear circuit elements- circuit components for which current voltage relationship is linear Example resistor, capacitor and inductor

Non Linear circuit elements- circuit components for which current voltage relationship is non-linear Example diode, transistor etc.

Unilateral elements- a unilateral element has different law relating current and voltage for two possible directions example- vacuum diode, silicon diode etc

Bilateral elements- a bilateral element has same law relating current and voltage for two possible directions example- resistor, capacitor and inductor.

 RESISTANCE $V(t) = R\,I(t)$ $I(t) = \frac{V(t)}{R}$	 INDUCTOR $V(t) = L\frac{d}{dt}I(t)$ $I(t) = \frac{1}{L}\int V(t)\,dt$	 CAPACITOR $I(t) = C\frac{d}{dt}V(t)$ $V(t) = \frac{1}{C}\int I(t)\,dt$	TRANSFORMER  $\frac{V_S}{V_P} = \frac{N_S}{N_P}$

Voltage and current sources

Ideal voltage source: An ideal voltage source is a voltage generator whose output voltage is independent of current delivered by the generator. An ideal voltage source must have zero internal impedance. Hence output voltage is independent on the current delivered by the source.

Practical voltage source: A practical voltage source always has some internal impedance. Hence output voltage depend upon the current, delivered by the source. A practical voltage source can be represented by an ideal voltage source in series with a resistance or an impedance.

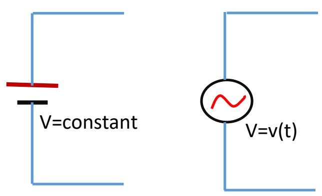
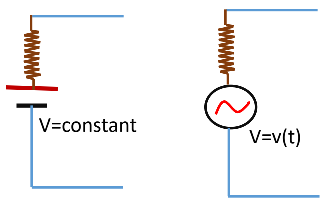
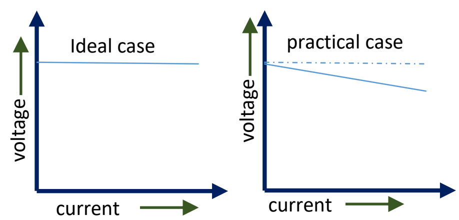
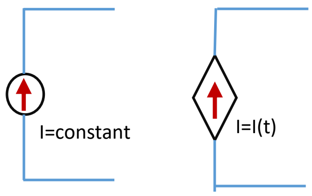
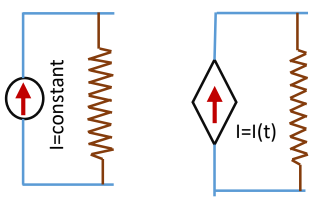
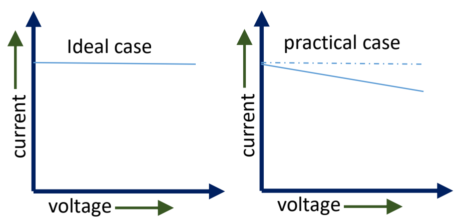
Ideal current source: An ideal current source is a current generator which supplies a current a current independent of the voltage across the terminals of the current generators. An ideal current source must have infinite internal impedance.

Practical current source: A practical current source cannot have infinite internal impedance. Hence supply current depends on the voltage across the terminals of the current generator. A practical current source can be represented by an ideal current source can be represented by an ideal current source in parallel with an internal impedance.

Constant sources: A constant source is one whose voltage or current is constant of the voltage or current elsewhere in the ckt.

Controlled or dependent source: A controlled (or dependent) source is one whose voltage or current is a function of the voltage or current elsewhere in the ckt. For example, in the transistor equivalent ckt the voltage source $h_{re}V_O$ depend on the output voltage and is therefore, a controlled source.

Note: If load impedance (Z_L) is very large compared to internal impedance (Z_i) of a source then it can be considered as a voltage source. On the other hand, if the load impedance is very small compared to the internal impedance of the source then it may be considered as a current source. Again, if $\frac{Z_i}{Z_L} < 0\cdot01$ then practical voltage source can be considered as a good voltage source. If $\frac{Z_i}{Z_L} \gg 100$ the current source can be considered as a good current source.

 Ideal voltage source	 Practical voltage source	
 Ideal current source	 Practical current source	

Network Definition

Circuit: A circuit may be defined as a complete path for electric current flow.

Branch: A group of ckt elements, usually in series, and having two terminals is called a branch of the circuit.

Network: A network is combination of ckt elements, or branches interconnected in some way.

Mesh or loop: A loop is any closed path from by a number of branches in a network. A mesh is the simple possible closed path.

Node or junction: A node or junction is simply a common point where two or more ckt components meet.

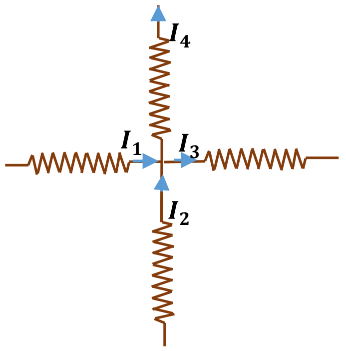
Short Circuit: If any two terminals of a network is connected by a wire of zero resistance then the terminals are said to be short circuited.

Open Circuit: If the load connected between any two terminals of any network is made infinite, that is, the conducting path between the terminals is made open then the terminals are said to be open circuited.

Mesh and Node methods of circuit analysis

The junction law (Kirchhoff's current law): The law states that the algebraic sum of the currents meeting at a junction point in a network is zero. The law is a consequence of conservation of charge. It leads to the node or junction analysis of networks.

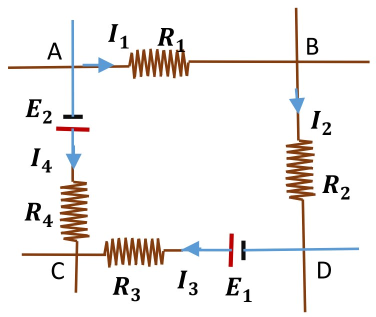
The loop law (Kirchhoff's voltage law): The law states that the algebraic sum of all voltage drops around a close path in a network s zero. The law is a consequence of conservation of energy. It leads to a method of network analysis known as mesh analysis.



From figure according to KCL

$$I_1 + I_2 - I_3 - I_4 = 0$$

(We take here current directed towards the node or point as positive)



From figure according to KVL

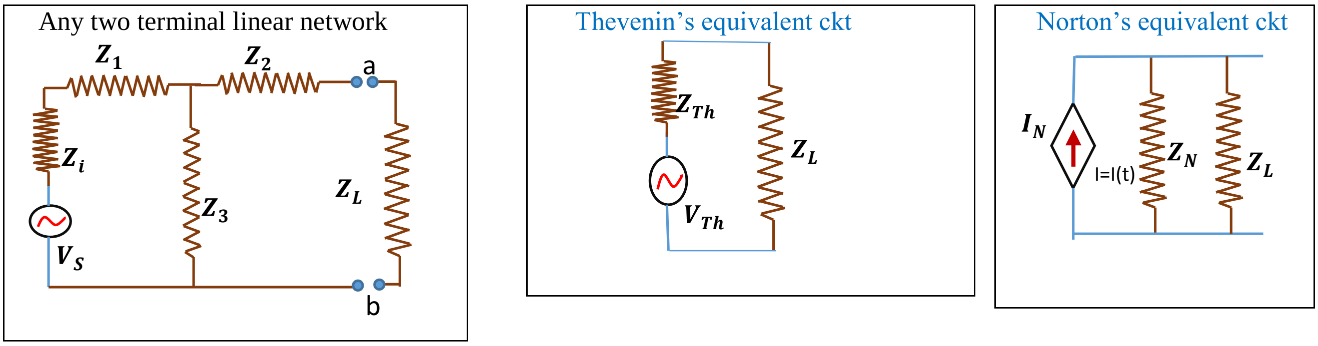
$$E_1 - E_2 = I_1R_1 + I_2R_2 + I_3R_3 - I_4R_4$$

(Currents in the clock wise direction is taken as positive EMF which produce current in a clockwise direction is taken as positive)

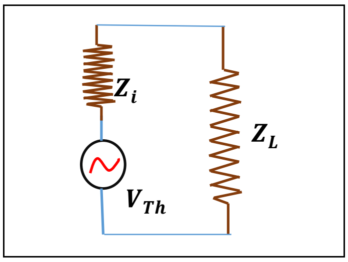
NETWORK THEOREMS

Thevenin's Theorem: Any two terminal linear network containing energy sources and impedances can be replaced by an equivalent circuit consisting of a voltage source V_{Th} in series with an impedance Z_{Th}, where V_{Th} is the open circuit voltage between the terminals of the network and Z_{Th} is the impedance measured between the terminals with all the energy sources replaced by their internal impedances.

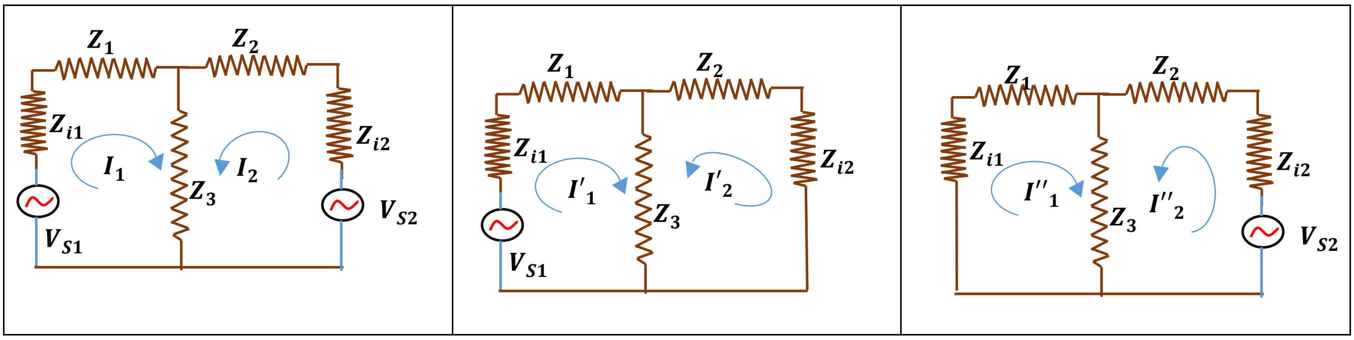
Norton's Theorem: Any two terminal linear network containing energy sources and impedances can be replaced by an equivalent circuit consisting of current source I_N in parallel with an impedance Z_N, where I_N is the short circuited current between the terminals of the network and Z_N is the impedance measured between the terminals with all the energy sources replaced by their internal impedances.



- **Maximum power transfer theorem:** Maximum power is delivered from a network to a load impedance Z_L, where Z_L is the complex conjugate of the internal impedance measured looking back into the terminal of the network. From figure according to maximum power transfer theorem power will be maximum when $Z_i = Z_L$

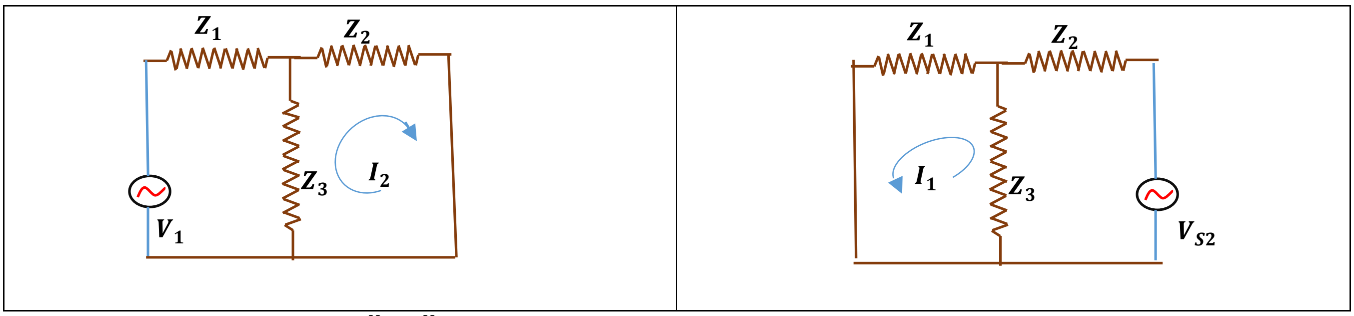


- **Superposition Theorem:** It states that in any linear bilateral network having several energy sources, the current and voltage for any element is the algebraic sum of the effects produced by each source acting separately.

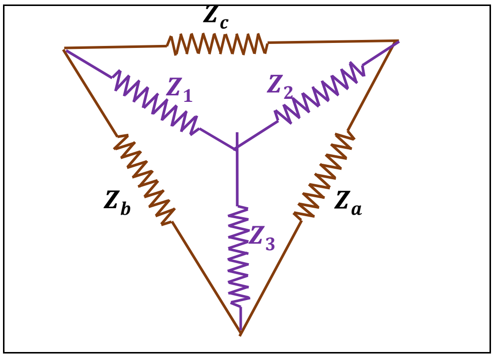


According to super position theorem $I_1 = I'_1 + I''_1$ & $I_2 = I'_2 + I''_2$

- **Reciprocity Theorem:** If an e.m.f acting in one mesh produces current in a second mesh, then the same e.m.f acting in the second mesh gives an identical current in the first mesh.



According to reciprocity theorem $\frac{V_1}{I_2} = \frac{V_2}{I_1}$



- **T to π Transformation:**

$$Z_a = \frac{Z_1Z_2+Z_2Z_3+Z_3Z_1}{Z_1};\ Z_b = \frac{Z_1Z_2+Z_2Z_3+Z_3Z_1}{Z_2};\quad Z_c = \frac{Z_1Z_2+Z_2Z_3+Z_3Z_1}{Z_3}$$

- **π to T Transformation:**

$$Z_1 = \frac{Z_bZ_c}{Z_a+Z_b+Z_c};\quad Z_2 = \frac{Z_cZ_a}{Z_a+Z_b+Z_c};\qquad Z_3 = \frac{Z_aZ_b}{Z_a+Z_b+Z_c}$$

STEPS FOR SOLVING A NETWORK USING PRINCIPLE OF SUPERPOSITION

STEP 1 – Keep dependent current and voltage source as it is in the analysis

STEP 2 – Take only one independent source of voltage/current and deactivate the other independent voltage/ current sources. For voltage source remove the source and short ckt the the respective ckt terminals and for current sources just delete the source keeping the respective ckt terminals is open. Obtain branch current.

STEP 3 – Repeat the above step for each of the independent sources.

STEP 4 – To determine the net branch current utilising superposition theorem, just add the currents obtained in step 2 and step 3. (Clockwise current assumed to be positive and anticlockwise negative)

STEPS FOR SOLVING A NETWORK UTILISING THEVENIN'S THEOREM

STEP 1- Remove the load resistance and find the open ckt voltage V_{Th} across the open ckted load terminal.

STEP 2- Deactivate the constant (independent) source [for voltage source remove it by its internal resistance for current sources delete the source by open circuit]. But all dependent sources are kept as
it is . Find the internal resistance (Thevenin's resistance) of the source side looking through the open circuited load terminal let the resistance be R_{Th}

STEP 3- Obtain Thevenin's equivalent circuit by placing R_{Th} series with V_{Th} and reconnect load resistance across the load terminal.

STEPS FOR SOLVING A NETWORK UTILISING NORTON'S THEOREM

STEP 1- When there is only independent sources in the circuit then remove the load resistance find internal resistance of the network by deactivating the constant (independent) source [for voltage source remove it by its internal resistance for current sources delete the source by open circuit]. But for dependent sources in the circuit, to find the equivalent impedance for the ckt, short circuited the voltage source and open circuited current source and apply the one volt source at the output terminal and find the current I. The inverse of I gives the Thevenin's or Norton's equivalent impedance or resistanceR_N.

STEP 2- Next short the load terminal and find the short circuited current following through shorted load terminal.

STEP 3- Norton's equivalent ckt is drawn by keeping R_N in parallel to I_N

STEP 4- Reconnect the load resistance (R_L) across the load terminals and current through it I_L is given by $I_L = I_N \frac{R_N}{R_N+R_L}$

NOTE THAT –1. Superposition theorem is only applicable to linear ckt, it is also requires that all the components must be bilateral

2. The superposition does not apply to the power since it is not a linear function (power is a square of current or voltage) (these are the limitation of superposition theorem)

3. The process of adjusting the load impedance to match the internal impedance of a network is known as impedance matching. (This is the significance of maximum power transfer theorem.)