



The Shirpur Education Society's  
R. C. Patel College of Engineering and Polytechnic, Shirpur  
Department of Electrical Engineering

**Notes**

**Unit - IV**

**Network Reduction Methods for DC  
Circuits**

**NAME OF COURSE: - ELECTRICAL CIRCUITS AND NETWORK**

**CODE OF COURSE: - 313332**

**SEMESTER: - SYEE-3K**

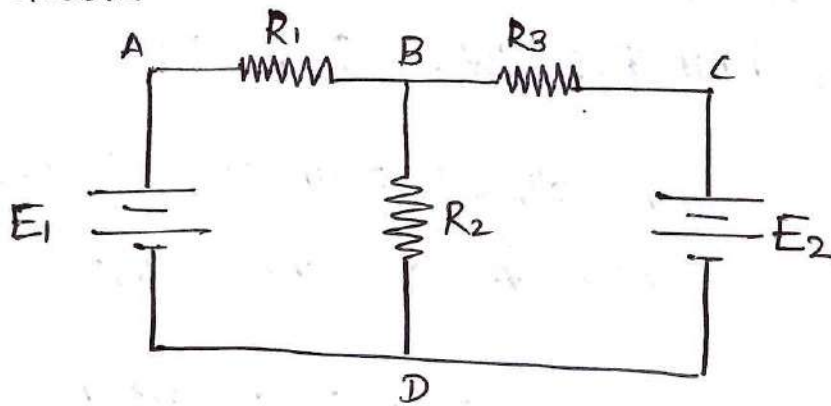
**SUBJECT TEACHER: - Mr. Jayesh M. Suryawanshi**

# Unit 4: Network Reduction Method for DC circuits. (12 Marks)

Prepared by: Mr. J.M. Suryawanshi

Subject: ECN (313332)

Network - An arrangement of electrical energy source & other circuit element is called Electrical Network



ABCD - A is Electrical Network

Active Element: An element is one which supplies electrical energy to the circuit.

$E_1$  &  $E_2$  are the Active element

Passive Element: An Element is one which receive electrical energy & convert into other form of energy.

$R_1, R_2, R_3$  are three passive element.

Node: A node of a Network is an equipotential surface at which two or more circuit elements are joined.

Circuit element  $R_1$  &  $E_1$  are joined at A Hence A is node. Similarly B, C, D are nodes.

Junction: A Junction is that point in a Network where three or more circuit elements are joined.  
B & D are only two junction.

Branch: A branch is that part of Network which lies between two junction points  
There are three branches BAD, BCD, BD

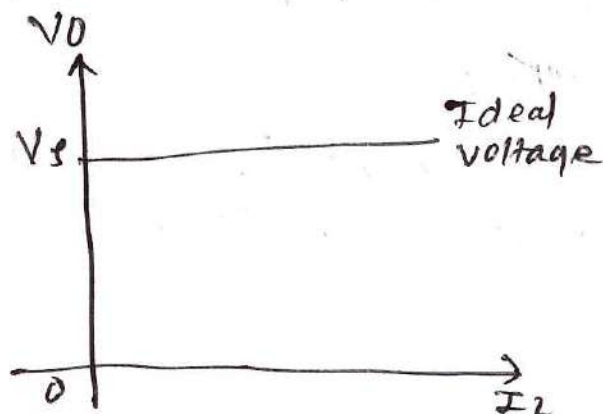
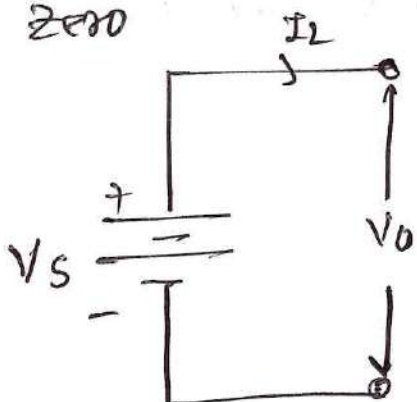
Loop: A loop is any closed path of a Network  
ABDA, BCD-B, ABCD-A are three loops.

Mesh: - A mesh is the loop but it can not be further divided into other loops.  
ABD-A, BCD-B are the two Mesh in circuit.

### Ideal voltage source

An Ideal voltage source maintain a constant terminal voltage no matter how much current drawn from it.

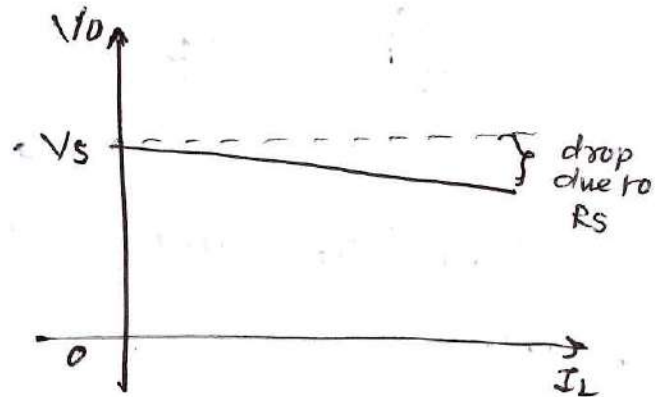
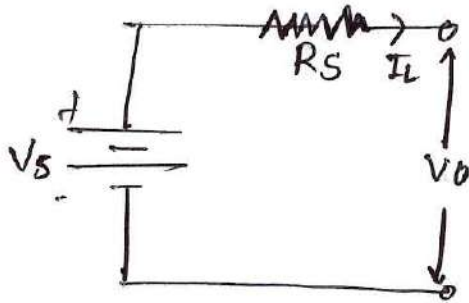
Internal resistance of ideal voltage source is zero



## Real / Practical voltage source.

A practical voltage source delivers electrical energy but experiences a drop in terminal voltage as the current drawn by load increases.

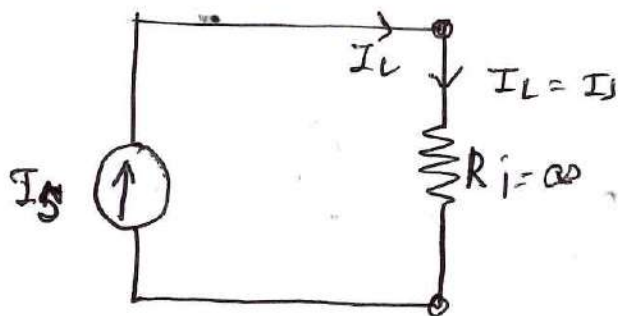
A real voltage source has internal resistance  $R_s$  that acts in series.



## Ideal current source

An ideal current source will supply the same current to any resistance connected to its terminals.

Ideal current source have infinite internal resistance ( $R_{in} = \infty$ )



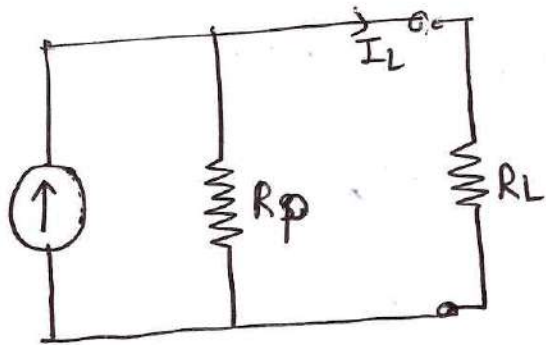
Symbol



Example: consider 1 A current supplied from source & current flowing through load is 1 A.

## Practical current source

Practical current source always has some internal resistance acts in parallel with source



Practical current source have finite internal resistance.

## Source Transformation technique

- ① Voltage source to current source
- ② Current source to Voltage source.

### ① Voltage Source to Current source

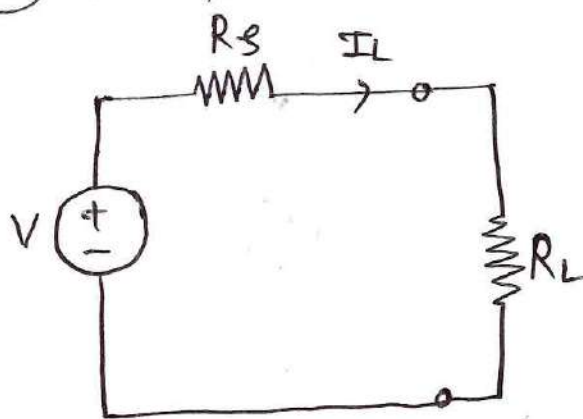


Fig. (a)

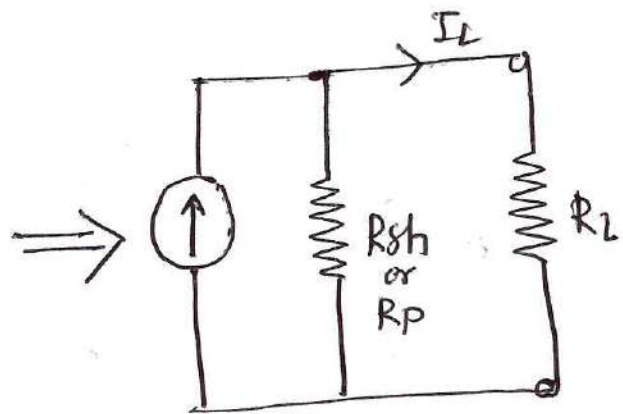


Fig. (b)

Steps for conversion

- ① Calculate load current  $I_L$  for voltage source from Fig. (a).  $R_s$  &  $R_L$  in series.  
Total Resistance  $R_T = R_s + R_L$

According to Ohm's law

$$\text{Current} = \frac{\text{Supply Voltage}}{\text{Total Resistance}}$$

$$I_L = \frac{V}{R_T} = \frac{V}{R_s + R_L} \quad \text{--- (1)}$$

② Calculate load current for current source  
from fig. (b)  
Using current division Rule

$$I_L = I \times \frac{R_{sh}}{R_{sh} + R_L} \quad \text{--- (2)}$$

③ Equate load current of both sources.  
Equate equation (1) & (2)

$$\therefore \frac{V}{R_s + R_L} = \frac{I \cdot R_{sh}}{R_{sh} + R_L}$$

$$\text{Let } R_s = R_{sh} = R.$$

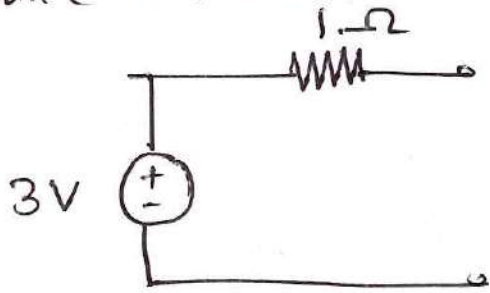
$$\therefore \frac{V}{R + R_L} = \frac{I \cdot R}{R + R_L}$$

$$\therefore V = IR$$

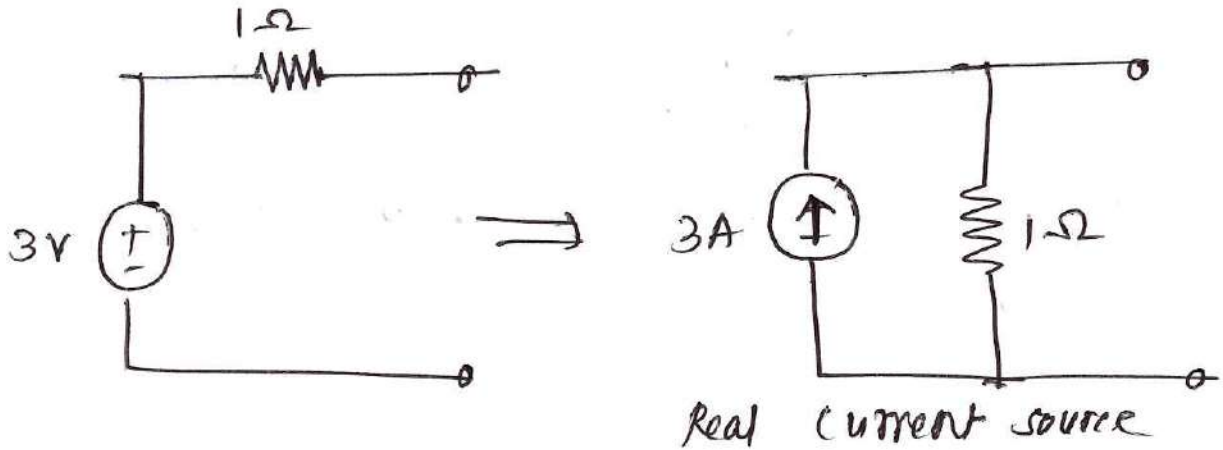
$$I = \frac{V}{R} = \frac{V}{R_s} \quad \text{--- (3)}$$

While converting voltage source to current source, calculate value of current source using equation (3).

Q. Convert voltage source circuit into current source circuit

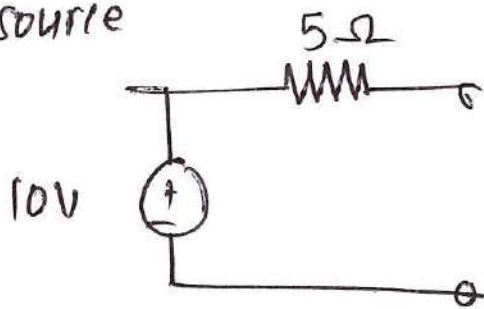


Solution

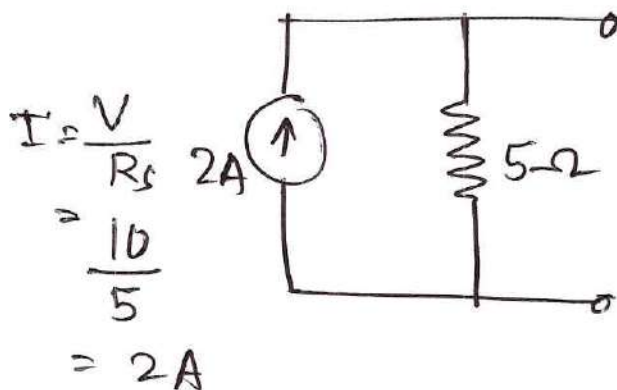


$$I = \frac{V}{R_s} = \frac{3}{1} = 3A$$

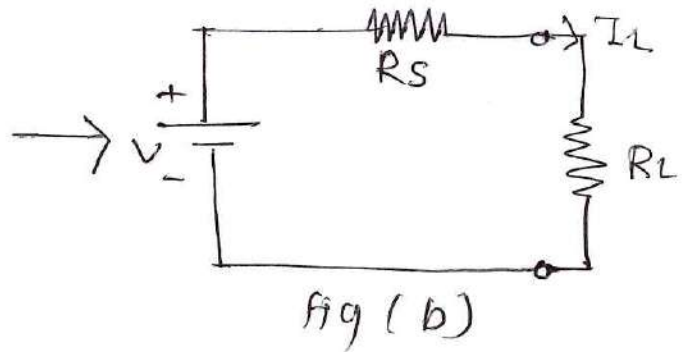
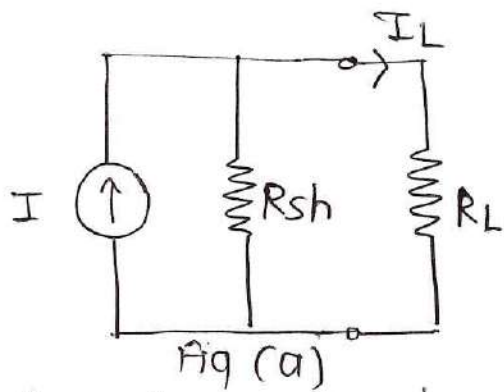
Q. Convert voltage source circuit into current source



Solution



## current source to voltage source transformation



Steps for conversion

- ① Calculate load current  $I_L$  for current source Fig (a)

Apply current division Rule,

$$I_L = I \times \frac{R_{sh}}{R_{sh} + R_L} \quad \text{--- (1)}$$

- ② Calculate load current  $I_L$  for voltage source Fig (b)

Apply ohm's law

$$I_L = \frac{V}{R_s + R_L} \quad \text{--- (2)}$$

- ③ Equate equation ① & ②

$$I \frac{R_{sh}}{R_{sh} + R_L} = \frac{V}{R_s + R_L}$$

Let  $R_{sh} = R_s = R$

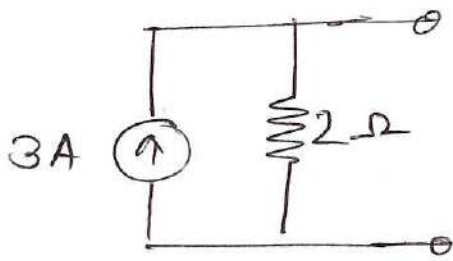
$$I \frac{R}{R + R_L} = \frac{V}{R + R_L}$$

$$I R = V$$

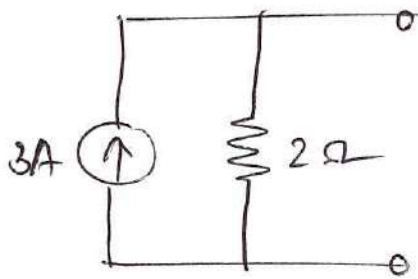
$$\boxed{V = I R_{sh}} \quad \text{--- (3)}$$

While converting current source to voltage source calculate value of  $V$  by using equation ③

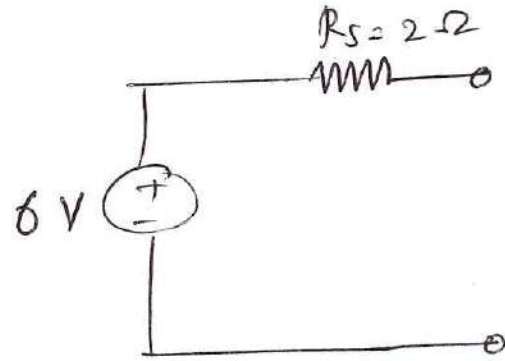
Q. Convert current source into voltage source circuit.



Solution:-



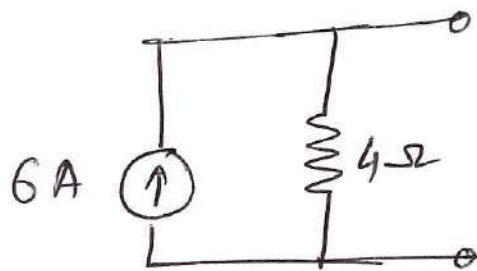
⇒



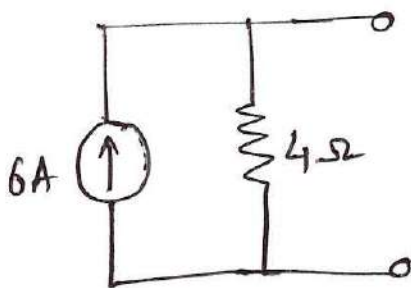
$$V = IR_{sh} = 2 \times 3 = 6 \text{ volt}$$

Q. Convert current source into voltage source circuit

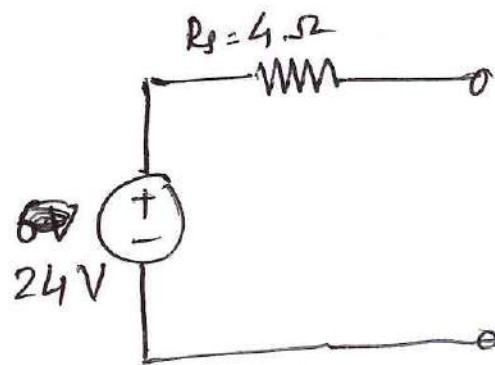
Solution



Solution

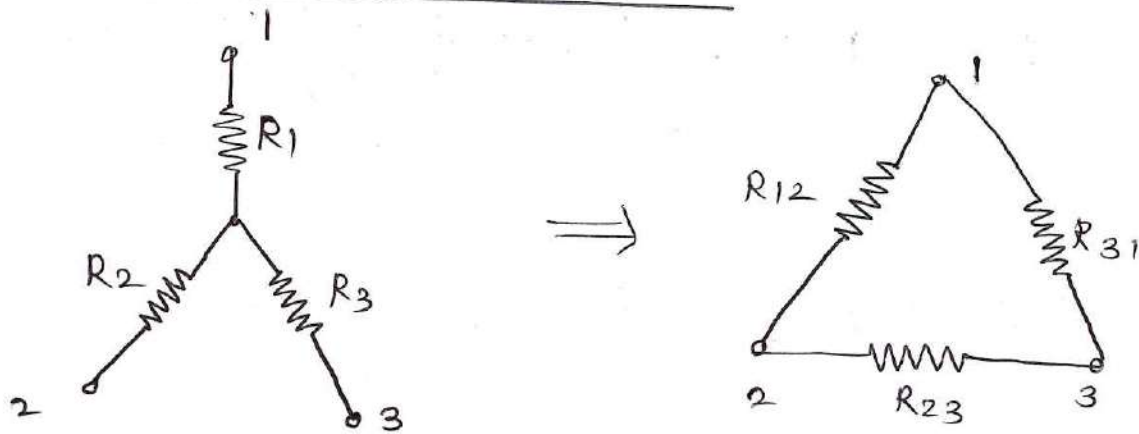


⇒



$$V = IR_{sh} = 6 \times 4 = 24 \text{ volt}$$

## Star to Delta transformation:



We know the value of  $R_1, R_2, R_3$  in terms of  $R_{12}, R_{23}, R_{31}$  from Delta to star transformation

$$R_1 = \frac{R_{12} R_{31}}{R_{12} + R_{23} + R_{31}} \quad \text{--- (1)}$$

$$R_2 = \frac{R_{23} R_{12}}{R_{12} + R_{23} + R_{31}} \quad \text{--- (2)}$$

$$R_3 = \frac{R_{31} R_{23}}{R_{12} + R_{23} + R_{31}} \quad \text{--- (3)}$$

Obtain values of  $R_1 R_2$  by multiplying equation (1) & (2)  
Similarly obtain values of  $R_2 R_3$  &  $R_3 R_1$  by  
multiplying equation (2) & (3), equation (3) & (1)

$$R_1 R_2 = \frac{R_{12}^2 R_{23} R_{31}}{(R_{12} + R_{23} + R_{31})^2} \quad \text{--- (4)}$$

$$R_2 R_3 = \frac{R_{23}^2 R_{12} R_{31}}{(R_{12} + R_{23} + R_{31})^2} \quad \text{--- (5)}$$

$$R_3 R_1 = \frac{R_{31}^2 R_{12} R_{23}}{(R_{12} + R_{23} + R_{31})^2} \quad \text{--- (6)}$$

Adding equation (4), (5) & (6)

$$R_1 R_2 + R_2 R_3 + R_3 R_1 = \frac{R_{12}^2 R_{23} R_{31} + R_{23}^2 R_{12} R_{31} + R_{31}^2 R_{12} R_{23}}{(R_{12} + R_{23} + R_{31})^2}$$

$$R_1 R_2 + R_2 R_3 + R_3 R_1 = \frac{R_{12} R_{23} R_{31} (R_{12} + R_{23} + R_{31})}{(R_{12} + R_{23} + R_{31})^2}$$

$$R_1 R_2 + R_2 R_3 + R_3 R_1 = \frac{R_{12} R_{23} R_{31}}{(R_{12} + R_{23} + R_{31})} \quad \text{--- (7)}$$

$$\text{But } R_3 = \frac{R_{23} R_{31}}{R_{12} + R_{23} + R_{31}}$$

Put in equation (7)

$$R_1 R_2 + R_2 R_3 + R_3 R_1 = R_{12} \cdot R_3$$

$$R_{12} = \frac{R_1 R_2 + R_2 R_3 + R_3 R_1}{R_3}$$

$$R_{12} = \frac{R_1 R_2}{R_3} + \frac{R_2 R_3}{R_3} + \frac{R_3 R_1}{R_3}$$

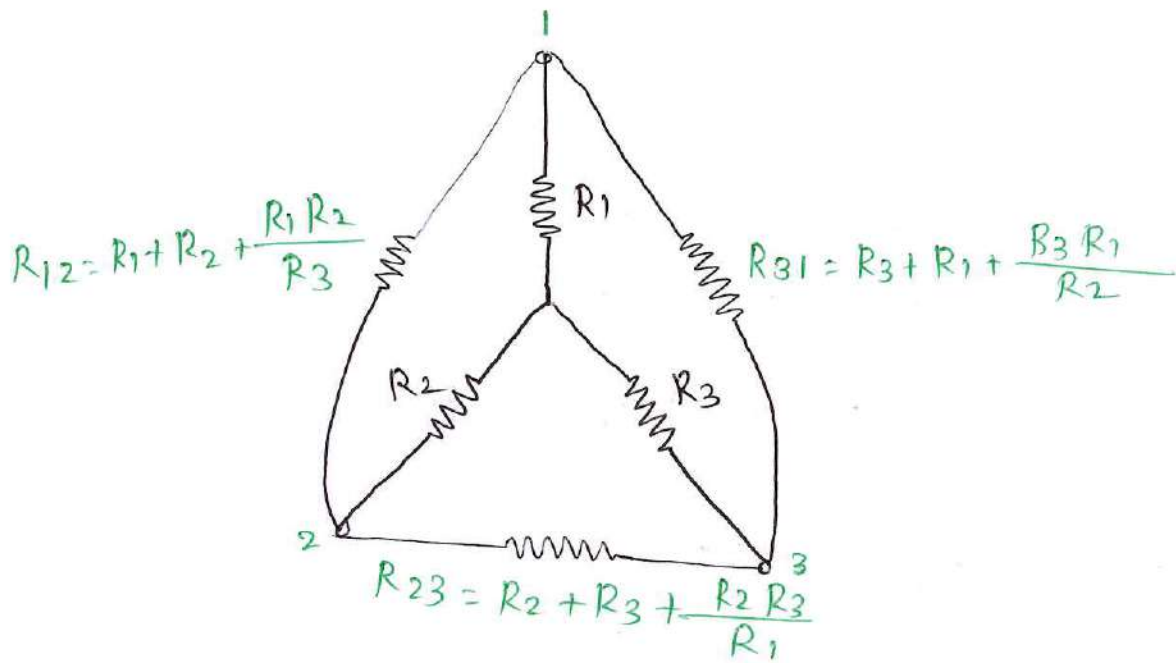
$$\boxed{R_{12} = R_1 + R_2 + \frac{R_1 R_2}{R_3}}$$

Similarly

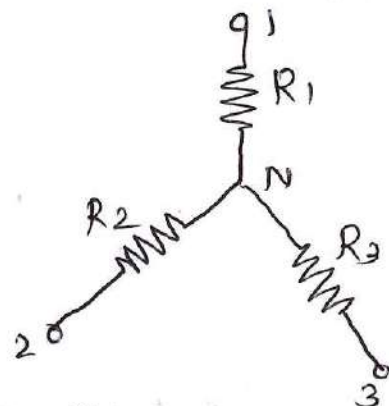
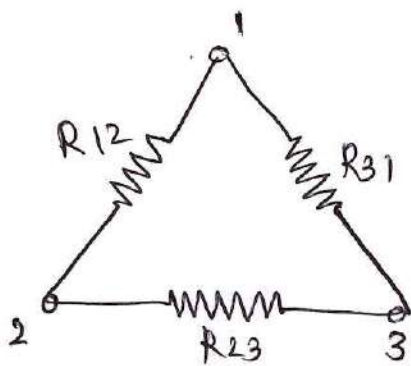
$$\boxed{R_{23} = R_2 + R_3 + \frac{R_2 R_3}{R_1}}$$

$$\boxed{R_{31} = R_3 + R_1 + \frac{R_3 R_1}{R_2}}$$

# Given star & equivalent Delta Network



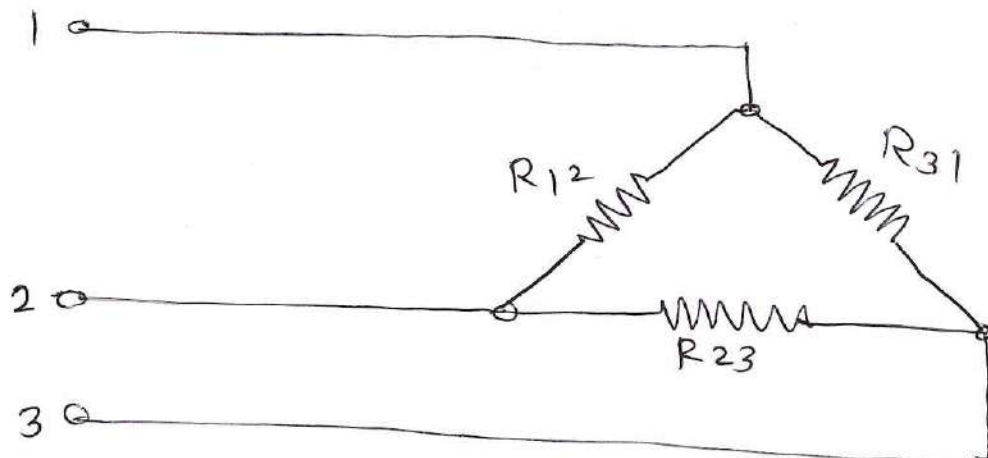
## Delta to star transformation



Delta Network to be converted

Equivalent Star Network

obtain resistance values for delta Network



Equivalent resistance between terminal 1 & 2  
i.e  $R_{12}'$

$$R_{12}' = R_{12} \parallel (R_{23} + R_{31})$$

$$R_{12}' = \frac{R_{12} (R_{23} + R_{31})}{R_{12} + R_{23} + R_{31}} \quad \text{--- (1)}$$

Equivalent resistance between terminal 2 & 3  
i.e  $R_{23}'$

$$R_{23}' = R_{23} \parallel (R_{12} + R_{31})$$

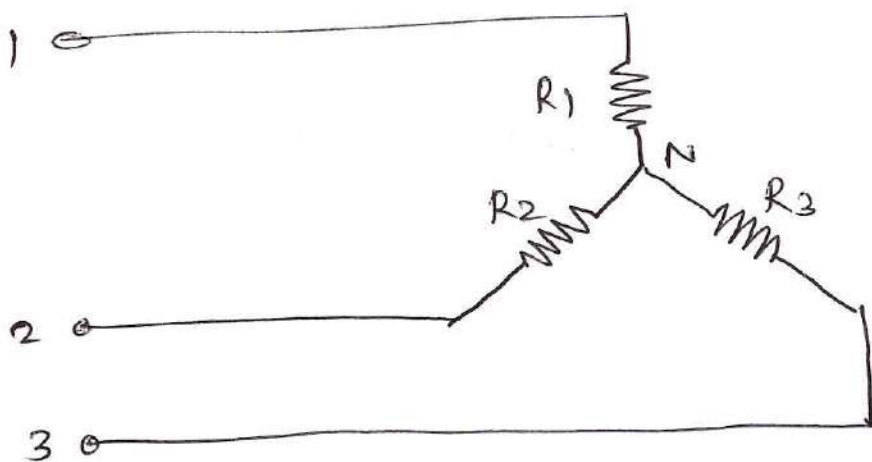
$$R_{23}' = \frac{R_{23} (R_{31} + R_{12})}{R_{12} + R_{23} + R_{31}} \quad \text{--- (2)}$$

Equivalent resistance between terminal 3 & 1  
i.e  $R_{31}'$

$$R_{31}' = R_{31} \parallel (R_{12} + R_{23})$$

$$R_{31}' = \frac{R_{31} (R_{12} + R_{23})}{R_{12} + R_{23} + R_{31}} \quad \text{--- (3)}$$

Obtain resistance values for Star Network



Equivalent resistance between 1 & 2 terminal i.e  $R_{12}$

$$R_{12}' = R_1 + R_2 \text{ ————— (4)}$$

Equivalent resistance between 2 & 3 terminal i.e  $R_{23}$

$$R_{23}' = R_2 + R_3 \text{ ————— (5)}$$

Equivalent resistance between 3 & 1 terminal i.e  $R_{31}$

$$R_{31}' = R_3 + R_1 \text{ ————— (6)}$$

Equate Equation (1) & (4)

$$R_1 + R_2 = \frac{R_{12} (R_{23} + R_{31})}{R_{12} + R_{23} + R_{31}} \text{ ————— (7)}$$

Equate equation (2) & (5)

$$R_2 + R_3 = \frac{R_{23} (R_{31} + R_{12})}{R_{12} + R_{23} + R_{31}} \text{ ————— (8)}$$

Equate equation (3) & (6)

$$R_3 + R_1 = \frac{R_{31} (R_{12} + R_{23})}{R_{12} + R_{23} + R_{31}} \text{ ————— (9)}$$

To obtain the  $R_1$ , add equation (8) & (10) and subtract equation (9)

$$\text{eq}^n (8) + \text{eq}^n (10) - \text{eq}^n (9)$$

$$R_1 + R_2 + R_3 + R_1 - R_2 - R_3 = \frac{R_{12} (R_{23} + R_{31})}{R_{12} + R_{23} + R_{31}}$$

$$+ \frac{R_{31} (R_{12} + R_{23})}{R_{12} + R_{23} + R_{31}} - \frac{R_{23} (R_{31} + R_{12})}{R_{12} + R_{23} + R_{31}}$$

$$2 R_1 = \frac{R_{12} R_{23} + R_{12} R_{31} + R_{31} R_{12} + R_{31} R_{23} - R_{23} R_{31} - R_{12} R_{31}}{R_{12} + R_{23} + R_{31}}$$

$$\cancel{Z} R_1 = \frac{Z (R_{12} R_{31})}{R_{12} + R_{23} + R_{31}}$$

$$R_1 = \frac{R_{12} R_{31}}{R_{12} + R_{23} + R_{31}}$$

Similarly

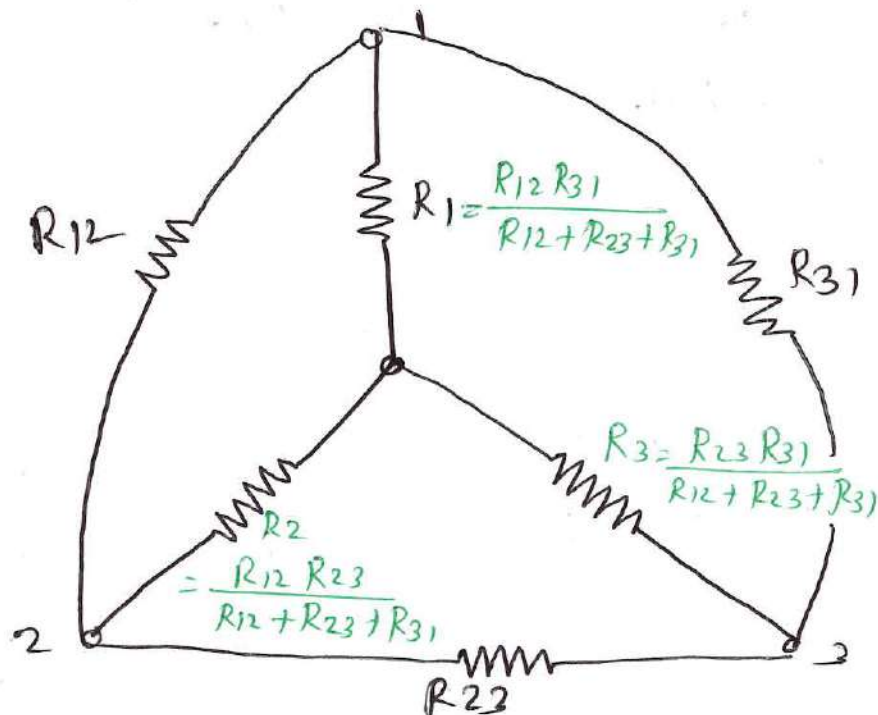
equation (8) + eq<sup>n</sup> (9) - eq<sup>n</sup> (10)

$$R_2 = \frac{R_{12} R_{23}}{R_{12} + R_{23} + R_{31}}$$

equation (9) + eq<sup>n</sup> (10) - eq<sup>n</sup> (8)

$$R_3 = \frac{R_{23} R_{31}}{R_{12} + R_{23} + R_{31}}$$

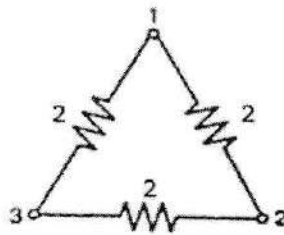
Given delta & equivalent star Network



## Unit - IV Network Reduction Methods for DC Circuits.

Subject: ECN (313332)

1. Give concept of ideal voltage and current source 2 marks (w-2024)
2. Define – i) Mesh ii) Loop 2 marks (s-2025)
3. State the value of internal resistance of – i) Ideal Voltage Source and ii) Ideal current source. 2 marks (s-2025)
4. Draw an ideal and a practical current source. Write difference between them. 2 marks (w-2025)
5. Define node and branch 2 marks (S-2026)
6. Convert Delta network into star Network 2 marks (S-2026)



7. Use source conversion technique to find the load current  $I$  for the Figure No. 4 marks(w-2025)

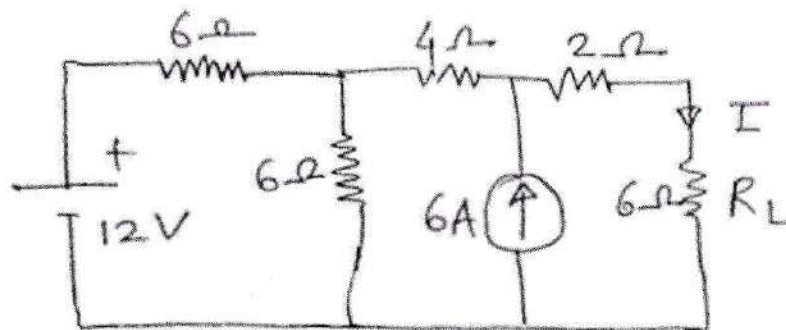


Fig. No. 1

8. Using nodal voltage method, find the magnitude and direction of current in  $10\Omega$  connected across AB in the network shown in Figure No. 2. 4marks(w-2025)

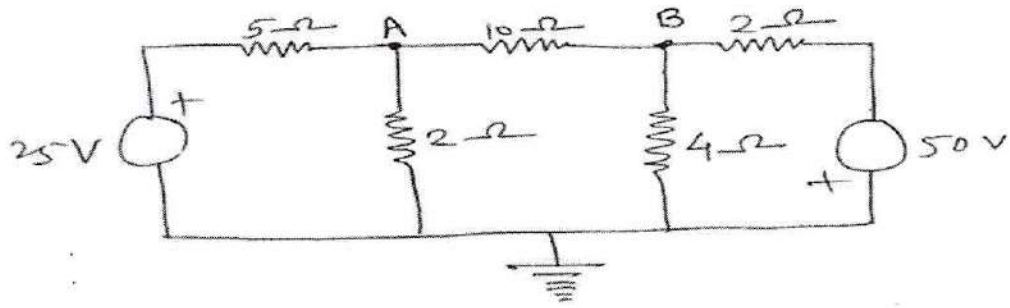


Fig. No. 2

9. Explain how voltage source can be converted into equivalent current source. Write the important points to be considered for transformation of source. 4marks(s-2025)
10. Find the current in  $6\ \Omega$  resistor in the circuit shown in Fig. No. 1 using mesh analysis. 4marks(s-2025)

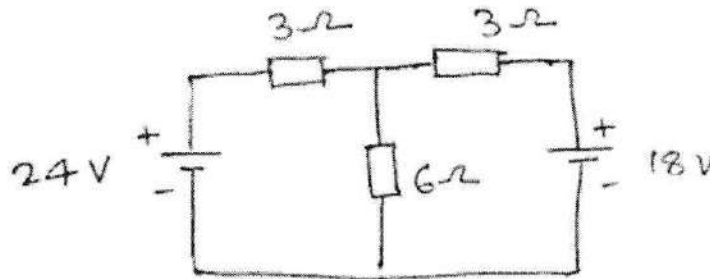


Fig. No. 1

11. State the equivalent delta  $R_{12}$ ,  $R_{23}$  and  $R_{31}$  for star connection of three resistances  $R_1$ ,  $R_2$  and  $R_3$  with proper equations for network shown in Figure No. 1 : . 4marks(w-2025)

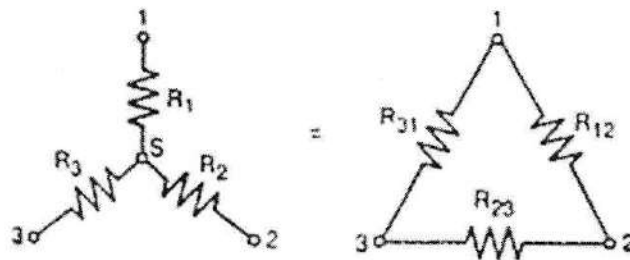


Fig. No. 1

12. Using mesh analysis, find current in 5 ohm resistor in the network shown in Figure No. 2. 4marks(w-2025)

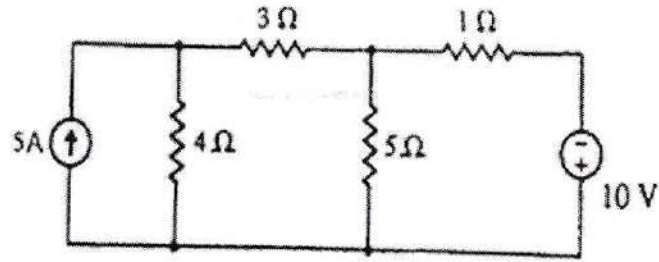


Fig. No. 2

13. Using Node analysis, find current  $I$  in the circuit shown in Figure No. 3.  
4marks(w-2025)

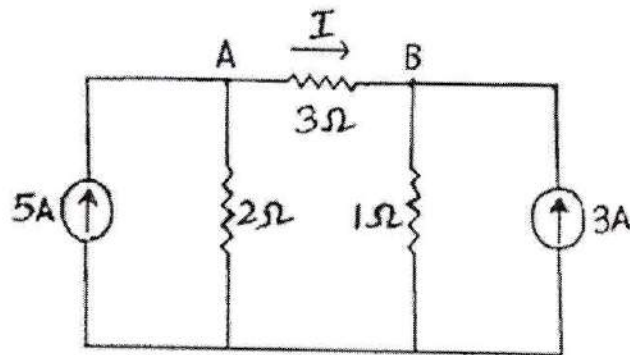


Fig. No. 3

14. With neat circuit diagram, explain how to convert a practical voltage source into an equivalent practical current source. 4marks(w-2025)
15. Explain with suitable diagram, steps to solve the given network using mesh analysis. (S-2026)
16. Determine current in  $5\Omega$  resistance by using mesh analysis for the Figure No. 7. 6 marks (w-2024)

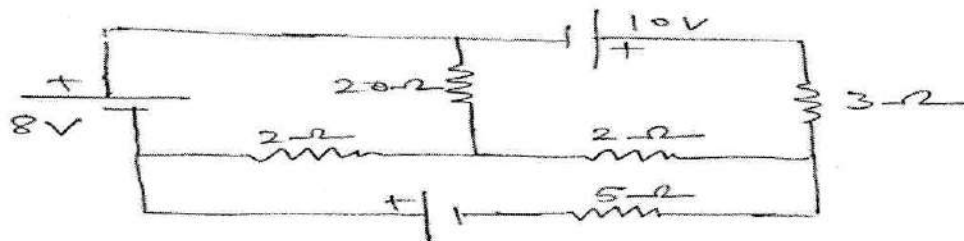


Fig. No. 7