Unit - II
2.3 Mesh Analysis

Dr.Santhosh.T.K.

SASTRA
DEEMED TO BE UNIVERSITY

Li-ion

Sodium ion battery

cylindrical

height

L

↳ NCR 26650 – 2300

dia

capacity

copper

26650

1500mAh.

↳ 2300mAh.

'C' rate

1C → CC

3C → 7.36W

0 – 55

−20 to +55

Tool chest

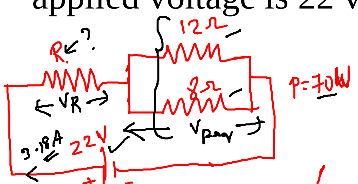
Syllabus

UNIT – II **14 Periods**

DC Circuit Analysis: Voltage source and current sources, ideal and practical, Kirchhoff's laws and applications to network solutions using mesh analysis, - Simplifications of networks using series- parallel, Star/Delta transformation, DC circuits-Current-voltage relations of electric network by mathematical equations to analyse the network (Superposition theorem, Thevenin's theorem, Maximum Power Transfer theorem), Transient analysis of R-L, R-C and R-L-C Circuits.

AC Steady-state Analysis: AC waveform definitions - Form factor - Peak factor - study of R-L - R-C -RLC series circuit - R-L-C parallel circuit - phasor representation in polar and rectangular form - concept of impedance - admittance - active - reactive - apparent and complex power - power factor, Resonance in R-L-C circuits - 3 phase balanced AC Circuits

- A resistance R is connected in series with a parallel circuit comprising two resistor 12 Ω and 8 Ω respectively. The total power dissipated in the circuit is 70 W. When the applied voltage is 22 volts. Calculate the value of R.



Sol:

Sol:

$P = V \cdot I$

$I = \frac{70}{22} = 3.18\,A$

$12 \parallel 8$

$R_{eq} = \frac{12 \times 8}{12 + 8} = 4.8\,\Omega$

Voltage across R_{eq}

$= 3.18 \times 4.8$

$= 15.26\,V$.

KVL

$22 - V_R - 15.26 = 0$

$\boxed{V_R = 6.73\,V}$

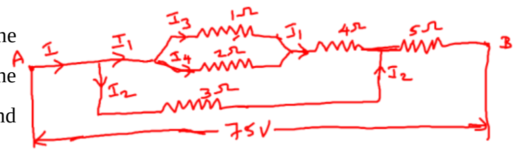
$R = \frac{V}{I} = \frac{6.73}{3.18} = 2.12\,\Omega$

$\boxed{R = 2.12\,\Omega}$

SASTRA DEEMED TO BE UNIVERSITY

Practice Problem

- Determine the effective resistance of the series-parallel combination shown in the figure. Also, find the current, voltage and power dissipated in each of the resistor in the given circuit.



$R_{eq} = 157/23\ \Omega$

$I = 10.98\ A$

$I_1 \simeq 4.3\ A$

$I_2 \simeq 6.78\ A$

$I_3 \simeq 2.86\ A$

$I_4 \simeq 1.43\ A$

SASTRA DEEMED TO BE UNIVERSITY

Practice Problem

Find the load current in the given circuit (Use KVL).

KVL → Loops → 3 loops

Loop I : (ABCDA)

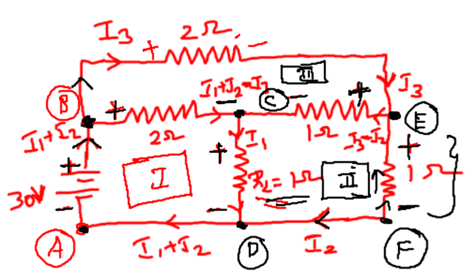
$30 - (I_1+I_2-I_3)2 - 1 I_1 = 0$

Loop II (ECDFE)

$-(I_3-I_2)1 - I_1 + I_2 = 0$

Loop III (BECB)

$-2I_3 - 1(I_3-I_2) + 2(I_1+I_2-I_3) = 0$



Assume branch Voltage & current

Loop → ABCDA, ECDFE, BECB } ABCEFDA, ABEFDA

$I_1 = \cancel{8.49}$

$I_2 = 10A$

$I_3 = 10A$

$\boxed{\text{Load current } I_L = I_1 = 10A}$

Mesh/Loop Analysis

- Loop analysis is developed by applying KVL around loops in the circuit
- Loop (mesh) analysis results in a system of linear equations which must be solved for unknown currents

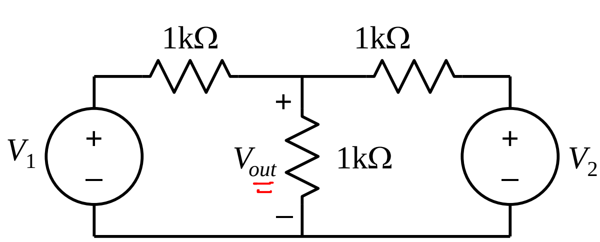
Loop → any closed path.

Mesh → a loop that can't be subdivided

SASTRA DEEMED TO BE UNIVERSITY

Summing Circuit

- The output voltage V of this circuit is proportional to the sum of the two input voltages V_1 and V_2



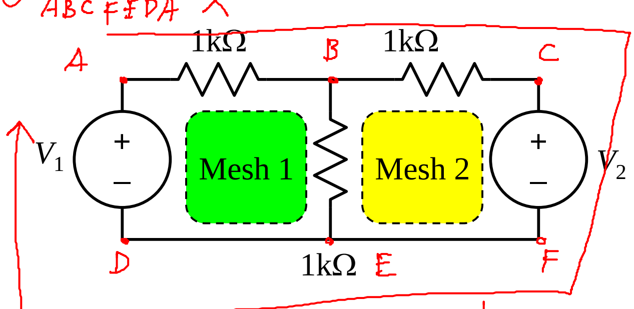
Steps of Mesh Analysis

1. **Identify mesh (loops).**
2. Assign a current to each mesh.
3. Apply KVL around each loop to get an equation in terms of the loop currents.
4. Solve the resulting system of linear equations for the mesh/loop currents.

1. Identifying the Meshes

Loops: ABEDA, BCFEB, ABCFEDA ~~X~~

Mesh



Planar circuits

Steps of Mesh Analysis

1. Identify mesh (loops).
2. **Assign a current to each mesh.** 2
3. Apply KVL around each loop to get an equation in terms of the loop currents.
4. Solve the resulting system of linear equations for the mesh/loop currents.

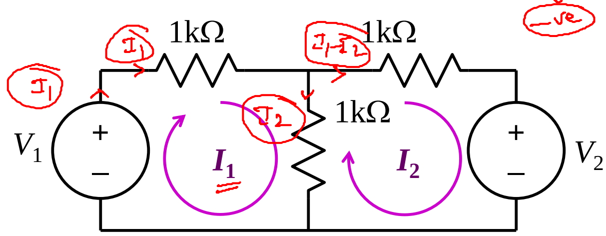
2. Assigning Mesh Currents

+ − ← Resistors as drop elements

−ve

CW —

ACW —



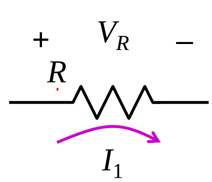
SASTRA DEEMED TO BE UNIVERSITY

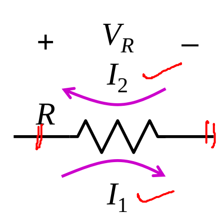
Steps of Mesh Analysis

1. Identify mesh (loops).
2. Assign a current to each mesh.
3. **Apply KVL around each loop to get an equation in terms of the loop currents.**
4. Solve the resulting system of linear equations for the mesh/loop currents.

SASTRA DEEMED TO BE UNIVERSITY

Voltages from Mesh Currents



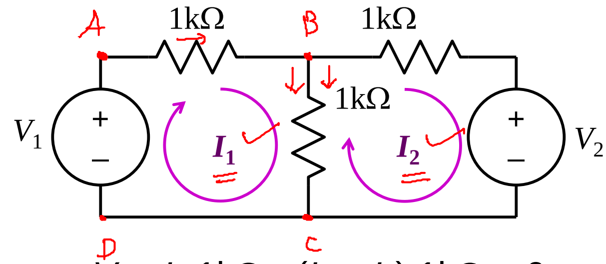


$$V_R = I_1 R$$

$$V_R = (I_1 - I_2)\, R \rightarrow \text{mesh } 1$$

$$V_R = (I_2 - I_1)\, R \leftarrow \text{Mesh } 2$$

3. KVL Around Mesh 1



B
I_1 I_2
C

$V = IR$
$= (I_1 - I_2)R$

$$+V_1 - I_1\,1\text{k}\Omega - (I_1 - I_2)\,1\text{k}\Omega = 0$$

$-I_1(1k) - (I_1 - I_2)(1k) + V_1 = 0$

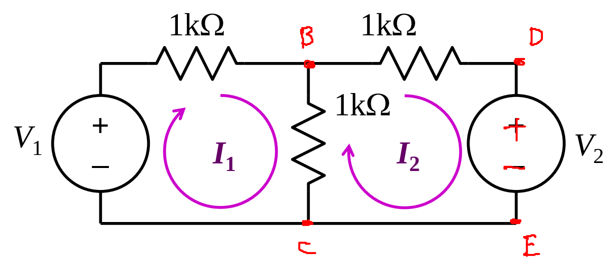
$$I_1\,1\text{k}\Omega + (I_1 - I_2)\,1\text{k}\Omega = V_1$$

$$I_1\,2\text{k}\Omega - I_2\,1\text{k}\Omega = V_1$$

3. KVL Around Mesh 2

mesh2 B-D-E-C-B

$-I_2 \cdot (1k) - V_2 - (I_2 - I_1)(1k) = 0$



$$-(I_2 - I_1)\,1\text{k}\Omega - I_2\,1\text{k}\Omega - V_2 = 0$$

$$(I_2 - I_1)\,1\text{k}\Omega + I_2\,1\text{k}\Omega = -V_2$$

$$-I_1\,1\text{k}\Omega + I_2\,2\text{k}\Omega = -V_2$$

Steps of Mesh Analysis

1. Identify mesh (loops).
2. Assign a current to each mesh.
3. Apply KVL around each loop to get an equation in terms of the loop currents.
4. **Solve the resulting system of linear equations for the mesh/loop currents.**

Matrix Notation

- The two equations can be combined into a single matrix/vector equation

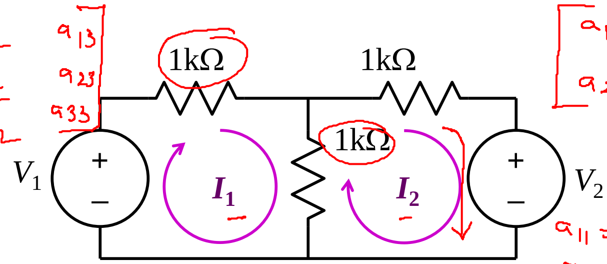
$$I_1\, 2\text{k}\Omega - I_2\, 1\text{k}\Omega = V_1$$
$$-I_1\, 1\text{k}\Omega + I_2\, 2\text{k}\Omega = -V_2$$

$\underline{\underline{R}}$ I = V

$$\begin{bmatrix} 1\text{k}\Omega + 1\text{k}\Omega & -1\text{k}\Omega \\ -1\text{k}\Omega & 1\text{k}\Omega + 1\text{k}\Omega \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} V_1 \\ -V_2 \end{bmatrix}$$

SASTRA

Inspection Method



$a_{11} = 2k\Omega$

$a_{12} = -1k$

$a_{21} = -1k$

$\boxed{a_{21} = a_{12}}$

$$\begin{bmatrix} 1k\Omega + 1k\Omega & -1k\Omega \\ -1k\Omega & 1k\Omega + 1k\Omega \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} +V_1 \\ -V_2 \end{bmatrix} \begin{bmatrix} 7 \\ -4 \end{bmatrix}$$

SASTRA

4. Solving the Equations

Let: V_1 = 7V and V_2 = 4V

Results:

I_1 = 3.33 mA

I_2 = –0.33 mA

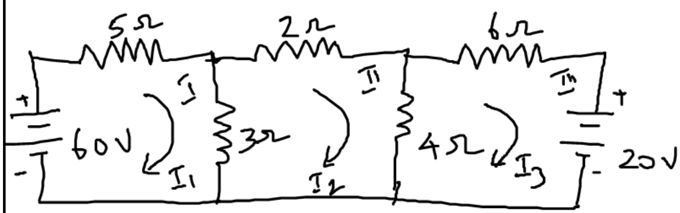
Finally

$V_{out} = (I_1 - I_2)\ 1k\Omega = 3.66V$

3.334
0.334
$I_1 =$
$I_2 =$
1kΩ
1Ω

Practice Problem

Determine the power dissipation in the 4Ω resistor of the given network.



SASTRA
DEEMED TO BE UNIVERSITY
(U/S 3 of the UGC Act, 1956)
THINK MERIT | THINK TRANSPARENCY | THINK SASTRA

Summary

KVL, KCL

→ branch V/I

→ +− → KVL → Equation → Unknowns.

Mesh

+− R → drop

I_1 → R I_2 ←

$V = (I_1 - I_2)R$

$(I_2 - I_1)R$

→ Mesh

→ Assume

→ KVL (mesh)

→ Solve

→ Inspection