Unit - II
2.5 Super Mesh and Star –Delta Transformation

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5G

MM waves

30 - 300 GHz

Small Cells

Massive MIMO

100-200 Ports

22

full duplex

Beam forming

- https://spectrum.ieee.org/everything-you-need-to-know-about-5g

Syllabus

Toolchest

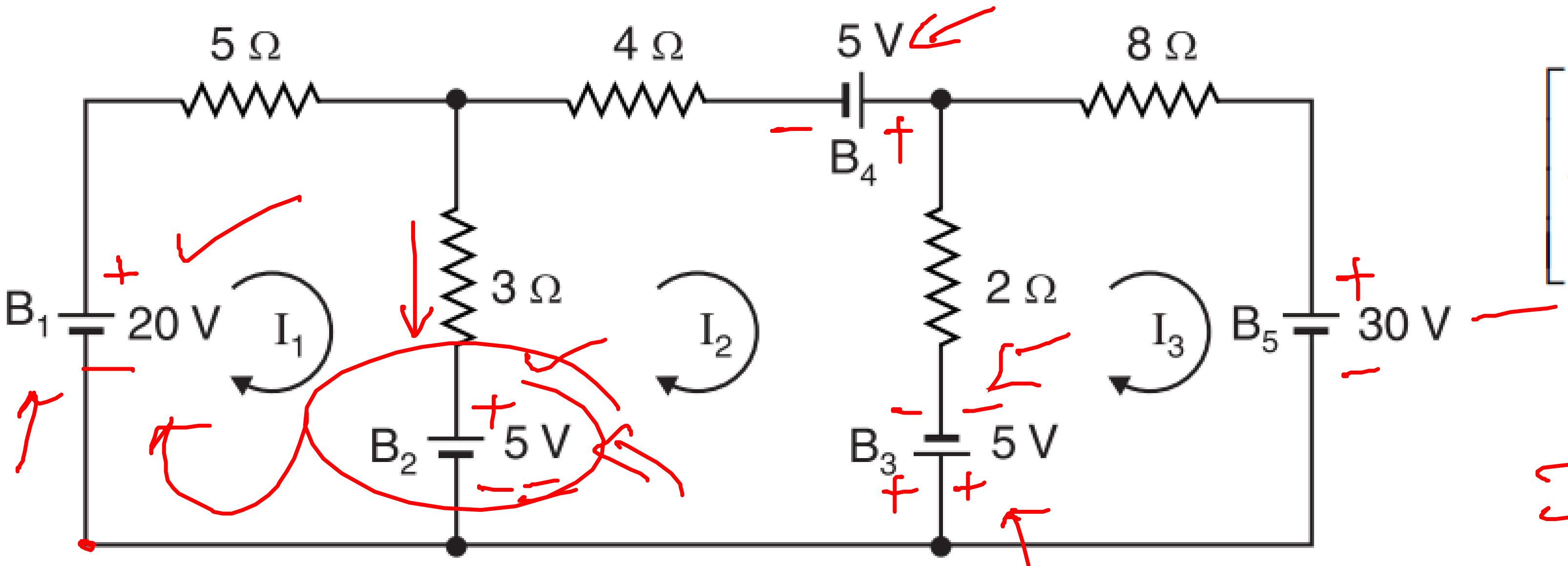
ohm's
Reduction
Division
KVL, KCL
Mesh

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

Mesh



$$\begin{bmatrix} 8 & -3 & 0 \\ -3 & 9 & -2 \\ 0 & -2 & 10 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} 15 \\ 15 \\ -35 \end{bmatrix}$$

Inspection method

$V_1 = +20 - 5 = 15V$

$V_2 = +5 +5 +5 = 15V$

$V_3 = -30 - 5 = -35V$

Current supplied by battery B_1 $= \boxed{I_1 = \mathbf{2{\cdot}56\ A}}$

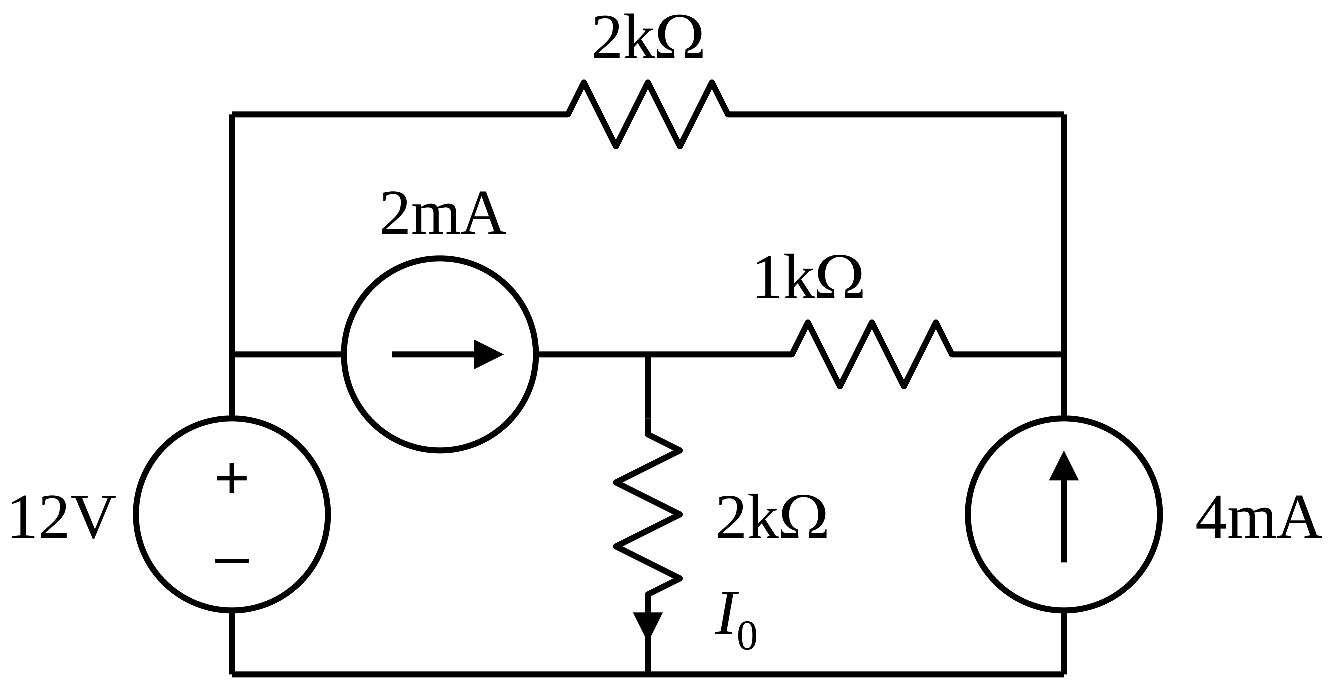
Current supplied to battery B_2 $= I_1 - I_2 = 2{\cdot}56 - 1{\cdot}82 = \mathbf{0{\cdot}74\ A}$

Current supplied by battery B_3 $= I_2 + I_3 = 1{\cdot}82 + 3{\cdot}13 = \mathbf{4{\cdot}95\ A}$

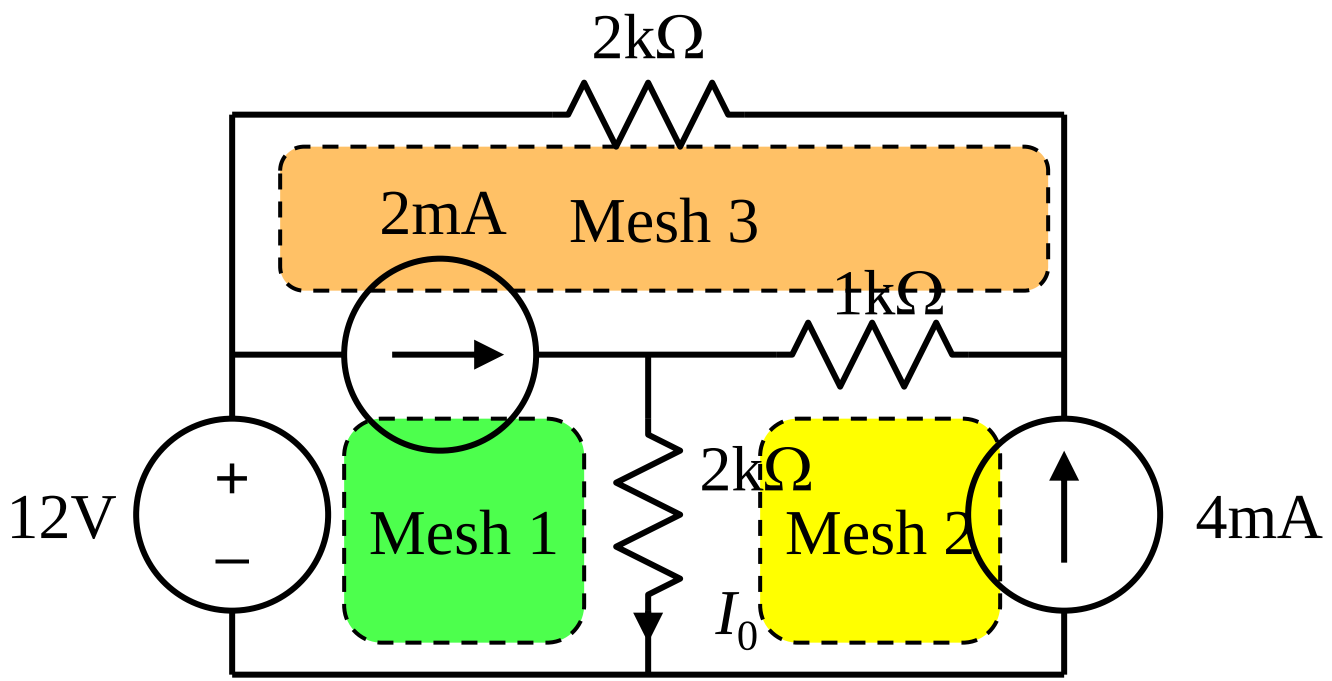
Current supplied by battery B_4 $= I_2 = \mathbf{1{\cdot}82\ A}$

Current supplied by battery B_5 $= I_3 = \mathbf{3{\cdot}13\ A}$

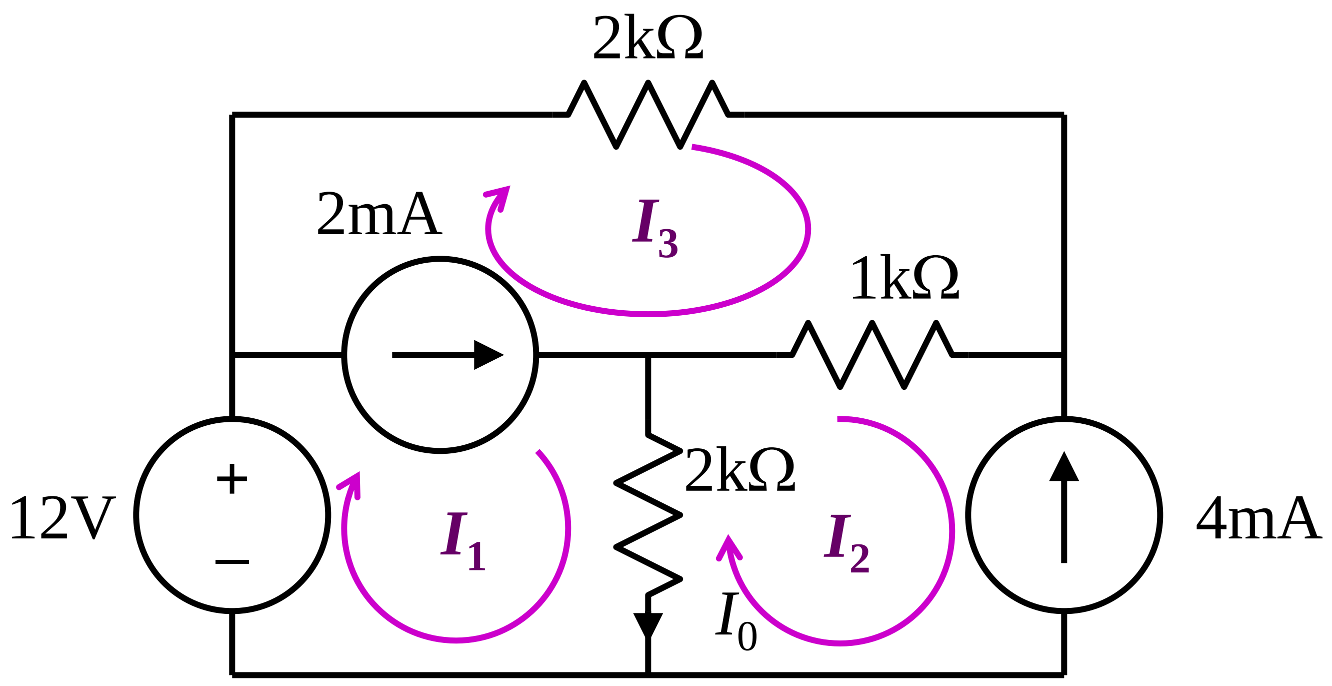
Another Example



1. Identify Meshes



2. Assign Mesh Currents



Current Sources

- The current sources in this circuit will have whatever voltage is necessary to make the current correct

- We can't use KVL around any mesh because we don't know the voltage for the current sources

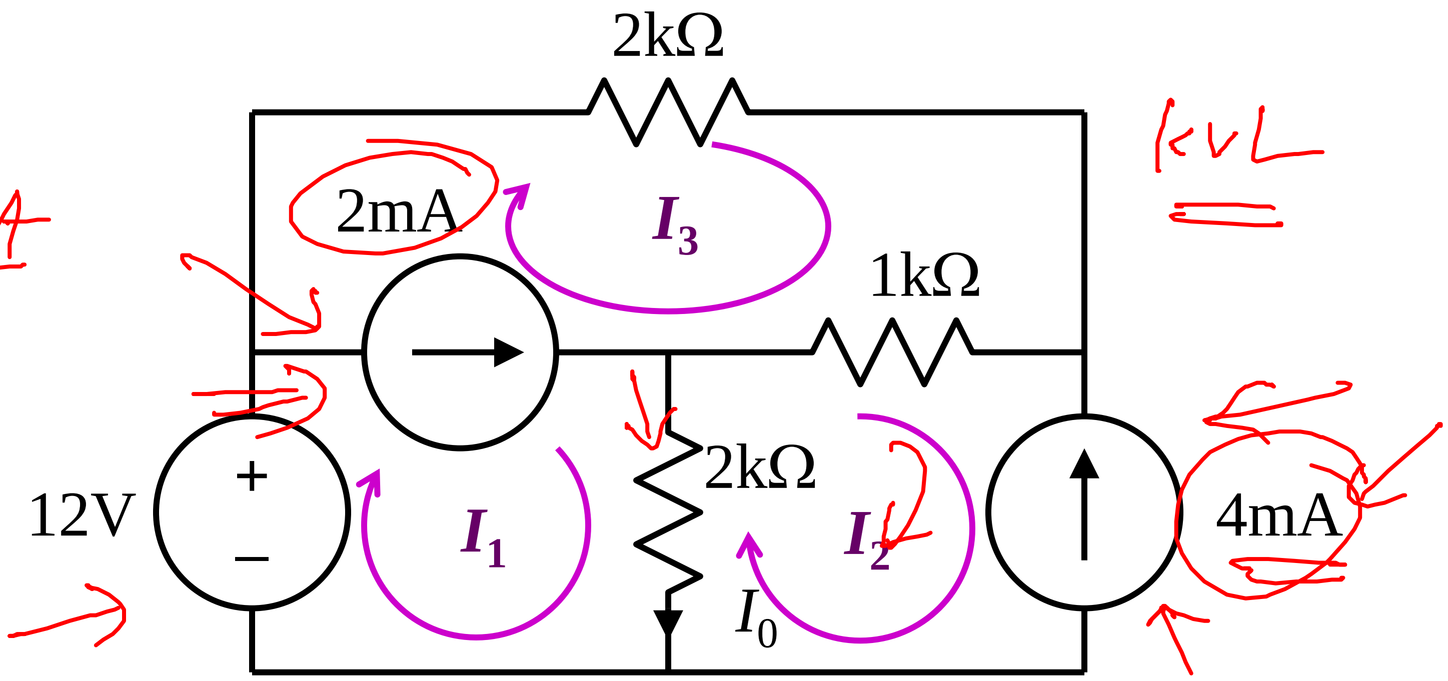
- What to do?

$I_1 =$

$I_2 = -4mA$

$I_3 =$

$2mA \rightarrow I_1 - I_3 = 2mA$



KVL

Current Sources

- The 4mA current source sets I_2:

$$I_2 = -4 \text{ mA}$$

- The 2mA current source sets a *constraint* on I_1 and I_3:

$$I_1 - I_3 = 2 \text{ mA} \quad 1$$

- We have two equations and three unknowns. Where is the third equation?

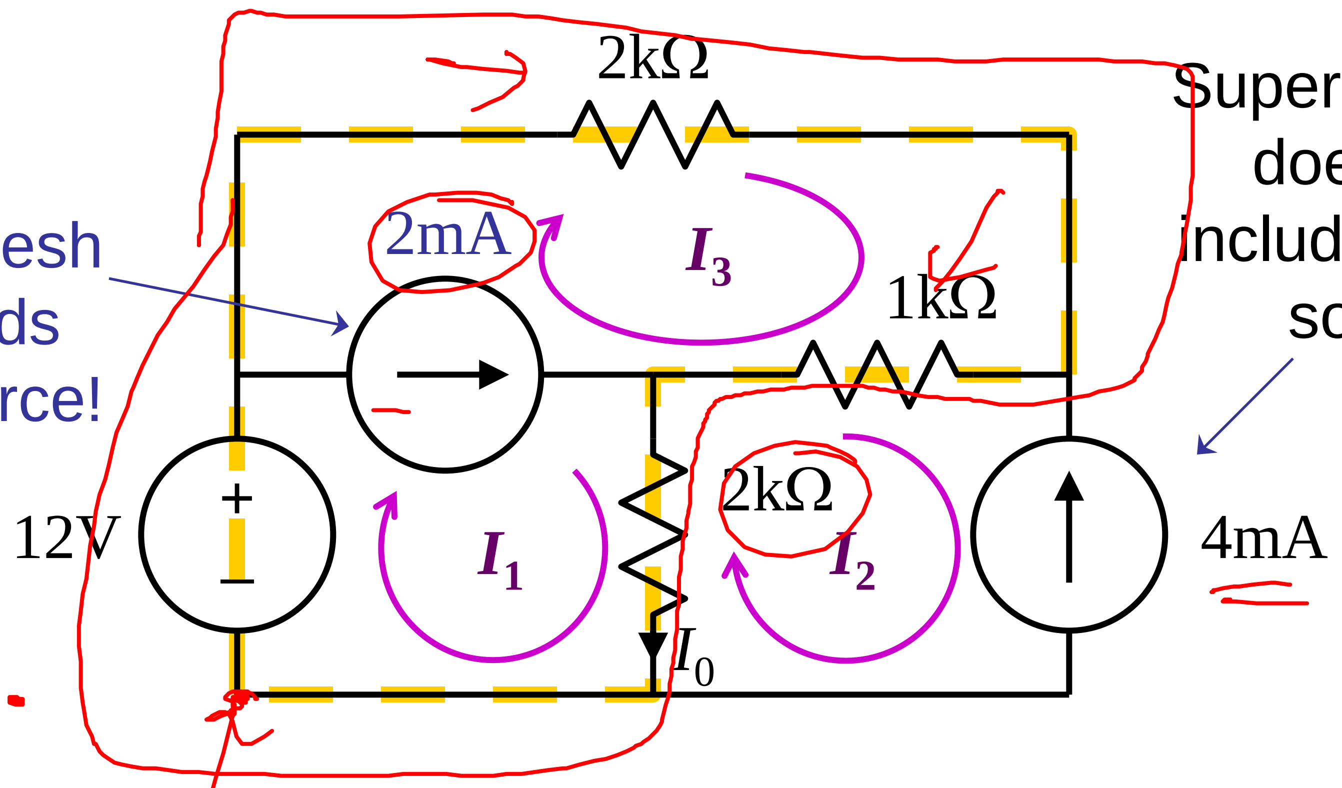
$I_1 =$

$I_2 =$

$I_3 =$

The Supermesh!

The Supermesh surrounds this source!



The Supermesh does not include this source!

4mA → mesh 2

KVL

$+12 - 2k(I_3) - 1k(I_3 - I_2) - 2k(I_1 - I_2) = 0$

3. KVL Around the Supermesh

$$-12V + I_3\, 2k\Omega + (I_3 - I_2)1k\Omega + (I_1 - I_2)2k\Omega = 0$$

$$I_3\, 2k\Omega + (I_3 - I_2)1k\Omega + (I_1 - I_2)2k\Omega = 12V \quad \text{— 4 — 3}$$

$$I_2 = -4mA \quad \text{— 1}$$

$$I_1 - I_3 = 2mA \quad \text{— 2}$$

Matrix Notation

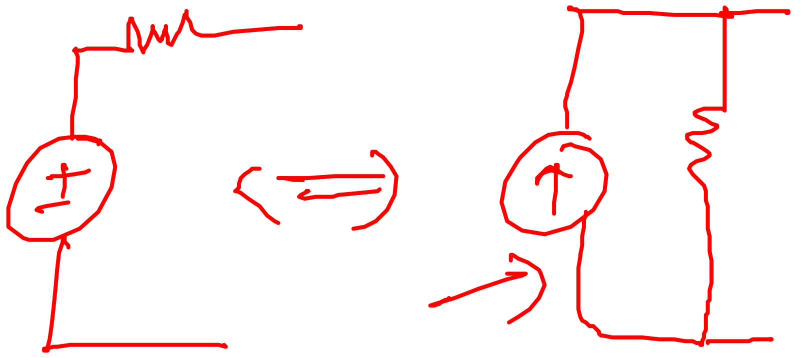
- The three equations can be combined into a single matrix/vector equation

$$\begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & -1 \\ 2\text{k}\Omega & -1\text{k}\Omega - 2\text{k}\Omega & 2\text{k}\Omega + 1\text{k}\Omega \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \\ I_3 \end{bmatrix} = \begin{bmatrix} -4\text{mA} \\ 2\text{mA} \\ 12\text{V} \end{bmatrix}$$

Solution

$$I_1 = 1.2 \text{ mA}$$
$$I_2 = -4 \text{ mA}$$
$$I_3 = -0.8 \text{ mA}$$

$$I_0 = I_1 - I_2 = 5.2 \text{ mA}$$



Mesh → KVL →

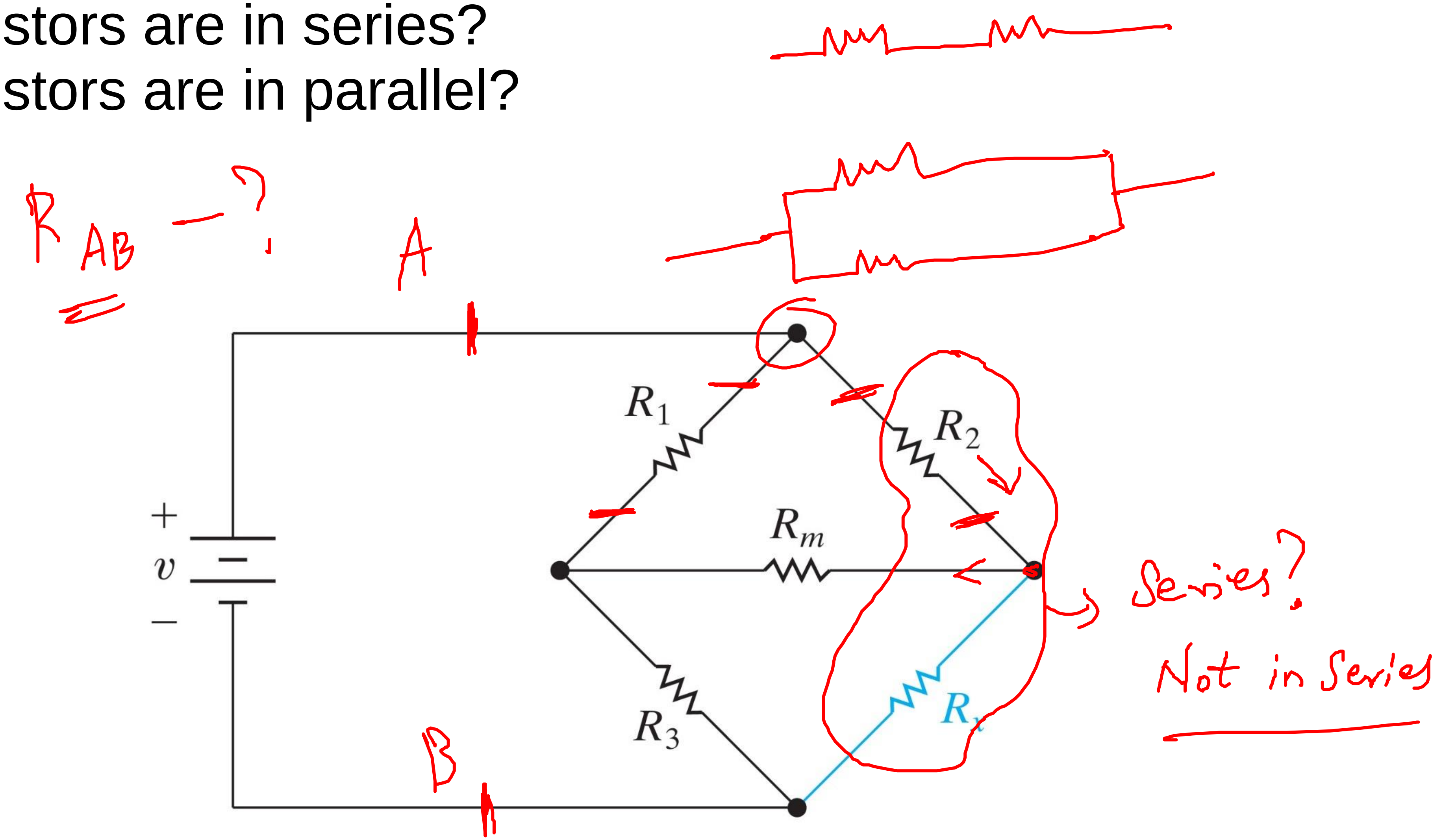
Current Sources → Source transformation

→ Supermesh

Reduction →

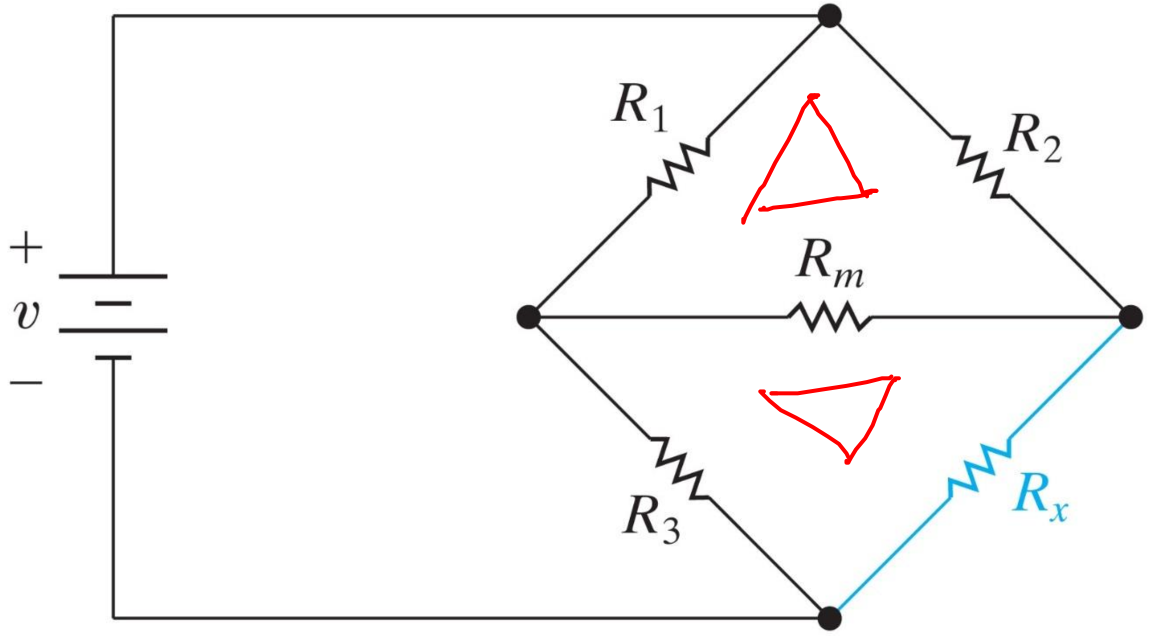
Back to the Bridge

- Which resistors are in series?
- Which resistors are in parallel?



Delta (Δ) Connection

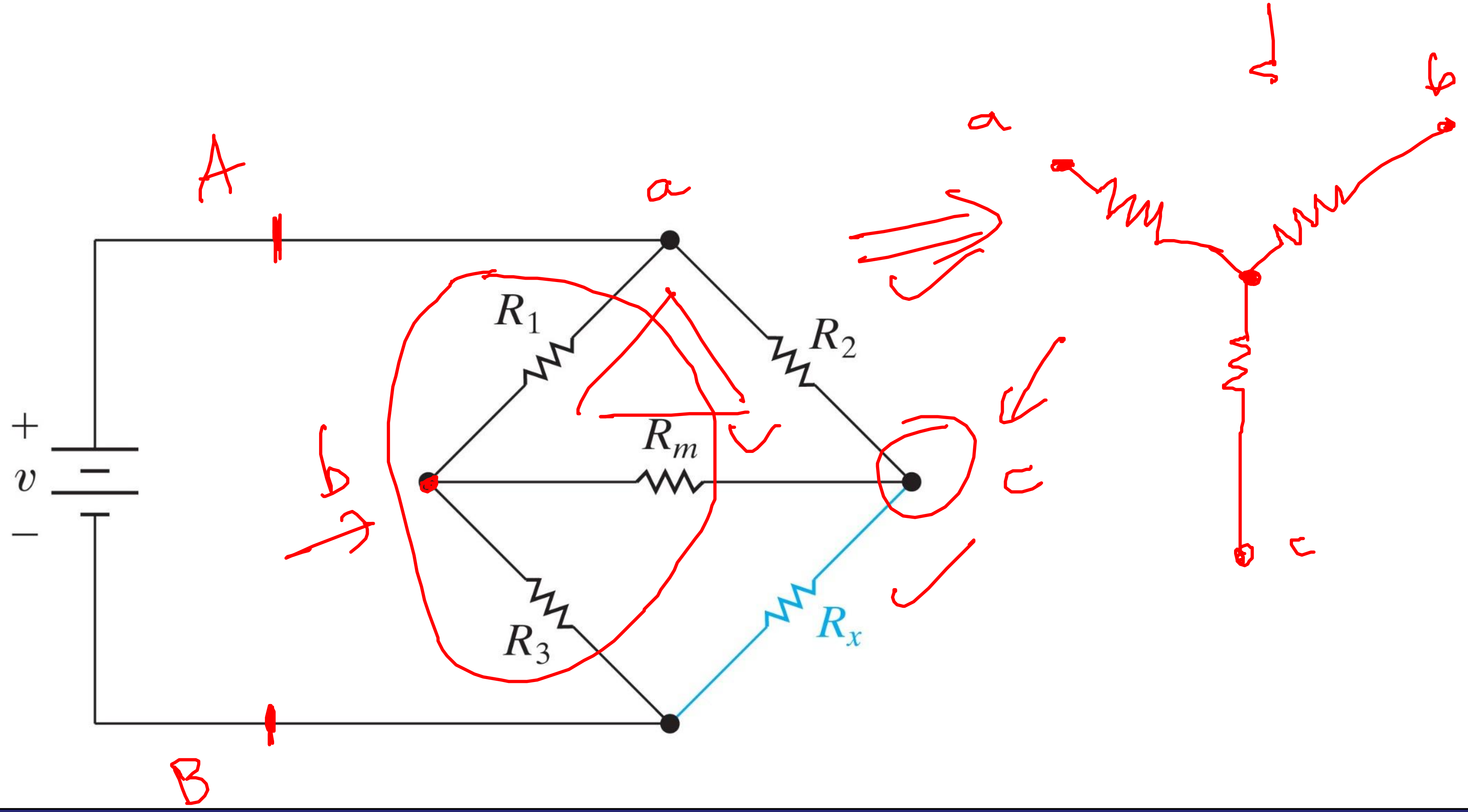
- Resistors R_1, R_2, and R_m (or R_3, R_m, and R_x) are in a Delta (Δ), or pi (π) connection.



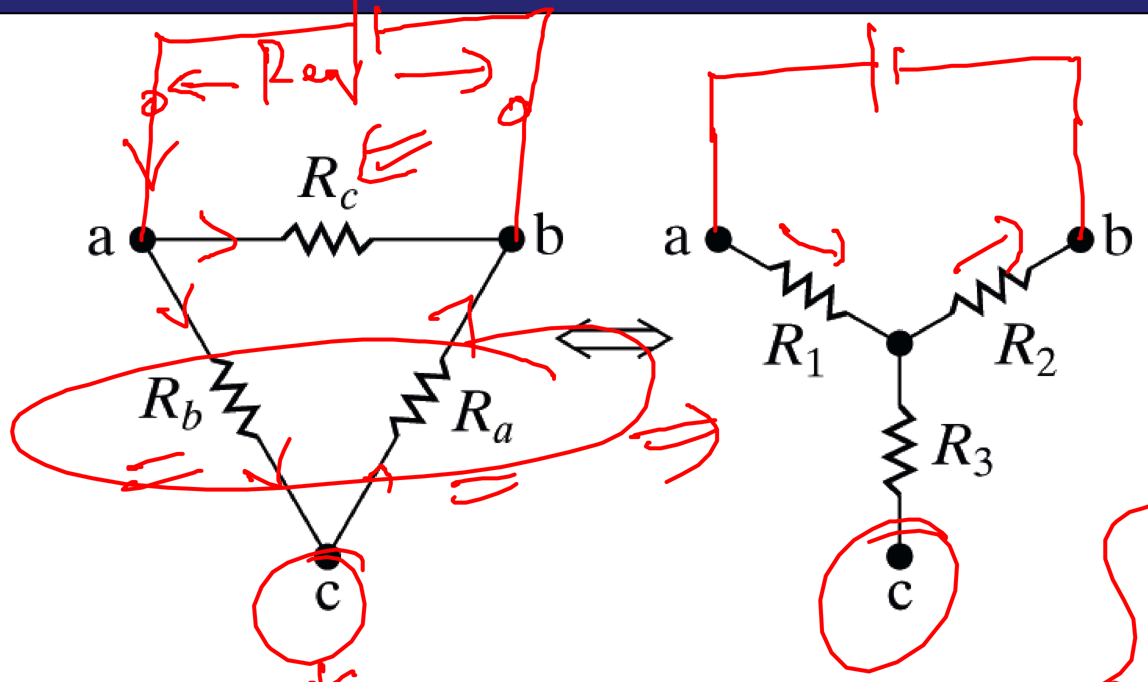
Wye (Y) Connection

Star

- Resistors R_1, R_m, and R_3 (or R_2, R_m, and R_x) are in a wye (Y), or tee (T) connection.



Δ – Y Conversion



a – b

Delta

$R_{ab(d)} = R_c \parallel (R_a + R_b)$

$R_{ab(star)} = \cancel{R_a}\ R_1 + R_2$

1

bc — 2

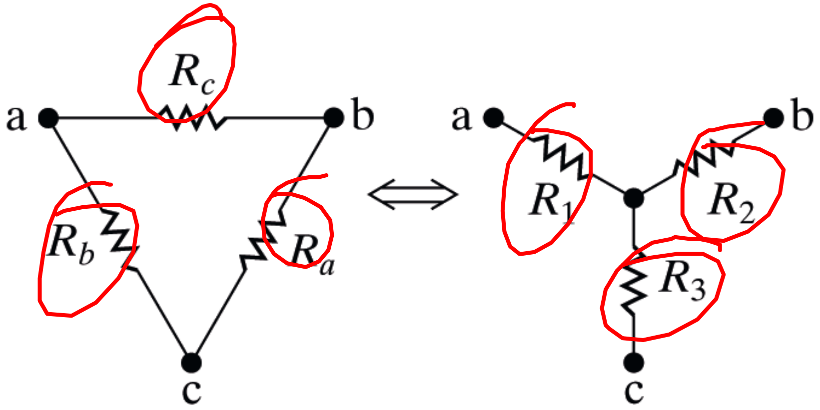
ca — 3

Δ – Y Conversion (continued)

- The resistance between the terminal pairs must be the same for both circuits

delta

$R_c \parallel R_a + R_b$



$$R_{ab} = \frac{R_c(R_a + R_b)}{R_a + R_b + R_c} = R_1 + R_2 \quad \text{(1)}$$

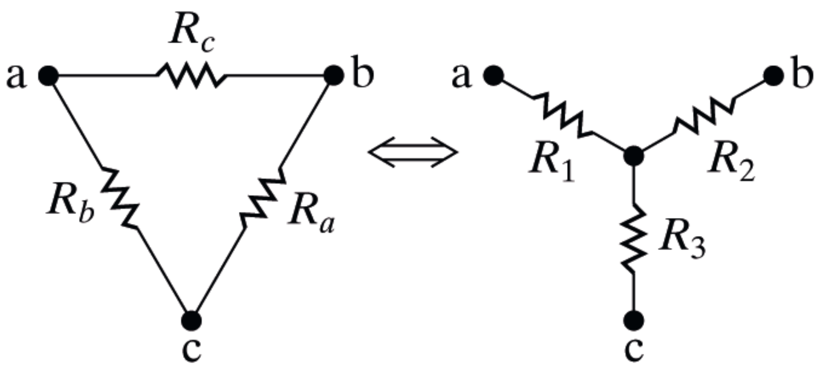
$$R_{bc} = \frac{R_a(R_b + R_c)}{R_a + R_b + R_c} = R_2 + R_3 \quad \text{(2)}$$

$$R_{ca} = \frac{R_b(R_c + R_a)}{R_a + R_b + R_c} = R_1 + R_3 \quad \text{(3)}$$

Δ – Y Conversion (continued)

- After some algebraic manipulation

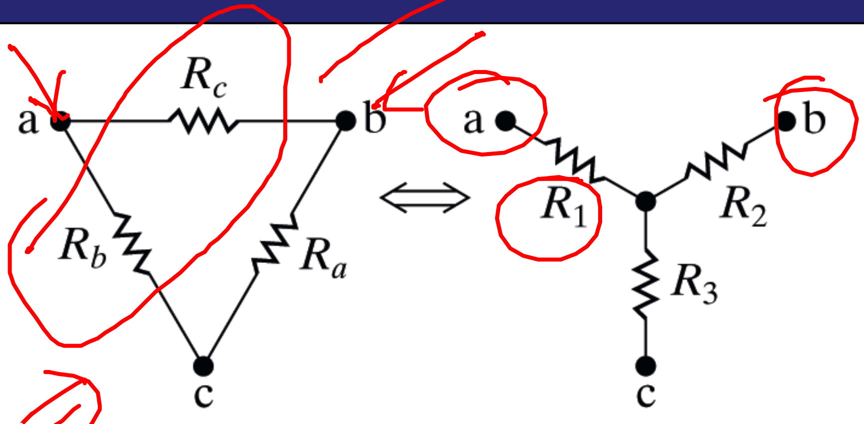
Delta – Star Conversion



$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c}$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c}$$

$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c}$$



$$R_1 = \frac{R_b R_c}{R_a + R_b + R_c} = \frac{1}{3}\,\Omega$$

$$R_2 = \frac{R_c R_a}{R_a + R_b + R_c} = \frac{1}{3}\,\Omega$$

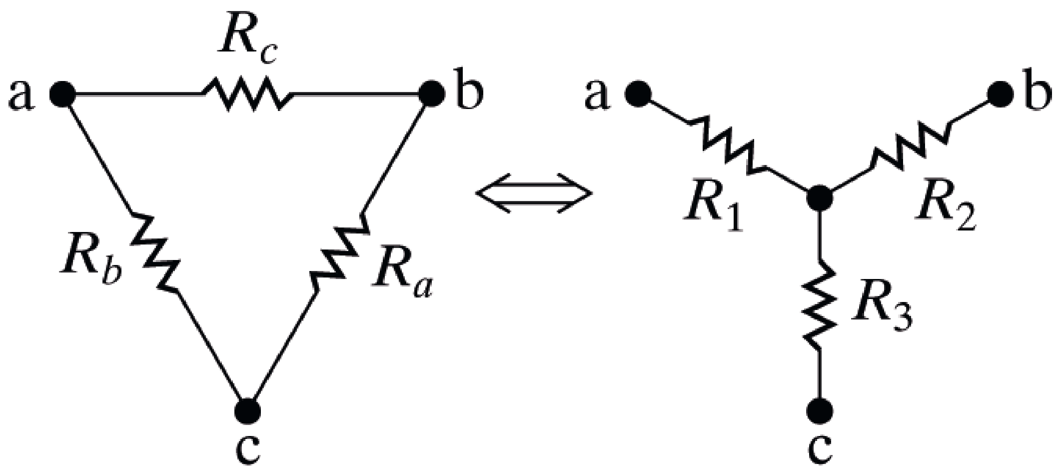
$$R_3 = \frac{R_a R_b}{R_a + R_b + R_c} = \frac{1}{3}\,\Omega$$

$R_a = 1\,\Omega$

$R_b = 1\,\Omega$

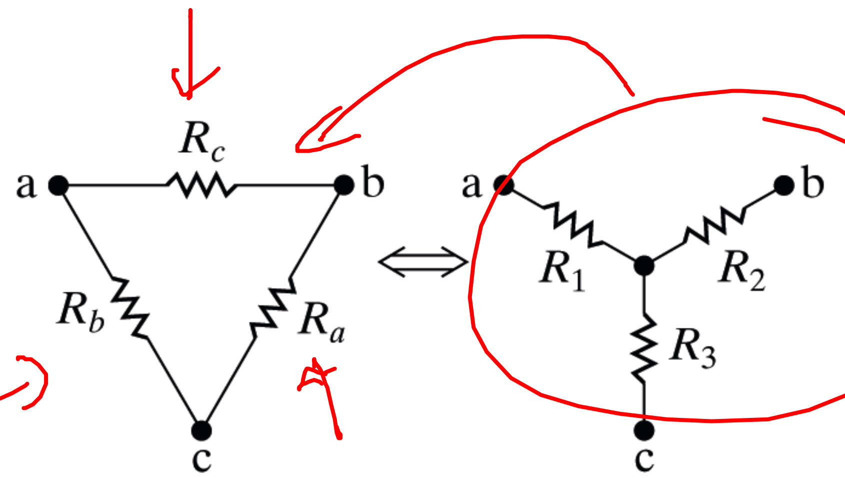
$R_c = 1\,\Omega$

Y – Δ Conversion



Y – Δ Conversion (continued)

- The resistance between the terminal pairs must be the same for both circuits



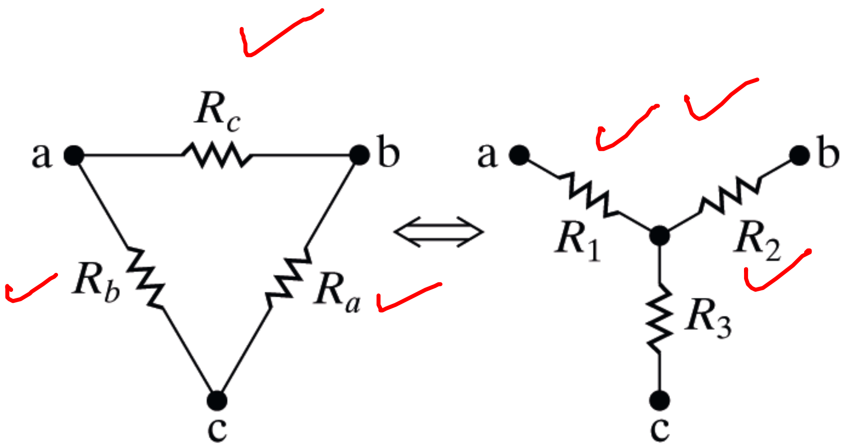
$$R_{ab} = \frac{R_c(R_a + R_b)}{R_a + R_b + R_c} = R_1 + R_2$$

$$R_{bc} = \frac{R_a(R_b + R_c)}{R_a + R_b + R_c} = R_2 + R_3$$

$$R_{ca} = \frac{R_b(R_c + R_a)}{R_a + R_b + R_c} = R_1 + R_3$$

Y – Δ Conversion (continued)

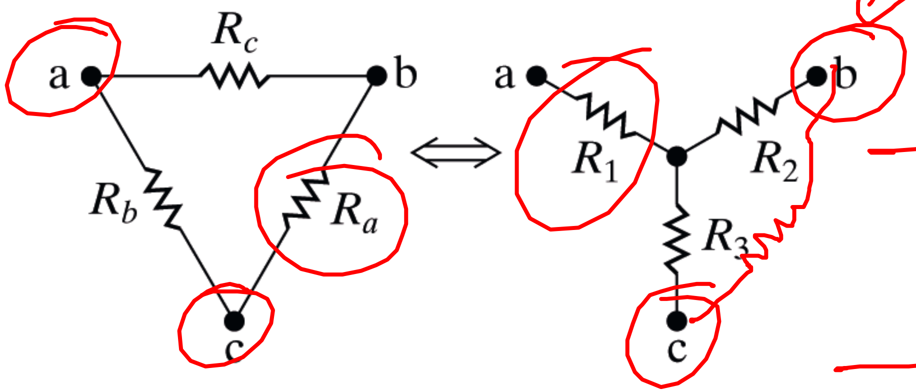
- After some algebraic manipulation



$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1}$$

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2}$$

$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3}$$



$R_1 = 1\,\Omega$

$R_2 = 2\,\Omega$

$R_3 = 3\,\Omega$

$$R_a = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_1} = \frac{11}{1}\,\Omega$$

$$R_b = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_2} = \frac{11}{2}\,\Omega$$

$$R_c = \frac{R_1R_2 + R_2R_3 + R_3R_1}{R_3} = \frac{11}{3}\,\Omega$$

Summary

Toolchest

- ohm's
- Division
- Reduction, Star/delta
- KVL, KCL
- Mesh (Supermesh)