Unit - II
2.6 Network Theorem - I

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Syllabus

Circuit Analysis → V, I → Toolchest → ohm's, mesh, kvl, kcl, Reduction, Division, source transformation, Star-delta

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

Constant-current and Constant Voltage Source

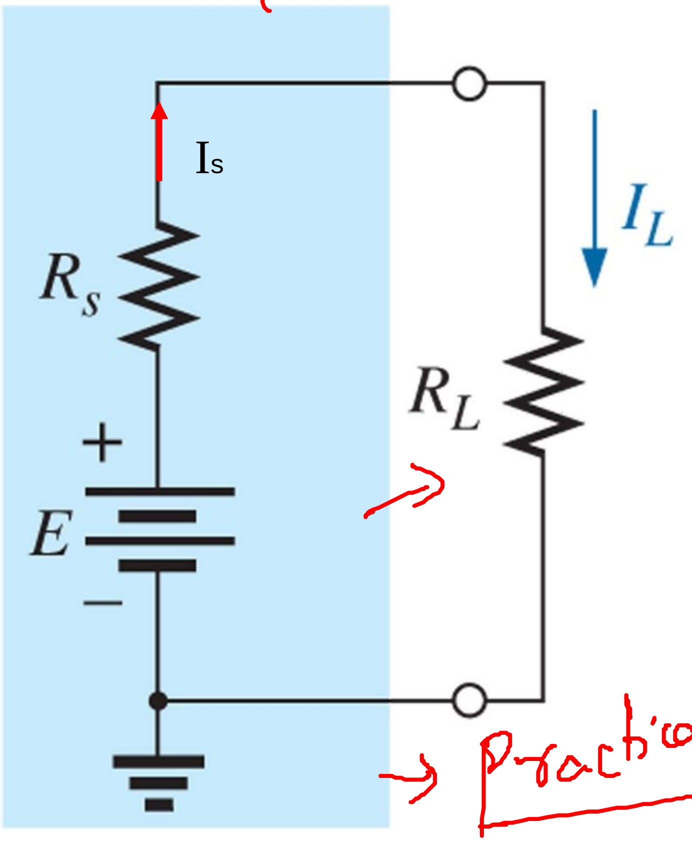
- In an electric circuit, a source of electrical energy could be represented by a source of e.m.f in series with a resistance.
- This is not, however, the only form of representation
- Consider a source load resister R_L

Constant-current and Constant Voltage Source

$$I_L = \frac{R_s}{R_s + R_l} \times I_s$$

Where $I_s = E/R_s$ is the current which flow across output terminals of the source

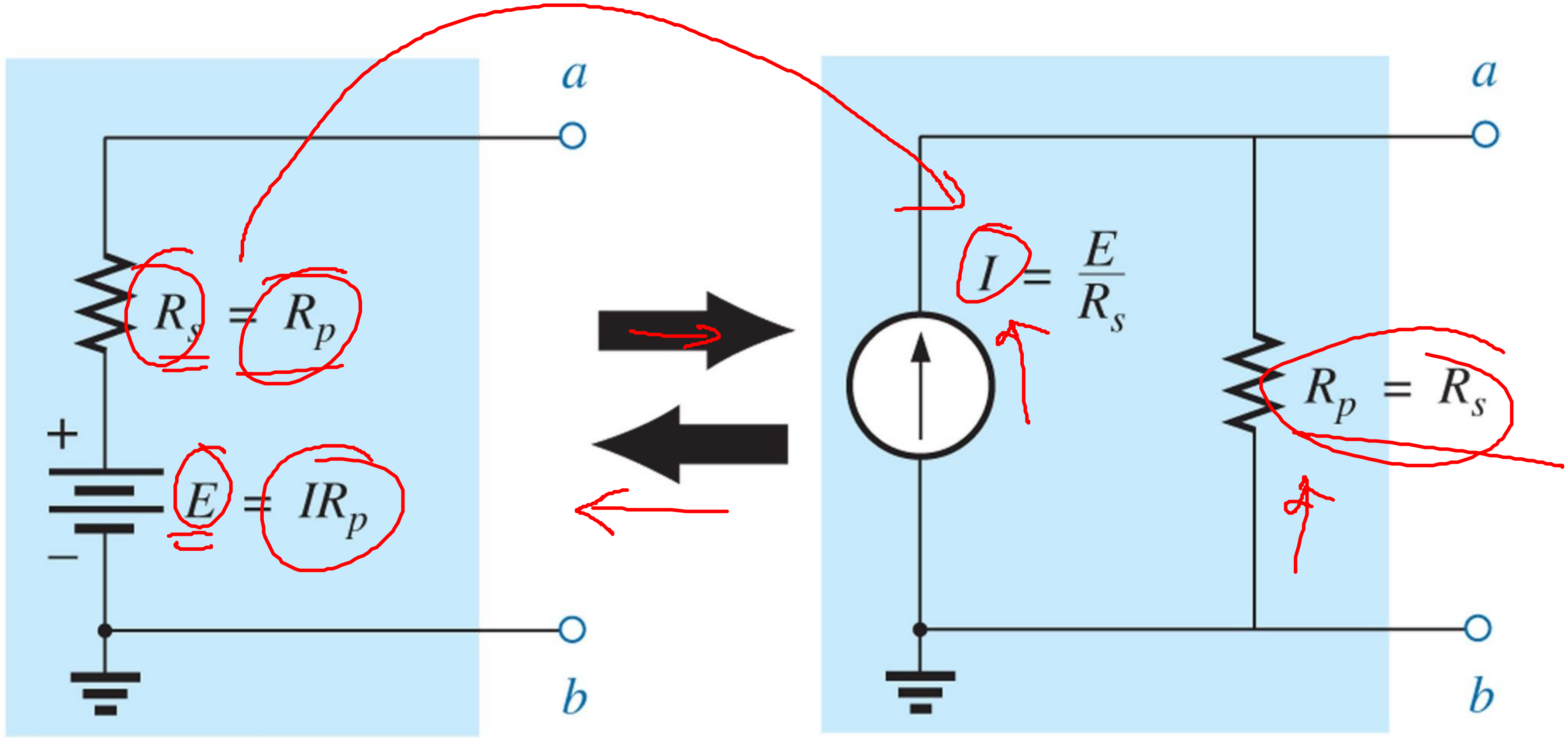
Source



Practical

(a)

Constant-current and Constant Voltage Source



Superposition Theorem

- The superposition theorem state that,

  The current in any given branch of a multiple-source linear circuit can be found by determining the currents in that particular branch produced by each source acting alone, with all the other source replaced by their internal resistance. The total current in the branch is the algebraic sum of the individual source currents in that branch.

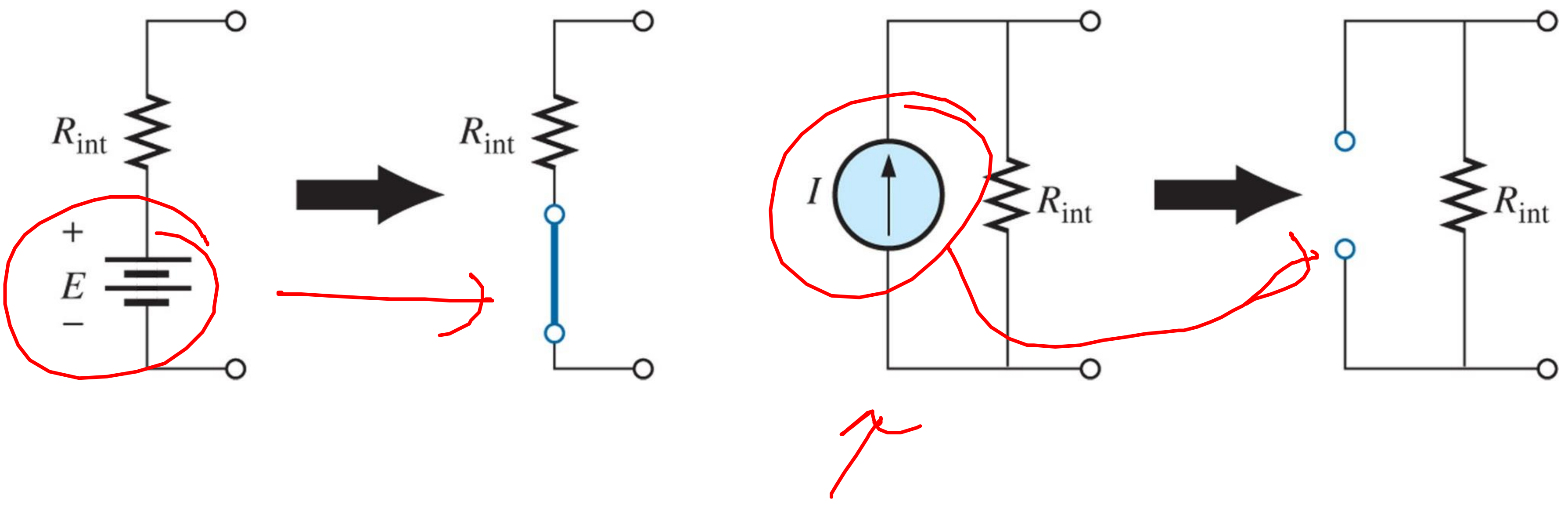
Superposition Theorem

$\Leftarrow I = 0 \leftarrow I$

$V = 0$

- Applying Superposition Theorem
  1. Take one voltage source at a time and replace each of the other voltage source with a short (a short represent zero resistance)
  2. Determine the current or voltage just as if there were was only one source in the circuit.
  3. Take the next source in the circuit and repeat the previous two steps for each source.
  4. To find actual current or voltage, add or substract the currents or voltages due to individual source. If the currents are in the same directions or the voltages are of the same polarity, add them and vice versa.

Removing a voltage source and a current source to permit the application of the superposition theorem.



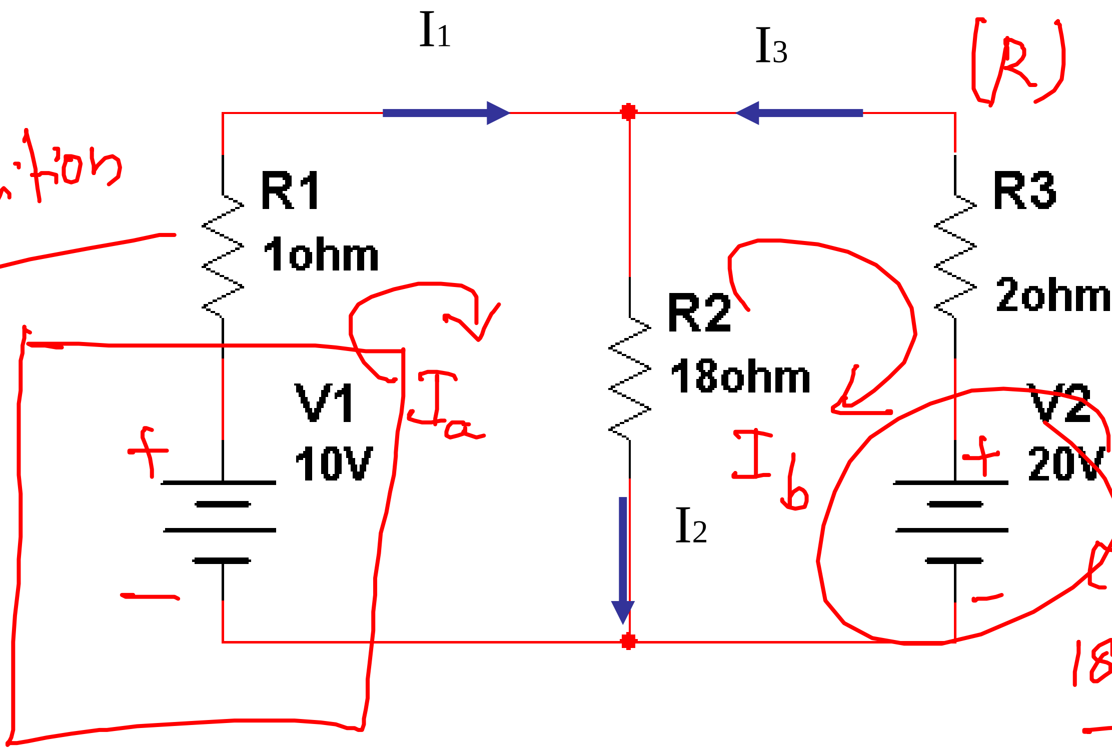
Example

Mesh

$$\begin{bmatrix} 19 & -18 \\ -18 & 20 \end{bmatrix} \begin{bmatrix} I_a \\ I_b \end{bmatrix} = \begin{bmatrix} +10 \\ -20 \end{bmatrix}$$

(R)

Superposition



I_1 $I_a = -2.86$

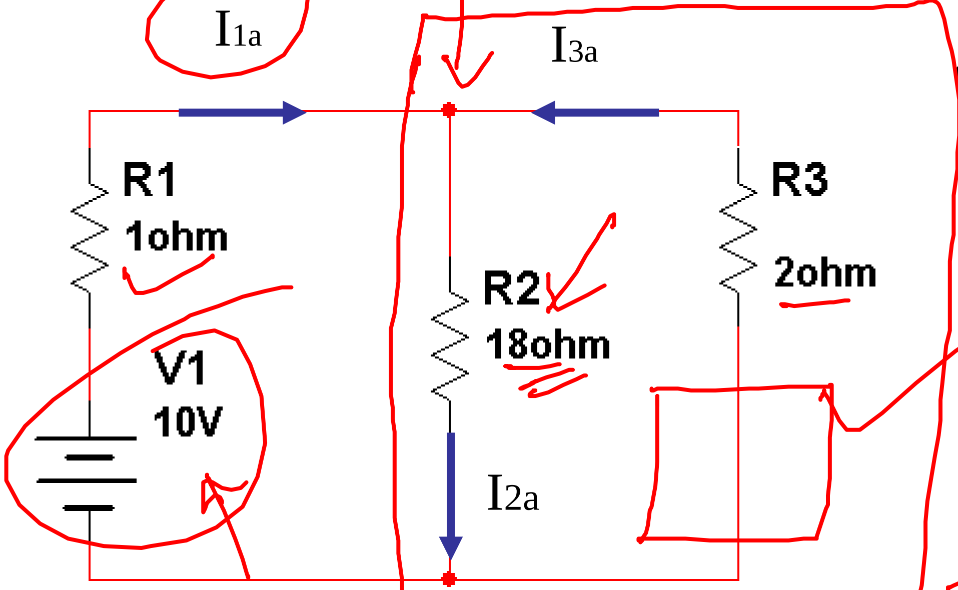
$I_b = -3.57$

Current through 18 Ω resistor

$$I_{18\Omega} = I_a - I_b$$

$$\boxed{V_{18\Omega} = }$$

Example



- The network with the 20V source replaced by a short-circuit.

$$R_T = 1 + \frac{2 \times 18}{2 + 18} = 2.8\Omega$$

Hence,

$$I_{1_a} = \frac{10}{2.8} = 3.57A$$

$$I_{2_a} = \frac{2}{2 + 18} \times 3.57 = 0.36A$$

The current I_{2b} is negative because opposite direction

Current division

Example

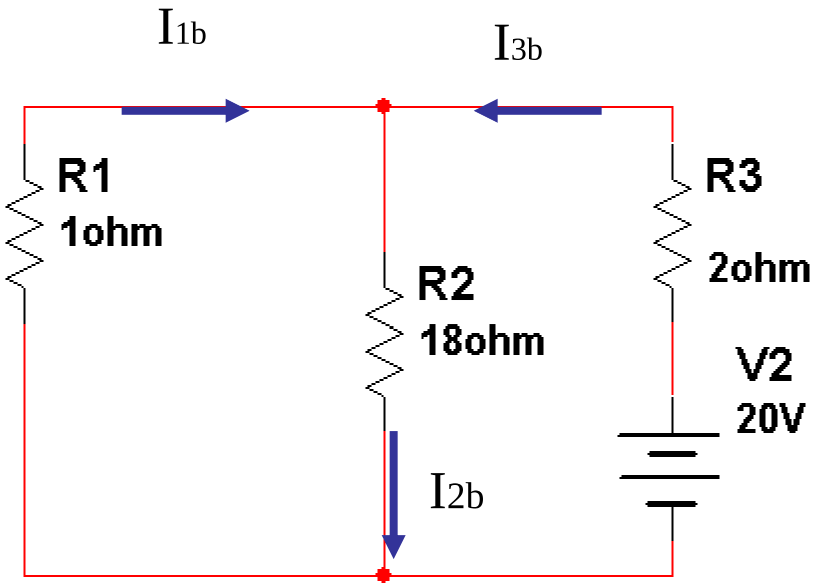
- Next replace 10V source with a short.

$$R_T = 1 + \frac{1\times 18}{1+18} = 2.95\Omega$$

$$Hence,$$

$$I_{3_b} = \frac{20}{2.95} = 6.78A$$

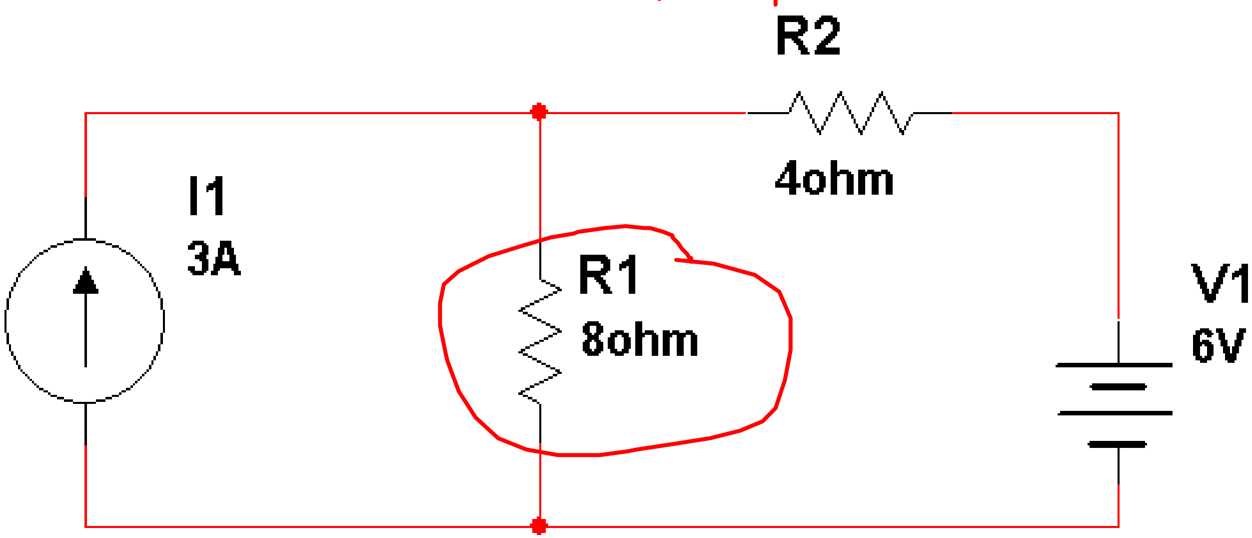
$$I_{2_b} = \frac{1}{1+18}\times 6.78 = 0.36A$$



$$I_2 = I_{2_a} + I_{2_b}$$
$$= 0.36 + 0.36 = 0.72A$$

Example

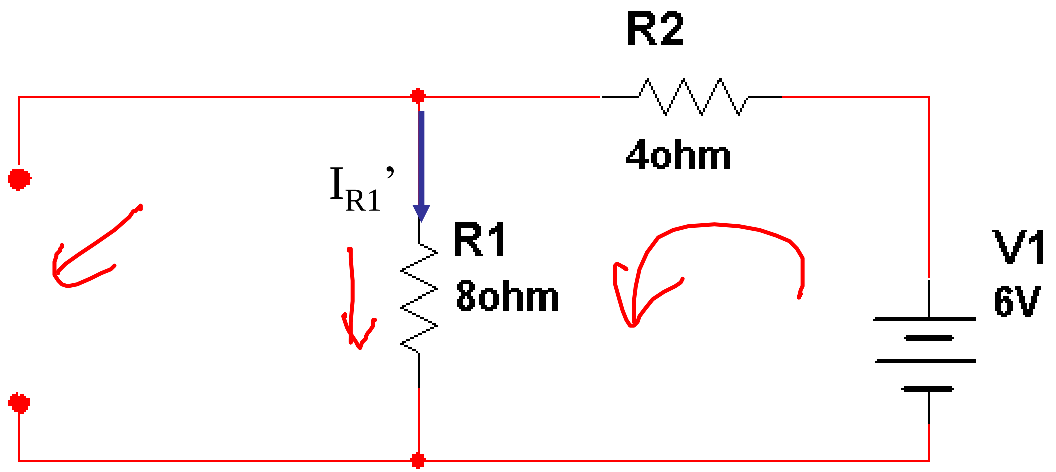
- Determine the current in the 8 Ω resistor (R1) in the circuit. using superposition theorem



- The network with the 3 A source replaced by an open circuit.

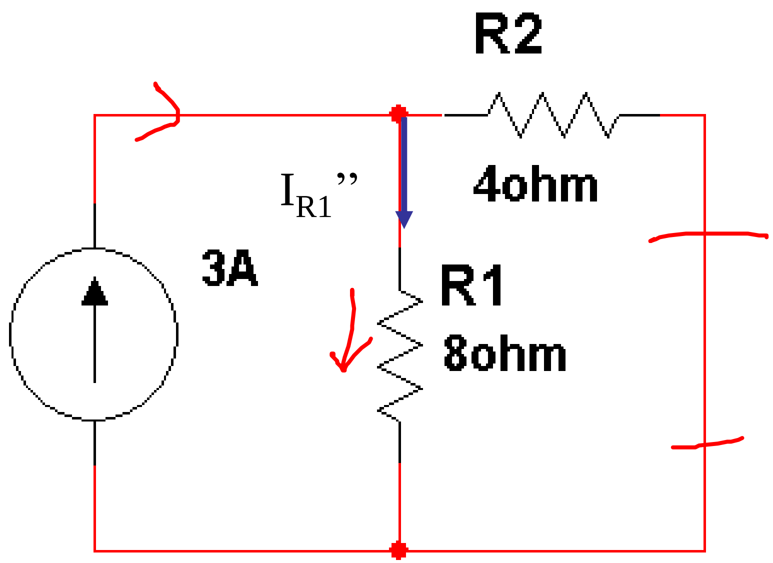
$$R_T = 8 + 4 = 12\Omega$$

$$I'_{R_1} = \frac{V_1}{R_T} \frac{6}{12} = 0.5A$$



- Then, replaced 6 V source by a short circuit
  - Apply current devider rule to determine I_{R1}''

$$I''_{R_1} = \frac{4}{4+8} \times 3 = 1A$$

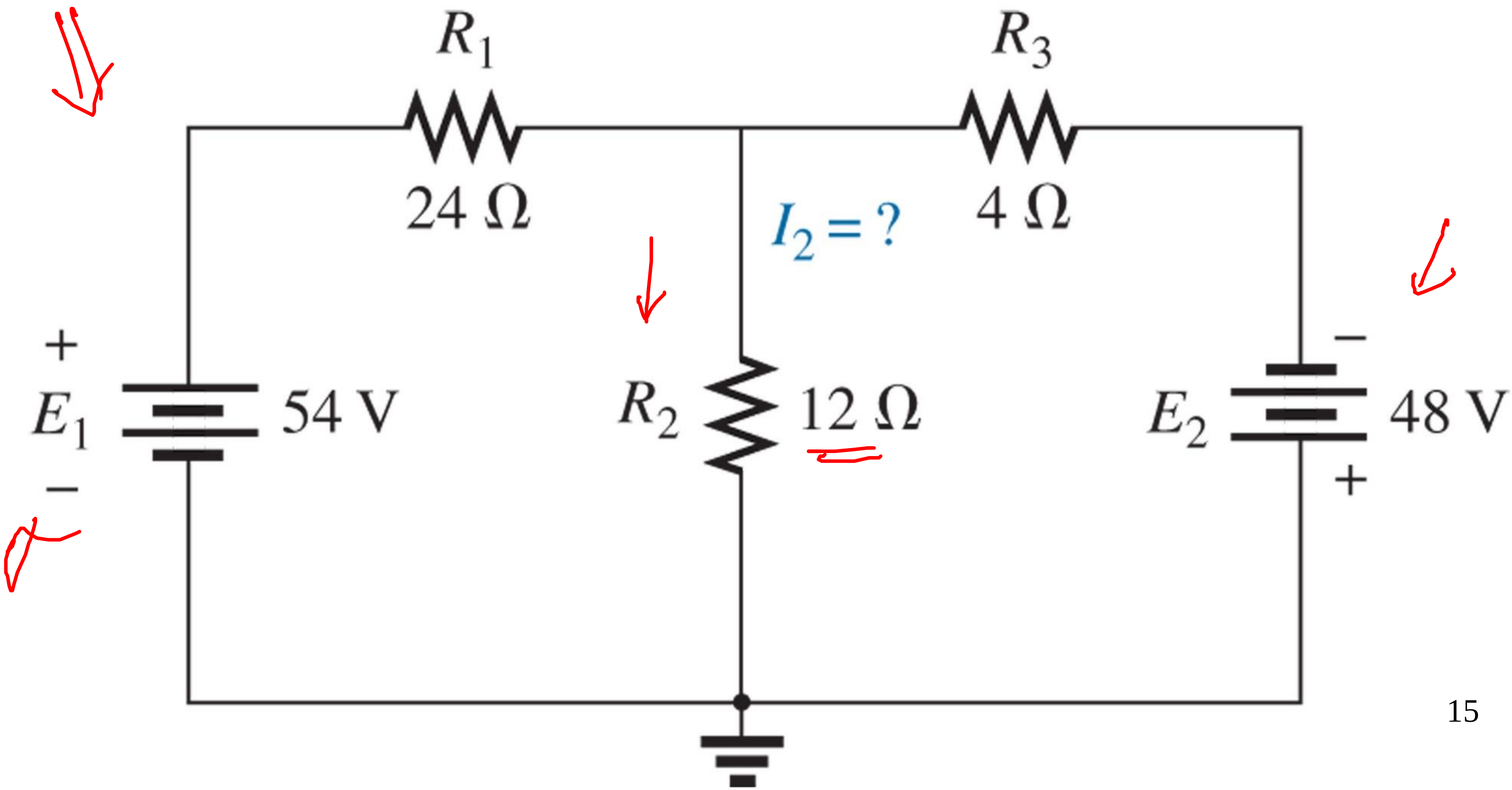


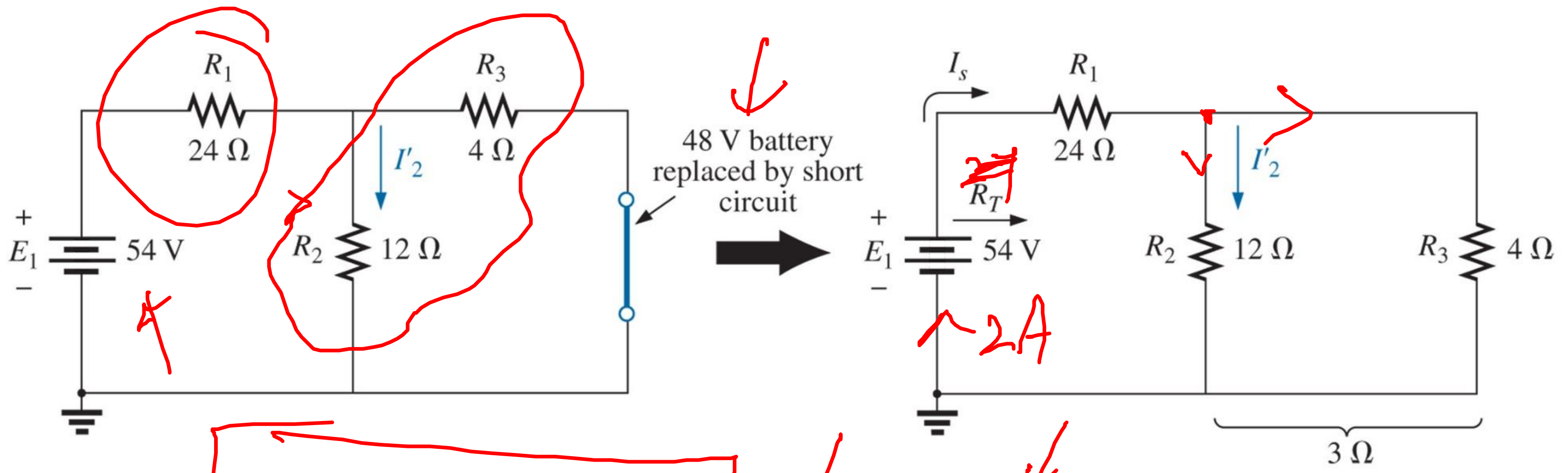
so,

$$I_{R_1} = I'_{R_1} + I''_{R_1} = 0.5 + 1 = 1.5A$$

Example 3

- Determine the current in the 12 Ω resistor



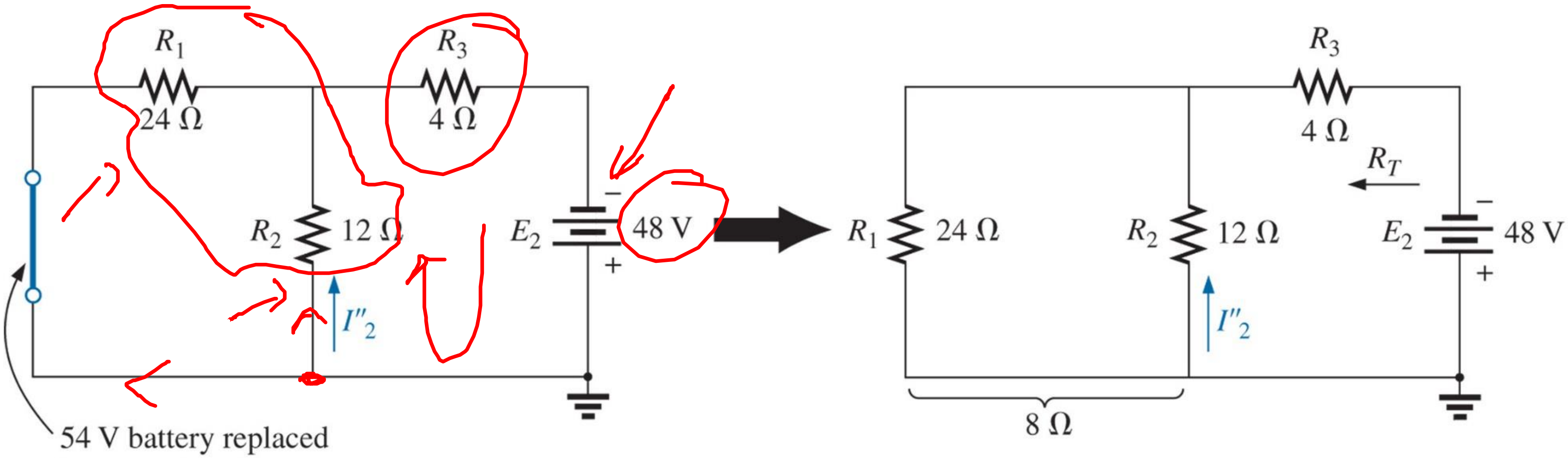


$$R_T = R_1 + R_2 \| R_3 = 24 + \frac{12 \times 4}{12 + 4} = 24 + 3 = 27\Omega$$

$$I_s = \frac{E_1}{R_T} = \frac{54}{27} = 2A$$

Used current devider rule to determine I’$_2$

$$I'_2 = \left(\frac{R_3}{R_3 + R_2} \right) I_s = \frac{4}{4+12} \times 2 = 0.5A$$



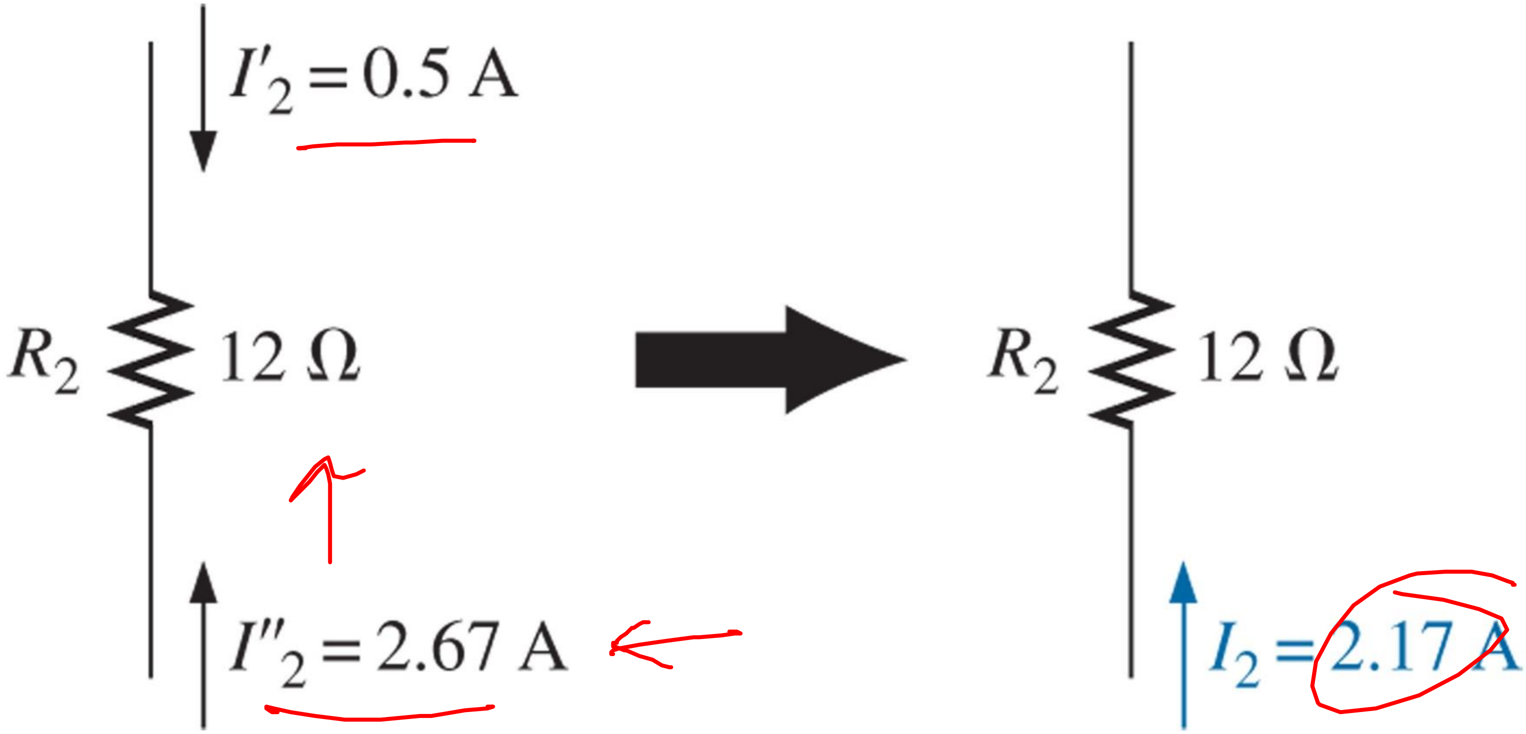
$$R_T = R_3 + R_2 \| R_1 = 4 + \frac{12 \times 24}{12 + 24} = 4 + 8 = 12\Omega$$

$$I_s = \frac{E_1}{R_T} = \frac{48}{12} = 4A$$

Used current devider rule to determine I''2

$$I''_2 = \left(\frac{R_1}{R_1 + R_2} \right) I_s = \frac{24}{24 + 12} \times 4 = 2.677\,A$$

To determine current I_2 for the network:



The net current therefore is the difference of the two and in the direction of the larger current:

$$I_2 = I''_2 - I'_2 = 2.667 - 0.5 = 2.167\,A$$

Summary

Toolchest

- → Superposition theorem
  - → V → short circuit
    I → open circuit
  - → Response
  - → Algebraic Sum