LECTURE 9
CIRCUIT ANALYSIS TECHNIQUE
SOURCE TRANSFORMATION

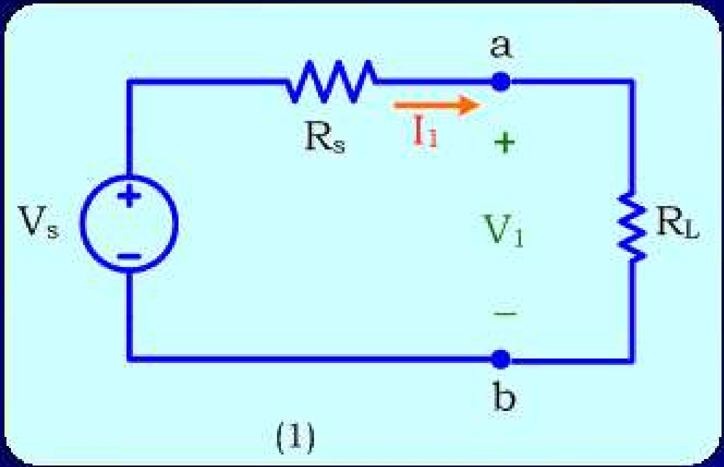
Topics

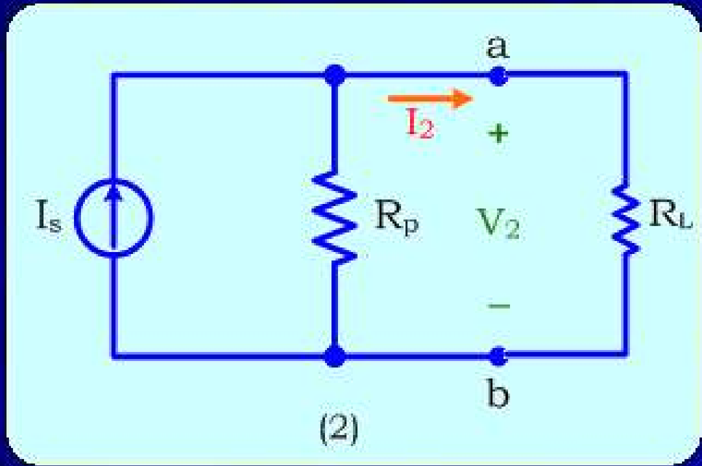
- Source Transformation
- Use of Source Transformation in Circuit Analysis

Objectives

- Understand the meaning of Source Transformation
- Apply Source Transformation
- Recognize when Source Transformation is not applicable
- Use Source Transformation to analyze and simplify circuits

Source Transformation



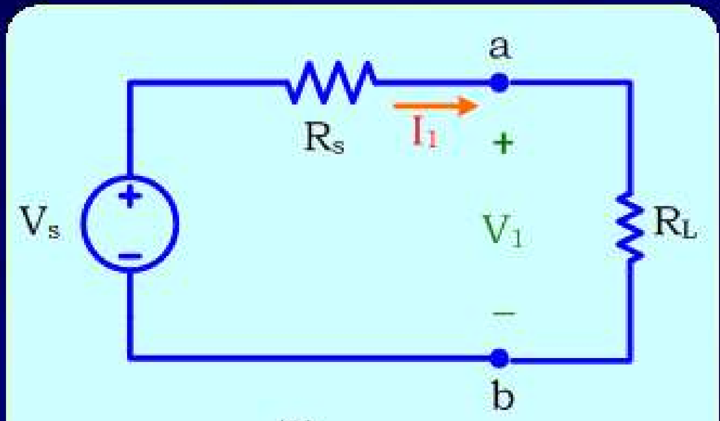


Given an ideal voltage V_s in series with a resistor R_s ⇔ Given an ideal voltage I_s in parallel with a resistor R_p

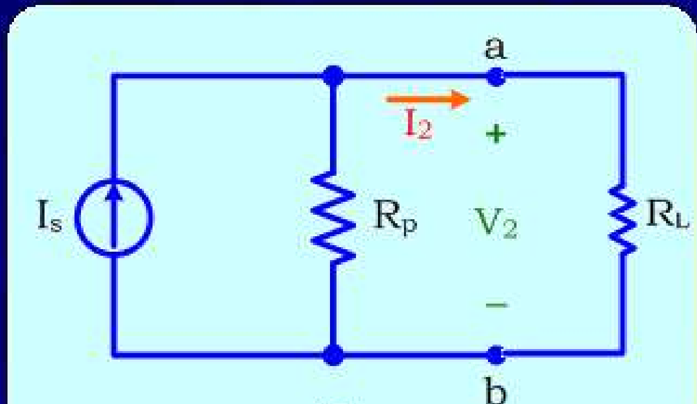
Connect the same load R_L across the terminal "a-b" in both circuits

If circuits (1) and (2) are equivalent: ⟹ $I_1 = I_2$ & $V_1 = V_2$

Source Transformation



(1)



(2)

If circuits (1) and (2) are equivalent: $\Rightarrow$ $I_1 = I_2$ & $V_1 = V_2$

$$I_1 = \frac{V_s}{R_{eq}} = \frac{V_s}{R_s + R_L}$$

$$I_2 = \frac{R_p}{R_p + R_L} I_s$$

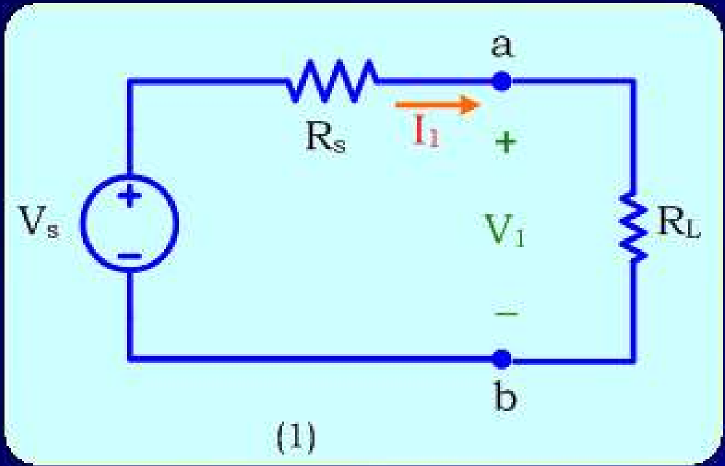
$$I_1 = I_2 \Rightarrow \frac{V_s}{R_s + R_L} = \frac{R_p I_s}{R_p + R_L}$$

If we choose: $R_p = R_s \Rightarrow V_s = I_s R_p = I_s R_s$

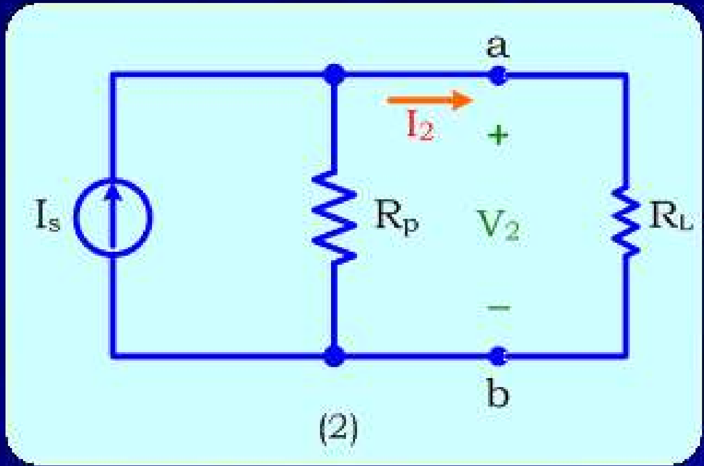
$\therefore R_s = R_p$ & $V_s = I_s R_s$

$\Rightarrow$ V_s in series with R_s $\Leftrightarrow$ I_s in parallel with R_p

Source Transformation: Comments



⟺



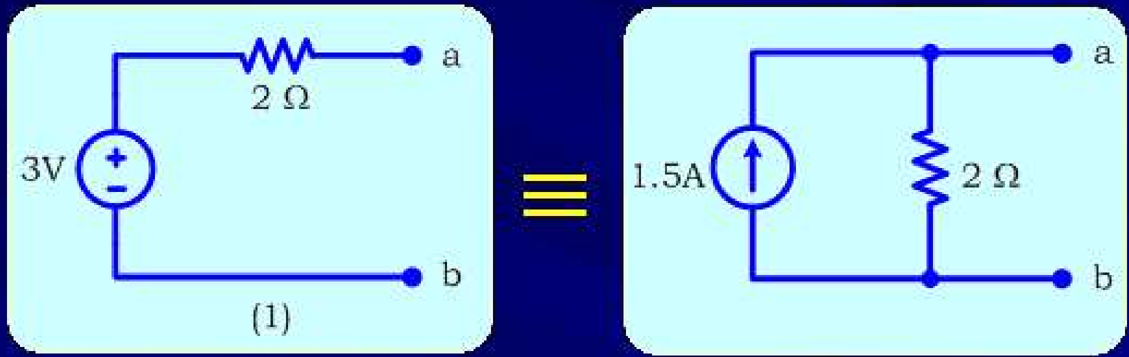
The above conversion is called *Source Transformation (ST)*.

Circuits (1) and (2) are equivalent. However, they are not the same.

When any load is connected to terminals "a" & "b" of circuits (1) and (2), the load cannot distinguish between the two circuits.

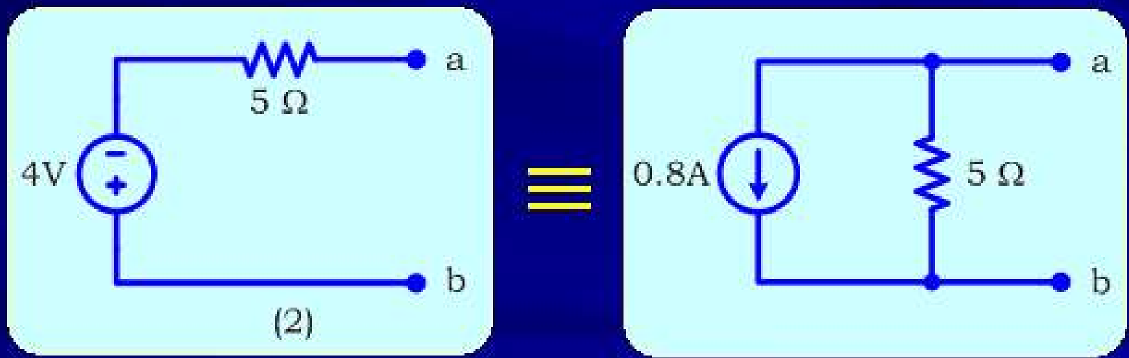
Circuits (1) and (2) are *equivalent from the outside* when accessed from terminals "a" & "b". But, they are *different from the inside*.

Example 1: Convert the following circuits using Source Transformation.



$$R_p = R_s = 2\Omega$$

$$I_s = \frac{V_s}{R_s} = \frac{3}{2} = 1.5A$$

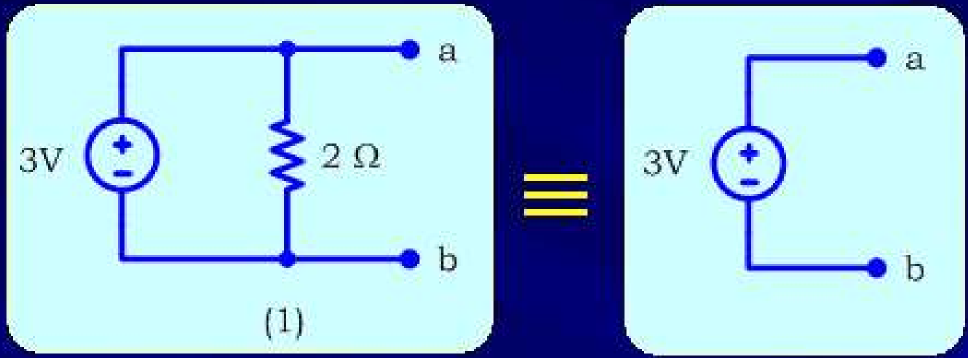


$$R_p = R_s = 5\Omega$$

$$I_s = \frac{V_s}{R_s} = \frac{4}{5} = 0.8A$$

Example 2

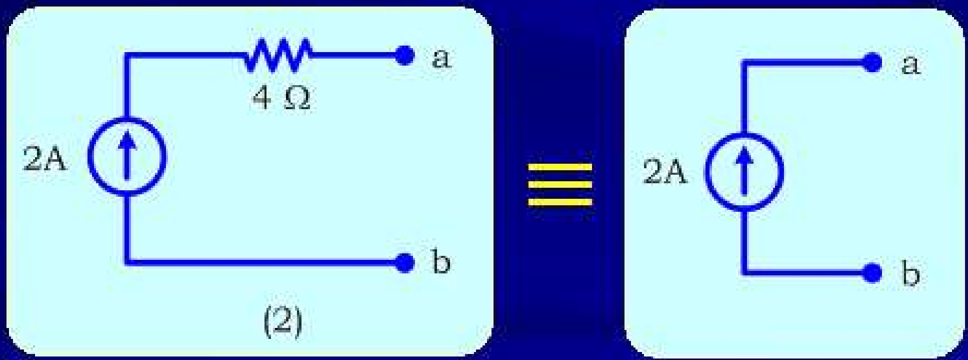
Convert the following circuits using Source Transformation.



A resistor in parallel with a voltage source (not in series)

⇒ equivalent to a voltage source

⇒ ST does not apply



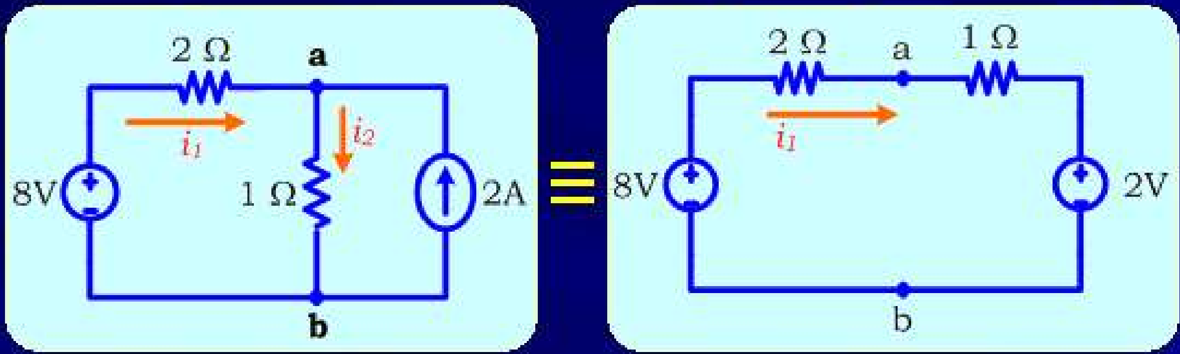
A resistor in series with a current source (not in parallel)

⇒ equivalent to a current source

⇒ ST does not apply

Example 3

Use ST to calculate i_1 and i_2.



Solution: Apply ST to the 2A and 1Ω combination $\Rightarrow$ $V = IR = 2(1) = 2V$

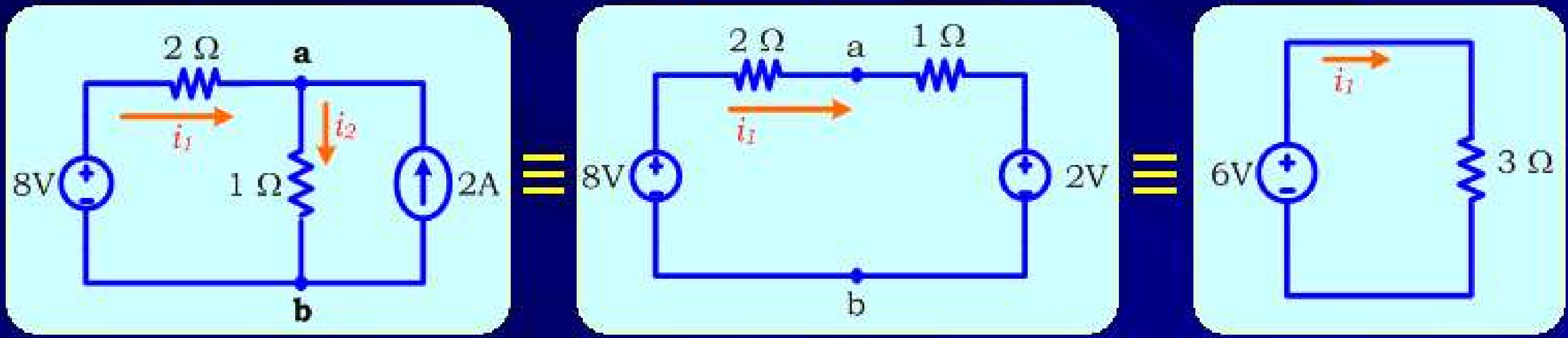
Notice that i_2 cannot be drawn. It disappears. Why?

The current through the 1Ω of the transformed circuit is not i_2. Why?

Reason: $R_p = R_s$ means the two resistors have the same value. It does not mean we have the same resistor!!

Since, 1Ω & 2Ω are in series $\Rightarrow$ current through the 1Ω of the transformed circuit is i_1.

Example 3 Use ST to calculate i_1 and i_2.



Solution: We have 2Ω & 1Ω are in series ⟹ 3Ω

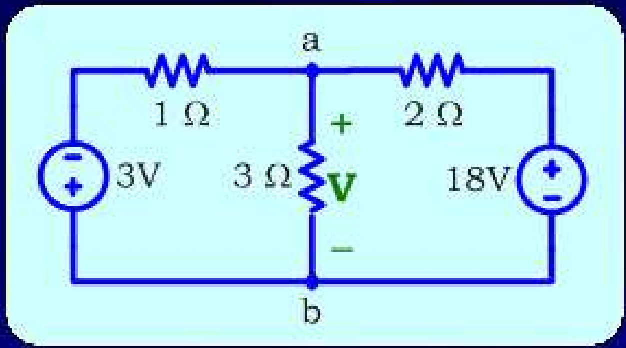
We also have *8V* and *2V* are in series ⟹ *8 - 2 = 6V*

Therefore, $i_1 = \frac{6}{3} = 2A$

KCL at node a (of the original circuit)

$$i_2 = i_1 + 2 = 2 + 2 = 4A$$

Example 4 Use ST to calculate *V*.



Solution:

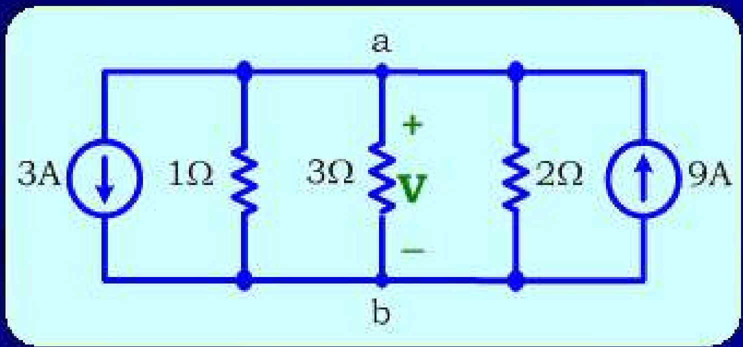
Apply ST to ($3V/1\Omega$) and to ($18V/2\Omega$)

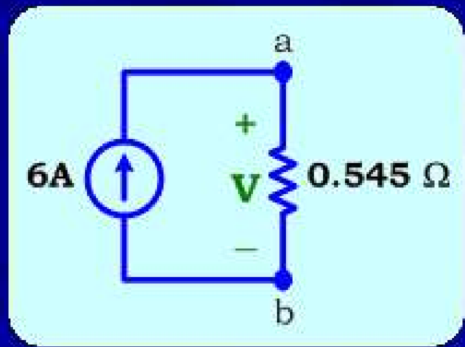
$$\Rightarrow \quad I_{s1}=\frac{3}{1}=3A \quad \& \quad I_{s2}=\frac{18}{2}=9A$$

$$\Rightarrow \quad R_{eq}=\frac{1}{1+\frac{1}{3}+\frac{1}{2}}=0.545\Omega \quad [1\Omega \| 3\Omega \| 2\Omega]$$

$$I_{eq}=9-3=6A \quad [3A \| 9A]$$

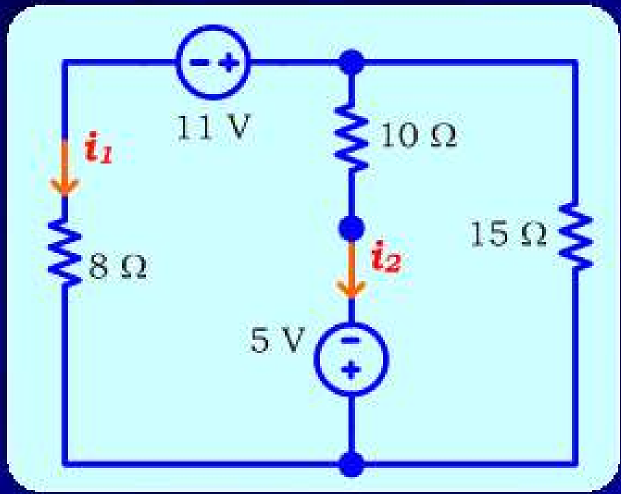
$$\therefore \quad V=I_{eq}R_{eq}=6(.545)=3.273V$$





Practice Problem

Find the currents i_1 & i_2 for the circuit shown:



Answer:

$i_1 = -1A \ \& \ i_2 = 0.8A$