

Methods of analysis

Introduction

Introduction

INTRODUCTION

The circuits you previously studied had only one source or two or more sources in series or parallel.

The step-by-step procedures can be applied only if the sources are in series or parallel. There will be an interaction of sources that will not permit the reduction techniques used to find quantities such as the total resistance and the source current.

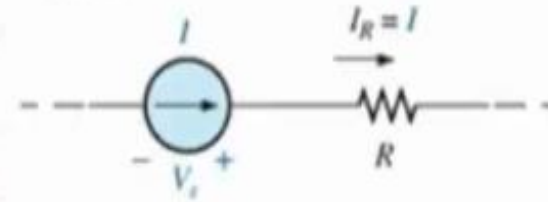
Current source

CURRENT SOURCES

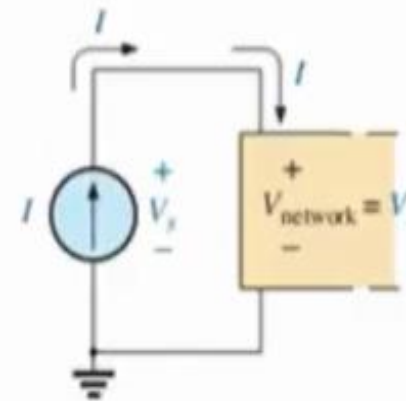
- The current source is often described as the dual of the voltage source.

- Just as a battery provides a fixed voltage to a network, a current source establishes a fixed current in the branch where it is located.

- The symbol for a current source appears in Fig



(a)



Example

EXAMPLE

Find the source voltage, the voltage V_1 , and current I_1 for the circuit in Fig.

Solution:

Since the current source establishes the current in the branch in which it is located, the current I_1 must equal I , and :

$$I_1 = I = 10 \text{ mA}$$

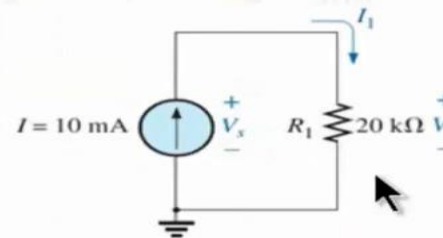
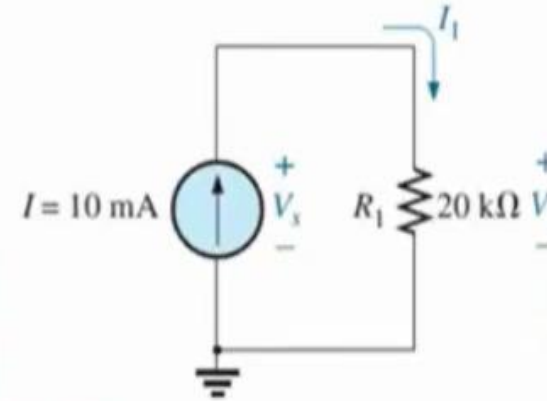
The voltage across R_1 is then determined by Ohm's law:

$$V_1 = I_1 R_1 = (10 \text{ mA})(20 \text{ k}\Omega) = 200 \text{ V}$$

Since resistor R_1 and the current source are in parallel, the voltage across each must be the same, and

$$V_s = V_1 = 200 \text{ V}$$

with the polarity shown.

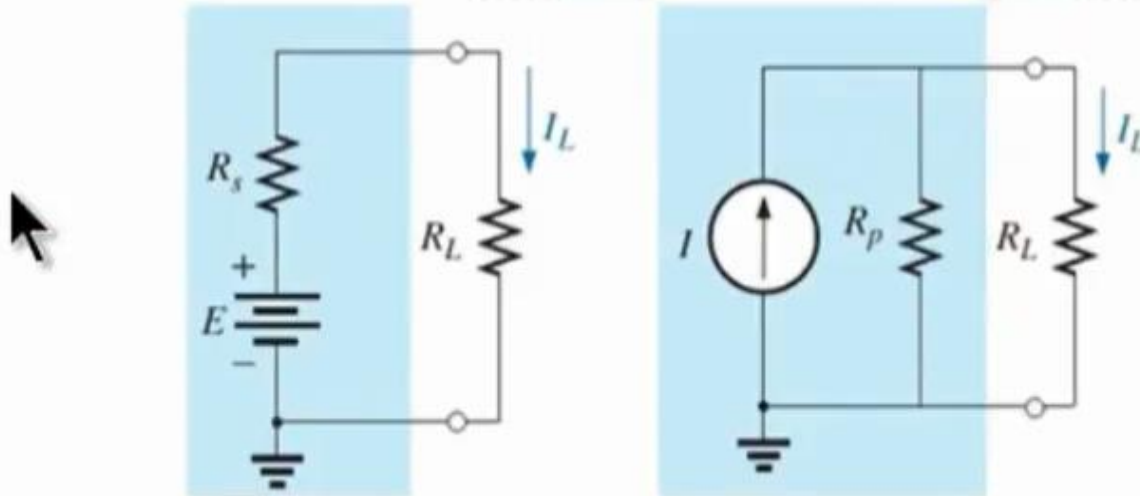


Source Conversions

SOURCE CONVERSIONS

The current source appearing in the previous section is called an ideal source due to the absence of any internal resistance.

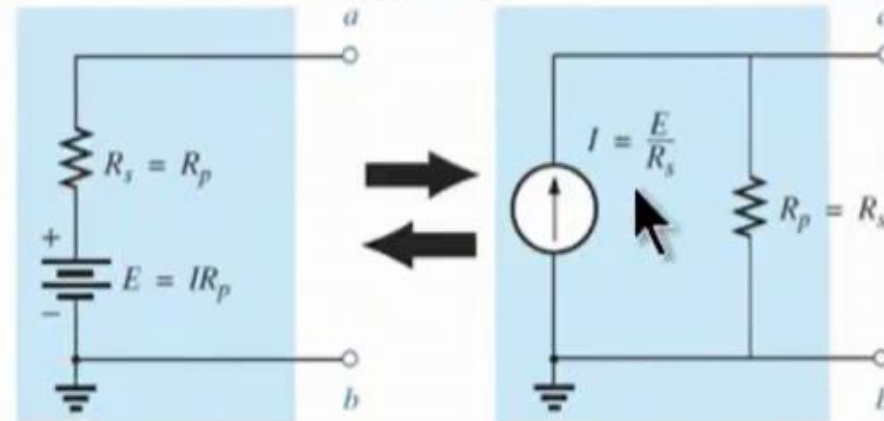
In reality, all sources whether they are voltage sources or current sources have some internal resistance in the relative positions shown in Fig.



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SOURCE CONVERSIONS

This type of equivalence is established using the equations appearing in Fig. First note that the resistance is the same in each configuration a nice advantage. For the voltage source equivalent, the voltage is determined by a simple application of Ohm's law to the current source:



Example

EXAMPLE

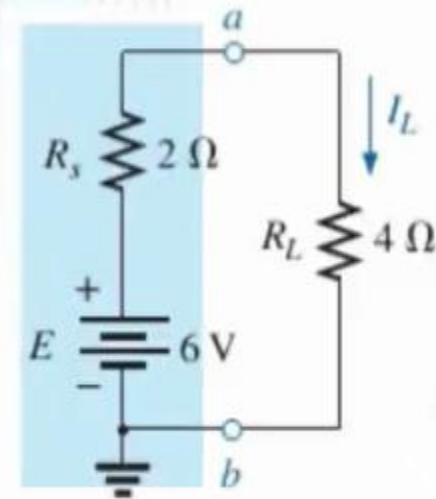
For the circuit in Fig. :

- Determine the current I_L .
- Convert the voltage source to a current source.
- Using the resulting current source of part (b), calculate the current through the load resistor, and compare your answer to the result of part (a).

Solution:

- Applying Ohm's law gives

$$I_L = \frac{E}{R_s + R_L} = \frac{6 \text{ V}}{2 \Omega + 4 \Omega} = \frac{6 \text{ V}}{6 \Omega} = 1 \text{ A}$$

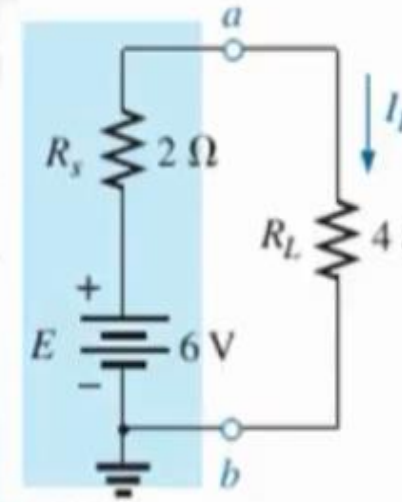


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b. Using Ohm's law again gives

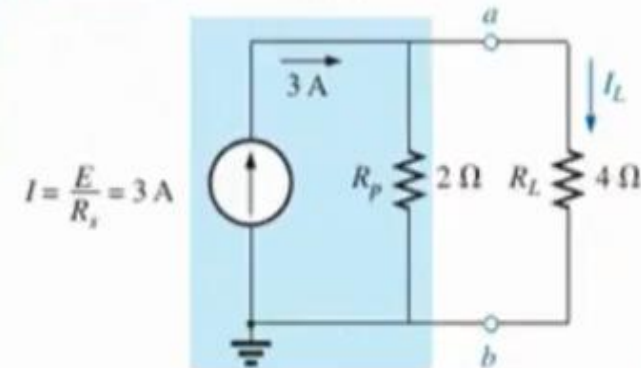
$$I = \frac{E}{R_s} = \frac{6 \text{ V}}{2 \Omega} = 3 \text{ A}$$

and the equivalent source appears in Fig shown below with the load reapplied.



c. Using the current divider rule gives

$$I_L = \frac{R_p I}{R_p + R_L} = \frac{(2\Omega)(3\text{ A})}{2\Omega + 4\Omega} = \frac{1}{3}(3\text{ A}) = 1\text{ A}$$

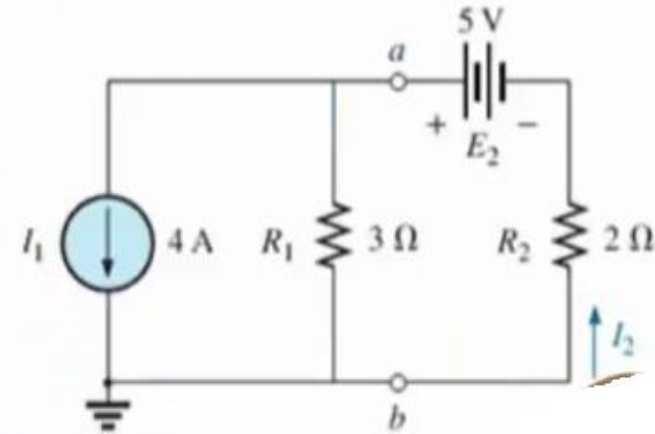


Example

EXAMPLE

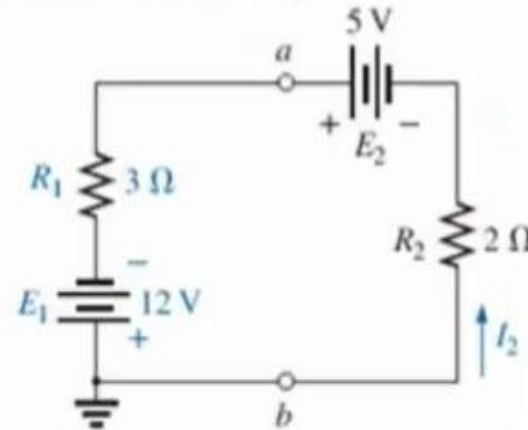
Determine current I_2 for the network in Fig.

Solution:



$$E_1 = I_1 R_1 = (4\text{ A})(3\ \Omega) = 12\text{ V}$$

$$I_2 = \frac{E_1 + E_2}{R_1 + R_2} = \frac{12\text{ V} + 5\text{ V}}{3\ \Omega + 2\ \Omega} = \frac{17\text{ V}}{5\ \Omega} = 3.4\text{ A}$$



Current Source In Parallel

- **Two or more current sources in parallel can be replaced by a single current source having a current magnitude determined by the difference of sum of the currents in one direction and the sum in the opposite direction.**
- **The new parallel internal resistance is the total resistance of the resulting parallel resistive elements**

Example

EXAMPLE

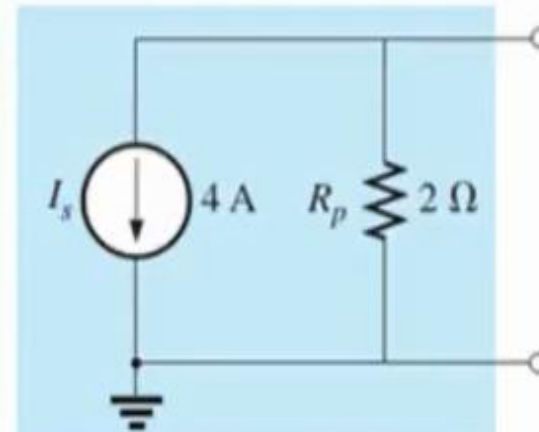
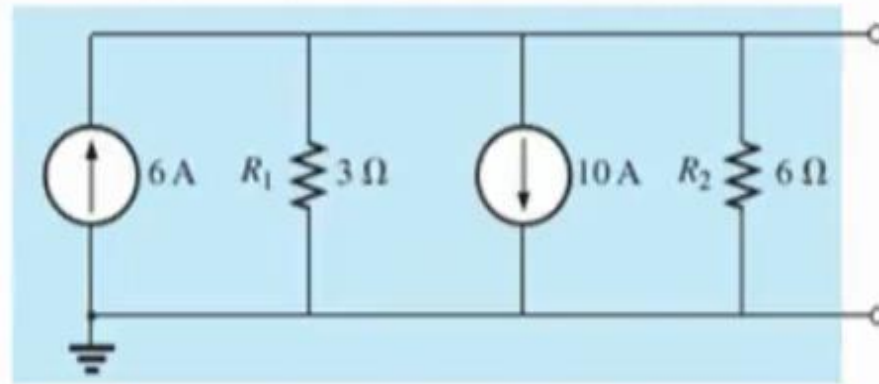
Reduce the parallel current sources in Fig. to a single current source.

Solution:

The net source current is

$$I = 10\text{ A} - 6\text{ A} = 4\text{ A}$$

$$R_p = 3\ \Omega // 6\ \Omega = 2\ \Omega$$



Example

EXAMPLE

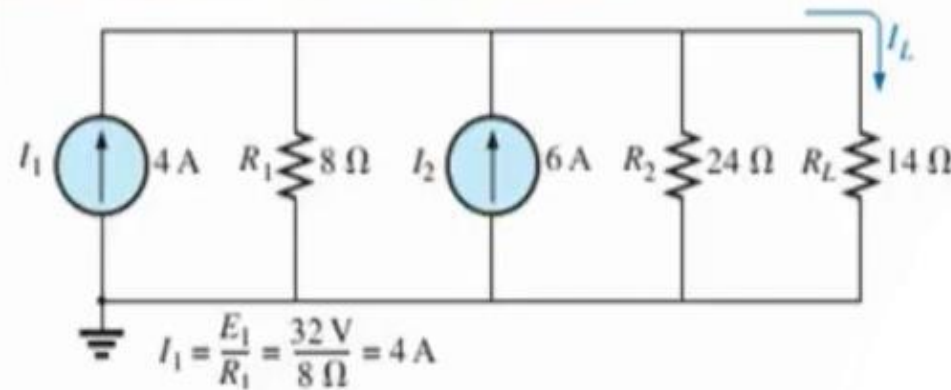
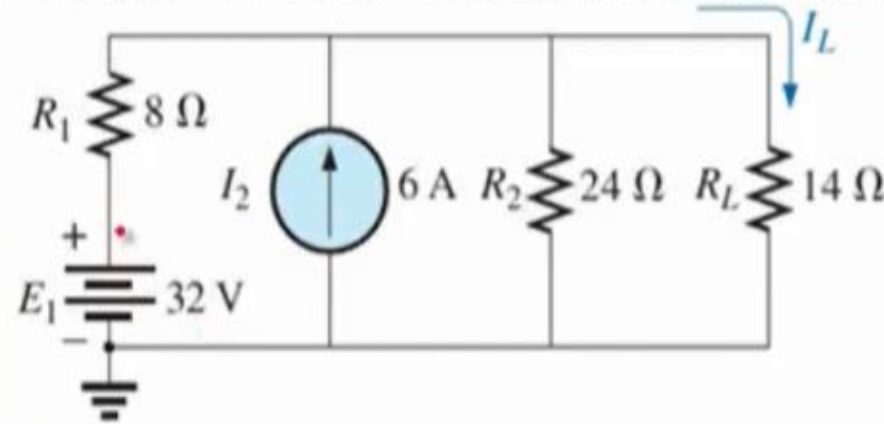
Reduce the network in Fig. to a single current source, and calculate the current through R_L

Solution:

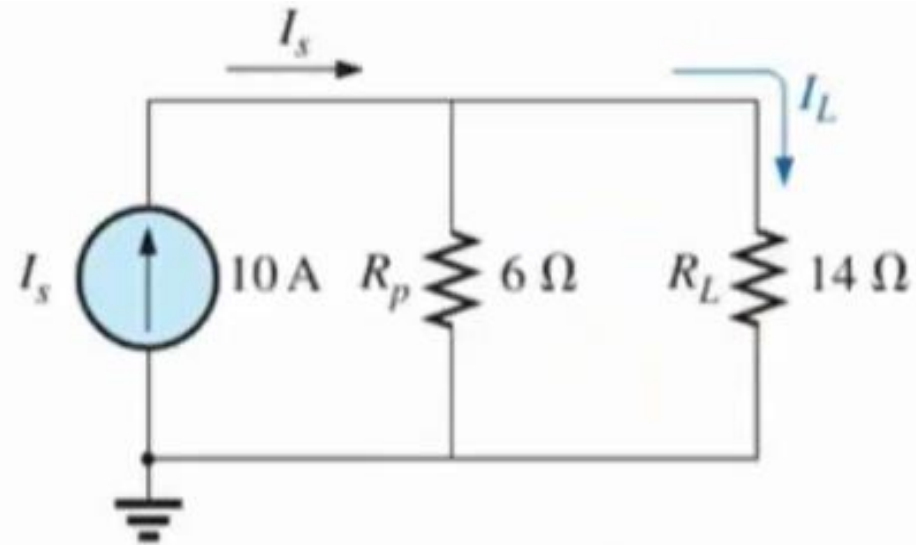
In this example, the voltage source will first be converted to a current source as shown in Fig

$$I_s = I_1 + I_2 = 4 \text{ A} + 6 \text{ A} = \mathbf{10 \text{ A}}$$

$$R_s = R_1 \parallel R_2 = 8 \Omega \parallel 24 \Omega = \mathbf{6 \Omega}$$



continue



Applying the current divider rule to the resulting network in previous Fig. gives

$$I_L = \frac{R_p I_s}{R_p + R_L} = \frac{(6 \Omega)(10 \text{ A})}{6 \Omega + 14 \Omega} = \frac{60 \text{ A}}{20} = 3 \text{ A}$$

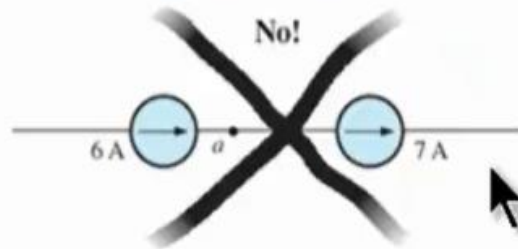
Current Sources In Series

CURRENT SOURCES IN SERIES

We found that voltage sources of different terminal voltages cannot be placed in parallel because of a violation of Kirchhoff's voltage law.

Similarly, ***current sources of different values cannot be placed in series due to a violation of Kirchhoff's current law.***

Therefore,
current sources of different current ratings are not connected in series



Conclusion

Conclusion

Most likely, in your previous studies, the voltage source was the only source appearing in the circuit analysis. This was primarily because voltage sources such as the battery and supply are the most common in our daily lives and in the laboratory environment.

But in this chapter, We turned our attention to a second type of source, called the current source , which appeared throughout the analysis.