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جامعة الشام الخاصة
كلية الهندسة المعلوماتية

أسس الهندسة الكهربائية
لطلاب السنة الثانية
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Chapter 3
Basic Concepts

الفصل الثالث
مفاهيم أساسية

2020 - 2021

References

1. Charles K. Alexander, Matthew N. O. Sadiku, “Fundamentals of Electric Circuits”, 2nd Ed, McGraw Hill, 2009.
ISBN 978–0–07–352955–4

3. Basic Concepts

3.1 Systems of Units

3.2 Charge and Current

3.3 Voltage

3.4 Power and Energy

3.5 Circuit Elements

3.6 Summary

3.4 Power and Energy

- على الرغم من أن التيار والتوتر هما المتغيران الاساسيان في الدارة الكهربائية، فهما غير كافيان في حد ذاتهما.

- ومن الناحية العملية، نحتاج لمعرفة استطاعة **power** الجهاز الكهربائي الذي نتعامل معه. ونحن جميعا نعرف من التجربة أن لمبة ١٠٠ وات تعطي مزيدا من الضوء أكثر من لمبة ٦٠ وات.

- عندما ندفع فواتيرنا لشركات الطاقة الكهربائية، نحن ندفع ثمن الطاقة الكهربائية المستهلكة خلال فترة معينة من الزمن **energy** .

- وهكذا فإن حسابات الاستطاعة **power** والقدرة **energy** مهمة في تحليل الدارات.

Power is the time rate of absorbing energy, measured in watts (W).

$$p = \frac{dw}{dt}$$

w = energy (J), t = time (s)

$$p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt}$$

$$p = \frac{dw}{dt} = \frac{dw}{dq} \cdot \frac{dq}{dt} = vi$$

(v = $\frac{dw}{dq}$, i = $\frac{dq}{dt}$)

$$p = vi \quad (instantaneous\ power)$$

Passive sign convention is satisfied when the current enters through the positive terminal of an element and p = + vi. If the current enters through the negative terminal, p = - vi.

$$+Power\ absorbed = -\ Power\ supplied$$

مستهلك

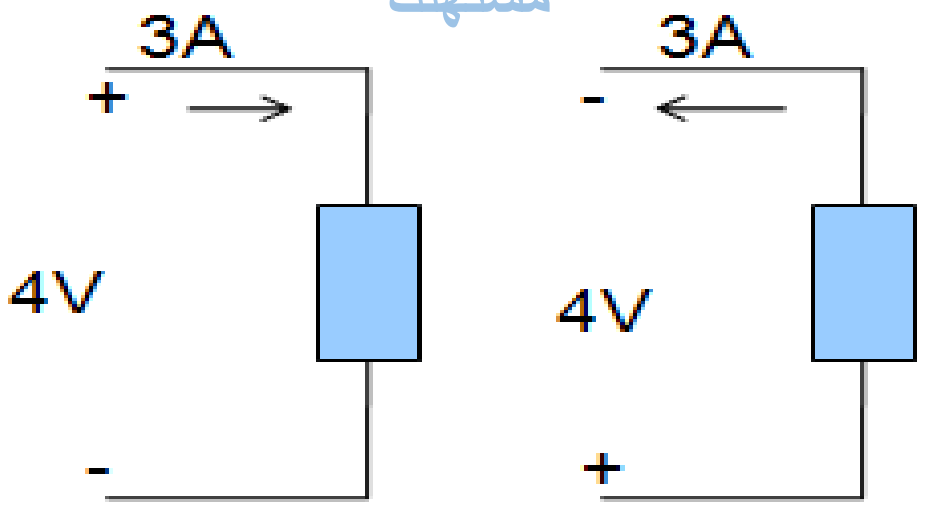


Fig. 1: Cases of absorbing power
(p = 12 W; Element absorbs 12 W)

منبع

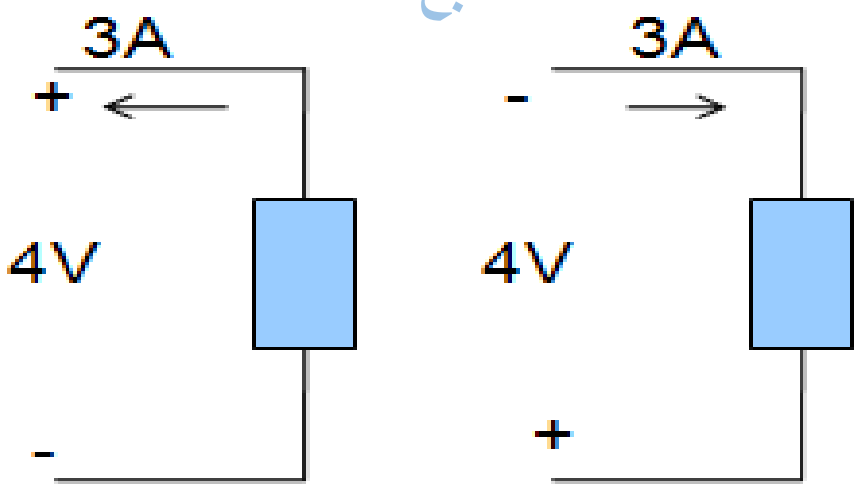


Fig. 2: Cases of supplying power
(p = -12 W; Element supplies 12 W)

- **Law of conservation of energy**: **قانون مصونية الطاقة**

- المجموع الجبري للاستطاعات في الدارة في أي لحظة زمنية يجب أن تساوي الصفر.أو الاستطاعة الكلية المتولدة في الدارة يجب أن تساوي الاستطاعة المستهلة.

$$\sum p = 0$$

القدرة المستهلكة أو المتولدة من أي عنصر من اللحظة t_0 الى اللحظة t تعطى بالعلاقة:

$$W = \int_{t_0}^{t} p \, dt = \int_{t_0}^{t} vi \, dt$$

- القدرة Energy هي المقدرة على تنفيذ عمل مقاسة بالجول (j) .
- شركات الطاقة الكهربائية تقيس القدرة بالواط الساعي (wh)، حيث :

1 Wh = 3600 J

Example 3.4

An energy source forces a constant current of 2 A for 10 S to flow through a light bulb. If 2.3 kJ is given off in the form of light and heat energy, calculate the voltage drop across the bulb.

Solution:

المطلوب : $v = \frac{\Delta w}{\Delta q}$?

المعطيات:

$i = 2\ A$

$\Delta t = 10\ S$

$\Delta w = 2.3\ Kj$

The total charge is

$$\Delta q = i\,\Delta t = 2 \times 10 = 20\ \text{C}$$

The voltage drop is

$$v = \frac{\Delta w}{\Delta q} = \frac{2.3 \times 10^3}{20} = 115\ \text{V}$$

Practice Problem 3.4

To move charge q from point a to point b requires -30 J. Find the voltage drop v_{ab} if: (a) q = 2 C, (b) q = -6 C.

Answer: (a) -15 V, (b) 5 V.

Example 3.5

Find the power delivered to an element at t = 3ms if the current entering its positive terminal is:

i = 5 cos 60 π t A and the voltage is:

(a) **v = 3i**. (b) **v = 3 di/dt.**

Solution:

(a) The voltage is $v = 3i = 15 \cos 60\pi t$; hence, the power is

$$p = vi = 75 \cos^2 60\pi t \text{ W}$$

At $t = 3$ ms,

$$p = 75 \cos^2 (60\pi \times 3 \times 10^{-3}) = 75 \cos^2 0.18\pi = 53.48 \text{ W}$$

(b) We find the voltage and the power as

$$v = 3\frac{di}{dt} = 3(-60\pi)5 \sin 60\pi t = -900\pi \sin 60\pi t \text{ V}$$

$$p = vi = -4500\pi \sin 60\pi t \cos 60\pi t \text{ W}$$

At $t = 3$ ms,

$$p = -4500\pi \sin 0.18\pi \cos 0.18\pi \text{ W}$$

$$= -14137.167 \sin 32.4^\circ \cos 32.4^\circ = -6.396 \text{ kW}$$

Practice Problem 3.5

Find the power delivered to the element in Example 1.5 at t = 5 ms if the current remains the same but the voltage is: (a) v = 2i V,

Answer: (a) 17.27 W, (b) 29.7 W.

$$\text{(b) } v = \left(10 + 5\int_0^t i\,dt\right) \text{V}.$$

Example 3.6

كم من الطاقة الكهربائية تستهلك لمبة استطاعتها ١٠٠ واط في ساعتين ؟

Solution:

$$w = pt = 100\,(\mathrm{W}) \times 2\,(\mathrm{h}) \times 60\,(\mathrm{min/h}) \times 60\,(\mathrm{s/min})$$
$$= 720{,}000\ \mathrm{J} = 720\ \mathrm{kJ}$$

This is the same as

$$w = pt = 100\ \mathrm{W} \times 2\ \mathrm{h} = 200\ \mathrm{Wh}$$

Practice Problem 3.6

A stove element draws 15 A when connected to a 240-V line. How long does it take to consume 60 kJ?

Answer: 16.667 s.

3.5 Circuit Elements عناصر الدارة

- الدارة الكهربائية هي ببساطة ترابط بين عناصر الدارة
- تحليل الدارة هو عملية تحديد التوتر الهابط على عناصرها أو التيار المار بهذه العناصر.
- يوجد نوعان من العناصر:

العناصر الخاملة (Passive elements) وهي العناصر التي لا تولد استطاعة مثل المقاومات والملفات والمكثفات.

العناصر الفعالة (Active elements) وهي العناصر القادرة على توليد استطاعة مثل المولدات والبطاريات.

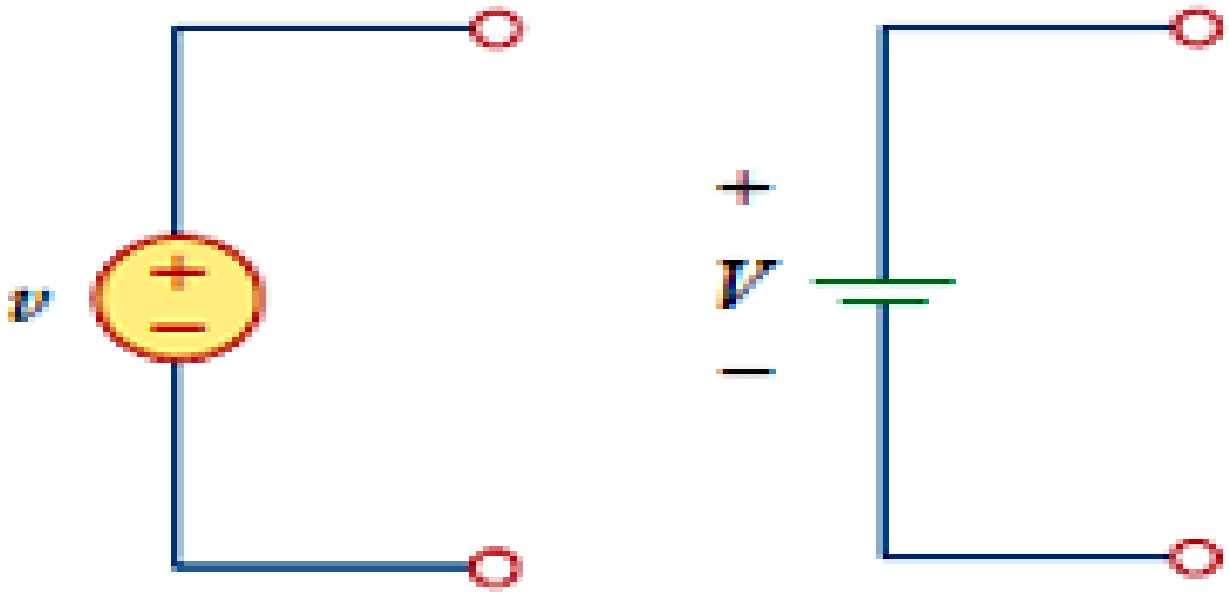
- العناصر الفعالة الاكثر أهمية هي منابع التوتر أو منابع التيار.
- يوجد نوعان من المنابع منابع مستقلة ومنابع غير مستقلة.

An ideal independent source *is an active element that provides a specified voltage or current that is completely independent of other circuit elements.*

An ideal dependent (controlled) source *is an active element in which the source quantity is controlled by another voltage or current.*

المنابع المستقلة:

منابع توتر مستقلة



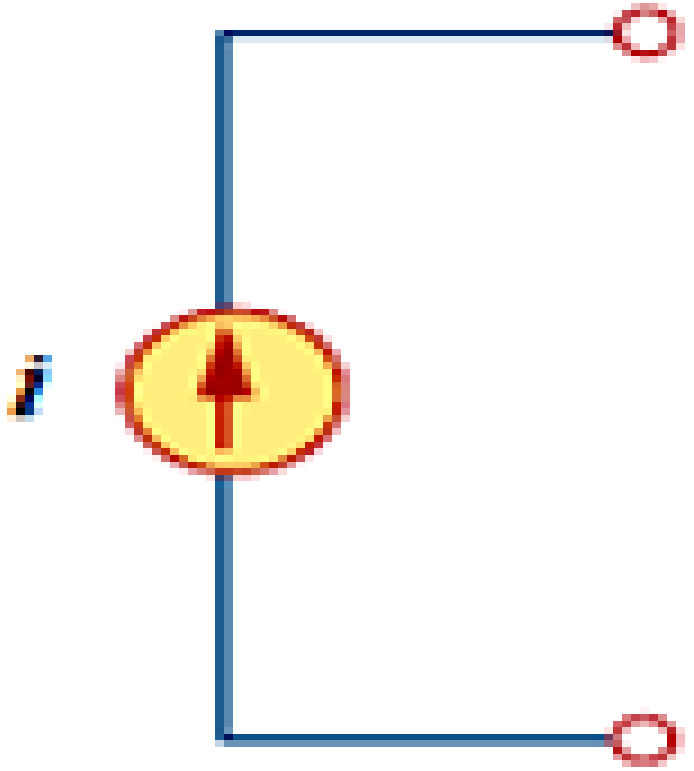
(a) (b)

يستخدم لكلا حالتي المنبعين المستمر والمتناوب.

يستخدم في حالة المنبع المستمر فقط.

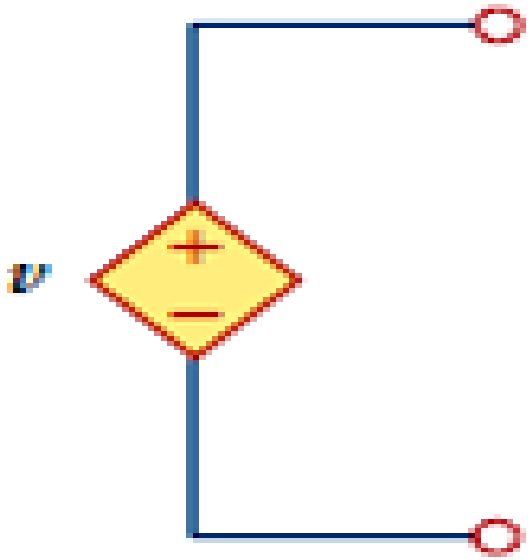
Symbols for independent voltage sources: (a) used for constant or time-varying voltage, (b) used for constant voltage (dc).

منبع تيار مستقل



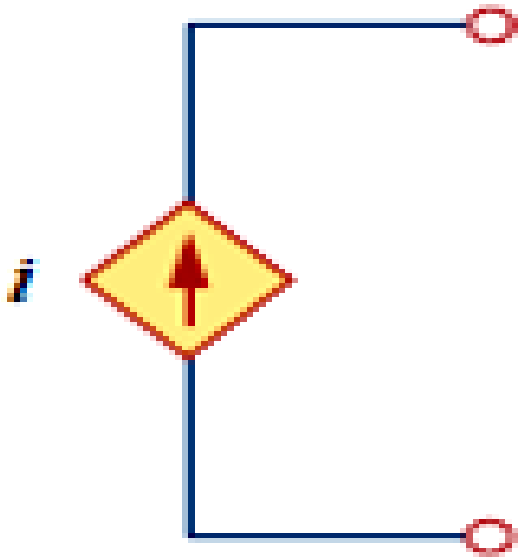
Symbol for independent current source.

المنابع غير المستقلة:



(a)

منبع توتر غير مستقل



(b)

منبع تيار غير مستقل

Symbols for: (a) dependent voltage source,
(b) dependent current source.

فمثلاً هذه الدارة تحوي منبعين منبعاً مستقلاً ومنبعاً غير مستقل.

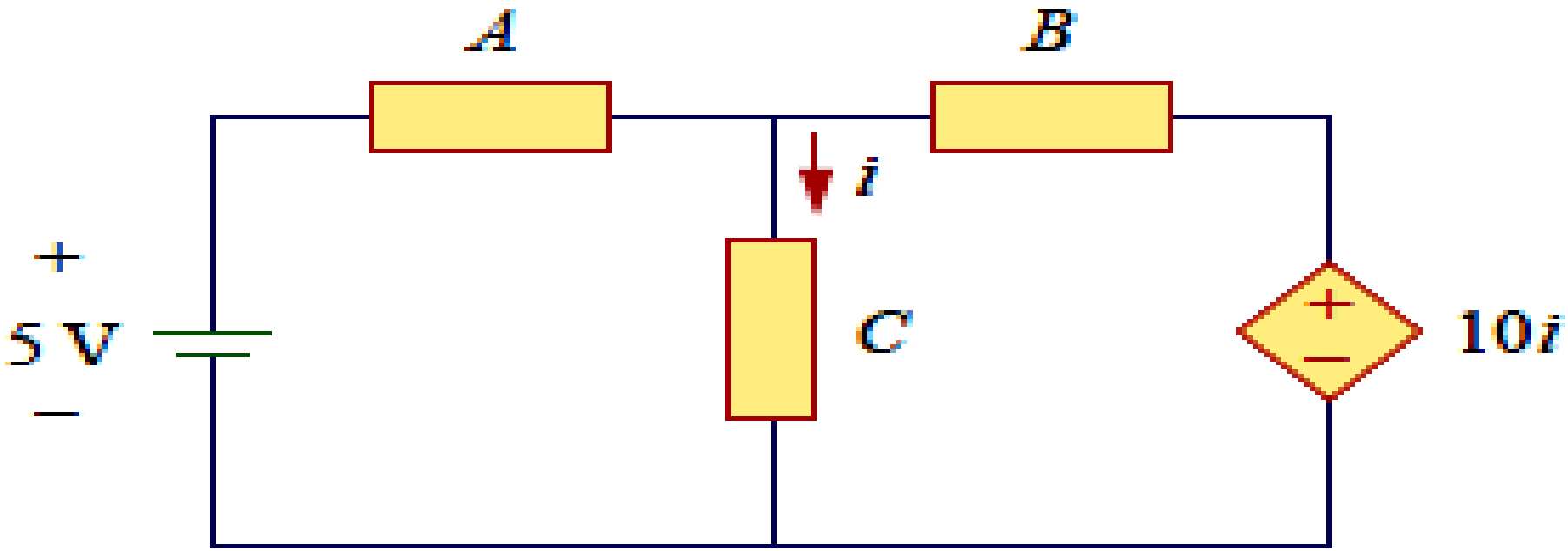


Figure 1.14
The source on the right-hand side is a current-controlled voltage source.

Example 3.7

Calculate the power supplied or absorbed by each element in Fig. 1.15.

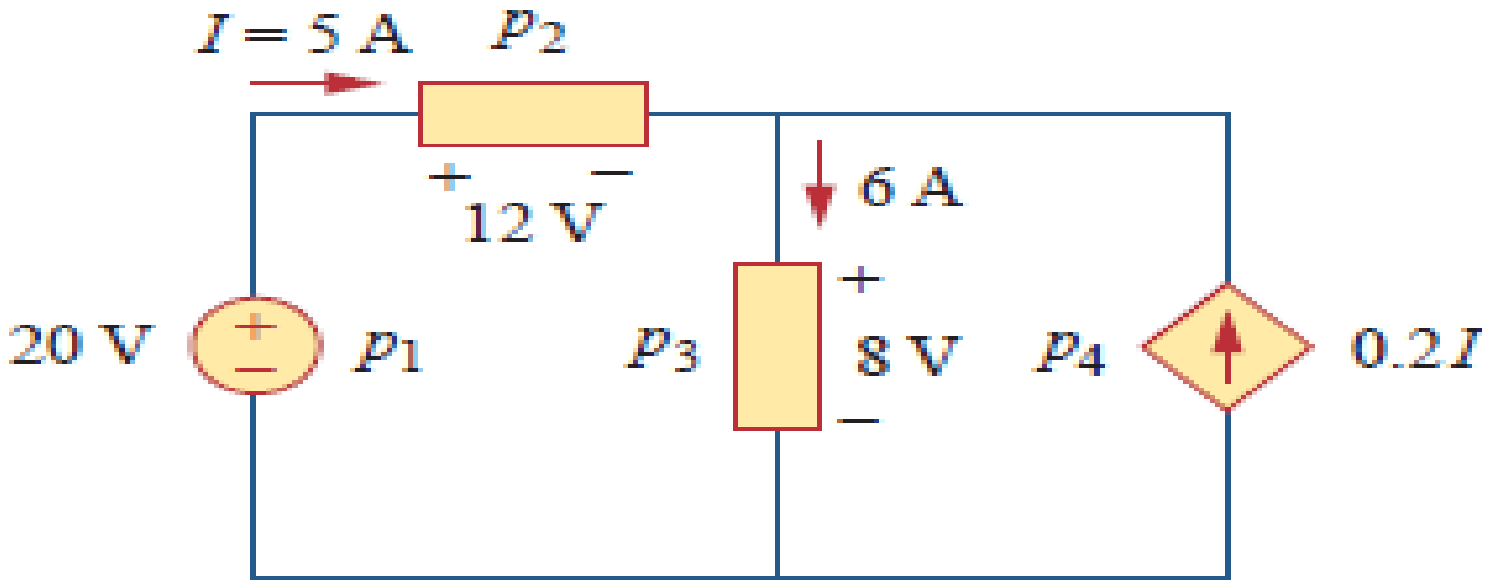


Fig. 1.15

Solution:

For p_1, the 5-A current is out of the positive terminal (or into the negative terminal); hence,

$$p_1 = 20(-5) = -100 \text{ W} \qquad \text{Supplied power}$$

For p_2 and p_3, the current flows into the positive terminal of the element in each case.

$$p_2 = 12(5) = 60 \text{ W} \qquad \text{Absorbed power}$$
$$p_3 = 8(6) = 48 \text{ W} \qquad \text{Absorbed power}$$

For p_4, we should note that the voltage is 8 V (positive at the top), the same as the voltage for p_3, since both the passive element and the dependent source are connected to the same terminals. (Remember that voltage is always measured across an element in a circuit.) Since the current flows out of the positive terminal,

$$p_4 = 8(-0.2I) = 8(-0.2 \times 5) = -8 \text{ W} \qquad \text{Supplied power}$$

We should observe that the 20-V independent voltage source and $0.2I$ dependent current source are supplying power to the rest of the network, while the two passive elements are absorbing power. Also,

$$p_1 + p_2 + p_3 + p_4 = -100 + 60 + 48 - 8 = 0$$

the total power supplied equals the total power absorbed.

Practice Problem 3.7

Compute the power absorbed or supplied by each component of the circuit in Fig. 1.16.

Answer: p1 = 40 W, p2 = 16 W, p3 = 9 W, p4 = 15 W

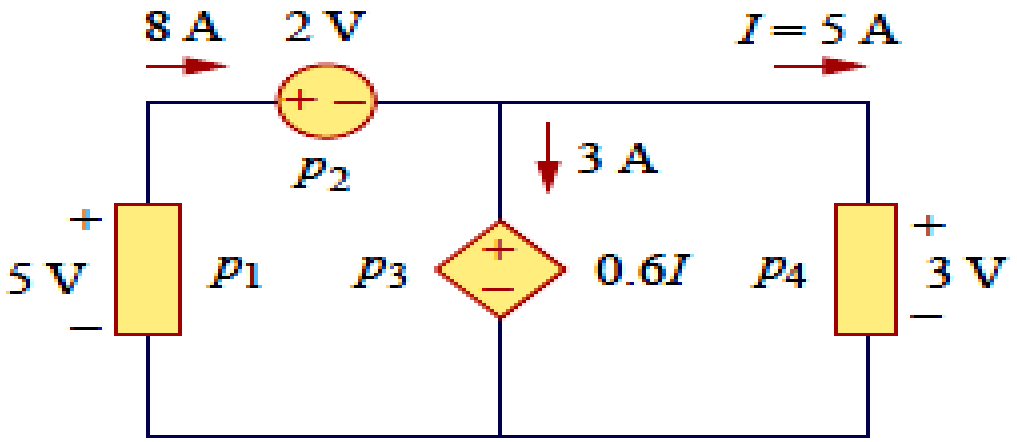


Figure 1.16

3.6 Summary

1. An electric circuit consists of electrical elements connected together.
2. The International System of Units (SI) is the international measurement language, which enables engineers to communicate their results. From the six principal units, the units of other physical quantities can be derived.
3. Current is the rate of charge flow. $\mathrm{i} = \frac{\mathrm{dq}}{\mathrm{dt}}$
4. Voltage is the energy required to move 1 C of charge through an element. $v = \frac{dw}{dq}$
5. Power is the energy supplied or absorbed per unit time. It is also the product of voltage and current. $p = \frac{dw}{dt} = vi$
6. According to the passive sign convention, power assumes a positive sign when the current enters the positive polarity of the voltage across an element.
7. An ideal voltage source produces a specific potential difference across its terminals regardless of what is connected to it. An ideal current source produces a specific current through its terminals regardless of what is connected to it.
8. Voltage and current sources can be dependent or independent. A dependent source is one whose value depends on some other circuit variable.
9. Two areas of application of the concepts covered in this chapter are the TV picture tube and electricity billing procedure.

END OF LECTURE