



PART 1 : DC ANALYSIS

Chapter 1 Basic Concept

2022.1



Chapter 1 Basic Concept

1.1 Charge and Current

1.2 Voltage

1.3 Passive sign convention

1.4 Circuit Elements

1.5 Summary and Review

1.1 Charge and Current

1. Charge

- The most basic quantity in an electric circuit is the electric charge.
- **Charge** is an electrical property of the atomic particles of which matter consists, measured in **coulombs (C)**.
- The charge **e** on one electron is negative and equal in magnitude to $1.602 \times 10^{-19} \text{ C}$ which is called as **electronic charge**.
- A unique feature of electric charge is the fact that it can be transferred from one place to another, where it can be converted to another form of energy.

2. Current

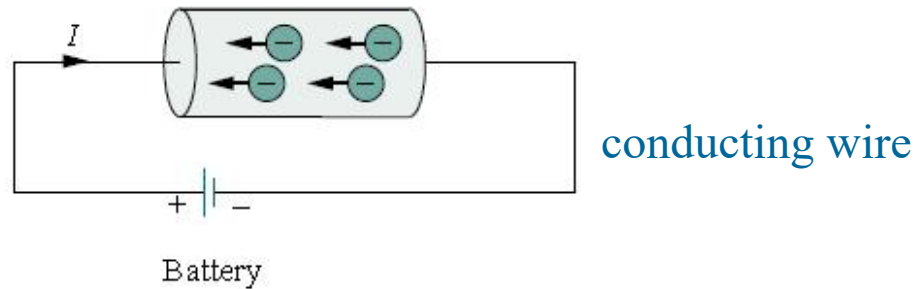


Figure 1.1 Electric current due to flow of electronic charge in a conductor.

- When a conducting wire (consisting of several atoms) is connected to a battery (a source of electromotive force), the charges are compelled to move;
- Positive charges move in one direction while negative charges move in the opposite direction.
- **This motion of charges creates electric current.**
- **The current has two factors: a numerical value ,a direction.**
- It is conventional to take the current flow as the movement of positive charges,so opposite to the flow of negative charges(see Figure 1,1, current direction)

2. Current

Electric current is the time rate of change of charge, measured in amperes (A).

- The relationship between current i , charge q , and time t

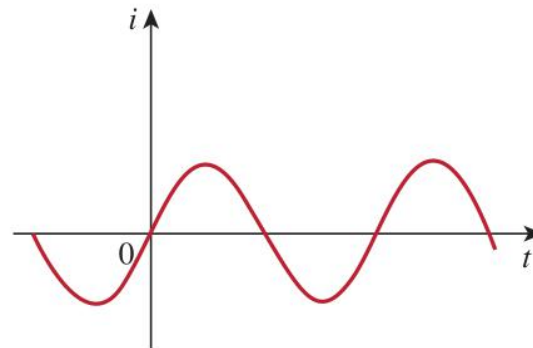
$$i = \frac{dq}{dt}$$

$$q = \int_{t_0}^t i dt$$

- The unit of current is the ampere (A), and it can be derived as **1 A = 1C/s**.
- A **direct current (dc)** is a current that remains constant with time.
- An **alternating current (ac)** is a current that varies sinusoidally with time.



(a) direct current (dc)



(b) alternating current (ac)

Figure 1.2 Two common types of current

EXAMPLE 1.1

The total charge entering a terminal is given by

$q = 5t \sin 4\pi t$ mC. Calculate the current at $t = 0.5$ s.

$$i = \frac{dq}{dt}$$

Solution:

$$i = \frac{dq}{dt} = \frac{d}{dt}(5t \sin 4\pi t) \text{ mC/s} = (5 \sin 4\pi t + 20\pi t \cos 4\pi t) \text{ mA}$$

At $t = 0.5$,

$$i = 5 \sin 2\pi + 10\pi \cos 2\pi = 0 + 10\pi = 31.42 \text{ mA}$$

2. Current

- **Note:** Definition of the current contains two factors:
a numerical value, a direction.

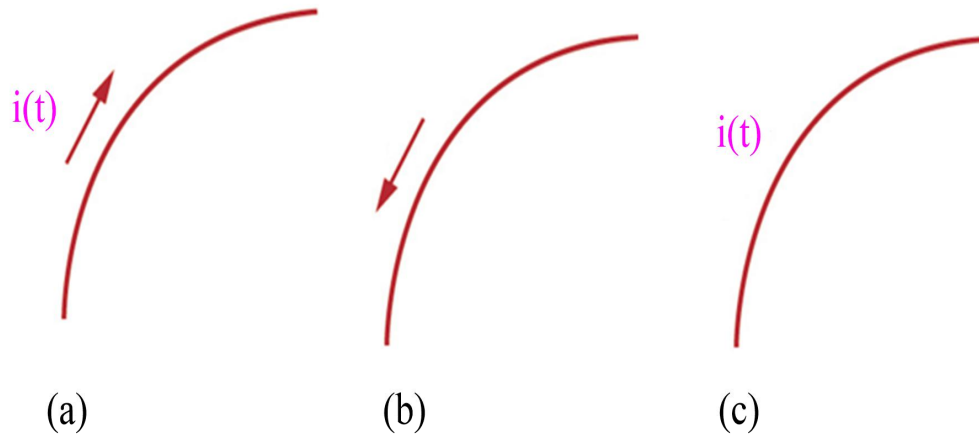


Figure 1.3 (a) the correct definition of $i(t)$ (b, c) incomplete, improper and incorrect definitions of a current

2. Current

EXAMPLE 1.2

In the wire of Fig. 1.4 electrons moving from *left* to *right* to create a current of 1 mA. Determine I_1 and I_2 .

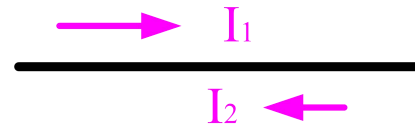


Figure 1.4

Solution:

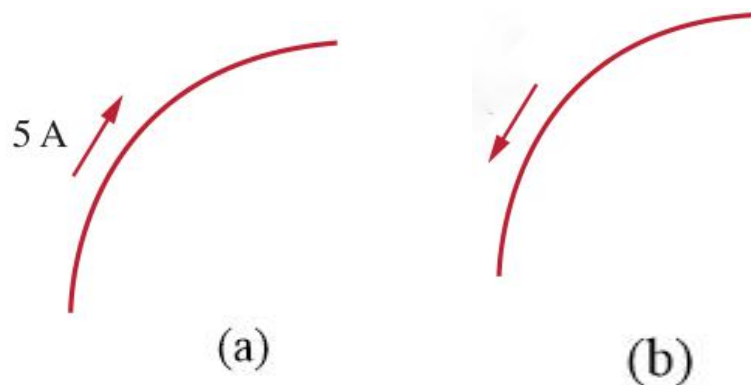
The direction of current is conventionally taken as the direction of positive charge movement, so

$$I_1 = -1 \text{ mA}; \quad I_2 = +1 \text{ mA}.$$

Note: For the same wire in Figure 1.4, the direction of I_2 is the opposite of I_1 , and its value is also the opposite of I_1 .

The real value and direction of the current is the same.

The current of one wire is shown in fig1(a). If its direction is as fig 1(b), then its numerical value is



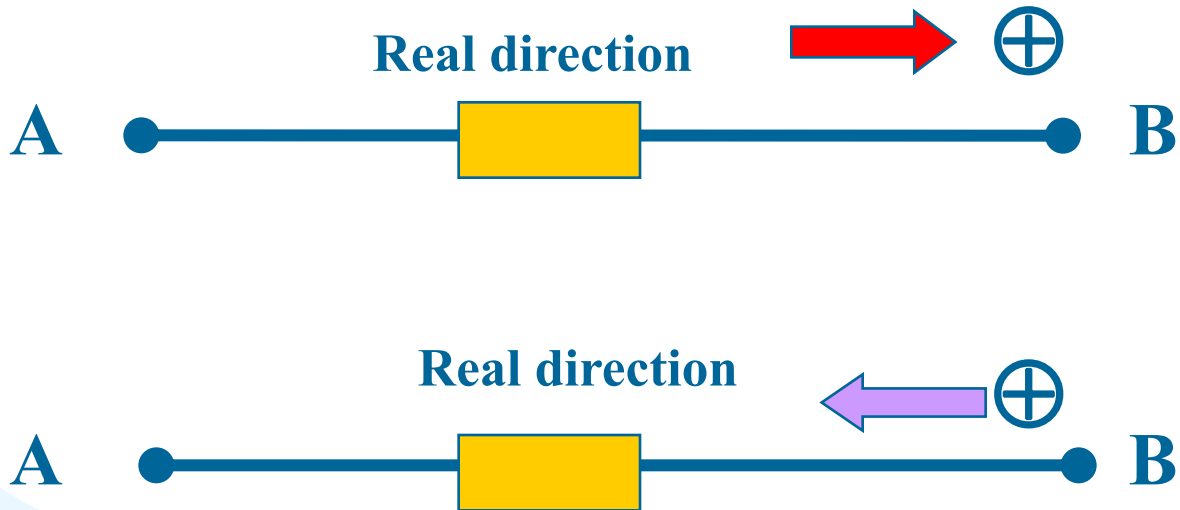
- ☐ A 5A
- ☒ B -5A
- ☐ C 0A

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2. Current

Current direction

- The direction of current flow is conventionally taken as the direction of positive charge movement



Question:

In a complex circuit or direction of current flow change with time, how to estimate real direction of current?

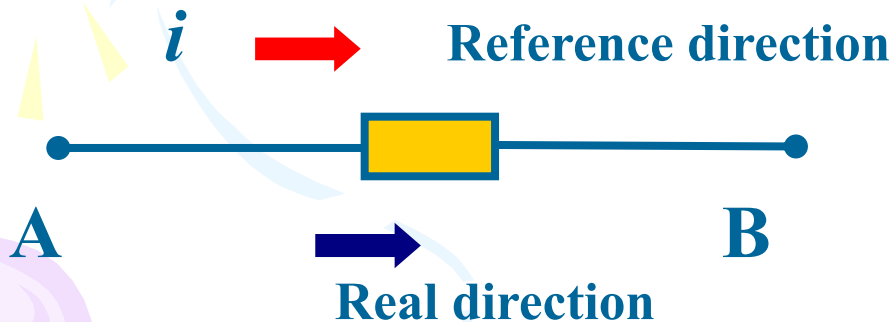
2. Current

Reference direction

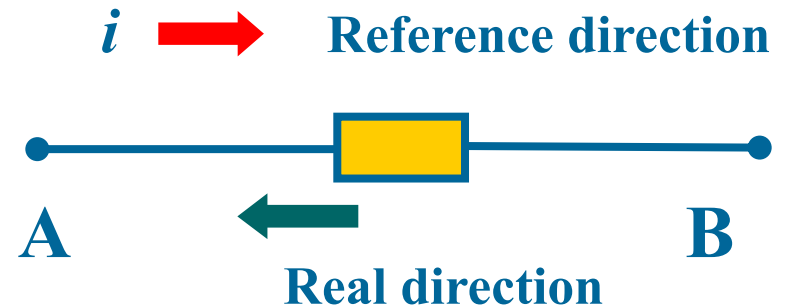
The direction of positive charge movement



Relation of reference direction and real direction:



$$i > 0$$

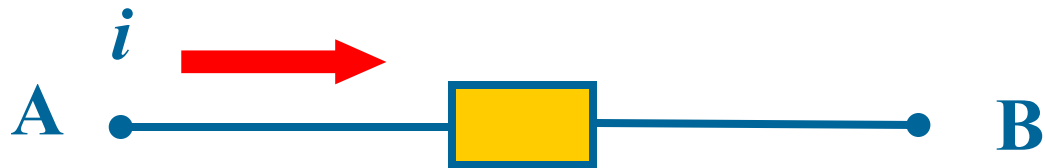


$$i < 0$$

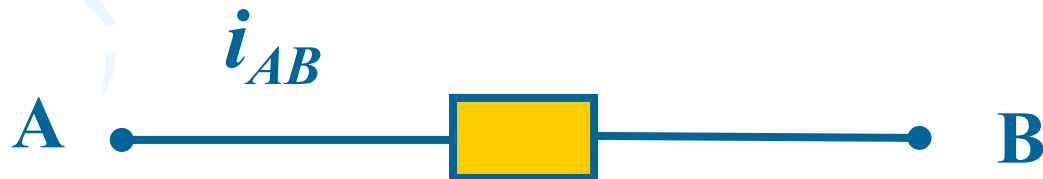
2. Current

Two express of reference direction:

- Arrowhead: Arrowhead point to current referent direction

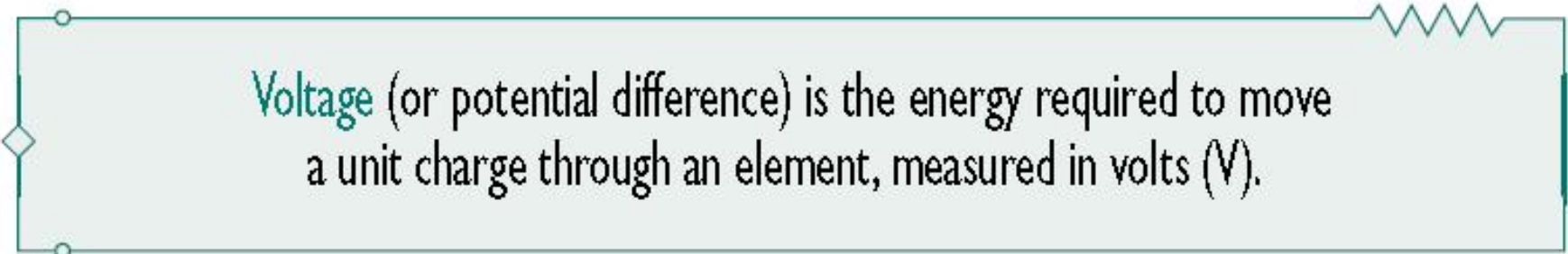


- Subscript: such as i_{AB} ; referent direction: from A to B.



1.2 Voltage

- The voltage (or potential difference) across a terminal pair is the work (energy) required to move a unit charge through an element, measured in volts (V).
- Mathematically,
$$v_{ab} = \frac{dw}{dq} \text{ (volt)}$$



Voltage (or potential difference) is the energy required to move a unit charge through an element, measured in volts (V).

- Definition of the current contains two factors:
a numerical value, a direction.

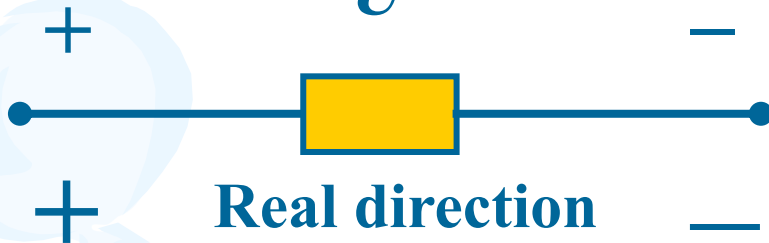
Question:

For complex circuit, how to make certain voltage direction?

Voltage drop reference direction

Reference Direction

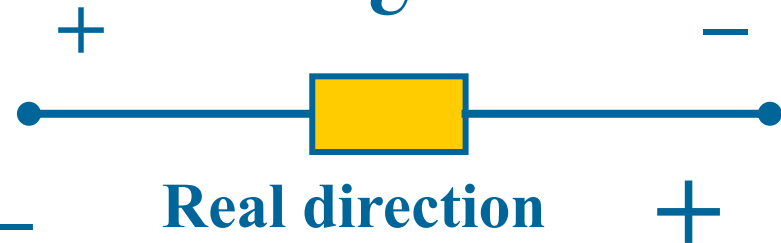
U



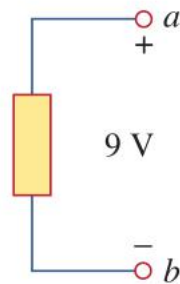
$$U > 0$$

Reference Direction

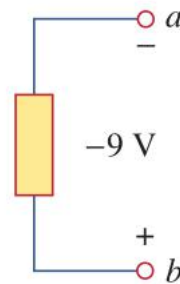
U



$$U < 0$$



(a)

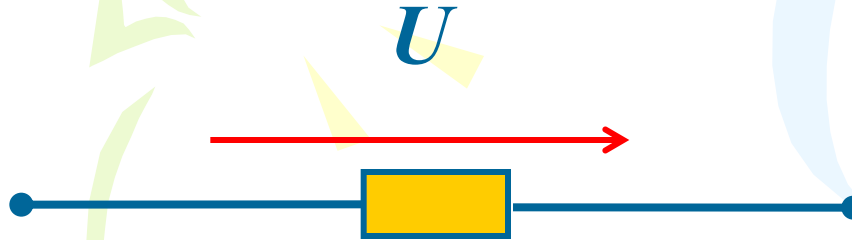


(b)

Figure 1.5 Two equivalent representations of the same voltage :
(a) Point a is 9 V above point b; (b) point b is 9 V above point a.

Express for Voltage drop reference direction:

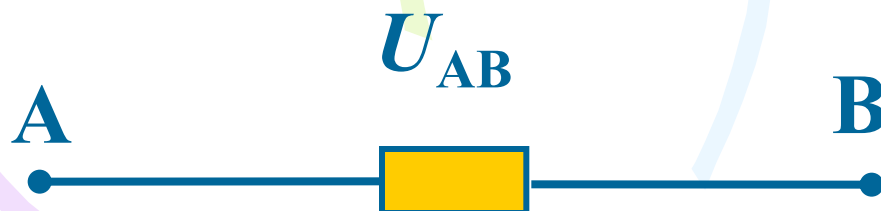
(1) Arrow :



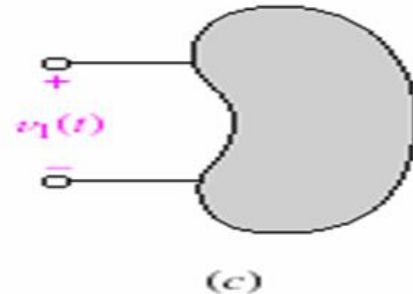
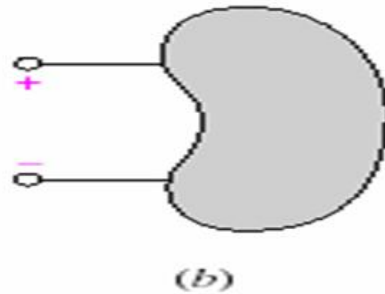
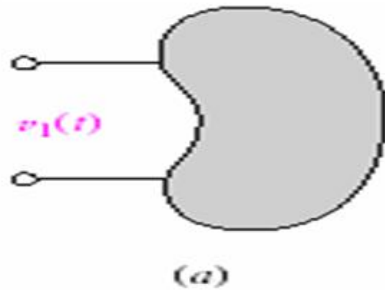
(2) Polarity of plus and minus:



(3) Subscript:



Which voltage expression is incorrect?



☒ A (a)

☒ B (b)

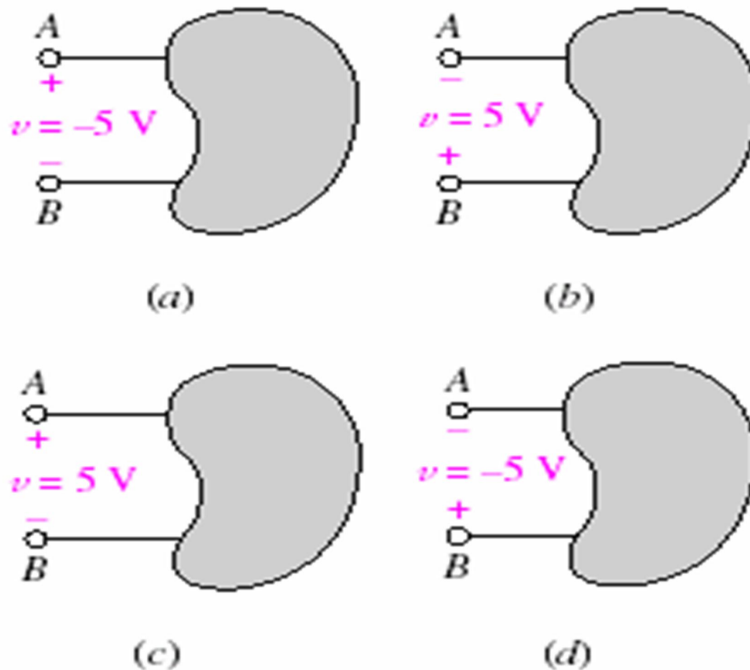
☐ C (c)

☐ D All

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In Fig. 1.6, which two volateges are the same.

Figure 1.6



(a, b) Terminal B is 5 V positive with respect to terminal A; (c, d) terminal A is 5 V positive with respect to terminal B.

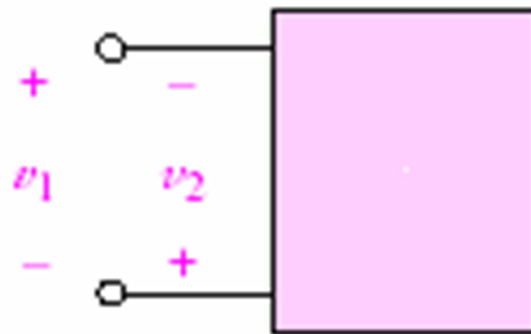
(a) and ?

(d) and ?

For the element in the following figure 1.7.

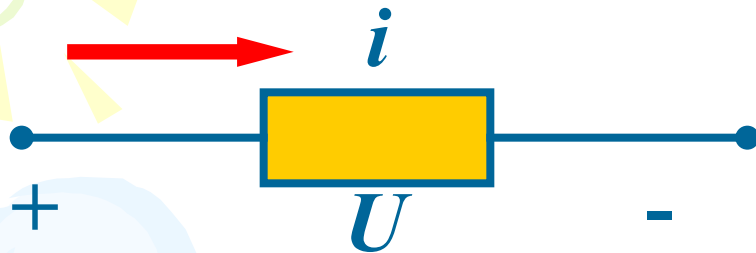
$v_1 = 17$ V. Then $v_2 =$ [填空1]

Figure 1.7

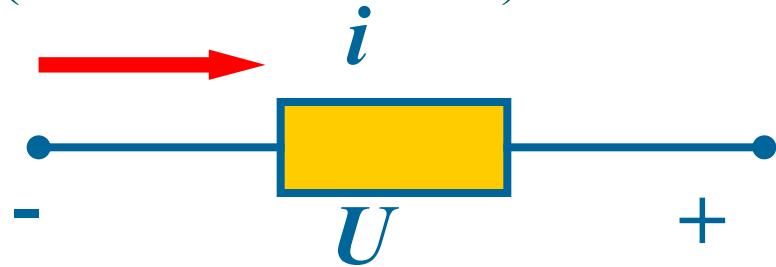


1.3 Passive sign convention

- Passive sign convention: current(reference direction) enters through the positive polarity of the voltage (reference direction).

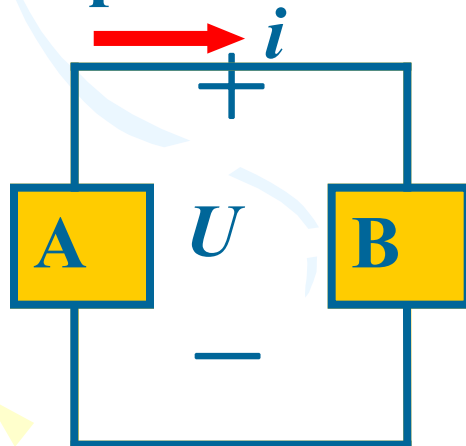


Passive sign convention
Associate Reference Direction



Active sign convention
Non-associate Reference Direction

Example:



Solution:

A Active sign convention

Non-associate Reference Direction

B Passive sign convention

Associate Reference Direction

Summary



The current has two factors:

value, reference direction

If $i > 0$, reference direction and real direction are the same.

If $i < 0$, reference direction and real direction are the opposite.

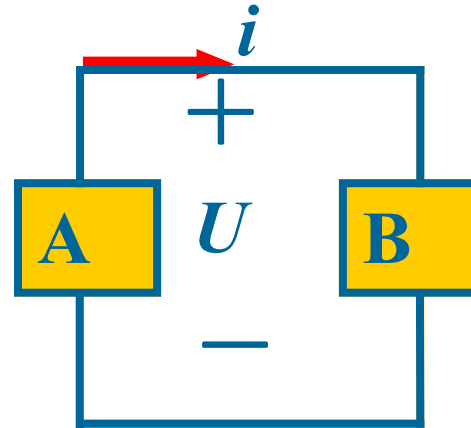


The voltage has two factors:

value, reference direction

If $u > 0$, reference direction and real direction are the same.

If $u < 0$, reference direction and real direction are the opposite.



For A: Active sign convention

Non-associate Reference Direction

For B: Passive sign convention

Associate Reference Direction

Absorbing power

For A: $P = -vi$

For B: $P = vi$

For an element:

Supplying power = Absorbing power

Homework (First time)

1. The charge entering a certain element is shown in Fig.1. Find the current at: (a) $t=1\text{ms}$ (b) $t=6\text{ms}$ (c) $t=10\text{ms}$
2. Determine whether the voltage and current are Passive sign convention or not for the element in Figure 2(a) and 2(b).
3. Determine whether the voltage and current are Passive sign convention or not for the element in Figure 3.

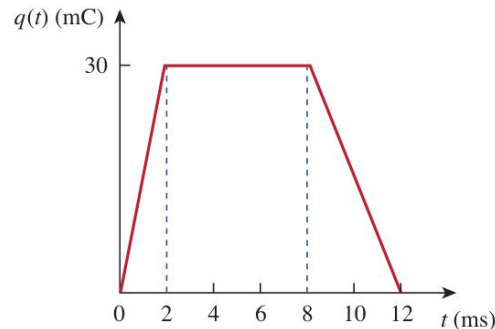


Figure 1

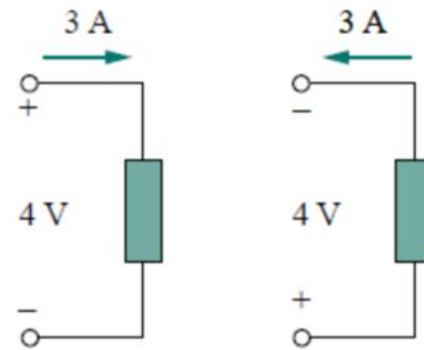


Figure 2

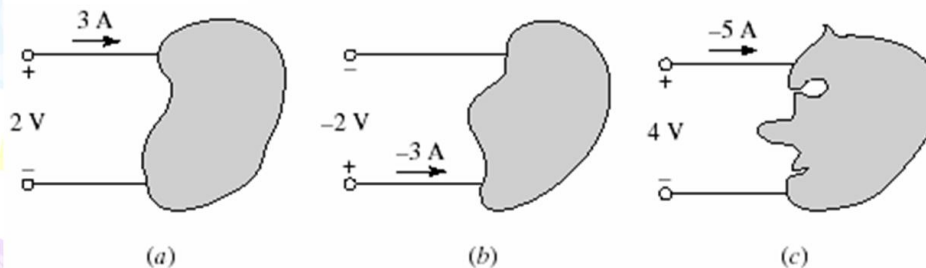


Figure 3