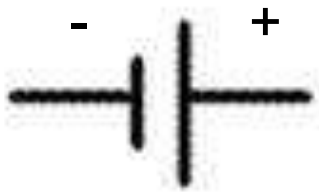
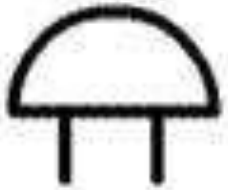
Electronic circuit analysis

Switch



Voltage Source

bulb



bell

electromotor

amperemeter

voltmeter

Resistor

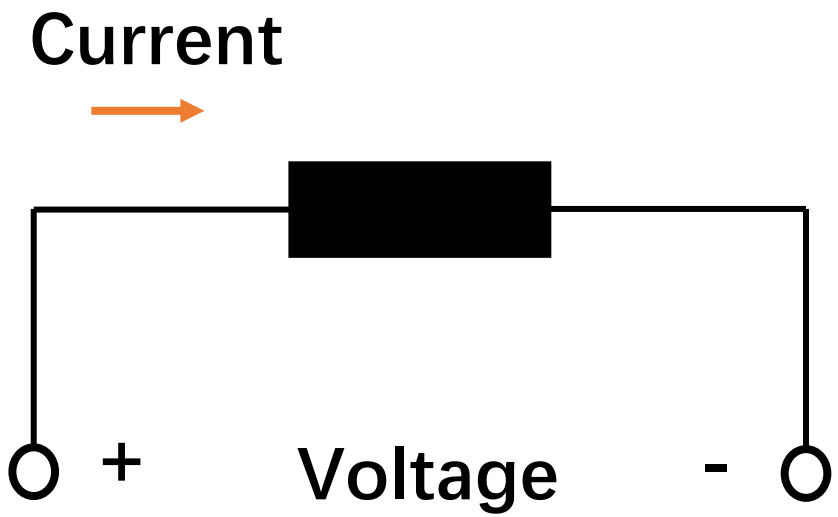
1 Ohm's law

2 Kirchhoff's theorem

3 Thevenin-Norton theorem

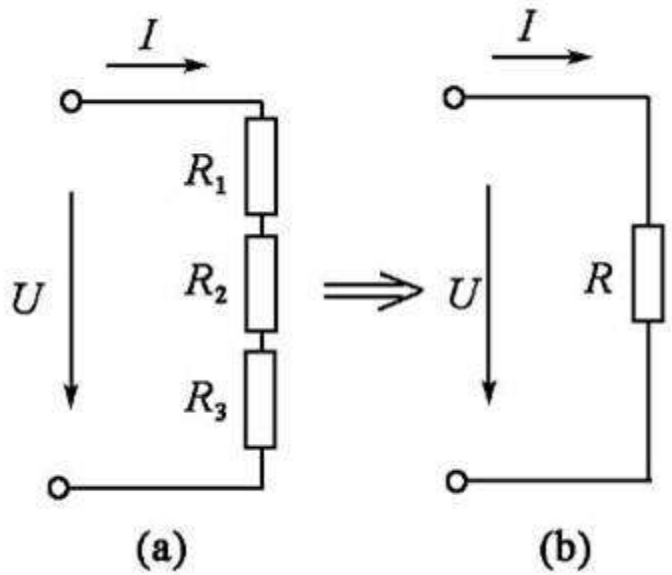
1 Ohm's law

$$V = I \cdot R$$



How it works?

Equivalent等效



Series resistor

Equivalent

$$R=R_1+R_2+R_3$$

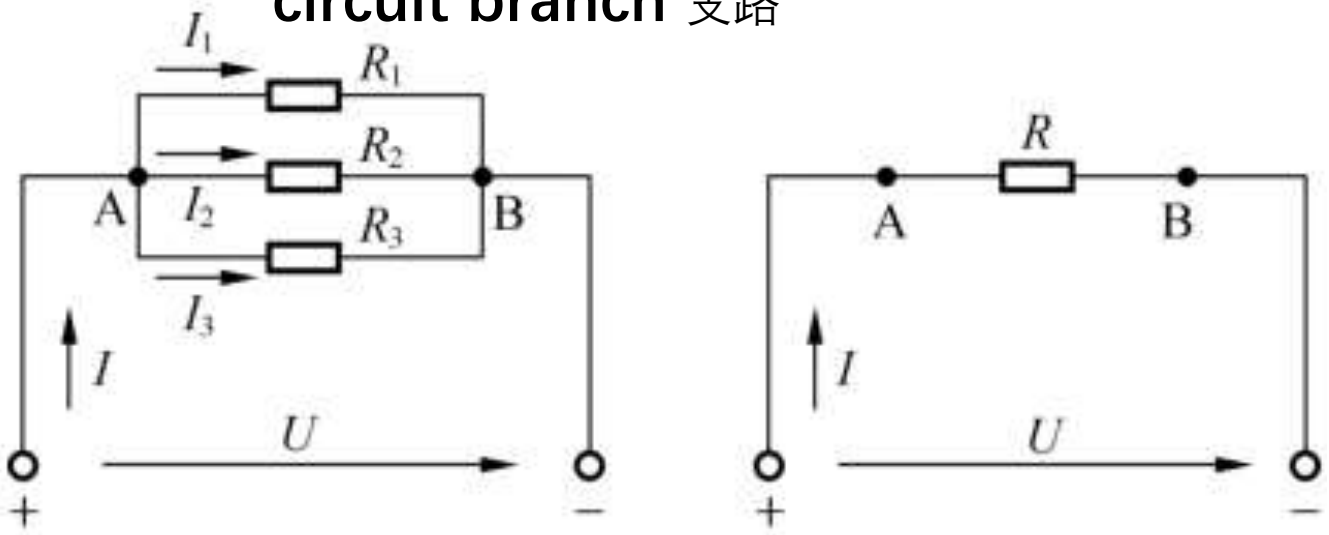
Only one current in the circuit, but

$$U=U_1+U_2+U_3$$

$$U_i=R_i/R$$

The partial voltage of a resistor in a circuit depends on the ratio of its resistance to the total resistance.

circuit branch 支路



Parallel resistor

Equivalent

As a result, $U=U_1=U_2=U_3$

$I=I_1+I_2+I_3$

$I_i=?$

并联电路的总电阻

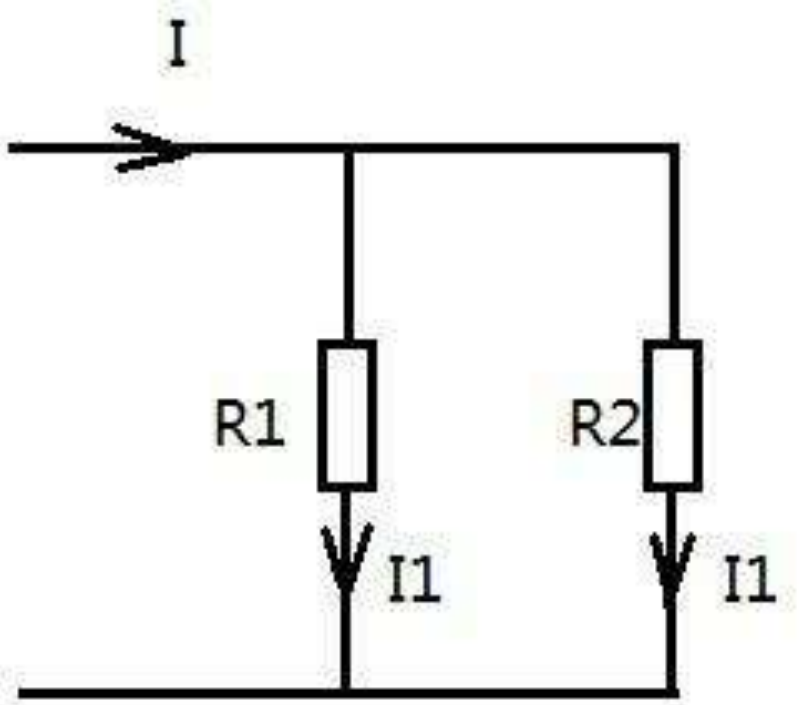
$$R=\frac{U}{I}=\frac{U}{I_1+I_2+\cdots+I_n}$$

$$\therefore \frac{1}{R}=\frac{I_1+I_2+\cdots+I_n}{U}$$

$$=\frac{I_1}{U}+\frac{I_2}{U}+\cdots+\frac{I_n}{U}$$

$$=\frac{1}{R_1}+\frac{1}{R_2}+\cdots+\frac{1}{R_n}$$

$$\therefore \frac{1}{R}=\frac{1}{R_1}+\frac{1}{R_2}+\cdots+\frac{1}{R_n}.$$

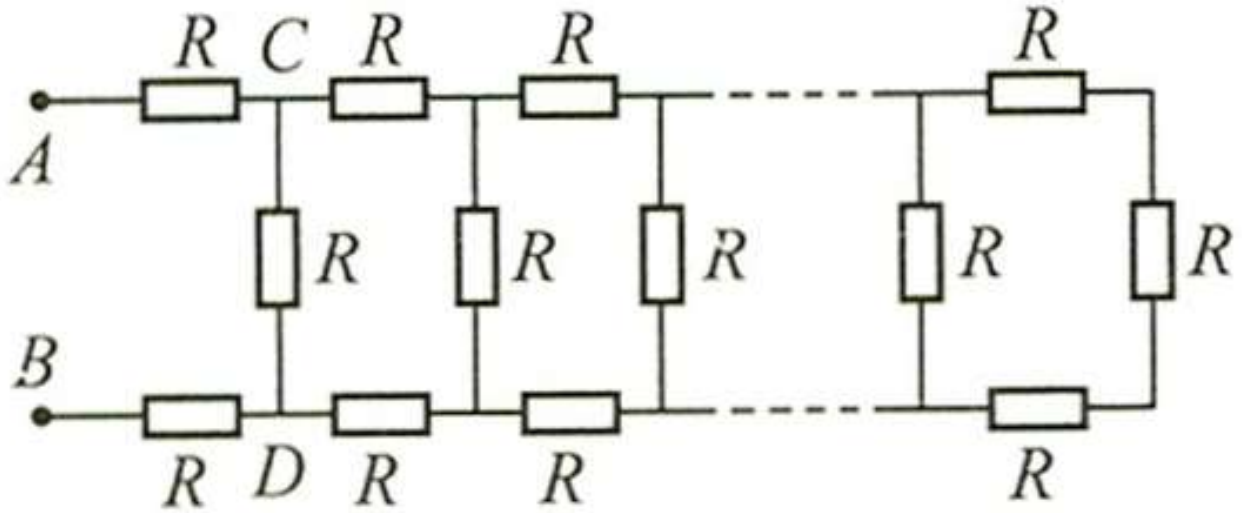


$$I_1 = \frac{R_2}{R_1 + R_2} I$$

$$I_2 = \frac{R_1}{R_1 + R_2} I$$

Branch shunt law

Application



Infinite resistance network

$$R_{AB}=R_{CD}$$

Application

Equivalent transformation

$$r_1 = \frac{R_{12}R_{31}}{R_{12}+R_{23}+R_{31}}$$

$$r_2 = \frac{R_{23}R_{12}}{R_{12}+R_{23}+R_{31}}$$

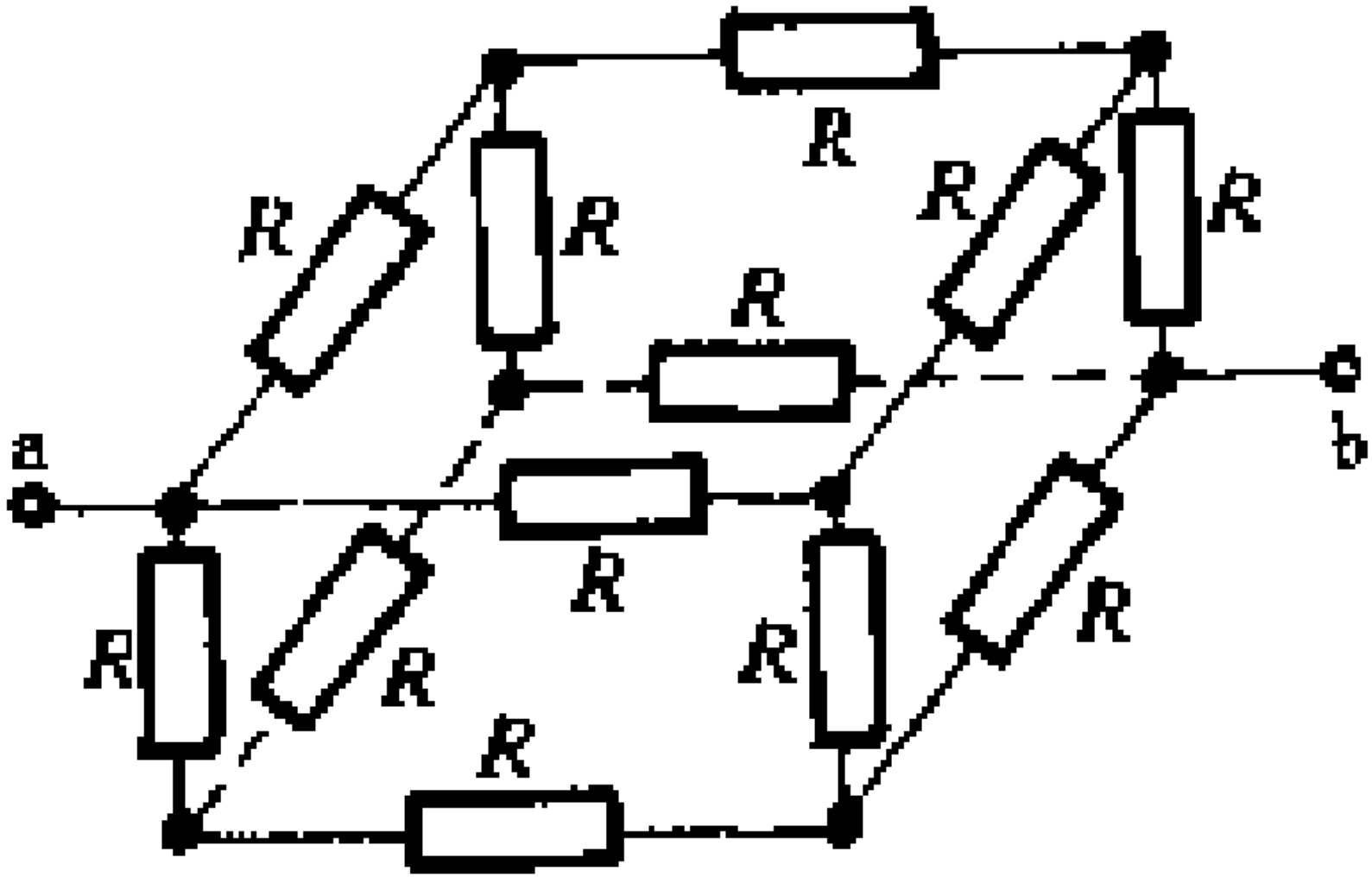
$$r_3 = \frac{R_{23}R_{31}}{R_{12}+R_{23}+R_{31}}$$

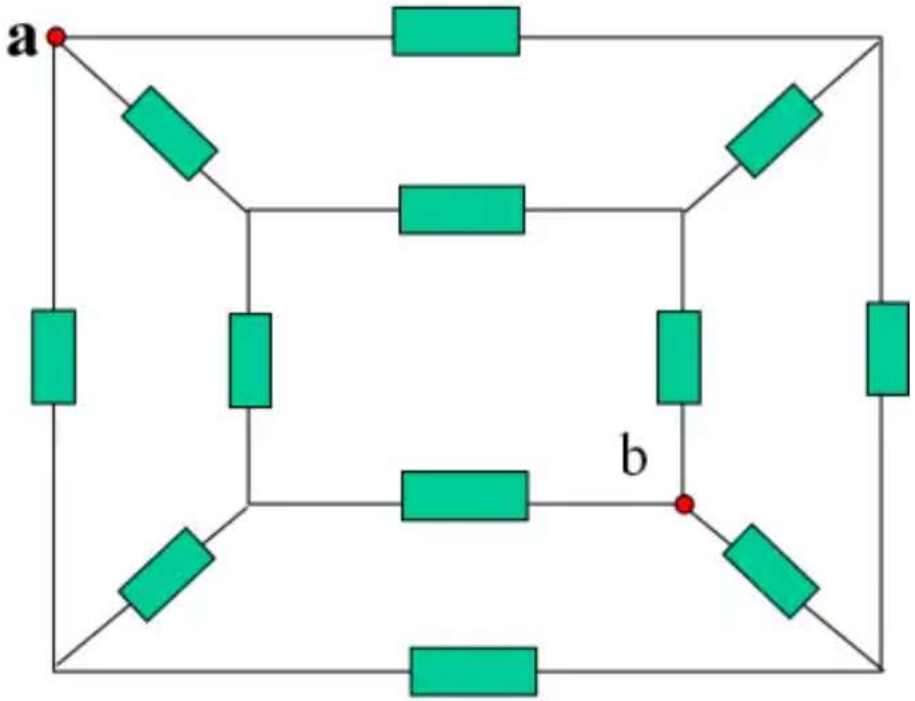
$$R_{12} = r_1 + r_2 + \frac{r_1 r_2}{r_3}$$

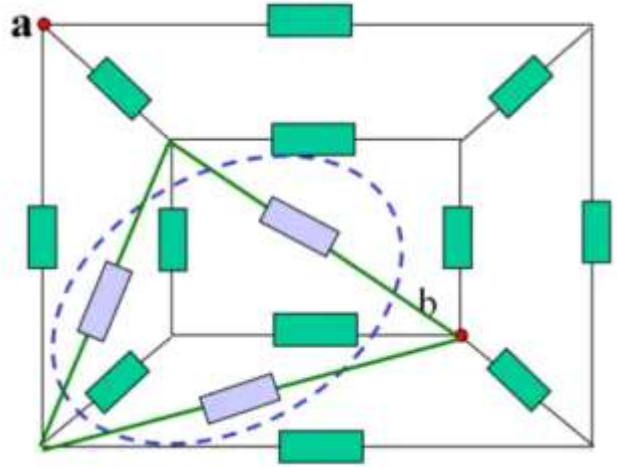
$$R_{23} = r_2 + r_3 + \frac{r_2 r_3}{r_1}$$

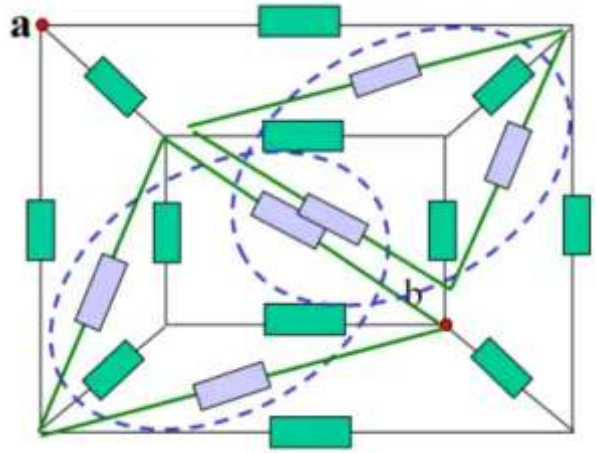
$$R_{31} = r_3 + r_1 + \frac{r_3 r_1}{r_2}$$

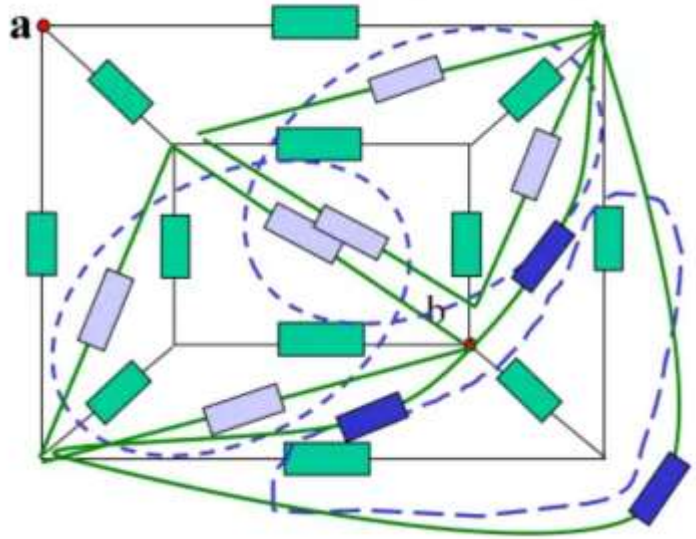
Complex resistance network

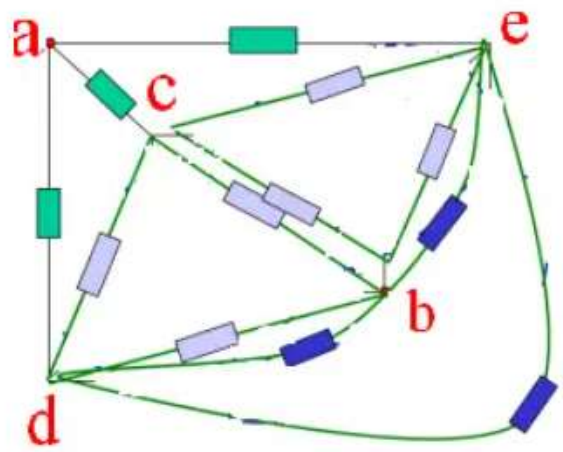

R
R
R
R
R
R
R
R
R
R
R
R
a
b

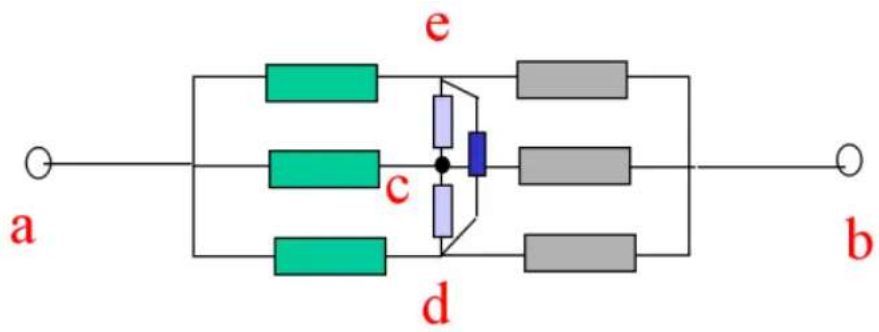

a
b


a
b


a
b

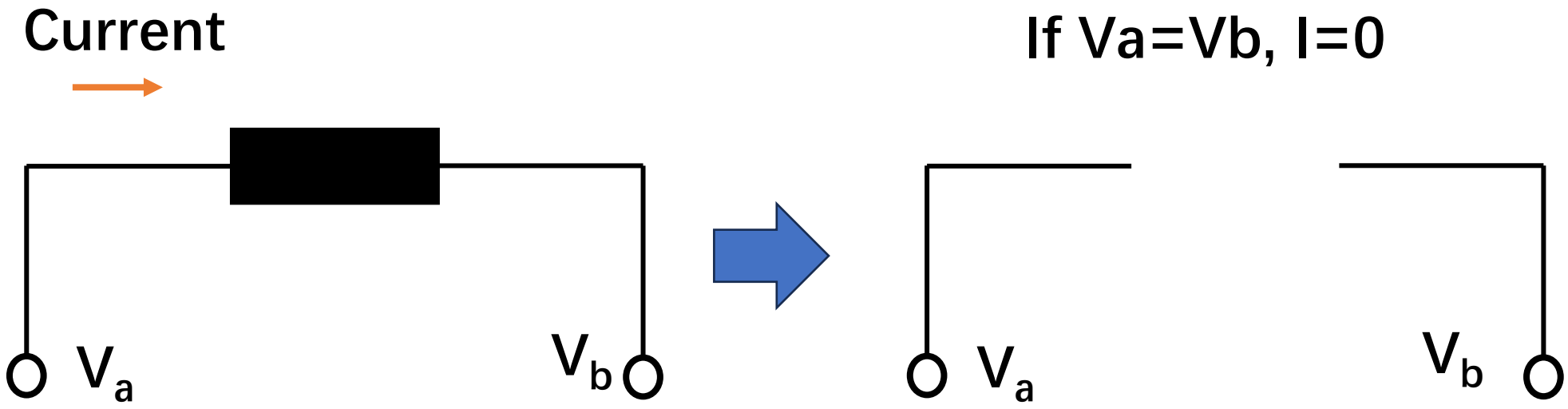

a
b


a
e
c
b
d


e
c
a
b
d

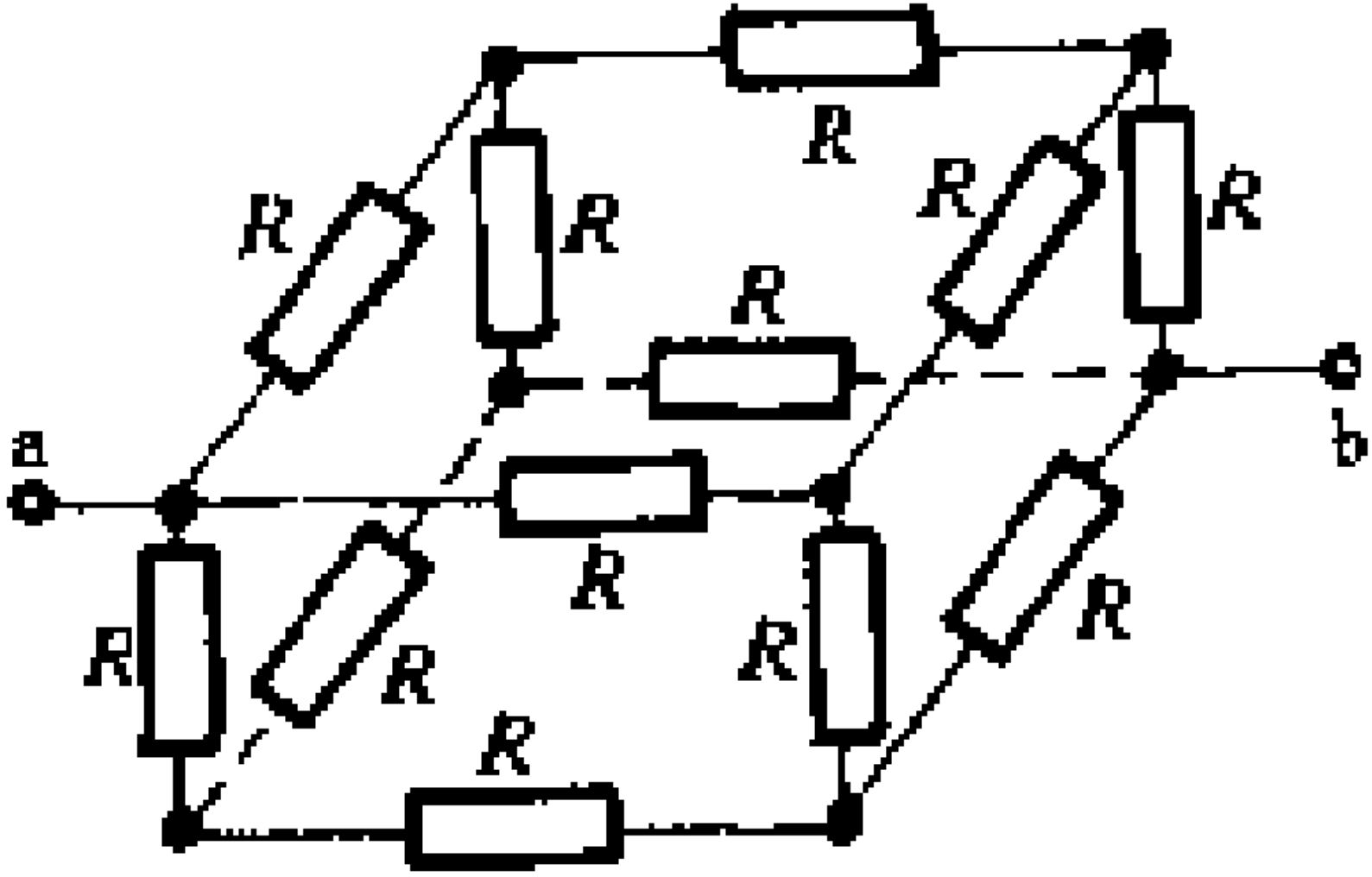
Application

Equivalent Principle： When the potential between two points is equal, No circuit will be generated between the two points, equivalent to disconnection!

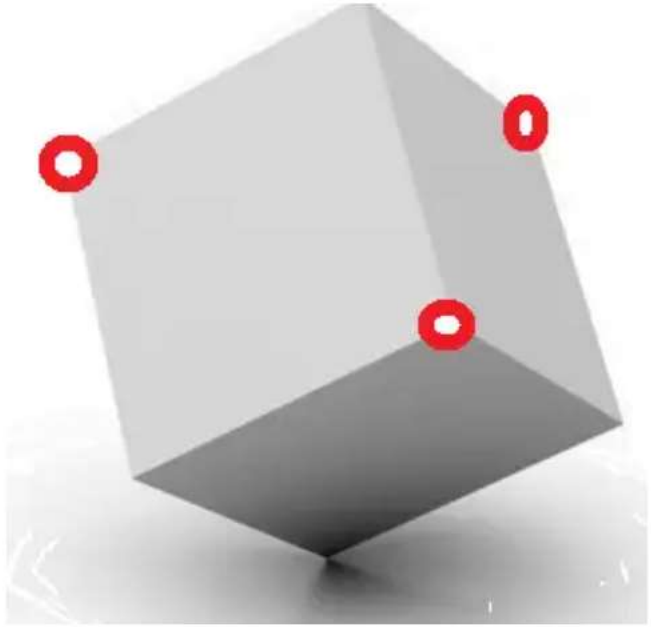


Equipotential point :
These equipotential points play a very important role in the circuit. According to Ohm's theorem, we can find them from the geometric symmetry of the circuit.

For example, try analysis again



a

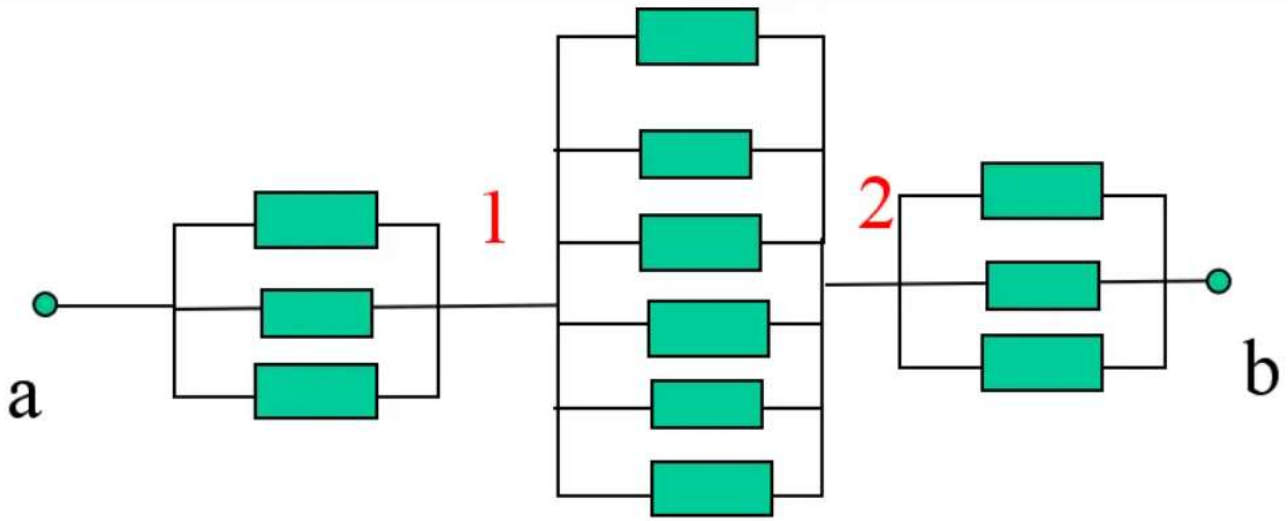


b

1 Find symmetry points

2 Find circuit branches

3 Use Equivalent Principle



Rab=R/3+R/6+R/3=5R/6

Conclusion:

$U_i = R_i / R$ Voltage division theorem of series circuit

$$I_1 = \frac{R_2}{R_1 + R_2} I$$ Branch shunt law

& Equivalent Principles

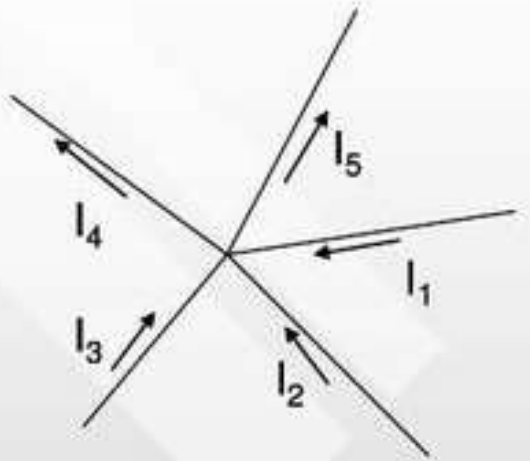
Proof of om's law

2 Kirchhoff's law

1.基尔霍夫电流定律（KCL）

$$\sum I = 0$$

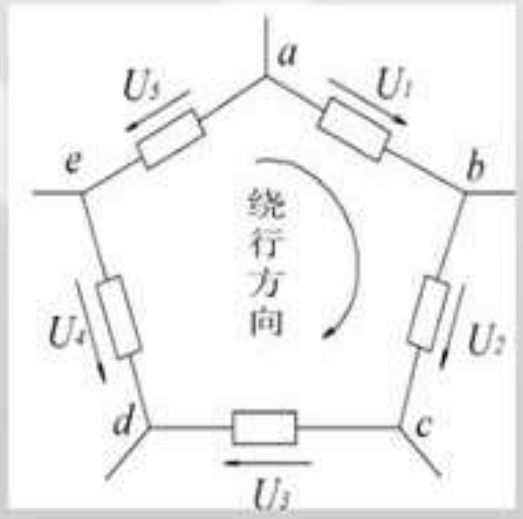
$$\sum I = I_1 + I_2 + I_3 - I_4 - I_5 = 0$$



2.基尔霍夫电压定律（KVL）

$$\sum U = 0$$

$$\sum U = U_1 + U_2 + U_3 - U_4 - U_5 = 0$$



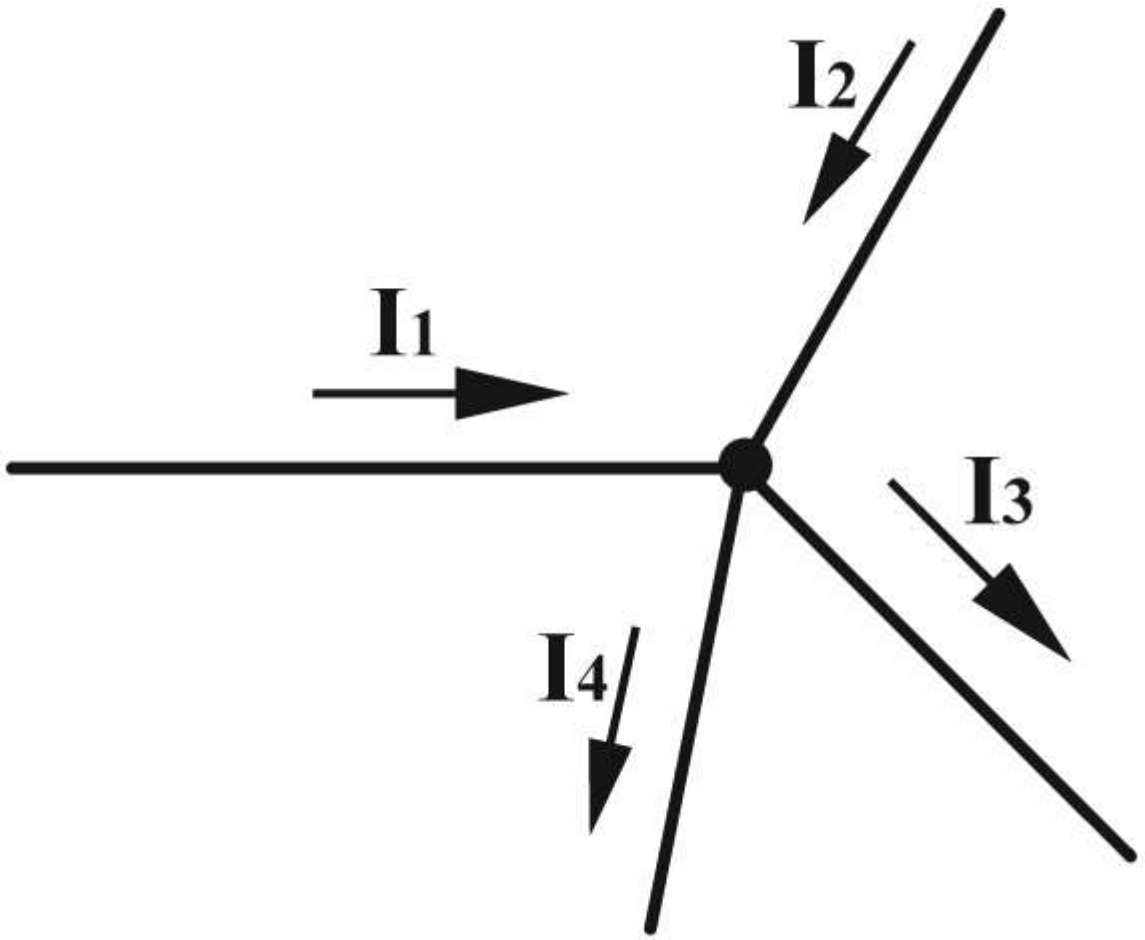
Some Interesting experiments

lumped model

In the general circuit analysis, all the parameters of the circuit, such as impedance, capacitive reactance, inductive reactance are concentrated on each point in space, each component, and the signal between each point is transmitted instantaneously, this idealized circuit model is called a lumped circuit.

Generally speaking： An idealized circuit model

KCL：

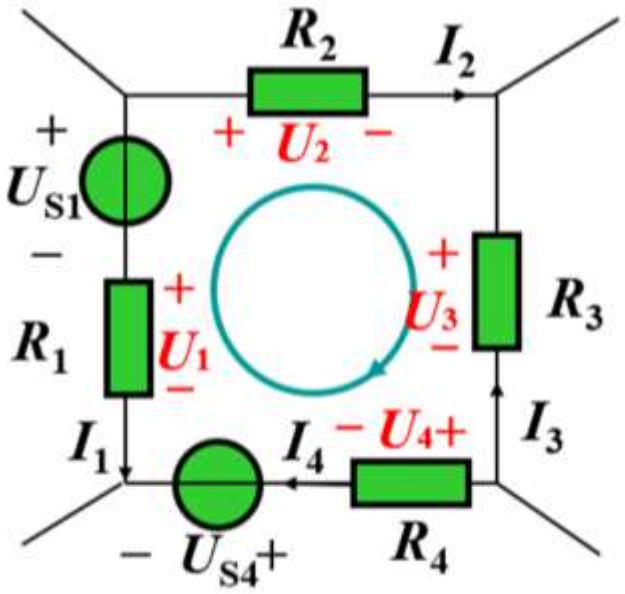


The total current of the incoming and outgoing circuit nodes is 0.

$$\sum u(t) = 0$$

例　　取顺时针方向绕行：

$$\sum U = 0$$



$$-U_1 - U_{S1} + U_2 + U_3 + U_4 + U_{S4} = 0$$

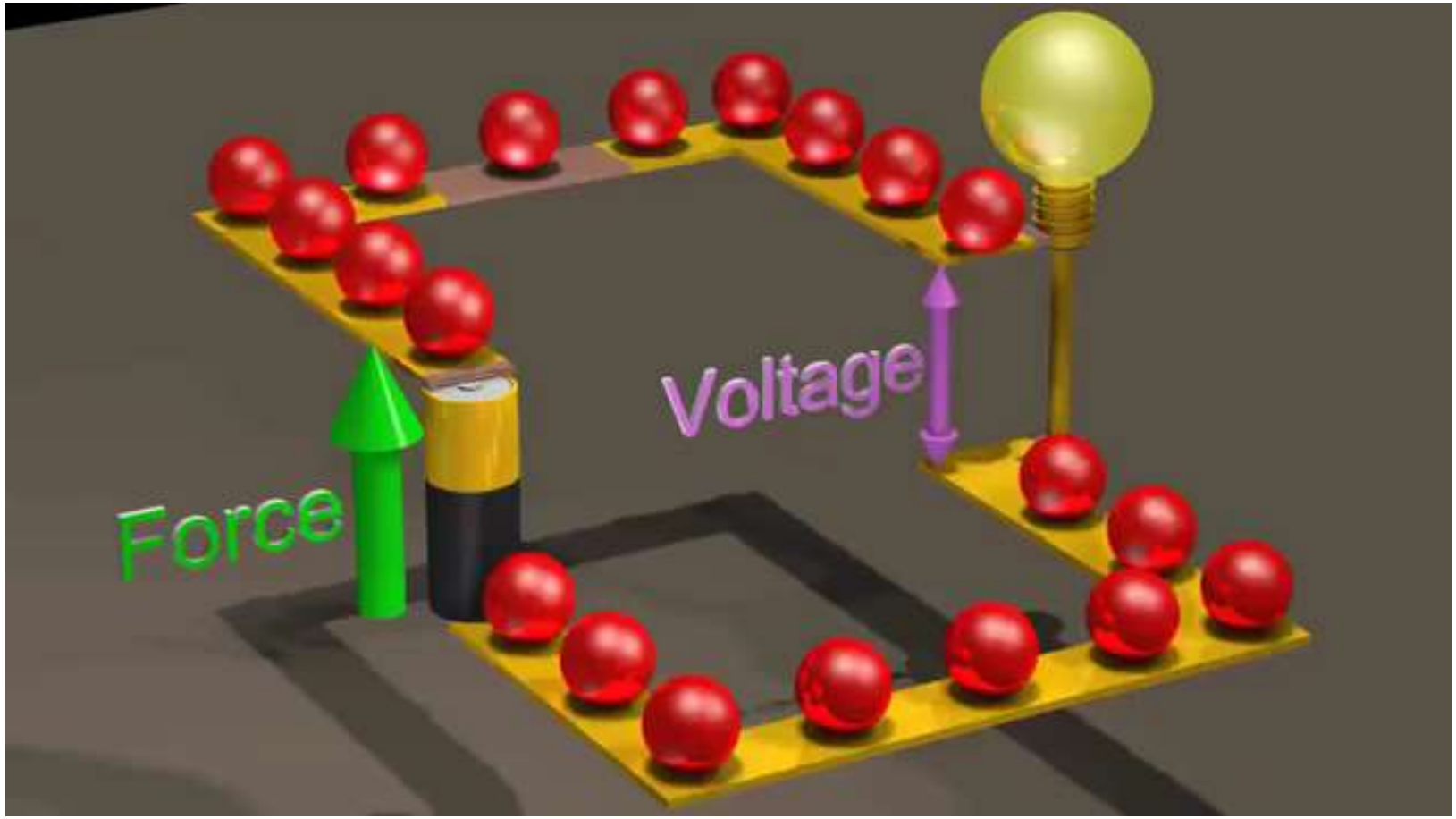
$$-U_1 + U_2 + U_3 + U_4 = U_{S1} - U_{S4}$$

即　$\sum U_R = \sum U_S$

电阻压降　　电源压升

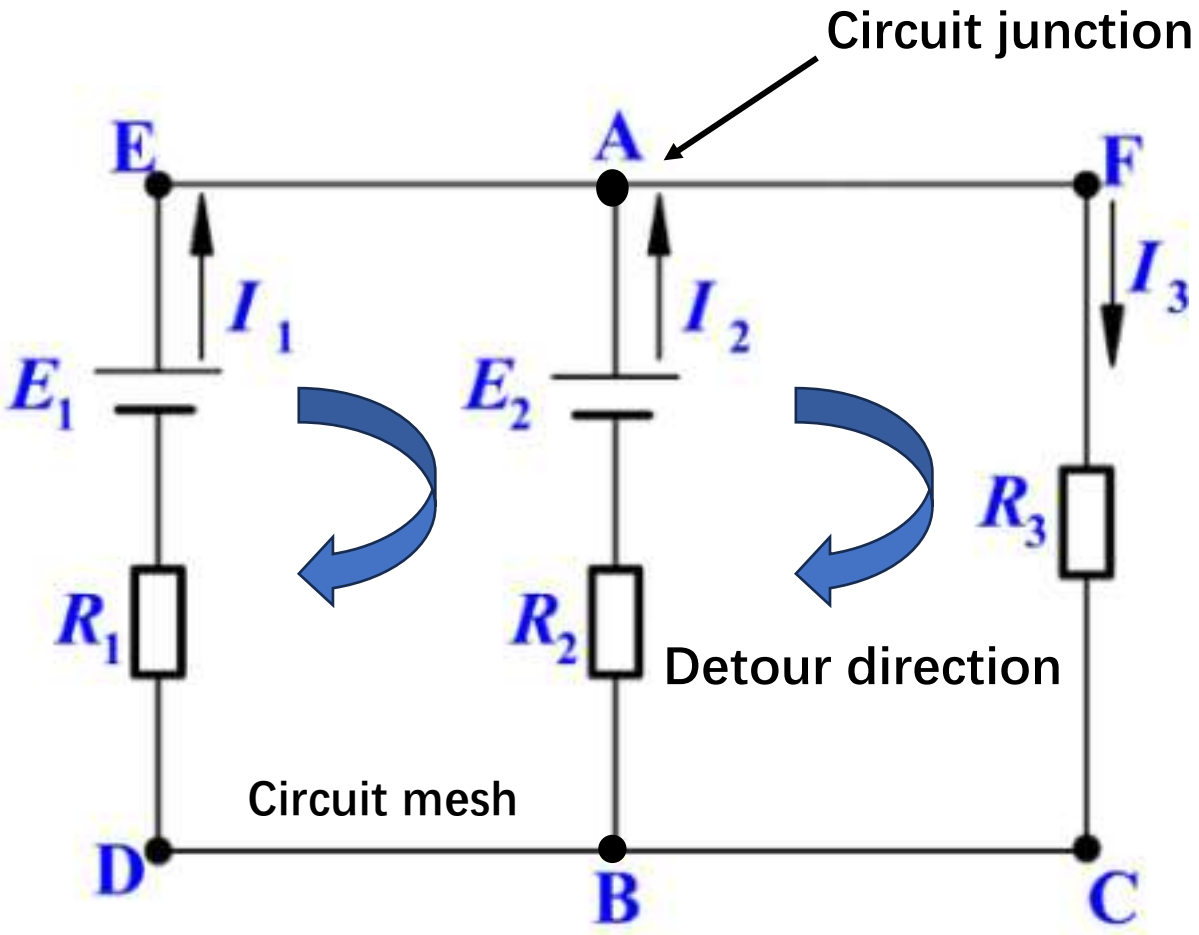
The algebraic sum of the potential difference (voltage) at both ends of all elements of the closed loop is equal to zero.

Principle of KCL and KVL

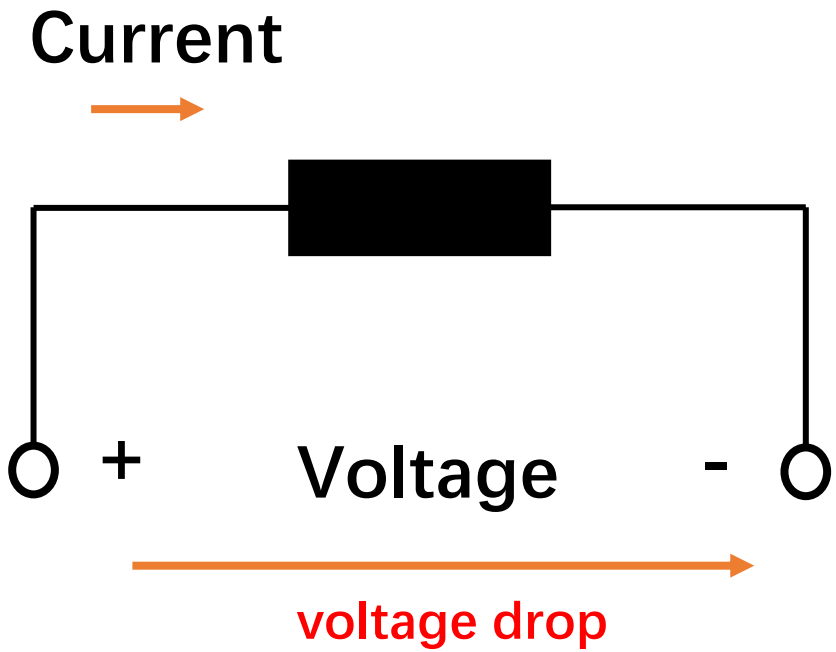


Discuss：Is Kirchhoff's law always true?

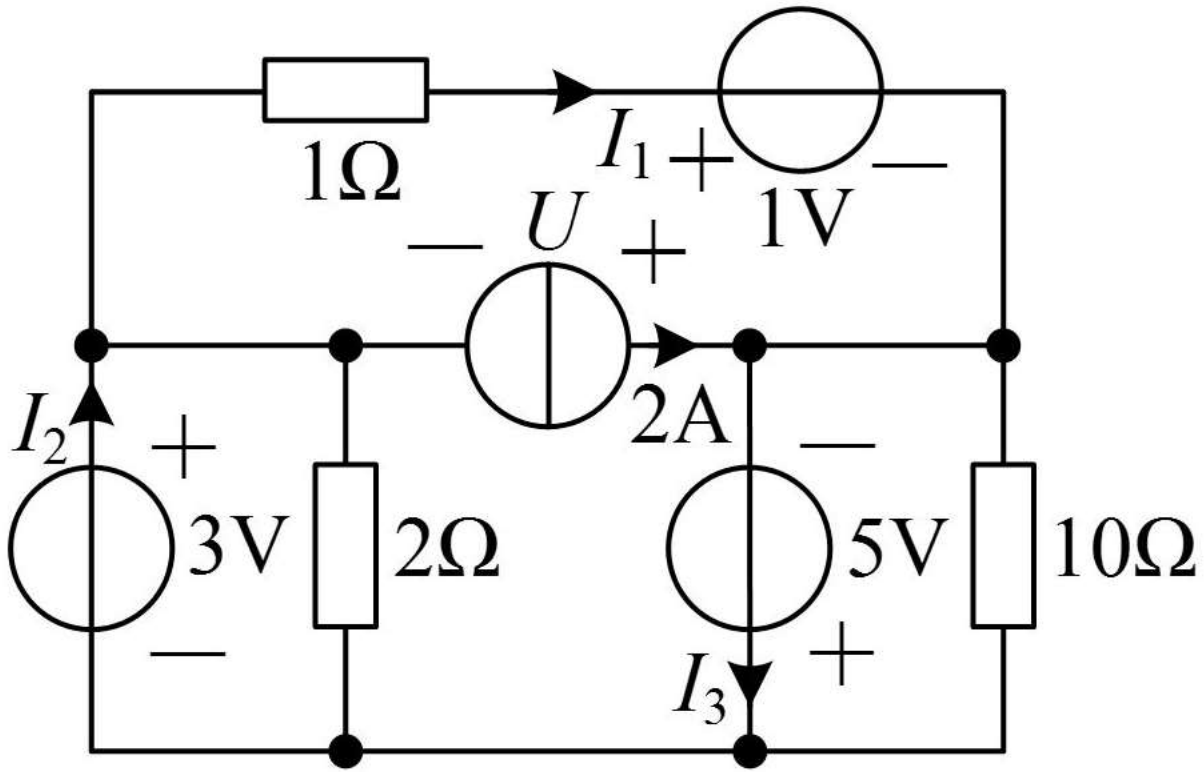
TEST：Misjudgment caused by testing equipment


Circuit junction
E
A
F
I_1
I_2
I_3
E_1
E_2
R_3
R_1
R_2
Detour direction
Circuit mesh
D
B
C

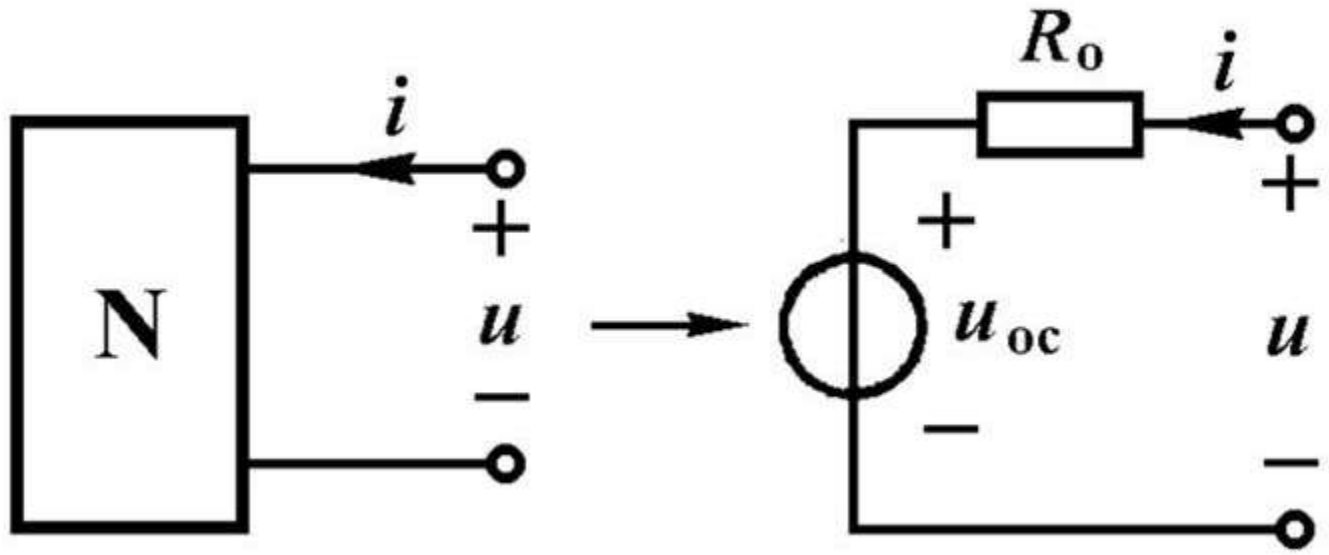
$$V = I \cdot R$$


Current
+
Voltage
-
voltage drop

Question: I_1 I_2 I_3 ?& U ?

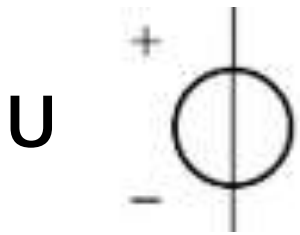


3 Thevenin-Norton theorem

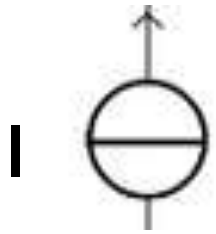


Both ends of a linear network consisting of an independent voltage source, an independent current source, and a resistance can be electrically equivalent by a combination of an independent voltage source and a series resistance.

Ideal Voltage source & Ideal Real Current source

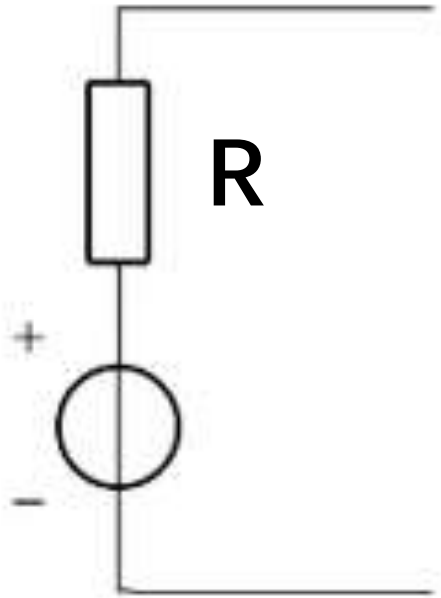


Constant Voltage number& Constant Voltage drop

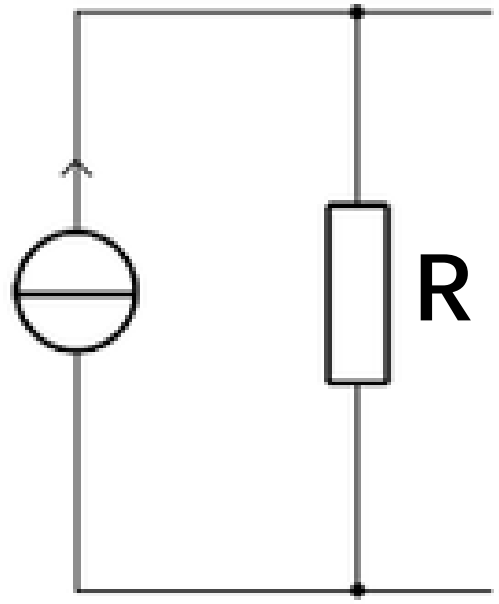


Constant Current number& Constant Current direction

Real Voltage source & Real Current source

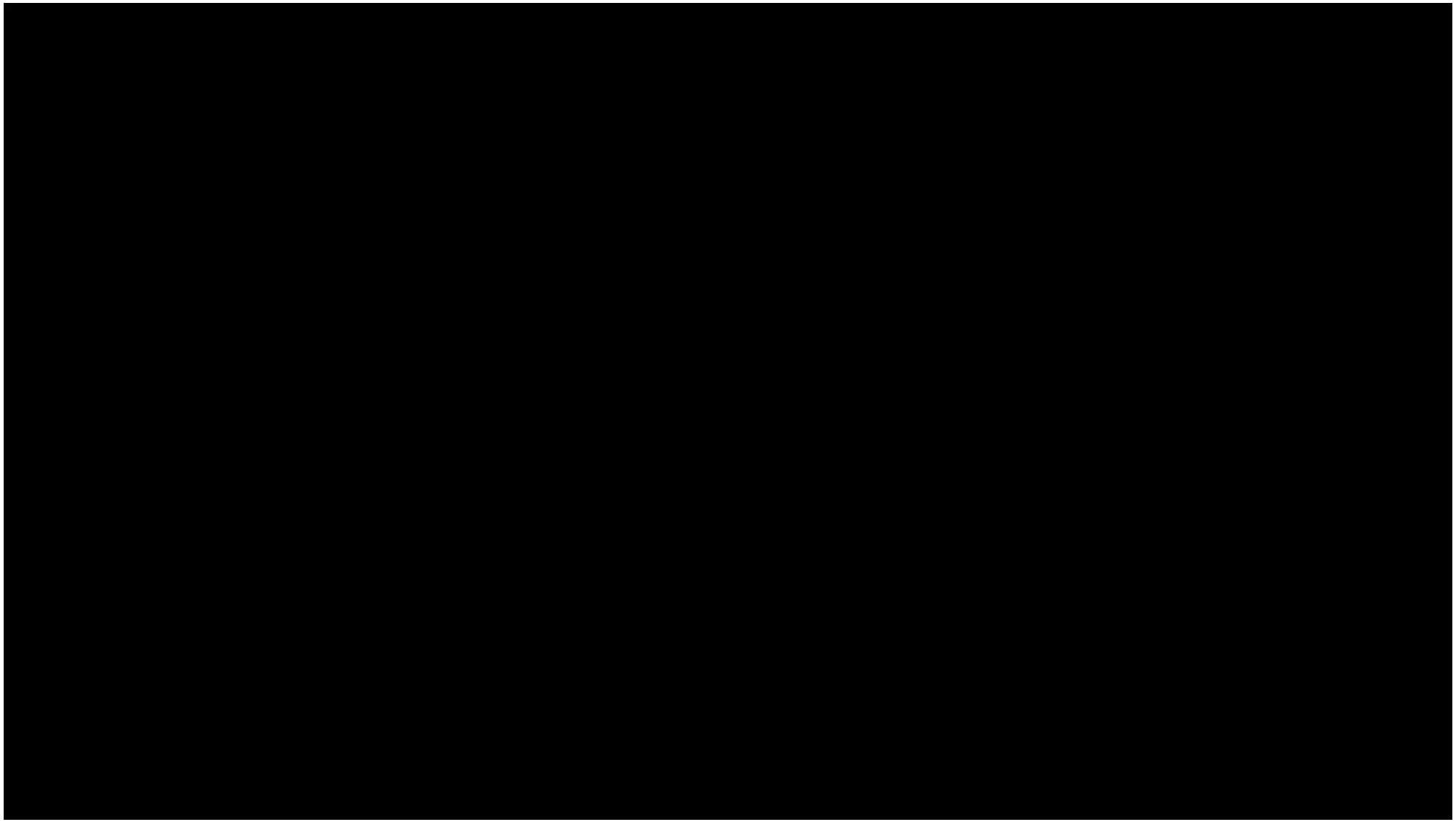


With a series resistance



With a parallel resistance

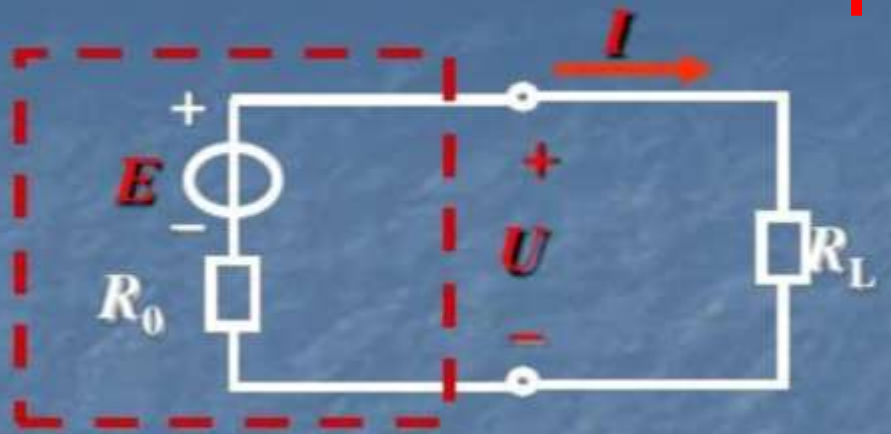
Source transformation



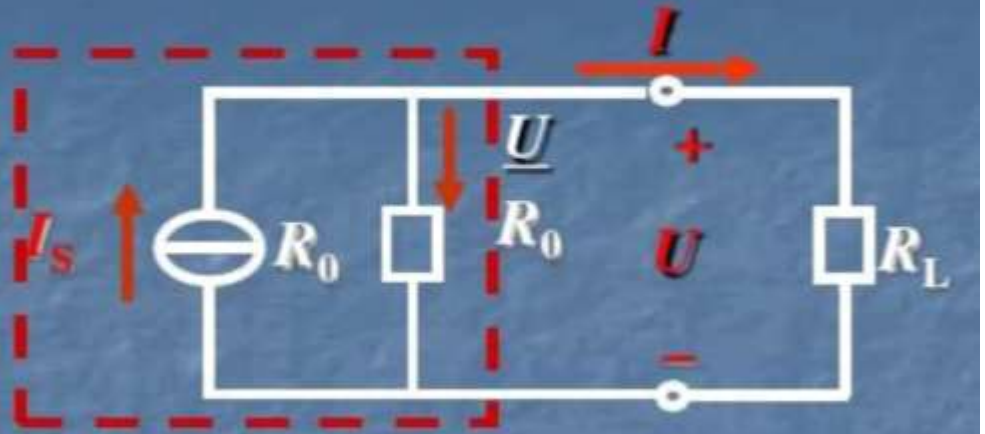
The circuit structure is simplified

Real Voltage source ⇄ Real Current source

Equivalent !!!



电压源



电流源

由图a:

$U = E - IR_0$

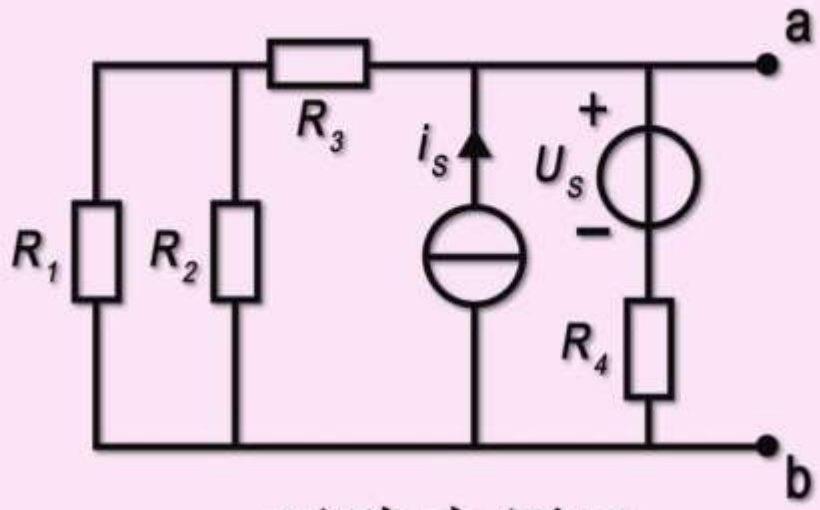
由图b:

$U = I_S R_0 - IR_0$

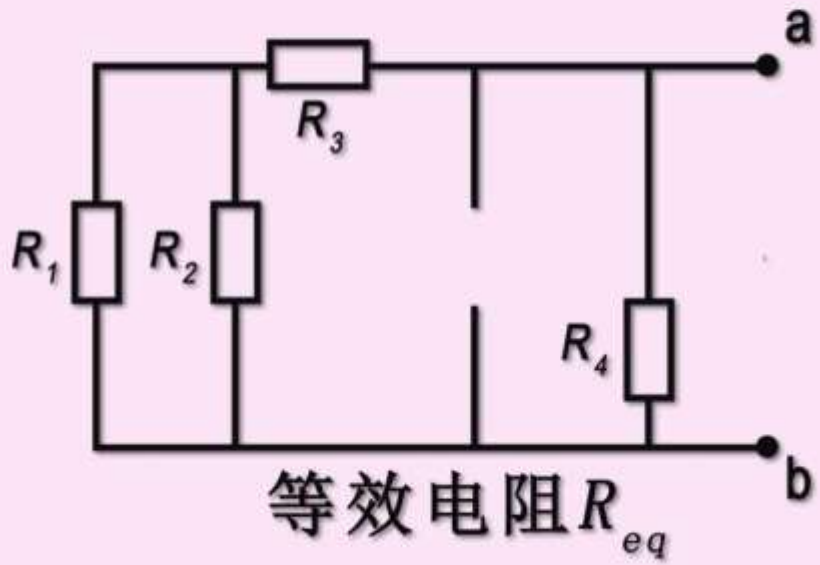
等效变换条件:

$$\begin{cases} E = I_S R_0 \\ I_S = \dfrac{E}{R_0} \end{cases}$$

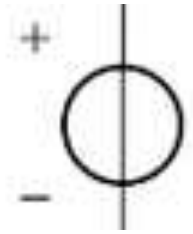
Thevenin’s law



开路电压U_{oc}

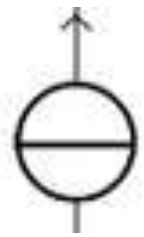


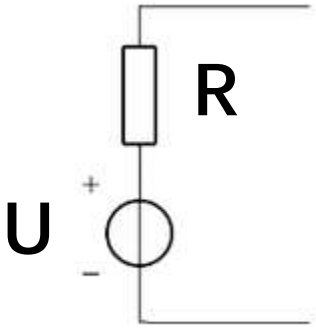
等效电阻R_{eq}



Switch On

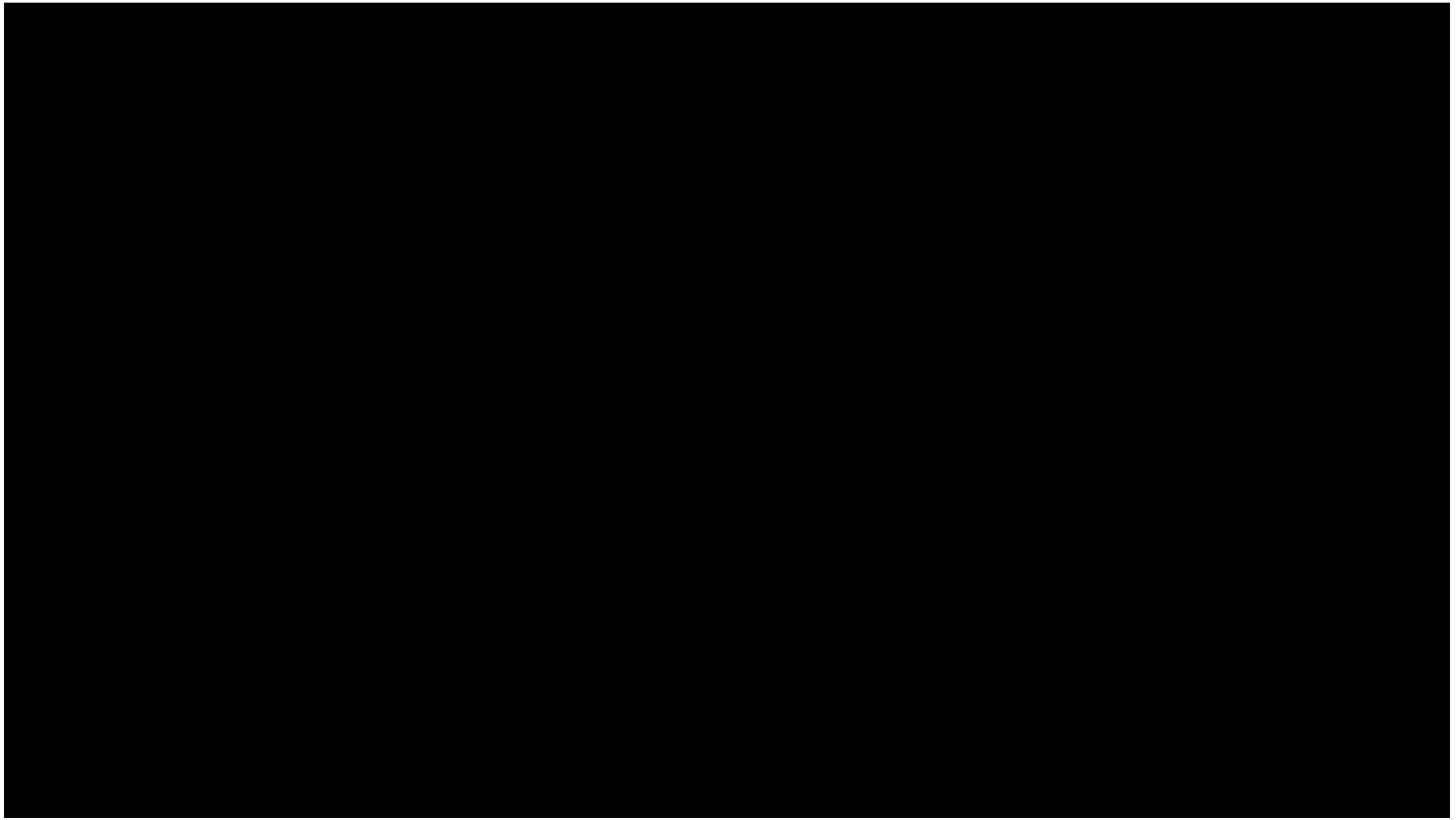
Switch Off



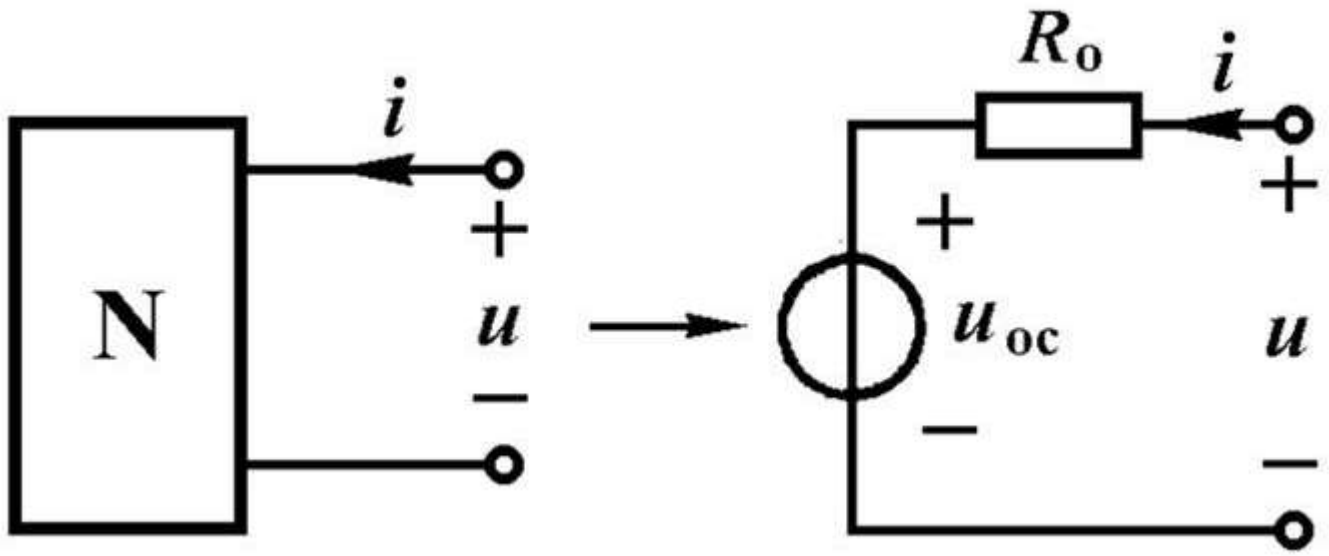


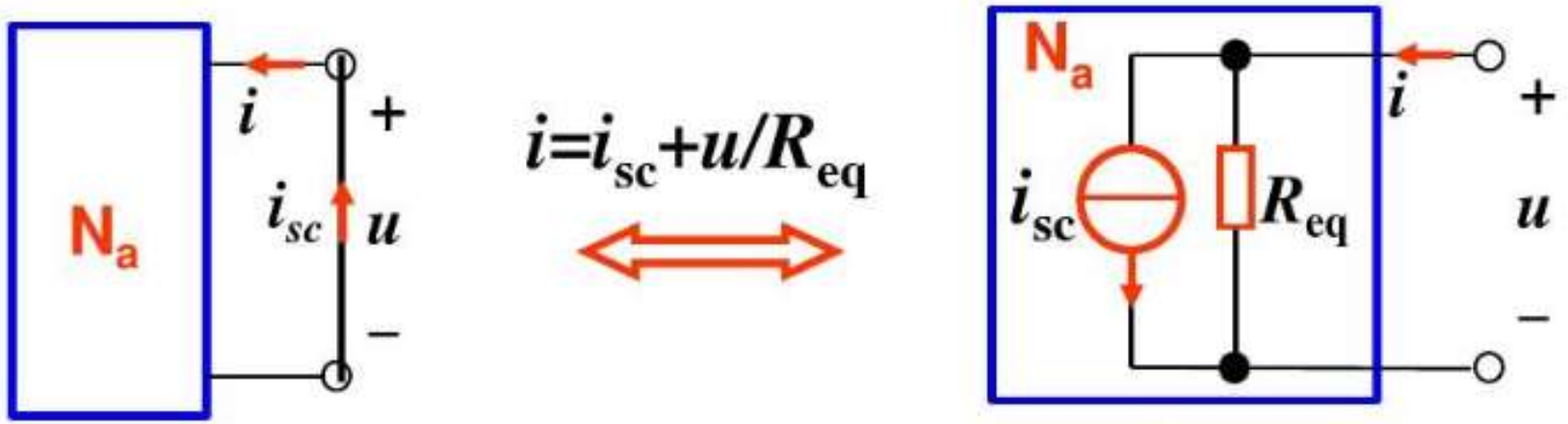
U= U_{ab} R=R_{eq}

Norton’s law

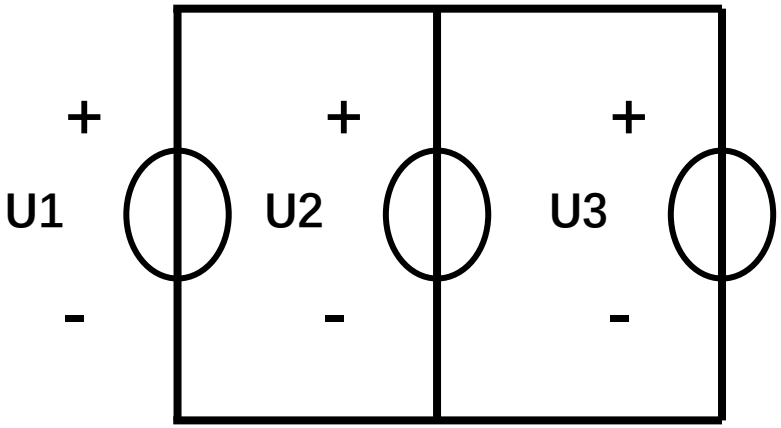


Real Voltage source ⇌ Real Current source

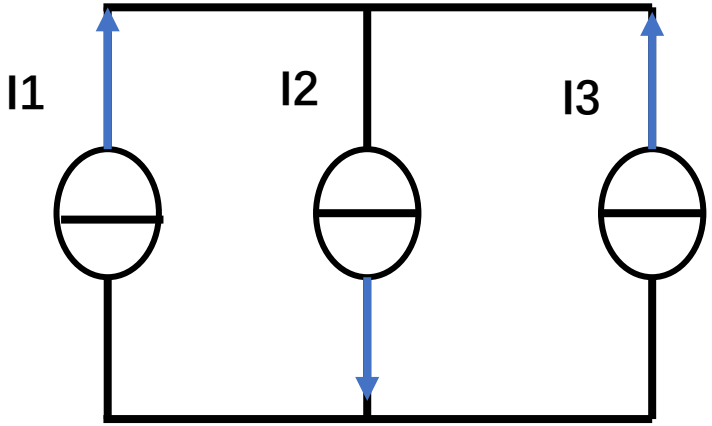




Some considerations:

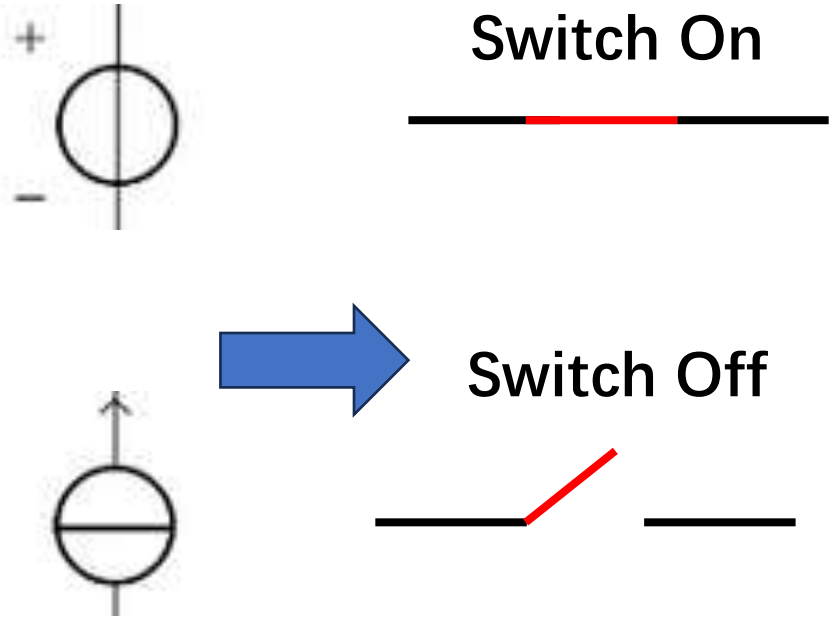


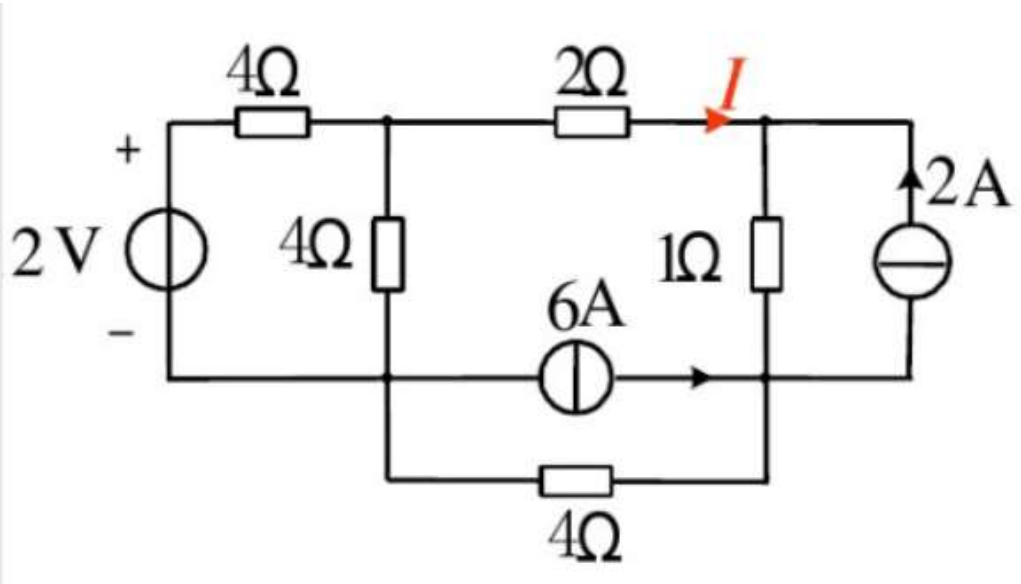
U=???



I=???

Further application: Superposition Principle





The contribution of each power supply to the circuit can be considered separately!!!