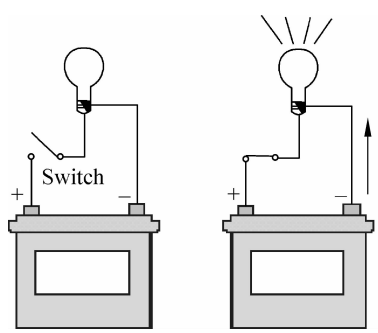
Unit 3

Text A Simple Electrical Circuit

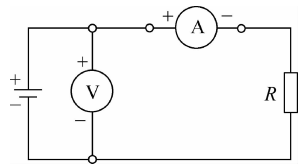
1. An electric circuit

A fundamental relationship exists between current, voltage, and resistance. A simple electrical circuit consists of a voltage source, some type of load, and a conductor to allow electrons to flow between the voltage source and the load.[1] In the following circuit a battery provides the voltage source, electrical wire is used for the conductor, and a light provides the resistance. An additional component has been added to this circuit, a switch. There must be a complete path for current to flow. If the switch is open, the path is incomplete and the light will not illuminate. Closing the switch completes the path, allowing electrons to leave the negative terminal and flow through the light to the positive terminal.



2. An electrical circuit schematic

The following schematic is a representation of an electrical circuit, consisting of a battery, a resistor, a voltmeter and an ammeter. The ammeter, connected in series with the circuit, will show how much current flows in the circuit. The voltmeter, connected across the voltage source, will show the value of voltage supplied from the battery. Before an analysis can be made of a circuit, we need to understand Ohm's Law.



3. Ohm's Law

The relationship between current, voltage and resistance was studied by the 19th century German mathematician, George Simon Ohm. Ohm formulated a law which states that current varies proportionally with voltage and inversely with resistance. From this law the following formula is derived:

$$I = \frac{U}{R} \quad \text{or} \quad \text{Current} = \frac{\text{Voltage}}{\text{Resistance}}$$

Ohm's Law is the basic formula used in all electrical circuits. Electrical designers must decide how much voltage is needed for a given load, such as computers, clocks, lamps and motors. Decisions must be made concerning the relationship of current, voltage and resistance. All electrical design and analysis begins with Ohm's Law. There are three mathematical ways to express Ohm's Law. Which of the formulas is used depends on what facts are known before starting and what facts need to be known.

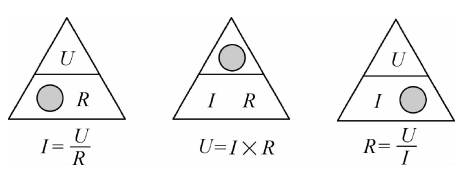
$$I = \frac{U}{R} \quad U = I \times R \quad R = \frac{U}{I}$$

4. Ohm's Law triangle

There is an easy way to remember which formula to use. By arranging current, voltage and resistance in a triangle, one can quickly determine the correct formula.

5. Using the triangle

To use the triangle, cover the value you want to calculate. The remaining letters make up the formula. [2]



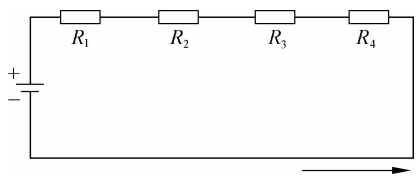
Ohm's Law can only give the correct answer when the correct values are used. Remember the following three rules:

- Current is always expressed in amperes or amp.
- Voltage is always expressed in volt.
- Resistance is always expressed in ohm.

DC Series Circuit

1. Resistance in a series circuit

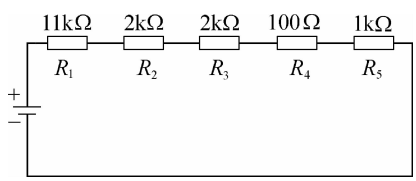
A series circuit is formed when a number of resistors are connected end-to-end so that there is only one path for current to flow.[3] The resistors can be actual resistors or other devices that have resistance. The illustration shows four resistors connected end-to-end. There is one path of electron flow from the negative terminal of the battery throughR_4, R_3, R_2, R_1returning to the positive terminal.



2. Formula for series resistance

The values of resistance add in a series circuit. If a 4Ω resistor is placed in series with a 6Ω resistor, the total value will be 10Ω. This is true when other types of resistive devices are placed in series. The mathematical formula for resistance in series is

$$R_t = R_1 + R_2 + R_3 + R_4$$



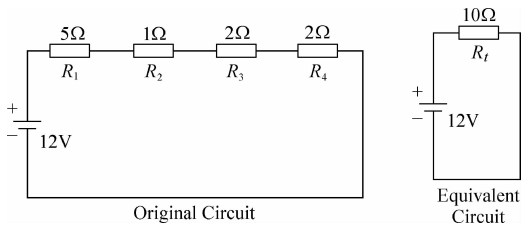
Given a series circuit where R_1 is 11kΩ, R_2 is 2kΩ, R_3 is 2kΩ, R_4 is 100Ω, and R_5 is 1kΩ, what is the total resistance?

$$\begin{aligned} R_t &= R_1 + R_2 + R_3 + R_4 + R_5 \\ &= 11\ 000 + 2\ 000 + 2\ 000 + 100 + 1\ 000 \\ &= 16\ 100\Omega \end{aligned}$$

3. Current in a series circuit

The equation for total resistance in a series circuit allows us to simplify a circuit. Using Ohm's Law, the value of current can be calculated. Current is the same anywhere when it is measured in a series circuit.

$$I = \frac{U}{R} = \frac{12}{10} = 1.2\text{A}$$

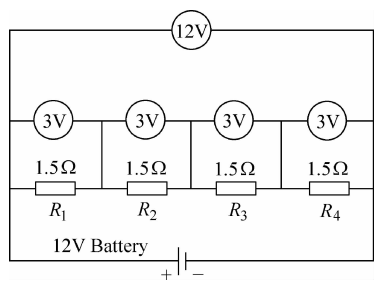


4. Voltage in a series circuit

Voltage can be measured across each of the resistors in a circuit. The voltage across a resistor is referred to as a voltage drop. A German physicist, Kirchhoff, formulated a law which states the sum of the voltage drops across the resistances of a closed circuit equals the total voltage applied to the circuit. [4] In the following illustration, four equal value resistors of 1.5Ω each have been placed in series with a 12V battery. Ohm's Law can be applied to show that each resistor will "drop" an equal amount of voltage.

First, solve for total resistance:

$$R_t = R_1 + R_2 + R_3 + R_4 = 1.5 + 1.5 + 1.5 + 1.5 = 6\Omega$$



Second, solve for current:

$$I = \frac{U}{R} = \frac{12}{6} = 2\text{A}$$

Third, solve for voltage across any resistor:

$$U = I \times R = 2 \times 1.5 = 3\text{V}$$

If voltages were measured across any single resistor, the voltmeter would read 3V. [5] If voltage were measured across a combination of R_3 and R_4 the voltmeter would read 6V. If voltage were measured across a combination of R_2, R_3, and R_4 the voltmeter would read 9V. If the voltage drops of all four resistors were added together the sum would be 12V, the original supply voltage of the battery.

5. Voltage division in a series circuit

It is often desirable to use a voltage potential that is lower than the supply voltage. To do this, a voltage divider can be used. The battery represents U_I which in this case is 50V. The desired voltage is represented by U_O which mathematically works out to be 40V. To calculate this voltage, first solve for total resistance:

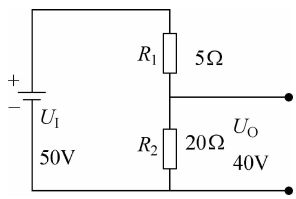
$$R_t = R_1 + R_2 = 5 + 20 = 25\Omega$$

Second, solve for current:

$$I = \frac{U_1}{R_t} = \frac{50}{25} = 2\text{A}$$

Finally, solve for voltage:

$$U_0 = I \times R_2 = 2 \times 20 = 40\text{V}$$



New Words and Phrases

circuit	['sə:kit]	*n.* 电路,一圈,周游,巡回
fundamental	[ˌfʌndə'mentl]	*adj.* 基础的,基本的
consist of		由……组成
load	[ləud]	*n.* 负荷,负载,加载
battery	['bætəri]	*n.* 电池
component	[kəm'pəunənt]	*n.* 成分
switch	[switʃ]	*n.* 开关,电闸,转换
illuminate	[i'lju:mineit]	*vt.* 阐明,说明(问题等),照明,照亮
negative	['negətiv]	*n.* 否定,负数
		adj. 否定的,消极的,负的,阴性的
		vt. 否定,拒绝(接受)
positive	['pɔzətiv]	*adj.* 阳的
		adj. 肯定的,积极的,绝对的,确实的
		adj. [数]正的
schematic	[ski'mætik]	*adj.* 示意性的
		n. 电路原理图
voltmeter	['vəultˌmi:tə(r)]	*n.* 电压表
ammeter	['æmitə]	*n.* 电流表
Ohm's Law		欧姆定律
mathematician	[ˌmæθimə'tiʃən]	*n.* 数学家
vary	['vɛəri]	*vt.* 改变,变更,使多样化
		vi. 变化,不同,违反
inverse	['in'və:s]	*adv.* 相反地,倒转地
derive	[di'raiv]	*vt.* 得自
		vi. 起源

designer	[di'zainə(r)]	*n.* 设计者
lamp	[læmp]	*n.* 灯
relationship	[ri'leiʃənʃip]	*n.* 关系,关联
analysis	[ə'nælisis]	*n.* 分析,分解
triangle	['traiæŋgl]	*n.* 三角形
calculate	['kælkjuleit]	*vt.* & *vi.* 计算,考虑,计划,打算
		vt. & *vi.* (美)以为,认为
series circuit		串联电路
equation	[i'kweiʃən]	*n.* 相等,平衡,综合体,因素,方程式,等式
series resistance		串联电阻
be referable to		可归因于,与……有关
voltage drop		电压降
meter	['mi:tə]	*n.* 仪表,米,计,表
divider	[di'vaidə]	*n.* 分割者,间隔物,分配器

Notes

[1] A simple electric circuit consists of a voltage source, some type of load, and a conductor to allow electrons to flow between the voltage source and the load.

本句中的谓语动词是 consist of,意为"由……组成"。to allow electrons to flow between the voltage source and the load 修饰的是 conductor,表明是什么样的导线,而不是整个句子。

[2] To use the triangle, cover the value you want to calculate. The remaining letters make up the formula.

这两个句子关系紧密,要联系起来理解。后一个句子表明的是使用三角形,盖住要计算的值的结果,剩下的字母组成公式。

[3] A series circuit is formed when a number of resistors are connected end-to-end so that there is only one path for current to flow.

本句中的 end-to-end 不能凭字面理解为尾对尾,而是首尾相连的意思。so that 引导了一个结果状语从句。when 引导的从句做状语,指明串联电路形成的条件。

[4] A German physicist, Kirchhoff, formulated a law which states the sum of the voltage drops across the resistances of a closed circuit equals the total voltage applied to the circuit.

看懂这个句子的关键是分析它的句子结构。这是一个多层从句的句子。全句的主语是 A German physicist,谓语是 formulated,宾语是 a law,Kirchhoff 是同位语。which 引导的定语从句修饰 a law。在该定语从句中,which 做主语,states 是谓语动词,states 后又是一个宾语从句,省略了引导词 that。在这个宾语从句中,主语为 the sum of the voltage drops,谓语为 equals,宾语为 the total voltage。结构清楚后,整个句子的意思就一目了然了:德国物理学家陈述了一条定律,定律的内容是,穿过闭路电阻的电压降的总和等于这个回路上的电压。

[5] If voltage were measured across any single resistor, the voltmeter would read 3V.

注意,"表的读数为……"的表达是本句中的 volt meter would read,而不是 voltmeter would be read。read 应理解"显示,指示"。例如,The dial reads 32. 刻度显示出 32。

Exercises

【Ex. 1】 根据课文内容,回答以下问题。

(1) What does Ohm's Law state?

(2) According to the passage, how to use the triangle?

(3) What is a series circuit?

(4) How do we measure the voltage drop of each of the resistors in a circuit?

(5) If three resistors of 10Ω, 20Ω and 30Ω respectively have been placed in series with a 12V battery, what is the voltage drop of each of the resistors in a circuit?

【Ex. 2】 根据下面的英文解释,写出相应的英文词汇。

英文解释	词　汇
a closed path followed or capable of being followed by an electric current	
a device used to break or open an electric circuit or to divert current from one conductor to another	
a position in a circuit or device at which a connection is normally established or broken	
an instrument, such as galvanometer, for measuring potential differences in volts	
an instrument that measures electric current	
a device that generates light, heat, or therapeutic radiation	
a device that converts any form of energy into mechanical energy, especially an internal-combustion engine or an arrangement of coils and magnets that converts electric current into mechanical power	
scientist who specializes in physics	
the work required to bring a unit electric charge, magnetic pole, or mass from an infinitely distant position to a designated point in a static electric, magnetic, or gravitational field, respectively	
the international standard unit of length, approximately equivalent to 39.37 inches. It was redefined in 1983 as the distance traveled by light in a vacuum in 1/299 792 458 second	

【Ex. 3】 把下列句子翻译为中文。

(1) A power supply could be something as simple as a 9V battery or it could be as complex as a precision laboratory power supply.

(2) Variable resistors are common components. They have a dial or a knob that allows you to change the resistance. This is very useful for many situations.

(3) Diodes are components that allow current to flow in only one direction. They have a positive side and a negative side.

(4) LEDs use a special material which emits light when current flows through it. Unlike light bulbs, LEDs never burn out unless their current limit is reached.

(5) Well the letter L stands for inductance. The simplest inductor is consists of a piece of wire.

(6) Two metallic plates separated by a non-conducting material between them make a simple capacitor.

(7) The time required for a capacitor to reach its maximum charge is proportional to the capacitance value and the resistance value.

(8) When AC current flows through an inductance a opposite emf or voltage develops opposing any change in the initial current.

(9) Reactance is the property of resisting or impeding the flow of AC current or AC voltage in inductors and capacitors.

(10) To produce a drift of electrons, or electric current, along a wire it is necessary that there be a difference in "pressure" or potential between the two ends of the wire. This potential

difference can be produced by connecting a source of electrical potential to the ends of the wire.

【Ex. 4】 把下列短文翻译成中文。

Switches are devices that create a short circuit or an open circuit depending on the state of the switch. For a light switch, ON means short circuit (current flows through the switch, lights light up). When the switch is OFF, that means there is an open circuit (no current flows, lights go out). When the switch is ON it looks and acts like a wire. When the switch is OFF there is no connection.

【Ex. 5】 通过 Internet 查找资料,借助如"金山词霸"等电子词典和辅助翻译软件,完成以下技术报告。通过 E-mail 发送给老师,并附上你收集资料的网址。

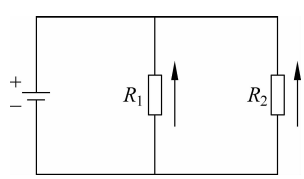
(1) 一个电路包括哪些主要元件,各种元件由哪些公司生产(附上各种最新产品的图片)。

(2) 叙述德国物理学家基尔霍夫的生平简历及其重大贡献。

Text B DC Parallel Circuit

1. Resistance in a parallel circuit

A parallel circuit is formed when two or more resistances are placed in a circuit side-by-side so that current can flow through more than one path. The illustration shows two resistors placed side-by-side. There are two paths of current flow. One path is from the negative terminal of the battery through R_1 returning to the positive terminal. The second path is from the negative terminal of the battery through R_2 returning to the positive terminal of the battery.



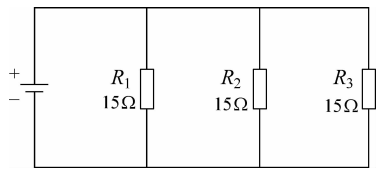
2. Formula for equal value resistors in a parallel circuit

To determine the total resistance when resistors are of equal value in a parallel circuit, use the following formula:

$$R_t = \frac{\text{Value of one resistor}}{\text{Number of resistors}}$$

In the following illustration there are three 15Ω resistors. The total resistance is

$$R_t = \frac{\text{Value of one resistor}}{\text{Number of resistors}} = \frac{15}{3} = 5\Omega$$



3. Formula for unequal resistors in a parallel circuit

There are two formulas to determine total resistance for unequal value resistors in a parallel circuit. The first formula is used when there are three or more resistors. The formula can be extended for any number of resistors.

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

In the following illustration there are three resistors, each has different value. The total resistance is

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

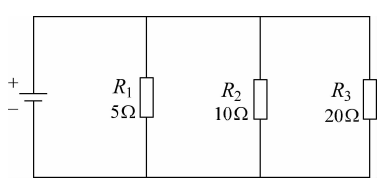
$\frac{1}{R_t} = \frac{1}{5} + \frac{1}{10} + \frac{1}{20}$ Insert value of the resistors

$= \frac{4}{20} + \frac{2}{20} + \frac{1}{20}$ Find lowest common multiple

$= \frac{7}{20}$ Add the numerators

$\frac{R_t}{1} = \frac{20}{7}$ Invert both sides of the equation

$R_t = 2.86\Omega$ Divide



The second formula is used when there are only two resistors.

$$R_t = \frac{R_1 \times R_2}{R_1 + R_2}$$

In the following illustration there are two resistors, each has different value. The total resistance is

$$R_t = \frac{R_1 \times R_2}{R_1 + R_2} = \frac{5 \times 10}{5 + 10}$$

$$= \frac{50}{15} = 3.33\Omega$$