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Методические рекомендации к практическим занятиям для студентов специальности 1-53 01 05 «Автоматизированные электроприводы» и направления подготовки 13.03.02 «Электроэнергетика и электротехника» очной и заочной форм обучения

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Составитель ст. преподаватель А. А. Размахнина

Рецензент Е. Н. Мельникова

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Ответственный за выпуск	Н. Н. Рытова
Корректор	Т. А. Рыжикова
Компьютерная верстка	Н. П. Полевничая

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Section I. Electricity Basics

Unit 1. Atom and Current

1. Study and remember the vocabulary.

flow – поток
particle – частица
electron – электрон
proton – протон
neutron – нейтрон
nucleus – ядро
ion – ион
charge – заряд
to whirl – вращаться
to gain – приобрести
to attract – притягиваться
to repel – отталкиваться
electric field – электрическое поле
negatively charged – отрицательно заряженный
positively charged – положительно заряженный
uncharged particle – незаряженная частица
like charges – одноименные заряды
unlike charges – разноименные заряды

2. Look at the picture below. Can you explain the structure of an atom?

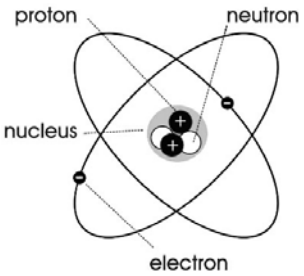


Figure 1

Atom Structure

Electricity is a flow of energy which is produced by the movement of electrons. Everything around us consists of atoms. Atoms, in turn, are made up of three main types of tiny *particles*, including *electrons, protons,* and *neutrons.* Both electrons and protons have an electric charge. An electron has one unit of negative charge, and proton has one unit of positive charge. A neutron has no charge. Protons and neutrons are heavier than electrons and are crowded into the *nucleus,* the central core of an atom. Electrons whirl around the nucleus.

Ordinarily, an atom has an equal number of electrons and protons (Figure 1), and so it is electrically neutral. If an atom gains some electrons, it becomes negatively charged. If an atom loses some electrons, it becomes positively charged. Atoms that have an electric charge, either negative or positive, are called *ions.*

Every charged particle is surrounded by an electric field, the space around the particle in which the charge has an effect. Uncharged particles do not exert forces on one another. If two balls without electric charges are suspended near each other, they remain still because they are not surrounded by electric fields. Particles with unlike charges *attract* one another. If a positively charged ball and a negatively charged ball are suspended near each other, their electric fields interact and pull the balls together. Particles with like charges *repel* one another. If two negatively charged balls are suspended near each other, their electric fields interact and cause the balls to move apart.

3. Finish the sentences.

1. An atom consists of … .
   a) a nucleus and protons.
   b) protons and neutrons.
   c) a nucleus and electrons.
2. Electricity is a flow of ….
   a) positively charged particles i. e. electrons.
   b) negatively charged particles i. e. electrons.
   c) ions.
   d) atoms.
3. An ion … /
   a) is a particle with no charge.
   b) has either positive or negative charge.
   c) whirls around the nucleus.
   d) is an uncharged particle.
4. Atom is electrically neutral because … .
   a) it consists of neutrons.
   b) electrons and protons have the same charge.
   c) of an equal number of electrons and neutrons.
   d) it has the same number of electrons and protons.
5. Two particles repel one another when they …
   a) are not electrically charged.
   b) have like charges.
   c) have unlike charges.
   d) don't have an electric field.

4. Answer the questions.

1. What is electricity? 2. What does atom consist of? 3. What charge does each of the particles have? 4. What structure does an atom have? 5. Why is an atom electrically neutral? 6. How does an atom become an ion? 7. What is an electric field? 8. When do particles attract each other?

5. Read the passage and fill in the gaps using the following words: *atoms*, *electrons*, *free*, *ion*, *negative*, *neutrons*, *neutral*, *nucleus*, *positive*, *protons*.

A matter is composed of microscopic particles called [1)]… . In the center of each atom there is a [2)]… made of protons and neutrons. Other particles, called [3)]…, whirl around the nucleus. Electrons carry a negative electric charge, protons carry a positive electric charge and [4)]… are electrically neutral. Normally, the number of electrons in an atom is exactly equal to the number of [5)]… . The positive electric charge of the protons is balanced by the negative electric charge of the electrons and the atom as whole is electrically [6)]… . However, electrons orbit at different distances from the nucleus and those which orbit farthest away can become detached from the atom and change into '[7)]… electrons'. If an atom loses an electron it then has more protons than electrons and is called a ' [8)]… ion'. If a free electron meets a neutral atom, it may go into the outer orbit around the nucleus. The atom now has an overall [9)]… charge. An atom in this state is called a 'negative [10)]… '. Electric energy is the result of the movement through material of free electrons passing from atom to atom.

6. Self-check. Complete the descriptions.

a) **The structure of an atom.** In an atom [1)]… is a central nucleus [2)]… up of protons and [3)]… . A number of [4)]… move in orbits [5)]… it. The [6)]… of electrons in a normal atom is [7)]… to the number of [8)]… .

b) **How we obtain current electricity.** [9)]… electrons normally move at [10)]… among the atoms of a [11)]…, but if we make them [12)]… in a uniform [13)]… we obtain an [14)]… current.

Unit 2. Charges and Electricity

1. Study and remember the vocabulary.

to rub – тереть
to lose – терять
to capture – захватывать
to build up – накапливать
to charge – заряжать
to discharge – разряжать
to disappear – исчезать
friction – трение
attraction – притяжение
repulsion – отталкивание
irreversible – необратимый
wire – провод
lightning – молния
lightning rod – громоотвод
shock – удар, электрошок
spark – искра
dangerous – опасный
conductor – проводник
insulator – диэлектрик, изолятор
electrostatic field – электростатическое поле
static charge – статический заряд
static electricity – статическое электричество

2. Complete the descriptions using the following words.

a) *charged*, *electrons*, *glass*, *negatively*, *rod*, *silk*, *sticks*.

If you rub a [1)]… rod with a silk cloth, some [2)]… move from the [3)]... to the cloth. The [4)]… cloth becomes charged while the rod becomes positively [5)]… . As a result, the cloth [6)]… to the rod.

b) *loses*, *positively*, *repels*, *rub*, *pullover*, *water*.

When you [7)]… a plastic ruler against your [8)]…, the ruler [9)]… some electrons. If you place the ruler near [10)]… running from a tap, the ruler [11)]… the water because they are both [12)]… charged.

c) *bottom*, *cloud*, *discharge*, *flash*, *ground*, *ice*, *part*, *static*, *top*, *winds*.

Lightning happens when [13)]… electricity builds up in a [14)]… . There is friction between strong [15)]… and particles of water, dust or [16)]… in the cloud. The [17)]… of the cloud usually become positively charged while the [18)]… is negatively charged. The [19)]… of light we see is the [20)]… of electricity from one [21)]… of the cloud to another or, from the cloud to the [22)]… .

Static electricity

Sometimes, when you rub two different materials together, *friction* causes one of the materials to lose some of its outer electrons, and these electrons are captured by the atoms in the other material. When this happens, static charges *build up* in the two materials. The charge is positive in the material that has lost electrons and negative in the material that has gained electrons. When charges exist but stay separated in the two materials, you have static electricity. Hard rubber, glass, plastic, wax, silk, nylon, ceramics etc. are all *insulators* and therefore easily build up static electricity. This does not happen with *conductors*, such as copper or iron, because

their electrons move freely and the charges are quickly neutralized.

When objects are charged with static electricity, they behave as follows. If a positively charged object is placed near one which is negatively charged, they will attract each other. If the two objects have the same type of charge, either positive or negative, they will repel each other. The force that produces the effect of attraction or repulsion is called the electric field of force, or *electrostatic field*. Electric charges are not *irreversible*: charged materials can be *discharged* and neutralized by connecting a *wire* (conductor) from one material to the other so that the electrons of the negative charge can cross over to the positive charge. The charges also disappear if the materials are simply touched together.

If the electrons have strong charges, they may jump from the negative charge to the positive charge before the two materials come into contact and the discharge can be unpleasant or even *dangerous*. This is why sometimes on a dry day you get an unpleasant *shock* and even see sparks when you touch a metal object or another person. Another example of a discharge of static electricity is *lightning*. An electric charge may jump from the negatively charged particles at the bottom of a cloud to the ground below. The energy in a stroke of lightning is enormous, therefore tall buildings are usually protected from it by lightning rods that attract the charge and conduct it into the ground.

3. Match the words with their definitions.

1 conductor	a) rubbing of one object against another
2 dangerous	b) a material that heat or electricity can pass through
3 discharge	c) a material that heat or electricity cannot easily pass through
4 friction	d) a long thin bar of metal or wood
5 ground	e) the surface of the earth
6 insulator	f) a flash of light caused by electricity
7 spark	g) free an object of an electric charge
8 rod	h) not safe; able to cause injury to people

4. Choose the correct adverb or preposition to complete the sentence: *from*, *into*, *over*, *together*, *up*, *with*.

1. When you rub two materials … you sometimes produce sparks. 2. Insulators easily build … static electricity. 3. Objects charged … static electricity either attract or repel each other. 4. When two charged objects are connected by a wire, electrons of the negative charge cross … to the positive charge. 5. Sometimes electrons jump from one charged material to another before the two materials come … contact. 6. Metal rods are placed on tall buildings to protect them … lightning.

5. Answer the questions.

1. What sometimes happens when you rub two materials together? 2. What kind of charge builds up in the material that has gained electrons? 3. Give some examples of materials which build up static electricity easily. 4. What causes the effect of attraction or repulsion between charged materials? 5. How can charged

materials be discharged? 6. What is lightning caused by? 7. How do lightning rods protect buildings?

6. Self-check. Complete the descriptions.

a) **How static electricity is created.** When you[1)]… two different materials together, some [2)]… go from one [3)]… to the other, building up negative and [4)]… static [5)]… if these charges stay [6)]… in the two materials you have [7)]… electricity.

b) **How static electricity is discharged.** Charged materials can be [8)]… by connecting a [9)]… from one material to the [10)]… or by [11)]… the two [12)]… together. If the charges are very [13)]…, the electrons may jump from the [14)]… charge to the [15)]… charge before contact. In that case, the discharge is seen in the form of an [16)]… .

Unit 3. Conducting Electricity

1. Study and remember the vocabulary.

conductor – проводник
insulator – диэлектрик
semiconductor – полупроводник
superconductor – сверхпроводник
expensive – дорогой
cheap – дешевый
equipment – оборудование
alloy – сплав
substance – вещество
pure – чистый, без примесей
impurity – примесь
solution – раствор
acid – кислота
poor – слабый
conductivity – проводимость
resistance – сопротивление
solid – твердое вещество
integrated circuit – интегральная микросхема
practical application – практическое применение
to allow – позволять
to handle – обращаться (с ч.-л.)
to manufacture – производить
to dope – легировать
to rise – подниматься
to decrease – снижаться
to limit – ограничивать

2. Read, translate and remember the list of substances below.

aluminium germanium
air
arsenide [ˈärs(ə)ˌnīd]
porcelain ['pɔːs(ə)lɪn]
selenium
nylon ['naɪlɔn]
copper ['kɔpə]
plastic
gallium ['gælɪəm]
rubber ['rʌbə]
salt
gold
silicon ['sɪlɪkən]
graphite ["græfaɪt]
lead [led]
silver
glass
water

3. Decide which of the following definitions describes *insulators, conductors* or *semiconductors*. Fill in Table 1. Use the list above to provide examples. Read the text and check.

Table 1

Material	Definition	Examples
a) _____	materials through which electric current can flow easily, because they have a large number of free electrons	
b) _____	materials which become conductors when carefully controlled impurities are added to them during manufacture	
c) _____	materials which resist the movement of electric current because their electrons are not easily detached from the atoms and there are few free electrons	

From insulators to superconductors

Materials can be divided into different groups according to how easily they allow the free motion of electrons. These groups are: conductors, insulators, semiconductors and superconductors.

Conductors. All metals are conductors. The best are silver and gold, but they are expensive. Copper and aluminium are normally used in electric and electronic equipment – and in cable manufacture – because they are much cheaper. Copper and aluminium are generally used pure because their conductivity falls rapidly when alloying elements are added to them. A nonmetal which conducts well is a common form of carbon, known as graphite. Pure water is a poor conductor, but salt water and solutions of salts and acids are good conductors. That is why electricity can flow through the human body and give an electric shock. Therefore electrical equipment should never be handled with wet hands.

Insulators. No substance is a perfect insulator because in all insulators there is a slight flow of electrons. So there is no sharp division between conductors and insulators; insulators are really poor conductors. Their opposition to the flow of current is called resistance. Most nonmetallic solids such as plastic, rubber, glass, nylon, porcelain etc. are insulators. Air is an insulator, too.

Semiconductors. These are basically insulators that become conductors when they are doped or when the temperature rises enough to free some electrons within the material. The most important semiconductor is silicon, the material used to manufacture most transistors and integrated circuits. Others are germanium, selenium and gallium arsenide, which are used in many light-emitting diodes (LEDs). The important thing about semiconductors is not that they are midway between insulators and conductors. It is that they conduct electricity better in one direction than in the other direction.

Superconductors. In some materials, resistance to the flow of electrons decreases at very low temperatures. If, for example, some metals like lead are cooled to about –270 °C, they become almost perfect conductors. However, because of these

extreme conditions, the practical applications of superconductivity are at present limited.

4. Match each word with its definition.

1 alloy	a) a small circuit printed on a single silicon chip
2 cable	b) go up; increase
3 decrease	c) go down
4 degree	d) decline
5 equipment	e) a metal made by mixing two or more metals together
6 fall	f) a thick wire which carries electric or electronic signals
7 integrated circuit	g) a heavy grey metal
8 lead	h) produce things in a factory
9 manufacture	i) tools or other things used to do a particular job
10 rise	j) unit used to measure temperature

5. Provide opposites using the adjectives from the text.

a) *dry* hands – … hands; b) *high* temperatures – … temperatures; c) an *intense* flow – a … flow; d) an *imprecise* division – … division; e) a *good* conductor – a … conductor; f) a *cheap* material – a … material.

6. Finish the sentences using the words with the opposite meaning.

1. *Conductors* have a *low* resistance while … .
2. Current passes through *insulators with great difficulty* while … .
3. *Metals* are common *conductors* while … .
4. To make *insulators* conduct, currents of *great* value must be applied while …
5. *Carbon decreases* its resistance when the temperature increases while … .

7. Choose the correct preposition in each sentence.

1. In insulators there is resistance *at/from/to* the flow of electrons.
2. Conductors are materials *across/through/over* which current can flow easily.
3. A common form of carbon – known *as/like/by* graphite – is a good conductor.
4. In superconductors, resistance decreases *at/to/from* very low temperatures.
5. Some materials, if cooled *by/to/from* –270 °C, become almost perfect conductors.
6. The conductivity of copper falls if an alloying element is added *at/to/by* it.

8. Answer the questions.

1. Which metals conduct electricity best? 2. Why are copper and aluminum normally used for cable manufacture? 3. Why are copper and aluminum generally used pure? 4. Why is it a good rule never to handle electrical equipment with wet hands? 5. Is any material a perfect insulator? Why (not)? 6. What is the most important property of semiconductors? 7. When do some metals become superconductors?

9. Self-check. Complete these passages.

a) **Comparing conductors.** [1)]… and silver are [2)]… conductors than [3)]… and aluminium but being very [4)]…, they are not used [5)]… frequently in electric and electronic [6)]… . The [7)]… of copper and aluminum [8)]… rapidly when an alloying element is [9)]… , so they are generally used [10)]… .

b) **Semiconductors.** [11)]… is the [12)]… important semiconductor because it is [13)]… to make most transistors and integrated [14)]… . But [15)]… are others; for example selenium used in the xerographic photocopying process, and [16)]… arsenide, used in the manufacture of many [17)]… .

Unit 4. Measuring Electricity

1. Study and remember the vocabulary.

voltage – напряжение
current – ток
resistance – сопротивление
conductance – электропроводность
force – сила
difference – разница
power source – источник питания
unit of measure – единица измерения
rate – скорость
carrier – носитель
opposition – противодействие
property – свойство
matter – вещество, материя
essential – необходимый
to depend on – зависеть (от)
to deal with – иметь дело (с)
to express – выражать
to cause – вызывать
to indicate – указывать
to define – определять
in order to – для того чтобы

2. Do you know basic electrical parameters and their measurement units? Find 5 mistakes in Table 2. Read the text and check.

Table 2

Parameter	Unit
Voltage	*Ohm*
Current	*Ampere*
Resistance	*Watt*
Conductance	*Siemens*
Capacitance	*Farad*
Charge	*Hertz*
Inductance	*Henry*
Power	*Volt*
Energy	*Joule*
Frequency	*Coulomb*

Electrical quantities

The knowledge of the basic electrical quantities is essential for technicians and for all those who deal with electricity. When we refer to the electricity flowing through an electric circuit, we use the terms *voltage, current, resistance, conductance* and *charge*.

Voltage is the force that maintains the current flow through the circuit, and is abbreviated in V. Voltage is expressed in volts. The volt, whose symbol is V as well, is named after Alessandro Volta, and is the difference in potential between the positive and the negative terminals of the *power source*. The force acting to cause current to flow in a *circuit* depends on the voltage: the higher the voltage, the greater is the force.

Current is any movement of electric charge *carriers*, such as electrons, protons and ions. Term current is represented by letter I; the unit of measure for current flow is the amp (A), indicating the rate at which electricity flows through a circuit. The higher the current, the faster the current flows in the circuit.

Resistance is the opposition found in the various circuit components to the flow of electric current. The letter R represents the term resistance and the Greek letter omega (Ω) indicates the unit of resistance, the ohm. Except superconductors, all materials oppose the flow of electricity. We can tell insulators, which are materials having a very high resistance, from conductors, materials with a very low resistance.

Conductance is another electrical parameter. Conductance is the opposite of resistance, and it can be defined as the comparative ease with which current flows through a component or a circuit. The abbreviation for the term conductance is G, and the unit of conductance is the siemens (S), named after the scientist Ernst Von Siemens.

Charge is the basic *property* of elementary particles of *matter*. An electron carries only a tiny charge of electricity, so a very great number of electrons has to flow in order to have a measurable current. The unit of charge is the coulomb, whose abbreviation is C, while the letter Q represents the term charge. The relationship between voltage, current and resistance is expressed in the Ohm's law. According to this law: V (voltage) = I (current) ×R (resistance).

3. Finish the sentences.

1. The main terms we use when talking about electricity are… .
2. Voltage can be defined as … .
3. The higher the voltage … .
4. Ampere indicates … .
5. The higher the current … .
6. All materials except for superconductors … .
7. Conductance and resistance … .
8. Alessandro Volta and Ernst Von Siemens … .
9. The basic property of elementary particles … .
10. The Ohm's law expresses … .

4. Self-check. Complete Table 3.

Table 3

Definition of quantity	Electrical quantity	Unit of measure	Unit symbol
Excess or deficiency of electrons			
Force able to move electrons			
Progressive flow of electrons			
Opposition to current flow			

Unit 5. Fathers of Electricity

1. What famous scientists who worked with electricity have you heard of?
2. Do you know their discoveries and inventions?
3. Are you familiar with the works of modern scientists in this field?

1. Fill in the missing information in the passages below using the words from the box. Then listen and check.

communication, *signals*, *forces*, *cell*, *stationary*, *balance*, *field*, *inventor*, *theory*, *spark*, *radiations*, *refraction*, *battery*, *coil*, *relativity*, *produce*, *currents*, *wire*, *generation*

1. The French physicist Charles-Augustin de Coulomb (1736–1806) invented a torsion … to measure electric and magnetic … and formulated Coulomb's Law. The "coulomb", an electrical unit, was named in his honour.

2. The Italian scientist Alessandro Volta was born in 1745. Volta invented the voltaic …; then by connecting several of these in series, he developed the first electric … in 1800. The "volt", a unit of electromotive force that drives current, was named after him. He died in 1827.

3. In 1819, the Danish physicist and chemist Hans Christian Oersted (1777–1851) found that the current flowing in a current-carrying … caused a nearby compass needle to deflect, thus discovering that electricity could … magnetism. Before him, electricity and magnetism were considered independent phenomena.

4. Soon after Oersted's discovery, the French physicist Andre-Marie Ampere (1775–1836), invented the solenoidal … for producing magnetic fields and theorized correctly that the atoms in a magnet are magnetized by tiny electric … circulating in them.

5. In 1831, the English physicist Michael Faraday (1791–1867) demonstrated that a changing magnetic … could produce an electric current. Whereas Oersted found that electricity could produce magnetism, Faraday discovered that magnetism could produce electricity.

6. Faraday's investigations enabled James Clerk Maxwell (1831–1879) to publish the first unified … of electricity and magnetism and thus to found the science of electromagnetics. He postulated that light was electromagnetic in nature and that electromagnetic … of other wavelengths should be possible.

7. The German physics professor Henry Hertz (1857–1894) generated and detected radio waves and, using a … transmitter and receiver, demonstrated that, except for a difference in wavelength, the polarization, reflection and … of radio waves were identical with light. Hertz was the father of radio, but his invention remained a laboratory curiosity until the arrival of Marconi.

8. Guglielmo Marconi (1874–1937) adapted Hertz's spark system to send messages across space. In 1901, he created a sensation by sending radio … across the Atlantic Ocean. Marconi pioneered the development of radio … for ships. Prior to radio, complete isolation shrouded a ship at sea. Marconi changed all that, and radio began to be of great commercial importance.

9. American Thomas Alva Edison was born in 1847. A prolific … and the holder of over 1,000 patents, Edison put electricity and magnetism to practical use in telegraphy, telephony, lighting and power … and transmission. He died in 1931.

10. In 1905, Albert Einstein (1879 – 1955) formulated his … theory, according to which there is no such thing as a pure electric or a pure magnetic field which retains its identity for all observers. Thus, what appears to be a static electric field to a … observer appears, at least partially, as a magnetic field to a moving observer.

2. Has any of the inventions you've read about sparked your interest? Has any of the inventors inspired or challenged you? Choose on of the inventions or discoveries that you consider one of the most important for the humanity, make a research and present it to the class.

Section II. Electric Circuits

Unit 1. Current and Circuits

1. Study and remember the vocabulary.

circuit – цепь
switch – переключатель
function – назначение
open – обрыв
short – короткое замыкание
trouble – повреждение
no current – отсутствие тока

to reduce – сокращать
to supply – снабжать
to connect – связывать
to compare (with) – сравнивать (с)
to pass through – проходить через
to result in – приводить к ч.-л.
to result from – следовать из ч.-л.

Electric circuit

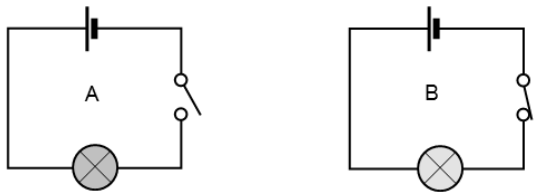


Figure 2

This is a circuit (Figure 2). Its elements are a voltage source, a resistor, a switch and a conductor. The circuit consists of a voltage source, a resistor and a conductor. A voltage source supplies current. A resistor reduces current. A conductor connects the elements of the circuit. Compare circuit *a* with circuit *b*. What is the difference between them? Current passes through circuit *b* while no current passes through circuit *a*. Circuit *a* has an open. No current through circuit *a* results from an open. An open and a short are troubles in a circuit. A trouble in a circuit may result in no current in it.

2. Finish the sentences.

1. Circuit *a* includes … .
   a) resistors; conductors;
   b) a voltage source and resistors;
   c) a voltage source, a switch and a conductor.
2. A voltage source … .
   a) conducts current;
   b) reduces current;
   c) supplies current.
3. A conductor … .
   a) connects the elements;
   b) supplies voltage;
   c) conducts current.
4. A resistor … .
   a) connects the elements;
   b) supplies current;
   c) reduces current.

5. No current results from … .
   a) an open;
   b) a short.

3. Answer the questions.

1. What elements does a circuit consist of?
2. What is the function of a voltage source?
3. What is the function of a conductor?
4. What is the function of a resistor?
5. When is there no current in a circuit?
6. What does an open or a short result in?
7. What does no current in a circuit result from?

4. Most electric circuits include more elements than the basic ones. What function does each of the elements in the circuit have?

ammeter, *battery*, *bulb*, *fuse*, *resistor*, *switch*, *voltmeter*, *wire*

1. to allow or to stop the flow of electrons at any moment;
2. to reduce the strength of the current in one part of the circuit;
3. to provide the source of the electric energy;
4. to measure the current flowing through part of the circuit;
5. to measure the electromotive force at one point in the circuit;
6. to break the circuit if too much current flows through it;
7. to carry electric energy around the circuit;
8. to convert electric energy into light.

5. Self-check. Look at the questions and match them with the answers.

1. What is a circuit?
2. What does a switch do?
3. When does short circuit occur?
4. What causes a short circuit?
5. What is a resistor used for?

a) When a low-resistance connection allows a larger than normal current to flow between points on a circuit. This can damage the circuit elements or cause overheating or even a fire.

b) It is a combination of a power source, a conductor and a consuming device, or load.

c) It is used to control the flow of current. It is often used in electric and electronic circuits, where it is represented by the letter R.

d) It opens and closes a circuit. When we turn it on, we close the circuit and allow electrons to flow. When we turn it off, the circuit is open and the flow stops.

e) There can be several causes. It can happen when two bare wires touch; when the wiring is improper; when the resistance terminals are directly connected; when

the battery leads contact each other; or when a low-resistance wire is placed across the consuming device.

Unit 2. Types of Circuits

1. Study and remember the vocabulary.

branch – отвод
line – линия
main – главный, основной
series – последовательное
parallel – параллельное
value – величина
voltage drop – падение напряжения
to use – использовать
to be equal – быть равным
the same – одинаковый

Series and parallel circuits

Compare circuits *a* and *b* (Figure 3). Circuit *a* consists of a voltage source and two resistors. The resistors are connected in series. Circuit *a* is a series circuit. Circuit *b* consists of a voltage source and two resistors. The resistors are connected in parallel. Circuit *b* is a parallel circuit. A parallel circuit has the main line and parallel branches.

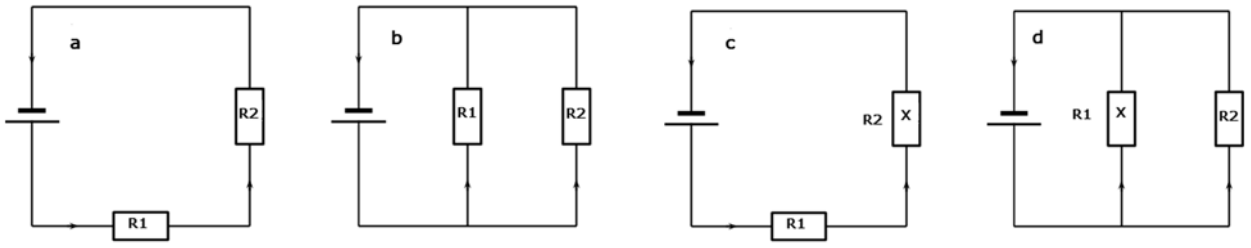


Figure 3

In circuit *b* the value of voltage in R_1 equals the value of voltage in R_2. The value of voltage is the same in all the elements of a parallel circuit while the value of current is different. A parallel circuit is used in order to have the same value of voltage.

In circuit *a* the value of current in R_1 equals the value of current in R_2. The value of current is the same in all the elements of a series circuit while the value of voltage is different. A series circuit is used in order to have the same value of current. In circuit *c* a trouble in one element results in no current in the whole circuit. In circuit *d* a trouble in one branch results in no current in that branch only, a trouble in the main line results in no current in the whole circuit.

2. Finish the sentences.

1. A parallel circuit has … .
   a) parallel branches only;
   b) the main line and parallel branches.

2. A parallel circuit is used in order … .
   a) to have the same value of current in all the elements;
   b) to have the same value of voltage in all the elements.
3. In a parallel circuit a trouble in one branch … .
   a) results in no current in that branch only;
   b) results in no trouble in the whole circuit.
4. No current in a parallel circuit … .
   a) results from a trouble in one branch;
   b) results from a trouble in the main line.

3. Complete the sentences using words with *opposite meaning*.

1. Resistors connected *in series* have *different* values of voltage while ... .
2. A trouble in one element of a *series* circuit results in no current in the *whole circuit* while ... .
3. In order to have the same value of *current* in all the elements, a *series* circuit is used while ... .
4. No current in a *parallel* circuit results from a trouble in the *main line* while ...

4. Answer the questions.

1. What type of circuit has the main line and parallel branches?
2. What type of circuit is used in order to have the same value of current in all the elements?
3. What type of circuit is used in order to have the same value of voltage in all the elements?
4. What does a trouble in the main line result in?
5. What does a trouble in a branch result in?
6. What does no current in a series circuit result from?
7. What is the difference between series and parallel circuits?

5. Self-check. Complete the text using the words from the box.

branches, *current*, *devices*, *directly*, *flow*, *lights*, *measure*, *more*, *parallel*, *resistance*, *series*, *series-parallel*, *voltage*, *wiring*

There are two basic types of circuits: series circuits and parallel circuits.

In a [1)]… circuit two or more resistors or consuming [2)]… are connected one after the other. So, all the current must [3)]… through every component. A typical example is a set of [4)]… on a Christmas tree. The total circuit [5)]… is the sum of the individual resistances ($R_t = R_1 + R_2 + ...$).

A [6)]… circuit is made up of branches, like the electrical [7)]… of a house. The current divides and part of it flows through each branch. The voltage across all [8)]… of the circuit is the same. The current depends on the resistance of the branch (low resistance branches draw [9)]… current than high resistance branches). To [10)]… the total resistance you can use the following formula: $1/R_t = 1/R_1 + 1/R_2 + ...$). If we combine

the two kinds of circuits we obtain a [11)]… circuit: it takes a minimum of three resistances to make one.

Ohm's law states that current varies [12)]… with the voltage and inversely with the resistance. We can express Ohm's law as follows: I = E/R. This formula is used to find the [13)]… when the voltage and the resistance are known. To find the [14)]… we use E = I · R. To find the resistance we use R = E/I.

Section III. Sources of Current

Unit 1. Types of Current

1. Study and remember the vocabulary.

alternating – переменный
direct – постоянный (*о токе*)
direction – направление
frequency – частота
to apply – применять
to consider – рассматривать
provided that – при условии
rectifier – выпрямитель

2. Give Russian equivalents to: *cycle*, *type*, *per second*, *one time*, *sixty times*, *direct voltage source*, *alternating voltage source*, *direction of flow.*

Types of current

Current is a flow of electricity through a circuit. Let us consider two main types of current: *direct* and *alternating*. A direct current (DC) flows through a conducting circuit in one direction only. It flows provided a direct voltage source is applied to the circuit.

An alternating current (AC) is a current that changes its direction of flow through a circuit. It flows provided an alternating voltage source is applied to the circuit. Alternating current flows in cycles. The number of cycles per second is called the frequency of the current. Frequency is measured in units called hertz. In a 60-cycle alternating current circuit the current flows in one direction 60 times and in the other direction 60 times per second.

It is easy to transform AC power from one voltage to another by a transformer. Transformers are also used to step down the voltage at the receiving point of the line to the low values that are necessary for use.

When necessary AC can be changed into DC but this is seldom necessary. Devices called rectifiers easily change AC into DC.

3. Complete the sentences.

1. DC is a current that … .
   a) changes its direction of flow; b) flows in one direction.
2. AC flows provided … .
   a) a direct voltage source is applied; b) an alternating voltage source is applied.

3. In an alternating current circuit … .

a) current flows in one direction 60 times per second; b) current flows in both directions 60 times per second.

4. AC … .

a) can be changed into DC; b) cannot be changed into DC.

4. Complete these sentences using *while*.

1. An *alternating* current *changes* its direction of flow … .
2. A *direct* current flows provided a *direct* voltage source is applied … .

5. Answer the questions.

1. What is current? 2. What types of current do you know? 3. When does a direct current flow? 4. What type of current is called an alternating current? 5. What type of current is called a direct current? 6. What is called the frequency of current? 7. What device is used to transform AC power from one voltage to another? 8. Is it often necessary to change AC into DC? 9. What device is used to change AC into DC?

Unit 2. Sources of Electricity

1. Study and remember the vocabulary.

electric cell – гальванический элемент
solar cell – фотоэлемент
loop – петля
liquid – жидкий
generator – генератор
battery – батарея, аккумулятор
electrode – электрод
electrolyte – электролит
to induce – индуцировать
to rotate – вращать(ся)
to convert – преобразовывать
approximately – примерно
artificial – искусственный

Sources of electricity

The sources of electricity produce electric energy from some type of nonelectric energy. The main sources are generators, batteries, solar cells.

Generators convert mechanical energy into electricity. They produce most of our electricity. If a loop of wire rotates between the poles of a magnet, electric current is induced in the wire. The amount of electric energy produced by a generator is approximately equal to the amount of mechanical energy that is used in moving the magnet or wire. One generator can provide enough power for a city of 500,000 people.

Batteries change chemical energy into electricity. A battery consists of one or more units called electric cells. Each cell has two electrodes, which are made of different chemically active materials. One of the electrodes is positively charged, and the other is negatively charged. An electric cell also contains a liquid or paste called an electrolyte. The electrolyte is a chemical substance that conducts electric current in

the cell. When the electrodes of a battery are connected to an electric circuit, the battery produces current, which flows through the circuit.

Solar cells convert sunlight into electricity. They provide nearly all the electric power for artificial satellites and space vehicles. Most solar cells are made of a silicon crystal.

2. Complete the sentences.

1. Generators … .
   a) are used to produce electric current;
   b) convert electrical energy into mechanical energy.
2. An electric cell … .
   a) contains two positively charged electrodes;
   b) contains two negatively charged electrodes;
   c) is a part of a battery.
3. The battery produces electricity … .
   a) when the positively charged electrode and the negatively charged electrode are connected;
   b) when the electrodes and the electrolyte are connected;
   c) when the electrodes are connected to an electric circuit.

3. Answer the questions.

1. What are the main sources of electricity? 2. What devices are used to convert mechanical energy into electricity? 3. How much power can one generator provide? 4. How do batteries produce electricity? 5. What are the main components of a battery? 6. What is the function of an electrolyte? 7. Where are solar cells commonly used? 8. What are most solar cells made of?

Unit 3. Generators

1. Study and remember the vocabulary.

armature – якорь
commutator – коллектор
brushes – щетки
field magnet – возбуждающий магнит
electromagnetic force – электродвижущая сила
slip rings – контактные кольца
split rings – разрезные кольца

Components of a generator

The elementary generator consists of a loop of wire, the armature, which has to be rotated in the magnetic field supplied by a stationary magnet, called field magnet, to cause an induced emf (electromagnetic force) in the loop. The loop is placed

between the north and south poles of the magnet. The terminals of the armature loop are connected to rings, called slip rings, in AC generators, or to a split ring, called commutator, in DC generators. These rings rotate with the armature. Brushes of metal or carbon ride up against the slip rings or the commutator to connect the armature to the external circuit. As the sides of the loop cut through the magnetic field, the emf induced in them causes a current to flow through the loop, rings, brushes and load resistor, all connected in series.

2. Label the parts of the generator in Figure 4

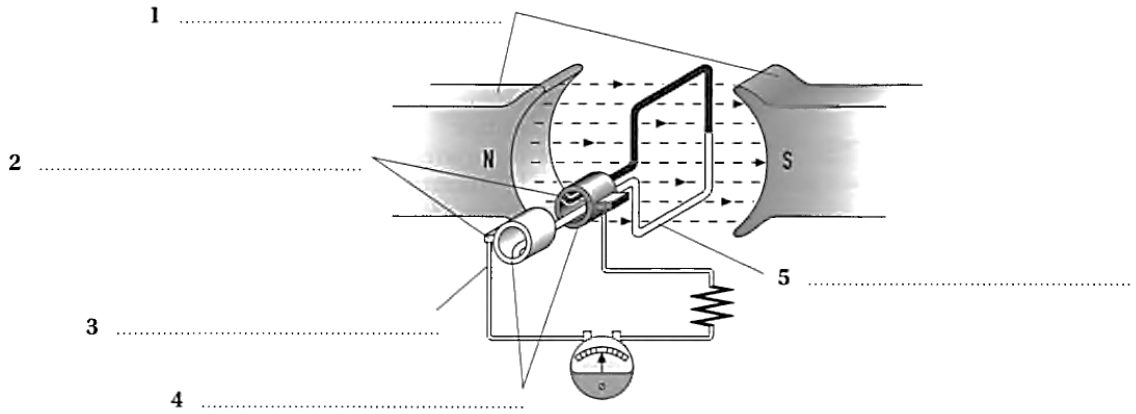


Figure4

3. Answer the questions.

1. What does an elementary generator consist of?
2. What are the terminals of the armature connected to in AC generators?
3. What are the terminals of the armature connected to in DC generators?
4. Do the slip rings rotate with the armature?
5. What is the function of the brushes?
6. What causes a current to flow through the loop?
7. When is a current induced in the loop?

Unit 4. Motors

1. In the text below, the sentences have been mixed up. Can you rearrange them?

What is a motor?

a) Though this frame is often called the armature, the term is not always applied correctly.

b) Thus, depending upon the design of the machine, either the rotor or the stator can serve as the armature.

c) In a motor, the rotating part (usually on the inside) is called the rotor, and the stationary part is called the stator.

d) As a matter of fact, the armature is that part of the motor across which the input voltage is supplied.

e) A motor transforms electrical energy into mechanical energy following the principle of electromagnetic reaction.

f) The motor contains electromagnets that are wound on a frame.

g) Motors are classified as AC or DC according to their power source.

2. Read the description of how motors work and complete it.

armature, *commutator*, *direction*, *polarity*, *repel*, *rotate*, *rotor*, *stator*

When the coil of a DC motor is powered, a magnetic field is generated around the [1)]…, which revolves and provides a torque* (i.e. a turning force) because its left side is pushed away from the left magnet and pulled towards the right one, of opposite polarity.

The armature continues to [2)]… and, when unlike poles of the armature and field are facing each other, the [3)]… reverses the direction of current through the coil, thus reversing the [4)]… of the armature field. Like poles then [5)]… each other, causing continuous armature rotation.

AC motors are less difficult to operate because they do not involve the action of commutation, since alternating current reverses its [6)]… independently. AC is supplied to the coils of the outside stationary [7)]… to produce a rotating magnetic field; this field gives a torque to the output shaft** attached to the inside [8)]… .

* torque – крутящий момент
** output shaft – выходной вал

3. Complete Table 4.

Table 4

Noun	*Verb*	*Adjective/ Participle*
		polar
	rotate	
generation		
	continue	

Unit 5. Direct Current Motors

1. Study and remember the vocabulary.

series motor – электродвигатель последовательного возбуждения
shunt motor – электродвигатель параллельного возбуждения
universal motor – универсальный двигатель
brushless motor – бесщёточный двигатель
field winding – обмотка возбуждения
armature coil – катушка якоря

spark – искра
precise – точный
intermittently – время от времени
friction – трение

DC motors

In a series motor, the field windings are connected in series with the armature coils. If the armature current changes, the field strength will vary. When its speed is reduced by a load, the series motor develops a large torque and when the load is removed the speed increases sharply. It is used in machines like cranes, electric hoists, electrically powered trains, trams, cars and buses since it is a motor well-suited to starting heavy loads.

In shunt motors, the field windings are connected in parallel across the armature coils. The field strength is independent of the armature current. Shunt-motors are constant speed motors, even though their speed decreases slightly as the load is increased. They are used in industrial and automotive applications, where precise control of speed and torque is required.

The universal motor uses AC or DC supply current. The advantage is that AC supplies may be used on motors which have the typical characteristics of DC motors. The negative aspect is the maintenance as well as the short life of the commutator. Thus such motors are usually used in AC devices such as food mixers, vacuum cleaners and hair dryers, where high-speed operation is desired, but which are used only intermittently.

The applications of DC motors are limited because of the brushes conducting electric current to the commutator. They create friction, difficulty in maintaining contact at high speeds and sparks. They also need frequent replacement. The brushless motor solves these problems, as commutator and brushes are replaced by an external electronic switch synchronized to the rotor's position. Brushless motors are used where precise speed control is necessary, for example in video cassette or tape recorders, laser printers and photocopiers.

2. Complete the sentences.

1. In a series motor …
   a) the field windings are connected in parallel with the armature coils;
   b) the armature coils and the field windings are connected in series;
   c) the armature windings and the field coils are connected in series.
2. In a series motor …
   a) speed is independent from the load;
   b) speed changes with the load.
3. In a shunt motor …
   a) the field windings and armature coils are connected in parallel;
   b) the armature coils and the field windings are connected in series.
4. In a shunt motor …
   a) the speed changes sharply with the load;

b) the speed changes slightly with the load.

5. The disadvantage of a universal motor is … .
   a) that it can use only AC supply current;
   b) that it cannot be used in DC devices;
   c) the commutator needs frequent replacement.
6. The main troubles in DC motors are caused by … .
   a) sparks; b) brushes; c) a commutator.
7. Brushless motors … .
   a) is more reliable than other DC motors;
   b) doesn't have any advantages over other DC motors.

3. Complete the sentences using *while*.

1. In a *series* motor, the field windings are connected *in series* … .
2. In a *series* motor, if the armature current *changes*, the field strength will *vary* … .
3. *Universal* motors are usually used in AC devices such as *food mixers, vacuum cleaners and hair dryers* … .
4. A *brushless* motor uses an *external electronic switch* … .

4. Answer the questions.

1. How many types of DC motors are there? 2. How are the field windings connected with the armature coils in a series motor? 3. Why are series motors used in machines like cranes and trolleys? 4. How are the field windings connected with the armature coils in a shunt motor? 5. What happens in shunt motors if we increase the load? 6. Where are shunt motors commonly used? 7. What are the main features of universal motors? 8. What devices usually use universal motors? 9. Why are brushes a limitation for DC motors? 10. How do brushless motors solve this problem?

Unit 7. Alternating Current Motors

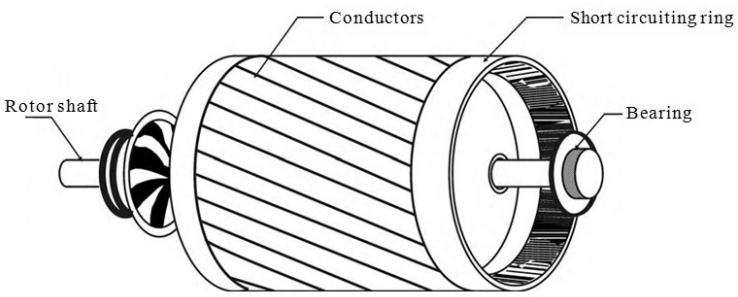
1. Study and remember the vocabulary.

synchronous motor – синхронный двигатель
induction motor – асинхронный двигатель
stepper motor – шаговый двигатель
squirrel cage – беличье колесо (тип короткозамкнутой обмотки двигателя)
to exert – приводить в действие
discrete – дискретный

AC motors

The rotor of a synchronous motor is supplied with DC and is attracted by the rotating stator field. This attraction exerts a torque on the rotor and causes it to rotate synchronously with the field. A synchronous motor maintains a constant speed and is therefore suitable for devices such as CD players or clocks.

The induction motor has the same stator as the synchronous motor, but a different rotor, which does not require an external source of power. Current is induced in it by the action of the rotating field cutting through the rotor conductors. This current generates a magnetic field which interacts with the stator field. As a result, a torque is exerted on the rotor causing it to rotate. Most induction motors use the "squirrel cage" rotor (Figure 5). It takes its name from its shape – a ring at either end of the rotor, with copper bars connecting the rings running the length of the rotor. Virtually every washing machine, dishwasher, etc. uses a rotor made like this.



Rotor of Squirrel Cage Induction Motor

Figure 5

Stepper motors are like synchronous motors in design. They have an internal rotor containing permanent magnets controlled by a set of external magnets that are switched electronically. Stepper motors convert electrical pulses into discrete mechanical rotational movement or "steps". They offer high precision and are used where position control is necessary, such as in computer hard disks, CD drives or barbecue grills.

2. Look at the following features of AC motors and refer them in the corresponding column in Table 5.

Table 5

Synchronous motor	Induction motor	Stepper motor
…	…	…

a) the rotor doesn't use an external source of power;
b) the rotor and the stator are supplied by different currents;
c) the rotor contains permanent magnets;
d) current is induced in the rotor by the action of the rotating stator field;
e) the rotor moves slightly slower than the stator field;
f) the rotor moves synchronously with the stator field;
g) the stator field is controlled electronically.

3. Answer the questions.

1. What is the stator of a synchronous motor supplied with? 2. How are synchronous and induction motors different? 3. How is current induced in an induction motor? 4. What are "squirrel cage" rotors? 5. How are synchronous and stepper motors different? 6. What are "steps"? 7. Why are stepper motors used in applications where position control is important?

4. Self-check. Explain:

1. why DC motors are more difficult to operate than AC motors. 2. the differences between shunt motors and series motors. 3. the advantages of brushless motors. 4. how stepper motors work. 5. why synchronous and induction motors are called so.

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