МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
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ENGLISH FOR ELECTRONICS

Part I

Навчальний посібник з англійської мови
для студентів спеціальності 171 «Електроніка»

Рекомендовано Методичною радою НУК

ВИДАВНИЦТВО
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Рекомендовано Методичною радою НУК

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К76 English for Electronics. Part 1 : навчальний посібник з англійської мови для студентів спеціальності 171 «Електроніка» / Г. Л. Кошкіна. – Миколаїв : НУК, 2022. – 132 с.

Представлено оригінальні тексти за професійною тематикою, наведено комплекс вправ, спрямованих на формування у студентів знань, умінь та навичок із чотирьох видів мовленнєвої діяльності (читання, аудіювання, говоріння, письма). Окрему увагу приділено опрацюванню та закріпленню лексичного матеріалу. Застосовано різноманітні візуальні засоби для кращого засвоєння навчального матеріалу. Зроблено акцент на виконанні вправ за допомогою сучасних цифрових ресурсів та інструментів.

Призначено для очного та дистанційного навчання студентів І курсу галузі знань 17 «Електроніка та телекомунікації» спеціальності 171 «Електроніка», освітня програма «Електронні системи».

811.11:621.382(075)

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CHAPTER 1. WELCOME TO ELECTRONICS

UNIT 1

WHAT IS ELECTRONICS?

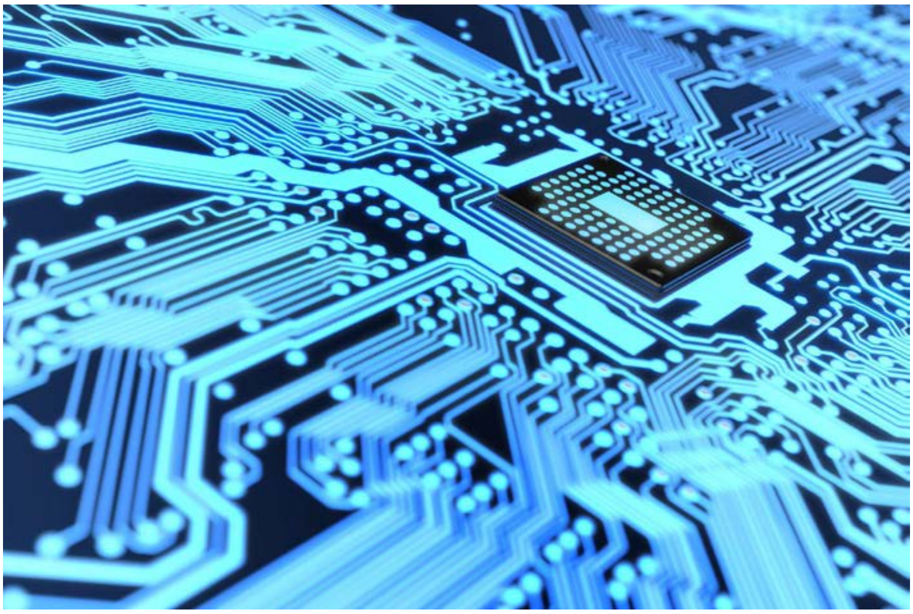


Figure 1.1. Electronic circuit

WARM-UP

1. **Answer the following questions:**
    1. What is electronics?
    2. Have your ever disassembled electronic devices? Why?

READING

2. **Read the text and define the following statements as true (T) or false (F).**
    1. Consumer electronics are electronic (analog or digital) equipment intended for everyday use, typically in private homes.
    2. An electrical circuit is a complete path for transmitting electric current.
    3. Electrical systems control the current to fulfil various functions.
    4. Electronic systems use electric current to power different devices.
    5. Electronics is a field of study that focuses on the control of electrical energy and the physical systems that implement this control.

You probably have some idea about the topic of electronics. You've been up close and personal with lots of consumer electronics devices, such as smartphones, tablets, iPods, stereo equipment, personal computers, digital cameras, and televisions, but to you, they may seem like mysteriously magical boxes with **buttons** that respond to your every desire. You know that underneath each **sleek** exterior lies an amazing assortment of tiny electronic parts connected in just the right way to make something happen. And now you want to understand how.

When you turn on a light in your home, you're connecting a source of electrical energy to a **light bulb** in a complete path, known as an electrical **circuit**. If you add a **dimmer** or a **timer** to the light bulb circuit, you can control the operation of the light bulb in a more interesting way than just manually **switching** it **on** and **off**.

Electrical systems use electric current to power things such as light bulbs and kitchen **appliances**. Electronic systems take this a step further. They control the current, switching it on and off, changing its **fluctuations**, direction, and timing in various ways to **accomplish** a variety of functions, from dimming a light bulb, to **flashing** your holiday light display in sync with your favorite holiday tune, to communicating via **satellites** and lots of other things. This control **distinguishes** electronic systems from electrical systems.

The word electronics describes both the field of study that focuses on the control of electrical energy and the physical systems (including circuits, components, and **interconnections**) that implement this control of electrical energy.

To understand what it means to control electric current, first you need a good working sense of what electric current really is and how it powers things such as light bulbs, speakers, and motors.

VOCABULARY

3. Match the words (1–13) with the definitions (A–M).

Word		Definition	
1	button	A	an electrical device that provides a path for electrical current to flow
2	sleek	B	frequent change in the amount, value, or level of something
3	light bulb	C	to cause (light) to appear suddenly or in intermittent bursts
4	circuit	D	to succeed in doing something, especially something that you have been trying to do for a period of time
5	dimmer	E	to cause an electric current or appliance to begin or cease operation
6	timer	F	an object that is sent into space to travel round the Earth in order to receive and send information

7	switch on/off	G	a rheostat or other device used to vary the intensity of an electric light
8	appliance	H	to recognize the differences between things
9	fluctuation	I	fashionable and attractive in design
10	accomplish	J	a small object that you press to make a machine start working or perform a particular action
11	flash	K	a light-emitting device that consists of a gas-filled glass tube and is used inside electric light fixtures and flashlights
12	satellite	L	a small piece of equipment used for measuring time
13	distinguish	M	a device designed to perform a specific function for household use

1	2	3	4	5	6	7	8	9	10	11	12	13

LISTENING

4. Listen to and watch the video "Why study Electronic Engineering?"
https://youtu.be/Xy4xf3SEwvM

Fill in the gaps in the following sentences:

1. Electronics ___________ our heat and light, ___________ our health, ___________ our travel, ___________ our music, ___________ our transport moving, ___________ us to family and friends across the world via the Internet.
2. Without electronics our world would __________ __________ __________.
3. You will learn how to write the computer code which drives many of the digital devices we __________ to run and monitor our technological world.
4. You will learn how the hardware controlled by the code is __________ and __________.
5. You will see the __________ why electronics never stands still.

6. You will __________ the future as advances in nanotechnology and quantum physics __________ electronic devices still further and make them operate at almost __________ speed.
7. You will learn how to send sound and data __________ via phone masts, cables, fibers and satellites that reach every part of the world.
8. You could even produce your own music tracks and develop digital effects that make them sound __________ and __________.
9. A world where a career in electronics is a career in IT, __________, broadcasting, healthcare, design, industry, robotics, art, conservation agriculture, research, finance.

SPEAKING

5. Speak about the reasons why you have decided to study electronics.

WRITING

6. Analyze the information about the history of electronics presented in the text below and here*:* "Timeline of Electrical and Electronic Engineering, History of Electronics". Make your own timeline infographic using these online resources: https://www.visme.co/ and https://piktochart.com/.

A BRIEF HISTORY OF ELECTRONICS

1874: Irish scientist George Johnstone Stoney (1826–1911) suggests electricity must be "built" out of tiny electrical charges. He coins the name "electron" about 20 years later.

1875: American scientist George R. Carey builds a photoelectric cell that makes electricity when light shines on it.

1879: Englishman Sir William Crookes (1832–1919) develops his cathode-ray tube (similar to an old-style, "tube"-based television) to study electrons (which were then known as "cathode rays").

1883: Prolific American inventor Thomas Edison (1847–1931) discovers thermionic emission (also known as the Edison effect), where electrons are given off by a heated filament.

1887: German physicist Heinrich Hertz (1857–1894) finds out more about the photoelectric effect, the connection between light and electricity that Carey had stumbled on the previous decade.

1897: British physicist J.J. Thomson (1856–1940) shows that cathode rays are negatively charged particles. They are soon renamed electrons.

1904: John Ambrose Fleming (1849–1945), an English scientist, produces the Fleming valve (later renamed the diode). It becomes an indispensable component in radios.

1906: American inventor Lee De Forest (1873–1961), goes one better and develops an improved valve known as the triode (or audion), greatly improving the design of radios. De Forest is often credited as a father of modern radio.

1947: Americans John Bardeen (1908–1991), Walter Brattain (1902–1987), and William Shockley (1910–1989) develop the transistor at Bell Laboratories. It revolutionizes electronics and digital computers in the second half of the 20th century.

1958: Working independently, American engineers Jack Kilby (1923–2005) of Texas Instruments and Robert Noyce (1927–1990) of Fairchild Semiconductor (and later of Intel) develop integrated circuits.

1971: Marcian Edward (Ted) Hoff (1937–) and Federico Faggin (1941–) manage to squeeze all the key components of a computer onto a single chip, producing the world's first general-purpose microprocessor, the Intel 4004.

1987: American scientists Theodore Fulton and Gerald Dolan of Bell Laboratories develop the first single-electron transistor.

2008: Hewlett-Packard researcher Stanley Williams builds the first working memristor, a new kind of magnetic circuit component that works like a resistor with a memory, first imagined by American physicist Leon Chua almost four decades earlier (in 1971).

UNIT 2

WHAT IS ELECTRICITY?

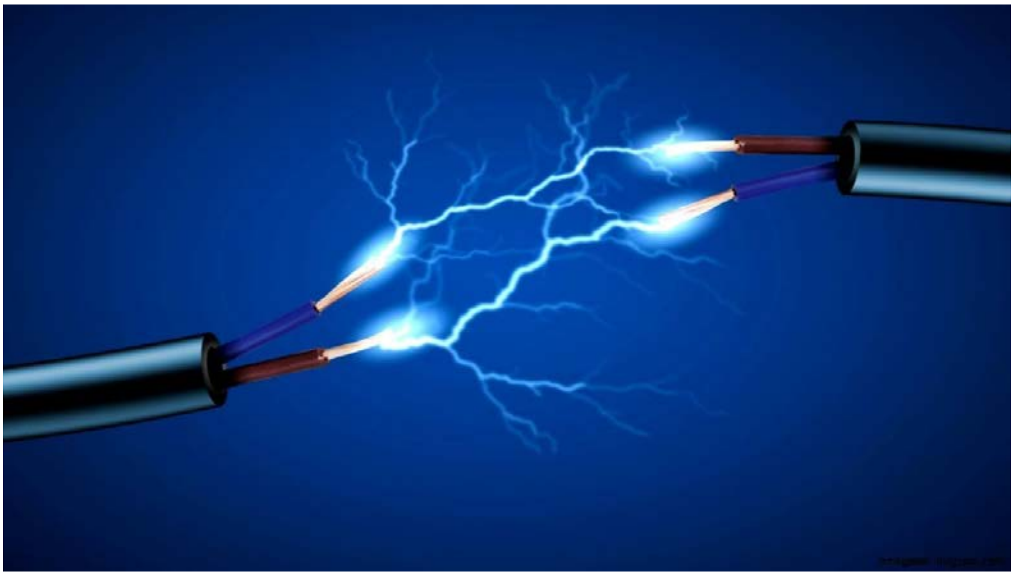


Figure 2.1. Electricity

WARM-UP

1. **Answer the following questions:**
    1. What is electricity?
    2. What are some interesting facts about electricity?

READING

2. **Read the text and answer the questions below:**
    1. What tiny particles of matter stand behind the phenomenon of electricity?
    2. What are electrons?
    3. What are the types of electricity?
    4. What are the examples of static electricity?
    5. Where does current electricity flow?

Electricity comes out of the wall **sockets** in our homes and makes the lights go on. It can **hurt** you if you **touch** it. Why is that? Why do you **get a shock** when you touch a doorknob? **Lightning** looks like electricity. Why is that?

Everything in the world is made up of tiny **particles** called **atoms**. They are so small that they cannot be seen even with a microscope. Atoms are made of two kinds of electric **charge**. In the middle of the atoms are the positive charges and flying around the outside are the negative charges. Most of the time, there are just as many positive charges as negative charges. Each positive charge has a negative partner. Sometimes, however, there are too many of one kind of charge. These extra charges go looking for a companion. These negative charges are called **electrons** and are not held very tightly in the atom so it is easy for them to move around. The moving electrons make up what we call electricity. There are two kinds of electricity: static and current.

Static electricity is what makes your hair stand up when you rub a balloon against it or gives you a shock from your doorknob. In static electricity, electrons are moved around mechanically (i.e. by someone rubbing two things together). When you drag your feet across the carpet, extra charge is scraped off the rug and collects on your body. When you touch a doorknob, all the charge wants to leave you and go to the doorknob. You see a spark and get a shock as the electrons leave you.

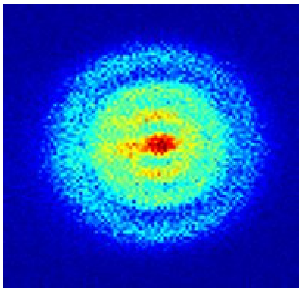
Lightning is the result of static electricity. In a thunderstorm, negatively charged particles can build up in a cloud. Electrons repel each other; they really don't like each other and want to get as far away from each other as possible. The farthest they can get away from each other is if they go into the ground because it's the biggest thing around. As the electrons jump to the group, we see lightning. It's just like a big spark. Benjamin Franklin found out that lightning can be very dangerous. Lightning has more than 20 million Volts!

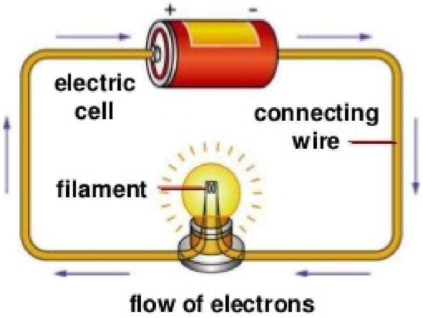
Current electricity has to flow in a closed loop called a circuit. If the **loop** is broken anywhere, the electricity can't get through. This is like blood in the body. Blood gets pumped through your arteries by the heart and eventually comes back to the heart through your veins. In a circuit, electric charges are the blood and the **wires** are the arteries and veins. Electric charges have a certain amount of energy. The measure of this energy is called voltage (Volts). A **flashlight** battery has about 1 ½ Volts and your wall socket has about 120 Volts. The electrons moving through a circuit are called a current. You can get an electric shock when a big current – lots of electrons – flows through your body.

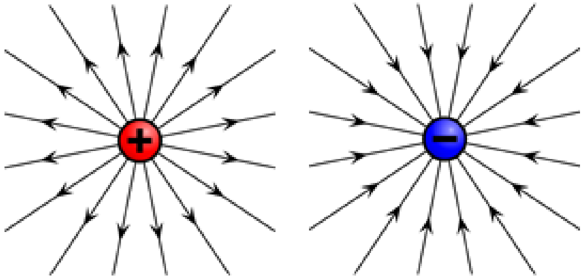
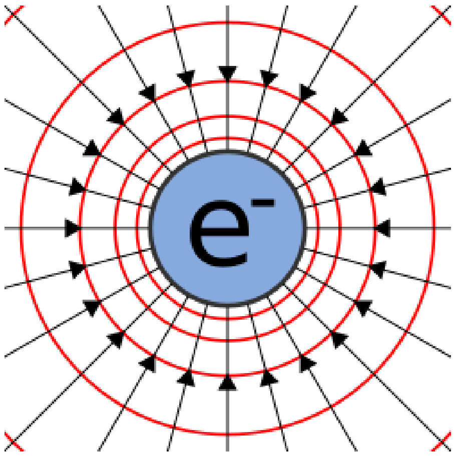
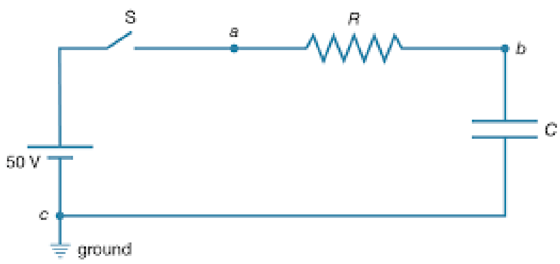
The electrons in a circuit have to be pushed by something, like a battery. If you look at one end of a battery, there is a + sign, this where the extra positive charges are. At the other end, where there's a – sign, there are extra negative charges (electrons). When we turn on a flashlight the electrons race out of the battery through the wires to get to where the positive charges are. On their way, they run through the wire inside the light bulb. The thin wire inside the bulb gets very hot and makes light.

VOCABULARY

3. Match the words and word combinations (1–14) with the pictures (A–N).

Word		Picture	
1	socket	A	
2	hurt	B	
3	touch	C	
4	get an electric shock	D	
5	lightning	E	

			
6	particles	F	
7	atom	G	
8	charge	H	
9	electron	I	

10	static electricity	J	
11	current electricity	K	
12	loop	L	
13	wire	M	
14	flashlight	N	

1	2	3	4	5	6	7	8	9	10	11	12	13	14

LISTENING

4. **Listen to and watch the video "What is Electricity?"**
   https://youtu.be/q58P_39UFHw

Define the following statements as true (T) or false (F).

1. Three smaller particles make up atoms: neutrons, electrons and protons.
2. Electrons have a positive charge, protons have a negative charge.
3. Neutrons and protons make up the nucleus of the atom.
4. In insulators electrons are tightly bound, in conductors they are loosely bound.
5. Opposite charges repel each other whereas similar charges attract each other.
6. Current electricity is a charge in motion, static electricity is a charge at rest.
7. Electricity is a primary energy source.
8. Natural power sources are wind, water and solar energy.

SPEAKING

5. **With the help of "Voki" speak about electricity, follow these instructions:**
   1. Prepare your speech about electricity.
   2. Go to **Voki**.
   3. Choose an appropriate character.
   4. Record your speech.
   5. Mind, please, that you will have only 1 minute of recording time.
   6. Share your hyperlink.

WRITING

6. **Write a compare and contrast essay on the following topic:**

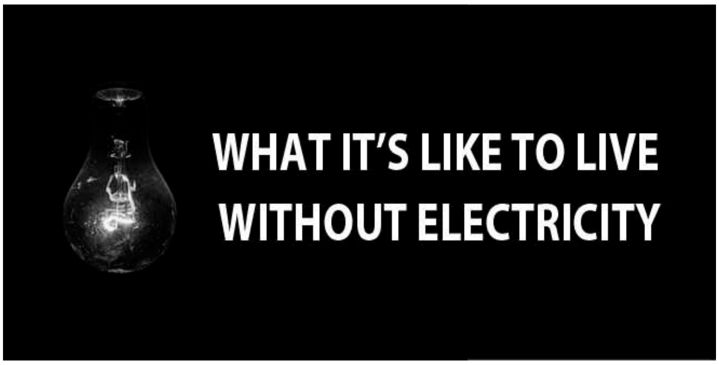


Figure 2.2. What it's like to live without electricity

Use these instructions: How to write a compare and contrast essay.

UNIT 3

CURRENT AND VOLTAGE

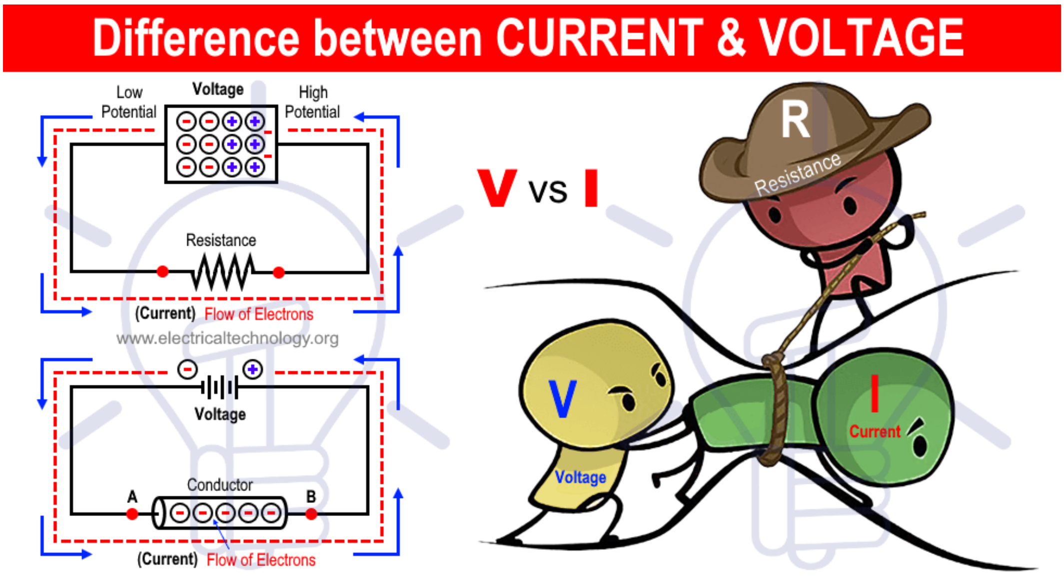


Figure 3.1. Current and voltage

WARM-UP

1. **Answer the following questions:**
   What is electric current?
   What is voltage?

READING

2. **Read the text and make an oral summary of it in no more than 30 words.**

Electric **current** is the **flow** of negatively **charged** electrons through a conductor when a force is **applied**. But just what is the force that **provokes** the electrons to move in harmony? What commands the electronic bucket brigade?

The force that pushes electrons along is technically called an **electromotive force** (abbreviated EMF or E), but it is more commonly known as **voltage** (abbreviated V). You measure voltage by using units called volts. Apply enough voltage to a **conductor**, provide a complete path through which an electric charge can move, and the free electrons in the conductor's atoms will move in the same **direction**, like sheep being herded into a pen – only much faster. Think of voltage as electric **pressure**. In much the way water pressure pushes water through **pipes** and **valves**, voltage pushes electrons through conductors. The higher the water pressure, the stronger the push. The higher the voltage, the stronger the electric current that flows through a conductor.

A voltage is simply a difference in electrical charge between two points. In a battery, negatively charged atoms (atoms with an **abundance** of electrons) build up on one of two metal plates, and positively charged atoms (atoms with a **dearth** of electrons) build up on the other metal plate, creating a voltage across the plates. If you provide a conductive path between the metal plates, you enable **excess** electrons to travel from one plate to the other, and current will flow in an effort to neutralize the charges. The electromotive force that **compels** current to flow when the circuit is completed is created by the difference between charges at the battery terminals.

VOCABULARY

3. Match the words (1–11) with the synonyms (A–K).

Word		Synonyms	
1	current	A	lead, line, wire, cable
2	charged	B	absence, insufficiency, lack, scarcity, shortage
3	apply	C	electromotive force, potential difference, pressure
4	provoke	D	constrain, urge, force
5	voltage	E	implement, utilize
6	conductor	F	flow, flux, movement
7	direction	G	faucet, tap
8	pipe	H	extra, surplus
9	valve	I	beeline, bias, orientation, way
10	dearth	J	full, filled, saturated
11	abundance	K	cause, electrify, elicit, induce
12	excess	L	duct, hose, line, sewer
13	compel	M	bounty, plenty, sufficiency

1	2	3	4	5	6	7	8	9	10	11	12	13

LISTENING

4. Listen to and watch the video “Charge, Current and Voltage”
https://youtu.be/y9fgfQ078wc

Arrange the following sentences into the correct order:

1. The more potential difference we give it the faster the current flows. ___
2. Charge is measured in coulombs. ___
3. The potential to do work is given in joules per coulomb and one of these is the same as one volt because people decided to give it a name. ___
4. Current is the amount of coulombs passing through a point every second. ___
5. There are three things to understand when we talk about electricity: charge, current and voltage. ___
6. The battery gives one side of the wire more electric potential energy than the other side so the current travels through the wire. ___
7. The movement of this charge is called a current. ___
8. If there are more electrons the substance will be negatively charged and if there are more protons it will be positively charged. ___
9. All objects and materials have charge which is created by the net of electrons or protons. ___
10. Voltage or potential difference is a bit trickier to understand. _____

SPEAKING

5. In pairs, discuss the difference between current and voltage.

WRITING

6. With the help of Make Beliefs Comix create your own online comics on the topic: "Current vs Voltage".

UNIT 4

DIRECT AND ALTERNATING CURRENT

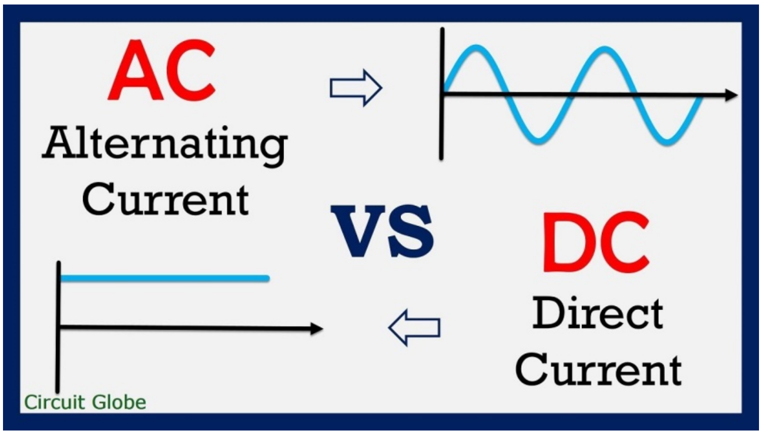


Figure 4.1. Direct and alternating current

WARM UP

1. Answer the following questions:

1. What is direct current?
2. What is alternating current?

READING

3. Read the text and match the sentence parts.

1	An electric current that flows in one direction	A	relative to the positive end
2	The voltage in a direct current circuit must be constant	B	so does the direction of the current flow
3	The positive end of the battery is always positive	C	lose much less power than DC circuits
4	The negative end of the battery is always negative	D	is called direct current
5	In an alternating current circuit	E	that they don't really go anywhere
6	When the voltage reverses	F	to keep the current flowing in a single direction
7	AC circuits	G	relative to the negative end
8	The net effect is	H	voltage periodically reverses itself

1	2	3	4	5	6	7	8

An electric current that flows continuously in a single direction is called **direct current**, or DC. The electrons in a wire carrying direct current move slowly, but eventually they travel from one end of the wire to the other because they keep **plodding along** in the same direction.

The voltage in a direct current circuit must be **constant**, or at least relatively constant, to keep the current flowing in a single direction. Thus, the voltage provided by a flashlight battery remains steady at about 1.5 V. The positive end of the battery is always positive relative to the negative end, and the negative end of the battery is always negative relative to the positive end. This constancy is what pushes the electrons in a single direction.

Another common type of current is called **alternating current**, abbreviated AC. In an alternating current circuit, voltage periodically **reverses** itself. When the voltage reverses, so does the direction of the current flow. In the most common form of alternating current, used in most **power distribution systems** throughout the world, the voltage reverses itself either 50 or 60 times per second, depending on the country. In the United States, the voltage is reversed 60 times per second.

Alternating current is used in nearly all the world's power distribution systems, for the simple reason that AC current is much more efficient when it's transmitted through wires over long distances. All electric currents lose power when they flow for long distances, but AC circuits lose much less power than DC circuits.

The electrons in an AC circuit don't really move along with the current flow. Instead, they sort of sit and **wiggle** back and forth. They move one direction for 1/60th of a second, and then turn around and go the other direction for 1/60th of a second. The **net effect** is that they don't really go anywhere.

VOCABULARY

4. **Fill in the gaps in the sentences with the word and word combinations from the table.**

a	wiggle	b	alternating current	c	direct current	d	power distribution systems
e	constant	f	net effect	g	reverse	h	plodding along

1. The invention relates to _____ generators for motor vehicles.
2. I saw them, I was _____ and I came this way.
3. Your heart and your head have been in _____ conflict.
4. The electric motor relates to nonreversible direct and single-phase _____ electric machines.
5. Concrete efforts are urgently needed to _____ this trend.
6. They are used with buzz bars to produce _____.
7. Well, I can _____ my toes, it must be a good sign.
8. The ___ of these changes, however, has not been adequately studied yet.

LISTENING

5. **Listen to and watch the video "Alternating Current (AC) and Direct Current (DC)"**
   https://youtu.be/EY_EphcrpDI

   Arrange the words in the correct order to make complete sentences.
   1. know/comes/when/to/need/now/types/current/are/there/two/you/to/it/ about.
   2. current AC often which we alternating write DC and current or direct.
   3. is back direction forth alternating in an current the of the constantly swapping and current.
   4. use currents difference we these rotating whenever alternating potential get we an.
   5. see potential or if measure can this we the difference we current time over.
   6. and it constantly between negative and in the positive level circuit fluctuates.
   7. will which the charge that constantly flowing the direction this forth is be means back swapping in and.
   8. same that current will the also rate fluctuate at.

SPEAKING

6. **Retell the text from Exercise 2.**

WRITING

7. **Fill in the gaps in the table below.**

	Alternating Current	**Direct Current**
Direction		
Magnitude		
Flow of electrons		
Generated from		
Passive parameters		
Power factor		
Types		

UNIT 5

MARVELLING AT WHAT ELECTRONS CAN DO

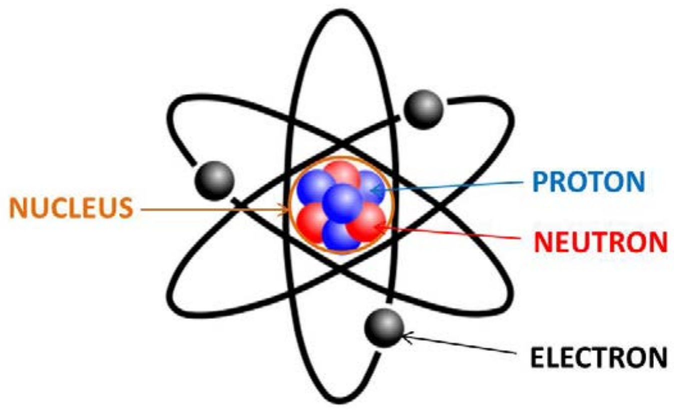


Figure 5.1. Atomic structure

WARM UP

1. Answer the following questions:

1. What is an electron?
2. What can electrons do?

READING

2. Read the text and match the headings (1–6) with the gaps at the start of each paragraph (A–F).

1. Controlling motion
2. Voice, video, and data communications
3. Creating good vibrations
4. Computing
5. Sensing and alarming
6. Seeing is believing

Imagine applying a constant electric current to a pair of speakers without using anything to control, or “shape,” the current. What would you hear? Guaranteed it wouldn’t be music! By using the proper **combination** of electronics **assembled** in just the right way, you can control the way each speaker diaphragm vibrates, producing **recognizable** sounds such as speech or music. There’s so much more you can do with electric current when you know how to control the flow of electrons.

Electronics is all about using specialized devices known as **electronic components** (for example, **switches**, **resistors**, **capacitors**, **inductors**, and **transistors**) to control current (also known as the flow of electrons) in such a way that a specific function is performed.

The nice thing is that after you understand how a few individual electronic components work and how to apply some basic principles, you can begin to understand and build interesting electronic circuits.

This section provides just a **sampling** of the sorts of things you can do by controlling electric current with electronic circuits.

A __________

Electronic components in your iPod, car stereo, and other audio systems convert electrical energy into sound energy. In each case, the system's speakers are the load, or **destination**, for electrical energy. The job of the electronic components in the system is to "shape" the current flowing to the speakers so that the diaphragm within each speaker moves in such a way as to reproduce the original sound.

B __________

In visual systems, electronic components control the timing and intensity of light **emissions**. Many **remote-control devices**, such as your TV remote, **emit infrared light** (which is not visible) when you press a button, and the specific pattern of the emitted light acts as a sort of code thatis understood by the device you are controlling. A circuit in your TV detects the infrared light and, in effect, decodes the instructions sent by the remote.

A flat-screen **liquid crystal display (LCD)** or plasma TV consists of millions of tiny picture elements, or pixels, each of which is a red, blue, or green light that can be switched on or off electronically. The electronic circuits in the TV control the timing and on/off state of each pixel, thus controlling the pattern painted across the TV screen, which is the image you see.

C __________

Electronics can be used also to make something happen in response to a specific level or absence of light, heat, sound, or motion. Electronic sensors generate or change an electrical current in response to a stimulus. Microphones, motion detectors, temperature sensors, **humidity** sensors, and light sensors can be used to **trigger** other electronic components to perform some action, such as activating an automatic door opener, sounding an alarm, or switching a **sprinkler system** on or off.

D __________

A common use of electronics is to control the on/off activity and speed of motors. By connecting various objects – for instance, wheels, **airplane**

flaps, or **fan blades** – to motors, you can use electronics to control their motion. Such electronics can be found in robotic systems, aircraft, spacecraft, elevators, and lots of other places.

E __________

In much the same way that the ancients used the abacus to perform arithmetic operations, so you use electronic calculators and computers to perform **computations**. With the abacus, beads were used to represent numbers, and calculations were performed by manipulating those beads. In computing systems, **patterns** of stored electrical energy are used to represent numbers, letters, and other information, and computations are performed by manipulating those patterns using electronic components. (Of course, the **worker bee** electrons inside have no idea that they are **crunching** numbers!) The result of a computation is stored as a new pattern of electrical energy and often directed to special circuits designed to display the result on a monitor or other screen

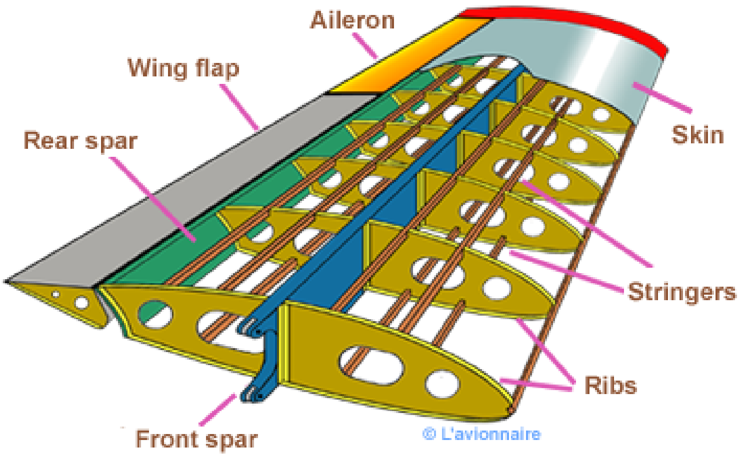
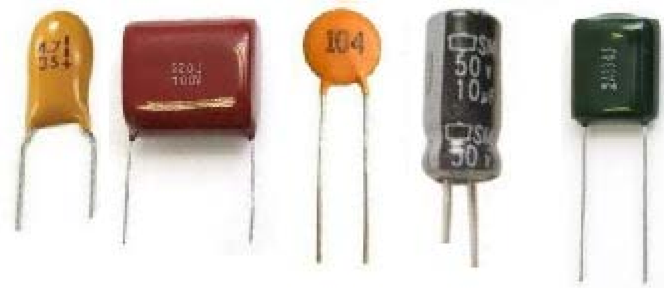
F __________

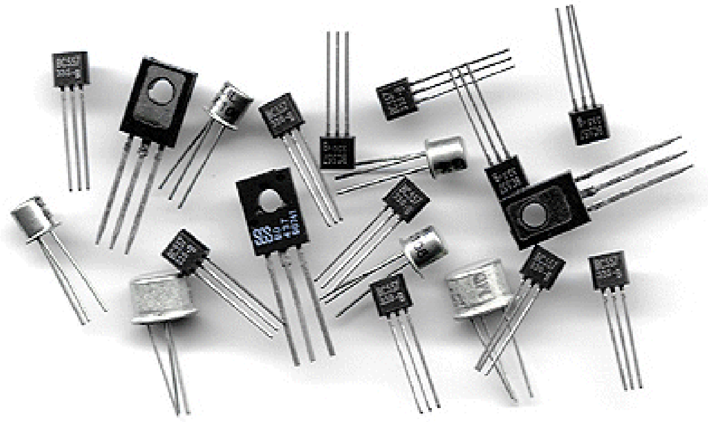
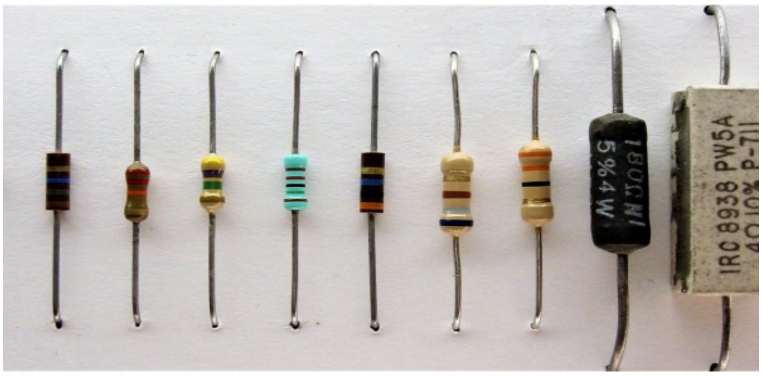
Electronic circuits in your cellphone work together to convert the sound of your voice into an electrical pattern, manipulate the pattern (to compress and encode it for efficient, secure **transmission**), transform it into a radio signal, and send it out through the air to a **communication tower**. Other electronic circuits in your handset detect incoming messages from the tower, decode the messages, and convert an electrical pattern in the message into sound (through a speaker) or a text or video message (through your phone’s display). Data communication systems use electronics to **transmit** information encoded in electrical patterns between two or more endpoints. When you shop online, your order is transmitted by sending an electrical pattern from your data communication device (such as a laptop, smartphone, or tablet) over the Internet to a communication system operated by a **vendor**. With a little help from electronic components, you can get electrons to convert your materialistic desires into shopping orders – and charge the order to your credit card.

VOCABULARY

3. Match the words and word combinations (1–11) with the pictures (A–K).

Word		Picture	
1	switches	A	
2	resistors	B	
3	capacitors	C	

4	inductors	D	
5	transistors	E	
6	remote-control device	F	
7	liquid crystal display (LCD)	G	

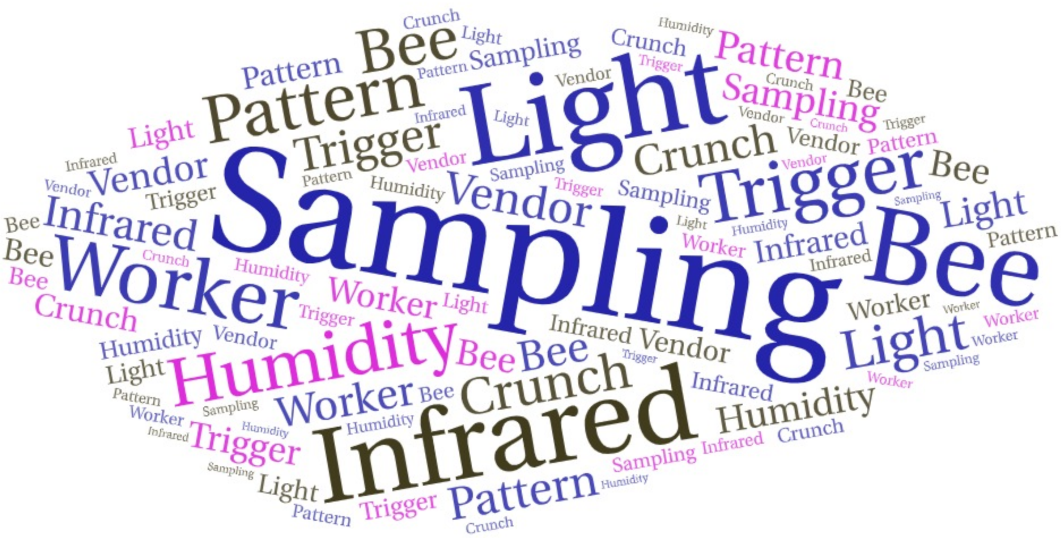
8	sprinkler system	H	
9	airplane flap	I	
10	fan blade	J	
11	communication tower	K	

1	2	3	4	5	6	7	8	9	10	11

Fill in the gaps in the table.

	Verb	Noun	Adjective
1		combination	
2			assembled
3			recognizable
4	convert		
5		destination	
6	emit		
7		computation	
8	transmit		

Find 6 words and 2 word combinations in this word cloud and translate them.



LISTENING

3. **Listen to and watch the video "Power Electronic Applications"**
   https://youtu.be/6KHJ5JA4BbY

Use the correct form of the verbs in brackets.

1. Semikron's power electronics components and systems _________ customers to develop smaller, more energy efficient power electronic systems that make an important contribution to reducing global energy consumption and emissions. *(allow)*

2. E-mobility _________ one of the fastest growing markets of the future. *(be)*
3. Semikron's power electronics _________ in fast charging stations and in vehicles at the interface between the motor and the battery. *(use)*
4. Power electronics also help to control the output power of drives for long distance and urban electric trains and _________ energy to auxilary units such as lighting, ventilation and air-conditioning systems. *(supply)*
5. The largest application area for power electronics can _________ in industrial and commercial applications such as motors and electric drives for robots, pumps, fans, cranes and machines. *(find)*
6. Power supplies _________ for systems that need to be available at all times such as in data processing centers. *(require)*
7. Silicon carbide modules _________ increasingly _________ in medium and large systems. *(use)*
8. Renewable energy _________ our second most important market. *(be)*
9. For the solar market, in addition to standard modules we also _________ customer specific solutions. *(offer)*
10. Our customers in the wind market can _________ on intelligent power modules in pre-tested units consisting of the power circuit, driver, heatsink and sensors. *(depend)*

WRITING

5. **Write three statements about electronics applications. Two of them should be true, and one should be a lie.**

SPEAKING

6. **Tell about your three statements (Ex. 5) and answer the questions of your groupmates trying to determine which statement is a lie.**

CHAPTER 2. PASSIVE ELECTRONIC COMPONENTS

UNIT 6

RESISTORS: PASSIVE YET POWERFUL

Figure 6.1. Resistors

Figure 6.2. International resistor circuit symbol

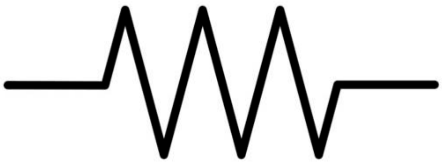


Fig.6.3. USA resistor circuit symbol

WARM UP

1. **Answer the following questions:**
   1. What is a resistor?
   2. How does a resistor work?

READING

2. **Read the text and choose the correct words in the following sentences:**
   1. Resistance is *a measure/unit* of an object's opposition to the flow of electrons.
   2. Resistors are *passive/active* components electronic components that are designed to provide controlled amounts of resistance.

3. Resistors are simple yet *versatile/different*.
4. One of the most common uses of a resistor is to *limit/enlarge* the amount of current in part of a circuit.
5. Resistors come in two basic *flavors/branches*.
6. A *fixed/variable* resistor supplies a constant, factory-determined resistance.
7. A *variable/fixed* resistor, commonly called a potentiometer, allows you to adjust the resistance.

If you **toss** a marble into a sandbox, the marble won't go very far. But if you toss a marble onto the surface of a large frozen lake, the marble will enjoy a nice little ride before it eventually comes to a stop. A mechanical force called **friction** stops that marble on either surface – it's just that the sand provides more friction than the ice.

Resistance in electronics is a lot like friction in mechanical systems. It **puts the brakes** on electrons (those microscopic moving particles that make up electric current) as they move through materials.

Resistance is a measure of an object's opposition to the flow of electrons. This may sound like a bad thing, but it's actually useful. Resistance is what makes it possible to generate heat and light, **restrict** the flow of electric current when necessary, and ensure that the correct voltage is supplied to a device. For instance, as electrons travel through the **filament** of an **incandescent** light bulb, they meet so much resistance that they slow down a lot. As they fight their way through the filament, the atoms of the filament **bump** into each other **furiously**, generating heat – which produces the glow that you see from your light bulb.

Resistors are passive electronic components that are specially designed to provide controlled amounts of resistance. Although a resistor won't **boost** current or control its direction (because it's passive), you'll find it to be a powerful little device because it enables you to put the brakes on current flow in a controlled way. By carefully choosing and arranging resistors in different parts of your circuit, you can control just how much – or how little – current each part of your circuit gets.

Resistors are among the most popular electronic components around because they're simple yet **versatile**. One of the most common uses of a resistor is to **limit** the amount of current in part of a circuit. However, resistors can also be used to control the amount of voltage provided to part of a circuit and to help create timing circuits.

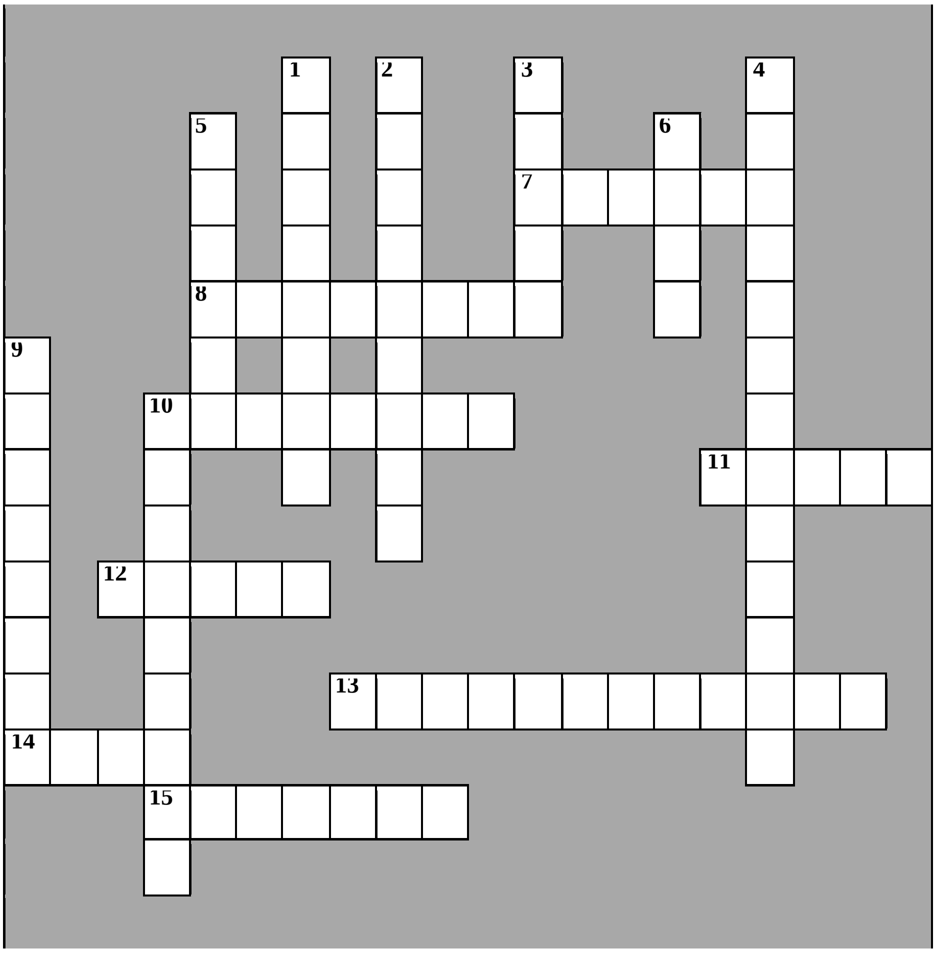
Resistors come in two basic **flavors**: fixed and variable. Both types are commonly used in electronic circuits. Here's the **lowdown** on each type and why you would choose one or the other:

✓ A **fixed resistor** supplies a constant, **factory-determined** resistance. You use it when you want to restrict current to within a certain range or divide voltage in a particular way. Circuits with LEDs use fixed resistors to limit the current, thus protecting the LED from damage.

✓ A **variable resistor**, commonly called a **potentiometer** (pot for short), allows you to **adjust** the resistance from virtually zero ohms to a factory-determined maximum value. You use a potentiometer when you want to vary the amount of current or voltage you're supplying to part of your circuit. A few examples of where you might find potentiometers are light-dimmer switches, volume controls for audio systems, and position sensors, although digital controls have largely replaced potentiometers in consumer electronics.

VOCABULARY

3. **Solve the clues of this crossword puzzle. You can also do it online: <u>Resistors</u>**



Across

7. To regulate.

8. A type of resistor that is used to vary the amount of current that flows through a circuit.

10. The rubbing of one object or surface against another.

11. To lift or push from behind.

12. A type of resistor that has no provision for varying its resistance value.

13. Emitting light.

14. To throw with an initial upward direction.

15. The real and unadorned facts.

Down

1. To prevent or prohibit beyond a certain limit.

2. Having varied uses or many functions.

3. A device used to slow or stop the motion.

4. Manually adjustable, variable, electrical resistor.

5. A kind or type.

6. To knock against.

9. A fine thread or wire.

10. Angrily.

LISTENING

4. **Listen to and watch the video "How to Read Resistor Color Code"**
   https://youtu.be/GLD7AgAYqwA

Mark the following statements as true (T) or false (F).

1. Resistor color code allows you to define resistance values and tolerance.
2. You should memorize a color chart table to become proficient at decoding and using resistors.
3. In a four band resistor the first three bands represent the digits or significant figures.
4. The third band indicates the multiplier.
5. The first band indicates the tolerance.

6. You read resistor bands beginning with the end that has the least bands.
7. A space between the third and fourth bands also indicates the reading direction.

Practise reading the resistor color code with the help of these exercises: Resistor Color Code Description and Resistor Color Code Practice.

SPEAKING

5. **In pairs, role play the interview with an experienced electronics expert discussing resistors.**

WRITING

6. **Go to PicLits and create your own pic-lit about resistors.**

ENTERTAIN YOURSELF

Watch the video “MAKE presents: the resistor”

UNIT 7

CAPACITORS: RESERVOIRS FOR ELECTRICAL ENERGY

Figure 7.1. Capacitors

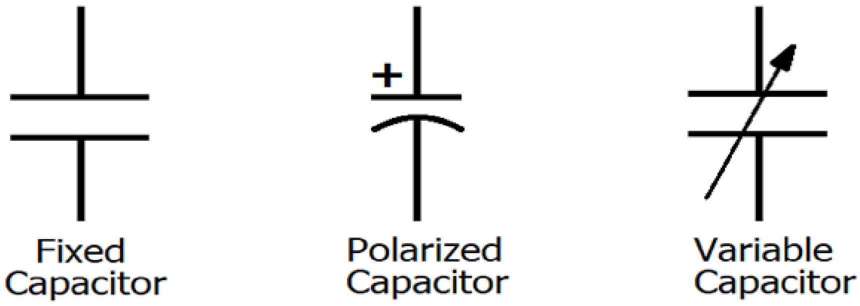


Figure 7.2. Capacitor circuit symbols

WARM UP

1. Answer the following questions:

1. What is a capacitor?
2. What are capacitors used for in circuits?

READING

2. Read the text and find the words and word combinations with the following meanings:

1. To use someone or something to achieve one's own purposes.
2. Having little or no ability to conduct electricity.
3. To move, carry or transport from one person or place to another.
4. To let go or set free.

5. An electric circuit element used to store charge temporarily, consisting in general of two metallic plates separated and insulated from each other by a dielectric.
6. Refuse to accept or acknowledge.
7. The property of a capacitor which determines how much charge can be stored in it for a given potential difference between its terminals.
8. Use of a capacitor to transfer energy from one circuit to another.
9. The dimension through an object as opposed to its length or width.
10. A device that accepts a small signal and outputs a larger signal that generally matches the waveform characteristics of the input.
11. To make even or level.
12. The outer face or side of something.
13. To provide or do something that is missing.
14. A device that provides battery backup when the electrical power fails or drops to an unacceptable voltage level.

Capacitance is the capability of a body to store an electric charge. The same term is used to describe just how much charge a capacitor can store on either one of its plates. The higher the capacitance, the more charge the capacitor can store at any one time. The capacitance of any given capacitor depends on three things: the surface area of the metal plates, the thickness of the dielectric between the plates, and the type of dielectric used. Capacitance is measured in units called farads.

A capacitor is a two-terminal electronic device that stores electrical energy transferred from a voltage source. If you remove the voltage source and electrically isolate the capacitor (so that it isn't connected in a complete circuit), it holds onto the stored electrical energy. If you connect it to other components in a complete circuit, it will release some or all of the stored energy. A capacitor is made from two metal plates separated by an insulator, which is known as a dielectric.

Capacitors are put to good use in most electronic circuits you encounter every day. The key capabilities of capacitors – storing electrical energy, blocking DC current, and varying opposition to current depending on applied frequency – are commonly exploited by circuit designers to set the stage for extremely useful functionality in electronic circuits. Here are some of the ways capacitors are used in circuits:

✓ **Storing electrical energy:** Many devices use capacitors to store energy temporarily for later use. Uninterruptible Power Supplies (UPSs) and alarm clocks keep charged capacitors on hand in case there's a power failure. The energy stored in the capacitor is released the moment the charging circuit is disconnected (which it will be if the power goes out!). Cameras use capacitors for temporary storage of the energy used to generate the flash, and many electronic devices use capacitors to supply energy while the batteries are being changed. Car audio systems commonly use capacitors to supply energy when the amplifier needs more than the car's electrical system can give. Without a capacitor in your system, every time you hear a heavy bass note, your lights would dim!

✓ **Preventing DC current from passing between circuit stages:** When connected in series with a signal source (such as a microphone), capacitors block DC current but pass AC current. This is known as capacitive coupling or AC coupling, and when used this way, the capacitor is known as a coupling capacitor. Multistage audio systems commonly use this functionality between stages so that only the AC portion of the audio signal – the part that carries the encoded sound information – from one stage is passed to the next stage. Any DC current used to power components in a previous stage is removed before the audio signal is amplified.

✓ **Smoothing out voltage:** Power supplies that convert AC to DC, such as your cellphone charger, often take advantage of the fact that capacitors don't react quickly to sudden changes in voltage. These devices use large electrolytic capacitors to smooth out varying DC supplies. These smoothing capacitors keep the output voltage at a relatively constant level by discharging through the load when the DC supply falls below a certain level. This is a classic example of using a capacitor to store electrical energy until you need it: When the DC supply can't maintain the voltage, the capacitor gives up some of its stored energy to take up the slack.

✓ **Creating timers:** Because it takes time to charge and discharge a capacitor, they are often used in timing circuits to create ticks and tocks when the voltage rises above or falls below a certain level. The timing of the ticking and tocking can be controlled through the selection of the capacitor and other circuit components.

✓ **Tuning in (or out) frequencies:** Capacitors are often used to help select or reject certain electrical signals – which are time-varying electric currents that carry encoded information – depending on their frequency.

VOCABULARY

3. Unscramble the words.

1	pitaacccnae	_ _ _ _ _ _ _ _ _ _ _
2	ipcacaort	_ _ _ _ _ _ _ _ _
3	fescrau	_ _ _ _ _ _ _
4	ssnctkihe	_ _ _ _ _ _ _ _ _
5	resanrft	_ _ _ _ _ _ _ _
6	aleeers	_ _ _ _ _ _ _
7	cicdeitlre	_ _ _ _ _ _ _ _ _ _
8	ilpxoet	_ _ _ _ _ _ _
9	mfiirelap	_ _ _ _ _ _ _ _ _
10	htomso	_ _ _ _ _ _
11	lacks	_ _ _ _ _
12	ceejr	_ _ _ _ _

LISTENING

4. Listen to and watch the video "How Capacitors Work"

https://youtu.be/5hFC9ugTGLs

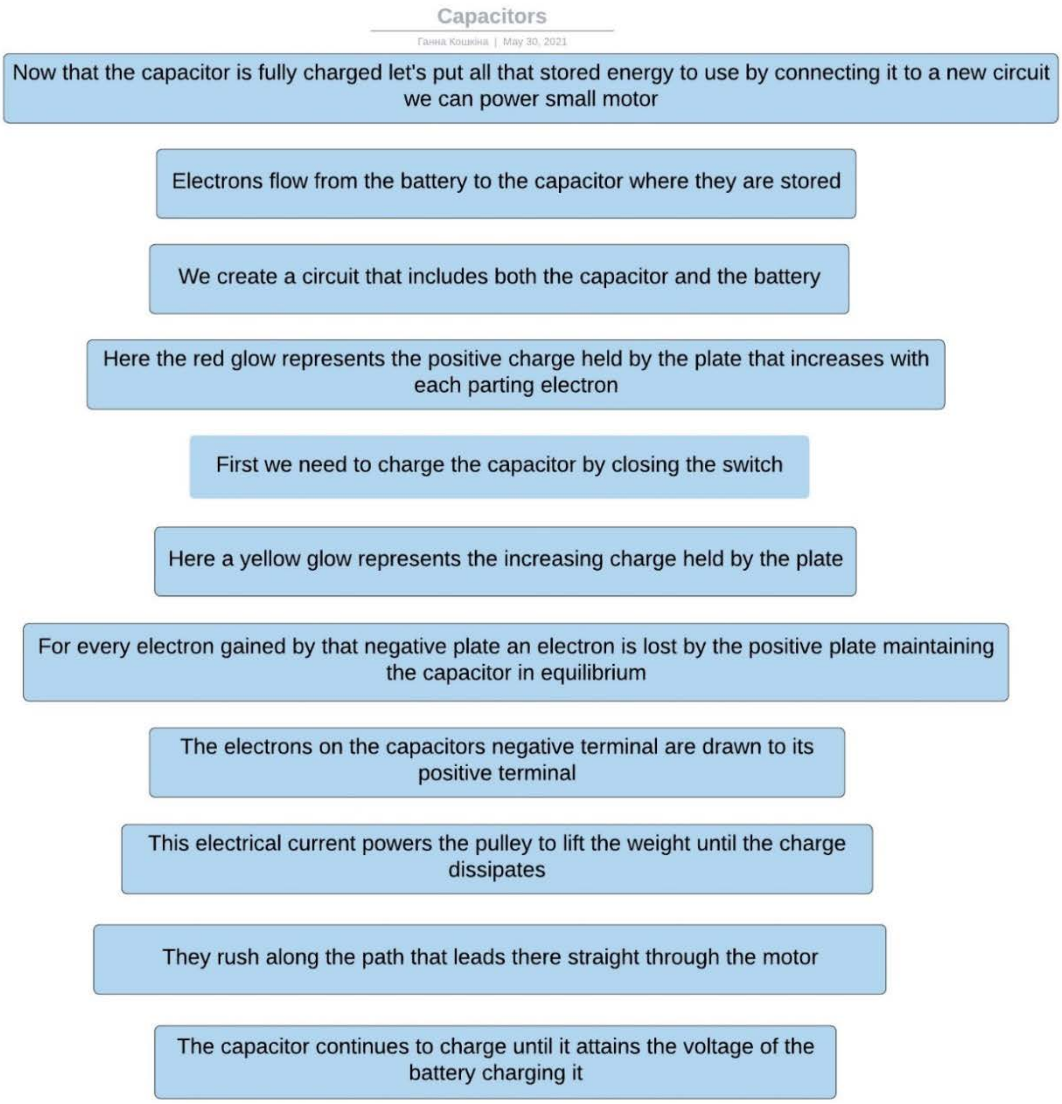
Take this multiple choice test.

1. A capacitor is similar to a battery in that both _____
   a) store electrical energy;
   b) control electrical energy;
   c) prevent electrical energy from flowing.
2. When we close the switch electricity immediately _____
   a) increases;
   b) stops running through the circuits;
   c) runs through the circuits.
3. The battery is not much good at powering the motor to lift the weight because it _____
   a) charges gradually much more slowly;
   b) discharges gradually much more slowly;
   c) discharges gradually much more quickly.
4. Like a battery the capacitor has _____
   a) one terminal;

b) two terminals;
c) three terminals.

5. Inside the capacitor the terminals connect the two metal plates separated by_____
   a) an insulator;
   b) a conductor;
   c) a semiconductor.
6. _____ successfully powers the motor lifting the weight.
   a) the capacitor;
   b) the battery;
   c) the bulb.
7. Capacitors are useful for powering things that need _____
   a) a slow surge of energy;
   b) a discharge;
   c) a quick surge of energy.

Put the following sentences in the correct order to create a flowchart.



SPEAKING

5. **Search the Internet for the information about the types of capacitors and speak about them.**

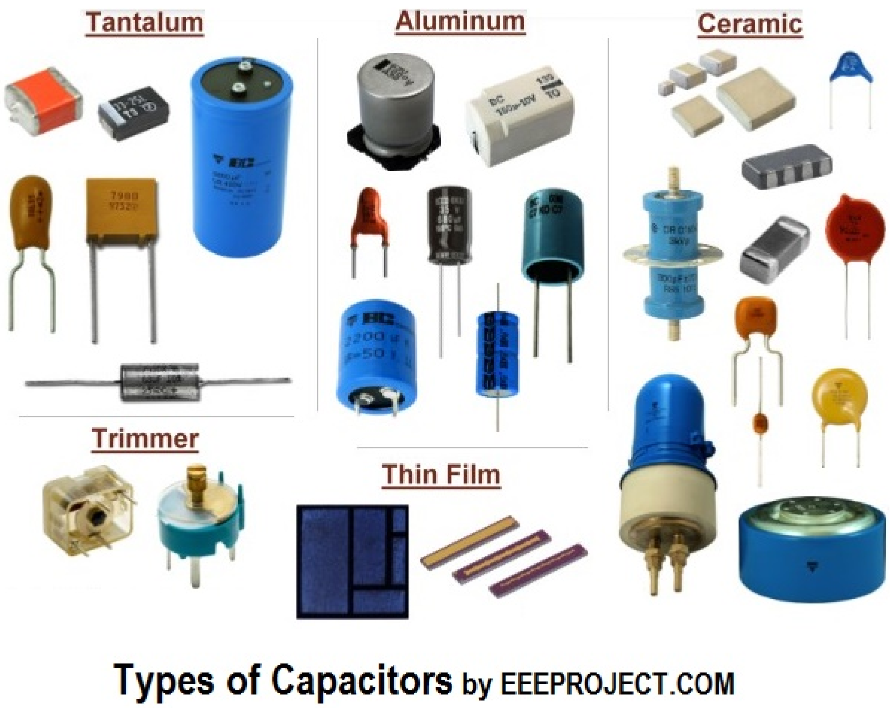


Figure 7.3. Types of capacitors

WRITING

6. **Choose one sentence from the text (Ex. 2) and write 5 types of questions to it.**

ENTERTAIN YOURSELF

Watch the video "MAKE presents: The Capacitor"

UNIT 8

INDUCTORS: COILS WITH A MAGNETIC PERSONALITY

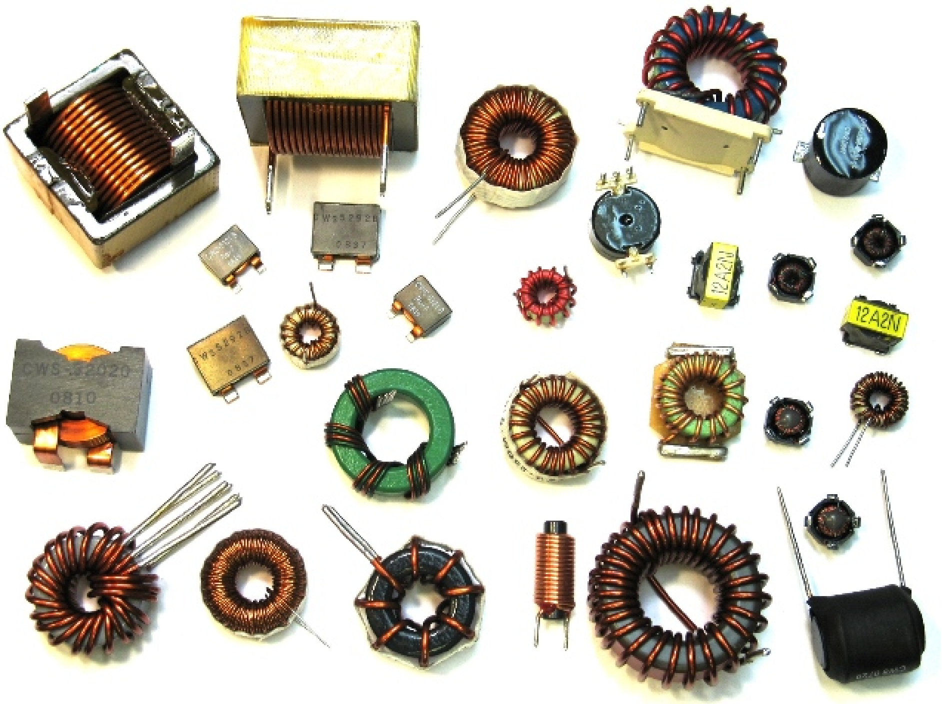


Figure 8.1. Inductors

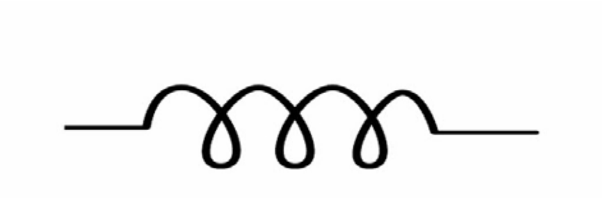


Figure 8.2. Inductor circuit symbol

WARM UP

1. **Answer the following questions:**
   1. What is an inductor?
   2. How does an inductor work?

READING

2. **Listen to the teacher reading 15 words from the text below and cross them off as you hear them.**

An inductor is a passive electronic component made from a coil of wire wrapped around a core – which could be air, iron, or ferrite (a brittle material made from iron). Iron-based core materials increase the strength of the magnetic field induced by current several hundred times. Inductors are sometimes known as coils, chokes, electromagnets, and solenoids, depending on how they're used in circuits.

If you pass current through an inductor, you create a magnetic field around the wire. If you change the current, increasing it or decreasing it, the magnetic flux around the coil changes, and a voltage is induced across the inductor. That voltage, sometimes called back voltage, causes a current flow that opposes the main current. This property of inductors is known as self-inductance, or simply inductance. Inductance, symbolized by L, is measured in units called henrys.

Don't worry about the ins and outs of induced currents, expanding and contracting magnetic fields, and the like. Just remember a few things about inductors:

✓ An inductor opposes (resists) changes in current.

✓ An inductor acts like an open circuit when DC is first applied – that is, no current flows right away, and the entire source voltage is dropped across the inductor.

✓ An inductor eventually acts like a short in DC circuits – that is, when all the magnetic-field magic settles down, the voltage is zero, and the inductor allows the full DC current to pass through.

Inductors are used primarily in tuned circuits, to select or reject signals of specific frequencies, and to block (or choke) high-frequency signals, such as eliminating radio frequency (RF) interference in cable transmissions. In audio applications, inductors are also commonly used to remove the 60 Hz hum known as noise (often created by nearby power lines). Here's a list that explains some of the amazing things a simple coil of wire can do:

✓ **Filtering and tuning:** Like capacitors, inductors can be used to help select or reject certain electrical signals depending upon their frequency. Inductors are often used to tune in target frequencies in radio receiver systems.

✓ **AC motors:** In an AC induction motor, two pairs of coils are energized by an AC power supply (50 or 60 Hz), setting up a magnetic field that then induces a current in a rotor placed in the center of the magnetic field. That current then creates another magnetic field that opposes the original magnetic field, causing the rotor to spin. Induction motors are commonly used in fans and household appliances.

✓ **Blocking AC:** A choke is an inductor used to prevent a signal from passing through it to another part of a circuit. Chokes are often used in radio transmission systems to prevent the transmitted signal (an AC waveform) from shorting out through the power supply. By blocking the signal from traveling through a path to ground, a choke enables the signal to follow its intended path to the antenna, where it can be transmitted.

✓ **Contactless sensors:** Many traffic-light sensors use an inductor to trigger the light to change. Embedded in the street several yards before the intersection is an inductive loop consisting of several turns of a gigantic coil, roughly six feet in diameter. This loop is connected to a circuit that controls the traffic signal. As your car passes over the loop, the steel underbody of your car changes the magnetic flux of the loop. The circuit detects this change – and gives you the green light. Metal detectors use inductors in a similar way to pick up the presence of magnetic or metallic objects.

✓ **Smoothing out current:** Inductors can be used to reduce current swings (ripple) in a power supply. As the current changes, the magnetic flux around the coil changes and a back voltage is induced across the inductor, causing a current flow that opposes the main current.

VOCABULARY

3. **Find 15 words in the puzzle and circle them. Write the words next to the definitions below.**

y	m	i	r	e	c	e	i	v	e	r	d
t	u	n	e	d	c	i	r	c	u	i	t
k	v	d	v	n	n	b	m	m	v	e	h
d	b	u	f	p	g	i	y	p	k	f	j
y	p	c	r	b	r	i	t	t	l	e	k
n	c	t	e	v	n	n	d	u	f	r	c
u	h	a	q	d	e	d	x	g	t	r	r
p	o	n	u	g	k	j	n	c	o	i	l
j	k	c	e	t	w	i	o	a	p	t	v
b	e	e	n	r	w	r	a	p	p	e	d
d	y	p	c	s	e	s	l	m	v	x	s
l	l	v	y	i	v	e	c	l	p	e	e

№	Definition	Word
1	A length of rope or wire curled to form a series of circles, one above the other	
2	Covered, enveloped, or encased	
3	Central part	
4	Any of a group of ferromagnetic highly resistive ceramic compounds	
5	Delicate and easily broken	
6	Resulting from a nearby electromagnetic field	
7	A coil of low resistance and high inductance used in electrical circuits to pass direct current and attenuate alternating current	
8	Flow or flowing	
9	The property of an electric circuit by which an electromotive force is induced in it as the result of a changing magnetic flux	
10	To increase something in size, number, or importance	
11	A circuit whose components can be adjusted to make the circuit responsive to a particular frequency in a tuning range.	
12	The number of oscillations per unit time of a vibrating system	
13	A piece of equipment that changes radio and television signals into sounds and pictures	
14	A small wave or fluctuation	
15	Slight movement of a surface	

LISTENING

4. Listen to and watch the video "How Inductors Work within a Circuit"

https://youtu.be/VFPwgjGHqFQ

Match the sentence parts.

1	The electrical property that resists either an increase or decrease in current	A	the electromagnetic field in the inductor forms and expands rapidly
2	An inductor is created when	B	therefore the bulb will not turn on instantaneously
3	As the switch is closed and the current flows through the circuit	C	the changing current generates a voltage that resists the current coming from the source
4	As the flux lines of the electromagnetic field expand,	D	the electromagnetic field will diminish rapidly and simultaneously release stored energy in the form of voltage

5	The maximum opposition to current flow occurs at the instant the switch is closed	E	the inductor uses current
6	Once the electromagnetic field stops expanding based on the level of changing current	F	is known as inductance
7	If you open the switch and stop the flow of current from the source	G	the flux will no longer generate an opposing voltage in the circuit
8	Whereas a capacitor uses voltage to store energy	H	an electrical current flows in a wire wrapped around a magnetic core

1	2	3	4	5	6	7	8

SPEAKING

5. Retell the text below according to the following plan:

1. Frequency-dependent behavior.
2. Types of filters.
3. What filters are inductors and capacitors?
4. Alter egos of capacitors.

Behaving Differently Depending On Frequency

Like capacitors, inductors in an AC circuit act differently depending on the frequency of the voltage applied to them. Because the current passing through an inductor is affected by frequency, the voltage drops across the inductor and other components in the circuit are also affected by frequency. This frequency-dependent behavior forms the basis for useful functions, such as filters, which are circuits that allow some frequencies to pass through to another circuit stage while blocking other frequencies. When you adjust the bass and treble settings on your stereo system, you're using filters.

Here are some common types of filters:

Low-pass filters are circuits that allow lower frequencies to pass from input to output while blocking frequencies above a particular cutoff frequency.

✓ **High-pass filters** are circuits that allow higher frequency signals to pass while blocking frequencies below the cutoff frequency.

✓ **Band-pass filters** are circuits that allow a band of frequencies — between a lower cutoff frequency and an upper cutoff frequency – to pass.

✓ **Band-stop (or band-rejection) filters** are circuits that allow every frequency except a specific band of frequencies to pass. You might use such a filter to filter out unwanted hum from a 60 Hz power line – as long as you know the frequency range of the hum.

Because inductors pass DC and block more and more AC as frequency increases, they are natural low-pass filters. Capacitors block DC signals and allow AC signals to pass, so (as you might guess) they are natural high-pass filters. In electronic filter design components are carefully selected to precisely control which frequencies are allowed to pass through to the output.

Inductors are sort of the alter egos of capacitors. Capacitors oppose voltage changes; inductors oppose current changes. Capacitors block DC and pass more and more AC as frequency increases; inductors pass DC and block more and more AC as frequency increases.

WRITING

6. **Create a mind map on the topic: "Inductors" with the help of Bubbl.us.**

ENTERTAIN YOURSELF

Watch the video "MAKE presents: The Inductor".

UNIT 9

ENSURING ROCK-SOLID RESONANCE WITH CRYSTALS

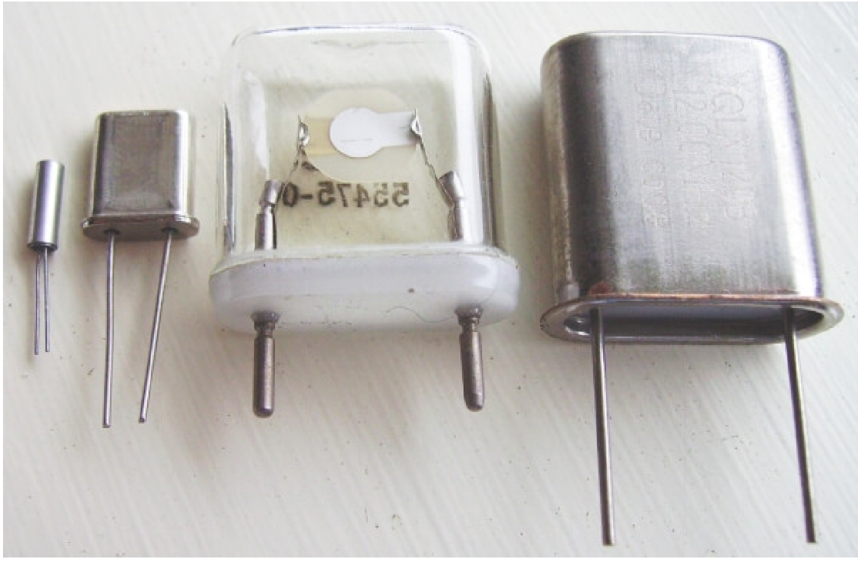


Figure 9.1. Crystals

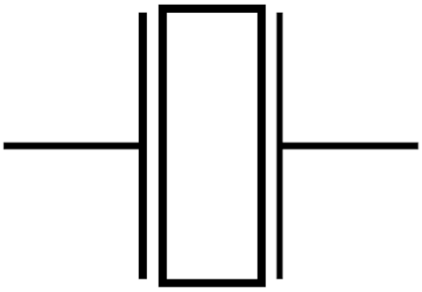


Figure 9.2. Crystal circuit symbol

WARM UP

1. **Answer the following questions:**
    1. What is a crystal?
    2. How does a crystal work?

READING

2. **Work in groups. Each group chooses the initial roles for each member. You will need a runner, a writer, an artist, and a cheerleader/editor.** The members will take turns rotating through roles according to the posted order of rotation. See the image here with roles explained:

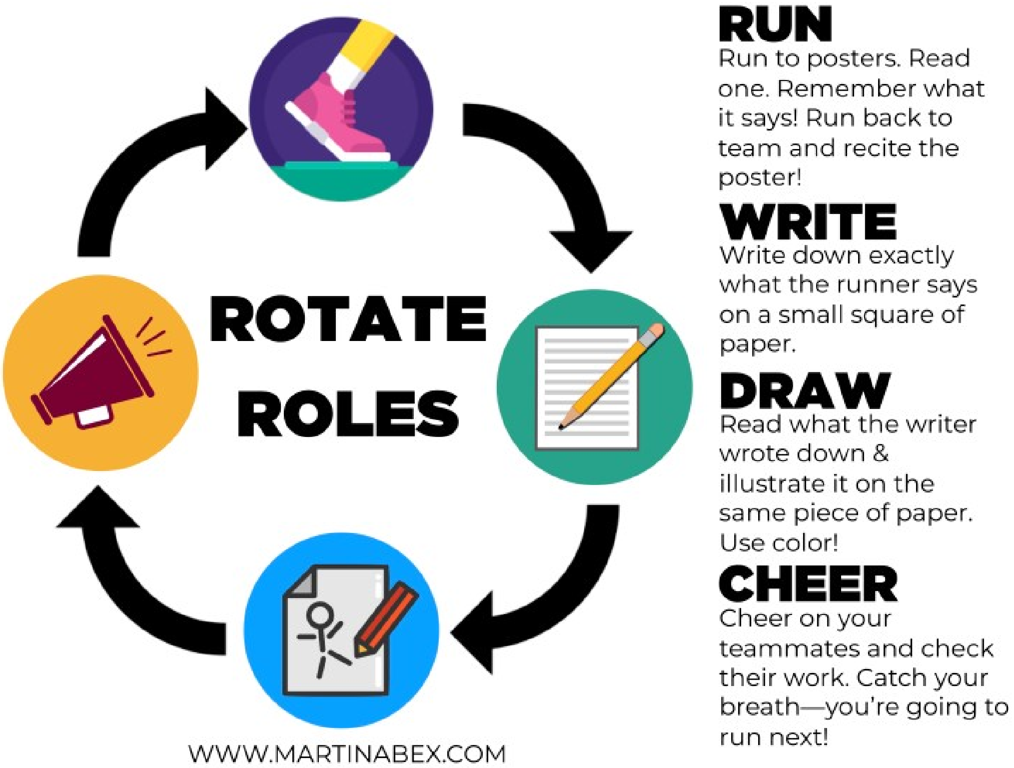


Figure 9.3. Roles explained

ROLE RESPONSIBILITIES:

THE RUNNER runs from wherever the team is gathered to wherever the signs are posted. The runner READS one of them and memorizes it, then RUNS back to his or her team. The runner DICTATES the memorized information to his or her team for transcription. If the runner forgets anything (even spelling!), they must run back to the signs to REMIND themselves of what it was before running back to the team to continue transcription.

THE WRITER assigns a letter to the runner ("Go read "A"!"). He or she listens to the runner and transcribes what they say precisely on one of the quarter sheets of paper. The writer should ask clarifying questions to guarantee accuracy – even spelling!

THE ARTIST takes the quarter sheet of paper from the writer once a transcription is finished (notice: this person will not have a job on the first round, and so should join the cheerleader!). On the same quarter sheet of paper, the artist should illustrate what the writer transcribed from the runner. Use color if possible! The artist can continue working through two rotations if necessary, until it is time for him or her to run.

THE CHEERLEADER cheers on all team members and checks for quality.

NOW, GET RUNNING!

1. Once you're set up, it's time to start your Running Dictation! Here's how to play:

2. The team members take turns rotating through the roles. Roles change each time that a transcription of one of the posters that you placed in the hall (or at the other side of the room) is completed. Role responsibilities are outlined below.

3. When all signs have been transcribed and illustrated, team members may have to complete an additional task (ex: put them in the correct order)–although not necessarily–and then present them to the teacher for approval.

4. The teacher checks for accuracy and tells the group which of the papers contain errors and therefore need to be re-checked by running back out into the hall.

5. The first team to receive teacher seal of approval wins!

The text for this activity is in the Answer Key.

VOCABULARY

3. Match the words and word combinations (1–16) with the definitions (A–P). Write your answers in the table below.

1	mount	A	to make larger or more powerful; increase
2	lead	B	to come back, get back
3	enclose	C	to put trust in with confidence
4	sealed	D	a drawback
5	RLC combo	E	a transducer that converts vibrations, as of a phonograph needle or guitar string, into electrical impulses for subsequent conversion into sound
6	precise	F	a circuit which is constructed by the combination of resistor, inductor, and capacitor
7	resonate	G	to fix, attach
8	piezoelectric effect	H	to exhibit or produce resonance or resonant effects
9	settle back	I	a wire, cable, or other conductor for making an electrical connection
10	pickup	J	a slender piece of jewel or steel used to transmit vibrations from the grooves of a phonograph record
11	amplify	K	exact, definite
12	predate	L	to hold, contain
13	needle	M	the production of electricity or electric polarity by applying a mechanical stress to certain crystals
14	rely on	N	dependable, responsible, trustworthy, trusty
15	reliable	O	to precede in time
16	a catch	P	closed or secured with or as if with a seal

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

LISTENING

4. **Listen to and watch the video "How to Squeeze Electricity out of Crystals"**
   https://youtu.be/YEJ2qryXcIQ

Define the following statements as true (T) or false (F).

1. Piezoelectric materials turn mechanical stress, like pressure, sound waves, and other vibrations into electricity and vice versa.
2. The piezoelectric effect was first discovered by the physicist Pierre Curie and his brother Jacques in 1890.
3. The first practical application of the piezoelectric effect was in sonar instruments used to detect German submarines during World War II.
4. Clapping your hands sends sound vibrations through the air and causes the piezo element to move.
5. The piezoelectric effect of materials depends on their atomic structure, and how electric charge is distributed within them.
6. If a quartz crystal is squeezed along a certain direction, the atoms are distributed symmetrically around a central point.
7. Piezoelectric materials have unit cells which lack a center of symmetry.
8. DNA, bone, and silk can't turn mechanical energy into electrical.
9. Piezoelectricity is responsible for the rhythmic oscillations of the quartz crystals that keep watches running on time.
10. There are train stations that use passengers' footsteps to power the ticket gates and displays.

SPEAKING

5. **In pairs, make a dialogue discussing crystals.**
   Requirements for the dialogue:
   - consisting of 20 replicas;
   - 10 replicas for each student (5 questions and 5 answers);
   - 5 questions of all types (general, special, direct, disjunctive and alternative).

WRITING

6. **Write an informative essay about crystals. Use active vocabulary and answer the following questions:**
   1. What are crystals?
   2. How do crystals work?
   3. What is the piezoelectric effect?
   4. What is the difference between crystals and oscillators?

ENTERTAIN YOURSELF

Watch the video "Collin's Lab: Homebrew Piezo"

UNIT 10

TRANSFORMERS

Figure 10.1. An electronic transformer

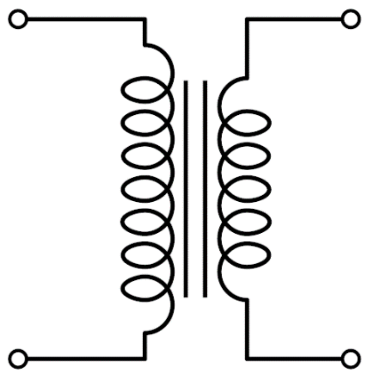


Figure 10.2. Transformer circuit symbol

WARM UP

1. **Answer the following questions:**
   1. What is a transformer?
   2. How does a transformer work?

READING

2. **Read the text and answer the following questions.**
   1. Why are inductors used in tuning circuits shielded?
   2. What is the difference between mutual inductance and self-inductance?
   3. What is transformer action?
   4. How are the windings in the transformer called?
   5. What is the difference between a step-up and step-down transformer.

Inductors used in tuning circuits are **shielded** so that the magnetic field they produce doesn't interact with other circuit components. **Unshielded** coils are sometimes placed close to one another for the express purpose of allowing their magnetic fields to interact.

When you place two unshielded coils near each other, the varying magnetic field created as a result of passing AC through one coil induces a voltage in that coil as well as in the other coil. **Mutual inductance** is the term used to describe the effect of inducing a voltage in another coil, while **self-inductance** refers to the effect of inducing a voltage in the same coil that produced the varying magnetic field in the first place. The closer the coils, the stronger the interaction. Mutual inductance can add to or oppose the self-inductance of each coil, depending on how you match up the north and south poles of the inductors.

If you have an unshielded coil in one circuit, and place it close to an unshielded coil in another circuit, the coils will interact. By passing a current through one coil, you will cause a voltage to be induced in the neighboring coil – even though it is in a separate, unconnected circuit. This is known as **transformer action**.

A transformer is an electronic device that consists of two coils wound around the same core material in such a way that the mutual inductance is maximized. Current passing through one coil, known as the primary, induces a voltage in the other coil, known as the secondary. The job of a transformer is to transfer electrical energy from one circuit to another.

If the number of turns in the **primary winding** of a transformer is not the same as the number of turns in the **secondary winding**, the voltage induced in the secondary will be different from the voltage across the primary. The two voltages will be proportional to each other, with the proportion determined by the ratio of the number of turns in the secondary to the number of turns in the primary.

The power **applied to** the primary winding is **transferred to** the secondary. Because power is the product of voltage and current, the current induced in the secondary winding is inversely proportional to the voltage induced in the secondary. So a **step-up transformer** steps up the voltage while stepping down the current; a **step-down transformer** steps down the voltage while stepping up the current.

Step-up and step-down transformers are used in **electrical power-transmission systems**. Electricity generated at a power plant is stepped up to voltages of 110 kV or more, transported over long distances to a substation, and then stepped down to lower voltages for **distribution** to customers.

VOCABULARY

3. Fill in the gaps in the sentences with the words and word combinations from the table below.

step-up transformer	applied to	electric power transmission systems	shielded	step-down transformer
unshielded	transferred	distribution	primary and secondary windings	mutual inductance

1. I'm sure all his circuits are ____________.
2. If cables are long and are coiled, ____________ will increase and cause malfunctions.
3. ____________ are located inside the upper part of the transformer.
4. This sets the frequency cut-off point above which boost current is no longer ____________ the motor.
5. A polarised two-pin ____________ connector, designed for connecting a loudspeaker to a power amplifier is known as the loudspeaker connector.
6. To achieve the best measuring results it is important that no real power is ____________ during the measurement.
7. It's basically a ____________ which converts relatively low-voltage, high current, to high-voltage, low current at high frequencies.
8. The alternating current excited in the low-voltage winding of the ____________ is supplied to the consumer.
9. High-voltage direct current (HVDC) ____________ use DC for the bulk transmission of electrical power, in contrast with the more common alternating current systems.
10. They should also endeavour to place this material on computer networks for wider and instant ____________.

LISTENING

4. Listen to and watch the video "How Do Transformers Work?"
https://youtu.be/YQQ-mgjCpn8

Mark the following sentences as true (T) or false (false).

1. Transformers are used to step electric voltage up or down.
2. Original power distribution voltage can range from 120 to 220 volts.
3. Transmission lines connect the power to substations.
4. A transformer consist of an iron core and two coils.
5. As the electricity flows through the low voltage coil it creates a magnetic field and induces a higher voltage in the other coil.
6. Charging your cell phone with 5 volts will fry it instantly so the charger converts the voltage to a more tolerable 120 volts or so.

SPEAKING

5. **Using the diagram on Figure 10.3 tell and Internet resources tell about the types of transformers.**

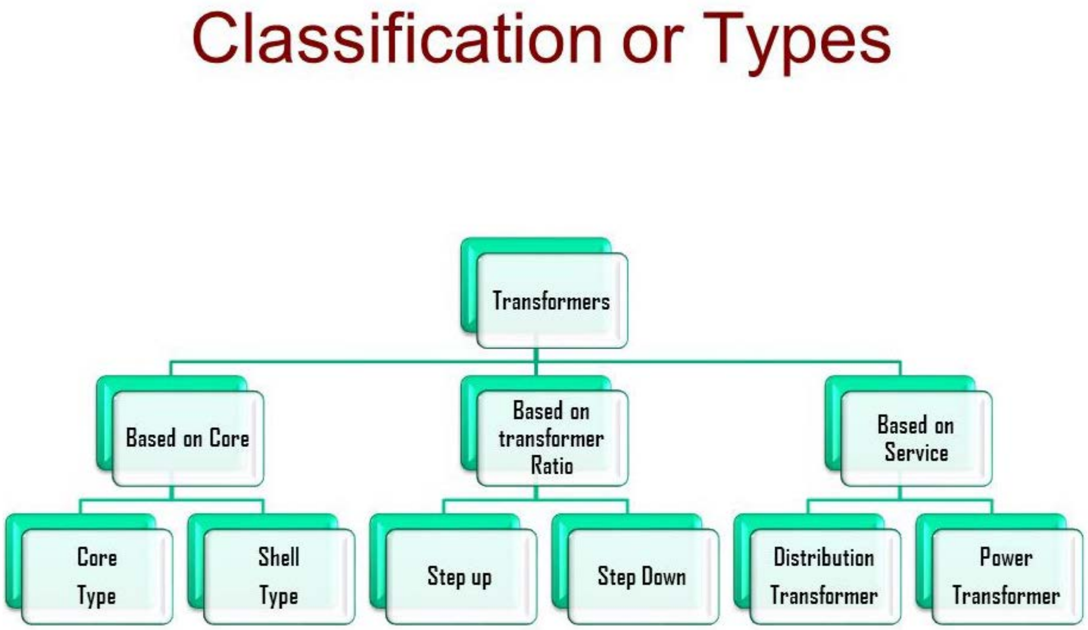


Figure 10.3. Types of transformer

WRITING

6. **Describe the process of bringing electricity to our homes and the role of transformers in it.**

CHAPTER 3. ACTIVE ELECTRONIC COMPONENTS

UNIT 11

CONDUCTORS, INSULATORS AND SEMICONDUCTORS

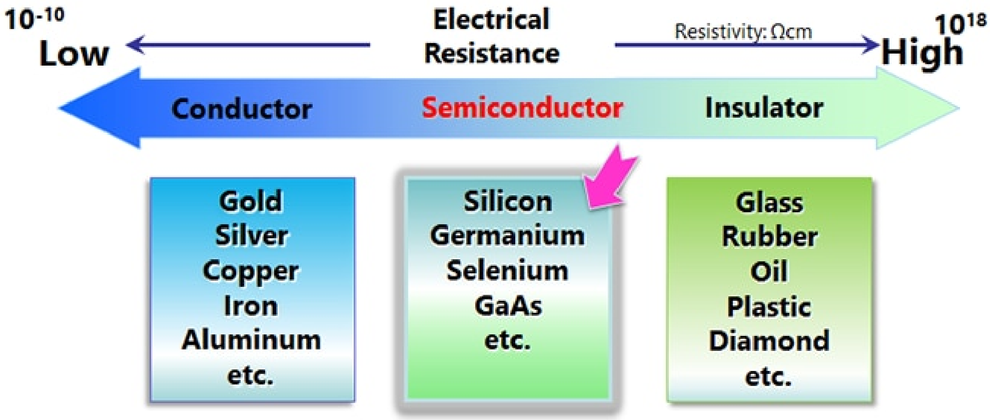


Figure 11.1. Conductors, insulators and semiconductors

WARM UP

1. Answer the following questions:

1. What is the difference between a conductor and an insulator?
2. What elements are called semiconductors?

READING

2. Read the text and define its main idea and make a list of key words.

Levels of conductivity are the main difference between conductors, insulators and semiconductors. Conductors display high conductivity, which means they allow energy, such as electricity, heat or sound, to easily flow through them. Whereas insulators exhibit low conductivity and semiconductors allow a moderate flow. Whilst conductivity is the principal difference between conductors, insulators and semiconductors, there are a number of other differences between the three. These differences may also need to be considered when thinking about their industrial and commercial uses.

Band theory is one of the main ways of explaining differences in conduction. This uses the 'band' of material to explain a number of physical properties of conduction. Electrons orbit the positive nucleus of an individual atom within permitted levels of energy. In a lot of atoms, energy levels reorganise into two bands, namely the valence band and the conduction band. The valence band is the lower level of electrons and the conduction band is the higher level of electrons. An energy gap exists between the bands where electrons can't exist. When conduction occurs electrons move and for this to happen there has to be spaces in the energy bands for the electrons to move into.

A conductor facilitates the easy flow of an electron from one atom to another atom when the proper application of voltage. This is because there are no band gaps between the valence and conduction bands. In some materials, there is an overlapping of the conductor and valence bands, which means electrons can move between the two overlapping bands. As there is space for electrons to move into in the conduction band, valence band electron moves into the other band and conduction is allowed. Silver is probably the best electrical conductor we encounter in everyday life. Other metals, such as gold, copper, steel, aluminium and brass also represent good conductors. You'll find these materials in everyday electrical equipment, either in the form of wires or etched onto circuit boards. Solids are normally the best types of conductors, however, some liquids including liquid metals such as mercury are also good at permitting the transmission of energy through them. Some materials are classed as superconductors. At extremely low temperatures these materials will conduct without resistance.

An insulator prevents the flow of energy between two objects. For example, insulators may prevent the flow of electricity, heat or sound. Thermal insulators, reduce the transfer of heat between two objects of differing temperatures. Thermal insulators do this by reflecting thermal energy. The insulative capacity of a material is the inverse of thermal conductivity (k) and therefore those materials with low thermal conductivity will have high insulating capability or resistance value. Other important properties to consider are product density (ρ) and specific heat capacity. A substance that does not conduct electricity is called a dielectric material. These substances can be polarised by an applied electric field so electric charges do not flow through them as they would through a conductor. Therefore, the internal electrical field reduces the overall field within the dielectric. In insulators, there are larger gaps between the conduction and valence bands. The electrons cannot move into the conduction band and this means the material cannot conduct.

With moderate conductivity, a semiconductor has a conductivity value between that of a conductor such as silver and an insulator, such as the mica. The resistance of a semiconductor falls as its temperature rises. Elements like silicon (Si), germanium (Ge), selenium (Se); compounds like gallium arsenide (GaAs) and indium antimonide (InSb) are all examples of semiconductor elements. Silicon represents the most widely used semiconductor. There is a gap between the valance and conduction bands in a semiconductor, however, it’s small enough to facilitate the movement of electrons at room temperature, enabling some conduction. A rise in temperature increases the conductivity of a semiconductor because more electrons will have enough energy to move into the conduction band. Ordinarily, gases are poor conductors due to the space between atoms. However, in some circumstances – such as when it contains a large number of ions – gasses can be fair conductors and act as semiconductors.

VOCABULARY

3. Find the words and word combinations in the text (Ex. 2) with the following meanings:

1. The difference of energy between the bottom of the conduction band and the top of the valence band of the electrons in a crystalline solid.
2. To have an area or range in common with.
3. Any of a group of chemically and physically related aluminum silicate minerals, common in igneous and metamorphic rocks, characteristically splitting into flexible sheets used in insulation and electrical equipment.
4. To allow; to afford opportunity.
5. A theory of the electrical properties of metals, semiconductors, and insulators based on energy bands.
6. The outermost electron shell of atoms in an insulator or semiconductor in which the electrons are too tightly bound to the atom to carry electric current.
7. To meet, especially unexpectedly; come upon.
8. The property of transmitting heat, electricity, or sound.
9. To fix or imprint firmly.
10. The set of electron orbitals, generally the outermost shells of the atoms in a conductor or semiconductor, in which electrons are free to move and thereby carry an electric current.

LISTENING

4. Listen to and watch the video “Band Gap and Semiconductor Current Carriers”

https://youtu.be/N8MuD_xu6L4

Give definitions and explanations to the terms below:

1. atomic structure
2. valence shell (band)
3. conduction band
4. band (energy) gap
5. conductor
6. insulator
7. semiconductor
8. current (charge) carrier
9. free electron
10. hole
11. covalent bond

SPEAKING

5. **With the help of the scheme depicted in Figure 11.2 explain the difference between conductors, insulators and semiconductors.**

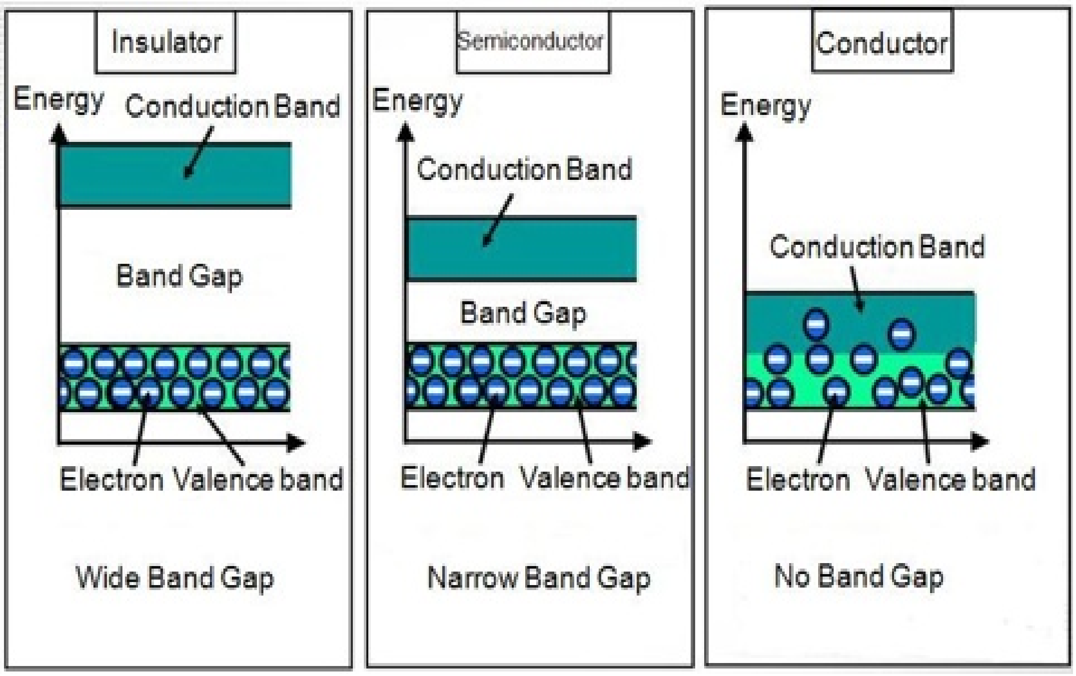


Figure 11.2. Conductors, insulators and semiconductors

WRITING

6. **Write 3 explanatory paragraphs about conductors, insulators and semiconductors. Use this hyperlink: "How to Do an Explanatory Paragraph" to help you.**

UNIT 12

GETTING FANCY WITH SEMICONDUCTORS

Figure 12.1. Silicon

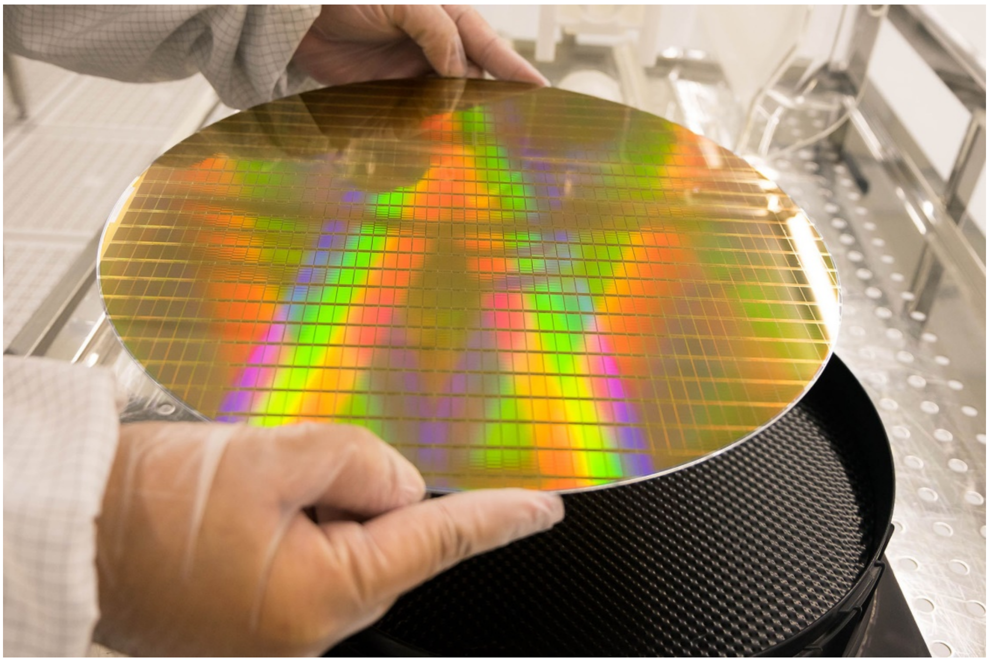


Figure 12.2. Semiconductor Wafer

WARM UP

1. **Answer the following questions:**
   1. What is a semiconductor?
   2. What is the role of semiconductors?

READING

2. Read the text and mark the following statements as true (T) or false (F).

1. The electrons in an atom are organized in shells (bands).
2. Semiconductors have one electron in their valence band.
3. Semiconductors are made out of silicon crystals.
4. Pure silicon conducts electricity.
5. The process of deliberately introducing other elements into a crystal is called doping.
6. N-type semiconductor is created when the dopant is an element that has five electrons in its valence layer.
7. P-type semiconductor happens when the dopant (such as boron) has only four electrons in the valence shell.
8. The random electron and hole movement that's always present in a semiconductor becomes organized in one direction, creating measurable electric current.

Semiconductors are used extensively in electronic circuits. As its name **implies**, a semiconductor is a material that conducts current, but only partly. The conductivity of a semiconductor is somewhere between that of an insulator, which has almost no conductivity, and a conductor, which has almost full conductivity. Most semiconductors are crystals made of certain materials, most commonly **silicon**.

To understand how semiconductors work, you must first understand a little about how electrons are organized in an atom. The electrons in an atom are organized in layers. These layers are called **shells**. The outermost shell is called the **valence band**.

The electrons in this shell are the ones that form bonds with neighboring atoms. Such bonds are called **covalent bonds**. Most conductors have just one electron in the valence band. Semiconductors, on the other hand, typically have four electrons in their valence band.

If all the neighboring atoms are of the same type, it's possible for all the valence electrons to **bind** with valence electrons from other atoms. When that happens, the atoms arrange themselves into structures called crystals. Semiconductors are made out of such crystals, usually silicon crystals.

Pure silicon crystals are not all that useful electronically. But if you introduce small amounts of other elements into a crystal, the crystal starts to conduct in an interesting way.

The process of deliberately introducing other elements into a crystal is called **doping**. The element introduced by doping is called a **dopant**. By carefully controlling the doping process and the dopants that are used, silicon crystals can transform into one of two distinct types of conductors:

✓ **N-type semiconductor** is created when the dopant is an element that has five electrons in its valence layer. Phosphorus is commonly used for this purpose.

The phosphorus atoms join right in the crystal structure of the silicon, each one bonding with four adjacent silicon atoms just like a silicon atom would. Because the phosphorus atom has five electrons in its valence shell, but only four of them are bonded to adjacent atoms, the fifth valence electron is left hanging out with nothing to bond to.

The extra valence electrons in the phosphorous atoms start to behave like the single valence electrons in a regular conductor such as copper. They are free to move about. Because this type of semiconductor has extra electrons, it's called an N-type semiconductor.

✓ **P-type semiconductor** happens when the dopant (such as boron) has only three electrons in the valence shell. When a small amount is incorporated into the crystal, the atom is able to bond with four silicon atoms, but since it has only three electrons to offer, a hole is created. The hole behaves like a positive charge, so semiconductors doped in this way are called P-type semiconductors.

Like a positive charge, holes attract electrons. But when an electron moves into a hole, the electron leaves a new hole at its previous location. Thus, in a P-type semiconductor, holes are constantly moving around within the crystal as electrons constantly try to fill them up.

When voltage is applied to either an N-type or a P-type semiconductor, current flows, for the same reason that it flows in a regular conductor: The negative side of the voltage pushes electrons, and the positive side pulls them. The result is that the random electron and hole movement that's always present in a semiconductor becomes organized in one direction, creating measurable electric current.

VOCABULARY

3. Fill in the gaps in the sentences using the words and word combinations from the table below.

doping	N-type or P-type semiconductor	covalent bond	implies
valence band	dopant	bind	silicon

1. This generally __________ that no information or personal data may be made available or published, particularly in the media.
2. The structure is based on long molecules with a strong backbone of ___________ atoms but linked to each other by weak bonds.
3. The band has the shape typical of a degenerate n-type semiconductor, and in the ___________, that of a p-type semiconductor.
4. In an ordinary ___________ a pair of electrons bonds two atoms together.
5. We cannot ___________ ourselves to the inheritance of other times and other problems.
6. In 1977 they discovered that ___________ with iodine vapor could enhance the conductivity of polyacetylene.
7. The introduction of a ___________ into a semiconductor to modify its electrical properties by creating a concentration of N or P carriers.
8. Aluminum is another important contact metal for silicon which can be used with either the __________.

LISTENING

4. **Listen to and watch the video "Intrinsic and Extrinsic Semiconductors"**
   https://youtu.be/vwU-Telalwo

Match the sentence parts.

1	The semiconductor where the electrical conductivity is due to movement of electrons and holes	A	the majority carriers in the P-type semiconductor
2	The addition of impurity atoms to increase the conductivity	B	such as N-type semiconductor or P-type semiconductor
3	These extrinsic semiconductors are classified, depending upon the type of impurity added	C	are the majority carriers

4	The holes are	D	is known as intrinsic semiconductor
5	In the N-type semiconductors, the electrons	E	is more in the N-type compared to the P-type semiconductors
6	The conduction of electric current	F	is termed as doping

1	2	3	4	5	6

SPEAKING

5. **In pairs, role play the dialogue. Follow these instructions:**
   Student A: Imagine that you are an intrinsic semiconductor.
   Student B: Imagine that you are an extrinsic semiconductor.

WRITING

6. **Fill in the gaps in the table below.**

Basis of difference	Intrinsic semiconductor	Extrinsic semiconductor
Doping of impurity		
Density of electrons and holes		
Electrical conductivity		
Dependency of electrical conductivity		
Example		

UNIT 13

DIVING INTO DIODES

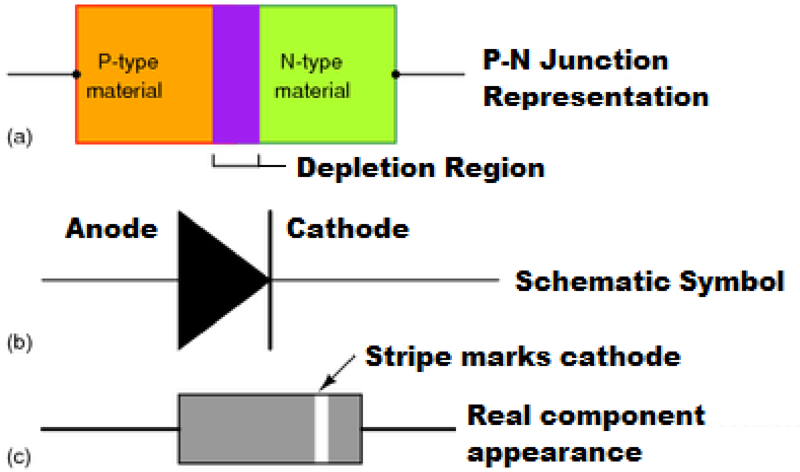


Figure 13.1. Diode

WARM UP

1. Answer the following questions:

1. What is a diode?
2. How does a diode work?

READING

2. Read the text and answer the following questions:

1. What is a PN-junction?
2. Is diode a rectifier?
3. What is the anode?
4. What is the cathode?
5. What is conventional current?
6. What is the difference between a forward-biased and reverse-biased diode?
7. What is the peak reverse voltage (PRV), or peak inverse voltage (PIV)?

A semiconductor diode is a **two-terminal** electronic device that consists of a single **PN-junction**. Diodes act like one-way **valves**, allowing current to flow in only one direction when a voltage is applied to them. This capability is sometimes referred to as the **rectifying** property.

You refer to the P-side of the PN-junction in a diode as the **anode** and the N-side as the **cathode**. For most diodes, if you apply a more positive voltage to the anode and a more negative voltage to the cathode, current will flow from the anode to the cathode. If you reverse the voltage, the diode will not conduct current (Zener diodes are an exception).

In electronics, current refers to conventional current – which is just the opposite of real electron flow. So when you say that (conventional) current flows from the anode to the cathode, the electrons are moving from the cathode to the anode.

You can think of the junction within a diode as a hill and the current as a ball you are trying to move from one side of the hill to the other: Pushing the ball down the hill (from anode to cathode) is easy, but pushing the ball up the hill (from cathode to anode) is difficult.

Diodes are cylindrical, like resistors, but aren't quite as colorful as resistors. Most diodes **sport** a stripe or other mark at one end, signifying the cathode.

Biasing the diode

When you **bias** a diode, you apply a voltage, known as the bias voltage, across the diode (from anode to cathode) so that the diode either allows current to flow from anode to cathode or blocks current from flowing. A standard diode has two basic operating modes:

✓ **Forward-bias (conducting)**: When a high enough positive voltage is applied from anode to cathode, the diode turns on (conducts current). This minimum turn-on voltage is known as the forward voltage, and its value depends on the type of diode. A typical silicon diode has a forward voltage of about 0.6 V to 0.7 V, whereas forward voltages for light-emitting diodes (LEDs) range from about 1.5 V to 4.6 V (depending on the color). When the diode is forward-biased, current, known as forward current, flows easily across the PN-junction from anode to cathode. You can increase the amount of current flowing through the diode (up to the maximum current it can safely handle), but the forward voltage drop won't vary that much.

✓ **Reverse-bias (non-conducting)**: When a reverse voltage (a negative voltage from anode to cathode) is applied across the diode, current is **prohibited** from flowing. Actually, a small amount of current, in the μA range, will flow. If the reverse-biased voltage **exceeds** a certain level (usually 50 V or more), the diode breaks down and reverse current starts flowing from cathode to anode. The reverse voltage at which the diode breaks down is known as the **peak reverse voltage (PRV)**, or **peak inverse voltage (PIV)**.

If no voltage or a low voltage (less than the forward voltage) is applied across a diode, it is unbiased.

Rating your diode

Most diodes don’t have values like resistors and capacitors. A diode simply does its thing in controlling the on/off flow of electrons, without altering the shape or size of the electron flow. But that doesn’t mean all diodes are the same. Standard diodes are rated according to two main criteria: peak reverse voltage (PRV) and current. These criteria guide you to choosing the right diode for a particular circuit, as follows:

✓ **The PRV rating** tells you the maximum reverse voltage the diode can handle before breaking down. For example, if the diode is rated at 100 V, you shouldn’t use it in a circuit that applies more than 100 V to the diode. Circuit designers build in considerable headroom above the PRV rating to accommodate **voltage spikes** and other conditions. For instance, it’s common practice to use a 1,000 V PRV rectifier diode in power supply circuits running on 120 VAC.

✓ **The current rating** tells you the maximum forward current the diode can withstand without **sustaining** damage. A diode rated for 3 A can’t safely conduct more than 3 A without overheating and failing.

VOCABULARY

3. Find 12 words in the puzzle and circle them.

f	p	t	c	a	t	h	o	d	e	l	u
v	o	a	p	p	c	u	v	n	n	i	f
a	t	r	z	u	a	e	i	n	d	r	d
e	r	b	w	a	g	a	e	t	j	e	p
s	l	f	n	a	t	n	r	v	e	v	d
b	i	w	t	s	r	o	g	c	n	y	s
d	d	l	u	b	p	d	x	k	u	a	t
z	o	s	a	s	r	e	-	c	i	t	z
v	r	t	p	r	o	h	i	b	i	t	e
v	p	n	-	j	u	n	c	t	i	o	n
t	w	o	-	t	e	r	m	i	n	a	l
r	e	v	e	r	s	e	-	b	i	a	s

two-terminal	PN-junction	anode	cathode
sport	bias	forward-bias	reverse-bias
prohibit	exceed	voltage	sustain

LISTENING

4. **Listen to and watch the video “How does a Diode work?”**
   https://youtu.be/JNi6WY7WKAI

   Correct mistakes in the sentences below.

   1. A diode is a two-way valve for electricity.
   2. Pure silicon has free electrons.
   3. At the p-side of the diode we will have free electrons, and at the n-side, we will have vacant positions for electrons.
   4. The p-side boundary is slightly positively charged, and the n-side boundary is slightly negatively charged.
   5. The resulting electric field will support any further natural migration of electrons.
   6. A forward-biased diode doesn’t conduct electricity.
   7. At the reverse biased side, applying a very low voltage will damage normal diodes and result in a high current flow.

SPEAKING

5. Make a PPT presentation about the types of diodes.

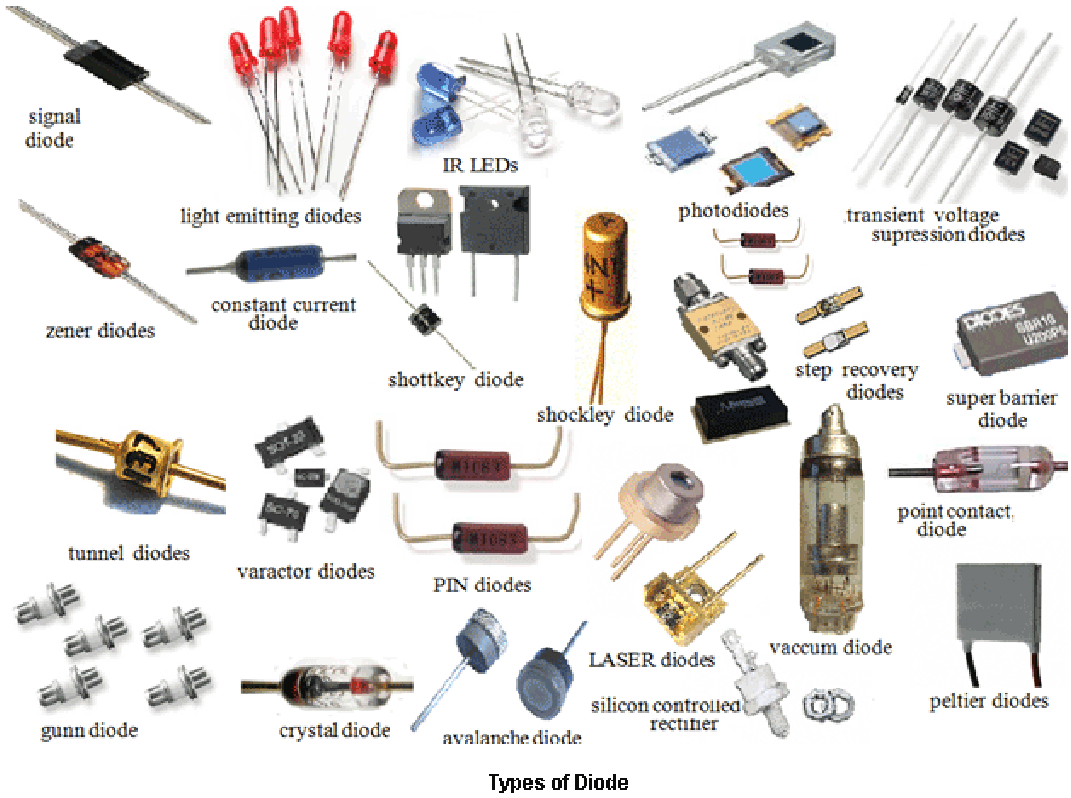


Figure 13.2. Types of diodes

WRITING

6. Create your own story about diodes with the help of *Pixton*.

ENTERTAIN YOURSELF

Watch the video "MAKE presents: The Diode"

UNIT 14

TREMENDOUSLY TALENTED TRANSISTORS

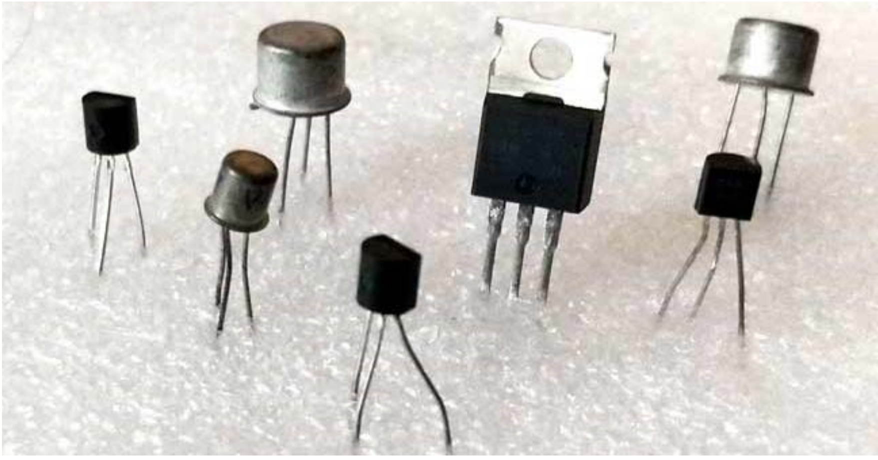


Figure 14.1. Transistors

WARM UP

1. **Answer the following questions:**
   1. What is a transistor?
   2. How does a transistor work?

READING

2. **Read the text and fill in the gaps in the sentences below.**
   1. Transistors work as _____________ and _____________ in electronic circuits.
   2. Switching helps you ____________ the flow and ____________ involved circuits.
   3. Switching is pretty ___________ important.
   4. Amplifying enables you to store and ___________ tiny signals and ___________ them when you need them to make something happen.
   5. The synonyms of amplify are _____________ and _____________.
   6. Before the invention of the transistor, _____________ did all the switching and amplifying
   7. The inventors of transistors are _____________.
   8. The trio was awarded the Nobel Prize in Physics in __________.
   9. Transistors ____________ of a lot less power than their vacuum-tube ______________.

Transistors basically do just two things in electronic circuits: switch and amplify. But those two jobs are the key to getting really interesting things done. Here’s why those functions are so important:

✓ **Switching:** If you can switch electron flow on and off, you have control over the flow, and you can build involved circuits by incorporating lots of switches in the right places. Consider, for instance, the telephone-switching system: By dialing a 10-digit number, you can connect with any one of millions of people around the world. Or look at the Internet. Switching enables you to access a website hosted in, say, Sheboygan while you're sitting on a train in, say, London. Other systems that rely on switching are computers, traffic lights, the electric power grid – well, you get the idea. Switching is pretty **darn** important.

✓ **Amplifying:** If you can amplify an electrical signal, you can store and transmit tiny signals and **boost** them when you need them to make something happen. For instance, radio waves carry tiny audio signals over long distances, and it's up to the amplifier in your stereo system to **magnify** the signal so it can move the diaphragm of a speaker so you can hear the sound.

Before the invention of the transistor, **vacuum tubes** did all the switching and amplifying. In fact, the vacuum tube was widely **regarded as** the greatest marvel in electricity in the early 20th century. Then, Bardeen, Brattain, and Shockley showed the world that tiny semiconductor transistors could do the same job – only better and for less money. The trio was awarded the 1956 Nobel Prize in Physics for their invention of the transistor.

Transistors these days are microscopically small, have no moving parts, are reliable, and **dissipate a heck** of a lot less power than their vacuum-tube **predecessors**. However, many **audiophiles** believe tubes offer superior sound quality compared to solid-state transistor technology.

VOCABULARY

3. **Create a *Quizlet* set with the words in bold (Exercise 2).**

LISTENING

4. **Listen to and watch the video "Bipolar Junction and Field Effect Transistors (BJTs and FETs)"**
   https://youtu.be/IMv6OS9qF-M

Mark the following statements as true (T) or false (F).

1. NPN and PNP transistors are the types of a Bipolar Junction Transistor (BJT).
2. In an NPN transistor the controlling current flows from the base to the emitter and the regulated current flows from the collector to the emitter.
3. In a PNP transistor the controlling current flows from the base to the emitter and the regulated current flows from the emitter to the collector.
4. A field effect transistor or FET uses an electric field to regulate current so a FET allows a large voltage to regulate a small current, well a BJT allows a small current to regulate a large current.
5. A field effect transistor consists of two doped semiconductor regions that are separated by a channel.
6. The terminals in a FET are called emitter, collector and base.
7. The terminals in a BJT are called source, drain and gate.
8. A MOSFET has an insulating layer that separates the gate from the channel.
9. The majority carriers in an N channel are electrons.
10. The majority carriers in a P channel are holes.

SPEAKING

5. **Compare the diagrams below, search the Internet for additional information and tell about the types of transistors.**

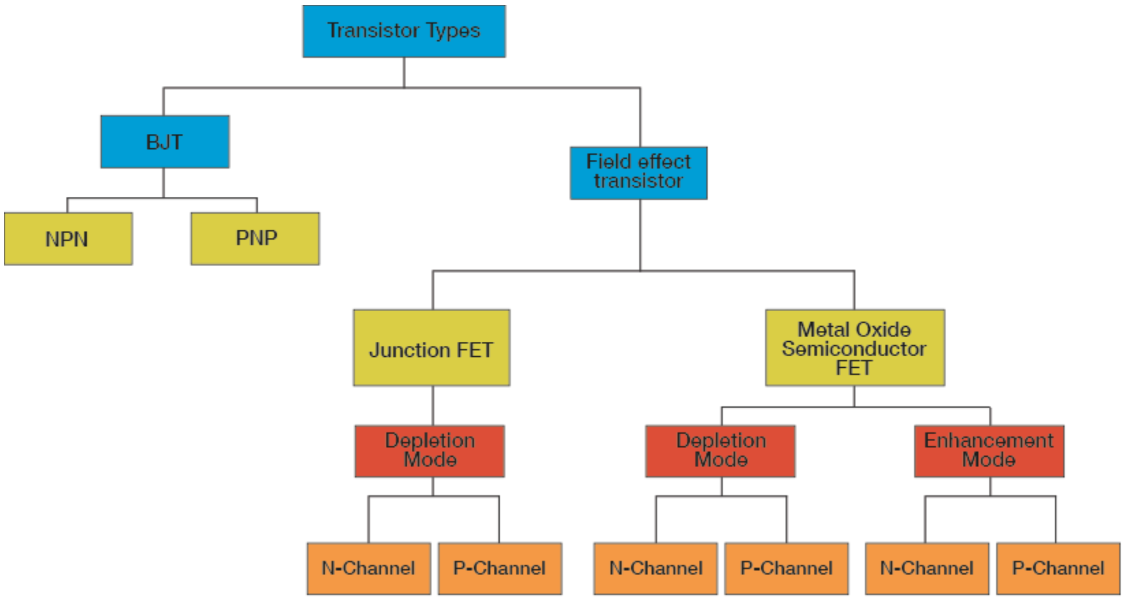


Figure 14.2. Types of transistors

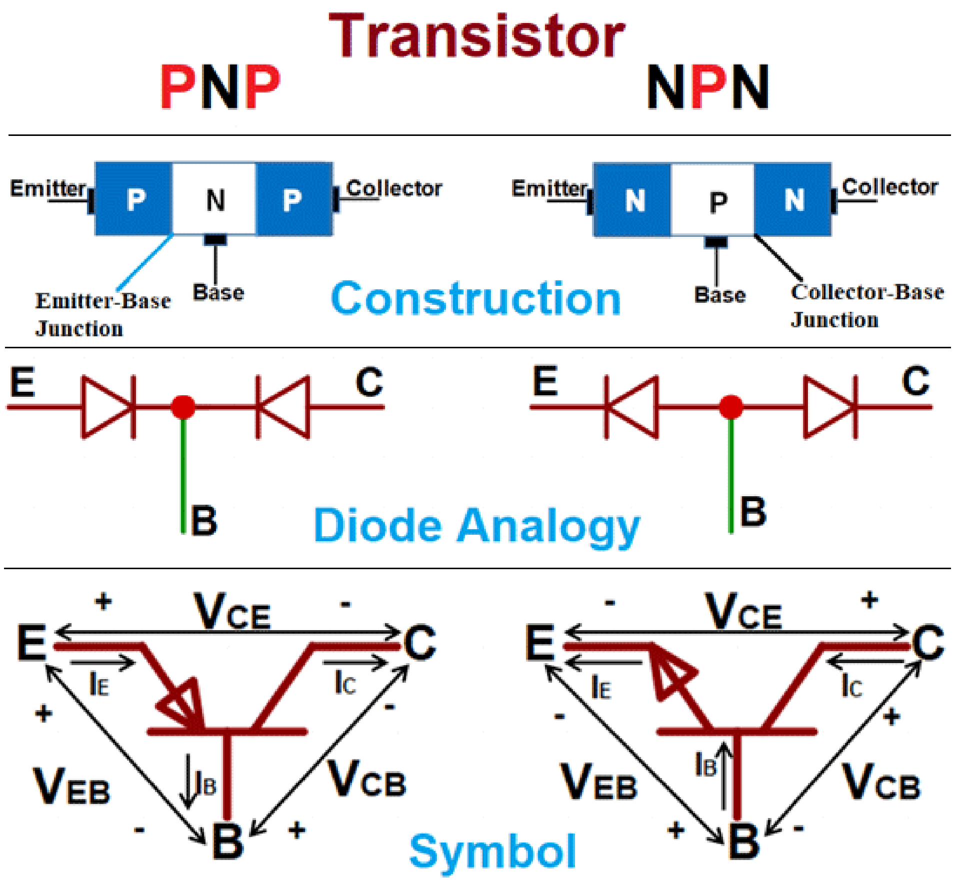


Figure 14.3. Bipolar Junction Transistor (BJT) types, construction, diode analogy and circuit symbols

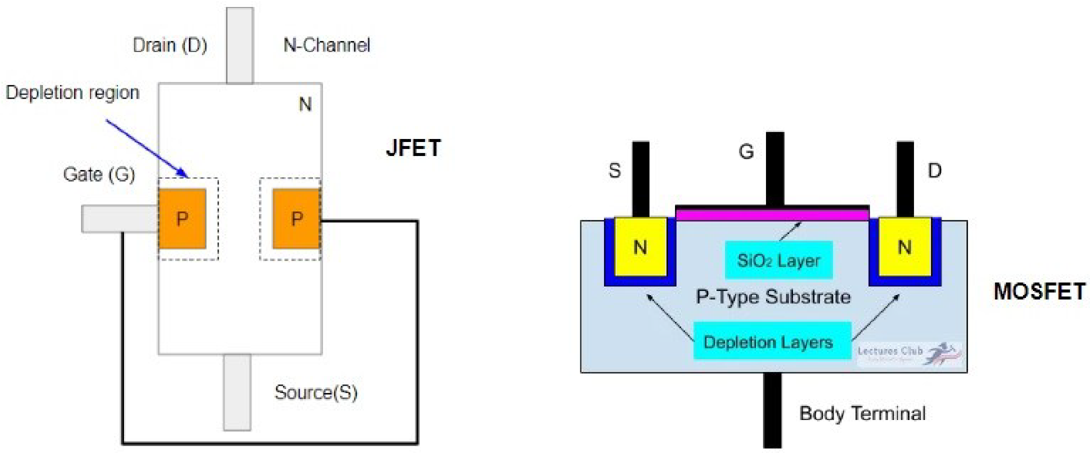


Figure 14.4. Junction Field Effect Transistor (JFET) and Metal Oxide Semiconductor Field Effect Transistor (MOSFET) structure

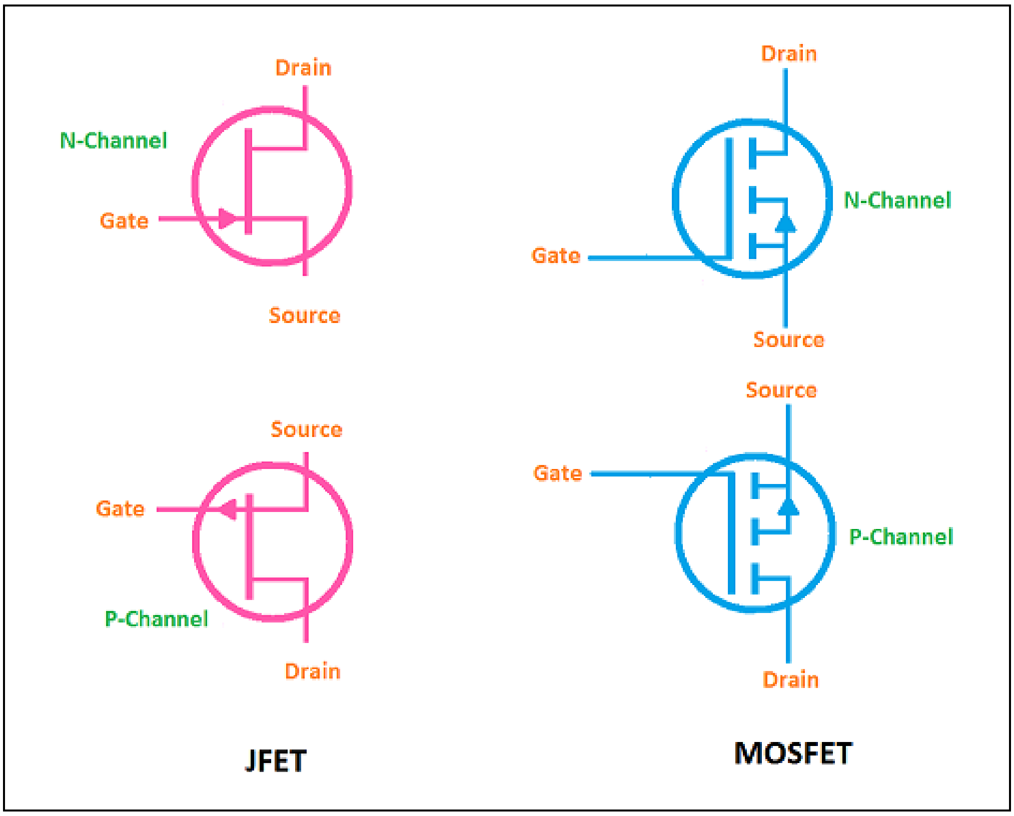


Figure 14.5 JFET and MOSFET circuit symbols

WRITING

6. Complete the table below.

Parameter	BJT	FET
Control method		
Impedance		
Polarity		
Noise level		
Thermal stability		
Size		

Make your own interactive book about transistors with the help of "Book Creator".

ENTERTAIN YOURSELF

Watch the videos: "MAKE presents: The Transistor"

How Does a Transistor Work?

UNIT 15

THYRISTORS

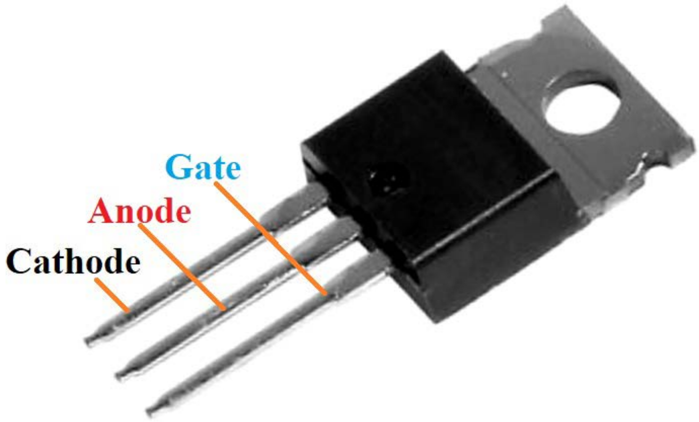


Figure 15.1. Thyristor or Silicon-Controlled Rectifier (SCR)

WARM UP

1. **Answer the following questions:**
   1. What is a thyristor?
   2. How does a thyristor work?

READING

2. **Read the text and make 10 question to it.**

Thyristors are an interesting class of semiconductor devices. They share similar characteristics with other solid-state components made from silicon, like diodes and transistors. Therefore, distinguishing thyristors from diodes and transistors could be difficult. To add to the difficulty, there are different types of thyristors available on the market. In some instances, what sets thyristors apart from one another could be just a tiny detail. Also, depending on the manufacturer, a given thyristor may be known by another name.

To apply thyristors successfully when designing circuits, it is important to know their unique characteristics, limitations, and their relationship with the circuit. That's why we're taking some time to sort it all out so that you can have a better understanding of what thyristor is most suitable for your application.

A thyristor is a four-layer device with alternating P-type and N-type semiconductors (P-N-P-N). In its most basic form, a thyristor has three terminals: anode (positive terminal), cathode (negative terminal), and gate (control terminal). The gate controls the flow of current between the anode and cathode.

The primary function of a thyristor is to control electric power and current by acting as a switch. For such a small and lightweight component, it offers adequate protection to circuits with large voltages and currents (up to 6000 V, 4500 A).

It is attractive as a rectifier because it can switch rapidly from a state of conducting current to a state of non-conduction. In addition, its cost of maintenance is low and, operating under the right conditions, remains functional in the long term without developing a fault. Thyristors are used in a wide range of electric circuits, from simple burglar alarms to power transmission lines.

A thyristor with a P-N-P-N structure has three junctions: PN, NP, and PN. If the anode is a positive terminal with respect to the cathode, the outer junctions, PN and PN are forward-biased, while the center NP junction is reverse-biased. Therefore, the NP junction blocks the flow of a positive current from the anode to cathode. The thyristor is said to be in a forward blocking state. Similarly, the flow of a negative current is blocked by the outer PN junctions. The thyristor is in a reverse blocking state.

Another state a thyristor can exist in is the forward conducting state, whereby it receives a sufficient signal to switch on, and it starts conducting.

VOCABULARY

3. **For each box below, choose a word from the text in Exercise 2 to apply to each blank space. Make sure the first letter of the word matches the box you choose. Then, give a definition of the word. "A" is done for you.**

A **Anode** A positively charged electrode, as of an electrolytic cell, storage battery, or electron tube	**B**	**C**	**D**
E	**F**	**G**	**H**
I	**J**	**K**	**L**
M	**N**	**O**	**P**
Q	**R**	**S**	**T**
U	**V**	**W/X**	**Y/Z**

LISTENING

4. **Listen to and watch the video "What is a thyristor?"**
   https://youtu.be/LBb_Qz7J3zA

Put the sentences in the correct logical order:

1. Although thyristors can only transmit currents in one direction, they have three different operating modes: reverse blocking, forward blocking and forward conducting.
2. When a current is applied at the gate, the thyristor allows an amplified current to flow from anode to cathode.
3. Thyristors are used in motor speed controls, light dimmers, pressure control systems and liquid level regulators.
4. Using this type of circuit large amount of power can be switched or controlled using a small triggering current or voltage.
5. Thyristors are primarily designed to amplify and rectify the electrical currents that flow in high-powered electronic devices.
6. The SCR begins to conduct and continues to conduct until the voltage between the cathode and the anode is reversed or reduced below a certain threshold value.
7. A thyristor is a four layer semiconductor rectifier in which the flow of current between two electrodes is triggered by a signal at a third electrode.
8. When the cathode is negatively charged relative to the anode no current flows until a pulse is applied to the gate.
9. A thyristor usually has three electrodes an anode, a cathode and a gate.
10. The most common type of a thyristor is the silicon controlled rectifier or SCR.

1	2	3	4	5	6	7	8	9	10

SPEAKING

5. Explain the operating principle of a thyristor with the help of the diagram below and search the Internet for additional information.

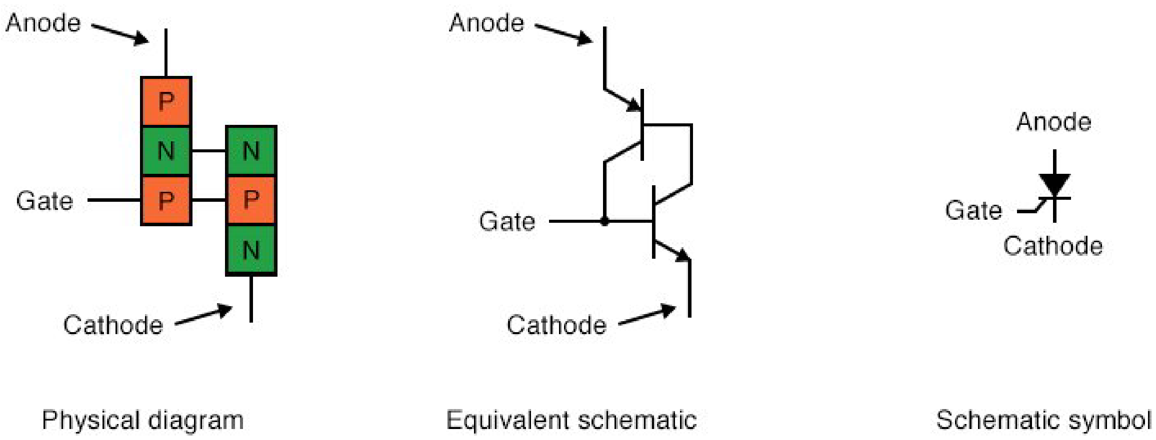


Figure 15.2. Thyristor physical diagram, equivalent schematic and schematic symbol

WRITING

6. Complete the gaps in the table below.

Parameter	Transistor	Thyristor
Basic		
Number of junctions		
Device triggering		
Power rating		
Cost		
Size		
Current rating		
Turn-on time		
Commutation circuit		
Power losses		
Suitability in application		

GLOSSARY

Here are many of the terms you'll run into throughout your electronics life.

alkaline battery:

A type of nonrechargeable battery. See also battery.

alternating current (AC):

Current characterized by a change in direction of the flow of electrons. See also direct current (DC).

ampere:

The standard unit of electric current, commonly referred to as amps. One ampere is the strength of an electric current when 6.241 x 10 18 electrically charged particles move past the same point within a second. See also current, I.

amplitude:

The magnitude of an electrical signal, such as voltage or current.

analog circuit:

A circuit that processes analog signals. See also digital circuit.

analog signal:

A varying voltage or current that constitutes a one-to-one mapping of a physical quantity, such as sound or displacement.

anode:

The terminal of a device into which conventional current (hypothetical positive charge) flows. In power-consuming devices, such as diodes, the anode is the positive terminal; in power-releasing devices, such as batteries, the anode is the negative terminal. See also cathode.

antistatic wrist strap:

A device used to prevent the buildup of static electricity on individuals working on sensitive electronic equipment.

autoranging:

A feature of some multimeters that automatically sets the test range.

AWG (American Wire Gauge):

See wire gauge.

battery:

A power source that uses an electrochemical reaction to produce a positive voltage at one terminal and a negative voltage at the other terminal. This process involves placing two different types of metal in a certain type of chemical. See also alkaline battery, lithium battery, nickel-cadmium (NiMH) battery, nickel-metal hydride (NiCd) battery and, zinc-carbon battery.

biasing:

Applying a small amount of voltage to a diode or to the base of a transistor to establish a desired operating point.

bipolar transistor:

A common type of transistor consisting of two fused pnjunctions. See also transistor.

bit:

Short for binary digit. A digit that has a value of 0 or 1.

breadboard:

Also known as prototyping board or solderless breadboard; a rectangular plastic board (available in a variety of sizes) that contains groups of electrically interconnected contact holes. You plug in components – resistors, capacitors, diodes, transistors, and integrated circuits, for example – and then string wires to build a circuit. See also solder breadboard.

bus strip:

See power rail.

byte:

A grouping of eight bits used as a basic unit of information for storage in computer systems.

cable:

A group of two or more wires protected by an outer layer of insulation, such as a common power cord.

capacitance:

The capability to store energy in an electric field, measured in farads. See also capacitor.

capacitor:

A component that provides the property of capacitance in a circuit. See also capacitance.

cathode:

The terminal of a device from which conventional current (hypothetical positive charge) flows. In power-consuming devices, such as diodes, the cathode is the negative terminal; in power-releasing devices, such as batteries, the cathode is the positive terminal. See also anode.

circuit:

A complete path that allows electric current to flow.

cladding:

An extremely thin sheet of copper that you glue over a base made of plastic, epoxy, or phenol to make a printed circuit board.

closed circuit:

An uninterrupted circuit through which current can flow. See also open circuit.

closed position:

The position of a switch that allows current to flow. See also open position.

cold solder joint:

A defective joint that occurs when solder doesn't properly flow around the metal parts.

commutator:

A device used to change the direction of electric current in a motor or generator.

component:

A part used in a circuit, such as a battery or a diode.

conductor:

A substance through which electric current can move freely.

connector:

A metal or plastic receptacle on a piece of equipment (a phone jack in your wall, for example) that a cable end fits into.

continuity:

A type of test you perform with a multimeter to establish whether a circuit is intact between two points.

conventional current:

The flow of hypothetical positive charge from positive to negative voltage; the reverse of real current. See also real current.

current:

The flow of electrically charged particles. See also ampere, I.

desoldering pump:

See solder sucker.

digital circuit:

A circuit that processes digital signals. See also analog circuit.

digital signal:

A pattern consisting of just two voltage or current levels representing binary digital data.

diode:

A semiconductor electronic component consisting of a p-n junction that allows electric current to flow one way more easily than the other way.

Diodes are commonly used toconvert alternating current to direct current by limiting the flow of current to one direction.

direct current (DC):

A type of current in which the electrons move in only one direction, such as the electric current generated by a battery.

double-pole, double-throw (DPDT) switch:

A type of switch that has two input contacts and four output contacts. It is a dual on/on switch that behaves like two SPDT switches acting in sync.

double-pole, single-throw (DPST) switch:

A type of switch that has two input contacts and two output contacts. It is a dual on/off switch that behaves like two SPST switches acting in sync.

DPDT:

See double-pole, double-throw (DPDT) switch.

DPST:

See double-pole, single-throw (DPST) switch.

earth ground:

A direct electrical connection to the earth. See also ground.

electric current:

See current.

electrical signal:

The pattern over time of an electrical current. Often, the way an electrical signal changes its shape conveys information about something physical, such as the intensity of light, heat, or sound, or the position of an object, such as the diaphragm in a microphone or the shaft of a motor.

electricity:

The displacement of electrons along a conductor.

electromagnet:

A temporary magnet consisting of a coiled wire around a piece of metal (typically, an iron bar). When you run current through the wire, the metal becomes magnetized. When you shut off the current, the metal loses its magnetic quality.

electromotive force:

An attractive force between positive and negative charges, measured in volts.

electron:

A negatively charged subatomic particle. See also proton.

ESD (electrostatic discharge):

See static electricity.

fillet:

A raised area formed by solder.

floating ground:

A circuit ground that isn't connected to earth ground.

flux:

A wax-like substance that helps molten solder flow around components and wire and ensures a good joint.

frequency:

A measurement of how often an AC signal repeats, measured in cycles per second, or hertz (Hz). The symbol for frequency is f. See also hertz (Hz).

gain:

The amount that a signal is amplified (the voltage of the signal coming out divided by the voltage of the signal coming in).

gauge:

See wire gauge.

ground:

A connection in a circuit used as a reference (0 volts) for a circuit. See also earth ground.

heat sink:

A piece of metal that you attach securely to the component that you want to protect. The sink draws off heat and helps prevent the heat from destroying the component.

helping hands clamp:

Also called a third-hand clamp; adjustable clips that hold small parts while you're working on projects.

hertz (Hz):

The measurement of the number of cycles per second in alternating current. See also frequency.

high signal:

In digital electronics, a signal at or near 5 volts (typically 3 – 5 V) that represents one of two binary states.

inductance:

The capability to store energy in a magnetic field (measured in henrys). See also inductor.

inductor:

A component that provides the property of inductance to a circuit. See also inductance.

infrared temperature sensor:

A kind of temperature sensor that measures temperature electrically.

insulator:

A substance through which electric current is unable to move freely.

integrated circuit (IC):

Also known as a chip; a component that contains several miniaturized components, such as resistors, transistors, and diodes, connected in a circuit that performs a designated function.

inverter:

Also known as a NOT gate; a single-input logic gate that inverts the input signal. A low input produces a high output, and a high input produces a low output. See also logic gate.

inverting mode:

A process by which an op amp flips an input signal to produce the output signal.

jack:

A type of connector. See also connector.

lithium battery:

A lightweight disposable battery that generates about 3 volts and has a higher capacity than does an alkaline battery. See also battery.

live circuit:

A circuit to which you've applied voltage.

logic gate:

A digital circuit that accepts input values and determines which output value to produce based on a set of rules.

low signal:

In digital electronics, a signal at or near 0 volts (typically 0 – 2 V) that represents one of two binary states.

microcontroller:

A programmable integrated circuit.

multimeter:

An electronics testing device used to measure such factors as voltage, resistance, and current.

negative temperature coefficient (NTC) thermistor:

A resistor whose resistance decreases with a rise in temperature. See also resistor, thermistor.

nickel-cadmium (NiCd) battery:

The most popular type of rechargeable battery. Some NiCad batteries exhibit the memory effect, requiring that they be fully discharged before they can be recharged to full capacity. See also battery.

nickel-metal hydride (NiMH) battery:

A type of rechargeable battery that offers higher energy density than does a NiCd rechargeable battery. See also battery.

nominal value:

The stated value of a resistor or other component. The real value can vary up or down from the nominal value based on the tolerance of the device. See also tolerance.

N-type semiconductor:

A semiconductor doped with impurities so that it has more free electrons than a pure semiconductor.

ohm:

A unit of resistance; its symbol is Ω. See also R, resistance.

Ohm's Law:

An equation that defines the relationship between voltage, current, and resistance in an electrical circuit.

open circuit:

A type of circuit in which a wire or component is disconnected, preventing current from flowing. See also closed circuit.

open position:

The position of a switch that prevents current from flowing. See also closed position.

operational amplifier (op amp):

An integrated circuit containing several transistors and other components. In many applications, it performs much better than an amplifier made from a single transistor. For example, an op amp can provide uniform amplification over a much wider range of frequencies than can a single-transistor amplifier.

oscillator:

A circuit that generates a repeating electronic signal.

oscilloscope:

An electronic device that measures voltage, frequency, and various other parameters for varying waveforms.

pad:

A contact point on a printed circuit board used for connecting components.

Phillips:

Both a screw with a plus-sign-shaped (+) slot in its head and the screwdriver used with it.

piezoelectric effect:

The capability of certain crystals, such as quartz or topaz, to expand or contract when you apply voltage to them or to produce voltage when you squeeze or move them.

p-n junction:

The point of contact between a P-type semiconductor, such as silicon doped with boron, and an N-type semiconductor, such as silicon doped with phosphorus. The pn-junction is the foundation for diodes and bipolar transistors. See also bipolar transistor, diode.

positive temperature coefficient (PTC) thermistor:

A device whose resistance increases with a rise in temperature. See also resistance, thermistor.

potentiometer:

A variable resistor that allows for the continual adjustment of resistance from virtually zero ohms to a maximum value.

power:

The measure of the amount of work that electric current does while running through an electrical component, measured in watts.

power rail:

A series of interconnected electrical contact holes in a column of a solderless breadboard that is intended to be used for power distribution. Also known as bus strip.

precision resistor:

A type of resistor with low tolerance (the allowable deviation from its stated, or nominal, value). See also nominal value, tolerance.

proton:

A positively charged subatomic particle. See also electron.

prototyping board:

See breadboard.

P-type semiconductor:

A semiconductor doped with impurities so that it has fewer free electrons than a pure semiconductor.

pulse:

A burst of current or voltage, usually beginning with an abrupt rise and ending with an abrupt fall.

pulse-width modulation:

A method of controlling the speed of a motor that turns voltage on and off in quick pulses. The longer the on intervals, the faster the motor.

RC time constant:

A calculation of the product of resistance and capacitance that defines the length of time it takes to charge a capacitor to twothirds of its maximum voltage or to discharge it to one-third of its maximum voltage.

real current:

The flow of electrons from a negative to a positive voltage. See also conventional current.

relay:

A device that acts like a switch in that it closes or opens a circuit depending on the voltage supplied to it.

resistance:

A measure of a component's opposition to the flow of electric current, measured in ohms. See also ohm, R.

resistor:

A component with a fixed amount of resistance that you can add to a circuit to restrict the flow of current. See also resistance.

rosin flux remover:

A detergent used after soldering to clean any remaining flux to prevent it from oxidizing a circuit. Available in a bottle or spray can.

schematic:

A drawing showing how components in a circuit are connected.

semiconductor:

A material, such as silicon, that has some of the properties of both conductors and insulators.

semiconductor temperature sensor:

A kind of temperature sensor that measures temperature electrically.

sensor:

An electronic component that senses a condition or an effect, such as heat or light, and converts it into an electrical signal.

series circuit:

A circuit in which the current runs through each component sequentially.

short circuit:

An accidental connection between two wires or components allowing current to pass through them rather than through the intended circuit.

single-pole, double-throw (SPDT) switch:

A type of switch that has one input contact and two output contacts. It switches the input between two choices of outputs. It is also known as an on/on or changeover switch.

single-pole, single-throw (SPST) switch:

A type of switch that has one input contact and one output contact. It is also known as an on/off switch.

60/40 rosin core:

Solder containing 60 % tin and 40 % lead (the exact ratio can vary a few percentage points) with a core of rosin flux. This type of solder is ideal for working with electronics. See also solder, soldering.

slide switch:

A type of switch where you slide the switch forward or backward to turn something (such as a flashlight) on or off.

solar cell:

A type of semiconductor that generates a current when exposed to light.

solder:

A metal alloy that is heated and applied to two metal wires or leads and allowed to cool, forming a conductive joint. See also 60/40 rosin core, soldering.

solder breadboard:

A breadboard on which you solder components in place. See also breadboard.

soldering:

The method you use in your electronics projects to assemble components on a circuit board to build a permanent electrical circuit. Rather than using glue to hold things together, you use small globs of molten metal, or solder. See also solder.

soldering iron:

A wand-like tool that consists of an insulated handle, a heating element, and a polished metal tip used to apply solder.

soldering pencil:

See soldering iron.

solderless breadboard:

See breadboard.

solder sucker:

Also known as a desoldering pump; a tool consisting of a spring-loaded vacuum used for removing excess solder.

solder wick:

Also known as solder braid; a device used to remove hard-toreach solder. The solder wick is a flat braid of copper that works because the copper absorbs solder more easily than the tin plating of most components and printed circuit boards.

solid wire:

A wire consisting of only a single strand.

SPDT:

See single-pole, double-throw (SPDT) switch.

SPST:

See single-pole, single-throw (SPST) switch.

static electricity:

Charge that builds on or within an object and remains stationary until a path is provided for the charge to flow. Lightning is a form of static electricity.

strain relief:

A device that clamps around a wire and prevents you from tugging the wire out of the enclosure.

stranded wire:

A metal wire consisting of several fine wires twisted together into a bundle that is wrapped in insulation.

stray capacitance:

Energy that's stored in a circuit unintentionally when electric fields occur between wires or leads that are placed too close together.

terminal:

A piece of metal to which you hook up wires (as with a battery terminal).

thermistor:

A resistor whose resistance value varies with changes in temperature.

thermocouple:

A type of sensor that measures temperature electrically.

third-hand clamp:

Also called helping hands clamp; a small, weighted clamp that holds parts while you solder.

tinning:

The process of heating up a soldering tool and applying a small amount of solder to the tip to prevent solder from sticking to the tip.

tolerance:

The variation from the nominal value of a component due to the manufacturing process expressed as a percentage. See also nominal value.

trace:

A wire on a circuit board that runs between the pads to electrically connect the components.

transistor:

A semiconductor device that's commonly used to switch and amplify electrical signals.

variable capacitor:

A capacitor whose capacitance can be dynamically altered mechanically or electrically. See also capacitance, capacitor.

variable inductor:

A coil of wire surrounding a movable metal slug. By turning the slug, you change the inductance of the coil.

variable resistor:

See potentiometer.

voltage:

An attractive force between positive and negative charges.

voltage divider:

A circuit that uses voltage drops to produce voltage lower than the supply voltage at specific points in the circuit.

voltage drop:

The resulting lowering of voltage when voltage pulls electrons through a resistor (or other component), and the resistor absorbs some of the electrical energy.

wire:

A long strand of metal, usually made of copper, that you use in electronics projects to conduct electric current.

wire gauge:

A system of measurement of the diameter of a wire.

zinc-carbon battery:

A low-quality, disposable battery. See also battery

VIDEO SCRIPTS

Unit 1

We live in an electronic world. Electronics regulates our heat and light, monitors our health, maps our travel, plays our music, keeps our transport moving, links us to family and friends across the world via the Internet. Without electronics, our world would grind to a halt. You will learn how to write the computer code which drives many of the digital devices we rely on to run and monitor our technological world. You will learn how the hardware controlled by the code is designed and fabricated. You will see the reasons why electronics never stands still. As greater and greater computing power is squeezed into smaller and smaller processors so that a smartphone is faster, more versatile and more powerful than computers which once filled a room. You will glimpse the future as advances in nanotechnology and quantum physics shrink electronic devices still further and make them operate at almost unimaginable speed. You will learn how to send sound and data wirelessly via phone masts, cables, fibers and satellites that reach every part of the world, and far beyond. You could even produce your own music tracks and develop digital effects that make them sound exciting and unique. A world where a career in electronics is a career in IT, telecommunications, broadcasting, healthcare design, industry, robotics, art, conservation agriculture, research, finance anywhere that uses electronics which is almost everywhere. Electronics is the future. Your future. Why not find out more?

Unit 2

Hi! I'm Emerald Robinson. In this “what is” video we're going to take a closer look at electricity. Electricity is a natural force that we've harnessed for our energy needs. To understand electricity we need to know a little more about atoms the tiny particles that make up our universe. Three smaller particles make up atoms: neutrons, electrons and protons. Electrons have a negative charge, protons have a positive charge and neutrons are neutral. The center of the atom includes neutrons and protons. While the electrons orbit the center like the Earth orbits the Sun. Stable atoms have an equal number of protons and electrons and have no charge. If a material holds onto its electrons tightly it is known as an insulator. If its electrons are more loosely bound it's called a conductor. When a large number of free electrons pile up at one end of a conductor particles that have the same charge repel each other, while particles that have opposite charges attract. These negative electrons push each other apart jumping from atom to atom through the conductor creating electricity. There are two forms of electricity: current and static. Current electricity travels. It is composed of flowing electrons passing from one atom to another through a conductive material. It is this form of electricity that powers our homes. Static electricity is a charge at rest on an object. Sometimes your body picks up extra electrons through friction and becomes negatively charged when you touch a conductor like a metal doorknob you experience a small shock as the static charge jumps from your body to the doorknob. Electricity is a secondary energy source meaning we have to convert energy from another source into electric power. Sources of electricity include burning natural gas and coal, nuclear power and natural sources of power such as wind water and solar energy and that's the shocking truth about electricity.

Unit 3

There are three things to understand when we talk about electricity: charge, current and voltage. All objects and materials have charge which is created by the net of electrons or protons. If there are more electrons the substance will be negatively charged, and if there are more protons it will be positively charged. When a non-conductive substance such as plastic gets charged by having electrons transferred to it, it creates a static electric charge such as when you rub a balloon on your head or when you put your hand on a Van de Graaff. Charge is measured in coulombs and one coulomb is equal to the charge of approximately 6.241×10^{18} electrons. The movement of this charge is called a current. Then it's best to think of it as a river just as we measure the amounts of water passing through a point every second. Current is the amount of coulombs passing through a point every second. To measure it we can put an ammeter in place to tell us how many coulombs are passing that point in second. But because physicists and engineers use the measurement so much they decided to give it a name called an ampere or amp.

Voltage or potential difference is a bit trickier to understand. The way I like to visualize it is by thinking of a lake that is completely still and therefore has no current. If we were to turn the lake on inside, the water would rush from the high gravitational potential to the lower. It's the same concept for voltage only instead of gravitational potential difference we give it an electrical potential difference. We do this by using a battery, for example. The battery gives one side of the wire more electric potential energy than the other side so the current travels through the wire. The more potential difference we give it the faster the current flows. Just as a steeper waterfall causes water to fall quicker. But why do we call it potential? Because it has the potential to do work. The potential to do work is given in joules per coulomb and one of these is the same as one volt because people decided to give it a name. Let's think of a 1.5 volt battery connected to a light bulb. What does the 1.5 volt mean? Well, it means if one coulomb were to come out at the end of the battery it could transfer 1.5 joules of light and heat before entered the other side of the battery again.

Unit 4

Now when it comes to current there are two types you need to know about. Alternating current which we often write AC and direct current or DC. In an alternating current the direction of the current is constantly swapping back and forth so the charge flows in one direction then the other direction and back again. We get these rotating currents whenever we use an alternating potential difference or alternating voltage so the one that fluctuates between positive and negative. We can see this if we measure the potential difference or current over time. It constantly fluctuates between negative and positive and in the circuit level. This means that the direction in which the charge is flowing will constantly be swapping back and forth. Here in the UK all main supply electricity which is the electricity that comes from our plug sockets and powers our computers and kettles and so on is AC. And specifically UK main supply is 50 Hertz and around 240 volts which means that on our bottom graph the potential difference fluctuates from positive 240 volts to negative 240 volts and back again 50 times every second and so. The current will also fluctuate at that same rate. One thing we should mention is that you sometimes hear that the voltage is 230 volts rather than 240. Basically it can be either in the UK so they're both correct.

As far as your exams are concerned direct current on the other hand is produced by a direct potential difference which is either positive or negative the entire time so the charge is always flowing in the same direction. We find direct current and things like cells and batteries like those in your phone or a calculator the last thing means together is that in order to get these potential difference first time graphs we use devices called oscilloscopes which display the graphs on a monitor.

Unit 5

Semikron's power electronics components and systems allow customers to develop smaller, more energy efficient power electronic systems that make an important contribution to reducing global energy consumption and emissions. E- mobility is one of the fastest growing markets of the future. Semikron's power electronics are used in fast charging stations and in vehicles at the interface between the motor and the battery. Power electronics also help to control the output power of drives for long distance and urban electric trains and supply energy to auxilary units such as lighting, ventilation and air-conditioning systems. The largest application area for power electronics can be found in industrial and commercial applications such as motors and electric drives for robots, pumps, fans, cranes and machines. Power supplies are required for systems that need to be available at all times such as in data processing centers. Silicon carbide modules are increasingly used in medium and large systems. Renewable energy is our second most important market. For the solar market, in addition to standard modules we also offer customer specific solutions. Our customers in the wind market can depend on intelligent power modules in pre-tested units consisting of the power circuit, driver, heatsink and sensors.

Unit 6

Resistors are color-coded with markings or bands that allow you to quickly identify resistance values and tolerance. Using a color chart table will allow you to determine the value of any common four band resistor. Memorizing this color chart will enable you to become proficient at quickly decoding and using resistors. In a four band resistor the first two bands represent the digits or significant figures. The third band indicates the multiplier, and the fourth band indicates the tolerance. You read resistor bands beginning with the end that has the most bands. A space between the third and fourth bands also indicates the reading direction. The first band is red so the first digit value is two. The second band is violent so digit two is seven. The third band is yellow so we multiply the first two numbers by ten to the fourth or ten thousand, thus the value of this resistor is 270 kilo ohms with a tolerance of plus or minus five percent. In this example, the first band is orange so the first digit is 3. The second band is white so digit 2 is 9. The third band is silver so we multiply the first two numbers by 10 to the negative second power or point zero one. In this instance we would take the 39 and move the decimal point two places to the left resulting in a value of 0.39 ohms, thus the value of this resistor is point three nine ohms with a tolerance of plus or minus 10 %. Now let's determine what the bands would be on a 15 kilo ohm resistor. Since the first digit is 1, the first band would need to be brown. The second digit is 5 so the band color would need to be green. The resistor value is 15,000 ohms so we need to add three zeros two 15. Three zeros is a thousand so we need to have a multiplier of 10 to the third, thus the third band would need to be orange. The last band would need to be silver to indicate that the resistor has a tolerance of plus or minus 10 %.

Unit 7

A capacitor is similar to a battery in that both store electrical energy. The capacitor is a much simpler device that can't produce new electrons, it only stores them. However capacitors can do things, a battery can't, as we will show here. For the purposes of this animation we'll focus on different parts of the current propagating through the wires at different times. When we close the switch electricity immediately runs throughout the circuits. Although the convention is to think of electrical current is moving from positive to negative, electrons actually move from negative to positive, as we represent here with yellow particles. As you can see, the battery is not much good at powering this motor to lift this weight, because it discharges gradually much more slowly than with a capacitor with the same charge. Here we'll learn why capacitor is much better suited to such a task than the battery. Like a battery the capacitor has two terminals positive and negative. Inside the capacitor the terminals connect the two metal plates separated by an insulator that keeps the plates from touching each other and allows them to hold opposite charges maintaining an electric field. Capacitors can be useful for storing and quickly discharging electricity so you can power, for example, an electric motor as we'll show here. First we need to charge the capacitor by closing the switch. We create a circuit that includes both the capacitor and the battery. Electrons flow from the battery to the capacitor where they are stored. Here a yellow glow represents the increasing charge held by the plate. For every electron gained by that negative plate an electron is lost by the positive plate maintaining the capacitor in equilibrium. Here the red glow represents the positive charge held by the plate that increases with each parting electron. The capacitor continues to charge until it attains the voltage of the battery charging it. Now that the capacitor is fully charged let's put all that stored energy to use by connecting it to a new circuit we can power small motor. This electrical current powers the pulley to lift the weight until the charge dissipates. The electrons on the capacitors negative terminal are drawn to its positive terminal. They rush along the path that leads there straight through the motor. Let's watch this again. Even though the battery and the capacitor attempted this task with the same amount of charge, only the capacitor successfully powers the motor lifting the weight, because it discharges much more quickly. This feature makes capacitor useful for powering things that need a quick surge of energy such as flash bulbs, and cameras, and starter motors, and audio amplifiers in your car.

Unit 8

The purpose of an inductor is to oppose any change in the magnitude of current within a circuit. The electrical property that resists either an increase or decrease in current is known as inductance. An inductor is created when an electrical current flows in a wire wrapped around a magnetic core. You may recognize this as an electromagnet represented by flux lines that develop around the core with the formation of a north and south pole at their respective ends. To demonstrate the properties of an inductor we'll add a resistance or light bulb to this circuit. As the switch is closed and the current flows through the circuit, the electromagnetic field in the inductor forms and expands rapidly. However because of the unique properties of an inductor as the flux lines of the electromagnetic field expand, the changing current generates a voltage that resists the current coming from the source. The maximum opposition to current flow occurs at the instant the switch is closed, therefore the bulb will not turn on instantaneously. However once the electromagnetic field stops expanding based on the level of changing current, the flux will no longer generate an opposing voltage in the circuit. The current will continue to flow and reach its maximum value after five time constants or five T where T is equal to L divided by R. The light bulb will then be at its maximum brightness. If you open the switch and stop the flow of current from the source, the electromagnetic field will diminish rapidly and simultaneously release stored energy in the form of voltage. It will actually generate enough voltage to cause a spark across the switch as it opens. Whereas a capacitor uses voltage to store energy the inductor uses current. Inductance of an inductor is defined as the amount of voltage induced divided by the change in current per second. Therefore if one V is induced by a change of one A in one second there is one Henry one H of inductance.

Unit 9

This is a crystal of sugar. If you press on it, it will actually generate its own electricity. How can this simple crystal act like a tiny power source? Because sugar is piezoelectric. Piezoelectric materials turn mechanical stress, like pressure, sound waves, and other vibrations into electricity and vice versa. This odd phenomenon was first discovered by the physicist Pierre Curie and his brother Jacques in 1880. They discovered that if they compressed thin slices of certain crystals, positive and negative charges would appear on opposite faces. This difference in charge, or voltage, meant that the compressed crystal could drive current through a circuit, like a battery. And it worked the other way around, too. Running electricity through these crystals made them change shape. Both of these results, turning mechanical energy into electrical, and electrical energy into mechanical, were remarkable. But the discovery went uncelebrated for several decades.

The first practical application was in sonar instruments used to detect German submarines during World War I. Piezoelectric quartz crystals in the sonar's transmitter vibrated when they were subjected to alternating voltage. That sent ultrasound waves through the water. Measuring how long it took these waves to bounce back from an object revealed how far away it was.

For the opposite transformation, converting mechanical energy to electrical, consider the lights that turn on when you clap. Clapping your hands sends sound vibrations through the air and causes the piezo element to bend back and forth. This creates a voltage that can drive enough current to light up the LEDs, though it's conventional sources of electricity that keep them on.

So what makes a material piezoelectric? The answer depends on two factors: the materials atomic structure, and how electric charge is distributed within it. Many materials are crystalline, meaning they're made of atoms or ions arranged in an orderly three-dimensional pattern. That pattern has a building block called a unit cell that repeats over and over. In most non-piezoelectric crystalline materials, the atoms in their unit cells are distributed symmetrically around a central point. But some crystalline materials don't possess a center of symmetry making them candidates for piezoelectricity. Let's look at quartz, a piezoelectric material made of silicon and oxygen. The oxygens have a slight negative charge and silicons have a slight positive, creating a separation of charge, or a dipole along each bond. Normally, these dipoles cancel each other out, so there's no net separation of charge in the unit cell. But if a quartz crystal is squeezed along a certain direction, the atoms shift.

Because of the resulting asymmetry in charge distribution, the dipoles no longer cancel each other out. The stretched cell ends up with a net negative charge on one side and a net positive on the other. This charge imbalance is repeated all the way through the material, and opposite charges collect on opposite faces of the crystal. This results in a voltage that can drive electricity through a circuit. Piezoelectric materials can have different structures. But what they all have in common is unit cells which lack a center of symmetry. And the stronger the compression on piezoelectric materials, the larger the voltage generated. Stretch the crystal, instead, and the voltage will switch, making current flow the other way. More materials are piezoelectric than you might think. DNA, bone, and silk all have this ability to turn mechanical energy into electrical. Scientists have created a variety of synthetic piezoelectric materials and found applications for them in everything from medical imaging to ink jet printers. Piezoelectricity is responsible for the rhythmic oscillations of the quartz crystals that keep watches running on time, the speakers of musical birthday cards, and the spark that ignites the gas in some barbecue grill lighters when you flick the switch. And piezoelectric devices may become even more common since electricity is in high demand and mechanical energy is abundant. There are already train stations that use passengers' footsteps to power the ticket gates and displays and a dance club where piezoelectricity helps power the lights. Could basketball players running back and forth power the scoreboard? Or might walking down the street charge your electronic devices? What's next for piezoelectricity?

Unit 10

Let's talk about transformers. Not the machines that transform from cars to combat robots you see in the movies, but the kind you see at the top of utility poles or on the ground in your neighborhood. Transformers are used to step electric voltage up or down before it makes its way to its final destination. Why does this need to happen? Original power distribution voltage can range from 7200 to 24900 volts depending on your electric utility providers practice, and the distance to the furthest member, and the amount of load served. That's much too high a voltage for safe home or business use. Transmission lines connect the power to substations brimming with transformers and control equipment. This is the first place where they transform the voltage to saver more manageable levels or the distribution system. The voltage then travels through distribution lines takes one or two more steps down and arrives at your home. Power beats into your home's electrical outputs and lights at 120 volts while water heaters ranges and HVAC systems receive 240 volts. Both considerably lower than the original voltage. Here's a quick look at how transformers actually work for a typical American home. Transformers start with an iron core. On two sides of this iron core wire is coiled. On the high voltage side the coil is wrapped around the core many times. This side receives or produces high voltage. On the other side the coil is wrapped around fewer times receiving or producing lower voltage. As the electricity flows through the high voltage coil it creates a magnetic field and induces a lower voltage in the other coil. That's how the magic of transformation takes place. Transformers are everywhere in our daily lives not just on your utility providers lines. Take your cell phone charger for example. Many of these small cousins of utility transformers perform a similar function. Charging your cell phone with 120 volts will fry it instantly so the charger converts the voltage to a more tolerable 5 volts or so. The use of electricity touches nearly every aspect of our modern lives and we have transformers to thank for bringing it safely into our homes.

Unit 11

In this video, we are going to discuss about band gap and semiconductor current carriers, which will help us understand how current is produced in a semiconductor. If we recall some basic topics in chemistry, we'll remember that all atoms consist of neutrons, protons, and electrons, except for a normal hydrogen atom which doesn't have a neutron. Using the Bohr model, we can visualize that an atom has a central nucleus consisting of protons and neutrons that is surrounded by orbiting electrons. The orbits surrounding the nucleus are grouped into energy levels known as shells and the outermost shell is called the valence shell. The valence shell of an atom represents a band of energy levels, which is why it's also called a "valence band" and valence electrons are confined to that band. When a valence electron gains enough energy from an external source, it can escape from the valence band and goes to the conduction band. The difference in energy between the valence band and the conduction band is called "band gap". It is the amount of energy a valence electron must possess so that it can jump from the valence band to the conduction band, wherein the electron is free to move throughout the material. If the band gap is really big, electrons will have a hard time jumping to the conduction band, which is the reason of material's poor conductivity.

Let's try to examine the energy diagram of the three types of materials used in electronics and discuss the conductivity of each material based on their band gap. As we can see, the band gap between the valence band and conduction band in an insulator is really big. That is why it doesn't conduct current. The band gap in a semiconductor is smaller compared to an insulator and allows valence electrons in the valence band to jump into the conduction band if it receives external energy. In a conductor, like copper, there's no band gap. Actually, the conduction band and valence band overlaps, which means that electrons can freely move into the conduction band. This is why you may hear the electrons in metal referred to as a "sea of electrons" – they're just floating around.

Now that we know more about band gap, let's discuss the two types of current carriers in a semiconductor, free electrons and holes, and see how they produce current in a semiconductor. Atoms may combine to form a solid crystalline material through covalent bonding. For example, a silicon atom covalently bonds with four adjacent silicon atoms to form an intrinsic silicon crystal. Intrinsic because it doesn't contain impurities and a crystal because there is a pattern in how the atoms are connected. At room temperature, intrinsic silicon crystal gains enough heat energy that enables some of the valence electrons to jump into the conduction band, becoming free electrons. When this happens, vacancies are left in the valence band within the crystal. These vacancies are known as holes. Now, if we put a voltage source across an intrinsic silicon material, the thermally-generated free electrons in the conduction band will be attracted to the positive end of the voltage source. They will move toward the positive end and this movement produces current in the material. This type of current is called electron current.

While electron current happens in the conduction band, the other type of current, hole current, happens in the valence band. Remember that as valence electrons jumped into the conduction band, vacancies or holes are left in the valence band. Electrons that remain in the valence band can move into a nearby hole when it receives a small amount of energy. This movement produces a current in the valence band called hole current. Though the current is produced by valence electrons moving into a nearby hole, it is called hole current so that it won't be confused with the electron current produced in the conduction band. In this video, we learned about band gap and the current carriers in a semiconductor. We examined the energy diagram of the three types of materials used in electronics, insulators, semiconductors, and conductors and briefly discussed their conductivities. We also talked about the two types of semiconductor current carriers, free electrons and holes, and mentioned how they produce current in a semiconductor material.

Unit 12

In this modern world, the electronic devices around us like television, laptops and many others consist of semiconducting devices like transistors, diodes and so on. These devices use two types of semiconductors, intrinsic and extrinsic semiconductors. Nowadays, electronic devices mainly use extrinsic semiconductors over intrinsic semiconductors. But, why? Regarding intrinsic semiconductor, it is nothing but, a silicon structure by which the valence electrons absorb some amount of thermal energy and gets excited from the valence band to the conduction band, which results in a vacancy in the valence band called a hole. This movement results in the formation of electron-hole pairs. Now, if the potential difference (power supply) is applied across the semiconductor, the current will flow through the external circuit. This semiconductor where the conduction of electric current (electrical conductivity) is due to movement of electrons and holes (electron-hole pair) known as intrinsic semiconductor, which is a pure form of semiconductor. The conductivity of intrinsic semiconductor is very less at room temperature, and it is very poor. But, electrical conductivity relies on impurity atoms (external impurities) in them. So, to increase the conductivity, some amount of impurity is added to the intrinsic semiconductor known as extrinsic semiconductor. This addition of external impurities (impurity atoms) to increase the conductivity, is termed as doping. These extrinsic semiconductors are classified, depending upon the type of impurity added such as N-type semiconductor or P-type semiconductor. But, the N-type semiconductor has better conductivity than the P-type. Let's see why it has such better conductivity? We know that pure silicon is a semiconductor. The atom of silicon has four electrons in its outermost shell which form bonds with its neighbouring atoms. For the N-type Semiconductor, the pentavalent impurity phosphorus-containing five valence electrons is doped into a silicon structure. In the five valence electrons, it has one extra electron where the other four occupied its positions in the shell. This doping increases the number of free electron carriers in the N-type semiconductor. Similarly, for a P-type semiconductor, a trivalent impurity Boron is doped into the silicon structure which has three electrons. By this process, it creates an extra hole, and the holes are the majority carriers in the P-type. Meanwhile, in the N-type semiconductors, as electrons are the majority carriers, the conduction of electric current is more in the N-type compared to the P-type semiconductors.

Unit 13

Diodes have numerous applications across the electronic industry, and they are an integral part of any electronic device. In this video, we will explore the inner workings and applications of the diode in great detail. Basically, a diode is a one-way valve for electricity. Let's take a look at the internal structure of a diode. The diode is made of a semiconductor such as silicon. Pure silicon does not have any free electrons, but the silicon used here is not pure: one part is doped with n-type impurity and the other part is doped with p-type impurity. So at the n-side of the diode we will have free electrons, and at the p-side, we will have vacant positions for electrons. Something very interesting happens at the p-n junction of the diode. The abundant electrons on the n-side have a natural tendency to migrate to the holes that are available on the p-side, so the p-side boundary is slightly negatively charged, and the n-side boundary is slightly positively charged. You can see the depletion region that is created. The resulting electric field will oppose any further natural migration of electrons. In short, it builds a potential barrier for electron flow. If you apply an external power source across the diode as shown, the power source will attract the electrons and holes. Electricity flow is impossible in this case. This condition is known as reverse bias of the diode. You can see that the width of the depletion region increases here. However, if you connect positive terminal of the power source to the p-side of the diode, the situation is quite different. Assume that the power source has enough voltage to overcome the barrier potential. You can immediately see that the electrons will be pushed away by the negative terminal. When the electrons cross the potential barrier, they will be drained of energy, and will easily occupy the holes in the p-region. But due to the attraction of the positive terminal, these electrons can now jump to the holes nearby in the p-region and flow through the external circuit. This is known as the forward biasing of a diode. Simply put, a diode acts like a one-way valve for the flow of electricity. Now, let's vary the input voltage and study the diode's response to it. In reverse voltage, as explained, you can observe a negligible electricity flow. In the forward condition, up to 0.7 volt, you will find a negligible electricity flow. But right after crossing this barrier potential value, there will be a steep increase in the current flow. However, you can note that voltage across the diode does not go much higher than 0.7 volts, even with high input voltage. This is due to forward-biased condition. The diode offers very low resistance against the current flow. At the reverse biased side, applying a very high voltage will damage normal diodes and result in a high current flow. The one-way electricity flow that is characteristic of the diode leads to interesting applications like a bridge rectifier. During the positive half, the circuit will conduct as shown. The other two diodes will be in a reverse biased state. During the negative half, the reverse will be the case. So we will get the same current flow direction at the output. We can further smooth this output by introducing a capacitive filter and regulator.

Unit 14

In a previous tutorial we learned about the special characteristics of a PN-junction. If we add one more section of a semiconductor material to a PN-junction we have a bipolar junction transistor or BJT. We can add a section of n-type semiconductor to create an NPN transistor or we can add a section of p-type semiconductor to form a PNP transistor. A three layer combination of n-type and p-type semiconductor results in a three terminal device that allows a small current flowing through the base terminal to regulate a larger current flowing between the emitter and collector terminals. In an NPN transistor the controlling current flows from the base to the emitter and the regulated current flows from the collector to the emitter. In a PNP transistor the controlling current flows from the emitter to the base and the regulated current flows from the emitter to the collector. As the name implies a field effect transistor or FET uses an electric field to regulate current so a FET allows a small voltage to regulate a large current, well a BJT allows a small current to regulate a large current. A field effect transistor consists of two doped semiconductor regions that are separated by a channel. And a voltage is applied to the device in such a way as to alter the current carrying properties of the channel. The terminals separated by the channel are called the source and the drain. And the gate is the terminal to which the controlling voltage is applied. Though this diagram helps to introduce general FET operation. It is actually depicting a relatively uncommon device called a junction field effect transistor or JFET. But the majority of FETs are metal oxide semiconductor field effect transistors or MOSFETs. A MOSFET has an insulating layer that separates the gate from the channel and the current flowing through the channel can be regulated simply by applying a voltage. This diagram conveys the physical structure and basic operation of an N channel MOSFET also called an NMOS transistor. The majority carriers in an NMOS transistor are electrons. While a P channel MOSFET or PMOS transistor has holes as majority carriers. Too heavily doped n-type regions are separated by a p-type channel. Let's assume that the source and the substrate are connected to ground. If the gate is also grounded current cannot flow through the channel because a voltage applied to the drain results in a reverse biased PN Junction. However a positive voltage applied to the gate repels holes in the channel thus creating a depletion region and attracts electrons from the source and drain sections. If the voltage is sufficiently high the channel will have enough mobile electrons to allow current to flow from drain to source when a voltage is applied to the drain.

Unit 15

I am Katie with your Galco TV tech tip. A thyristor is a four layer semiconductor rectifier in which the flow of current between two electrodes is triggered by a signal at a third electrode. A thyristor usually has three electrodes an anode, a cathode and a gate. Thyristors are primarily designed to amplify and rectify the electrical currents that flow in high-powered electronic devices. A thyristor’s four layers consist of a series of N and P-type material that connect with the anode, cathode and a logic gate. When a current is applied at the gate, the thyristor allows an amplified current to flow from anode to cathode. Although thyristors can only transmit currents in one direction, they have three different operating modes: reverse blocking, forward blocking and forward conducting. In reverse blocking mode voltage is applied in the direction that would be blocked by a diode. In forward blocking mode voltage is applied in the direction that would cause a diode to conduct, but the thyristor has not been triggered into conduction. And in forward conducting mode the thyristor has been triggered into conduction and will remain conducting until the forward current drops below a threshold value known as holding current. The most common type of a thyristor is the silicon controlled rectifier or SCR. When the cathode is negatively charged relative to the anode no current flows until a pulse is applied to the gate. The SCR begins to conduct and continues to conduct until the voltage between the cathode and the anode is reversed or reduced below a certain threshold value. Using this type of circuit large amount of power can be switched or controlled using a small triggering current or voltage. Thyristors are used in motor speed controls, light dimmers, pressure control systems and liquid level regulators.

ANSWER KEY

UNIT 1

1.

1. Electronics is the branch of science that deals with the study of flow and control of electrons (electricity) and the study of their behavior and effects in vacuums, gases, and semiconductors, and with devices using such electrons.

2.

6. T
7. T
8. F
9. F
10. T

3.

1	2	3	4	5	6	7	8	9	10	11	12	13
J	I	K	A	G	L	E	M	B	D	C	F	H

4.

10. regulates, monitors, maps, plays, keeps, links
11. grind to a halt
12. rely on
13. designed, fabricated
14. reasons
15. glimpse, shrink, unimaginable
16. wirelessly
17. exciting, unique
18. telecommunications

UNIT 2

1.

1. Electricity is a fundamental form of energy observable in positive and negative forms that occurs naturally (as in lightning) or is produced (as in a generator) and that is expressed in terms of the movement and interaction of electrons.
2. Some interesting facts about electricity:
   1. Electricity travels at the speed of light which is 186,000 miles per second.
   2. A spark of static electricity can measure up to 3,000 volts.

3. One bolt of lightning can contain up to 3 million volts – that's enough to power 200000 homes.
4. Before electricity was a way of life, ancient Egyptians were aware that lightning and electric shocks from fish were very powerful. They used to refer to these fish as the "Thunderers of the Nile".
5. Electric eels can produce strong electric shocks of around 500 volts for both self-defense and hunting.
6. Coal is the world's biggest source of energy for producing electricity.
7. In the 1880s there was a "war of currents" between Nicola Tesla and Thomas Edison. Tesla invented AC current and Edison helped invent DC current, and both wanted their currents to be popularized. AC won the battle because it's safer and can be used across long distances.
8. Birds won't get electrocuted if they sit on one power line.
9. The world's biggest light bulb is located in Edison, New Jersey. It is 14 feet tall, weighs 8 tons, and sits on top of Thomas Edison Memorial Tower.
10. Benjamin Franklin didn't discover electricity, but he proved that lightning is a form of electricity.
11. Electricity is present in our bodies – our nerve cells use it to pass signals to our muscles.
12. Fossil fuels are the largest source of electricity, but wind, water and the sun can also produce it.

2.

1. Atoms are tiny particles of matter that stand behind the phenomenon of electricity.
2. Electrons are negatively charged particles of an atom.
3. There are two kinds of electricity: static and current.
4. The examples of static electricity are making your hair stand up when rubbing a balloon against it, getting a shock from a doorknob, and lightning.
5. Current electricity has to flow in a closed loop called a circuit.

3.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
G	D	E	F	C	B	A	J	M	H	I	N	K	L

4.

1. T
2. F

3. T
4. T
5. F
6. T
7. F
8. T

UNIT 3

1.

1. Electric current is a flow of negatively charged particles called electrons.
2. Voltage is the pressure from an electrical circuit's power source that pushes charged electrons (current) through a conducting loop, enabling them to do work such as illuminating a light.

2.

Electric current is the flow of negatively charged electrons through a conductor when a force is applied. The force that pushes electrons along is called an electromotive force, but it is more commonly known as voltage.

3.

1	2	3	4	5	6	7	8	9	10	11	12	13
F	J	E	K	C	A	I	L	G	B	M	H	D

4.

10. There are three things to understand when we talk about electricity: charge, current and voltage.
11. All objects and materials have charge which is created by the net of electrons or protons.
12. If there are more electrons the substance will be negatively charged and if there are more protons it will be positively charged.
13. Charge is measured in coulombs.
14. The movement of this charge is called a current.
15. Current is the amount of coulombs passing through a point every second.
16. Voltage or potential difference is a bit trickier to understand.
17. The battery gives one side of the wire more electric potential energy than the other side so the current travels through the wire.
18. The more potential difference we give it the faster the current flows.
19. The potential to do work is given in joules per coulomb and one of these is the same as one volt because people decided to give it a name.

UNIT 4

1.

1. Direct current is a flow of electrons in one direction only.
2. Alternating Current (AC) is a type of electrical current, in which the direction of the flow of electrons switches back and forth at regular intervals or cycles.

2.

1	2	3	4	5	6	7	8
D	F	G	A	H	B	C	E

3.

1. c
2. h
3. e
4. b
5. g
6. d
7. a
8. f

4.

1. Now when it comes to current there are two types you need to know about.
2. Alternating current which we often write ac and direct current or dc.
3. In an alternating current the direction of the current is constantly swapping back and forth.
4. We get these rotating currents whenever we use an alternating potential difference or alternating voltage so the one that fluctuates between positive and negative.
5. We can see this if we measure the potential difference or current over time.
6. It constantly fluctuates between negative and positive and in the circuit level.
7. This means that the direction in which the charge is flowing will constantly be swapping back and forth.
8. The current will also fluctuate at that same rate.

6.

	Alternating Current	Direct Current
Direction	It reverses its direction while flowing in a circuit	It flows in one direction in the circuit
Magnitude	It is the current of magnitude varying with time	It is the current of constant magnitude

Flow of electrons	Electrons keep switching directions – forward and backward	Electrons move steadily in one direction or 'forward'
Generated from	A.C Generator and mains	Cell or Battery
Passive parameters	Impedance	Resistance only
Power factor	Lies between 0 & 1.	it is always 1
Types	Sinusoidal, Trapezoidal, Triangular, Square	Pure and pulsating

UNIT 5

1.

1. An electron is a subatomic particle having a negative charge and orbiting the nucleus.

2.

A. 3
B. 6
C. 5
D. 1
E. 4
F. 2

3.

1	2	3	4	5	6	7	8	9	10	11
D	J	G	A	I	K	C	B	E	H	F

	Verb	Noun	Adjective
1	combine	**combination**	combinatory, combinational, combined, combining
2	assemble	assembly, assembler, assembling	**assembled**
3	recognize	recognition	**recognizable**
4	**convert**	conversion	convertible, converting, converted
5	destinate	**destination**	destinated
6	**emit**	emission	emitting, emitted, emissive
7	compute	**computation**	computed, computing, computable, computational
8	**transmit**	transmission	transmitted, transmitting

1. sampling
2. infrared light
3. humidity

4. trigger
5. pattern
6. worker bee
7. crunch
8. vendor

4.

1. allow
2. is
3. are used
4. supply
5. be found
6. are required
7. are used
8. is
9. offer
10. depend

UNIT 6

1.

1. A resistor is an electronic component that controls the level of current flowing in an electrical circuit by providing resistance.
2. If you break a resistor open, and scratch off the outer coating of insulating paint, you might see an insulating ceramic rod running through the middle with copper wire wrapped around the outside. A resistor like this is described as wire-wound. The number of copper turns controls the resistance very precisely: the more copper turns, and the thinner the copper, the higher the resistance. In smaller-value resistors, designed for lower-power circuits, the copper winding is replaced by a spiral pattern of carbon. Resistors like this are much cheaper to make and are called carbon-film. Generally, wire-wound resistors are more precise and more stable at higher operating temperatures.

2.

1. measure
2. passive
3. versatile
4. limit
5. flavors

6. fixed
7. variable

3.

1. restrict
2. versatile
3. brake
4. potentiometer
5. flavor
6. bump
7. adjust
8. variable
9. filament
10. friction/furiously
11. boost
12. fixed
13. incandescent
14. toss
15. lowdown

4.

1. T
2. T
3. F
4. T
5. F
6. F
7. T

UNIT 7

1.

1. A capacitor is an electric circuit element used to store charge temporarily, consisting in general of two metallic plates separated and insulated from each other by a dielectric.
2. In circuits capacitors are used for storing electrical energy, preventing DC current from passing between circuit stages, smoothing out voltage, creating timers, tuning in (or out) frequencies.

2.

1. exploit
2. dielectric

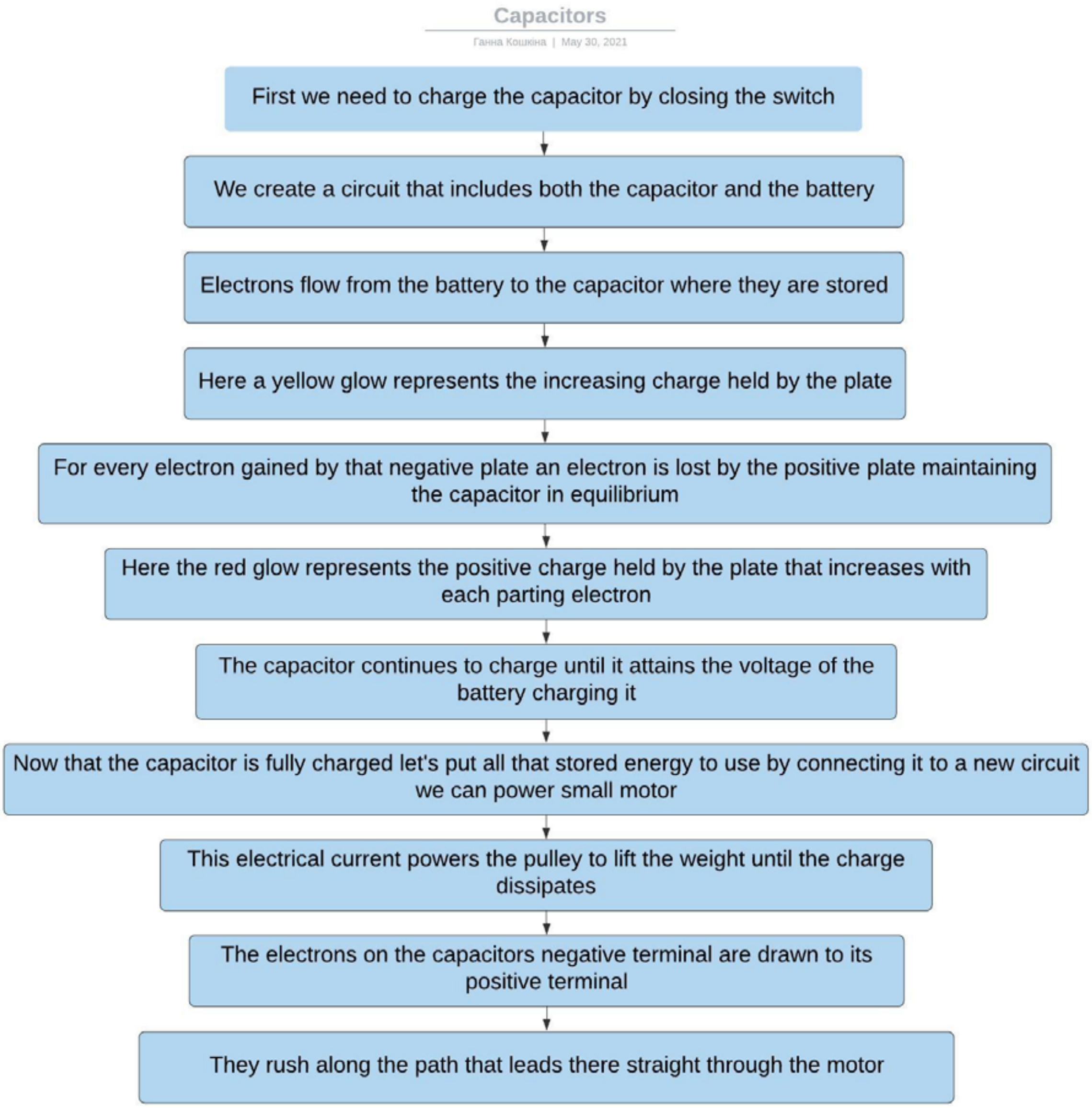
3. transfer
4. release
5. capacitor
6. reject
7. capacitance
8. capacitive coupling (AC coupling)
9. thickness
10. amplifier
11. smooth
12. surface
13. take up the slack
14. Uninterruptible Power Supply (UPS)

3.

1. capacitance
2. capacitor
3. surface
4. thickness
5. transfer
6. release
7. dielectric
8. exploit
9. amplifier
10. smooth
11. slack
12. reject

4.

1. a
2. c
3. b
4. b
5. a
6. a
7. c



UNIT 8

1.

1. An inductor, also called a coil, choke, or reactor, is a passive two-terminal electrical component that stores energy in a magnetic field when electric current flows through it.
2. An inductor uses a conductor that is wound into a coil, and when electricity flows into the coil from the left to the right, this will generate a magnetic field in the clockwise direction.

2.

1. coil
2. wrapped
3. core

4. ferrite
5. brittle
6. induced
7. choke
8. flux
9. inductance
10. expand
11. tuned circuit
12. frequency
13. receiver
14. swing
15. ripple

3.

y	m	i	r	e	c	e	i	v	e	r	d
t	u	n	e	d	c	i	r	c	u	i	t
k	v	d	v	n	n	b	m	m	v	e	h
d	b	u	f	p	g	i	y	p	k	f	j
y	p	c	r	b	r	i	t	t	l	e	k
n	c	t	e	v	n	n	d	u	f	r	c
u	h	a	q	d	e	d	x	g	t	r	r
p	o	n	u	g	k	j	n	c	o	i	l
j	k	c	e	t	w	i	o	a	p	t	v
b	e	e	n	r	w	r	a	p	p	e	d
d	y	p	c	s	e	s	l	m	v	x	s
l	l	v	y	i	v	e	c	l	p	e	e

1. coil – a length of rope or wire curled to form a series of circles, one above the other
2. wrapped – covered, enveloped, or encased
3. core – central part

4. ferrite – any of a group of ferromagnetic highly resistive ceramic compounds
5. brittle – delicate and easily broken
6. induced – resulting from a nearby electromagnetic field
7. choke – a coil of low resistance and high inductance used in electrical circuits to pass direct current and attenuate alternating current
8. flux – flow or flowing
9. inductance – the property of an electric circuit by which an electromotive force is induced in it as the result of a changing magnetic flux
10. expand – to increase something in size, number, or importance
11. tuned circuit – a circuit whose components can be adjusted to make the circuit responsive to a particular frequency in a tuning range
12. frequency – the number of oscillations per unit time of a vibrating system
13. receiver – a piece of equipment that changes radio and television signals into sounds and pictures
14. swing – small wave or a fluctuation
15. ripple – slight movement of a surface

4.

1	2	3	4	5	6	7	8
F	H	A	C	B	G	D	E

UNIT 9

1.

1. A crystal is a frequency-determining component, a wafer of quartz crystal or ceramic with electrodes connected to it. A more accurate term for it is piezoelectric resonator.
2. The operation of quartz crystal resonators or xtals depends upon the piezo-electric effect and the sharp mechanical resonances of the material. The electrical signals are converted from their electrical form into mechanical vibrations. It is these vibrations that are affected by the mechanical resonances of the quartz crystal and then linked back into electrical system.

2.

If you slice a quartz crystal in just the right way, **mount** two **leads** to it, and **enclose** it in a **hermetically sealed** package, you've created a single component that acts like an **RLC combo** in an RLC circuit, resonating at a particular frequency. Quartz crystals, or simply crystals, are used in circuits to generate an electrical signal at a very **precise** frequency. Figure 9.2 shows the circuit symbol for a crystal, which is labeled XTAL in schematics.

Crystals work because of something called the **piezoelectric effect**: If you apply a voltage in just the right way across a quartz crystal, it vibrates at a specific frequency, known as the resonant frequency. If you then remove the applied voltage, the crystal continues to vibrate until it **settles back** to its previous shape. As it vibrates, it generates a voltage at the resonant frequency.

You may be familiar with piezoelectric guitar **pickups**, which use crystals to convert the mechanical vibrations generated by guitar strings into electrical signals, which are then **amplified**. And if you **predate** compact disc (CD) technology, you may be interested to know that phonograph **needles relied on** the piezoelectric effect to convert the ups and downs of a vinyl record track into electrical energy.

The frequency at which a crystal resonates depends on its thickness and size, and you can find crystals with resonant frequencies ranging from a few tens of kilohertz to tens of megahertz. Crystals are more precise and more **reliable** than combinations of capacitors and inductors, but there's a **catch**: They're usually more expensive. You will find crystals used in circuits called oscillators to generate electric signals at a very precise frequency. Oscillators are responsible for the ticks and tocks that control quartz wristwatches and digital integrated circuits, and for controlling the accuracy of radio equipment.

3.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
H	I	L	P	F	K	H	M	B	E	A	O	J	C	N	D

4.

1. T
2. F
3. F
4. T
5. T
6. F
7. T
8. F
9. T
10. T

UNIT 10

1.

1. A transformer is an electronic device that consists of two coils wound around the same core material in such a way that the mutual inductance is maximized.
2. A transformer is based on a very simple fact about electricity: when a fluctuating electric current flows through a wire, it generates a magnetic field or "magnetic flux" all around it. The strength of the magnetism is directly related to the size of the electric current. So the bigger the current, the stronger the magnetic field. Now there's another interesting fact about electricity too. When a magnetic field fluctuates around a piece of wire, it generates an electric current in the wire. So if we put a second coil of wire next to the first one, and send a fluctuating electric current into the first coil, we will create an electric current in the second wire.

2.

1. Inductors used in tuning circuits are shielded so that the magnetic field they produce doesn't interact with other circuit components.
2. Mutual inductance is the term used to describe the effect of inducing a voltage in another coil, while self-inductance refers to the effect of inducing a voltage in the same coil that produced the varying magnetic field in the first place.
3. By passing a current through one coil, you will cause a voltage to be induced in the neighboring coil – even though it is in a separate, unconnected circuit. This is known as transformer action.
4. The windings in the transformer are called primary and secondary.
5. So a step-up transformer steps up the voltage while stepping down the current; a step-down transformer steps down the voltage while stepping up the current.

3.

1. shielded
2. mutual inductance
3. primary and secondary windings
4. applied to
5. unshielded
6. transferred
7. step-up transformer
8. step-down transformer

9. electric power transmission systems
10. distribution

4.

1. T
2. F
3. T
4. T
5. F
6. F

UNIT 11

1.

1. Conductors display high conductivity, which means they allow energy, such as electricity, heat or sound, to easily flow through them. Whereas insulators exhibit low conductivity and semiconductors allow a moderate flow.
2. Elements like silicon (Si), germanium (Ge), selenium (Se); compounds like gallium arsenide (GaAs) and indium antimonide (InSb) are all examples of semiconductor elements.

2.

1. The main idea of the text is explaining the difference between conductors, insulators and semiconductors.
2. Key words: conductors, insulators, semiconductors, conductivity, band theory, valence band, conduction band, energy gap

3.

1. energy gap
2. overlap
3. mica
4. permit
5. band theory
6. valence band
7. encounter
8. conductivity
9. etch
10. conduction band

4.

12. Atomic structure – the concept of an atom as a central positively charged nucleus consisting of protons and neutrons surrounded by a number of electrons.

13. Valence shell (band) – the outermost electron shell of atoms in an insulator or semiconductor in which the electrons are too tightly bound to the atom to carry electric current.
14. Conduction band – the set of electron orbitals, generally the outermost shells of the atoms in a conductor or semiconductor, in which electrons are free to move and thereby carry an electric current.
15. Band (energy) gap – an energy range in a solid where no electronic states can exist.
16. Conductor – an object, substance or material allowing the flow of an electric charge.
17. Insulator – a substance that resists electricity.
18. Semiconductor – a material which has an electrical conductivity value falling between that of a conductor, such as metallic copper, and an insulator, such as glass.
19. Current (charge) carrier – an electron, hole, or ion that transports the electric charge in an electric current.
20. Free electron – any electron that is not attached to an ion, atom, or molecule and is free to move under the influence of an applied electric or magnetic field.
21. Hole – a vacant position in an atom left by the absence of a valence electron, especially a position in a semiconductor that acts as a carrier of positive electric charge.
22. Covalent bond – a chemical bond formed by the sharing of one or more electrons, especially pairs of electrons, between atoms.

UNIT 12

1.

1. A semiconductor is a material that conducts current, but only partly. The conductivity of a semiconductor is somewhere between that of an insulator, which has almost no conductivity, and a conductor, which has almost full conductivity.
2. Semiconductors are an essential component of electronic devices, enabling advances in communications, computing, healthcare, military systems, transportation, clean energy, and countless other applications. Due to their role in the fabrication of electronic devices, semiconductors are an important part of our lives. Imagine life without electronic

devices. There would be no smartphones, radios, TVs, computers, video games, or advanced medical diagnostic equipment.

2.

1. T
2. F
3. T
4. F
5. T
6. T
7. F
8. T

3.

1. implies
2. silicon
3. valence band (shell)
4. covalent bond
5. bind
6. doping
7. dopant
8. N-type semiconductor or P-type semiconductor

4.

1	2	3	4	5	6
D	F	B	A	C	E

6.

Basis of difference	**Intrinsic semiconductor**	**Extrinsic semiconductor**
Doping of impurity	Doping or addition of impurity does not take place in intrinsic semiconductor	A small amount of impurity is dopped in a pure semiconductor for preparing extrinsic semiconductor
Density of electrons and holes	The number of free electrons in the conduction band is equal to the number of holes in the valence band	The number of electrons and holes are not equal
Electrical conductivity	Electrical conductivity is low	Electrical conductivity is high
Dependency of electrical conductivity	Electrical conductivity is a function of temperature alone	Electrical conductivity depends on temperature as well as on the amount of impurity doping in the pure semiconductor

Example	Crystalline form of pure Silicon and Germanium	Impurity like As, Sb, P, In, Bi, Al etc. are dopped with Germanium and Silicon atom

UNIT 13

1.

1. A diode is an electrical device through which flow of current is generally restricted to one direction.
2. Today's diodes are made from semiconductor materials such as silicon, germanium, or gallium arsenide. Semiconductor manufacturers introduce specific impurities into these materials to give a diode its particular properties.

This "doping" process creates three regions in the diode. First, there's a positively-charged p-region at the anode where doping creates a large number of electron holes. Then, there's a negatively-charged n-region at the cathode, where doping creates a large number of free electrons. The two meet at the p-n junction where n-region electrons jump over to fill the p-region's electron holes – this creates a third "depletion region" which acts as an insulator and resists current flow.

2.

1. A PN-junction is formed when an N-type material is fused together with a P-type material creating a semiconductor diode.
2. Diodes are often used in or as rectifiers.
3. The anode is a positively charged electrode.
4. The cathode is a negatively charged electrode.
5. The concept of current as the transfer of positive charge, so that its direction of flow is opposite to that of electrons which are negatively charged.
6. A forward-biased diode conducts electric current, while a reverse-biased one doesn't.
7. The peak reverse voltage (PRV), or peak inverse voltage (PIV) is either the specified maximum voltage that a diode rectifier can block, or, alternatively, the maximum voltage that a rectifier needs to block in a given circuit.

3.

f	p	t	c	a	t	h	o	d	e	l	u
v	o	a	p	p	c	u	v	n	n	i	f
a	t	r	z	u	a	e	i	n	d	r	d
e	r	b	w	a	g	a	e	t	j	e	p
s	l	f	n	a	t	n	r	v	e	v	d
b	i	w	t	s	r	o	g	c	n	y	s
d	d	l	u	b	p	d	x	k	u	a	t
z	o	s	a	s	r	e	-	c	i	t	z
v	r	t	p	r	o	h	i	b	i	t	e
v	p	n	-	j	u	n	c	t	i	o	n
t	w	o	-	t	e	r	m	i	n	a	l
r	e	v	e	r	s	e	-	b	i	a	s

two-terminal → PN-junction → anode ↓ cathode → sport ↗ bias ↗ forward-bias

reverse-bias → exceed ↗ voltage ↗ sustain ↗ prohibit →

12 words in Wordsearch: 1 vertical, 5 horizontal, 6 diagonal. (0 reversed)

4.

8. A diode is a **one**-way valve for electricity.
9. Pure silicon **doesn't have** free electrons.
10. At the **n-sid**e of the diode we will have free electrons, and at the **p-side**, we will have vacant positions for electrons.
11. The p-side boundary is slightly **negatively** charged, and the n-side boundary is slightly **positively** charged.
12. The resulting electric field will **oppose** any further natural migration of electrons.
13. A forward-biased diode **conducts** electricity.
14. At the reverse biased side, applying a very **high** voltage will damage normal diodes and result in a high current flow.

UNIT 14

1.

1. A transistor is a three-terminal, solid-state electronic device used for amplification and switching.
2. A transistor can be considered as two P-N junctions placed back to back. One of these, namely the base emitter junction is forward biased, whilst the other, the base collector junction is reverse biased. It is found that when a current is made to flow in the base emitter junction a larger current flows in the collector circuit even though the base collector junction is reverse biased. For clarity the example of an NPN transistor is taken. The same reasoning can be used for a PNP device, except that holes are the majority carriers instead of electrons. When current flows through the base emitter junction, electrons leave the emitter and flow into the base. However the doping in this region is kept low and there are comparatively few holes available for recombination. As a result most of the electrons are able to flow right through the base region and on into the collector region, attracted by the positive potential. Only a small proportion of the electrons from the emitter combine with holes in the base region giving rise to a current in the base-emitter circuit. This means that the collector current is much higher. The ratio between the collector current and the base current is given the Greek symbol B.

2.

1. switches, amplifiers
2. control, build
3. darn
4. transmit, boost
5. boost, magnify
6. vacuum tubes
7. Bardeen, Brattain, and Shockley
8. 1956
9. dissipate a heck, predecessors

4.

1. T
2. T
3. F
4. F
5. T

6. F
7. F
8. T
9. T
10. T

6.

	BJT	FET
Control method	Current controlled	Voltage controlled
Impedance	Low impedance	Very high impedance
Polarity	Bipolar	Unipolar
Noise level	More noisy	Less noisy
Thermal stability	Less temperature stable	More temperature stable
Size	Large in size	Small in size

UNIT 15

1.

1. Thyristor is a semiconductor switch used chiefly in power-control applications. Also called a silicon-controlled rectifier (SCR), it is a variation of the transistor.
2. A thyristor is capable of producing large direct currents by rectification of alternating currents and can be automatically triggered "off" for specified periods of time.

4.

1	2	3	4	5	6	7	8	9	10
7	9	5	2	1	10	8	6	4	3

6.

Parameter	Transistor	Thyristor
Basic	It is a 3 layer device used for amplification purpose	It is a 4 layer device used for rectification purpose
Number of junctions	It has 2 junctions	It consists of 3 junctions
Device triggering	To ensure proper conduction of the device regular current pulse must be provided to it	It requires single triggering pulse at initial state in order to start and maintain conduction
Power rating	Its rating is in Watts	Its rating is in Kilowatts
Cost	Low cost	It is quite expensive than transistor
Size	Small in size and less bulky	It has comparatively larger size thus is bulkier than transistor
Current rating	It possesses low current rating	Current rating is comparatively high in case of thyristor

Turn-on time	It turns on faster than thyristor	This device takes more time to turn on
Commutation circuit	Not required	Required
Power losses	It exhibits high power loss	The power loss is comparatively low in case of thyristor than transistor
Suitability in application	Suited for high frequency applications but not for high power applications	Suited for high power applications but not for high frequency applications

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Для нотаток

Для нотаток

Для нотаток

Навчальне видання

КОШКІНА Ганна Леонідівна

ENGLISH FOR ELECTRONICS

Part I

Навчальний посібник з англійської мови
для студентів спеціальності 171 «Електроніка»

(*англійською мовою*)

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