

5. TRANSISTORS

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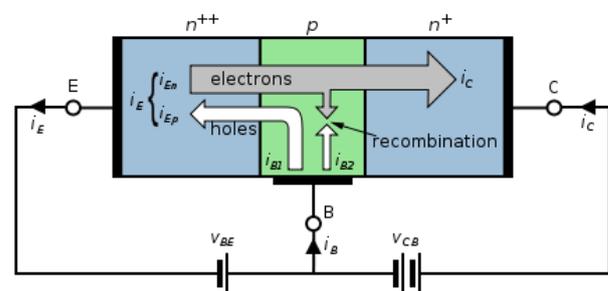
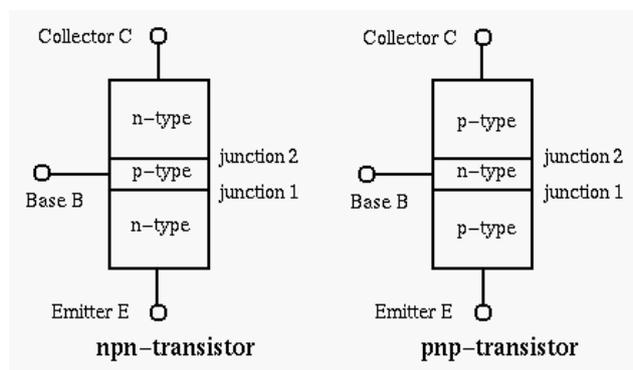
5.1. Transistors

A transistor, generally speaking, is a solid-state switch that allows a small signal to control a large signal, such as a current flow. The first transistor was invented by **John Bardeen**, **Walter Brattain**, and **William Shockley** in **1945**. They were awarded the Nobel Prize for physics in 1956. Since that time, transistors of all types have become crucial for modern **electronics** to function. They are used for a wide variety of control functions such as amplification, oscillation and frequency conversion. The term **transistor** was coined of the term "transfer resistor".



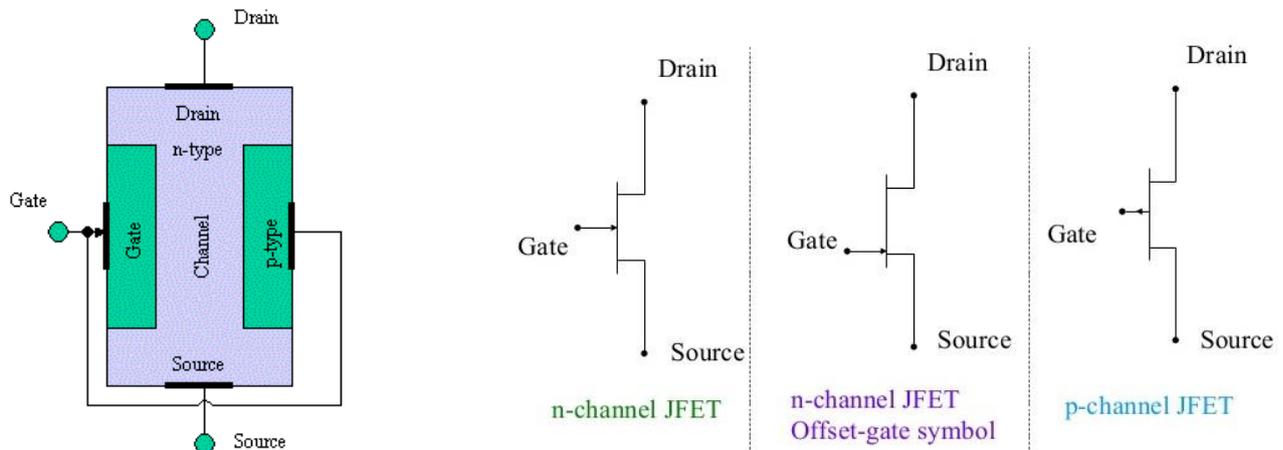
A transistor has three terminals. Current flows between two of them while the third one controls the current. In **semiconductors**, there are two charge carriers. One is the **electron**, which carries negative charges. The other is a **hole**, which carries positive charges. The amount of electrons and holes is often unequal. Consequently, the carrier which has a larger amount is called a **majority carrier** and the other is called a **minority carrier**. Depending on what carriers produce the current, transistors can be classified as **bipolar** or **unipolar** transistors.

In **bipolar transistors**, the current is carried by both majority and minority carriers. The three terminals are the **emitter**, the **collector**, and the **base**. Two structures are possible, p-n-p and n-p-n. In a "p" type the majority carriers are holes (positive), while "n" indicates the type where the majority carriers are electrons (negative).



In **unipolar transistors**, only the majority carriers carry the current. The field-effect transistor (FET) is an example of a unipolar transistor. The three terminals are the **source**, the **drain**, and the **gate**. The region between the source and drain is called a **substrate**. FETs are used widely in today's electronic industry. Depending on whether there is an insulation layer between the gate and the substrate, there are junction-gate FETs (JFET) or insulated gate FETs (IGFET). Oxide is often used as the insulation material, so IGFET is

often called MOSFET (Metal-Oxide-Semiconductor Field Effect Transistor). The electrical properties of JFET and MOSFET differ significantly.



Unipolar transistors differ from bipolar transistors because the current flow is controlled by the variation of the electric field, while with bipolar transistors it is controlled by the variation of the current in the base terminal. When building integrated circuits based on millions of transistors, many issues need to be taken into account. One is the **power** consumption. The type of transistors used, should not consume too much power. In making integrated circuits, FETs, built on silicon, turn out to be very good, which is why silicon devices are widely used today.

<http://www.bookrags.com/research/transistors> (adapted)

Complete this box where possible.

Verb	Noun	Adjective
collect	collection	collective
	difference	
	emitter	
vary		
convert		
		amplified
consume		
		operational
control		
insulate		

Fill in the gaps using the words from the box.

- Transistors are used for a _____ of control functions including _____, _____ and frequency _____.
- The current flow through FET is _____ by the variation of the electric field.
- Electrical properties of JFET and MOSFET _____ significantly.
- Oxide is often used as the _____ material.

5. One of the factors to be taken into account when building integrated circuits based on millions of transistors is the power _____.

Answer the questions.

1. What is a transistor?
2. Where does the name transistor come from?
3. What are the 3 parts of a transistor?
4. What does IC stand for?
5. What are transistors made of?

Circle the correct answer.

1. It can be made from a variety of materials, such as carbon; it inhibits the flow of current.
 - a) inductor
 - b) choke
 - c) capacitor
 - d) resistor
2. It consists of two plates and can store charge; it is useful in tuning and filtering circuits.
 - a) transistor
 - b) capacitor
 - c) relay
 - d) inductor
3. It can consist of a simple wire and develops a magnetic field when current passes through it. It is also used in tuning circuits and filters.
 - a) transistor
 - b) inductor
 - c) capacitor
 - d) semiconductor
4. It is a type of a semiconductor that only allows current to flow in one direction. It is usually used to rectify AC signals (conversion to DC).
 - a) inductor
 - b) diode
 - c) transformer
 - d) relay
5. It consists of an electromagnet, which is used to open or close a contact(s).
 - a) inductor
 - b) transistor
 - c) relay
 - d) rheostat
6. It is a type of a semiconductor in which the flow of current can be controlled through a base or gate terminal. It is usually used for electronic switching or amplifiers.
 - a) varistor
 - b) diode
 - c) resistor
 - d) transistor
7. It consists of two coils which usually share a magnetic core. It is used to convert an AC source or signal into another AC source or signal with the same power (ideally) but different voltage and current.
 - a) choke
 - b) transistor
 - c) transformer
 - d) relay
8. It is a special type of diode that breaks down when a critical reverse voltage is applied. It is most commonly used to regulate voltage.
 - a) LED
 - b) anode
 - c) Zener diode
 - d) cathode
9. It is a special type of a diode that lights up when a small voltage is applied; it is usually used as an indicator in displays.
 - a) Zener diode
 - b) LED
 - c) LCD
 - d) incandescent lamp

10. It is a type of a display that uses tiny polarized crystals; very popular in watches, calculators, and lap-tops.

a) LCD

b) LED

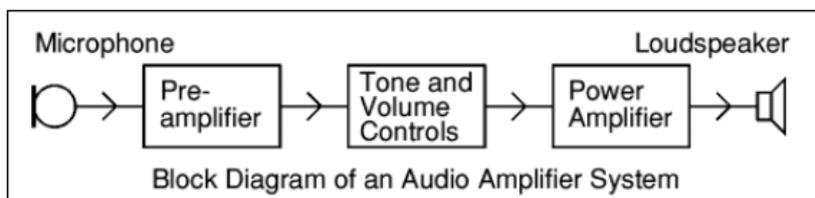
c) Quartz Crystal

d) CRT

5.2. Block Diagrams

Block diagrams are used to understand (and design) complete circuits by breaking them down into smaller units or blocks. Each block performs a particular function and the block diagram shows how they are connected together. No attempt is made to show the components used within a block (unit), only the inputs and outputs are shown. The way of looking at circuits by focusing on the function of each unit is called the **systems approach**.

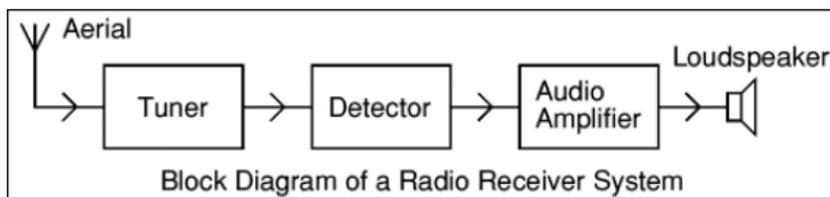
Audio Amplifier System



The power supply (not shown) is connected to the pre-amplifier and power amplifier blocks.

- **Microphone** - a transducer which converts sound to voltage.
- **Pre-Amplifier** - amplifies the small audio signal (voltage) from the microphone.
- **Tone and Volume Controls** - adjust the nature of the audio signal. The tone control adjusts the balance of high and low frequencies. The volume control adjusts the strength of the signal.
- **Power Amplifier** - increases the strength (power) of the audio signal.
- **Loudspeaker** - a transducer which converts the audio signal to sound.

Radio Receiver System

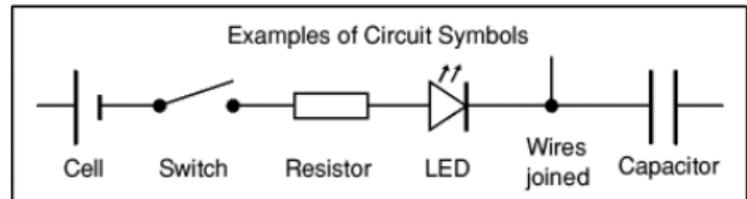


The power supply (not shown) is connected to the audio amplifier block.

- **Aerial** - picks up radio signals from many stations.
- **Tuner** - selects the signal from just one radio station.
- **Detector** - extracts the audio signal carried by the radio signal.
- **Audio Amplifier** - increases the strength (power) of the audio signal. This could be broken down into the blocks like the Audio Amplifier System shown above.
- **Loudspeaker** - a transducer which converts the audio signal to sound.

5.3. Circuit Diagrams

Circuit diagrams show how electronic components are connected together. Each component is represented by a symbol and a few are shown here.

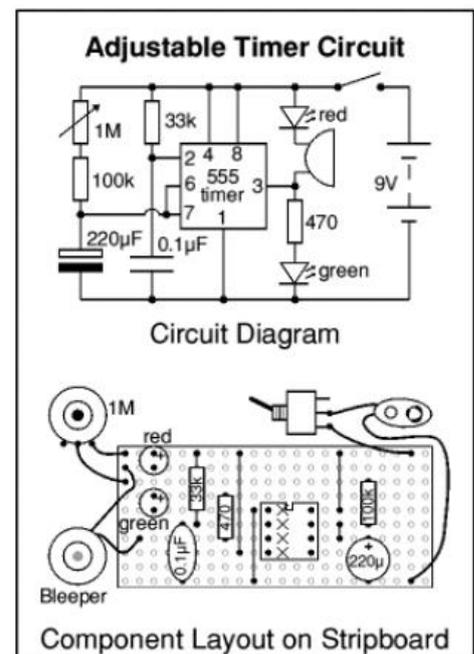


Circuit diagrams and component layouts

Circuit diagrams show the connections as clearly as possible with all wires drawn neatly as straight lines. The actual layout of the components is usually quite different from the circuit diagram and this can be confusing for the beginner. The secret is to concentrate on the connections, not the actual positions of components.

The circuit diagram and stripboard layout for the Adjustable Timer project are shown here so you can see the difference.

A circuit diagram is useful when testing a circuit and for understanding how it works. This is why the instructions for projects include a circuit diagram as well as the stripboard or printed circuit board layout which you need to build the circuit.



<http://www.kpsec.freeuk.com/bdiags.htm>

Diagrams: **Block diagram** - shows the function of each unit and the path of the signals between them.

Circuit diagram - shows the connection and values of the components.

Systems approach - understanding the function of each unit.

5.4. Exercises

Match two halves (one from column A, one from column B) to form correct sentences:

A

1. A motor is a machine that -
2. The principle of electromagnetic induction -
3. Electrical engineering -
4. Electricity may be used to -
5. A machine that converts mechanical energy into electrical energy -
6. If a wire is passed so that it crosses the magnetic lines of force, -

B

- a – is the basic principle of how electricity is generated.
- b – produce a magnetic field.
- c – converts electrical energy into mechanical energy.
- d – an electric current will flow along it.
- e – is a branch of science and technology.
- f – is called a generator.

Use the verb in brackets in the right Passive Voice tense:

- 1- The alternating-current motors _____ to operate on alternating current circuits. (to design)
- 2- Electricity may _____ to produce a magnetic field. (to use)
- 3- If a current _____ through a conductor located in a magnetic field, the field exerts a mechanical force on it. (to pass)
- 4- New electric machines _____ in the future. (to develop)
- 5- The generators which produce electricity for our daily use _____ to send out alternating-current. (to make)
- 6- Some generators _____ so that the current produced always flows in the same direction; this _____ direct-current. (to build/ to call)

Complete the texts with the words given below.

components current turn on branch amount
 positive appliances continue burns out path

The (1) components of a circuit can be wired in two different ways: series or parallel. If components are arranged one after another to form a single (2) _____ between the terminals and the components, the circuit is known as a series circuit. In this type of circuit, the (3) _____ flows from the negative terminal to the (4) _____ terminal, passing through all the other components of the circuit. This means that the (5) _____ of energy passing through all the components in the series is the same. The main disadvantage of a series circuit is that when a single component in the path (6) _____, the entire circuit stops operating.

A parallel circuit consists of several paths connecting the different components. Each separate path is called a (7) _____ of the circuit. Current from the source divides and flows through the different branches. Unlike series circuits, if one of the components in the parallel circuit burns out, the other paths (8) _____ to operate. Parallel circuits are commonly used to connect (9) _____ at home, so that each socket can function independently. For example, you don't have to (10) _____ the light in your room for the TV socket to work.

Complete the text with the words given below.

cell lines microprocessor photos radio
signals flash emails antenna movement

A cellular phone (or mobile phone) is designed to give the user freedom of (1)_____ while using a telephone. It uses (2)_____ signals to communicate between the phone and the (3)_____. The server area is divided into smaller areas called cells and an antenna is placed within each cell and connected by telephone (4)_____. These lines connect cellular phones to one another: a computer selects the antenna closest to the telephone when a call is made. If the phone moves to one serving (5)_____ to another, the radio signal is transferred to the actual cell without interrupting the conversation.

The circuit board is the heart of the system. A chip translates the outgoing and incoming (6)_____ from analogue to digital and back from digital to analogue. The (7)_____ handles all the functions for the keyboard, the display and the loudspeakers, and it controls the signal to the base station.

Other (8)_____ memory chips provide storage for the operating system.

A cellular phone is not only a phone but it provides an incredible amount of functions:

- store information;
- use a calculator;
- send and receive (9)_____
- surf the Internet;
- play simple games;
- play music, take (10)_____ and videos.

Can you imagine your life without your mobile phone?

Decide if the following statements are true (T) or false (F).

- 1- Mobile phones use radio signals to communicate.
- 2- The server area is divided into smaller areas called stations.
- 3- An antenna is placed every two or three cells.
- 4- There are interruptions when you move to one cell to another.
- 5- The antenna is the heart of the system.
- 6- The signal must be translated.
- 7- The flash memory handles all the functions.
- 8- The signal to the base station is controlled by the microprocessor.
- 9- You can text and send emails with your mobile phone.