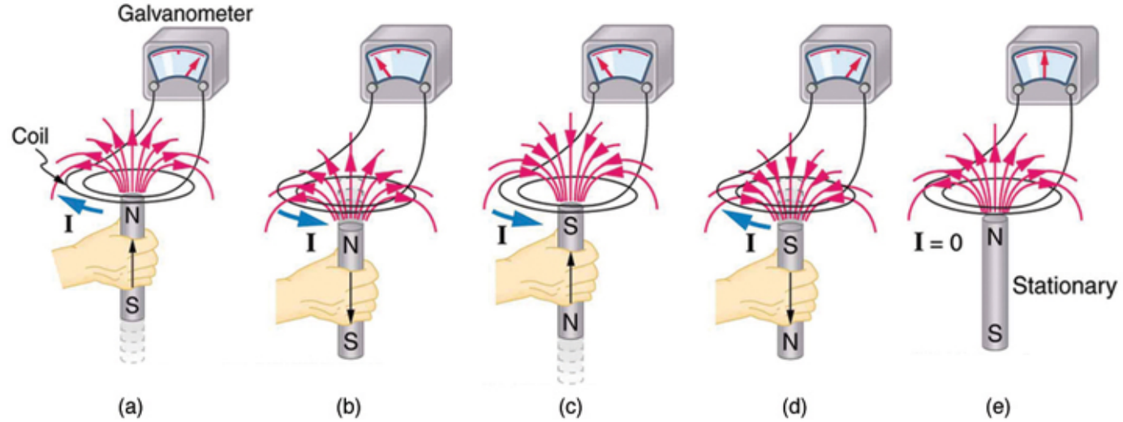
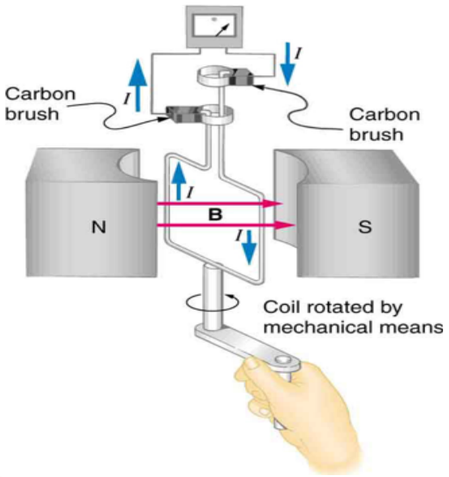
Basic knowledge
DIRECT CURRENT CIRCUITS

Direct Current Circuits (DC Circuits). EMF Source

Direct Current Circuits (DC Circuits) are electrical circuits in which current flows in one direction. They typically consist of power sources, resistors, and other components.
EMF is a measure of a source's ability to generate current in a circuit. It is typically measured in volts.
An EMF is induced in a coil when a rod-shaped magnet is brought in and out of it. EMFs of opposite signs are generated during movement in opposite directions and can also be reversed by flipping the poles. The same results are obtained if instead of moving the magnet, the coil is moved—what matters is the relative motion. The faster the movement, the greater the EMF, and no EMF is produced when the magnet remains stationary relative to the coil.



Movement of the magnet relative to the coil induces an EMF, as shown. The same EMFs are generated if the coil is moved relative to the magnet. The higher the speed, the greater the EMF, and the EMF is zero when there is no movement.
The method of inducing EMF, used in most electric generators, is shown in the diagram. The coil rotates in a magnetic field, generating an alternating current of EMF, which depends on the rotation speed and other factors.



Rotation of the coil in a magnetic field generates EMF. This is the basic design of a generator, where the work done to rotate the coil is converted into electrical energy. Thus, a change in the magnitude or direction of the magnetic field induces EMF.

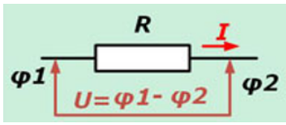
Basic knowledge
OHM'S LAW

Ohm's Law

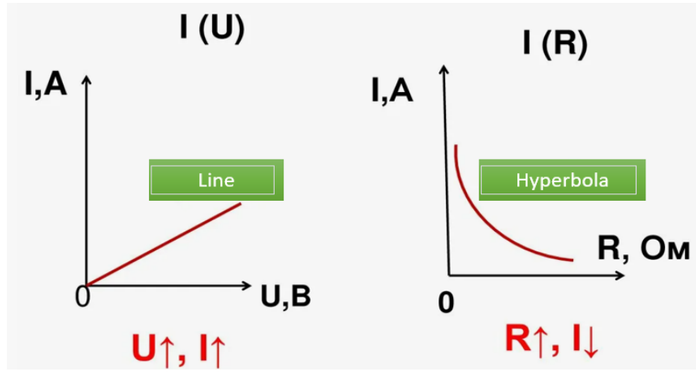
Ohm's Law is one of the fundamental concepts in electrical engineering. The German physicist Georg Ohm experimentally established that the current flowing through a section of a circuit is directly proportional to the applied voltage and inversely proportional to the resistance of that section.
This law is called Ohm's Law for a circuit segment and is expressed with the following formula:

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

where
I is the current, in amperes (A);
U is the applied voltage, in volts (V);
R is the resistance, in ohms (Ω).

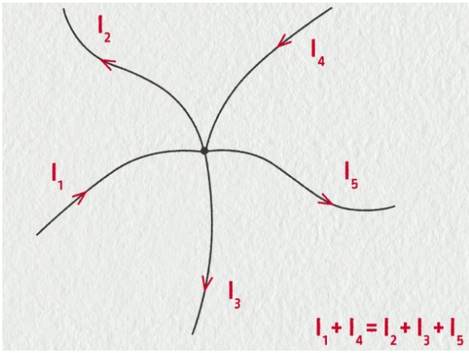


Graphs of the dependence of current on voltage and resistance



Kirchhoff's Laws

First Law (Current Law): The sum of currents entering a junction equals the sum of currents leaving the junction.

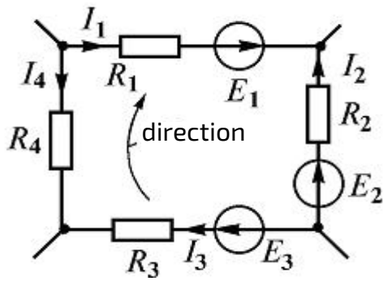


Second Law (Voltage Law): The sum of all voltages around a closed loop is zero.

The principle of reciprocity is as follows: if a certain electromotive force (EMF) located in one branch of any arbitrarily complex linear electrical circuit causes a current in another branch of the same circuit, then in the absence of other EMFs, the same EMF, when transferred to the second branch, will induce a current of the same magnitude and phase in the first branch.

Basic knowledge

KIRCHHOFF'S LAWS

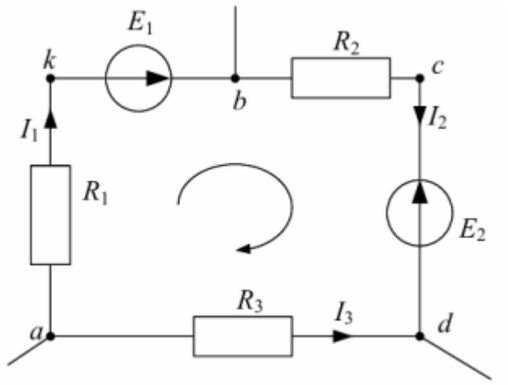


Note on the signs of the obtained equation:

- The EMF is positive if its direction coincides with the direction of the arbitrarily chosen loop traversal.
- The voltage drop across the resistor is positive if the direction of the current in it coincides with the direction of the loop traversal.
- Physically, Kirchhoff's second law describes the voltage equilibrium in any loop of the circuit.

Potential diagram — this is a graphical representation of Kirchhoff's second law, used to verify the correctness of calculations in linear resistive circuits. A potential diagram is constructed for a loop without current sources, with the potentials at the starting and ending points of the diagram being equal.

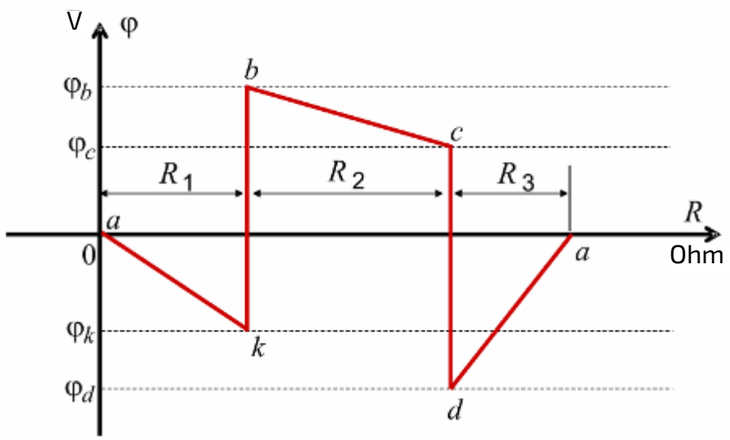
Consider the loop abcda in the diagram shown. In the branch ab, between resistor R1 and EMF E1, we designate an additional point k.



Loop for constructing the potential diagram

The potential of any node is taken as zero (for example, a=0). We choose a traversal of the loop and determine the potentials at the points along the loop.

When constructing the potential diagram, it is important to remember that the resistance of the EMF is zero (see Fig.).



Potential diagram

Basic knowledge

CIRCUITS

Single-phase RLC Circuits

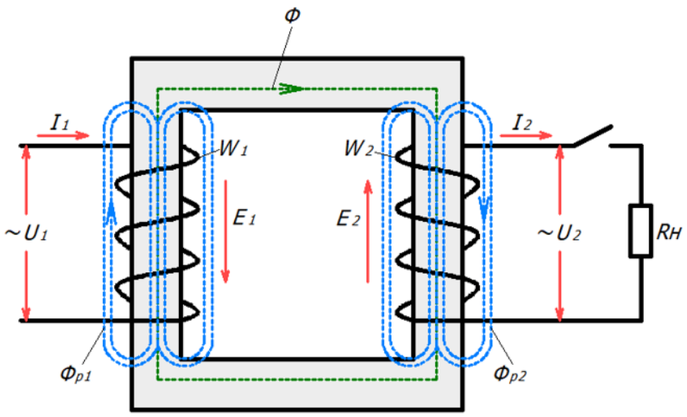
Circuits containing resistors (R), inductors (L), and capacitors (C) operating with alternating current. The analysis includes impedance and resonance.

Single-phase Transformer

A transformer is a static electromagnetic device used to convert alternating current of one voltage to alternating current of another voltage without changing the frequency.

Transformers have become widespread as devices that allow electrical energy to be transmitted over long distances with minimal energy losses in power lines. They also enable the connection of electrical energy sources of different voltage levels into a unified power system.

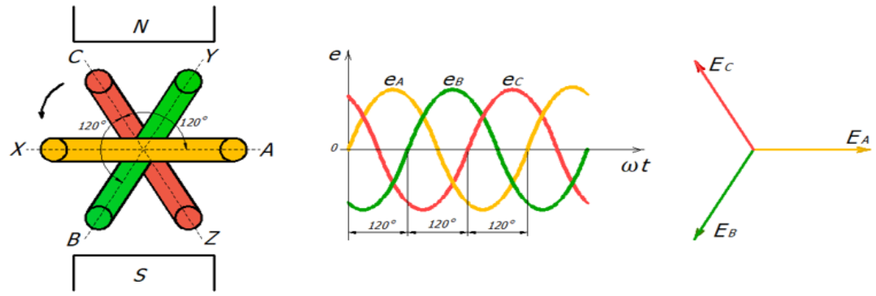
The schematic diagram of a transformer is shown in Figure.



Three-phase Circuits

A three-phase circuit is a combination of three electrical circuits in which sinusoidal electromotive forces (EMFs) of the same frequency act, shifted relative to each other by 120°, generated by a common source. The section of the three-phase system through which the same current flows is called a phase. A three-phase circuit consists of a three-phase generator, connecting wires, and recipients or loads, which can be either single-phase or three-phase.

In Figure (a), a diagram of the simplest generator is shown, which easily illustrates the principle of obtaining a three-phase EMF. In a uniform magnetic field of a permanent magnet, three loops, offset in space by 120°, rotate at a constant angular speed.



Basic knowledge

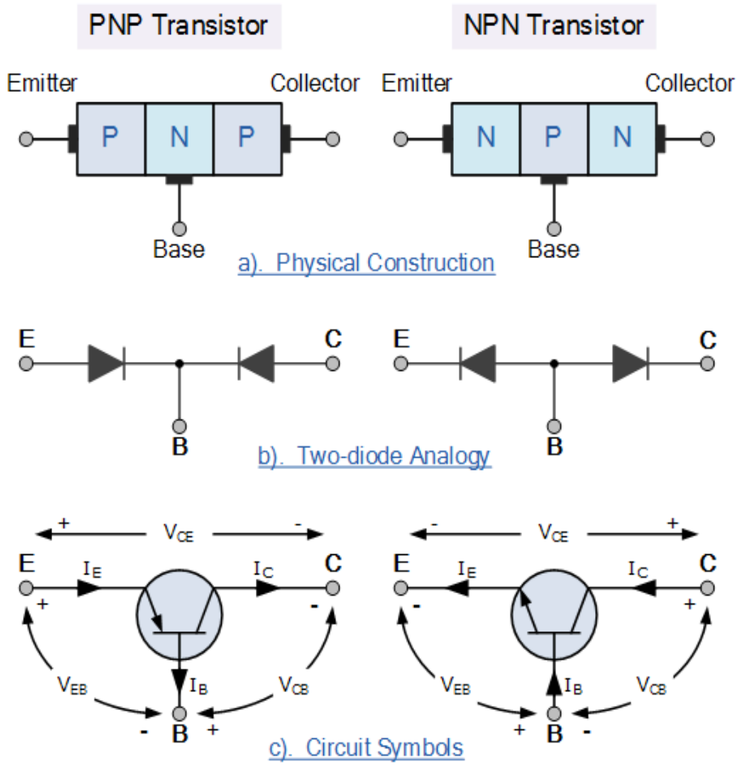
BIPOLAR TRANSISTOR

The Bipolar Transistor basic construction consists of two pn-junctions producing three connecting terminals with each terminal being given a name to identify it from the other two. These three terminals are known and labelled as the Emitter (E), the Base (B) and the Collector (C) respectively.

Bipolar Transistors are current regulating devices that control the amount of current flowing through them from the emitter to the collector terminals in proportion to the amount of biasing voltage applied to their base terminal, thus acting like a current-controlled switch. As a small current flowing into the base terminal controls a much larger collector current forming the basis of transistor action.

The principle of operation of the two types, the PNP Transistor and the NPN Transistor, is exactly the same the only difference being in their biasing and the voltage polarity of the power supply used to power each type.

Bipolar Transistor Construction



The construction and circuit symbols for both the PNP transistor and the NPN transistor are given above with the arrow in the circuit symbol always showing the direction of "conventional current flow" between the base terminal and its emitter terminal.

The direction of the arrow always points from the positive P-type region to the negative N-type region for both transistor types, exactly the same as for the standard diode symbol.

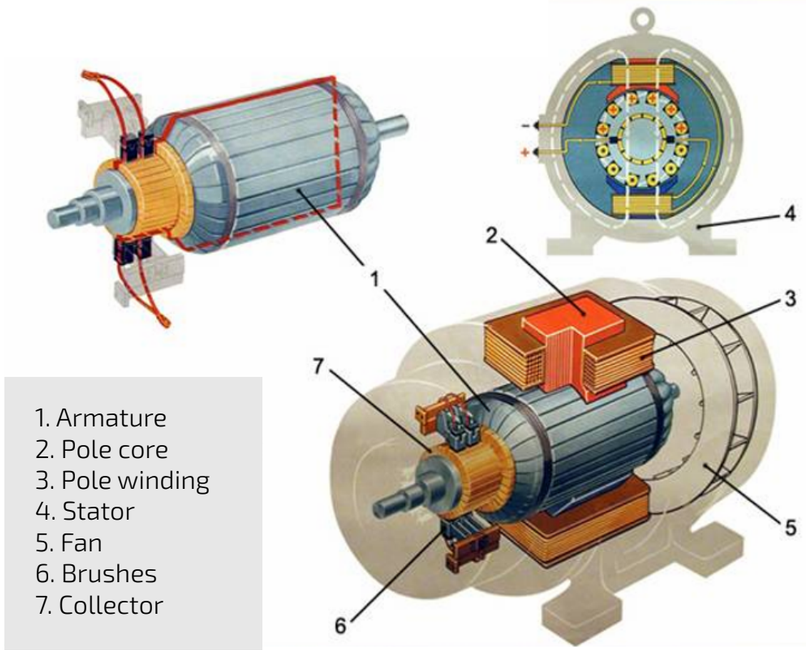
Basic knowledge

ELECTRICAL MACHINES

DC Motor

DC motor consists of:

- A stationary part — the stator;
- A rotating part — the armature.



Construction of a DC motor

The stator is a hollow steel cylinder with an even number of main poles with excitation windings of direct current affixed to its inner surface. If the excitation windings are powered from an external source of direct voltage, the motor is called an independently excited motor.

The armature is a cylinder mounted on the shaft of the machine, made from a pack of thin sheets of electrical steel with slots filled with the winding connected to the collector plates, onto which a system of brushes is applied.

Mechanical characteristics of a DC motor