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OPERATION OF SENSORS RELAY OPERATION PROCESS

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A N N O T A T I O N: Another type of sensors is determined by the nature of his physical nature. The output amount, that is, resistance, indication, capacity, voltage, phase, phase, frequency sensors are the most common.

A N N O T A S I YA: Датчикларни бошқача тури, *чиқиш у миқдорини физикавий табиатига* қараб ҳам белгиланади. Чиқиш миқдори–электр бўлган датчиклар, яьни қаршилик, индуктивлик, сиғим, ток, кучланиш, фаза, частота датчиклари энг кўп тарқалган.

А Н Н О Т А Ц И Я: Другой тип датчиков определяется природой его физической природы. Выходная сумма, то есть сопротивление, индикационная, емкость, напряжение, фаза, фаза, датчики частоты являются наиболее распространенными.

The accurate and reliable operation of sensors determines the corresponding main indicators of the entire system operation. Sensors must possess high sensitivity and accuracy, long service life and reliability in operation, small dimensions and weight, as well as low cost.

Conditionally, sensors can be considered to consist of receiving, intermediate, and executive parts. The **receiving part**, being affected by changes in the input quantity *x*, converts it into some **intermediate** quantity. This quantity is compared with the reference (standard) value of a similar physical quantity. Then, acting on the **executive part** of this sensor, it forms the output signal *y*. According to the **physical composition of the input quantity x**—electrical, thermal, mechanical, optical, acoustic, liquid and gas sensors are distinguished. Electrical sensors measure current, voltage, power, frequency, magnetic flux; thermal sensors measure temperature and heat quantity; mechanical sensors measure force, pressure, displacement, velocity, acceleration; optical sensors measure light intensity, illumination; acoustic sensors measure sound intensity, its frequency, power; liquid and gas sensors measure pressure and velocity.

Each type of sensor is, in turn, also classified according to **the operating principle of its receiving part**, i.e., divided into groups. For example, optical sensors are divided into photoelectric, photochemical, photothermal, and photomechanical groups. Another type of sensors is also determined by **the physical nature of the output quantity y**. Sensors with electrical output quantities, namely resistance, inductance, capacitance, current, voltage, phase, frequency sensors are the most widespread.

Sensors are also divided into separate groups according to **their conversion of input signal x by number and type**. Direct conversion sensors directly convert the input signal *x* into the output signal *y*. Such sensors are convenient because they do not require intermediate conversion parts. In sensors with intermediate conversion parts, multiple signal conversions lead to complications and, to a certain extent, loss of accuracy. According to the form of **x-y** conversion, sensors are divided into two groups: continuous and discrete (discontinuous) converters. Continuously varying sensors are considered measuring devices. In them, continuous change of *x* corresponds to continuous change of *y*. Often, discretely operating sensors monitor the state of discrete objects, i.e., objects with finite states. Most monitored objects have two positions, namely

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"connected" and "disconnected" states. For this reason, discrete sensors are considered binary information sensors with output quantities y=0 or y=1.

Due to the development of semiconductor technology and the widespread use of microprocessors and computers in modern automatic systems, new ideas and directions have emerged in sensor development. The characteristics of this development are marked by sensors working together with microprocessors and computers. For this reason, an important quality of modern sensors is their integrated design and small dimensions. Due to these characteristics, it became possible to place several sensors in one housing and thereby create a combined sensor that simultaneously measures several physical quantities.

Direct Conversion Sensors

An example of a direct conversion sensor is the **strain gauge** (Figure 3). They are used to measure deformations and mechanical stresses on part surfaces. The strain gauge is made from wire with high specific resistance and small diameter (0.006-0.020 mm) made of constantan in a U-shape. The wire is placed densely and evenly between thin paper sheets and glued together. The wire ends are welded to copper wires, through which the strain gauge is connected to the measuring circuit. The strain gauge is firmly attached to the part surface and deforms together with it. The relative change in resistance ΔR/R is proportional to the deformation Δl/l and the stress on the part surface,

$$\frac{\Delta R}{R} = k\frac{\Delta l}{l}$$

where k is a constant quantity.

Thus, in a strain gauge, a mechanical quantity (deformation) is directly converted to an electrical (resistance) quantity.

Thermal sensors are also simple in construction. In them, temperature is converted to voltage (in thermocouples) or resistance change (in thermal resistors). Thermal resistors (Figure 3) are made from steel, nickel, or platinum wires because their resistance depends on temperature. For temperature measurement, ferrites and capacitors with magnetic and dielectric conductivity sensitive to heat are used. In thermosensitive diodes and thyristors, the property of conductivity dependence on temperature in the *p-n* junction in silicon crystal is utilized.

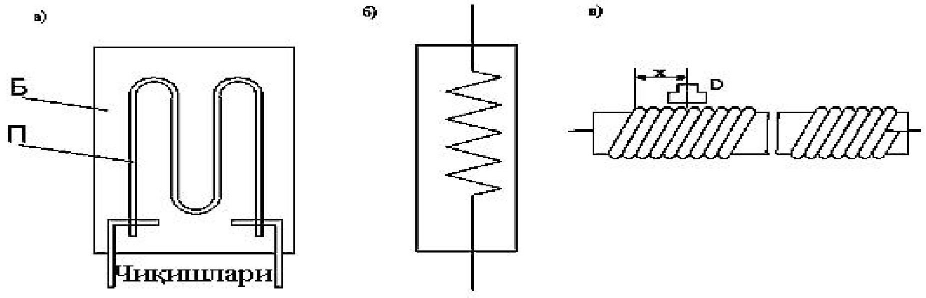

Figure 1. Resistance sensors

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Resistance sensors group includes the widely used rheostat sensor (Figure 1,c). They convert the linear displacement of mechanisms into corresponding resistance *R* change. When slider *D* is moved by distance *x*, the resistance *R* of the rheostat changes proportionally.

In **inductive sensors**, the measured quantity is converted to inductance change. For example: a sensor (Figure 2) measures the thickness *h* of ferromagnetic material. If the value *h* increases, then the air gap δ decreases, resulting in an increase in the inductance of coil O, which is registered by the measuring circuit.

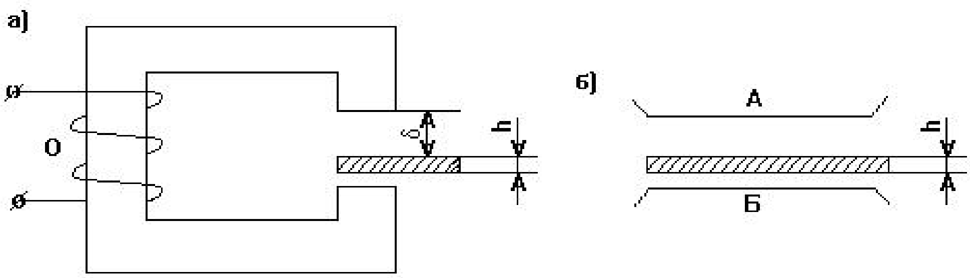
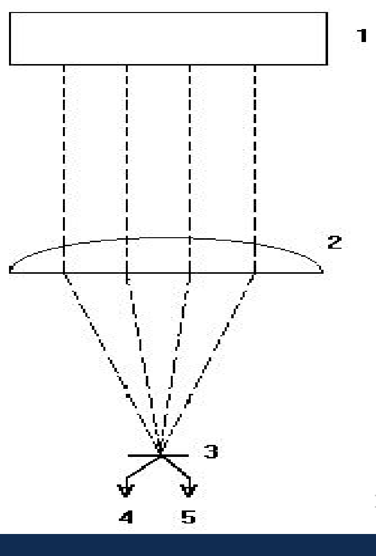


Figure 2. Thickness measurement circuits

In **capacitive sensors**, the relationship between capacitor capacitance, plate area, distance between them, and dielectric constant is utilized. With the help of capacitive sensors, linear and angular displacements, temperature, relative humidity of air, and other parameters can be measured. Particularly, the capacitive sensor shown in Figure 3 measures the thickness *h* of a sheet placed between plates A and B of a capacitor made of dielectric material.

Infrared radiation optical sensors (Figure 3) measure the temperature of heated objects. It consists of a lens 2 that registers infrared rays on the surface of sensitive element 3, and a heated object 1 that emits rays. As a result of this measurement, the resistance of sensitive element 3 changes, and voltage appears at outputs 4 and 5. A similar sensor (bolometer) is used in automatic detection devices for overheated bearings in trains.



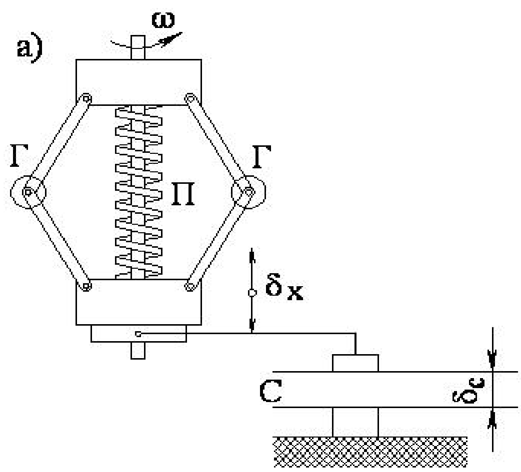


Figure 3. Scheme of the infrared light emitting sensor

Sensors with Intermediate Converters

These sensors consist of several direct conversion sensors operating in sequence. The output quantity of one sensor serves as the input quantity for the next sensor.

The sensor shown in Figure 4 serves to convert angular velocity ω to capacitor *C* capacitance. The receiving body of the sensor is a centrifugal regulator. It converts angular velocity to centrifugal force that is compared with the compression force of spring Π (intermediate part). The force in the intermediate part leads to displacement δ_x of the regulator's lower sleeve covered with the upper plate of capacitor *C*. The capacitor is the executive part of the sensor, whose capacitance changes according to the distance δc between plates.

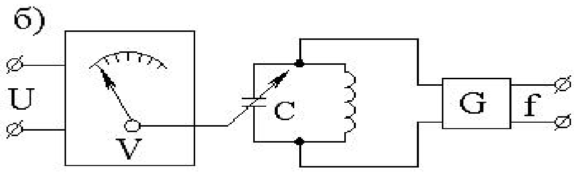


Figure 4. Schemes of sensors with intermediate converter

The sensor in Figure 4 converts voltage *U* to frequency *f*. Voltage *U* is measured by voltmeter *V* connected to variable capacitor *C* whose arrow is related to capacitance *C*. Capacitor *C* is connected to the circuit of task-giving generator *G* whose output frequency *f* depends on capacitance. Thus, the sensor performs the following conversions: *U*→ angular displacement of voltmeter *V* arrow → *C* → *f*.

Discrete Conversion Sensors

These sensors monitor the state of objects and serve as sources of input information in railway automation and telemechanics systems.

A **track circuit** (Figure 5) is used to monitor the freedom of track sections from rolling stock. A track circuit is a part of a track section bounded by insulating joints IT. Power supply is connected to the rails at one end of the track circuit, while at the other end a control device CD operating on current in the rails used as conductors is connected. Usually, an electromagnetic or induction relay is used as CD. If the section is free, a large current passes through CD (relay armature is attracted). If the section is occupied by at least one wheelset (whose resistance is 0.06 Ohm and much smaller than CD resistance), the current in CD sharply decreases (relay releases its armature). Thus, based on the CD state, one can judge whether the track section is free or occupied.

Figure 5. Scheme of the rail chain

The **magnetic sensor** shown in Figure 6 registers the passage of wagon wheels through a certain point on the track. Such a sensor is called a contactless magnetic pedal and consists of permanent magnet DM, coil Ch, and control apparatus CA. The pedal is placed near the rail. When a wheel approaches the pedal, the magnetic field parameters in the DM magnetic apparatus change. As a result, electromotive force (EMF) is generated in coil Ch, and current begins to flow, which is registered by CA.

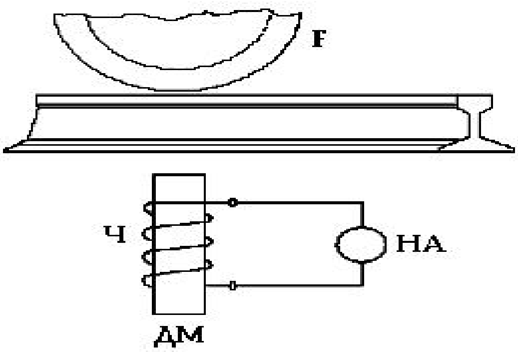


Figure 6. Magnetic reaction (pedal)

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