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АВТОМАТИЗАЦИЯ ТЕХНОЛОГИЧЕСКИХ ПРОЦЕССОВ

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Настоящий практикум предназначен для студентов, обучающихся по направлению подготовки 15.02.14 «Оснащение средствами автоматизации технологических процессов и производств (по отраслям)», составлен в соответствии с рабочей программой по учебной дисциплине «Иностранный язык в профессиональной деятельности».

Практикум содержит тексты научно-технического характера по автоматизации и комплекс заданий с учетом профессиональных интересов обучаемых и принципа междисциплинарности обучения.

Рекомендуется как для аудиторной, так и для самостоятельной подготовки студентов 3 курса к профессионально-ориентированному иноязычному общению.

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Содержание

Введение 4
1. INDUSTRIAL AUTOMATION 5
1.1. WHAT IS INDUSTRIAL AUTOMATION? 5
1.2. HISTORY OF INDUSTRIAL AUTOMATION 6
1.3. ADVANTAGES OF INDUSTRIAL AUTOMATION 10
1.4. EXAMPLES OF INDUSTRIAL AUTOMATION 12
1.5. TYPES OF INDUSTRIAL AUTOMATION 12
2. INDUSTRIAL CONTROL SYSTEMS 15
2.1. SCADA (SUPERVISORY CONTROL AND DATA ACQUISITION) 17
2.2. PLC (PROGRAMMABLE LOGIC CONTROLLER) 19
2.3. ACTUATORS 20
2.4. SENSORS 23
3. AUTOMATION OF METALLURGICAL INDUSTRY 35
AN ESSENTIAL GLOSSARY OF TERMS 38
СПИСОК ЛИТЕРАТУРЫ 55

ВВЕДЕНИЕ

Важной задачей современной системы образования является подготовка специалиста, обладающего профессиональной компетенцией. Как правило, такой специалист способен разбираться в информационных потоках своей области деятельности, находить, систематизировать, использовать информацию и обмениваться ею, а также постоянно развивать свои знания и повышать уровень культуры. Принимая во внимание тот факт, что значительная часть информации во многих сферах деятельности доступна только в иноязычном виде, можно заключить, что сегодня выпускники колледжа должны владеть иностранным языком на достаточно высоком уровне, чтобы заниматься повышением своего профессионального уровня самостоятельно. При этом наиболее доступным способом получения необходимой информации является чтение аутентичных профессионально-ориентированных текстов.

Использование таких текстов поможет обучающимся оперировать основными терминами в области автоматизации технологических процессов, формировать языковые навыки и умения, необходимые для решения профессиональных задач и реального профессионального общения.

1. INDUSTRIAL AUTOMATION

1.1. What is Industrial Automation?

Рис.1. An automated industrial process

1. Read the text about industrial automation and answer the questions.

What …
1. does industrial automation involve?
2. is the goal industrial automation?

Industrial automation refers to the use of control systems and technology to monitor and control industrial processes and equipment.

It involves the use of computers, programmable logic controllers (PLCs), and other devices to automatically perform tasks that were previously done by human operators.

The goal of industrial automation is to increase efficiency, reduce the need for human labor, and improve the quality and consistency of the products being produced.

It is used in a wide variety of industries, including manufacturing, power generation, water and wastewater treatment, oil and gas production, and chemical processing.

Industrial automation systems can include a variety of components, such as sensors and actuators to monitor and control processes, human-machine interfaces (HMIs) to allow operators to monitor and input commands, and communication networks to allow different components to communicate with one another.

Industrial automation is an important tool for improving the efficiency and effectiveness of industrial processes.

2. Complete the table.

Automation Components	Application
1. Sensors and actuators	
2. Human-machine interfaces	
3. Communication networks	

1.2. History of Industrial Automation

1. Read the text about the history of industrial automation.

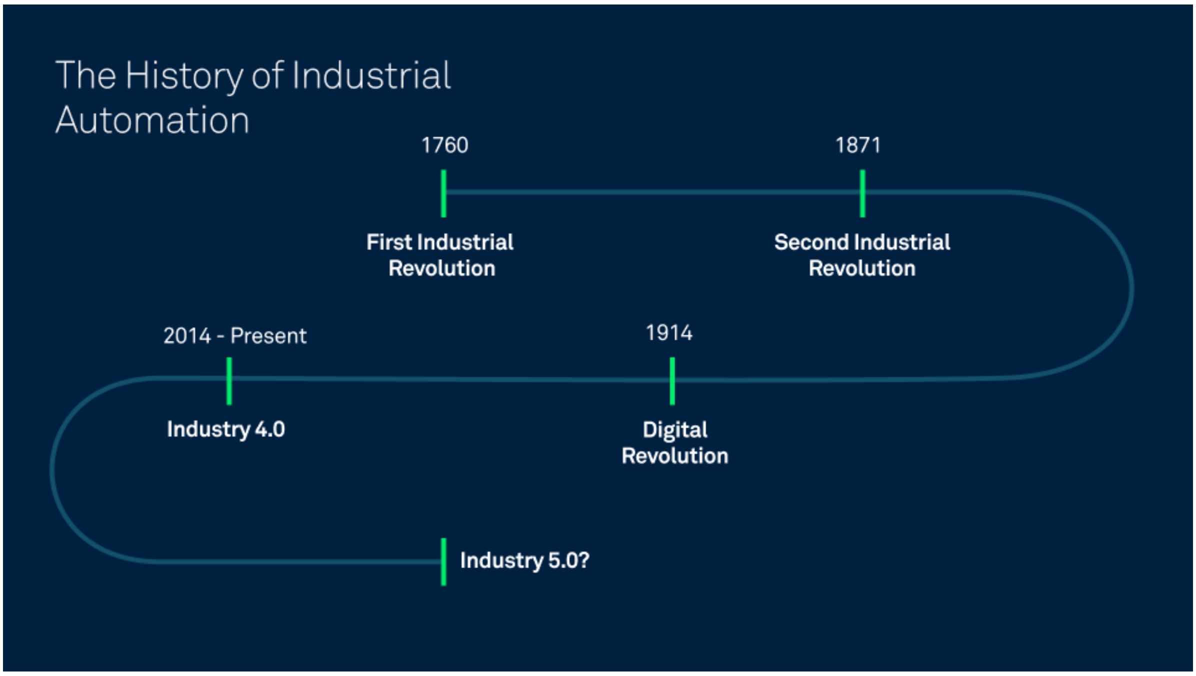

Рис. 2. The history of industrial automation

Even though automation as a separate technology field has emerged only in the twentieth century, it is safe to say that it existed long before, being the foundation of a strive to increase manufacturing efficiencies from the very beginning of human civilization. Biggest manufacturers were creating specialized machinery to improve productivity and precision of work beyond human capabilities for centuries prior to the industrial revolution. And modern-day industrial automation technologies, designed to operate without downtimes and with minimal human intervention for maximum efficiency, are the crowning achievement of this urge to automate.

1. The dawn of automation (300 BC to 1700s AD)

The earliest kinds of automation tools and techniques date as far back in history as 300 BC, invented by the leading civilizations of that time such as Ancient Greece and Persia.

2. First Industrial Revolution (1760 to 1840)

But it wasn't until the mid-19th century when the development of automation technologies truly exploded and gave birth to industrial automation. The creation of the steam engine and first self-driven machines in the seventeenth century led to the need to invent first automatic control systems such as speed control devices, temperature and pressure regulators, etc.

During the period in history known as the Industrial Revolution (or the First Industrial Revolution), which lasted from about 1760 to 1840, a bunch of groundbreaking industrial automation systems and devices emerged. Fully automated spinning mill driven by water power (invented in 1771), automated loom (1745) and punch-card system to program looms (1800), automatic flour mill (1785) are some of the most notable examples of earliest automation in industrial environments.

Industrial automation received a powerful impetus to the development with the invention and rapid adoption of factory electrification early in the twentieth century. Electrification gave birth to a new generation of automation solutions. Such as control and monitoring systems of various kinds, as well as new means of communication (long-distance telephony) and signal processing.

3. Second Industrial Revolution (1871 and 1914)

The period between 1871 and 1914 went down in history as the Second Industrial Revolution, marked by wide adoption of electricity, telegraph networks and railroads worldwide. The combination of these allowed us to achieve a new level of productivity and economic growth.

Being a second step in evolution following mechanization, the term "automation" itself was coined and initially popularized by the U.S. automobile industry. A number of innovative industrial automation products and tools, such as feedback controllers, were introduced and started to gain popularity mainly among the automobile manufacturers in the 1930s. Ford was one of the pioneers in this field, establishing an automation department in 1947 as part of its operations.

4. Digital Revolution (1947 - present)

Another notable period in time when the industrial automation field underwent the next big development spiral was the Third Industrial Revolution, also commonly known as the Digital Revolution. It began in the second half of the 20th century, following the end of the two world wars, and was marked by the shift from mechanical and analogue electronic systems to digital technologies, rapidly evolving thanks to the advancement of computing and communications.

The Third Industrial Revolution is the period we are still living through. Industrial automation naturally flourishes in our time, powered by the introduction of microprocessors, integrated circuit (IC) chips and other elements of advanced computing systems. Communication technologies, such as mobile telephony and the Internet, are also an essential component of the modern-day automation industry.

5. What is Industry 4.0?

The transition from automation history to its present brings us to the concept of the Fourth Industrial Revolution or Industry 4.0, which is inextricably linked to industrial automation. The shift to Industry 4.0 is marked by wide adoption of multiple technologies that are part of the automation field. The most notable and important industrial automation-powering technology fields being AI, robotics, large-scale machine-to-machine communication (M2M), IoT, smart automation and interconnection techniques, and some others.

These technological innovations, along with other more specific solutions and approaches, had a dramatic effect on industrial automation, significantly increasing overall efficiency and productivity to unprecedentedly high levels.

6. What is Industry 5.0?

Industry 5.0 is another major set of industrial concepts, coexisting with Industry 4.0. The concept of Industry 5.0 is mostly focused on the integration of humans working alongside robots and IoT devices in the automated industrial environments of the future. As opposed to Industry 4.0 that was mostly about leveraging robots and smart machines for maximum efficiency and high performance in manufacturing, Industry 5.0 is centered around the human impact and how latest technologies can be leveraged to empower human work and capabilities.

7. Robotics

Robots today are utilized in a wide range of industrial automation applications and processes, including welding, painting, assembling, material handling, packaging, palletizing, product inspection, testing, etc. With the development and adoption of latest tech innovations (mainly machine vision, AI, and Edge computing) the industrial robotics field received a new boost of development, leading to the emergence of increasingly complex and powerful solutions able to take care of a growing number of tasks that were previously considered to be non-automatable and thus, had to be performed by humans.

2. Complete the table.

Date	Event
1771	
1745	
1785	
1800	
1914	
1930s	
1947	

3. Answer the questions.

What
1. is an essential component of the modern-day automation industry?
2. is the concept of Industry 5.0 is mostly focused on?

3. Complete the notes.

A. Industrial automation naturally flourishes in our time, powered by the introduction of …	1. ___________ 2. ___________ **3. ___________**
B. The most notable and important industrial automation-powering technology fields being …	1. ___________ 2. ___________ **3. ___________** **4. ___________** **5. ___________** **6. ___________**
C. Robots today are utilized in a wide range of industrial automation applications and processes, including …	1. ___________ 2. ___________ **3. ___________** **4. ___________** **5. ___________** **6. ___________** **7. ___________** **8. ___________**

1.3. Advantages of Industrial Automation

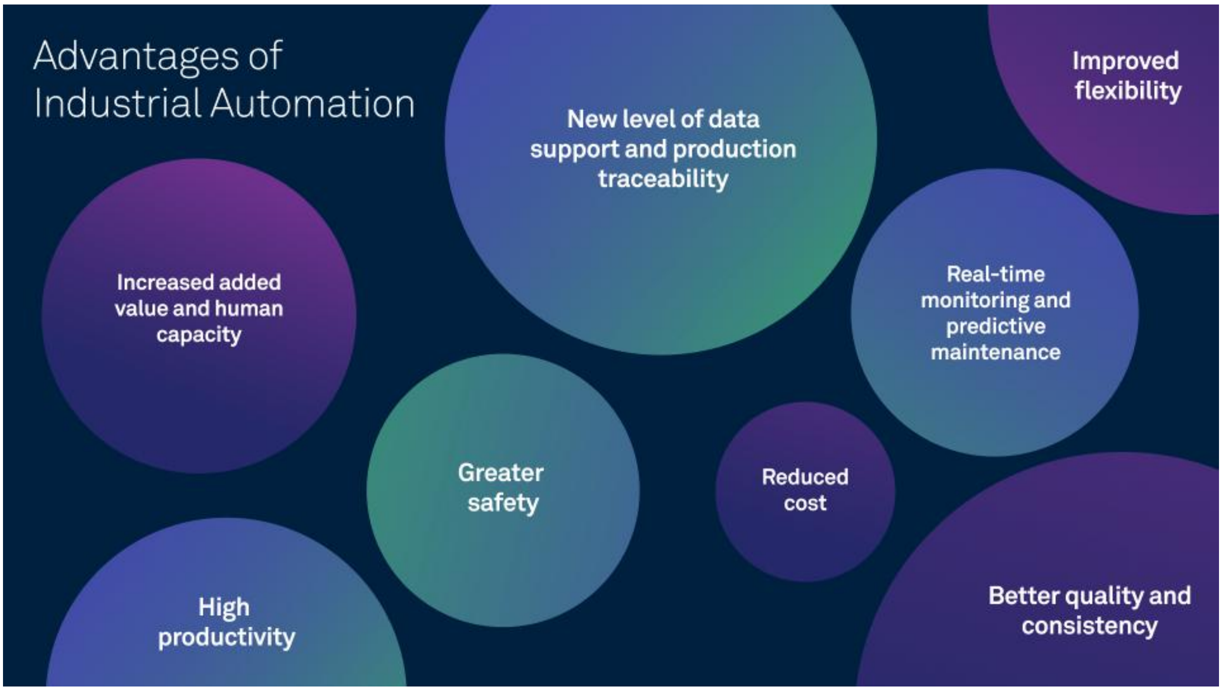

Рис. 3. The advantages of industrial automation

1. Match the columns.

1. real-time monitoring and predictive maintenance	A. высокая производительность
2. new level of data support and production traceability	B. снижение затрат
3. increased added value and human capacity	C. повышение качества и согласованности
4. greater safety	D. бóльшая безопасность
5. improved flexibility	E. повышенная гибкость
6. better quality and consistency	F. повышение добавленной стоимости и укрепление человеческого потенциала
7. reduced costs	G. новый уровень поддержки данных и отслеживаемости производства
8. high productivity	H. мониторинг и прогнозирование в режиме реального времени

2. Read and translate the text about the advantages of industrial automation.

Even though it may seem fairly obvious how utilizing machines, robots and industrial automation solutions adds value and allows companies to reach new, previously unimaginable levels of efficiency and productivity, let's briefly go through the main advantages of industrial automation solutions. They would also be the reasons why this market is growing so rapidly.

1. High productivity

Industrial automation solutions are what enables a continuous mass production today, allowing plants and factories to run 24/7 with minimal downtime. Automation solutions speed up all the processes, reduce assembly times and improve productivity.

2. Reduced costs

The reduction of costs is one of the most substantial business benefits of implementing industrial automation solutions. The introduction of technological innovations, such as robotics, smart machinery, and AI systems, helped to increasingly reduce production costs. Which enhances the value of business assets and makes companies more profitable.

3. Better quality and consistency

Another valuable advantage of implementing automation solutions is the elimination of human error and much greater consistency, leading to better quality of the products as well as this high level staying consistently stable. The average rate in manual processes is 1.15%, whereas industrial automation solutions typically have error rates as low as 0.00001%.

4. Greater safety

Considerably improved work safety and employee protection is another valuable advantage of wide implementation of industrial automation solutions. The minimization of human errors leads to reduction of accidents and injuries, while deploying robots and machines to handle tasks in dangerous and hazardous conditions allows employees to avoid risks and prevent long-term health effects of working in industrial environments.

5. Improved flexibility

Automation solutions are also designed to make the industrial processes and machinery a lot more flexible. The ability to reprogram robots and devices allows organizations to adapt robustly to the fast-changing market demands.

6. Increased added value and human capacity

Designed to liberate employees from having to perform repetitive and mundane work, automation solutions are adding value by allowing humans to concentrate on more complex creative tasks. This is why combining powerful industrial automation solutions with expert human labour also leads to a great increase in human capacity.

7. New level of data support and production traceability

Automated data collection is another crucial component of automation, and Industry 4.0 solutions in particular. Innovative systems able to collect and analyse various kinds of data in real time provide a whole new level of possibilities. They allow companies to improve traceability, reduce waste and continuously optimize all work processes.

8. Real-time monitoring and predictive maintenance

As a final advantage that we would like to highlight, one of the key functions of industrial automation systems is to enable continuous monitoring of all the processes in real-time mode. Thanks to a variety of highly sensitive sensors in modern-day industrial machinery, issues and errors in production processes can be easily detected and addressed. This results in lower maintenance costs and longer life cycles of the equipment, as well as minimization of incidental malfunctions.

1.4. Examples of Industrial Automation

1. Read and translate the text about the examples of industrial automation.

Industrial automation is an incredibly wide field that incorporates a huge variety of techniques and solutions. In order to illustrate this diversity and all-encompassing complexity of industrial automation.

Here are some examples of industrial automation solutions.

- Automated material handling systems
- Packaging machines
- Assembly systems
- Conveyor systems of all kinds
- Machining transfer lines
- Metal fabrication; machining, welding, cutting, etc.
- Paint and coating automation processes
- Quality control and inspection
- Programmable logic controllers of all kinds
- Industrial robots
- Food and beverage processing machines
- Non-destructive testing and inspection
- Automated swage machines
- Robotic drilling and fastening
- Equipment condition monitoring
- Command and data handling
- Industrial transport automation

1.5. Types of Industrial Automation

1. Read the text about the types of industrial automation and answer the questions.

What …

1. is the difference between programmable and flexible automation?

Why …

2. are fixed industrial automation systems typically used in mass production and continuous flow systems?

There are several different types of industrial automation, which can be classified based on the level of control and the degree to which tasks are automated.

1. Fixed (hard) automation

Fixed automation, which is also often referred to as hard or rigid automation, describes the most permanent and application-specific kind of industrial automation systems, which are typically designed to carry out a single process, tasks or a set of tasks and can't be easily adapted for other applications.

Once a fixed automation solution is implemented, it would be challenging to configure it or modify the way it handles processes. This is why fixed industrial automation systems are typically used in mass production and continuous flow systems to automate repetitive non-variational processes of all kinds.

Here are some examples of fixed automation solutions:

- Automated conveyor belts
- Assembly lines in the automotive industry
- Material handling conveyor systems
- Machining transfer lines
- Paint and coating stations
- Welding machines

2. Programmable automation

Programmable automation describes a field of industrial automation solutions that can perform multiple functions and are controllable via commands delivered by the means of entering computer code in the systems. Designed to be more adjustable than fixed tools, programmable automation components are widely used across the industries, but today most commonly can be found in manufacturing operations focused on producing goods in batches. Programmable automation solutions allow customization and adjustment of the manufacturing equipment in accordance with the requirements for each specific product.

Examples of programmable automation are:

- Computer Numerical controlled (CNC) machine tools
- Programmable logic controllers (PLC)
- Machine vision-based quality control systems
- Industrial robots
- Various automobile and machinery manufacturing systems

3. Flexible (soft) automation

Flexible automation, also sometimes referred to as soft automation, includes computer-controlled industrial automation systems and software solutions designed to interconnect, adjust control and measure the sequence of operations of various machines and equipment, as well as human workers.

Here are some examples of flexible automation:

- Robots and robotic devices that can be configured to perform a number of activities
- Movable welding, painting and coating stations
- Configurable material-handling systems
- Other industrial tools that are highly versatile and customizable

Flexible automation is in many ways an extension of programmable automation. The difference between these two types is essentially in the extent of flexibility they provide.

Programmable automation products are typically designed as a way to produce batch quantities of goods of the same kind or perform a range of tasks with low variations.

Flexible automation systems are more universal and adjustable for different kinds of tasks and requirements, hence the name.

4. Integrated automation

Integrated automation, also referred to as totally-integrated automation, describes what is essentially viewed as the next step in the evolution of industrial automation systems. Integrated automation includes solutions designed to centralize and further automate the utilization of tools and management of processes in order to achieve maximum optimization and minimize the need for human involvement.

Here are several examples of integrated automation systems:

- Distributed control system programming
- Computer-aided process planning (CAPP) systems
- Manufacturing Execution Systems (MES)
- Production line control systems
- IT and software environment integration solutions
- Production process test systems
- Automated material handling systems
- Coordinated data management systems
- Automatic storage and retrieval systems

2. Find the words in the text which correspond to these descriptions.

1. describes the most permanent and application-specific kind of industrial automation systems, which are typically designed to carry out a single process, tasks or a set of tasks __________

2. includes solutions designed to centralize and further automate the utilization of tools and management of processes in order to achieve maximum optimization and minimize the need for human involvement __________

3. includes computer-controlled industrial automation systems and software solutions designed to interconnect, adjust control and measure the sequence of operations of various machines and equipment __________

4. describes a field of industrial automation solutions that can perform multiple functions and are controllable via commands delivered by the means of entering computer code in the systems __________

2. INDUSTRIAL CONTROL SYSTEMS

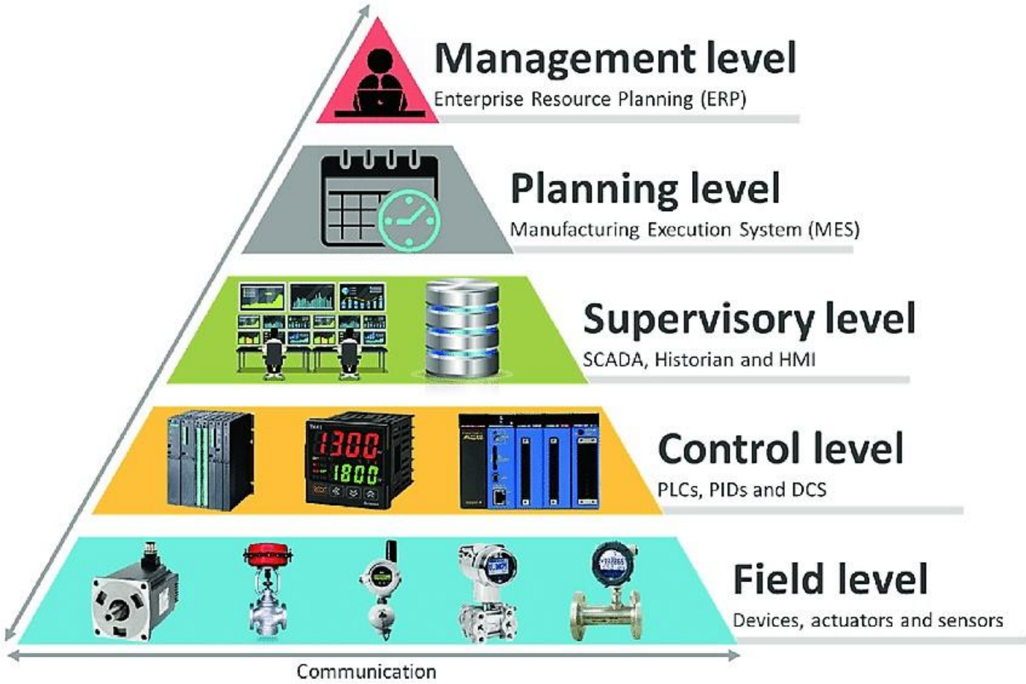

Рис. 4 The automation pyramid of a typical industrial plant

1. Read the text about industrial control.

One of the technologies that are fundamental to industrial automation are industrial control systems (ICSs).

Industrial control systems are a wide technology field that incorporates a number of control systems and related software tools used to automate and manage various industrial processes.

Control systems can vary in size and complexity, ranging from rather simple controllers to comprehensive SCADA systems, able to manage manufacturing and other industrial processes across the technological layers and geographical locations.

The most common types and components of industrial control systems are:

1. SCADA systems

Supervisory control and data acquisition (SCADA) is a term for complex industrial automation control systems that use a combination of components, such as computers, graphical user interfaces and networked data communications, to provide a high level of automated controls and monitoring of processes.

2. Programmable logic controllers (PLC)

Programmable logic controllers are modular devices of various sizes that include a microprocessor with the appropriate number (ranging from dozens to hundreds and even thousands) of inputs and outputs (I/O). They are used to interconnect different kinds of industrial solutions in one network, enabling automated control and monitoring of industrial machinery and processes.

3. Distributed control systems (DCS)

Distributed control systems (DCSs) are serving a similar purpose with PLCs, providing controls, monitoring and management for large industrial equipment. The difference is that in DCSs controller functions and field connection modules are not centralized and instead are distributed throughout the system. This feature allows these industrial automation solutions to cover even large-scale processes while also enabling easy interfacing with other computer systems and configuration of equipment.

4. Human-machine interfaces (HMI)

A human-machine interface is a component of industrial automation control systems, a user interface or dashboard that allows humans to interact with machines, systems and devices, as well as monitoring the status of the processes.

5. Proportional-integral-derivative controllers (PID)

PID control is a way of driving a system towards a position or level that is specified as desirable. Proportional-integral-derivative controllers are programmed in a specific way to be able to use closed-loop control feedback to keep the actual output from a process as close to the target or setpoint output as possible. They are mostly used in industrial automation systems for continuously modulated control of crucial process variables such as flow, pressure, speed, temperature, etc.

6. Programmable automation controllers (PAC)

Programmable automation controllers are similar to PLCs, but more complex. Typically, they have a number of microprocessors that increase their computing power and allow PACs to control multiple processes and perform various tasks simultaneously.

7. Discrete controllers

Discrete controllers are some of the simplest kinds of industrial automation control devices. They are mostly used for basic on and off controls in devices such as thermostats or timers.

2. Complete the notes.

A. Supervisory control and data acquisition is a term for complex industrial automation control systems that use a combination of components, such as …	1. ___________ 2. ___________ **3. ___________**
B. Programmable logic controllers are modular devices of various sizes that include …	1. ___________
C. Distributed control systems (DCSs) are serving a similar purpose with PLCs, providing …	1. ___________ 2. ___________

	3. ___________
D. A human-machine interface is a component of industrial automation control systems, a user interface or dashboard that allows humans to interact with …	1. ___________ 2. ___________ **3. ___________**
E. Proportional-integral-derivative controllers are mostly used in industrial automation systems for continuously modulated control of crucial process variables such as …	1. ___________ 2. ___________ **3. ___________** **4. ___________**
F. Programmable automation controllers have a number of microprocessors that increase their computing power and allow PACs to …	1. ___________ 2. ___________
G. Discrete controllers are mostly used for basic on and off controls in devices such as	1. ___________ 2. ___________

2.1. SCADA (Supervisory Control and Data Acquisition)

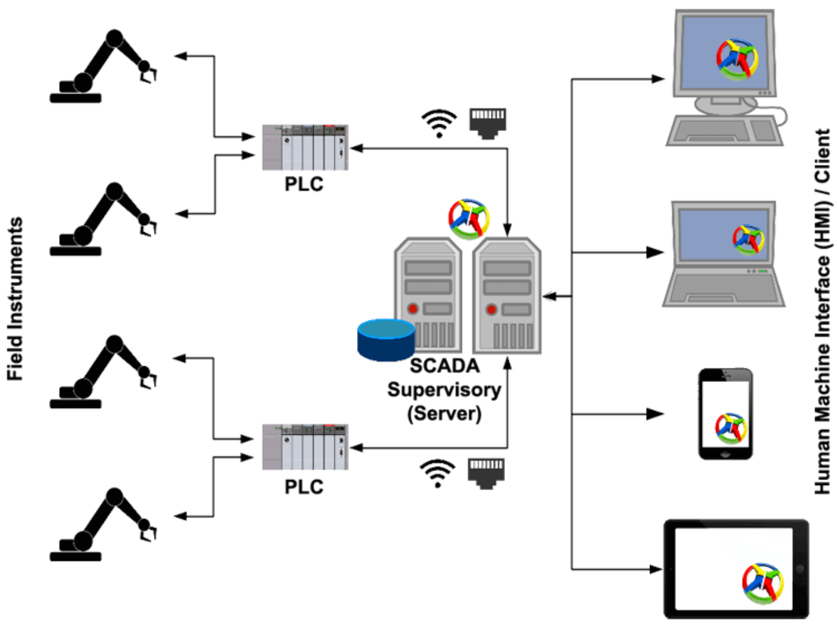

Рис.5 SCADA system

1. Read the text about SCADA systems and answer the questions.

What …
1. is SCADA?
2. is the difference between SCADA and HMI?

SCADA/HMI is one of the most important concepts related to the automation industry.

Generally speaking, SCADA/HMI is a wide category of software architecture used to build industrial automation control systems that rely on networked data and have a graphical user interface as a way to provide performance monitoring and control capabilities to human operators.

SCADA (supervisory control and data acquisition) is a term for all kinds of complex industrial control systems that use a combination of components - such as computers, graphical user interfaces and networked data communications - to provide a high level of automated controls and monitoring of processes.

HMI (human-machine interface) is essentially a component of larger industrial control systems such as SCADA, a user interface or dashboard that allows humans to interact with machines, systems and devices, as well as to monitor the status of the processes.

Industrial automation solutions and the process control were increasingly handled by electronic systems since the early 1960s. The term SCADA emerged in the mid-1970s, describing a universal concept of automated control, data acquisition and remote-access to a variety of local control modules.

1. First generation of SCADA (monolithic systems)

First SCADA solutions provided by industrial automation suppliers were based on monolithic mainframe systems with very limited networking capabilities. Unable to communicate with each other, they were used as physically isolated standalone systems.

2. Second generation of SCADA (distributed systems)

Second generation of SCADA arrived in the early 1980s, utilizing some of the technological innovations that emerged at the time. Specifically, the second generation of SCADA solutions was able to advance thanks to local area network (LAN) technology and small sized MTU computers. Second generation SCADA were distributed systems able to communicate with each other and allow multiple stations to exchange data in real time. They also became smaller in size and more affordable.

3. Third generation of SCADA (networked systems)

Further evolution of networking technologies in the late 1980s and early 1990s brought us the third generation of SCADA systems. They extended the integration of LAN networks, making it possible to establish SCADA control over multiple geographical locations, with several distributed SCADA systems working under the supervision of a single and centralized master SCADA system.

4. Fourth generation of SCADA (Internet of things systems)

Finally, the fourth and current generation of SCADA came in the 2000s, using the latest technological advances in industrial automation engineering. Specifically, SCADA solutions of the fourth generation utilize cloud computing, IoT, and WAN protocols, such as Internet Protocol (IP), available thanks to the introduction of an open system architecture. These innovations allowed SCADA systems to enable real-time communication of different components through an Ethernet connection, easier maintenance, high level of integration and reduced costs.

2. Complete the table.

Time period	Event
the early 1960s	
the mid-1970s	
the early 1980s	
the early 1990s	
the 2000s	

2.2. PLC (Programmable Logic Controller)

Рис. 6 Programmable logic controller

1. Read the text about programmable logic controllers and answer the questions.

What …
1. are programmable logic controllers?
2. is the application of PLC in steel industry?

Programmable logic controllers or just programmable controllers are modular industrial computers used for the control of various automated processes, machines, robotic devices and basically any activity that requires reliability and control.

PLCs can come in various sizes depending on the specific needs. They typically include a microprocessor with the appropriate number of inputs and outputs (I/O), ranging from dozens to hundreds and even thousands. I/O are used to interconnect other components, such as other PLCs and SCADA systems, in one network.

PLC control system is used to control and adjust many parameters in the process of high strength steel production. These include quenching temperature and tempering temperature, cooling rate in the actual production process, and many more. The successful application of PLC control system in the production line of high strength steel greatly improves the quality and production of high strength steel products, makes production lines stable, control mechanism flexible, accurate and saves huge production costs.

Задание 2. Complete the notes.

A. PLC control system is used to control and adjust many parameters in the process of high strength steel production. These include …	1. ___________ 2. ___________ **3. ___________**
B. The successful application of PLC control system in the production line of high strength steel greatly improves …	1. ___________ 2. ___________ **3. ___________** **4. ___________**

2.3. Actuators

1. Read the text about the types of actuators and answer the question.

What …
1. is an actuator?

An actuator is a device that converts any source of energy into physical motion movement. It receives an energy source and then, it converts that into a motion that moves the object on which the actuator is mounted.

In industrial automation applications, take a simple example of a valve. The actuator is a mechanical or electro-mechanical device, which when connected with the valve; moves the valve through the mechanical force applied by the actuator.

Actuators are chosen depending on the power source available, motion required, accuracy required and the safety and environmental concerns taken into account.

There are several types of actuators used in industrial applications

1. Hydraulic Actuators

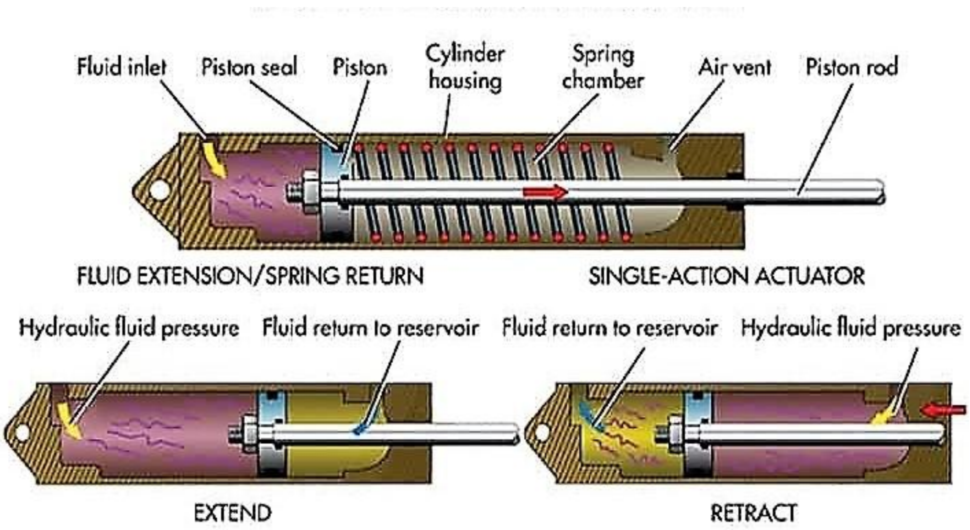

Рис.7. Hydraulic linear actuator

The hydraulic actuator uses a hydraulic fluid (for example, oil) to energize the actuator and cause motion. They have a hollow cylindrical tubing or fluid motor, which generates pressure to cause motion. A piston is suspended at the center of the actuator. When the fluid enters the bottom of the cylinder, a large pressure is formed by the fluid, which forces the piston to move and slide. This piston then moves the device with which the actuator is connected. The piston moves in the direction opposite to the spring connected at the other side (upper part of the cylinder) and the applied pressure moves the device.

2. Pneumatic Actuators

The pneumatic actuator uses compressed air as a source of energy for moving the device. Similar to hydraulic actuators, compressed air enters the cylinder beneath which exerts pressure on the piston and moves it. Pneumatic actuators are very precise and accurate of all types of actuators.

3. Electrical Actuators

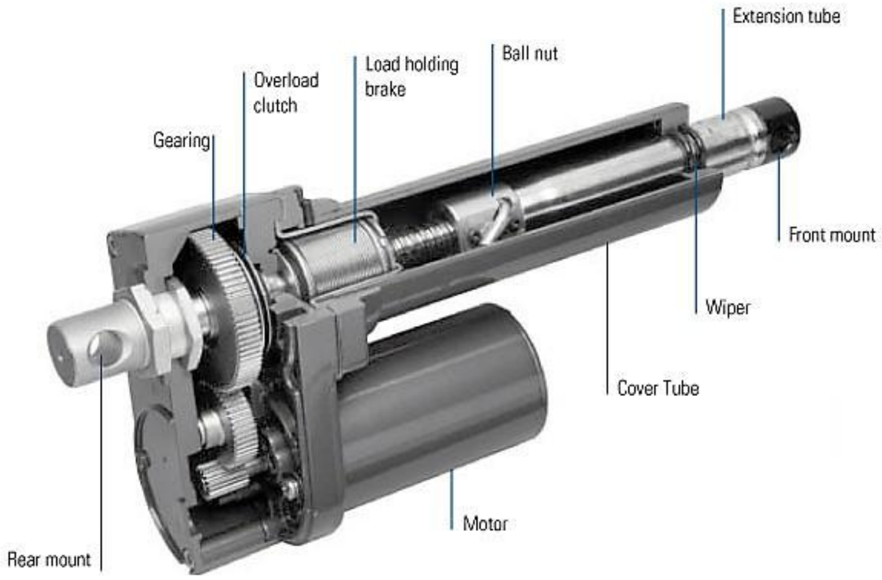

Рис.8. Electrical actuator

The electrical actuator converts electrical energy into mechanical energy. Typically, a motor is used as a power for electrical energy into mechanical torque. Similar to pneumatic actuators, electrical actuators are accurate and precise. They are widely used in all types of industrial machines.

4. Thermal Actuators

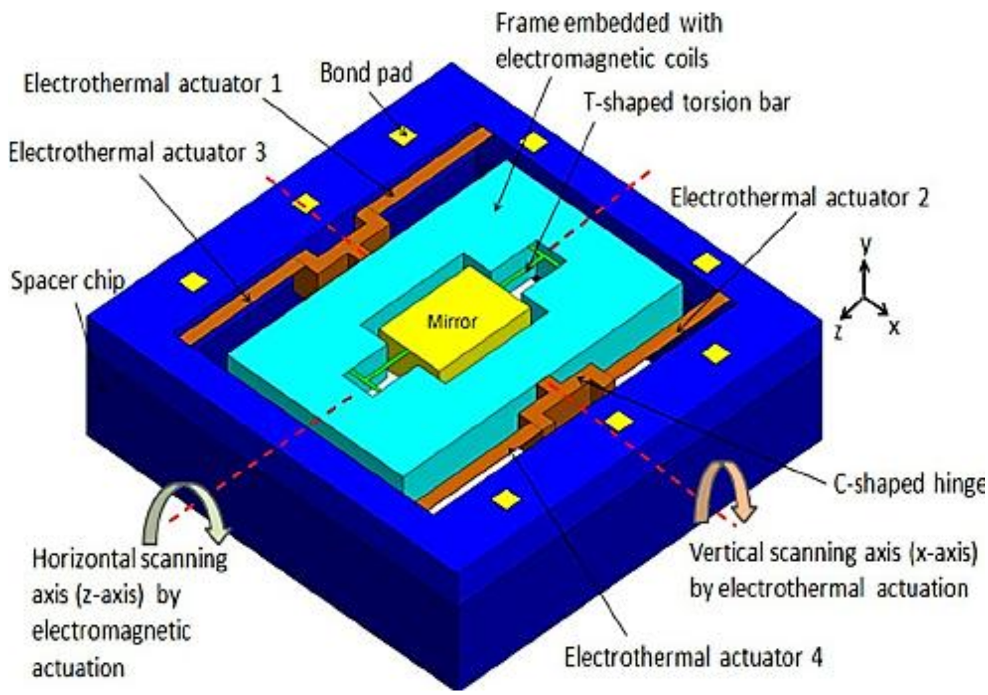

Рис.9. Thermal actuator

The thermal actuators are relatively simpler types of actuators. It uses thermal energy as a source of energy for movement. When the temperature rises, the temperature-sensitive material begins to expand exerting pressure on the piston.

When the temperature drops, the material begins to compress and starts pulling the piston back to its normal position.

Depending on the motion that actuators provide to the valves, two types of actuator mechanisms are available.

1. Linear Actuators

As the name suggests, the linear actuators produce linear motion (straight line motion). They are used in applications where lifting, tilting, pushing, and pulling are needed. Most industrial systems have equipment that moves in a straight line to perform a task. Such devices require linear actuators for their working. Linear actuators can be electrical, pneumatic, or hydraulic.

2. Rotary Actuators

Rotary actuators provide circular movement as compared to linear actuators. Most of the rotating devices and equipment in industrial machinery use rotary actuators for their motion. Similar to linear actuators, rotary ones too can be electrical, hydraulic, or pneumatic.

2. Find the words in the text which correspond to these descriptions.

1. provide circular movement as compared to linear actuators __________
2. produce linear motion __________
3. uses thermal energy as a source of energy for movement __________
4. converts electrical energy into mechanical energy __________
5. uses compressed air as a source of energy for moving the device _________
6. uses a hydraulic fluid to energize the actuator and cause motion _________

2.4. Sensors

1. Read and translate the text about sensors.

Sensors/Detectors/Transducers are electrical, opto-electrical, or electronic devices composed of specialty electronics or otherwise sensitive materials, for determining if there is a presence of a particular entity or function.

Many types of sensors, detectors, and transducers are available including those for detecting a physical presence such as flame, metals, leaks, levels, or gas and chemicals, among others.

Some are designed to sense physical properties such as temperature, pressure, or radiation, while others can detect motion or proximity.

They operate in a variety of manners depending on the application and may include electromagnetic fields, or optics, among others. Many applications over a wide range of industries use sensors, detectors, and transducers of many kinds to test, measure, and control various processes and machine functions.

With the advent of the Internet of Things (IoT), the need for sensors as a primary tool to provide enhanced automation is increasing.

2.4.1. Temperature Sensors

1. Read the text about the temperature sensors and answer the questions.

What …
1. are temperature sensors?
2. do thermocouples measure?
3. are most thermocouples covered with?
4. are infrared thermometers?
5. do vibrating wire temperature sensors consist of?

Temperature Sensors/Detectors/Transducers are electronic devices that detect thermal parameters and provide signals to the inputs of control and display devices. A temperature sensor typically relies on an RTD or thermistor to measure temperature and convert it to an output voltage.

Key specifications include sensor/detector type, maximum and minimum measurable temperatures, as well as the dimensions of diameter and length. Temperature sensors are used to measure the thermal characteristics of gases, liquids, and solids in many process industries and are configured for both general- and special-purpose uses.

Temperature sensors generally fall into one of these primary types:

- Thermocouples
- RTDs (Resistance Temperature Detectors)
- Thermistor Temperature Sensors
- Semiconductor Temperature Sensors
- Thermometers
- Vibrating Wire Temperature Sensors

The majority of these (the exception being infrared temperature sensors) are contact sensors, meaning that the sensor or probe must physically contact the object whose temperature is being measured in order to take a reading. Infrared sensors measure the radiated thermal energy from the object to establish its temperature and therefore are non-contact sensors.

With the exception of some forms of thermometers, most temperature sensors are designed to generate an electrical signal output that is used to establish the value of temperature.

1. Thermocouples

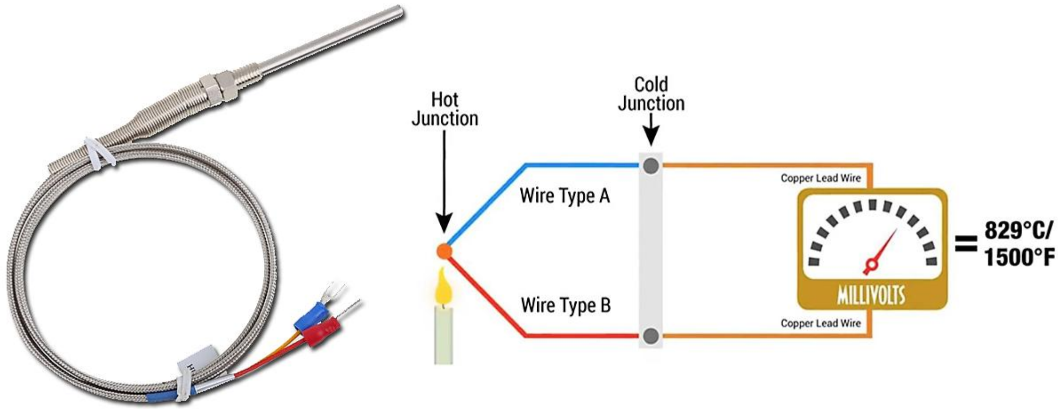

Рис. 10. Thermocouple

Thermocouples measure temperature by making use of a probe constructed by joining two different metals together to form a junction at one end and to which a voltmeter is connected at the other end. The end of the probe called the hot junction (where the metals are joined) is used to contact the object whose temperature is being measured, while the other end of the probe called the cold junction is sitting at a reference temperature. A potential difference in Volts recorded on the voltmeter will be present whose value proportionally represents the temperature difference between the hot and cold junctions of the thermocouple.

Most thermocouples are covered in a protective sheath to isolate the metals from the ambient temperature and to provide some degree of protection against corrosion. Sheath materials include 1316 stainless steel, 304 stainless steel, or Inconel 600 as examples.

Depending on the specific metals used to fabricate the thermocouple, the devices are assigned a letter type such as Type J, K, T, N, E, B, R, or S. Each of these types has specific characteristics relating to its temperature range, vibration resistance, chemical compatibility, and applications. Base metal thermocouples are types J, K, T, & E, and are the most common. So-called Noble metal thermocouples are types R, S, and B. Table 1 below lists the various types of thermocouples and their metal composition.

Таблица 1

Thermocouple types and metal composition

Thermocouple Type	Metal Composition
Type J	Iron/Constantan
Type K	Nickel-Chromium / Nickel-Alumel
Type T	Copper/Constantan
Type E	Nickel-Chromium/Constantan
Type N	Nicrosil / Nisil
Type S	Platinum Rhodium - 10% / Platinum
Type R	Platinum Rhodium -13% / Platinum
Type B	Platinum Rhodium - 30% / Platinum Rhodium - 6%

Thermocouple junctions are available in several styles, the most common being grounded thermocouples. In this style of thermocouple, both the metal wires and the sheath are welded together to form a single junction at the probe tip. This leads to very rapid response times because of the good thermal connection, the tradeoff is a greater susceptibility to electrical interference as the sheath and thermocouple wire are bonded together providing an increased pathway into the device. Ungrounded thermocouples do not have the sheath welded to the thermocouple wires but are isolated using an insulator. So-called bare wire thermocouples expose the thermocouple wire directly at the probe, which provides rapid response times for the device but also increases the risk of corrosion and device degradation resulting from the exposed junction. An uncommon ungrounded thermocouple is one in which a dual thermocouple arrangement is used with the sheath isolated from the thermocouple wires and each thermocouple is isolated from the other as well. For more on these sensors, check out our guide on types of thermocouples.

2. RTDs (Resistance Temperature Detectors)

Resistance Temperature Detectors, abbreviated RTDs, are temperature sensors that make use of the change in the electrical resistance that occurs in a conductive material to establish a value for the temperature. Conductors of electricity, such as metal, exhibit electrical resistance that is a measure of the relative ease with which electrical current will flow through the conductor when a given voltage or potential difference is applied. As the temperature changes, the electrical resistance, which is measured in Ohms, also changes, with higher temperatures resulting in an increase in resistance. RTDs consist of a resistive element through which a small electrical current is passed, typically in the range of 1-5 milliamps, and the resistance is measured. Any temperature changes will alter the value of the resistance measured, which can be equated to a temperature value by knowing the properties of the materials used for the resistive element. Platinum is a metal of choice used in RTDs owing to the fact that it is highly stable, is chemically inert, can function over a large range of temperature, and exhibits a very strong linear relationship between its resistance and temperature. This last characteristic simplifies the process of converting electrical resistance into temperature readings. Other choices for resistive elements in RTDs include Nickel and Copper. The material used in RTDs is specified by their temperature coefficient of resistance (TCR), which is a measure of how the electrical resistance of the material changes with respect to a one-degree change in temperature. Metals and electrically conductive materials exhibit a positive value of TCR, while semiconductors and non-metallic substances would exhibit a negative TCR, meaning that they become less resistive with increases in temperature.

RTDs are built typically constructed as either thin-film or wire wound type. Film type RTDs use platinum that is plated onto a ceramic plate which is encapsulated in glass, while wire-wound RTDs use platinum wire wound around a ceramic core and sealed with glass encapsulant. Different sensor wiring configurations are used with RTDs, generally 2-wire, 3-wire, or 4-wire. Using 2 wires provides a simple arrangement but suffers from accuracy given that the resistance of the wire leads cannot be isolated from the measured resistance value. The 3-wire configuration allows for two separate measurements to be made, allowing the impact of the wire lead resistance to be subtracted out from the total resistance measurement, providing a net resistance value. The 4-wire configuration allows for direct measurement of the sensor resistance to be made, excluding the impact of the lead wires. A Wheatstone bridge arrangement is typically used to perform the resistance measurements associated with RTDs to establish temperature values.

3. Thermistor Temperature Sensors

Thermistors, a term derived from a concatenation of the words THERMally sensitive resISTORS, are temperature sensing devices that make use of the property of the change in electrical resistance that occurs with temperature as a means of providing a reading for the temperature value. These passive devices exhibit a precise change in their electrical resistance that is proportional to the changes in temperature of the device. There are two primary types of thermistors – Negative Temperature Coefficient (NTC) thermistors and Positive Temperature Coefficient (PTC) thermistors.

Negative Temperature Coefficient (NTC) thermistors are ones whose resistance decreases with an increase in temperature, while Positive Temperature Coefficient (PTC) thermistors exhibit an increase in electrical resistance with increasing temperature. The NTC thermistor is most frequently used in temperature sensing applications, while the PTC thermistor has uses in electrical circuit protection applications such as limiting the inrush current or surge protection for a circuit or device.

Thermistors are available in a wide variety of materials, packages, and forms including disk, chip, bead, or rod depending on the need for operating temperature range and response time. They can be packaged or encapsulated in epoxy resin, glass, baked-on phenolic, or painted. Generally, they are small, low-cost temperature sensors that offer fast response times over a limited operating temperature range. They also have a larger change in resistance value per unit change in temperature, therefore offering a potential for more sensitivity and accuracy in readings. Limitations of thermistors are that they feature non-linear temperature response curves, unlike RTDs, and are subject to self-heating if the excitation currents are too high. They also have a limited temperature range can become unstable at higher temperatures. The temperature curves also vary from manufacturer to manufacturer, complicating interchangeability.

Applications for thermistors include aerospace, appliances, automotive, communications, HVAC, instrumentation, medical, military, and refrigeration.

4. Semiconductor Temperature Sensors

Semiconductor temperature sensors, sometimes called solid state temperature sensors, are temperature sensors that are fabricated into Small Outline Integrated Circuit (SOIC) or other package styles such as TO-223 that can then be mounted onto printed circuit boards (PCBs). The devices make use of semiconductor diodes or transistors whose voltage-current characteristics have temperature dependence.

The main types of semiconductor temperature sensors include:

- Voltage Output Temperature Sensors
- Current Output Temperature Sensors
- Digital Output Temperature Sensors

- Resistance Output Temperature Sensors
- Diode Temperature Sensors

These type of temperature sensors have fairly good linearity to their output with temperature and can provide reasonable accuracy in readings over their range provided that they are correctly calibrated. They do have limited temperature range, however, and are not suitable for the measurement of high temperatures.

5. Thermometers

Thermometers are the oldest and most familiar form of temperature sensor in use industry and households. Thermometers come in different types, one of the most recognizable of these being the liquid thermometer. This type of thermometer consists of a tube typically made of glass containing a fluid such as alcohol or mercury, whose volume changes proportionately with temperature. The tube is secured to a scale which has been calibrated to show the temperature directly in either the Fahrenheit or Celsius (centigrade) scales. Different varieties such as handheld, pocket, and black or red-colored reading liquid are available.

Another thermometer variety makes use of a bi-metal coil which is attached to a faceplate with a needle dial and graduations for the temperature reading. Each metal used in the bimetallic strip has a different thermal coefficient of expansion with temperature, which results in the coil unwinding and winding as the temperature changes. This rotary movement positions the needle against the faceplate to reflect the current temperature reading.

Infrared thermometers are non-contact electronic thermometers that display a digital reading of temperature as opposed to reading an analog scale. The devices sense the level of black body radiation emitted by the object and convert that radiation level into a reading of temperature. The thermometer focuses the energy through a lens onto a thermopile which produces an electrical output that is proportionate to the amount of heat absorbed. Infrared thermometers can record and store values, useful to safe time and make procedures more efficient. Infrared thermometers are used to record patient temperatures in areas such as the tympanic membrane (eardrum) which is too sensitive for the use of a standard contact thermometer. They are also valuable for firefighters to use as they can sense the temperature of walls to assess how fire has spread without needing to tear the wall apart to physically inspect it or check for hot spots in a burning building. The fact that the unit can take readings on a non-contact basis means that the devices are also useful in applications where direct contact would be hazardous to personnel or equipment.

While thermometers are useful, they are limited by the fact that many models require manual operation, are slow to record and recover from a reading, are not extremely accurate, and have a limited range in temperature over which readings may be made. In spite of these limitations, there are many different models of thermometers on the market and they find application in a variety of uses, including:

- Agricultural & Dairy
- Air Conditioning
- Appliances

- Aquariums
- Baking & Cooking
- Boilers & Furnaces
- Breweries & Distilleries
- Candy Making
- Canning
- Confectionary
- Fruit Testing
- Greenhouses
- Heating Pads
- Laboratories
- Medical and Clinical patient fever monitoring
- Power Plants
- Railroad Refrigerator Cars & Cold Storage
- Swimming Pools (stationary and floating)
- Veterinary

6. Vibrating Wire Temperature Sensors

Vibrating wire temperature sensors consist of a magnetic, high tensile strength wire that is stretched between and whose ends are attached to a dissimilar metal. The tension that exists in the wire is directly impacted by temperature. As the temperature changes, the wire tension changes, which alters the natural resonant frequency of the suspended wire. The frequency is proportional to temperature and can be used to establish the temperature of the sensor. Vibrating wire temperature sensors are used for measuring the temperature of water, soil, and concrete structures.

2. Complete the table.

Temperature Sensors	Application
1. Resistance Temperature Detectors	
2. Thermistor Temperature Sensors	
3. Semiconductor Temperature Sensors	
4. Thermometers	
5. Vibrating Wire Temperature Sensors	

2.4.2. Pressure Sensors

1. Read the text about the pressure sensors and answer the questions.

What …
1. are pressure sensors?
2. is an aneroid barometer?
3. is a manometer?

Pressure Sensors/Detectors/Transducers are electro-mechanical devices that detect forces per unit area in gases or liquids and provide signals to the inputs of control and display devices. A pressure sensor/transducer typically uses a diaphragm and strain gage bridge to detect and measure the force exerted against a unit area.

Key specifications include sensor function, minimum and maximum working pressures, full-scale accuracy, along with any features particular to the device. Pressure sensors are used wherever information about the pressure of a gas or liquid is needed for control or measurement.

Pressure sensors find wide applications in a range of markets including medical, general industrial, automotive, HVAC, and energy, to name a few. It is important to realize that while these devices sense pressure, they can be used to perform other important measurements since there is a relationship between a recorded pressure and the value of these other parameters.

In industrial process applications, pressure sensors can detect when a filter has become clogged in a process flow by assessing the difference between the influent and effluent pressures.

The most common types of pressure sensors.

1. Aneroid Barometer Sensors

An aneroid barometer device is composed of a hollow metal casing that has flexible surfaces on its top and bottom. What is the barometric pressure sensor working principle? Atmospheric pressure changes cause this metal casing to change shape, with mechanical levers augmenting the deformation in order to provide more noticeable results. The level of deformation can also be enhanced by manufacturing the sensor in a bellows design. The levers are usually attached to a pointer dial that translates pressurized deformation into scaled measurements or to a barograph that records pressure change over time. Aneroid barometer sensors are compact and durable, employing no liquid in their operations. However, the mass of the pressure sensing elements limits the device's response rate, making it less effective for dynamic pressure sensing projects.

2. Manometer Sensors

A manometer is a fluid pressure sensor that provides a relatively simple design structure and an accuracy level greater than that afforded by most aneroid barometers. It takes measurements by recording the effect of pressure on a column of liquid. The most common form of the manometer is the U-shaped model in which pressure is applied to one side of a tube, displacing liquid and causing a drop in fluid level at one end and a correlating rise at the other. The pressure level is indicated by the difference in height between the two ends of the tube, and measurement is taken according to a scale built into the device.

The precision of reading can be increased by tilting one of the manometer's legs. A fluid reservoir can also be attached to render the height decreases in one of the legs insignificant. Manometers can be effective as gauge sensors if one leg of the U-shaped tube vents into the atmosphere and they can function as differential sensors when pressure is applied to both legs. However, they are only effective within a specific pressure range and, like aneroid barometers, have a slow response rate that is inadequate for dynamic pressure sensing.

3. Bourdon Tube Pressure Sensors

Although they function according to the same essential principles as aneroid barometers, bourdon tubes employ a helical or C-shaped sensing element instead of a hollow capsule. One end of the bourdon tube is fixed into connection with the pressure, while the other end is closed. Each tube has an elliptical cross-section that causes the tube to straighten as more pressure is applied. The instrument will continue to straighten until fluid pressure is matched by the elastic resistance of the tube. For this reason, different tube materials are associated with different pressure ranges. A gear assembly is attached to the closed end of the tube and moves a pointer along a graduated dial to provide readings. Bourdon tube devices are commonly used as gauge pressure sensors and as differential sensors when two tubes are connected to a single pointer. Generally, the helical tube is more compact and offers a more reliable performance than the C-shaped sensing element.

4. Vacuum Pressure Sensors

Vacuum pressure is below atmospheric pressure levels, and it can be challenging to detect through mechanical methods. Pirani sensors are commonly used for measurements in the low vacuum range. These sensors rely on a heated wire with electrical resistance correlating to temperature. When vacuum pressure increases, convection is reduced, and wire temperature rises. Electrical resistance rises proportionally and is calibrated against pressure in order to provide an effective measurement of the vacuum.

Ion or cold cathode sensors are commonly used for higher vacuum range applications. These instruments rely on a filament that generates electron emissions. The electrons pass onto a grid where they may collide with gas molecules, thereby causing them to be ionized. A charged collection device attracts the charged ions, and the number of ions it accumulates directly corresponds to the number of molecules within the vacuum, thus providing an accurate reading of the vacuum pressure.

5. Sealed Pressure Sensors

Sealed pressure sensors are used when it is desired to obtain a pressure measurement relative to a reference value (such as atmospheric pressure at sea level), but where it is not possible to have the sensor directly open to that reference pressure. For example, on submersible vehicles, a sealed pressure sensor may be used to establish the depth of the vehicle by measuring the ambient pressure and comparing it to atmospheric pressure that is available in the sealed device.

2. Complete the table.

Pressure Sensors	Application
1. Aneroid Barometer Sensors	
2. Manometer Sensors	
3. Bourdon Tube Pressure Sensors	
4. Vacuum Pressure Sensors	
5. Sealed Pressure Sensors	

2.4.3. Humidity Sensors

1. Read the text about the humidity sensors and answer the questions.

What …
1. are humidity sensors?
2. do capacitive humidity sensors provide?
3. is a resistive humidity sensor?
4. are thermal conductivity humidity sensors suitable for?

Humidity Sensors/Detectors/Transducers are electronic devices that measure the amount of water in the air and convert these measurements into signals that can be used as inputs to control or display devices. Key specifications include maximum response time and minimum and maximum operating temperatures. Humidity sensors play a key role in many systems and applications to help measure the level of humidity so that it can be controlled and changed as needed.

Humidity sensors are used in many industrial, commercial, and consumer applications. Moisture analyzers contain humidity sensors and provide the means for measuring and controlling humidity and moisture conditions in production facilities as part of process control applications. Having an understanding of the density of the air at standard temperature and pressure conditions is important when using moisture analyzers in order to make precise measurements with these instruments.

In HVAC systems, humidity sensors are critical to maintaining proper climate conditions with energy efficiency. They are used in medical applications such a incubators and neonatal intensive care facilities. Ground and airborne weather stations use humidity sensors to track environmental conditions and assist with weather forecasting. The automotive industry makes use of humidity sensors to control cabin ventilation and to keep windshields from fogging. Food processing quality depends directly on accurate measurement of humidity levels for pasta and other food products such as baked goods. The semiconductor industry carefully monitors climatic conditions in production operations for integrated circuits as yields can be impacted should conditions fall outside of set ranges.

There are three primary types of humidity sensors employed which are defined around what approach is used to sense humidity and deliver an electrical signal that can be used to establish the value. These types of humidity sensors include:

- Capacitive humidity sensors
- Resistive humidity sensors
- Thermal conductivity humidity sensors

The first two of these are designed to sense relative humidity (RH) - the last one is used to detect absolute humidity (AH). Relative humidity sensors usually also contain a thermistor to establish the temperature reading.

1. Capacitive humidity sensors

Capacitive humidity sensors as implied by their name make use of a capacitor, which consists of two electrode layers between which is a dielectric material. In the case of capacitive humidity sensors, the dielectric material is one that is hygroscopic, meaning that it is capable of absorbing moisture from the surrounding air. A commonly used dielectric for capacitive humidity sensors is a polymer film, whose dielectric constants are somewhere around 2-15.

In the absence of moisture, the capacitance (the ability to store electric charge) is determined by the geometry of the capacitor and the permittivity (dielectric constant) of the dielectric material. The dielectric constant of water vapor at normal room temperature is around 80, much larger than that of the dielectric material. As the dielectric material absorbs water vapor from the surrounding air, the dielectric constant increases, which increases the capacitance of the sensor. There is a direct relationship between the relative humidity in the air, the amount of moisture contained in the dielectric material, and the capacitance of the sensor. The change in the dielectric constant is directly proportional to the value of the relative humidity. By measuring the change in capacitance (dielectric constant), the relative humidity level can be established. The sensor is one element in a chain that also includes a probe, cable, and an electronics unit (signaling circuit) that takes the signal from the sensor and produces an output signal conditioned for the desired use and application.

Capacitive humidity sensors provide stable readings over time and are capable of detecting a wide range in relative humidity. They also provide near linearity with signal amplitude over the range of humidity. They are limited by the distance between the sensor and the signaling circuit.

2. Resistive humidity sensors

A resistive humidity sensor, sometimes referred to as a hygristor or an electrical conductivity sensor, is one that makes use of the change in the resistivity measured between two electrodes to establish a value of relative humidity. The device contains a hygroscopic conductive layer in the form of a polymer humidity sensing film that is mounted on a substrate. The conductive film contains a set of comb-like electrodes, usually deposited from a noble metal like gold, silver, or platinum that are laid out in an interdigitated pattern to increase the amount of contact area between the electrodes and the conductive material. The resistivity of the conductive material will vary inversely with the amount of moisture that is absorbed. As more water vapor is absorbed, the non-metallic conductive material increases in conductivity and hence decreases in resistivity.

Resistive humidity sensors are low-cost devices with a small footprint and are readily interchangeable. Unlike capacitive humidity sensors, resistive humidity sensors can function in remote monitoring applications where the distance between the sensor element and the signaling circuit is large.

3. Thermal conductivity humidity sensors

Thermal conductivity humidity sensors are used to measure absolute humidity. They do so by calculating the difference in the thermal conductivity of dry air versus humid air.

Two NTC thermistors are suspended by thin wires with the sensor. One of the thermistors sits in a chamber that is exposed to the air through a series of ventilation holes. The second thermistor is placed in a different chamber within the sensor that is hermetically sealed in dry nitrogen. An electrical bridge circuit passes current to the thermistors which begin to self-heat. Since one of the thermistors is exposed to humidity from the air, it will have different conductivity. A measurement of the difference in resistance of the two thermistors can be made which will be directly proportional to the absolute humidity.

Thermal conductivity humidity sensors are suitable for use in high temperature or corrosive environments, are durable, and can provide higher resolution than other humidity sensor types.

2. Complete the table.

Humidity Sensors	Application
1. Capacitive humidity sensors	
2. Resistive humidity sensors	
3.Thermal conductivity humidity sensors	

2.4.4. Gas and Chemical Sensors

1. Read the text about the gas and chemical sensors.

Gas and Chemical Sensors/Detectors are fixed or portable electronic devices used to sense the presence and properties of various gases or chemicals and relay signals to the inputs of controllers or visual displays.

Key specifications include the intended application, sensor/detector type, measurement range, and features. Gas and chemical sensors/detectors are used for confined space monitoring, leak detection, analytical instrumentation, etc. and are often designed with the capability of detecting multiple gases and chemicals.

2. Complete the table.

Sensors	Key specifications
1. Temperature Sensors	
2. Pressure Sensors	
3. Humidity Sensors	
4. Gas and Chemical Sensors	

3. AUTOMATION OF METALLURGICAL INDUSTRY

1. Read and translate the text about the automation of metallurgical industry.

Metallurgical industry is a typical heavy industry with complex processes, many kinds of products, and a huge number of materials. Many operations are carried out under the conditions of high temperature, high pressure or low temperature, and negative pressure. From the initial stage of metallurgical industrial production to the development and application of modern metallurgical new technology, mechanization and automation of the metallurgical industry have always been important means.

The main purpose of the application of automation technology is to carry out various metallurgical operations accurately and stably; Improve the efficiency of the metallurgical production process, reduce material consumption and energy consumption, reduce production costs; Improve the manufacturing accuracy of metallurgical products, control the chemical composition, shape and dimensional accuracy of products, and improve the service performance and appearance quality; Reduce the labor intensity of operators, improve labor productivity, and realize some more difficult metallurgical operations.

The technical content mainly includes the mathematical model suitable for controlling the production process, the corresponding automatic control system, and the process detection instrument with high reliability.

The production process can be divided into mining automation, steelmaking automation, steel rolling automation, etc. In terms of automation level, the automation level of processes close to the final product is generally higher than that of processes close to raw material mining.

According to the degree close to the production process, the automation of the metallurgical industry can be divided into three levels:

1. Special metallurgical instruments, including detection technology, information processing, information display, interface, etc.
2. Electric drive, including drive motor, electric appliance, speed regulation system, etc.
3. Control computer, including a computer system, information transmission, etc.

Process Automation

On the basis of basic automation, the process control of the whole production line is automated. The equipment with process computer as the core realizes process automation according to the process mathematical model. Due to the complexity of the metallurgical production process and the obvious influence of non-structural and uncertain factors, robust control, adaptive control, stochastic optimal control, and intelligent control, such as fuzzy control, neural network, and the expert system can be further developed on the basis of the traditional industrial mathematical model combined with classical control and modern control theory.

Management Automation

On the basis of system science theory, it is an automatic system for enterprise management by applying computer technology, economics, and mathematical methods. On the basis of process automation, management automation can be divided into three levels: operation management level, plan management level, and strategic management level. The metallurgical industry began to use computers for management in the 1950s. It is one of the earliest industries to apply management automation, and it is also an industry with a high level of application management automation, such as computer integrated manufacturing systems (CIMS) and supply chain management (SCM).

2. Read and translate the text about industrial robot requirements for special uses in metallurgy.

The metallurgical industry is one of the most complex and specific industries and is therefore directly destined for the introduction of the modern elements of automation. One such solution is the integration of industrial robots, however robot-based automation has its requirements and limits. Specific operating conditions such as extreme temperatures and dust are a challenge for robot manufacturers' development department to come up with new advanced solutions and use modern materials to ensure flawless performance in extreme working conditions with sustainable performance and efficiency. Optimized industrial robots for harsh working environments are provided with a protective coating against heat, corrosion, and acid. To protect the robot from the environment, some exposed areas are covered with flexible robot jacket protective cover intended for a forge or foundry.

Рис. 11. Robotic aluminum cover jacket that suits foundry and forging

Another integral part of the robot, which is exposed to extreme conditions, is a robotic gripper. Gripping tools must withstand high temperature; therefore, grippers are made of special materials in order to cope with extreme production conditions and handle parts weighing up to 300 kg. Robot grippers are the physical interface between a robot arm and the work piece. Grippers are tailored made to meet the individual requirements of specific applications. Depending on the application, they can be operated either pneumatically, electrically or hydraulically. Regardless of the type and method of operation, grippers must handle parts quickly and reliably. During pyrometer measurement the temperature of the industrial robot arm and particularly the temperature of the gripper fingers (physical contacts) can reach more than 70° C, the adapter did not reach the temperature exceeding 45° C, and the TCP was heated to about 35° C.

Not only the tooling, but also the robot itself must meet strict requirements. The following are the most important features that can be affected by high temperature and characterize the performance of industrial robots [8]:

- Repeatability - a measure of precision with which the robot returns to the commanded point. It is a very important feature, especially in the situations where small tolerances are required.
- Accuracy - the measure of error showing how closely the robot can reach a particular point in the working space.
- Reliability - one of the most important features of the robot. It is the reliability that may in some cases stop the operation of the whole production plant.

3. Read and translate the text about industrial robots used in the forging industry.

Рис. 12 Industrial robot used in the forging

The manufacturers need a robotic system that could operate in a harsh environment, automate material handling for three crankshaft designs, and that features simple programming and maintenance while still improving process speed and product quality.

An excellent demonstration of a robotic forging cell is shown in Figure 2. It is hot forging process of the crankshaft of the internal combustion engine of a major producer of passenger cars which is classifies as a pressure forming process. For this process, forming die tools are moved towards each other and push the material in a specific direction.

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AN ESSENTIAL GLOSSARY OF TERMS

ABSOLUTE ENCODER
A type of position encoder that provides a unique and unambiguous position value for each point along its motion path without requiring a reference point. It is used in applications that require high precision and reliability in measuring and controlling motion.

ACTUATORS
Devices that control physical processes or systems based on instructions from automation systems. Examples include motors, valves, and solenoids.

ARC FLASH
A dangerous electrical discharge that generates heat, light, and pressure. It can cause severe injuries, equipment damage, and disruptions to operations. Proper precautions, including PPE (Personal Protective Equipment) and safety procedures, are essential to mitigate the risks. Compliance with safety standards is crucial in preventing arc flash incidents.

ARCHAIC SYSTEM
An outdated, obsolete, or inefficient method or technology. It may lack modern features and capabilities and often needs upgrading or replacement. Upgrading or replacing archaic systems can bring numerous benefits and help organizations stay competitive.

AUTOMATION
The use of technology or machinery to perform tasks without human intervention. It aims to increase efficiency, productivity, and accuracy while reducing labor costs and human error. It can be applied across different industries and involves varying levels of complexity, from simple rule-based tasks to advanced AI (Artificial Intelligence) systems.

BILLET
A solid block of metal that is formed into a specific shape or size through a process called “hot rolling” or “forging”. It is typically made from raw materials such as scrap metal and is used as a starting material for further processing, such as extrusion or machining.

BILLET ID
A system that tracks billets in manufacturing using high-quality printing and 3D laser scanning. It provides real-time barcode and tag verification, offers flexibility in installation, and improves safety by automating hot billet tagging. It reduces labor costs and requires minimal maintenance with off-the-shelf components.

BLEEDING EDGE

Referring to the most advanced and innovative technology at the forefront of research and development. It has the potential to disrupt industries and transform society but may also come with higher costs and uncertainties.

BOARDHOUND ™

A system that optimizes trimmer operations using stress and moisture data, maximizing board value. It supports up to 1,000 data points per board, integrates with existing equipment, and can queue up to 10,000 boards. It easily integrates into existing systems with minimal mechanical changes.

BOARDMARK ™

A barcode system that prints barcodes directly on the end-of-board, reducing costs, waste, and improving safety. It has high read rates, low consumable costs, and is weather resistant. It offers flexible installation options and is accepted by major retail chains.

COMPUTER NUMERICAL CONTROL (CNC)

A technology that automates machine tools using computer systems. It uses coded instructions to precisely control machining operations, replacing manual control methods. Widely used in manufacturing for producing complex and precise parts with high accuracy and efficiency.

COMMON MODE REJECTION RATIO (CMRR)

A measure of an electronic circuit's ability to reject common mode signals. It is expressed in decibels (dB) and indicates how well the circuit can attenuate or reject such signals. Higher CMRR values indicate better performance in differential signal processing applications.

COMMON MODE

Refers to signals that appear equally on both input terminals of a differential circuit. Common mode rejection is the ability of a circuit to reject or attenuate these signals, impacting circuit performance.

CONDUCTED NOISE

Unwanted electrical interference that can affect automation systems. It can originate from various sources and impact system performance. Mitigation techniques like shielding and filtering are used to minimize its effects.

CONTROL ALGORITHMS

Mathematical algorithms or logic that are used in automation systems to process data, make decisions, and generate control signals for actuators to achieve desired outcomes in automated processes.

CONTROL SYSTEM INTEGRATORS ASSOCIATION(CSIA)

A global, not-for-profit trade association with 500+ member companies in 35 countries. It promotes and advances control system integration, supporting business skills improvement, industry expertise sharing, and advocating for certified integrators. Control system integrators use engineering and technical skills to automate industrial equipment and systems for manufacturers and others.

CSIA CERTIFICATION
A rigorous process that involves implementing CSIA's Best Practices and confirming their adoption, resulting in a better company. CSIA Certified companies may be recognized in the top tier of supplier programs. It is important to involve everyone in the company to make Best Practices part of the organization's DNA.

COMPUTER-AIDED DESIGN (CAD)
The use of computer software to create, modify, and optimize designs in various industries. It allows designers to create 2D or 3D models with precision, simulate design performance, and produce visualizations and animations of the final product.

CONTROLCORE ™
A prefabricated, pretested, and mobile modular control room solution for large-scale industrial projects. Built to UL-508A standards, it offers reliable operation, environmental protection, and ease of maintenance. It is suitable for all weather conditions, power and network ready, and enhances project efficiency by mitigating risks during installation and/or start-up.

CONTROLLER
Manages and coordinates devices to automate a process. It receives inputs, processes information, and generates outputs to control actuators or devices. Controllers can be hardware or software-based and are critical in improving efficiency and productivity in automation applications.

CONTROLLER AREA NETWORK (CANBUS)
Is a standardized network protocol used for communication among electronic devices in vehicles and industrial applications. It allows reliable and efficient data exchange over a shared communication bus, known for its high reliability, real-time capabilities, and flexibility.

CONTROLLOGIX
A modular PLC system by Allen-Bradley for industrial automation. It offers scalability, flexibility, and reliability with support for multiple I/O modules, networking options, and programming languages.

CONTROLLOGIX 5000
A high-performance, modular PLC series by Allen-Bradley used in industrial automation. Offers advanced features like multiple I/O modules, networking options, and various programming languages. Widely used for scalable, flexible, and reliable automation applications.

CONTROLNET
An industrial automation communication protocol for high-speed, deterministic communication between devices such as PLCs and I/O devices. It is part of Rockwell

Automation protocols, used in motion control, process control, and discrete manufacturing.

CUTTING EDGE
The forefront or leading edge of technology, innovation, or progress. It represents the most advanced state of development in a particular field or industry.

DATA HIGHWAY
A communication network for transferring data between devices or systems in industrial automation. It uses standardized protocols and interfaces for efficient data exchange.

DEVICENET
A network protocol used in industrial automation for connecting and communicating between industrial devices, such as sensors, actuators, and controllers. It is a popular fieldbus network that enables data exchange and control signals between devices over a single cable, simplifying wiring and reducing installation costs.

DIFFERENTIAL MODE
A signaling mode where data is transmitted as the voltage difference between two lines. It is used in communication systems for its resistance to noise and interference.

DISTRIBUTED CONTROL SYSTEM (DCS)
An industrial automation system used for monitoring and controlling processes in manufacturing and production. It consists of interconnected control units distributed across a facility, enabling centralized control and monitoring for improved operational efficiency.

DISTRIBUTED I/O
A system where inputs and outputs of a control system are distributed across remote locations, improving flexibility, reducing wiring complexity, and enhancing scalability and modularity of the control system.

ELECTRICAL DESIGN AND DRAFTING
The creation of technical drawings for electrical systems using CAD or drafting tools. It involves designing and documenting electrical components, connections, and configurations. Essential in construction, maintenance, and troubleshooting of electrical systems in various applications.

EMBEDDED CONTROLLER (EC)
A microcontroller or microprocessor-based device that performs specific functions within an electronic system. It is integrated into the system and controls operations or functions. Commonly used in industrial automation, automotive systems, and consumer electronics, ECs are programmed with specialized firmware or software for efficient and reliable performance.

EMBEDDED I/O
Input/output modules that are integrated directly into a larger system or equipment, facilitating communication and interaction with the external environment.

ETHERNET
A networking technology that enables communication and data transfer between devices over a local area network (LAN) or wide area network (WAN). It is a standard for wired network connections and is widely used in computer networks, industrial automation, and other applications.

ETHERNET I/O
The use of Ethernet for input/output (I/O) operations in industrial automation, allowing for fast and reliable communication between devices for data acquisition, control, and monitoring.

ETHERNET/IP
An industrial communication protocol that is based on standard Ethernet technology. It enables seamless data communication among industrial devices and is widely used in industrial automation for real-time control, monitoring, and data exchange.

EXPANSION PORTS
Additional physical or virtual interfaces on a device or system that allow for the connection of additional modules, cards, or peripherals to expand its capabilities, such as adding more I/O points, communication interfaces, or other functionalities as needed.

FLEX I/O
A modular, distributed I/O system used in automation that eliminates the need for long wiring runs. It provides digital or analog I/O points for field devices and is known for its flexibility, scalability, and ease of installation.

FRICTION STIR WELDING (FSW)
A solid-state welding process that uses frictional heat and mechanical stirring to join materials. It is known for producing high-quality, defect-free welds in challenging materials such as aluminum and magnesium, with benefits including reduced distortion, improved mechanical properties, and increased productivity in certain applications.

FUNCTION BLOCK (FB)
A reusable software component in industrial automation used in programmable logic controllers (PLCs) or other automation systems. FBs encapsulate specific functionality and can be interconnected to create complex control logic. They are widely used in industrial control systems and are part of standards such as IEC (International Electrotechnical Commission) 61131-3.

GRADEMARKPRO

A high-speed wood printing system with customized grade marking at 200 lugs per minute. It integrates with PLCs for increased production speed, minimal downtime, and quick ROI (Return on Investment). It offers easy product switchover, auto board detect, and precise printing with up to 8 printers.

GRAPHICAL USER INTERFACE (GUI)
A visual interface that enables users to interact with electronic devices or software applications using graphical elements such as icons, menus, and buttons. GUIs have become ubiquitous in modern technology and are used in various devices, including desktop computers, mobile devices, and software applications.

GROUND PLANE
A common grounding connection that establishes a stable electrical reference potential for components or devices within a system. It minimizes electrical noise and interference for reliable operation.

HEADRIG
A machine used in the lumber industry to cut logs into rough lumber or timber. It typically consists of a large cutting saw and may be automated with CNC systems for optimized cutting accuracy and efficiency.

HIGH SPEED PRINTING (HSP)
A fast and efficient printing process used in industrial or commercial applications. It achieves rapid print speeds, incorporates advanced features, and is commonly used for packaging, labeling, mailing, and product marking.

HUMAN-MACHINE INTERFACE (HMI)
The interface or interaction point between humans and automation systems, typically through graphical user interfaces (GUIs), touch screens, or other devices. HMIs allow operators to monitor and control automated processes.

HYDRAULIC MOTION
The use of hydraulic systems for controlling mechanical motion. It uses fluid to transmit power and control movement of components. Commonly used in industrial applications, hydraulic motion relies on pumps, actuators, and valves for precise and efficient motion control.

I/O BRICK
A modular or compact module used in automation to interface between the control system and external devices. It includes multiple I/O points and allows for flexible and scalable I/O configurations. Commonly used in industrial automation and process control.

I/O RELAY
A device used in automation to interface between input/output devices and the control system. It receives input signals from sensors or switches and controls output

signals to actuators based on programmed logic. Commonly used in industrial automation, process control, and other applications.

INCREMENTAL ENCODER
A rotary device used in automation to measure angular position or motion. It generates pulses in response to rotation, with each pulse representing an angular increment. Commonly used for precise position or motion feedback in various applications.

INDUCED NOISE
Interference or electrical noise introduced into a system due to external factors. It can disrupt system operation, affecting accuracy and reliability of components. Mitigation measures include shielding, grounding, and filtering.

INDUSTRIAL INTERNET OF THINGS (IIoT)
The use of internet-connected devices, sensors, and data analytics in industrial automation to enable remote monitoring, diagnostics, and optimization of processes and systems.

INFORMATION SYSTEM
A combination of people, processes, data, and technology that collects, stores, processes, and communicates information. It supports decision-making, coordination, and control within an organization. Information systems include hardware, software, data, networks, and people. They facilitate data management, communication, and decision-making in various industries and sectors.

INTEGRATED
The seamless incorporation and coordination of various components, systems, or processes within an automated system or environment for efficient and unified operation.

INTEGRATION
The process of combining different automation components, systems, or technologies to work together seamlessly and effectively. This may involve hardware integration, software integration, or communication protocols.

INTERNATIONAL SOCIETY OF AUTOMATION (ISA)
A non-profit association founded in 1945, empowering the global automation community through standards, certification, education, publishing, and conferences. ISA addresses cybersecurity threats through the ISA Global Cybersecurity Alliance and owns Automation.com and its subsidiaries. ISA provides trusted technical resources for industrial automation professionals, driving technological advancements and sharing best practices.

LADDER LOGIC

A graphical programming language used in industrial automation for creating control logic using relay logic symbols. It is widely used in PLCs for creating sequential and parallel control logic in automated processes.

LEADING EDGE
The rising edge of a digital signal, which represents the transition from a low voltage level to a high voltage level, indicates the start of a specific action or event.

LENGTHSCANPRO™
An automation system for mills that offers accurate, non-contact stem measurement up to 1″ at line speeds of 150fpm. It increases recovery and productivity by optimizing bucking decisions, reducing waste, and minimizing trim loss. The system is customizable, low-maintenance, and can be integrated with control systems for automated sequencing. It utilizes Laser RADAR scanning technology for precise measurement and solution generation.

LIGHT CURTAIN
A safety device that uses beams of light to detect objects or personnel in a protected area. It sends signals to stop machinery or equipment when light beams are interrupted, ensuring worker safety.

LOCAL AREA NETWORK (LAN)
A computer network that connects devices within a limited area such as a building or facility. It enables communication, collaboration, and access to resources such as design files, software applications, and project management systems among team members.

MACHINE VISION
The use of computer vision technology in automation to capture, analyze, and interpret visual information for tasks such as inspection, measurement, identification, and guidance. It improves efficiency and accuracy in industrial processes.

MAIN AUTOMATION CONTRACTOR (MAC)
A specialized entity responsible for providing comprehensive automation and control solutions for large-scale industrial projects, acting as a single point of contact for all automation-related activities.

MANUFACTURING INTELLIGENCE
The use of data-driven analytics and technologies to optimize manufacturing processes and improve decision-making by collecting, analyzing, and interpreting data from various sources within the manufacturing environment.

MECHANICAL DESIGN AND FABRICATION
Creating and manufacturing mechanical components and systems for automated processes using CAD software, fabrication techniques, and materials.

MILLWRIGHT

A skilled tradesperson who installs, maintains, and repairs automated machinery. They ensure proper functioning of automated systems and may work with mechanical and electrical components. Millwrights in automation require expertise in automation principles, safety regulations, and industry standards. They work in industries where automation is used to improve productivity and efficiency.

MODULAR
A flexible system composed of standardized, self-contained modules that can be easily interconnected or interchanged to create scalable automation solutions.

MOTION CONTROL
The management of machinery movement using techniques like servo motors, actuators, drives, and controllers. It allows for precise control over velocity, position, and acceleration/deceleration in automation applications.

NATIONAL ELECTRICAL CODE (NEC)
A standard set of regulations for electrical installations in the United States, outlining safety requirements and guidelines for the design, installation, and maintenance of electrical systems to ensure safe and reliable operation.

NOISE REJECTION
The ability to filter out unwanted interference from signals, achieved through techniques like shielding, filtering, and signal processing, to ensure reliable and accurate performance of the automation system.

OSCILLATION
A cyclic variation of system outputs around a reference point. It can impact performance and requires careful management in automation systems.

OUTDATED
Technology, equipment, or systems that are no longer current or up to date in terms of their capabilities, features, or compatibility with modern requirements or standards. Outdated automation may be less efficient, less reliable, or incompatible with newer technologies, and may require upgrading or replacement to maintain optimal performance.

OVERDAMPED RESPONSE
A system response in which the output settles quickly to its steady-state value without any overshot or oscillation, typically due to excessive damping. It is characterized by a slower response compared to a critically damped or underdamped system, but with no overshot or oscillation.

PANEL
A control panel or operator interface is used to monitor and control automated systems. It contains switches, buttons, displays, and other control elements, and allows operators to adjust settings and monitor system parameters.

PANEL SELECT BY CONCEPT SYSTEMS
A website created by Concept Systems, Inc. that offers high quality control panel designs for easy specification, quoting, and ordering. Both configurable and off-the-shelf options are provided that comply with industry standards and are well-marked for ease of use.

PARALLEL
The simultaneous execution of multiple tasks or processes without dependencies on each other. It allows for faster and more efficient automation workflows, leveraging techniques such as multithreading, multiprocessing, or distributed computing.

PERSONAL COMPUTER (PC)
Any general-purpose computer whose size, capabilities, and original sales price make it useful for individuals, and which is intended to be operated directly by an end-user with no intervening computer operator.

PERSONAL PROTECTIVE EQIPMENT (PPE)
Specialized gear or clothing worn to protect individuals from workplace hazards. Examples include hard hats, goggles, respirators, gloves, and more. Proper use and maintenance of PPE are crucial for ensuring worker safety.

PIPING AND INSTRUMENTATION DIAGRAM (P&ID)
A visual representation of the interconnection of process piping and instrumentation in an industrial process. It includes symbols for pipes, valves, instruments, and equipment, and serves as a reference for system design, installation, operation, and maintenance in automation workflows.

PROCESS FLOW DIAGRAM (PFD)
A graphical representation of the main process steps, equipment, and flow of materials or energy in a process or system. It provides a high-level overview and serves as a starting point for process design and automation system configuration in industrial processes.

PROPORTIONAL INTEGRAL DERIVATIVE (PID)
A feedback control algorithm that uses three components – proportional, integral, and derivative – to calculate a control signal based on the error between the process variable and setpoint. PID controllers are widely used in automation for regulating process variables and achieving desired setpoints.

PROCESS CONTROL
A systematic management and regulation of industrial processes using sensors, controllers, and feedback loops to adjust process parameters in real-time. It is used in industries to achieve desired outcomes, such as consistent product quality and process efficiency. Efficient process control requires understanding of process dynamics, careful control strategy design, and continuous monitoring and maintenance of control systems.

PROCESS OPTIMIZATION
The use of automation systems and data analysis to optimize and improve the efficiency, quality, and performance of industrial processes, often through continuous monitoring, analysis, and adjustment of process parameters.

PROFIBUS
A widely used fieldbus communication protocol in industrial automation. It enables data exchange between devices and supports high-speed, deterministic, and reliable communication. It has different versions, including PROFIBUS DP and PROFIBUS PA, and is widely adopted due to its robustness and flexibility.

PROGRAMMABLE LOGIC CONTROLLER (PLC)
A specialized type of computer that is used to control and automate industrial processes. PLCs are designed for reliability, durability, and real-time control, and are widely used in manufacturing, process control, and other industrial applications.

PROTOCOL
A set of rules governing how devices or systems communicate. It defines the format for data exchange, including encoding, framing, error detection, addressing, and more. Protocols enable communication and coordination among devices in automation applications. Examples include Modbus, PROFIBUS, Ethernet/IP, and OPC UA.

RADIATED NOISE
Electromagnetic or radio frequency emissions from electronic devices that can interfere with nearby devices. It can arise from various sources and may impact performance and reliability. EMC measures, such as grounding, shielding, and filtering, are used to mitigate radiated noise in automation systems

RAILHAWK
A fully automated system for unloading railcars, designed for stationery, or moving cars, with faster and safer cycles than manual methods. It works in various environments and can be integrated with automated indexers/progressors. The system uses advanced algorithms to scan and track capstans, dispatching automated Car Door Openers (CDOs) for gate operations.

RECOMMENDED STANDARD 232 (RS232)
A widely used serial communication standard for data transmission between devices over a serial connection. It defines the electrical and functional characteristics of data communication and is commonly used in industrial automation, telecommunications, and other applications.

REMOTE I/O
A system in automation where devices are located remotely from the central control unit, allowing for efficient monitoring and control. Commonly used in industrial and building automation applications.

RESOLVER
A type of position or motion sensor used in automation to measure the position, speed, or angle of rotating machinery. It is known for its accuracy, durability, and resistance to environmental factors. It is commonly used in robotics, machine tools, aerospace, and automotive industries for precise motion control and feedback in automation systems.

RESPONSIVE
The ability of a system to adapt to changes quickly and efficiently in its environment or inputs. It involves real-time monitoring, feedback loops, and adaptive algorithms to adjust operations or parameters. Essential for maintaining productivity, quality, and safety in industrial applications. Examples include automated production lines, robotic systems, and smart buildings.

RETROFIT
The process of upgrading or modifying existing equipment, systems, or components with newer technology or features to improve performance, efficiency, or functionality. It is commonly done in various industries to optimize existing assets and improve their performance without replacing them entirely.

ROBOTIC PAINTING
The automated process of applying paint or coatings using robotic systems. It offers advantages of precision, consistency, speed, and safety. Widely used in industries like automotive, aerospace, and consumer goods for large surfaces, complex geometries, and high-volume production. Integrated into production lines or work cells, robotic painting systems achieve desired surface finishes and aesthetics through programmed techniques.

ROBOTICS
The design, construction, operation, and use of robots in automation systems. Robots are programmable machines that can perform tasks autonomously or semi-autonomously, and are used in various applications, such as assembly, welding, material handling, and inspection.

RS422 (aka TIA/EIA-422)
A standard for balanced electrical signaling used for serial communication over long distances. It uses differential signaling, supports full-duplex communication, and allows for higher data rates compared to RS232. Commonly used in industrial control systems and telecommunications for reliable long-distance communication.

RS485 MULTIDROP (aka TIA/EIA-485)
A standard for serial communication in a multidrop network. It allows for multiple devices to be connected on a single bus using differential signaling, enabling efficient communication over long distances. Commonly used in industrial automation, building automation, and other applications where reliable communication between multiple devices is needed.

RSLOGIX 5000
A software platform for programming Allen-Bradley Logix5000 series PLCs. It offers advanced programming, diagnostics, and communication capabilities for industrial automation. Widely used in manufacturing, process control, and discrete automation.

S88
An ANSI/ISA-88 standard for batch control systems. It provides guidelines for designing, implementing, and operating batch processes in industrial automation. S88 uses a modular and hierarchical approach, dividing batch processes into procedural, equipment, and control levels. It promotes consistency, interoperability, and reusability, and is widely used in industries like pharmaceuticals and food/beverage.

SAFETY CATEGORIES
Are classification systems that define the level of safety required based on risks and hazards. They range from low (Category B) to high (Category 4), guiding the selection and implementation of safety measures.

SAFETY INTEGRITY LEVEL (SIL)
A measure used in functional safety to assess the reliability of safety-related systems. It ranges from SIL 1 to SIL 4, with higher levels indicating higher risk reduction. It is used in the design and assessment of safety systems to ensure they meet the required level of risk reduction and reliability.

SAFETY RELAY
A specialized type of relay that monitors safety signals from sensors and triggers safety responses. It ensures safe operation of automated systems by evaluating inputs and making decisions to enable or disable system operation.

SAFETY SERVICES
Measures, protocols, and technologies that ensure safe operation of automated systems. They include safety sensors, controllers, interlocks, protocols, software, and training. Crucial for preventing accidents, protecting workers, and ensuring compliance with safety regulations in various industries.

SAFETY SYSTEMS
Systems or measures designed to ensure the safety of operators, equipment, and processes in automation systems, including safety sensors, emergency stop buttons, safety interlocks, and safety protocols.

SENSORS
Devices that detect and measure physical or chemical parameters, such as temperature, pressure, humidity, flow, or position, and provide feedback to automation systems for control and monitoring purposes.

SERIAL

A method to transmit data sequentially between devices over a single communication channel. It is commonly used in industrial automation for connecting sensors, controllers, and other components. Serial communication involves sending data one bit at a time and uses protocols like RS-232, RS-485, Modbus, etc. It is simple and cost-effective but has limitations in speed, distance, and noise immunity compared to other methods.

SERVO CONTROLS
Hardware and software components, such as servo drives, encoders, and control algorithms, ensure accurate and smooth motion control. Servo controls use closed-loop feedback systems for real-time adjustments and are commonly used in robotics, CNC machines, and other high-precision applications.

SERVO MOTOR
A precise electric motor is used in automation for accurate motion control. It typically includes a motor, encoder, or resolver for position feedback and a control system for generating control signals. Servo motors are used in closed-loop control systems, offering a high torque-to-inertia ratio, fast response time, and high positioning accuracy. They are critical in automation applications that require precise motion control.

SERVO SYSTEM
A combination of components used in automation for precise motion and position control. It typically includes a servo motor, servo drive, and feedback device. Controlled by a controller or motion control system, it achieves high accuracy and smooth motion in applications such as robotics and CNC machines.

SERVO VALVE
A precision control valve used in automation systems to precisely regulate fluid flow. It consists of a valve body, spool/poppet, and feedback mechanism. Servo valves are commonly used in applications that require accurate control of fluid flow for optimal performance and efficiency.

SHAFT ENCODER
A sensor used in automation to measure shaft position or motion. It consists of a rotating disc or wheel and a sensor that detects the position of the disc. It is commonly used for precise position or motion feedback in applications like robotics and CNC machines.

SHIELDED CABLE
An electrical cable with a protective metallic layer to reduce electromagnetic interference (EMI) and radio frequency interference (RFI). It is used in sensitive electronic systems to ensure reliable signal transmission and prevent interference.

SHIELDING

Using physical barriers or protective measures to reduce electromagnetic interference (EMI) and radio frequency interference (RFI). It ensures reliable operation of electronic devices and systems by preventing external interference.

SHUNT
A device or circuit that diverts or bypasses current around a component or subsystem. It is used for current sensing, voltage regulation, or overcurrent protection in electrical circuits.

SINGULARITY
A critical state where certain variables or parameters become undefined, leading to limitations or breakdowns in the system's performance. It can impact accuracy, stability, and safety in robotic systems with multiple degrees of freedom.

SOLDERING
The automated process of melting and fusing a filler material to join metal components. It uses robotic arms or specialized machines for precise and efficient soldering. Automation ensures consistent quality and increased productivity. It is commonly used in industries such as electronics, automotive, and aerospace.

SYNCHRONOUS SERIAL INTERFACE (SSI)
A digital communication protocol used in automation and control systems. It is known for its simplicity and reliability and is used for high-accuracy applications such as position and motion control. It uses a two-wire interface for data transmission and typically involves start and stop bits, along with a clock signal for synchronization. SSI finds widespread use in industries such as robotics, manufacturing, and automotive.

STABLE
A system or process that operates reliably and consistently without significant fluctuations or disruptions. It implies a state of equilibrium, where the system performs predictably and consistently over time, with minimal variability in its operation. Stability is desirable for achieving reliable and consistent results in automation systems.

STAND-ALONE
A self-sufficient system or component that operates independently without external dependencies. It can perform its functions autonomously without continuous communication or interaction with other systems. Typically used in remote or isolated locations or for specific tasks that do not require constant external control.

SUPERVISORY CONTROL AND DATA ACQUISITION (SCADA)
A type of control system used to monitor, control, and manage industrial processes remotely. SCADA systems typically collect data from sensors and other devices, and provide real-time visualization, control, and reporting capabilities.

SYSTEM INTEGRATOR

A company or individual that integrates components, subsystems, or technologies into a cohesive system. They design, install, configure, and test hardware and software to work together as a unified system. System integrators develop customized solutions, optimize processes, and help organizations achieve their automation objectives.

THEODOLITE
A precise measuring instrument used for measuring angles in horizontal and vertical planes. It is commonly used in construction, surveying, and engineering for tasks such as setting out points, determining elevations, and aligning structures. It consists of a telescope mounted on a tripod with horizontal and vertical axes for precise angular measurements.

THERMAL BLOCK
A component used to regulate heat in a system. It can be made of metal or ceramic and may include features such as channels or fins for heat transfer. It is used for precise temperature control in industrial processes, HVAC systems, and electronic devices.

THREE-PHASE
A type of electrical power distribution system that uses three alternating current (AC) voltage waveforms 120 degrees out of phase.

TÜV RHEINLAND
A global leader in inspection and testing services promoting safety, quality, and sustainability. With 22,000+ experts worldwide, the company has a 150+ year tradition. It tests systems, supports innovation, and certifies management systems. In North America since 1983 with 11 sites, TÜV Rheinland is investing in a product testing facility in Boston in 2023 and expanding its Bentonville Lab for hazardous substance testing.

UL PANEL SHOP & FABRICATION
A workshop that designs, fabricates, assembles, and tests electrical control panels that comply with UL safety standards. UL Panel Shop & Fabrication services include panel design, wiring, installation, testing, and certification for compliance with UL requirements. UL is a globally recognized organization that sets electrical safety standards, and UL-listed panels are widely trusted in the automation industry. See PanelSelect.

UL508A STANDARDS
A set of standards published by Underwriters Laboratories (UL) for industrial control panels. It outlines requirements for their design, construction, and performance to ensure safety and compliance with electrical codes. Compliance with UL 508A is important for manufacturers to demonstrate product safety and meet regulatory requirements.

UNDERDAMPED RESPONSE

A system's transient response that oscillates around the steady-state value with diminishing amplitude.

UNDERWRITER'S LABORATORY (UL)
UL Solutions is a global leader in applied safety science, providing testing, inspection, and certification services worldwide. Their mission is to promote safe, secure, and sustainable environments through science and expertise, with a focus on public safety, integrity, and quality.

UNSTABLE
A system or process that lacks stability and is unable to maintain a steady state or desired performance level. An unstable system may exhibit erratic behavior, excessive oscillations, or even divergence, leading to unpredictable or undesirable outcomes. Stability is a critical characteristic in automation systems to ensure reliable and predictable operation.

VARIABLE FREQUENCY DRIVE (VFD)
An electronic device used to control the speed and torque of electric motors in automation and industrial applications by varying the frequency and voltage of the input power. Also known as AFDs, VSDs, or Inverter Drives, they provide precise motor speed control and energy savings.

VISIONFEED-3D
A cutting-edge 3D imaging and sensing technology for automation and industrial applications, used for precise measurement, inspection, and guidance tasks. It utilizes advanced cameras and image processing algorithms to capture and analyze 3D visual information in real time.

WIDE AREA NETWORK (WAN)
A computer network that spans over a large geographic area, connecting devices across different locations or regions.

СПИСОК ЛИТЕРАТУРЫ

1. Automation of Metallurgical Industry - URL: https://www.hanmetallurgy.com/automation-of-metallurgical-industry/ - Загл. с экрана
2. Building Your Automation Vocabulary: An Essential Glossary of Terms - URL: https://conceptsystemsinc.com/automation-glossary-of-terms/ - Загл. с экрана
3. PLC Integration in Manufacturing Assembly Line - URL: https://www.agaraminfotech.com/blogs/2018/plc-integration-in-manufacturing-assembly-line - Загл. с экрана
4. The Complete Guide to Industrial Automation https://www.clarify.io/learn/industrial-automation - Загл. с экрана
5. What is an Actuator? – Different Types of Actuators - URL: https://instrumentationtools.com/what-is-an-actuator-different-types-of-actuators/ - Загл. с экрана

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