

MINISTRY SCIENCE AND HIGHER EDUCATION  
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"NORTH CAUCASUS FEDERAL UNIVERSITY"

**SUGGESTIONS FOR TEACHING**  
for the performance of practical work

in the discipline "Introduction to Engineering Culture" for students of the field of  
study

11.03.02 Infocommunication Technologies and Communication Systems,  
Profile "Intelligent Data Processing in Infocommunication Systems and Networks"

Stavropol  
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## INTRODUCTION

### **1. The purpose and objectives of mastering the discipline**

*The purpose of mastering the discipline* is to form students' universal and professional competencies based on mastering the features of the learning process in the direction of "Informatics and Computer Engineering", understanding the history, state, application and prospects for the development of information and communication technologies.

*Objectives of mastering the discipline:*

1. Formation of an idea of educational activities at the university, the main regulatory documents governing the educational activities of the student, the code of ethics of the NCFU student, the principles and forms of education, as well as teaching methods.
2. Acquisition, assimilation and transfer of knowledge. Organization and planning of independent work by the student.
3. Study of application packages necessary for the educational activities of students in this direction.
4. Study of the objects and characteristics of the professional activity of bachelors in the direction of training "Informatics and Computer Engineering".
5. Acquaintance of students with the basics of the theory of information transmission, modern communication systems, history and prospects for their development.
6. Formation of modern ideas about computer technology and the Internet, the history of computer development, Neumann computer architecture and various generations of computers.
7. Acquaintance with the history of the development of electronics and radio electronics.
8. Formation of an idea of passive radioelectronic components: resistors, capacitors, inductors; active radioelectronic components: electron tubes, transistors; basics of microelectronics, functional electronics and nanoelectronics.
9. Formation of an idea of the basics of robotics.

## **2. Place of the discipline in the structure of the educational program**

The discipline "Introduction to the specialty" belongs to the disciplines of the compulsory part.

## **3. List of planned learning outcomes in the discipline, correlated with the planned results of the development of the educational program**

| <b>Code, formulation of competence</b>                                                                                               | <b>Indicator code, wording</b>                                                                                                                                                                   | <b>Planned learning outcomes in the discipline (module), characterizing the stages of the formation of competencies, indicators</b>  |
|--------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| UK-6. Is able to manage his time, build and implement a trajectory of self-development based on the principles of lifelong education | ID-1 UK-6 sets personal and professional goals in accordance with the level of his resources and priorities of actions, for successful development in the chosen field of professional activity; | UK-6. Is able to manage his time, build and implement a trajectory of self-development based on the principles of lifelong education |

## **PRACTICAL WORK**

### **INFORMATION RETRIEVAL**

**The purpose of the work:** to learn how to search for information on a given topic to perform the tasks.

#### **Theoretical substantiation**

**Information retrieval** is an action, method and procedure that allows selecting certain information from a data array (according to GOST 7.73 – 96 "Search and dissemination of information. Terms and definitions"), i.e. classical information retrieval is a search for documents that satisfy the query in a certain collection of documents.

From the point of view of the use of computer technology, "information retrieval" means a set of logical and technical operations with the ultimate goal of finding documents, information about them, facts, data relevant to the consumer's request. Information retrieval also includes such tasks as user navigation through a collection of documents and filtering documents, as well as further processing of found documents.

Stages of information retrieval:

1. Clarification of the information need and formulation of the request.
2. Selection of sources of information that correspond to the user's request.
3. Extracting information from information arrays
4. Evaluation of search results.

#### **Clarification of information needs.**

**An information need** is a topic about which the user wants to know more. It should be distinguished from a query, i.e. from what the user enters into the search bar. The information need should be expressed by means that the information need is "understood" by the information system.

Often the person conducting the search has the most approximate idea of the topic of interest to him, or he is looking for a document that he is going to write. The user usually needs to find not some specific, pre-known document, but some information (facts), the knowledge of which is necessary to solve the problem.

The wording of the query on the topic should be formatted in the form of keywords or phrases. Keywords are a set of words or phrases that reflect the main topic of the document and describe the information need.

The accuracy and completeness of the search depend not only on the characteristics of the information retrieval system itself, but also on how the query is created. Modern systems do not yet have artificial intelligence and cannot ask you clarifying questions, so an answer that satisfies your information need can only be obtained to a very precisely formulated query, but the user is not always able to clearly and unambiguously formulate exactly the set of keywords that will lead him to the desired result. The main problems are associated with an unsuccessful choice of keywords and viewing unnecessary documents obtained in the list of query results.

And therefore, if possible, it is better to search by several words, their combinations, and sometimes by specific phrases. All function words (prepositions, conjunctions, particles, etc.) should be considered non-key, terms whose frequency of occurrence is low should not be included in the search, frequently occurring (MockBa) should be used in combination with other words that narrow their meaning.

The selection of information sources that meet the user's request includes the determination of what type of information source in each specific situation will correspond to the IP: a source on traditional media or access to information online, including subscription databases.

The main task of practical work is the information search for the questions raised by means of sites ncfu.ru, ecampus.ru, ncfu.catalog.ru, etc.

### **Equipment and materials**

To perform practical work, you need a personal computer with Internet access and Microsoft Office.

### **Safety Instructions**

It is necessary to comply with the safety requirements provided for the computer class

1. Do not turn on the computer without the permission of the class administrator and instructor.
2. It is forbidden to open the PC case on your own.
3. Do not touch the monitor screen and keyboard at the same time (increased electrostatic potential may be discharged).
4. Do not clutter the top panels of the devices with papers and foreign devices.
5. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.
6. It is forbidden to turn off the power supply during the execution of an active task.
7. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

### **Methodology and procedure for performing work**

1. Go to the website [ncfu.ru](http://ncfu.ru)
2. Search for the Charter of the University and explain its content.
3. Study the section of the site "For students" and the content of its subsections.
4. Search for information about the educational program 11.03.02 – Infocommunication Technologies and Communication Systems and 09.03.01 – Informatics and Computer Engineering, respectively.
5. Collect information: explanatory note of the educational program, curriculum, curriculum, annotations of disciplines.
6. Provide an explanation of the information received:
  - 1) what is the purpose of the educational program (EP),
  - 2) which FSES was the basis for the development of the EP in the relevant area of training;
  - 3) what competencies are implemented in the process of training in your field of study;

4) what professional standards were used in the development of professional competencies in the relevant field of training;

5) what the curriculum is;

6) to explain the content of the discipline "Introduction to the specialty" according to the abstract of the discipline.

7. By means of the site, ncfu.ru find information about the Department of Infocommunications and its composition. To get acquainted with the research topics of each of the teachers of the department.

8. Using search engines, thematic catalogs and other means of the Internet, search for one of the articles of the Scopus indexing database of any of the teachers of the department, the research topic of which is of interest to you the most.

9. To search for literature in the field of training 11.03.02 – Infocommunication Technologies and Communication Systems and 09.03.01 – Informatics and Computer Engineering, respectively, by means of the library of the University "Foliant".

10. The university provides students with access to modern information resources:

– electronic library system "University Library Online" – [www.biblioclub.ru](http://www.biblioclub.ru);

– IPRbooks electronic library system – <http://iprbooks.ru>;

– electronic library system Lan – <https://e.lanbook.com/>;

– scientific electronic library e-Library – <https://elibrary.ru/>.

### **Content of the report and its form**

The report must contain

– the title of the practical work;

– the purpose of the work;

– the procedure for performing work;

– results of implementation;

– answers to control questions;

– conclusion on the work done.

### **Control questions**

1. What is information retrieval?
2. What is a classic information retrieval?
3. What tasks of information retrieval do you know?
4. What are the stages of information retrieval?
5. What is the structure of the ncfu.ru website?
6. In which section is the information about your field of study?
7. What information is needed to obtain information about the OP, plan, schedule and content?
8. Дайте пояснения к сайтам [www.biblioclub.ru](http://www.biblioclub.ru), <http://iprbooks.ru>, [e.lanbook.com](http://e.lanbook.com), [elibrary.ru](http://elibrary.ru).

### **Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;
- report submission.

## PRACTICAL WORK

### APPLICATION PACKAGES

**The purpose of the work:** to get acquainted with the principle of operation of virtual machines and virtualization platforms, to get acquainted with VM VirtualBox, and also to study the purpose of the Microsoft Office software package.

#### Theoretical substantiation

Personal computer software

The capabilities of the computer as the technical basis of the data processing system are related to the software (programs) used.

**A program** is an ordered sequence of computer commands (instructions) for solving a problem.

**Software** is a set of data processing programs and documents necessary for their operation

All software tools can be divided into two groups: *general software* and *special software*.

The main functions of *the general software* are:

- 1) automatic control of the computing process, the passage of tasks through the computing system;
- 2) increasing the efficiency of the computing system due to the implementation of various modes of its operation, rational distribution of system resources, minimal intervention of the operator or programmer in the computing process;
- 3) ensuring interaction between the computer system and the user in user-friendly forms;
- 4) ensuring the control and reliability of the functioning of the computer with the help of adjustment, control and diagnostic programs.

General software, performing these functions, solves the problem of using computers as *a kind of universal* information processing system.

*Special software* is a set of programs that are added to the general software and solve the problem of using a computer as a *specialized* information processing system.

Common software consists of operating systems (OS), a set of functional software tools (or application packages) and maintenance software complexes (TSS).

**Operating systems** are a set of interrelated system programs, the purpose of which is to organize the interaction of the user with the computer and the execution of all other programs. The operating system plays the role of a link between the computer hardware, on the one hand, and the executing programs, as well as the user, on the other hand.

The operating system is usually stored in the external memory of the computer – *on the disk*. When the computer is turned on, it is read from the disk memory and placed in *RAM*.

**This process is called** booting the operating system.

The functions of the operating system include:

- 1) dialogue with the user;
- 2) I/O and data management;
- 3) planning and organization of the program processing process;
- 4) allocation of resources (RAM and cache, processor, external devices);
- 5) running programs for execution;
- 6) all kinds of auxiliary maintenance operations;
- 7) transfer of information between different internal devices;
- 8) Software support for peripheral devices (display, keyboard, disk drives, printer, etc.).

An operating system can be called a software extension of the computer's control device. The operating system hides from the user complex unnecessary details of interaction with the equipment, forming a layer between them. As a result, people are freed from the very laborious work of organizing interaction with the computer equipment.

Different computer models use operating systems with different architectures and capabilities. They require different resources to work. They provide different degrees of service for programming and working with ready-made programs.

An operating system for a personal computer focused on professional use should contain the following main components:

- 1) I/O control software;
- 2) programs that manage the file system and schedule tasks for the computer;
- 3) A command language processor that receives, parses, and executes commands addressed to the operating system.

Each operating system has its own *command language* that allows the user to perform certain actions:

- 1) access the catalog;
- 2) Mark up external media.
- 3) run programs;
- 4) other actions.

Functional **software tools** (often called *application software packages* ) are software complexes that are designed to solve certain tasks or a class of tasks. Usually, such a complex (or "package") is focused on solving problems of large volume and high complexity and is a separate element of general software. At present, hundreds of thousands of such software complexes have been developed for various applications. The most widely used are text editors, spreadsheet processors (or spreadsheets), database management systems (DBMS), graphic systems, programming systems, telecommunications, integrated systems [8, 12].

***Text editors*** are designed to create and modify (edit) the texts of programs and documents.

In total, there are several hundred text editors: from the simplest (with limited features) to the most complex.

***Spreadsheet processors*** (or spreadsheets) provide work with large tables of numbers and other data. When working with a spreadsheet processor, a rectangular table (or a fragment, if it is large) is displayed on the screen, in the cells of which there may be numbers, explanatory texts and formulas for calculating the values in the cell according to the available data.

***Database management systems (DBMS)*** allow you to manage large information arrays – databases. The simplest systems of this type allow you to process one array of information, for example, a personal card index. They provide input, search, sorting of

records, reporting, etc. However, it is often necessary to solve problems that involve many different types of objects and, accordingly, many information arrays connected with each other by various ratios. In such cases, it is necessary to create specialized information systems in which the necessary data processing is performed in the most natural way for the user – with a convenient presentation of input data, output forms, graphs and diagrams, search queries.

**Graphic systems** provide the creation and display of graphic images on the screen and for printing. Thus, business and scientific graphics systems allow you to visualize various data and dependencies on the screen, make it possible to display various types of graphs and diagrams. Graphics is one of the most intensively developing areas of functional software tools.

**Programming systems** (or, as they are sometimes called, *software tools*) provide the user with tools for developing programs.

**Telecommunications facilities** provide software support for work in a local computer network or the ability to connect to another (remote) computer using a communication channel.

**Integrated systems** combine the functions of individual systems (for example, they can combine the capabilities of a DBMS, a spreadsheet processor, a text editor, a business graphics system, etc.). At the same time, uniform rules of access to all components of the system are used, uniform forms of data are provided, and the speed of work increases.

**Virtualization software** creates a screen with a nested picture on the work computer, reminiscent of the PIP mode in modern high-end TVs, the only difference being that virtualization has a more powerful resolution.

Virtualization utilities allow you to fully run the Windows operating system on the Mac or Linux platform, as well as work with earlier versions on an updated Windows system.

A virtual machine generated by a program works like a real desktop or laptop computer in the mode of running a guest operating system, except that this does not require additional hardware.

VirtualBox (Oracle VM VirtualBox) is a virtualization software product for Microsoft Windows, Linux, FreeBSD, Mac OS X, Solaris/OpenSolaris, ReactOS, DOS and other operating systems.<sup>1</sup>

At the moment, VirtualBox includes the following features:

- cross-platform interface;
- support for multiprocessor and multi-core systems;
- x86–virtualization, which does not require support for Intel VT or AMD–V hardware techniques;
- support for Windows, Linux and Mac OS as host systems;
- the availability of add-ons to simplify interaction with host operating systems;
- support for virtualization of audio devices;
- support for various types of network interaction;
- support for saving virtual machine states (snapshots<sup>2</sup>);
- Support for shared folders for easy file sharing between the host and guest systems.
- support for 64-bit guests, even on 32-bit host systems;
- support for USB client devices;
- support for hardware 3D acceleration;
- support for a variety of hard disk image formats;
- support for desktop integration by the host and guest operating systems.

Unique features of VirtualBox:

- Pronounced modularity of the system.

### **Equipment and materials**

To perform practical work, it is recommended to use a personal computer, an operating system based on WINDOWS / OS X / Linux, Oracle VM VirtualBox, MS Office 2010.

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<sup>1</sup> VirtualBox – Wikipedia [Electronic resource]. – Mode of access: <http://ru.wikipedia.org/wiki/VirtualBox>

<sup>2</sup> Snapshot – a snapshot of the state of a virtual machine – a snapshot, a copy of files and directories of the file system, the state of RAM at a certain point in time (i.e. a complete copy of the current state of the virtual machine).

## **Safety Instructions**

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2. It is forbidden to open the PC case on your own.
3. Do not touch the monitor screen and keyboard at the same time (increased electrostatic potential may be discharged).
4. Do not clutter the top panels of the devices with papers and foreign devices.
5. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.
6. It is forbidden to turn off the power supply during the execution of an active task.
7. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

## **Methodology and procedure for performing work**

1. Запустите Oracle VM VirtualBox.

2. Create a new virtual machine. To do this, click on the "Create" button located on the button bar.



The New Virtual Machine Wizard starts.

3. In the first step of the wizard, you need to enter the name of the virtual machine, as shown in Figure 1. Enter the name "Windows 7" in the field. The type and version of the operating system are selected automatically if the "Name" field contains the name of the OS and its version.

At this stage, the user can choose one of the pre-installed guest OS templates, in which case VirtualBox will automatically configure most of the settings and select the most compatible virtual hardware.

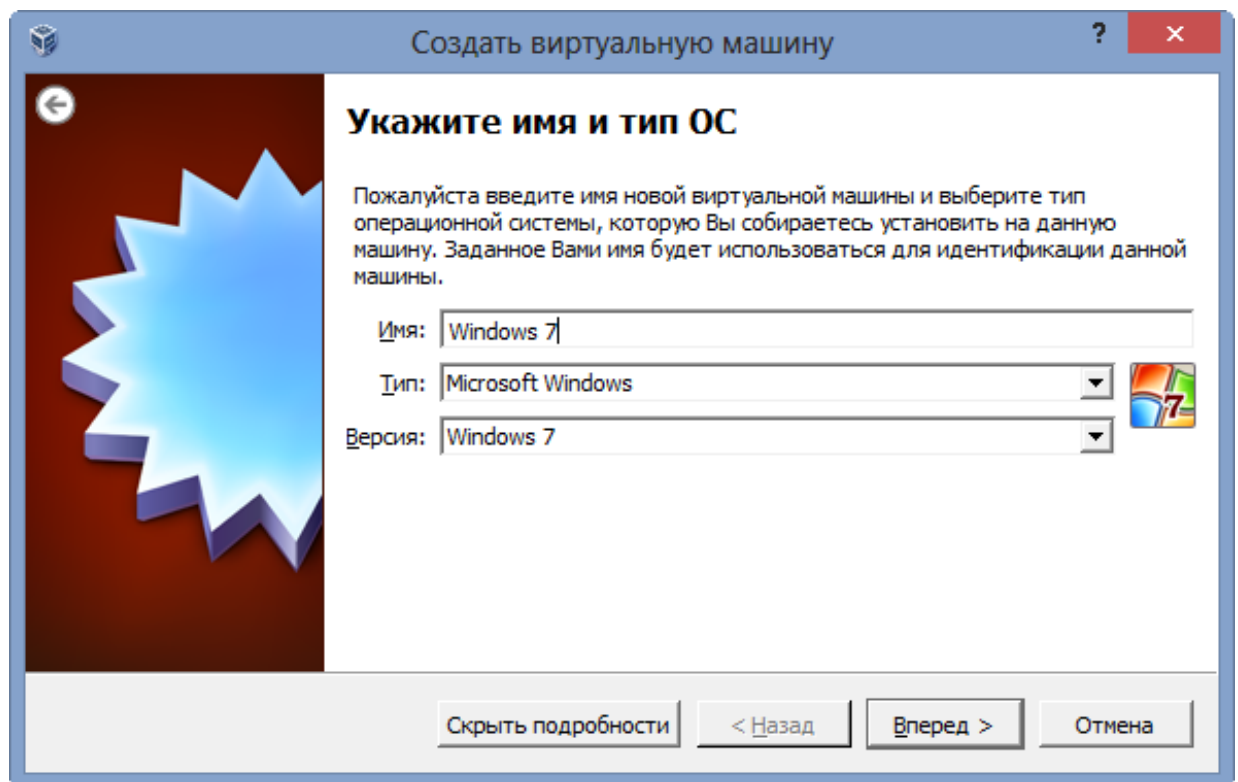


Figure 1. Entering the operating system name

4. In the next step of the Virtual Machine Creation Wizard, shown in Figure 2, you need to select the amount of RAM allocated to the virtual machine. As a rule, the recommended amount is indicated in the selection window if you selected one of the templates in the previous step, however, you can change it depending on your needs.

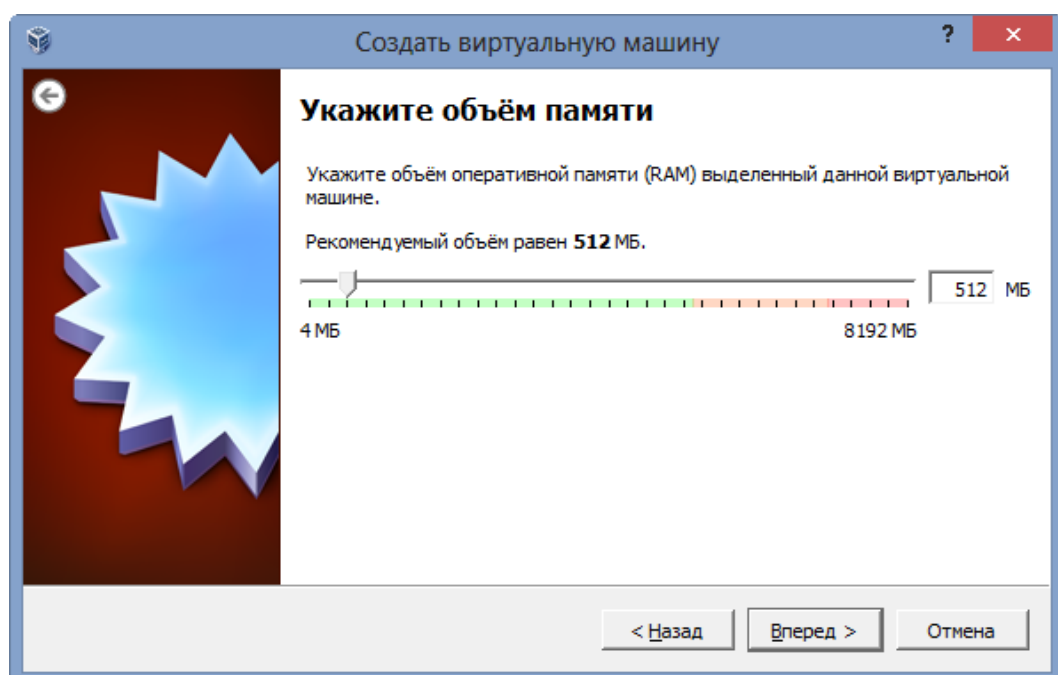


Figure 2. Window for selecting the amount of RAM

5. Figure 3 shows the next step in the Create Virtual Machine Wizard, which prompts you to select a hard disk. Since you are creating a new virtual machine, you need to create a new hard disk for it. Select "Create New Virtual Hard Disk" and click "Create".

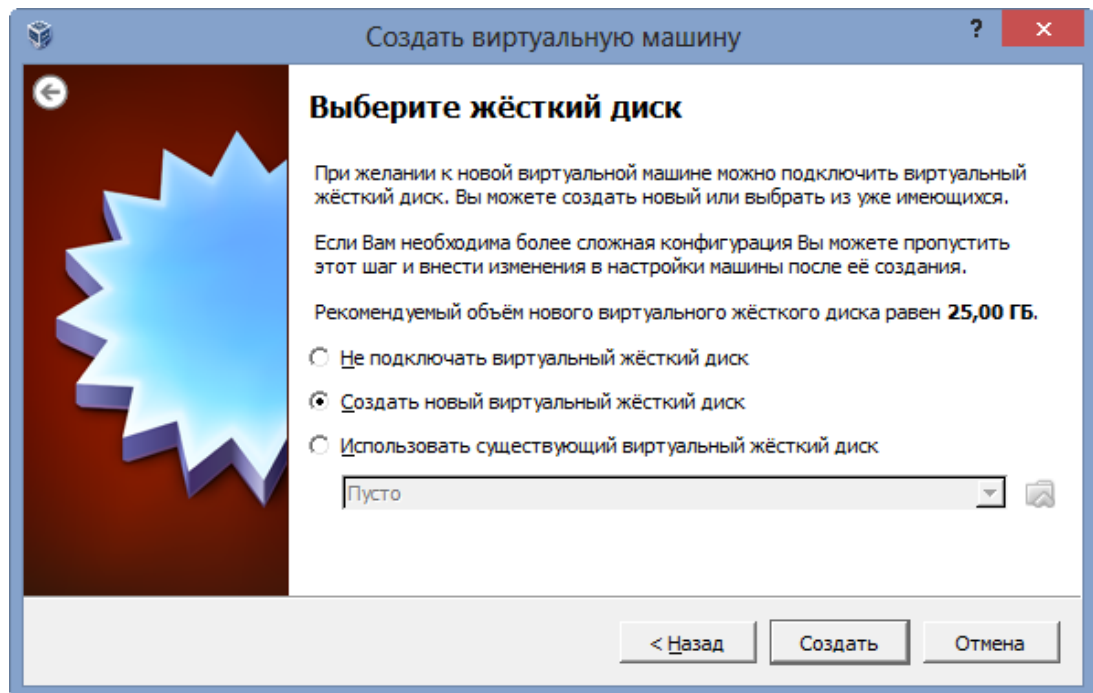


Figure 3. Selecting a hard disk for the virtual machine to be created

5.1 The virtual hard disk creation window shown in Figure 4 prompts you to select the disk type. You can leave the default value if you do not need to connect the hard disk to other virtual machines. Otherwise, you must select a hard disk format supported by the third-party virtual machine.

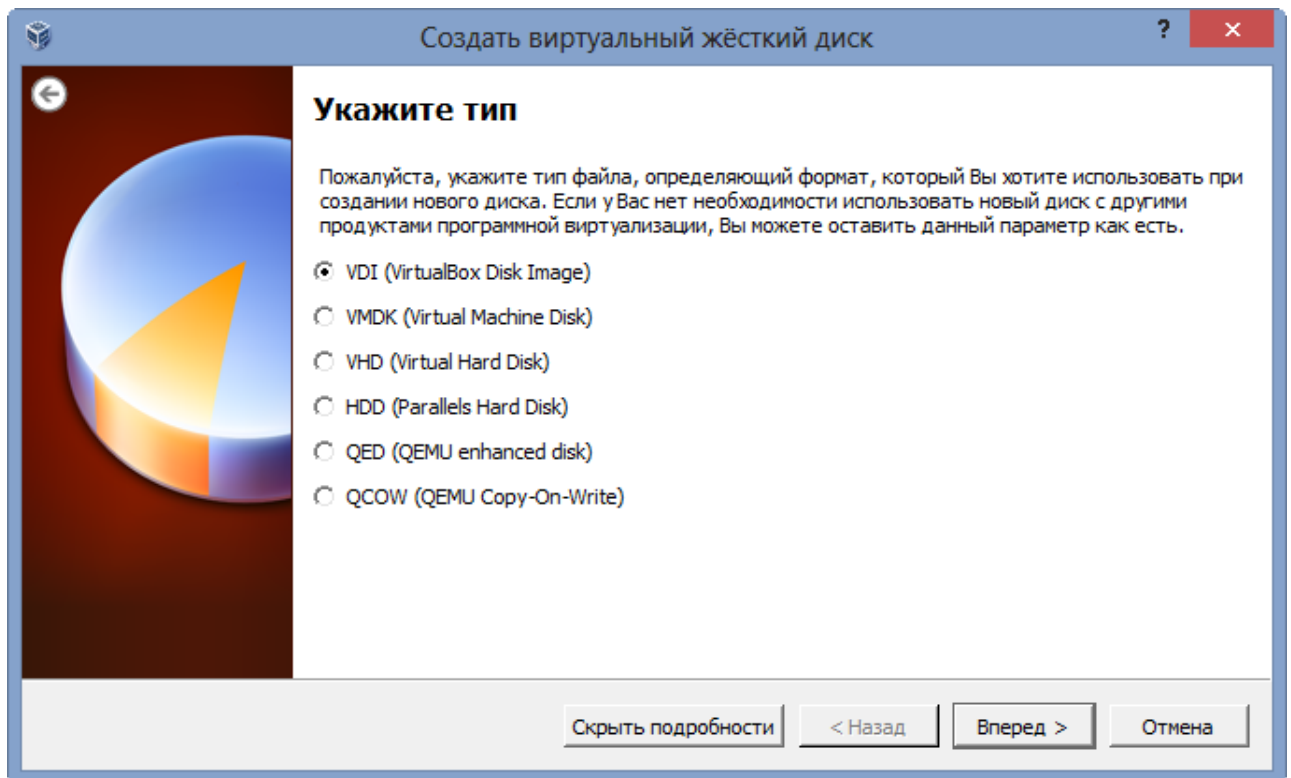


Figure 4. Selecting a Hard Drive Type

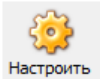
5.2 In the next step, you need to specify the data storage format. Specify "Dynamic Virtual Hard Disk".

In most cases, using a dynamically expanding virtual disk is preferable. Specifying a fixed size typically provides little performance gain. However, a fixed-size disk consumes disk space as soon as it is created, while a dynamic disk image consumes disk space as the virtual machine needs it. With a dynamically expanding virtual disk, you must provide enough space for image files to grow and control their fragmentation.

5.3 In the next step of the wizard, you need to specify the name of the hard disk file, its location, and size.

Please note that if you choose a fixed-size hard drive, you must choose the size of the disk in advance based on your anticipated needs, as it can be difficult to increase the disk in the future if there is not enough space on a fixed-size disk.

6. After completing the New Virtual Machine Wizard, you need to configure the created virtual machine. To do this, select the created virtual machine in the list

and click the "Configure" button  located on the button bar.

6.1 On the Display tab, enable 2D and 3D acceleration and increase the size of the video memory allocated.

6.2 On the "Audio" tab, disable the "Enable Audio" option

6.3 On the "USB" tab, enable the "Enable USB Controller" option

6.4 In the "Public Folders" tab, bring up the Add New Folder window by clicking "Insert" or the "Add Shared Folder" button .

6.4.1 In the window that appears, select the path to the temporary folder, enter a name for the folder and check the "Auto-connect" checkbox, as shown in Figure 5.

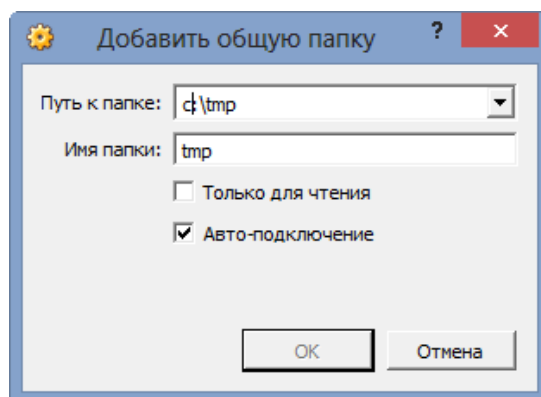


Figure 5. Adding a shared folder

7. Start the created virtual machine

A virtual machine running a guest behaves like a normal application to the host system.

4. In the boot disk selection dialog shown in Figure 6, select the Windows 7 disk image, or the optical drive that contains the operating system disk.

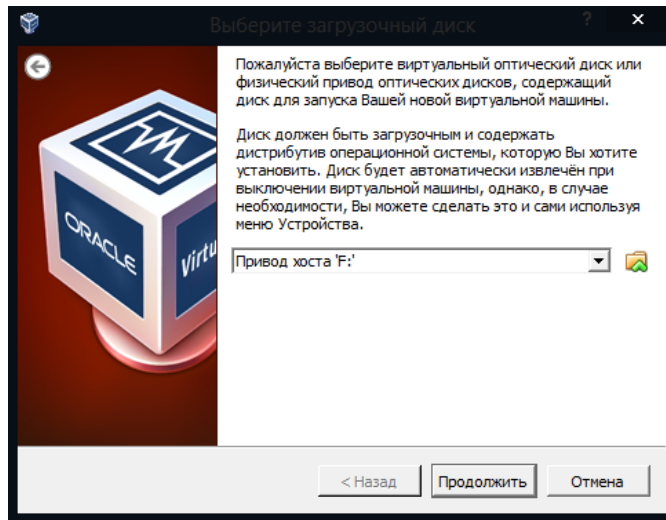


Figure 6. Choosing a drive with a disc to install the OS

5. In the next step, shown in Figure 7, select your preferred interface language, currency format, and keyboard layout.

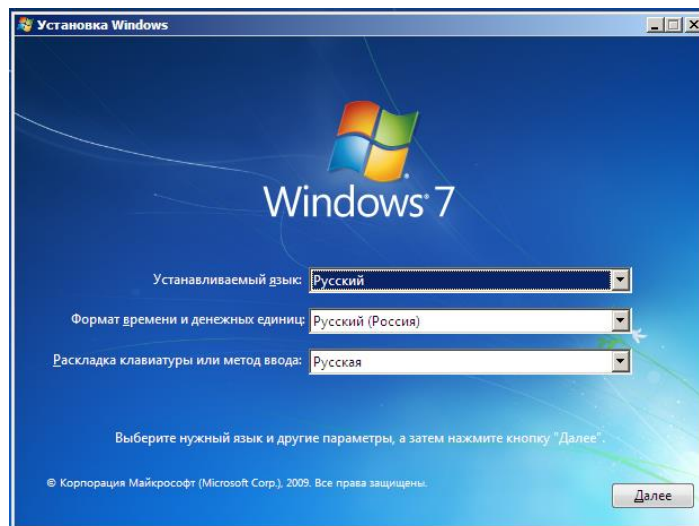


Figure 7. Choosing the language and culture settings of the OS to be installed

6. In the next step, click the "Install" button.

7. If your installation disc contains several OS versions, then you need to select the version to install in the next step of the OS installation wizard. The OS version selection dialog is shown in Figure 8.

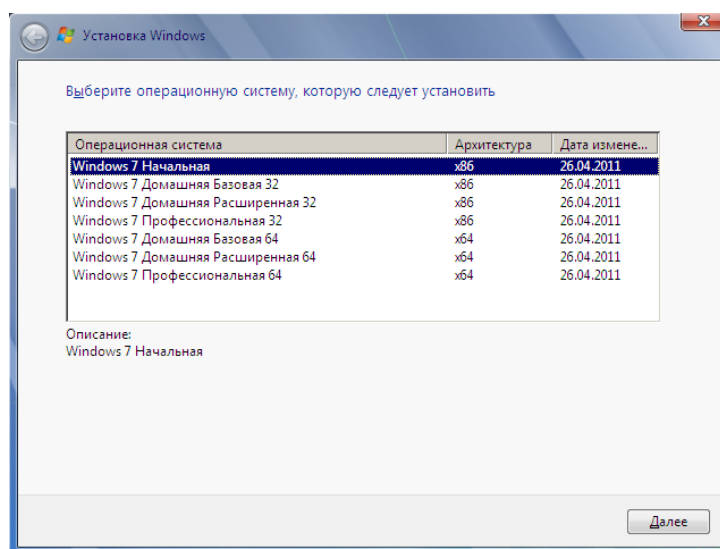


Figure 8. Selecting the OS version to be installed

8. In the next step of the operating system installation wizard, carefully read the license agreement.

Please note that the OS you are installing can only be used for educational purposes. To use Windows for non-educational purposes under a virtual machine, you need to purchase a special license.

9. Select the installation type "Full Installation".

10. At the stage of selecting a disk partition, create a partition in an unpartitioned area. Agree with the warning about creating an additional partition for system files.

11. Click Next and wait for the operating system installation process to complete. During the OS installation, the virtual machine may be rebooted several times.

12. After the installation is complete, you need to enter your username, password, time, and other parameters. Enter them yourself.

### Task

1. Установите Oracle VM VirtualBox.
2. Create a virtual machine.
3. Make the necessary settings of the virtual machine:
  - the name of the virtual machine to be created must contain the name of the operating system, your last name and initials (for example: ИвановИ–Windows7);

– select the optimal amount of RAM depending on the configuration of the computer with the host OS;

- The name of the virtual hard disk must be your last name.

4. Start the created virtual machine.

5. Install Windows

Next, you need to learn how to design a text document using Microsoft Office.

To do this, you need to complete the task:

1. Get a template of the title page of the report on practical work from the teacher.

2. Draw up the title page of your report.

3. From the second page onwards, adhere to the following requirements

– the topic of practical work is located in the middle of the line in capital bold;

– each paragraph of the text of the report is drawn up in accordance with the requirements presented in Figure 9;

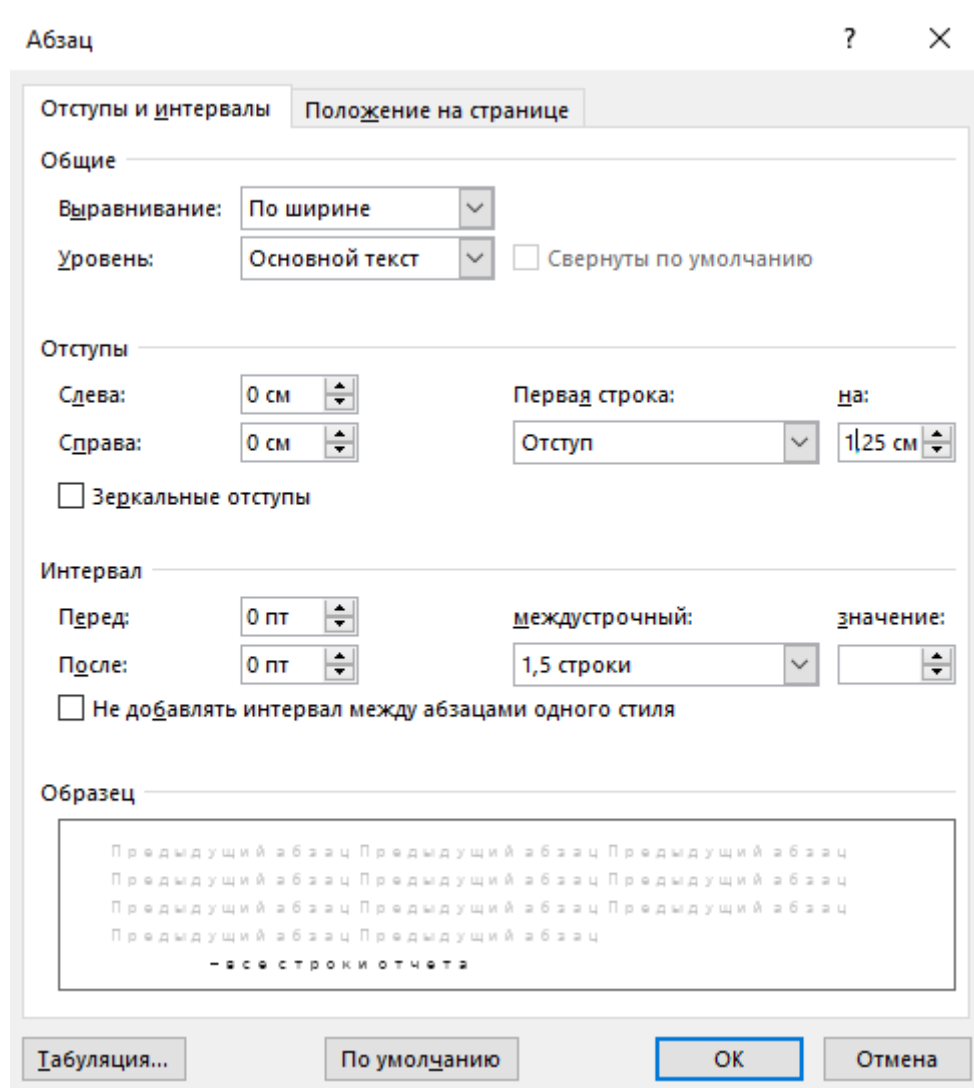


Figure 9. Formatting options

- the goal of the work begins with a capital letter and a red line, while the indent of the first line is 1.25 cm;
- each report contains sections: "Theoretical part", "Practical part", "Conclusion";
- the section "Theoretical part" contains a brief summary of the theoretical material of practical work;
- the section "Practical part" contains the results of practical work;
- the "Conclusion" section is contained at the end of the report;
- the entire text is placed "in width", the spacing between lines is 1.5 lines;
- when drawing up the list, the requirements should be followed, according to Figures 10, 11, 12 below

- цель работы начинается с заглавной буквы и красной строки, при этом отступ первой строки 1,25 см;¶
- каждый отчет содержит разделы: «Теоретическая часть», «Практическая часть»;¶
- раздел «Теоретическая часть» содержит краткий конспект теоретического материала лабораторной работы;¶
- раздел «Практическая часть» содержит результаты выполнения лабораторной работы;¶

Figure 10. Design of a bulleted list

#### **Контрольные вопросы¶**

1. → Дайте определение программы, программного обеспечения (ПО)?¶
2. → Текстовые и табличные процессоры.¶
3. → Графические системы.¶
4. → Средства телекоммуникации.¶
5. → Интегрированные системы.¶
6. → Системы программирования.¶

Figure 11. Formatting the numbered list

- 1) ввод имени виртуальной машины;¶
- 2) выбор объема оперативной памяти;¶
- 3) выбор имени жесткого диска;¶

Figure 12. Formatting the numbered list

- all pages of the report must be numbered at the bottom right, while the title page is not numbered;
- tables, figures, figure and table inscriptions in the report are placed in the middle;
- Figure and table inscriptions begin with a capital letter and do not put a period at the end;

- the text in the tables should be formatted in Time New Roman 12pt, line spacing – single;
- the text of the report is drawn up in Time New Roman 14pt, the line spacing is one and a half.

### **Content of the report and its form**

The report must contain

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;
- Results:
  - screen forms showing the order of practical work, and the results obtained in the course of its implementation:
    - 1) entering the name of the virtual machine;
    - 2) selection of the amount of RAM;
    - 3) selection of the name of the hard disk;
  - Screen forms that illustrate the shared folders you've added.
  - screen form of the running virtual machine.
- answers to control questions;
- conclusion on the work done.

### **Control questions**

1. Give a definition of a program, software (software)?
2. Word and table processors.
3. Graphic systems.
4. Telecommunications.
5. Integrated systems.
6. Programming systems.
7. DBMS.
8. Operating systems.

9. The process of booting the operating system.
10. What features does VM VirtualBox have?
11. Describe the Oracle VM VirtualBox deployment process.

### **Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;
- report submission.

## **PRACTICAL WORK**

### **CISCO PACKET TRACER INTERFACE**

**The purpose of the work:** to learn how to use the user interface of the Cisco Packet Tracer program as a tool when performing a task.

#### **Theoretical substantiation**

Cisco Packet Tracer includes a network simulation tool that allows you to simulate and simulate the state of the network and virtually any network event. For example, you can see how the network will react in the event of a failure, or for example, what happens if you disconnect a cable or disconnect the power to one of the network devices.

The simulation mode allows you to trace the structure of the packet and view with what parameters the packet passes through the layers of the OSI model.

#### **Cisco Packet Tracer Main Window**

Figure 1 shows the program interface, divided into regions.

1. The main menu of the program with the following contents:
  - File – contains document opening/saving operations;
  - Edit – standard "copy/cut, undo/redo" operations;
  - Settings – speak for themselves;
  - View – the scale of the workspace and toolbar;
  - Tools – color palette and customization of end devices;
  - Extensions – Project Wizard, multi-user mode and a few strays that can turn CPT (as I will sometimes affectionately call Cisco Packet Tracer) into a whole laboratory;
  - Help – you will never guess what is contained there;
2. Toolbar, some of which simply duplicate menu items;
3. Switch between logical and physical organization;

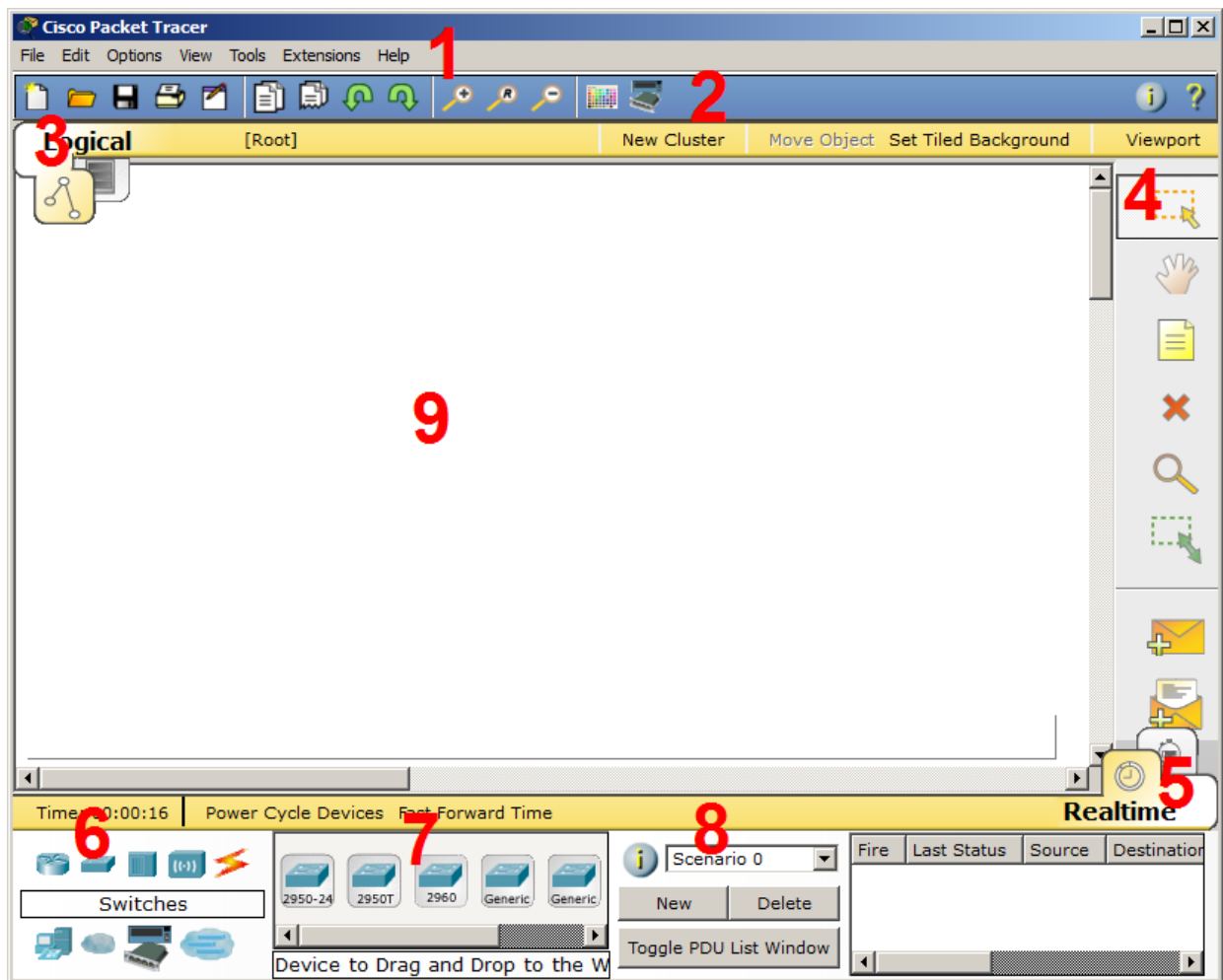


Figure 1. Cisco Packet Tracer Interface

4. Another toolbar contains tools for selecting, deleting, moving, scaling objects, as well as forming arbitrary batches;
5. Switch between Real-Time and Simulation Mode;
6. A panel with groups of end devices and communication lines;
7. The end devices themselves, contain all kinds of switches, nodes, access points, conductors.
8. Custom Scenario Creation Panel;
9. Workspace.

An example of the placement of color regions (Figure 2), for example, allows you to visually separate one subnetwork from another.

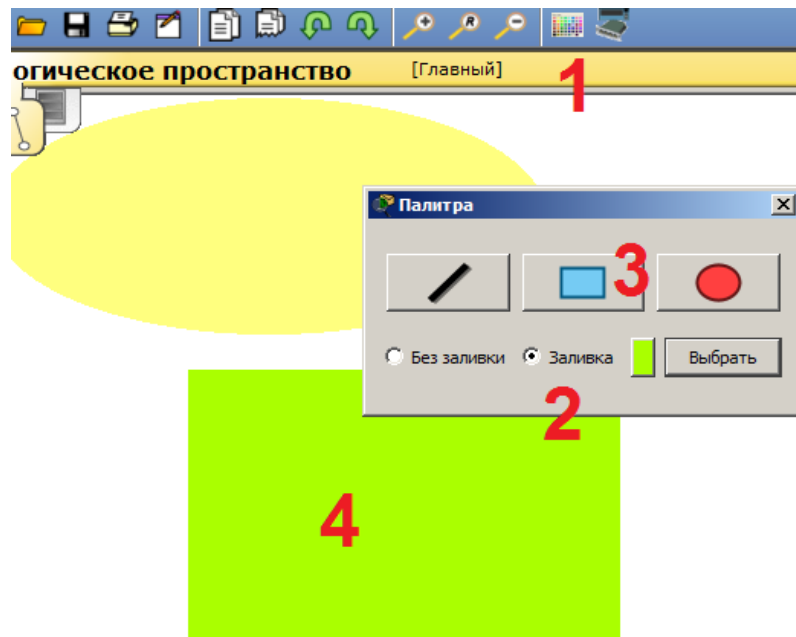


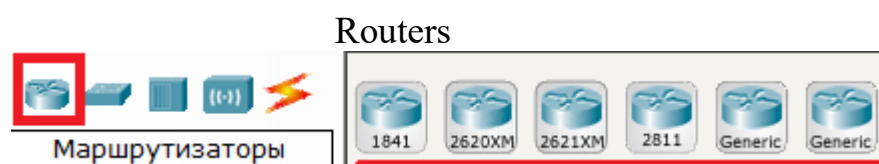
Figure 2. Example of color area placement.

To set color areas, follow these steps:

- 1 – Select the appropriate icon on the toolbar;
- 2 – Select the "Fill" area mode, for example;
- 3 – Choose color and shape;
- 4 – Draw an area on the workspace.

You can also add a signature and move/scale this area.

Equipment and communication lines in Cisco Packet Tracer.



Routers are used to find the optimal route for data transmission based on special routing algorithms, for example, choosing a route (path) with the least number of transit nodes.



They work at the network layer of the OSI model.

### Switches



Switches are devices that operate at the link layer of the OSI model and are designed to unite several nodes within one or more network segments. The switch transmits packets on the basis of an internal table – the switching table, therefore, traffic goes only to the MAC address to which it is intended, and is not repeated on all ports (as on a hub).



### Hubs



The hub repeats the packet received on one port on all other ports.

### Wireless Devices



Wi-Fi wireless technologies and networks based on them. Includes access points.

### Lines of communication



With the help of these components, node connections are created into a single scheme.

Packet Tracer supports a wide range of network connections (see Table 1).

Each type of cable can only be connected to certain types of interfaces.

Table 1. Types of cables.

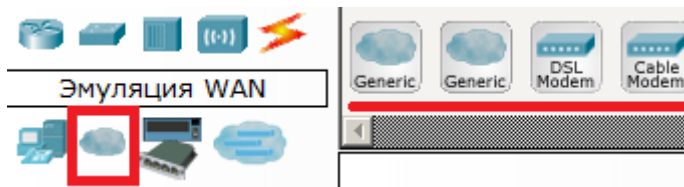
| Cable Type                                                                                                                                                                                             | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Console<br>                                                                                                           | A console connection can be made between a PC and routers or switches. Some requirements must be met for a console session to work with a PC: the connection speed on both sides must be the same, there must be 7 bits of data (or 8 bits) for both sides, parity must be the same, there must be 1 or 2 stop bits (but they do not have to be the same), and the data flow can be anything for both sides.                                                                                                                                   |
| Copper Straight<br>                                                                                                   | This type of cable is a standard Ethernet transmission medium for connecting devices, which operates at different OSI layers. It must be connected to the following types of ports: copper 10 Mbps (Ethernet), copper 100 Mbps (Fast Ethernet), and copper 1000 Mbps (Gigabit Ethernet).                                                                                                                                                                                                                                                       |
| Copper Crossover<br>                                                                                                | This type of cable is an Ethernet transmission medium for connecting devices that operate at the same OSI layers. It can be connected to the following types of ports: copper 10 Mbps (Ethernet), copper 100 Mbps (Fast Ethernet), and copper 1000 Mbps (Gigabit Ethernet).                                                                                                                                                                                                                                                                    |
| Optics<br>                                                                                                          | Fiber optic media is used for the connection between optical ports (100 Mbps or 1000 Mbps).                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| Telephone<br>                                                                                                       | A dial-up connection can only be made between devices that have modem ports. A standard view of a dial-up connection is an end device (such as a PC) dialing into a network cloud.                                                                                                                                                                                                                                                                                                                                                             |
| Coaxial<br>                                                                                                         | A coaxial medium is used for the connection between coaxial ports, such as a cable modem connected to the Packet Tracer cloud.                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Serial DCE<br><br>Serial DTE<br> | Connections via serial ports are often used for WAN links. To configure such connections, synchronization must be established on the DCE side of the device. DTE synchronization is optional. The DCE side can be determined by the small "clock" icon next to the port. If you select the Serial DCE connection type, the first device to which the connection is applied becomes the DCE device, and the second automatically becomes the DTE side. It is also possible to reverse the sides if the Serial DATE connection type is selected. |

## End devices



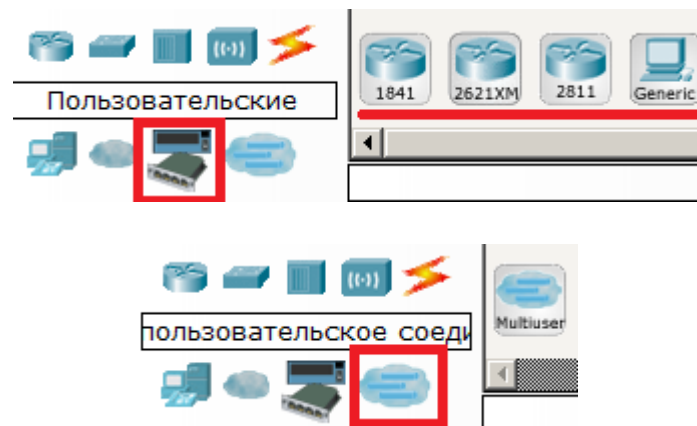
End nodes, hosts, servers, printers, phones, etc. are represented here.

### Internet Emulation



Example: WAN emulation. DSL modem, cloud, etc.

### Consumer devices and the cloud for multi-user work



Devices can be packaged independently. Custom connections can be created.

### Physical equipment

Install the Cisco 1841 router in the working field In the settings on the **router**, **open its** physical configuration (Fig. 3).

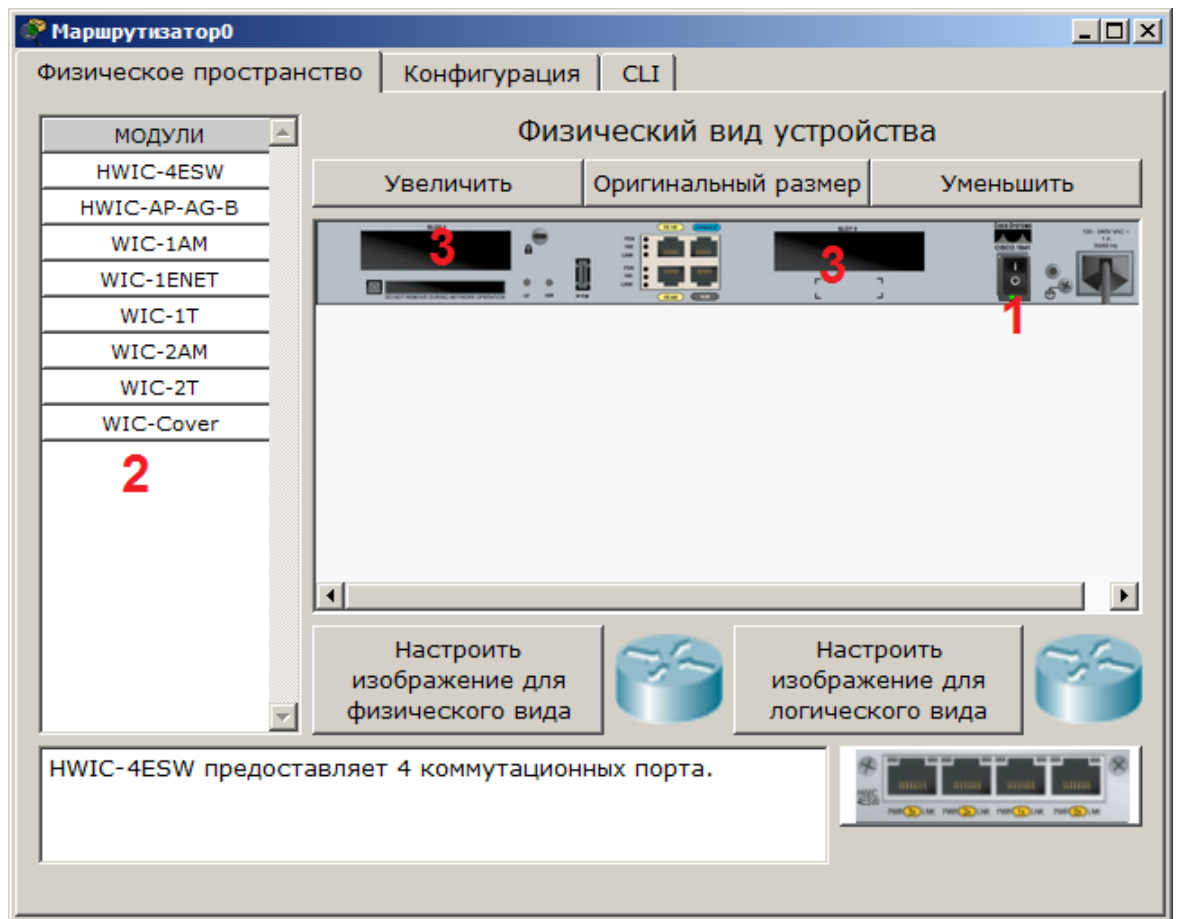


Figure 3. Physical configuration of the device.

On the left, as we can see, there is a list of modules (number 2) that can be equipped with this router. Now it has 2 voids (number 3). You can put these modules in them. Of course, this operation must be performed when the power is turned off (number 1).

WIC modules (HWIC, VWIC) are expansion cards that increase the functionality of the device:

1. **WIC** – WAN interface card. the first original models.
2. **HWIC**– high–speed wan interface card– the evolution of wic that is now in use on the ISR routers.
3. **VIC** – voice interface card, support voice only.
4. **VIC2** – evolution of the above
5. **VWIC** – voice and wan interface card. An E1/T1 card that can be user for voice or data.
6. **VWIC2** – evolution of the above

For example, for a computer there are boards connected to the PCI bus (TV tuners, sound cards, USB splitters, network cards), and the same is true here. In general, a Cisco device is the same system unit with its own operating system and many network cards, which can do something only with the network.

Below is information about each module:

**HWIC – 4ESW** is a high-performance module with 4 Ethernet switching ports for an RJ-45 connector. It allows you to combine the capabilities of a switch in a router.

**HWIC-AP-AG-B** is a high-speed WAN card that provides built-in access point functionality for Cisco 1800 (modular), Cisco 2800, and Cisco 3800 routers. This module supports Single Band 802.11b/g or Dual Band 802.11a/b/g radio channels.

**The WIC-1AM** includes two RJ-11 (telephone) connectors used to connect to the basic telephone service. The card uses one port to connect to the telephone line, the other can be connected to an analog phone to make calls when the modem is idle.

**WIC-1ENET** is a single-port 10 Mbps Ethernet card for a 10BASE-T Ethernet LAN.

**WIC-1T** provides single-port serial connectivity to remote offices or legacy off-the-shelf networking devices such as SDLC hubs, alarm systems, and packet over SONET (POS) devices.

**WIC-2AM** contains two RJ-11 connectors used to connect to the basic telephone service. WIC-2AM has two modem ports, allowing both channels to be used simultaneously.

**WIC-2T** – A 2-port synchronous/asynchronous serial network module provides flexible support for many protocols with each port individually configured in synchronous or asynchronous mode. Applications for synchronous/asynchronous support include:

- low-speed aggregation (up to 128 Kb/s);
- support for dial-up modems;

- synchronous or asynchronous connections to the control ports of other equipment and the transmission of legacy protocols such as Bi-sync and SDLC.

**WIC-Cover** is a wall for the WIC slot, necessary to protect electronic components and to improve the circulation of the cooling airflow.

To change the equipment configuration, you need to turn off the power supply by clicking on the power button, drag the **4ESW** module to an empty slot and turn on the power. Wait for the router to finish booting. In the GUI configuration, we can see 4 new interfaces (Fig. 4).

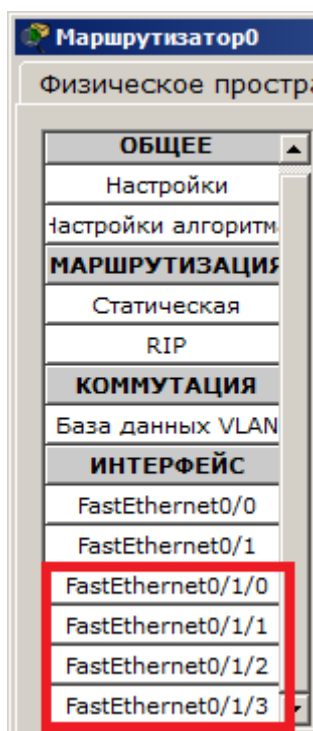


Figure 4. Configuration of the device interfaces.

The rest of the devices are equipped in the same way. New Ethernet modules (10/100/1000), fiber optic connectors of several types, wireless network adapters are added. It is possible to add, for example, a microphone with headphones, a hard disk for data storage to the work computer.

### Equipment and materials

To perform practical work, you need a personal computer with Internet access, Cisco Packet Tracer and Microsoft Office.

### Safety Instructions

It is necessary to comply with the safety requirements provided for the computer class

1. Do not turn on the computer without the permission of the class administrator and instructor.
2. It is forbidden to open the PC case on your own.
3. Do not touch the monitor screen and keyboard at the same time (increased electrostatic potential may be discharged).
4. Do not clutter the top panels of the devices with papers and foreign devices.
5. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.
6. It is forbidden to turn off the power supply during the execution of an active task.
7. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

### **Methodology and procedure for performing work**

The network consists of 4 nodes, a server, a printer and two hubs. The hubs are connected to each other by a crossover cable (Fig. 5).

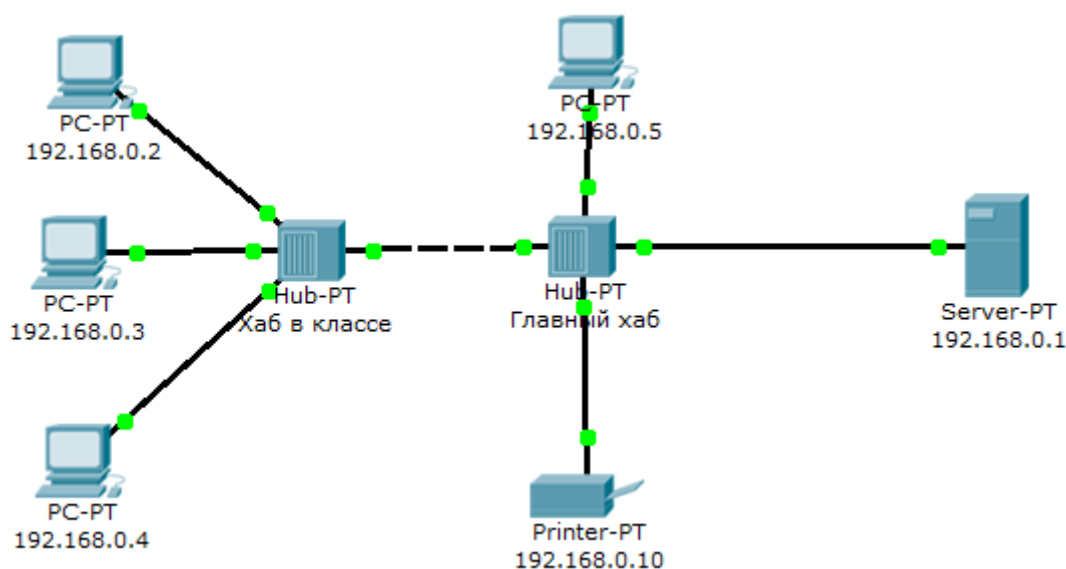


Figure 5. Network diagram

You need to switch to the simulation mode (Shift+S), or by clicking on the simulation icon in the lower right corner of the workspace. Here we see the event window, the reset button (clears the list of events), playback control and protocol filtering. Many protocols are proposed, but let's filter only ICMP for now, this will eliminate random traffic between nodes.

To move to the next event, use the "Forward" button or the automatic button (Fig. 6).

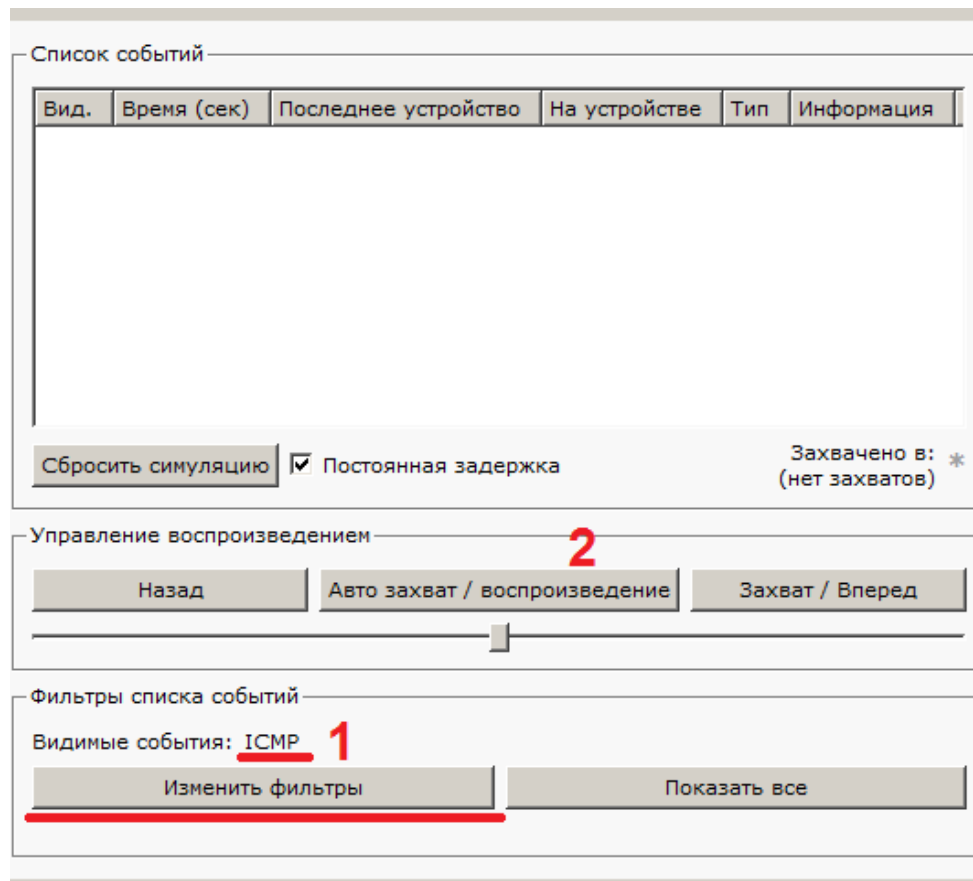


Figure 6. Simulator interface

Send a PING request.

From one of the nodes, try to ping the other node. Select distant nodes to see more clearly how packets will pass through the network in simulation mode. So, enter node .4 and send a ping request to node .5.

From the pink node, ping the green one. On the pink node, a package (envelope) has formed, which is waiting (pause icon on it). You can launch the

package to the network by clicking the "Next" button in the simulation window (Fig. 7).

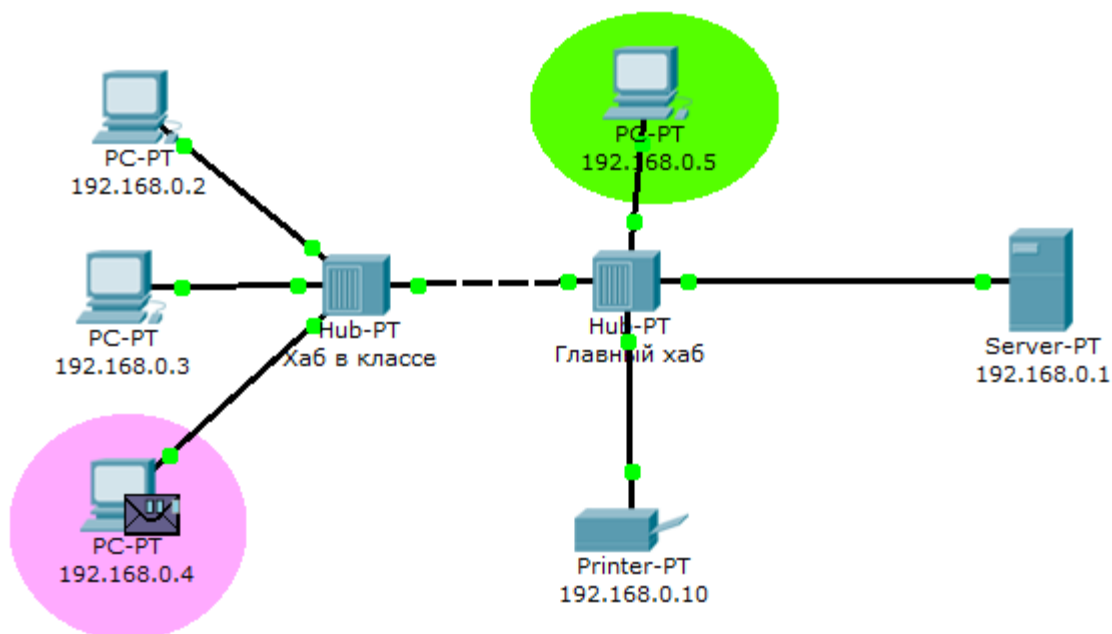


Figure 7. Simulator demonstration

Also in the simulation window, we will see this packet, noting its type (ICMP) and source (192.168.0.4) – Fig. 1. 8.

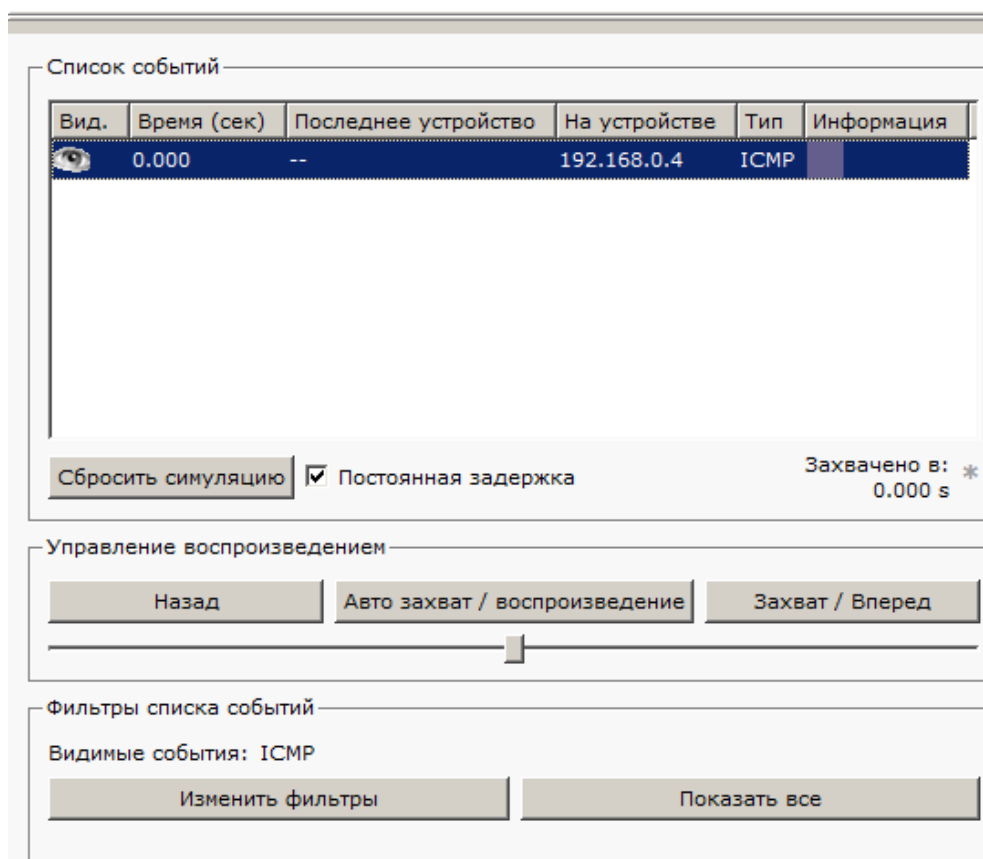


Figure 8. Monitoring the operation of protocols

Clicking on the packet will show us detailed information. At the same time, we will see the OSI model. It is immediately clear that at the 3rd layer (network), a packet has appeared in the outgoing direction, which will go to the second layer, then to the first, to the physical environment and will be transmitted to the next node (Fig. 9).

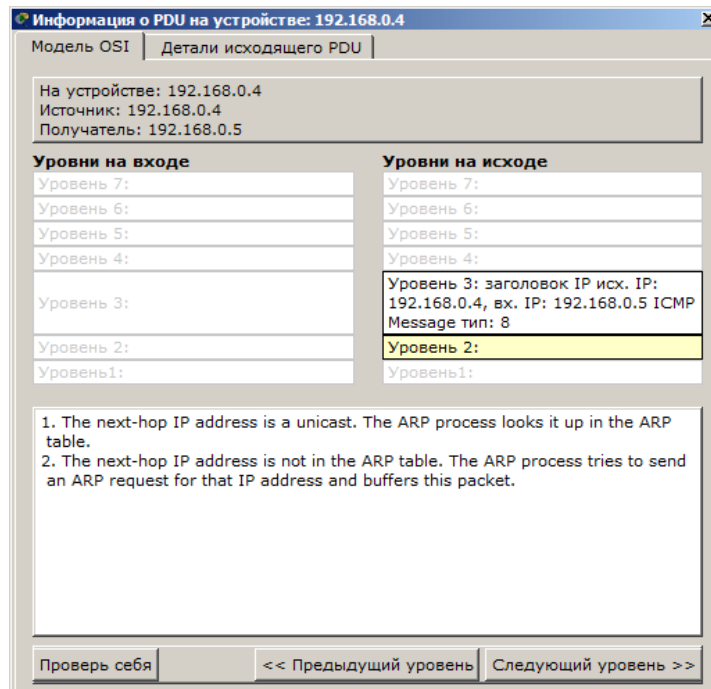


Figure 9. Monitoring OSI Model Operation

And on another tab, you can see the structure of the package (Fig. 10).

Информация о PDU на устройстве: 192.168.0.4

Модель OSI

Детали исходящего PDU

Форматы PDU

IP

|                        |     |           |         |        |     |     |
|------------------------|-----|-----------|---------|--------|-----|-----|
| 0                      | 4   | 8         | 16      | 19     | 31  | Бит |
| 4                      | IHL | DSCP: 0x0 | TL: 128 |        |     |     |
| ID: 0x1                |     |           | 0x0     | 0x0    |     |     |
| TTL: 128               |     | PRO: 0x1  |         | CHKSUM |     |     |
| SRC IP: 192.168.0.4    |     |           |         |        |     |     |
| DST IP: 192.168.0.5    |     |           |         |        |     |     |
| OPT: 0x0               |     |           |         |        | 0x0 |     |
| DATA (VARIABLE LENGTH) |     |           |         |        |     |     |

ICMP

|           |   |               |          |     |
|-----------|---|---------------|----------|-----|
| 0         | 8 | 16            | 31       | Бит |
| TYPE: 0x8 |   | CODE: 0x0     | CHECKSUM |     |
| ID: 0x2   |   | SEQ NUMBER: 1 |          |     |

Figure 10. Package structure

Press the "Next" button. And the packet will immediately move to the hub. This is the only network connection on this side (Fig. 11).

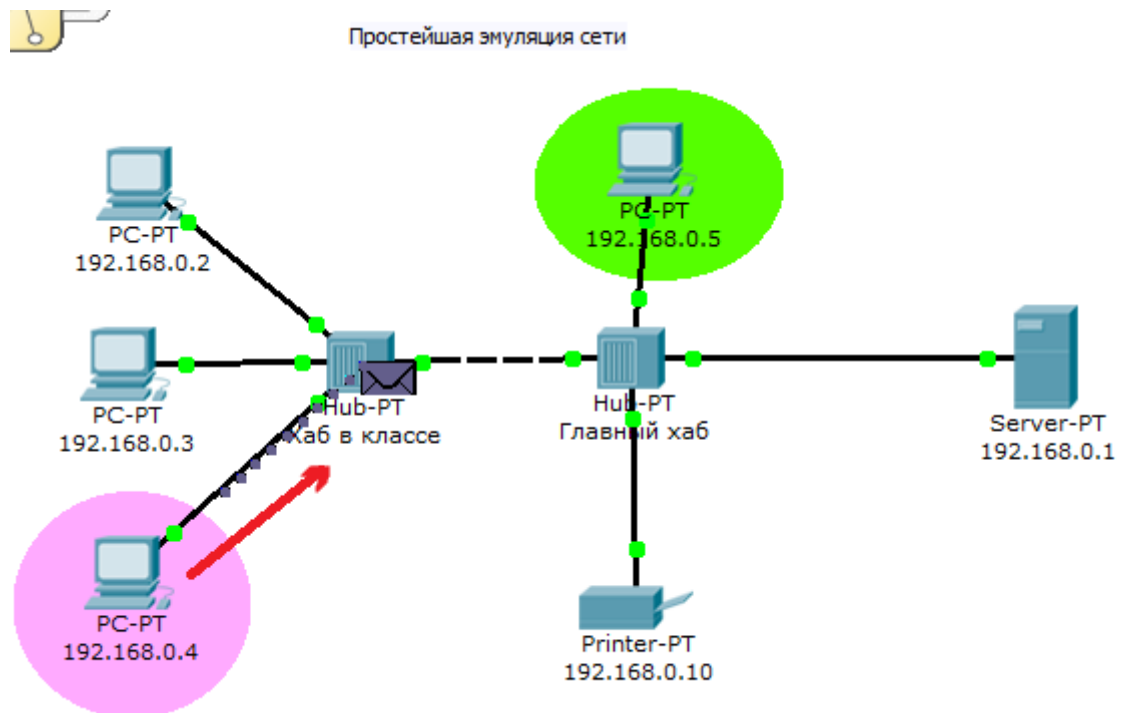


Figure 11. Passing the package. First stage

The hub repeats the packet on all other ports in the hope that one of them has a destination (see Figure 12)

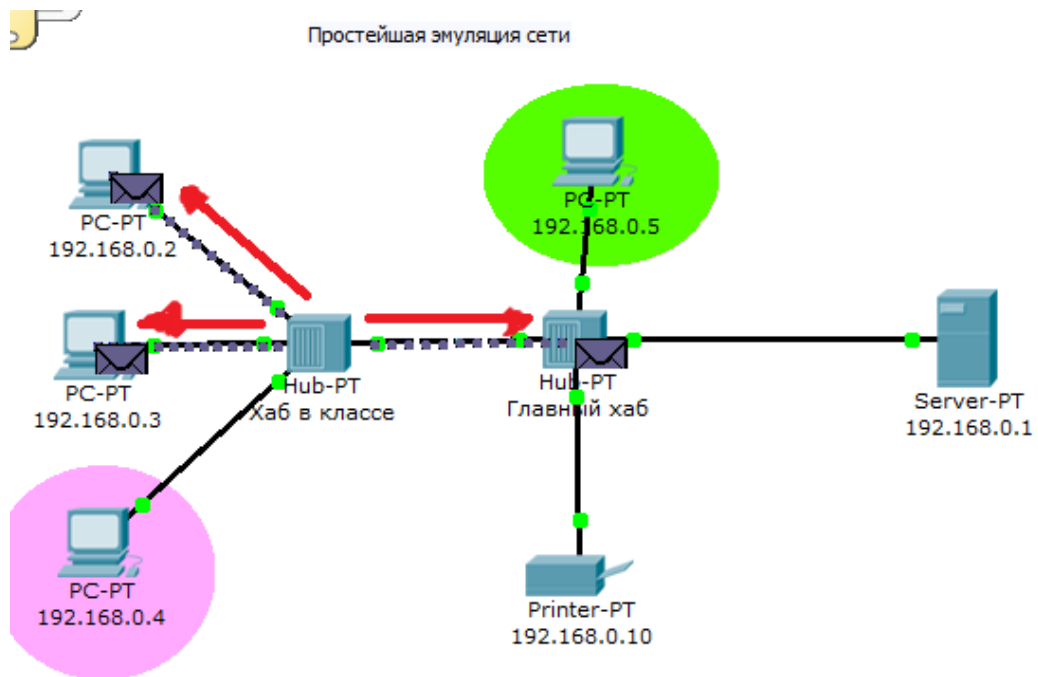


Figure 12. Passing the package. Second stage

If the packets are not intended for some nodes, they simply ignore them (Fig.

13).

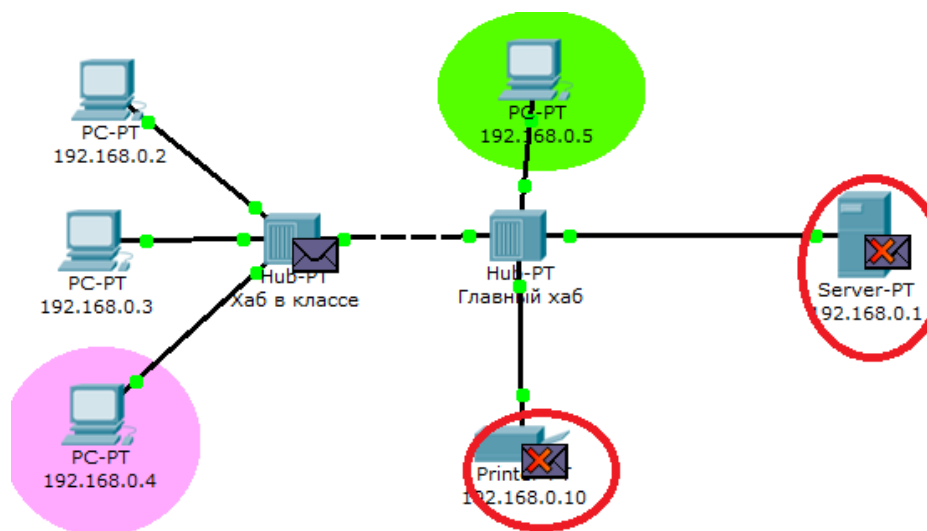


Figure 13. Passing the package. Third stage

When the packet is returned, we will see a connection confirmation:

### **Content of the report and its form**

The report must contain

- the title of the practical work;
- the purpose of the work;

- the procedure for performing work;
- results of implementation;
- answers to control questions;
- conclusion on the work done.

### **Control questions**

1. Which expansion card provides the functionality of the built-in access point?
2. Which expansion card provides single-port serial connectivity to remote offices or legacy off-the-shelf network devices?
3. What is the name of the high-performance module with 4 Ethernet switching ports for the RJ-45 connector?
4. List the network cards that allow you to connect to WAN networks?
5. What type of interface should I choose when creating a cluster?
6. What are the models of Layer 3 switches?
7. What type of cable should I use when connecting routers to each other?
8. Specify the series of trunk routers.
9. When is the SERIAL interface used?
10. How to organize communication between two backbone routers?
11. What are all the possible modes of operation of Cisco Paket Tracer?
12. What are the models of Layer 2 switches?
13. List all the types of links used in Cisco Paket Tracer and specify their purpose.
14. What is the simulation mode used for?
15. How do I view the progress of the package through the layers of the OSI model?
16. Is it possible to determine the reason why the packet sent in the simulation mode did not reach the destination and at what stage did the network fail?
17. Specify the IP addresses of the sender and recipient in the packet.
18. How do I change the filters of the event list?
19. How do I determine which protocols were involved in the network in simulation mode?
20. How can I track the changes in the contents of a packet as it passes through the network in simulation mode?

21. List the main features of the simulation mode.

**Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;
- report submission.

# PRACTICAL WORK

## EXPLORING THE CAPABILITIES OF THE CISCO PACKET TRACER NETWORK SIMULATOR

**The purpose of the work:** to study the capabilities of Packet Tracer, as well as to work with files in the simulator.

### Theoretical substantiation

Packet Tracer software products allow you to create network topologies from a wide range of Cisco routers and switches, workstations and network connections such as Ethernet, Serial, ISDN, Frame Relay. This function can be performed both for training and work, for example, to configure the network at the planning stage or to create a copy of the production network in order to eliminate a malfunction.

To start Cisco Packet Tracer, you need to call the executable file PacketTracer5.exe. The general view of the program is shown in Fig. 1.

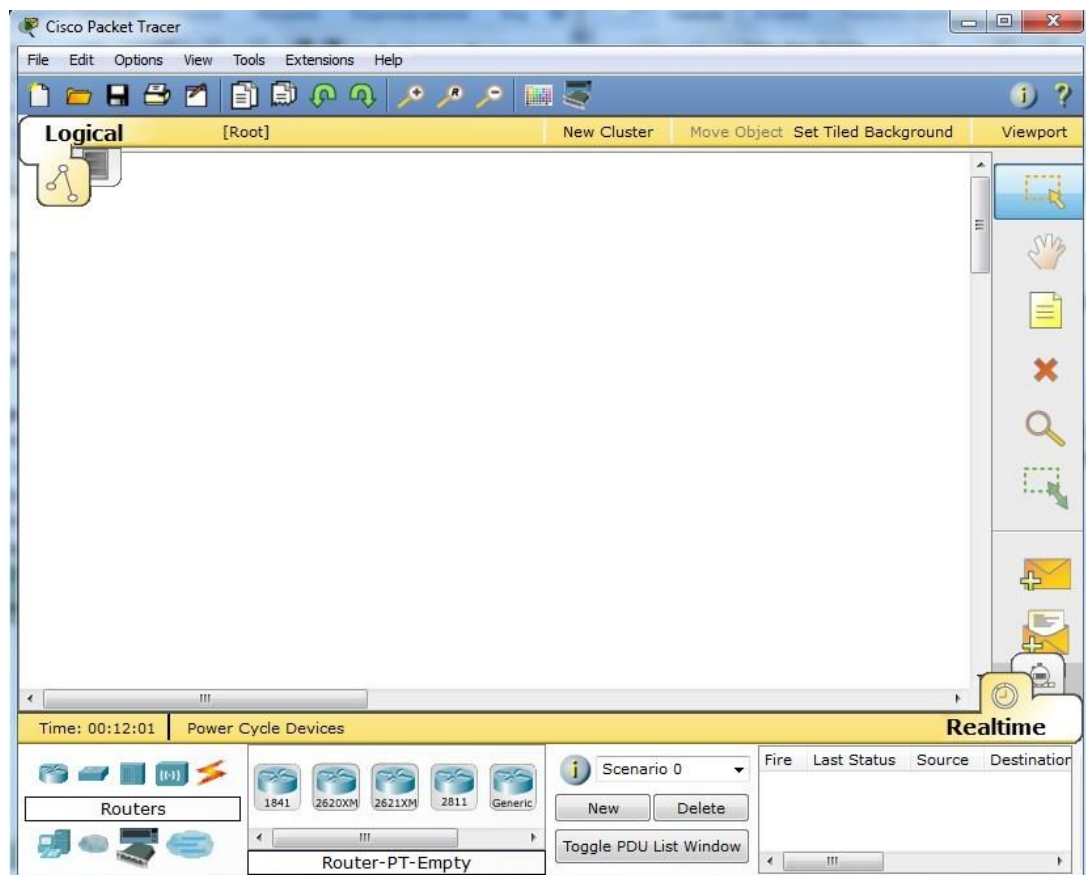


Figure 1. General view of the Packet Tracer program

The workspace of the application window consists of the following elements:

- 1 **Menu Bar** – a panel that contains the File, Edit, Options, View, Tools,

Extensions, Help menus.

2     **Main Tool Bar** – contains graphical shortcuts for accessing the File, Edit, View, and Tools menu commands, as well as a Network Information button.

3     **Common Tools Bar** – A panel that provides access to the most commonly used tools in the program: Select, Move Layout, Place Note, Delete, Inspect, Add Simple PDU, and Add Complex PDU.

4     **Logical/Physical Workspace and Navigation Bar** – a panel that allows you to switch the workspace: physical or logical, and also allows you to move between levels of the cluster.

5     **Workspace** – An area where the network is created, the simulation is observed, and various information and statistics are viewed.

6     **Realtime/Simulation Bar** —Use the tabs in this bar to toggle between Real Time and Simulation Mode. It also contains Power Cycle Devices-specific buttons, Play Control buttons, and an Event List toggle in Simulation mode.

7     **The Network Component Box** is an area where devices and relationships are selected to place in the workspace. It contains the Device–Type Selection and Device–Specific Selection areas.

8     **Device–Type Selection Box** —The area contains the available device types and associations in the Packet Tracer. The Device–Specific Selection area changes depending on the selected device.

9     **Device–Specific Selection Box** —The area is used to select the specific devices and connections needed to build in the network workspace.

10    **User Created Packet Window** – This window manages the packages that were created on the network during the scenario simulation.

To create a topology, select the device from the Network Component panel, and then select the device type from the Device–Type Selection panel. After that, you need to click the left mouse button in the Workspace field. You can also move the device directly from the Device–Type Selection area, but this will select the default device model.

To quickly create several instances of the same device, hold down the Ctrl

button, click on the device in the Device-Specific Selection area and release the Ctrl button. After that, you need to click several times in the workspace to add copies of the device.

Packet Tracer offers the following types of devices:

- routers;
- switches (including bridges);
- hubs and repeaters;
- end devices – PCs, servers, printers, IP phones;
- Wireless devices: Access points and a wireless router
- devices – cloud, DSL modem, and cable modem.

Let's add the necessary elements to the workspace of the program as shown in Fig. 2.

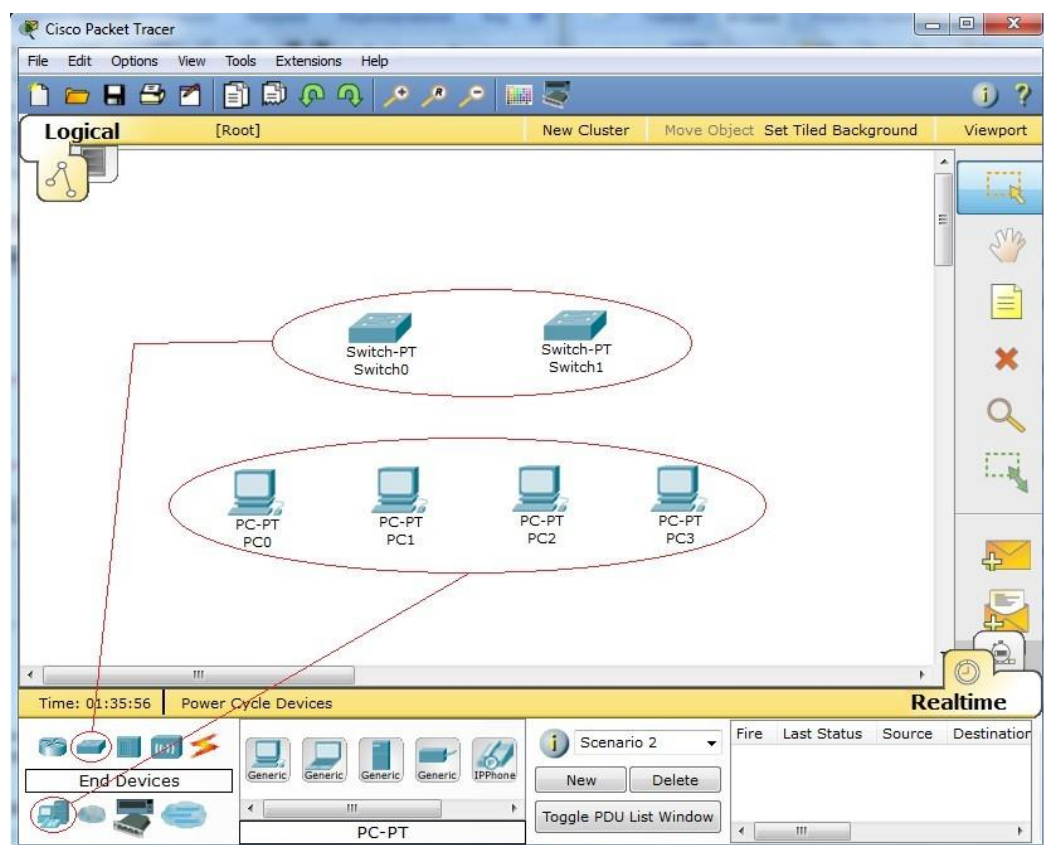


Figure 2. Adding network elements

When adding each element, the user has the opportunity to give it a name and set the necessary parameters. To do this, click on the desired element with the left mouse button (LMB) and go to the Config tab in the device dialog.

The properties dialog box for each item has two tabs:

- Physical – contains the graphical interface of the device and allows you to simulate working with it at the physical level.
- Config – contains all the necessary parameters for configuring the device and has a convenient interface for this.

Also, depending on the device, properties may have an additional tab to control the operation of the selected element: Desktop (if the end device is selected) or CLI (if the router is selected), etc.

To remove unnecessary devices from the workspace of the program, use the Delete (Del) button.

To do this, select the **Connections** tab from the Network Component Box panel. We will see all the possible types of connections between devices. Select the appropriate cable type. The mouse will change to the "connection" cursor (in the form of a connector). Click on the first device and select the appropriate interface to which you want to connect, then click on the second device and perform the same operation. You can also connect network elements using the **Automatically Choose Connection Type**. Select and click on each of the devices you want to connect. A cable connection will appear between the devices, and the indicators at each end will show the connection status (for interfaces that have an indicator).

Figure 3. Packet Tracer Cable Types Supported



Packet Tracer supports a wide range of network connections (see Table 1). Each type of cable can only be connected to certain types of interfaces.

Table 1. Types of connections in Packet Tracer

| Cable Type | Description |
|------------|-------------|
|------------|-------------|

|                                                                                                                   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Console</p>                   | <p>A console connection can be made between a PC and routers or switches. Some requirements must be met for a console session to work with a PC: the connection speed on both sides must be the same, there must be 7 bits of data (or 8 bits) for both sides, parity must be the same, there must be 1 or 2 stop bits for both sides.</p>                                                                                                                                                                                                            |
| <p>Copper Straight– through</p>  | <p>This type of cable is a standard Ethernet transmission medium for connecting devices, which operates at different OSI layers. It must be connected to the following types of ports: copper 10 Mbps (Ethernet), copper 100 Mbps (Fast Ethernet), and copper 1000 Mbps (Gigabit Ethernet).</p>                                                                                                                                                                                                                                                       |
| <p>Copper Cross– over</p>        | <p>This type of cable is an Ethernet transmission medium for connecting devices that operate at the same OSI layers. It can be connected to the following types of ports: copper 10 Mbps (Ethernet), copper 100 Mbps (Fast Ethernet), and copper 1000 Mbps (Gigabit Ethernet).</p>                                                                                                                                                                                                                                                                    |
| <p>Fiber</p>                     | <p>Fiber optic media is used for the connection between optical ports (100 Mbps or 1000 Mbps).</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| <p>Phone</p>                    | <p>A dial-up connection can only be made between devices that have modem ports. A standard dial-up connection is an end device (such as a PC) dialing into the network cloud.</p>                                                                                                                                                                                                                                                                                                                                                                     |
| <p>Coaxial</p>                 | <p>A coaxial medium is used for the connection between coaxial ports, such as a cable modem connected to the Packet Tracer cloud.</p>                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <p>Serial DCE and DTE</p>      | <p>Connections via serial ports are often used for WAN links. To configure such connections, synchronization must be established on the DCE side of the device. DTE synchronization is optional. The DCE side can be determined by the small "clock" icon next to the port. If you select the Serial DCE connection type, the first device to which the connection is applied becomes the DCE device, and the second automatically becomes the DTE side. It is also possible to reverse the sides if the Serial DATE connection type is selected.</p> |

After creating a network, you need to save it by selecting the File → Save menu item or the Save icon in the **Main Tool Bar**. The saved topology file has the \*.pkt extension.

Packet Tracer allows you to simulate the operation of the command line interface (ICS) of the IOS operating system, installed on all Cisco switches and

routers.

Once connected to a device, we can work with it as if we were on a console on a real device. The simulator provides support for almost all commands available on real devices.

Switches or routers can be connected to ICS by clicking on the required device and going to the CLI tab in the properties window.

To simulate the operation of the command line on the target device (computer), select the Desktop tab in the properties, and then click on the Command Prompt shortcut.

### **Working with files in the simulator**

Packet Tracer allows the user to store the configuration of some devices, such as routers or switches, in text files. To do this, go to the properties of the required device and click on the "Export..." button in the Config tab to export the Startup Config or Running Config configuration. Thus, we will get a dialog box for saving the required configuration to a file that will have the \*.txt extension. The text of the running-config.txt device configuration file (the default name) is similar to the text of the information received when using the show running-config command in IOS devices.

It should be noted that the configuration of each device is saved in a separate text file. The user also has the ability to change the configuration in the saved file manually using a custom text editor. To provide the device with saved or edited settings, click the "Load..." button in the Config tab to load the required Startup Config configuration or the "Merge..." button to load the Running Config configuration.

### **Equipment and materials**

To perform practical work, you need a personal computer with Internet access, Cisco Packet Tracer and Microsoft Office.

### **Safety Instructions**

It is necessary to comply with the safety requirements provided for the computer class

1. Do not turn on the computer without the permission of the class administrator and instructor.
2. It is forbidden to open the PC case on your own.
3. Do not touch the monitor screen and keyboard at the same time (increased electrostatic potential may be discharged).
4. Do not clutter the top panels of the devices with papers and foreign devices.
5. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.
6. It is forbidden to turn off the power supply during the execution of an active task.
7. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

### **Methodology and procedure for performing work**

1. Let's add Switch-PT switches to the program workspace 2. By default, they are named Switch0 and Switch1.
2. Let's add four computers to the workspace with the default names PC0, PC1, PC2, PC3.
3. Let's connect the devices to an Ethernet network, as shown in Fig.1.4.
4. Save the created topology by clicking the Save button (in the File → Save menu).
5. Open the properties of the PC0 device by clicking on its image. Go to the Desktop tab and simulate run by clicking Command Prompt.
6. The list of commands will be obtained if we enter the command ? and press Enter. To configure the computer, use the ipconfig command from the command line, for example, for computer PC0:

```
ipconfig 192.168.1.2 255.255.255.0
```

The IP address and network mask can also be entered in the device's easy-to-use graphical interface (see Figure 4 and Figure 5). In the DEFAULT GATEWAY field, enter the gateway address, in this case this information is not important, since

the network to be created does not require routing.

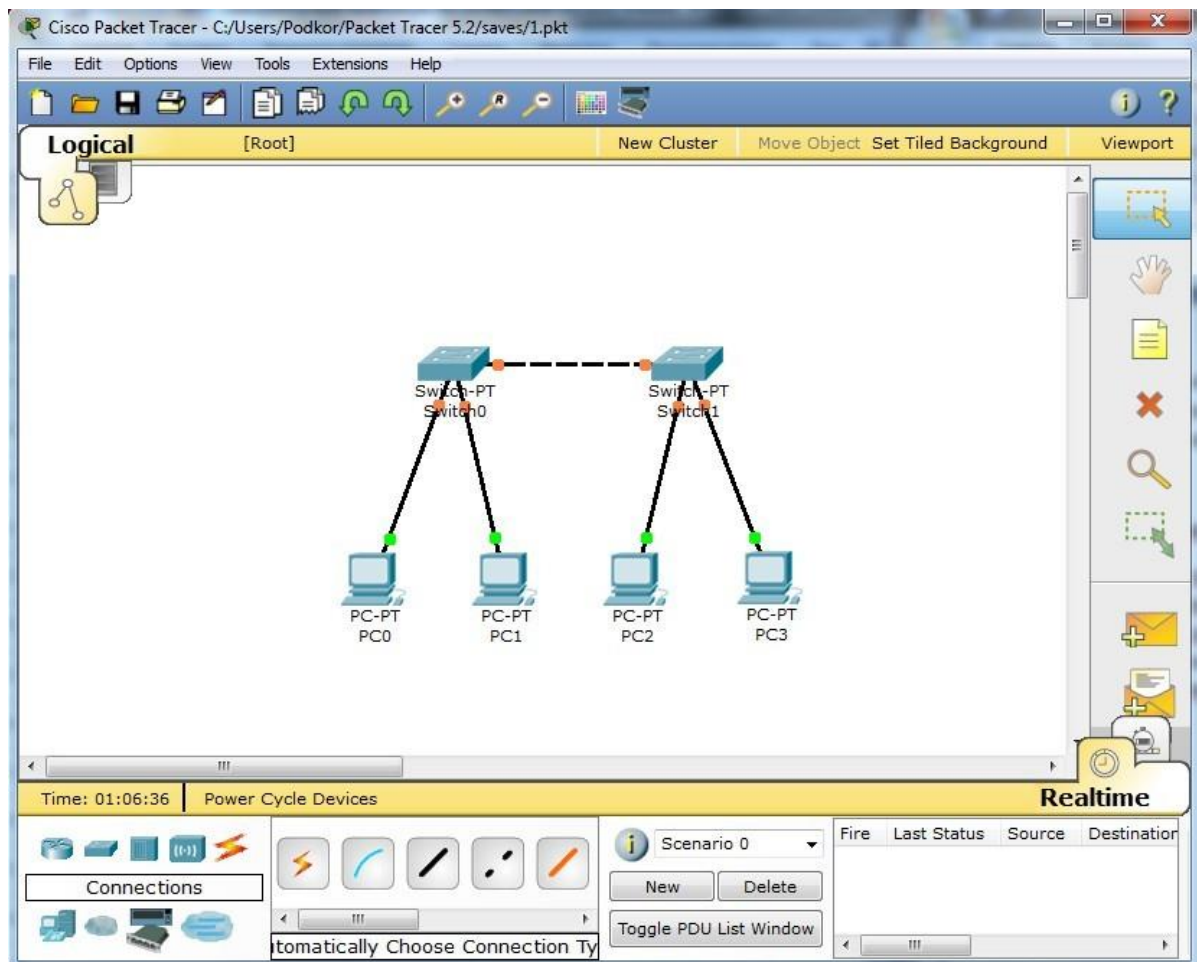


Figure 4. Created network fragment

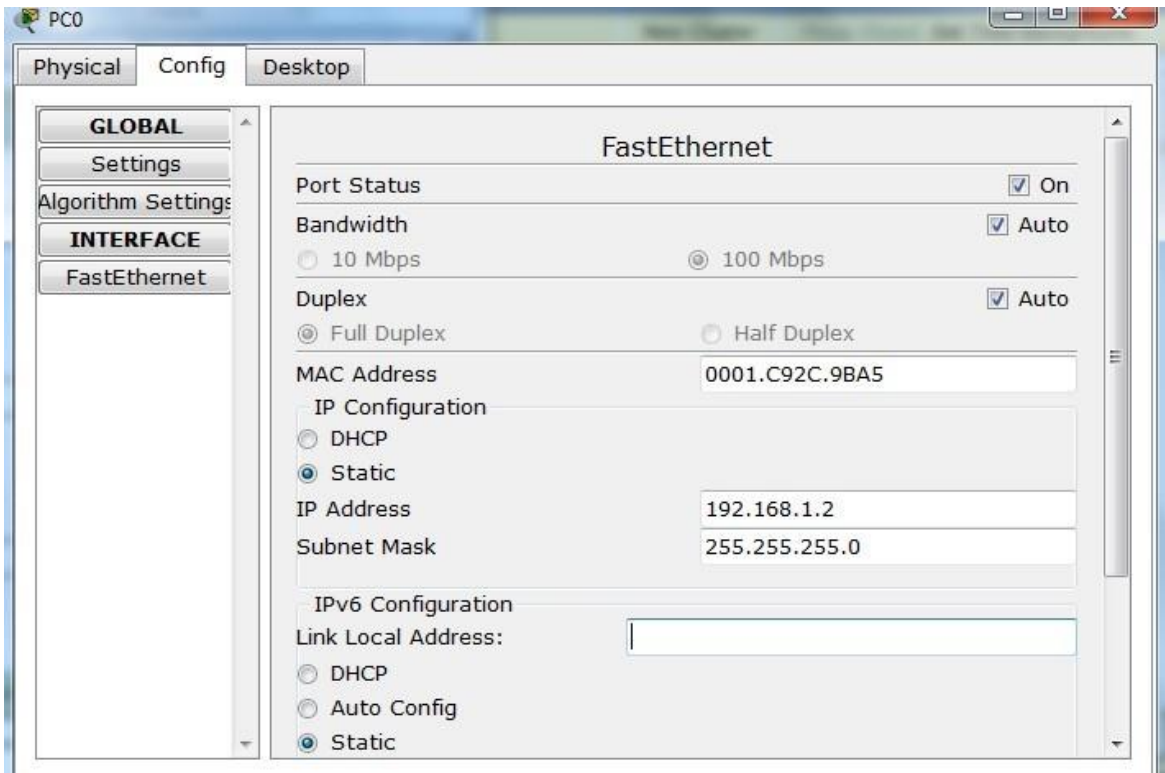


Figure 5. Setting up PC0

In the same way, configure each computer in Fig. 4.

Table 2. IP addresses and computer masks

| Device | IP ADDRESS  | SUBNET MASK   |
|--------|-------------|---------------|
| PC0    | 192.168.1.2 | 255.255.255.0 |
| PC1    | 192.168.1.3 | 255.255.255.0 |
| PC2    | 192.168.1.4 | 255.255.255.0 |
| PC3    | 192.168.1.5 | 255.255.255.0 |

7. On each computer, we will look at the assigned addresses with the ipconfig command without parameters. If everything is done correctly, we can check the connection of the computers using the ping command. For example, let's go to computer PC3 and ping it with computer PC0. We should see a ping report similar to Fig. 6.

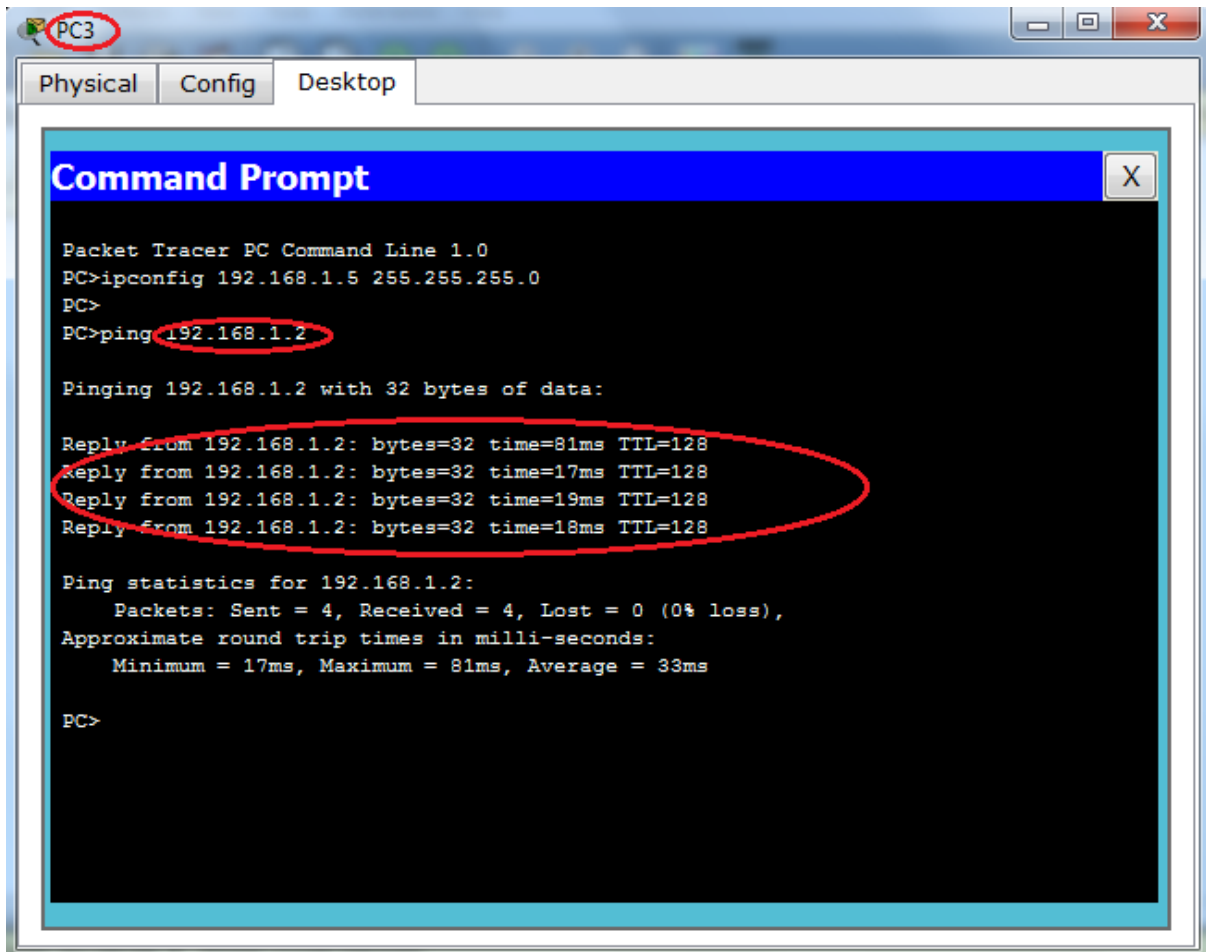


Figure 6. PC3 ping report

## Task

1. Create a topology

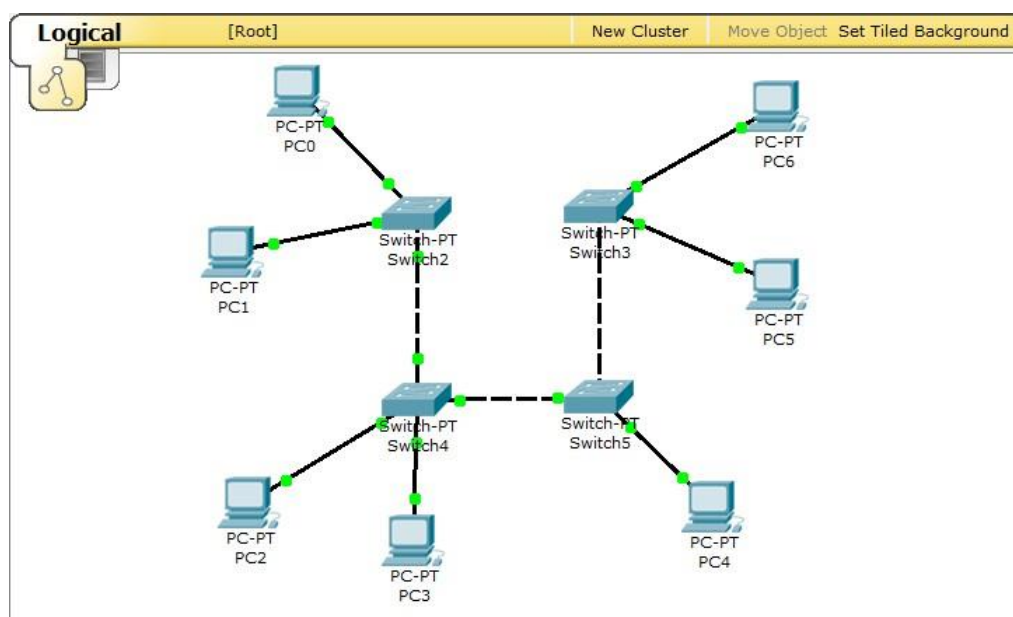


Figure 7. Network topology

2. Assign addresses to the computers according to your option

Table 3. IP addresses and computer masks

| Device | IP ADDRESS  | SUBNET MASK   |
|--------|-------------|---------------|
| PC1    | 192.168.1.1 | 255.255.255.0 |
| PC2    | 192.168.1.2 | 255.255.255.0 |
| PC3    | 192.168.1.3 | 255.255.255.0 |
| PC4    | 192.168.1.4 | 255.255.255.0 |
| PC5    | 192.168.1.5 | 255.255.255.0 |
| PC6    | 192.168.1.6 | 255.255.255.0 |
| PC0    | 192.168.1.7 | 255.255.255.0 |

3. Assign different IP addresses to computers on the command line.

4. If done correctly, you can ping any computer from any other computer.

Table 4. Variants of tasks

| Option No | Ping from | Ping in | Option No | Ping from | Ping in |
|-----------|-----------|---------|-----------|-----------|---------|
| 1         | PC1       | PC6     | 7         | PC0       | PC5     |
| 2         | PC2       | PC0     | 8         | PC1       | PC6     |
| 3         | PC3       | PC1     | 9         | PC2       | PC7     |
| 4         | PC4       | PC2     | 10        | PC3       | PC1     |
| 5         | PC5       | PC3     | 11        | PC4       | PC2     |
| 6         | PC6       | PC4     | 12        | PC5       | PC3     |

It is assumed to create a real fragment of the network in Fig. 1.7 and demonstrate the ping command to the teacher according to your version.

### Content of the report and its form

The report must contain

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;
- results of implementation;
- answers to control questions;
- conclusion on the work done.

### **Control questions**

1. What is the maximum number of devices on the network supported by Packet Tracer?
2. What types of network devices and connections can be used in Packet Tracer?
3. How to navigate to the device's CLI.
4. How do I configure devices from another computer?
5. How do I add to the topology and configure a new device?
6. How do I save my device configuration to .txt file?

### **Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;
- report submission.

## **PRACTICAL WORK**

### **NETWORK SERVICES**

**The purpose of the work:** to learn how to configure network services.

#### **Theoretical substantiation**

The Cisco Packet Tracer emulator allows you to configure network services such as: HTTP, DHCP, TFTP, DNS, NTP, EMAIL, FTP as part of the network server.

Let's consider the tincture of some of them.

#### **Equipment and materials**

To perform practical work, you need a personal computer with Internet access, Cisco Packet Tracer and Microsoft Office.

#### **Safety Instructions**

It is necessary to comply with the safety requirements provided for the computer class

8. Do not turn on the computer without the permission of the class administrator and instructor.

9. It is forbidden to open the PC case on your own.

10. Do not touch the monitor screen and keyboard at the same time (increased electrostatic potential may be discharged).

11. Do not clutter the top panels of the devices with papers and foreign devices.

12. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.

13. It is forbidden to turn off the power supply during the execution of an active task.

14. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

#### **Methodology and procedure for performing work**

Create the following network diagram shown in Fig. 1:

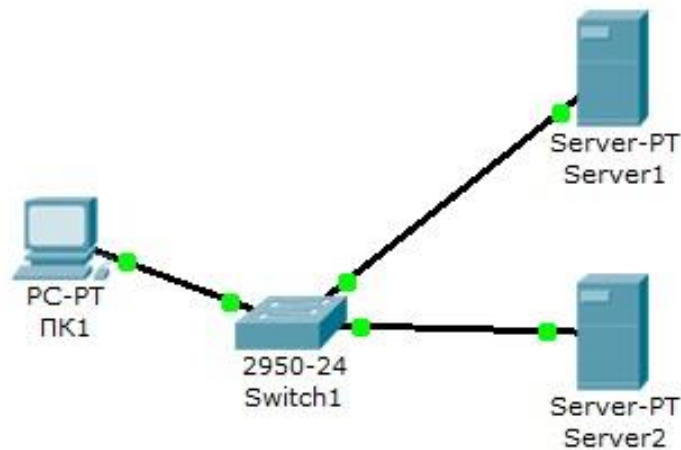


Figure 1. Network diagram

Task:

Configure the network as follows:

- 1 – Server1 – DNS and Web server;
- 2 – Server2 – DHCP server;
- 3 – PC 1 receives TCP/IP protocol parameters from the DHCP server and opens the [www.rambler.ru site](http://www.rambler.ru) on Server1.

Stage 1.

1.1 Configure TCP/IP protocol settings on PC1 and servers.

1.2 Enter the PC1 configuration and set the IP setting through the DHCP server (Fig. 1). 2.).

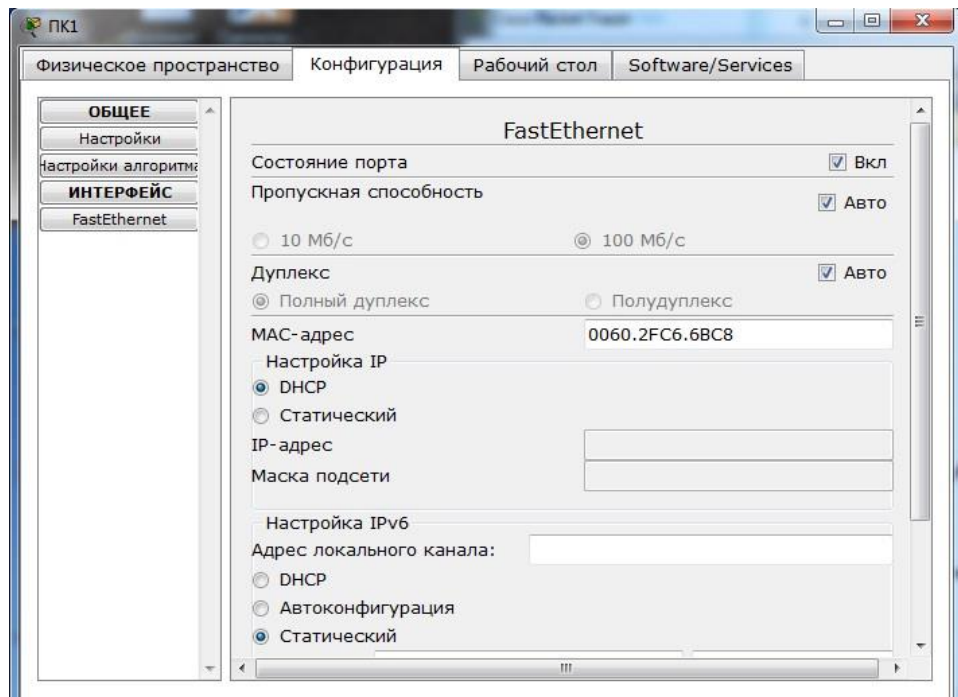


Figure 2. Setting up IP on PC1

1.3 Set the following IP settings in the server configuration:

Server1: IP address is 10.0.0.1, subnet mask is 255.0.0.0

Server2: IP address is 10.0.0.2, subnet mask is 255.0.0.0

Step 2. Configure the DNS service on Server1.

2.1 To do this, go to the DNS tab in the Server1 configuration and set two resource records in the direct DNS zone:

2.2 In the Type A resource record, associate the domain name of the computer with its IP address (Fig. 3.) and click the ADD button:

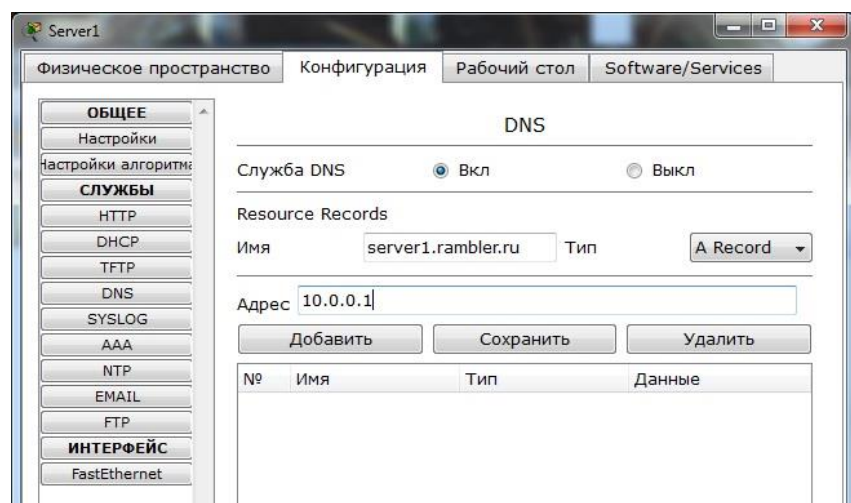


Figure 3. Entering a Type A Resource Record

2.3 In a resource record of type CNAME, associate the site alias with the computer (see Figure 1). 4.):

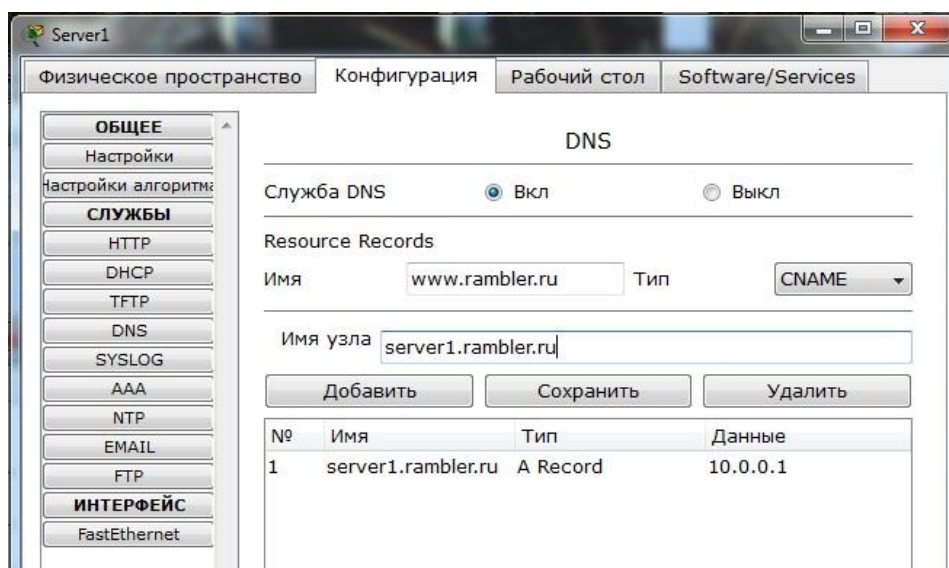


Figure 4. Entering a CNAME Resource Record

2.4 In the Server1 configuration, go to the HTTP tab and set the start page [of the site WWW.RAMBLER.RU](http://www.rambler.ru) (Fig. 1). 5.):

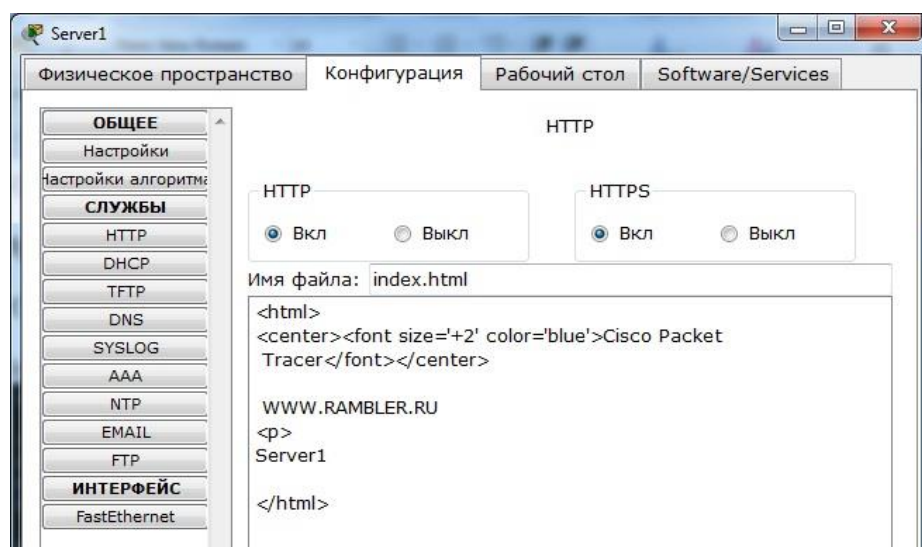


Figure 5. Start page of the site

2.5 Enable the command prompt on Server1 and test the DNS service. To check the direct DNS zone of the server, enter the command:

**SERVER>nslookup www.rambler.ru**

If everything is correct, you will get the response shown in Fig. 6., indicating the fully qualified domain name of the DNS server on the network and its IP address.

```

SERVER>nslookup www.rambler.ru

Server: [10.0.0.1]
Address: 10.0.0.1

Non-authoritative answer:
Name:   server1.rambler.ru
Address: 10.0.0.1

Aliases:   server1.rambler.ru

SERVER>

```

Figure 6. Checking a direct DNS zone

Step 3. Configure the DHCP service on Server2.

3.1 To do this, enter the Server2 configuration and configure the service on the DHCP tab (see Figure 1). 7.):

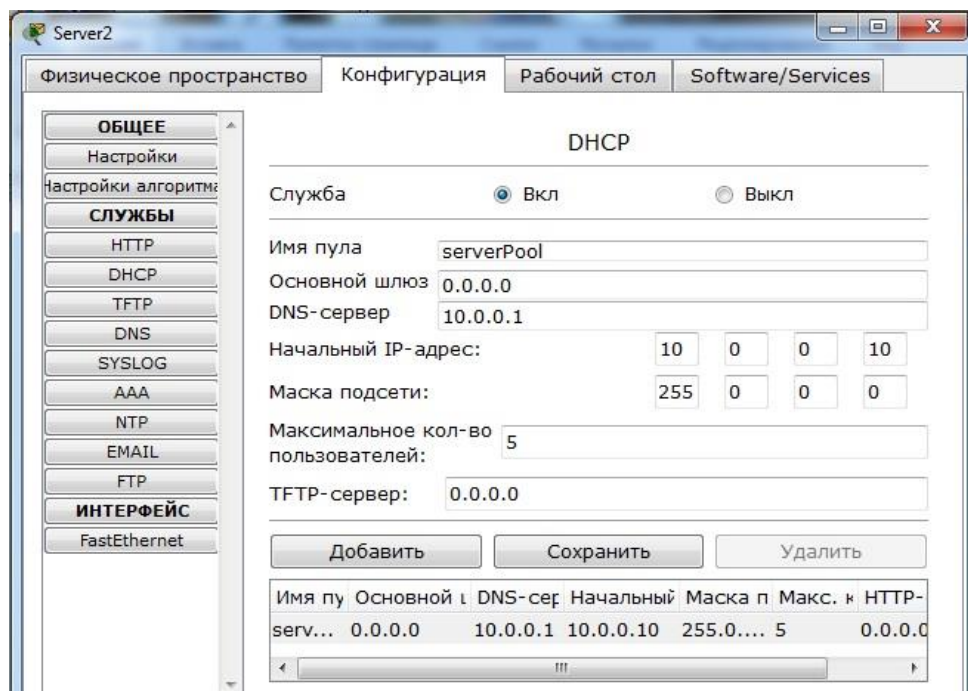


Figure 7. Configuring the DHCP Server

Stage 4. Checking the client's work.

4.1 Log in to the desktop in the PC1 host configuration and configure the TCP/IP protocol at the command prompt. Use the PC>ipconfig /release command to reset the old IP address settings, and use the PC>ipconfig /renew command to get the new settings from the DHCP server (see Figure 1). 8.):

```
PC>ipconfig /release

IP Address. . . . .: 0.0.0.0
Subnet Mask. . . . .: 0.0.0.0
Default Gateway. . . . .: 0.0.0.0
DNS Server. . . . .: 0.0.0.0

PC>ipconfig /renew

IP Address. . . . .: 10.0.0.10
Subnet Mask. . . . .: 255.0.0.0
Default Gateway. . . . .: 0.0.0.0
DNS Server. . . . .: 10.0.0.1

PC>
```

Figure 8. TCP/IP client configuration

4.2 Open the WWW.RAMBLER.RU site in a browser on the client (see Figure 1). 9.):

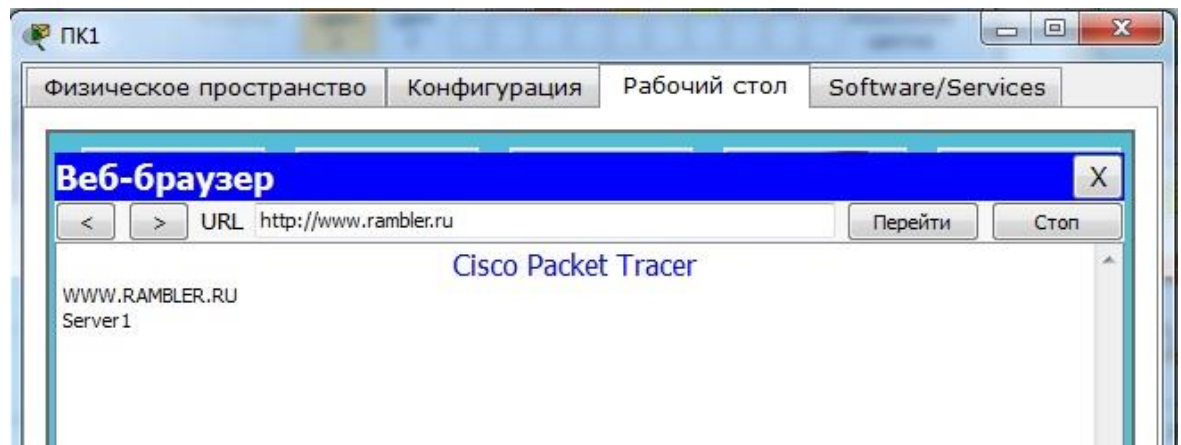


Figure 9. Checking the client's work

### Content of the report and its form

The report must contain

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;
- results of implementation;
- answers to control questions;
- conclusion on the work done.

### Control questions

1. What is a recursive DNS query and how does it work?

2. Specify the assignment of resource record types in the forward and reverse DNS zones.
3. How is the DNS server configured to forward packets to other DNS servers?
4. Describe how DHCP works.
5. How is a DHCP client configured?
6. Specify the locations of the folder with the content of the Web site and the FTP server.
7. How the composition of the reverse DNS server zones in the corporate network is determined.
8. Can you demonstrate how to configure DNS in Cisco Packet Tracer?
9. Can you demonstrate how to configure DHCP in Cisco Packet Tracer?
10. Can you demonstrate how to configure the FTP service in Cisco Packet Tracer?
11. Can you demonstrate how to configure a WEB server in Cisco Packet Tracer?

### **Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;
- report submission.

## **PRACTICAL WORK**

### **RESEARCH OF WIRELESS COMPUTER TECHNOLOGIES**

**The purpose of the work:** to gain skills and abilities in the development and configuration of the simplest Wi-Fi networks.

#### **Theoretical substantiation**

In the course of the work, it is necessary to study the composition and purpose of the equipment of the stand "Wireless Wi-Fi networks". Also, to gain skills in setting up wireless network elements based on the stand and to practice practical skills in creating and configuring a wireless Wi-Fi network.

In the modern world, wireless Wi-Fi networks are increasingly used, allowing customers to access network resources, such as the Internet, from a laptop or personal computer, using a radio channel as a data transmission medium, which does not require special wired connections of clients to the network, thus ensuring their mobility.

Each computer or printer connected to a local network must have a special card (network adapter). The main function of a network adapter is to transmit and receive information from the network. In wired LANs, computers are connected using a cable. Cables are connected to network adapters that can provide data rates of 10 Mbps, 100 Mbps, or 1000 Mbps.

In order for a TCP/IP WAN to work effectively as a collection of networks, routers that exchange packets between networks do not know the exact location of the host to which the packet is destined. Routers only know which network the host belongs to and use the information stored in the routing tables to deliver the packet to the destination node's network. Once the packet is delivered to the correct network, it is delivered to the appropriate node. The next element required for TCP/IP to work is the subnet mask. TCP/IP uses a subnet mask to determine whether a host is on a local subnet or a remote network.

In TCP/IP, the parts of the IP address used as the network and host address are not fixed, so the above network and host addresses cannot be determined without additional information. This information can be obtained from another 32-bit

number called the subnet mask. In this example, the subnet mask is 255.255.255.0. The meaning of this number is clear if you know that the number 255 in binary represents the number 11111111.

Internet addresses are allocated by the InterNIC (<http://www.internic.net>), which administers the Internet. These IP addresses are distributed into classes. The most common are classes A, B, and C. Classes D and E exist, but are not commonly used by end users. Each of the address classes has its own default subnet mask. You can identify an IP address class by its first octet. Class A networks use the default subnet mask of 255.0.0.0 and have values between 0 and 127 in the first octet. The address 10.52.36.11 is a Class A address. The first octet is the number 10, which is in the range 1 through 126. Class B networks use the default subnet mask of 255.255.0.0 and have a value between 128 and 191 in the first octet. The address 172.16.52.63 is a Class B address. The first octet is the number 172, which is in the range 128 to 191 inclusive. Class C networks use the default subnet mask of 255.255.255.0 and have a value between 192 and 223 in the first octet. The address 192.168.123.132 is a Class C address. In the first octet, the number is 192, which is between 192 and 223 inclusive.

Wireless networks such as Wi-Fi can provide data transfer speeds of up to 54 Mbps, but the speed depends on the number of connected computers and the distance to the access point.

Modern versions of the OS have built-in network capabilities that make connecting to a local network easy and fast.



Figure 1. Exterior of the stand

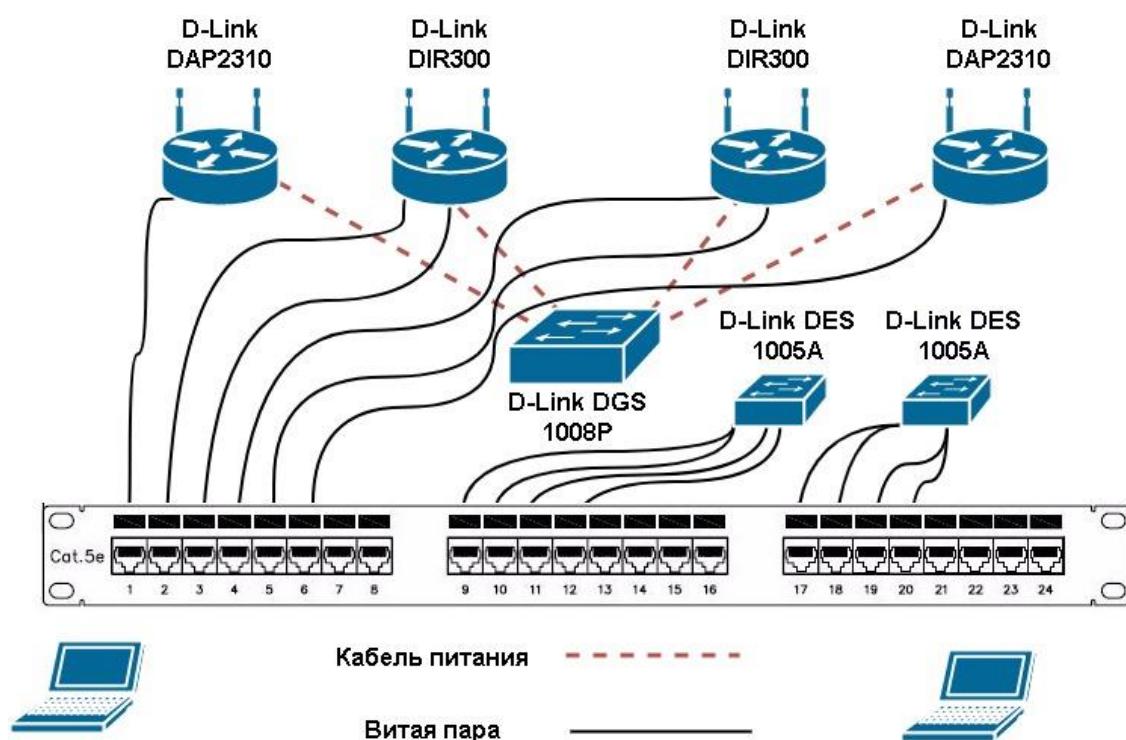


Figure 2. Structure of connection of stand elements

### Composition of the stand

The DAP-2310 access point (Fig. 1, 2) with support for the 802.11n standard is an ideal solution for building or increasing the bandwidth of wireless networks. The DAP-2310 access point can act as a base station for connecting devices operating under the 802.11b, 802.11g and 802.11n standards to the wireless network.

The DAP-2310 provides a manageable and reliable 802.11n wireless network. Two detachable antennas provide optimal range in the 2.4GHz frequency band (802.11g and 802.11n standards) using increased transmitter power to eliminate dead zones and increase throughput.

### DWL-P50 Adapter



Figure 3. DWL to P50 adapter

The DWL-P50 (Figures 3, 4) is a single-port Power over Ethernet adapter that provides DC power to non-PoE devices (PoE allows power to network devices over an Ethernet cable that is used to transmit data), such as security cameras or access points. It is designed to work with LAN switches and other equipment that supports the 802.3af Power over Ethernet (PoE) network device power standard, allowing network devices to be placed in places where power outlets are not available, such as rooftop or ceiling.



Figure 4. Simplifying the installation of network devices

**The wireless interface** is provided by the DIR-300 wireless router (Fig. 5), which acts as a base station for connecting devices operating under the 802.11b, 802.11g and 802.11n standards (at a speed of up to 150 Mbit/s) to the wireless network.



Figure 5. DIR-300 router

The router implements many functions for the wireless interface. The device supports several security standards (WEP, WPA/WPA2), filtering of connected devices by MAC address, and also allows you to use WPS and WMM technologies. (WPS – Wi-Fi Protected Setup is a special technology or standard that greatly simplifies the process of setting up a wireless WiFi network and allows you to connect devices simply, quickly and, most importantly, safely.

Setting up a WiFi wireless network using the WPS function takes minimal time. To connect the device, you just need to press the button of the same name and wait for the wireless devices to communicate with each other.

Wi-Fi Multimedia (WMM) technology improves wireless data transfer by allowing you to prioritize different types of data. By enabling WMM, you can set a high priority for multimedia applications, thereby ensuring minimal latency.

The DIR-300 wireless router is based on the 802.11g standard, but is also 802.11b compliant, ensuring compatibility with a wide range of wireless devices. The 802.11g wireless router contains four Ethernet ports that allow you to connect personal computers, printers, and other devices with an Ethernet interface.

Default settings:

The IP address of the wireless router is 192.168.0.1.

Username: admin.

Password: admin.

The name of the wireless network is DIR-300.

D-Link DGS-1008P switch (Fig. 6).



Figure 6. DGS-1008P switch

The 8-port **D-Link DGS-1008P** Gigabit Ethernet switch allows multiple workstations to be connected to a local network. Up to 8 different equipment (routers, computers...) can be connected, and users can easily connect and supply Power over Ethernet (PoE) to devices such as wireless access points (APs), IP cameras, and IP phones, as well as connect other Ethernet devices (computers, printers, NAS) to the network.

The 8-port DGS-1008P switch supports D-Link Green™ technology, which reduces power consumption and extends the life of the device without compromising the performance and functionality of the device.

#### **DES-1005A Switch**



Figure 7. Exterior view of the DES-1005A switch

The DES-1005A Switch (Figure 7) with 5 10/100 Mbps ports allows you to quickly create a high-speed, reliable, and efficient wired network. The DES-1005A Unmanaged Switch is designed to increase the performance of small workgroups while providing a high level of flexibility. This device allows users to simply connect any port to a 10/100 Mbps network for increased bandwidth, performance, and quality of operation with high traffic volumes.

## **Equipment and materials**

To perform practical work, you need a personal computer with Internet access, Cisco Packet Tracer and Microsoft Office.

Laboratory equipment: Patch panel, 3 laptops, 2 DAP2310 access points, 2 DIR300 routers, DGS1008 switches, DES1005A, single-port DWL-P50 adapters.

## **Safety Instructions**

It is necessary to comply with the safety requirements provided for the computer class

1. Do not turn on the computer without the permission of the class administrator and instructor.
2. It is forbidden to open the PC case on your own.
3. Do not touch the monitor screen and keyboard at the same time (increased electrostatic potential may be discharged).
4. Do not clutter the top panels of the devices with papers and foreign devices.
5. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.
6. It is forbidden to turn off the power supply during the execution of an active task.
7. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

## **Methodology and procedure for performing work**

**Task 1.** Using the laboratory stand, connect the network to the computer. To do this:

1. Turn off the power to the computer you are using.
2. Connect the Ethernet cable to one of the LAN ports (Fig. 9.8) located on the back of the router and to the Ethernet adapter of your computer through the Patch Panel.
3. Plug the power adapter into the appropriate connector on the back of the router, and then plug it into an electrical outlet.

4. Turn on the router by pressing the ON/OFF button on the back panel devices.
5. Turn on your computer and wait for the operating system to boot.
6. Next, you need to configure your computer to automatically obtain an IP address (as a DHCP client, a network protocol that allows computers to automatically receive an IP address and other parameters necessary to work in a TCP/IP network).

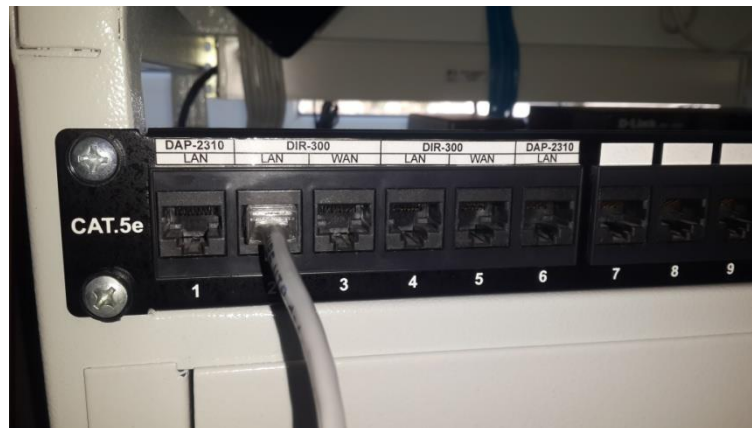


Figure 8. Connecting the router

**Task 2.** Setting an IP address on a computer with Windows 7/10.

1. Click the Start button and go to the Control Panel section.
2. Select Network and Sharing Center. (If the Control Panel is in category view (Category is selected in the upper-right corner of the window, in the View list), select the View Network and Tasks row under Network and Internet.)
3. From the menu on the left side of the window, select Change Adapter Settings.
4. In the window that opens, right-click on the corresponding LAN connection and select the Properties line from the context menu that appears.
5. In the LAN Connection – Properties window, on the Network tab, select the Internet Protocol version 4 (TCP/IPv4) line. Click the Properties button and enter the following settings:
  - Computer IP address: 192.168.0.101
  - Subnet mask: 255.255.255.0;

- Main gateway (DIR-300 router port address): 192.168.0.1;
- DNS server: 192.168.0.1.

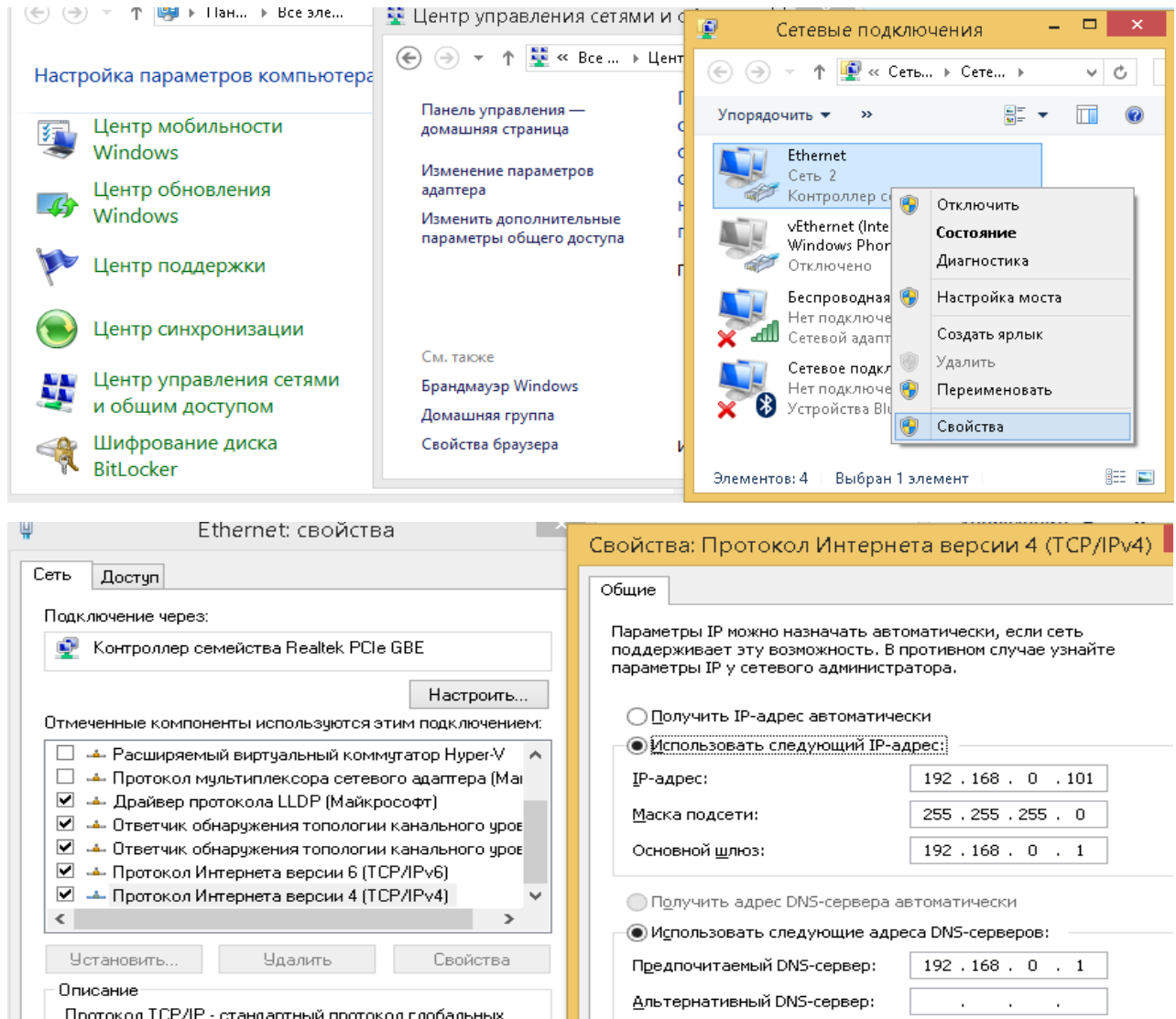


Figure 10. Setting an IP address on a computer running Windows XP/7/10

### Task 3. Setting up the D-Link DIR-300 router.

1. Launch a web browser.
2. In the address bar of the web browser, enter the IP address of the router (the default is 192.168.0.1). Press the Enter key.
3. On the page that opens, enter the administrator username and password to access the router's web interface (by default, the user name is admin, the password is admin). Click the Login link. In the address bar of the browser, enter the address 192.168.0.1 and go to the DIR300 router settings:



Figure 11. Login settings

2. By standard settings Login: admin; Password: admin

3. If you can't log in with this login/password, come to Hard Reset. To reset the settings to factory settings, you need to do the following:

If you lose the new administrator password, you will be able to access the router settings only after restoring the factory default settings using the hardware RESET button. This procedure will destroy all the router settings you have set. With the DIR-300 router enabled, find the recessed button on the back with the "Reset" inscription.

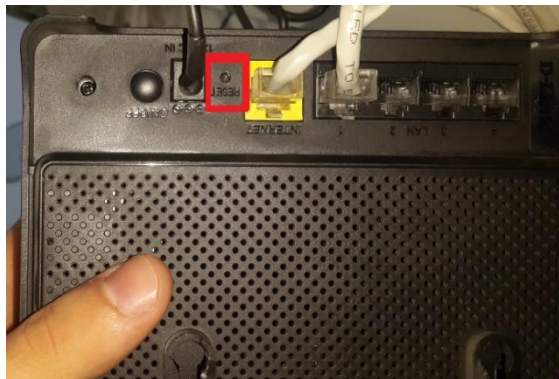


Figure 12. Turning on the DIR-300 router

2. Press the button with something sharp until it clicks and wait 15 seconds. After that, the router will perform a full reboot and a window will appear (Fig. 4), where you need to enter a new login, password.

3. After that, the DIR-300 router settings panel will open (Fig. 13):

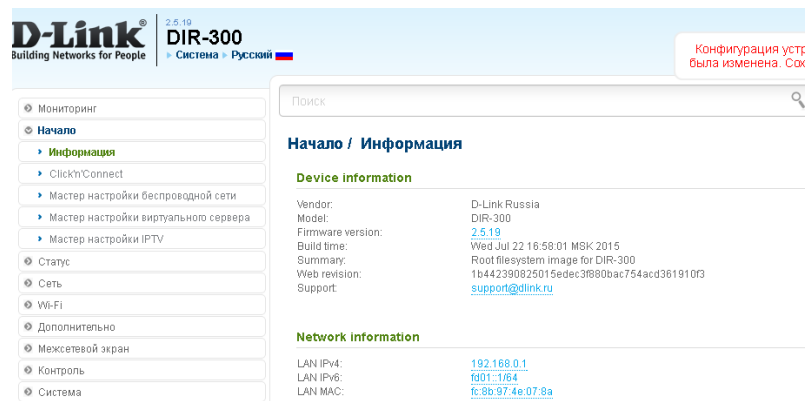


Figure 13. View of the D–Link DIR–300 router interface window

4. By selecting in the "Start – Information" tab, router parameters will appear on the screen, such as: Device model, firmware version, build time, MAC address and IP address of the router port

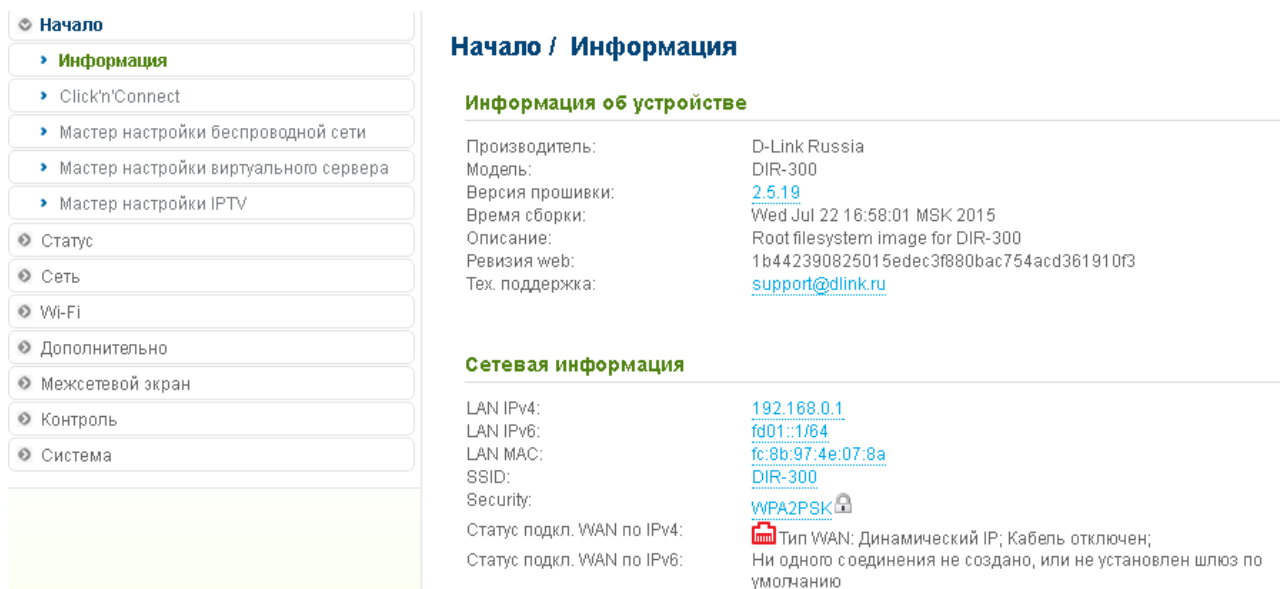


Figure 14. Device Information tab

#### Task 4. Setting up a wireless network.

By default, access to the router's wireless network is open. To prevent unauthorized use of your wireless network, change the default settings.

#### Wireless Network Setup Example (Figure 15)

1.Go to the Wi-Fi / Security Settings page.

**Wi-Fi / Основные настройки**

Включить беспроводное соединение: ☒

Вещать беспроводную сеть: ☒

Данная функция позволяет включить или выключить вещание беспроводной сети, не отключая радиомодуль маршрутизатора.

MBSSID: Выключено

BSSID: FC:8B:97:4E:07:8A

Скрыть точку доступа: ☐

Название беспроводной сети (SSID) не будет отображаться в списке доступных беспроводных сетей у клиентов. К скрытой сети можно подключиться, вручную указав SSID точки доступа.

SSID: DIR-300First

Страна: RUSSIAN FEDERATION

Канал: auto

Сейчас автоматически выбран канал 13

Беспроводной режим: 802.11 B/G/N mixed

При смене режима с "B"/"G" на любой из режимов с "N" рекомендуется заново произвести настройку безопасности!

Максимальное количество клиентов: 0

0 - неограниченное количество

Ограничение скорости (Кбит/с): 0

Figure 15. Wi-Fi – Basic Settings tab

2. In the Network Authentication list, select WPA2-PSK.
3. Enter the key (the password that will be used to access your wireless network) in the PSK Encryption Key field. Use numbers and Latin letters.
4. In the WPA Encryption list, select AES.

**Wi-Fi / Настройки безопасности**

Сетевая аутентификация: WPA2-PSK

Ключ шифрования PSK: 84733535

**Настройки шифрования WPA**

WPA-шифрование: AES

WPA период обновления ключа: 3600

Figure 16. Wi-Fi security settings

5. Click the Edit button.

If the router is initially configured via a Wi-Fi connection, you will need to re-establish a wireless connection to the router using the settings you just set after changing the default wireless network settings.

6. In the "Network authentication" drop-down list, select WPA–PSK/WPA2–PSK mixed – this is the most secure way to protect your wireless network.

7. In the "PSK encryption key" field, enter the password for a Wi-Fi network with a length of 8–63 characters. Click the Apply button to save the settings. To access the network, change the password, for example, to: 12345678.

#### Task 5. Setting up an Internet connection.

1. Connect the twisted pair with one end to the port of connection to the provider, the other end to port 3 (DIR-300 WAN) of the patch panel of the stand:



Figure 16. Connecting the router to the Internet

2. After connecting, the Internet will appear on the computer from which the setup is made, which will need to be redirected to the Wi-Fi network.

3. First, go to the "Network" tab (Fig. 17). Next, click on the "Add" button. In the "Connection type" drop-down list, select "Dynamic IP" to connect the router to the provider's network:

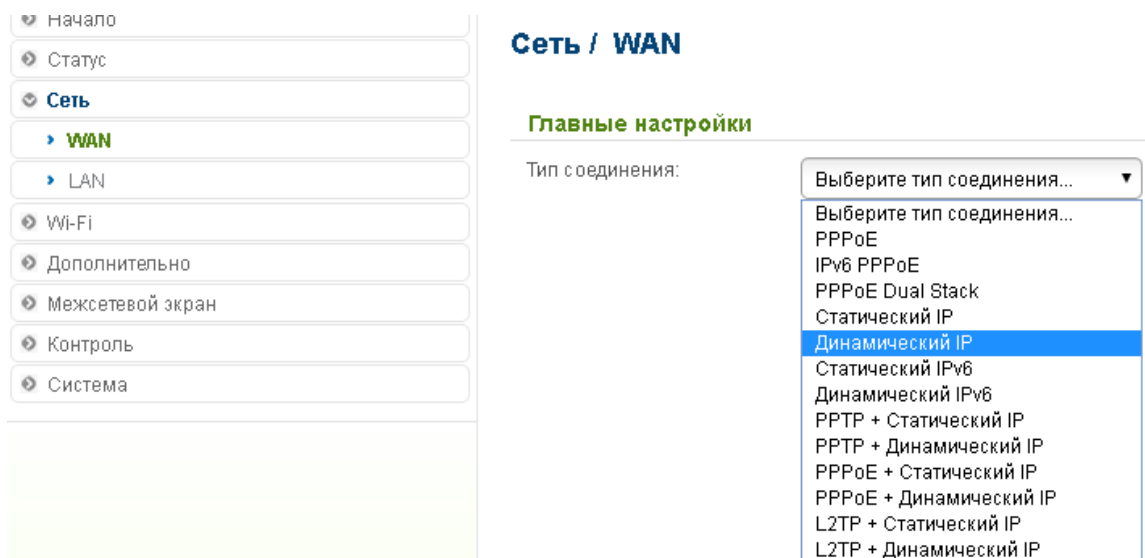


Figure 17. Network tab

5. In the "IP – Vendor ID" field, enter the domain address: dslforum.org, and in the MAC address field, select the number of your network card:

**Ethernet**

---

MTU:\*

MAC:   

**IP**

---

Получить адрес DNS-сервера автоматически: ☒

Vendor ID:

Имя устройства:

Figure 18. Dynamic WAN Connection Settings

5. Save the settings.
6. Check the configured network. Connect to the Wi-Fi network from your smartphone:

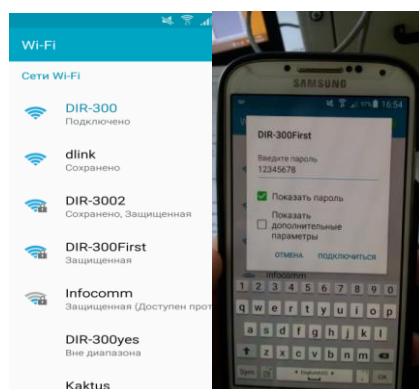


Figure 19. Checking the performance of the configured Wi-Fi network on the smartphone

### Content of the report and its form

The report must contain

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;

- results of implementation;
- answers to control questions;
- conclusion on the work done.

### **Control questions**

1. List the features of the functioning of wireless personal area networks and their possible topologies.
2. What network technologies can be used to deploy a wireless personal area network? How are network elements configured?
3. List the possible causes of wireless personal area network failures.

### **Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;
- report submission.

## PRACTICAL WORK

### STUDY OF FIBER-OPTIC COMMUNICATION LINES

**Objective:** To obtain estimates of the parameters of the television signal when it is transmitted through coaxial and symmetrical communication lines under the influence of external electromagnetic fields.

#### Theoretical substantiation

#### Types of Communication Line

A communication line generally consists of a physical medium through which information signals are transmitted, data transmission equipment and intermediate equipment. A synonym for the term *line* is the term *channel*.



Figure 1. Communication line

Depending on the data transmission medium, communication lines are divided into:

- wired (air);
- cable (copper and fiber-optic);
- terrestrial and satellite communication radio channels.

## Characteristics of communication lines

The main characteristics of communication lines include:

- Amplitude-frequency response – shows the attenuation of the signal amplitude for all possible frequencies;
- Bandwidth is a continuous range of frequencies for which attenuation does not exceed a predetermined limit;
- Attenuation is a relative decrease in the amplitude or power of a signal when a certain frequency is transmitted along a signal line.

$A = 10 \log_{10} P_{vH}/P_{vX}$ , (measured in decibels (dB, decibel – dB),  $P_{vX}$  and  $P_{vH}$  – input and output power);

- bandwidth – characterizes the maximum possible speed of data transmission along the communication line;
- reliability of data transmission – the probability of distortion for each bit of data transmitted;
- noise immunity – the ability to withstand external interference;
- cross-fire at the near end of the line;
- unit cost.

## Relationship between Line Capacity and Line Bandwidth

Claude Shannon established a relationship between the bandwidth of a line and its *maximum possible bandwidth*, regardless of the method of physical coding adopted:

$C = F \log_2 (1 + R_s/R_w)$ , where  $C$  is the maximum line bandwidth in bits per second,  $F$  is the bandwidth of the line in hertz,  $R_s$  is the signal power,  $P_{sh}$  is the noise power.

Nyquist also defines the maximum possible bandwidth of the communication line, but without taking into account the noise on the line:

$C = 2F \log_2(M)$ , where  $M$  is the number of distinguishable states of the information parameter.

The given ratios give the limit value of the line capacity, and the degree of approximation to this limit depends on the specific methods of physical coding.

Figure 2 shows the bandwidths of communication links and popular frequency bands.

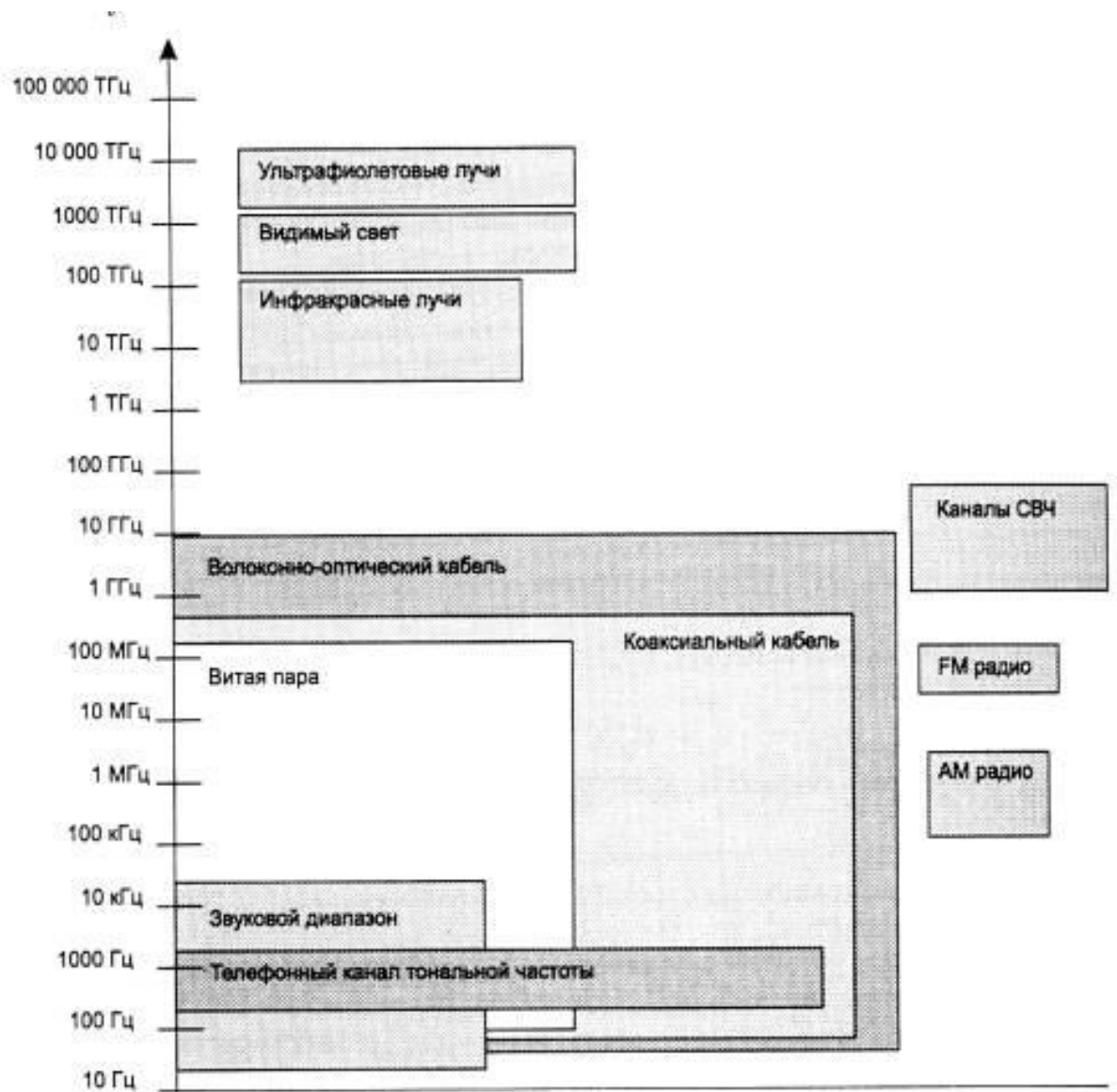


Figure 2. Link bandwidths and popular frequency bands

### Cable communication lines

A cable is a product made up of conductors, shield layers, and insulation. In some cases, the cable includes connectors that connect the cables to the equipment.

The most important characteristics:

- Attenuation;
- Near End Cross Talk (NEXT);
- Impedance (wave impedance) is the impedance (active and reactive) in an

electrical circuit;

- Active resistance is the resistance to direct current in an electrical circuit.

It does not depend on frequency and increases with increasing cable length;

- Capacitance is the property of metal conductors to accumulate energy;
- Level of external electromagnetic radiation or electrical noise;
- Diameter or cross-sectional area of the conductor.

### **Twisted pair cables**

**Twisted pair** is a type of communication cable that is one or more pairs of insulated conductors twisted together (with a small number of turns per unit length), covered with a plastic sheath.

The purpose of the conductors is as follows:

- increase in the communication of conductors of one pair (electromagnetic interference affects both wires of the pair equally);
- Reduce electromagnetic interference from external sources
- reducing mutual interference during the transmission of differential signals.
- Types of twisted pair cables
- Unshielded twisted pair (UTP) – there is no protective shield around the individual pair;
- Foiled twisted pair (FTP) – also known as F/UTP, there is one common external screen in the form of foil;
- Shielded twisted pair (STP) — there is a shield protection for each pair and a common external screen in the form of a grid;
- Screened Foiled Twisted Pair (S/FTP) - Outer shield made of copper braided and each pair in foil braided;
- Screened Foiled Unshielded twisted pair (SF/UTP) is a double outer shield made of copper braid and foil, each twisted pair without protection.

Table 1. Categories of Twisted Pair Cables

| Category | Bandwidth | Number of pairs | Bandwidth, Mbps                       | Application                           |
|----------|-----------|-----------------|---------------------------------------|---------------------------------------|
| CAT1     | 0.1 MHz   | 1               | up to 1 Mbps                          | Telephony, data requires modem        |
| CAT2     | 1 MHz     | 2               | Up to 4 Mbps                          | Sometimes found in telephone networks |
| CAT3     | 16 MHz    | 2,4             | 10 (10BASE-T)<br>100 (100BASE-T4)     | Suitable for voice and data           |
| CAT4     | 20 MHz    | 4               | 10 (10BASE-T)<br>100 (100BASE-T4)     | Practically not used                  |
| CAT5     | 100 MHz   | 4               | 100 (100BASE-T4)                      | Telephony, Fast Ethernet              |
| CAT5e    | 125 MHz   | 4               | 100 (100BASE-T4)<br>1000 (100BASE-T4) | Fast Ethernet и Gigabit Ethernet      |
| CAT6     | 250 MHz   | 4               | 1000 (100BASE-T4)                     | Fast Ethernet и Gigabit Ethernet      |
| CAT6A    | 500 MHz   | 4               | 1000 (100BASE-T4)<br>Up to 10 Gbps    | Fast Ethernet и Gigabit Ethernet      |
| CAT7     | 700 MHz   | 4               | Up to 100 Gbps                        | Fast Ethernet и Gigabit Ethernet      |

### Coaxial Cables

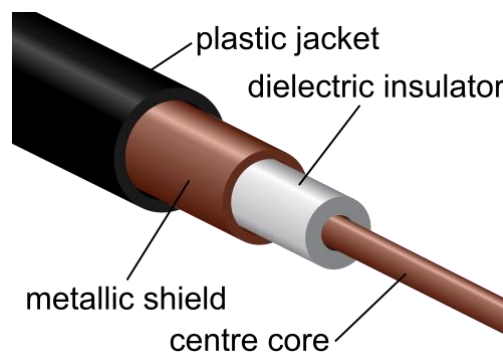


Figure 3. Coaxial cable

A coaxial cable has an internal conductor made of copper or copper-plated steel, an internal dielectric made of polyethylene foam and a screen made of foil and, in some cases, steel braiding.

Cables are divided according to the Radio Guide scale. The most common categories of cables are:

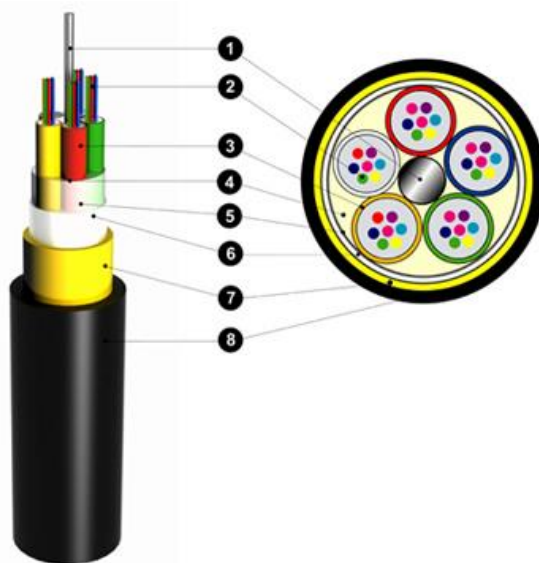
- RG-8 and RG-11 - Thicknet, 50 ohms. 10BASE5 standard;
- RG-58 - Thinnet, 50 ohms. 10BASE2 standard:
- RG-58/U — solid central conductor,

- RG-58A/U — stranded central conductor,
- RG-58C/U — military cable;
- RG-59 is a television cable (Broadband/Cable Television), 75 Ohm. The Russian analogue of RK-75-x ("radio frequency cable");
- RG-6 is a television cable (Broadband/Cable Television), 75 ohms. The RG-6 cable has several varieties that characterize its type and material. Russian analogue of RK-75-x-x;
- RG-62 - ARCNet, 93 ohms.

### **Fiber optic cables**

A fiber-optic cable consists of a central conductor of light (core) – a glass fiber surrounded by another layer of glass – a sheath that has a lower refractive index than the core.

The following sources of light emission in fiber-optic cables are used:



–LEDs;

–semiconductor lasers.

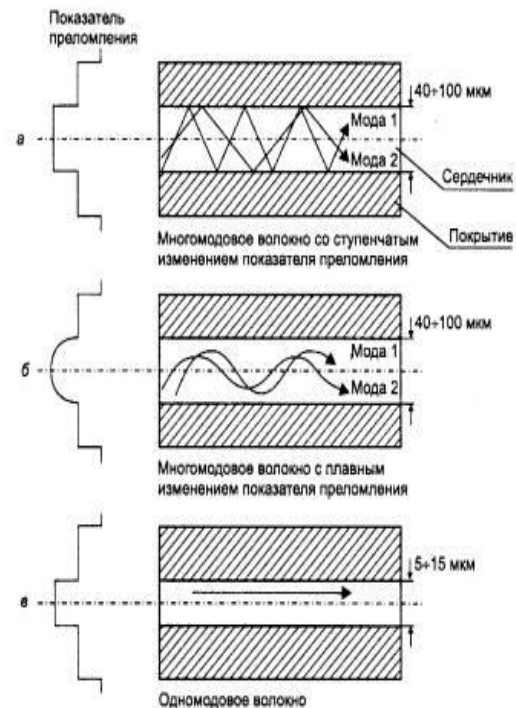
### **Fiber optic cable with reinforcement**

1. Central Strength Element
2. Optical Fiber
3. Optical module with hydrophobic compound filling
4. Filling with a hydrophobic compound
5. Polyethylene terephthalate film
6. Inner polymer sheath
7. Aramide thread layer
8. Outer polyethylene sheath

Depending on the distribution of the refractive index and on the size of the diameter of the core, a distinction is made:

- multimode fiber with a stepped change in the refractive index;
- multimode fiber with smooth change of refractive index;
- single-mode fiber.

Popular combinations of core diameter and cladding diameter are 9/125  $\mu\text{m}$ , 50/125  $\mu\text{m}$ , 62.5/125  $\mu\text{m}$ , and 100/140  $\mu\text{m}$ .



### Physical Coding

- Physical or linear coding is the representation of discrete information in the form of signals supplied to the communication line.
- Any discernible and unpredictable change in the received signal carries information.
- Most coding methods use a change in some parameter of a periodic signal - frequency, amplitude and phase of a sine wave or a sign of the potential of a sequence of pulses.
- Two types of coding are used in the transmission of discrete data: based on a sinusoidal carrier signal (analog modulation) and based on a sequence of square pulses (digital coding).

### Structure and principle of operation of the FOCL laboratory bench

Controls, main units and connectors are located on the front panel of the stand and are not removable in the process of working with the stand.

Auxiliary units (interference source, power supply, balancing devices) are located inside the unit.

Dimensional lengths of optical, coaxial and symmetrical twisted pair cables

are coiled together with the radiating loop of the interference source. All cables are located inside the bench housing and terminate with standard connectors located on the front panel.

The appearance of the front panel is shown in Figure 4.

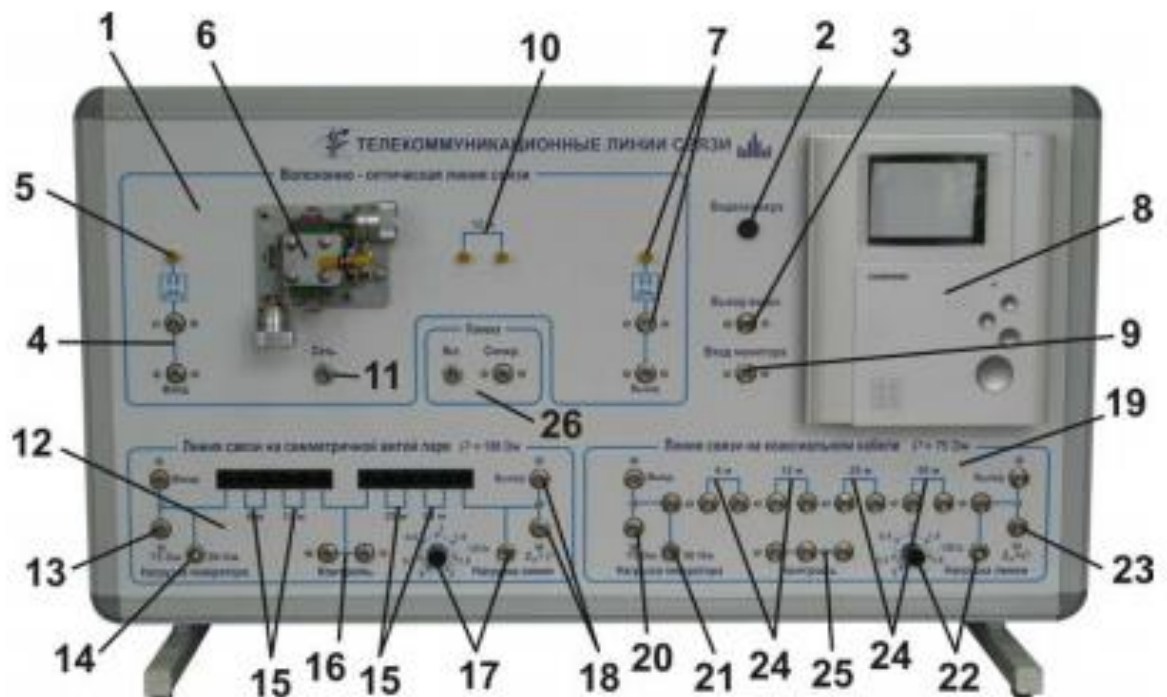


Figure 4. Front panel of the FOCL stand

The stand consists of four independent nodes:

Fiber-optic communication line (1), including:

- a transmitting television camera (2), the output signal from which is fed to the "Video Output" connector (3);
- the electron-optical converter is made on the basis of the POM 561 transmitting optical module. The input electrical signal for this converter is supplied to one of the "Input" connectors located on the front panel of the stand (4). Output optical connector of the converter (5);
- device for introducing heterogeneity into the optical cable joint (6). The rotation of the screw for moving the fiber optic connector is 0.005 mm;
- The opto-electric converter is made on the basis of the PROM 364 receiving optical module. The input optical and output electrical connectors of the

opto-electric converter are located on the front panel of the stand (7);

- Monitor Video Monitor (8), the input signal for the video monitor should be fed to the "Monitor Input" connector (9). The monitor monitor is equipped with an automatic shutdown circuit after 1 minute of operation. To turn it back on, press the "ON" button on the front of the monitor;

- 12 m optical cable with connectors for its connection (10);

- "Network" toggle switch for powering on the stand (11). All elements and controls of the fiber-optic communication line are limited by the contour line.

A link on a balanced UTP 5 Cat twisted pair cable with a wave impedance of 100 ohms (12), consisting of:

- "Input" input connectors (13);

- input balancing transformer;

- a switch that matches the output impedance of the generator with the input of the "Generator load" line (14);

- Cable lengths terminating with standard RJ-45 connectors on the front panel (15)

- RJ-45 control connectors, which can be connected to any section of the line using connectors (16);

- output balancing transformer;

- line loads providing a fixed value equal to the wave and smooth change within the range from 0 to  $2 \rho$  (17);

- output connectors "Output" (18). All elements and controls of the communication line are limited by a contour line.

4.2.3. A communication line on a coaxial cable with a wave impedance of 75 Ohm (19) consists of:

- "Input" input connectors (20);

- a switch that matches the output resistance of the generator with the input of the "Generator load" line (21);

- line loads providing a fixed value equal to the wave and smooth change within the range of 0 to  $2 \rho$  (22);

- Output connectors (23).
- Cable lengths terminating with standard RJ-45 connectors on the front panel (24)
- control connectors (25), which can be connected to any section of the line using connectors;

Built-in jammer (26), which forms rectangular current pulses that feed the telecoil. On the front panel there is a toggle switch for turning on the generator and a connector for the output of oscilloscope synchronization pulses by the jammer.

**Additional equipment:**

- oscilloscope (designed to study electrical signals in the frequency range from DC to 20 MHz and sensitivity of at least 5 mV/div) with an input divider of 1:10 ( $R_{BX}=1\text{ M}\Omega$ ,  $S_{VX}=13\text{ pF}$ );
- pulse signal generator G5–54 or similar (pulse duration from 0.1 to 200  $\mu\text{sec}$ , repetition rate from 10 Hz to 50 kHz, amplitude from 0.5 V to 10 V);
- high-frequency signal generator G4-102 A or similar (signal frequency from 0.1 to 50 MHz, signal amplitude up to 0.5 V).

All connections in link simulation and measurement are made using the included connection cables that are docked into standard connectors.

In the absence of a signal, the mechanism platform should be moved several times with the help of screws up - down and right - left.

Clockwise rotation of the screws increases the distance between the connectors or shifts the left connector upwards.

When connecting or disconnecting connecting cables, force should be applied only to the connectors and in no case to the cable itself.

## **1. Measurement of the wave resistance of a wire communication line**

The guiding system of wire communication lines (symmetrical twisted pair, coaxial cable) is conductors separated by a dielectric, which ensure the transmission of electromagnetic energy in a given direction. The physical properties of this system, from the point of view of the conditions for the transmission of

electromagnetic energy, depend on the geometric dimensions and permittivity. A wire communication line is characterized by a wave impedance numerically equal to the ratio of voltage to current acting in the line.

Where  $Z_0$  is the wave impedance of the line,  $U_m$  is the amplitude of the voltage in the line, and  $I_m$  is the amplitude of the current in the line. For high frequencies, the expression is true, where  $L$  and  $C$  are the linear inductance and capacitance of the communication line.

The process of signal (energy) transmission in an incident wave along a communication line is characterized by the direction, speed of propagation and alternate transfer of energy from  $L$  to  $C$  and further to  $L$ . Since the inductance and capacitance of the communication line have low losses, the attenuation of the signal in the line is small. At the end of the communication line, a load (consumer) is established. Only a "coordinated" consumer with an active resistance equal to the wave impedance of the line can completely absorb the energy of the incident wave. With an open or short-circuited line, it is impossible to use energy at all, and it is forced to return back to the source in the form of a reflected wave, dissipating in the communication line.

If the load is active, but its resistance is not equal to the wave resistance, then it absorbs only part of the energy, sending its rest into the reflected wave. Most methods for measuring the wave resistance of wire communication lines are based on the selection of the load that provides complete coordination and the measurement of its parameters.

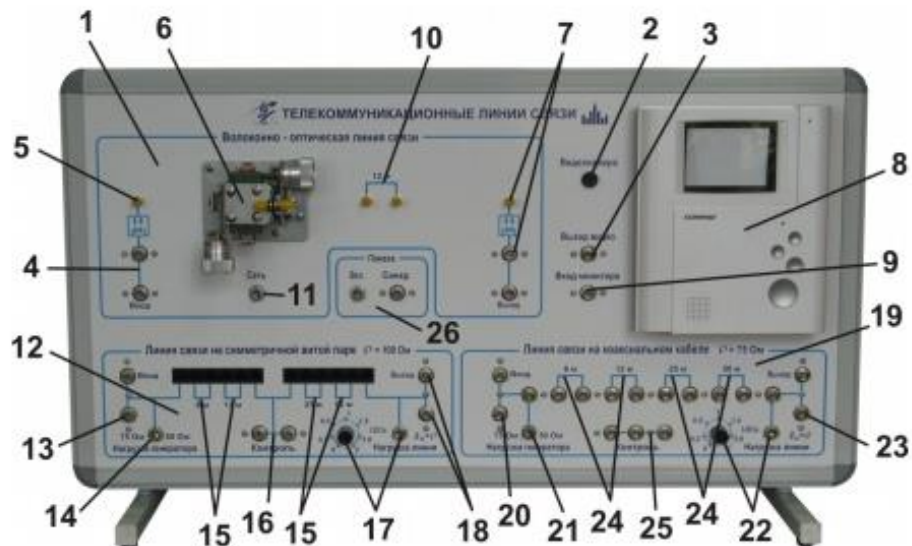


Figure 5. Components of the stand

Work procedure:

Use short connecting coaxial cables to model the longest coaxial communication line;

1. Using a connecting coaxial cable, connect the output of the pulse signal generator to the input (20) of the coaxial communication line;

2. Connect the oscilloscope input to the input (20) of the coaxial link;

3. Set the input signal amplitude to 2 V, pulse width of about 0.1  $\mu\text{sec}$  and pulse repetition frequency of about 50 kHz;

4. Use the toggle switch (22) to set the variable load of the line;

5. Synchronize the oscilloscope via the external synchronization channel from the pulse signal generator. In general, the input signal of the line will be present and delayed relative to the input, the signal "reflected" from the end of the line and returned to its input;

6. By changing the line load with the control (22), observe the change in the signal reflected from the end of the line. Note the change in the polarity of the "reflected" pulses when the resistance of the line load changes, explain the phenomenon;

7. By changing the load with the control (22), achieve the minimum amplitude of the reflected pulse. The absence of reflection from the load indicates that the line

is loaded on the impedance;

8. Disconnect the load from the line (remove one of the short jumper cables) and use a measuring device to measure the amount of load resistance, which will be equal to the wave impedance of the cable.

10. Compare the obtained values of wave impedance with the nameplate for the cable used.

11. Record the results obtained on the oscilloscope, how the amplitude of the reflected signal changes when the load changes.

12. Draw up a report based on the results of the study.

## **2. Determination of the nature of signal propagation in the line depending on the resistance of the load on the harmonic signal**

The influence of the resistance of the communication line load on the nature of propagation is convenient and visually observed on the harmonic signal.

When transmitting a harmonic signal along the communication line, the incident and reflected wave have the same frequency, and differ only in amplitude and phase. The value of the signal at any point of the line will be equal to the sum of the incident and reflected waves. Depending on the phase relations between the incident and reflected waves, the amplitude of the total oscillations along the length of the line will vary from  $(U_{\text{pad}} + U_{\text{op}})$  to  $(U_{\text{pad}} - U_{\text{otp}})$ . It should be taken into account that taking into account the attenuation in the cable, the reflected wave at the observation point will have a smaller amplitude, since it travels a longer distance. A "standing wave" is established in the line. The number of established maxima and minima depends on the speed of wave propagation, the length of the line and the frequency of oscillations. With an increase in frequency, their number increases.

Such a mode of line operation is characterized by the standing wave coefficient (SWR), which is numerically equal to the ratio of the highest value of the amplitude of the field strength to the smallest amplitude. With poor matching of the line with the load, the amplitude of oscillations can vary from a double value to values close to "0". With poor matching, the efficiency of the line sharply decreases and the probability of equipment failure due to overvoltages on the line and

equipment increases.

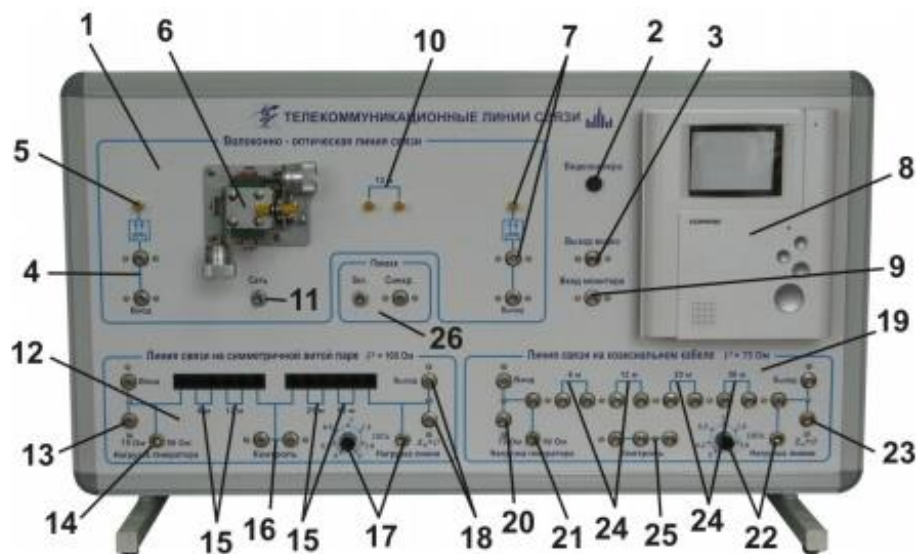


Figure 6. Bench installation

### 3. Determination of wire line bandwidth and signal attenuation

Even with optimal line matching, it is due to losses in conductors and dielectrics, depends on the geometric dimensions of the line elements, the quality of materials. At large line lengths, attenuation is very significant and can lead to signal loss in noise. Losses in conductors and dielectrics increase with increasing frequency. Specific attenuation is measured in decibels per meter of cable length. The RK-75-2-11-11-coaxial cable has attenuation at a frequency of 10 MHz- 0.028 dB/1 m. This means that a perfectly matched communication link from this cable with a length of 100 meters at a frequency of 10 MHz will have an attenuation of 2.8 dB. For the undistorted transmission of broadband signals, it is important that the components of all frequencies included in the signal spectrum experience approximately the same attenuation during transmission. within which the attenuation of individual harmonic components differs by no more than 3 dB, it is usually called the 3 dB bandwidth.

#### Equipment and materials

To perform practical work, you need a personal computer with Internet access, Cisco Packet Tracer and Microsoft Office.

Laboratory equipment: Patch panel, 3 laptops, 2 DAP2310 access points, 2 DIR300 routers, DGS1008 switches, DES1005A, single-port DWL-P50 adapters.

### **Safety Instructions**

Persons who are familiar with its structure, principle of operation and safety measures in accordance with the requirements given in this section are allowed to work at the "Examination of Telecommunication Lines" stand.

The power cord of the stand must only be connected to a mains outlet with a protective contact.

Adjustment work, inspections and repairs should be carried out only after the stand is disconnected from the power supply using a mains plug.

It is forbidden to work on the stand with the covers open and the casing removed. 4.5 When using additional equipment (Appendix 1.), use the safety instructions for this equipment.

When operating the stand, you should be especially careful with optical connectors.

- Remove the protective capillary plugs only when connected.
- Make the connection carefully, the socket key guide must be aligned with the plug key,
- The bending radii of the connectors during operation must be at least 40 mm.

When working with a device for introducing inhomogeneities into the joint of optical connectors, the free movement of the mechanism should be selected.

Do not apply excessive mechanical forces to the mechanism and connecting optical cables.

In addition, in the laboratory, when working with computer equipment, it is necessary to comply with the safety requirements provided for the computer class:

1. Do not turn on the computer without the permission of the class administrator and instructor.
2. It is forbidden to open the PC case on your own.
3. Do not touch the monitor screen and keyboard at the same time (increased

electrostatic potential may be discharged).

4. Do not clutter the top panels of the devices with papers and foreign devices.

5. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.

6. It is forbidden to turn off the power supply during the execution of an active task.

7. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

### **Methodology and procedure for performing work**

1. Using short coaxial cables, model a coaxial link of maximum length with a branch to the control connectors (25) from the middle of the line;

2. A harmonic signal with a frequency of about 5 MHz is connected to the input of the line;

3. The oscilloscope input is connected to the control sockets of the line (25);

4. Simulate a break in the communication line, remove the last jumper between the 50-meter segment and the load (23);

5. Smoothly increasing the frequency of the oscillator to 7 MHz, find the nearest maximum and minimum voltage on the line, write down the corresponding frequencies of the oscillator;

6. By changing the load value: load break, maximum value of the regulator, minimum value of the regulator and equal to the wave value, we measure the amplitudes at the first frequency;

7. Set the second frequency on the generator and measure the amplitudes under the same conditions;

8. Enter the measurement results in a table and calculate the VSWR for these three cases.

| Frequency, MHz. | Amplitude, | Voltage, V. |
|-----------------|------------|-------------|
|                 |            |             |

Next, it is necessary:

1. Using short coaxial cables, model a coaxial communication line with a maximum length of 100 meters and load it on the wave impedance (toggle switch 22).
2. A harmonic signal generator with a frequency range of 0.5 to 20 MHz is connected to the input of the line.
3. Connect Oscilloscope Input 1 to the line input (20) and Input 2 to the line output (23). A high-frequency voltmeter can also be used to measure the signal amplitude at the input and output of the line.
4. Set the frequency to 0.5 MHz and the signal amplitude at the input of 1 V. Measure the signal voltage at the output, and record the result in the table.
5. Do the same at frequencies of 1, 2, 3, 4, 5, 8, 10, 11, 12, 13, 14, 15, 20 MHz.
6. Calculate and enter into the table the signal attenuation values in the communication line at these frequencies in decibels. Compare the result with the passport value for the cable.

| Frequency, MHz. | Amplitude, | Voltage, V. |
|-----------------|------------|-------------|
|                 |            |             |

7. Next, determine the bandwidth of the communication line at the level of 3 dB, 1 dB.

Thus, in the course of practical work, it is necessary:

1. Study the equipment of the Abator Stand, get acquainted with its settings.
2. To work out practical skills in measuring wave resistance, bandwidth and attenuation of wire communication lines.
3. To conduct a comparative assessment of the noise immunity of communication lines under the influence of external electromagnetic fields.
4. To study the effect of external electromagnetic fields on the bandwidth and attenuation of coaxial and symmetrical communication lines.

### **Content of the report and its form**

The report must contain

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;
- results of implementation;
- answers to control questions;
- conclusion on the work done.

### **Control questions**

1. What is the bandwidth of a communication line?
2. What are the features of signal attenuation?
3. How does the resistance of the communication line load affect the nature of signal propagation?
4. What is the principle of operation of the FOCL laboratory stand?
5. Characterize twisted-pair cable, coaxial cable, and fiber-optic cable.
6. What is amplitude, frequency, voltage? What are the units of measurement?

### **Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;
- report submission.

## **PRACTICAL WORK**

### **EXPLORE VIDEO PARAMETERS**

**Objective:** To obtain estimates of the parameters of the video signal when it is transmitted through a fiber-optic communication line with inhomogeneities.

#### **Theoretical substantiation**

The advantages of using fiber-optic communication lines (FOCL) are obvious. Of course, it is advisable to transmit the signal from video surveillance cameras, especially megapixel ones with IP output within the framework of integrated security systems, as the most voluminous. However, there are many subtleties in the real design and construction of fiber-optic communication lines. Designers of video surveillance systems know that due to losses during the transmission of the signal through the network, the resolution of the system will deteriorate from block to block.

Losses in the transmitting path are also reduced by the contrast of the video image, which is especially important when working in low light (contrast is the number of gradations of brightness (halftones) with which the object will be drawn).

At the same time, if we are talking about a remote observer located several kilometers or tens of kilometers from video cameras and an observation point with an installed video recorder or server, then the influence of the transmitting path on the signal can be significant.

Fiber-optic technologies are based on the principle of using light as the main source of information. Light is much easier to transmit over long distances with less loss than electric current. In addition, it is much less affected by electromagnetic fields and is able to transmit orders of magnitude more information. Optical lines themselves are not sources of electrical noise.

Optical fiber transmits electromagnetic radiation in the optical wavelength range corresponding to frequencies of  $10^{14}$ – $10^{15}$  Hz, which provides very high bandwidth and speed.

The high noise immunity of fiber-optic communication lines is due to the fact that in nature and industry there are virtually no sources of electric and magnetic

fields of intensity, which can change the conditions for the propagation of a light pulse in an optical fiber. In addition, most often optical cables do not contain metal elements, so there are no problems associated with the potential difference between floors and buildings, with stray currents in the soil, etc. Fiber-optic systems have almost complete electrical insulation, are not afraid of high humidity, do not require equipment that protects them from leaks, breakdowns and short circuits. Semiconductor receivers and light transmitters have a fairly high stability.

It is known that light propagates through the air and in glass with the least losses. For example, modern fibers have attenuation equal to 0.2 dB/km, which gives an attenuation of 0.02 dB at a length of 100 m. At the same length, a modern high-quality electrical symmetrical cable has an attenuation of about 20 dB, i.e. 1000 times greater.

Of course, it is impossible to transmit the supply voltage for devices operating on PoE technology via FOCL, complex and expensive active optoelectronic equipment is used for FOCL, the technology for the production of optical cables and transceivers is more complex and expensive, work with FOCL causes increased requirements for the qualification and culture of production personnel. When working with FOCL, it is necessary to take into account the aging of optical fiber under the influence of moisture and harsh gamma radiation.

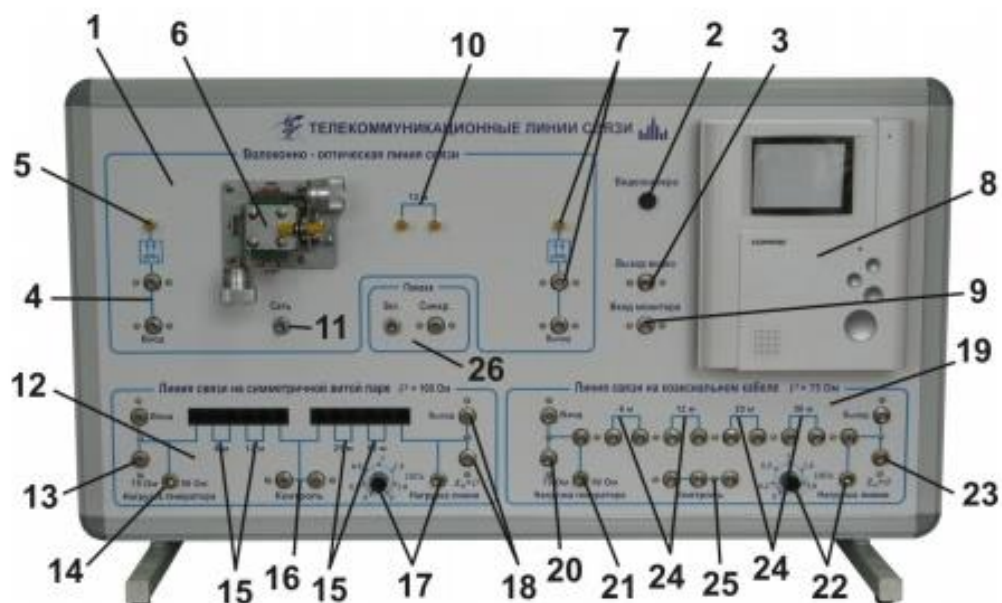


Figure 1. Laboratory setup

**Methodology and procedure for performing work (Fig. 1)**

1. Using short coaxial cables, connect the line input (4) to the video output (3).
2. Connect the monitor input (9) to the output (7).
3. Configure the device to introduce inhomogeneities into the optical cable joint (6).
4. Extend the line distance by 12 meters. Using an optical cable, connect the inhomogeneity device (6) to connector 1 (10), from connector 2 (10) to the input connector of the opto-electrical converter (7).
5. Examine the interference. To do this, connect the interference generator (26) to the line input (4).
6. Draw conclusions based on the research.
7. Fix the resulting image in a perfect line, and with the noise generator turned on.
8. Draw up a report based on the results of the study.

**Task**

1. Study the equipment of the Abator Stand, get acquainted with its settings.
2. To work out practical skills in measuring the bandwidth and attenuation of fiber-optic communication lines.
3. Study of television signal transmission via FOCL when introducing inhomogeneities.

**Content of the report and its form**

The report must contain

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;
- results of implementation;

- answers to control questions;
- conclusion on the work done.

### **Control questions**

1. How does the introduction of inhomogeneities affect the video signal?
2. What are the effects of transmission path losses?
3. What is the reason for the high noise immunity of FOCL?
4. What is the purpose of a jammer?
5. What is the peculiarity of introducing heterogeneities?

### **Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;
- report submission.

## PRACTICAL WORK

### IP TELEPHONY

**The purpose of the work** is to study the capabilities of the IP telephony stand, its structure and learn how to study IP telephony protocols.

#### **Theoretical substantiation**

#### **Structure of the laboratory bench for the study of IP telephony**

Voice and video communication through computer networks has become popular all over the world since the beginning of the 21st century and is now widely used by both private users and the corporate sector. The use of IP telephony systems allows telecom operators to significantly reduce the cost of calls (especially international ones) and integrate telephony with Internet services, provide intelligent services.

IP telephony is a set of communication protocols, technologies and methods that provide traditional telephony dialing, dialing and two-way voice communication, as well as video communication over the Internet or any other IP networks (Figure 1). The signal is transmitted digitally through the communication channel and, as a rule, is converted (compressed) before transmission in order to remove information redundancy and reduce the load on the data transmission network [1].

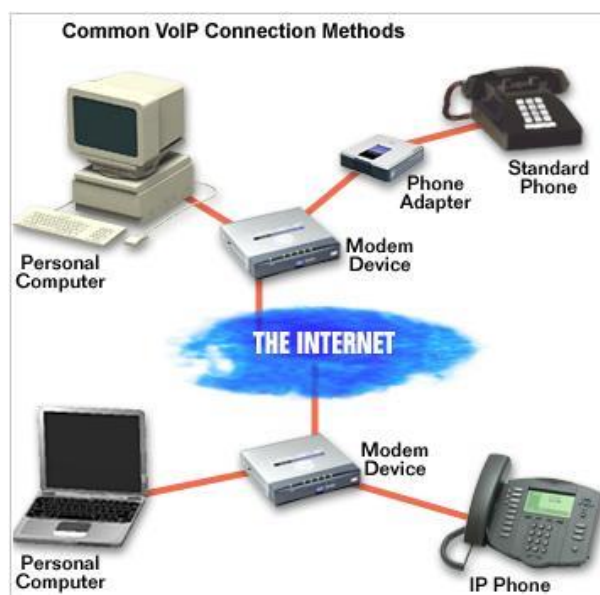


Figure 1. Example of an IP telephony channel structure diagram

### Types of IP telephony:

1. Communication is carried out between computers with the appropriate software, which connect via the Internet to the server that switches subscribers. Calls to the PSTN are also possible, in this case the server finds a proxy server with integrated gateways of the telephone network where the desired subscriber is located.

2. A subscriber who has a telephone set connected to the PSTN calls the phone number of the IP telephony provider, authenticates by PIN code and dials the number he needs. A proxy server with an integrated gateway of the provider finds a proxy server in the Internet network, through a gateway connected to the telephone network where the desired subscriber is located and connects to him. Due to the fact that a long-distance conversation takes place not through telephone channels, but through Internet traffic, its cost is much lower.

3. A subscriber who has an IP phone with an integrated VoIP gateway is connected via the Internet directly to the proxy server of his IP telephony provider, which searches the Internet for the corresponding proxy server using the dialed phone number and connects to it. The latter, in turn, is connected to the PSTN where the desired subscriber is located through the gateway. When calling back, the PBX determines that the number belongs to the IP phone and sends it to the PSTN proxy server, which connects to the corresponding proxy server of the IP telephony provider and the latter sends a call to its subscriber. For example, calls to numbers with DEF code 800 connected via IP telephony are used according to this scheme. The numbers of IP telephony subscribers are similar to regular ones. Instead of an IP phone, you can use a VoIP gateway with a regular telephone set connected to it.

The most common IP telephony protocol is SIP (Session Initiation Protocol), a data transfer protocol that describes the way to establish and terminate a user Internet session, including the exchange of multimedia content. (IP telephony, video and audio conferences, instant messaging, online games).

The protocol describes how a client application (e.g., a softphone) can request the start of a connection from another, possibly physically remote, client on the same

network using its unique name. The protocol defines a way for clients to agree on the opening of exchange channels based on other protocols that can be used to transmit information directly (e.g., RTP). It is allowed to add or remove such channels during the established session, as well as to connect and disconnect additional clients (that is, more than two parties are allowed to participate in the exchange - conference calls). The protocol also determines the order in which the session is terminated.



Figure 2. Structural diagram of a connection using the SIP protocol

SIP clients traditionally use TCP or UDP port 5060 to connect elements of a SIP network. SIP is mainly used to establish and disconnect voice and video calls. At the same time, it can be used in any other applications where a connection is required, such as public address systems, mobile terminals, and so on. There are a large number of RFC recommendations related to SIP that determine the behavior of such applications. Other transport protocols, most commonly RTP, are used to transmit the voice and video data themselves.

The main task of SIP development was to create an IP-based signaling protocol that could support the advanced set of call processing functions and services provided in the existing PSTN. The SIP protocol itself does not define these functions, but focuses only on the procedures for registering the user, establishing and ending the call and the corresponding signaling. At the same time, it was designed to support such functional network elements as Proxy Servers and User Agents. These elements provide a basic set of services: dialing a number, calling a telephone set, and audio informing the subscriber about the status of the call.

SIP-based telephone networks can also support the more modern services typically provided by SS-7, despite the significant difference between the two protocols. SS-7 is characterized by a complex, centralized, intelligent network and simple, non-intelligent terminals (traditional telephone sets). SIP, on the other hand, requires a very simple (and therefore highly scalable) network with intelligence built into endpoints at the edge (terminals built as physical devices or programs).

SIP is used in conjunction with several other protocols and participates only in the signaling part of the communication session. SIP acts as a carrier for the SDP, which describes the parameters of media transmission within the session, such as the IP ports and codecs used. In typical session applications, SIPs are simply streams of RTP packets. RTP is the direct carrier of voice and video data.

IP-PBX is an office telephone exchange based on the IP internetwork protocol. Like a regular PBX, it is designed to perform the same tasks. Since almost all functions are implemented through software, it is easy to increase functionality in an IP PBX, upgrade them, and correct errors.

Today, there are two types of IP PBX:

1. Hardware – supplied in the form of specialized equipment with pre-installed software. In such solutions, the hardware is not subject to improvement CPU, DDR, HDD, PRI and scaling is not as efficient (Figure 6).

2. Software – distributed in the form of ready-made distributions or executable files for the operating system used. The advantages of this class are the ability to work in a virtual environment and the ability to flexibly choose hardware characteristics (Fig. 1). 3). With the help of specialized PCI cards Digium, OpenVox, Sangoma, it is possible to seamlessly connect an IP PBX to the existing infrastructure via digital ports PRI, ISDN BRI and analog FXO, FXS.



Figure 3. Hardware IP PBX

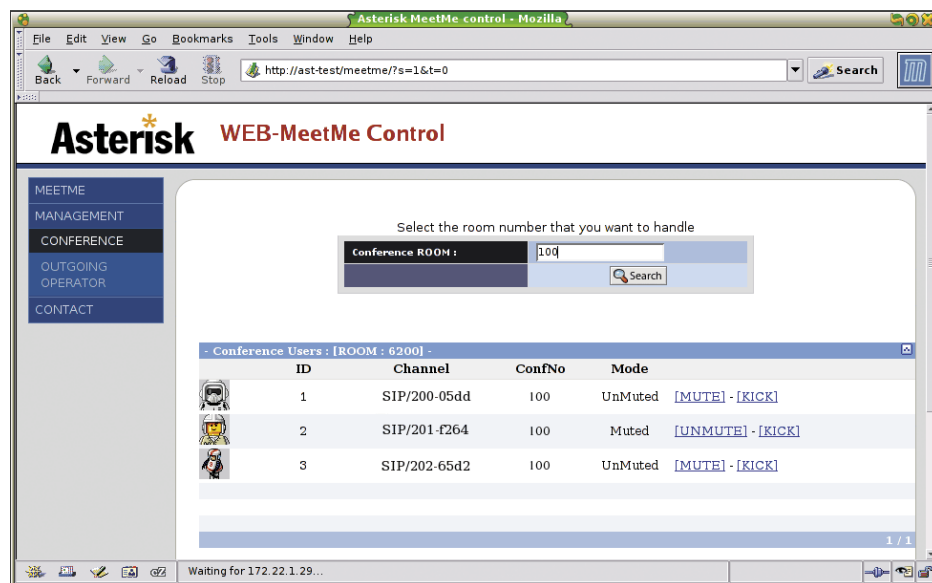


Figure 4. IP-PBX software interface

### Description of the IP Telephony stand

The stand is designed for laboratory and practical work for students of higher, secondary specialized and vocational educational institutions in order to gain experience and skills in the field of setting up and operating IP telephony software and hardware. The complex is equipped with equipment from D-Link, Panasonic and AddPac, as well as two computers with Linux OS and VirtualBox virtual environment.

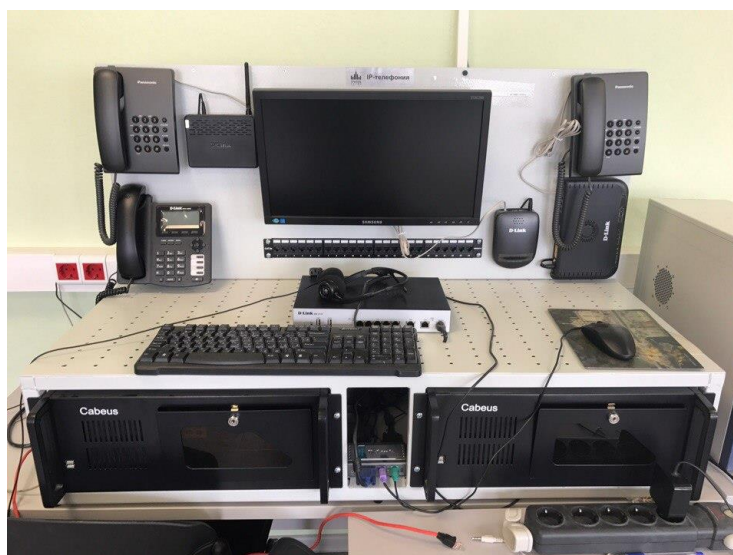


Figure 5. Stand "IP telephony"

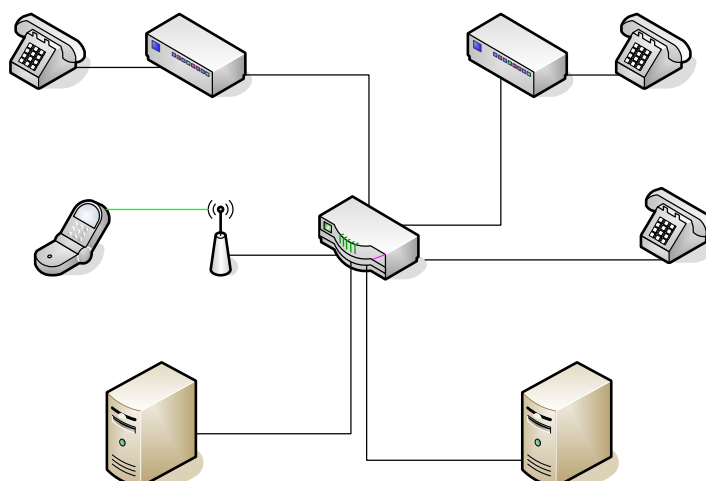


Figure 6. Structural diagram of the IP telephony stand

The stand includes:

The D-Link DVG-5004S voice gateway (Fig. 7) contains 4 FXS ports, 4 LAN ports, and one WAN port. It has a built-in web interface, which makes it faster, easier, and more convenient. This gateway is equipped with the function of hardware diagnostics of analog ports, for which it uses a web interface.



Figure 7. D-Link DVG-5004S voice gateway

Table 1. Characteristics of D-Link DVG-5004S

|                           |                          |
|---------------------------|--------------------------|
| Number of Switch Ports    | 4 x Ethernet 10/100 Mbps |
| Web interface             | Yes                      |
| Telnet Support            | Yes                      |
| Built-in VoIP adapter     | Yes                      |
| Number of FXS ports       | 4                        |
| WAN port                  | Ethernet 10/100 Mbps     |
| NAT                       | Yes                      |
| DHCP server               | Yes                      |
| Dynamic DNS support       | Yes                      |
| Demilitarized Zone (DMZ)  | Yes                      |
| Static Routing            | Yes                      |
| Dynamic routing protocols | RIP v1, RIP v2           |

**The D-Link DVG-2102S telephone adapter** allows you to connect to a cable or DSL modem to make low-cost calls over the Internet. This device combines the advantages of modern Voice over IP technology with advanced communication functions. Thanks to 2 FXS ports, a regular telephone can be connected to the DVG-2102S (Fig. 8), which will allow you to make calls over the Internet.



Figure 8. D-Link DVG-2102S telephone adapter

Table 2. Characteristics of D-Link DVG-2102S

|                            |             |
|----------------------------|-------------|
| SIP Support                | Yes         |
| Interfaces                 | LAN, FXS    |
| Echo compensation          | Yes         |
| Voice Activity Recognition | Yes         |
| Generate comfortable noise | Yes         |
| Caller ID                  | Yes         |
| Hold, Call Waiting         | Yes         |
| Web interface              | Yes         |
| More information           | 2 FXS Ports |

**The D-Link DIR-300 wireless router** (Fig. 9) **allows** you to create a wireless network with an information transfer rate of up to 150 Mbit/s.



Figure 9. D-Link DIR-300 Wireless Router

Table 3. Specifications of the D-Link DIR-300

|                                |                        |
|--------------------------------|------------------------|
| Wireless standard              | 802.11g                |
| Max. wireless connection speed | 54 Mbps                |
| Data protection                | WEP, WPA, WPA2, 802.1x |
| Transmitter Power              | 17 dBm                 |
| Indoor range                   | 100 m                  |
| Outdoor range                  | 400 m                  |
| Commutator                     | 4xLAN                  |
| Port Speed                     | 100 Mbps               |
| Firewall (FireWall)            | Yes                    |
| NAT                            | Yes                    |
| SPI                            | Yes                    |
| DHCP server                    | Yes                    |
| Dynamic DNS support            | Yes                    |
| Demilitarized Zone (DMZ)       | Yes                    |
| Static Routing                 | Yes                    |
| VPN pass through support       | Yes                    |
| VPN Tunnel Support             | Yes                    |
| Number of external antennas    | 1 x 2 dBi              |
| External Antenna Type          | Removable              |
| Web interface                  | Yes                    |

**The D-Link DSA-3110** ( Figure 10) is a VPN-based network access system that intelligently manages the authentication, Authorization, and Accounting (AAA) of connecting users. This device provides the network with a full range of features, including account management and traffic statistics using NetFlow technology.



Figure 10. D-Link DSA-3110 Router

Table 4. Specifications of D-Link DSA-3110

|                          |                          |
|--------------------------|--------------------------|
| RAM                      | 64 Mb                    |
| Number of Switch Ports   | 7 x Ethernet 10/100 Mbps |
| Console port             | Yes                      |
| Web interface            | Yes                      |
| Telnet Support           | Yes                      |
| NAT                      | Yes                      |
| Demilitarized Zone (DMZ) | Yes                      |
| Static Routing           | Yes                      |
| VPN pass through support | Yes                      |
| VPN Tunnel Support       | 50 tunnels               |

**The D-Link DPH-150S IP Phone** is equipped with 1 WAN port for connecting to a cable/DSL modem or a broadband router. Another LAN port allows you to connect a personal computer.



Figure 11. D-Link DPH-150S IP Phone

**Panasonic KX-TS2350 analog phones** support touchtone dialing and redial numbers.



Figure 12. Panasonic KX–TS2350 telephone set

**AddPac WP100 Wi-Fi Phone.** The convenience of Wi-Fi technology combines this device with the proven quality of AddPac's voice technology



Figure 13. Wi-Fi IP Phone AddPac WP100

Table 5. Specifications of AddPac WP100

|                         |                                                                            |
|-------------------------|----------------------------------------------------------------------------|
| <b>General Features</b> | Roaming in IEEE802.11b/g networks,<br>Push-to-talk,<br>Headset connectors, |
|-------------------------|----------------------------------------------------------------------------|

|                   |                                                                                                                                                                                                                                                              |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                   | WPA 802.11i support for negotiation security,<br>Support alert functions,<br>High quality voice transmission,<br>2' color display,<br>Vibrating alert,<br>Capacious 1330 mA battery (Lithium Polymer),<br>Convenient docking station with charging function, |
| <b>Networking</b> | Static routing,<br>802.1Q VLAN including VRRP,<br>SNMP v2,<br>Standard & Advanced Access Lists,<br>DHCP сервер, UPnP, DNSProxy,<br>NAT/PAT, IEEE Transparent Bridging                                                                                        |

Two personal computers with Linux OS based on the Intel Celeron Ivy Bridge processor and the VirtualBox virtual environment. The distribution of the freely distributed Asterisk+FreePBX is used as the basic software IP PBX



Figure 14. Personal computers with Linux OS and virtualization environment

### **IP–ATC Asterisk + FreePBX**

Asterisk is a free and open source computer telephony (including VoIP) solution from Digium, originally developed by Mark Spencer. The application runs on Linux, FreeBSD, OpenBSD, Solaris, etc.

Asterisk, together with the necessary equipment, has all the capabilities of a classic PBX, supports many VoIP protocols and provides rich call management functions, including:

Voicemail

Conference calls

IVR (Interactive Voice Response)

Call processing center (queuing calls and distributing them to subscribers using various algorithms)

Call Detail Record

To create additional functionality, you can use your own Asterisk language to write a numbering plan by writing a module in C, or using AGI, a flexible and universal interface for integration with external data processing systems. Modules executed through AGI can be written in any programming language.

Asterisk is distributed under a dual license, thanks to which it is possible to create closed modules containing licensed code simultaneously with the main code distributed under the GNU GPL open license: for example, a module to support the G.729 codec.

Thanks to the free license, Asterisk is actively developed and supported by thousands of people from all over the world.

The main Asterisk protocols are SIP and IAX2

SIP (Session Initiation Protocol) is a data transfer protocol that describes the method of establishing and terminating a user Internet session, including the exchange of multimedia content (IP telephony, video and audio conferences, instant messaging, online games).

The protocol describes how a client application (e.g., a softphone) can request the start of a connection from another, possibly physically remote, client on the same network using its unique name. The protocol defines a way for clients to agree on the opening of exchange channels based on other protocols that can be used to transmit information directly (e.g., RTP). It is allowed to add or remove such channels during the established session, as well as to connect and disconnect additional clients (that is, more than two parties are allowed to participate in the exchange - conference calls). The protocol also determines the order in which the session ends.

IAX2 (Inter-Asterisk eXchange protocol) is a VoIP data exchange protocol between IP-PBX Asterisk. Unlike SIP and H.323, it uses only one UDP port 4569 for signaling and media streaming, while the latter use different ports for this purpose. This protocol allows you to significantly save network traffic compared to the SIP protocol, which is explained by the transmission of signaling information in bitfields, and not by text. The protocol also allows you to combine multiple voice streams and transmit them within a single trunk, reducing the overhead associated with the transmission of IP packet headers.

### Installing an Asterisk IP PBX

Before installation, the distribution package with IP-PBX Asterisk + FreePBX must be burned to a standard DVD disk or the image must be connected to the virtual drive of the virtual server in the virtualization environment used

After booting from disk, a menu will appear with the option to select the version of Asterisk you want to install (see Figure 15).

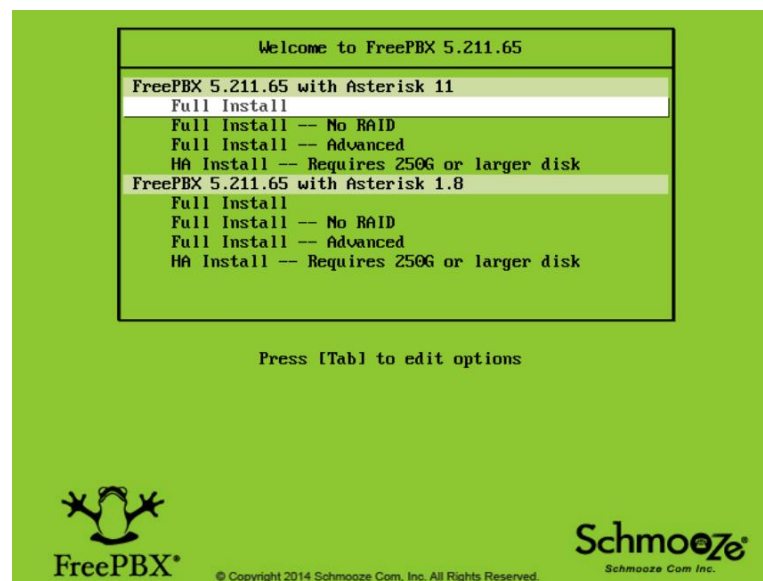


Figure 15. Menu for selecting the Asterisk version for installation

Installation parameters:

Full Install – The standard option for full installation. If you have two hard drives installed on your computer, both drives will be formatted and FreePBX Distro will automatically configure RAID 1 and mirroring. Having two hard drives is

recommended as this will allow the PBX to continue operating normally if one of the drives fails during operation.

Full Install – No RAID – This option installs FreePBX Distro without automatically configuring RAID 1 mirroring

Full Install – Advanced – This option allows you to manually partition the disk

HA Install – Requires 250G or larger disk – This option allows you to back up two servers to get the most out of your telephony experience.

Once the software has been downloaded, the options for setting up the network will be displayed. By default, in most cases, there is no need to configure, so you must press the "TAB" key until the "OK" button is highlighted in white, and then press the "Enter" key. If necessary, you can select the desired option and manually configure the network connection (Figure 16).

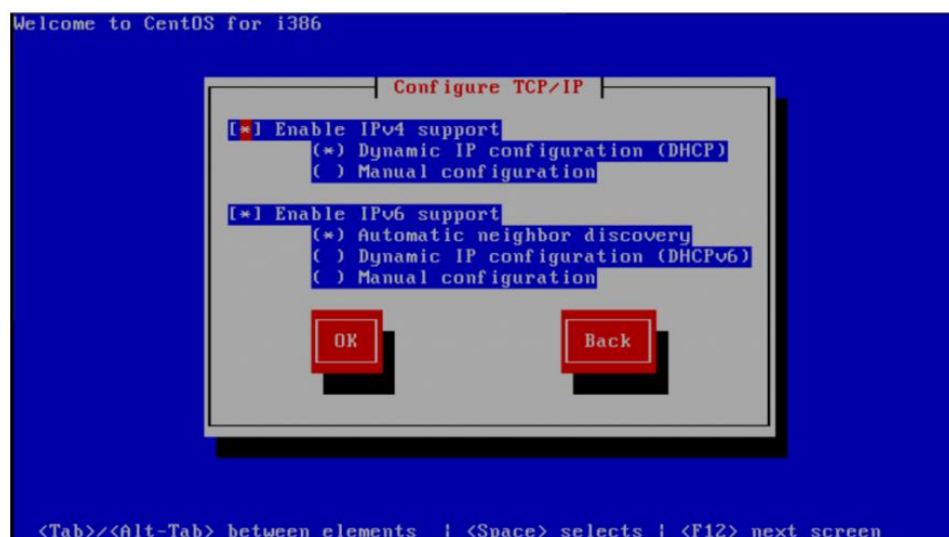


Figure 16: Network Setup Menu

As soon as you click "OK", the system will start setting up network connections.

After setting up the network, you will have a screen with the option to select a time zone. If your system clock uses GMT (extremely rarely), press the space bar. Then, press TAB to proceed to select the time zone. To select the desired time zone, use the "up" and "down" arrows, and then press TAB until the red "OK" button is highlighted in white. Then, press ENTER (see Figure 17).

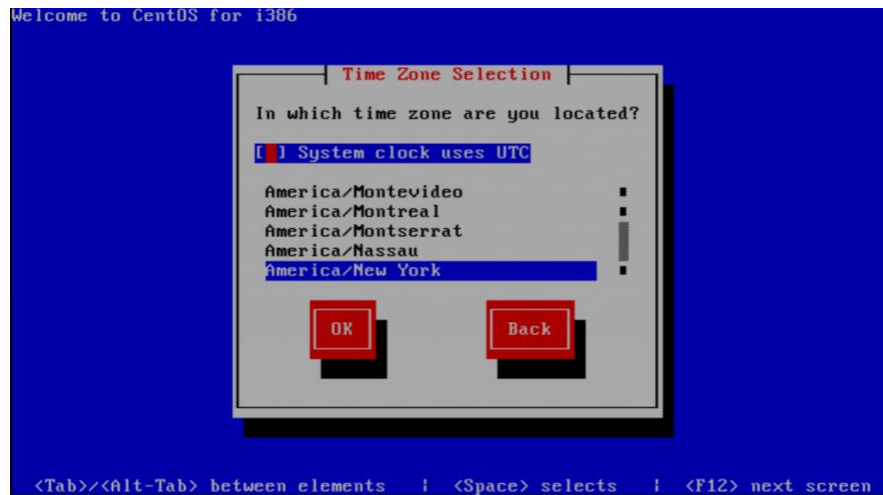


Figure 17. Time zone setting menu

Next, a window will appear with the option to enter the password for Root. This is the password that you will then use to log in to Linux from the command line. **IMPORTANT! USE STRONG PASSWORDS!.** Enter the password, press TAB, enter it again, press TAB, and then press ENTER (Figure 18).



Figure 18. OS administrator password menu

The installer will do a dependency check, then the hard disk will be formatted, and then the installation process of the downloaded packages will begin. There may be minor delays before the installation begins, so be patient and wait a little. As soon as the installation begins, a process progress bar will appear, displaying the percentage of completion and the estimated time until the process is completed. The



Figure 21. Authorization of the Asterisk web interface user

The FreePBX icons will appear on the screen with variant controls and further configuration (Fig. 12.22).



Figure 22. Start page of the Asterisk web interface

## Asterisc IP–PBX Configuration and SIP Subscribers Creation

In the browser, go to the IP address of the Asterisk IP-PBX interface. In case of the first launch, FreePBX will ask you to set a login-password for the WEB interface, as well as email for notifications (Figure 24).

After entering the login and password, we will see the Asterisk start page (Fig. 23) for configuration. Let's go to the FreePBX Administration tab (Fig. 24).

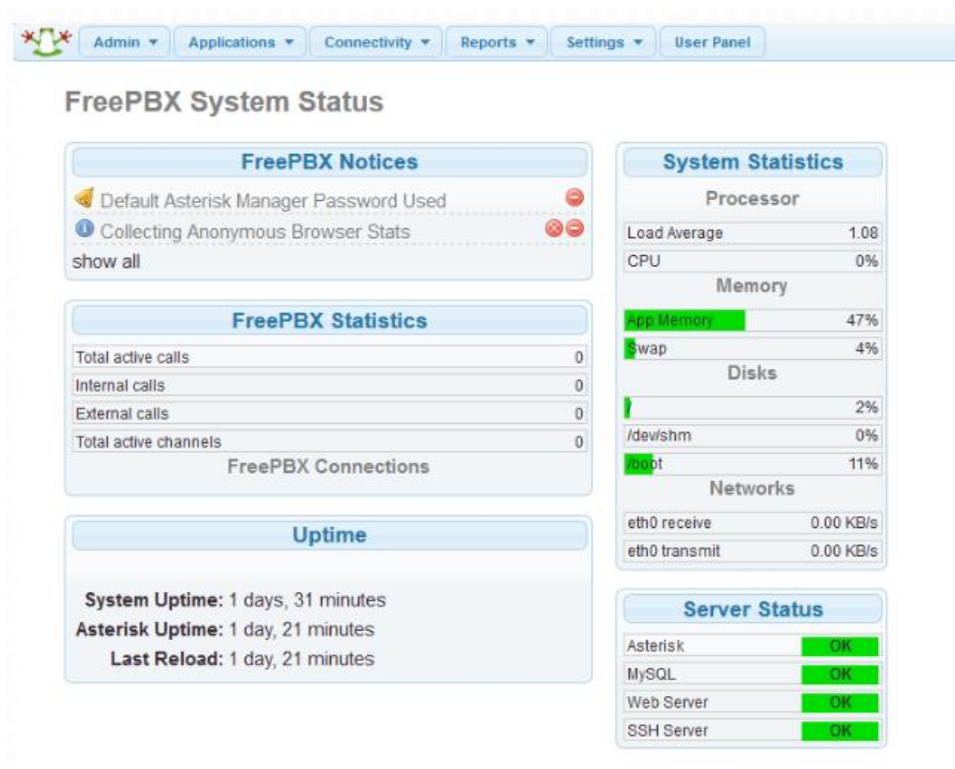


Figure 23. FreePBX Administration web interface page

Go to the Advanced Settings section, which is selected from the Settings menu. This is where the important settings of the asterisk are concentrated. Change the Country Indication Tones to Russian Federation and Ringtime Default to 60, in the Dialplan and Operational section. To apply the changes, click the green checkmark, and the red Apply Settings button to save the settings (Fig. 24).

|                                        |                    |   |
|----------------------------------------|--------------------|---|
| Asterisk Dial Options                  | tr                 |   |
| Asterisk Outbound Trunk Dial Options   | Tt                 |   |
| Country Indication Tones               | Russian Federation | ✓ |
| Display CallerID on Calling Phone      | True False         |   |
| Display Dialed Number on Calling Phone | True False         |   |
| Display Presence State of Callee       | True False         |   |
| Ringtime Default                       | 60                 | ✓ |
| Speaking Clock Time Format             | 12 Hour Format     |   |

Figure 24. Configuring Advanced Settings

Go to the GUI Behavior section and change False to True in the Show Language setting. Save the changes (see Figure 25).

|                                     |      |       |   |   |
|-------------------------------------|------|-------|---|---|
| Require Confirm with Apply Changes  | True | False | ↻ | ✓ |
| Show Language setting               | True | False | ↻ | ✓ |
| Use freepbx_menu.conf Configuration | True | False | ↻ |   |
| Use wget For Module Admin           | True | False |   |   |

Figure 25. Configuring the GUI Behavior

Go to the System Setup section, and in the User Portal Admin Password item, you can see the password that we set for the web in plain text. The password for the FreePBX web interface is stored in mysql in encrypted form (Fig. 26).

|                                 |                  |       |
|---------------------------------|------------------|-------|
| User & Devices Mode             | extensions       |       |
| Allow Login With DB Credentials | True             | False |
| User Portal Admin Username      | Adminko          | ↻     |
| User Portal Admin Password      | OmgMyPassIsHere! | ↻ ✓   |
| Asterisk VMU Mask               | 007              |       |
| Browser Stats                   | True             | False |

Figure 12.26. Configuring Admin Password

In the Asterisk Manager section, you also need to change the password for the administrator's AMI (Fig. 27).

|                           |            |
|---------------------------|------------|
| Asterisk Manager          |            |
| Asterisk Manager Password | JokeAndFun |
| Asterisk Manager User     | admin      |

Figure 27. Configuring Manager Password

Go to the Fail2Ban settings to add your IP address to the whitelist, select System Admin in the Admin menu. Here you can change the system settings, for example, the IP address of Asterisk. Find the item – Intrusion Detection (Fig. 28).

## System Admin

### Intrusion Detection

When the service is running, attempts to compromise you are reset after the Find Time is exceeded.  
Schmooze Com Inc recommends this service always run.

Status: running

Intrusion Detection

Ban Time:

Max Retry:

Find Time:

E-mail:

Whitelist

127.0.0.1  
192.168.254.220

Banned IP's

Figure 28. Configuring Fail2Ban

In the WhiteList field, add the address of the administrator's PC separated by a space. You can specify both addresses and networks, for example, 192.168.0.0/24. You need to add addresses separated by a space. To save, click Send request. The basic Asterisk configuration is completed (Fig. 28).

To create SIP subscribers, go to the Applications menu and select Extensions.

By default, the SIP device is already selected, SIP is the main protocol with which asterisk works, so this is what we will use. Click the Submit button and fill in several fields in a new window. These are the User Extension number of the user, for example, 101 and the Display Name (nr. 29).

- Добавить внутренний номер

|                               |                                        |
|-------------------------------|----------------------------------------|
| Внутренний номер пользователя | <input type="text" value="101"/>       |
| Отображаемое имя              | <input type="text" value="FirstUser"/> |
| Псевдоним Caller ID           | <input type="text"/>                   |
| Псевдоним SIP                 | <input type="text"/>                   |

Figure 29. Configuring the user's SIP

In the Device Options section, a secret has already been generated, and you can set the required password manually (Fig. 30).

- Опции устройства

|                                      |                                                               |
|--------------------------------------|---------------------------------------------------------------|
| Устройство использует sip технологию |                                                               |
| secret                               | <input type="text" value="2851407c7a9cb3a18c94364ef9eb0637"/> |
| dtmfmode                             | <input type="text" value="RFC 2833"/>                         |
| nat                                  | <input type="text" value="Да"/>                               |

Figure 30. Configuring the user's SIP password

In the iSymphony Settings section, it is recommended to set the Create User item to No

In the Recording Options section, we can set which conversations for this number will be recorded, choosing only external calls (Fig. 31).

- Опции записи

|                                                    |                                                                                                                            |
|----------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------|
| Контроль внешних входящих соединений               | <input type="button" value="Всегда"/> <input type="button" value="Не существенно"/> <input type="button" value="Никогда"/> |
| Контроль внешних исходящих соединений              | <input type="button" value="Всегда"/> <input type="button" value="Не существенно"/> <input type="button" value="Никогда"/> |
| Контроль внутренних входящих соединений            | <input type="button" value="Всегда"/> <input type="button" value="Не существенно"/> <input type="button" value="Никогда"/> |
| Контроль внутренних исходящих соединений           | <input type="button" value="Всегда"/> <input type="button" value="Не существенно"/> <input type="button" value="Никогда"/> |
| Запись разговоров                                  | <input type="button" value="Выключить"/> <input type="button" value="Включить"/>                                           |
| Приоритет политики использования записи разговоров | <input type="text" value="10"/>                                                                                            |

Figure 31. Configuring call recording

Then click the Submit button at the very bottom and the red Apply Settings button.

To test the user, you can use a softphone, or an IP phone with SIP support. By dialing \*65 from it, the system will dictate your extension number to you.

You can view the rest of the service codes in the Feature Codes section of the Admin menu (see Figure 32).

**Управление сервисными кодами**

|                                                      | Используется по умолчанию?               | Сервис Статус  |
|------------------------------------------------------|------------------------------------------|----------------|
| <b>Черный список</b>                                 |                                          |                |
| Внести номер в черный список                         | *30 <input checked="" type="checkbox"/>  | Активировано ▼ |
| Внести в черный список номер последнего позвонившего | *32 <input checked="" type="checkbox"/>  | Активировано ▼ |
| Удалить номер из черного списка                      | *31 <input checked="" type="checkbox"/>  | Активировано ▼ |
| <b>Перенаправление вызова</b>                        |                                          |                |
| Задать перенаправление всех вызовов                  | *72 <input checked="" type="checkbox"/>  | Активировано ▼ |
| Снять перенаправление всех вызовов                   | *73 <input checked="" type="checkbox"/>  | Активировано ▼ |
| Call Forward All Promptinn Activate                  | *720 <input checked="" type="checkbox"/> | Активировано ▼ |

Figure 32. Setting Up Service Tags

### Connecting the D-Link DPH-150S to the IP-PBX

Connect the router to the phone's WAN connector with the mains wire. Connect the power supply to the phone, then to the power supply. When the phone boots up, press the "Menu" button on it, use the "down" arrow to find "IP Address" and look at the IP address assigned by the router automatically (via DHCP). This address should be written down and entered into the address bar of a web browser (Internet Explorer or Mozilla Firefox) and press "Enter" on the keyboard. A window of the phone's web interface will appear on the computer screen with a prompt to enter the username and password to enter its settings. Login admin, password admin. In the "Language/Mmi Set" item of the "General/BASIC" section, select the Russian language, if necessary (Fig. 33).

Go to the "VOIP" – "SIP" – "Basic settings" section and enter the registration data of the subscriber previously created in Asterisk SIP according to the sample in Fig. 34.

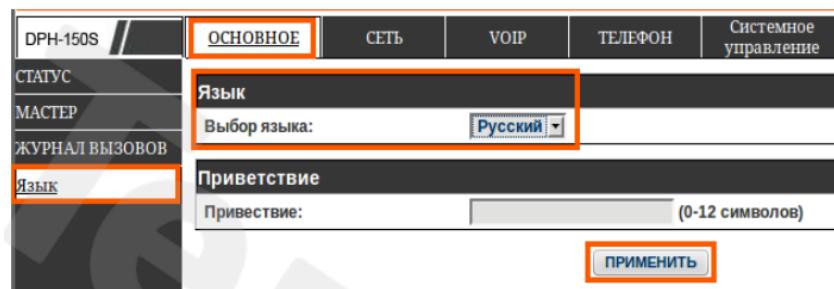


Figure 33. Setting the interface language

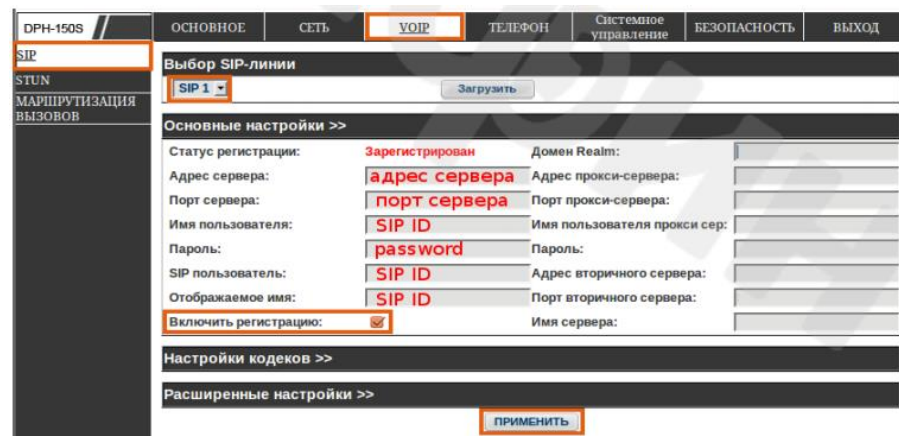


Figure 34. Configuring SIP Subscriber Identification Data

Click apply and make sure that "Registration Status" has become "Registered"  
To test, dial \*65 - the system will dictate your extension number to you.

### Equipment and materials

To perform practical work, you need a personal computer with Internet access, Cisco Packet Tracer and Microsoft Office.

To perform these studies, it is necessary to use the set of educational equipment "Wireless Computer Networks" WI-FI, which includes:

1. Patch panel – 1 pc.
2. Commutator-injector – 1 pc.
3. Unmanaged switch – 2 pcs.
4. 1 x Stand-Mounted Documentation Drawer
5. 19" rack-integrated socket block

#### Access Equipment

6. Intel Celeron ivy-bridge processor-based PC
7. IP-телефон D-Link DPH-150S

9. Virtual machine with Windows OS
10. D-Link DIR-300 router.
11. Virtual Machine with IP-ATC Asterisk
12. Text editor (Microsoft Word 2003/2007/2010/2013 or its equivalent) designed to create and edit a report on practical work.
13. WireShark Traffic Analyzer Software

### **Safety Instructions**

Persons familiar with its structure, principle of operation and security measures in accordance with the requirements given in this section are allowed to work at the IP telephony stand.

The power cord of the stand must only be connected to a mains outlet with a protective contact.

Adjustment work, inspections and repairs should be carried out only after the stand is disconnected from the power supply using a mains plug.

It is forbidden to work on the stand with the covers open and the casing removed. 4.5 When using additional equipment, use the safety instructions for this equipment.

In addition, in the laboratory, when working with computer equipment, it is necessary to comply with the safety requirements provided for the computer class:

1. Do not turn on the computer without the permission of the class administrator and instructor.
2. It is forbidden to open the PC case on your own.
3. Do not touch the monitor screen and keyboard at the same time (increased electrostatic potential may be discharged).
4. Do not clutter the top panels of the devices with papers and foreign devices.
5. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.
6. It is forbidden to turn off the power supply during the execution of an

active task.

7. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

### **Methodology and procedure for performing work**

The content of the study:

IP-PBX Deployment Study

Study of SIP registration of IP-PBX subscribers

Investigation and analysis of SIP protocol traffic during subscriber registration on IP-PBX

Investigation and analysis of traffic between two SIP subscribers when making a call.

Sequence of work

Deploying Asterisk IP-ATC

Creating multiple SIP subscribers

Connecting subscribers to IP-PBX via softphone

Analysis of traffic between subscribers via SIP protocol during a call using Wireshark

Traffic Analysis with Wireshark Software Traffic Analyzer

Wireshark is a fairly well-known tool for capturing and analyzing network traffic, in fact, the standard for both education and troubleshooting.

Wireshark works with the vast majority of known protocols, has a clear and logical graphical interface based on GTK+ and a powerful filter system.

It is cross-platform, works on Linux, Solaris, FreeBSD, NetBSD, OpenBSD, Mac OS X, and, of course, Windows. It is distributed under the GNU GPL v2 license.

To start the capture, simply select your network interface and press Start (Figure 35).



Figure 35. Selecting a network interface

After that, the capture process will begin, and the arriving packages will appear in real time.

In the process of reviewing and studying packages, there are situations when you need to return to the previous package. There are two buttons for this (Fig. 36).

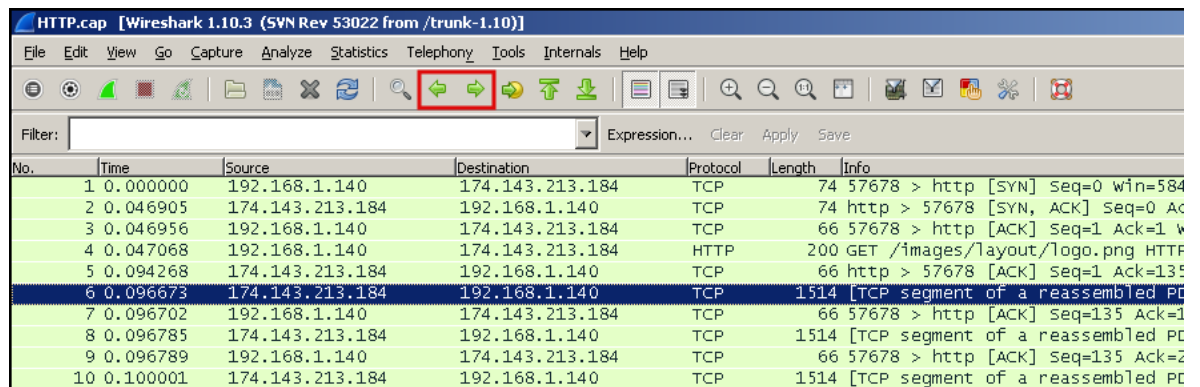


Figure 36. Wireshark interface

And the next button allows you to make a quick transition to the package by specifying its number.

If the columns overlap and overlap each other, you can right-click on such a column and select "Resize Column". The size will be automatically adjusted to the current situation. Also, there is a "Resize all Columns" button that will put all the columns in order.

Using the View – Time Display Format menu, you can, for example, configure the time to start counting from the beginning of the capture, but from the time of receiving the previous packet (Since Previous Captured Packet).

The most important thing in each program (Help – About Wireshark) will show not only the version and the list of authors, but also contains the Folders tab, which will show the paths for placing directories with configurations.

By examining the interface, you can select, for example, an http packet, and see that HTTP is encapsulated in TCP (transport layer), TCP is encapsulated in IP (network layer), and IP in turn is encapsulated in Ethernet (see Figure 37).

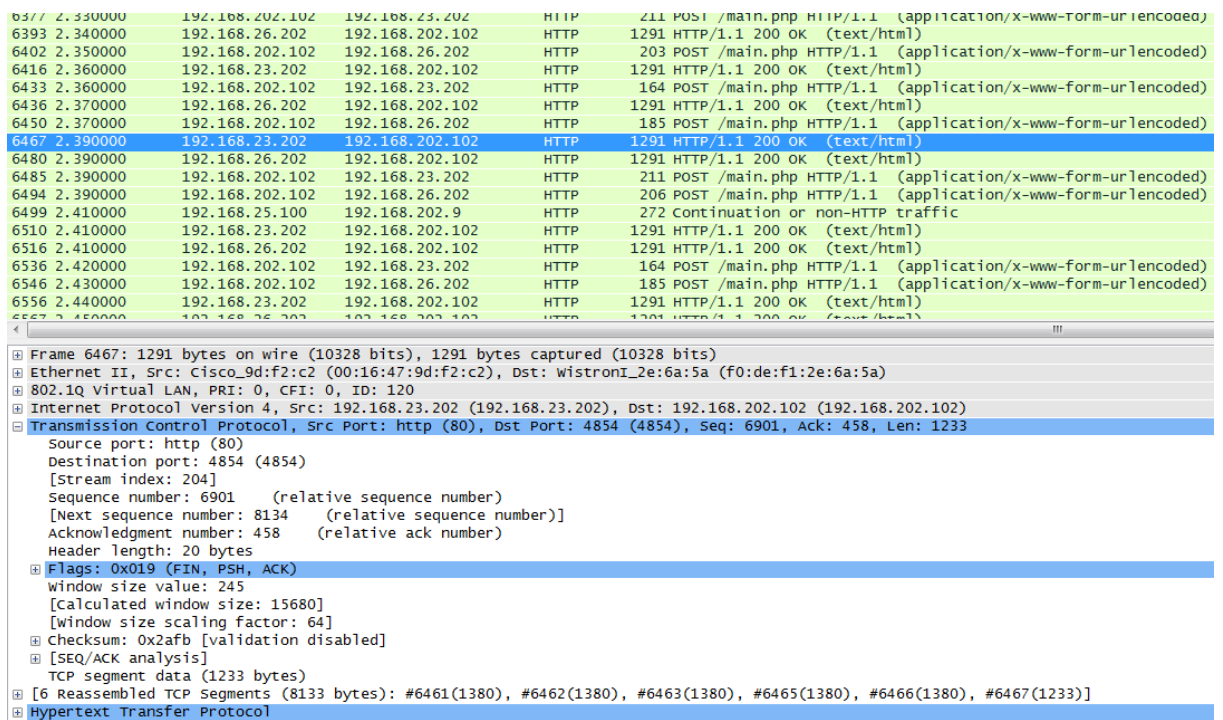


Figure 37. Analyzing an HTTP packet

For the convenience of searching/viewing information about the necessary packets, Wireshark can filter the captured packets by IP address or port number.

For example, if you want to filter captured packets by destination IP address 88.255.67.145, in the "Filter" field, specify the filter rule `ip.dst==88.255.67.145` (Fig. 38)

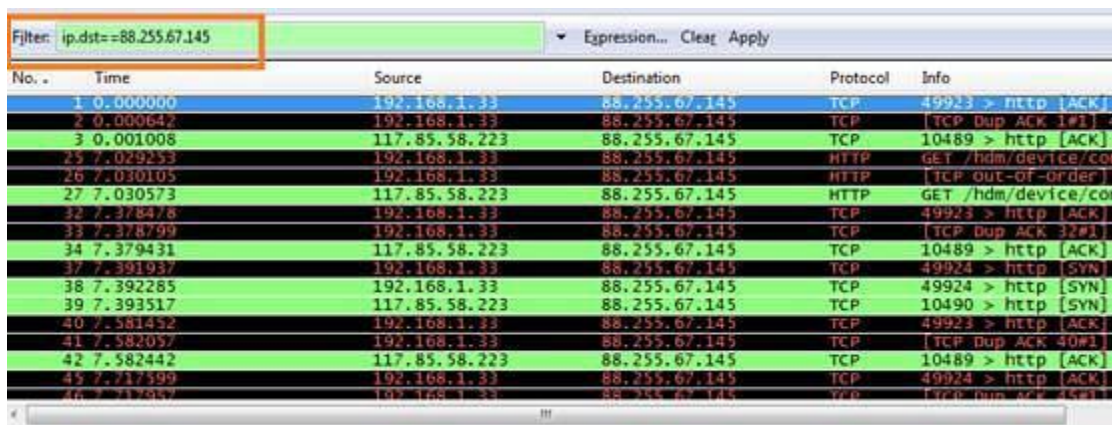


Figure 38. IP filter

If you want to filter captured packets by a specific TCP port (for example, by port 80), in the "Filter" field, specify the filter rule `tcp.port==80` (Fig. 39)

| Filter: tcp.ports==80 |          | Expression... Clear Apply |               |          |               |
|-----------------------|----------|---------------------------|---------------|----------|---------------|
| No. .                 | Time     | Source                    | Destination   | Protocol | Info          |
| 1                     | 0.000000 | 192.168.1.33              | 88.255.67.145 | TCP      | 49923 → http  |
| 2                     | 0.000642 | 192.168.1.33              | 88.255.67.145 | TCP      | [TCP Seq ACK  |
| 3                     | 0.001008 | 117.85.58.223             | 88.255.67.145 | TCP      | 10489 → http  |
| 25                    | 7.029253 | 192.168.1.33              | 88.255.67.145 | HTTP     | GET /hdm/dev1 |
| 26                    | 7.030105 | 192.168.1.33              | 88.255.67.145 | HTTP     | [TCP Out-of-o |
| 27                    | 7.030573 | 117.85.58.223             | 88.255.67.145 | HTTP     | GET /hdm/dev1 |
| 28                    | 7.377980 | 88.255.67.145             | 117.85.58.223 | TCP      | [TCP segment  |
| 29                    | 7.378357 | 88.255.67.145             | 192.168.1.33  | TCP      | [TCP segment  |
| 30                    | 7.378364 | 88.255.67.145             | 117.85.58.223 | TCP      | [TCP segment  |
| 31                    | 7.378366 | 88.255.67.145             | 192.168.1.33  | TCP      | [TCP segment  |
| 32                    | 7.378478 | 192.168.1.33              | 88.255.67.145 | TCP      | 49923 → http  |
| 33                    | 7.378709 | 192.168.1.33              | 88.255.67.145 | TCP      | [TCP Seq ACK  |
| 34                    | 7.379431 | 117.85.58.223             | 88.255.67.145 | TCP      | 10489 → http  |
| 35                    | 7.381014 | 88.255.67.145             | 117.85.58.223 | TCP      | [TCP segment  |
| 36                    | 7.381379 | 88.255.67.145             | 192.168.1.33  | TCP      | [TCP segment  |
| 37                    | 7.391937 | 192.168.1.33              | 88.255.67.145 | TCP      | 49924 → http  |

Figure 39. Filter by port number

## Content of the report and its form

The report must contain

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;
- results of implementation;
- answers to control questions;
- conclusion on the work done.

## Work protection

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;

## Control questions:

1. What is a network interface?
2. What is a well-known enough tool for capturing and analyzing network traffic?
3. What is a wireless router?
4. Could you describe the structural diagram of the IP telephony stand?
5. What is an IP PBX?
6. What is the structural diagram of a SIP connection?

## PRACTICAL WORK

## HARDWARE OF PERSONAL COMPUTERS

**The purpose of the work:** to learn how to develop logical coherent schemes from a given technical material for the fastest assimilation of information and the formation of working presentations.

### **Theoretical substantiation:**

Hardware of personal computers

*Electronic computer (computer) is a set of technical means designed for automatic processing of information in the process of solving computational and information problems.*

Computers can be classified according to a number of characteristics, in particular: by the principle of operation, purpose, methods of organizing the computing process, size and computing power, functionality, ability to parallel execution of programs, and [1, 8].

Classification of computers according to the principle of operation

According to the principle of operation, computers are divided into three large classes: ***analog*** (AVM), ***digital*** (DVM) and ***hybrid***.

The criterion for dividing computers into these three classes is the form of representation of the information with which they work.

***Digital*** computers are discrete computers that work with information presented in discrete, or rather, in *digital* form.

***Analog*** computers are continuous computers that work with information presented in a continuous (*analog*) form, i.e. in the form of a continuous series of values of a physical quantity (most often electrical voltage).

Analog computers are very simple and easy to operate; the speed of solving problems can be changed at the request of the operator and can be made almost arbitrarily large (more than a digital computer), but the accuracy of solving problems is very low (relative error of 2-5%). On an AVM, mathematical problems containing differential equations that do not require complex logic can be solved most effectively.

***Hybrid*** computers are combined computing machines that work with information presented *in both digital and analog form*; they combine the advantages of AVMs and

digital computers. It is advisable to use hybrid VMs to solve the problems of controlling complex high-speed technical complexes.

#### Classification of computers by purpose

According to their purpose, computers can be divided into three groups: *universal* (general-purpose), *problem-oriented* and *specialized*.

*Universal* computers are designed to solve a variety of engineering and technical problems: economic, mathematical, informational and other problems that are distinguished by the complexity of algorithms and a large amount of processed data. They are widely used in computer centers for collective use and in other powerful computing complexes.

Characteristic features of universal computers are:

- 1) high productivity;
- 2) a variety of forms of processed data: binary, decimal, symbolic, with a wide range of their change and high accuracy of their representation;
- 3) an extensive range of operations performed, both arithmetic, logical and special;
- 4) large capacity of RAM; developed organization of the information input-output system, which provides connection of various types of external devices.

*Problem-oriented* computers serve to solve a narrower range of tasks, related, as a rule, to:

- 1) management of technological facilities;
- 2) registration, accumulation and processing of relatively small data volumes;
- 3) performing calculations using relatively simple algorithms.

They have limited hardware and software resources in comparison with universal computers.

Problem-oriented computers include, in particular, all kinds of control computer complexes.

*Specialized* computers are used to solve a narrow range of tasks or to implement a strictly defined group of functions. Such a narrow orientation of computers makes it

possible to clearly specialize their structure, significantly reduce their complexity and cost while maintaining high performance and reliability.

#### Personal computer architecture

Usually, personal computers externally consist of 4 main parts (blocks) [1, 8]:

- 1) system unit – the main unit of a computer system;
- 2) a keyboard that allows you to enter characters into a computer;
- 3) monitor (or display) – for displaying text and graphic information;
- 4) mouse is a "graphic" control device.

In addition, the computer may include various peripheral devices designed for information input and output. Such devices are:

- 1) printer – for printing text and graphic information;
- 2) mouse – a device that facilitates entering information into a computer;
- 3) scanner – a device for entering graphic information;
- 4) and other devices.

They are connected using cables through special sockets (connectors), usually located on the back wall of the system unit.

Some peripherals can be inserted inside the system unit, for example:

- 1) modem – for exchanging information with other computers via the telephone network;
- 2) Fax-modem combines the capabilities of a modem and a telefax.

#### 1. System unit

The system unit is the main unit inside which the most important components are installed. Devices located inside the system unit are called *internal*, and devices connected to it from the outside are called *external*. External additional devices designed for input, output and long-term storage of data are also called *peripherals*.

#### Internal Devices of the System Unit

*The motherboard* is the largest PC board, to which everything that makes up the computer itself is connected. It contains:

- The backbones that connect the processor to RAM are the so-called *buses*. All other internal computer devices are also connected to the motherboard buses.

- microprocessor chipset – the so-called *chipset*, which controls the operation of the motherboard;

- *microprocessor* is the main chip of a PC. All calculations are performed in it. The main characteristic of the processor is clock speed. The higher the clock speed, the higher the performance of the computer. The only device that the processor knows about is RAM;

- *RAM (RAM)* is designed for storage and operational exchange of information with other units of the machine. RAM contains two types of memory devices: read-only memory (ROM) – a chip designed for long-term storage of data, including when the computer is turned off, and random access memory (RAM) – a set of chips designed for temporary storage of data when the computer is turned on;

- Connectors for connecting additional devices (*slots*).

*Hard drives (hard drives)* are used for long-term storage of data and programs. Turning off the power supply of the computer does not lead to cleaning up external memory. A hard disk is not a single disk, but a package (set) of disks with a magnetic coating, rotating on a common axis.

*A video adapter (video card)* is an internal device installed in one of the motherboard connectors, and serves to process information coming from the processor or from RAM to the monitor, as well as to generate control signals.

*Sound card* is one of the latest improvements in the personal computer. It is connected to one of the motherboard slots in the form of a child card and performs computational operations related to the processing of sound, speech, music. Sound is reproduced through external sound speakers connected to the output of the sound card. A special connector allows you to send a sound signal to an external amplifier. There is also a microphone connector, which allows you to record speech or music and save them on a hard disk for subsequent processing and use.

*A network card* (or a local area network communication card) is used to connect computers within the same enterprise, department or room located at a distance of no more than 150 meters from each other.

With special additional devices, it is possible to organize communication between computers over long distances.

The main parameter of a network card is the speed of information transfer and it is measured in megabytes per second. The typical norm is from 10 to 100 megabytes per second.

Floppy disks (floppy disks) and CD-ROM CDs are used to transport data between remote computers.

A floppy drive is used to write and read data placed on floppy disks .

The capacity of one floppy disk is 1.44 MB, the CD is 650-700 MB.

## 2. Display

*A monitor* is a device for visual representation of data. It is not the only possible, but the main output device. Its main consumer parameter is the size of the screen.

*The size of the monitor* is measured between the opposite corners of the tube diagonally. The unit of measurement is inches. Standard sizes are 14"; 15"; 17"; 19"; 20"; 21". Currently, 15" and 17" monitors are the most versatile, and 19-21" monitors are desirable for graphics operations.

## 3. Keyboard

The computer keyboard is used to enter a command of text. According to the purpose of the keys on the keyboard, they can be divided into five groups:

- 1) alphabet block,
- 2) function keys,
- 3) digital block,
- 4) cursor control keys,
- 5) auxiliary keys.

The computer keyboard is used to enter a command of text. According to the purpose of the keys on the keyboard, they can be divided into five groups: alphabet block, function keys, number pad, cursor control keys, auxiliary keys.

*The numeric keypad* is located on the right side of the keyboard. *The function keys* are in the first row of keys at the top. To the left of the numeric keypad are *the cursor control keys*. In the center of the keyboard is *the alphabet block*.

Keys for entering text characters are located in the alphabet block. To the left and right of the alphabet block there are two auxiliary Shift keys - case switches. If you just press the alphabet keys, small (lowercase) letters will be printed on the screen. To

type uppercase (uppercase) letters, you need to press and hold the ***Shift key***, then press the alphabet keys.

On the left side of the keyboard there is another auxiliary Caps ***Lock key*** - case fixation, after pressing it once, the Caps Lock light will light up in the upper right corner, while you can constantly enter capital letters without having to press the Shift key at the same time. This rule does not apply to the keys that are in the first row from the top in the alphabet block. This row consists of keys with numbers. Special characters are displayed above the numbers. If you simply press the keys of the top row, the numbers or symbols that are depicted on the keys at the bottom will be printed. If you press the ***Shift key*** and any key of the top row at the same time, the symbols that are depicted on the keys at the top will be printed.

When entering text, you will need to insert empty spaces between words - spaces. To do this, use a long key without a designation at the bottom of the keyboard, which is called a "space". The most important of the auxiliary keys is ***Enter***. This key is also called "enter" or "enter key", it is located to the right of the alphabet block. The purpose of the key is very broad, for example, it can be moving to the next line, completing typing a command or selecting from a menu.

The auxiliary keys ***Ctrl*** and ***Alt*** usually work differently in each specific program, only when pressed simultaneously with other keys, or they can be used to switch the keyboard alphabet from Russian to Latin and vice versa.

Another Esc auxiliary key is located in the upper left corner of the keyboard. You can use it to cancel any command.

*Function keys F1... F12* are located at the top of the keyboard and are designed for quick one-key command input in various programs.

*The cursor control keys* are located at the bottom of the keyboard, to the right of the alphabet block – these are the keys with the image of **forward, backward, up, and down arrows**.

*A text cursor* is a special character that indicates the place in the line where the next character will be entered. In different programs, the cursor can have a different appearance, for example, a flickering rectangle or a vertical stroke. Cursor control keys are designed to move through text or menu commands. These keys are duplicated on

the numeric keypad. On the right side of the keyboard is the so-called numeric keypad – keys with numbers. If you press the **Num Lock key** to fix the numbers, the Num Lock light switch turns on and you can use the numeric keypad to enter numbers. If the **Num Lock** light is off, you can use the keys of the numeric keypad to control the movement of the text cursor.

#### 4. Mouse

A mouse is a manipulator-type control device. It is a flat box with two or three buttons. The movement of the mouse on a flat surface is synchronized with the movement of a graphic object (*mouse pointer*) on the monitor screen.

The computer controls the movement of the mouse on a plane and the brief presses of the right and left buttons. (These presses are called *clicks*.) Unlike the keyboard, the mouse cannot be directly used to enter symbolic information—its control principle is *event-driven*. The movements of the mouse and the clicks of its buttons are *events* from the point of view of its driver. By analyzing these events, the driver determines when the event occurred and where on the screen the pointer was at that moment. This data is transmitted to the application program with which the user is currently working.

The combination of a monitor and a mouse provides the most modern type of user interface, which is called *graphic*. The user observes graphical *objects* and *controls* on the screen. With the mouse, he changes the *properties of the objects* and activates the *controls* of the computer system, and with the help of the monitor, he receives feedback from it in graphical form.

##### Mouse control techniques

- *click* – quickly press and release the left mouse button;
- *Double click* – two clicks made with a short time interval between them;
- *right-click* – the same as clicking, but using the right button;
- *drag-and-drop* – performed by moving the mouse while holding down the left button (usually accompanied by moving the on-screen object on which the pointer is placed);
- *mouse drag* – is performed like dragging, but it does not move the screen object, but changes its shape;

- *special drag* – performed like dragging, but with the right mouse button pressed, not the left one;
- *Hanging* – hovering the mouse pointer over an object icon or control and holding it for a while (usually with a tooltip that summarizes the object's properties).

### **Equipment and materials**

To perform practical work, you need a personal computer with Internet access and Microsoft Office.

### **Safety Instructions**

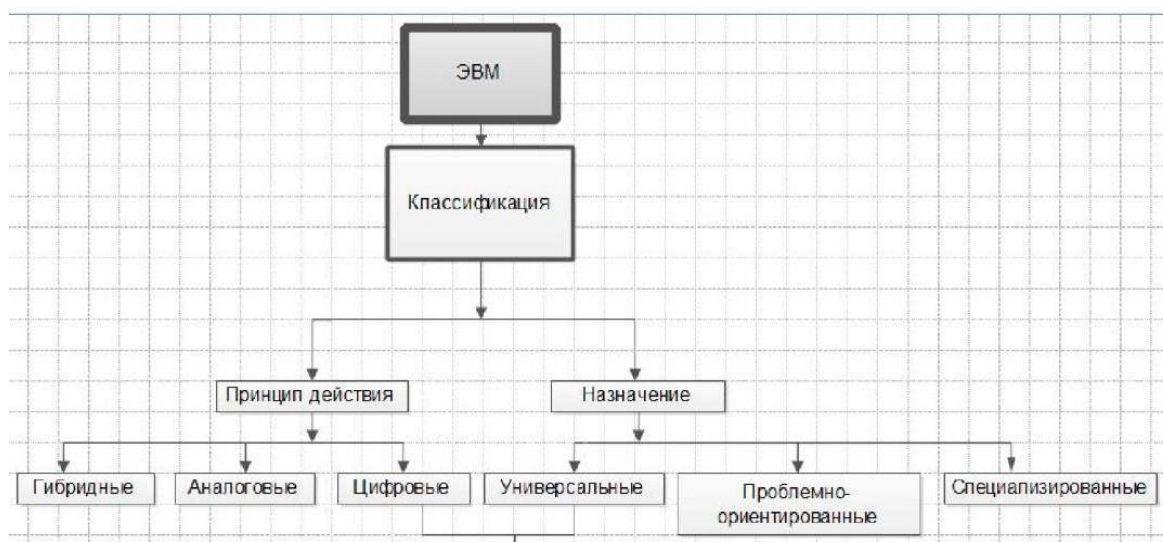
It is necessary to comply with the safety requirements provided for the computer class

1. Do not turn on the computer without the permission of the class administrator and instructor.
2. It is forbidden to open the PC case on your own.
3. Do not touch the monitor screen and keyboard at the same time (increased electrostatic potential may be discharged).
4. Do not clutter the top panels of the devices with papers and foreign devices.
5. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.
6. It is forbidden to turn off the power supply during the execution of an active task.
7. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

### **Methodology and procedure for performing work**

To study the dependence of computer components, it is necessary to create a diagram for the clarity of the information provided. It should logically reflect the connections of objects. For example, computers differ in classification, which in turn is divided into the principle of operation of the computer and its purpose (Figure 1).

Figure 1. Fragment of the diagram "Classification of computers by principle of



operation and purpose"

In its principle of operation, the PC is digital, and in its purpose it is universal (Figure 2).



Figure 2. Fragment of the diagram "PC classification according to the principle of operation and purpose"

PC elements are main, peripheral and additional devices, as well as software (Figure 3).

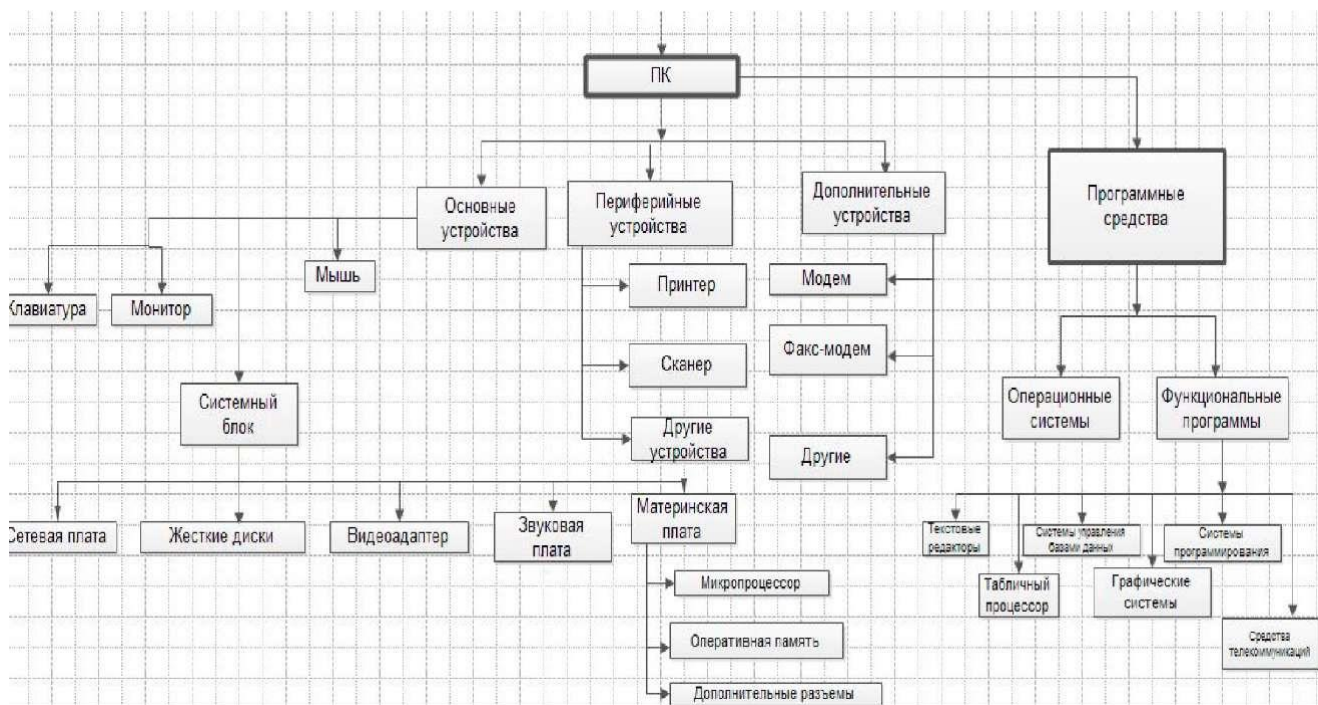
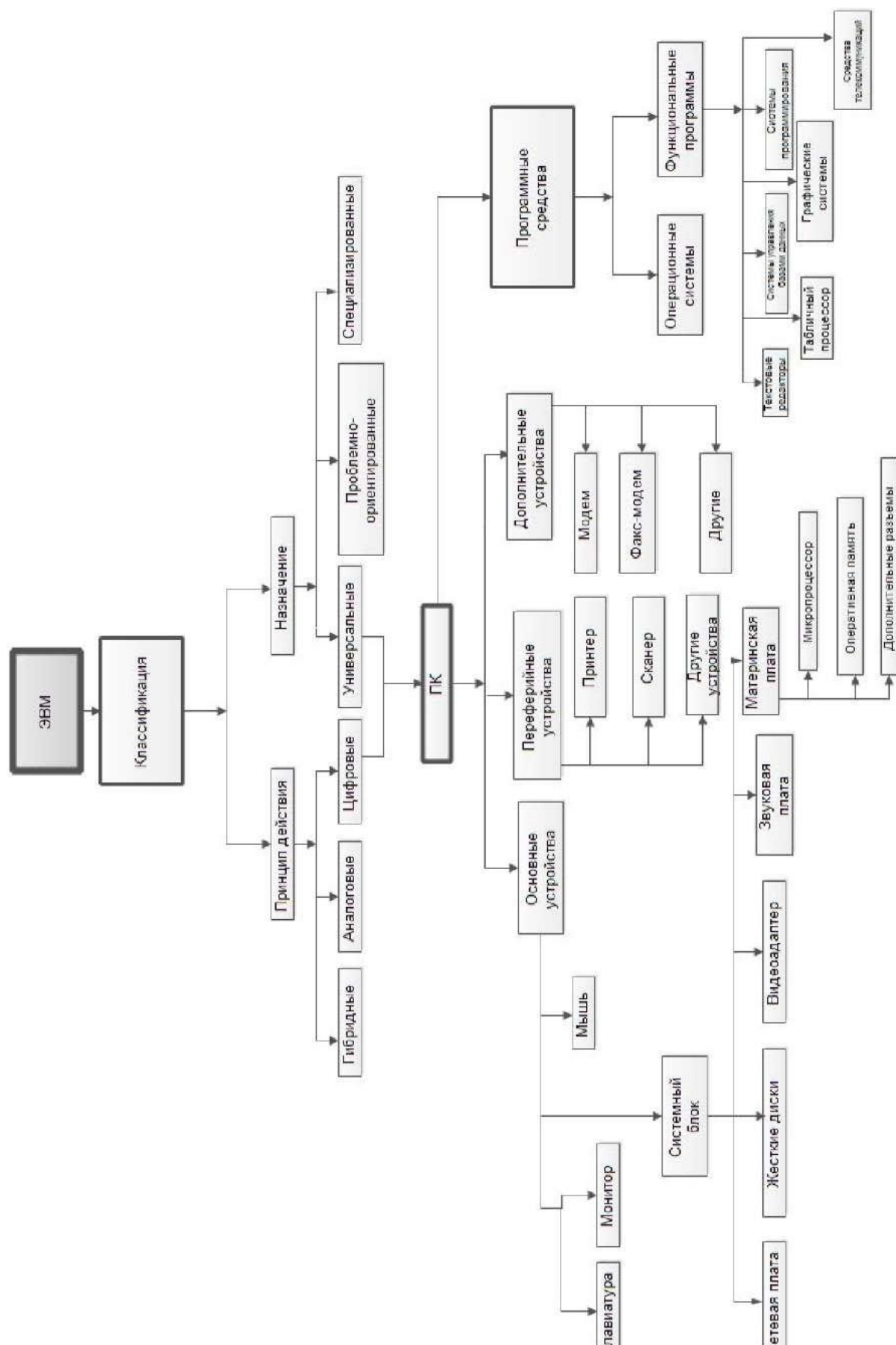


Figure 3. Fragment of the diagram "Main elements of the SC composition"

Thus, in the course of the work, a structural diagram of the computer was formed (Figure 4).

Figure 4. Full diagram "Hardware and software of personal computers



The diagram logically displays the connections of objects, divided into three most important parts: the classification of computers, PCs and PC software.

### **Quests**

1. Answer the control questions of the work.
2. Draw up a report on the following requirements: title page (title of the work, surname, name, patronymic of the bachelor, group number), the purpose of the work; description of the implementation of the individual task; solution of the tasks set in the work; conclusions on the tasks to be solved.
3. Give a brief description in the report to the topic stated by the teacher in a graphic form, the presented logically related scheme.
4. Draw up information on characteristics in the form of an answer plan.

### **Content of the report and its form**

The report must contain

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;
- results of implementation;
- answers to control questions;
- conclusion on the work done.

### **Control questions**

1. What is a Computing Machine?
2. List the internal devices of the system unit, what are they intended for?
3. What is a monitor, keyboard, mouse?
4. Which devices are input devices and which are output devices?
5. What is drag-and-drop?
6. Mouse control techniques.
7. Classification of computers by purpose.
8. Classification of computers by the principle of operation.
9. Personal computer architecture

### **Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;
- report submission.

## **PRACTICAL WORK**

### **ACTIVE RADIOELECTRONIC COMPONENTS: TRANSISTORS**

**The purpose of the work:** to learn to identify, understand the purpose of transistors - radio-electronic elements and apply knowledge when performing the task.

#### **Theoretical substantiation**

Let's consider the active elements – transistors.

A transistor, a semiconductor triode, is a radioelectronic component made of a semiconductor material, usually with three pins, that allows the input signal to control the current in an electrical circuit.

Classification of transistors

1. By basic semiconductor material
2. From silicon,
3. With germanium,
4. From the arsenide,
5. Gallium.
6. By structure
7. Bipolar n-p-n structures, "reverse conduction"; p-n-p structures, "forward conduction".
8. Field-effect with p-n junction; insulated gate – MDP transistor.
9. In terms of power
10. Low-power transistors up to 100mW.
11. Medium-power transistors from 0.1 to 1 watt.
12. High-power transistors (more than 1 W).
13. By execution
14. Discrete transistors.
15. Hull.
16. For free editing.
17. For installation on a radiator.

18. For automated soldering systems.
19. Unenclosed.
20. Transistors as part of integrated circuits.
21. By material and design of the body
22. Metal-glass.
23. Metal-ceramic.
24. Plastic.

A **bipolar transistor** is a three-electrode semiconductor device, one of the types of transistor, which has 3 terminals (emitter, collector and base). The electrodes are connected to three semiconductor layers in series with an alternating type of impurity conductivity.

In a bipolar transistor, unlike a field-effect transistor, two types of charges are used simultaneously, the carriers of which are electrons and holes (from the word "bi" - "two").

Figure 1 shows the structural diagram and UGO of a bipolar transistor of type n-p-n and p-n-p.

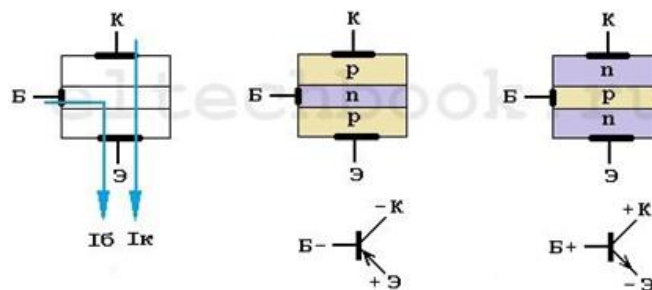


Figure 1. Structural diagram and UGO of a bipolar transistor of type n-p-n and p-n-p

**The base** is the control output;

**Collector** – is under a positive potential (for an n-p-n transistor);

**The emitter** is under a negative potential (for an n-p-n transistor).

Modes of operation of a bipolar transistor

1. Normal Active Mode (Figure 2)

The emitter-base transition is enabled in the forward direction (open), and the collector-base transition is enabled in the reverse direction (closed)

$U_{EB} > 0$ ;  $U_{GB} < 0$  (for p-n-p transistor type);

$U_{EB} < 0$ ;  $U_{GB} > 0$  (for type n-p-n transistor).

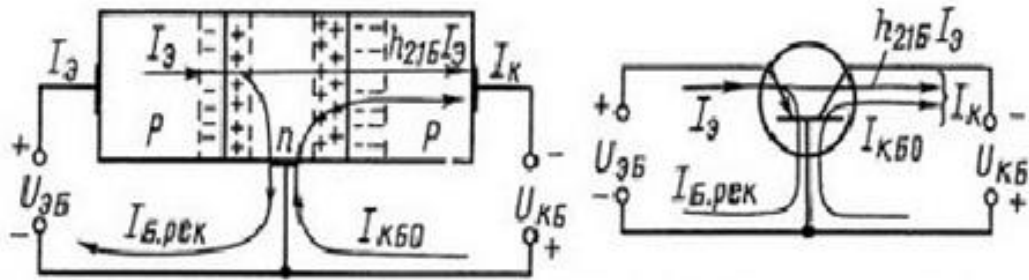


Figure 2. Normal Active Mode

### 1. Saturation mode (Figure 3)

Both p-n junctions are offset in the forward direction (both are open). If the emitter and collector p-n junctions are connected to external sources in the forward direction, the transistor will be in saturation mode.

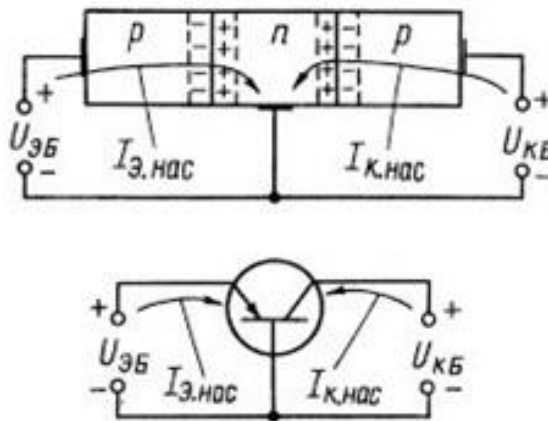


Figure 3. Saturation mode

### 1. Cut-off mode (Figure 4)

In this mode, the collector p-n junction is shifted in the opposite direction, and both reverse and forward displacement can be applied to the emitter junction, not exceeding the threshold value at which the emission of non-basic charge carriers into the base area from the emitter begins.

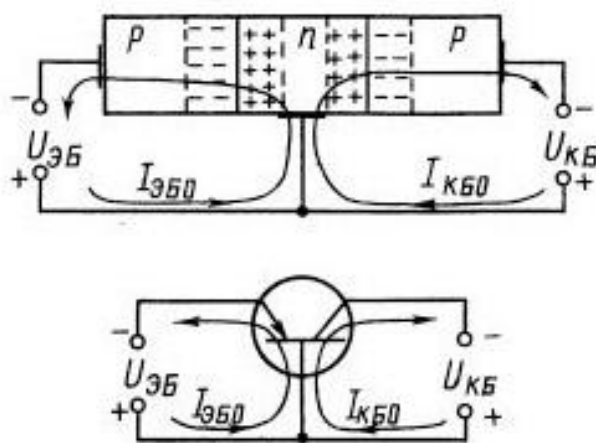


Figure 4. Cut-off mode

### Bipolar transistor wiring diagrams

Any transistor switching circuit is characterized by two main indicators:

- current gain  $I_{\text{вых}}/I_{\text{bx}}$ .
- input impedance  $R_{\text{xx}} = \hat{A}_{\text{xx}}/I_{\text{bx}}$ .

In most electrical circuits, a transistor is used as a four-terminal transistor, i.e. a device with two input and two output terminals. Obviously, since a transistor has only three terminals, in order to be used as a four-terminal transistor, one of the transistor pins must be shared between the input and output circuits.

Figure 5 shows the polarities of the voltages between the electrodes and the directions of the currents corresponding to the active mode in the indicated transistor switching circuits. It should be noted that the currents of the transistor are indicated by one index corresponding to the name of the electrode in the external circuit of which the current flows, and the voltages between the electrodes are indicated by two indices, the second indicating the index corresponding to the name of the common electrode.

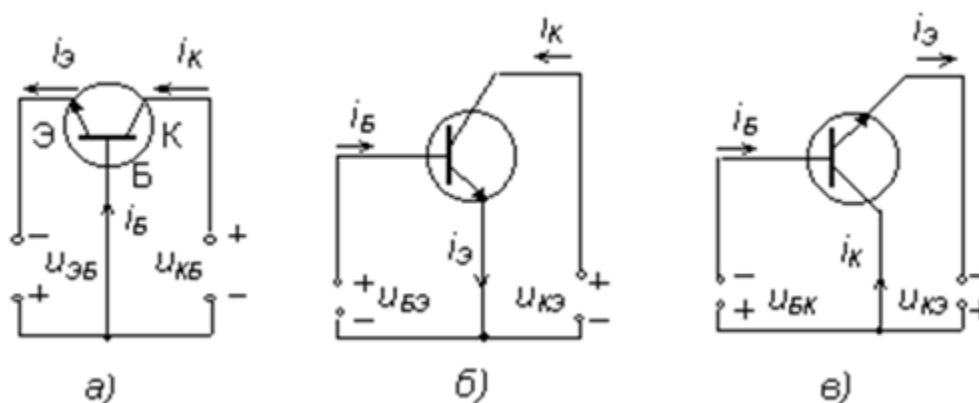


Figure 5. Circuits for connecting a bipolar transistor a) OB; b) OE; c) OK

In the diagram with a common base (see Figure 5, a), the input circuit is the emitter circuit, and the output circuit is the collector circuit. The OP diagram is the easiest to analyze, since in it each of the external voltages is applied to a specific junction: the  $U_{EB}$  voltage is applied to the emitter junction, and the  $U_{EC}$  voltage is applied to the collector junction. It should be noted that the voltage drops on the emitter, base, and collector areas can be neglected in the first approximation, since the resistances of these regions are much less than the transition resistance $\leq$ s.  $U_{CB} > 0$ ) provide an open state of the emitter junction and a closed state of the collector junction, which corresponds to the active mode of operation of the transistor.

In a common-emitter circuit (see Figure 1.3.1.5, b), the input circuit is the base circuit and the output circuit is the collector circuit. In the OE circuit, the  $U_{BE} > 0$  voltage is applied directly to the emitter junction and unlocks it. The  $U_{KE}$  voltage is distributed between both junctions:  $U_{KE} = U_{QB} + U_{BE}$ . In order for the collector junction to be closed,  $U_{KE} = U_{KE} - U_{BE} > 0$  is required, which is achieved with  $U_{KE} > U_{BE} > 0$ .

In a common-collector circuit (see Figure 5, c), the input circuit is the base circuit and the output circuit is the emitter circuit.

Basic parameters.

1. Current transfer ratio.
2. Input impedance.

3. Output conductivity.
4. Reverse current collector-emitter.
5. Turn-on time.
6. Limiting frequency of the base current transfer coefficient.
7. Collector reverse current.
8. Maximum permissible current.
9. The limiting frequency of the current transfer coefficient in a common-emitter circuit.

Transistor parameters are divided into eigen(primary) and secondary. Eigenparameters characterize the properties of the transistor, regardless of the circuit of its connection. The following are taken as the main eigenparameters:

- Current gain  $\alpha$ ;
- resistance of the emitter, collector and base to alternating current  $R_E$ ,  $R_K$ ,  $R_B$ , which are:

$r_e$  is the sum of the resistances of the emitter region and the emitter junction;

$r_k$  is the sum of the resistances of the collector area and the collector junction;

$R_B$  is the lateral resistance of the base.

The use of transistors.

1. Amplifiers, amplification stages
2. Signal generator
3. Modulator
4. Demodulator (Detector)
5. Inverter (log element)

**A field-effect transistor is** a semiconductor device in which the current is regulated by changing the conductivity of the conducting channel using a transverse electric field.

Unlike bipolar, the current of a field-effect transistor is due to the flow of the main carriers.

The electrodes of a field-effect transistor are called the source (I), drain (C) and gate (Z). The control voltage is applied between the gate and the source. The conductivity of the channel, and consequently the value of the current, depends on the voltage between the gate and the source.

Thus, the field-effect transistor can be considered as a current source controlled by the gate-source voltage. If the amplitude of the change in the control signal is large enough, the resistance of the channel can vary within very large limits. In this case, the field-effect transistor can be used as an electronic switch. Classification of field-effect transistors in Figure 6.

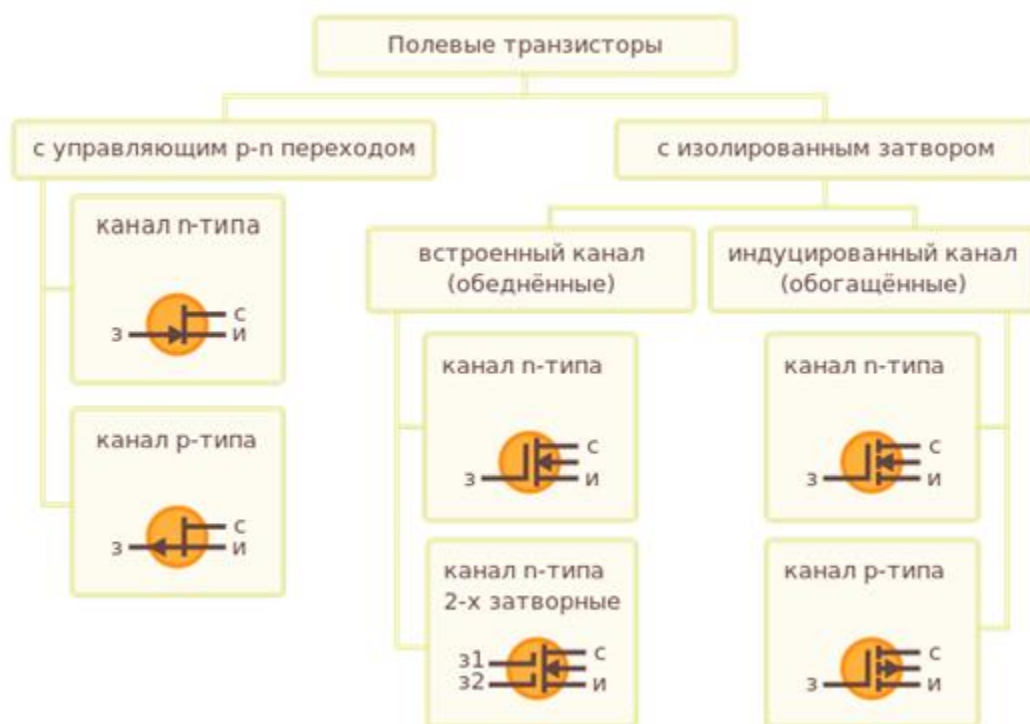


Figure 6. Classification of FETs

Advantages and disadvantages of FETs over bipolar transistors.

FETs have practically replaced bipolar transistors in a number of applications. They are most widely used in integrated circuits as switches (electronic switches)

The main advantages of FETs are:

1. Due to the very high input impedance, the FET circuit consumes very little power, as it consumes almost no input current.
2. The current gain of FETs is much higher than that of bipolar transistors.

3. Noise immunity and reliability of operation are significantly higher, since due to the lack of current through the transistor gate, the control circuit on the gate side is isolated from the output circuit on the drain and source sides.

4. FETs have an order of magnitude higher transition speed between the conductivity and non-conductivity states. Therefore, they can operate at higher frequencies than bipolar ones.

The main disadvantages of FETs are:

The structure of FETs begins to break down at a lower temperature ( $150^{\circ}\text{C}$ ) than the structure of bipolar transistors ( $200^{\circ}\text{C}$ ).

Despite the fact that FETs consume much less power compared to bipolar transistors, the situation changes dramatically when operating at high frequencies.

The most important disadvantage of FETs is their **sensitivity to static electricity**. Since the insulating layer of the dielectric at the gate is extremely thin, sometimes even a relatively low voltage is enough to destroy it. And the discharges of static electricity, present in almost every medium, can reach several thousand volts.

A JFET with an N-channel (a field-effect transistor with a control PN-junction).

As shown in Figure 7, the region of the N-type semiconductor forms a channel between the P-type zones. The electrodes connected to the ends of the N-channel are called drain and source. P-type semiconductors are electrically connected to each other (shorted) and represent a single electrode – a gate.

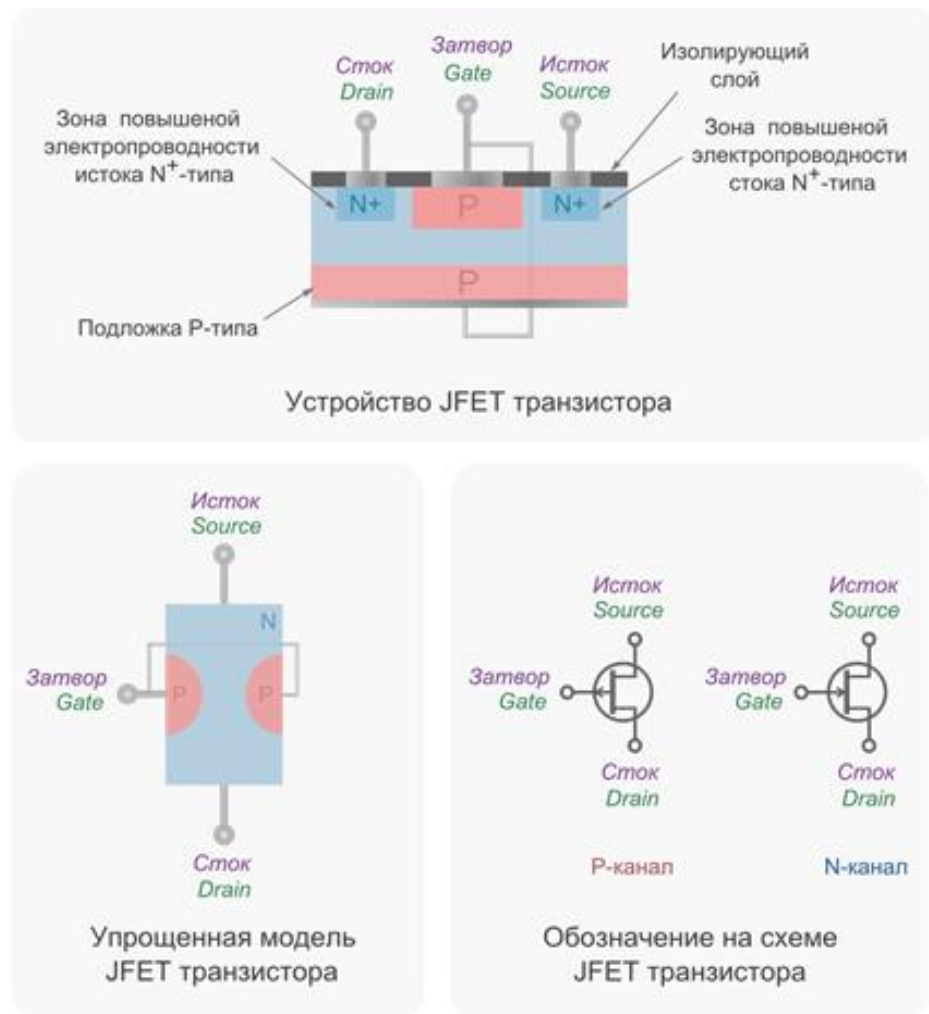


Figure 7. JFET FET with N-channel

Near the drain and source there are regions of increased N<sup>+</sup> doping, i.e. zones with an increased concentration of electrons. This improves the conductivity of the channel. In addition, the presence of N<sup>+</sup> regions weakens the effect of parasitic PN junctions in the case of joining conductors made of trivalent aluminum.

The names of the drain and source electrodes are conventional. If you take a separate field-effect transistor that is not connected to any circuit, it will not matter which leg of the drain case and which source. The name of the electrode will depend on its location in the electrical circuit.

Operation of the JFET with N-channel

1. Gate voltage  $U_{zi}=0$  (Figure 8).

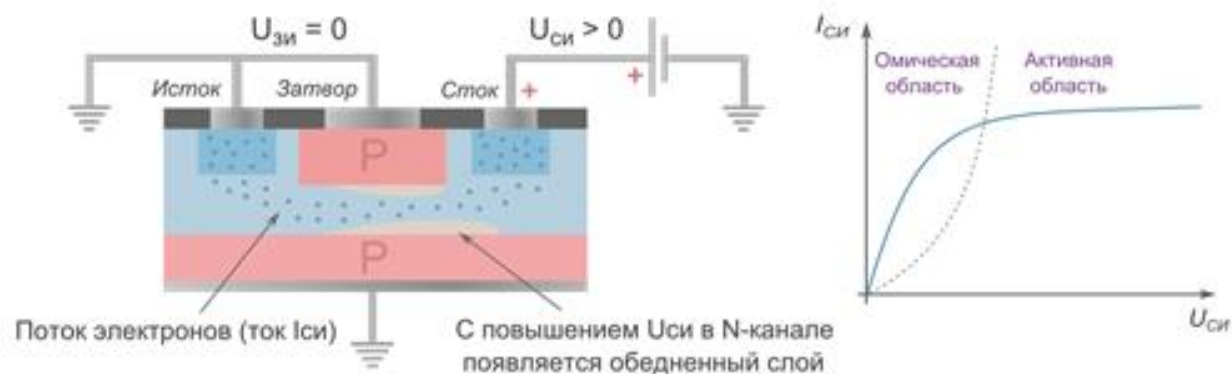


Figure 8. Operation of a JFET FET with N-channel  $U_{зи}=0$

Connect the positive voltage source to the drain and the ground to the source. Connect the gate to the ground as well ( $U_{зи}=0$ ). Let's start gradually increasing the voltage at the  $U_{си}$  drain. As long as the  $U_{си}$  is low, the channel width is maximum. In this state, the field-effect transistor behaves like an ordinary conductor. The higher the voltage between the drain and the source of the  $U_{си}$ , the greater the current through the channel between the drain and the source of the  $U_{си}$ . This state is also called the ohmic region.

With an increase in  $U_{си}$ , in an N-type semiconductor in the PN-junction zones, the number of free electrons gradually decreases – a depleted layer appears. This layer grows asymmetrically – larger on the drain side, since the voltage source is connected there. As a result, the channel narrows so much that with a further increase in  $U_{си}$ , the  $I_{си}$  will grow very slightly. This state is called the saturation regime.

1. The voltage at the gate is  $U_{зи}<0$  (Figure 9).

When the transistor is in saturation mode, the channel is relatively narrow. It is enough to apply a slight negative voltage to the  $U_{зи}$  gate in order to narrow the channel even further and significantly reduce the  $I_{си}$  current (for a transistor with a P-channel, a positive voltage is applied to the gate). If you continue to lower the  $U_{зи}$ , the channel will narrow until it is completely closed and the  $I_{си}$  current stops. The  $U_{зи}$  value at which the  $I_{си}$  current stops is called the cut-off voltage ( $U_{отс}$ ).

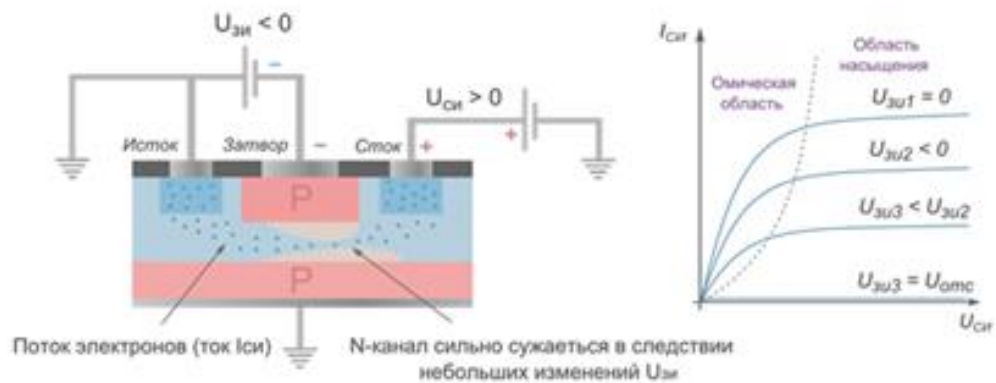


Figure 9. Operation of a JFET FET with the N-channel  $U_{зи} < 0$

To amplify the signal, the JFET is used in the saturation mode, since in this state the  $I_{си}$  changes greatly due to small changes in the  $U_{си}$ . The JFET amplification parameter is the slope of the gate characteristic (Mutual Transconductance). It is denoted by  $g_m$  or  $S$ , and measured in mA/V (milliAmpere/Volt) is shown in Figure 10.

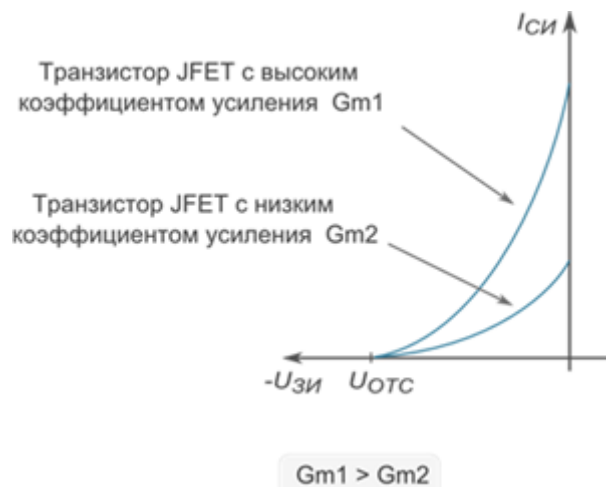


Figure 10. Drain-gate characteristic

### MOSFET Isolated Gate FET

**An insulated gate field-effect transistor** is a field-effect transistor whose gate is electrically isolated from the conductive channel of the semiconductor by a dielectric layer. Due to this, the transistor has a very high input impedance (in some models it reaches  $10^{17}$  ohms).

The principle of operation of this type of FET (Figure 11), as well as a FET with a control PN junction, is based on the influence of an external electric field on the conductivity of the device.



Figure 11. Principle of operation of a field-effect transistor

In accordance with its physical structure, an insulated gate field-effect transistor is called a **MOSFET** (Metal-Oxide-Semiconductor), or **MDP transistor** (Metal-Dielectric-Semiconductor). The international name of the device is **MOSFET** (Metal-Oxide-Semiconductor-Field-Effect-Transistor).

MDP transistors are divided into two types – with a built-in channel and with an induced channel. Each of the types has transistors with an N-channel and a P-channel (Figure 12)

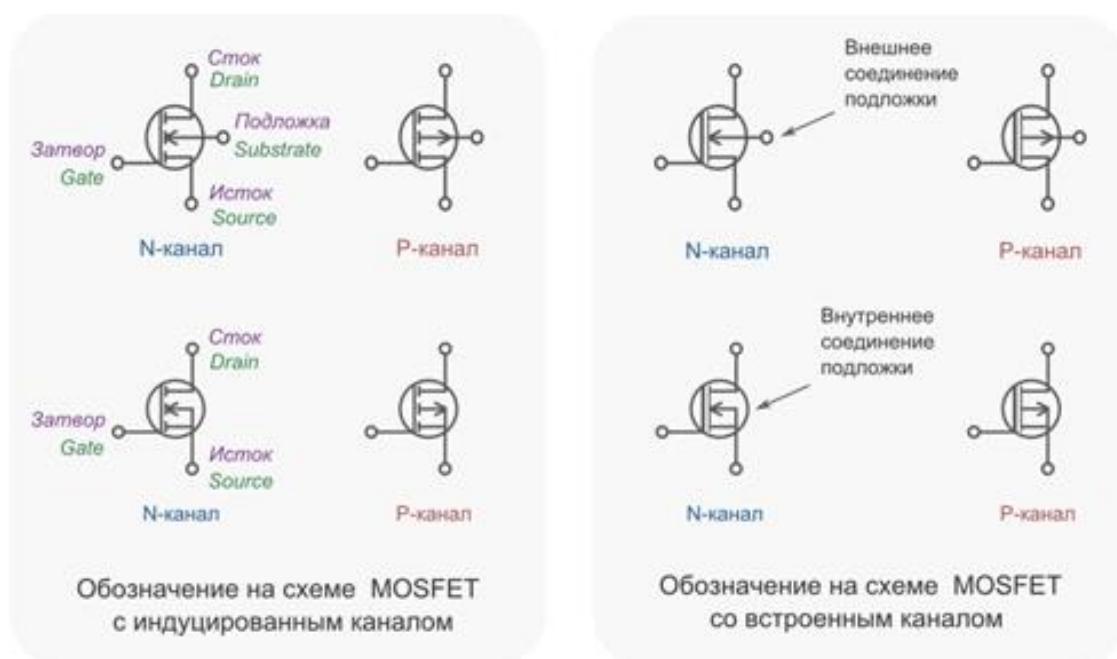


Figure 12. MDP transistors

MDP transistor (MOSFET) device with an induced channel.

On the base (substrate) of a semiconductor with P-type conductivity (for a transistor with an N-channel), two zones with increased electrical conductivity of the N+-type are created. All this is covered with a thin layer of a dielectric, usually silicon dioxide SiO<sub>2</sub>. Metal leads from N+-type regions, called drain and source, pass through the dielectric layer. Above the dielectric is a metal layer of the gate. Sometimes there is also a lead from the substrate, which is shorted with the source (Figure 13)

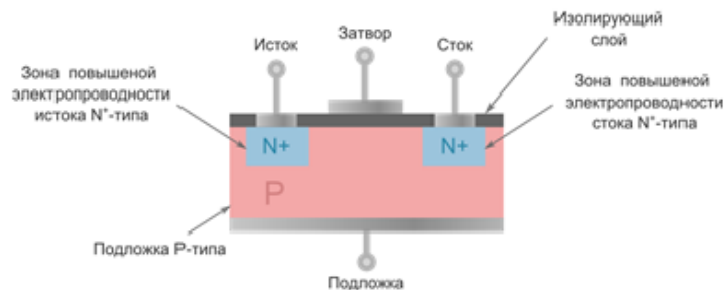
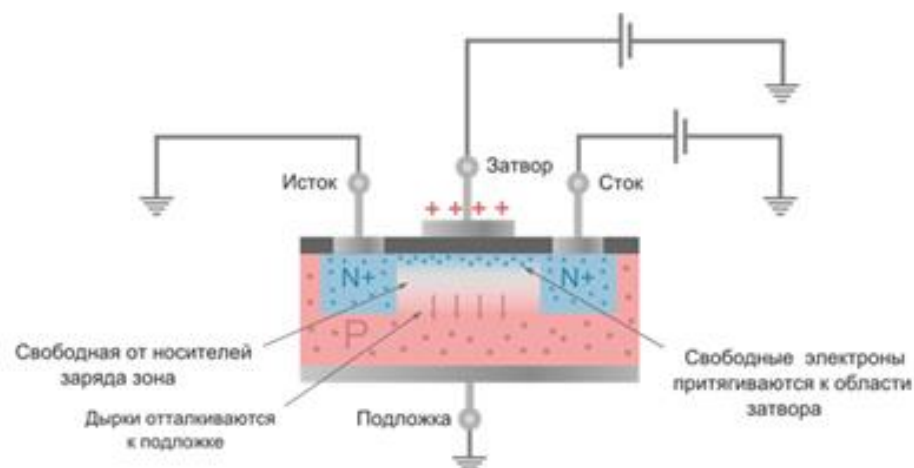


Figure 13. Device of a TIR transistor with an N-type induced channel

Operation of a MDP transistor (MOSFET) with an N-type induced channel.

Let's connect a voltage of any polarity between the drain and the source. In this case, the electric current will not flow, since between the N+ bands there is a region P that does not allow electrons to pass through (Figure 14)



#### Figure 14. Operation of a MDP transistor with an N-type induced channel

Further, if a positive voltage is applied to the gate relative to the source of Uzi, an electric field will appear. It will push positive ions (holes) from the P zone towards the substrate. As a result, the concentration of holes under the gate will begin to decrease, and their place will be taken by electrons attracted by the positive voltage at the gate.

When the Uzi reaches its threshold value, the concentration of electrons in the gate region will exceed the concentration of the holes. A thin channel with N-type electrical conductivity will be formed between the drain and the source, through which the Isi current will go. The higher the voltage at the gate of the Uzi transistor, the wider the channel and, consequently, the greater the amperage. This mode of operation of the FET is called the enrichment mode.

The principle of operation of a PDP transistor with a P-type channel is the same, only a negative voltage must be applied to the gate relative to the source.

A MOSFET device with a built-in channel.

The physical device of a MDP transistor with an integrated channel differs from the type with an induced channel in the presence of a conducting channel between the drain and the source.

Operation of a MDP transistor (MOSFET) with a built-in N-type channel.

Let's connect the voltage between the drain and the source of Us of any polarity to the transistor. Let's leave the gate turned off ( $U_{zi}=0$ ). As a result, the Isi current, which is a flow of electrons, will go through the channel.

Next, connect a negative voltage relative to the source to the gate. A transverse electric field will appear in the channel, which will begin to push electrons out of the channel area towards the substrate. The number of electrons in the channel will decrease, its resistance will increase, and the current will decrease. With an increase in the negative voltage at the gate, the current will decrease. Such a state of operation of the transistor is called the lean mode.

If a positive voltage is connected to the gate, the resulting electric field will attract electrons from the drain, source, and substrate areas. The channel will expand,

its conductivity will increase, and the  $I_{si}$  current will increase. The transistor will enter the enrichment mode.

### **Equipment and materials**

To perform practical work, you need a personal computer with Internet access, Microsoft Office.

### **Safety Instructions**

It is necessary to comply with the safety requirements provided for the computer class

1. Do not turn on the computer without the permission of the class administrator and instructor.
2. It is forbidden to open the PC case on your own.
3. Do not touch the monitor screen and keyboard at the same time (increased electrostatic potential may be discharged).
4. Do not clutter the top panels of the devices with papers and foreign devices.
5. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.
6. It is forbidden to turn off the power supply during the execution of an active task.
7. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

### **Methodology and procedure for performing work**

1. Study the theoretical material.
2. Complete the task "System Operator". The system (object) will be a "transistor".
3. It is necessary to fill in all the elements of the table consisting of 9 cells. The object itself is placed in the center of the table, under number 1. It is necessary to fill in all the cells of the table gradually, in accordance with the numbering (see table).

|   |   |   |
|---|---|---|
| 6 | 3 | 9 |
|---|---|---|

| The supersystem in the past       | Supersystem                                   | Supersystem in the future     |
|-----------------------------------|-----------------------------------------------|-------------------------------|
| 4<br>The system in the past       | 1<br>System<br>Selected object, its functions | 7<br>The system in the future |
| 5<br>Parts of systems in the past | 2<br>Subsystem<br>System Parts                | 8<br>Subsystem in the future  |

A system is an object that is in the center of consideration. A supersystem is the immediate environment of an object, a system of which the object is a part. A subsystem is a structural unit of a system, parts that make up the object itself.

4. After filling in the table, place it in the report.

Sample of the task

|                        |                            |                                           |
|------------------------|----------------------------|-------------------------------------------|
| Electrical Engineering | Electrical circuit element | Microelectronics                          |
| Passive element        | <b>Capacitor</b>           | Integrated circuit component              |
| Electrical Materials   | Plates, dielectric, leads  | Electron-hole transitions of a transistor |

### **The report must contain**

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;
- results of implementation;
- answers to control questions;
- conclusion on the work done.

### **Control questions:**

1. What are active radioelectronic components?
2. Name the active radioelectronic components.
3. Are transistors active elements? Why?
4. What is the classification of transistors?
5. What is the peculiarity of a bipolar transistor?
6. What is the structural diagram and UGO of a type n-p-n and p-n-p bipolar transistor?
7. Describe a field-effect transistor.

8. What is the classification of FETs?
9. What are the main advantages of FETs?
10. What are the features of MDP transistors?

### **Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for Performing Work";
- demonstration of the results of the work;
- answers to control questions;
- report submission.

# PRACTICAL WORK

## PASSIVE RADIO-ELECTRONIC COMPONENTS

**The purpose** of the work: to learn how to identify and use passive radio-electronic elements when performing a task.

### Theoretical substantiation

Let's consider passive elements.

#### 2. Resistors

**Resistors are** an element that regulates and distributes electrical energy between circuits and circuit elements. The principle of operation of resistors is based on the use of the properties of various materials to resist electric current.

Why is it necessary? To reduce the current in the circuit: we need to reduce the brightness of the bulb in the pocket torch, for this we will apply a current to it through a resistor, and the brightness of the lamp will be less the greater the resistance of the resistor.

Resistors are mainly used to form predetermined values of voltages and currents in the electrical circuit of all radio-electronic devices. It is also possible to use certain active components when creating the necessary electrical modes, as well as when matching electrical circuits.

In the diagrams, the resistor is designated by the letter R. The classification of resistors is shown in Figure 1.



Figure 1. Classification of resistors

Resistors can be constant, variable and tuning.

**Constant resistors** are resistors whose resistance value is constant and does not depend on external influences (temperature, light, current flowing through it, applied voltage, etc.).

Industrially produced permanent resistors in the diagrams are indicated in Figure 2:

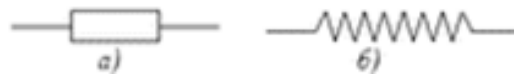


Figure 2. a) in Europe b) in the USA

The power of constant resistors is shown in Figure 3:

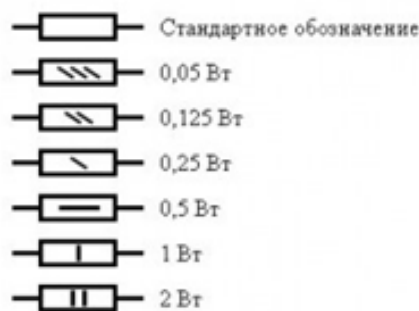


Figure 3. Power of permanent resistors

What does 0.05 W, 0.125 W, 0.25 W, etc., mean? This is a designation for the power of resistors, that is, the power at which it will still work, and will not darken and burn out.

**Variable resistors** are resistors in which the resistance value is changed using a special knob (rotating, or slider type). A striking representative of variable resistors is the volume control on your computer speakers.

**Trim resistors** are resistors designed for rare adjustments, in which the resistance value is changed using a slot rotated with a screwdriver. Trimming resistors are installed, as a rule, on printed circuit boards of radio circuits. Most often,

AC and trim resistors are connected on circuits as voltage dividers, or as current dividers.

**The main parameters of resistors are:**

- nominal resistance,
- Admission,
- Nominal dissipation power,
- maximum operating voltage,
- stability of resistance.

**Resistor Specifications**

Among the main parameters, the following resistor characteristics stand out:

- resistance by nominal value,
- possible deviation,
- power dissipation,
- Maximum operating voltage,
- maximum temperature,
- temperature coefficient of resistance,
- Frequency Response
- noises

**Code and color marking of resistors**

The first method is shown in Figure 4:



Figure 4. Resistor marking

The letters "E", "K" and "M2", denoting multiple prefixes and placed as decimal commas. The letter "E" is 1, the letter "K" is 1000 and the letter "M" is 1000000. Here are examples of how it looks and is deciphered:

12E – 12 ohms;

K12 – 0.12K – 120 Ohm; 1K2 – 1.2 kOhm; 12K – 12 kOhm;

M12 – 0.12M – 120 kOhm; 1M2 – 1.2 mΩ; 12M – 12 mΩ.

The second method of marking resistors is shown in Figure 5:



Figure 5. Resistor marking

It differs in that all notations are digits, that is, both the value and the multiplier. The notation consists of three digits: the first two are the value, the third is the multiplier. The factors are "0", "1", "2", "3" and "4". You can understand this if you know that they show how many zeros you need to add to the value: 120 – 12 Ohms 121 – 120 Ohms 122 – 1200 Ohms 123 – 12000 Ohms 124 – 120000 Ohms

The third method. (Color marking of resistors with 6 stripes) is shown in Figure 6.

| Полоса      | 1         | 2         | 3         | 4               | 5        | 6                         |
|-------------|-----------|-----------|-----------|-----------------|----------|---------------------------|
| Значение    | 1-я цифра | 2-я цифра | 3-я цифра | Множитель       | Допуск % | Температурный Коэффициент |
| Серебрянный |           |           |           | 0.01            | +/-10%   |                           |
| Золотой     |           |           |           | 0.1             | +/-5%    |                           |
| Черный      | 0         | 0         | 0         | 1               |          |                           |
| Коричневый  | 1         | 1         | 1         | 10              | +/-1%    | 100ppm/°C                 |
| Красный     | 2         | 2         | 2         | 100             | +/-2%    | 50ppm/°C                  |
| Оранжевый   | 3         | 3         | 3         | 1000            |          | 15ppm/°C                  |
| Желтый      | 4         | 4         | 4         | 10 <sup>4</sup> |          | 25ppm/°C                  |
| Зеленый     | 5         | 5         | 5         | 10 <sup>5</sup> | +/-0.5%  |                           |
| Синий       | 6         | 6         | 6         | 10 <sup>6</sup> | +/-0.25% | 10ppm/°C                  |
| Фиолетовый  | 7         | 7         | 7         | 10 <sup>7</sup> | +/-0.1%  | 5ppm/°C                   |
| Серый       | 8         | 8         | 8         |                 | +/-0.05% |                           |
| Белый       | 9         | 9         | 9         |                 |          | 1ppm/°C                   |

Figure 6. Marking the resistor

### 3. Capacitors

A **capacitor** is an element designed to create the required value of electrical capacitance in an electrical circuit.

Structurally, a capacitor is a device consisting of two or more electrically conductive plates (plates) separated by a thin layer of dielectric. Solid organic (paper, films) and inorganic (mica, ceramics, glass) substances, liquids and gases are used as a dielectric.

They are used to separate direct and alternating current components and in electrical filters, to smooth out rectified voltage ripples and to reduce the electrical coupling between the stages. With inductors, capacitors form oscillating circuits, which are widely used in various electronic devices.

The principle of operation of a capacitor is based on its ability to accumulate charge on its plates if a voltage is applied to them.

The classification of capacitors is shown in Figure 7.



Figure 7. Classification of the capacitor

**Constant capacitors** are capacitors whose capacitance is fixed and does not change during the operation of the equipment.

**Variable capacitors** are capacitors that are used in circuits where it is necessary to change the capacitance during operation. At the same time, the capacitance can be changed in various ways: mechanically, by changing the control voltage, changing the ambient temperature, etc.

**Tuning capacitors** are capacitors that are used for initial setup of equipment or periodic tuning of circuits where a small range of capacitance changes is required.

**Self-regulating capacitors** are capacitors whose capacitance changes under the influence of the voltage applied to the capacitor. Self-regulating capacitors also include semiconductor diodes called varicaps.

The capacitor designation in the diagram is provided in Figure 8:

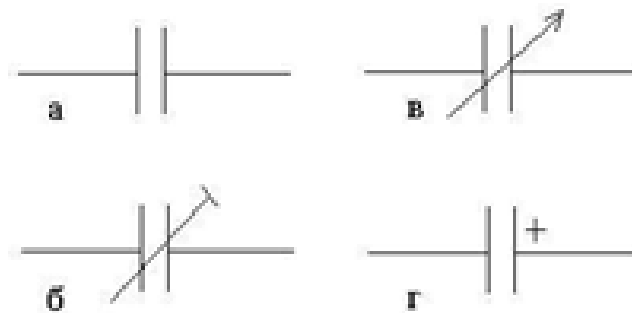


Figure 8. Designation of capacitors in the diagrams:

a) constant capacitance; b) tuning; c) variable; d) electrolytic.

#### **Main parameters:**

- nominal capacitance (*Capacitance of a capacitor (C) is defined as the ratio of the amount of electric charge (Q) to voltage (U)*),
- permissible deviation of the capacitance of the capacitor from the nominal one,
- Admission,
- rated operating voltage,
- Temperature coefficient of capacitance.

In its purpose, the capacitor resembles a battery, but still it is very different in the principle of operation, maximum capacity, as well as the speed of charging/discharging.

Let's consider the principle of operation of a flat capacitor. If you connect a power source to it, negatively charged particles in the form of electrons will begin to collect on one plate of the conductor, and positively charged particles in the form of ions on the other. Since there is a dielectric between the plates (**a dielectric** (insulator) is a substance that practically does not conduct electric current), charged particles cannot "jump" to the opposite side of the capacitor.

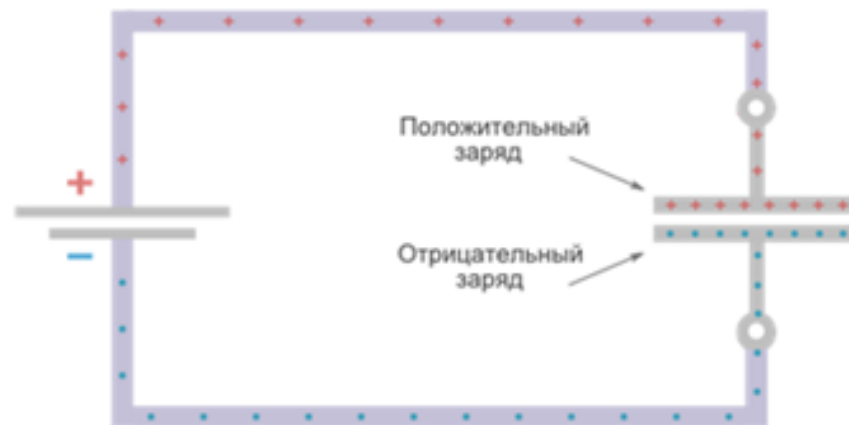


Figure 9. Capacitor charge

At the very beginning of the capacitor's connection to the circuit, there is the most free space on its plates. Consequently, the initial current at this moment meets the least resistance and is the maximum. As the capacitor is filled with charged particles, the current gradually decreases until there is no free space on the plates and the current stops completely.

The time between the states of an "empty" capacitor with the maximum current value, and a "full" capacitor with a minimum current value (i.e. its absence), is called the capacitor charge transition period.

After the capacitor is charged, disconnect the power supply and connect the load R. Since the capacitor is already charged, it has turned into a power source itself. Load R has formed a passage between the plates. Negatively charged electrons accumulated on one plate, according to the force of attraction between the charges of different names, will move towards the positively charged ions on the other plate (Figure 10).



Figure 10. Capacitor discharge

At the time of connection R, the voltage across the capacitor is the same as after the end of the charging transient. The initial current according to Ohm's law will be equal to the voltage on the plates divided by the load resistance.

$$I_c = \frac{U_c}{R}$$

As soon as the current flows in the circuit, the capacitor will begin to discharge. As the charge is lost, the voltage will begin to drop. Therefore, the current will also drop. As the voltage and current values decrease, their fall rate will decrease.

The charging and discharging time of a capacitor depends on two parameters – capacitance of capacitor C and total resistance in circuit R.

### **Code and color coding of capacitors**

#### **1. Three-digit encoding**

The first two digits indicate the value of the capacitance in picofarads (pF), the last one indicates the number of zeros. When the capacitor has a capacitance of less than 10 pF, the last digit can be "9". For capacitances less than 1.0 pF, the first digit is "0".

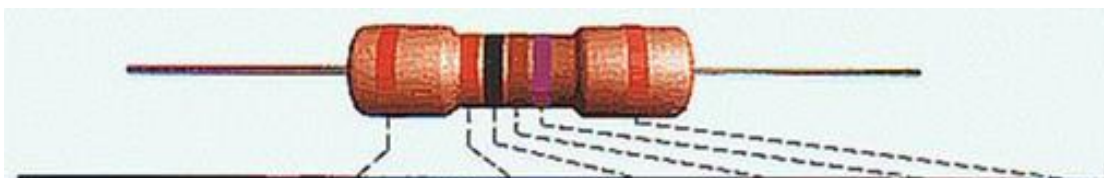
The letter R is used as a decimal point. For example, the code 010 is 1.0 pF, the code 0R5 is 0.5 pF.

#### **1. Four-digit encoding**

Encoding with a 4-digit number is possible. But even in this case, the last digit indicates the number of zeros, and the first three indicate the capacitance in picofarads (pF).

### 1. Color-coded

In practice, several color marking techniques are used to color code permanent capacitors (Figure 11)



| МЕТКИ<br>(полосы, точки, кольца) | 1             | 2         | 3         | 4          | 5          | 6   |
|----------------------------------|---------------|-----------|-----------|------------|------------|-----|
| 3 метки*                         | 1-я цифра     | 2-я цифра | Множитель | —          | —          | —   |
| 4 метки                          | 1-я цифра     | 2-я цифра | Множитель | Допуск     | —          | —   |
| 4 метки                          | 1-я цифра     | 2-я цифра | Множитель | Напряжение | —          | —   |
| 4 метки                          | 1 и 2-я цифры | Множитель | Допуск    | Напряжение | —          | —   |
| 5 меток                          | 1-я цифра     | 2-я цифра | Множитель | Допуск     | Напряжение | —   |
| 5 меток**                        | 1-я цифра     | 2-я цифра | Множитель | Допуск     | ТКЕ        | —   |
| 6 меток                          | 1-я цифра     | 2-я цифра | 3-я цифра | Множитель  | Допуск     | ТКЕ |

Figure 11. Color-coded capacitor

\* 20% tolerance; a combination of two rings and a dot indicating the multiplier is possible.

\*\* The color of the housing indicates the value of the operating voltage.

## 3. Inductor

**Inductors** are elements whose main property is the effect of converting the energy of an electric current into the energy of a magnetic field and vice versa.

Inductors are used in stabilizers as an element that accumulates energy and converts voltage levels. Coils are also used as electromagnets-actuators.

The conventional graphic designation of the inductor coil is presented in Figure 12:

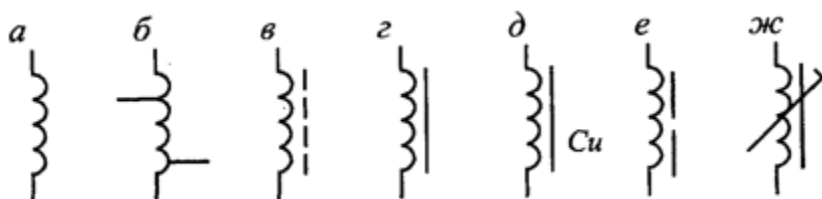


Figure 12. Inductor symbol:

a) without a core; b) with bends; c) with a magnetoelectric core; d) with a ferromagnetic core; e) with a copper core; f) with a gap in a ferromagnetic magnetic core; g) with an inductance adjustable by changing the position of the magnetic core.

### **Classification of inductors.**

Inductors can be classified according to a number of features:

By design, they are divided into:

1. single-layer and multi-layer,
2. framed and frameless,
3. with and without hearts,
4. into shielded and unshielded,
5. high-frequency and low-frequency

According to the purpose, inductors are divided into:

1. contoured,
2. communication coils,
3. High and low frequency chokes

### **Main Characteristics and Parameters of Inductance Coils**

The main characteristics of the coils are:

- inductance,
- own capacity,
- active resistance,
- Q factor (The Q-factor of an inductor determines the relationship between the active and reactance resistances of the coil.)
- Temperature stability of inductance.
- Loss resistance

### **Equipment and materials**

To perform practical work, you need a personal computer with Internet access, Microsoft Office.

### **Safety Instructions**

It is necessary to comply with the safety requirements provided for the computer class

8. Do not turn on the computer without the permission of the class administrator and instructor.
9. It is forbidden to open the PC case on your own.
10. Do not touch the monitor screen and keyboard at the same time (increased electrostatic potential may be discharged).
11. Do not clutter the top panels of the devices with papers and foreign devices.
12. Do not touch the metal parts of the PC and devices that have natural grounding at the same time.
13. It is forbidden to turn off the power supply during the execution of an active task.
14. Do not allow moisture to get on the surface of the system unit, monitor, keyboard, printers and other devices.

### **Methodology and procedure for performing work**

1. Study the theoretical material.
2. Make a table "Practical application of passive elements".

| Applications and functions performed by passive elements |            |           |
|----------------------------------------------------------|------------|-----------|
| Resistors                                                | Capacitors | Inductors |
| ...                                                      | ...        | ...       |

#### **Passive elements of the electrical circuit are used:**

- for rapid change in potential;
- in an oscillating circuit;
- to increase the power factor;
- for the formation of predetermined values of voltages and currents in the electrical circuit of all radio-electronic devices;
- when coordinating electrical circuits;
- for discharge electric welding;
- as electromagnets-actuators;

- to protect the equipment of power circuits of electric locomotives;
- when creating the necessary electrical modes of certain active components;
- in rectifiers as filters to smooth out pulsations;
- In the computer keyboard.
- in switching stabilizers as an element that accumulates energy and converts voltage levels;
- as an energy source for the excitation of inductively coupled plasma;
- for radio communication – emission and reception of electromagnetic waves (magnetic antenna, ring antenna);
- for separating circuits of different frequencies;
- in radar devices – for the purpose of generating high-power pulses;
- as a displacement sensor;
- for the distribution of electrical energy between circuits and circuit elements;
- in telegraphy and telephony – for separation of DC and AC circuits, currents of different frequencies, cable symmetry, contact sparking;
- for heating electrically conductive materials in induction furnaces;
- for separating pulsed and direct current circuits;
- for spark extinguishing contacts;
- in electrical measuring equipment – to obtain samples of capacity, to create variable containers (laboratory variable capacitive devices, tank magazines);
- in laser devices – to form powerful pulses;
- to start capacitor electric motors and to create the required phase shift of additional motor windings;
- in lighting fixtures based on fluorescent lamps;
- to dampen radio interference caused by electrical equipment and electric vehicles;
- for use in frequency-setting circuits of generators;

- to absorb electrical energy;
- to change the speed of the heater electric motor.

**The report must contain**

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;
- results of implementation;
- answers to control questions;
- conclusion on the work done.

**Control questions:**

1. What are radio-electronic components?
2. What are the features and purpose of passive elements?
3. What is the difference between passive and active radioelectronic components?
4. What elements can be classified as passive?
5. Explain resistors, types of resistors, basic parameters of resistors.
6. What is the marking of resistors?
7. What are capacitors?
8. What is the classification of capacitors?
9. How are capacitors indicated in the diagrams?
10. What are the main parameters of capacitors?
11. What does the charge and discharge of a capacitor mean?
12. What are the code and color coding of capacitors?
13. What is an inductor?
14. What is the classification of inductors?
15. What is the convention for an inductor?
16. What are the main characteristics and parameters of inductors?

**Work protection**

The protection of the work consists in:

- performing tasks from the section "Methodology and Procedure for

Performing Work";

- demonstration of the results of the work;
- answers to control questions;
- report submission.

## **PRACTICAL WORK**

### **INTRODUCTION TO WEBOTS MOBILE ROBOT SIMULATOR**

**The purpose of the work:** to get acquainted with the user interface and the principle of operation of the Webots simulator.

#### **Theoretical substantiation**

Webots is an open-source professional mobile robot simulator developed by Cyberbotics. It provides a complete environment for simulating, programming, and testing robot behavior in virtual conditions.

The main elements of the simulator user interface:

Main window—Contains a 3D scene for modeling visualization.

Toolbar - Includes simulation control buttons (start, pause, reset).

Scene tree is a hierarchical representation of all objects in the simulation.

Property Editor – allows you to configure the parameters of selected objects.

Console – displays system messages and program output.

#### **How the simulator works:**

Creating a virtual world (adding robots, objects, and environments).

Configure the physical parameters and properties of objects.

Writing controllers for robots (C++, Python, Java, MATLAB are supported).

Run the simulation and observe the behavior of the robots.

Analysis of results and debugging.

#### **Key features:**

1. Realistic physics (ODE engine)
2. Support for a variety of sensors and actuators.
3. Ability to work with ROS.
4. Cross-platform (Windows, Linux, macOS).

#### **Methodology and procedure for performing work**

1. Install the Webots simulator on your computer.
2. Create a new project.

3. Add an E-puck robot to the project.
4. Create a new controller.
5. Extend the functionality of the controller to speed control.
6. To formulate conclusions on the work done.
7. Answer control questions.
8. Draw up a report on the work done.

### **Sequence of actions**

1. Installing Webots Simulator
2. Creating a new project
3. Adding an E-puck robot
4. Creating a New Controller
5. Setting up speed control.

### **Content of the report and its form**

The report must contain

- the title of the practical work;
- the purpose of the work;
- the procedure for performing work;
- results of implementation;
- answers to control questions;
- conclusion on the work done.

### **Control questions**

1. What is Webots and what tasks is it used for?
2. What are the main elements of the Webots interface that you know?
3. What programming languages are supported for writing robot controllers in Webots?
4. How do I create a new project?
5. What features of the simulator are you aware of?

6. Name the robots that you can choose for the project?
7. How do I create a new controller?
8. How do I set up speed control?

## **EDUCATIONAL, METHODOLOGICAL AND INFORMATION SUPPORT OF THE DISCIPLINE**

1. List of basic and additional literature necessary for mastering the discipline (module)

1.1. List of basic literature:

1. Kulpinov A.A. Vvedenie v spetsial'nost': ucheb. posobie: Napravlenie – Infokommunikatsionnye tekhnologii i sistemy svyazi. Profile of training "Communication Networks and Switching Systems". Bachelor's degree. - Stavropol: NCFU, 2014. - 130 p., unlimited copies.

2. Levchenko V.I. Radio Electronics: Introduction to the Specialty: Textbook / V.I. Levchenko; Ministry of Education and Science of Russia; Omsk State Technical University. - Omsk: OmSTU Publishing House, 2017. - 202 p.: tabl., schemes, ill. - <http://biblioclub.ru/>. - ISBN 978-5-8149-2476-6, unlimited copies.

1.2. List of additional literature:

1. Shcheglov, A. Yu. - Models, Methods and Means of Access Control to Computing Systems. - Models, Methods and Means of Access Control to Computing Systems, 2022-10-01. - St. Petersburg: ITMO University, 2014. - 95 p. - The book is in the premium version of EBS IPR BOOKS. - ISBN 2227-8397

2. Mandra A. G., Popov A. V., Dyakonov A. I. Informatics and Information Technologies: Laboratory Practicum / A. G. Mandra, A. V. Popov, A. I. Dyakonov. - Informatics and Information Technologies, 2026-09-20. - Elektron. dan. (1 file). - Samara : Samara State Technical University, EBS ASV, 2020. - 64 p. - electronic. - The book is in the premium version of EBS IPR BOOKS. - ISBN 2227-8397

3. Bugrov A. N., Kirpicheva E. Yu., Milovidova A. A., Makhalkina T. O. : textbook. - Dubna: State University "Dubna", 2019. - 71 p. - Recommended by the Educational and Methodological Council of the University "Dubna" as a textbook for students studying in the areas of training "Informatics and Computer Engineering", "Applied Informatics", "Business Informatics", "Fundamental

Informatics and Information Technologies" (bachelor's degree). - ISBN 978-5-89847-570-3

4. Bratchenko, N. Y. (North Caucasian Federal University). Fundamentals of Programming in High-Level Languages: Textbook. Manual : Direction 230100 - Informatics and Computer Engineering. Specialty 230102.65 - Automated Information Processing and Control Systems. Bachelor's Degree / N. Y. Bratchenko; North-Kav. Feder. University. - Stavropol : NCFU, 2013. - 179 p. : ill. - Grif: Add. UMO. - ISBN 978-5-88648-878-4

1.3. List of resources of the information and telecommunication network "Internet" necessary for the development of the discipline (module)

[www.biblioclub.ru](http://www.biblioclub.ru) – Electronic Library System "University Library Online"

[www.eLibrary.ru](http://www.eLibrary.ru) – Scientific Electronic Library

[www.iprbookshop.ru](http://www.iprbookshop.ru) – IPRbooks Electronic Library System

**A LIST OF INFORMATION TECHNOLOGIES USED IN THE  
IMPLEMENTATION OF THE EDUCATIONAL PROCESS IN THE  
DISCIPLINE (MODULE), INCLUDING A LIST OF SOFTWARE AND  
INFORMATION REFERENCE SYSTEMS**

When reading lectures, computer equipment is used, demonstration of presentation multimedia materials. In laboratory classes, students perform laboratory work and demonstrate the result by means of computer technology and reports in electronic form, prepared by them during the hours of independent work.

MINISTRY OF SCIENCE AND HIGHER EDUCATION  
OF THE RUSSIAN FEDERATION  
FEDERAL STATE AUTONOMOUS EDUCATIONAL  
INSTITUTION OF HIGHER EDUCATION  
"NORTH CAUCASUS FEDERAL UNIVERSITY"

**SUGGESTIONS FOR TEACHING  
for independent work of students  
in the discipline "Introduction to Engineering Culture"**

for students of the field of study  
11.03.02 Infocommunication Technologies and Communication Systems  
Profile "Intelligent Data Processing in Infocommunication Systems and Networks"

Stavropol, 2026

Methodical instructions for the organization of independent work of students are compiled in accordance with the requirements of the program of the discipline "Introduction to the specialty" for bachelors of the direction of training 11.03.02 Infocommunication technologies and communication systems. The textbook is devoted to the planned educational work of students, carried out in extracurricular (classroom) time on the assignment and under the methodological guidance of the teacher, but without his direct participation, with partial, direct participation of the teacher.

Compiler: Bratchenko N.Yu.

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## INTRODUCTION

### **The purpose and objectives of mastering the discipline**

*The purpose of the discipline is to form students' universal and professional competencies based on mastering the features of the learning process in the direction 11.03.02 Infocommunication Technologies and Communication Systems, understanding the history, state, application and prospects for the development of information and communication technologies.*

#### *Objectives of mastering the discipline:*

1. Formation of an idea of educational activities at the university, the main regulatory documents governing the educational activities of the student, the code of ethics of the NCFU student, the principles and forms of education, as well as teaching methods.
2. Acquisition, assimilation and transfer of knowledge. Organization and planning of independent work by the student.
3. Study of application packages necessary for the educational activities of students in this direction.
4. Study of the objects and characteristics of the professional activity of bachelors in the field of training "Infocommunication Technologies and Communication Systems".
5. Acquaintance of students with the basics of the theory of information transmission, modern communication systems, history and prospects for their development.
6. Formation of modern ideas about computer technology and the Internet, the history of computer development, Neumann computer architecture and various generations of computers.
7. Acquaintance with the history of the development of electronics and radio electronics.
8. Formation of an idea of passive radioelectronic components: resistors, capacitors, inductors; active radioelectronic components: electron tubes, transistors; basics of microelectronics, functional electronics and nanoelectronics.

## 9. Formation of an idea of the basics of robotics

### **The place of the discipline in the structure of the educational program**

The discipline "Introduction to Engineering Culture" belongs to the disciplines of the mandatory part of the disciplines.

List of planned learning outcomes in the discipline correlated with the planned results of the development of the educational program

| <b>Code,<br/>formulation of<br/>competence</b>                                                                                       | <b>Indicator code, wording</b>                                                                                                                                                                   | <b>Planned learning<br/>outcomes in the<br/>discipline (module),<br/>characterizing the<br/>stages of the formation<br/>of competencies,<br/>indicators</b> |
|--------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| UK-6. Is able to manage his time, build and implement a trajectory of self-development based on the principles of lifelong education | ID-1 UK-6 sets personal and professional goals in accordance with the level of his resources and priorities of actions, for successful development in the chosen field of professional activity; | UK-6. Is able to manage his time, build and implement a trajectory of self-development based on the principles of lifelong education                        |

## **1. INDEPENDENT WORK AS THE MOST IMPORTANT FORM OF THE EDUCATIONAL PROCESS**

Independent work is the planned educational, research, research work of students, performed in extracurricular (classroom) time on the assignment and under the methodological guidance of the teacher, but without his direct participation (with the partial direct participation of the teacher, leaving the leading role behind the work of students).

Independent work of students at the university is an important type of educational and scientific activity of the student. Independent work of students plays a significant role in the rating technology of education. Education at the university includes two parts that are almost the same in volume and mutual influence - the process of learning and the process of self-study. Therefore, the SRS should become an effective and purposeful work of the student.

The concept of modernization of Russian education defines the main tasks of vocational education - "training a qualified worker of the appropriate level and profile, competitive in the labor market, competent, responsible, fluent in his profession and oriented in related fields of activity, capable of effective work in the specialty at the level of world standards, ready for constant professional growth, social and professional mobility."

The solution of these problems is impossible without increasing the role of students' independent work on educational material, increasing the responsibility of teachers for the development of independent work skills, for stimulating the professional growth of students, fostering creative activity and initiative.

Society imposes a fairly wide list of requirements on a modern specialist, among which it is important that graduates have certain abilities and ability to independently obtain knowledge from various sources, systematize the information received, and assess a specific financial situation. The formation of such a skill occurs during the entire period of study through the participation of students in laboratory classes, the performance of control tasks and tests, the writing of term papers and graduation qualification papers. At the same time, the independent work of students plays a decisive role in the entire educational process.

The forms of independent work of students are diverse. In this discipline "Introduction to Engineering Culture" the following are provided:

### **Use of the material of the educational and methodological complex of the discipline**

At the first stage, it is necessary to familiarize yourself with the mandatory minimum content of the main educational program in the discipline studied. Next, it is necessary to study the work program of the discipline, which considers the content of the topics of the lecture course, the relationship between the topics of lectures and laboratory classes, topics and types of independent work. For each type of independent work, certain forms of reporting are provided, presented in the curriculum for the discipline "Introduction to the specialty".

### **Work with literature**

For the successful development of the discipline, it is necessary to independently study the presented topics in detail according to the recommended sources of information that are presented in the curriculum.

Independent work introduces students to scientific creativity, the search for and solution of urgent modern problems.

## **2. GOALS AND MAIN TASKS OF THE SAS**

The leading goal of the organization and implementation of SRS should coincide with the goal of teaching a student - the preparation of a bachelor with higher education. In the organization of SRS, an important and necessary condition is the formation of the ability to work independently to acquire knowledge, skills and the ability to organize educational and scientific activities.

The purpose of students' independent work is to master fundamental knowledge, professional skills and abilities in the profile, experience in creative and research activities. Independent work of students contributes to the development of independence, responsibility and organization, a creative approach to solving problems of the educational and professional level.

The objectives of the SRS are:

- systematization and consolidation of the theoretical knowledge and practical skills of students;
- deepening and expanding theoretical knowledge;
- formation of skills to use regulatory, legal, reference documentation and special literature;
- development of cognitive abilities and activity of students: creative initiative, independence, responsibility and organization;
- formation of independent thinking, abilities for self-development, self-improvement and self-realization;
- development of research skills;

- the use of material collected and obtained in the course of independent studies at seminars, laboratory classes, when writing term papers and final qualification papers, for effective preparation for final tests and exams.

### 3. TYPES OF INDEPENDENT WORK

In the educational process of a higher professional educational institution, two types of independent work are distinguished: classroom, under the guidance of a teacher, and extracurricular. A close relationship between these types of work provides for differentiation and effectiveness of the results of its implementation and depends on the organization, content, logic of the educational process (interdisciplinary connections, promising knowledge, etc.):

Classroom independent work on the discipline is carried out in classes under the direct guidance of the teacher and on his assignment.

Extracurricular independent work is performed by the student on the instructions of the teacher, but without his direct participation.

The main types of independent work of students without the participation of a teacher in this discipline are:

- formation and assimilation of the content of lecture notes on the basis of educational literature recommended by the lecturer, including information educational resources (electronic textbooks, electronic libraries, etc.);
- preparation for laboratory work, their design.

The main types of independent work of students with the participation of teachers are:

- ongoing consultations;
- acceptance and defense of laboratory work (during the L/R).

During the interview on laboratory work, the student must answer the following questions:

Practical work: Information retrieval.

1. What is information retrieval?
2. What is a classic information retrieval?
3. What tasks of information retrieval do you know?
4. What are the stages of information retrieval?
5. What is the structure of the ncfu.ru website?
6. In which section is the information about your field of study?
7. What information is needed to obtain information about the OP, plan, schedule and content?
8. Explain the sites [www.biblioclub.ru](http://www.biblioclub.ru), <http://iprbooks.ru>, [e.lanbook.com](http://e.lanbook.com), [elibrary.ru](http://elibrary.ru).

Practical work: Application software packages.

1. Give a definition of a program, software (software)?
2. Word and table processors.
3. Graphic systems.
4. Telecommunications.
5. Integrated systems.
6. Programming systems.
7. DBMS.
8. Operating systems.
9. The process of booting the operating system.
10. What features does VM VirtualBox have?

Practical work: Cisco Packet Tracer interface.

1. Which expansion card provides the functionality of the built-in access point?
2. Which expansion card provides single-port serial connectivity to remote offices or legacy off-the-shelf network devices?
3. What is the name of the high-performance module with 4 Ethernet switching ports for the RJ-45 connector?
4. List the network cards that allow you to connect to WAN networks?
5. What type of interface should I choose when creating a cluster?
6. What are the models of Layer 3 switches?
7. What type of cable should I use when connecting routers to each other?
8. Specify the series of trunk routers.
9. When is the SERIAL interface used?
10. How to organize communication between two backbone routers?
11. What are all the possible modes of operation of Cisco Paket Tracer?
12. What are the models of Layer 2 switches?
13. List all the types of links used in Cisco Paket Tracer and specify their purpose.
14. What is the simulation mode used for?
15. How do I view the progress of the package through the layers of the OSI model?
16. Is it possible to determine the reason why the packet sent in the simulation mode did not reach the destination and at what stage did the network fail?
17. Specify the IP addresses of the sender and recipient in the packet.
18. How do I change the filters of the event list?
19. How do I determine which protocols were involved in the network in simulation mode?
20. How can I track the changes in the contents of a packet as it passes through the network in simulation mode?
21. List the main features of the simulation mode.

Practical work: Study of the capabilities of the Cisco Packet Tracer software network simulator.

1. What is the maximum number of devices on the network supported by Packet Tracer?
2. What types of network devices and connections can be used in Packet Tracer?
3. How to navigate to the device's CLI.
4. How do I configure devices from another computer?
5. How do I add to the topology and configure a new device?
6. How do I save my device configuration to .txt file?

Practical work: Network services.

1. What is a recursive DNS query and how does it work?
2. Specify the assignment of resource record types in the forward and reverse DNS zones.
3. How is the DNS server configured to forward packets to other DNS servers?
4. Describe how DHCP works.
5. How is a DHCP client configured?
6. Specify the locations of the folder with the content of the Web site and the FTP server.
7. How the composition of the reverse DNS server zones in the corporate network is determined.
8. Can you demonstrate how to configure the DNS service in Cisco Pocket Tracer?
9. Can you demonstrate how to configure DHCP in Cisco Pocket Tracer?
10. Can you demonstrate how to configure the FTP service in Cisco Pocket Tracer?
11. Can you demonstrate how to configure a WEB server in Cisco Pocket Tracer?

Practical work: Study of wireless computer networks.

1. List the features of the functioning of wireless personal area networks and their possible topologies.
2. Using what network technologies can a wireless personal area network be deployed?
3. How are network elements configured?
4. List the possible causes of wireless personal area network failures.

Practical work: Study of fiber-optic communication lines.

1. What is the bandwidth of a communication line?

2. What are the features of signal attenuation?
3. How does the resistance of the communication line load affect the nature of signal propagation?
4. What is the principle of operation of the FOCL laboratory stand?
5. Characterize twisted pair cable, coaxial cable, and fiber optic cable.
6. What is amplitude, frequency, voltage? What are the units of measurement?

Practical work: Study of video signal parameters.

1. How does the introduction of inhomogeneities affect the video signal?
2. What are the effects of transmission path losses?
3. What is the reason for the high noise immunity of FOCL?
4. What is the purpose of a jammer?
5. What is the peculiarity of introducing heterogeneities?

Practical work: IP telephony.

7. What is a network interface?
8. What is a well-known enough tool for capturing and analyzing network traffic?
9. What is a wireless router?
10. Could you describe the structural diagram of the IP telephony stand?
11. What is an IP PBX?
12. What is the structural diagram of a SIP connection?

Practical work: Hardware of personal computers.

1. What is a Computing Machine?
2. List the internal devices of the system unit, what are they intended for?
3. What is a monitor, keyboard, mouse?
4. Which devices are input devices and which are output devices?
5. What is drag-and-drop?
6. Mouse control techniques.
7. Classification of computers by purpose.
8. Classification of computers by the principle of operation.
9. Personal computer architecture

Practical work: Passive radioelectronic components.

1. What are radio-electronic components?
2. What are the features and purpose of passive elements?
3. What is the difference between passive and active radioelectronic components?
4. What elements can be classified as passive?
5. Explain resistors, types of resistors, basic parameters of resistors.
6. What is the marking of resistors?

7. What are capacitors?
8. What is the classification of capacitors?
9. How are capacitors indicated in the diagrams?
10. What are the main parameters of capacitors?
11. What does the charge and discharge of a capacitor mean?
12. What are the code and color coding of capacitors?
13. What is an inductor?
14. What is the classification of inductors?
15. What is the convention for an inductor?
16. What are the main characteristics and parameters of inductors?

Practical work: Active radioelectronic components: transistors.

1. What are active radioelectronic components?
2. Name the active radioelectronic components.
3. Are transistors active elements? Why?
4. What is the classification of transistors?
5. What is the peculiarity of a bipolar transistor?
6. What is the structural diagram and UGO of a type n-p-n and p-n-p bipolar transistor?
7. Describe a field-effect transistor.
8. What is the classification of FETs?
9. What are the main advantages of FETs?
10. What are the features of MDP transistors?

Practical work: Introduction to the Webots mobile robot simulator.

1. What is Webots and what tasks is it used for?
2. What are the main elements of the Webots interface that you know?
3. What programming languages are supported for writing robot controllers in Webots?
4. How do I create a new project?
5. What features of the simulator are you aware of?
6. Name the robots that you can choose for the project?
7. How do I create a new controller?
8. How do I set up speed control?

At the same time, the evaluation criteria:

The grade "excellent" is given if the student has demonstrated the exact completion of the tasks of practical work, correctly completed the report, actively participates in the work, knows the material, is able to logically and clearly express thoughts, answering the questions asked, creatively approaches the solution of the presented individual tasks, shows independent thinking.

A grade of "good" is given if the student has demonstrated the exact completion of the tasks of practical work, correctly completed the report, actively participates in the work, knows the material, is able to logically and clearly express

thoughts, answering the questions asked, creatively approaches the solution of the presented individual tasks, shows independent thinking. , while making no more than one mistake.

The grade "satisfactory" is given if the student has demonstrated the accurate completion of the tasks of practical work, correctly completed the report, actively participates in the work, knows the material, is able to logically and clearly express thoughts when answering the questions asked, creatively approaches the solution of the presented individual tasks, shows independent thinking, while making more than two mistakes when answering the questions.

The grade "unsatisfactory" is given if the student has not demonstrated the exact performance of the tasks of practical work, incorrectly completed the report, does not participate in the work, does not know the material, does not know how to logically and clearly express thoughts when answering the questions asked, does not cope with individual tasks, demonstrates a lack of independent thinking and makes serious mistakes when answering the questions posed.

#### Scorecard

| Student's full name | Assessment for answering security questions | Grade for the practical work task | Overall rating |
|---------------------|---------------------------------------------|-----------------------------------|----------------|
|                     |                                             |                                   |                |
|                     |                                             |                                   |                |

## 4. ORGANIZATION OF THE SPC

The methodology for organizing students' independent work depends on the structure, nature and features of the discipline "Introduction to the specialty", the number of hours for its study, the type of tasks for students' independent work, the individual qualities of students and the conditions of educational activity.

The process of organizing students' independent work includes the following stages:

- preparatory (definition of goals, drawing up a program, preparation of methodological support, preparation of equipment);
- the main one (implementation of the program, the use of methods of information search, assimilation, processing, application, transfer of knowledge, recording of results, self-organization of the work process);
- final (assessment of the significance and analysis of the results, their systematization, assessment of the effectiveness of the program and methods of work, conclusions about the directions of labor optimization).

## **Students' Activities for the Formation and Development of Skills of Educational Independent Work**

In the process of independent work, the student acquires the skills of self-organization, self-control, self-management, self-reflection and becomes an active independent subject of educational activity.

*Performing independent work under the supervision of a teacher*

*The student must:*

- master the minimum content submitted for independent work of students and proposed by the teacher in accordance with the educational standards of higher education;
- plan independent work in accordance with the schedule of independent work proposed by the teacher;
- the student must carry out independent work in the organizational forms provided for by the curriculum and the teacher's work program;
- perform independent work and report on its results in accordance with the schedule for submitting results, types and terms of reporting on students' independent work.

*A student can:*

in addition to the one proposed by the teacher (with justification and agreement with him) and the minimum mandatory content determined by the program for this discipline:

- independently determine the level (depth) of the study of the content of the material;
- to suggest topics and questions for independent study;
- within the framework of the general schedule for the performance of independent work, offer a reasonable individual schedule for the implementation and reporting on the results of independent work;
- offer their own options for organizational forms of independent work;
- to use for independent work methodological manuals, manuals, developments in addition to the list proposed by the teacher;
- to use not only control, but also self-control of the results of independent work in accordance with the methods of self-control proposed by the teacher or chosen independently.

Independent work of students should have an important impact on the formation of the personality of the future bachelor, it is planned by the student independently. Each student independently determines the mode of his work and the degree of work spent on mastering the educational content in each discipline. He

performs extracurricular work according to a personal individual plan, depending on his preparation, time and other conditions.

## **5. GENERAL RECOMMENDATIONS FOR THE ORGANIZATION OF INDEPENDENT WORK**

The main form of independent work of the student is the study of lecture notes, their supplementation, recommended literature, active participation in laboratory classes. But for successful educational activity, its intensification, it is necessary to take into account the following subjective factors:

1. Knowledge of school program material, the presence of a solid system of gaps necessary for mastering the main university courses. This is especially important for mathematical disciplines. It is necessary to distinguish gaps in knowledge that make it difficult to assimilate new material from small abilities. By spending effort to overcome these gaps, the student will ensure normal academic performance and believe in his abilities.

2. Availability of skills, skills of mental work:

- a) the ability to take notes at lectures and when working with a book;
- b) mastery of logical operations: comparison, analysis, synthesis, generalization, definition of concepts, rules of systematization and classification.

3. The specifics of cognitive mental processes: attention, memory, speech, observation, intelligence and thinking. Poor development of each of them becomes a serious obstacle in learning.

4. Good working capacity, which is ensured by normal physical condition. After all, serious learning is a large, versatile and diverse work. The result of learning is evaluated not by the amount of information communicated, but by the quality of its assimilation, the ability to use it and the development of one's ability to further independent education.

5. Correspondence of the chosen activity, profession to individual abilities. It is necessary to develop the ability to self-regulate one's emotional state and eliminate circumstances that disturb the business mood, interfere with the planned work.

6. Mastering the optimal style of work that ensures success in activities. Alternating work and pauses in work, rest periods, individually justified sleep duration, preference for evening or morning classes, stress resistance at exams and features of preparation for them,

7. The level of demands on oneself, determined by the established self-esteem.

An adequate assessment of knowledge, advantages, disadvantages is an important component of a person's self-organization, without it it is impossible to successfully manage one's behavior and activity.

One of the main features of education in higher school is that constant external control is replaced by self-control, the active role in learning belongs not so much to the teacher as to the student.

Knowing the basic methods of scientific organization of mental work, it is possible to achieve the best results with the least expenditure of time, money and labor efforts.

The effectiveness of assimilation of incoming information depends on the working capacity of a person at a particular moment of his activity.

*Working capacity* is the ability of a person to work with a high degree of intensity for a certain time. There are internal and external factors of working capacity.

Internal factors of working capacity include intellectual characteristics, will, and state of health.

External:

- organization of the workplace, work and rest schedule;
- the level of labor organization - the ability to obtain information and use information;
- the amount of mental load.

The outstanding Russian physiologist N. E. Vvedensky identified the following conditions for the productivity of mental activity:

- Any work should be entered gradually;
- dimensionality and rhythm of work. Different people have a more or less different pace of work;
- the usual sequence and systematicity of activity;
- correct alternation of work and rest.

Rest does not imply obligatory complete inaction on the part of a person, it can be achieved by a simple change of business. During the day, the working capacity changes. The most fruitful is the *morning time* (from 8 to 14 hours), and the maximum working capacity falls on the period from 10 to 13 hours, then *the afternoon* (from 16 to 19 hours) and *the evening* (from 20 to 24 hours). It is better to study the material that is very difficult to understand at the beginning of each period of time (preferably in the morning) after a good rest. After 1-1.5 hours, breaks of 10 - 15 minutes are needed, after 3 - 4 hours of work, the rest should be long - about an hour.

An integral part of the scientific organization of mental labor is the mastery of the technique of mental labor.

The time that the student has to complete the curriculum consists of two components: one of them is classroom work at the university according to the schedule of classes, the other is extracurricular independent work. Tasks and

materials for independent work are given during classes according to the schedule, in the same classes the teacher controls independent work, and also assists students in the correct organization of work.

Self-study will require intensive mental work, which must not only be properly organized, but also stimulated. At the same time, it is very important to be able to maintain steady attention to the material being studied. The development of attention requires significant volitional efforts. That is why, if a student notices that he is often distracted during independent studies, he needs to force himself to concentrate. Such a procedure must be done constantly, as this is attention training. Sustained attention appears when a person treats the matter with interest.

It is necessary to properly organize your classes in time: 50 minutes - work, 5-10 minutes - break; after 3 hours of work, a break - 20-25 minutes. Otherwise, increasing fatigue will lead to instability of attention. A very significant factor affecting the increase in mental performance is systematic physical education. The organization of active recreation provides for the alternation of mental and physical activity, which completely restores a person's working capacity.

## **6. INDEPENDENT WORK OF A STUDENT IS A NECESSARY LINK IN THE FORMATION OF A RESEARCHER**

The progress of science and technology, information technology leads to a significant increase in scientific information, which imposes higher requirements not only on the moral and ethical qualities of a person, but also, in particular, constantly increasing requirements in the field of education - renewal, modernization of general and professional knowledge, skills of a specialist.

Any education should act as a dynamic process inherent in a person and continuing throughout his life. Mastering scientific thought and the language of science is a necessary component in the self-organization of a future research specialist. This is understood not so much as the accumulation of knowledge, but the mastery of scientifically based ways of acquiring it. This, generally speaking, is the main task of the university.

The specificity of the university educational process, in the organization of which more and more space is given to the independent work of the student, is that it seems to be the last and most adequate link for the implementation of this task. For during the study at the university, the development of the style and skills of educational (cognitive) activity takes place, the rational nature of which will contribute to the constant renewal of the knowledge of a highly qualified university graduate.

However, there are certain difficulties before this path, in particular, the transition of the student from the synthetic process of learning in secondary school to the analytical one in higher school. This is due both to the new content of education (expansion of general education and deepening of professional training) and to new, hitherto unknown forms of training (lectures, seminars, laboratory classes, etc.). The student receives not only the knowledge provided by the program and teaching aids, but he must also become familiar with the ways of acquiring knowledge in such a way as to be able to assess what we know, how we know it and how we have achieved this knowledge. All this is achieved through one's own independent work.

This is also because self-acquired knowledge is more operational, it becomes personal property, as well as a motive for behavior, develops intellectual traits, attention, observation, criticality, and the ability to evaluate. The role of the teacher is mainly to guide the accumulation of knowledge (in relation to first-year students), and in the subsequent years of study, in the senior years, in the joint identification of problems and care for the student's independent search, as well as control over their activities. It should be noted that it is not possible to limit oneself only to the acquisition of knowledge provided for by the program of the discipline studied, it is necessary to constantly deepen the knowledge gained, focusing it on some narrow specific area corresponding to the interests of the student. In-depth study of all subjects provided for by the program is possible in practice, and good organization of work allows you to save time, which creates conditions for a deep, systematic, interested study of the topic independently chosen by the student.

Of course, all the advice, examples, recommendations in this area, given by the teacher, or certain publications, or other sources, do not guarantee any success without the manifestation of one's own activity in this matter, i.e. they do not give ready-made recipes, but should contribute to the analysis of one's own work, its goals, organization in accordance with individual characteristics. Taking into account personal capabilities, existing living and working conditions, skills, on the basis of these recommendations, it is possible to develop an individually justified set of methods, ways, find one's own style or improve it, so that, having studied certain material, have time to assess its significance, suitability and possibilities of its application, in order to ultimately ensure the success of one's studies from future professional activity

## **7. METHODOLOGICAL RECOMMENDATIONS FOR STUDENTS ON CERTAIN FORMS OF INDEPENDENT WORK**

The system of university education implies much greater independence of students in planning and organizing their activities.

### **Work with literature**

When working with literature, it is necessary to select literature, learn how to read it correctly, and keep notes. For the selection of literature in the library, alphabetical and systematic catalogs are used.

It is important to remember that rational skills of working with a book are always a great saving of time and effort.

The correct selection of textbooks is recommended by the teacher who reads the lecture course. The necessary literature can also be indicated in the methodological developments for this course.

Studying the material from the textbook, you should move on to the next question only after the correct understanding of the previous one, describing on paper all the calculations and calculations (including those that are omitted in the textbook or given in the lecture for independent conclusion).

In the study of any discipline, independent individual work plays a large and important role.

Particular attention should be paid to the definition of the basic concepts of the course. The student should analyze in detail the examples that explain such definitions, and be able to build similar examples independently. It is necessary to achieve an accurate idea of what you are studying. It is useful to make reference notes. When studying the material from the textbook, it is useful to supplement the lecture notes in the notebook (in specially designated margins). There you should also note the questions selected by the student for consultation with the teacher.

It is recommended to highlight the conclusions obtained as a result of the study in the notes so that they are better remembered when rereading the notes.

Experience shows that many students are helped by compiling a list of reference signals containing the most important and most frequently used formulas and concepts. Such a sheet helps to memorize formulas, the main points of the lecture, and can also serve as a permanent reference for the student.

There are two types of reading; primary and secondary. *Primary reading* is attentive, unhurried reading, in which you can dwell on difficult places. After it, not a single incomprehensible tin should remain. The content may not always be understood after the primary reading.

The task of *secondary* reading is the complete assimilation of the meaning of the whole (this reading may not be the second, but the third or fourth).

Reading a scientific text is a part of cognitive activity. Its purpose is to extract the necessary information from the text. The effectiveness of the action largely depends on how conscious the reader is of his own inner attitude when referring to

the printed word (to find the necessary information, to assimilate the information fully or partially, to critically analyze the material, etc.).

There are ***four main attitudes in reading a scientific text***:

1. information retrieval (the task is to find, highlight the information sought)
2. assimilative (the reader's efforts are aimed at understanding and remembering as fully as possible both the information presented by the author and the entire logic of his reasoning)
3. analytical-critical (the reader seeks to critically comprehend the material, analyzing it, determining his attitude to it)
4. creative (creates in the reader a readiness in one form or another – as a starting point for his reasoning, as an image for action by analogy, etc. – to use the author's judgments, the course of his thoughts, the result of observation, the developed methodology, to supplement them, to subject them to a new check).

The existence of several types of reading ***is associated with the presence of different attitudes to addressing a scientific text***:

1. Bibliographic – viewing catalog cards, recommendation lists, summary lists of journals and articles for the year, etc.;
2. Viewing – used to search for materials containing the necessary information, usually it is used immediately after working with lists of references and catalogs, as a result of such viewing the reader establishes which of the sources will be used in further work;
3. introductory – implies a continuous, sufficiently detailed reading of the selected articles, chapters, individual pages, the purpose is to get acquainted with the nature of the information, to find out what issues are submitted by the author for consideration, to sort the material;
4. Studying – assumes a thorough mastery of the material; in the course of such reading, the reader's trust in the author, readiness to accept the information presented, the attitude to the most complete understanding of the material is realized;
5. Analytical-critical and creative reading are two types of reading that are close to each other in that they participate in solving research problems. The first of them involves a directed critical analysis of both the information itself and the ways in which it is obtained and presented by the author; the second is the search for those judgments, facts, on which or in connection with which the reader considers it necessary to express his own thoughts.

Of all the types of reading considered, the main one for students is the learning one - it allows them to accumulate knowledge in various fields when working with educational literature. That is why this type of reading should be mastered in the first place. In addition, when mastering this type of reading, the main techniques are formed that increase the effectiveness of working with a scientific text.

### **The main types of systematized recording of what has been read:**

1. Annotation is an extremely brief coherent description of the book (article) viewed or read, its contents, sources, nature and purpose;
2. Planning is a brief logical organization of the text, revealing the content and structure of the studied material;
3. Thesis is a concise reproduction of the author's main statements without involving factual material;
4. Quotation is a verbatim excerpt from the text of excerpts, extracts that most significantly reflect one or another thought of the author;
5. Note-taking is a brief and consistent presentation of the content of what has been read.

A synopsis is a complex way of presenting the content of a book or article in a logical sequence. A synopsis accumulates the previous types of notes, allows you to comprehensively cover the content of a book or article. Therefore, the ability to make a plan, theses, make extracts and other notes determines the technology of compiling a synopsis.

### **Methodical recommendations for compiling a synopsis:**

1. Read the text carefully. Clarify the incomprehensible words in the reference literature. When writing down, do not forget to put the reference data in the margins of the note.
2. Highlight the main thing, make a plan.
3. Briefly formulate the main provisions of the text, note the author's argumentation.
4. Take notes of the material, clearly following the points of the plan. When taking notes, try to express the idea in your own words. Notes should be kept clearly.
5. Write down quotes correctly. When quoting, take into account the conciseness and significance of the thought.

In the text of the synopsis, it is desirable to give not only thesis statements, but also their proofs. When drawing up a synopsis, it is necessary to strive for the capacity of each sentence. The thoughts of the author of the book should be stated briefly, taking care of the style and expressiveness of what is written. The number of additional elements of the synopsis should be logically justified, the notes should be distributed in a certain sequence that corresponds to the logical structure of the work. Margins should be left for clarification and addition.

Mastering the skills of taking notes requires purposefulness and daily independent work from the student.

### **Practical exercises**

It should be emphasized that only after mastering the lecture material from a certain point of view (namely, from the point of view from which it is presented at lectures) it will be consolidated in laboratory classes both as a result of discussion and analysis of the lecture material, and by performing practical tasks and tasks. Under these conditions, the student will not only learn the material well, but also learn how to apply it in practice, and will also receive an additional incentive (and this is very important) for active study of the lecture.

When performing tasks independently, it is necessary to justify each stage of the solution, based on the theoretical provisions of the course. If the student sees several ways to solve a problem (task), then it is necessary to compare them and choose the most rational one. It is useful to draw up a brief plan for solving the problem (task) before starting calculations. The solution of problems or examples should be presented in detail, calculations should be arranged in a strict order, separating auxiliary calculations from the main ones. Solutions, if necessary, should be accompanied by comments, diagrams, drawings and drawings.

It should be remembered that the performance of each educational task should be brought to the final logical answer required by the condition, and, if possible, with a conclusion. The performance of tasks of this type should be continued until the acquisition of solid skills in solving them.

### **Self-Test**

After studying a certain topic from the notes in the notes and textbook, as well as solving a sufficient number of relevant tasks in laboratory classes and independently, the student is recommended, using a sheet of reference materials, to reproduce from memory definitions, conclusions of formulas, formulations of the main provisions and evidence.

If necessary, you need to carefully understand the material again.

Sometimes the insufficiency of assimilation of a particular issue becomes clear only when studying further material. In this case, it is necessary to go back and repeat the poorly mastered material. An important criterion for mastering theoretical material is the ability to solve problems or pass a test on the material covered. However, it should be remembered that the correct solution to the problem can be obtained as a result of the use of mechanically memorized formulas without understanding the essence of theoretical provisions.

### **Consulting**

If in the process of independent work on the study of theoretical material or when performing tasks, the student has questions that cannot be solved independently, it is necessary to contact the teacher to obtain explanations or

instructions from him. In his questions, the student should clearly express what he is experiencing difficulties, the nature of this difficulty. Advice should also be sought if there are doubts about the correctness of the answers to the self-test questions.

### **Preparation for the test in the discipline "Introduction to Engineering Culture"**

The study of many general professional and special disciplines ends with an exam. Preparation for a test with a grade contributes to the consolidation, deepening and generalization of knowledge obtained in the process of study, as well as its application to solving practical problems. Preparing for the exam, the student eliminates the existing gaps in knowledge, deepens, systematizes and organizes his knowledge.

To prepare for the test with a grade, the student must fully complete the tasks of the laboratory work of the classes, prepare a report on each practical work and a report on the results of independent study of topics, according to the curriculum. If there are debts on the current certification in this discipline, the student will not score the appropriate number of points on the test and his result of work in the semester is evaluated.

Systematic preparation for classes during the semester will allow you to use the time of the exam session to systematize knowledge.

The current certification of students is carried out by teachers who conduct laboratory classes in the discipline in the following forms: interview when defending practical work with the provision of a written report. Admission to practical work occurs if students have a printed version of the report. The defense of the report takes place in the form of an interview. The student receives the maximum grade if the report meets the established requirements, and the report fully reveals the essence of the work. The grounds for reducing the grade are:

- poorly performed work on a personal computer,
- the written report is made in a sloppy form and with errors,
- the student does not give an exhaustive answer to the teacher's question,
- Gets confused or finds it difficult to demonstrate work on the computer.

The report can be sent for revision in the following cases of negligent implementation and with errors.

The criteria for evaluating the interview are given in the Fund of Assessment Tools for the discipline "Introduction to the Specialty".

## **8. EDUCATIONAL, METHODOLOGICAL AND INFORMATION SUPPORT OF THE DISCIPLINE**

On this discipline, the teacher recommends the following literature:

As basic literature:

1. Kulpinov A.A. Vvedenie v spetsial'nost': ucheb. posobie: Napravlenie – Infokommunikatsionnye tekhnologii i sistemy svyazi. Profile of training "Communication Networks and Switching Systems". Bachelor's degree. - Stavropol: NCFU, 2014. - 130 p., unlimited copies.

2. Levchenko V.I. Radio Electronics: Introduction to the Specialty: Textbook / V.I. Levchenko; Ministry of Education and Science of Russia; Omsk State Technical University. - Omsk: OmSTU Publishing House, 2017. - 202 p.: tabl., schemes, ill. - <http://biblioclub.ru/>. - ISBN 978-5-8149-2476-6, unlimited copies.

As additional literature:

1. Shcheglov, A. Yu. - Models, Methods and Means of Access Control to Computing Systems. - Models, Methods and Means of Access Control to Computing Systems, 2022-10-01. - St. Petersburg: ITMO University, 2014. - 95 p. - The book is in the premium version of EBS IPR BOOKS. - ISBN 2227-8397

2. Mandra A. G., Popov A. V., Dyakonov A. I. Informatics and Information Technologies: Laboratory Practicum / A. G. Mandra, A. V. Popov, A. I. Dyakonov. - Informatics and Information Technologies, 2026-09-20. - Elektron. dan. (1 file). - Samara : Samara State Technical University, EBS ASV, 2020. - 64 p. - electronic. - The book is in the premium version of EBS IPR BOOKS. - ISBN 2227-8397

3. Bugrov A. N., Kirpicheva E. Yu., Milovidova A. A., Makhalkina T. O. : textbook. - Dubna: State University "Dubna", 2019. - 71 p. - Recommended by the Educational and Methodological Council of the University "Dubna" as a textbook for students studying in the areas of training "Informatics and Computer Engineering", "Applied Informatics", "Business Informatics", "Fundamental Informatics and Information Technologies" (bachelor's degree). - ISBN 978-5-89847-570-3

4. Bratchenko, N. Y. (North Caucasian Federal University). Fundamentals of Programming in High-Level Languages. Manual: Direction 230100 - Informatics and Computer Engineering. Specialty 230102.65 - Automated Information Processing and Control Systems. Bachelor's Degree / N. Y. Bratchenko; North-Kav. Federal. University. - Stavropol: NCFU, 2013. - 179 p. : ill. - Grif: Add. UMO. - ISBN 978-5-88648-878-4.

List of Educational and Methodological Support for Students' Independent Work in a Discipline (Module)

1 Bratchenko N.Y. Introduction to the specialty: methodological recommendations for students' independent work. – Stavropol: NCFU Publ., 2022. – 20 p.

List of resources of the information and telecommunication network "Internet" necessary for mastering the discipline (module):

Scientific electronic library e-Library – <https://elibrary.ru/>

IPRbooks Electronic Library System – <http://iprbooks.ru>

Electronic Library System Lan – <https://e.lanbook.com/>

List of information technologies used in the implementation of the educational process in the discipline (module), including a list of software and information reference systems

When giving lectures, computer equipment is used, demonstrations of presentation multimedia materials are used. In laboratory classes, students perform and defend laboratory work, providing reports prepared by them during the hours of independent work.

*Information reference systems:*

*Information and reference and information and legal systems used in the study of the discipline:*

1. IPRbooks Electronic Library System – <http://iprbooks.ru>
2. Electronic Library System Lan – <https://e.lanbook.com/>
3. Scientific electronic library e-Library – <https://elibrary.ru/>