Siberian Federal University

Research Seminar

Course Guide

This course contributes to the requirements for the Degree of Candidate of Science in Computer Science

Krasnoyarsk, 2020.

Table of Contents

1. Course Description

This course contributes to the requirements for the Degree of Candidate of Science in Computer Science.

Title of the Academic Program	Post-graduate Programs in English "Elements and devices of computer technology and control systems"
Type of the course	core /mandatory
Course period	3 semesters First semester: from February, the 1st to June, the 1st (13 weeks) Second semester: from October, the 1st to February, the 1st (12 weeks) Third semester: from February, the 1st to June, the 1st (16 weeks)
Study credits	5 ECTS credits
Duration	180 hours
Language of instruction	English
Academic requirements	• Master's Degree in Computer Science or equivalent (transcript of records), • good command of English (certificate or other official document) **Prerequisites:** • **Advanced knowledge** of math**,** digital electronics, programming skills.

1.1 Course overview

"Research Seminar" is a core course.

The aim of this course is twofold: one, to allow you to make progress on your research in a structured way and to help fulfill program requirements, and two, to present professionalization information crucial to success in the field. At first, graduate students have a discussion and make the presentation of a draft of a research paper. The course is organized largely around working on the research paper, with the goal of making it a conference-presentable and journal-publishable work. Topics covered include abstracts, publishing, handouts, presentation skills, course design, creating and maintaining a cv, cover letters, webpages, and in general everything that is required for you to successfully compete for jobs in intelligent computer system.

1.2 Special features

Each research project is unique. The course focuses on principles, methods, and strategies that apply regardless of your project size, content, or research methodology.

The course reflects our experience in the field of computer science, but it is relevant for any field of research.

1.3 Course aims and objectives

Course Aims

- The aim of the course is to guide graduate students through the process of writing a thesis. This demands ability to link research question, research strategy, theory and methodology of experiment. The seminars in this course will help the graduate students make a research and write a thesis. Students will use the knowledge gained from course.

Course Objectives

- to teach graduate students to identify a research problem or research question;
- to familiarize graduate students with the methodology of working with primary sources and performing patent searches;
- to familiarize graduate students with the main body of the science work;
- to teach graduate students to present and discuss their own work;

- to teach graduate students to read and comment on the work of other graduate students;
- to familiarize graduate students with the basic principles and requirements for submitting a dissertation for defense.

1.4 Learning outcomes

By the end of the course, students will know:

- writing a thesis and an article outline;
- references and research ethics;
- prepare a presentation of science project.

By the end of the course, students will be able to:

- define a research problem or research question;
- build a scientific argument;
- present and discuss own work;
- read and comment upon another students' work.

By the end of the course, students will possess:

- independent work, critical/analytical thinking;
- use scientific methods to analyze technical dimensions of knowledge and technology.

2. Course Lecturer, Contact Information

Oleg V. Nepomnuashchiy,

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(room ULK 3-12B) 26, Kirenskogo st, Krasnoyarsk, Russia

e-mail: ONepomnuashy@sfu-kras.ru

Google Scholar page: https://scholar.google.ru/citations?user=JxdeoasAAAAJ&hl=ru

Additional information is available at:

https://structure.sfu-kras.ru/node/2153

Tel: +7 391 291 2931

3. Prerequisites

This course does not require any prior special knowledge or skills.

It is recommended to master the course simultaneously with the implementation of the research project. This allows you to try out the methods and guidelines suggested in the course.

The knowledge and skills gained during the course will be useful when implementing projects for other courses and thesis.

4. Course Outline

Week	Seminars/ Assignments	Hours Sem/HA
Semester 1		
1-2	Survey of the subject area of research. Search and selection of a personal area of interest. Review of sources in the subject area of research.	4/2
3-6	Presentation of the results of the analytical review in the selected area of interest. Collective discussion of the research topic.	4/2
7-9	Development of a research plan. Discussion of the main idea for the practical implementation of the research results. Collective brainstorming to shape the proposed scientific novelty of the research.	6/2
10-11	Review of patents and presentation of the results of the patent search.	6/2
12-13	Preparation of the theses of the report and overview presentation of the project.	6/2
Semester 2		
1-4	Development and filling of the project's WEB-site.	6/3
5-8	Development of a dissertation plan, formation of a list of the main sources used and design of the first section of the dissertation.	6/3
9-10	Preparation of an article based on the results of the work. Project presentation for collective discussion.	6/3
11-12	Development of the required models and the formation of a list of basic metrics for modeling technical solutions on the research topic.	6/3
Semester 3		
1-4	Presentation of the second section of the thesis. Preparation of an article based on the results of model development. Preparation of an application for an intellectual property object.	4/16
5-6	Development of a plan for experimental testing of the solutions obtained. Creation of a research engineer's workplace in laboratory conditions. Presentation of the laboratory test bench.	4/4
7-8	Development of report abstracts on the practical implementation of elements, assemblies and embedded software in laboratory conditions. Experimental development of the obtained technical solutions.	4/4
9-10	Preparation of an article based on the results of practical development of the obtained technical solutions.	4/4
11-12	Development and presentation of the third section of the dissertation based on the results of experimental testing.	4/16
13-14	Comparative analysis of the expected and obtained results of the dissertation work. Proof of the alleged scientific novelty of the research. Presentation of the fourth section of the dissertation.	6/32

15-16	Complex presentation of dissertation work.	6/16

4.1 Course requirements

4.1.1 Web-page of the course

Course materials and required reading materials are available on the webpage of the course **Research Seminar**, SibFU E-learning portal, www.e.sfu-kras.ru. You must be logged in to access this course. https://e.sfu-kras.ru/course/view.php?id=1120

4.1.2 Required reading

The main book for this course is The ***Course Book***. It provides students with all the information they need to master methods and tools for designing master tesis.

1. Jan Recker. Scientific Research in Information Systems. A Beginner's Guide. Springer International Publishing. 2013., p.164. ISBN 978-3-642-30048-6.

2. David Hitchcock. Patent searching made easy: how to do patent searches on the internet & in the library. Sixth edition. Berkeley, CA: Nolo, April 2013 p.257. ISBNs: 9781413318722, 141331872X, 9781413318739.

3. Yvonne N. Bui. How to Write a Master's Thesis. Third Edition. SAGE publications, Inc. 2020. p.298. ISBN-13: 978-1506336091, ISBN-10: 1506336094.

4.1.3 Course materials

The main book that will guide a student through the course is ***Research Seminar*** book. It contains all of topics of this course according to the schedule. It will provide you with useful links at the end of each chapter that will help students to improve their understanding of the topics.

4.1.4 Required feedbacks

Students are free to contact the lecturer by email. The name of department and a number of a group should be written in the subject or in the beginning of the letter for convenience. More information on how to contact the lecturer can be found in «Lecturer information» section of this Guide.

Student's Home Assignment reports must be attached as a separate pdf file. Student's name and group number should be written on the first page of the file. It is recommended to insert comments for key elements of text. Students send this report in electronic form only before the deadline.

If necessary, the lecturer will schedule a video-conference, upon request.

4.2 Course Structure

Learning Activities	**Hours**
Lectures	-
Seminars	82
Assignments	98
Final Exam (including preparation)	-
Total study hours	**180**

4.3 Time schedule of the course and course outline

№	*Theme*	*Week*	*Learning Activities*	*Hours*	*Home Assignment and Reading*
			Semester 1		
1	Course Overview. Getting started.	1-2	**Seminar 1** "Survey of the subject area of research. Search and selection of a personal area of interest. Review of sources in the subject area of research"	4	**Reading:** Course Book Chapter 1. The subject area of research. Answer the test questions on the topic in the e-course.
		3-6	**Seminar 2** "Presentation of the results of the analytical review in the selected area of interest. Collective discussion of the research topic"	4	**Reading:** Course Book Chapter 2. Preparing a presentation of theme of research. Answer the test questions on the topic in the e-course.
		1-6	**Home assignment 1**	4	Make a presentation and report about the results of the analytical review.
2	Preparing for Research Project	7-9	**Seminar 3** "Development of a research plan. Discussion of the main idea for the practical implementation of the research results. Collective brainstorming to shape the proposed scientific novelty of the research"	6	Course Book: Chapter 3. Development of a research plan. Answer the test questions on the topic in the e-course
		10-11	**Seminar** 4 "Review of patents and presentation of the results of the patent search"	6	Course Book: Chapter 4. Review of patents. Answer the test questions on the topic in the e-course
		12-13	**Seminar** 5 "Preparation of the theses"	6	Course Book: Chapter 5. Preparation of the theses. Answer the test questions on the topic in the e-course
		7-13	**Home assignment 2**	6	Make theses, presentation and report about the results of the review of patents.

№	Theme	Week	Learning Activities	Hours	Home Assignment and Reading
			Semester 2		
3	Research Design	1-4	**Seminar 6** "Development and filling of the project's WEB-site"	6	Course Book: Chapter 6 The project's WEB-site. Answer the test questions on the topic in the e-course
		5-8	**Seminar 7** "Development of a dissertation plan, formation of a list of the main sources used and design of the first section of the dissertation"	6	Course Book: Chapter 7. The first section of the dissertation. Answer the test questions on the topic in the e-course
		9-10	**Seminar 8** **"**Preparation of an article based on the results of the work. Project presentation for collective discussion"	6	Course Book: Chapter 8. The article. Answer the test questions on the topic in the e-course
		11-12	**Seminar 9** "Development of the required models and the formation of a list of basic metrics for modeling technical solutions on the research topic"	6	**Reading:** Course Book Chapter 9. The required models. Answer the test questions on the topic in the e-course.
		1-12	**Home assignment 3**	12	Make a WEB – site and preparation of an article based on the results of the work. Project presentation for collective discussion.
			Semester 3		
4	Modeling	1-4	**Seminar 10** "Presentation of the second section of the dissertation. Preparation of an article based on the results of model development. Preparation of an application for an intellectual property object"	4	**Reading:** Course Book Chapter 10. The second section of the dissertation. Answer the test questions on the topic in the e-course.
		1-4	**Home assignment 4**	4	Make a presentation and report about the results of

№	Theme	Week	Learning Activities	Hours	Home Assignment and Reading
					the modeling.
5	Experimental researches	5-6	**Seminar 11** ”Development of a plan for experimental testing of the solutions obtained. Creation of a research engineer's workplace in laboratory conditions. Presentation of the laboratory test bench”	4	Course Book: Chapter 11. The experimental testing. Answer the test questions on the topic in the e-course
		7-8	**Seminar** 12 ” Development of report abstracts on the practical implementation of elements, assemblies and embedded software in laboratory conditions. Experimental development of the obtained technical solutions”	4	Course Book: Chapter 12. A report abstracts on the practical implementation. Answer the test questions on the topic in the e-course
		9-10	**Seminar** 13 ” Preparation of an article based on the results of practical development of the obtained technical solutions”	4	Course Book: Chapter 13. Preparation an article based on the results of practical development. Answer the test questions on the topic in the e-course
		5-10	**Home assignment 5**	12	Make article, presentation and report about the results of the practical implementation.
6	Report about dissertation research	11-12	**Seminar 14** “Development and presentation of the third section of the dissertation based on the results of experimental testing”	4	Course Book: Chapter 14. The third section of the dissertation. Answer the test questions on the topic in the e-course
		13-14	**Seminar 15** “Comparative analysis of the expected and obtained results of the dissertation work. Proof of the alleged	6	Course Book: Chapter 15. The furth section of the dissertation Answer the test questions on the topic in the e-course

№	*Theme*	*Week*	*Learning Activities*	*Hours*	*Home Assignment and Reading*
			scientific novelty of the research. Presentation of the fourth section of the dissertation”		
		15-16	**Seminar 16** **“**Complex presentation of dissertation work”	6	Course Book: Chapter 16. The dissertation. Answer the test questions on the topic in the e-course
		11-16	**Home assignment 6**	52	Make a complex report about the results of the work. Project presentation for collective discussion.

5. Assessment

Assessment strategy	Points, max	Evaluation criteria
Personal project	60	Presentations, thesis, articles, the dissertation.
Final exam	40	Complex presentation of the project.

Grade policy for final assessment is:

A (excellent work) 91–100 points

B (above average work) 81–90 points

C (average work) 71–80 points

D (below average work) 50–70 points

F (failed work) < 50 points

6. Attendance Policy

The course is designed to use e-learning and distance learning technologies.

The course can be implemented in two versions: classroom lessons or distance learning.

If the course is implemented as classroom lessons, students are expected to attend classes regularly. In case of missing an in-lab activity a student should perform additional work submitted to the instructor within a week after a class was missed.

If the course is implemented in a distance format:

1. It is recommended to attend online lectures.

If a student skips an online lecture, he or she must pass the e-course element "Lecture with test questions" on the relevant topic.

2. Timely submissions of work reports are anticipated.

If the work is not completed on time, you must contact the teacher through the e-course message indicating the reason for the delay and the estimated deadline. No more than 3 postponements are allowed.

3. Participation in the following events held in the format of videoconferences is mandatory:

- presentation of a presentation on the research topic;
- defence of the final report.

Those events can only be rescheduled for good reason.

7. Required Course Participation

There are no special requirements for the course participation. The preferred type of report submission is the electronic one. Students can use the web-version of the course https://e.sfu-kras.ru/course/view.php?id=1120 for a better progress. All problems for solution could be found there together with text from the course book.

8. Facilities, Equipment and Software

Internet access;

Microsoft Office®.

Annex 1 Example of Self-Study Assignment

The task: Make a Chapter "Introduction" of Dissertation. Define the main aim, lists of global tasks, research methods and the scientific novelty. Prepare a report about.

Solution:

THEME «METHODS, ALGORITHMS AND SOFTWARE TOOLS ARCHITECTURAL - INDEPENDENT, HIGH-LEVEL SYNTHESIS SINGLE CRYSTAL DIGITAL SYSTEMS»

INTRODUCTION

Relevance of the work. Constantly improving technologies for the production of crystals and the transition to new technological standards determine the active introduction of advanced achievements in microelectronics. Technologies for the manufacture of three-dimensional crystals are entering the market [1], single-chip, multiprocessor systems are being actively introduced, the direction of production of very large-scale integrated circuits (VLSI) with dynamically reconfigurable architecture is developing, etc.

Advances in technology, in turn, pose a range of design problems. First of all, it is necessary to highlight the global problem of the gap between the number of logical elements that the applied technology allows to be placed on one substrate, and the number of elements that can be really designed and verified in an economically feasible time.

In addition, when developing VLSI, the following tasks are solved:

- system and algorithmic design subject to territorial division of the development team;

- optimization of design solutions in conditions of limited computing resources;

- search for architectural solutions subject to time constraints on development dictated by financial considerations.

For complex projects, the problems of verification and testing of ready-made systems are highlighted. Today, in the design route, verification of the operation algorithm and VLSI circuit reaches 60-80% of the total development time. At the same time, the main engineering tasks remain in terms of ensuring reliability, limitations of real-time operation, severe operating conditions, etc.

To date, the final, low-level stages of creating a VLSI project have been sufficiently developed and automated. Also, the results achieved in the areas of high-level modular, sectional and platform approaches can be considered satisfactory.

However, most of the tasks of the system organization of the design process, the tasks of an effective architectural organization of "Systems on Chip" still remain unsolved.

Unlike the final stages, when describing a project at the upper levels of the hierarchy, the concepts of a system-wide view of the organization of the entire design process are laid. Thus, the development of routes and technologies based on the principles of high-level, architecturally independent design, allowing the formation of an integrated approach to the organization of all phases of the project creation, comes to the fore.

The studies of design methods for computing systems on a chip that implement the possibility of a high-level approach are devoted to the works of I.A. Kalyaev, A.L. Stempkovsky, S.G. Rusakov, A.N. Terekhov, V.V. Toporkov, A.K. Kim, A.E. Platunov, V.G. Nemudov, A.I. Legalov, among foreign experts, first of all, it should be noted the works of D. Dongar, A. Sanjovanni-Vincentelli, E. Lee, A. Ferrari, G. Martin, G. Aha, A. Jerraia etc.

However, the well-known works do not allow one to assert unambiguously about the creation of effective methodologies for high-level architecture-independent design of single-chip systems. In most cases, the designed system model is developed for a specific architecture in an application language based on standard or manufacturer-recommended libraries used for a specific implementation in the target chip or platform.

Thus, despite the significant success achieved in the field of traditional VLSI design and promising areas of high-level development of architectural solutions, there are a number of problems in the development of parallel data processing systems:

- there are no methods for effective development of architectural solutions for single-chip systems for parallel processing of information flows that do not depend on the final form of implementation;

- there are no tools that provide an effective transfer of an architecture-independent, high-level description of the applied problems to be solved to the target platform;

- with rare exceptions, the programming languages used at the present stage to describe single-chip systems for parallel data processing are either intended for circuit descriptions, or focused on traditional programming.

Known attempts to solve the aforementioned issues are mainly aimed at bridging the semantic gap between the high-level and low-level description of systems using universal programming languages or developing our own language tools from a specialized assembler to a high-level parallel language, for example COLAMO [2]. Such approaches mainly implement the solution of the high-performance computing problem on reconfigurable platforms such as FPGAs. In addition, the known tools have not found wide application and, as a rule, do not go beyond the scope of academic projects [65,17,60,64].

Therefore, the development of methods and tools that provide an architecturally independent description of single-chip computing systems with natural parallelism is an urgent task.

At the same time, it is required to create new approaches to describing VLSI at the architectural level, which would provide the maximum abstraction of functioning algorithms from the architecture of the target chip and their representation in the languages of hardware description for adequate mapping to the lower layers in the design hierarchy. This will make it possible to operate not at the level of ready-made hardware platforms or previously developed and verified blocks for a single-chip system, but at the level of algorithms of the computational process, with the transfer of the resulting model to the target crystal.

The purpose of the thesis is to research and develop methods and tools for high-level synthesis of digital single-chip systems.

To achieve this goal, the following **main tasks** are solved in the work:

1. Research of models, methods, algorithms, languages and software tools for high-level design of very large-scale integrated circuits.

2. Development of a computation model and a method of architecture-independent description of parallel algorithms and programs for digital data processing, implemented in the form of VLSI.

3. Development of algorithms and software tools for organizing the process of architecture-independent design and translation of high-level VLSI representation into hardware description languages.

4. Development of projects of digital integrated circuits using the proposed method and developed software tools and evaluating the effectiveness of the proposed solutions based on the results of practical implementation.

Research methods

The tasks are solved using graph theory, system analysis, simulation, analysis and synthesis of digital logic circuits. When developing the main provisions of the dissertation, the methods of systems analysis of heterogeneous computing systems, functional-stream and object-oriented design and programming were used.

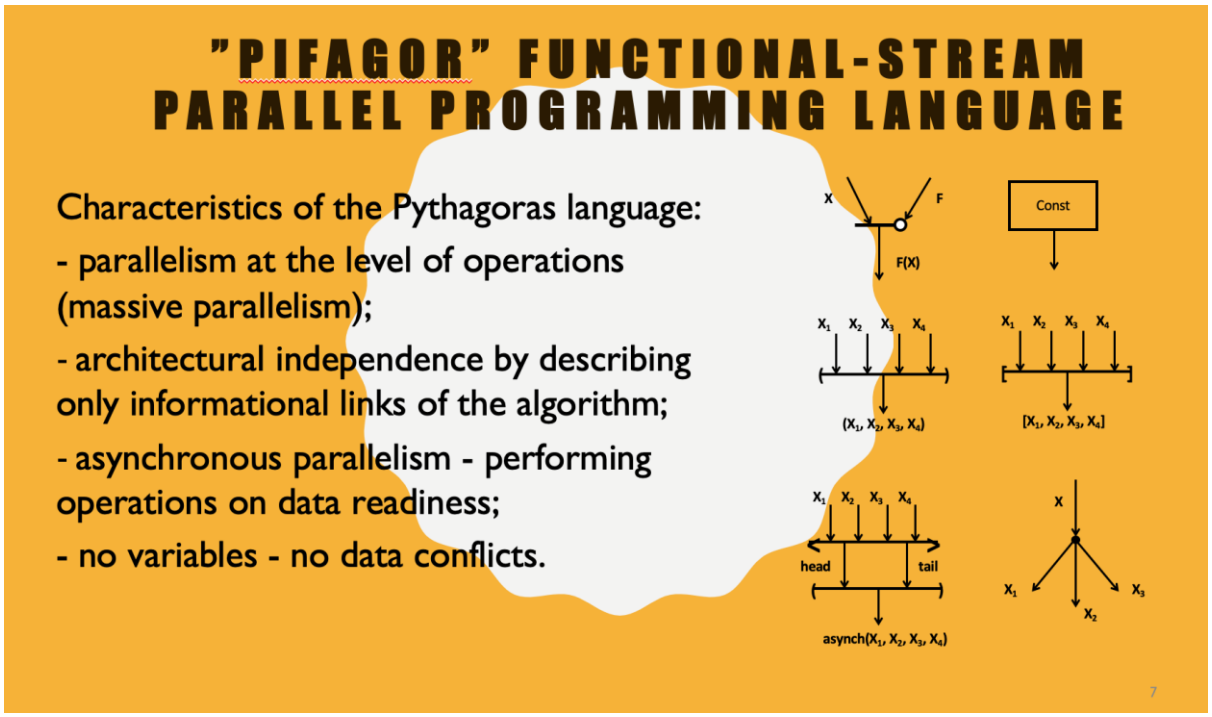
Scientific novelty:

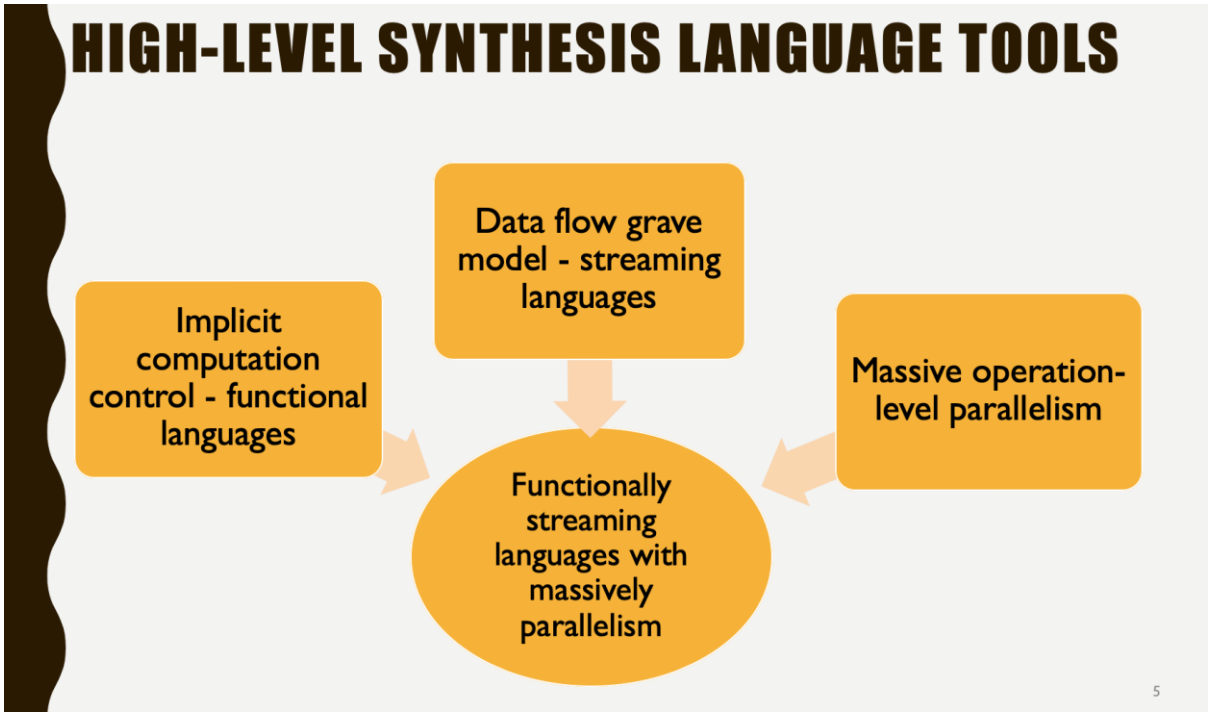
1. For the first time, a method of architecture-independent high-level synthesis of digital single-chip ICs has been proposed, which allows to take into account the maximum parallelism of the task at the level of describing the algorithm of VLSI operation through the use of the functional-flow paradigm and the absence of project binding to the target platform.

2. Methods are proposed for describing the functional composition and algorithms for controlling computations in the FPP language, focused on the descriptions of digital VLSI and allowing efficient transformation of a high-level architecture-independent representation of digital circuits into a low-level architecture-dependent representation.

3. On the basis of the proposed methods, language and tools have been developed that provide the synthesis of the VLSI description in the hardware description languages.

Examples of Report presentation:





Annex 2 Example of Pre-Course Test Questions

1. Synchronous logic gates. Special and multifunctional elements. Logic expanders. Digital switches and keys.

2. Programmable logic devices: programmable logic matrices, programmable matrix logic, programmable gate matrices, programmable logic sequence controllers, programmable logic element, programmable macro logic, programmable logic integrated circuits (FPGA)

3. Ultrasonic sensors. Piezoresonance sensors. Acousto-optical converters and spectrum analyzers. Intelligent sensors.

4. Analog-to-digital and digital-to-analog converters. Construction principles. Main characteristics and parameters.

5. Typical elements of computer technology: logical elements, decoders, encoders, code converters, adders, triggers, programmable logic integrated circuits.

6. Microprocessor-based information processing facilities in control systems. Hardware implementation of computational algorithms in signal processing devices, fast Fourier transform processors.

7. Single-chip computers, architecture, command system. Debugging tools for microprocessors and systems based on them. Assessment of the capabilities of modern microprocessors and the prospects for their development.

8. Multiprocessor and multicore computing systems with ultra-high performance. Multiprocessor computing systems with multiple command streams and multiple data streams. Multi-machine computing systems.

9. Radiation resistance of elements and devices. Types of influencing radiation: corpuscular, quantum, wave. Reversible and residual effects. Changes in the parameters of passive and active components under the influence of radiation. Ways to increase the radiation resistance of elements and devices.

10. Calculation of the spread of device parameters. Deterministic calculation methods. Worst-case calculations. Numerical probabilistic calculations. Accuracy assessment. Comparison of methods of probabilistic calculation.

11. Reliability of elements and devices, its quantitative characteristics. Sudden and gradual failures. Influence of electrical and thermal modes of elements on their reliability. Methods for improving reliability. Accelerated Test Methods for Reliability.

12. Resistance of elements and devices to external influences. Characteristics of climatic influences. Mechanical strength.

Annex 3 Outlines of Home Assignment works

(List one. The title)

"SIBERIAN FEDERAL UNIVERSITY"
Institute of Space and Information Technologies
Department of Computer Science
PhD Degree Program in Computer Science

Group No ***(Group identifier)***

REPORT ON HOME ASSIGNMENT No. ***(Number of HA)***
Theme: ***(Theme of task).***

Tutor: ***(Tutor's / Lecture's Name and Surname).***

Student: ***(Graduate Student`s Name and Surname).***

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(List two, etc. The progress)

Main aim: ***(Describe the aim of HA).***
The task: ***(Describe the task of HA).***
Solution: ***(short description (no more than 2-3 pages) of the problem solving process).***

Annex A Diagram(s)

(diagrams and graphs).

Annex B Code(s)

(Photo, code etc. (if you need).