Black Sea Economic Cooperation

Project cipher **BSEC/PDF/13/05 2007**

Network of Integrated Circuit Design Teaching Centers in Black Sea Region

Interim Report

Niš, Yerevan, Sofia

March 2008

Contents

1 Strategy for building Network of Integrated Circuit Design Teaching Centers

The primary goal of building the Network of Integrated Circuit Design Teaching Centers in Black Sea Region is to establish mutually compatible knowledge and skills of design engineers in BSEC countries in order to strength competitiveness with other European regions in the field of Information Communication Technologies. In order to achieve it we should

1. Determine our current resources
2. Compare our possibilities in IC Design with the leaders in the field
3. Define procedures and steps needed to reach competence.

The competence attainment should be appraised by running an international project.

After competence attainment the network should spread by including other centers from the region.

2 Survey of current state at three IC Design Teaching Centers

2.1 Survey of current state at LEDA Laboratory, Faculty of Electronic Engineering, University of Niš

LEDA Laboratory for Electronic Design Automation of Electronic Circuits and Microsystems has been established in 1987 as the first research laboratory at Faculty of Electronic Engineering, University of Niš. Persistently it is the leader in using and developing new Information-Communication Technologies (ICT) at University of Niš.

In recent years, the LEDA group has developed research in Integrated Circuits Design technology with particular emphases on prototyping ICs using ASIC approach and standard cell method. The most widely-cited contributions were made in Mixed-Signals Circuit Simulation.

LEDA laboratory had successful collaboration with many university centers. The best results were achieved through collaboration with the University of Southampton (UK), Middlesex University (UK), Technical University of Vienna (A), Technical University of Madrid (E) and the universities of Ilmenau (D), Sofia (BG), Skopje (FYRM) and Banja Luka (B&H).

LEDA group approved its competence in IC design field performing many national and international projects. The national projects were generally funded by Ministry of Science. The international projects were funded by DAAD, TEMPUS and WUS. Currently members of LEDA group are engaged in two national and three international projects. One of these is the project donated by DAAD within Stability Pact for South-Eastern Europe, one TEMPUS project is in the starting phase and the BSEC project.

2.1.1 Software resources

LEDA laboratory recognized the importance of *EUROPRACTICE Service* in IC Design and Universities support. Therefore, it approached to EURORACTICE in 2002. According to the available finances, since then, LEDA participated for license for Cadence *IC Design Tools*, occasionally (in 2003 and 2007). Thankfully to funds approved with this (BSEC/PDF) project we will expand the license for the next year. So far, this software was available for Ph.D. students and for research purposes.

The first software that was primarily dedicated for teaching comes in 2005. thanks to WUS (World University Service) Austria. At first, WUS funded one license of *IC Nanometer Design* package provider by Mentor Graphics. This license was valid for three years. Then our collaboration with Mentor Graphics started. In 2006 Mentor Graphics donated with fifteen free *Design, Verification and Test flow* licenses and enlarged validity of *IC Nanometer Design* to 15 licenses. Moreover as the three-year licenses would expire next school year, Mentor Graphics provide us the software, licenses and support for free without time limit. Actually, we approached to Higher Educational Program (HEP) and use all available tools and resources (related to technology files).

Mentor Graphics' *IC Nanometer Design* package provides a complete environment for the design, capture, layout and verification of analog, digital and mixed-signal integrated circuits.
IC Nanometer Design platform comprises: Design Architect-IC ; IC Station ; ICassemble ; ADVance MS and ADVance MS RF ; Eldo and Eldo RF ; ADiT™ ; Calibre ; Calibre xRC.

The *Design, Verification and Test* package provides complete solutions for HDL design, verification, synthesis and test of ASICs and FPGAs.

The products in this category comprise: Questa Advanced Functional Verification platform; inFact FPGA Design and Verification; C Based Design and Verification; Design-for-Test; Hardware-Software Co-Verification; System Modeling.

Detailed description of every tool is given in Appendix 1.

2.1.2 Hardware resources

LEDA Laboratory physically occupies three rooms. Two of them are dedicated for research and one is teaching laboratory. Figure 1 shows their interconnection. Laboratory LAB 321 has 8 PCs and Beowulf cluster of 8 PCs. The cluster is a node in European Greed network. LAB 322 is supplied by five Sun Blade 150 Workstations (Sun Ultra 10, Model 440, 1x440Mhz UltraSPARC-III). All were provided in 2003. One of them works as a server for *IC nanometer Design* and *Design, Verification and Test* package. The others runs Cadence *IC Design Tools* package.

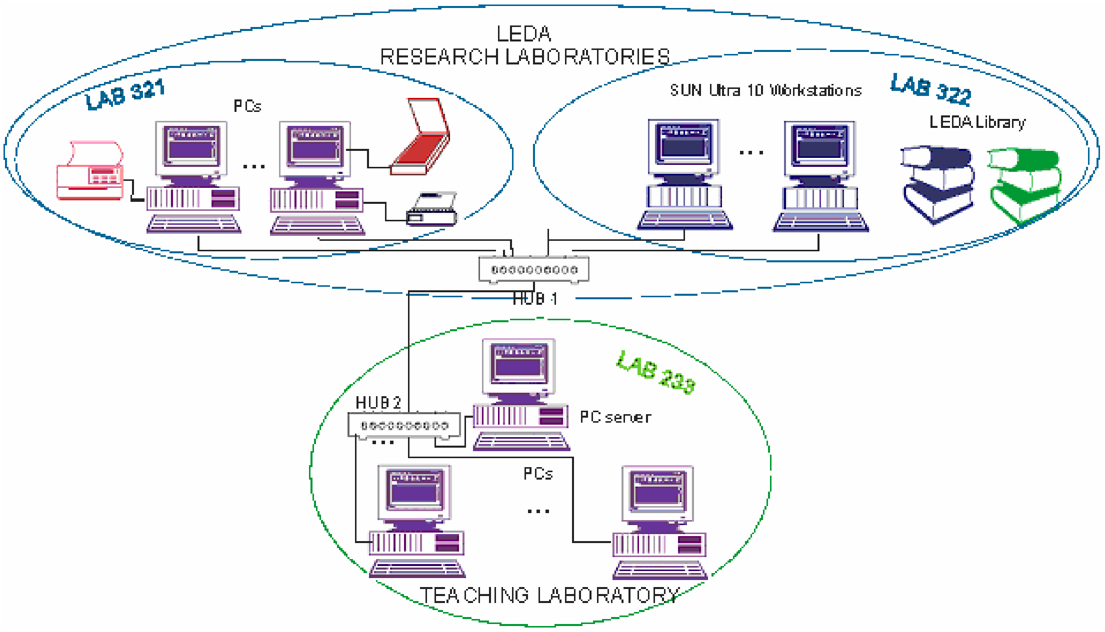

Figure 1 Hardware resources of Faculty of Electronic Engineering in Niš

In 2005. CAD teaching laboratory was established thanks to WUS (World University Service) Austria. It is denoted as LAB 233 in Figure 1. It is equipped with 10 PC Acer Power F1 (Intel P4, 2.8GHz, 400MHz FSB, 40GB HDD, 512MB RAM, DVD, nVidia MX 4000 Video, 19” Samsung SyncMaster Monitor, Keyboard, Mouse) connected in LAN with a local server. The server is PC with enhanced performances than client PCs (2x80GB HDD, 1GB RAM). The local area network is organized using TRENDnet 16-port (16 10/100Mbbs) N-Way Mini Switch. This laboratory is equipped with video-beam and is suitable for a group of 10 students.

All hardware peaces are interconnected by local network. Moreover, teaching staff is distributed in smaller offices supplied with PCs, printers, scenners.

2.1.3 Human resources

LEDA group has four full professors, 3 teaching assistants, all of them Ph. D. students, and two additional Ph.D. student.

So far, 10 students received Ph. D degree working in LEDA laboratory. Much more received M. S. degree and continued education abroad. Therefore we have strong connections with people that work in many world-famous corporations like Fujitsu, Phillips, Infineon, IBM…

Besides, we have good cooperation with people at universities in Europe that were our partners in international projects. All these projects were completed or are still running successfully. Moreover, several of our ex-students are professors at universities in U.S. and are open for collaboration in field of IC Design.

2.1.4 IP resources, technologies

LEDA was engaged in tenths of projects sponsored by government of Serbia or by industrial partners and in several international projects. Eight projects resulted with designed and prototyped integrated circuits. The last one was completed in 2004. It is an integrated solid state energy meter named – IMPEG or LEDA 08. It was developed and prototyped under financial support of Serbian Ministry of science, technology and development as a part of the project entitled: "Development of equipment and system for measurements and power supply control in industry". The project lasted from 01.01.2002. until 21.12.2004. Based on the strict demands of Mackatica, a.d. (the power meter producer) and with strong cooperation with Star Engineering (the unintegrated version designer) LEDA 08 is highly integrated CMOS power meter IC. It is designed to accurately measure and calculate: active, reactive and apparent power and energy, power factor, IRMS, VRMS and frequency for 2 or 3 wire power meter applications. Figure 2 presents a block diagram of IMPEG

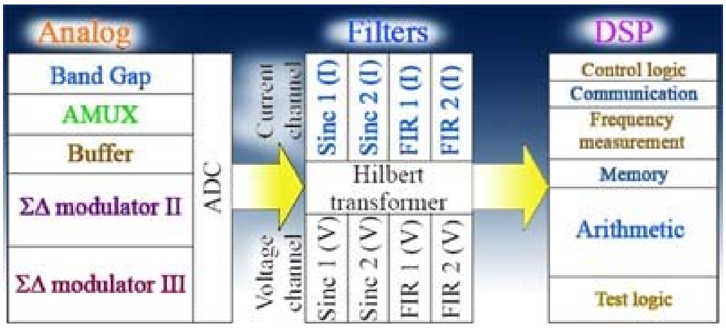

Figure 2. Structure of IMPEG chip

As one can conclude, this project consists of many reusable blocks recognized as Intellectual Property (IP) Cores. Some of them are listed below.

Analogue and Mixed-signal Circuits IPs are available as in software form as schematic and in hardware form as layout in AMIS 0.35µ C035M-A 5M/2P/HR technology.

- A/D Converter
  - Second-order ADC, Third-order ADC
- Analog Comparator
- Analog Multiplexer
- Operational Amplifier
- Oversampling Modulator
- Switched Cap Filter
- Voltage Reference
- Voltage Regulator

Digital IPs available as VHDL code or as layout in in AMIS 0.35µ C035M-A 5M/2P/HR technology:

- Arithmetic and Mathematic Functions
  - Adder/Subtractor, Decimation FIR, Decimation Sinc, Divider-Reciprocal, Multipliers, Square Root
- Digital Signal Processing
  - Dedicated Power Meter DSP, Single-MAC, 24-bit
- Peripheral Cores
  - Power-On Reset

- Other
  - Real Time Clock, Callendar
- Wireline Communications
  - Serial Communication Port

One may find more information about IPs at URL:

http://www.rakita.co.yu/designersBoutique/IntelectualProperty/orderSelector.php

LEDA bibliography contains more than 800 published titles.

2.1.5 Syllabus

Computer aided design (CAD) of integrated circuits (IC) is taught within several courses since 1978.

Actually the Faculty of Electronic Engineering enters the national accreditation process and prepares updated syllabuses.

Currently the The studies are divided on three levels: undergraduate – Bachelor (8 semesters x 30 ECTS = 240 ECTS), graduate - Master (2 semesters x 30 ECTS = 60 ECTS) and Ph. D level (6 semesters). According to the new syllabus CAD will be taught within the graduate study program (M.S.) “Electronics and Microprocessor Technique” as a module entitled “Systems on Chip Design (SoCD)”.

Table 1 presents syllabus of the module.

Study program**: ELECTRONICS AND MICROPROCESOR TECHNIQUES**

Semester	**Bachelor Degree**	**Lessons**			**ECTS**
III		L	TA	TL	
	Basics of Electronics	2	2	1	6
	Digital Electronics	2	2	1	6
	Signals and Systems	2	1	2	6
	Measurements	2	1	2	6
	Mathematics 3	2	2	**1**	6
	ECTS:				**30**
IV					
	Telecommunications	2	2	1	6
	Digital signal processing	3	1	1	6
	Analog Electronics	2	2	1	6
	Object Oriented Design Techniques	2	2	1	6
	Elective 1 Electronic Circuits Design	2	2	1	6

	Computer Graphics and Design				
	ECTS:				**30**
V					
	English language I	2	0	0	3
	Computer Networks and Interfaces	2	1	2	6
	RF Electronics	2	2	1	6
	Multimedia Systems	2	2	1	5
	Elective 2 Digital integrated Circuits Audio Signal Processing	2	2	1	5
	Elective 3 Digital Systems Architectures TV Systems	2	2	1	5
	ECTS:				**30**
VI					
	English language II	2	0	0	3
	Microprocessor Techniques	2	2	1	6
	Basics of Power Electronics	2	2	1	6
	Elective 4 Digital IC Design Multimedia Tools	2	2	1	6
	Elective 5 Electronic Systems Design Microarchitectures Multimedia Communications Audio and Video Techniques	2	2	1	6
	Practice/ Team Projects				3
	ECTS:				**30**
VII					
	Real Time Systems	2	2	1	6
	Power Sources	2	2	1	6
	Elective 6 VLSI Design Digital Figure Processing	2	2	1	6
	Elective 7	2	2	1	6

	Sustainable Design Microcontrollers Signal Conversion Technique Mixed Signal Circuits Communication Circuits and Systems Computer animations I				
	Elective 8 Reusable power sources Electronics in Medicine Power Converters Digital Telecommunications Architectures of complex Digital Systems Concurrent and Distributed programming WEB and Internet Technologies	2	2	1	6
	ECTS:				**30**
VIII					
	Elective 9 Embedded systems Wireless computer networks and circuits Electronic Systems in Medicine Economy of Sustainable Manufacturing Figure Transfer Techniques	2	2	1	6
	Elective 10 Data Acquisition Systems Autoelectronics Analog IC Design Computer animations II	2	2	1	6
	Elective 11 Testing and Diagnostics of Electronic Circuits and Systems Thermovision Ultrasound Techniques Multimedia Equipment Data Acquisition Techniques	2	2	1	5
	Elective 12	2	2	1	5

	Neural Networks				
	Control Systems				
	Power motors Regulation				
	Sensors Transducers and Actuators				
	Integrated Sensors				
	Radio communications				
	Satellite and Cable TV				
	Antennas and Broadcasting				
	Data coding and Compression				
	Operational Systems				
	WEB programming				
	Data Bases				
	Parallel programming				
	Final Project				8
	ECTS:				**30**
	Total ECTS				**240**

Semester	**Master Degree Module System on Chip Design**	**Lessons**			**ECTS**
I		PR	IR	LV	
	Systems on Chip	2	2	1	6
	Microsensors and Microsystems	2	2	1	6
	Elective 1	2	1	2	6
	Advanced Computer Architectures				
	Mixed-Signal IC Design				
	Video Systems				
	Elective 2	2	1	2	6
	DSP Architectures and Algorithms				
	RF IC Design				
	Adaptive Signal Processing				
	Elective 3	2	1	2	6
	Power Converter Control				
	Medical Electronic Equipment				
	Control and Monitoring Systems in Industry				
	Digital Signal Processors				
	EMC				

	Introduction to Robotics Telemetrics Discrete Mathematics Numerical Mathematics Probability and Statistics Mathematical Methods				
	ECTS:				**30**
II					
	Elective 4 Reconfigurable Architectures Electronic Circuit Simulation and Optimization Time-Frequency Signal Analysis	2	2	1	6
	Elective 5 Circuits and Systems Modeling Electronic Equipment Design RF System Design Video Signal Processing Virtual Instrumentation	2	2	1	6
	Diploma Thesis				18
	ECTS:				**30**
	Total ECTS				**60**

Contents of courses that cover IC design topics are given in Appendix 2

2.2 Survey of current state at State Engineering University of Armenia (SEUA), Microelectronic Circuits and Systems Interdepartmental Chair

Microelectronic Circuits and Systems Interdepartmental Chair was established in 2001. On December 1, 2004, a cooperation agreement was signed between SEUA and Synopsys Armenia CJSC, according to which the SEUA Interdepartmental Chair of Microelectronic Circuits and Systems became a member of Synopsys' Worldwide University Program. According to the the new Industry/Academia educational model, Synopsys Armenia CJSC provided the SEUA Interdepartmental Chair of Microelectronic Circuits and Systems with: classrooms, laboratories, Synopsys EDA tools, computer hardware and software, professors' salaries, students' scholarships, professors' training, university degrees (Bachelor, Master, PhD), development of the University's technical infrastructure, and employment offers to students upon successful graduation.

The Chair cultivated a deep relationship with the academic community in Armenia, providing the fertile ground in which a new educational model could be realized. The continuing mission of the Chair is to train qualified specialists who meet specific requirements of semiconductor industry companies for well-educated and skilled engineers. The Chair has successful collaboration with many universities. The best results were achieved through collaboration with the State Engineering University of Armenia (SEUA), other universities include: Yerevan State University (YSU), American University of Armenia (AUA) and Russian-Armenian (Slavonic) State University, Moscow Institute of Electronic Technology (MIET). The Chair's new educational model augments students' basic training and promotes their specialization in the field of semiconductors. In the first years of the Bachelor program, students obtain a fundamental education in mathematics, physics, or other technical field at their selected university. Further education in Bachelor and Master Programs and PhD studies is conducted using customized curricula of the Chair which address contemporary requirements of the semiconductor industry.

In recent years, the Chair has developed curriculum which is used in well-known educational institutions like Moscow Institute of Electronic Technology (MIET), Chinese Academy of Sciences, etc.

MCS Chair approved its competence in IC design field performing many international projects. Currently the students of the Chair are engaged in international projects. One of these is the creation of SAED_EDK90nm Educational Design Kit (EDK).

The new Industry/Academia cooperation model, during the several years of its existence, has demonstrated obvious advantages. It is worth mentioning that as a result of the Synopsys and SEUA cooperation which began more than 6 years ago, more than 60% (about 200) of graduates have become employees of Synopsys by meeting the necessary requirements put forth during implementation of the model. They are filling the positions of leading specialists of the Company and even Technical Managers. The rest of the students continue their education in other programs – Master and PhD.

2.2.1 Software resources

According to the Cooperation Agreement signed between Synopsys and SEUA, Synopsys donated 70 packages of Synopsys EDA tools to MCS Chair which are currently used during laboratory works, practice classes, course projects, diploma works, Master theses, PhD dissertations.

Synopsys EDA tools provide a complete environment for the design, layout and verification of analog, digital and mixed-signal integrated circuits.

The *Galaxy Design Platform* package provides the most comprehensive solution for advanced integrated circuit design. It is a comprehensive solution for digital IC implementation. Galaxy generates a production ready IC design in GDSII format. Galaxy RTL and Physical implementation products concurrently balance design constraints by performing intelligent tradeoffs between speed, area, power, test and yield. Galaxy Sign-off engines accurately model complex physical interactions to ensure signal and power integrity.

The products in this category comprise: Astro; Hercules; Star-RCXT; Milkyway; Design Compiler Ultra; DFT Compiler MAX; Physical Compiler; Jupiter XT; Prime Time SI; TetraMAX; Power Compiler; Module Compiler; coreAssembler; coreBuilder; Library Compiler ;

The *Discovery Verification Platform* package delivers verification for complex chip design. It is an integrated system, RTL, equivalence checking, and mixed-signal verification solution that provides high performance and efficient interactions among best-in-class technologies. These technologies include mixed-HDL simulation, mixed-signal simulation, system-level verification, assertions, verification IP, code coverage, functional coverage, testbenches, and formal analysis. Discovery's components support Verilog, VHDL, mixed-HDL, SystemVerilog, SystemC and analog/mixed-signal designs.

The products in this category comprise: HSIM^{plus}; HSPICE; NanoSim; Formality; Saber; System Studio; VCS; Leda; Cosmos; PathMill; Vera;

The *DFM* package

The products in this category comprise: TCAD Sentaurus; TCAD Raphael; TCAD Taurus.

The detailed description of every tool is given in Appendix 1

2.2.2 Hardware resources

MCS Chair is supplied by 110 Workstations (Pentium IV, 1.8 GHz, RAM – 512MB, HDD – 40GB). All were provided by Synopsys. One of them works as a server (2x Dual Core Intel® Xeon® 5110 (1.60GHz, 1066 FSB) Processor, HP 4GB Fully Buffered DIMM PC2-5300 4X1GB Memory). The others runs Synopsys EDA tools package.

2.2.3 Human resources

MCS Chair has 8 full professors, 20 Associate Professors and 6 lecturers.

So far, 8 graduates of the Chair received Ph. D. degree, 70 graduates received M. S. degree.

Besides, the MCS Chair has good cooperation with people at universities in Europe that were partners in international projects. All these projects were completed or are still running successfully. Moreover, several of ex-students of MCS Chair are teaching in the Chair.

2.2.4 IP resources, technologies

With active participation of the students, Educational Design Kit (EDK) has been created in MCS Chair. It is free from intellectual property restrictions EDK, anticipated for the use of educational purposes aimed at training highly qualified specialists in the area of microelectronics, foreseen to support the trainees to better master advanced design methodologies and anticipated for designing different ICs by the application of 90nm technology.

2.2.5 Syllabus

Computer aided design (CAD) of integrated circuits (IC) has been taught within several courses since 2001 within two Specializations:

- VLSI Design Specialization
- EDA Specialization

Figures 2 and 3 gives graphical presentation of VLSI Design and EDA Specialization, respectively.

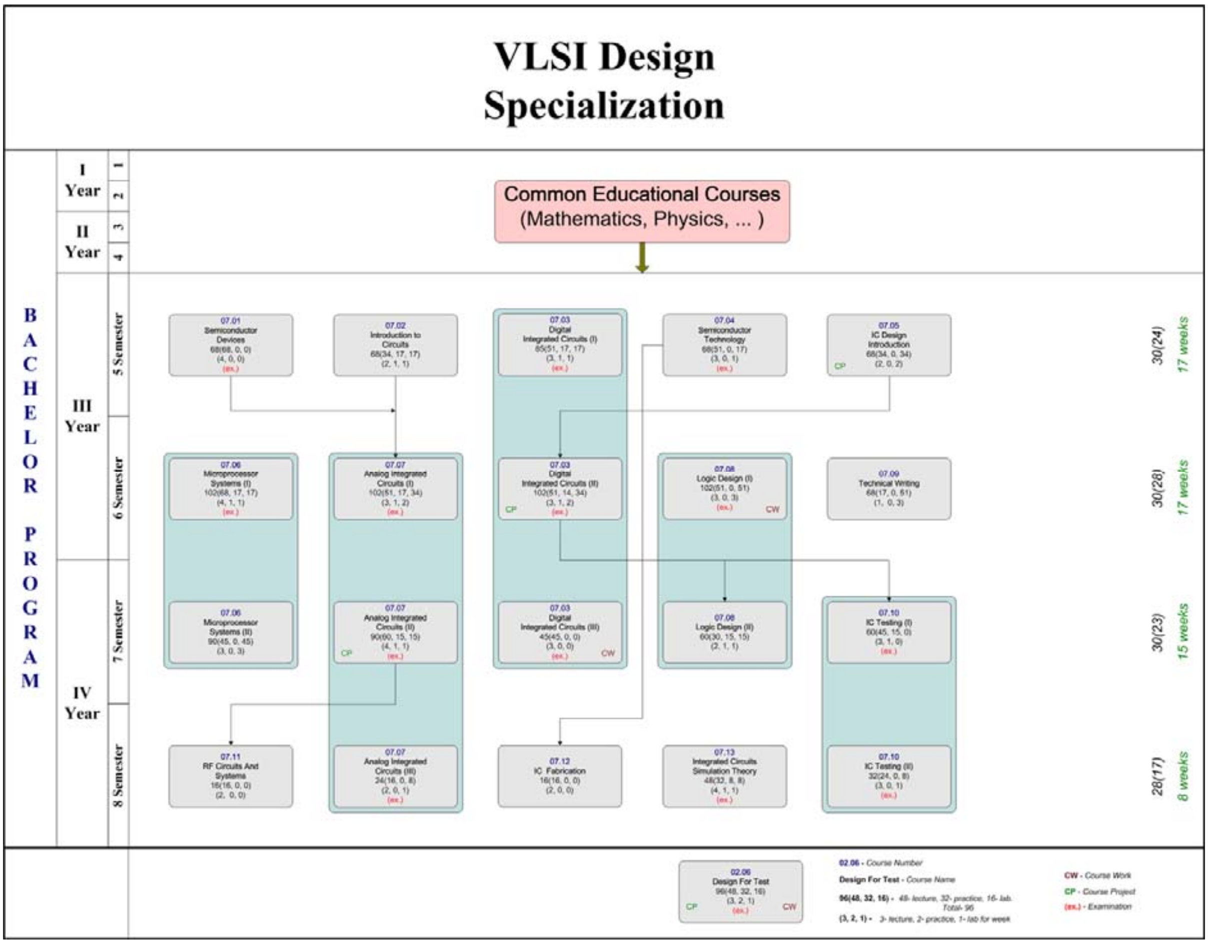

Figure 2. Graphical presentation of VLSI Design Syllabus

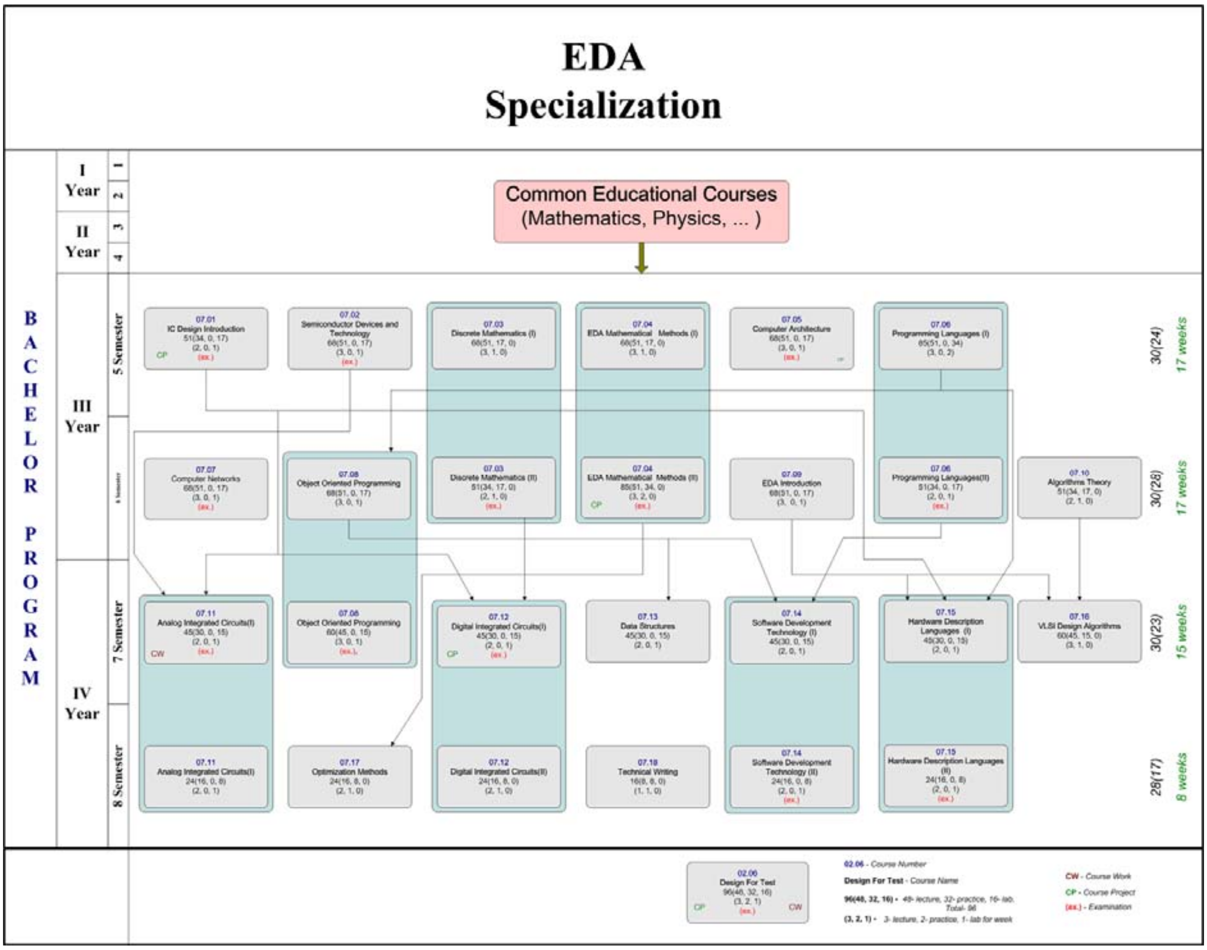

Figure 3. Graphical presentation of EDA Specialization Syllabus

Detailed contents of courses related to IC Design is given in Appendix 2.

2.3 Survey of current state at Faculty of Electronics at Technical University of Sofia

The Faculty of Electronic Engineering and Technology was established in 1987 following the division of the then existing Faculty of Radioelectronics.
The Faculty of Electronics comprises 4 departments:

1. Department of Electronic Engineering
2. Department of Power Electronics
3. Department of Semiconductor and Microelectronic Devices Design and technology
4. Department of Chemistry

The faculty has at its disposal 2 laboratories:

1. Faculty Laboratory on CAD in Electronics and Microelectronics
2. Faculty Laboratory on Automated Measurements and Testing

The Faculty offers the 4-year Bachelor's degree and 1,5-year Master's degree courses in Electronics, completed with the defence of a diploma project.

The course has 4 specialisations:

1. Electronic Medical Equipment Engineering, lectured by the Department of Electronic Engineering
2. Electronic Control Systems, lectured by the above department;
3. Microelectronics, lectured by the Department of Semiconductor and Microelectronic Devices Design and Technology.
4. Power Electronics, lectured by the department of the same name.

Department of Electronic Engineering

The department was established in 1963, with the establishment of the faculty of Radio Electronics. Its staff currently numbers 33 lecturers /3 professors, 12 associate professors and 18 assistant professors/, and 3 supporting staff.

Scientific degree holders are 15 members. The department has provided scientific guidance to 23 Ph.D. students.

Currently the department reads 38 courses. Its members have authored or co-authored 48 university books and monographs.

Department of Power Electronics

The department was established in 1976, when it was separated from the then existing De-partment of Electronic Engineering. Its staff currently numbers 12 lecturers (2 professors, 5 associate professors, 5 assistant professors) and 2 supporting staff.

Scientific degree holders are 9 members. The department has provided scientific guidance to 4 Ph.D. students .

Currently the department reads 27 courses and its members have authored or co-authored 10 university books and 2 monographs.

Department of Semiconductor and Microelectronic Devices Design and Technology

The department was established in 1982 from the Research and Design Laboratory on Semiconductor and Hybrid Technologies. Its staff currently numbers 13 lecturers (3 professors, 7 associate professors, 3 assistant professors) and 3 supporting staff.

Scientific degree holders are 10 members, two of them - Doctors of Sciences. The department has provided scientific guidance to 20 Ph.D. students.

Currently the department reads 17 courses. Its members have authored or co-authored 11 university books and 5 monographs.

Department of Chemistry

The department was established in 1976, when it separated from the then existing Department of Physics and Chemistry. Its staff currently numbers 12 lecturers /2 associate professors, 10 assistant professors/, and 3 supporting staff.

Scientific degree holders are 7 members.

Currently the department reads 17 courses. Its members have authored or co-authored 6 university books and 1 monograph.

ECAD Laboratory

The Electronics Computer Aided Design (ECAD) Laboratory was founded under the TEMPUS SJEP Project 3038 in 1993. The Laboratory is a national information and training centre in the fields of Electronics and Microelectronics design, Open and Distance Learning. A substantial amount of scientific research activities, Integrated Circuits and System design, undergraduate and Ph.D. students education is carried out here. The equipment is: Sun Microsystems equipment and PCs connected to a network. The following software is being used: CADENCE and Mentor Graphics (functional and layout top-down design of Integrated Circuits), SYNOPSYS (functional design), Design Center (schematic design), OrCAD, EASY-PC (board design), ALTERA (ASIC design), XILINX, PROMIS, MINIMOS, ZOMBIE, BIPOLE, BAMBI (technological processes and device simulations), etc.

In its activity the laboratory integrates the experience and knowledge of lecturers, experts and students from the Technical University - Sofia as well as from leading scientific research and manufacturing organizations in the field of Microelectronics in Bulgaria. The laboratory is a member of several international organizations and consortiums like EUROPRACTICE, MICN etc., the activities of which are connected with the design and manufacturing in Electronics and Microelectronics.

Some of the results of the activities in the Laboratory are many designed and manufactured CMOS digital, analog and digital-analog Integrated Circuits using CMOS and BiCMOS 0.8μm and 0.35μm technologies, development and implementation of CAD systems for hybrid Integrated Circuits, management of university administration, modelling of electronic devices and processes, application software, database etc.

2.3.1 Software resources

Unique for Bulgaria software is installed and used successfully for the carrying out of the main activities. Three of the leading Microelectronics software packages in the World:

- CADENCE (for functional and layout top-down design);
- Mentor Graphics (for functional and layout top-down design)
- SYNOPSYS (for functional digital circuit design).

Detailed description of CADENCE Design Platforma.

IC package consists of the following components:**IUS 5.7/QSR2; SPMN 5.0.3**; **VMGR 1.3.1**; **CCD 6.1**; **CONFRML 6.1**; **SOC 5.2/USR3**; **EXT 5.1/USR1(5.1.1)**; **SEV 4.1/USR3(4.1.3)**; **TSI 5.2/USR2:; ASSURA3.1.5/USR1:; IC 5.1.41/ISR**; **ICC 11.2.41/USR3**; **MMSIM 6.0/ISR**; **AES 1.0**; **NEOCKT 3.3/ISR(3.3.4**; **VSDE 4.1/USR1; Systems package:; IUS 5.7/QSR2**; **SPMN 5.0.3**; **VMGR 1.3.1**,; **SPB 15.5.1/ISR**;

Combined IC and Systems package: CCD 6.1; CONFRML 6.1; **SOC 5.2/USR3; EXT 5.1/USR1(5.1.1)**; **SEV 4.1/USR3(4.1.3)**; **TSI 5.2/USR2**; **PCB Studio**:; **IUS 5.4/QSR5**.; **SPB 15.5.1/ISR**;

Optional package 1: IFV 5.7: Incisive Formal Verifier

Optional package 2:ET 3.1:, Encounter® Test Architect-XL, Diagnostics-XL, True-time Test-XL

Mentor Graphics design Platform consists of**:; Analog/Mixed-Signal (AMS) 2007.1; ADVance VCB v1.3c; Calibre 2007.2_34; Time-it 1.2_1.0; Design-for-Test v8.2007_2; HDL Designer Series 2006.1; Leonardo Spectrum 2007a; ModelSim SE 6.3a; System Vision Professional 5.0 , SystemVision Pro Overlay 5.0 ; Seamless FPGA 5.4_2007.1; Perspecta 3.2.2; 0-In V2.5d; BridgePoint 1.4.2; Board Station XE Flow 2006; BoardLink Pro v3.1** Bridges FPGA and PCB Sub-Processes; **Expedition Flow 2005 SPac3,; Hyper Lynx for Expedition Flow 7.7; Questa Codelink 3.0, Questa SV/AFV 6.3a**

SYNOPSYS Design Platform *Front End and Verification Tools (2007)* consists of: **Design Compiler Ultra**; **Physical Compiler**; **DesignVision**; **Library Compiler**; **Power Compiler**; **DFT Compiler**; **DFT Max; BSD Compiler**; **Formality**; **ESPCV**; **DesignWare**; **VCS-MX**; **Pioneer NTB**; **PrimeTime**; **PrimeTime Si**; **PrimeTime PX**; **LEDA**; **Vera**; **TetraMax**; **Nanosim**; **Nanochar; Cosmos Scope**; **PathMill**; **Milkyway**.

Detailed description of every package and tool is given in Appendix 1

2.3.2 Hardware resources

The ECAD laboratory occupies 4 rooms in 2 buildings. All computers and workstations are connected to the Internet.

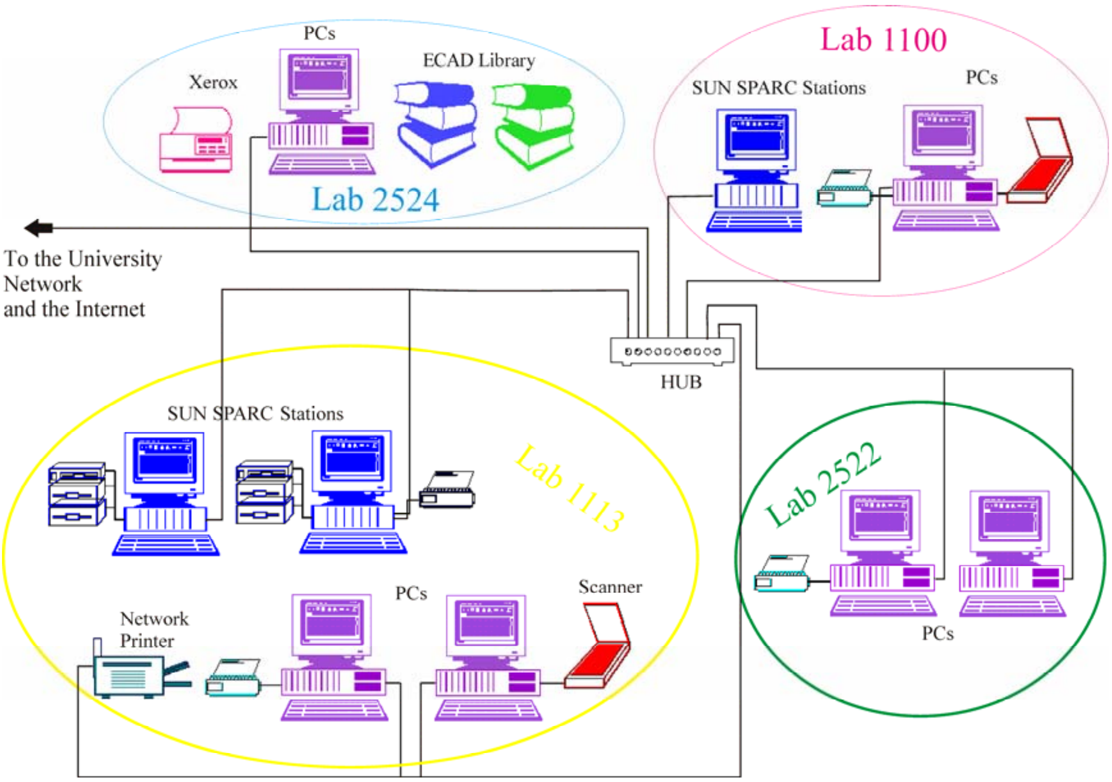

Figure 2. Network structure of ECAD.

The equipment comprises:

- SUN Fire V240 server – 2;
- SUN SPARC workstation 10/40 – 2;
- SUN SPARC workstation 4;
- SUN Ultra 5 workstation;
- SUN Blade 100 workstation – 6;
- X-terminals SUN Ray 1g – 12;
- X-terminals SUN Ray 2 – 4;
- P IV and AMD based PCs – 18;
- peripheral devices - printers, plotters, scanners, etc.

2.3.3 Human resources

The academic and supporting staff at the Faculty of Electronics amount to 81 persons. 8 of them are full professors, 26 – associated professors, 36 – assistant professors and 15 supporting technical and administrative staff. The academic staff also trains students from other engineering courses in the field of Electronics and Microelectronics at the Technical University of Sofia.

Currently there are 47 PhD students at the faculty, 25 of them are full-time and 8 - part time. 14 Ph.D. students have defended their theses during the last 5 years. There are 1200 Bachelor degree and 360 Master degree students per year.

The ECAD Laboratory has a very specific structure regarding the staff. There are 1 full-time professor, 1 full-time engineer (Laboratory and faculty System administrator and Design tools manager) and 12 PhD students.

Each specific project has a specific team which is being gathered from all departments at TUS, Bulgarian Academy of Science and industry. The team leader is usually the most experienced person in the filed in Bulgaria. The rest of the team consists of professors, associate professors, engineers, designers, PhD and Master students with the relevant knowledge and skills.

2.3.4 IP resources, technologies

There are 30 educational and 10 research laboratories at the faculty. Their activities are related to all fields of Electronics and Microelectronics.

The following is a short description only of the ECAD Lab's IP resources and technologies.

There are two fields of interests in the laboratory research activity:

- **Digital design**

ECAD Laboratory has designed and manufactured several CMOS Digital Integrated Circuits. Some examples of developed projects follow:

  - Development Of Baseband And LMP Layers In Bluetooth For General Purpose In Fuzzy Logic Devices;
  - Design Of System For Satellite Identification;
  - Design Of OFDM Based Wireless Network Modules;
  - Design Of SDI Controller;
  - Analog Lowpass Filter With FPAA Matrix;
  - Lin Protocol controller;
  - CAN Controller;
  - Digital Circuit for PWM Signals.

- **Analog Project**

The research interests are focused in the design of monolithic spiral inductors, investigation of electrical circuits and the physical implementation of power amplifiers and mixed analog-digital circuit for experimental use in educational process. Some examples follow:

  - Design, Analysis And Optimization Of Monolithic Inductors For RF Applications;
  - Artificial Neural Matrix of Analog Neurons Implemented On Standard CMOS Technology;
  - Monolithic RF Power Class DE Inverter;
  - A 1GHz, 10DBM Class E Power Amplifier;
  - Analog Transmitting Modules For Wireless Communications;
  - BiCMOS Integrated Circuit for a Phase Control;
  - Mixed Signal Circuit for Educational Purposes;

▪

2.3.5 Syllabus

IC Design students learn within the study program Electronics. The structure and syllabus of the program is illustrated in the following tables.

No	Subject	Week load					Assessment				ECTS subject code	ECTS credits
		L	Tut.	Lab.	Self study	Total	E	CA	SP	SA		
SEMESTER I												
1	Introduction into subject	1	0	0	2	3					BE01	2
2	Mathematics - I	2	1,5	0	4,5	8	1				BE02	5
3	Mathematics - II	2	1,5	0	4,5	8	1				BE03	5
4	Physics - I	2	0	1,5	3,5	7	1				BE04	4
5	Chemistry	1,5	0	1	3,5	7	1				BE05	4
6	Computing - I	1,5	0	1,5	4	7		1		1	BE06	4
7	Engineering documentation -I	1	0	1,5	3,5	5				1	BE07	3
8	Foreign language	0	2	0	3	5					BE08	3
9	Sports	0	(3)	0	0	(3)					BE09	-
	Total	**11**	**5**	**5,5**	**28,5**	**50**	**4**	**1**	**0**	**2**		**30**
SEMESTER II												
10	Mathematics - III	2	1,5	1	5,5	10	1				BE10	5
11	Physics - II	2	0	1	4	7	1				BE11	5
12	Materials science	2	0	1	4	7	1				BE12	4
13	Machines and mechanisms	2	0	1,5	4,5	8	1				BE13	5
14	Computing - II	1,5	0	1,5	4	7		1		1	BE14	5
15	Industrial Training	0	1	(2)	2	3					BE15	1
16	Engineering documentation-II	0	0	1,5	1,5	3		1		1	BE16	2
17	Foreign language	0	2	0	3	5					BE17	3
18	Sports	0	(3)	0	(3)						BE18	
	Total	**9,5**	**4,5**	**7,5**	**28,5**	**50**	**4**	**2**	**0**	**2**		**30**
SEMESTER III												
19	Mathematics - IV	2	1,5	0	5,5	9	1				BE19	5
20	Electrical Engineering - I	2	1,5	1	5,5	10	1			1	BE20	6
21	Electrical measurements	2	0	1,5	5,5	9	1				BE21	5
22	Electronics and semiconductor elements - I	3	0	2	5	10	1				BE22	6
23	Economics	1,5	1,5	0	4	7		1			BE23	5
24	Foreign language	0	2	0	3	5		1			BE24	3
25	Sports	0	(3)	0	(3)						BE25	
	Total	**10,5**	**6,5**	**4,5**	**28,5**	**50**	**4**	**2**	**0**	**1**		**30**

SEMESTER IV

26	Electrical Engineering - II	1,5	1,5	0	3	6	1				BE26	4
27	Signals and systems	2	0	1,5	4,5	8	1				BE27	5
28	Electronic circuits theory	1,5	1	1,5	5	9	1			1	BE28	5
29	Automatic Control Theory	1,5	1,5	0	4	7		1			BE29	4
30	Analogue circuits I	2	1	1,5	5,5	10	1		1		BE30	6
31	Electronics and semiconductor elements - II	1,5	0	1	3,5	6		1			BE31	4
32	Foreign language	0	2	0	2	4					BE32	2
33	Sports	0	(3)	0	(3)						BE33	
	Total	**10**	**7**	**5,5**	**27,5**	**50**	**4**	**2**	**1**	**0**		**30**

SEMESTER V

34	Analogue circuits - II	1,5	1	1	4,5	8	1				BE34	5
35	Switching circuits design	1,5	1	1,5	5	9		1			BE35	5
36	Digital electronics	2	1	1,5	5	9,5	1				BE36	6
37	Power supply devices	2	1	1,5	5	9,5	1			1	BE37	6
38	Electronic measurements	2	0	2	5	9	1			1	BE38	5
39	Computer architectures	1,5	0	1	2,5	5		1			BE39	3
40	Introduction to Internet*	(1,5)	0	(1,5)		(3)	(1)				BE40	0
	Total	**10,5**	**4**	**8,5**	**27**	**50**	**4**	**2**	**0**	**2**		**30**

* Facultative learned object

SEMESTER VI

41	Microprocessor circuits design	2	1	1,5	5	9,5	1		1		BE41	6
42	Computer aided design in electronics	2	0	1,5	4,5	8	1				BE42	5
43	Converters	2	0	2	4,5	8,5	1				BE43	6
44	Design and technology of electronic equipment	2	0	1,5	4,5	8	1				BE44	4
45	Quality and reliability of electronic equipment	1,5	1	1	4,5	8		1			BE45	4
46	Technical Safety	1,5	0	1	2,5	5		1			BE46	3
47	Practicum in circuit design	0	0	1,5	2,5	4					BE47	2
	Total	**11**	**2**	**10**	**27**	**50**	**4**	**2**	**1**	**0**		**30**

* One TA should be chosen

SEMESTER VII

48	Microelectronics	1,5	0	1,5	3	6		1		1*	BE48	4
49	Electronic regulators	2	0	1,5	3,5	7	1				BE49	4
50	Electromechanical devices	1,5	0	1,5	3	6		1			BE50	4
51	Industrial Training	0	0	1,5	1,5	3			1		BE51	1
TP	Course project – common to subjects of respective direction				1	1					BEKP	1
	Subjects – lists 2a, 2b, 2c or 2d											
52	Optional subject № 1	2	0	1,5	4,5	8	1				BE52	5
53	Optional subject № 2	2	0	1,5	4,5	8	1				BE53	5
54	Optional subject № 3	2	0	1,5	4,5	8	1				BE54	5
55	Research	0	0	1,5	1,5	3					BE55	1
	Total	**11**	**0**	**12**	**27**	**50**	**4**	**2**	**1**	**1**		**30**

SEMESTER VIII (ten weeks)

No	SUBJECT	L	Tut.	Lab.	Self study	Total	E	CA	SP	SA	ESTS subject code	ECTS credits
57	Electronic manufacturing automation	2	0	2	5	9	1				BE57	4
58	Communication systems	2	0	2	4	8	1				BE58	3
59	Optional subject - list 1	3	2*	2*	5	10		1			BE59	4
60	Course project in the subject				3	3			1		BE60	1
	Subjects – lists 3a, 3b, 3c or 3d											
61	Optional subject № 1	3	0	2	5	10		1			BE61	4
62	Optional subject № 2	3	0	2	5	10		1			BE62	4
63	Diploma project										BE63	10
	Total	**13**	**2***	**8+2***	**27**	**50**	**2**	**3**	**1**	**0**		**30**

* Seminars or Labs training

Master studies

No	SUBJECT	Week Load					Assessment				ESTS subject code	ECTS credits
		L	Tut.	Lab.	Self study	Total	E	CA	SP	SA		
	SEMESTER I											
1	Mathematical Methods for Digital Processing	1,5	1,5	0	5	8		1			ME01	5
2	Mathematical Methods for Digital Processing	2	0	1,5	5,5	9	1				ME02	6
3	Design Systems in Microelectronics	2	0	1,5	5,5	9	1		1		ME03	6
4	Electronic Power Transformers	2	0	1,5	5,5	9	1				ME04	6
5	Applied Electronics Circuits and Devices	2	0	1,5	5,5	9	1			1	ME05	6
6	Specializing training I	0	0	2	4	6					ME06	1
	Total	**9,5**	**1,5**	**8**	**31**	**50**	**4**	**1**	**1**	**1**		**30**
	SEMESTER II											
7	Embedded System Programming	1,5	1,5	0	5	9	1				ME07	5
	Obligatory specialized group subjects A, B, C or D from list 1											
8	Obligatory specialized discipline No 1	2	0	1,5	5,5	9	1			1	ME08	5
9	Obligatory specialized discipline No 2	2	0	1,5	5,5	9		1			ME09	5
10	Obligatory specialized discipline No 3	2	0	1,5	5,5	9	1				ME10	5
*	Term project – common to subjects of respective direction				2	2				1	MEKP	2
	Elective group subjects – list 2											
11	Elective discipline from list 2	2	0	1,5	4,5	9	1				ME11	5
12	Specializing training II	0	0	2	2	4					ME12	3
	Total	**9,5**	**1,5**	**8**	**31**	**50**	**4**	**1**	**0**	**2**		**30**

Detailed content of courses related to IC Design is given in Appendix 2.

2.4 Recapitulation

Analysis of the current state in all three institutions shows very good matching in all crucial aspects:

- Software resources
- hardware resources and
- syllabus.

Arguing this we will give a brief comparison in these three aspects.

2.4.1 Software resources

Although it is not quite appropriate to express software resources only by the number showing quantity of items, it is the easiest way to get a quick view on software resources.

The following Table shows the number of software items from different software providers in each institution.

	LEDA	MCS	ECAD
Cadence	0	0	18
Mentor Graphics	17	0	21
Synopsys	0	70	15

Actually, ECAD laboratory was (and still is) the best equipped. It has software tools from three leading tool providers. The tools cover full custom, semicustom and FPGA design flows for digital, analog and mixed-signal circuits.

MCS is completely supported by Synopsys for all design styles.

LEDA is equipped by Mentor Graphics design tools within Higher Education Program that covers full custom and semicustom design using ASIC Design Kit that offers few CMOS technologies.

As one can see at the beginning of the project the matching in software was relatively poor. Therefore this aspect should be improved in the future. During our first meeting this was highlighted and LEDA partner assets founds from this project in buying license for Cadence IC Package, as given in the financial part of this Report.

After this intervention our matching was improved, as the following Table shows.

	LEDA	MCS	ECAD
Cadence	19	0	18
Mentor Graphics	17	0	21
Synopsys	0	70	15

It is important to stress that the cooperation between Design Centers depends more on data format than on tools. Therefore, as far as we are able to interchange data (VHDL description, GDSII files, etc) our collaboration is not jeopardized.

Detailed insight into particular design tools for each participant is given in Appendix 1.

In the future we should keep tracking world trends in design tool development. The best way is through direct cooperation with providers as MCS has with Synopsys.

2.4.2 Hardware resources

At the moment, hardware resources meet the requirements for IC Design training at all three participants. However one should aware that today technology lifetime of hardware is less than three years for PCs without any indication that it will be greater soon. New software releases are greedy for hardware requires and there is a permanent need for hardware upgrading. Therefore, maintaining achieved hardware resources should be the primary task for all three institutions in the future.

2.4.3 Syllabus

At the beginning of the project the structure of studies at University of Niš, Faculty of Electronic Engineering was established quite different to all neighbor Schools of Electrical Engineering, including Belgrade and Novi Sad Universities in Serbia. Actually the bachelor studies lasted six semesters in three years, and master lasted four semesters in two school years. Other neighbor universities, including TU Sofia, have eight semesters at bachelor and two (or two and a half) at master level. Although all students graduate after five years, there was a problem in student transfer from bachelor to master degree. Therefore, during the last six months an effort was made to reorganize study program at Faculty of Electronic Engineering in Niš in order to harmonize syllabuses with TU Sofia and State Engineering University of Armenia.

Now, we can conclude that matching is almost excellent. Syllabus comparison shows that all universities have similar curricula. All have general subjects in first 2-3 semesters and afterwards offers courses that have almost the same titles and, more important, very similar contents. Namely, students learn basics of:

- electronics (analogue, digital, power, RF)
- CMOS technology
- Design techniques and styles

Obviously students from all three institutions have common knowledge about properties, function, structure and layout of combinational and sequential digital logic cells, amplifiers, filters and mixed-signal circuits. Besides, they consider electronic modules at higher level as microcontrollers and microprocessors.

Students learn CMOS fabrication process, because of its dominating role in contemporary microelectronics. During the studies they realize connection between masks and layout process in order to understand how transistor level design affects physical characteristics of designed circuits. This helps them to identify signification of physical design rules.

It is important that students in all three institutions learn design flows for ASIC and SASIC design. Namely they gain knowledge of

- full custom design,
- cell based semicustom design and
- FPGA based design.

For building network of IC Design teaching centres it is very important that students are able to use VHDL for design entry. Actually, this ability gives them potential to work on common projects.

As presented in Appendix 2, courses provide students skills to use hardware description language, transistor level simulation tools, logic level simulators, logic synthesis tools, tools for DFT and, generally speaking to use one of three leading design platforms (Appendix 1).

Although we expected at the beginning that syllabus harmonization should be the hardest part of the project, the analysis of the current state showed that matching in sufficient to establish direct cooperation. In the future it is necessary to coordinate development of courses in order to retain compatibility.

3 SWOT Analysis of building Network of Integrated Circuit in BSEC Region

3.1 Strength

There was well developed electronic and microelectronic industry in Bulgaria, former Yugoslavia and Armenia 15 years ago. Regarding to that, a large number of well-educated and experienced people were involved. The level of their competencies was very high. Strong theoretical and practical experience has been accumulated at the respective faculties in the universities. Some of those people were re-qualified, other went abroad, but a substantial part of them is still in the countries. The usage of that human and intellectual potential is of great importance for the development of IT technologies in the countries. Connections with our colleagues that work in design centers around the word are still strong. They are willing to help and experience shows that their advices are very useful. The number of analog designers in the word decreases in last decade. Designing is mainly shifted from circuits toward systems. The lack of analog designers gives us the chance to take part in analog and mixed-signal IC design projects. Additional advantage for building design center in Black Sea region is relatively small salaries. As far as we know there are enough highly motivated people from universities and research organizations willing to revive those activities.

3.2 Weakness

Local industry is not developed enough in Black Sea region. Moreover, there is no true state policy for financial support and development in this area. On the other hand the size of the countries in scope of potential IT market is not enough to attract interest of big investors to setup big industrial units.

3.3 Opportunities

Deigning ICs is not connected physically for fabrication. It can be done separately far away from foundry. This means that designing can be done in Black Sea region countries. Profit margin in ICT industry decreases. From the other hand fixed costs related to mask fabrication in submicron CMOS get higher with every technology generation (it is higher than $4 million). The most obvious way to decrease fixed costs is to reduce design cost and the easiest way is to employ designer who cost less. As is well known, salaries in the region are far below those in developed EU countries. Therefore, one may expect interest of IC design companies to invest into Black Sea Region in the future. This opportunity should wait well prepared – namely with well trained and skilled designers.

FP7 and recognized South-East Europe as European Research Area (SEE-ERA) offer to Black Sea region help to approach to European founds. Therefore it is of crucial importance to to strengthen links with similar faculties, laboratories and research laboratories in Europe, Balkan region and widely.

Other sources faced toward education like Tempus, Maria Curie are open and should be studied in details.

3.4 Treats

As government institutions all three participants are vitally related to found coming from state government. However interest of students for electronics decreases because there is no supporting factory in the region. Besides, the interest for circuit level design within electronics is shifted to system level design. Therefore, the small number of students together with lost filling about importance of having national design team could affect to lost support of local government (Ministry of science and/or Ministry of education). Unstable political situation in Serbia and recently in Armenia can jeopardize cooperation with EU design centers and universities. Rebuilding such connection is difficult especially without serious financial support.

4 Recommendations for required modifications within every center

4.1 Recommendations for Faculty of Electronic Engineering, University of Nis

- As the new curriculum is just established, it is necessary to find partners capable to evaluate it. In that sense we need both industrial and university partners that are qualified and experienced to make expertise of course content, teaching methods and marking system.
- Motivate students for IC circuit design. First they have to find inspiration working more on practical than on academic examples. Second, they should see their own perspective in getting job and opportunity to make for living working on jobs they like. In that scope collaboration with other design centers is decisive.
- Motivate teachers to update courses and to keep track with new trends in IC design.
- Call design companies (HDL Design, Elsys in Serbia), foundries (AMIS) and design tool providers (Mentor Graphics, Cadence Synopsys) to give presentations of their products at the Faculty.

4.2 Recommendations for Interdepartmental Chair of "Microelectronic Circuits and Systems" (MCS) of State Engineering University of Armenia

- Tightly cooperate with similar filed oriented Universities in the region and the country. Exchange of curriculum, knowledge and experience, exchange of students, professors, designers and post doctorate young engineers.
- Update of the existing curricula and syllabus of Bachelor and Master Programs to meet the requirements of contemporary Low Power Design techniques for 90nm and below technologies.
- Continuous maintenance, update and upgrade of the existing software and hardware.
- Organization of microelectronics related Olympiads, other competitions of that kind to discover young, talented engineers; increase interest in microelectronics among Armenia's youth; and identify necessary improvements in educational programs.

4.3 Recommendations for Faculty of Electronics, Technical University of Sofia

- To strengthen links with similar faculties and laboratories in the Black Sea region and neighbouring countries. Establishment of cooperation and contracts for collaboration in the field of education and research area. Exchange of information, knowledge and experience, activities for preparation of new European project proposals. Exchange of students, professors, designers and post doctorate young engineers;

- Activities for development and establishment of a new common Master international program in the field of microelectronic design. Official recognition of diplomas and/or certificates by other partners;
- Inventory of the existing curricula and subjects' contents of Bachelor and Master Degree courses at the Faculty of electronics, TUS. Proposal for new update curricula, subjects' contents, project, industrial practice, etc. Initialisation of a procedure for official approval of the changes/updates by university authorities;

4.4 Recommendations for all three partners

- Continuous maintenance, update and upgrade of the existing software and hardware. Activities for raising additional funds for those activities.
- Searching for possibilities for defining and setting up joint research projects among Interdepartmental Chair of "Microelectronic Circuits and Systems" (MCS) of State Engineering University of Armenia, LEDA Laboratory, Faculty of Electronic Engineering, University of Niš and the ECAD Laboratory, Faculty of Electronics, Technical University of Sofia;
- Establish cooperation and contracts for collaboration in the field of education and research area with surrounding universities.
- Permanent advices to official state authorities for development of national programmes in the fields of Microelectronics and IT technologies to raise cooperation and contracts for collaboration in the field to interstate level. Active spreading ideas given in Opportunities section 3.3 to local authorities.
- The exchange of students, professors, designers and post doctorate young engineers is also of crucial importance. Therefore we have motivate design companies, foundries and design tools providers to support common seminars, student competitions, to give themes for diploma theses.

5 Financial part

Expenses occurred during the period:

Participannt from Serbia

Institution	Type of expenses	Amount (local currency)	Amount in USD on day of payment
Faculty of electronic Engineering, LEDA	EUROPRACTICE Full IC Subscription 2007/2008 Software Service Membership	600.00 EUR	816.27
	EUROPRACTICE Full IC Subscription 2007/2008 Hardware Service Membership	500.00 EUR	680.23
	Cadence IC Package	990.00 EUR	1346.85
	IC Package option	150.00 EUR	204.07
	Travel to Sozopol - meeting with Prof. Marin Hristov		
	Rent-a-car	14,112.80 RSD	254.59
	Hotel BB	135.00 BGN	96.43
	Conference Fee	60.00 EUR	84.82
	Insurance fee	569.00 RSD	9.97
	Fuel 1	3500.00 RSD	63.14
	Fuel 2	79.01 BGN	56.95
	Per Diems	4164.14 RSD	77.50
	Other expenses		
	Bank currency transfer expenses	2001.05 RSD	37.24
	Faculty of Electronic Engineering, University of Nis provision	21670.72 RSD	403.32
	Total*		**4131.38 USD**

Remarks:

- Currency conversion rates calculated according to http://www.oanda.com/convert/classic and to rate of National Bank of Serbia http://www.nbs.yu/internet/cirilica/scripts/ondate.html at dates as given in invoices that are attached in file NICDTC_Interim Report A3.pdf.

Participant from Armenia had no expenses in this period.

Participannt from Bulgaria

Institution	Type of expenses	Amount (local currency)	Amount in USD on day of payment
Faculty of Electronics, Technical University of Sofia, ECAD	EUROPRACTICE Full IC Subscription 2007/2008 including Software Only membership (invoice No. 24174)	500 EUR[1]	683.19 USD
	EUROPRACTICE Full IC Subscription 2007/2008 including IC Design kit(invoice No. 24174)	500 EUR[2]	686.45 USD
	EUROPRACTICE Full IC Subscription 2007/2008 including Software Only membership – additional fee (invoice No. 25291)	100 EUR[3]	144.79 USD
	Total		**1514.43 USD**

Remarks:

The conversion rates EUR/BGN and USD/BGN on the payment dates in Bulgaria are as follows:

[1] 1 August 2007 – 1 EUR = 1.95583 BGN, 1 USD = 1.4314 BGN;

[2] 8 August 2007 – 1 EUR = 1.95583 BGN, 1 USD = 1.4246 BGN;

[3] 2 November 2007 – 1 EUR = 1.95583 BGN, 1 USD = 1.3508 BGN;

Explanation of payment: The EUROPRACTICE Full IC Subscription 2007/2008 payment was carried in three parts:

- payment of 500 EUR in respect to invoice No 24174 on 1 August 2007;
- payment of 500 EUR in respect to invoice No 24174 on 8 August 2007;
- payment of 100 EUR in respect to invoice No 24174 on 2 November 2007;

Scanned invoices are collected in file NICDTC_Interim Report A3.pdf and attached as a part of this Report.

Hard copies of all invoices will be sent on request.