Follow-up Courses
ECE Department

 Programs

MS in Electrical Engineering
MS EE

- Communications & Networking
- Signal Processing
- Control & Robotics
- Microelectronics/Nanoelectronics
- System Design
- Bioengineering

MS in Computer Engineering
MS CpE

- Digital Systems Design
- Microprocessors & Embedded Systems
- Computer Networks
- Network & System Security

Specializations
Concentration advisors: Kris Gaj

1. **ECE 545 Digital System Design with VHDL**
   - K. Gaj, project, FPGA design with VHDL, Aldec/Synplicity/Xilinx/Altera

2. **ECE 645 Computer Arithmetic**
   - K. Gaj, project, FPGA design with VHDL or Verilog, Aldec/Synplicity/Xilinx/Altera

3. **ECE 586 Digital Integrated Circuits**
   - D. Ioannou

4. **ECE 681 VLSI Design for ASICs**
   - T.K. Ramesh, project/lab, front-end and back-end ASIC design with Synopsys tools

5. **ECE 682 VLSI Test Concepts**
   - T. Storey, homework
Possible New Graduate Computer Engineering Courses

• 5xx Digital System Design with Verilog
• 6xx Digital Signal Processing Hardware Architectures
• 6xx Reconfigurable Computing

(looking for instructors)
NETWORK AND SYSTEM SECURITY

Concentration advisors: Jens-Peter Kaps, Kris Gaj

1. **ECE 542 Computer Network Architectures and Protocols**
   – S.-C. Chang, et al.

2. **ECE 646 Cryptography and Computer Network Security**
   – K. Gaj, J-P. Kaps – lab, project: software/hardware/analytical

3. **ECE 746 Advanced Applied Cryptography**
   – K. Gaj, J-P. Kaps – lab, project: software/hardware/analytical

4. **ECE 699 Cryptographic Engineering**
   – J-P. Kaps – lectures + student/invited guests seminars

5. **ECE 699 Ubiquitous Computing** aka **Advanced User Interfaces and Ambient Intelligence**
   – J-P. Kaps, J-P. Sousa – lectures + student seminars

6. **ISA 656 Network Security**
   – A. Stavrou
ECE 645
Computer Arithmetic

Instructor: Dr. Kris Gaj
Advanced digital circuit design course covering

Efficient architectures for
- addition and subtraction
- multiplication
- division and modular reduction
- exponentiation

Integers
- unsigned and signed

Real numbers
- fixed point
- single and double precision floating point

Elements of the Galois field GF($2^n$)
- polynomial base
Course Objectives

At the end of this course you should be able to:

• Understand mathematical and gate-level algorithms for computer addition, subtraction, multiplication, division, and exponentiation
• Understand tradeoffs involved with different arithmetic architectures between performance, area, latency, scalability, etc.
• Synthesize and implement computer arithmetic blocks on FPGAs
• Be comfortable with different number systems, and have familiarity with floating-point and Galois field arithmetic for future study
• Understand sources of error in computer arithmetic and basics of error analysis

This knowledge will come about through homework, projects and practice exams.
Lecture topics

INTRODUCTION

1. Applications of computer arithmetic algorithms. Initial Discussion of Project Topics.
ADDITION AND SUBTRACTION

1. Basic addition, subtraction, and counting

2. Carry-lookahead, carry-select, and hybrid adders

3. Adders based on Parallel Prefix Networks
MULTIOPERAND ADDITION

1. Carry-save adders

2. Wallace and Dadda Trees

3. Adding multiple unsigned and signed numbers
TECHNOLOGY

1. Internal Structure of Xilinx and Altera FPGAs
2. Two-operand and multi-operand addition in FPGAs
3. Pipelining
NUMBER REPRESENTATIONS

• Unsigned Integers
• Signed Integers
• Fixed-point real numbers
• Floating-point real numbers
• Elements of the Galois Field GF(2^n)
LONG INTEGER ARITHMETIC

1. Modular Exponentiation

2. Montgomery Multipliers and Exponentiation Units
MULTIPLICATION

1. Tree and array multipliers

2. Sequential multipliers

3. Multiplication of signed numbers and squaring
TECHNOLOGY

Multiplication in Xilinx and Altera FPGAs
- using distributed logic
- using embedded multipliers
- using DSP blocks
DIVISION

1. Basic restoring and non-restoring sequential dividers

2. SRT and high-radix dividers

3. Array dividers
FLOATING POINT
AND
GALOIS FIELD ARITHMETIC

1. Floating-point units

2. Galois Field GF(2^n) units
Broad introduction to basic concepts, techniques, and tools of modern VLSI testing. Fundamentals of defect modeling, fault simulation, design for testability, built-in self-test techniques, and failure analysis. Test economics, physical defects and fault modeling, automated test pattern generation, fault simulation, design for test, built-in self test, memory test, PLD test, mixed-signal test, Iddq test, boundary scan and related standards, test synthesis, diagnosis and failure analysis, automated test equipment, embedded core test.
Essentials of Electronic Testing
For Digital, Memory & Mixed-Signal VLSI Circuits

Michael L. Bushnell
Vishwani D. Agrawal
<table>
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<th>Course Topics</th>
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<tr>
<td>Introduction to Test Methods, Test Equipment, and the Economics of Test</td>
</tr>
<tr>
<td>Logic Test Generation</td>
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<tr>
<td>Memory Test</td>
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<tr>
<td>Advanced Testing Methods</td>
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Course Changes

• New Text
  – Updated to reflect advances in state of the art
  – Covers a broader range of test topics
  – More engaging text, figures

• Course Content
  – Redone to reflect textbook change
  – Added developments since text was written
  – More emphasis on industry examples/war stories