EE563 – Digital Signal Processing using FPGAs

Course Overview

The course will present and examine the use of FPGAs for DSP algorithms, applications, and architecture. The course will feature the entire software design flow from concept, to bit true simulation, to actual hardware implementation. The course projects and lab work will focus on applications in radar and Electronic Warfare (EW) applications.

Perquisites

GEF/EEE250 and GEF/EEE350 or equivalent experience.

Course Outline

1. Introduction to DSP and FPGA hardware technologies
2. DSP arithmetic
3. FIR and IIR digital filters
4. Multirate signal processing
5. Fourier transforms
6. Adaptive filters
7. Advanced topics

Evaluation Scheme

- Assignments/Labs – 40 %
- Research Project – 30 %
- Hardware Project – 30 %

Target Device

Xilinx Kintex-7 FPGA DSP Development Kit

References

[1] Meyer-Baese, U., *Digital Signal Processing with Field Programmable Gate Arrays*, Springer, 2007.

[2] Wood, R., McAllister, J., Lightbody, G., and Ying, Y., *FPGA-based Implementation of Signal Processing Systems*, Wiley, 2008.

[3] Kilts, S., *Advanced FPGA Design: Architecture, Implementation, and Optimization*, Wiley, 2007.

	Objective	Details	References	Status
Week 1	FPGA/VHDL Review	Course introduction and review of necessary material	EEE350 Course Notes FPGA Prototyping by VHDL Examples	
Week 2	Introduction to DSP Hardware Technologies	DSP cores and processors, custom/semi-custom ASIC, SoC, FPGAs vs programmable DSPs	[1] Chapter 1 [3] Chapter 8	
Week 3	FGPA Technology	The Xilinx Kintex-7 FPGA development board		
Week 4	DSP Arithmetic Fundamentals	Fixed point arithmetic, adder and multiplier arrays, word length issues, overflow and underflow	[1] Chapter 2	
Week 5	FIR Digital Filters	FIR theory, design, and implementation	[1] Chapter 3	
Week 6	IIR Digital Filters	Theory, computation, implementation, finite word length effects, fast IIR filters	[1] Chapter 4	
Week 7	Multirate Signal Processing I	Decimation, Interpolation, polyphase decomposition, CIC filters	[1] Chapter 5	
Week 8	Multirate Signal Processing II	Multi-stage decimator, arbitrary sampling rate convertors, filter banks, wavelets	[1] Chapter 5	
Week 9	Fourier Transforms	FFT algorithms, Fourier related algorithms	[1] Chapter 6	
Week 10	Adaptive Filters	Optimum estimation techniques, implementation of the LMS algorithm, recursive least square algorithms, beam forming	[1] Chapter 8 [2] Chapter 12	
Week 11	Advanced Topics	Rectangular and number theoretic transforms, error control, cryptography, modulation, demodulation	[1] Chapter 7	
Week 12	Review/Presentations			

EEE563 – Student Learning Plan

The scheme of maneuver for this course is based on a progressive learning plan, building skills in FPGA implementation while educating you in DSP. You will then examine the state of the art in an area of DSP, and implement a novel system on an FPGA.

Assignments and Labs

- FPGA / VHDL review
- FIR filter implementation
- IIR numerical oscillator
- FFT implementation
- Wigner-Ville distribution implementation

Research Project

All students must complete a literature survey of a DSP topic, preferably with a focus on radar and EW applications.

Hardware Project

After completing their literature survey, students must then implement on an FPGA development board a discussed in their literature survey.