

VLSI-DSP for the ASIC and FPGA Engineer

Course Description

Many applications in today's technological world require fast DSP processing. Anything from physical layer processing in communication infrastructure to extraordinary image and sound processing in medical equipment. DSP is a unique area in VLSI design. There are many ways to implement the same DSP algorithm, though the efficient implementation may not be so obvious and would usually require particular expertise. The course introduces important basic concepts in DSP designing, surveys a variety of structures and advanced DSP implementations in VLSI.

The course is largely based on examples and relevant hands-on analytical exercises.

Level: Intermediate

Training Duration: 3 days

Who Should Attend?

Hardware design engineers (ASIC/FPGA)

Prerequisites:

- Thorough knowledge in digital circuits design
- Basic knowledge in digital signal processing

Course Outline

1. Introduction

- What is DSP?
- Sampling Theory (Nyquist)
 - Nyquist
 - Sampling rate
 - Bit width
- DSP building blocks
- Representing a DSP algorithm

2. Basic Arithmetic

- Number systems and representations
 - Floating point
 - Fixed point
 - Signed/unsigned
 - Representing fractions
- Arithmetic operations
 - Addition
 - Addition trees and chains accumulation
 - Multiplication
- Fixed point operations
 - Quantization
 - Overflow

3. Basic Filters

- Convolution and correlation
- IIR
 - Direct form I and II
 - Transposed form
 - Quantization & overflow
- FIR
 - Direct form I and II
 - Transposed form
 - GLP
 - Symmetry
 - Throughput & processing rate
 - MAC
 - Adaptive filters
- Multirate
 - Up sampling
 - Down sampling
 - Interpolation
 - Decimation
 - Polyphase
 - Half band
 - Multi stage
 - Filter banks
 - Multi-channel processing
 - Block processing

4. Scaling and Roundoff Noise

- State-variable description
- Noise computation
 - Scaling
 - Roundoff

5. Advanced Arithmetic

- Bit-level arithmetic
 - Multiplication (carry ripple, carry save, baugh-wooley, booth, CSD, Horner)
 - Distributed arithmetic
- Numerical strength reduction
 - Subexpression elimination
 - MCM
 - Subexpression sharing
 - CSD common subexpressions

6. Advanced Filtering

- Pipelining and parallel in FIR
- Retiming
 - Cutsets (FIR)
 - Systematic retiming for systems with cycles (period and register minimizations)
- Folding
 - Register minimization (lifetime analysis)
- Fast convolution
 - Cook Toom
- Fast FIR algorithms
 - Polyphase
- Pipelining IIR

7. Applications (optional)

- Matrix transpose
 - Using memories
- NCO
 - Dithering, Taylor correction
- CVI
 - Chebychef polynomials
 - Farrow structure
- FFT
 - DIT, DIF, fixed point issues