

Vlsi Digital Signal Processing Systems Design And Implementation

The main objective of our research is the study of new algorithms and implementations suitable for VLSI. A primary assumption in this research is that algorithms must match the available computational resources in order to obtain efficient algorithms. The starting point is not the algorithm for a specific class of digital processing problems; the starting point is the resource available for computing. The characteristics of this resource dictate what will be effective and efficient. VLSI technology presents digital signal processing with a unique environment with special qualities not heretofore used in computation. Each class of processing problems coupled with VLSI technology requires new algorithms for effective use of VLSI chips. Thus, our research has considered several classes of problems and various algorithms for each class. We have also considered certain theoretical problems associated with the representation of processing systems. The reason alternate representations are important is that they suggest new and more general methods of uniting different processing tasks.

Top-down approach to practical, tool-independent, digital circuit design, reflecting how circuits are designed.

This is the only book that offers a thorough treatment of the following: design and application of programmable digital signal processors; formal specification and optimization of signal processing architectures and circuits; high-level synthesis of DSP architectures and datapaths; detailed treatment of application-specific integrated circuits (ASICs); scheduling, allocation and assignment algorithms for multiple processor DSP systems; and hardware/software co-design issues in DSP. VLSI Digital Signal Processors: An Introduction to Rapid Prototyping and Design Synthesis provides a cohesive, quantitative and clear exposition of the implementation and prototyping of digital signal processing algorithms on programmable signal processors, parallel processing systems and application-specific ICs. Included are both programmable and dedicated digital signal processors, and discussions of the latest optimization methods and the use of computer-aided-design techniques.

This book is the first in a set of forthcoming books focussed on state-of-the-art development in the VLSI Signal Processing area. It is a response to the tremendous research activities taking place in that field. These activities have been driven by two factors: the dramatic increase in demand for high speed signal processing, especially in consumer electronics, and the evolving microelectronic technologies. The available technology has always been one of the main factors in determining algorithms, architectures, and design strategies to be followed. With every new technology, signal processing systems go through many changes in concepts, design methods, and implementation. The goal of this book is to introduce the reader to the main features of VLSI Signal Processing and the ongoing developments in this area. The

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focus of this book is on:

- Current developments in Digital Signal Processing (DSP) processors and architectures - several examples and case studies of existing DSP chips are discussed in Chapter 1.
- Features and requirements of image and video signal processing architectures - both applications specific integrated circuits (ASICs) and programmable image processors are studied in Chapter 2.
- New market areas for signal processing - especially in consumer electronics such as multimedia, teleconferencing, and movie on demand.
- Impact of arithmetic circuitry on the performance of DSP processors - several topics are discussed in Chapter 3 such as: number representation, arithmetic algorithms and circuits, and implementation.

Addresses a wide selection of multimedia applications, programmable and custom architectures for the implementations of multimedia systems, and arithmetic architectures and design methodologies. The book covers recent applications of digital signal processing algorithms in multimedia, presents high-speed and low-priority binary and finite field arithmetic architectures, details VHDL-based implementation approaches, and more.

Over the past few years, the demand for high speed Digital Signal Processing (DSP) has increased dramatically. New applications in real-time image processing, satellite communications, radar signal processing, pattern recognition, and real-time signal detection and estimation require major improvements at several levels; algorithmic, architectural, and implementation. These performance requirements can be achieved by employing parallel processing at all levels. Very Large Scale Integration (VLSI) technology supports and provides a good avenue for parallelism. Parallelism offers efficient solutions to several problems which can arise in VLSI DSP architectures such as:

1. Intermediate data communication and routing: several DSP algorithms, such as FFT, involve excessive data routing and reordering. Parallelism is an efficient mechanism to minimize the silicon cost and speed up the processing time of the intermediate middle stages.
2. Complex DSP applications: the required computation is almost doubled. Parallelism will allow two similar channels processing at the same time. The communication between the two channels has to be minimized.
3. Application specific systems: this emerging approach should achieve real-time performance in a cost-effective way.
4. Testability and fault tolerance: reliability has become a required feature in most of DSP systems. To achieve such property, the involved time overhead is significant. Parallelism may be the solution to maintain acceptable speed performance.

This book comprises selected peer-reviewed papers from the International Conference on VLSI, Signal Processing, Power Systems, Illumination and Lighting Control, Communication and Embedded Systems (VSPICE-2019). The contents are divided into five broad topics - VLSI and embedded systems, signal processing, power systems, illumination and control, and communication and networking. The book focuses on the latest innovations, trends, and challenges encountered in the different areas of electronics and communication, and electrical engineering. It also offers potential solutions and provides an insight into various emerging areas such as image fusion, bio-sensors, and underwater sensor networks. This book can prove to be useful for academics and professionals interested in the various sub-fields of electronics and communication engineering.

Digital signal processing lies at the heart of the communications revolution and is an essential element of key technologies such as mobile phones and the Internet. This book covers all the major topics in digital signal processing (DSP) design and analysis, supported by MatLab

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examples and other modelling techniques. The authors explain clearly and concisely why and how to use digital signal processing systems; how to approximate a desired transfer function characteristic using polynomials and ratio of polynomials; why an appropriate mapping of a transfer function on to a suitable structure is important for practical applications; and how to analyse, represent and explore the trade-off between time and frequency representation of signals. An ideal textbook for students, it will also be a useful reference for engineers working on the development of signal processing systems.

This volume on implementation techniques in digital signal processing systems clearly reveals the significance and power of the techniques that are available, and with further development, the essential role they will play as applied to a wide variety of areas. The authors are all to highly commended for their splendid contributions to this volume, which will provide a significant and unique international reference source for students, research workers, practicing engineers, and others for years to come.

Digital Signal Processing (DSP) is a term encompassing a variety of techniques for transforming digital samples of analog signals into samples of analog signals having more desirable characteristics. This paper is concerned only with DSP techniques which involve arithmetic in the usual sense, i.e., addition, multiplication, etc.

Digital audio, speech recognition, cable modems, radar, high-definition television-these are but a few of the modern computer and communications applications relying on digital signal processing (DSP) and the attendant application-specific integrated circuits (ASICs). As information-age industries constantly reinvent ASIC chips for lower power consumption and higher efficiency, there is a growing need for designers who are current and fluent in VLSI design methodologies for DSP. Enter VLSI Digital Signal Processing Systems-a unique, comprehensive guide to performance optimization techniques in VLSI signal processing. Based on Keshab Parhi's highly respected and popular graduate-level courses, this volume is destined to become the standard text and reference in the field. This text integrates VLSI architecture theory and algorithms, addresses various architectures at the implementation level, and presents several approaches to analysis, estimation, and reduction of power consumption. Throughout this book, Dr. Parhi explains how to design high-speed, low-area, and low-power VLSI systems for a broad range of DSP applications. He covers pipelining extensively as well as numerous other techniques, from parallel processing to scaling and roundoff noise computation. Readers are shown how to apply all techniques to improve implementations of several DSP algorithms, using both ASICs and off-the-shelf programmable digital signal processors. The book features hundreds of graphs illustrating the various DSP algorithms, examples based on digital filters and transforms clarifying key concepts, and interesting end-of-chapter exercises that help match techniques with applications. In addition, the abundance of readily available techniques makes this an extremely useful resource for designers of DSP systems in wired, wireless, or multimedia communications. The material can be easily adopted in new courses on either VLSI digital signal processing architectures or high-performance VLSI system design. An invaluable reference and practical guide to VLSI digital signal processing. A tremendous source of optimization techniques indispensable in modern VLSI signal processing, VLSI Digital Signal Processing Systems promises to become the standard in the field. It offers a rich training ground for students of VLSI design for digital signal processing and provides immediate access to state-of-the-art, proven techniques for designers of DSP applications-in wired, wireless, or multimedia communications. Topics include: * Transformations for high speed using pipelining, retiming, and parallel processing techniques * Power reduction transformations for supply voltage reduction as well as for strength or capacitance reduction * Area reduction using folding techniques * Strategies for arithmetic implementation * Synchronous, wave, and asynchronous pipelining * Design of programmable DSPs. An Instructor's Manual presenting detailed solutions to all the problems in the book

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is available from the Wiley editorial department.

The process of Integrated Circuits (IC) started its era of VLSI (Very Large Scale Integration) in 1970's when thousands of transistors were integrated into one single chip. Nowadays we are able to integrate more than a billion transistors on a single chip. However, the term "VLSI" is still being used, though there was some effort to coin a new term ULSI (Ultra-Large Scale Integration) for fine distinctions many years ago. VLSI technology has brought tremendous benefits to our everyday life since its occurrence. VLSI circuits are used everywhere, real applications include microprocessors in a personal computer or workstation, chips in a graphic card, digital camera or camcorder, chips in a cell phone or a portable computing device, and embedded processors in an automobile, et al. VLSI covers many phases of design and fabrication of integrated circuits. For a commercial chip design, it involves system definition, VLSI architecture design and optimization, RTL (register transfer language) coding, (pre- and post-synthesis) simulation and verification, synthesis, place and route, timing analyses and timing closure, and multi-step semiconductor device fabrication including wafer processing, die preparation, IC packaging and testing, et al. As the process technology scales down, hundreds or even thousands of millions of transistors are integrated into one single chip. Hence, more and more complicated systems can be integrated into a single chip, the so-called System-on-chip (SoC), which brings to VLSI engineers ever increasingly challenges to master techniques in various phases of VLSI design. For modern SoC design, practical applications are usually speed hungry. For instance, Ethernet standard has evolved from 10Mbps to 10Gbps. Now the specification for 100Mbps Ethernet is on the way. On the other hand, with the popularity of wireless and portable computing devices, low power consumption has become extremely critical. To meet these contradicting requirements, VLSI designers have to perform optimizations at all levels of design. This book is intended to cover a wide range of VLSI design topics. The book can be roughly partitioned into four parts. Part I is mainly focused on algorithmic level and architectural level VLSI design and optimization for image and video signal processing systems. Part II addresses VLSI design optimizations for cryptography and error correction coding. Part III discusses general SoC design techniques as well as other application-specific VLSI design optimizations. The last part will cover generic nano-scale circuit-level design techniques. Field programmable gate arrays (FPGAs) are an increasingly popular technology for implementing digital signal processing (DSP) systems. By allowing designers to create circuit architectures developed for the specific applications, high levels of performance can be achieved for many DSP applications providing considerable improvements over conventional microprocessor and dedicated DSP processor solutions. The book addresses the key issue in this process specifically, the methods and tools needed for the design, optimization and implementation of DSP systems in programmable FPGA hardware. It presents a review of the leading-edge techniques in this field, analyzing advanced DSP-based design flows for both signal flow graph- (SFG-) based and dataflow-based implementation, system on chip (SoC) aspects, and future trends and challenges for FPGAs. The automation of the techniques for component architectural synthesis, computational models, and the reduction of energy consumption to help improve FPGA performance, are given in detail. Written from a system level design perspective and with a DSP focus, the authors present many practical application examples of complex DSP implementation, involving: high-performance computing e.g. matrix operations such as matrix multiplication; high-speed filtering including finite impulse response (FIR) filters and wave digital filters (WDFs); adaptive filtering e.g. recursive least squares (RLS) filtering; transforms such as the fast Fourier transform (FFT). FPGA-based Implementation of Signal Processing Systems is an important reference for practising engineers and researchers working on the design and development of DSP systems for radio, telecommunication, information, audio-visual and security applications. Senior level electrical and computer engineering graduates taking courses in signal processing or digital signal processing shall also find this volume of

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interest.

About The Book: This book fuses signal processing algorithms and VLSI circuit design to assist digital signal processing architecture developers. The author then shows how this technique can be used in applications such as: signal transmission and storage, manufacturing process quality control and assurance, autonomous mobile system control and biomedical process analysis. This new publication is a revised and expanded version.

Digital Design of Signal Processing Systems discusses a spectrum of architectures and methods for effective implementation of algorithms in hardware (HW). Encompassing all facets of the subject this book includes conversion of algorithms from floating-point to fixed-point format, parallel architectures for basic computational blocks, Verilog Hardware Description Language (HDL), SystemVerilog and coding guidelines for synthesis. The book also covers system level design of Multi Processor System on Chip (MPSoC); a consideration of different design methodologies including Network on Chip (NoC) and Kahn Process Network (KPN) based connectivity among processing elements. A special emphasis is placed on implementing streaming applications like a digital communication system in HW. Several novel architectures for implementing commonly used algorithms in signal processing are also revealed. With a comprehensive coverage of topics the book provides an appropriate mix of examples to illustrate the design methodology. Key Features: A practical guide to designing efficient digital systems, covering the complete spectrum of digital design from a digital signal processing perspective Provides a full account of HW building blocks and their architectures, while also elaborating effective use of embedded computational resources such as multipliers, adders and memories in FPGAs Covers a system level architecture using NoC and KPN for streaming applications, giving examples of structuring MATLAB code and its easy mapping in HW for these applications Explains state machine based and Micro-Program architectures with comprehensive case studies for mapping complex applications The techniques and examples discussed in this book are used in the award winning products from the Center for Advanced Research in Engineering (CARE). Software Defined Radio, 10 Gigabit VoIP monitoring system and Digital Surveillance equipment has respectively won APICTA (Asia Pacific Information and Communication Alliance) awards in 2010 for their unique and effective designs.

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The intense requirements for high processing rates of multidimensional Digital Signal Processing systems in practical applications justify the Application Specific Integrated Circuits designs and parallel processing implementations. In this dissertation, we propose novel theories, methodologies and architectures in designing high-performance VLSI implementations for general multidimensional multirate Digital Signal Processing systems by exploiting the parallelism within those applications. To systematically exploit the parallelism within the multidimensional multirate DSP algorithms, we develop novel transformations including (1) nonlinear I/O data space transforms, (2) intercalation transforms, and (3) multidimensional multirate unfolding transforms. These transformations are applied to the algorithms leading to systematic methodologies in high-performance architectural designs. With the novel design methodologies, we develop several architectures with parallel and distributed processing features for implementing multidimensional multirate applications. Experimental results have shown that those architectures are much more efficient in terms of execution time and/or hardware cost compared with existing hardware implementations.

This book is a uniquely practical DSP text which places the emphasis on understanding the principles and applications of DSP

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with a minimum of mathematics. In one volume, it covers a broad area of digital signal processing systems such as A/D and D/A converters, adaptive filters, spectral estimation, neural networks, Kalman filters, fuzzy logic, data compression, error correction and DSP programming. Many courses will find that this book will replace several texts currently in use. The level is ideal for introductory university modules, and similar courses such as HNC/D. As DSP has come to be studied at a lower academic level over recent years this text meets a genuine need. It is also suitable for use on industrial training courses and ideal as a reference text for professionals. A readable introduction to the practical application of DSP Broad coverage of the subject means this will cover a typical undergraduate module in just one book Practical focus with maths treated as a practical tool - not an advanced maths text

Designing VLSI systems represents a challenging task. It is a transfunction among different specifications corresponding to different levels of design: abstraction, behavioral, structural and physical. The behavioral level describes the functionality of the design. It consists of two components; static and dynamic. The static component describes operations, whereas the dynamic component describes sequencing and timing. The structural level contains information about components, control and connectivity. The physical level describes the constraints that should be imposed on the floor plan, the placement of components, and the geometry of the design. Constraints of area, speed and power are also applied at this level. To implement such multilevel transfunction, a design methodology should be devised, taking into consideration the constraints, limitations and properties of each level. The mapping process between any of these domains is non-isomorphic. A single behavioral component may be transfunctioned into more than one structural component. Design methodologies are the most recent evolution in the design automation era, which started off with the introduction and subsequent usage of module generation especially for regular structures such as PLA's and memories. A design methodology should offer an integrated design system rather than a set of separate unrelated routines and tools. A general outline of a desired integrated design system is as follows: * Decide on a certain unified framework for all design levels. * Derive a design method based on this framework. * Create a design environment to implement this design method.

DSP Integrated Circuits establishes the essential interface between theory of digital signal processing algorithms and their implementation in full-custom CMOS technology. With an emphasis on techniques for co-design of DSP algorithms and hardware in order to achieve high performance in terms of throughput, low power consumption, and design effort, this book provides the professional engineer, researcher, and student with a firm foundation in the theoretical as well as the practical aspects of designing high performance DSP integrated circuits. Centered around three design case studies, DSP Integrated Circuits thoroughly details a high-performance FFT processor, a 2-D Discrete Cosine Transform for HDTV, and a wave digital filter for interpolation of the sampling frequency. The case studies cover the essential parts of the design process in a top-down manner, from specification of algorithm design and optimization, scheduling of operations, synthesis of optimal architectures, realization of processing elements, to the floor-planning of the integrated circuit. Details the theory and design of digital filters - particularly wave

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digital filters, multi-rate digital filters, fast Fourier transforms (FFT's), and discrete cosine transforms (DCT's) Follows three complete "real-world" case studies throughout the book Provides complete coverage of finite word length effects in DSP algorithms In-depth survey of the computational properties of DSP algorithms and their mapping to optimal architectures Outlines DSP architectures and parallel, bit-serial, and distributed arithmetic Presents the design process in a top-down manner and incorporates numerous problems and solutions

This book presents the select proceedings of the International Conference on Automation, Signal Processing, Instrumentation and Control (i-CASIC) 2020. The book mainly focuses on emerging technologies in electrical systems, IoT-based instrumentation, advanced industrial automation, and advanced image and signal processing. It also includes studies on the analysis, design and implementation of instrumentation systems, and high-accuracy and energy-efficient controllers. The contents of this book will be useful for beginners, researchers as well as professionals interested in instrumentation and control, and other allied fields.

When comparing conventional computing architectures to the architectures of biological neural systems, we find several striking differences. Conventional computers use a low number of high performance computing elements that are programmed with algorithms to perform tasks in a time sequenced way; they are very successful in administrative applications, in scientific simulations, and in certain signal processing applications. However, the biological systems still significantly outperform conventional computers in perception tasks, sensory data processing and motory control. Biological systems use a completely different computing paradigm: a massive network of simple processors that are (adaptively) interconnected and operate in parallel. Exactly this massively parallel processing seems the key aspect to their success. On the other hand the development of VLSI technologies provide us with technological means to implement very complicated systems on a silicon die. Especially analog VLSI circuits in standard digital technologies open the way for the implement at ion of massively parallel analog signal processing systems for sensory signal processing applications and for perception tasks. In chapter 1 the motivations behind the emergence of the analog VLSI of massively parallel systems is discussed in detail together with the capabilities and limitations of VLSI technologies and the required research and developments. Analog parallel signal processing drives for the development of very compact, high speed and low power circuits. An important technologicallimitation in the reduction of the size of circuits and the improvement of the speed and power consumption performance is the device inaccuracies or device mismatch.

High-Level Synthesis for Real-Time Digital Signal Processing is a comprehensive reference work for researchers and practicing ASIC design engineers. It focuses on methods for compiling complex, low to medium throughput DSP system, and on the implementation of these methods in the CATHEDRAL-II compiler. The emergence of independent silicon foundries, the reduced price of silicon real estate and the shortened processing turn-around time bring silicon technology within reach of system houses. Even for low volumes, digital systems on application-specific integrated circuits (ASICs) are becoming an economically meaningful alternative for traditional boards with analogue and digital commodity chips. ASICs cover the application region where inefficiencies inherent to general-purpose components cannot be tolerated. However, full-custom handcrafted ASIC design is often not affordable in this competitive market. Long design times, a high development cost for a low production volume, the lack of silicon designers and the lack of suited design facilities are inherent difficulties to manual full-custom chip design. To overcome these drawbacks, complex systems have to be integrated in ASICs much faster and without losing too much efficiency in silicon area and operation speed compared to handcrafted chips. The gap between system design and silicon

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design can only be bridged by new design (CAD). The idea of a silicon compiler, translating a behavioural system specification directly into silicon, was born from the awareness that the ability to fabricate chips is indeed outrunning the ability to design them. At this moment, CAD is one order of magnitude behind schedule. Conceptual CAD is the keyword to mastering the design complexity in ASIC design and the topic of this book.

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