

Verilog 2001 A Guide To The New Features Of The Verilog Hardware Description Language The Springer International Series In Engineering And Computer Science

This book uses a "learn by doing" approach to introduce the concepts and techniques of VHDL and FPGA to designers through a series of hands-on experiments. FPGA Prototyping by VHDL Examples provides a collection of clear, easy-to-follow templates for quick code development; a large number of practical examples to illustrate and reinforce the concepts and design techniques; realistic projects that can be implemented and tested on a Xilinx prototyping board; and a thorough exploration of the Xilinx PicoBlaze soft-core microcontroller.

This title builds on the student's background from a first course in logic design and focuses on developing, verifying, and synthesizing designs of digital circuits. The Verilog language is introduced in an integrated, but selective manner, only as needed to support design examples. The Verilog Programming Language Interface is a powerful feature of the Verilog standard. Through this interface, a Verilog simulator can be customized to perform virtually any engineering task desired, such as adding custom design debug utilities, adding proprietary file read/write utilities, and interfacing bus functional C language models to a simulator. This book serves as both a user's guide for learning the Verilog PLI, and as a comprehensive reference manual on the Verilog PLI standard. Both the TF/ACC ("PLI 1.0") and the VPI ("PLI 2.0") generations of the PLI are presented, based on the IEEE 1364 Verilog standard. The second edition of this book adds detailed coverage of the many enhancements added in the latest IEEE 1364-2001 Verilog standard ("Verilog-2001").

VERILOG HDL, Second Edition by Samir Palnitkar With a Foreword by Prabhu Goel Written for both experienced and new users, this book gives you broad coverage of Verilog HDL. The book stresses the practical design and verification perspective of Verilog rather than emphasizing only the language aspects. The information presented is fully compliant with the IEEE 1364-2001 Verilog HDL standard. Among its many features, this edition-

- Describes state-of-the-art verification methodologies
- Provides full coverage of gate, dataflow (RTL), behavioral and switch modeling
- Introduces you to the Programming Language Interface (PLI)
- Describes logic synthesis methodologies
- Explains timing and delay simulation
- Discusses user-defined primitives
- Offers many practical modeling tips

Includes over 300 illustrations, examples, and exercises, and a Verilog resource list. Learning objectives and summaries are provided for each chapter. About the CD-ROM The CD-ROM contains a Verilog simulator with a graphical user interface and the source code for the examples in the book. What people are saying about Verilog HDL- "Mr. Palnitkar illustrates how and why Verilog HDL is used to develop today's most complex digital designs. This book is valuable to both the novice and the experienced Verilog user. I highly recommend it to anyone exploring Verilog based design." -Rajeev Madhavan, Chairman and CEO, Magma Design Automation "This book is unique in its breadth of information on Verilog and Verilog-related topics. It is fully compliant with the IEEE 1364-2001 standard, contains all the information that you need on the basics, and devotes several chapters to advanced topics such as verification, PLI, synthesis and modeling techniques." -Michael McNamara, Chair, IEEE 1364-2001 Verilog Standards Organization This has been my favorite Verilog book since I picked it up in college. It is the only book that covers practical Verilog. A must have for beginners and experts." -Berend Ozceri, Design Engineer, Cisco Systems, Inc. "Simple, logical and well-organized material with plenty of illustrations, makes this an ideal textbook." -Arun K. Somani, Jerry R. Junkins Chair Professor, Department of Electrical and Computer Engineering, Iowa State University, Ames PRENTICE HALL Professional Technical Reference Upper Saddle River, NJ 07458 www.phptr.com ISBN: 0-13-044911-3

The role of arithmetic in datapath design in VLSI design has been increasing in importance over the last several years due to the demand for processors that are smaller, faster, and dissipate less power. Unfortunately, this means that many of these datapaths will be complex both algorithmically and circuit wise. As the complexity of the chips increases, less importance will be placed on understanding how a particular arithmetic datapath design is implemented and more importance will be given to when a product will be placed on the market. This is because many tools that are available today, are automated to help the digital system designer maximize their efficiency. Unfortunately, this may lead to problems when implementing particular datapaths. The design of high-performance architectures is becoming more complicated because the level of integration that is capable for many of these chips is in the billions. Many engineers rely heavily on software tools to optimize their work, therefore, as designs are getting more complex less understanding is going into a particular implementation because it can be generated automatically. Although software tools are a highly valuable asset to designer, the value of these tools does not diminish the importance of understanding datapath elements. Therefore, a digital system designer should be aware of how algorithms can be implemented for datapath elements. Unfortunately, due to the complexity of some of these algorithms, it is sometimes difficult to understand how a particular algorithm is implemented without seeing the actual code.

by Phil Moorby The Verilog Hardware Description Language has had an amazing impact on the modern electronics industry, considering that the essential composition of the language was developed in a surprisingly short period of time, early in 1984. Since its introduction, Verilog has changed very little. Over time, users have requested many improvements to meet new methodology needs. But, it is a complex and time consuming process to add features to a language without ambiguity, and maintaining consistency. A group of Verilog enthusiasts, the IEEE 1364 Verilog committee, have broken the Verilog feature doldrums. These individuals should be applauded. They invested the time and energy, often their personal time, to understand and resolve an extensive wish-list of language enhancements. They took on the task of choosing a feature set that would stand up to the scrutiny of the standardization process. I would like to personally thank this group. They have shown that it is possible to evolve Verilog, rather than having to completely start over with some revolutionary new language. The Verilog 1364-2001 standard provides many of the advanced building blocks that users have requested. The enhancements include key components for verification, abstract design, and other new methodology capabilities. As designers tackle advanced issues such as automated verification, system partitioning, etc., the Verilog standard will rise to meet the continuing challenge of electronics design.

Based on the highly successful second edition, this extended edition of SystemVerilog for Verification: A Guide to Learning the Testbench Language Features teaches all verification features of the SystemVerilog language, providing hundreds of examples to clearly explain the concepts and basic fundamentals. It contains materials for both the full-time verification engineer and the student learning this valuable skill. In the third edition, authors Chris Spear and Greg Tumbush start with how to verify a design, and then use that context to demonstrate the language features, including the advantages and disadvantages of different styles, allowing readers to choose between alternatives. This textbook contains end-of-chapter exercises designed to enhance students' understanding of the material. Other features of this revision include: New sections on static variables, print specifiers, and DPI from the 2009 IEEE language standard Descriptions of UVM features such as factories, the test registry, and the configuration database Expanded code samples and explanations Numerous samples that have been tested on the major SystemVerilog simulators SystemVerilog for Verification: A Guide to Learning the Testbench Language Features, Third Edition is suitable for use in a one-semester SystemVerilog course on SystemVerilog at the undergraduate or graduate level.

Many of the improvements to this new edition were compiled through feedback provided from hundreds of readers.

This book describes the life cycle process of IP cores, from specification to production, including IP modeling, verification, optimization, and protection. Various trade-offs in the design process are discussed, including those associated with many of the most common memory cores, controller IPs and system-on-chip (SoC) buses. Readers will also benefit from the author's practical coverage of new verification methodologies, such as bug localization, UVM, and scan-chain. A SoC case study is presented to compare traditional verification with the new verification methodologies. Discusses the entire life cycle process of IP cores, from specification to production, including IP modeling, verification, optimization, and protection; Introduce a deep introduction for Verilog for both implementation and verification point of view. Demonstrates how to use IP in applications such as memory controllers and SoC buses. Describes a new verification methodology called bug localization; Presents a novel scan-chain methodology for RTL debugging; Enables readers to employ UVM methodology in straightforward, practical terms.

FPGA Prototyping Using Verilog Examples will provide you with a hands-on introduction to Verilog synthesis and FPGA programming through a "learn by doing" approach. By following the clear, easy-to-understand templates for code development and the numerous practical examples, you can quickly develop and simulate a sophisticated digital circuit, realize it on a prototyping device, and verify the operation of its physical implementation. This introductory text that will provide you with a solid foundation, instill confidence with rigorous examples for complex systems and prepare you for future development tasks.

This book provides a hands-on, application-oriented guide to the language and methodology of both SystemVerilog Assertions and Functional Coverage. Readers will benefit from the step-by-step approach to learning language and methodology nuances of both SystemVerilog Assertions and Functional Coverage, which will enable them to uncover hidden and hard to find bugs, point directly to the source of the bug, provide for a clean and easy way to model complex timing checks and objectively answer the question 'have we functionally verified everything'. Written by a professional end-user of ASIC/SoC/CPU and FPGA design and Verification, this book explains each concept with easy to understand examples, simulation logs and applications derived from real projects. Readers will be empowered to tackle the modeling of complex checkers for functional verification and exhaustive coverage models for functional coverage, thereby drastically reducing their time to design, debug and cover. This updated third edition addresses the latest functional set released in IEEE-1800 (2012) LRM, including numerous additional operators and features. Additionally, many of the Concurrent Assertions/Operators explanations are enhanced, with the addition of more examples and figures. - Covers in its entirety the latest IEEE-1800 2012 LRM syntax and semantics; - Covers both SystemVerilog Assertions and SystemVerilog Functional Coverage languages and methodologies; - Provides practical applications of the what, how and why of Assertion Based Verification and Functional Coverage methodologies; - Explains each concept in a step-by-step fashion and applies it to a practical real life example; - Includes 6 practical LABs that enable readers to put in practice the concepts explained in the book.

Starts with an overview of today's FPGA technology, devices, and tools for designing state-of-the-art DSP systems. A case study in the first chapter is the basis for more than 30 design examples throughout. The following chapters deal with computer arithmetic concepts, theory and the implementation of FIR and IIR filters, multirate digital signal processing systems, DFT and FFT algorithms, and advanced algorithms with high future potential. Each chapter contains exercises. The VERILOG source code and a glossary are given in the appendices, while the accompanying CD-ROM contains the examples in VHDL and Verilog code as well as the newest Altera "Baseline" software. This edition has a new chapter on adaptive filters, new

sections on division and floating point arithmetics, an up-date to the current Altera software, and some new exercises.

SystemVerilog language consists of three categories of features -- Design, Assertions and Testbench. Assertions add a whole new dimension to the ASIC verification process. Engineers are used to writing testbenches in verilog that help verify their design. Verilog is a procedural language and is very limited in capabilities to handle the complex ASICs built today.

SystemVerilog assertions (SVA) is a declarative language. The temporal nature of the language provides excellent control over time and allows multiple processes to execute simultaneously. This provides the engineers a very strong tool to solve their verification problems. The language is still new and the thinking is very different from the user's perspective when compared to standard verilog language. There is not enough expertise or intellectual property available as of today in the field. While the language has been defined very well, there is no practical guide that shows how to use the language to solve real verification problems. This book is a practical guide that will help people to understand this new language and adopt assertion based verification methodology quickly.

Field Programmable Gate Arrays (FPGAs) are devices that provide a fast, low-cost way for embedded system designers to customize products and deliver new versions with upgraded features, because they can handle very complicated functions, and be reconfigured an infinite number of times. In addition to introducing the various architectural features available in the latest generation of FPGAs, The Design Warrior's Guide to FPGAs also covers different design tools and flows. This book covers information ranging from schematic-driven entry, through traditional HDL/RTL-based simulation and logic synthesis, all the way up to the current state-of-the-art in pure C/C++ design capture and synthesis technology. Also discussed are specialist areas such as mixed hardware/software and DSP-based design flows, along with innovative new devices such as field programmable node arrays (FPNAs). Clive "Max" Maxfield is a bestselling author and engineer with a large following in the electronic design automation (EDA) and embedded systems industry. In this comprehensive book, he covers all the issues of interest to designers working with, or contemplating a move to, FPGAs in their product designs. While other books cover fragments of FPGA technology or applications this is the first to focus exclusively and comprehensively on FPGA use for embedded systems. First book to focus exclusively and comprehensively on FPGA use in embedded designs World-renowned best-selling author Will help engineers get familiar and succeed with this new technology by providing much-needed advice on choosing the right FPGA for any design project

This book is both a tutorial and a reference for engineers who use the SystemVerilog Hardware Description Language (HDL) to design ASICs and FPGAs. The book shows how to write SystemVerilog models at the Register Transfer Level (RTL) that simulate and synthesize correctly, with a focus on proper coding styles and best practices. SystemVerilog is the latest generation of the original Verilog language, and adds many important capabilities to efficiently and more accurately model increasingly complex designs. This book reflects the SystemVerilog-2012/2017 standards. This book is for engineers who already know, or who are learning, digital design engineering. The book does not present digital design theory; it shows how to apply that theory to write RTL models that simulate and synthesize correctly. The creator of the original Verilog Language, Phil Moorby says about this book (an excerpt from the book's Foreword): "Many published textbooks on the design side of SystemVerilog assume that the reader is familiar with Verilog, and simply explain the new extensions. It is time to leave behind the stepping-stones and to teach a single consistent and concise language in a single book, and maybe not even refer to the old ways at all! If you are a designer of digital systems, or a verification engineer searching for bugs in these designs, then SystemVerilog will provide you with significant benefits, and this book is a great place to learn the design

aspects of SystemVerilog."

Ready-to-use building blocks for integrated circuit design. Why start coding from scratch when you can work from this library of pre-tested routines, created by an HDL expert? There are plenty of introductory texts to describe the basics of Verilog, but Verilog Designer's Library is the only book that offers real, reusable routines that you can put to work right away. Verilog Designer's Library organizes Verilog routines according to functionality, making it easy to locate the material you need. Each function is described by a behavioral model to use for simulation, followed by the RTL code you'll use to synthesize the gate-level implementation. Extensive test code is included for each function, to assist you with your own verification efforts. Coverage includes: Essential Verilog coding techniques Basic building blocks of successful routines State machines and memories Practical debugging guidelines Although Verilog Designer's Library assumes a basic familiarity with Verilog structure and syntax, it does not require a background in programming. Beginners can work through the book in sequence to develop their skills, while experienced Verilog users can go directly to the routines they need. Hardware designers, systems analysts, VARs, OEMs, software developers, and system integrators will find it an ideal sourcebook on all aspects of Verilog development.

This book concentrates on common classes of hardware architectures and design problems, and focuses on the process of transitioning design requirements into synthesizable HDL code. Using his extensive, wide-ranging experience in computer architecture and hardware design, as well as in his training and consulting work, Ben provides numerous examples of real-life designs illustrated with VHDL and Verilog code. This code is shown in a way that makes it easy for the reader to gain a greater understanding of the languages and how they compare. All code presented in the book is included on the companion CD, along with other information, such as application notes.

The Verilog Hardware Description Language was first introduced in 1984. Over the 20 year history of Verilog, every Verilog engineer has developed his own personal "bag of tricks" for coding with Verilog. These tricks enable modeling or verifying designs more easily and more accurately. Developing this bag of tricks is often based on years of trial and error. Through experience, engineers learn that one specific coding style works best in some circumstances, while in another situation, a different coding style is best. As with any high-level language, Verilog often provides engineers several ways to accomplish a specific task. Wouldn't it be wonderful if an engineer first learning Verilog could start with another engineer's bag of tricks, without having to go through years of trial and error to decide which style is best for which circumstance? That is where this book becomes an invaluable resource. The book presents dozens of Verilog tricks of the trade on how to best use the Verilog HDL for modeling designs at various level of abstraction, and for writing test benches to verify designs. The book not only shows the correct ways of using Verilog for different situations, it also presents alternate styles, and discusses the pros and cons of these styles.

This book will help engineers write better Verilog/SystemVerilog design and verification code as well as deliver digital designs to market more quickly. It shows over 100 common coding mistakes that can be made with the Verilog and SystemVerilog languages. Each example explains in detail the symptoms of the error, the languages rules that cover the error, and the correct coding style to avoid the error. The book helps digital design and verification engineers to recognize, and avoid, these common coding mistakes. Many of these errors are very subtle, and can potentially cost hours or days of lost engineering time trying to find and debug them. This textbook provides a starter's guide to Verilog, to be used in conjunction with a one-semester course in Digital Systems Design, or on its own for readers who only need an introduction to the language. This book is designed to match the way the material is actually taught in the classroom. Topics are presented in a manner which builds foundational knowledge before moving onto advanced topics. The author has designed the presentation

with learning goals and assessment at its core. Each section addresses a specific learning outcome that the student should be able to “do” after its completion. The concept checks and exercise problems provide a rich set of assessment tools to measure student performance on each outcome. Written the way the material is taught, enabling a bottom-up approach to learning which culminates with a high-level of learning, with a solid foundation; Emphasizes examples from which students can learn: contains a solved example for nearly every section in the book; Includes more than 200 exercise problems, as well as concept check questions for each section, tied directly to specific learning outcomes.

The skills and guidance needed to master RTL hardware design This book teaches readers how to systematically design efficient, portable, and scalable Register Transfer Level (RTL) digital circuits using the VHDL hardware description language and synthesis software. Focusing on the module-level design, which is composed of functional units, routing circuit, and storage, the book illustrates the relationship between the VHDL constructs and the underlying hardware components, and shows how to develop codes that faithfully reflect the module-level design and can be synthesized into efficient gate-level implementation. Several unique features distinguish the book:

- * Coding style that shows a clear relationship between VHDL constructs and hardware components
- * Conceptual diagrams that illustrate the realization of VHDL codes
- * Emphasis on the code reuse
- * Practical examples that demonstrate and reinforce design concepts, procedures, and techniques
- * Two chapters on realizing sequential algorithms in hardware
- * Two chapters on scalable and parameterized designs and coding
- * One chapter covering the synchronization and interface between multiple clock domains

Although the focus of the book is RTL synthesis, it also examines the synthesis task from the perspective of the overall development process. Readers learn good design practices and guidelines to ensure that an RTL design can accommodate future simulation, verification, and testing needs, and can be easily incorporated into a larger system or reused. Discussion is independent of technology and can be applied to both ASIC and FPGA devices. With a balanced presentation of fundamentals and practical examples, this is an excellent textbook for upper-level undergraduate or graduate courses in advanced digital logic. Engineers who need to make effective use of today's synthesis software and FPGA devices should also refer to this book.

SystemVerilog is a rich set of extensions to the IEEE 1364-2001 Verilog Hardware Description Language (Verilog HDL). These extensions address two major aspects of HDL based design. First, modeling very large designs with concise, accurate, and intuitive code. Second, writing high-level test programs to efficiently and effectively verify these large designs. This book, SystemVerilog for Design, addresses the first aspect of the SystemVerilog extensions to Verilog. Important modeling features are presented, such as two-state data types, enumerated types, user-defined types, structures, unions, and interfaces. Emphasis is placed on the proper usage of these enhancements for simulation and synthesis. A companion to this book, SystemVerilog for Verification, covers the second aspect of SystemVerilog.

The Verilog Hardware Description Language (Verilog-HDL) has long been the most popular language for describing complex digital hardware. It started life as a proprietary language but was donated by Cadence Design Systems to the design community to serve as the basis of an open standard. That standard was formalized in 1995 by the IEEE in standard 1364-1995. About that same time a group named Analog Verilog International formed with the intent of proposing extensions to Verilog to support analog and mixed-signal simulation. The first fruits of the labor of that group became available in 1996 when the language definition of Verilog-A was released. Verilog-A was not intended to work directly with Verilog-HDL. Rather it was a language with similar syntax and related

semantics that was intended to model analog systems and be compatible with SPICE-class circuit simulation engines. The first implementation of Verilog-A soon followed: a version from Cadence that ran on their Spectre circuit simulator. As more implementations of Verilog-A became available, the group defining the analog and mixed-signal extensions to Verilog continued their work, releasing the definition of Verilog-AMS in 2000. Verilog-AMS combines both Verilog-HDL and Verilog-A, and adds additional mixed-signal constructs, providing a hardware description language suitable for analog, digital, and mixed-signal systems. Again, Cadence was first to release an implementation of this new language, in a product named AMS Designer that combines their Verilog and Spectre simulation engines.

As part of the Modern Semiconductor Design series, this book details a broad range of e-based topics including modelling, constraint-driven test generation, functional coverage and assertion checking.

This textbook for courses in Embedded Systems introduces students to necessary concepts, through a hands-on approach. It gives a great introduction to FPGA-based microprocessor system design using state-of-the-art boards, tools, and microprocessors from Altera/Intel® and Xilinx®. HDL-based designs (soft-core), parameterized cores (Nios II and MicroBlaze), and ARM Cortex-A9 design are discussed, compared and explored using many hand-on designs projects. Custom IP for HDMI coder, Floating-point operations, and FFT bit-swap are developed, implemented, tested and speed-up is measured. Downloadable files include all design examples such as basic processor synthesizable code for Xilinx and Altera tools for PicoBlaze, MicroBlaze, Nios II and ARMv7 architectures in VHDL and Verilog code, as well as the custom IP projects. Each Chapter has a substantial number of short quiz questions, exercises, and challenging projects. Explains soft, parameterized, and hard core systems design tradeoffs; Demonstrates design of popular KCPSM6 8 Bit microprocessor step-by-step; Discusses the 32 Bit ARM Cortex-A9 and a basic processor is synthesized; Covers design flows for both FPGA Market leaders Nios II Altera/Intel and MicroBlaze Xilinx system; Describes Compiler-Compiler Tool development; Includes a substantial number of Homework's and FPGA exercises and design projects in each chapter.

Why learn and use Verilog if you're a student, beginning designer, or leading edge systems designer? The naive would ignore Verilog and "standardize" by using VHDL, the result of a decade-long committee design process. A single language for the whole world would appear to: ease the training of designers and others who use descriptions, increase tool competition to lower costs, and increase design sharing and library usage. Further, the U. S. Department of Defense (DOD) mandated its use for design description Mandated standards rarely are best, and often not very good. Competition is good because it encourages rapid evolution. Also, we know that evolved, de facto standards embodied in a time-tested product based on initial conceptual clarity from one

person or organization versus de jure standards coming from large committees or government mandates are often preferred. A standard must be "open" so that many others can use it, build on it, and compete to make it better. One only has to compare: C, C++, and FORTRAN versus ADA (DOD's mandated language), PLI; TCP/IP versus OSI; the Intel X86 or PowerPC microprocessors versus DOD's many architectures; Windows versus the many UNIX dialects; and various industry buses versus DOD's Futurebus. Verilog, introduced in 1985, was developed by one person, Phil Moorby at Gate way Design Automation. It was Phil's third commercial logic simulator.

The IEEE 1364-2001 standard, nicknamed `Verilog-2001', is the first major update to the Verilog language since its inception in 1984. This book presents 45 significant enhancements contained in Verilog-2001 standard. A few of the new features described in this book are: This book assumes that the reader is already familiar with using Verilog. It supplements other excellent books on how to use the Verilog language, such as The Verilog Hardware Description Language, by Donald Thomas and Philip Moorby (Kluwer Academic Publishers, ISBN: 0-7923-8166-1) and Verilog Quickstart: A Practical Guide to Simulation and Synthesis, by James Lee (Kluwer Academic Publishers, ISBN: 0-7923-8515-2). With over 30 years of experience in both industrial and university settings, the author covers the most widespread logic design practices while building a solid foundation of theoretical and engineering principles for students to use as they go forward in this fast moving field.

Explores the unique hardware programmability of FPGA-based embedded systems, using a learn-by-doing approach to introduce the concepts and techniques for embedded SoPC design with Verilog An SoPC (system on a programmable chip) integrates a processor, memory modules, I/O peripherals, and custom hardware accelerators into a single FPGA (field-programmable gate array) device. In addition to the customized software, customized hardware can be developed and incorporated into the embedded system as well—allowing us to configure the soft-core processor, create tailored I/O interfaces, and develop specialized hardware accelerators for computation-intensive tasks. Utilizing an Altera FPGA prototyping board and its Nios II soft-core processor, Embedded SoPC Design with Nios II Processor and Verilog Examples takes a "learn by doing" approach to illustrate the hardware and software design and development process by including realistic projects that can be implemented and tested on the board. Emphasizing hardware design and integration throughout, the book is divided into four major parts: Part I covers HDL and synthesis of custom hardware Part II introduces the Nios II processor and provides an overview of embedded software development Part III demonstrates the design and development of hardware and software of several complex I/O peripherals, including a PS2 keyboard and mouse, a graphic video controller, an audio codec, and an SD (secure digital) card Part IV provides several case studies of the integration of hardware accelerators, including a custom GCD (greatest common

divisor) circuit, a Mandelbrot set fractal circuit, and an audio synthesizer based on DDFS (direct digital frequency synthesis) methodology While designing and developing an embedded SoPC can be rewarding, the learning can be a long and winding journey. This book shows the trail ahead and guides readers through the initial steps to exploit the full potential of this emerging methodology. A hands-on introduction to FPGA prototyping and SoC design This is the successor edition of the popular FPGA Prototyping by Verilog Examples text. It follows the same “learning-by-doing” approach to teach the fundamentals and practices of HDL synthesis and FPGA prototyping. The new edition uses a coherent series of examples to demonstrate the process to develop sophisticated digital circuits and IP (intellectual property) cores, integrate them into an SoC (system on a chip) framework, realize the system on an FPGA prototyping board, and verify the hardware and software operation. The examples start with simple gate-level circuits, progress gradually through the RT (register transfer) level modules, and lead to a functional embedded system with custom I/O peripherals and hardware accelerators. Although it is an introductory text, the examples are developed in a rigorous manner, and the derivations follow the strict design guidelines and coding practices used for large, complex digital systems. The book is completely updated and uses the SystemVerilog language, which “absorbs” the Verilog language. It presents the hardware design in the SoC context and introduces the hardware-software co-design concept. Instead of treating examples as isolated entities, the book integrates them into a single coherent SoC platform that allows readers to explore both hardware and software “programmability” and develop complex and interesting embedded system projects. The new edition: Adds four general-purpose IP cores, which are multi-channel PWM (pulse width modulation) controller, I2C controller, SPI controller, and XADC (Xilinx analog-to-digital converter) controller. Introduces a music synthesizer constructed with a DDFS (direct digital frequency synthesis) module and an ADSR (attack-decay-sustain-release) envelope generator. Expands the original video controller into a complete stream based video subsystem that incorporates a video synchronization circuit, a test-pattern generator, an OSD (on-screen display) controller, a sprite generator, and a frame buffer. Provides a detailed discussion on blocking and nonblocking statements and coding styles. Describes basic concepts of software-hardware co-design with Xilinx MicroBlaze MCS soft-core processor. Provides an overview of bus interconnect and interface circuit. Presents basic embedded system software development. Suggests additional modules and peripherals for interesting and challenging projects. FPGA Prototyping by SystemVerilog Examples makes a natural companion text for introductory and advanced digital design courses and embedded system courses. It also serves as an ideal self-teaching guide for practicing engineers who wish to learn more about this emerging area of interest. Create low power, higher performance circuits with shorter design times using this practical guide to asynchronous design. This practical alternative to

conventional synchronous design enables performance close to full-custom designs with design times that approach commercially available ASIC standard cell flows. It includes design trade-offs, specific design examples, and end-of-chapter exercises. Emphasis throughout is placed on practical techniques and real-world applications, making this ideal for circuit design students interested in alternative design styles and system-on-chip circuits, as well as circuit designers in industry who need new solutions to old problems.

by Maq Mannan President and CEO, DSM Technologies Chairman of the IEEE 1364 Verilog Standards Group Past Chairman of Open Verilog International One of the major strengths of the Verilog language is the Programming Language Interface (PLI), which allows users and Verilog application developers to infinitely extend the capabilities of the Verilog language and the Verilog simulator. In fact, the overwhelming success of the Verilog language can be partly attributed to the existence of its PLI. Using the PLI, add-on products, such as graphical waveform displays or pre and post simulation analysis tools, can be easily developed. These products can then be used with any Verilog simulator that supports the Verilog PLI. This ability to create third-party add-on products for Verilog simulators has created new markets and provided the Verilog user base with multiple sources of software tools. Hardware design engineers can, and should, use the Verilog PLI to customize their Verilog simulation environment. A Company that designs graphics chips, for example, may wish to see the simulation results of a new design in some custom graphical display. The Verilog PLI makes it possible, and even trivial, to integrate custom software, such as a graphical display program, into a Verilog simulator. The simulation results can then dynamically be displayed in the custom format during simulation. And, if the company uses Verilog simulators from multiple simulator vendors, this integrated graphical display will work with all the simulators.

The book is divided into four major parts. Part I covers HDL constructs and synthesis of basic digital circuits. Part II provides an overview of embedded software development with the emphasis on low-level I/O access and drivers. Part III demonstrates the design and development of hardware and software for several complex I/O peripherals, including PS2 keyboard and mouse, a graphic video controller, an audio codec, and an SD (securedigital) card. Part IV provides three case studies of the integration of hardware accelerators, including a custom GCD (greatest common divisor) circuit, a Mandelbrot set fractal circuit, and an audio synthesizer based on DDFS (direct digital frequency synthesis) methodology. The book utilizes FPGA devices, Nios II soft-core processor, and development platform from Altera Co., which is one of the two main FPGA manufacturers. Altera has a generous university program that provides free software and discounted prototyping boards for educational institutions (details at <http://www.altera.com/university>). The two main educational prototyping boards are known as DE1 (\$99) and DE2 (\$269). All experiments can

be implemented and tested with these boards. A board combined with this book becomes a “turn-key” solution for the SoPC design experiments and projects. Most HDL and C codes in the book are device independent and can be adapted by other prototyping boards as long as a board has similar I/O configuration.

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