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Error Correction Codes for Non-Volatile Memories

 Springer

Error Correction Codes For Non Volatile Memories

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Error Correction Codes For Non Volatile Memories:

Error Correction Codes for Non-Volatile Memories Rino Micheloni, A. Marelli, R. Ravasio, 2008-06-03 Nowadays it is hard to find an electronic device which does not use codes for example we listen to music via heavily encoded audio CDs and we watch movies via encoded DVDs. There is at least one area where the use of encoding/decoding is not so developed yet: Flash non-volatile memories. Flash memory's high density, low power cost effectiveness and scalable design make it an ideal choice to fuel the explosion of multimedia products like USB keys, MP3 players, digital cameras and solid state disks. In ECC for Non-Volatile Memories, the authors expose the basics of coding theory needed to understand the application to memories as well as the relevant design topics with reference to both NOR and NAND Flash architectures. A collection of software routines is also included for better understanding. The authors form a research group now at Qimonda which is the typical example of a fruitful collaboration between mathematicians and engineers.

Machine Learning and Non-volatile Memories Rino Micheloni, Cristian Zambelli, 2022-05-25 This book presents the basics of both NAND flash storage and machine learning, detailing the storage problems the latter can help to solve. At a first sight, machine learning and non-volatile memories seem very far away from each other. Machine learning implies mathematics, algorithms and a lot of computation; non-volatile memories are solid state devices used to store information, having the amazing capability of retaining the information even without power supply. This book will help the reader understand how these two worlds can work together, bringing a lot of value to each other. In particular, the book covers two main fields of application: analog neural networks (NNs) and solid state drives (SSDs). After reviewing the basics of machine learning in Chapter 1, Chapter 2 shows how neural networks can mimic the human brain to accomplish this result: neural networks have to perform a specific computation called vector-by-matrix (VbM) multiplication, which is particularly power hungry. In the digital domain, VbM is implemented by means of logic gates which dictate both the area occupation and the power consumption; the combination of the two poses serious challenges to the hardware scalability, thus limiting the size of the neural network itself, especially in terms of the number of processable inputs and outputs. Non-volatile memories, phase change memories in Chapter 3, resistive memories in Chapter 4, and 3D flash memories in Chapter 5 and Chapter 6, enable the analog implementation of the VbM, also called neuromorphic architecture, which can easily beat the equivalent digital implementation in terms of both speed and energy consumption. SSDs and flash memories are strictly coupled together as 3D flash scales; there is a significant amount of work that has to be done in order to optimize the overall performances of SSDs. Machine learning has emerged as a viable solution in many stages of this process. After introducing the main flash reliability issues, Chapter 7 shows both supervised and unsupervised machine learning techniques that can be applied to NAND. In addition, Chapter 7 deals with algorithms and techniques for a proactive reliability management of SSDs. Last but not least, the last section of Chapter 7 discusses the next challenge for machine learning in the context of the so-called computational storage. No doubt that machine learning and non-volatile memories can

help each other but we are just at the beginning of the journey this book helps researchers understand the basics of each field by providing real application examples hopefully providing a good starting point for the next level of development

VLSI-Design of Non-Volatile Memories Giovanni Campardo,Rino Micheloni,David Novosel,2005-12-06 The electronics and information technology revolution continues but it is a critical time in the development of technology Once again we stand on the brink of a new era where emerging research will yield exciting applications and products destined to transform and enrich our daily lives The potential is staggering and the ultimate impact is unimaginable considering the continuing marriage of technology with fields such as medicine communications and entertainment to name only a few But who will actually be responsible for transforming these potential new products into reality The answer of course is today's and tomorrow's design engineers The design of integrated circuits today remains an essential discipline in support of technological progress and the authors of this book have taken a giant step forward in the development of a practice oriented treatise for design engineers who are interested in the practical industry driven world of integrated circuit design

Inside NAND Flash Memories Rino Micheloni,Luca Crippa,Alessia Marelli,2010-07-27 Digital photography MP3 digital video etc make extensive use of NAND based Flash cards as storage media To realize how much NAND Flash memories pervade every aspect of our life just imagine how our recent habits would change if the NAND memories suddenly disappeared To take a picture it would be necessary to find a film as well as a traditional camera disks or even magnetic tapes would be used to record a video or to listen a song and a cellular phone would return to be a simple mean of communication rather than a multimedia console The development of NAND Flash memories will not be set down on the mere evolution of personal entertainment systems since a new killer application can trigger a further success the replacement of Hard Disk Drives HDDs with Solid State Drives SSDs SSD is made up by a microcontroller and several NANDs As NAND is the technology driver for IC circuits Flash designers and technologists have to deal with a lot of challenges Therefore SSD system developers must understand Flash technology in order to exploit its benefits and countermeasure its weaknesses Inside NAND Flash Memories is a comprehensive guide of the NAND world from circuits design analog and digital to Flash reliability including radiation effects from testing issues to high performance DDR interface from error correction codes to NAND applications like Flash cards and SSDs

Inside Solid State Drives (SSDs) Rino Micheloni,Alessia Marelli,Kam Eshghi,2018-07-11 The revised second edition of this respected text provides a state of the art overview of the main topics relating to solid state drives SSDs covering NAND flash memories memory controllers including boot hardware and software I/O interfaces PCIe SAS SATA reliability error correction codes BCH and LDPC encryption flash signal processing and hybrid storage Updated throughout to include all recent work in the field significant changes for the new edition include A new chapter on flash memory errors and data recovery procedures in SSDs for reliability and lifetime improvement Updated coverage of SSD Architecture and PCI Express Interfaces moving from PCIe Gen3 to PCIe Gen4 and including a section on NVMe over fabric NVMf An additional section on 3D flash memories An

update on standard reliability procedures for SSDs Expanded coverage of BCH for SSDs with a specific section on detection A new section on non binary Low Density Parity Check LDPC codes the most recent advancement in the field A description of randomization in the protection of SSD data against attacks particularly relevant to 3D architectures The SSD market is booming with many industries placing a huge effort in this space spending billions of dollars in R D and product development Moreover flash manufacturers are now moving to 3D architectures thus enabling an even higher level of storage capacity This book takes the reader through the fundamentals and brings them up to speed with the most recent developments in the field and is suitable for advanced students researchers and engineers alike **3D Flash Memories** Rino

Michelsoni,2016-05-26 This book walks the reader through the next step in the evolution of NAND flash memory technology namely the development of 3D flash memories in which multiple layers of memory cells are grown within the same piece of silicon It describes their working principles device architectures fabrication techniques and practical implementations and highlights why 3D flash is a brand new technology After reviewing market trends for both NAND and solid state drives SSDs the book digs into the details of the flash memory cell itself covering both floating gate and emerging charge trap technologies There is a plethora of different materials and vertical integration schemes out there New memory cells new materials new architectures 3D Stacked BiCS and P BiCS 3D FG 3D VG 3D advanced architectures basically each NAND manufacturer has its own solution Chapter 3 to chapter 7 offer a broad overview of how 3D can materialize The 3D wave is impacting emerging memories as well and chapter 8 covers 3D RRAM resistive RAM crosspoint arrays Visualizing 3D structures can be a challenge for the human brain this is way all these chapters contain a lot of bird s eye views and cross sections along the 3 axes The second part of the book is devoted to other important aspects such as advanced packaging technology i e TSV in chapter 9 and error correction codes which have been leveraged to improve flash reliability for decades Chapter 10 describes the evolution from legacy BCH to the most recent LDPC codes while chapter 11 deals with some of the most recent advancements in the ECC field Last but not least chapter 12 looks at 3D flash memories from a system perspective Is 14nm the last step for planar cells Can 100 layers be integrated within the same piece of silicon Is 4 bit cell possible with 3D Will 3D be reliable enough for enterprise and datacenter applications These are some of the questions that this book helps answering by providing insights into 3D flash memory design process technology and applications

Solid-State-Drives (SSDs) Modeling Rino Michelsoni,2017-03-28 This book introduces simulation tools and strategies for complex systems of solid state drives SSDs which consist of a flash multi core microcontroller plus NAND flash memories It provides a broad overview of the most popular simulation tools with special focus on open source solutions VSSIM NANDFlashSim and DiskSim are benchmarked against performances of real SSDs under different traffic workloads PROs and CONs of each simulator are analyzed and it is clearly indicated which kind of answers each of them can give and at a what price It is explained that speed and precision do not go hand in hand and it is important to understand when to simulate what

and with which tool Being able to simulate SSD s performances is mandatory to meet time to market together with product cost and quality Over the last few years the authors developed an advanced simulator named SSDExplorer which has been used to evaluate multiple phenomena with great accuracy from QoS Quality Of Service to Read Retry from LDPC Soft Information to power from Flash aging to FTL SSD simulators are also addressed in a broader context in this book i e the analysis of what happens when SSDs are connected to the OS Operating System and to the end user application for example a database search The authors walk the reader through the full simulation flow of a real system level by combining SSD Explorer with the QEMU virtual platform The reader will be impressed by the level of know how and the combination of models that such simulations are asking for

Computer Systems Architecture Aharon Yadin, 2016-08-19 Computer Systems Architecture provides IT professionals and students with the necessary understanding of computer hardware It addresses the ongoing issues related to computer hardware and discusses the solutions supplied by the industry The book describes trends in computing solutions that led to the current available infrastructures tracing the initial need for computers to recent concepts such as the Internet of Things It covers computers data representation explains how computer architecture and its underlying meaning changed over the years and examines the implementations and performance enhancements of the central processing unit CPU It then discusses the organization hierarchy and performance considerations of computer memory as applied by the operating system and illustrates how cache memory significantly improves performance The author proceeds to explore the bus system algorithms for ensuring data integrity input and output I O components methods for performing I O various aspects relevant to software engineering and nonvolatile storage devices such as hard drives and technologies for enhancing performance and reliability He also describes virtualization and cloud computing and the emergence of software based systems architectures Accessible to software engineers and developers as well as students in IT disciplines this book enhances readers understanding of the hardware infrastructure used in software engineering projects It enables readers to better optimize system usage by focusing on the principles used in hardware systems design and the methods for enhancing performance

[Bits on Chips](#) Harry Veendrick, 2018-06-21 This book provides readers with a broad overview of integrated circuits also generally referred to as micro electronics The presentation is designed to be accessible to readers with limited technical knowledge and coverage includes key aspects of integrated circuit design implementation fabrication and application The author complements his discussion with a large number of diagrams and photographs in order to reinforce the explanations The book is divided into two parts the first of which is specifically developed for people with almost no or little technical knowledge It presents an overview of the electronic evolution and discusses the similarity between a chip floor plan and a city plan using metaphors to help explain concepts It includes a summary of the chip development cycle some basic definitions and a variety of applications that use integrated circuits The second part digs deeper into the details and is perfectly suited for professionals working in one of the

semiconductor disciplines who want to broaden their semiconductor horizon **Flash Memories** Igor Stievano, 2011-09-06 Flash memories and memory systems are key resources for the development of electronic products implementing converging technologies or exploiting solid state memory disks This book illustrates state of the art technologies and research studies on Flash memories Topics in modeling design programming and materials for memories are covered along with real application examples **In Search of the Next Memory** Roberto Gastaldi, Giovanni Campardo, 2017-03-07 This book provides students and practicing chip designers with an easy to follow yet thorough introductory treatment of the most promising emerging memories under development in the industry Focusing on the chip designer rather than the end user this book offers expanded up to date coverage of emerging memories circuit design After an introduction on the old solid state memories and the fundamental limitations soon to be encountered the working principle and main technology issues of each of the considered technologies PCRAM MRAM FeRAM ReRAM are reviewed and a range of topics related to design is explored the array organization sensing and writing circuitry programming algorithms and error correction techniques are reviewed comparing the approach followed and the constraints for each of the technologies considered Finally the issue of radiation effects on memory devices has been briefly treated Additionally some considerations are entertained about how emerging memories can find a place in the new memory paradigm required by future electronic systems This book is an up to date and comprehensive introduction for students in courses on memory circuit design or advanced digital courses in VLSI or CMOS circuit design It also serves as an essential one stop resource for academics researchers and practicing engineers

Genetic Programming Krzysztof Krawiec, Alberto Moraglio, Ting Hu, A. Sima Etaner-Uyar, Bin Hu, 2013-03-14 This book constitutes the refereed proceedings of the 16th European Conference on Genetic Programming EuroGP 2013 held in Vienna Austria in April 2013 co located with the Evo 2013 events EvoMUSART EvoCOP EvoBIO and EvoApplications The 18 revised full papers presented together with 5 poster papers were carefully reviewed and selected from 47 submissions The wide range of topics in this volume reflects the current state of research in the field including different genres of GP tree based linear grammar based Cartesian theory novel operators and applications **Nonvolatile Memory Design** Hai Li, Yiran Chen, 2017-12-19 The manufacture of flash memory which is the dominant nonvolatile memory technology is facing severe technical barriers So much so that some emerging technologies have been proposed as alternatives to flash memory in the nano regime Nonvolatile Memory Design Magnetic Resistive and Phase Changing introduces three promising candidates phase change memory magnetic random access memory and resistive random access memory The text illustrates the fundamental storage mechanism of these technologies and examines their differences from flash memory techniques Based on the latest advances the authors discuss key design methodologies as well as the various functions and capabilities of the three nonvolatile memory technologies **Advances in Non-volatile Memory and Storage Technology** Yoshio Nishi, Blanka Magyari-Kope, 2019-06-15 Advances in Nonvolatile Memory and Storage Technology Second Edition addresses

recent developments in the non volatile memory spectrum from fundamental understanding to technological aspects The book provides up to date information on the current memory technologies as related by leading experts in both academia and industry To reflect the rapidly changing field many new chapters have been included to feature the latest in RRAM technology STT RAM memristors and more The new edition describes the emerging technologies including oxide based ferroelectric memories MRAM technologies and 3D memory Finally to further widen the discussion on the applications space neuromorphic computing aspects have been included This book is a key resource for postgraduate students and academic researchers in physics materials science and electrical engineering In addition it will be a valuable tool for research and development managers concerned with electronics semiconductors nanotechnology solid state memories magnetic materials organic materials and portable electronic devices Discusses emerging devices and research trends such as neuromorphic computing and oxide based ferroelectric memories Provides an overview on developing nonvolatile memory and storage technologies and explores their strengths and weaknesses Examines improvements to flash technology charge trapping and resistive random access memory

Combinatorial Optimization and Applications Xiaofeng Gao,Hongwei Du,Meng Han,2017-12-06 The two volume set LNCS 10627 and 10628 constitutes the refereed proceedings of the 11th International Conference on Combinatorial Optimization and Applications COCOA 2017 held in Shanghai China in December 2017 The 59 full papers and 19 short papers presented were carefully reviewed and selected from 145 submissions The papers cover most aspects of theoretical computer science and combinatorics related to computing including classic combinatorial optimization geometric optimization complexity and data structures and graph theory They are organized in topical sections on network approximation algorithm and graph theory combinatorial optimization game theory and applications [Springer Handbook of Optical Networks](#) Biswanath Mukherjee,Ioannis Tomkos,Massimo Tornatore,Peter Winzer,Yongli Zhao,2020-10-15 This handbook is an authoritative comprehensive reference on optical networks the backbone of today s communication and information society The book reviews the many underlying technologies that enable the global optical communications infrastructure but also explains current research trends targeted towards continued capacity scaling and enhanced networking flexibility in support of an unabated traffic growth fueled by ever emerging new applications The book is divided into four parts Optical Subsystems for Transmission and Switching Core Networks Datacenter and Super Computer Networking and Optical Access and Wireless Networks Each chapter is written by world renown experts that represent academia industry and international government and regulatory agencies Every chapter provides a complete picture of its field from entry level information to a snapshot of the respective state of the art technologies to emerging research trends providing something useful for the novice who wants to get familiar with the field to the expert who wants to get a concise view of future trends

Wisdom Of Solomon, The: The Genius And Legacy Of Solomon Golomb Beatrice A Golomb,Guang G Gong,Alfred W Hales,2023-07-07 Solomon Wolf Golomb left an unparalleled legacy of accomplishment and

recognition for his work in the applications of mathematics to coding and communication theory His legacy also includes a host of individuals whose lives and careers were immeasurably enriched by their interactions with him The co editors have attempted to collect many articles essays in this volume of a not too technical sort by a representative collection of such individuals Among their motivations is the wish to convince the reader of the incredibly prescient choice of his given name The first section consists of three articles which have already appeared elsewhere by noted experts in the fields where the majority of Sol s contributions lie mathematics computer science and electrical engineering The second section consists of three articles by the co editors in memory of and tribute to Sol The third section contains 25 30 articles by Sol s family friends students colleagues etc They cover a great range of topics and vary widely in length technicality and other aspects In the last section are contributions by Sol himself covering various aspects of his career and interests as well as other related material

Dependable Embedded Systems Jörg Henkel,Nikil Dutt,2020-12-09 This Open Access book introduces readers to many new techniques for enhancing and optimizing reliability in embedded systems which have emerged particularly within the last five years This book introduces the most prominent reliability concerns from today s points of view and roughly recapitulates the progress in the community so far Unlike other books that focus on a single abstraction level such circuit level or system level alone the focus of this book is to deal with the different reliability challenges across different levels starting from the physical level all the way to the system level cross layer approaches The book aims at demonstrating how new hardware software co design solution can be proposed to effectively mitigate reliability degradation such as transistor aging processor variation temperature effects soft errors etc Provides readers with latest insights into novel cross layer methods and models with respect to dependability of embedded systems Describes cross layer approaches that can leverage reliability through techniques that are pro actively designed with respect to techniques at other layers Explains run time adaptation and concepts means of self organization in order to achieve error resiliency in complex future many core systems

Digital TV and Wireless Multimedia Communication Guangtao Zhai,Jun Zhou,Xiaokang Yang,2018-02-02 This book presents revised selected papers from the 14th International Forum on Digital TV and Wireless Multimedia Communication IFTC 2017 held in Shanghai China in November 2017 The 46 papers presented in this volume were carefully reviewed and selected from 122 submissions They were organized in topical sections named image processing machine learning quality assessment social media telecommunications video surveillance virtual reality computer vision and image compression

Nanometer CMOS ICs Harry J.M. Veendrick,2017-04-28 This textbook provides a comprehensive fully updated introduction to the essentials of nanometer CMOS integrated circuits It includes aspects of scaling to even beyond 12nm CMOS technologies and designs It clearly describes the fundamental CMOS operating principles and presents substantial insight into the various aspects of design implementation and application Coverage includes all associated disciplines of nanometer CMOS ICs including physics lithography technology design memories VLSI power consumption variability

reliability and signal integrity testing yield failure analysis packaging scaling trends and road blocks The text is based upon in house Philips NXP Semiconductors Applied Materials ASML IMEC ST Ericsson TSMC etc courseware which to date has been completed by more than 4500 engineers working in a large variety of related disciplines architecture design test fabrication process packaging failure analysis and software

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