Multiple-Valued Logic in VLSI: Challenges and Opportunities

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Abstract

In recent years, there have been major advances in integrated circuit technology which have both made feasible and generated great interest in electronic circuits which employ more than two discrete levels of signal. Such circuits, called multiple-valued logic circuits, offer several potential opportunities for the improvement of present VLSI circuit designs. In this paper, we give an overview of recent developments in multiple-valued logic circuit design, revealing both the opportunities they offer and the challenges they face.

1   Introduction

When people ask me why I am doing research in multiple-valued logic, I often reply that it is like painting a picture having all possible colors available. Once you tried them, you will never return to just black and white. Multiple-valued logic displays us phenomena, we would never see in binary case, where the only two values available are *null* and *unit* elements of Boolean algebra[1], possessing very specific properties. Reflected back to two-valued scale, these phenomena give us a new, deeper understanding of the matter.

Apart from giving us a better insight into binary problems, multiple-valued logic has many other useful applications. They can be classified into two groups. The first group uses multiple-valued logic domain to solve binary problems more efficiently. For example, a well-known approach to represent a multiple-output Boolean function is to convert it to a single–output multiple-valued function, by treating its output part as a single multiple-valued variable. Such an approach is used, for instance, in Berkeley's tool for verification and synthesis VIS [1].

The second group targets the design of electronic circuits which employ more than two discrete levels of signals, such as multiple-valued memories, arithmetic circuits, Field Programmable Gate Arrays etc. Multiple-valued logic (MVL) circuits offer several potential opportunities for the improvement of present VLSI circuit designs. For example, serious difficulties with limitations on the number of connections of an integrated circuit with the

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[1]The *null* **0** and *unit* **1** elements of an algebra over a set A have the properties that, for each $x \in A$, $x + \mathbf{0} = x$ and $x \cdot \mathbf{1} = x$

Multiple Valued Logic Design An Introduction

David C. Rine

Multiple Valued Logic Design An Introduction:

   Multiple-valued Logic Design George Epstein,1993 Multiple Valued Logic Design An Introduction explains the theory and applications of this increasingly important subject Written in a clear and understandable style the author develops the material in a skillful way Without using a huge mathematical apparatus he introduces the subject in a general form that includes the well known binary logic as a special case The book is further enhanced by more 200 explanatory diagrams and circuits hardware and software applications with supporting PASCAL programming and comprehensive exercises with even numbered answers for every chapter Requiring introductory knowledge in Boolean algebra 2 valued logic or 2 valued switching theory Multiple Valued Logic Design An Introduction is an ideal book for courses not only in logic design but also in switching theory nonclassical logic and computer arithmetic Computer scientists mathematicians and electronic engineers can also use the book as a basis for research into multiple valued logic design Provided by publisher   Multiple-Valued Logic Design G Epstein,1993-01-01 Multiple Valued Logic Design An Introduction explains the theory and applications of this increasingly important subject Written in a clear and understandable style the author develops the material in a skillful way Without using a huge mathematical apparatus he introduces the subject in a general form that includes the well known binary logic as a special case The book is further enhanced by more 200 explanatory diagrams and circuits hardware and software applications with supporting PASCAL programming and comprehensive exercises with even numbered answers for every chapter Requiring introductory knowledge in Boolean algebra 2 valued logic or 2 valued switching theory Multiple Valued Logic Design An Introduction is an ideal book for courses not only in logic design but also in switching theory nonclassical logic and computer arithmetic Computer scientists mathematicians and electronic engineers can also use the book as a basis for research into multiple valued logic design   **Computer Science and Multiple-Valued Logic** David C. Rine,2014-05-12 Computer Science and Multiple Valued Logic Theory and Applications focuses on the processes methodologies and approaches involved in multiple valued logic and its relationship to computer science The selection first tackles an introduction to multiple valued logic lattice theory of post algebras multiple valued logic design and applications in binary computers smallest many valued logic for the treatment of complemented and uncomplemented error signals and chain based lattices Discussions focus on formulation representation theory theory and circuit design logical tables and unary operations The text then examines multiple valued signal processing with limiting development of multiple valued logic as related to computer science p algebras and an algorithm for axiomatizing every finite logic The book takes a look at completeness properties of multiple valued logic algebras computer simplification of multi valued switching functions and minimization of multivalued functions Topics include generation of prime implicants realizations minimization algorithms decomposition algorithm for multi valued switching functions and relation between the sum of products form and array of cubes The selection is aimed at computer engineers computer scientists applied mathematicians and physicists interested in

multiple valued logic as the discipline relates to computer engineering and computer science   Multiple-valued Logic in VLSI Design Jon T. Butler,1991   *Multi-Valued Logic, Neutrosophy, and Schrodinger Equation* Florentin Smarandache,Vic Christianto,2005-12 This book was intended to discuss some paradoxes in Quantum Mechanics from the viewpoint of Multi Valued logic pioneered by Lukasiewicz and a recent concept Neutrosophic Logic Essentially this new concept offers new insights on the idea of identity which too often it has been accepted as given Neutrosophy itself was developed in attempt to generalize Fuzzy Logic introduced by L Zadeh While some aspects of theoretical foundations of logic are discussed this book is not intended solely for pure mathematicians but instead for physicists in the hope that some of ideas presented herein will be found useful The book is motivated by observation that despite almost eight decades there is indication that some of those paradoxes known in Quantum Physics are not yet solved In our knowledge this is because the solution of those paradoxes requires re examination of the foundations of logic itself in particular on the notion of identity and multi valuedness of entity The book is also intended for young physicist fellows who think that somewhere there should be a complete explanation of these paradoxes in Quantum Mechanics If this book doesn t answer all of their questions it is our hope that at least it offers a new alternative viewpoint for these old questions   Multiple Valued Logic D. Michael Miller,Mitchell Aaron Thornton,2008 Multiple Valued Logic Concepts and Representations begins with a survey of the use ofmultiple valued logic in several modern application areas including electronic design automation algorithms and circuit design The mathematical basis and concepts of various algebras and systems of multiple valued logic are provided including comparisons among various systems and examples of their application The book also provides an examination of alternative representations of multiple valued logic suitable for implementation as data structures in automated computer applications Decision diagram structures for multiple valued applications are described in detail with particular emphasis on the recently developed quantum multiple valued decision diagram   *The Eighth International Symposium on Multiple-Valued Logic* ,1978   **Ternary Digital System** A P Dhande,V T Ingole,V R Ghiye,2014-10-01 Ternary digital system is commonly known as three valued digital system Three valued logic is an elementary set of Multiple Valued Logic which is introduced in the book at the beginning The book provides a detail overview of every concept required for the design and applications of ternary circuits It covers the basic concepts for ternary logic fundamentals ternary logic gates its logic gate truth tables Boolean rules for ternary logic up to ternary logic families function synthesis and minimization techniques and an applications like one trit T ALU Two trit T ALU Slice Ternary R S and D memory elements and an analog to ternary converter for DSP application as a fundamental block are developed and simulated using EDA tool Finally computer simulation using EDA Electronic Design Automation tools like Tanner spice and VHDL is also illustrated In the first half of 19 th century G Boolean have proposed the Algebra for two valued Binary logic system after that Shanon has expressed the behavior of electrical switches in terms of Boolean algebra and he paved the ramp to an industrial development that is recognized as initiating one of the most revolutionary economic

changes ever MVL is also known as Multi Valued Multiple Valued or Many Valued logic Multi Value logic is regarded as a switch with more than two states Such as a 3 value switch with states 0 1 and 2 Or a 4 value switch with states 0 1 2 and 3 In case of 3 Valued logic the term ternary logic is used term quaternary logic for 4 Valued logic Alexander 1964 showed that the most efficient radix for implementation of switching systems is the natural base e 2 71828 it seems likely that the best integral radix is 3 rather than 2 It should be noted that this book emphasis on Ternary logic with concepts and applications The fundamental work on Multiple Valued Logic MVL System was done by E L Post in the beginning of 19 th centuries and based on that work P C Rosen Bloom modeled the Algebra for MVL is called Post Algebra   *Multiple-valued Switching Theory,* Jon C. Muzio,T. C. Wesselkamper,1986 An essentially self contained presentation of all the relevant techniques of multiple valued analysis this book will be of great value to undergraduates or postgraduate students of computer logic and design and all who need to master this subject The entire range of techniques built up throughout the book is applied to a number of case studies with emphasis placed firmly on the achievement of switching circuits to accomplish required tasks

1987 IEEE Workshop on Languages for Automation ,1987   **A Bi-directional Current-mode CMOS Multiple Valued Logic Memory Circuit** Michael E. Hurlston,1990   Proceedings of the 1974 International Symposium on Multiple-valued Logic ,1974   *Twelfth International Conference on VLSI Design* VLSI Society of India,IEEE Circuits and Systems Society,1999 The proceedings of the January 1999 conference consist of 103 papers 11 talks and six tutorials The papers are grouped under the headings of TCAD to ECAD low power testing co design and synthesis analog design multi valued logic verification digital signal processor DSP logic synthesis   1997 27th International Symposium on Multiple-Valued Logic ,1997   ISMVL 2004 International Symposium on Multiple Valued Logic (34, 2004, Toronto),IEEE Computer Society,2004   **Memoirs of Faculty of Technology, Tokyo Metropolitan University** Tōkyō Toritsu Daigaku. Kōgakubu,1979   **Conference Record of the ... International Symposium on Multiple-valued Logic** ,1973   Information Processing ,1986   **Subject Guide to Books in Print** ,1993   **Applied Simulation and Modelling, ASM '86** International Association of Science and Technology for Development,1986

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