

# 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<sup>1</sup>, 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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<sup>1</sup>The *null*  $\mathbf{0}$  and *unit*  $\mathbf{1}$  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

**CH Cherryholmes**



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*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 than 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.

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[Introduction to Logic Design](#) Svetlana N. Yanushkevich, Vlad P. Shmerko, 2008-01-25 With an abundance of insightful examples, problems, and computer experiments, *Introduction to Logic Design* provides a balanced, easy-to-read treatment of the fundamental theory of logic functions and applications to the design of digital devices and systems. Requiring no prior knowledge of electrical circuits or electronics, it supplies the

*Multiple-valued Logic in VLSI Design* Jon T. Butler, 1991 *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 The Eighth International Symposium on Multiple-Valued Logic, 1978 **Artificial Intelligence in Logic Design** Svetlana N. Yanushkevich, 2013-03-19 There are three outstanding points of this book First for the first time a collective point of view on the role of artificial intelligence paradigm in logic design is introduced Second the book reveals new horizons of logic design tools on the technologies of the near future Finally the contributors of the book are twenty recognizable leaders in the field from the seven research centres The chapters of the book have been carefully reviewed by equally qualified experts All contributors are experienced in practical electronic design and in teaching engineering courses Thus the book's style is accessible to graduate students practical engineers and researchers **A Bi-directional Current-mode CMOS Multiple Valued Logic Memory Circuit** Michael E. Hurlston, 1990 **Multiple Valued Logic** D. Michael Miller, Mitchell Aaron Thornton, 2008 **Multiple Valued Logic Concepts and Representations** begins with a survey of the use of multiple 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 **ISMVL 2004** International Symposium on Multiple Valued Logic (34, 2004, Toronto), IEEE Computer Society, 2004 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 Constraint Solving Over Multi-valued Logics Francisco Azevedo, 2003 Systems are subject to faults in their components affecting their overall behaviour In a black box system such faults only become apparent in the output when appropriate inputs are given which poses a number of satisfaction and optimization problems regarding both testing and diagnosing This work addresses such problems developing models with multi valued logics that it formalizes and generalizes to multiple faults Such logics extend Boolean logic by encoding dependencies on faults thus allowing the modelling of an arbitrary number of diagnostic theories The effectiveness

of constraint solving over finite domains and sets is shown on several problems      **1987 IEEE Workshop on Languages for Automation** ,1987      **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      **Digest of Technical Papers** ,1984      **Logic Design Principles** Edward J. McCluskey,1986      **Proceedings** International Telemetering Conference,1986      *Modeling and Simulation, Volume 19* Marlin H. Mickle,William G. Vogt,1988      **International Telemetering Conference** ,1986  
1997 *27th International Symposium on Multiple-Valued Logic* ,1997

## **Multiple Valued Logic Design An Introduction** Book Review: Unveiling the Magic of Language

In an electronic era where connections and knowledge reign supreme, the enchanting power of language has become more apparent than ever. Its capability to stir emotions, provoke thought, and instigate transformation is truly remarkable. This extraordinary book, aptly titled "**Multiple Valued Logic Design An Introduction**," published by a highly acclaimed author, immerses readers in a captivating exploration of the significance of language and its profound effect on our existence. Throughout this critique, we shall delve in to the book is central themes, evaluate its unique writing style, and assess its overall influence on its readership.

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