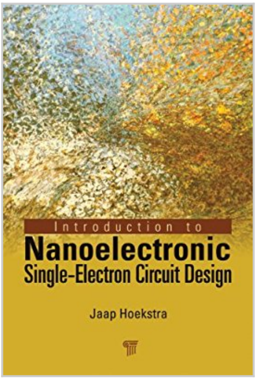

Introduction to Nanoelectronic Single-Electron Circuit Design

By Jaap Hoekstra

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This book examines single-electron circuits as an introduction to the rapidly expanding field of nanoelectronics. It discusses both the analysis and synthesis of circuits with the nanoelectronic metallic single-electron tunneling (SET) junction device. The basic physical phenomena under consideration are the quantum mechanical tunneling of electrons through a small insulating gap between two metal leads, the Coulomb blockade and Coulomb oscillations — the last two resulting from the quantization of charge. The author employs an unconventional approach in explaining the operation and design of single-electron circuits.

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Editorial Review

Review

"The spectacular evolution of microelectronics has demonstrated the power of the ‘circuit paradigm’. During the last decade, a broad class of nanoelectronic discrete devices has been proposed and successfully demonstrated; however, there still exists a gap between device physics and nanoelectronic integrated circuit design. This book offers an insight into an original and outstanding effort to bridge the gap between device physics and engineering of nanoelectronic integrated architectures. Original equivalent circuit models of metallic single-electron tunneling (SET) junctions and efficient analysis and synthesis techniques of nanoelectronic circuits are presented. This book in recommended to researchers and students interested in nanoscience and nanotechnology, especially in nanoelectronics."
?Arpad I. Csurgay, University, Hungary and University of Notre Dame, USA

"Single electron devices are promising candidates for next-generation circuits. By clarifying the relationship between models of different levels, this book offers useful knowledge on modeling which makes single electron devices treated the same as conventional transistors during circuit design. The new perspectives involved also help to conceive novel nano-devices. It is a very good reference for researchers who are engaged in this exciting area."
?Ning Deng, Tsinghua University, China

From the Inside Flap
In Introduction to Nanoelectronic Single-electron Circuit Design, single-electron circuits are studied as an introduction to the rapidly expanding field of nanoelectronics. Treated are both the analysis and synthesis of circuits with the nanoelectronic metallic single-electron tunneling (SET) junction device. The basic physical phenomena under consideration are the quantum mechanical tunneling of electrons through a small insulating gap between two metal leads, the Coulomb blockade, and Coulomb oscillations the last two resulting from the quantization of charge. While electron transport in nanoelectronic devices can best be described by quantum physics; nanoelectronic circuits can best be described by Kirchhoff's voltage and current laws.

The author employs an unconventional approach in explaining the operation and design of single-electron circuits. All models and equivalent circuits are derived from first principles of circuit theory. This is a must if we want to understand the characteristics of the nanoelectronic devices and subcircuits. Besides this, a circuit theoretical approach is necessary for considering possible integration in current and future IC technology. Based on energy conservation, in circuit theory connected to Tellegen's theorem, the circuit model for single-electron tunneling is an impulsive current source. Modeling distinguishes between bounded and unbounded currents. The Coulomb blockade is explained as a property of a tunnel junction, not of an island.

About the Author

Jaap Hoekstra was born in Amsterdam, the Netherlands, in 1955. He received an MSc in experimental physics from the University of Amsterdam and a PhD degree for research on (junction) charge-coupled devices, involving device physics, device development and subsystem concepts, from the Delft University of Technology, the Netherlands. From 1988 to 1995 he was at the Computer Architecture Laboratory at the

TU-Delft working in the field of artificial neural networks. From 1996 to 1997 he worked on chaotic dynamics in power systems at the laboratory of Electrical Power Systems. In April 1997 he joined the Electronic Research Laboratory, where he is currently involved in research projects on artificial neural nets, biologic-inspired networks, neuromorphic circuits, nanoscale electronic devices, and single-electron tunneling devices.

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