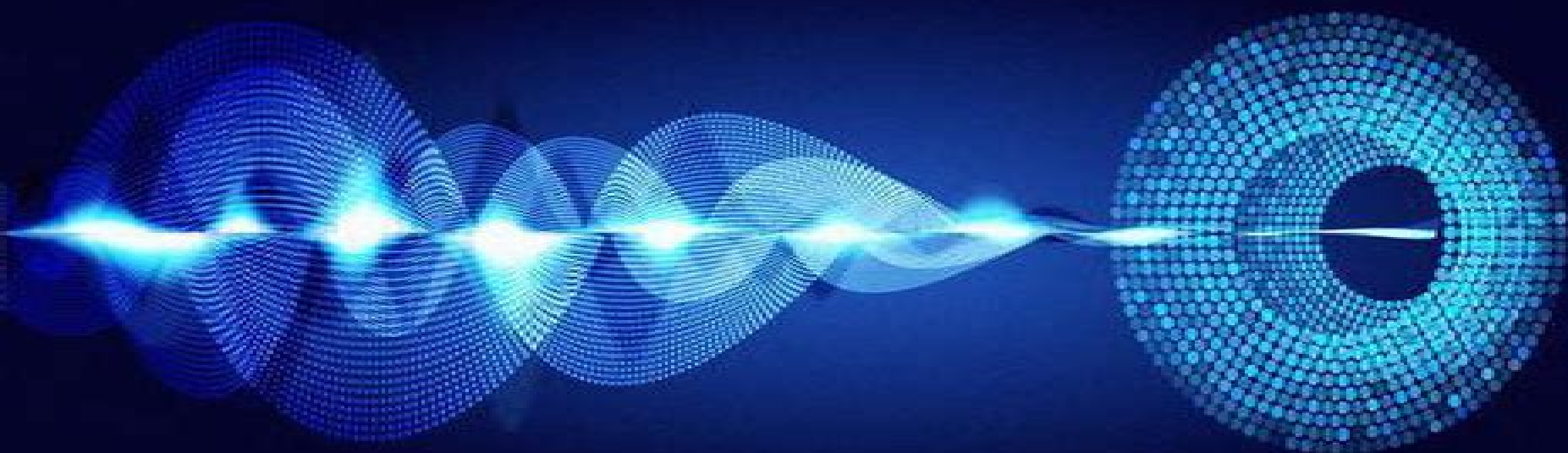


Design of CMOS Millimeter-Wave and Terahertz Integrated Circuits with Metamaterials



Hao Yu • Yang Shang



CRC Press
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Design Of Cmos Millimeter Wave And Terahertz Integrated Circuits With Metamaterials

Kiat Seng Yeo, Chirn Chye Boon, Xiang Yi (Researcher in microelectronics), Fanyi Meng (Professor at Tianjin University)

Design Of Cmos Millimeter Wave And Terahertz Integrated Circuits With Metamaterials:

Design of CMOS Millimeter-Wave and Terahertz Integrated Circuits with Metamaterials Hao Yu, Yang Shang, 2015-10-19

This book shows that with the use of metamaterials one can have coherent THz signal generation amplification transmission and detection for phase arrayed CMOS transistors with significantly improved performance Offering detailed coverage from device to system the book describes the design and application of metamaterials in actual CMOS integrated circuits includes real circuit examples and chip demonstrations with measurement results and also evaluates system performance after CMOS based system on chip integration The book reflects the latest research progress and provides a state of the art reference on CMOS based metamaterial devices and mm wave and THz systems

CMOS Integrated Lab-on-a-chip System for Personalized Biomedical Diagnosis Hao Yu, Mei Yan, Xiwei Huang, 2018-04-04 A thorough examination of lab on a chip circuit level operations to improve system performance A rapidly aging population demands rapid cost effective flexible personalized diagnostics Existing systems tend to fall short in one or more capacities making the development of alternatives a priority CMOS Integrated Lab on a Chip System for Personalized Biomedical Diagnosis provides insight toward the solution with a comprehensive multidisciplinary reference to the next wave of personalized medicine technology A standard complementary metal oxide semiconductor CMOS fabrication technology allows mass production of large array miniaturized CMOS integrated sensors from multi modal domains with smart on chip processing capability This book provides an in depth examination of the design and mechanics considerations that make this technology a promising platform for microfluidics micro electro mechanical systems electronics and electromagnetics From CMOS fundamentals to end user applications all aspects of CMOS sensors are covered with frequent diagrams and illustrations that clarify complex structures and processes Detailed yet concise and designed to help students and engineers develop smaller cheaper smarter lab on a chip systems this invaluable reference Provides clarity and insight on the design of lab on a chip personalized biomedical sensors and systems Features concise analyses of the integration of microfluidics and micro electro mechanical systems Highlights the use of compressive sensing super resolution and machine learning through the use of smart SoC processing Discusses recent advances in complementary metal oxide semiconductor integrated lab on a chip systems Includes guidance on DNA sequencing and cell counting applications using dual mode chemical optical and energy harvesting sensors The conventional reliance on the microscope flow cytometry and DNA sequencing leaves diagnosticians tied to bulky expensive equipment with a central problem of scale Lab on a chip technology eliminates these constraints while improving accuracy and flexibility ushering in a new era of medicine This book is an essential reference for students researchers and engineers working in diagnostic circuitry and microsystems

High-Speed Devices and Circuits with THz Applications Jung Han Choi, 2017-09-19 Presenting the cutting edge results of new device developments and circuit implementations High Speed Devices and Circuits with THz Applications covers the recent advancements of nano devices for terahertz THz applications and the latest

high speed data rate connectivity technologies from system design to integrated circuit IC design providing relevant standard activities and technical specifications Featuring the contributions of leading experts from industry and academia this pivotal work Discusses THz sensing and imaging devices based on nano devices and materials Describes silicon on insulator SOI multigate nanowire field effect transistors FETs Explains the theory underpinning nanoscale nanowire metal oxide semiconductor field effect transistors MOSFETs simulation methods and their results Explores the physics of the silicon germanium SiGe heterojunction bipolar transistor HBT as well as commercially available SiGe HBT devices and their applications Details aspects of THz IC design using standard silicon Si complementary metal oxide semiconductor CMOS devices including experimental setups for measurements detection methods and more An essential text for the future of high frequency engineering

High Speed Devices and Circuits with THz Applications offers valuable insight into emerging technologies and product possibilities that are attractive in terms of mass production and compatibility with current manufacturing facilities

Plasmonic Metamaterials and Electromagnetic Devices Zhen Liao,Kai-Da Xu,Hui Feng Ma,Zhewang Ma,2022-08-25

Antenna Technology for Terahertz Wireless Communication Uri Nissanov,Ghanshyam Singh,2023-07-11 This book discusses terahertz THz wireless communication particularly for 6G enabling technologies including antenna design and channel modeling with channel characteristics for the success of reliable 6G wireless communication The authors describe THz microstrip antenna technologies with different substrates and introduce some useful substrates to reduce the conductor and substrate losses at the THz frequencies The discussion also includes the design of the THz unit cell microstrip antenna and the techniques to boost the microstrip antennas gain directivity and impedance bandwidth BW which influence the wireless communication range which is highly affected by the path losses of atmospheric conditions and transmit and receive data rates respectively Moreover this book discusses the multi beam and beamforming THz antenna technologies with the multi user multiple input multiple output MU MIMO features Additionally this book describes the reconfigurable capabilities artificial intelligence machine learning and deep learning technologies that will influence the success of 6G wireless communication and the authors suggest a remedy for integrating multiple radios into the system on chip SoC design

Design of Terahertz CMOS Integrated Circuits for High-Speed Wireless Communication Minoru Fujishima,Shuhei Amakawa,2019-06-24 Communications technology at a frequency range into Terahertz THz levels has attracted attention because it promises near fibre optic speed wireless links for the 5G and post 5G world Transmitter and receiver integrated circuits based on CMOS which has the ability to realize such circuits with low power consumption at a low cost are expected to become increasingly widespread with much research into the underlying electronics currently underway

Millimeter-Wave Integrated Circuits Mladen Božanić,Saurabh Sinha,2020-03-16 This peer reviewed book explores the methodologies that are used for effective research design and innovation in the vast field of millimeter wave circuits and describes how these have to be modified to fit the uniqueness of high frequency nanoelectronics design Each

chapter focuses on a specific research challenge related to either small form factors or higher operating frequencies The book first examines nanodevice scaling and the emerging electronic design automation tools that can be used in millimeter wave research as well as the singular challenges of combining deep submicron and millimeter wave design It also demonstrates the importance of considering in the millimeter wave context system level design leading to differing packaging options Further it presents integrated circuit design methodologies for all major transceiver blocks typically employed at millimeter wave frequencies as these methodologies are normally fundamentally different from the traditional design methodologies used in analogue and lower frequency electronics Lastly the book discusses the methodologies of millimeter wave research and design for extreme or harsh environments rebooting electronics the additional opportunities for terahertz research and the main differences between the approaches taken in millimeter wave research and terahertz research

Cmos Millimeter-wave Integrated Circuits For Next Generation Wireless Communication Systems Kiat Seng Yeo,Chirn Chye Boon,Xiang Yi,Fanyi Meng,2019-07-09 This book addresses in depth technical issues limitations considerations and challenges facing millimeter wave MMW integrated circuit and system designers in designing MMW wireless communication systems from the complementary metal oxide semiconductor CMOS perspective It offers both a comprehensive explanation of fundamental theories and a broad coverage of MMW integrated circuits and systems CMOS Millimeter Wave Integrated Circuits for Next Generation Wireless Communication Systems is an excellent reference for faculty researchers and students working in electrical and electronic engineering wireless communication integrated circuit design and circuits and systems While primarily written for upper level undergraduate courses it is also an excellent introduction to the subject for instructors graduate students researchers integrated circuit designers and practicing engineers Advanced readers could also benefit from this book as it includes many recent state of the art MMW circuits

Related Link s **Ultra High-Speed CMOS Circuits** Sam Gharavi,Babak Heydari,2011-09-25 The book covers the CMOS based millimeter wave circuits and devices and presents methods and design techniques to use CMOS technology for circuits operating beyond 100 GHz Coverage includes a detailed description of both active and passive devices including modeling techniques and performance optimization Various mm wave circuit blocks are discussed emphasizing their design distinctions from low frequency design methodologies This book also covers a device oriented circuit design technique that is essential for ultra high speed circuits and gives some examples of device circuit co design that can be used for mm wave technology

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Philippe Ferrari,Rolf Jakoby,Onur Hamza Karabey,Gustavo P. Rehder,Holger Maune,2022-05-26 Describes the theory modeling and design of tunable mm wave circuits and systems using CMOS RF MEMS and microwave liquid crystals

CMOS Analog IC Design for 5G and Beyond Sangeeta Singh,Rajeev Arya,M. P. Singh,Brijesh Iyer,2021-02-07 This book is focused on addressing the designs of FinFET based analog ICs for 5G and E band communication networks In addition it also incorporates some of the contemporary developments over different fields It highlights the latest advances problems and challenges and presents the latest research results in the field of mm wave integrated circuits designing based on scientific literature and its practical realization The traditional approaches are excluded in this book The authors cover various design guidelines to be taken care for while designing these circuits and detrimental scaling effects on the same Moreover Gallium Nitrides GaN are also reported to show huge potentials for the power amplifier designing required in 5G communication network Subsequently to enhance the readability of this book the authors also include real time problems in RFIC designing case studies from experimental results and clearly demarking design guidelines for the 5G communication ICs designing This book incorporates the most recent FinFET architecture for the analog IC designing and the scaling effects along with the GaN technology as well Advanced Metamaterial Circuits for Microwave and Millimeter Wave Applications

David Eliecer Senior,2012 Additional experimental implementations include a surface micromachined SU8 embedded CSRR loaded HMSIW bandpass filter working at 12 GHz At the end the proposed cavities are also applied for the design of a set of bandpass filters for operation at 25 GHz and 60 GHz using the flexible substrate LCP and the BCB resin as dielectrics Finally since the conventional printed circuit board PCB low resistivity silicon and glass are selected as the supporting substrates for the micromachined CRLH devices and filters the compatibility with conventional microwave PCB implementations and CMOS integrated circuits is maintained Millimeter-Wave Integrated Circuits Eoin Carey,Sverre Lidholm,2005-12-05 Millimeter

Wave Integrated Circuits delivers a detailed overview of MMIC design specifically focusing on designs for the millimeter wave mm wave frequency range The scope of the book is broad spanning detailed discussions of high frequency materials and technologies high frequency devices and the design of high frequency circuits The design material is supplemented as appropriate by theoretical analyses The broad scope of the book gives the reader a good theoretical and practical understanding of mm wave circuit design It is best suited for both undergraduate students who are reading or studying high

frequency circuit design and postgraduate students who are specializing in the mm wave field *mm-Wave Silicon Technology* Ali M. Niknejad, Hossein Hashemi, 2008-01-03 This book compiles and presents the research results from the past five years in mm wave Silicon circuits This area has received a great deal of interest from the research community including several university and research groups The book covers device modeling circuit building blocks phased array systems and antennas and packaging It focuses on the techniques that uniquely take advantage of the scale and integration offered by silicon based technologies **Millimeter-wave and Terahertz Technology for Integrated Circuits** Bhavana Benakaprasad, 2018 Micromachined Circuits and Devices Shibani Kishen Koul, Sukomal Dey, 2022-02-07 This book presents the design of different switching and resonant devices using the present state of the art radio frequency RF micromachining MEMS technology Different topologies of MEMS switches have been discussed considering optimum performances over microwave to millimeter wave frequency range Wide varieties of micromachined switching networks starting from single pole double throw SPDT to single pole fourteen throw SP14T are discussed utilizing vertical and lateral actuation movements of the switch Different transduction mechanisms of micromachined resonators are highlighted that includes capacitive piezoelectric and piezoresistive types The book provides major design guidelines for the development of MEMS based digital phase shifters tunable filters and antennas with extensive measurement data Apart from the radio frequency RF requirements an extensive guideline is given for the improvement of the reliability of micromachined switches and digital phase shifters where multiple switches are operating simultaneously It takes multiple iterations and extensive characterizations to conclude with a reliable MEMS digital phase shifter and these aspects are given one of the prime attentions in this book Detailed performance analysis of metamaterial inspired MEMS switches is then discussed for application in millimeter wave frequency bands up to about 170 GHz The book concludes with future research activities of RF MEMS technology and its potential in space defense sensors and biomedical applications CMOS Front Ends for Millimeter Wave Wireless Communication Systems Noël Defam, Patrick Reynaert, 2015-03-23 This book focuses on the development of circuit and system design techniques for millimeter wave wireless communication systems above 90GHz and fabricated in nanometer scale CMOS technologies The authors demonstrate a hands on methodology that was applied to design six different chips in order to overcome a variety of design challenges Behavior of both actives and passives and how to design them to achieve high performance is discussed in detail This book serves as a valuable reference for millimeter wave designers working at both the transistor level and system level Solid-state Terahertz and Millimeter-wave Electronics Omeed Momeni, 2011 There is a growing interest in terahertz and mm wave systems for compact low cost and energy efficient imaging and spectroscopy Detection of concealed weapons cancer diagnosis food quality control and breath analyses for disease diagnosis are among many examples that will rapidly flourish if compact and on chip terahertz systems are realized There are few implementations of terahertz building blocks using compound semiconductors at lower terahertz

range Unfortunately these processes have low yield are cost inefficient and are not suitable for integration of digital blocks on the same chip On the other hand while CMOS can overcome these challenges the best reported f_{max} of CMOS transistors fall well below terahertz frequencies To overcome these drawbacks we have introduced systematic methodologies for designing circuits and components operating close to and beyond the conventional limits of the devices These circuit blocks can effectively generate combine and process signals from multiple devices to achieve performances orders of magnitude better than the state of the art The proposed techniques are general and can be used in any technology including CMOS and other processes As an example in Chapter 1 we show a traveling wave frequency multiplier for high power and wide band terahertz and mm wave signal generation It takes advantage of standing wave formation and loss cancelation in a distributed structure to generate high amplitude signals resulting in high harmonic power Wide bandwidth operation and odd harmonic cancelation around the center frequency are the inherent properties of this frequency multiplier Using this methodology we implemented a frequency doubler that operates from 220 GHz to 275 GHz in a standard 65 nm CMOS process Output power of 6.6 dBm (0.22 mW) and conversion loss of 11.4 dB are measured at 244 GHz This signal source has twice the operating frequency and tuning range of the best reported CMOS multiplier and 10 times higher output power than the best reported CMOS realization In Chapter 2 a systematic approach to designing high frequency and high power oscillators using activity condition is introduced This method finds the best topology to achieve frequencies close to the f_{max} of the transistors It also determines the maximum frequency of oscillation for a fixed circuit topology considering the quality factor of the passive components Using this technique in a 0.13 μ m CMOS process we design and implement 121 GHz and 104 GHz fundamental oscillators with the output power of 3.5 dBm and 2.7 dBm respectively Next we introduce a novel triple push structure to realize 256 GHz and 482 GHz oscillators The 256 GHz oscillator was implemented in a 0.13 μ m CMOS process and the output power of 17 dBm was measured The 482 GHz oscillator generates 7.9 dBm (160 μ W) in a 65 nm CMOS process which is 8 000 times more than any other CMOS sources at this frequency range A systematic method to design high gain amplifiers at frequencies close to the f_{max} of the transistors is introduced in Chapter 3 This approach finds the optimum termination conditions to reach the maximum achievable gain of the device Using this technique in a standard 130 nm CMOS process we design and implement a 107 GHz amplifier with a gain of 12.5 dB PAE of 4.4% and saturated output power of 2.3 dBm consuming 31 mW from a 0.95 V supply The center frequency of this amplifier is higher than any other reported amplifier in 130 nm and 90 nm CMOS process Other specifications such as gain and PAE is comparable to amplifiers in 65 nm CMOS process while consuming 1/3 of the DC power Moreover to go beyond the conventional limitations of passive circuits we develop a method to perform signal processing using 2-D electrical lattices in Chapter 4 The rich 2-D propagation properties of the medium are used to introduce a novel high quality factor filter called an electrical prism which is compatible with today's conventional integrated circuit processes The proposed filter shows a

quality factor much larger than the quality factor of the individual components at high mm wave and terahertz frequencies This structure also provides a negative effective index in a low pass LC lattice Based on this idea we show filters with quality factors of 130 at 230GHz and 420 at 460GHz consisting of elements with the quality factor of 10 and 20 respectively The negative effective index and the filter behavior of the lattice is verified by measuring a prototype on a CMOS process at 32GHz 40GHz

Metamaterials and THz Integrated Circuits Mark Douglas McDonald, 2017 Two THz oscillator designs are presented that use a metamaterial as the resonant element The design methodology process and simulation techniques are discussed Finally the simulated results are shown

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