RF and mm-Wave Power Generation in Silicon

Edited by Hua Wang Kaushik Sengupta



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RF and mm-Wave Power Generation in Silicon Hua Wang, Kaushik Sengupta, 2015-12-10 RF and mm Wave Power Generation in Silicon presents the challenges and solutions of designing power amplifiers at RF and mm Wave frequencies in a silicon based process technology It covers practical power amplifier design methodologies energy and spectrum efficient power amplifier design examples in the RF frequency for cellular and wireless connectivity applications and power amplifier and power generation designs for enabling new communication and sensing applications in the mm Wave and THz frequencies With this book you will learn Power amplifier design fundamentals and methodologies Latest advances in silicon based RF power amplifier architectures and designs and their integration in wireless communication systems State of the art mm Wave THz power amplifier and power generation circuits and systems in silicon Extensive coverage from fundamentals to advanced design topics focusing on various layers of abstraction from device modeling and circuit design strategy to advanced digital and mixed signal architectures for highly efficient and linear power amplifiers New architectures for power amplifiers in the cellar and wireless connectivity covering detailed design methodologies and state of the art performances Detailed design techniques trade off analysis and design examples for efficiency enhancement at power back off and linear amplification for spectrally efficient non constant envelope modulations Extensive coverage of mm Wave power generation techniques from the early days of the 60 GHz research to current state of the art reconfigurable digital mm Wave PA architectures Detailed analysis of power generation challenges in the higher mm Wave and THz frequencies and novel technical solutions for a wide range for potential applications including ultrafast wireless communication to sensing imaging and spectroscopy Contributions from the world class experts from both academia and industry **Automotive Radar Sensors** in Silicon Technologies Vipul Jain, Payam Heydari, 2012-09-27 One of the leading causes of automobile accidents is the slow reaction of the driver while responding to a hazardous situation State of the art wireless electronics can automate several driving functions leading to significant reduction in human error and improvement in vehicle safety With continuous transistor scaling silicon fabrication technology now has the potential to substantially reduce the cost of automotive radar sensors This book bridges an existing gap between information available on dependable system architecture design and circuit design It provides the background of the field and detailed description of recent research and development of silicon based radar sensors System level requirements and circuit topologies for radar transceivers are described in detail Holistic approaches towards designing radar sensors are validated with several examples of highly integrated radar ICs in silicon technologies Circuit techniques to design millimeter wave circuits in silicon technologies are discussed in depth Circuits for 5G Applications Sangeeta Singh, Rajeev Kumar Arya, B. C. Sahana, Ajay Kumar Vyas, 2023-03-10 RF CIRCUITS FOR 5G APPLICATIONS This book addresses FinFET based analog IC designing for fifth generation 5G communication networks and highlights the latest advances problems and challenges while presenting the latest research results in the field

of mmwave integrated circuits designing The wireless communication sector is experiencing exponential expansion particularly in the areas of mobile data and the 5G mobile network creating fresh market possibilities for designing the integrated circuits ICs needed in the industry Drawing from scientific literature and practical realization this book explores FinFET based analog IC designing for 5G communication networks and considers the latest breakthroughs and obstacles It also presents the recent research trends and future roadmaps for the 5G communication circuits RF Circuits for 5G Applications includes design guidelines to be considered when designing these circuits and detrimental scaling effects of the same In addition to enhance the usability of this book the editors have included real time problems in RFIC designing and case studies from experimental results as well as clearly demarcated design guidelines for the 5G communication ICs designing Audience The primary target audience includes researchers postgraduate students and industry professionals pursuing specializations in RF engineering electronics engineering electrical engineering information and communication technology IEEE Circuits & Devices ,2004 IEEE Transactions on Circuits and Systems ,2005 **Electronics World** mm-Wave Silicon Technology Ali M. Niknejad, Hossein Hashemi, 2008-01-03 This book compiles and presents the .1998 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 Science Citation Index ,1975 Vols for 1964 have guides and Self-healing Techniques for RF and Mm-Wave Transmitters and Receivers Kaushik Dasgupta, 2015 With journal lists continuing advances in CMOS technology feature sizes of modern Silicon chip sets have gone down drastically over the past decade In addition to desktops and laptop processors a vast majority of these chips are also being deployed in mobile communication devices like smart phones and tablets where multiple radio frequency integrated circuits RFICs must be integrated into one device to cater to a wide variety of applications such as Wi Fi Bluetooth NFC wireless charging etc While a small feature size enables higher integration levels leading to billions of transistors co existing on a single chip it also makes these Silicon ICs more susceptible to variations A part of these variations can be attributed to the manufacturing process itself particularly due to the stringent dimensional tolerances associated with the lithographic steps in modern processes Additionally RF or millimeter wave communication chip sets are subject to another type of variation caused by dynamic changes in the operating environment Another bottleneck in the development of high performance RF mm wave Silicon ICs is the lack of accurate analog high frequency models in nanometer CMOS processes This can be primarily attributed to the fact that most cutting edge processes are geared towards digital system implementation and as such there is little model to hardware correlation at RF frequencies All these issues have significantly degraded yield of high performance mm wave and RF CMOS systems which often require multiple trial and error based Silicon validations thereby

incurring additional production costs This dissertation proposes a low overhead technique which attempts to counter the detrimental effects of these variations thereby improving both performance and yield of chips post fabrication in a systematic way The key idea behind this approach is to dynamically sense the performance of the system identify when a problem has occurred and then actuate it back to its desired performance level through an intelligent on chip optimization algorithm We term this technique as self healing drawing inspiration from nature s own way of healing the body against adverse environmental effects To effectively demonstrate the efficacy of self healing in CMOS systems several representative examples are designed fabricated and measured against a variety of operating conditions. We demonstrate a high power mm wave segmented power mixer array based transmitter architecture that is capable of generating high speed and non constant envelope modulations at higher efficiencies compared to existing conventional designs. We then incorporate several sensors and actuators into the design and demonstrate closed loop healing against a wide variety of non ideal operating conditions We also demonstrate fully integrated self healing in the context of another mm wave power amplifier where measurements were performed across several chips showing significant improvements in performance as well as reduced variability in the presence of process variations and load impedance mismatch as well as catastrophic transistor failure Finally on the receiver side a closed loop self healing phase synthesis scheme is demonstrated in conjunction with a wide band voltage controlled oscillator to generate phase shifter local oscillator LO signals for a phased array receiver The system is shown to heal against non idealities in the LO signal generation and distribution significantly reducing phase errors across a wide range of Solid-state Microwave/millimeter-wave Power Generation, Amplification, and Control, 1979 frequencies

Millimeter-Wave Circuits for 60GHz and Beyond Bagher Afshar,2010 Research in the mm wave band using CMOS and SiGe technologies has gained momentum over the past few years Millimeter wave circuits are expected to enter consumer electronics in the near future 60GHz circuits have the potential to be used in high definition wireless video transmission and high data rate point to point communication 77GHz has been explored for automotive radar and is expected to become more ubiquitous in coming years 90GHz has been investigated for imaging and remote sensing applications Raw silicon transistor performance has improved dramatically in the past decade which has spurred much of the research The potential low cost of silicon ICs especially CMOS is great motivation to design mm wave circuits for volume production This dissertation is divided into two parts In the first part the design of a 60GHz CMOS receiver is presented Design methodologies for robust operation at 60GHz are introduced at device and circuit levels Key building blocks of a 60GHz receiver are investigated and several design techniques are proposed to increase the performance of the 60GHz circuits Second part explores the potential of mm wave design for imaging applications Performance requirements and challenges of a 90GHz power amplifier for imaging applications are explored Circuit and system level design details of a pulsed power amplifier are provided and methodologies for enhancing the performance of those designs are introduced In the end A

prototype of this power amplifier and its integrated version in an ultra wideband pulsed transmitter are presented This thesis is expected to provide a design framework for achieving predictable and desired performance at mm wave band

Microwave and Millimeter-wave Signal Power Generation Dzenan Hadziabdic, 2008 Efficiency Improvement Techniques for Millimeter-Wave Transmitters Narek Rostomyan, 2018 Strong demand for mm wave high data rate links in emerging 5G communication systems has resulted in substantial interest in mm wave silicon Si based radio front ends The efficiency of the PA is a significant factor in the overall power dissipation and thermal management of mm wave transceivers which have arrays with a large number of antennas RF channels This dissertation focused mainly on circuit design techniques for cm mm wave CMOS power amplifier efficiency improvement at frequencies from 15 GHz to 28 GHz In addition a DSP based solution is proposed to increase efficiency and performance of cellular LTE band transmitters in the 1 3 GHz frequency range For digital communication signals with multi carrier modulation and high peak to average power ratios PAPRs high back off efficiency of the PA is of significant importance In the first part of the dissertation possible implementations of linear and efficiency enhanced CMOS PAs are described The concept of stacking multiple FETs is applied in the design of symmetric and asymmetric Doherty power amplifiers as well as compact linear PAs The dissertation demonstrates that high power density can be achieved with PAs based on 4 stack power devices while 2 stack devices can be designed to have exceptionally high efficiency due to lower losses A two stage high power Doherty PA that uses 4 stack devices in the final stages is demonstrated with more than 25 dBm output power and 25% back off power added efficiency PAE at 6 dB back off operating in the 15 GHz band To minimize chip area the Doherty combiner is based on an optimized lumped element 90 degrees phase shifter To overcome the inherent non linear gain response of Doherty PAs and to minimize the complexity of digital pre distortion DPD due to large channel bandwidth at mm wave bands a simple RF domain analog pre distorter is demonstrated for the first time Various compact linear 2 stack PAs are demonstrated based nMOS and pMOS FETs for saturated output powers in the range of 20 dBm in the Ka band Performance and reliability advantages of pMOS based PAs are shown Also by using inter node impedance tuning with a shunt feedback drain source capacitor the PAE of the 2 stack PAs is increased even further resulting in world record 46% PAE for the pMOS PA at 26 5 GHz Due to high passive losses in CMOS achieving high efficiency Doherty PAs requires careful design and non conventional synthesis methodology for the Doherty combiner A high efficiency symmetric Doherty PA for the Ka band that is based on efficient 2 stack power devices and a low loss Doherty combiner synthesis technique is presented At 6 dB back off the PAE exceeds 28% which corresponds to 1 4x higher PAE than achievable with ideal class B back off from peak PAE Such high efficiency is attained due to low combiner losses of 0 5 dB which is less than half of what can be achieved with a conventional Doherty combiner Furthermore an asymmetric Doherty PA is reported that is based on low loss output Doherty combiner and uses a 2 stack cell in the main path and a 4 stack cell in the peaking path thus improving efficiency at more than 6 dB back off and achieving

high output power In addition a compact modeling approach for large parasitic extracted PA transistors is presented which considerably reduces simulation time and accelerates developments of CMOS PAs A typical time division duplex TDD transmit receive T R mm wave front end comprises a power amplifier a low noise amplifier LNA an antenna switch and appropriate passive matching and combining networks In this thesis a synthesis methodology is proposed that minimizes the overall losses by combining the PA output and the LNA input matching networks together with the TR switch into one network The technique improves mm wave transceiver performance in terms of PA efficiency and LNA noise figure NF The proposed T R combiner can achieve high linearity and can handle large PA output voltage swings The architecture can be implemented in any process which provides high integration capability A Ka band implementation is demonstrated in CMOS SOI that includes a high power 4 stack based PA and an inductively source degenerated cascode based LNA Within the front end the PA achieves saturated output power of 23 6 dBm with peak PAE of 28% while the LNA achieves NF of 3 2 dB Finally in frequency division duplex FDD systems spurious emissions from the transmitter TX can fall onto the receive RX band and lead to significant receiver desensitization This dissertation proposes a DSP based solution that relies on a linear auxiliary receiver to cancel the RX band noise from the received signal This technique allows reduction of duplexer rejection requirements in the RX band and reduction of insertion loss in the TX band thus resulting in high PA efficiency and smaller duplexer footprint PA architectures that inherently have high receive band noise envelop tracking and digital PAs can substantially benefit from this technique More than 22 dB improvement in the signal to noise ratio SNR is shown without the presence of desired signal at the antenna Elements of Radio Frequency Energy Harvesting and Wireless Power Transfer Systems Taimoor Khan, Nasimuddin (Institute of Infocomm Research Singapore), Yahia M. M. Antar, 2023-09-25 This is the first book which specifically focuses on RF energy harvesting and comprehensively introduces circuit design for RF energy harvesting and wireless power transfer applications It focusses on systematic overview of key components for RF energy harvesting and wireless transfer applications

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