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Howard C. Luong and Gerry C. T. Leung

# Low-Voltage CMOS RF Frequency Synthesizers

CAMBRIDGE

# Low Voltage Cmos Rf Frequency Synthesizers

**Bram De Muer, Michiel Steyaert**



## **Low Voltage Cmos Rf Frequency Synthesizers:**

**Low-Voltage CMOS RF Frequency Synthesizers** Howard Cam Luong, Gerry Chi Tak Leung, 2004-08-26 A frequency synthesizer is one of the most critical building blocks in any wireless transceiver system Its design is getting more and more challenging as the demand for low voltage low power high frequency wireless systems continuously grows As the supply voltage is decreased many existing design techniques are no longer applicable This book provides the reader with architectures and design techniques to enable CMOS frequency synthesizers to operate at low supply voltage at high frequency with good phase noise and low power consumption In addition to updating the reader on many of these techniques in depth this book will also introduce useful guidelines and step by step procedure on behaviour simulations of frequency synthesizers Finally three successfully demonstrated CMOS synthesizer prototypes with detailed design consideration and description will be elaborated to illustrate potential applications of the architectures and design techniques described For engineers managers and researchers working in radio frequency integrated circuit design for wireless applications

**Low-voltage CMOS RF Frequency Synthesizers** Howard Cam Luong, 2004 This book provides the reader with architectures and design techniques to enable CMOS frequency synthesizers to operate at low supply voltage at high frequency with good phase noise and low power consumption For engineers managers and researchers working in RFIC design for wireless applications

**Low Voltage CMOS Frequency Synthesizers for RF Applications** Hyung-Seuk Kim, 2005 Frequency synthesizers play an important role in modern communications and timing systems The output of frequency synthesizers may be used as the local oscillator signal in superheterodyne transceivers or in frequency modulation demodulation Fully integrated CMOS RF synthesizers are currently a major research topic Several publications demonstrated improvements in a variety of aspects such as phase noise power consumption and tuning range However very low voltage frequency synthesizers are very challenging since they usually have a limited tuning range and a relatively high phase noise This research work demonstrates a new architecture to achieve a wide tuning range and low phase noise from a very low voltage supply The synthesizer is fully integrated in a 0.18  $\mu\text{m}$  CMOS technology covering the 5 GHz WLAN frequency range requiring only a 1 V power supply The second part of this thesis consists of the implementation of a 2.4 GHz fractional N frequency synthesizer to be compatible with two MEMS resonators that resonate at 20 MHz and 70 MHz

**Ultra-Low-Voltage Frequency Synthesizer and Successive-Approximation Analog-to-Digital Converter for Biomedical Applications** Chung-Chih Hung, Shih-Hsing Wang, 2021-12-07 This book introduces the origin of biomedical signals and the operating principles behind them and introduces the characteristics of common biomedical signals for subsequent signal measurement and judgment Since biomedical signals are captured by wearable devices sensor devices or implanted devices these devices are all battery powered to maintain long working time We hope to reduce their power consumption to extend service life especially for implantable devices because battery replacement can only be done through

surgery Therefore we must understand how to design low power integrated circuits Both implantable and in vitro medical signal detectors require two basic components to collect and transmit biomedical signals an analog to digital converter and a frequency synthesizer because these measured biomedical signals are wirelessly transmitted to the relevant receiving unit The core unit of wireless transmission is the frequency synthesizer which provides a wide frequency range and stable frequency to demonstrate the quality and performance of the wireless transmitter Therefore the basic operating principle and model of the frequency synthesizer are introduced We also show design examples and measurement results of a low power low voltage integer N frequency synthesizer for biomedical applications The detection of biomedical signals needs to be converted into digital signals by an analog to digital converter to facilitate subsequent signal processing and recognition Therefore the operating principle of the analog to digital converter is introduced We also show implementation examples and measurement results of low power low voltage analog to digital converters for biomedical applications

Transformer-Based Design Techniques for Oscillators and Frequency Dividers Howard Cam Luong,Jun Yin,2015-10-07 This book provides in depth coverage of transformer based design techniques that enable CMOS oscillators and frequency dividers to achieve state of the art performance Design optimization and measured performance of oscillators and frequency dividers for different applications are discussed in detail focusing on not only ultra low supply voltage but also ultra wide frequency tuning range and locking range This book will be an invaluable reference for anyone working or interested in CMOS radio frequency or mm Wave integrated circuits and systems *Design Of Cmos Rf Integrated Circuits And Systems* Kiat Seng Yeo,Manh Anh Do,Chirn Chye Boon,2010-03-24 This book provides the most comprehensive and in depth coverage of the latest circuit design developments in RF CMOS technology It is a practical and cutting edge guide packed with proven circuit techniques and innovative design methodologies for solving challenging problems associated with RF integrated circuits and systems This invaluable resource features a collection of the finest design practices that may soon drive the system on chip revolution Using this book s state of the art design techniques one can apply existing technologies in novel ways and to create new circuit designs for the future *All-Digital Frequency Synthesizer in Deep-Submicron CMOS* Robert Bogdan Staszewski,Poras T. Balsara,2006-10-25 A new and innovative paradigm for RF frequency synthesis and wireless transmitter design Learn the techniques for designing and implementing an all digital RF frequency synthesizer In contrast to traditional RF techniques this innovative book sets forth digitally intensive design techniques that lead the way to the development of low cost low power and highly integrated circuits for RF functions in deep submicron CMOS processes Furthermore the authors demonstrate how the architecture enables readers to integrate an RF front end with the digital back end onto a single silicon die using standard ASIC design flow Taking a bottom up approach that progressively builds skills and knowledge the book begins with an introduction to basic concepts of frequency synthesis and then guides the reader through an all digital RF frequency synthesizer design Chapter 2 presents a digitally controlled oscillator DCO which

is the foundation of a novel architecture and introduces a time domain model used for analysis and VHDL simulation Chapter 3 adds a hierarchical layer of arithmetic abstraction to the DCO that makes it easier to operate algorithmically Chapter 4 builds a phase correction mechanism around the DCO such that the system's frequency drift or wander performance matches that of the stable external frequency reference Chapter 5 presents an application of the all digital RF synthesizer Chapter 6 describes the behavioral modeling and simulation methodology used in design The final chapter presents the implementation of a full transmitter and experimental results The novel ideas presented here have been implemented and proven in two high volume commercial single chip radios developed at Texas Instruments Bluetooth and GSM While the focus of the book is on RF frequency synthesizer design the techniques can be applied to the design of other digitally assisted analog circuits as well This book is a must read for students and engineers who want to learn a new paradigm for RF frequency synthesis and wireless transmitter design using digitally intensive design techniques Architectures for RF Frequency Synthesizers

Cicero S. Vaucher, 2006-04-18 This text describes a conceptual framework for analyzing the performance of PLL frequency synthesizers and presents optimization procedures for the different performance aspects It contains basic information and in depth knowledge widely illustrated with practical design examples used in industrial products **Wireless CMOS**

**Frequency Synthesizer Design** J. Craninckx, Michiel Steyaert, 2013-06-29 The recent boom in the mobile telecommunication market has trapped the interest of almost all electronic and communication companies worldwide New applications arise every day more and more countries are covered by digital cellular systems and the competition between the several providers has caused prices to drop rapidly The creation of this essentially new market would not have been possible without the appearance of small low power high performant and certainly low cost mobile terminals The evolution in microelectronics has played a dominant role in this by creating digital signal processing DSP chips with more and more computing power and combining the discrete components of the RF front end on a few ICs This work is situated in this last area i.e. the study of the full integration of the RF transceiver on a single die Furthermore in order to be compatible with the digital processing technology a standard CMOS process without tuning trimming or post processing steps must be used This should flatten the road towards the ultimate goal the single chip mobile phone The local oscillator LO frequency synthesizer poses some major problems for integration and is the subject of this work The first and also the largest part of this text discusses the design of the Voltage Controlled Oscillator VCO The general phase noise theory of LC oscillators is presented and the concept of effective resistance and capacitance is introduced to characterize and compare the performance of different LC tanks **CMOS Fractional-N Synthesizers**

Bram De Muer, Michiel Steyaert, 2005-12-29 CMOS Fractional N Synthesizers starts with a comprehensive introduction to general frequency synthesis Different architectures and synthesizer building blocks are discussed with their relative importance on synthesizer specifications The process of synthesizer specification derivation is illustrated with the DCS 1800 standard as a general test case The book tackles the design of

fractional N synthesizers in CMOS on circuit level as well as system level The circuit level focuses on high speed prescaler design up to 12 GHz in CMOS and on fully integrated low phase noise LC VCO design High Q inductor integration and simulation in CMOS is elaborated and flicker noise minimization techniques are presented ranging from bias point choice to noise filtering techniques On a higher level a systematic design strategy has been developed that trades off all noise contributions and fast dynamics for integrated capacitance area Moreover a theoretical DeltaSigma phase noise analysis is presented extended with a fast non linear analysis method to accurately predict the influence of PLL non linearities on the spectral purity of the DeltaSigma fractional N frequency synthesizers

**Integrated Frequency Synthesis for Convergent Wireless Solutions** Jad G. Atallah, Mohammed Ismail, 2012-05-30 This book describes the design and implementation of an electronic subsystem called the frequency synthesizer which is a very important building block for any wireless transceiver The discussion includes several new techniques for the design of such a subsystem which include the usage modes of the wireless device including its support for several leading edge wireless standards This new perspective for designing such a demanding subsystem is based on the fact that optimizing the performance of a complete system is not always achieved by optimizing the performance of its building blocks separately This book provides hands on examples of this sort of co design of optimized subsystems which can make the vision of an always best connected scenario a reality

*Intelligent Electronic Devices* Teen-Hang Meen, Wenbing Zhao, Cheng-Fu Yang, 2020-05-20 In a modern technological society electronic engineering and design innovations are both academic and practical engineering fields that involve systematic technological materialization through scientific principles and engineering designs Engineers and designers must work together with a variety of other professionals in their quest to find systems solutions to complex problems Rapid advances in science and technology have broadened the horizons of engineering while simultaneously creating a multitude of challenging problems in every aspect of modern life Current research is interdisciplinary in nature reflecting a combination of concepts and methods that often span several areas of mechanics mathematics electrical engineering control engineering and other scientific disciplines In addition the 2nd IEEE International Conference on Knowledge Innovation and Invention 2019 IEEE ICKII 2019 was held in Seoul South Korea on 12 15 July 2019 This book *Intelligent Electronic Devices* includes 13 excellent papers from 260 papers presented in this conference about intelligent electronic devices The main goals of this book were to encourage scientists to publish their experimental and theoretical results in as much detail as possible and to provide new scientific knowledge relevant to the topics of electronics

**Operational Amplifier Speed and Accuracy Improvement** Vadim V. Ivanov, Igor M. Filanovsky, 2005-12-30 *Operational Amplifier Speed and Accuracy Improvement* proposes a new methodology for the design of analog integrated circuits The usefulness of this methodology is demonstrated through the design of an operational amplifier This methodology consists of the following iterative steps description of the circuit functionality at a high level of abstraction using signal flow graphs equivalent transformations and modifications of

the graph to the form where all important parameters are controlled by dedicated feedback loops and implementation of the structure using a library of elementary cells

**Operational Amplifier Speed and Accuracy Improvement** shows how to choose structures and design circuits which improve an operational amplifier's important parameters such as speed to power ratio open loop gain common mode voltage rejection ratio and power supply rejection ratio The same approach is used to design clamps and limiting circuits which improve the performance of the amplifier outside of its linear operating region such as slew rate enhancement output short circuit current limitation and input overload recovery

*CMOS High Efficiency On-chip Power Management* John Hu, Mohammed Ismail, 2011-09-03 This book will introduce various power management integrated circuits IC design techniques to build future energy efficient green electronics The goal is to achieve high efficiency which is essential to meet consumers growing need for longer battery lives The focus is to study topologies amiable for full on chip implementation few external components in the mainstream CMOS technology which will reduce the physical size and the manufacturing cost of the devices

**Static and Dynamic Performance Limitations for High Speed D/A Converters** Anne van den Bosch, Michiel Steyaert, Willy M.C. Sansen, 2013-06-29 Static and Dynamic Performance Limitations for High Speed D A Converters discusses the design and implementation of high speed current steering CMOS digital to analog converters Starting from the definition of the basic specifications for a D A converter the elements determining the static and dynamic performance are identified Different guidelines based on scientific derivations are suggested to optimize this performance Furthermore a new closed formula has been derived to account for the influence of the transistor mismatch on the achievable resolution of the current steering D A converter To allow a thorough understanding of the dynamic behavior a new factor has been introduced Moreover the frequency dependency of the output impedance introduces harmonic distortion components which can limit the maximum attainable spurious free dynamic range Finally the last part of the book gives an overview on different existing transistor mismatch models and the link with the static performance of the D A converter

**Phase Lock Loops and Frequency Synthesis** Venceslav F. Kroupa, 2003-06-02 Phase lock loop frequency synthesis finds uses in a myriad of wireless applications from local oscillators for receivers and transmitters to high performance RF test equipment As the security and reliability of mobile communication transmissions have gained importance PLL and frequency synthesizers have become increasingly topical subjects Phase Lock Loops Frequency Synthesis examines the various components that make up the phase lock loop design including oscillators crystal voltage controlled dividers and phase detectors Interaction amongst the various components are also discussed Real world problems such as power supply noise shielding grounding and isolation are given comprehensive coverage and solved examples with MATHCAD programs are presented throughout Presents a comprehensive study of phase lock loops and frequency synthesis in communication systems Written by an internationally recognised expert in the field Details the problem of spurious signals in PLL frequency synthesizers a topic neglected by available competing titles Provides detailed theoretical background coupled with practical

examples of state of the art device design MATHCAD programs and simulation software to accompany the design exercises and examples This combination of thorough theoretical treatment and guidance on practical applications will appeal to mobile communication circuit designers and advanced electrical engineering students

**Wireless Technologies** Krzysztof Iniewski, 2017-12-19 Advanced concepts for wireless technologies present a vision of technology that is embedded in our surroundings and practically invisible From established radio techniques like GSM 802 11 or Bluetooth to more emerging technologies such as Ultra Wide Band and smart dust motes a common denominator for future progress is the underlying integrated circuit technology Wireless Technologies responds to the explosive growth of standard cellular radios and radically different wireless applications by presenting new architectural and circuit solutions engineers can use to solve modern design problems This reference addresses state of the art CMOS design in the context of emerging wireless applications including 3G 4G cellular telephony wireless sensor networks and wireless medical application Written by top international experts specializing in both the IC industry and academia this carefully edited work uncovers new design opportunities in body area networks medical implants satellite communications automobile radar detection and wearable electronics The book is divided into three sections wireless system perspectives chip architecture and implementation issues and devices and technologies used to fabricate wireless integrated circuits Contributors address key issues in the development of future silicon based systems such as scale of integration ultra low power dissipation and the integration of heterogeneous circuit design style and processes onto one substrate Wireless sensor network systems are now being applied in critical applications in commerce healthcare and security This reference which contains 25 practical and scientifically rigorous articles provides the knowledge communications engineers need to design innovative methodologies at the circuit and system level

**Biomedical Engineering, Trends in Electronics** Anthony Laskovski, 2011-01-08 Rapid technological developments in the last century have brought the field of biomedical engineering into a totally new realm Breakthroughs in material science imaging electronics and more recently the information age have improved our understanding of the human body As a result the field of biomedical engineering is thriving with new innovations that aim to improve the quality and cost of medical care This book is the first in a series of three that will present recent trends in biomedical engineering with a particular focus on electronic and communication applications More specifically wireless monitoring sensors medical imaging and the management of medical information

Imaging Sensors, Power Management, PLLs and Frequency Synthesizers Kofi A. A. Makinwa, Andrea Baschiroto, Bram Nauta, 2024-12-23 This book is based on the 18 tutorials presented during the 31st workshop on Advances in Analog Circuit Design held in Villach Austria In it expert designers share their insights on a variety of topics at the frontier of analog circuit design with specific contributions focusing on the design of imaging sensors power management circuits PLLs and frequency synthesizers As such for anyone involved in analog circuit research and development this book provides a valuable overview of the state of the art

**Analog Circuit Design** Rudy J. van de



Plassche, Johan Huijsing, Willy M.C. Sansen, 2000-09-30 This volume of Analog Circuit Design concentrates on 3 topics High Speed Analog to Digital Converters Mixed Signal Design and PLLs and Synthesizers The book comprises 6 papers on each topic written by internationally recognized experts These papers have a tutorial nature aimed at improving the design of analog circuits The book is divided into 3 parts Part I High Speed Analog to Digital Converters describes the latest techniques for producing analog to digital converters for applications in disk drives radio circuits XDSL and super HiFi audio conversion Converters having resolutions between 7 bit and 12 bit using CMOS techniques are presented A 13 bit bandpass sigma delta modulator for IF signal conversion concludes this part Part II Mixed Signal Design presents papers that detail nearly all known techniques and design issues for mixed signal circuits using CAD tools Applications for telecom sigma delta converters systems on a chip and RF circuitry are described Part III PLLs and Synthesizers illustrates up to date techniques for combination of inductors on a CMOS chip together with PLL techniques to obtain low noise frequency synthesizers for telecom applications Special attention is paid to fractional N synthesizers using sigma delta algorithms Analog Circuit Design is an essential reference source for analog design engineers and researchers wishing to keep abreast with the latest developments in the field The tutorial nature of the contributions also makes it suitable for use in an advanced design course

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