

RF and Microwave Power Amplifier Design

Second Edition

ANDREI GREBENNIKOV

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Rf And Microwave Power Amplifier Design Second Edition By

Amal Banerjee



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RF and Microwave Power Amplifier Design, Second Edition Andrei Grebennikov, 2015-02-12 Publisher's Note
Products purchased from Third Party sellers are not guaranteed by the publisher for quality authenticity or access to any online entitlements included with the product The latest power amp design methods Fully updated to address cutting edge technologies the new edition of this practical guide provides comprehensive state of the art coverage of RF and microwave power amplifier design The book describes both existing and new schematic configurations theoretical approaches circuit simulation results and implementation techniques New chapters discuss linearization and efficiency enhancement and high efficiency Doherty power amplifiers Featuring a systematic approach this comprehensive resource bridges the theory and practice of RF and microwave engineering RF and Microwave Power Amplifier Design Second Edition covers Two port network parameters and passive elements Nonlinear circuit design methods Nonlinear active device modeling Impedance matching Power transformers combiners and couplers Power amplifier design fundamentals High efficiency power amplifier design Broadband power amplifiers Linearization and efficiency enhancement techniques High efficiency Doherty power amplifiers

RF and Microwave Power Amplifier Design, Second Edition Andrei Grebennikov, 2015-02-09 The latest power amp design methods Fully updated to address cutting edge technologies the new edition of this practical guide provides comprehensive state of the art coverage of RF and microwave power amplifier design The book describes both existing and new schematic configurations theoretical approaches circuit simulation results and implementation techniques New chapters discuss linearization and efficiency enhancement and high efficiency Doherty power amplifiers Featuring a systematic approach this comprehensive resource bridges the theory and practice of RF and microwave engineering RF and Microwave Power Amplifier Design Second Edition covers Two port network parameters and passive elements Nonlinear circuit design methods Nonlinear active device modeling Impedance matching Power transformers combiners and couplers Power amplifier design fundamentals High efficiency power amplifier design Broadband power amplifiers Linearization and efficiency enhancement techniques High efficiency Doherty power amplifiers

Microwave Power Amplifier Design with MMIC Modules Howard Hausman, 2018-06-30 Solid state power amplifiers SSPA are a critical part of many microwave systems Designing SSPAs with monolithic microwave integrated circuits MMIC has boosted device performance to much higher levels focused on PA modules This cutting edge book offers engineers practical guidance in selecting the best power amplifier module for a particular application and interfacing the selected module with other power amplifier modules in the system It also explains how to identify and mitigate peripheral issues concerning the PA modules SSPAs and microwave systems This authoritative volume presents the critical techniques and underpinnings of SSPA design enabling professionals to optimize device and system performance Engineers gain the knowledge they need to evaluate the optimum topologies for the design of a chain of microwave devices including power amplifiers Additionally the book addresses the interface between

the microwave subsystems and the primary DC power the control and monitoring circuits and the thermal and EMI paths Packed with 240 illustrations and over 430 equations this detailed book provides the practical tools engineers need for their challenging projects in the field *RF and Microwave Oscillator Design* Micha Odyniec,2002 This groundbreaking book is the first to present the state of the art in microwave oscillator design with an emphasis on new nonlinear methods A compilation of pioneering work from experts in the field it also provides rigorous theory and historical background Invaluable for professionals at all levels of design expertise this volume helps you to bridge the gap between design practice and new powerful design methods learn all aspects of modern oscillator design and review practical designs and experimental results of fixed frequency high Q low noise oscillators **Millimeter-Wave GaN Power Amplifier Design** Edmar Camargo,2022-05-31 This book gives you in one comprehensive and practical resource everything you need to successfully design modern and sophisticated power amplifiers at mmWave frequencies The book provides an in depth treatment of the design methodology for MMIC power amplifiers then brings you step by step through the various phases of design from the selection of technology and preliminary architecture considerations to the effective design of the matching circuits and conversion of electrical to electromagnetic models Detailed figures and numerous practical applications are included to help you gain valuable insights into these technologies and learn to identify the best path to a successful design You ll be guided through a range of new mmWave power applications that show particular promise to support new 5G systems while mastering the use of GaN technology that continues to dominate the power mmWave applications due to its high power gain and efficiency This is a valuable resource for power amplifier design engineers technicians industry R D staff and anyone getting into the area of power MMICs who wants to learn how to design at mmWave frequencies *Radio Frequency Machine Learning: A Practical Deep Learning Perspective* Scott Kuzdeba,2025-01-31 Radio Frequency Machine Learning A Practical Deep Learning Perspective goes beyond general introductions to deep learning offering a focused exploration of how modern deep learning techniques can be applied directly to radio frequency RF challenges It covers a wide range of applications including classification tasks where deep learning is used to label and categorize signals based on a labeled training dataset as well as clustering tasks that group similar signals together without labels Additionally it expands into deep learning generative AI for waveform synthesis and how reinforcement learning can be used within the domain This book also investigates advanced topics like RF sensor control feedback mechanisms and real time system operations offering a comprehensive understanding of how deep learning can be integrated into dynamic RF environments This resource addresses the practical concerns of deploying machine learning in operational RF systems It goes beyond applications and techniques covering how to ensure the robustness of solutions with insights into data sources augmentation techniques and strategies for integrating ML with existing RF infrastructure The full development process is examined from data collection to deployment along with numerous case studies throughout Looking to the future the book explores emerging trends like

edge computing and federated learning offering a forward looking perspective on the continued evolution of RF machine learning Whether the reader is just beginning the journey into RF machine learning or is looking to refine skills this book provides an essential resource for understanding the intersection of deep learning and RF technology This is a must have resource for anyone interested in the cutting edge of wireless technologies and their potential to shape the future of communication

Advanced Techniques in RF Power Amplifier Design Steve C. Cripps, 2002 This much anticipated volume builds on the author's best selling and classic work *RF Power Amplifiers for Wireless Communications* Artech House 1999 offering experienced engineers a more in depth understanding of the theory and design of RF power amplifiers An invaluable reference tool for RF digital and system level designers the book includes discussions on the most critical topics for professionals in the field including envelope power management schemes and linearization

Microstrip Lines and Slotlines, Fourth Edition Ramesh Garg, Inder J. Bahl, 2024-10-31 *Microstrip Lines and Slotlines Fourth Edition* is an indispensable resource for practicing engineers This edition is updated to reflect the latest developments in the field providing extensive analysis techniques and CAD design and modeling information This volume covers approximate and full wave analysis techniques accurate circuit model extraction and design information focusing on miniaturization broadband operation and precise design It also incorporates the most recent information from conferences journals books and personal research New topics on Metamaterial Based Transmission Lines and Numerical Simulation and Modeling of transmission lines are introduced aligning with the book's core themes Some of the key updates included in this fourth edition are the integration of significant materials significant revisions reflecting the latest research and the introduction of cutting edge topics enhancing the existing content With these comprehensive updates *Microstrip Lines and Slotlines Fourth Edition* ensures that readers have access to the most relevant and cutting edge information in the field of printed transmission lines This book is a must have for professionals and researchers dedicated to advancing their knowledge and expertise in this dynamic area

RF Power Amplifiers Marian K. Kazimierczuk, 2014-12-15 This second edition of the highly acclaimed *RF Power Amplifiers* has been thoroughly revised and expanded to reflect the latest challenges associated with power transmitters used in communications systems With more rigorous treatment of many concepts the new edition includes a unique combination of class tested analysis and industry proven design techniques Radio frequency RF power amplifiers are the fundamental building blocks used in a vast variety of wireless communication circuits radio and TV broadcasting transmitters radars wireless energy transfer and industrial processes Through a combination of theory and practice *RF Power Amplifiers Second Edition* provides a solid understanding of the key concepts the principle of operation synthesis analysis and design of RF power amplifiers This extensive update boasts up to date end of chapter summaries review questions and problems an expansion on key concepts new examples related to real world applications illustrating key concepts and brand new chapters covering hot topics such as RF LC oscillators and dynamic power supplies Carefully edited

for superior readability this work remains an essential reference for research development staff and design engineers Senior level undergraduate and graduate electrical engineering students will also find it an invaluable resource with its practical examples summaries review questions and end of chapter problems Key features A fully revised solutions manual is now hosted on a companion website alongside new simulations Extended treatment of a broad range of topologies of RF power amplifiers In depth treatment of state of the art of modern transmitters and a new chapter on oscillators Includes problem solving methodology step by step derivations and closed form design equations with illustrations *Fundamentals of RF and Microwave Transistor Amplifiers* Inder Bahl, 2009-06-17 A Comprehensive and Up to Date Treatment of RF and Microwave Transistor Amplifiers This book provides state of the art coverage of RF and microwave transistor amplifiers including low noise narrowband broadband linear high power high efficiency and high voltage Topics covered include modeling analysis design packaging and thermal and fabrication considerations Through a unique integration of theory and practice readers will learn to solve amplifier related design problems ranging from matching networks to biasing and stability More than 240 problems are included to help readers test their basic amplifier and circuit design skills and more than half of the problems feature fully worked out solutions With an emphasis on theory design and everyday applications this book is geared toward students teachers scientists and practicing engineers who are interested in broadening their knowledge of RF and microwave transistor amplifier circuit design Practical RF Circuit Design for Modern Wireless Systems Rowan Gilmore, Les Besser, 2003 A practical approach to RF circuit design this volume covers nonlinear circuits and modelling RF transistor amplifiers oscillators and mixers **HF-Leistungsverstärker in modernen Silizium- und**

Verbindungshalbleitern-Technologien Daniel Gruner, 2012-11-01 Kurzbeschreibung Diese Dissertation beschäftigt sich mit HF Leistungsverstärkern auf Basis moderner Transistortechnologien und verfolgt aktuelle Trends im Bereich Silizium und III V Verbindungshalbleiter Dies umfasst den Entwurf von innovativen HF Leistungstransistoren und Verstärkern Aspekte zur Charakterisierung und Aufbautechnik sowie den Vergleich zum aktuellen Stand von Wissenschaft und Technik Im ersten Teil richtet sich der Fokus auf MMIC Leistungsverstärker für 5 6 GHz WLAN Anwendungen Hierbei wird zunächst auf den Entwurf eines Push Pull PAs in einer 0 25 µm BiCMOS Technologie eingegangen Mit einer Betriebsspannung von lediglich 1 8 V zeigt dieser Verstärker ein breitbandiges Verhalten und erreicht im Frequenzbereich 5 6 2 GHz eine Sättigungsleistung von 24 dBm Der maximale Wirkungsgrad liegt bei 27 % PAE 18 % mit einer Verstärkung von typischerweise 9 dB Um diese Performance weiter zu verbessern wird eine innovative Transformer Combining Topologie vorgestellt Im Vergleich zum Push Pull Verstärker kann diese eine erhöhte Verstärkung 12 dB sowie einen exzellenten PAE Maximalwert von 23 % bei sonst ähnlichen Eigenschaften erzielen Als zweite Zielstellung wird die Steigerung der HF Leistungs Performance innerhalb moderner BiCMOS Technologien verfolgt In diesem Rahmen stehen die Analyse der Entwurf und die Evaluierung von LDMOS Transistoren für Anwendungen bis in den 6 GHz Bereich im Mittelpunkt Der Einfluss von Transistorgröße und Geometrie sowie

auch der Stabilitätsnetzwerke wird unter Verwendung HF optimierter LDMOS Strukturen untersucht Die Evaluierung der Source Load Pull Messungen wird mit Hilfe mehrerer hybrider Verstärkermodule durchgeführt Als eine der ersten Veröffentlichungen kann diese Arbeit eine 6 GHz LDMOS Implementation in einer Standard BiCMOS Technologie mit einer Ausgangsleistung von mehr als 1 W und einem Wirkungsgrad über 40 % demonstrieren Der dritte Teil beschäftigt sich mit GaN Doherty Verstärkern für das 6 GHz Band Die Kombination von Doherty Konzept mit Strategien zur Harmonischen Terminierung einem auf Device Referenzebene optimierten Entwurf und der entwickelten Chip Wire Aufbautechnik erlaubt die Realisierung von einem der ersten 6 GHz Doherty Verstärker mit exzellenter Wirkungsgrad Leistungs sowie Linearitäts Performance Unter Verwendung zweier GaN Chip Transistoren kann eine maximale Ausgangsleistung von 41.5 dBm mit einem maximalen Wirkungsgrad von 63 % erreicht werden Im 6 dB Backoff Punkt wird dabei ein exzellenter Wirkungsgrad von 49 % erzielt

Description This work focuses on RF power amplifiers based on modern transistor technologies and investigates current trends in silicon as well as III V semiconductors This includes the design of innovative RF power devices and amplifiers characterization and assembling techniques as well as the comparison to other state of the art achievements The first part focuses on MMIC power amplifiers for WLAN applications in the 5.6 GHz range Based on a 0.25 μ m BiCMOS technology a low voltage push pull power amplifier using integrated transformers is presented At a supply voltage of 1.8 V this fully integrated amplifier achieves a wideband performance showing a maximum output power of 24 dBm across 5.6-6.2 GHz A maximum efficiency of 27 % PAE 18 % is obtained with a small signal gain of typically 9 dB To further improve this performance an innovative transformer combining topology is developed Compared to the push pull amplifier this topology achieves an increased gain of 12 dB and an enhanced maximum PAE of up to 23 % with otherwise similar characteristics showing state of the art performance The RF power enhancement of Bi CMOS technologies is a second major aim of this work In this context the analysis design and evaluation of medium voltage LDMOS FETs for wireless applications up to 6 GHz is presented Using RF optimized NLDMOS transistors power devices of different sizes were fabricated in a standard 0.25 μ m BiCMOS technology The influences of the finger geometry and the stabilization networks on the RF performance are studied Power evaluation of the LDMOS transistors is carried out by means of hybrid power amplifier modules As one of the first contributions this work shows a 6 GHz LDMOS implementation in a standard BiCMOS technology that achieves an output power of greater than 1 W with a drain efficiency of more than 40 % In the third part a harmonically tuned GaN Doherty amplifier targeted for vehicular applications at 6 GHz is presented The combination of the Doherty concept with harmonic tuning strategies an optimized design approach and the developed chip wire assembly technology results in one of the first Doherty amplifiers implemented for the 6 GHz frequency range with excellent efficiency output power and linearity performance Using two bare die GaN devices a maximum output power of 41.5 dBm with 63% peak drain efficiency is obtained At 6 dB output power back off an excellent drain efficiency of still 49 % can be achieved

RF Circuits and

Applications for Practicing Engineers Mouqun Dong, 2020-10-31 This comprehensive resource explains the theory of RF circuits and systems and the practice of designing them The fundamentals for linear and low noise amplifier designs including the S and noise parameters and their applications in amplifier designs and matching network designs using the Smith chart are covered Theories of RF power amplifiers and high efficiency power amplifiers are also explained The underpinnings of wireless communications systems as well as passive components commonly used in RF circuits and measurements are discussed RF measurement techniques and RF switches are also presented The book explores stability criteria and the invariant property of lossless networks and includes detailed theoretical treatments The basic concepts and techniques covered in this book are routinely used in today's engineering practice especially from the perspective of printed circuit board PCB based RF circuit design and system integration Intended for practicing engineers and circuit designers this book focuses on practical topics in circuit design and measurement techniques It bridges the gap between academic materials and real circuit designs using real circuit examples and practical tips Readers develop a numerical feel for RF problems as well as awareness of the concepts of design for cost and design for manufacturing which is a critical skill set for today's engineers working in an environment of commercial product development *RF and Microwave Power Amplifier Design* Andrei Grebennikov, 2004-09-15 This is a rigorous tutorial on radio frequency and microwave power amplifier design teaching the circuit design techniques that form the microelectronic backbones of modern wireless communications systems Suitable for self study corporate training or Senior Graduate classroom use the book combines analytical calculations and computer aided design techniques to arm electronic engineers with every possible method to improve their designs and shorten their design time cycles **Lumped Elements for RF and Microwave Circuits, Second Edition** Inder J. Bahl, 2022-12-31 Fully updated and including entirely new chapters this Second Edition provides in depth coverage of the different types of RF and microwave circuit elements including inductors capacitors resistors transformers via holes airbridges and crossovers Featuring extensive formulas for lumped elements design trade offs and an updated and current list of references the book helps you understand the value and usefulness of lumped elements in the design of RF microwave and millimeter wave components and circuits You'll find a balanced treatment between standalone lumped elements and their circuits using MICs MMICs and RFICs technologies You'll also find detailed information on a broader range of RFICs that was not available when the popular first edition was published The book captures in one consolidated volume the fundamentals equations modeling examples references and overall procedures to design test and produce microwave components that are indispensable in industry and academia today With its superb organization and expanded coverage of the subject this is a must have go to resource for practicing engineers and researchers in industry government and university and microwave engineers working in the antenna area Students will also find it a useful reference with its clear explanations many examples and practical modeling guidelines Practical RF Amplifier Design and Performance Optimization with

SPICE and Load- and Source-pull Techniques Amal Banerjee, 2021-03-01 This book explains and demonstrates with an exhaustive set of design examples how common types of radio frequency RF amplifiers classes A B AB C D E F G and H can be designed and then have their performance characteristics evaluated and optimized with SPICE The author demonstrates the transient analysis features of SPICE along with industry standard load and source pull techniques to simulate the steady state long term time domain behavior of any test RF amplifier Describes methods for designing and evaluating optimizing the performance characteristics of an RF amplifier that circumvent the issues involved with existing traditional methods and don't require expensive high end software tools Includes C language executables for each RF amplifier type eliminating errors that might creep in while computing passive component capacitor inductor resistor values for a given RF amplifier type Demonstrates industry standard load and source pull schemes that can be included easily in text SPICE netlists allowing accurate calculation of impedance matching and impedance values at the input and output ports of the test RF amplifier eliminating messy error prone S parameter based calculations

Nonlinear Design: FETs and HEMTs Peter H. Ladbrooke, 2021-11-30 Despite its continuing popularity the so called standard circuit model of compound semiconductor field effect transistors FETs and high electron mobility transistors HEMTs is shown to have a limitation for nonlinear analysis and design it is valid only in the static limit When the voltages and currents are time varying as they must be for these devices to have any practical use the model progressively fails for higher specification circuits This book shows how to reform the standard model to render it fully compliant with the way FETs and HEMTs actually function thus rendering it valid dynamically Proof of principle is demonstrated for several practical circuits including a frequency doubler and amplifiers with demanding performance criteria Methods for extracting both the reformulated model and the standard model are described including a scheme for re constructing from S parameters the bias dependent dynamic or RF I V characteristics along which devices work in real world applications and as needed for the design of nonlinear circuits using harmonic balance and time domain simulators The book includes a historical review of how variations on the standard model theme evolved leading up to one of the most widely used the Angelov or Chalmers model

Relativistic Field Theory for Microwave Engineers Matthew A. Morgan, 2024-06-30 This book explores the fundamental but often overlooked connection between Maxwell's equations as they are taught in undergraduate electrical engineering courses and special relativity Written for an audience of practical engineers instead of theoretical physicists it exposes the underlying contradictions brought about by the emergence of electromagnetic theory one of the greatest triumphs in mathematical physics of all time that unified the phenomena of electricity magnetism and light into a world in which the classical Galilean principle of relativity was considered incontrovertible It explains how Einstein redefined the concepts of space and time and what it means to measure them while altogether disbanding the notion of global simultaneity A manifestly relativistic formulation of electromagnetic laws is first presented and then applied to common engineering problems like the interaction of

electromagnetic fields at dynamic interfaces the derivation of propagating modes in closed metal waveguides and the foundations of microwave network theory Mathematical toolkits for relativistic analysis such as tensor notation and spacetime algebra are explained These tools are then used to analyze the consequences of motion at relativistic speeds upon otherwise well known electromagnetic circuit behaviors Well drawn and insightful diagrams along with articulate explanations help the reader to gain an intuitive understanding of four dimensional spacetime and the nature of the electromagnetic field in that context while summary tables and comprehensive appendices serve as a resource for further selfdirected exploration Readers trained in microwave engineering will learn to see their field from a new perspective and shall gain from that new insight the ability to conceive of unexpected solutions to practical engineering problems that might otherwise defy one s intuition

Design of RF and Microwave Amplifiers and Oscillators Pieter L. D. Abrie, 2009 This newly revised edition offers a comprehensive and current treatment of the subject and includes expanded derivations and problem sets helping to make the material even more accessible and easier to master

Design and Applications of Active Integrated Antennas Mohammad S. Sharawi, Oualid Hammi, 2018-05-31 This comprehensive new resource guides professionals in the latest methods used when designing active integrated antennas AIA for wireless communication devices for various standards This book provides complete design procedures for the various elements of such active integrated antennas such as the matching network the amplifier active element as well as the antenna This book offers insight into how active integration and co design between the active components amplifier oscillator mixer diodes and the antenna can provide better power transfer higher gains increased efficiencies switched beam patterns and smaller design footprints It introduces the co design approach of active integrated antennas and its superior performance over conventional methods Complete design examples are given of active integrated antenna systems for narrow and wideband applications as well as for multiple input multiple output MIMO systems Readers find the latest design methods for narrow and broadband RF matching networks This book provides a complete listing of performance metrics for active integrated antennas The book serves as a complete reference and design guide in the area of AIA

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