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Advanced Power Mosfet Concepts

Michael Brown

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Advanced Power MOSFET Concepts B. Jayant Baliga,2010-06-26 During the last decade many new concepts have been proposed for improving the performance of power MOSFETs The results of this research are dispersed in the technical literature among journal articles and abstracts of conferences Consequently the information is not readily available to researchers and practicing engineers in the power device community There is no cohesive treatment of the ideas to provide an assessment of the relative merits of the ideas Advanced Power MOSFET Concepts provides an in depth treatment of the physics of operation of advanced power MOSFETs Analytical models for explaining the operation of all the advanced power MOSFETs will be developed The results of numerical simulations will be provided to give additional insight into the device physics and validate the analytical models The results of two dimensional simulations will be provided to corroborate the analytical models and give greater insight into the device operation **Advanced High Voltage Power Device Concepts** B. Jayant Baliga,2011-09-21 The devices described in Advanced MOS Gated Thyristor Concepts are utilized in microelectronics production equipment in power transmission equipment and for very high power motor control in electric trains steel mills etc Advanced concepts that enable improving the performance of power thyristors are discussed here along with devices with blocking voltage capabilities of 5 000 V 10 000 V and 15 000 V Throughout the book analytical models are generated to allow a simple analysis of the structures and to obtain insight into the underlying physics The results of two dimensional simulations are provided to corroborate the analytical models and give greater insight into the device operation

Fundamentals of Power Semiconductor Devices B. Jayant Baliga,2018-09-28 Fundamentals of Power Semiconductor Devices provides an in depth treatment of the physics of operation of power semiconductor devices that are commonly used by the power electronics industry Analytical models for explaining the operation of all power semiconductor devices are shown The treatment here focuses on silicon devices but includes the unique attributes and design requirements for emerging silicon carbide devices The book will appeal to practicing engineers in the power semiconductor device community

Advanced Power Rectifier Concepts B. Jayant Baliga,2009-06-16 During the last decade many new concepts have been proposed for improving the performance of power rectifiers and transistors The results of this research are dispersed in the technical literature among journal articles and abstracts of conferences Consequently the information is not readily available to researchers and practicing engineers in the power device community There is no cohesive treatment of the ideas to provide an assessment of the relative merits of the ideas Advanced Power Rectifier Concepts provides an in depth treatment of the physics of operation of advanced power rectifiers Analytical models for explaining the operation of all the advanced power rectifier devices will be developed The results off numerical simulations will be provided to provide additional insight into the device physics and validate the analytical models The results of two dimensional simulations will be provided to corroborate the analytical models and provide greater insight into the device operation Silicon Carbide Power Devices

Yuan Gao,Yan Zhang,2025-10-02 This book provides comprehensive technical information on SiC power devices from multiple perspectives covering topics from device research and development to system applications Chapters 1 to 4 focus on the characteristics of SiC devices initially outlining the limitations of Si power devices and explaining why SiC has superior properties at the material level It then offers updates on the latest developments in the SiC industry chain and products innovations along with a detailed discussion of the characteristics and specifications of SiC Diodes and MOSFETs Chapters 5 and 6 zoom in on SiC device testing and evaluation techniques including CP testing FT testing system application testing reliability assessment failure analysis and double pulse testing Chapters 7 to 12 focus on SiC device application technology addressing common challenges in real applications and providing solutions This includes voltage spikes during turn off crosstalk common mode current common source inductance and driver circuits concluding with case studies of SiC device applications in various scenarios The book can serve as a textbook for higher education and vocational training as well as a reference material for engineers in the power semiconductor and electrical electronics industries To make the book genuinely helpful for readers the authors have invested significant effort in content and data selection First the chosen technical points come from real world requirements in device R D and applications Second the book emphasizes practicality while integrating cutting edge developments detailing research outcomes with industrial potential Third the book offers a wealth of data and waveforms most of which are actual measurements to bridge the gap between theory and practice Lastly extensive further reading materials are provided at the end of each chapter for broader and deeper exploration **The IGBT Device** B. Jayant Baliga,2022-11-25 The IGBT Device Physics Design and Applications of the Insulated Gate Bipolar Transistor Second Edition provides the essential information needed by applications engineers to design new products using the device in sectors including consumer industrial lighting transportation medical and renewable energy The IGBT device has proven to be a highly important Power Semiconductor providing the basis for adjustable speed motor drives used in air conditioning and refrigeration and railway locomotives electronic ignition systems for gasoline powered motor vehicles and energy saving compact fluorescent light bulbs The book presents recent applications in plasma displays flat screen TVs and electric power transmission systems alternative energy systems and energy storage but it is also used in all renewable energy generation systems including solar and wind power This book is the first available on the applications of the IGBT It will unlock IGBT for a new generation of engineering applications making it essential reading for a wide audience of electrical and design engineers as well as an important publication for semiconductor specialists Presents essential design information for applications engineers utilizing IGBTs in the consumer industrial lighting transportation medical and renewable energy sectors Teaches the methodology for the design of IGBT chips including edge terminations cell topologies gate layouts and integrated current sensors Covers applications of the IGBT a device manufactured around the world by more than a dozen companies with sales exceeding 5 Billion Written by the inventor of the device this is the first book to highlight the key role of the IGBT in enabling electric vehicles and renewable energy systems with global impacts on climate change **Modern Silicon Carbide Power Devices** B Jayant Baliga,2023-09-18 Silicon Carbide power devices are being increasingly adopted for many applications such as electric vehicles and charging stations There is a large demand for a resource to learn and understand the basic physics of operation of these devices to create engineers with in depth knowledge about them This unique compendium provides a comprehensive design guide for Silicon Carbide power devices It systematically describes the device structures and analytical models for computing their characteristics The device structures included are the Schottky diode JBS rectifier power MOSFET JBSFET IGBT and BiDFET Unique structures that address achieving excellent voltage blocking and on resistance are emphasized This useful textbook and reference innovations for achieving superior high frequency operation and highlights manufacturing technology for the devices The book will benefit professionals academics researchers and graduate students in the fields of electrical and electronic engineering circuits and systems semiconductors and energy studies **Gallium Nitride And Silicon Carbide Power Devices** B Jayant Baliga,2016-12-12 During the last 30 years significant progress has been made to improve our understanding of gallium nitride and silicon carbide device structures resulting in experimental demonstration of their enhanced performances for power electronic systems Gallium nitride power devices made by the growth of the material on silicon substrates have gained a lot of interest Power device products made from these materials have become available during the last five years from many companies This comprehensive book discusses the physics of operation and design of gallium nitride and silicon carbide power devices It can be used as a reference by practicing engineers in the power electronics industry and as a textbook for a power device or power electronics course in universities *Springer Handbook of Semiconductor Devices* Massimo Rudan,Rossella Brunetti,Susanna Reggiani,2022-11-10 This Springer Handbook comprehensively covers the topic of semiconductor devices embracing all aspects from theoretical background to fabrication modeling and applications Nearly 100 leading scientists from industry and academia were selected to write the handbook s chapters which were conceived for professionals and practitioners material scientists physicists and electrical engineers working at universities industrial R D and manufacturers Starting from the description of the relevant technological aspects and fabrication steps the handbook proceeds with a section fully devoted to the main conventional semiconductor devices like e g bipolar transistors and MOS capacitors and transistors used in the production of the standard integrated circuits and the corresponding physical models In the subsequent chapters the scaling issues of the semiconductor device technology are addressed followed by the description of novel concept based semiconductor devices The last section illustrates the numerical simulation methods ranging from the fabrication processes to the device performances Each chapter is self contained and refers to related topics treated in other chapters when necessary so that the reader interested in a specific subject can easily identify a personal reading path through the vast contents of the handbook **On the perspectives of**

SiC MOSFETs in high-frequency and high-power isolated DC/DC converters Eial Awwad, Abdullah,2020-08-11 Increasing demand for efficiency and power density pushes Si based devices to some of their inherent material limits including those related to temperature operation switching frequency and blocking voltage Recently SiC based power devices are promising candidates for high power and high frequency switching applications Today SiC MOSFETs are commercially available from several manufacturers Although technology affiliated with SiC MOSFETs is improving rapidly many challenges remain and some of them are investigated in this work The research work in this dissertation is divided into the three following parts Firstly the static and switching characteristics of the state of the art 1 2 kV planar and double trench SiC MOSFETs from two different manufacturers are evaluated The effects of different biasing voltages DC link voltages and temperatures are analysed The characterisation results show that the devices exhibit superior switching performances under different operating conditions Moreover several aspects of using the SiC MOSFET s body diode in a DC DC converter are investigated comparing the body diodes of planar and double trench devices Reverse recovery is evaluated in switching tests considering the case temperature switching rate forward current and applied voltage Based on the measurement results the junction temperature is estimated to guarantee safe operation A simple electro thermal model is proposed in order to estimate the maximum allowed switching frequency based on the thermal design of the SiC devices Using these results hard and soft switching converters are designed and devices are characterised as being in continuous operation at a very high switching frequency of 1 MHz Thereafter the SiC MOSFETs are operated in a continuous mode in a 10 kW 100 250 kHz buck converter comparing synchronous rectification the use of the body diode and the use of an external Schottky diode Further the parallel operation of the planar devices is considered Thus the paralleling of SiC MOSFETs is investigated before comparing the devices in continuous converter operation In this regard the impact of the most common mismatch parameters on the static and dynamic current sharing of the transistors is evaluated showing that paralleling of SiC MOSFETs is feasible Subsequently an analytical model of SiC MOSFETs for switching loss optimisation is proposed The analytical model exhibits relatively close agreement with measurement results under different test conditions The proposed model tracks the oscillation effectively during both turn on and off transitions This has been achieved by considering the influence of the most crucial parasitic elements in both power and gate loops In the second part a comprehensive short circuit ruggedness evaluation focusing on different failure modes of the planar and double trench SiC devices is presented The effects of different biasing voltages DC link voltages and gate resistances are evaluated Additionally the temperature dependence of the short circuit capability is evaluated and the associated failure modes are analysed Subsequently the design and test of two different methods for overcurrent protection are proposed The desaturation technique is applied to the SiC MOSFETs and compared to a second method that depends on the stray inductance of the devices Finally the benefits of using SiC devices in continuous high frequency high power DC DC converters is experimentally evaluated In this regard a design optimisation of a high frequency transformer is introduced and the impact of different core materials conductor designs and winding arrangements are evaluated A ZVZCS Phase Shift Full Bridge unidirectional DC DC converter is proposed using only the parasitic leakage inductance of the transformer Experimental results for a 10 kW 100 250 kHz prototype indicate an efficiency of up to 98 1% for the whole converter Furthermore an optimized control method is proposed to minimise the circulation current in the isolated bidirectional dual active bridge DC DC converter based on a modified dual phase shift control method This control method is also experimentally compared with traditional single phase shift control yielding a significant improvement in efficiency The experimental results confirm the theoretical analysis and show that the proposed control can enhance the overall converter efficiency and expand the ZVZCS range Die steigende Nachfrage nach Effizienz und Leistungsdichte bringt Si basierte eistungsbauteile an einige inh rente Materialgrenzen die unter anderem mit der Temperaturbelastung der Schaltfrequenz und der Blockierspannung in Zusammenhang stehen In j ngster Zeit sind SiC basierte Leistungsbauelemente vielversprechende Kandidaten f r Hochleistungs und Hochfrequenzanwendungen Aktuell sind SiC MOSFETs von mehreren Herstellern im Handel erh ltlich Obwohl sich die Technologie der SiC MOSFETs rasch verbessert werden viele Herausforderungen bestehen bleiben Einige dieser Herausforderungen werden in dieser Arbeit untersucht Die Untersuchungen in dieser Dissertation gliedern sich in die drei folgenden Teile Im ersten Teil erfolgt die statische und die transiente Charakterisierung der aktuellen 1 2 kV Planarund Doubletrench SiC MOSFETs verschiedener Hersteller Die Auswirkungen unterschiedlicher Gatespannungen Zwischenkreisspannungen und Temperaturen werden analysiert Die Ergebnisse der Charakterisierung zeigen dass die Bauteile berlegene Schaltleistungen unter verschiedenen Betriebsbedingungen aufweisen Dar ber hinaus wird der Einsatz der internen SiC Bodydioden in einem DC DC Wandler untersucht wobei die Unterschiede zwischen Planar und Doppeltrench Bauteilen aufgezeigt werden Das Reverse Recovery Verhalten wird unter Ber cksichtigung der Geh usetemperatur der Schaltgeschwindigkeit des Durchlassstroms und der angelegten Spannung bewertet Anhand der Messergebnisse wird die Sperrschichttemperatur gesch tzt damit ein sicherer Betrieb gew hrleistet ist Ein einfaches elektrothermisches Modell wird vorgestellt um die maximal zul ssige Schaltfrequenz auf der Grundlage des thermischen Designs der SiC Bauteile abzusch tzen Anhand dieser Ergebnisse werden hart und weichschaltende Umrichter konzipiert und die Bauteile werden im Dauerbetrieb mit einer sehr hohen Schaltfrequenz von 1 MHz untersucht Danach werden die SiC MOSFETs im Dauerbetrieb in einem 10 kW 100 250 kHz Tiefsetzsteller betrieben Dabei wird die Synchrongleichrichtung die Verwendung der internen Diode und die Verwendung einer externen Schottky Diode verglichen Au erdem wird die Parallelisierung von SiC MOSFETs untersucht bevor die Parallelschaltung der verschiedenen Bauelemente ebenso im kontinuierlichen Konverterbetrieb verglichen wird Es wird der Einfluss der h ufigsten Parametervariationen auf die statische und dynamische Stromaufteilung der Transistoren analysiert was zeigt dass eine Parallelisierung von SiC MOSFETs m glich ist Anschlie end wird ein analytisches Modell der SiC MOSFETs zur

Schaltverlustoptimierung vorgeschlagen Das analytische Modell zeigt eine relativ enge bereinstimmung mit den Messergebnissen unter verschiedenen Testbedingungen Das vorgeschlagene Modell bildet die Schwingungen sowohl beim Ein als auch beim Ausschalten effektiv nach Dies wurde durch die Ber cksichtigung der wichtigsten parasit ren Elemente in Strom und Gatekreisen erreicht Im zweiten Teil wird eine umfassende Bewertung der Kurzschlussfestigkeit mit Fokus auf verschiedene Ausfallmodi der planaren und double trench SiC Bauelemente vorgestellt Die Auswirkungen unterschiedlicher Gatespannungen Zwischenkreisspannungen und Gate Widerst nde werden ausgewertet Zus tzlich wird die temperaturabh ngige Kurzschlussf higkeit ausgewertet und die zugeh rigen Fehlerf lle werden analysiert Anschlie end wird die Auslegung und Pr fung von zwei verschiedenen Verfahren zum berstromschutz evaluiert Die Desaturation Technik wird auf SiC MOSFETs angewendet und mit einer zweiten Methode verglichen welche die parasit re Induktivit t der Bauelemente nutzt Schlie lich wird der Nutzen des Einsatzes von SiC Bauteilen in kontinuierlichen Hochfrequenz Hochleistungs DC DC Wandlern experimentell untersucht In diesem Zusammenhang wird eine Designoptimierung eines Hochfrequenztransformators vorgestellt und der Einfluss verschiedener Kernmaterialien Leiterausf hrungen und Wicklungsanordnungen wird bewertet Es wird ein unidirektionaler ZVZCS Vollbr cken DC DC Wandler vorgestellt der nur die parasit re Streuinduktivit t des Transformators verwendet Experimentelle Ergebnisse f r einen 10 kW 100 250 kHz Prototyp zeigen einenWirkungsgrad von bis zu 98 1% f r den gesamten Umrichter Abschlie end wird ein optimiertes Regelverfahren verwendet welches auf einem modifizierten Dual Phase Shift Regelverfahren basiert um den Kreisstrom im isolierten bidirektionalen Dual Aktiv Br cken DC DC Wandler zu minimieren Diese Regelmethode wird experimentell mit der herk mmlichen Single Phase Shift Regelung verglichen Hierbei zeigt sich eine deutliche Effizienzsteigerung durch die neue Regelmethode Die experimentellen Ergebnisse best tigen die theoretische Analyse und zeigen dass die vorgeschlagene Regelung den Gesamtwirkungsgrad des Umrichters erh hen und den ZVZCS Bereich erweitern kann Radiation Tolerant Electronics Paul Leroux,2019-08-26 Research on radiation tolerant electronics has increased rapidly over the past few years resulting in many interesting approaches to modeling radiation effects and designing radiation hardened integrated circuits and embedded systems This research is strongly driven by the growing need for radiation hardened electronics for space applications high energy physics experiments such as those on the Large Hadron Collider at CERN and many terrestrial nuclear applications including nuclear energy and nuclear safety With the progressive scaling of integrated circuit technologies and the growing complexity of electronic systems their susceptibility to ionizing radiation has raised many exciting challenges which are expected to drive research in the coming decade In this book we highlight recent breakthroughs in the study of radiation effects in advanced semiconductor devices as well as in high performance analog mixed signal RF and digital integrated circuits We also focus on advances in embedded radiation hardening in both FPGA and microcontroller systems and apply radiation hardened embedded systems for cryptography and image processing targeting space applications The BaSIC Topology B. Jayant Baliga,Ajit Kanale,2025-05-19 The BaSIC topology is a revolutionary method for controlling power semiconductor devices It enables monitoring the current flow through the devices while providing a unique current limiting capability that enhances their short circuit withstand capability The book describes the BaSIC topology concept and contrasts it with previous approaches It provides an extensive description of the application of the BaSIC topology to silicon IGBTs silicon carbide power MOSFETs and GaN HEMT devices The ability to extend the short circuit withstand time to over 10 ms for SiC power MOSFETs has been achieved for the first time with the BaSIC topology The BaSIC topology is the only approach shown to eliminate the failure of these devices under repetitive short circuit events The sensing of current in paralleled devices is demonstrated eliminating the need for external sensors The BaSIC topology has utility for various power electronics applications including electric vehicles and industrial motor drives Introduces the BaSIC topology a revolutionary new approach for the control of power devices Describes the application of the BaSIC topology to silicon IGBTs silicon carbide power MOSFETs and GaN HEMT devices Written by the inventor of the insulated gate bipolar transistor IGBT and the BaSIC topology concept **Integrated Power Devices and TCAD Simulation** Yue Fu,Zhanming Li,Wai Tung Ng,Johnny K.O. Sin,2017-12-19 From power electronics to power integrated circuits PICs smart power technologies devices and beyond Integrated Power Devices and TCAD Simulation provides a complete picture of the power management and semiconductor industry An essential reference for power device engineering students and professionals the book not only describes the physics inside integrated power semiconductor devices such lateral double diffused metal oxide semiconductor field effect transistors LDMOSFETs lateral insulated gate bipolar transistors LIGBTs and super junction LDMOSFETs but also delivers a simple introduction to power management systems Instead of abstract theoretical treatments and daunting equations the text uses technology computer aided design TCAD simulation examples to explain the design of integrated power semiconductor devices It also explores next generation power devices such as gallium nitride power high electron mobility transistors GaN power HEMTs Including a virtual process flow for smart PIC technology as well as a hard to find technology development organization chart Integrated Power Devices and TCAD Simulation gives students and junior engineers a head start in the field of power semiconductor devices while helping to fill the gap between power device engineering and power management systems Power Integrity for Electrical and Computer Engineers J. Ted Dibene, II,David Hockanson,2019-09-24 A professional guide to the fundamentals of power integrity analysis with an emphasis on silicon level power integrity Power Integrity for Electrical and Computer Engineers embraces the most recent changes in the field offers a comprehensive introduction to the discipline of power integrity and provides an overview of the fundamental principles Written by noted experts on the topic the book goes beyond most other resources to focus on the detailed aspects of silicon and optimization techniques in order to broaden the field of study This important book offers coverage of a wide range of topics including signal analysis EM concepts for PI frequency domain analysis for PI numerical methods overview for PI and silicon device PI modeling Power Integrity for Electrical and Computer Engineers examine platform technologies system considerations power conversion system level modeling and optimization methodologies To reinforce the material presented the authors include example problems This important book Includes coverage on convergence accuracy and error analysis and explains how these can be used to analyze power integrity problems Contains information for modeling the power converter from the PDN to the load in a full system level model Explores areas of device level modeling of silicon as related to power integrity Contains example word problems that are related to an individual chapter s subject Written for electrical and computer engineers and academics Power Integrity for Electrical and Computer Engineers is an authoritative guide to the fundamentals of power integrity and explores the topics of power integrity analysis power integrity analytics silicon level power integrity and optimization techniques Embedded Systems and Artificial Intelligence Vikrant Bhateja,Suresh Chandra Satapathy,Hassan Satori,2020-04-07 This book gathers selected research papers presented at the First International Conference on Embedded Systems and Artificial Intelligence ESAI 2019 held at Sidi Mohamed Ben Abdellah University Fez Morocco on 2 3 May 2019 Highlighting the latest innovations in Computer Science Artificial Intelligence Information Technologies and Embedded Systems the respective papers will encourage and inspire researchers industry professionals and policymakers to put these methods into practice

Proceedings of SIE 2024 Maurizio Valle,Paolo Gastaldo,Ernesto Limiti,2025-01-02 This book showcases the state of the art in the field of electronics as presented by researchers and engineers at the 55th Annual Meeting of the Italian Electronics Society SIE held in Genoa Italy on June 26 28 2024 It covers a broad range of aspects including integrated circuits and systems micro and nano electronic devices microwave electronics sensors and microsystems optoelectronics and photonics power electronics electronic systems and applications **Proceedings of Mechanical Engineering Research Day 2017** Mohd Fadzli Bin Abdollah,Tee Boon Tuan,Mohd Azli Salim,Mohd Zaid Akop,Rainah Ismail,Haslinda Musa,2017-05-29 This e book is a compilation of papers presented at the Mechanical Engineering Research Day 2017 MERD 17 Melaka Malaysia on 30 March 2017 Fundamentals of Power Electronics Robert W. Erickson,Dragan Maksimović,2020-07-14 Fundamentals of Power Electronics Third Edition is an up to date and authoritative text and reference book on power electronics This new edition retains the original objective and philosophy of focusing on the fundamental principles models and technical requirements needed for designing practical power electronic systems while adding a wealth of new material Improved features of this new edition include new material on switching loss mechanisms and their modeling wide bandgap semiconductor devices a more rigorous treatment of averaging explanation of the Nyquist stability criterion incorporation of the Tan and Middlebrook model for current programmed control a new chapter on digital control of switching converters major new chapters on advanced techniques of design oriented analysis including feedback and extra element theorems average current control new material on input filter design new treatment of averaged switch modeling simulation and indirect power and sampling effects in DCM CPM and digital control Fundamentals of Power Electronics Third Edition is intended for use in introductory power electronics courses and related fields for both senior undergraduates and first year graduate students interested in converter circuits and electronics control systems and magnetic and power systems It will also be an invaluable reference for professionals working in power electronics power conversion and analog and digital electronics **Wide Bandgap Semiconductor Power Devices** B. Jayant Baliga,2018-10-17 Wide Bandgap Semiconductor Power Devices Materials Physics Design and Applications provides readers with a single resource on why these devices are superior to existing silicon devices The book lays the groundwork for an understanding of an array of applications and anticipated benefits in energy savings Authored by the Founder of the Power Semiconductor Research Center at North Carolina State University and creator of the IGBT device Dr B Jayant Baliga is one of the highest regarded experts in the field He thus leads this team who comprehensively review the materials device physics design considerations and relevant applications discussed Comprehensively covers power electronic devices including materials both gallium nitride and silicon carbide physics design considerations and the most promising applications Addresses the key challenges towards the realization of wide bandgap power electronic devices including materials defects performance and reliability Provides the benefits of wide bandgap semiconductors including opportunities for cost reduction and social impact *Introduction to RF Power Amplifier Design and Simulation* Abdullah Eroglu,2018-09-03 Introduction to RF Power Amplifier Design and Simulation fills a gap in the existing literature by providing step by step guidance for the design of radio frequency RF power amplifiers from analytical formulation to simulation implementation and measurement Featuring numerous illustrations and examples of real world engineering applications this book Gives an overview of intermodulation and elaborates on the difference between linear and nonlinear amplifiers Describes the high frequency model and transient characteristics of metal oxide semiconductor field effect transistors Details active device modeling techniques for transistors and parasitic extraction methods for active devices Explores network and scattering parameters resonators matching networks and tools such as the Smith chart Covers power sensing devices including four port directional couplers and new types of reflectometers Presents RF filter designs for power amplifiers as well as application examples of special filter types Demonstrates the use of computer aided design CAD tools implementing systematic design techniques Blending theory with practice Introduction to RF Power Amplifier Design and Simulation supplies engineers researchers and RF microwave engineering students with a valuable resource for the creation of efficient better performing low profile high power RF amplifiers

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