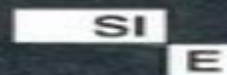


Robert W. Erickson
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Fundamentals of Power Electronics *Second Edition*



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Fundamentals Of Power Electronics Second Edition

Toru Tanzawa



Fundamentals Of Power Electronics Second Edition:

Fundamentals of Power Electronics Robert W. Erickson, Dragan Maksimovic, 2007-05-08 Fundamentals of Power Electronics Second 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 A new chapter on input filters showing how to design single and multiple section filters Major revisions of material on averaged switch modeling low harmonic rectifiers and the chapter on AC modeling of the discontinuous conduction mode New material on soft switching active clamp snubbers zero voltage transition full bridge converter and auxiliary resonant commutated pole Also new sections on design of multiple winding magnetic and resonant inverter design Additional appendices on Computer Simulation of Converters using averaged switch modeling and Middlebrook's Extra Element Theorem including four tutorial examples and Expanded treatment of current programmed control with complete results for basic converters and much more This edition includes many new examples illustrations and exercises to guide students and professionals through the intricacies of power electronics design Fundamentals of Power Electronics Second 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 analogue and digital electronics

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

Digital Control in Power Electronics, 2nd Edition Simone Buso, Paolo Mattavelli, 2022-05-31 This book

presents the reader whether an electrical engineering student in power electronics or a design engineer a selection of power converter control problems and their basic digital solutions based on the most widespread digital control techniques The presentation is primarily focused on different applications of the same power converter topology the half bridge voltage source inverter considered both in its single and three phase implementation This is chosen as the test case because besides being simple and well known it allows the discussion of a significant spectrum of the most frequently encountered digital control applications in power electronics from digital pulse width modulation DPWM and space vector modulation SVM to inverter output current and voltage control ending with the relatively more complex VSI applications related to the so called smart grid scenario This book aims to serve two purposes 1 to give a basic introductory knowledge of the digital control techniques applied to power converters and 2 to raise the interest for discrete time control theory stimulating new developments in its application to switching power converters

Magnetic Components for Power Electronics Alex Goldman, 2012-12-06 Magnetic Components for Power Electronics concerns the important considerations necessary in the choice of the optimum magnetic component for power electronic applications These include the topology of the converter circuit the core material shape size and others such as cost and potential component suppliers These are all important for the design engineer due to the emergence of new materials changes in supplier management and the examples of several component choices Suppliers using this volume will also understand the needs of designers Highlights include Emphasis on recently introduced new ferrite materials such as those operating at megahertz frequencies and under higher DC drive conditions Discussion of amorphous and nanocrystalline metal materials New technologies such as resonance converters power factors correction PFC and soft switching Catalog information from over 40 magnetic component suppliers Examples of methods of component choice for ferrites amorphous nanocrystalline materials Information on suppliers management changes such as those occurring at Siemens Philips Thomson and Allied Signal Attention to the increasingly important concerns about EMI This book should be especially helpful for power electronic circuit designers technical executives and material science engineers involved with power electronic components

Handbook of Power Management Circuits Haruo Kobayashi, Takashi Nabeshima, 2016-03-23 This comprehensive book focuses on DC DC switching power supply circuits which are receiving attention as a key technology in green IT especially in the automotive and consumer electronics industries It covers buck converters isolated converters PFC converters their modeling and analysis several control methods passive components and their

Power Electronics Issa Batarseh, Ahmad Harb, 2017-12-22 This fully updated textbook provides complete coverage of electrical circuits and introduces students to the field of energy conversion technologies analysis and design Chapters are designed to equip students with necessary background material in such topics as devices switching circuit analysis techniques converter types and methods of conversion The book contains a large number of examples exercises and problems to help enforce the material presented in each chapter A detailed discussion of resonant

and softswitching dc to dc converters is included along with the addition of new chapters covering digital control non linear control and micro inverters for power electronics applications Designed for senior undergraduate and graduate electrical engineering students this book provides students with the ability to analyze and design power electronic circuits used in various industrial applications

CMOS R. Jacob Baker, 2019-06-19 A revised guide to the theory and implementation of CMOS analog and digital IC design The fourth edition of CMOS Circuit Design Layout and Simulation is an updated guide to the practical design of both analog and digital integrated circuits The author a noted expert on the topic offers a contemporary review of a wide range of analog digital circuit blocks including phase locked loops delta sigma sensing circuits voltage current references op amps the design of data converters and switching power supplies CMOS includes discussions that detail the trade offs and considerations when designing at the transistor level The companion website contains numerous examples for many computer aided design CAD tools Using the website enables readers to recreate modify or simulate the design examples presented throughout the book In addition the author includes hundreds of end of chapter problems to enhance understanding of the content presented This newly revised edition Provides in depth coverage of both analog and digital transistor level design techniques Discusses the design of phase and delay locked loops mixed signal circuits data converters and circuit noise Explores real world process parameters design rules and layout examples Contains a new chapter on Power Electronics Written for students in electrical and computer engineering and professionals in the field the fourth edition of CMOS Circuit Design Layout and Simulation is a practical guide to understanding analog and digital transistor level design theory and techniques

Principles of Power Electronics John G. Kassakian, David J. Perreault, George C. Verghese, Martin F. Schlecht, 2023-08-03 Substantially expanded and updated the new edition of this classic textbook provides unrivalled coverage of the fundamentals of power electronics Comprehensive coverage of foundational concepts in circuits magnetics devices dynamic models and control establishes a strong conceptual framework for further study Extensive discussion of contemporary practical considerations enhanced by real world examples prepares readers for design scenarios ranging from low power dc dc converters to multi megawatt ac machine drives New topics include SiC and GaN wide bandgap materials superjunction MOSFET and IGBT devices advanced magnetics design multi level and switched capacitor converters RF converter circuits and EMI Over 300 new and revised end of chapter problems enhance and expand understanding of the material with solutions for instructors Unique in its breadth and depth and providing a range of flexible teaching pathways at multiple levels this is the definitive guide to power electronics for graduate and senior undergraduate students in electrical engineering and practicing electrical engineers

Fully-Integrated Power Management Circuits for Thermoelectric Energy Harvesting Toru Tanzawa, 2024-06-19 This book describes fully integrated power management circuits for thermoelectric energy harvesting Readers will learn about the applications system design fundamentals designs of building blocks maximum power point tracking techniques and design of battery chargers The book

covers the following key topics 1 minimizing the cost of a thermoelectric generator TEG by considering the maximum open circuit voltage of TEG and the dependence of the power conversion efficiency of the converter on the input voltage 2 controlling the input voltage of the converter system to ensure it remains higher than the minimum operating voltage 3 designing a charge pump operating in the sub threshold region considering factors such as clock frequency stage capacitor size rectifying device size and the number of stages 4 implementing maximum power point tracking techniques with a small circuit area and 5 designing a fully integrated battery charger Readers will gain a comprehensive understanding of these concepts and their practical applications

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 SiC basierte Leistungsbauteile an einige inhärente Materialgrenzen die unter anderem mit der Temperaturbelastung der Schaltfrequenz und der Blockierspannung in Zusammenhang stehen In jüngster Zeit sind SiC basierte Leistungsbaulemente vielversprechende Kandidaten für Hochleistungs- und Hochfrequenzanwendungen Aktuell sind SiC MOSFETs von mehreren Herstellern im Handel erhältlich 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 Planar- und 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 Darüber 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 Berücksichtigung der Gehäusetemperatur der Schaltgeschwindigkeit des Durchlassstroms und der angelegten Spannung bewertet Anhand der Messergebnisse wird die Sperrschichttemperatur geschätzt damit ein sicherer Betrieb gewährleistet ist Ein einfaches elektrothermisches Modell wird vorgestellt um die maximal zulässige Schaltfrequenz auf der Grundlage des thermischen Designs der SiC Bauteile abzuschätzen 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. Außerdem wird die Parallelisierung von SiC MOSFETs untersucht, bevor die Parallelschaltung der verschiedenen Bauelemente ebenso im kontinuierlichen Konverterbetrieb verglichen wird. Es wird der Einfluss der häufigsten Parametervariationen auf die statische und dynamische Stromaufteilung der Transistoren analysiert, was zeigt, dass eine Parallelisierung von SiC MOSFETs möglich ist. Anschließend wird ein analytisches Modell der SiC MOSFETs zur Schaltverlustoptimierung vorgeschlagen. Das analytische Modell zeigt eine relativ enge Übereinstimmung 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 Berücksichtigung der wichtigsten parasitären 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 Widerstände werden ausgewertet. Zusätzlich wird die temperaturabhängige Kurzschlussfestigkeit ausgewertet und die zugehörigen Fehlerfälle werden analysiert. Anschließend wird die Auslegung und Prüfung von zwei verschiedenen Verfahren zum Überstromschutz evaluiert. Die Desaturation Technik wird auf SiC MOSFETs angewendet und mit einer zweiten Methode verglichen, welche die parasitäre Induktivität der Bauelemente nutzt. Schließlich 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, Leiterauführungen und Wicklungsanordnungen wird bewertet. Es wird ein unidirektionaler ZVZCS Vollbrücken-DC/DC Wandler vorgestellt, der nur die parasitäre Streuinduktivität des Transformators verwendet. Experimentelle Ergebnisse für einen 10 kW 100 250 kHz Prototyp zeigen einen Wirkungsgrad von bis zu 98,1% für den gesamten Umrichter. Abschließend wird ein optimiertes Regelverfahren verwendet, welches auf einem modifizierten Dual-Phase-Shift-Regelverfahren basiert, um den Kreisstrom im isolierten bidirektionalen Dual-Aktiv-Brücken-DC/DC Wandler zu minimieren. Diese Regelmethode wird experimentell mit der herkömmlichen Single-Phase-Shift-Regelung verglichen. Hierbei zeigt sich eine deutliche Effizienzsteigerung durch die neue Regelmethode. Die experimentellen Ergebnisse bestätigen die theoretische Analyse und zeigen, dass die vorgeschlagene Regelung den Gesamtwirkungsgrad des Umrichters erhöhen und den ZVZCS-Bereich erweitern kann.

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